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A VORTEX-LATTICE METHOD FOR THE MEAN CAMBER SHAPES OF TRIMMED NONCOPLANAR PLANFORMS WITH MINIMUM VORTEX DRAG

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SUMMARY

A new subsonic method has been developed by which the mean camber surface can be determined for trimmed noncoplanar planforms with minimum vortex drag. This method uses a vortex lattice and overcomes previous difficulties with chord loading specification. This method uses a Trefftz plane analysis to determine the optimum span loading for minimum drag, then solves for the mean camber surface of the wing, which will provide the required loading. Pitching-moment or root-bending-moment constraints can be employed as well at the design lift coefficient.

Sensitivity studies of vortex-lattice arrangement have been made with this method and are presented. Comparisons with other theories show generally good agreement. The versatility of the method is demonstrated by applying it to (1) isolated wings, (2) wing-canard configurations, (3) a tandem wing, and (4) a wing-winglet configuration.

INTRODUCTION

Configuration design for subsonic transports usually begins with the wing, after which the body and its effects are taken into account, and then the tails are sized and located by taking into account stability and control requirements. With the advent of highly maneuverable aircraft having closely coupled lifting surfaces, there has been an increased interest in changing the design order so that multiple surfaces could be designed together to yield a trimmed configuration with minimum induced drag at some specified lift coefficient. Such a combined design approach requires that the mutual interference of the lifting surfaces be considered initially.

Single planform design methods are available to optimize the mean camber surface, better called the local elevation surface, for wings flying at subsonic speeds (for example, ref. 1) and at supersonic speeds (for example, refs. 2 and 3). The design method presented in reference 1 was developed from an established analysis method (Multhopp type), also presented in reference 1, by using the same mathematical model, but the design method solves for the local mean slope rather than the lifting pressures. In the usual implementation of reference 1, the design lifting pressures are taken to be linear chordwise, but must be represented in this solution by a sine series which oscillates about them. An example presented herein demonstrates that corresponding oscillations may appear in pressure distributions measured on wings which have been designed by the method of reference 1. The method developed herein overcomes this oscillatory lifting pressure behavior by specifying linear chord loadings at the outset.

The development approach used in the two-planform design problem will be similar to that used for a single planform. The analytic method employed, selected because of its geometric versatility, is the noncoplanar two-planform vortex-lattice method of reference 4.

The design procedure is essentially an optimization or extremization problem. Subsonic methods (for example, see refs. 5 and 6) are available for determining the span load distributions on bent lifting lines in the Trefftz plane, but they do not describe the necessary local elevation surface. This is one of the objectives of the present method which will utilize the Lagrange multiplier technique (also employed in refs. 2 and 3). The method of reference 4 is used to provide the needed geometrical relationships between the circulation and induced normal flow for complex planforms, as well as to compute the lift, drag, and pitching moment.

This paper also presents the results of precision studies and comparisons with other methods and data. Several examples of solutions for configurations of recent interest are also presented. The FORTRAN computer program written to perform the computation is described (appendix A), along with details of the program input data (appendix B) and output data (appendix C). Listings and typical running times of example configurations are given (appendix D), and a FORTRAN program listing is provided (appendix E). Appendix F provides details concerning the changes needed to substitute a root-bending-moment constraint for the basic constraint on configuration pitching-moment balance.

SYMBOLS

The geometric description of planforms is based on the body-axis system. (See fig. 1 for positive directions.) For computational purposes the planform is replaced by a vortex lattice which is in a wind-axis system. Both the body axes and the wind axes have their origins in the planform plane of symmetry. (See sketch (a) for details.) The axis system of a particular horseshoe vortex is wind oriented and referred to the origin of that horseshoe vortex (fig. 1). For the purpose of the computer program, the length dimension is arbitrary for a given case; angles associated with the planform are always in degrees. (The variable names used for input data in the computer program are described in appendix B.)

$A_{l,n}$ element of influence function matrix A, $\frac{\overline{F}_{w,l,n} - \overline{F}_{v,l,n} \tan \phi_l}{4\pi}$, which contains induced normal flow at lth point due to nth horseshoe vortex of unit strength; total number of elements is $\frac{N}{2} \times \frac{N}{2}$

AR aspect ratio

a fractional chord location where chord load changes from constant value to linearly varying value toward zero at trailing edge

a_i,b_i,c_i coefficients in spanwise scaling polynomial

b wing span

C_B root-bending-moment coefficient about $\overline{X}$-axis, $\frac{\text{Root bending moment}}{q_\infty S_{ref}(b/2)}$

C_D drag coefficient, $\frac{\text{Drag}}{q_\infty S_{ref}}$

$C_{D,o}$ drag coefficient at $C_L = 0$

C_L lift coefficient, $\frac{\text{Lift}}{q_\infty S_{ref}}$

C_m pitching-moment coefficient about $\overline{Y}$-axis, $\frac{\text{Pitching moment}}{q_\infty S_{ref} c_{ref}}$

C_N normal-force coefficient, $\frac{\text{Normal force}}{q_\infty S_{ref}}$

ΔC_p lifting pressure coefficient

c chord

c_l section lift coefficient

c_{ref} reference chord

$F_{w,l,n}, F_{v,l,n}$ influence function which geometrically relates induced effect of nth horseshoe vortex to quantity which is proportional to induced downwash or sidewash at slope point l (see sketch (a) and also eqs. (5) and (6))

$\bar{F}_{w,l,n}, \bar{F}_{v,l,n}$ sum of influence function $F_{w,l,n}$ or $F_{v,l,n}$ at slope point l on planform caused by two symmetrically located horseshoe vortices, left wing panel vortex denoted by n and right wing panel vortex denoted by $N + 1 - n$ (see fig. 1)

G function to be extremized (see eq. (19))

I $\equiv \left[\bar{N}_c a + 0.75\right]$ (brackets indicate "take the greatest integer")

K maximum number of spanwise scaling terms (see eqs. (25) to (27))

L lift

$M_{\bar{Y}}$ pitching moment about coordinate origin

M_∞ free-stream Mach number

m number of span stations where pressure modes are defined as used in reference 1

N maximum number of elemental panels on both sides of configuration; maximum number of chordal control points at each of m span stations as used in reference 1

$\bar{N}_c$ number of elemental panels from leading to trailing edge in chordwise row

$\bar{N}_s$ total number of (chordwise) rows in spanwise direction of elemental panels on configuration semispan

q_∞ free-stream dynamic pressure

S_{ref} reference area

s horseshoe vortex semiwidth in plane of horseshoe (see fig. 2)

U	free-stream velocity
X,Y,Z	axis system of given horseshoe vortex (see fig. 1)
$\bar{X},\bar{Y},\bar{Z}$	body-axis system for planform (see fig. 1)
$\hat{X},\hat{Y},\hat{Z}$	wind-axis system for planform (see sketch (a))
x,y,z	distance along X-, Y-, and Z-axis, respectively
x'	$= x/\beta$
$\bar{x},\bar{y},\bar{z}$	distance along $\bar{X}$-, $\bar{Y}$-, and $\bar{Z}$-axis, respectively
$\Delta\bar{x}$	incremental movement of $\bar{X}$-$\bar{Y}$ coordinate origin in streamwise direction
$\bar{x}_{c/4}$	midspan $\bar{x}$-location of quarter-chord of elemental panel
$\bar{x}_{3c/4}$	midspan $\bar{x}$-location of three-quarter-chord of elemental panel
y^*,z^*	y and z distances from image vortices located on right half of plane of symmetry, as viewed from behind, to points on left panel
$\bar{z}_c$	canard height with respect to wing plane, positive down
$\bar{z}/c$	local elevation normalized by local chord, referenced to local trailing-edge height, positive down
$(\partial\bar{z}/\partial\bar{x})_l$	lth elemental local slope in vector $\{\partial\bar{z}/\partial\bar{x}\}$ of $N/2$ elements (see eq. (1))
α	angle of attack, deg
β	Prandtl-Glauert correction factor to account for effect of compressibility in subsonic flow, $\sqrt{1 - M_\infty^2}$
Γ_n	vortex strength of nth element in vector $\{\Gamma\}$ of $N/2$ elements
δ	independent variable in extremization process

ϵ incidence angle, positive leading edge up, deg

η nondimensional spanwise coordinates, $\frac{\bar{y}}{b/2}$

η_l nondimensional spanwise coordinate based on local planform semispan

Λ planform leading-edge sweep angle in $\bar{X}$-$\bar{Y}$ plane, deg

λ Lagrange multiplier (see eq. (19))

ξ distance along local chord normalized by local chord

ξ' fractional chordwise location of point where mean camber height is to be computed (see eq. (28))

σ,σ' dihedral angle from trailing vortex to point on left panel being influenced; σ measured from left panel, σ' measured from right panel

ϕ constraint function (see eqs. (20) and (21)); also horseshoe vortex dihedral angle in $\bar{Y}$-$\bar{Z}$ plane on left wing panel, deg

ϕ' horseshoe vortex dihedral angle on right wing panel, $\phi' = -\phi$, deg

ψ quarter-chord sweep angle of elemental panel; because of small angle assumption, also used as sweep angle of spanwise horseshoe vortex filament in X-Y plane, deg

ψ' $= \tan^{-1}\left(\frac{\tan \psi}{\beta}\right)$

Subscripts:

c canard

d design

i,j,k indices to vary over the range indicated

le leading edge

l,n associated with slope point and horseshoe vortex, respectively, ranging from 1 to N/2

L left trailing leg

R right trailing leg

r root-chord location

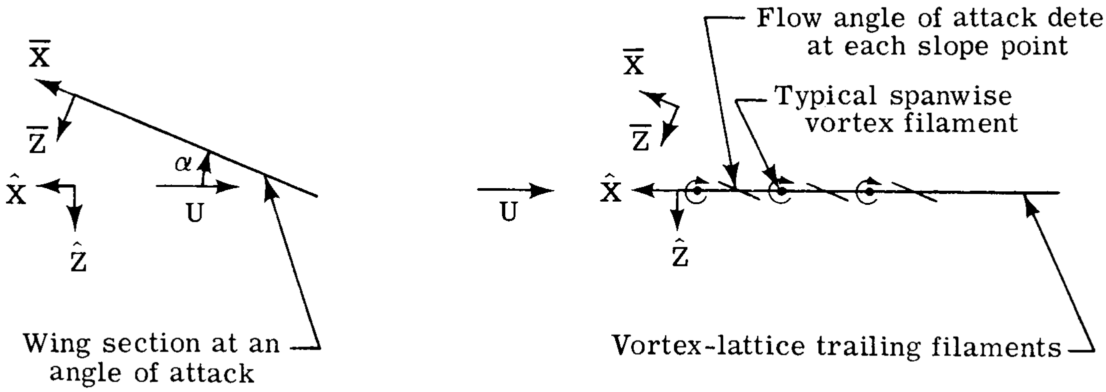
v vortex

w wing

Matrix notation:

{ } column vector

[ ] square matrix



Sketch (a)

THEORETICAL DEVELOPMENT

This section presents the application of vortex-lattice methodology to the mean-camber-surface design of two lifting planforms which may be separated vertically and have dihedral. For a given planform, local vertical displacements of the surfaces with respect to their chord lines in the wing axis (see sketch (a)) are assumed to be negligible; however, vertical displacements of the solution surfaces due to planform separation or dihedral are included. The wakes of these bent lifting planforms are assumed to lie in their respective extended bent chord planes with no roll up. For a two-planform configuration the resulting local elevation surface solutions are those for which both the vortex drag is minimized at the design lift coefficient and the pitching moment is constrained to be zero about the origin. For an isolated planform no pitching-moment constraint is imposed. Thus, the solution is the local elevation surface yielding the minimum vortex drag at the design lift coefficient. Lagrange multipliers together with suitable interpolating and integrating procedures are used to obtain the solutions. The details of the solution are given in the following five subsections.

Relationship Between Local Slope and Circulation

From reference 4, the distributed circulation over a lifting system is related to the local slope by

$$\left\{\frac{\partial \bar{z}}{\partial \bar{x}}\right\} = \left[A\right]\left\{\frac{\Gamma}{U}\right\} \tag{1}$$

where the matrix $\left[A\right]$ is the aerodynamic influence coefficient matrix based on the paneling technique described in reference 4. This matrix has elements of

$$A_{l,n} = \frac{1}{4\pi}\left[\bar{F}_{w,l,n}(x',y,z,s,\psi',\phi) - \bar{F}_{v,l,n}(x',y,z,s,\psi',\phi) \tan \phi_l\right] \tag{2}$$

which, because of the assumed spanwise symmetry of loading, leads to

$$\bar{F}_{w,l,n}(x',y,z,s,\psi',\phi) \equiv F_{w,l,n}(x',y,z,s,\psi',\phi)_{\text{left panel}} + F_{w,l,N+1-n}(x',y,z,s,\psi',\phi)_{\text{right panel}} \tag{3}$$

and

$$\bar{F}_{v,l,n}(x',y,z,s,\psi',\phi) \equiv F_{v,l,n}(x',y,z,s,\psi',\phi)_{\text{left panel}} + F_{v,l,N+1-n}(x',y,z,s,\psi',\phi)_{\text{right panel}} \tag{4}$$

where

$$F_w(x',y,z,s,\psi',\phi) = \frac{(y \tan \psi' - x') \cos \phi}{(x')^2 + (y \sin \phi)^2 + \cos^2 \phi\left(y^2 \tan^2 \psi' + z^2 \sec^2 \psi' - 2yx' \tan \psi'\right) - 2z \cos \phi \sin \phi(y + x' \tan \psi')}$$

$$\times \left\{\frac{(x' + s \cos \phi \tan \psi') \cos \phi \tan \psi' + (y + s \cos \phi) \cos \phi + (z + s \sin \phi) \sin \phi}{\left[(x' + s \cos \phi \tan \psi')^2 + (y + s \cos \phi)^2 + (z + s \sin \phi)^2\right]^{1/2}}\right.$$

$$\left. - \frac{(x' - s \cos \phi \tan \psi') \cos \phi \tan \psi' + (y - s \cos \phi) \cos \phi + (z - s \sin \phi) \sin \phi}{\left[(x' - s \cos \phi \tan \psi')^2 + (y - s \cos \phi)^2 + (z - s \sin \phi)^2\right]^{1/2}}\right\}$$

$$- \frac{y - s \cos \phi}{(y - s \cos \phi)^2 + (z - s \sin \phi)^2}\left\{1 - \frac{x' - s \cos \phi \tan \psi'}{\left[(x' - s \cos \phi \tan \psi')^2 + (y - s \cos \phi)^2 + (z - s \sin \phi)^2\right]^{1/2}}\right\}$$

$$+ \frac{y + s \cos \phi}{(y + s \cos \phi)^2 + (z + \sin \phi)^2}\left\{1 - \frac{x' + s \cos \phi \tan \psi'}{\left[(x' + s \cos \phi \tan \psi')^2 + (y + s \cos \phi)^2 + (z + s \sin \phi)^2\right]^{1/2}}\right\} \qquad (5)$$

and

$$F_v(x',y,z,s,\psi',\phi) = \frac{x' \sin \phi - z \cos \phi \tan \psi'}{(x')^2 + (y \sin \phi)^2 + \cos^2 \phi(y^2 \tan^2 \psi' + z^2 \sec^2 \psi' - 2yx' \tan \psi') - 2z \cos \phi \sin \phi(y + x' \tan \psi')}$$

$$\times \left\{\frac{(x' + s \cos \phi \tan \psi') \cos \phi \tan \psi' + (y + s \cos \phi) \cos \phi + (z + s \sin \phi) \sin \phi}{\left[(x' + s \cos \phi \tan \psi')^2 + (y + s \cos \phi)^2 + (z + s \sin \phi)^2\right]^{1/2}}\right.$$

$$\left. - \frac{(x' - s \cos \phi \tan \psi') \cos \phi \tan \psi' + (y - s \cos \phi) \cos \phi + (z - s \sin \phi) \sin \phi}{\left[(x' - s \cos \phi \tan \psi')^2 + (y - s \cos \phi)^2 + (z - s \sin \phi)^2\right]^{1/2}}\right\}$$

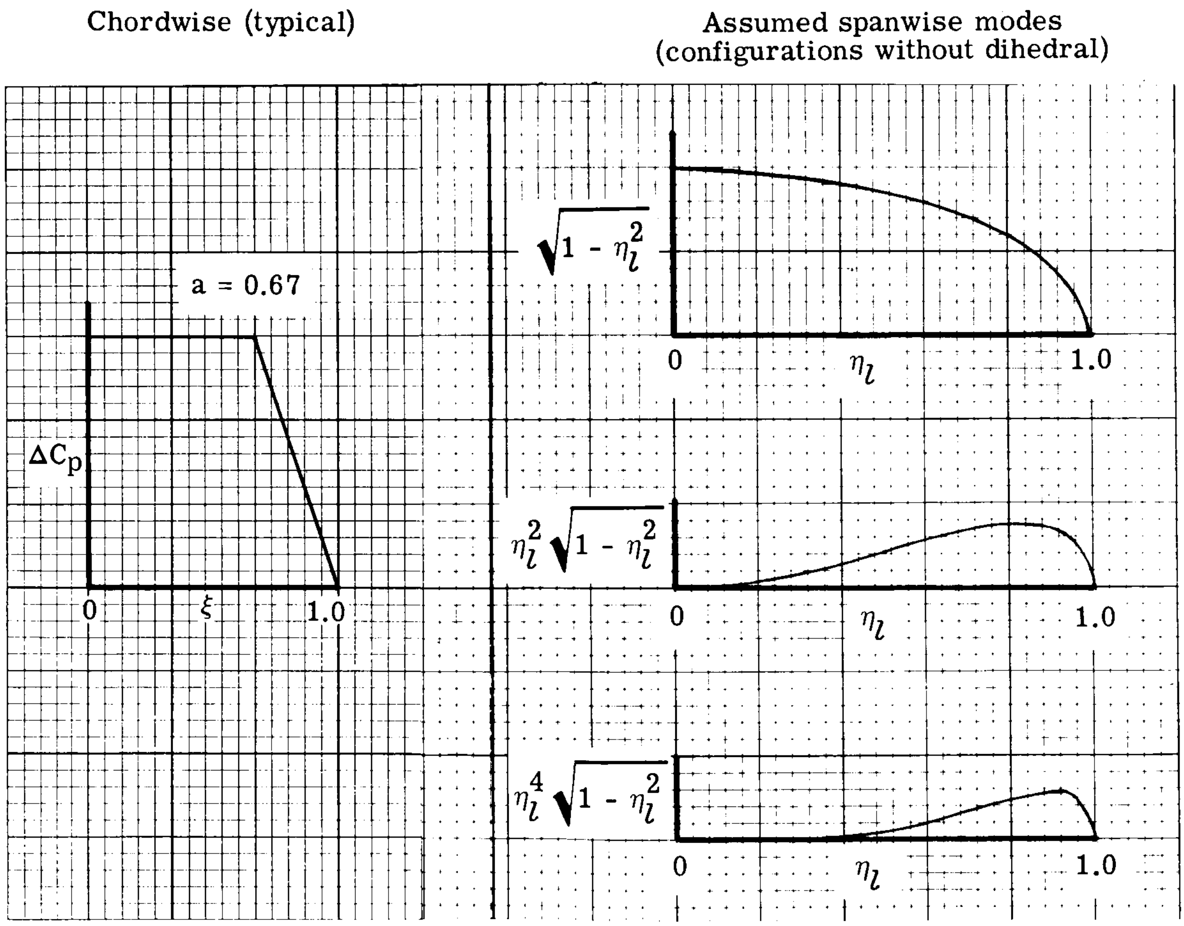
$$+ \frac{z - s \sin \phi}{(y - s \cos \phi)^2 + (z - s \sin \phi)^2}\left\{1 - \frac{x' - s \cos \phi \tan \psi'}{\left[(x' - s \cos \phi \tan \psi')^2 + (y - s \cos \phi)^2 + (z - s \sin \phi)^2\right]^{1/2}}\right\}$$

$$- \frac{z + s \sin \phi}{(y + s \cos \phi)^2 + (z + s \sin \phi)^2}\left\{1 - \frac{x' + s \cos \phi \tan \psi'}{\left[(x' + s \cos \phi \tan \psi')^2 + (y + s \cos \phi)^2 + (z + s \sin \phi)^2\right]^{1/2}}\right\} \qquad (6)$$

with l signifying the particular slope point and n the particular horseshoe vortex influencing the slope point.

Circulation Specification

Once the surface slope matrix $\{\partial\bar{z}/\partial\bar{x}\}$ is known, chordwise integration can be performed to determine the local elevation surface $\bar{z}/c$, which contains the effects of camber, twist, and angle of attack. The major problem to be solved is determining the necessary circulation matrix $\{\Gamma/U\}$ to employ in equation (1). The problem is simplified somewhat by having the chordwise shape of the bound circulation remain unchanged across each span, although the chordwise shape may vary from one planform to another. (This simplification can easily be removed without any new analysis and would require only a small programing change.) The chordwise loadings allowable in the program range from rectangular to right triangular toward the leading edge and were selected because they are of known utility. An example is given in sketch (b). Two different techniques are utilized to arrive at the spanwise scaling of the chordwise shapes. The particular technique to be employed depends on whether the configuration has dihedral.



Sketch (b)

For a configuration having dihedral, the spanwise scaling must be determined discretely because no finite polynomial representation of the scaling is known with certainty, even for an isolated wing. However, for configurations with no dihedral, the spanwise scaling can be written as a polynomial for each planform,

$$\sqrt{1 - \eta_l^2}\left(a_i + b_i\eta_l^2 + c_i\eta_l^4\right)$$

(see sketch (b)) with a maximum of three coefficients per planform being determined as part of the solution. It is possible to write this polynomial as a solution because the isolated wing solution is known to be of the elliptical form $\sqrt{1 - \eta_l^2}$, and the presence of the other planform is assumed to generate a loading disturbance which can be represented by the other two terms in addition to adjusting a_i. Once the scaling is known from either technique, then $\{\Gamma/U\}$ is readily obtained by multiplication.

Lift, Pitching-Moment, and Drag Contributions

The contributions to C_L and to C_m, respectively, from the jth chordwise row of horseshoe vortices are

$$C_{L,j} = \frac{L_j}{q_\infty S_{ref}} = \frac{4q_\infty s \cos \phi_j}{q_\infty S_{ref}} \sum_{i=1}^{\overline{N}_c} \left(\frac{\Gamma}{U}\right)_i \tag{7}$$

and

$$C_{m,j} = \frac{M_{\overline{Y},j}}{q_\infty S_{ref} c_{ref}} = \frac{4q_\infty s \cos \phi_j}{q_\infty S_{ref} c_{ref}} \sum_{i=1}^{\overline{N}_c} \left(\frac{\Gamma}{U}\right)_i \bar{x}_{j,i} \tag{8}$$

where

$$\left(\frac{\Gamma}{U}\right)_i \equiv \begin{cases} 1 & (\xi_i \leq a) \\ \dfrac{1 - \xi_i}{1 - a} & (\xi_i > a) \end{cases} \tag{9a}$$

$$\xi_i \equiv \frac{i - 0.75}{\overline{N}_c} \tag{9b}$$

and

$$\bar{x}_{j,i} \equiv \left(\bar{x}_{le}\right)_j - \left(\frac{i - 0.75}{\bar{N}_c}\right)c_j \tag{10}$$

It should be observed that no contribution from the drag forces is included in equation (8).

Even though $C_{L,j}$ and $C_{m,j}$ actually occur on the wing at the jth spanwise location, they can be utilized in a Trefftz plane solution if the chordwise summations are performed. This utilization is possible herein because the trailing wake is assumed not to roll up, and the general configuration has specifiable chord loading shapes. Summing the chordwise loadings at this point allows the solution of the spanwise scaling to be performed on a bent lifting line located in the Trefftz plane, which is, of course, ideally suited for the vortex drag computation. In addition, the summation reduces the number of unknowns from the product of $\bar{N}_c$ and $\bar{N}_s$ to only $\bar{N}_s$. Hence, a larger value of $\bar{N}_s$ can be used in the Trefftz plane, which should yield improved accuracy in the spanwise scaling factors without affecting the number of horseshoe vortices on the wing. Then, when the circulations are needed on the wing for use in equation (1), the well-defined variations of the spanwise scaling factors are interpolated to the original spanwise positions of the wing vortex lattice which is used to generate $[A]$. The procedure is implemented as follows:

The summation in the lift expression (eq. (7)) can be written as

$$\sum_{i=1}^{\bar{N}_c}\left(\frac{\Gamma}{U}\right)_i = \sum_{i=1}^{I}\left(\frac{\Gamma}{U}\right)_i + \sum_{i=I+1}^{\bar{N}_c}\left(\frac{\Gamma}{U}\right)_i \tag{11}$$

where I is the last i value which satisfies $\xi_i \leqq a$; that is,

$$I \equiv \left[\bar{N}_c a + 0.75\right] \tag{12}$$

where the brackets indicate "take the greatest integer." Hence,

$$\sum_{i=1}^{\bar{N}_c}\left(\frac{\Gamma}{U}\right)_i = I + \frac{\left(\bar{N}_c + 0.75\right)\left(\bar{N}_c - I\right)}{\bar{N}_c(1 - a)} - \frac{1}{\bar{N}_c(1 - a)}\sum_{i=I+1}^{\bar{N}_c} i \tag{13}$$

Similarly, the summation in the pitch expression (eq. (8)) can be written as

$$\sum_{i=1}^{\overline{N}_c} \left(\frac{\Gamma}{U}\right)_i \bar{x}_{j,i} = \left[\left(\bar{x}_{le}\right)_j + \frac{0.75c_j}{\overline{N}_c}\right]\left[I + \frac{\left(\overline{N}_c + 0.75\right)\left(\overline{N}_c - I\right)}{\overline{N}_c(1 - a)}\right] - \frac{c_j}{\overline{N}_c} \sum_{i=1}^{I} i$$

$$- \frac{1}{\overline{N}_c(1 - a)}\left[\left(\bar{x}_{le}\right)_j + c_j + \frac{1.5c_j}{\overline{N}_c}\right] \sum_{i=I+1}^{\overline{N}_c} i + \frac{c_j}{\overline{N}_c^{\,2}(1 - a)} \sum_{i=I+1}^{\overline{N}_c} i^2 \tag{14}$$

The contribution to the vortex drag coefficient at the ith chordwise row due to the jth chordwise row is obtained by using only half the trailing vortex induced normal wash from the Trefftz plane. The result is

$$C_{D,i,j} = \frac{s}{\pi S_{ref}}\left[\sum_{i=1}^{\overline{N}_c}\left(\frac{\Gamma}{U}\right)_i \sum_{j=1}^{\overline{N}_c}\left(\frac{\Gamma}{U}\right)_j\right]\left[\frac{\pm\cos\left(\sigma_{L,i,j} - \phi_i\right)}{\sqrt{\left(y_{i,j} + s\cos\phi_j\right)^2 + \left(z_{i,j} + s\sin\phi_j\right)^2}}\right.$$

$$- \frac{\pm\cos\left(\sigma_{R,i,j} - \phi_i\right)}{\sqrt{\left(y_{i,j} - s\cos\phi_j\right)^2 + \left(z_{i,j} - s\sin\phi_j\right)^2}} - \frac{\cos\left(\sigma'_{L,i,j} - \phi_i\right)}{\sqrt{\left(y^*_{i,j} + s\cos\phi'_j\right)^2 + \left(z^*_{i,j} + s\sin\phi'_j\right)^2}}$$

$$\left. + \frac{\cos\left(\sigma'_{R,i,j} - \phi_i\right)}{\sqrt{\left(y^*_{i,j} - s\cos\phi'_j\right)^2 + \left(z^*_{i,j} - s\sin\phi'_j\right)^2}}\right] \tag{15}$$

In the ± sign, plus indicates that the trailing vortex filament is to the left of the influenced point; minus, to the right.

In using equations (7), (8), and (15), a new vortex system is set up in the Trefftz plane in which the bent chord plane is represented by a system of uniformly spaced trailing vortices (the quantity $2s$ in fig. 2). This uniformity of vortex spacing leads to a simplification in the equations and can be thought of as a discretization of the ideas of Munk (ref. 7) and Milne-Thomson (ref. 8) for a bound vortex of constant strength.

Spanwise Scaling Determination

To determine the spanwise scaling with either technique requires the combination of the contributions from each spanwise position for configurations with dihedral or the mode shape contributions for configurations without dihedral. These contributions must be employed in the appropriate total C_L and C_m constraint equations as well as in the $C_{D,v}$ extremization operation. The details of the solution for configurations with dihedral are as follows:

$$C_L = 2 \sum_{j=1}^{\overline{N}_s} \delta_j C_{L,j} \tag{16}$$

$$C_m = 2 \sum_{j=1}^{\overline{N}_s} \delta_j C_{m,j} \tag{17}$$

and

$$C_{D,v} = 2 \sum_{i=1}^{\overline{N}_s} \sum_{j=1}^{\overline{N}_s} \delta_i C_{D,i,j} \delta_j \tag{18}$$

where the δ_j terms are the spanwise scaling factors and the independent variables in the solution.

The problem is formalized in the Lagrange extremization method by forming the function to be extremized

$$G = C_{D,v} + \sum_{i=1}^{2} \lambda_i \phi_i \tag{19}$$

with the two constraint equations

$$\phi_1 = 2 \sum_{k=1}^{\overline{N}_s} \delta_k C_{L,k} - C_{L,d} = 0 \tag{20}$$

$$\phi_2 = 2 \sum_{k=1}^{\overline{N}_s} \delta_k C_{m,k} - 0 = 0 \tag{21}$$

where λ_1 and λ_2 are the Lagrange multipliers. In order to extremize the function G, it is necessary to find a solution to the set of linear equations resulting from

$$\frac{\partial G}{\partial \delta_\ell} = 0 \qquad \left(\ell = 1, 2, \ldots, \overline{N}_s\right) \tag{22}$$

and

$$\frac{\partial G}{\partial \lambda_i} = 0 \qquad (i = 1, 2) \tag{23}$$

where equation (23) is just a restatement of equations (20) and (21). The $\overline{N}_s$ equations represented in equation (22) are explicitly

$$\sum_{k=1}^{\overline{N}_s} \left(C_{D,i,k} + C_{D,k,i}\right)\delta_k + C_{L,i}\lambda_1 + C_{m,i}\lambda_2 = 0 \qquad \left(i = 1, 2, \ldots, \overline{N}_s\right) \tag{24}$$

Equations (24), (20), and (21) provide $\overline{N}_s + 2$ relations having as the $\overline{N}_s + 2$ unknowns the $\overline{N}_s$ values of δ_k, λ_1, and λ_2.

The matrix to be solved for configurations with dihedral can be as large as 102 square, and it is possible for this matrix to become ill conditioned if the trailing vortex filaments from the two planforms coincide. If this coincidence occurs, an alternative matrix inversion routine, based on least squaring, is utilized.

It is difficult to assess the accuracy of the calculated values of δ_k because minimum vortex drag $\left(C_{D,v}\right)$ solutions are not generally known, even for isolated wings having dihedral. As a numerical check, the ratio of the normal induced velocity to the cosine of the local dihedral angle is computed. According to Munk (ref. 7), this ratio should be constant across the configuration span for minimum vortex drag. Hence, the uniformity of this ratio is an indication of the accuracy of those solutions for which only the lift constraint is operative. If both the lift and moment constraints are operative, then the vortex drag will be the minimum obtainable for the problem posed but not necessarily an absolute minimum. Under the pitching-moment-constraint conditions, this numerical check is meaningless and should be ignored.

It should be noted that equation (21) could be changed from a pitching-moment constraint to one which involved the root bending moment. In fact, this has been done in one of the examples discussed in the text. Details for implementing this constraint are given in appendix F.

For configurations without dihedral, the solution technique is similar to that already presented and the details follow.

$$C_L = 2 \sum_{k=1}^{K} \delta_k C_{L,k} \tag{25}$$

$$C_m = 2 \sum_{k=1}^{K} \delta_k C_{m,k} \tag{26}$$

and

$$C_{D,v} = 2 \sum_{i=1}^{K} \sum_{k=1}^{K} \delta_i C_{D,i,k} \delta_k \tag{27}$$

where $K \leqq 6$ and $C_{L,k}$ and $C_{m,k}$ are the C_L and C_m contributions associated with the kth term in the polynomials

$$\sqrt{1 - \eta_l^2}\left(\delta_1 + \delta_2 \eta_l^2 + \delta_3 \eta_l^4\right)$$

or

$$\sqrt{1 - \eta_l^2}\left(\delta_4 + \delta_5 \eta_l^2 + \delta_6 \eta_l^4\right)$$

(Note that $k = 1, 2,$ and 3 are assigned to the first planform and 4, 5, and 6 to the second.) These contributions are computed by first assuming a unit value of scaling with each term in the polynomial, then multiplying each resulting spanwise scaling distribution by the $C_{L,j}$ and $C_{m,j}$ terms of equations (7) and (8), and finally summing spanwise over all the chordwise rows associated with each set of k values (or planform). The vortex drag coefficient associated with the ith and kth combination of spanwise scaling distributions $C_{D,i,k}$ is computed similarly. The δ_k terms are equivalent to the unknown coefficients in the polynomial and are the independent variables in the solution.

The extremization of equation (27), with the same C_L and C_m constraints as before, produces $K + 2$ relations with the K values of δ_k, λ_1, and λ_2 as the unknowns. Obviously, this matrix, no larger than 8 square, is much smaller and hence faster to invert than that utilized for configurations having dihedral.

Determination of Local Elevation Curves

With δ_k known, then $\{\Gamma/U\}$, C_L, C_m, and $C_{D,v}$ can be determined. The results for $\{\Gamma/U\}$ are interpolated to the original spanwise positions of the paneling which is used in equation (1) and in the following equation to find the local elevation curves. The equation for the local elevation above the computational plane at a particular point $(\xi',\bar{y})$ is

$$\frac{\bar{z}}{c}(\xi',\bar{y}) = \int_1^{\xi'} \frac{\partial\bar{z}}{\partial\bar{x}}(\xi,\bar{y})\, d\xi \tag{28}$$

Further discussion is given regarding this integration in the section "Precision," but it should be noted that cubic splines are utilized to interpolate the local surface slopes between slope points as well as to integrate the resulting distribution.

Three additional aspects of the present method should be noted: (1) The local slope and elevation results obtained are linearly dependent on C_L; hence, they can be used to obtain design information at other than the original design C_L by multiplying these results by the ratio of the new value to the old value of C_L. (2) For an isolated planform with zero dihedral, the three assumed spanwise distributions are self-reducing; that is, the Lagrange multipliers of the second and third distributions become zero, leaving only the first (the elliptic form) to give the correct minimum vortex drag. Thus, only the elliptic spanwise distribution is imposed for mean-camber-surface solutions of isolated planforms without dihedral. (3) As a result of the relationship between Γ/U and the lift on an elemental panel, Γ/U is related to the assumed constant value of ΔC_p over the panel by

$$\frac{\Gamma}{U} = \frac{\Delta C_p}{2} \frac{c}{\bar{N}_c} \tag{29}$$

for a uniform chordwise distribution of elemental panels. If a nonuniform distribution is used, then equation (29) as well as the computer implementation must be modified.

RESULTS AND DISCUSSION

General

Before the design method just outlined is employed, it is necessary to examine the sensitivity of its results to vortex-lattice arrangement. It is also important to compare results obtained with this method with those available in the literature. Unfortunately, the available solutions, whether exact or numerical, may not be for configurations which will exercise the constraint or extreminization capabilities of the present method. In fact, the available exact solutions are for configurations which are either two-dimensional sections or isolated three-dimensional wings with a nonelliptic span loading. The solutions for such configurations require program modifications to the span loading and involve no optimization. The numerical solution used for comparison is for an isolated planform without dihedral.

Two-dimensional comparisons are used to determine suitable chordwise locations and the number $\overline{N}_c$ of horseshoe vortices. The effect that different extrapolations of the chordwise representation of $\partial\bar{z}/\partial\bar{x}$ ahead of the first and behind the last slope points have on the local elevation curve has also been investigated. In addition, the sensitivity of the local elevation solutions to the number $\overline{N}_s$ and location of chordwise rows of horseshoe vortices was investigated for an isolated planform.

Following the section "Precision," an application of the present method to a wing-canard configuration is given for various vertical separations and moment trim points, as well as a comparison of the local incidence distributions, vortex drag values, and span loadings. Calculated results for a tandem wing and for a wing-winglet combination are also presented.

Precision

Results of the present method are presented in figures 3, 4, 5, 6, and 7 in terms of local midsurface slopes and elevations along the chord. The local elevation results can be thought of as including the effects of incidence, twist, and mean camber. In these figures results of the present method are compared with those obtained from other methods. Where appropriate, these comparisons are made at a number of spanwise locations.

Two-dimensional.- Figure 3 presents, for the three particular chordwise lifting pressure distributions shown in the inset sketches, the local slope and elevation variations along the chord obtained from the present method and from two-dimensional theory (ref. 9) at $C_{L,d} = 1.0$ and $M_\infty = 0$. The predictions of the present method were obtained by utilizing an aspect-ratio-50 rectangular wing with a rectangular span loading. In order to avoid the tip effects, only the results near the plane of symmetry are presented and they are for the different chordwise patterns and extrapolations denoted. It should be noted that the diamond symbol does not appear in those parts of figure 3 which present the local slope since the results are coincident with the results denoted by the square symbol. Only in the parts of the figure presenting local elevation do the two symbols not coincide, which is a result of the differences evolving from methods of extrapolation. A discussion of the extrapolation methods will be presented later in this section.

The local elevation curves are identified by values of a of 0.2, 0.6, and 1.0 which denote the fractional chordwise locations where the net pressure changes from a constant value to a linearly varying value toward zero. (The symbol a employed in the text and figures is the same as the variables XCFW or XCFT used in appendix B.)

The following observations can be made from figure 3:

(1) For all patterns studied and for all values of a, the present method predicts both the amplitude and trend of the local slope analytic curves with reasonable accuracy.

(2) Of the uniform chordwise vortex patterns, the one with $\overline{N}_c = 20$ is superior to that with $\overline{N}_c = 10$. This result can be attributed to two causes: (a) increasing $\overline{N}_c$ from 10 to 20 provides more definition to the approximate curve, especially near the chordwise edges, where the analytic result may have a steep gradient, and (b) the extrapolations to the chordal edges, which must be employed with the approximate curve for integration purposes, are more accurate as a result of the smaller distance over which they must be applied. Because the chordwise integration of local slope occurs from the trailing edge forward, any errors in matching the analytic local slopes at or ahead of the trailing edge will be seen forward of that chordwise location and will accumulate.

The incidence angles have been extracted from the local elevation curves for comparison with the exact solution. The following table summarizes the incidence angles obtained with $\overline{N}_c = 10$ and 20, as well as those for $\overline{N}_c > 20$ from a modified version of the program. The results from $\overline{N}_c > 20$ are provided so that the solution convergence and its rate can be examined. The table clearly shows that the results of the present method are more positive than, but tend toward, the exact ones with increasing values of $\overline{N}_c$ but at a slower rate as $\overline{N}_c$ increases. Though not shown herein, it was observed that the results obtained for $\overline{N}_c = 40$ also gave the best agreement with the local elevation curve, especially for a = 1.0. Also, with $\overline{N}_s$ held constant, doubling the value of $\overline{N}_c$ provides a reduction in percent error of less than a factor of two while approximately quadrupling the computer time. Hence, $\overline{N}_c = 20$ is the largest number that will be employed; however, the best chordwise spacing of these bound vortices is still to be determined.

a	Incidence angle, deg, from –				
	Present method (uniform spacing)				Exact solution (ref. 9)
	$\overline{N}_c = 10$	$\overline{N}_c = 20$	$\overline{N}_c = 30$	$\overline{N}_c = 40$	
0.2	5.3359	4.9097	4.7504	4.6650	4.1752
.6	3.5421	3.2109	------	3.0167	2.6052
1.0	1.3863	.8594	------	.5386	0

(3) Because the $\overline{N}_c = 20$ uniform solution has slope points nearer the chordal edges and yielded better local elevation curves than the solution for $\overline{N}_c = 10$, it was anticipated that by arranging the locations of the elemental panels nearer the chordwise edges, as in a cosine manner, there could be improvements in the $\overline{N}_c = 10$ solution. The results of this change are as follows: (a) Better agreement with the analytic local slope curves near the leading edge is produced for all values of a and near the trailing edge for $a = 1.0$. (b) There is poorer agreement from 0.1 to 0.7 chord where the new local slopes are less than those of the uniform spacing and the analytic curve. The error accumulates to a larger overestimation of local elevation from 0.1 to 0.5 chord than for the other patterns. (c) As a result of the better local slope prediction near the leading edge, the local elevation predictions at the leading edge are better with the cosine spacing than for the uniform spacing solution with the same number of divisions.

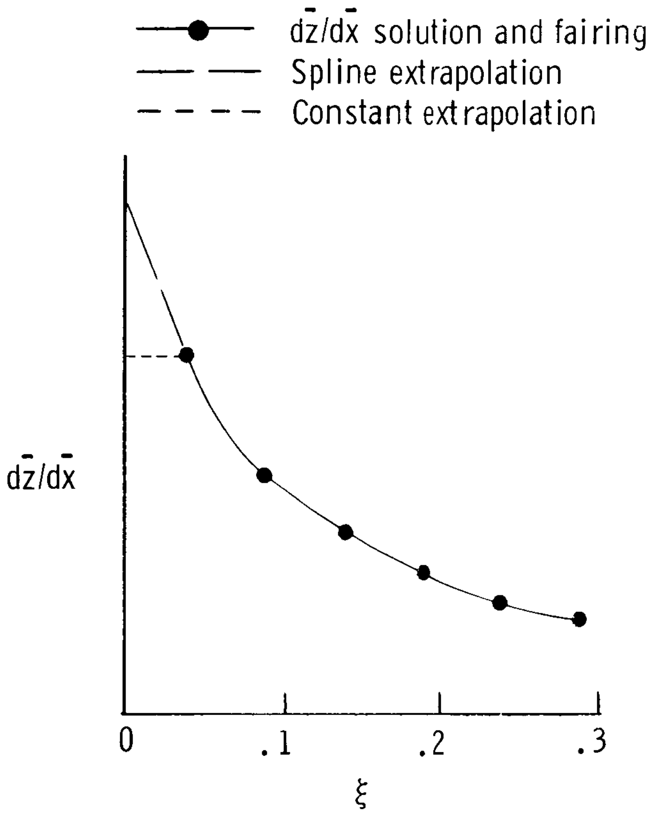
The incidence angles have also been computed for the solutions just discussed along with those for $\overline{N}_c = 20$ which employed a cosine spacing. These results are summarized in the following table:

a	Incidence angle, deg, from –		
	Present method (cosine spacing)		Exact solution (ref. 9)
	$\overline{N}_c = 10$	$\overline{N}_c = 20$	
0.2	4.9836	4.6650	4.1752
.6	3.3594	3.0567	2.6052
1.0	1.1859	.6474	0

This table shows the improvement in incidence angle prediction with increasing values of $\overline{N}_c$ which were obtained for a cosine spacing. If these results are compared with those from the previous table, it can be seen that the percent error decreases with a change from a uniform spacing to a cosine spacing at a given value of $\overline{N}_c$. However, the local elevation solutions with the cosine spacing are generally poorer when compared with the exact solutions over the midchord range than those with the uniform spacing. Since the local elevation surface is the primary purpose of the computation, the uniform spacing is utilized in the following numerical studies and applications and is also employed in the program.

(4) The solution for $\overline{N}_c = 20$ uniformly spaced horseshoe vortices gives the best overall results. Furthermore, the effect of changing the method of extrapolation of the local slope curve ahead of the first and behind the last slope points is not significant. (See sketch (c) for a comparison of the two extrapolation techniques near the leading edge.)

Consequently, the constant extrapolation method is employed because of the projected computer resource savings.



Sketch (c)

Number of rows along semispan $(\bar{N}_S)$.- The number of chordwise rows $\bar{N}_S$ needed on a semispan is studied in three dimensions by using a low-aspect-ratio (2.50) trapezoidal wing as an example planform. The local slopes and elevations along the chord are presented in figure 4. The fixed parameters are rectangular chord loading (a = 1.0), elliptic span loading, $C_{L,d} = 0.35$, $M_\infty = 0.40$, and $\bar{N}_C = 20$. The value of $\bar{N}_S$ is taken to be either 10 or 20, with both uniform and cosine distributions employed over the semispan. From the data of figure 4, little sensitivity is noted across the semispan to either the number or the distribution of chordwise rows used in the solutions. The one exception is at $\frac{\bar{y}}{b/2} = 0.95$ with $\bar{N}_S = 20$ and a cosine distribution, where a local elevation surface with a larger reversal in the incidence near the tip occurs. The incidence reversal is so great that it is suspect; better results could be obtained from a smooth fairing of the inboard results to the tip.

An effect of changing $\overline{N}_s$ is that there is little benefit to be gained by using large values of $\overline{N}_s$, except for the expanded number of local elevation curves tabulated in the computer output. This lack of benefit is associated with prescribing the span and chord loadings in advance in the design problem for the wing without dihedral, whereas they must be determined locally in the analysis problem. Hence, less sensitivity in the results is noted. For the example wing, a value of $\overline{N}_s = 10$ was found to be sufficient; however, $\overline{N}_s$ values of this magnitude may not be large enough for other planforms and Mach numbers. A second effect is that a cosine distribution across the span of chordwise rows does not improve the solutions and can in fact lead to poorer ones because of an unreasonable incidence distribution for spanwise locations too near the tip. Hence, a uniform distribution of chordwise rows is recommended and utilized herein.

Precision of the solution for wings with dihedral.- It is useful to consider whether the type of studies conducted for wings with no dihedral needs to be repeated for wings with dihedral. Since the difference in technique is limited to the procedure for determining the spanwise scaling, the results of the $\overline{N}_c$ study should be valid for both techniques. Concerning the $\overline{N}_s$ study, the spanwise scaling differences are restricted to the optimization part of the program where repaneling occurs. In either solution the set of answers is evaluated or interpolated to the original paneling scheme for the computation of $\{\partial\bar{z}/\partial\bar{x}\}$. Hence, it is only necessary to determine whether there are enough discrete spanwise scaling values to obtain a good approximation to the functional form of the solution. Thus, the technique usually used only when dihedral is present was applied to the isolated flat wing of figure 4, and the interpolated span loading results for both techniques are presented in figure 5. The agreement is seen to be generally good except in the outer 10 percent of semispan. In that region the functional form has the largest variation and is more difficult to represent discretely. However, the discrete solution did yield a constant value of normal velocity across the span, which is the proper result. The $c_l c$ interpolated results shown in figure 5 for wings without dihedral are a part of the original elliptical curve. In addition, the difference in $C_{D,v}$ between the two techniques is 0.0008. Comparing $C_{D,v}$ with $C_L^2/\pi AR$ shows that the difference due to the technique employed is -0.0003 for wings without dihedral and 0.0005 for wings with dihedral. Also, the absolute value of the maximum incidence angle difference was determined to be less than 4° at 98 percent semispan. At the next inboard station, 94 percent semispan, the absolute value of the difference was reduced to less than 1°. Hence, the error is highly localized and could be accounted for by extrapolation of information inboard of the tip in the layout of a model. Thus the sensitivity to $\overline{N}_s$ is essentially the same as before. Consequently, further calculations presented herein for wings with dihedral use values of $\overline{N}_s$ based on the initial sensitivity for wings without dihedral.

Three-dimensional comparisons.- Two comparisons with available mean-camber-surface solutions will be made. The comparisons are for a high-aspect-ratio sweptback and tapered wing with a uniform area loading at $C_{L,d} = 1.0$ and $M_\infty = 0.90$ and a lower aspect-ratio trapezoidal wing with $a = 1.0$, spanwise elliptic loading at $C_{L,d} = 0.35$, and $M_\infty = 0.40$.

Figure 6 presents the predicted results from the present method for the sweptback wing and compares these results with those from references 1 and 10. A comparison of the three solutions indicates that they are all in generally good agreement with the exception of the results at $\frac{\bar{y}}{b/2} = 0.05$. The surprising result is that the present method and the modified Multhopp method (ref. 1) agree as well as they do at this span station because of the known differences that exist between them near the plane of symmetry. The reason for the larger disagreement between the present method and that of reference 10 near $\frac{\bar{y}}{b/2} = 0$ is not clear, but this disagreement may be caused by the different $\overline{N_c}$ values utilized by the two methods. Reference 10 effectively uses an infinite number since over each infinitesimal span strip across the wing the method locates a single quadrilateral vortex around the periphery of the enclosed area. This vortex extends from the leading edge to the trailing edge and includes segments of the edges as well. For a uniform area loading, the trailing leg parts of the quadrilateral vortices cancel with adjacent spanwise ones all across the wing. This leaves only the edge segments to contribute to the induced flow field. The present method utilizes a numerical rather than a graphical solution in order to provide a general capability; hence, $\overline{N_c}$ values are limited as discussed previously. Also, vortices are not placed around the leading and trailing edges in the present method.

A comparison of the present design method with that of reference 1 is shown in figure 7. The wing and loadings are the same as those used in figure 4. The local slopes and elevations determined by the two methods are in reasonably close agreement at the three spanwise locations detailed; however, an oscillatory trend is evident in the local slopes obtained from the method of reference 1 (fig. 7(a)). These oscillations apparently originate in the truncated sine series used in reference 1 to represent a uniform chordwise distribution. Integration of the local slopes to obtain local elevations tends to suppress the oscillations (fig. 7(b)); however, the local pressures depend upon the slope rather than the elevation. Consequently, the measured chordwise pressure distribution will demonstrate the same oscillatory character. A model built according to the design of reference 1 was tested (ref. 11), and the measured pressure distributions for a typical spanwise location (fig. 7(c)) indicate that indeed the oscillations are present. Presumably, similar measurements on a model designed by the present method would not behave in this manner since the input loadings are truly linear.

Force tests (ref. 12) of an essentially identical model indicate that the measured drag polar was tangent to $C_D = C_{D,o} + \frac{C_L^2}{\pi A\!R}$; that is, the vortex drag was indeed a minimum at the design C_L (or 100 percent leading-edge suction was obtained). It is presumed from the small differences in local slope between the present method and the method of reference 1 that a similar result would be obtained for a design by the present method.

Application to a Wing-Canard Combination

The present method has been demonstrated by optimizing a wing-canard combination (fig. 8). The effects of varying the vertical separation and the moment trim point on the resulting drag, span loading, and mean camber surfaces are also illustrated. All surfaces are designed for $C_{L,d} = 0.2$, $a_c = 0.6$, $a_w = 0.8$, and $M_\infty = 0.30$ and have $C_m = 0$ about the moment trim point. Figure 8 shows that for all vertical separations, moving the moment trim point forward increases the vortex drag over some range, and furthermore, increasing the out-of-plane vertical separation reduces the vortex drag. Of course, not all moment trim points utilized will produce a stable configuration. These variations illustrate the importance of balancing the lift between the two lifting surfaces so that for some reasonable moment trim point and vertical separation, the vortex drag will be at a minimum. The minimum point on each vortex drag curve occurs with the pitching-moment constraint not affecting the extremization.

The idea of lift balancing is an interesting one and is explored further for a moment trim point corresponding to $\frac{\Delta \bar{x}}{b/2} = 0.1$. Figure 9 shows the individual and total span loadings for the wing-canard configuration at $\frac{\bar{z}_c}{b/2} = 0$ for various values of a_c and a_w. From these figures there are three important observations to be made: (1) The individual span loadings change in the anticipated direction with the changing chord loadings in order to meet the same C_L and C_m constraints; (2) the total span loading does not change; (3) consequently, the vortex drag of the configuration is constant, as would be anticipated from Munk's stagger theorem.

Figure 10 presents the individual span loadings with increasing vertical separation $\left(\frac{\bar{z}_c}{b/2} < 0 \text{ above the wing plane}\right)$ with $a_c = 0.6$ and $a_w = 0.8$. There are three observations which can be made from these results for increasing vertical separation: (1) The individual span loadings tend to become more elliptical; (2) consequently, the vortex drag decreases; (3) the individual lift contributions show only a little sensitivity to separation distance once the canard is above the wing, when compared with the coplanar results.

Figure 11 shows the effect of moving the moment reference point on the spanwise distribution of wing and canard incidence angle for $\frac{\bar{z}_c}{b/2} = -0.169$. The general result shows that moving the moment reference point aft reduces the amount of incidence-angle nonuniformity required on each planform. This reduction is attributed to the change in loading on the canard required to meet the pitching-moment constraint.

Figure 12 shows the effect of varying the vertical separation on the spanwise distribution of wing and canard incidence angles for $\frac{\Delta\bar{x}}{b/2} = 0.1$. As expected, with increasing vertical separation the incidence requirements on each planform are generally reduced and should tend to the free-air result as $\frac{\bar{z}_c}{b/2} \rightarrow -\infty$. Note that for $\frac{\bar{z}_c}{b/2} = 0$, the wing is required to have severe incidence gradients near the canard tip at $\frac{\bar{y}}{b/2} = 0.673$. This unrealistic result occurs because the canard tip vortex intersects the wing, thereby inducing a strong downwash field inboard and a strong upwash field outboard. These large incidence gradients indicate that large out-of-plane displacements are called for in this solution. The preceding results are, however, academic and occur as a result of the planar wake assumption and do not account for any real-wing effects or canard-wake rollup.

Two additional canard positions were examined: one at $\frac{\bar{z}_c}{b/2} = -0.0845$ and the other at $\frac{\bar{z}_c}{b/2} = 0$ with 20° of dihedral. In each position, as could be expected, the large changes in incidence on the wing, which occur near the canard tip spanwise location, are significantly reduced and approach those of the other $\frac{\bar{z}_c}{b/2}$ solutions. This helps to confirm that the earlier solution for $\frac{\bar{z}_c}{b/2} = 0$ is special, and the large incidence gradients noted can be avoided by providing the canard with a small effective displacement relative to the wing. Additional details of the solution with $\frac{\Delta\bar{x}}{b/2} = 0.1$ and $\frac{\bar{z}_c}{b/2} = 0.0$ are given in appendix D in sample case 2.

Figure 13 presents selected local elevations for the wing and canard designed in the presence of one another and alone at $\frac{\Delta\bar{x}}{b/2} = 0.1$ and $\frac{\bar{z}_c}{b/2} = -0.676$. For the wing the primary effect of adding the canard is to increase the incidence angle of the wing to compensate for the canard downwash field. For the canard there is only a small effect of being designed in the presence of the wing – a reduction (or increase) in the incidence required when the wing induced field is upwash (or downwash). When the surfaces were designed alone, the same individual C_L as obtained in the combination design was used, and the chord load fraction $\left(a_c \text{ or } a_w\right)$ was retained. Thus, the only loading variable between the two sets was the span loading, which was kept elliptical for the planform alone designs.

Application to Tandem Wing Design

This design method has been employed in the determination of the local elevation surfaces for a tandem wing. Figure 14 shows a sketch of a tandem wing configuration and selected results taken from the wind-tunnel tests made with a model based on this design at a Mach number of 0.30 (ref. 13). At $C_{L,d} = 0.35$ the vortex drag increment is correctly estimated. The measured C_m is slightly positive (0.02). Reference 13 states that a part of the C_m error $\left(C_m \text{ should be zero}\right)$ is a result of a difference in the fuselage length between the designed and constructed model.

Design of a Wing-Winglet Configuration

Figure 15 presents a wing-winglet combination of interest along with pertinent aerodynamic characteristics and local elevations obtained from the present method. For comparison these same items are calculated with a program modification that adds a root-bending-moment constraint to produce the same moment that would be obtained on the original wing extending to the plane of symmetry but without its basic wingtip. The assumed span loading is elliptical. (See appendix F for a discussion of the root-bending-moment constraint.) The force and moment coefficients are based on the wing outside of a representative fuselage and without the basic wingtip.

The results of this comparison are as follows: (1) The root-bending-moment constraint increases the vortex drag slightly because of the changes in the $c_l c$ distribution required; (2) the differences in local elevations are confined primarily to the outer 50 percent semispan and are mainly due to the differences in the incidence angles; (3) significant amounts of incidence are required in the winglet region with or without the root-bending-moment constraint.

Additional details of the solution without the root-bending-moment constraint are provided in appendix D in sample case 1.

The local elevation surfaces for a wing having both an upper and lower winglet can also be designed with this program when the two-planform option is employed. However, for such a configuration it is recommended that the pitching-moment constraint be dropped.

CONCLUDING REMARKS

A new subsonic method has been developed by which the mean camber (local elevation) surface can be determined for trimmed noncoplanar planforms with minimum vortex drag. This method employs a vortex lattice and overcomes previous difficulties with chord loading specification. This method designs configurations to have their local mid-surface elevations determined to yield the span load for minimum vortex drag while simultaneously controlling the pitching-moment or root-bending-moment constraint at the design lift coefficient. This method can be used for planforms which (1) are isolated, (2) are in pairs, (3) include a winglet, or (4) employ variable sweep, but only at a specified sweep position.

Results obtained with this method are comparable with those from other methods for appropriate planforms. The versatility of the present method has been demonstrated by application to (1) isolated wings, (2) wing-canard configurations, (3) a tandem wing, and (4) a wing-winglet configuration.

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APPENDIX A

VORTEX-LATTICE COMPUTER PROGRAM FOR DETERMINATION OF MEAN CAMBER SURFACE (LANGLEY COMPUTER PROGRAM A4062)

Basic Concepts and Limitations

The vortex-lattice method is used in this computer program to determine the mean camber surfaces of planforms at subsonic speeds. This method assumes steady, irrotational, inviscid, incompressible, attached flow. The effects of compressibility are represented by application of the Prandtl-Glauert similarity rule to modify the planform geometry. Potential flow theory in the form of the Biot-Savart law is used to represent disturbances created in the flow field by the lift distribution of the planform. Those vertical displacements which occur in the configuration as a result of either dihedral or noncoplanar planforms are taken into account in the implementation of the Biot-Savart law. However, local displacements above or below the chord line at any spanwise position are ignored in the implementation.

The planform is divided into many elemental panels. Each panel is replaced by a horseshoe vortex. This horseshoe vortex has a vortex filament across the quarter-chord of the panel and two filaments streamwise, one on each side of the panel starting at the quarter-chord and trailing downstream in the free-stream direction to infinity. Figure 1 shows a typical horseshoe-vortex representation of a planform.

The lifting-surface planform is represented for the computer program by a series of up to 24 straight segments which are positioned counterclockwise around the perimeter of the left half of the planform. Lateral symmetry is presumed. The lines start on the leading edge at the most inboard $\bar{y}$-location, go along the leading edge to the left tip of the planform, return along the trailing edge, and end on the trailing edge of the most inboard $\bar{y}$-location. The preciseness of the $\bar{x}$ and $\bar{y}$ Cartesian coordinates and dihedral angles, given as input data, determines the accuracy of the planform representation. It is recommended that the planform coordinates listed in the second group of geometry output data given in appendix C be plotted and examined after each computation to verify the accuracy of the planform representation. This check should be made before using the aerodynamic or local elevation output data.

There are a number of restrictions and limitations in the application of this computer program. These limitations are discussed in detail in the program description and are noted with the appropriate input variables in appendix B. For the convenience of the program user, a complete list of restrictions and limitations is presented here.

APPENDIX A

The restrictions in the first group apply to all planforms and are as follows:

(1) A maximum of two planforms may be specified. For examples, see sample case 1 for one planform and sample case 2 for two planforms.

(2) A maximum of 24 straight-line segments may be used to define the left half of a planform. The lateral separation of the ends of these lines can be critical when the horseshoe vortices are laid out by the computer program. For details of the manner in which the program handles the lateral separation, see Part I, Sections 2 and 3 under "Program Description."

(3) The maximum number of horseshoe vortices on the left side of the configuration plane of symmetry is 400. When two planforms are specified, the sum total of the vortices in both is limited to 400. Within this limit, the number of horsehsoe vortices in any chordwise row may vary from 1 to 20 and the total number of chordwise rows may vary from 1 to 50. For examples, see the sample cases in appendix D.

The limitations that apply only to variable-sweep planforms are as follows: (1) There should always be a fixed-sweep panel between the root chord and the outboard variable-sweep panel; (2) the pivot cannot be canted from the vertical; (3) no provisions have been made for handling dihedral in the geometry calculations for the variable-sweep panel or at the intersection of this panel with the fixed position of the wing. Restrictions on allowed values or codes for individual items of input data are described in appendix B.

The calculations presented herein were made with a computer which used approximately 15 decimal digits. For other computers with fewer significant digits, it may be necessary to use double precision for some of the calculations. In addition, it may be necessary to change some of the tolerances used in the program. These tolerances are given in the program listing.

Program Description

This FORTRAN program is used to compute the local elevation shapes of multiple lifting planforms and is divided into three parts. Part I contains the geometric calculations, Part II contains the circulation term calculations, and Part III contains the final output terms and answer listings. These three parts describe the three types of computations performed in the FORTRAN computer program. The input data are described in detail in appendix B, and the output data are described in detail in appendix C. Two sample cases are given to illustrate the use of the program. Listings of the input data and computed results for these sample cases are given in appendix D, and the FORTRAN computer program is given in appendix E.

APPENDIX A

Part I – Geometry Computation

The first part of the program is used to compute the geometric arrangement required to represent the planform by a system of horseshoe vortices and is divided into three sections. In Section 1, a description of the planform (group one of the input data in appendix B) is read into the computer. In Section 2, configuration details (group two of the input data) are read into the computer. In Section 3, the horseshoe vortex lattice is laid out. When two planforms are used to describe a wing-body-tail configuration, each of these sections is repeated for the second planform. At the beginning of the geometry computation, a data card is read which describes the number of planforms (either 1 or 2), the number of configurations for which values are to be computed, and the reference values for chord and area.

Section 1 – Reference Planform:

The planform is described by a series of straight lines which are projected onto the $\overline{X}$-$\overline{Y}$ plane from the deflected planform as shown in figure 1 for a double-delta type planform. The primary geometric data are the locations of the intersections of the perimeter lines, the dihedral angles, and an indication as to whether the lines are on a fixed or movable panel. (See ref. 4 for an example.) The pivot location is also required for a variable-sweep planform. These data are described in group one of the input data (appendix B). For variable-sweep wings, the planform used for input should be the configuration with the movable panel in a position where the maximum number of lines required to form its perimeter is exposed.

Section 2 – Configuration Computations:

The particular configuration for which the local elevation surface is sought is described by group two input data which are read in this section. These data include the following quantities: an appropriate configuration number, the number of horseshoe vortices chordwise, the nominal number of chordwise rows of vortices spanwise, the Mach number, the particular lift coefficient at which the local elevation surface is desired, and the sweep angle of the outboard panel for variable-sweep wings.

The number of horseshoe vortices used in each chordwise row (SCW) must be constant across the span. Simply indicate the number on the configuration card and this value will be used on each planform of the group one input. For all but the most simple planforms, the program adds some extra rows of horseshoe vortices. (This is discussed in Section 3.) As a result, the number of chordwise rows actually laid out (SSW) is usually greater than the nominal number of rows (VIC), and it takes one complete run through the program to determine the exact number and location of the rows. If variations in the basic wing planform are desired for additional computer cases, the entire computer program must be rerun with all geometry data and the appropriate changes in any of the aforementioned variables in the group two input data.

APPENDIX A

For a variable-sweep planform, the angle which describes the sweep should be on the leading edge of the movable panel adjacent to the fixed portion. The intersection points and sweep for the planform in the desired position are then computed. For a fixed planform, the sweep-angle specification is not required because the program will use the unaltered basic planform. The planform breakpoints are checked to see whether the spacing between any consecutive pair in the spanwise direction is less than $\frac{b/2}{2000}$. If this occurs, the points are adjusted to coincide with each other. The adjustment is necessary to avoid a poorly conditioned matrix which could result in biased results for the $\partial\bar{z}/\partial\bar{x}$ terms. Although this adjustment is usually adequate for planforms with no dihedral, it may not be sufficient for a particular configuration with dihedral or for use of this program in computers which have fewer than 15 significant decimal digits. This problem is discussed in detail in Section 3.

When two planforms are specified, the program compares the spanwise location of the breakpoints on both planforms inboard of the tip of the planform with the shorter semispan. If all the breakpoints coincide spanwise, no action is taken. However, if one planform has a breakpoint which does not occur on the other planform, an additional breakpoint is added to the other planform on its leading edge. This is done to force all trailing legs from the horseshoe vortices to occur at the same spanwise location, which keeps a trailing leg from one planform from passing too close to a slope point on the other planform and prevents unrealistic induced velocities at that slope point.

The program determines the planform area and span projected to the $\bar{X}$-$\bar{Y}$ plane and uses these values to compute the average chord. Planforms which have a constant angle of dihedral from the root chord to the tip chord have an average chord which is independent of dihedral angle. However, wings with more than one dihedral angle have an average chord which is dependent on the individual dihedral angles.

Section 3 – Horseshoe Vortex Lattice:

In this section, the procedure by which the horseshoe vortex lattice is laid out is described. The planform is divided chordwise and spanwise along the surface into trapezoidally shaped elemental panels; one horseshoe vortex is assigned to represent each panel. The horseshoe vortices are the same as those described in reference 4 and one is sketched in figure 2 for a typical panel. The horseshoe vortex is composed of three vortex lines: a bound vortex which is swept to coincide with the elemental-panel quarter-chord sweep angle in the plane of the wing and two trailing vortices which extend chordwise parallel to the free stream to infinity behind the wing. Figure 1 shows a typical chordwise row of horseshoe vortices on an arbitrary planform. The nominal width of these horseshoe vortices is the total semispan in the plane of the wing divided by the variable VIC. (See appendix B.)

The procedure for laying out the elemental panels and, consequently, the horseshoe vortices is to begin at the left leading-edge tip with a chordwise row of horseshoe vortices and then to proceed inboard toward the most inboard $\bar{y}$-location of the wing. The actual spanwise locations of the chordwise rows of horseshoe vortices are adjusted so that there is always a trailing vortex filament at points where there are intersections of perimeter lines or breakpoints on the planform. This adjustment may cause the horseshoe vortex width to be narrower or wider than the nominal width. When a horseshoe vortex has one trailing vortex filament which coincides with a breakpoint, the width of the horseshoe vortex may vary from 0.5 to 1.5 times the nominal width. When both trailing legs coincide with breakpoints, the width may vary from a maximum of 1.5 times the nominal width to a minimum width of $\frac{b/2}{2000}$, as described previously in Section 2. The number of chordwise rows actually laid out is given by the variable SSW.

In the chordwise direction, the horseshoe vortices are distributed uniformly and the number of vortices is given by the variable SCW. The maximum number of horseshoe vortices in the chordwise direction is 20, and in the spanwise direction the maximum total number of chordwise rows is 50 on a semispan. However, the total number of horseshoe vortices (the product of SCW and SSW) permitted by the program is 400 on the left half of a configuration. The exact number generated by the program depends on the value of VIC and SCW and on the details of the planform. As many as one additional chordwise row of horseshoe vortices may be generated by the program at each breakpoint outboard of the root. Wings with dihedral must always have at least two horseshoe vortices chordwise; wings without dihedral may have only one.

The Prandtl-Glauert correction factor is applied to the $\bar{x}$-coordinates and the tangents of the sweep angle of the horseshoe vortices at this point to account for compressibility effects.

Part II – Vortex Strength Computation

The vortex lattice laid out in Part I is not employed to determine the vortex strengths, but instead is utilized to find the local elevation shapes (Part III) because of the smaller computer resource requirements. (See the section "Lift, Pitching-Moment, and Drag Contributions" for additional discussion.) The solution for the vortex strengths is accomplished in the Trefftz plane by using the one or two lifting lines which may be bent. These lines are divided into equal segments, with 50 divisions per planform semispan used for the planform with the larger true length. In case of two planforms of unequal length, the number of equal segments assigned to the shorter lifting line is proportional to the length ratio of the two planforms. These segments are laid out from inboard to outboard on the lifting lines. For the shorter lifting line, a small portion near the tip may not be included but will always be less than 2 percent of the larger semispan true length because of the use of whole equal segments.

After the optimization is performed, in which the spanwise scaling factors are determined based on a Trefftz plane solution, these scaling factors are interpolated back to the original spanwise paneling layout for the vortex lattice. It is these results which provide the multipliers for the chordwise shapes. They lead to the computation of the span loadings, C_L, and C_m developed for each planform. The circulations are listed and then employed in Part III.

Part III – Local Elevation Shape Computation

The vortex strengths determined in Part II and the influence coefficient matrix based on the original paneling (see fig. 1) are used in this part of the program to compute the local slope at the midspan three-quarter-chord location of each elemental panel (called the slope point in fig. 2) by employing equation (1). By using cubic splines to interpolate between the local slopes, the local elevation shape at each spanwise location is determined by equation (28). Outside the range of slope points a constant extrapolation procedure is used to determine the integrand of equation (28). (See the section "Precision" for a discussion of the extrapolation methods examined.)

APPENDIX B

INPUT DATA

Group One

The input data required for the reference planform are described in the order that they are called for by the computer program. All coordinates and sweeps should be given for the left half of the wing planform. The axis system used is given in figure 1 and any consistent set of units is acceptable. (The output will be in terms of the input units.) The $\overline{X}$-axis coincides with the plane of symmetry and is positive pointing into the wind; the $\overline{Y}$-axis is positive pointing along the right wing. The origin of the axis system may lie anywhere along the plane of symmetry and determines the trim point for the two-planform solution. All the cards use a format of 8F10.6 for group one data.

Data on the first card are for the four named variables and are to be supplied in the following order:

PLAN — number of planforms for the configuration; use 1 or 2; this sets the maximum number for the IT variable used subsequently

TOTAL — use 1 for this field

CREF — reference chord of the configuration; this chord is used only to nondimensionalize the pitching-moment terms and must be greater than zero

SREF — reference area of the configuration; this area is used only to nondimensionalize the lift, drag, pitching moment, and root bending moment and must be greater than zero

The data required to define each planform are then provided by a set of cards. The initial card in this set is composed of the following data:

AAN(IT) — number of line segments used to define left half of a wing planform (does not include root chord); a maximum of 24 line segments may be used

XS(IT) — $\bar{x}$-location of the pivot; use 0 on a fixed wing; the axis system used is given in figure 1

YS(IT) — $\bar{y}$-location of the pivot; use 0 on a fixed wing

RTCDHT(IT) — vertical distance of particular planform being read in with respect to the wing-root-chord height; use 0 for a wing

The rest of this set of data requires one card for each line segment used to define the basic planform (variable AAN(IT)). All data described below are required on all except the last card of this set; the last card uses only the first two variables in the following list:

XREG(I,IT) — $\bar{x}$-location of ith breakpoint; the first breakpoint is located at the intersection of the left wing leading edge with the root chord; the breakpoints are numbered in increasing order for each intersection of lines in a counterclockwise direction

YREG(I,IT) — $\bar{y}$-location of ith breakpoint

DIH(I,IT) — dihedral angle (degrees) in $\bar{Y}$-$\bar{Z}$ plane of line from breakpoint i to $i + 1$, positive upward; along a streamwise line, the dihedral angle is not defined; use 0 for these lines; the dihedral angle will have the same sign and magnitude along the leading and trailing edges of a planform over the same spanwise extent

AMCD — move code; this number indicates whether the line segment is on the movable panel of a variable-sweep wing; use 1 for a line which is fixed or 2 for a line which is movable

Group Two

Two sections of data form the group two data. The first section is a single card which describes the details of the particular configuration for which the mean camber surface is desired. This card requires a format of 5F5.1, 2F10.4. The second section is used to supply the fractional chordwise locations where the chord load changes from a constant value to a linearly varying value toward zero. This card uses a format of 8F10.4.

Section one data are to be supplied in the following order:

CONFIG — arbitrary configuration number which may include up to four digits

SCW — number of chordwise horseshoe vortices to be used to represent the wing; a maximum value of 20 may be used; do not set to zero

VIC — nominal number of spanwise rows at which chordwise horseshoe vortices will be located; the variable VIC must not cause more than 50 chordwise rows of vortices to be used by the program to describe the left half of the configuration; in addition, the product of SSW and SCW cannot exceed 400; the use of the variable VIC is discussed in detail in Part I, Section 3 of appendix A

MACH — Mach number; use a value other than 0 only if the Prandtl-Glauert compressibility correction factor $\left(\beta = \sqrt{1 - M_\infty^2}\right)$ is to be applied; it should be less than the critical Mach number

CLDES — design lift coefficient for lifting system

SA(1) — variable sweep angle of the first planform; specify leading-edge sweep angle (degrees) for the first movable line adjacent to the fixed portion of the planform; for a fixed planform this quantity may be omitted

SA(2) — variable sweep angle for the second planform

Section two data consist of two quantities:

XCFW — fractional chord location where the chord load changes from a constant value to a linearly varying value toward zero at the trailing edge of the first planform; this is the same as the symbol a used in the body of the paper

XCFT — fractional chord location where the chord load changes from a constant value to a linearly varying value toward zero at the trailing edge of the second planform; this is the same as the symbol a used in the body of the paper; if only one planform is present, the variable XCFT should be omitted from the input data

Guidelines for Program Use

The following guidelines for the use of this program have been developed from isolated wing studies using the solution technique for configurations without dihedral:

APPENDIX B

(1) More than 10 and perhaps as many as 20 horseshoe vortices are needed along a chord to assure a good solution for the mean camber surface.

(2) At least 10 chordwise rows of horseshoe vortices should be used along a semi-span. More chordwise rows can be used to save interpolating time, although they will not necessarily yield a better solution.

(3) Uniform spacing of horseshoe vortices chordwise and of the chordwise rows spanwise is preferred.

APPENDIX C

OUTPUT DATA

The printed results of this computer program appear in three sections: geometry data, aerodynamic data, and local elevation data.

Geometric and Aerodynamic Data

The geometry data are described in the order that they are found on the printout. The first group of data describes the basic planform, stating the numbers of lines used to describe the planform, the root-chord height, and the pivot position and then listing the breakpoints, sweep and dihedral angles, and move codes. These data are a listing of the input data except for the sweep angle, which is computed from the input data.

The second group of data describes the particular planform for which the local elevation data are being computed. Included are the configuration number, the sweep position, a listing of the breakpoints of the wing planform in terms of $(\bar{x},\bar{y},\bar{z})$, the sweep and dihedral angles, and the move codes. These data are listed primarily for variable-sweep wings to provide a definition of the planform where the outer panel sweep is different from that of the reference planform.

The spanwise scale factors and the term

$$\frac{\text{Normal induced velocity}}{(\text{Free-stream velocity})\left[\cos\text{ (local dihedral angle)}\right]}$$

are listed between the second and third groups of data if the configuration has dihedral.

The third group of data presents a detailed description of the horseshoe vortices used to represent the planform. These data are listed in eight columns, with each line describing one elemental panel of the wing. The following items of data are presented for each elemental panel:

X C/4	$\bar{x}$-location of quarter-chord at horseshoe vortex midspan
X 3C/4	$\bar{x}$-location of three-quarter-chord at horseshoe vortex midspan; this is the $\bar{x}$-location of the slope point
Y	$\bar{y}$-location of horseshoe vortex midspan
Z	$\bar{z}$-location of horseshoe vortex midspan

S	semiwidth of horseshoe vortex
C/4 SWEEP ANGLE	sweep angle of quarter-chord
DIHEDRAL ANGLE	dihedral angle of elemental panel
GAMMA/U AT CLDES =	Γ/U distribution at the design C_L

The fourth group of data presents the following geometric data:

REF. CHORD	reference chord of wing
C AVERAGE	average chord (true planform area divided by true span)
TRUE AREA	true area computed from planform listed in second group of geometry data
REF. AREA	reference area
B/2	largest true semispan of the planforms listed in second group of geometry data
REF. AR	reference aspect ratio computed from reference planform area and true span
TRUE AR	true aspect ratio computed from true planform area and true span
MACH NUMBER	Mach number

The following aerodynamic data are given:

CL*C	$c_l c$, span loading
CL DESIGN	$C_{L,d}$, design C_L
CL COMPUTED	total C_L actually developed from the interpolated spanwise scaling results

CM COMPUTED	total C_m actually developed from the interpolated spanwise scaling results
CD V	$C_{D,v}$, vortex drag coefficient based on the far-field solution at $C_{L,d}$

Local Elevation Data

This section contains the local elevation solutions along the semispan of up to two planforms. An explanation of the variables listed is as follows:

Y	$\bar{y}$, physical spanwise location
Y/B/2	$\frac{\bar{y}}{b/2}$, fraction physical spanwise location based on semispan of larger planform
CHORD	physical chord at $\bar{y}$
DZ/DX	$\partial\bar{z}/\partial\bar{x}$, slope of local elevation curves along the chord
X/C	fractional chordwise distance measured from the leading edge, positive aft
Z/C	$\bar{z}/c$, local elevation normalized by the chord measured with respect to the local trailing edge, positive down
DELTA X	(x/c) (chord)
DELTA Z	($\bar{z}$/c) (chord)

APPENDIX D

SAMPLE CASES

Input data, sketches, and output data for two sample cases are presented in the following order:

Sample case	Configuration	Item	Page
1	100	Input data	42
		Sketch	42
		Output data	43
2	2	Input data	70
		Sketch	70
		Output data	71

Using the same solution technique leads to the central processing time for a configuration generally increasing as the square of the increase in the number of horseshoe vortices used to represent the left half of the planform. Some typical times for the sample cases with a Control Data Corporation 6600 computer system are as follows:

Sample case	Solution technique for configuration having –	Number of horseshoe vortices	CPU time, sec
1	Dihedral	340	140
2	No dihedral	400	183

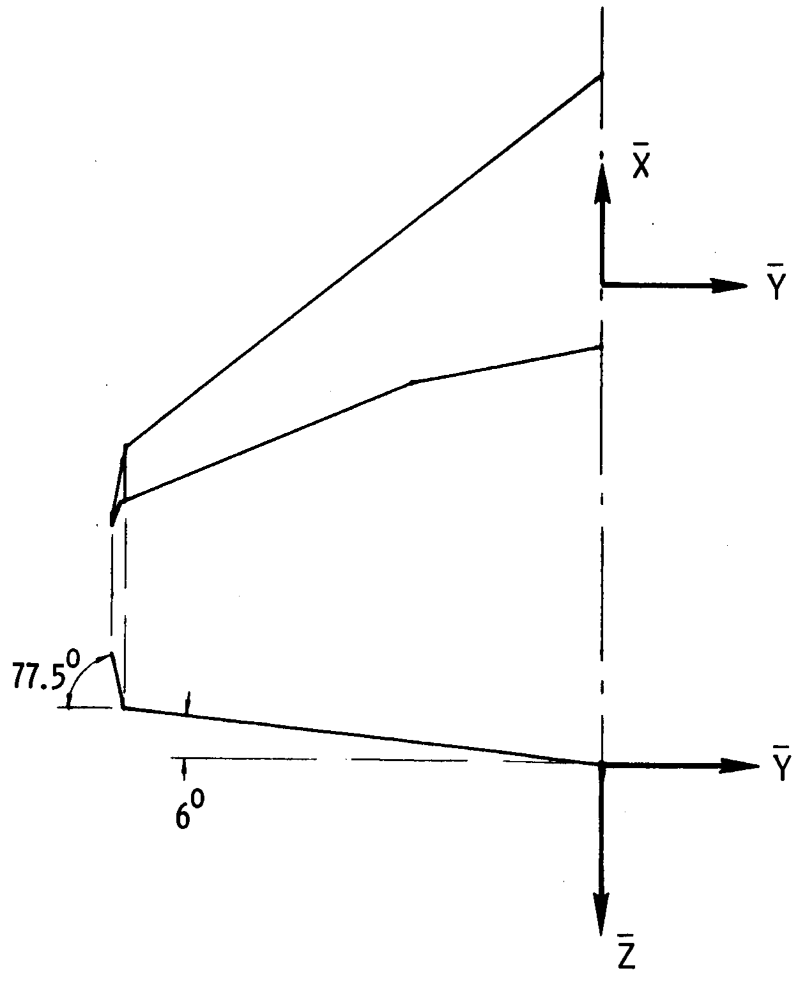
APPENDIX D

Input Data and Sketch for Sample Case 1

```
                 C O L U M N   N U M B E R S   F O R   I N P U T   D A T A
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

          GROUP ONE DATA
  1.          1.          18.145    1762.272
  8.          0.          0.          0.
 26.68       -0.          6.          1.
-20.52      -60.          77.5        1.
-22.82      -60.65        77.5        1.
-29.06      -61.861       0.          1.
-30.58      -61.861       77.5        1.
-27.72      -60.65        77.5        1.
-27.54      -60.0         6.          1.
-12.12      -24.          6.          1.
 -7.92       -0.
          GROUP TWO DATA
 100.  20.  18.  0.8  0.5
    1.0
```

No root-bending-moment constraint is employed.



Output Data for Sample Case 1

GEOMETRY DATA

REFERENCE PLANFORM HAS 8 CURVES

ROOT CHORD HEIGHT = 0.00000 VARIABLE SWEEP PIVOT POSITION X(S) = 0.00000 Y(S) = 0.00000

BREAK POINTS FOR THE REFERENCE PLANFORM

POINT	X REF	Y REF	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	26.68000	-0.00000	38.19095	6.00000	1
2	-20.52000	-60.00000	74.21925	77.50000	1
3	-22.82000	-60.65000	79.01711	77.50000	1
4	-29.06000	-61.86100	90.00000	0.00000	1
5	-30.58000	-61.86100	67.05091	77.50000	1
6	-27.72000	-60.65000	15.47864	77.50000	1
7	-27.54000	-60.00000	23.18706	6.00000	1
8	-12.12000	-24.00000	9.92625	6.00000	1
9	-7.92000	-0.00000			

CONFIGURATION NO. 100

CURVE 1 IS SWEPT 38.19095 DEGREES ON PLANFORM 1

BREAK POINTS FOR THIS CONFIGURATION

POINT	X	Y	Z	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	26.68000	-0.00000	0.00000	38.19095	6.00000	1
2	-20.52000	-60.00000	-6.30625	74.21925	77.50000	1
3	-22.82000	-60.65000	-9.23821	79.01711	77.50000	1
4	-29.06000	-61.86100	-14.70068	90.00000	0.00000	1
5	-30.58000	-61.86100	-14.70068	67.05091	77.50000	1
6	-27.72000	-60.65000	-9.23821	15.47864	77.50000	1
7	-27.54000	-60.00000	-6.30625	23.18706	6.00000	1
8	-12.12000	-24.00000	-2.52250	9.92625	6.00000	1
9	-7.92000	-0.00000	0.00000			

340 HORSESHOE VORTICES USED ON THE LEFT HALF OF THE CONFIGURATION

PLANFORM	TOTAL	SPANWISE
1	340	17

20 HORSESHOE VORTICES IN EACH CHORDWISE ROW

MINIMUM FIELD LENGTH = 63000

SPANWISE SCALE FACTORS AND (NORMAL WASH)/(U * COSINE(DIHEDRAL))

FIRST PLANFORM

DISTANCE ALONG PLANFORM	FACTORS	WN/(U*COS(PHI))
-68.23945	.03041	.20582
-66.86088	.04580	.20671
-65.48230	.05736	.20745
-64.10373	.06657	.20198
-62.72515	.07218	.03373
-61.34658	.05962	.05568
-59.96800	.08594	-.89099
-58.58943	.12091	.48577
-57.21085	.12541	.28991
-55.83228	.12751	.21326
-54.45370	.13163	.20671
-53.07513	.13619	.20504
-51.69655	.14079	.20443
-50.31798	.14530	.20416
-48.93940	.14966	.20402
-47.56083	.15385	.20394
-46.18225	.15787	.20389
-44.80368	.16172	.20386
-43.42510	.16539	.20384
-42.04653	.16889	.20383
-40.66796	.17223	.20382
-39.28938	.17541	.20382
-37.91081	.17844	.20381
-36.53223	.18132	.20381
-35.15366	.18406	.20381
-33.77508	.18667	.20380
-32.39651	.18915	.20380
-31.01793	.19149	.20380
-29.63936	.19372	.20380
-28.26078	.19582	.20380
-26.88221	.19781	.20380
-25.50363	.19968	.20380
-24.12506	.20144	.20380
-22.74648	.20309	.20380
-21.36791	.20464	.20380
-19.98933	.20608	.20380
-18.61076	.20742	.20380
-17.23218	.20866	.20380
-15.85361	.20980	.20380
-14.47503	.21084	.20381
-13.09646	.21179	.20381
-11.71789	.21264	.20381
-10.33931	.21339	.20382
-8.96074	.21406	.20384
-7.58216	.21463	.20386
-6.20359	.21511	.20392
-4.82501	.21549	.20404
-3.44644	.21579	.20444
-2.06786	.21599	.20622
-.68929	.21599	.20015

X C/4	X 3C/4	Y	Z	S	C/4 SWEEP ANGLE	DIHEDRAL ANGLE	GAMMA/U AT CLDES= .5000
-25.98012	-26.06037	-61.25550	-11.96945	2.79755	47.92547	77.50000	.05192
-26.14062	-26.22087	-61.25550	-11.96945	2.79755	47.13657	77.50000	.05192
-26.30112	-26.38137	-61.25550	-11.96945	2.79755	46.32354	77.50000	.05192
-26.46162	-26.54187	-61.25550	-11.96945	2.79755	45.48561	77.50000	.05192
-26.62212	-26.70237	-61.25550	-11.96945	2.79755	44.62199	77.50000	.05192
-26.78262	-26.86287	-61.25550	-11.96945	2.79755	43.73190	77.50000	.05192
-26.94312	-27.02337	-61.25550	-11.96945	2.79755	42.81453	77.50000	.05192
-27.10362	-27.18387	-61.25550	-11.96945	2.79755	41.86912	77.50000	.05192
-27.26412	-27.34437	-61.25550	-11.96945	2.79755	40.89490	77.50000	.05192
-27.42462	-27.50487	-61.25550	-11.96945	2.79755	39.89111	77.50000	.05192
-27.58512	-27.66537	-61.25550	-11.96945	2.79755	38.85705	77.50000	.05192
-27.74562	-27.82587	-61.25550	-11.96945	2.79755	37.79201	77.50000	.05192
-27.90612	-27.98637	-61.25550	-11.96945	2.79755	36.69536	77.50000	.05192
-28.06662	-28.14687	-61.25550	-11.96945	2.79755	35.56652	77.50000	.05192
-28.22712	-28.30737	-61.25550	-11.96945	2.79755	34.40495	77.50000	.05192
-28.38762	-28.46787	-61.25550	-11.96945	2.79755	33.21020	77.50000	.05192
-28.54812	-28.62837	-61.25550	-11.96945	2.79755	31.98193	77.50000	.05192
-28.70862	-28.78887	-61.25550	-11.96945	2.79755	30.71988	77.50000	.05192
-28.86912	-28.94937	-61.25550	-11.96945	2.79755	29.42391	77.50000	.05192
-29.02962	-29.10987	-61.25550	-11.96945	2.79755	28.09401	77.50000	.05192
-21.74450	-21.89350	-60.32500	-7.77223	1.50157	37.12715	77.50000	.06404
-22.04250	-22.19150	-60.32500	-7.77223	1.50157	35.81960	77.50000	.06404
-22.34050	-22.48950	-60.32500	-7.77223	1.50157	34.46752	77.50000	.06404
-22.63850	-22.78750	-60.32500	-7.77223	1.50157	33.07017	77.50000	.06404
-22.93650	-23.08550	-60.32500	-7.77223	1.50157	31.62700	77.50000	.06404
-23.23450	-23.38350	-60.32500	-7.77223	1.50157	30.13764	77.50000	.06404
-23.53250	-23.68150	-60.32500	-7.77223	1.50157	28.60193	77.50000	.06404
-23.83050	-23.97950	-60.32500	-7.77223	1.50157	27.01999	77.50000	.06404
-24.12850	-24.27750	-60.32500	-7.77223	1.50157	25.39223	77.50000	.06404
-24.42650	-24.57550	-60.32500	-7.77223	1.50157	23.71936	77.50000	.06404
-24.72450	-24.87350	-60.32500	-7.77223	1.50157	22.00246	77.50000	.06404
-25.02250	-25.17150	-60.32500	-7.77223	1.50157	20.24296	77.50000	.06404
-25.32050	-25.46950	-60.32500	-7.77223	1.50157	18.44269	77.50000	.06404
-25.61850	-25.76750	-60.32500	-7.77223	1.50157	16.60391	77.50000	.06404
-25.91650	-26.06550	-60.32500	-7.77223	1.50157	14.72925	77.50000	.06404
-26.21450	-26.36350	-60.32500	-7.77223	1.50157	12.82180	77.50000	.06404
-26.51250	-26.66150	-60.32500	-7.77223	1.50157	10.88501	77.50000	.06404
-26.81050	-26.95950	-60.32500	-7.77223	1.50157	8.92271	77.50000	.06404
-27.10650	-27.25750	-60.32500	-7.77223	1.50157	6.93909	77.50000	.06404
-27.40650	-27.55550	-60.32500	-7.77223	1.50157	4.93862	77.50000	.06404
-19.11831	-19.31087	-58.09580	-6.10611	1.91469	37.87944	6.00000	.12147
-19.50343	-19.69599	-58.09580	-6.10611	1.91469	37.23789	6.00000	.12147
-19.88854	-20.08110	-58.09580	-6.10611	1.91469	36.58523	6.00000	.12147
-20.27366	-20.46622	-58.09580	-6.10611	1.91469	35.92134	6.00000	.12147

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-21.81413	-22.00669	-58.09580	-6.10611	1.91469	33.15148	6.00000	.12147
-22.19924	-22.39180	-58.09580	-6.10611	1.91469	32.43002	6.00000	.12147
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-23.35460	-23.54715	-58.09580	-6.10611	1.91469	30.19508	6.00000	.12147
-23.73971	-23.93227	-58.09580	-6.10611	1.91469	29.42649	6.00000	.12147
-24.12483	-24.31739	-58.09580	-6.10611	1.91469	28.64610	6.00000	.12147
-24.50995	-24.70250	-58.09580	-6.10611	1.91469	27.85391	6.00000	.12147
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-25.28018	-25.47274	-58.09580	-6.10611	1.91469	26.23437	6.00000	.12147
-25.66530	-25.85786	-58.09580	-6.10611	1.91469	25.40715	6.00000	.12147
-26.05041	-26.24297	-58.09580	-6.10611	1.91469	24.56842	6.00000	.12147
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-16.59278	-16.81946	-54.28741	-5.70584	1.91469	37.23789	6.00000	.13123
-17.04613	-17.27281	-54.28741	-5.70584	1.91469	36.58523	6.00000	.13123
-17.49948	-17.72616	-54.28741	-5.70584	1.91469	35.92134	6.00000	.13123
-17.95283	-18.17951	-54.28741	-5.70584	1.91469	35.24612	6.00000	.13123
-18.40613	-18.63286	-54.28741	-5.70584	1.91469	34.55946	6.00000	.13123
-18.85953	-19.08621	-54.28741	-5.70584	1.91469	33.86128	6.00000	.13123
-19.31288	-19.53956	-54.28741	-5.70584	1.91469	33.15148	6.00000	.13123
-19.76623	-19.99291	-54.28741	-5.70584	1.91469	32.43002	6.00000	.13123
-20.21959	-20.44626	-54.28741	-5.70584	1.91469	31.69682	6.00000	.13123
-20.67294	-20.89961	-54.28741	-5.70584	1.91469	30.95185	6.00000	.13123
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-21.57964	-21.80631	-54.28741	-5.70584	1.91469	29.42649	6.00000	.13123
-22.03299	-22.25966	-54.28741	-5.70584	1.91469	28.64610	6.00000	.13123
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-23.84639	-24.07307	-54.28741	-5.70584	1.91469	25.40715	6.00000	.13123
-24.29974	-24.52642	-54.28741	-5.70584	1.91469	24.56842	6.00000	.13123
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-13.68213	-13.94293	-50.47901	-5.30556	1.91469	37.23789	6.00000	.14386
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-15.76847	-16.02926	-50.47901	-5.30556	1.91469	34.55946	6.00000	.14386
-16.29006	-16.55085	-50.47901	-5.30556	1.91469	33.86128	6.00000	.14386
-16.81164	-17.07243	-50.47901	-5.30556	1.91469	33.15148	6.00000	.14386
-17.33322	-17.59402	-50.47901	-5.30556	1.91469	32.43002	6.00000	.14386
-17.85481	-18.11560	-50.47901	-5.30556	1.91469	31.69682	6.00000	.14386
-18.37639	-18.63719	-50.47901	-5.30556	1.91469	30.95185	6.00000	.14386
-18.89798	-19.15877	-50.47901	-5.30556	1.91469	30.19508	6.00000	.14386
-19.41956	-19.68035	-50.47901	-5.30556	1.91469	29.42649	6.00000	.14386
-19.94115	-20.20194	-50.47901	-5.30556	1.91469	28.64610	6.00000	.14386
-20.46273	-20.72352	-50.47901	-5.30556	1.91469	27.85391	6.00000	.14386

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-20.98432	-21.24511	-50.47901	-5.30556	1.91469	27.04999	6.00000	.14386
-21.50590	-21.76669	-50.47901	-5.30556	1.91469	26.23437	6.00000	.14386
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-22.54907	-22.80986	-50.47901	-5.30556	1.91469	24.56842	6.00000	.14386
-23.07065	-23.33145	-50.47901	-5.30556	1.91469	23.71832	6.00000	.14386
-10.18167	-10.47658	-46.67061	-4.90528	1.91469	37.87944	6.00000	.15570
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-13.13076	-13.42567	-46.67061	-4.90528	1.91469	34.55946	6.00000	.15570
-13.72058	-14.01549	-46.67061	-4.90528	1.91469	33.86128	6.00000	.15570
-14.31040	-14.60531	-46.67061	-4.90528	1.91469	33.15148	6.00000	.15570
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-20.20858	-20.50349	-46.67061	-4.90528	1.91469	25.40715	6.00000	.15570
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-13.12526	-13.45428	-42.86222	-4.50500	1.91469	31.69682	6.00000	.16622
-13.78331	-14.11233	-42.86222	-4.50500	1.91469	30.95185	6.00000	.16622
-14.44136	-14.77039	-42.86222	-4.50500	1.91469	30.19508	6.00000	.16622
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-15.75746	-16.08649	-42.86222	-4.50500	1.91469	28.64610	6.00000	.16622
-16.41552	-16.74454	-42.86222	-4.50500	1.91469	27.85391	6.00000	.16622
-17.07357	-17.40259	-42.86222	-4.50500	1.91469	27.04999	6.00000	.16622
-17.73162	-18.06065	-42.86222	-4.50500	1.91469	26.23437	6.00000	.16622
-18.38967	-18.71870	-42.86222	-4.50500	1.91469	25.40715	6.00000	.16622
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-4.22391	-4.58705	-39.05382	-4.10472	1.91469	37.87944	6.00000	.17545
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-5.67648	-6.03962	-39.05382	-4.10472	1.91469	36.58523	6.00000	.17545
-6.40277	-6.76591	-39.05382	-4.10472	1.91469	35.92134	6.00000	.17545
-7.12905	-7.49219	-39.05382	-4.10472	1.91469	35.24612	6.00000	.17545
-7.85534	-8.21848	-39.05382	-4.10472	1.91469	34.55946	6.00000	.17545

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-10.03419	-10.39734	-39.05382	-4.10472	1.91469	32.43002	6.00000	.17545
-10.76048	-11.12362	-39.05382	-4.10472	1.91469	31.69682	6.00000	.17545
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-12.93934	-13.30248	-39.05382	-4.10472	1.91469	29.42649	6.00000	.17545
-13.66562	-14.02877	-39.05382	-4.10472	1.91469	28.64610	6.00000	.17545
-14.39191	-14.75505	-39.05382	-4.10472	1.91469	27.85391	6.00000	.17545
-15.11820	-15.48134	-39.05382	-4.10472	1.91469	27.04999	6.00000	.17545
-15.84448	-16.20762	-39.05382	-4.10472	1.91469	26.23437	6.00000	.17545
-16.57077	-16.93391	-39.05382	-4.10472	1.91469	25.40715	6.00000	.17545
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-18.02334	-18.38648	-39.05382	-4.10472	1.91469	23.71832	6.00000	.17545
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-5.21763	-5.61489	-35.24542	-3.70444	1.91469	34.55946	6.00000	.18350
-6.01215	-6.40941	-35.24542	-3.70444	1.91469	33.86128	6.00000	.18350
-6.80667	-7.20393	-35.24542	-3.70444	1.91469	33.15148	6.00000	.18350
-7.60118	-7.99844	-35.24542	-3.70444	1.91469	32.43002	6.00000	.18350
-8.39570	-8.79296	-35.24542	-3.70444	1.91469	31.69682	6.00000	.18350
-9.19022	-9.58748	-35.24542	-3.70444	1.91469	30.95185	6.00000	.18350
-9.98474	-10.38200	-35.24542	-3.70444	1.91469	30.19508	6.00000	.18350
-10.77926	-11.17652	-35.24542	-3.70444	1.91469	29.42649	6.00000	.18350
-11.57378	-11.97104	-35.24542	-3.70444	1.91469	28.64610	6.00000	.18350
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-13.16282	-13.56008	-35.24542	-3.70444	1.91469	27.04999	6.00000	.18350
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-15.54638	-15.94364	-35.24542	-3.70444	1.91469	24.56842	6.00000	.18350
-16.34090	-16.73816	-35.24542	-3.70444	1.91469	23.71832	6.00000	.18350
1.73385	1.30247	-31.43703	-3.30416	1.91469	37.87944	6.00000	.19048
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.00834	-.42303	-31.43703	-3.30416	1.91469	36.58523	6.00000	.19048
-.85441	-1.28578	-31.43703	-3.30416	1.91469	35.92134	6.00000	.19048
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-6.03093	-6.46230	-31.43703	-3.30416	1.91469	31.69682	6.00000	.19048
-6.89368	-7.32506	-31.43703	-3.30416	1.91469	30.95185	6.00000	.19048
-7.75643	-8.18781	-31.43703	-3.30416	1.91469	30.19508	6.00000	.19048
-8.61919	-9.05056	-31.43703	-3.30416	1.91469	29.42649	6.00000	.19048
-9.48194	-9.91332	-31.43703	-3.30416	1.91469	28.64610	6.00000	.19048
-10.34469	-10.77607	-31.43703	-3.30416	1.91469	27.85391	6.00000	.19048
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-12.07020	-12.50158	-31.43703	-3.30416	1.91469	26.23437	6.00000	.19048

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-12.93295	-13.36433	-31.43703	-3.30416	1.91469	25.40715	6.00000	.19048
-13.79571	-14.22708	-31.43703	-3.30416	1.91469	24.56842	6.00000	.19048
-14.65846	-15.08984	-31.43703	-3.30416	1.91469	23.71832	6.00000	.19048
5.38715	4.91393	-26.76641	-2.81326	2.78165	37.87944	6.00000	.19776
4.44071	3.96749	-26.76641	-2.81326	2.78165	37.23789	6.00000	.19776
3.49428	3.02106	-26.76641	-2.81326	2.78165	36.58523	6.00000	.19776
2.54784	2.07462	-26.76641	-2.81326	2.78165	35.92134	6.00000	.19776
1.60141	1.12819	-26.76641	-2.81326	2.78165	35.24612	6.00000	.19776
.65497	.18175	-26.76641	-2.81326	2.78165	34.55946	6.00000	.19776
-.29146	-.76468	-26.76641	-2.81326	2.78165	33.86128	6.00000	.19776
-1.23790	-1.71112	-26.76641	-2.81326	2.78165	33.15148	6.00000	.19776
-2.18433	-2.65755	-26.76641	-2.81326	2.78165	32.43002	6.00000	.19776
-3.13077	-3.60399	-26.76641	-2.81326	2.78165	31.69682	6.00000	.19776
-4.07721	-4.55042	-26.76641	-2.81326	2.78165	30.95185	6.00000	.19776
-5.02364	-5.49686	-26.76641	-2.81326	2.78165	30.19508	6.00000	.19776
-5.97008	-6.44329	-26.76641	-2.81326	2.78165	29.42649	6.00000	.19776
-6.91651	-7.38973	-26.76641	-2.81326	2.78165	28.64610	6.00000	.19776
-7.86295	-8.33616	-26.76641	-2.81326	2.78165	27.85391	6.00000	.19776
-8.80938	-9.28260	-26.76641	-2.81326	2.78165	27.04999	6.00000	.19776
-9.75582	-10.22903	-26.76641	-2.81326	2.78165	26.23437	6.00000	.19776
-10.70225	-11.17547	-26.76641	-2.81326	2.78165	25.40715	6.00000	.19776
-11.64869	-12.12190	-26.76641	-2.81326	2.78165	24.56842	6.00000	.19776
-12.59512	-13.06834	-26.76641	-2.81326	2.78165	23.71832	6.00000	.19776
9.03441	8.50729	-22.09580	-2.32236	1.91469	37.76685	6.00000	.20368
7.98017	7.45306	-22.09580	-2.32236	1.91469	36.66169	6.00000	.20368
6.92594	6.39882	-22.09580	-2.32236	1.91469	35.52386	6.00000	.20368
5.87170	5.34458	-22.09580	-2.32236	1.91469	34.35284	6.00000	.20368
4.81746	4.29034	-22.09580	-2.32236	1.91469	33.14816	6.00000	.20368
3.76323	3.23611	-22.09580	-2.32236	1.91469	31.90946	6.00000	.20368
2.70899	2.18187	-22.09580	-2.32236	1.91469	30.63650	6.00000	.20368
1.65475	1.12763	-22.09580	-2.32236	1.91469	29.32914	6.00000	.20368
.60052	.07340	-22.09580	-2.32236	1.91469	27.98738	6.00000	.20368
-.45372	-.98084	-22.09580	-2.32236	1.91469	26.61138	6.00000	.20368
-1.50796	-2.03508	-22.09580	-2.32236	1.91469	25.20146	6.00000	.20368
-2.56219	-3.08931	-22.09580	-2.32236	1.91469	23.75811	6.00000	.20368
-3.61643	-4.14355	-22.09580	-2.32236	1.91469	22.28204	6.00000	.20368
-4.67067	-5.19779	-22.09580	-2.32236	1.91469	20.77414	6.00000	.20368
-5.72490	-6.25202	-22.09580	-2.32236	1.91469	19.23552	6.00000	.20368
-6.77914	-7.30626	-22.09580	-2.32236	1.91469	17.66753	6.00000	.20368
-7.83338	-8.36050	-22.09580	-2.32236	1.91469	16.07172	6.00000	.20368
-8.88761	-9.41473	-22.09580	-2.32236	1.91469	14.44989	6.00000	.20368
-9.94185	-10.46897	-22.09580	-2.32236	1.91469	12.80406	6.00000	.20368
-10.99609	-11.52321	-22.09580	-2.32236	1.91469	11.13646	6.00000	.20368
12.00123	11.41588	-18.28741	-1.92208	1.91469	37.76685	6.00000	.20762
10.83052	10.24517	-18.28741	-1.92208	1.91469	36.66169	6.00000	.20762
9.65981	9.07445	-18.28741	-1.92208	1.91469	35.52386	6.00000	.20762
8.48910	7.90374	-18.28741	-1.92208	1.91469	34.35284	6.00000	.20762
7.31839	6.73303	-18.28741	-1.92208	1.91469	33.14816	6.00000	.20762
6.14768	5.56232	-18.28741	-1.92208	1.91469	31.90946	6.00000	.20762
4.97697	4.39161	-18.28741	-1.92208	1.91469	30.63650	6.00000	.20762
3.80626	3.22090	-18.28741	-1.92208	1.91469	29.32914	6.00000	.20762

2.63555	2.05019	-18.28741	-1.92208	1.91469	27.98738	6.00000	.20762
1.46484	.87948	-18.28741	-1.92208	1.91469	26.61138	6.00000	.20762
.29413	-.29123	-18.28741	-1.92208	1.91469	25.20146	6.00000	.20762
-.87658	-1.46194	-18.28741	-1.92208	1.91469	23.75811	6.00000	.20762
-2.04729	-2.63265	-18.28741	-1.92208	1.91469	22.28204	6.00000	.20762
-3.21800	-3.80336	-18.28741	-1.92208	1.91469	20.77414	6.00000	.20762
-4.38871	-4.97407	-18.28741	-1.92208	1.91469	19.23552	6.00000	.20762
-5.55942	-6.14478	-18.28741	-1.92208	1.91469	17.66753	6.00000	.20762
-6.73013	-7.31549	-18.28741	-1.92208	1.91469	16.07172	6.00000	.20762
-7.90084	-8.48620	-18.28741	-1.92208	1.91469	14.44989	6.00000	.20762
-9.07155	-9.65691	-18.28741	-1.92208	1.91469	12.80406	6.00000	.20762
-10.24226	-10.82762	-18.28741	-1.92208	1.91469	11.13646	6.00000	.20762
14.96805	14.32446	-14.47901	-1.52181	1.91469	37.76685	6.00000	.21078
13.68087	13.03728	-14.47901	-1.52181	1.91469	36.66169	6.00000	.21078
12.39368	11.75009	-14.47901	-1.52181	1.91469	35.52386	6.00000	.21078
11.10650	10.46291	-14.47901	-1.52181	1.91469	34.35284	6.00000	.21078
9.81932	9.17572	-14.47901	-1.52181	1.91469	33.14816	6.00000	.21078
8.53213	7.88854	-14.47901	-1.52181	1.91469	31.90946	6.00000	.21078
7.24495	6.60136	-14.47901	-1.52181	1.91469	30.63650	6.00000	.21078
5.95777	5.31417	-14.47901	-1.52181	1.91469	29.32914	6.00000	.21078
4.67058	4.02699	-14.47901	-1.52181	1.91469	27.98738	6.00000	.21078
3.38340	2.73981	-14.47901	-1.52181	1.91469	26.61138	6.00000	.21078
2.09621	1.45262	-14.47901	-1.52181	1.91469	25.20146	6.00000	.21078
.80903	.16544	-14.47901	-1.52181	1.91469	23.75811	6.00000	.21078
-.47615	-1.12174	-14.47901	-1.52181	1.91469	22.28204	6.00000	.21078
-1.76534	-2.40893	-14.47901	-1.52181	1.91469	20.77414	6.00000	.21078
-3.05252	-3.69611	-14.47901	-1.52181	1.91469	19.23552	6.00000	.21078
-4.33970	-4.98330	-14.47901	-1.52181	1.91469	17.66753	6.00000	.21078
-5.62639	-6.27048	-14.47901	-1.52181	1.91469	16.07172	6.00000	.21078
-6.91407	-7.55766	-14.47901	-1.52181	1.91469	14.44989	6.00000	.21078
-8.20126	-8.84485	-14.47901	-1.52181	1.91469	12.80406	6.00000	.21078
-9.48844	-10.13203	-14.47901	-1.52181	1.91469	11.13646	6.00000	.21078
17.93487	17.23304	-10.67061	-1.12153	1.91469	37.76685	6.00000	.21318
16.53121	15.82939	-10.67061	-1.12153	1.91469	36.66169	6.00000	.21318
15.12756	14.42573	-10.67061	-1.12153	1.91469	35.52386	6.00000	.21318
13.72390	13.02207	-10.67061	-1.12153	1.91469	34.35284	6.00000	.21318
12.32024	11.61841	-10.67061	-1.12153	1.91469	33.14816	6.00000	.21318
10.91659	10.21476	-10.67061	-1.12153	1.91469	31.90946	6.00000	.21318
9.51293	8.81110	-10.67061	-1.12153	1.91469	30.63650	6.00000	.21318
8.10927	7.40744	-10.67061	-1.12153	1.91469	29.32914	6.00000	.21318
6.70561	6.00379	-10.67061	-1.12153	1.91469	27.98738	6.00000	.21318
5.30196	4.60013	-10.67061	-1.12153	1.91469	26.61138	6.00000	.21318
3.89830	3.19647	-10.67061	-1.12153	1.91469	25.20146	6.00000	.21318
2.49464	1.79281	-10.67061	-1.12153	1.91469	23.75811	6.00000	.21318
1.09099	.38916	-10.67061	-1.12153	1.91469	22.28204	6.00000	.21318
-.31267	-1.01450	-10.67061	-1.12153	1.91469	20.77414	6.00000	.21318
-1.71633	-2.41816	-10.67061	-1.12153	1.91469	19.23552	6.00000	.21318
-3.11999	-3.82181	-10.67061	-1.12153	1.91469	17.66753	6.00000	.21318
-4.52364	-5.22547	-10.67061	-1.12153	1.91469	16.07172	6.00000	.21318
-5.92730	-6.62913	-10.67061	-1.12153	1.91469	14.44989	6.00000	.21318
-7.33096	-8.03279	-10.67061	-1.12153	1.91469	12.80406	6.00000	.21318

APPENDIX D

-8.73461	-9.43644	-10.67061	-1.12153	1.91469	11.13646	6.00000	.21318
20.90169	20.14163	-6.86222	-.72125	1.91469	37.76685	6.00000	.21486
19.38156	18.62150	-6.86222	-.72125	1.91469	36.66169	6.00000	.21486
17.86143	17.10136	-6.86222	-.72125	1.91469	35.52386	6.00000	.21486
16.34130	15.58123	-6.86222	-.72125	1.91469	34.35284	6.00000	.21486
14.82117	14.06110	-6.86222	-.72125	1.91469	33.14816	6.00000	.21486
13.30104	12.54097	-6.86222	-.72125	1.91469	31.90946	6.00000	.21486
11.78091	11.02084	-6.86222	-.72125	1.91469	30.63650	6.00000	.21486
10.26078	9.50071	-6.86222	-.72125	1.91469	29.32914	6.00000	.21486
8.74065	7.98058	-6.86222	-.72125	1.91469	27.98738	6.00000	.21486
7.22052	6.46045	-6.86222	-.72125	1.91469	26.61138	6.00000	.21486
5.70039	4.94032	-6.86222	-.72125	1.91469	25.20146	6.00000	.21486
4.18025	3.42019	-6.86222	-.72125	1.91469	23.75811	6.00000	.21486
2.66012	1.90006	-6.86222	-.72125	1.91469	22.28204	6.00000	.21486
1.13999	.37993	-6.86222	-.72125	1.91469	20.77414	6.00000	.21486
-.38014	-1.14020	-6.86222	-.72125	1.91469	19.23552	6.00000	.21486
-1.90027	-2.66033	-6.86222	-.72125	1.91469	17.66753	6.00000	.21486
-3.42040	-4.18046	-6.86222	-.72125	1.91469	16.07172	6.00000	.21486
-4.94053	-5.70059	-6.86222	-.72125	1.91469	14.44989	6.00000	.21486
-6.46066	-7.22072	-6.86222	-.72125	1.91469	12.80406	6.00000	.21486
-7.98079	-8.74086	-6.86222	-.72125	1.91469	11.13646	6.00000	.21486
24.31630	23.48921	-2.47901	-.26055	2.49266	37.76685	6.00000	.21593
22.66212	21.83503	-2.47901	-.26055	2.49266	36.66169	6.00000	.21593
21.00793	20.18084	-2.47901	-.26055	2.49266	35.52386	6.00000	.21593
19.35375	18.52666	-2.47901	-.26055	2.49266	34.35284	6.00000	.21593
17.69957	16.87247	-2.47901	-.26055	2.49266	33.14816	6.00000	.21593
16.04538	15.21829	-2.47901	-.26055	2.49266	31.90946	6.00000	.21593
14.39120	13.56411	-2.47901	-.26055	2.49266	30.63650	6.00000	.21593
12.73702	11.90992	-2.47901	-.26055	2.49266	29.32914	6.00000	.21593
11.08283	10.25574	-2.47901	-.26055	2.49266	27.98738	6.00000	.21593
9.42865	8.60156	-2.47901	-.26055	2.49266	26.61138	6.00000	.21593
7.77446	6.94737	-2.47901	-.26055	2.49266	25.20146	6.00000	.21593
6.12028	5.29319	-2.47901	-.26055	2.49266	23.75811	6.00000	.21593
4.46610	3.63901	-2.47901	-.26055	2.49266	22.28204	6.00000	.21593
2.81191	1.98482	-2.47901	-.26055	2.49266	20.77414	6.00000	.21593
1.15773	.33064	-2.47901	-.26055	2.49266	19.23552	6.00000	.21593
-.49645	-1.32355	-2.47901	-.26055	2.49266	17.66753	6.00000	.21593
-2.15064	-2.97773	-2.47901	-.26055	2.49266	16.07172	6.00000	.21593
-3.80482	-4.63191	-2.47901	-.26055	2.49266	14.44989	6.00000	.21593
-5.45901	-6.28610	-2.47901	-.26055	2.49266	12.80406	6.00000	.21593
-7.11319	-7.94028	-2.47901	-.26055	2.49266	11.13646	6.00000	.21593

REF. CHORD	C AVERAGE	TRUE AREA	REFERENCE AREA	B/2	REF. AR	TRUE AR	MACH NUMBER
18.14500	18.54030	2293.84262	1762.27200	61.86100	8.68602	6.67314	.80000

F I R S T   P L A N F O R M   S P A N   L O A D I N G

Y	CL*C
-61.25550	.44949
-60.32500	.55447
-58.09580	4.83238
-54.28741	5.22063
-50.47901	5.72299
-46.67061	6.19390
-42.86222	6.61220
-39.05382	6.97966
-35.24542	7.29962
-31.43703	7.57765
-26.76641	7.86707
-22.09580	8.10273
-18.28741	8.25923
-14.47901	8.38485
-10.67061	8.48045
-6.86222	8.54748
-2.47901	8.58975

CL DEVELOPED ON THIS PLANFORM= .503771
CM DEVELOPED ON THIS PLANFORM= -.132987

CL DESIGN = .500000   CL COMPUTED= .503771   CM COMPUTED= -.132987   CD V= .008109

APPENDIX D

LOCAL ELEVATION DATA

Y= -61.2555 Y/B/2= -.9902 CHORD= 3.2100

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.6728 .5583 .4843 .4272 .3790 .3360 .2963 .2585 .2219 .1858 .1495 .1125 .0743 .0340-.0096-.0583-.1154-.1884-.2992-.6026

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
-.0000	.1620	-.0000	.5201
.0250	.1451	.0802	.4658
.0500	.1284	.1605	.4120
.0750	.1128	.2407	.3620
.1000	.0988	.3210	.3171
.1250	.0859	.4012	.2758
.1500	.0738	.4815	.2370
.1750	.0624	.5617	.2004
.2000	.0517	.6420	.1661
.2250	.0417	.7222	.1338
.2500	.0322	.8025	.1034
.2750	.0233	.8827	.0748
.3000	.0149	.9630	.0478
.3250	.0070	1.0432	.0225
.3500	-.0004	1.1235	-.0013
.3750	-.0073	1.2037	-.0236
.4000	-.0138	1.2840	-.0443
.4250	-.0198	1.3642	-.0636
.4500	-.0254	1.4445	-.0814
.4750	-.0304	1.5247	-.0977
.5000	-.0351	1.6050	-.1126
.5250	-.0393	1.6852	-.1261
.5500	-.0430	1.7655	-.1381
.5750	-.0463	1.8457	-.1486
.6000	-.0491	1.9260	-.1577
.6250	-.0515	2.0062	-.1652
.6500	-.0533	2.0865	-.1711
.6750	-.0547	2.1667	-.1755
.7000	-.0555	2.2470	-.1782
.7250	-.0558	2.3272	-.1792
.7500	-.0556	2.4075	-.1785
.7750	-.0548	2.4877	-.1758
.8000	-.0533	2.5680	-.1711
.8250	-.0512	2.6482	-.1643
.8500	-.0483	2.7285	-.1550
.8750	-.0444	2.8087	-.1426
.9000	-.0397	2.8890	-.1276
.9250	-.0343	2.9692	-.1102
.9500	-.0267	3.0495	-.0857
.9750	-.0148	3.1297	-.0474
1.0000	0.0000	3.2100	0.0000

Y= -60.3250 Y/B/2= -.9752 CHORD= 5.9600

SLOPES,DZ/DX,AT SLOPE POINTS,FRCM FRCNT TO REAR

.5599 .4988 .4604 .4305 .4045 .3807 .3584 .3372 .3170 .2978 .2800 .2637 .2489 .2351 .2208 .2041 .1817 .1481 .0885-.0980

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	.2993	0.0000	1.7837
.0250	.2852	.1490	1.7000
.0500	.2713	.2980	1.6168
.0750	.2579	.4470	1.5373
.1000	.2454	.5960	1.4629
.1250	.2336	.7450	1.3920
.1500	.2220	.8940	1.3234
.1750	.2109	1.0430	1.2570
.2000	.2001	1.1920	1.1928
.2250	.1897	1.3410	1.1307
.2500	.1796	1.4900	1.0705
.2750	.1698	1.6390	1.0120
.3000	.1603	1.7880	.9553
.3250	.1510	1.9370	.9002
.3500	.1421	2.0860	.8468
.3750	.1334	2.2350	.7950
.4000	.1250	2.3840	.7448
.4250	.1168	2.5330	.6960
.4500	.1089	2.6820	.6488
.4750	.1012	2.8310	.6030
.5000	.0937	2.9800	.5587
.5250	.0865	3.1290	.5156
.5500	.0795	3.2780	.4739
.5750	.0727	3.4270	.4334
.6000	.0661	3.5760	.3941
.6250	.0597	3.7250	.3560
.6500	.0535	3.8740	.3189
.6750	.0475	4.0230	.2828
.7000	.0416	4.1720	.2478
.7250	.0359	4.3210	.2138
.7500	.0304	4.4700	.1809
.7750	.0250	4.6190	.1492
.8000	.0199	4.7680	.1188
.8250	.0151	4.9170	.0898
.8500	.0105	5.0660	.0628
.8750	.0065	5.2150	.0385
.9000	.0027	5.3640	.0163
.9250	-.0007	5.5130	-.0039
.9500	-.0028	5.6620	-.0165
.9750	-.0023	5.8110	-.0135
1.0000	0.0000	5.9600	0.0000

Y= -58.0958 Y/B/2= -.9391 CHORD= 7.7023

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.1354 .0962 .0742 .0558 .0401 .0262 .0136 .0020-.0090-.0195-.0299-.0404-.0511-.0622-.0741-.0872-.1022-.1211-.1494-.2265

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0218	.0000	-.1678
.0250	-.0252	.1926	-.1941
.0500	-.0286	.3851	-.2200
.0750	-.0315	.5777	-.2429
.1000	-.0340	.7702	-.2619
.1250	-.0361	.9628	-.2781
.1500	-.0380	1.1554	-.2924
.1750	-.0396	1.3479	-.3049
.2000	-.0410	1.5405	-.3156
.2250	-.0422	1.7330	-.3248
.2500	-.0432	1.9256	-.3325
.2750	-.0440	2.1181	-.3389
.3000	-.0447	2.3107	-.3439
.3250	-.0451	2.5033	-.3477
.3500	-.0455	2.6958	-.3503
.3750	-.0457	2.8884	-.3518
.4000	-.0457	3.0809	-.3522
.4250	-.0456	3.2735	-.3515
.4500	-.0454	3.4661	-.3498
.4750	-.0451	3.6586	-.3470
.5000	-.0446	3.8512	-.3433
.5250	-.0440	4.0437	-.3385
.5500	-.0432	4.2363	-.3328
.5750	-.0423	4.4288	-.3260
.6000	-.0413	4.6214	-.3182
.6250	-.0402	4.8140	-.3094
.6500	-.0389	5.0065	-.2996
.6750	-.0375	5.1991	-.2887
.7000	-.0359	5.3916	-.2767
.7250	-.0342	5.5842	-.2636
.7500	-.0324	5.7768	-.2493
.7750	-.0304	5.9693	-.2338
.8000	-.0282	6.1619	-.2170
.8250	-.0258	6.3544	-.1989
.8500	-.0233	6.5470	-.1792
.8750	-.0205	6.7395	-.1576
.9000	-.0174	6.9321	-.1343
.9250	-.0142	7.1247	-.1096
.9500	-.0105	7.3172	-.0805
.9750	-.0056	7.5098	-.0430
1.0000	0.0000	7.7023	0.0000

Y= -54.2874 Y/B/2= -.8776 CHORD= 9.0670

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.1277 .0944 .0736 .0579 .0452 .0342 .0244 .0153 .0067-.0015-.0096-.0178-.0261-.0348-.0442-.0547-.0672-.0833-.1081-.1777

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0675 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0034	0.0000	-.0309
.0250	-.0066	.2267	-.0601
.0500	-.0098	.4534	-.0889
.0750	-.0126	.6800	-.1145
.1000	-.0150	.9067	-.1361
.1250	-.0171	1.1334	-.1546
.1500	-.0189	1.3601	-.1713
.1750	-.0205	1.5867	-.1862
.2000	-.0220	1.8134	-.1993
.2250	-.0233	2.0401	-.2109
.2500	-.0244	2.2668	-.2212
.2750	-.0254	2.4934	-.2301
.3000	-.0262	2.7201	-.2379
.3250	-.0270	2.9468	-.2445
.3500	-.0276	3.1735	-.2500
.3750	-.0281	3.4001	-.2545
.4000	-.0285	3.6268	-.2580
.4250	-.0287	3.8535	-.2605
.4500	-.0289	4.0802	-.2620
.4750	-.0290	4.3068	-.2626
.5000	-.0289	4.5335	-.2622
.5250	-.0288	4.7602	-.2610
.5500	-.0285	4.9869	-.2588
.5750	-.0282	5.2135	-.2557
.6000	-.0278	5.4402	-.2516
.6250	-.0272	5.6669	-.2467
.6500	-.0266	5.8936	-.2408
.6750	-.0258	6.1202	-.2339
.7000	-.0249	6.3469	-.2260
.7250	-.0239	6.5736	-.2171
.7500	-.0228	6.8003	-.2070
.7750	-.0216	7.0269	-.1958
.8000	-.0202	7.2536	-.1834
.8250	-.0187	7.4803	-.1698
.8500	-.0170	7.7070	-.1545
.8750	-.0151	7.9336	-.1373
.9000	-.0131	8.1603	-.1185
.9250	-.0108	8.3870	-.0983
.9500	-.0081	8.6137	-.0734
.9750	-.0044	8.8403	-.0396
1.0000	0.0000	9.0670	0.0000

Y= -50.4790 Y/B/2= -.8160 CHORD= 10.4317

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.1195 .0878 .0680 .0531 .0409 .0304 .0210 .0124 .0042-.0036-.0113-.0190-.0269-.0352-.0441-.0541-.0660-.0813-.1050-.1714

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0054	0.0000	-.0559
.0250	-.0084	.2608	-.0873
.0500	-.0113	.5216	-.1182
.0750	-.0140	.7824	-.1458
.1000	-.0162	1.0432	-.1688
.1250	-.0181	1.3040	-.1886
.1500	-.0198	1.5648	-.2063
.1750	-.0213	1.8255	-.2221
.2000	-.0226	2.0863	-.2360
.2250	-.0238	2.3471	-.2481
.2500	-.0248	2.6079	-.2588
.2750	-.0257	2.8687	-.2681
.3000	-.0265	3.1295	-.2760
.3250	-.0271	3.3903	-.2827
.3500	-.0276	3.6511	-.2882
.3750	-.0280	3.9119	-.2926
.4000	-.0284	4.1727	-.2958
.4250	-.0286	4.4335	-.2979
.4500	-.0287	4.6943	-.2990
.4750	-.0287	4.9551	-.2991
.5000	-.0286	5.2158	-.2982
.5250	-.0284	5.4766	-.2962
.5500	-.0281	5.7374	-.2933
.5750	-.0277	5.9982	-.2893
.6000	-.0273	6.2590	-.2843
.6250	-.0267	6.5198	-.2784
.6500	-.0260	6.7806	-.2713
.6750	-.0252	7.0414	-.2632
.7000	-.0244	7.3022	-.2541
.7250	-.0234	7.5630	-.2437
.7500	-.0223	7.8238	-.2322
.7750	-.0210	8.0846	-.2194
.8000	-.0197	8.3454	-.2053
.8250	-.0182	8.6061	-.1898
.8500	-.0165	8.8669	-.1726
.8750	-.0147	9.1277	-.1532
.9000	-.0127	9.3885	-.1321
.9250	-.0105	9.6493	-.1093
.9500	-.0078	9.9101	-.0816
.9750	-.0042	10.1709	-.0440
1.0000	0.0000	10.4317	0.0000

Y= -46.6706 Y/B/2= -.7544 CHORD= 11.7964

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.1115 .0812 .0622 .0479 .0362 .0261 .0171 .0088 .0010-.0065-.0139-.0213-.0289-.0368-.0453-.0549-.0662-.0808-.1035-.1671

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0081	0.0000	-.0959
.0250	-.0109	.2949	-.1291
.0500	-.0137	.5898	-.1617
.0750	-.0162	.8847	-.1907
.1000	-.0182	1.1796	-.2148
.1250	-.0200	1.4745	-.2354
.1500	-.0215	1.7695	-.2537
.1750	-.0229	2.0644	-.2699
.2000	-.0241	2.3593	-.2841
.2250	-.0251	2.6542	-.2964
.2500	-.0260	2.9491	-.3070
.2750	-.0268	3.2440	-.3162
.3000	-.0275	3.5389	-.3239
.3250	-.0280	3.8338	-.3303
.3500	-.0284	4.1287	-.3353
.3750	-.0287	4.4236	-.3391
.4000	-.0290	4.7185	-.3417
.4250	-.0291	5.0135	-.3431
.4500	-.0291	5.3084	-.3434
.4750	-.0290	5.6033	-.3426
.5000	-.0289	5.8982	-.3407
.5250	-.0286	6.1931	-.3377
.5500	-.0283	6.4880	-.3335
.5750	-.0278	6.7829	-.3284
.6000	-.0273	7.0778	-.3221
.6250	-.0267	7.3727	-.3147
.6500	-.0260	7.6676	-.3062
.6750	-.0251	7.9625	-.2965
.7000	-.0242	8.2575	-.2856
.7250	-.0232	8.5524	-.2736
.7500	-.0221	8.8473	-.2602
.7750	-.0208	9.1422	-.2455
.8000	-.0194	9.4371	-.2293
.8250	-.0179	9.7320	-.2116
.8500	-.0163	10.0269	-.1920
.8750	-.0144	10.3218	-.1702
.9000	-.0124	10.6167	-.1464
.9250	-.0103	10.9116	-.1209
.9500	-.0076	11.2065	-.0900
.9750	-.0041	11.5015	-.0485
1.0000	0.0000	11.7964	0.0000

APPENDIX D

Y= -42.8622 Y/B/2= -.6929 CHORD= 13.1610

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.1039 .0748 .0566 .0429 .0317 .0220 .0134 .0054-.0021-.0093-.0163-.0234-.0306-.0381-.0463-.0554-.0661-.0801-.1018-.1625

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0107	.0000	-.1408
.0250	-.0133	.3290	-.1753
.0500	-.0159	.6581	-.2092
.0750	-.0182	.9871	-.2392
.1000	-.0201	1.3161	-.2640
.1250	-.0217	1.6451	-.2850
.1500	-.0231	1.9742	-.3036
.1750	-.0243	2.3032	-.3199
.2000	-.0254	2.6322	-.3341
.2250	-.0263	2.9612	-.3462
.2500	-.0271	3.2903	-.3567
.2750	-.0278	3.6193	-.3654
.3000	-.0283	3.9483	-.3727
.3250	-.0288	4.2773	-.3785
.3500	-.0291	4.6064	-.3829
.3750	-.0293	4.9354	-.3859
.4000	-.0295	5.2644	-.3877
.4250	-.0295	5.5934	-.3883
.4500	-.0294	5.9225	-.3876
.4750	-.0293	6.2515	-.3857
.5000	-.0291	6.5805	-.3827
.5250	-.0288	6.9095	-.3784
.5500	-.0283	7.2386	-.3731
.5750	-.0278	7.5676	-.3665
.6000	-.0273	7.8966	-.3588
.6250	-.0266	8.2256	-.3500
.6500	-.0258	8.5547	-.3399
.6750	-.0250	8.8837	-.3286
.7000	-.0240	9.2127	-.3161
.7250	-.0230	9.5418	-.3022
.7500	-.0218	9.8708	-.2870
.7750	-.0205	10.1998	-.2703
.8000	-.0192	10.5288	-.2521
.8250	-.0176	10.8579	-.2323
.8500	-.0160	11.1869	-.2105
.8750	-.0141	11.5159	-.1862
.9000	-.0122	11.8449	-.1599
.9250	-.0100	12.1740	-.1318
.9500	-.0074	12.5030	-.0979
.9750	-.0040	12.8320	-.0527
1.0000	0.0000	13.1610	0.0000

Y= -39.0538　　Y/B/2= -.6313　　CHORD= 14.5257

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0965 .0687 .0512 .0380 .0273 .0180 .0098 .0022-.0050-.0119-.0186-.0253-.0322-.0394-.0471-.0557-.0660-.0793-.1000-.1580

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0131	0.0000	-.1907
.0250	-.0156	.3631	-.2261
.0500	-.0180	.7263	-.2608
.0750	-.0201	1.0894	-.2914
.1000	-.0218	1.4526	-.3165
.1250	-.0232	1.8157	-.3376
.1500	-.0245	2.1789	-.3562
.1750	-.0256	2.5420	-.3724
.2000	-.0266	2.9051	-.3862
.2250	-.0274	3.2683	-.3980
.2500	-.0281	3.6314	-.4079
.2750	-.0286	3.9946	-.4161
.3000	-.0291	4.3577	-.4226
.3250	-.0294	4.7209	-.4276
.3500	-.0297	5.0840	-.4312
.3750	-.0298	5.4471	-.4333
.4000	-.0299	5.8103	-.4341
.4250	-.0298	6.1734	-.4336
.4500	-.0297	6.5366	-.4317
.4750	-.0295	6.8997	-.4287
.5000	-.0292	7.2629	-.4244
.5250	-.0288	7.6260	-.4188
.5500	-.0284	7.9891	-.4121
.5750	-.0278	8.3523	-.4041
.6000	-.0272	8.7154	-.3949
.6250	-.0265	9.0786	-.3845
.6500	-.0257	9.4417	-.3728
.6750	-.0248	9.8049	-.3598
.7000	-.0238	10.1680	-.3455
.7250	-.0227	10.5311	-.3299
.7500	-.0215	10.8943	-.3128
.7750	-.0202	11.2574	-.2941
.8000	-.0189	11.6206	-.2739
.8250	-.0173	11.9837	-.2519
.8500	-.0157	12.3469	-.2279
.8750	-.0139	12.7100	-.2013
.9000	-.0119	13.0731	-.1726
.9250	-.0098	13.4363	-.1420
.9500	-.0072	13.7994	-.1052
.9750	-.0039	14.1626	-.0565
1.0000	0.0000	14.5257	0.0000

Y= -35.2454 Y/B/2= -.5698 CHORD= 15.8904

SLOPES,DZ/DX,AT SLOPE POINTS,FRCM FRCNT TO REAR

.0892 .0626 .0458 .0332 .0229 .0141 .0062-.0011-.0079-.0144-.0208-.0272-.0337-.0405-.0478-.0560-.0658-.0784-.0981-.1535

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0155	0.0000	-.2459
.0250	-.0177	.3973	-.2817
.0500	-.0199	.7945	-.3168
.0750	-.0219	1.1918	-.3477
.1000	-.0235	1.5890	-.3727
.1250	-.0248	1.9863	-.3936
.1500	-.0259	2.3836	-.4118
.1750	-.0269	2.7808	-.4274
.2000	-.0277	3.1781	-.4407
.2250	-.0284	3.5753	-.4517
.2500	-.0290	3.9726	-.4608
.2750	-.0295	4.3699	-.4681
.3000	-.0298	4.7671	-.4737
.3250	-.0301	5.1644	-.4777
.3500	-.0302	5.5616	-.4802
.3750	-.0303	5.9589	-.4812
.4000	-.0303	6.3562	-.4808
.4250	-.0301	6.7534	-.4790
.4500	-.0299	7.1507	-.4759
.4750	-.0297	7.5479	-.4714
.5000	-.0293	7.9452	-.4657
.5250	-.0289	8.3425	-.4587
.5500	-.0283	8.7397	-.4504
.5750	-.0277	9.1370	-.4409
.6000	-.0271	9.5342	-.4301
.6250	-.0263	9.9315	-.4180
.6500	-.0255	10.3288	-.4047
.6750	-.0245	10.7260	-.3899
.7000	-.0235	11.1233	-.3739
.7250	-.0224	11.5205	-.3564
.7500	-.0212	11.9178	-.3374
.7750	-.0199	12.3151	-.3168
.8000	-.0185	12.7123	-.2945
.8250	-.0170	13.1096	-.2705
.8500	-.0154	13.5068	-.2444
.8750	-.0136	13.9041	-.2155
.9000	-.0116	14.3014	-.1845
.9250	-.0095	14.6986	-.1514
.9500	-.0070	15.0959	-.1120
.9750	-.0038	15.4931	-.0601
1.0000	0.0000	15.8904	0.0000

Y= -31.4370   Y/B/2= -.5082   CHORD= 17.2551

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRCNT TO REAR

.0821 .0566 .0405 .0284 .0186 .0102 .0026-.0043-.0107-.0169-.0229-.0289-.0350-.0414-.0482-.0559-.0651-.0770-.0957-.1486

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0177	.0000	-.3048
.0250	-.0197	.4314	-.3406
.0500	-.0218	.8628	-.3757
.0750	-.0235	1.2941	-.4063
.1000	-.0250	1.7255	-.4309
.1250	-.0261	2.1569	-.4511
.1500	-.0272	2.5883	-.4686
.1750	-.0280	3.0196	-.4834
.2000	-.0287	3.4510	-.4957
.2250	-.0293	3.8824	-.5057
.2500	-.0298	4.3138	-.5138
.2750	-.0301	4.7451	-.5199
.3000	-.0304	5.1765	-.5243
.3250	-.0305	5.6079	-.5270
.3500	-.0306	6.0393	-.5282
.3750	-.0306	6.4706	-.5278
.4000	-.0305	6.9020	-.5259
.4250	-.0303	7.3334	-.5227
.4500	-.0300	7.7648	-.5181
.4750	-.0297	8.1962	-.5121
.5000	-.0293	8.6275	-.5048
.5250	-.0288	9.0589	-.4962
.5500	-.0282	9.4903	-.4863
.5750	-.0275	9.9217	-.4751
.6000	-.0268	10.3530	-.4626
.6250	-.0260	10.7844	-.4489
.6500	-.0251	11.2158	-.4337
.6750	-.0242	11.6472	-.4173
.7000	-.0231	12.0785	-.3994
.7250	-.0220	12.5099	-.3801
.7500	-.0208	12.9413	-.3593
.7750	-.0195	13.3727	-.3369
.8000	-.0181	13.8041	-.3128
.8250	-.0166	14.2354	-.2869
.8500	-.0150	14.6668	-.2587
.8750	-.0132	15.0982	-.2279
.9000	-.0113	15.5296	-.1948
.9250	-.0092	15.9609	-.1596
.9500	-.0068	16.3923	-.1178
.9750	-.0037	16.8237	-.0632
1.0000	0.0000	17.2551	0.0000

Y= -26.7664 Y/B/2= -.4327 CHORD= 18.9287

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0722 .0477 .0322 .0206 .0110 .0028-.0045-.0113-.0175-.0235-.0293-.0350-.0408-.0467-.0530-.0600-.0682-.0790-.0960-.1455

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0234	.0000	-.4436
.0250	-.0253	.4732	-.4781
.0500	-.0270	.9464	-.5119
.0750	-.0286	1.4197	-.5411
.1000	-.0298	1.8929	-.5638
.1250	-.0307	2.3661	-.5820
.1500	-.0316	2.8393	-.5972
.1750	-.0322	3.3125	-.6097
.2000	-.0327	3.7857	-.6194
.2250	-.0331	4.2590	-.6268
.2500	-.0334	4.7322	-.6320
.2750	-.0336	5.2054	-.6352
.3000	-.0336	5.6786	-.6365
.3250	-.0336	6.1518	-.6361
.3500	-.0335	6.6250	-.6339
.3750	-.0333	7.0983	-.6301
.4000	-.0330	7.5715	-.6248
.4250	-.0326	8.0447	-.6180
.4500	-.0322	8.5179	-.6097
.4750	-.0317	8.9911	-.6000
.5000	-.0311	9.4644	-.5889
.5250	-.0304	9.9376	-.5764
.5500	-.0297	10.4108	-.5625
.5750	-.0289	10.8840	-.5473
.6000	-.0280	11.3572	-.5307
.6250	-.0271	11.8304	-.5128
.6500	-.0261	12.3037	-.4935
.6750	-.0250	12.7769	-.4729
.7000	-.0238	13.2501	-.4508
.7250	-.0226	13.7233	-.4272
.7500	-.0212	14.1965	-.4021
.7750	-.0198	14.6697	-.3754
.8000	-.0183	15.1430	-.3470
.8250	-.0167	15.6162	-.3169
.8500	-.0150	16.0894	-.2846
.8750	-.0132	16.5626	-.2495
.9000	-.0112	17.0358	-.2122
.9250	-.0091	17.5090	-.1730
.9500	-.0067	17.9823	-.1270
.9750	-.0036	18.4555	-.0679
1.0000	0.0000	18.9287	0.0000

Y= -22.0958 Y/B/2= -.3572 CHORD= 21.0847

SLOPES,DZ/DX,AT SLOPE POINTS,FRCM FRCNT TO REAR

.0608 .0378 .0232 .0122 .0032-.0045-.0113-.0176-.0234-.0289-.0342-.0394-.0446-.0500-.0556-.0617-.0688-.0777-.0914-.1300

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0277	.0000	-.5836
.0250	-.0292	.5271	-.6161
.0500	-.0307	1.0542	-.6478
.0750	-.0320	1.5814	-.6746
.1000	-.0329	2.1085	-.6947
.1250	-.0337	2.6356	-.7100
.1500	-.0343	3.1627	-.7222
.1750	-.0347	3.6898	-.7315
.2000	-.0350	4.2169	-.7380
.2250	-.0352	4.7441	-.7419
.2500	-.0353	5.2712	-.7436
.2750	-.0353	5.7983	-.7433
.3000	-.0351	6.3254	-.7409
.3250	-.0349	6.8525	-.7367
.3500	-.0347	7.3797	-.7307
.3750	-.0343	7.9068	-.7231
.4000	-.0339	8.4339	-.7138
.4250	-.0333	8.9610	-.7030
.4500	-.0328	9.4881	-.6907
.4750	-.0321	10.0152	-.6769
.5000	-.0314	10.5424	-.6617
.5250	-.0306	11.0695	-.6450
.5500	-.0297	11.5966	-.6270
.5750	-.0288	12.1237	-.6076
.6000	-.0278	12.6508	-.5868
.6250	-.0268	13.1780	-.5647
.6500	-.0257	13.7051	-.5411
.6750	-.0245	14.2322	-.5162
.7000	-.0232	14.7593	-.4899
.7250	-.0219	15.2864	-.4621
.7500	-.0205	15.8136	-.4328
.7750	-.0191	16.3407	-.4019
.8000	-.0175	16.8678	-.3694
.8250	-.0159	17.3949	-.3351
.8500	-.0142	17.9220	-.2988
.8750	-.0123	18.4491	-.2600
.9000	-.0104	18.9763	-.2191
.9250	-.0084	19.5034	-.1764
.9500	-.0061	20.0305	-.1278
.9750	-.0032	20.5576	-.0677
1.0000	0.0000	21.0847	0.0000

Y= -18.2874 Y/B/2= -.2956 CHORD= 23.4142

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0526 .0314 .0181 .0082 .0001-.0067-.0127-.0181-.0231-.0278-.0323-.0368-.0412-.0457-.0505-.0558-.0620-.0699-.0824-.1182

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0265	0.0000	-.6201
.0250	-.0278	.5854	-.6513
.0500	-.0291	1.1707	-.6817
.0750	-.0302	1.7561	-.7071
.1000	-.0310	2.3414	-.7257
.1250	-.0316	2.9268	-.7394
.1500	-.0320	3.5121	-.7500
.1750	-.0324	4.0975	-.7576
.2000	-.0326	4.6828	-.7624
.2250	-.0327	5.2682	-.7647
.2500	-.0327	5.8536	-.7648
.2750	-.0326	6.4389	-.7628
.3000	-.0324	7.0243	-.7589
.3250	-.0322	7.6096	-.7532
.3500	-.0319	8.1950	-.7458
.3750	-.0315	8.7803	-.7367
.4000	-.0310	9.3657	-.7261
.4250	-.0305	9.9510	-.7140
.4500	-.0299	10.5364	-.7005
.4750	-.0293	11.1217	-.6855
.5000	-.0286	11.7071	-.6692
.5250	-.0278	12.2925	-.6516
.5500	-.0270	12.8778	-.6327
.5750	-.0262	13.4632	-.6125
.6000	-.0252	14.0485	-.5909
.6250	-.0243	14.6339	-.5681
.6500	-.0232	15.2192	-.5440
.6750	-.0221	15.8046	-.5186
.7000	-.0210	16.3899	-.4919
.7250	-.0198	16.9753	-.4637
.7500	-.0185	17.5607	-.4342
.7750	-.0172	18.1460	-.4031
.8000	-.0158	18.7314	-.3705
.8250	-.0144	19.3167	-.3362
.8500	-.0128	19.9021	-.2999
.8750	-.0112	20.4874	-.2611
.9000	-.0094	21.0728	-.2202
.9250	-.0076	21.6581	-.1775
.9500	-.0055	22.2435	-.1288
.9750	-.0029	22.8288	-.0683
1.0000	0.0000	23.4142	0.0000

Y= -14.4790 Y/B/2= -.2341 CHORD= 25.7437

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0445 .0249 .0126 .0034-.0041-.0103-.0158-.0207-.0252-.0295-.0335-.0374-.0413-.0453-.0495-.0542-.0598-.0670-.0784-.1113

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0279	.0000	-.7191
.0250	-.0291	.6436	-.7482
.0500	-.0302	1.2872	-.7764
.0750	-.0311	1.9308	-.7996
.1000	-.0317	2.5744	-.8158
.1250	-.0321	3.2180	-.8271
.1500	-.0324	3.8616	-.8352
.1750	-.0326	4.5051	-.8402
.2000	-.0327	5.1467	-.8424
.2250	-.0327	5.7923	-.8420
.2500	-.0326	6.4359	-.8394
.2750	-.0324	7.0795	-.8347
.3000	-.0322	7.7231	-.8281
.3250	-.0318	8.3667	-.8196
.3500	-.0314	9.0103	-.8095
.3750	-.0310	9.6539	-.7977
.4000	-.0305	10.2975	-.7843
.4250	-.0299	10.9411	-.7695
.4500	-.0293	11.5847	-.7533
.4750	-.0286	12.2282	-.7356
.5000	-.0278	12.8718	-.7167
.5250	-.0271	13.5154	-.6964
.5500	-.0262	14.1590	-.6749
.5750	-.0253	14.8026	-.6520
.6000	-.0244	15.4462	-.6280
.6250	-.0234	16.0898	-.6027
.6500	-.0224	16.7334	-.5761
.6750	-.0213	17.3770	-.5482
.7000	-.0202	18.0206	-.5191
.7250	-.0190	18.6642	-.4886
.7500	-.0177	19.3078	-.4567
.7750	-.0164	19.9513	-.4233
.8000	-.0151	20.5949	-.3885
.8250	-.0137	21.2385	-.3520
.8500	-.0122	21.8821	-.3135
.8750	-.0106	22.5257	-.2725
.9000	-.0089	23.1693	-.2294
.9250	-.0072	23.8129	-.1846
.9500	-.0052	24.4565	-.1337
.9750	-.0027	25.1001	-.0708
1.0000	0.0000	25.7437	0.0000

Y= -10.6706 Y/B/2= -.1725 CHORD= 28.0731

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0361 .0178 .0062-.0024-.0093-.0151-.0202-.0247-.0288-.0326-.0361-.0396-.0430-.0465-.0502-.0544-.0593-.0657-.0761-.1064

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0307	.0000	-.8623
.0250	-.0316	.7018	-.8881
.0500	-.0325	1.4037	-.9131
.0750	-.0332	2.1055	-.9328
.1000	-.0337	2.8073	-.9455
.1250	-.0340	3.5091	-.9531
.1500	-.0341	4.2110	-.9575
.1750	-.0342	4.9128	-.9587
.2000	-.0341	5.6146	-.9571
.2250	-.0339	6.3165	-.9528
.2500	-.0337	7.0183	-.9463
.2750	-.0334	7.7201	-.9377
.3000	-.0330	8.4219	-.9271
.3250	-.0326	9.1238	-.9146
.3500	-.0321	9.8256	-.9005
.3750	-.0315	10.5274	-.8847
.4000	-.0309	11.2293	-.8674
.4250	-.0302	11.9311	-.8486
.4500	-.0295	12.6329	-.8284
.4750	-.0287	13.3347	-.8068
.5000	-.0279	14.0366	-.7840
.5250	-.0271	14.7384	-.7599
.5500	-.0262	15.4402	-.7345
.5750	-.0252	16.1421	-.7079
.6000	-.0242	16.8439	-.6801
.6250	-.0232	17.5457	-.6511
.6500	-.0221	18.2475	-.6209
.6750	-.0210	18.9494	-.5895
.7000	-.0198	19.6512	-.5568
.7250	-.0186	20.3530	-.5229
.7500	-.0174	21.0549	-.4876
.7750	-.0161	21.7567	-.4510
.8000	-.0147	22.4585	-.4128
.8250	-.0133	23.1603	-.3731
.8500	-.0118	23.8622	-.3315
.8750	-.0102	24.5640	-.2874
.9000	-.0086	25.2658	-.2414
.9250	-.0069	25.9677	-.1935
.9500	-.0050	26.6695	-.1397
.9750	-.0026	27.3713	-.0738
1.0000	0.0000	28.0731	0.0000

Y= -6.8622 Y/B/2= -.1109 CHORD= 30.4026

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0262 .0088-.0023-.0104-.0169-.0224-.0270-.0311-.0348-.0381-.0412-.0442-.0470-.0500-.0531-.0565-.0606-.0662-.0753-.1031

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0356	.0000	-1.0832
.0250	-.0363	.7601	-1.1036
.0500	-.0369	1.5201	-1.1231
.0750	-.0374	2.2802	-1.1372
.1000	-.0376	3.0403	-1.1441
.1250	-.0377	3.8003	-1.1457
.1500	-.0376	4.5604	-1.1440
.1750	-.0375	5.3205	-1.1391
.2000	-.0372	6.0805	-1.1312
.2250	-.0369	6.8406	-1.1207
.2500	-.0364	7.6007	-1.1078
.2750	-.0359	8.3607	-1.0928
.3000	-.0354	9.1208	-1.0758
.3250	-.0348	9.8808	-1.0570
.3500	-.0341	10.6409	-1.0364
.3750	-.0334	11.4010	-1.0143
.4000	-.0326	12.1610	-.9907
.4250	-.0318	12.9211	-.9656
.4500	-.0309	13.6812	-.9392
.4750	-.0300	14.4412	-.9115
.5000	-.0290	15.2013	-.8825
.5250	-.0280	15.9614	-.8524
.5500	-.0270	16.7214	-.8211
.5750	-.0259	17.4815	-.7886
.6000	-.0248	18.2416	-.7551
.6250	-.0237	19.0016	-.7204
.6500	-.0225	19.7617	-.6847
.6750	-.0213	20.5218	-.6478
.7000	-.0201	21.2818	-.6098
.7250	-.0188	22.0419	-.5707
.7500	-.0174	22.8020	-.5304
.7750	-.0161	23.5620	-.4887
.8000	-.0147	24.3221	-.4458
.8250	-.0132	25.0822	-.4015
.8500	-.0117	25.8422	-.3553
.8750	-.0101	26.6023	-.3069
.9000	-.0084	27.3624	-.2567
.9250	-.0067	28.1224	-.2049
.9500	-.0048	28.8825	-.1472
.9750	-.0025	29.6425	-.0775
1.0000	0.0000	30.4026	0.0000

Y= -2.4790 Y/B/2= -.0401 CHORD= 33.0837

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0059-.0116-.0226-.0306-.0367-.0416-.0456-.0489-.0517-.0541-.0562-.0582-.0599-.0617-.0635-.0656-.0682-.0720-.0789-.1026

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0375 .0875 .1375 .1875 .2375 .2875 .3375 .3875 .4375 .4875 .5375 .5875 .6375 .6875 .7375 .7875 .8375 .8875 .9375 .9875

LOCAL ELEVATION

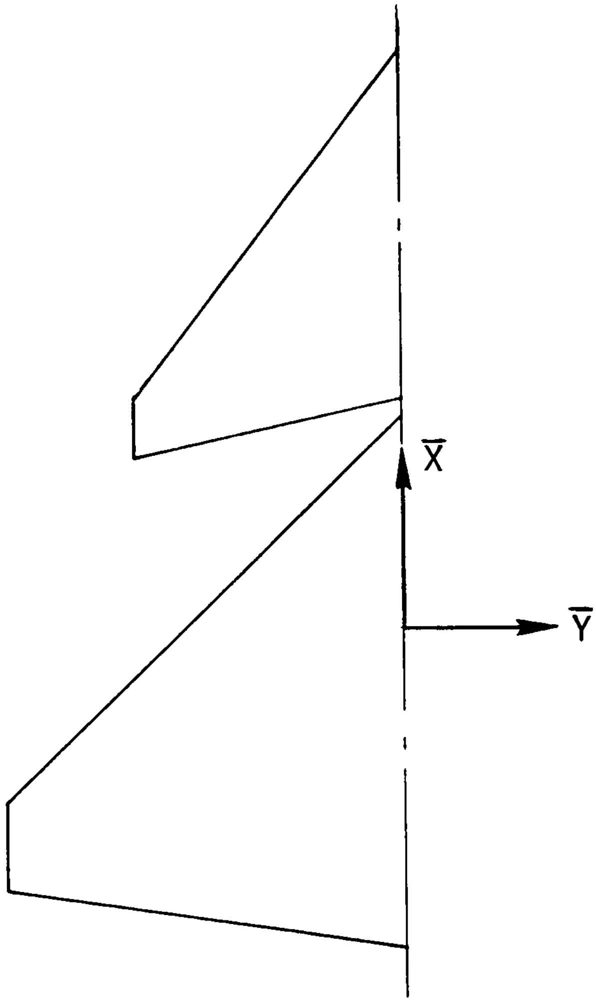
X/C	Z/C	DELTA X	DELTA Z
.0000	-.0499	.0000	-1.6493
.0250	-.0500	.8271	-1.6547
.0500	-.0502	1.6542	-1.6592
.0750	-.0501	2.4813	-1.6578
.1000	-.0498	3.3084	-1.6484
.1250	-.0494	4.1355	-1.6333
.1500	-.0488	4.9626	-1.6146
.1750	-.0481	5.7896	-1.5925
.2000	-.0474	6.6167	-1.5672
.2250	-.0465	7.4438	-1.5392
.2500	-.0456	8.2709	-1.5088
.2750	-.0446	9.0980	-1.4764
.3000	-.0436	9.9251	-1.4420
.3250	-.0425	10.7522	-1.4059
.3500	-.0414	11.5793	-1.3682
.3750	-.0402	12.4064	-1.3291
.4000	-.0390	13.2335	-1.2886
.4250	-.0377	14.0606	-1.2470
.4500	-.0364	14.8877	-1.2042
.4750	-.0351	15.7147	-1.1604
.5000	-.0337	16.5418	-1.1157
.5250	-.0323	17.3689	-1.0700
.5500	-.0309	18.1960	-1.0235
.5750	-.0295	19.0231	-.9761
.6000	-.0281	19.8502	-.9280
.6250	-.0266	20.6773	-.8792
.6500	-.0251	21.5044	-.8296
.6750	-.0236	22.3315	-.7793
.7000	-.0220	23.1586	-.7283
.7250	-.0204	23.9857	-.6765
.7500	-.0189	24.8128	-.6240
.7750	-.0172	25.6398	-.5706
.8000	-.0156	26.4669	-.5163
.8250	-.0139	27.2940	-.4611
.8500	-.0122	28.1211	-.4046
.8750	-.0105	28.9482	-.3464
.9000	-.0087	29.7753	-.2869
.9250	-.0068	30.6024	-.2264
.9500	-.0049	31.4295	-.1607
.9750	-.0025	32.2566	-.0840
1.0000	0.0000	33.0837	0.0000

APPENDIX D

Input Data and Sketch for Sample Case 2

```
              C O L U M N   N U M B E R S   F O R   I N P U T   D A T A
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

          GROUP ONE DATA
 2.0       1.0       9.18      160.0
 3.0       0.        0.        0.
14.57      0.        0.        1.
 5.73     -6.73      0.        1.
 4.29     -6.73      0.        1.
 5.77      0.
 3.0       0.        0.        0.
 5.29      0.        0.        1.
-4.45    -10.        0.        1.
-6.61    -10.        0.        1.
-8.12      0.
          GROUP TWO DATA
  2.  16.  15.   .3   .2
   0.6       0.8
```



Output Data for Sample Case 2

GEOMETRY DATA

FIRST REFERENCE PLANFORM HAS 3 CURVES

ROOT CHORD HEIGHT = 0.00000 VARIABLE SWEEP PIVOT POSITION X(S) = 0.00000 Y(S) = 0.00000

BREAK POINTS FOR THE REFERENCE PLANFORM

POINT	X REF	Y REF	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	14.57000	0.00000	52.71754	0.00000	1
2	5.73000	-6.73000	90.00000	0.00000	1
3	4.29000	-6.73000	12.40255	0.00000	1
4	5.77000	0.00000			

SECOND REFERENCE PLANFORM HAS 3 CURVES

ROOT CHORD HEIGHT = 0.00000 VARIABLE SWEEP PIVOT POSITION X(S) = 0.00000 Y(S) = 0.00000

BREAK POINTS FOR THE REFERENCE PLANFORM

POINT	X REF	Y REF	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	5.29000	0.00000	44.24539	0.00000	1
2	-4.45000	-10.00000	90.00000	0.00000	1
3	-6.61000	-10.00000	-8.58679	0.00000	1
4	-8.12000	0.00000			

CONFIGURATION NO. 2

CURVE 1 IS SWEPT 52.71754 DEGREES ON PLANFORM 1

CURVE 1 IS SWEPT 44.24539 DEGREES ON PLANFORM 2

BREAK POINTS FOR THIS CONFIGURATION

POINT	X	Y	Z	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	14.57000	0.00000	0.00000	52.71754	0.00000	1
2	5.73000	-6.73000	0.00000	90.00000	0.00000	1
3	4.29000	-6.73000	0.00000	12.40255	0.00000	1
4	5.77000	0.00000	0.00000			

SECOND PLANFORM BREAK POINTS

POINT	X	Y	Z	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	5.29000	0.00000	0.00000	44.24539	0.00000	1
2	-1.26502	-6.73000	0.00000	44.24539	0.00000	1
3	-4.45000	-10.00000	0.00000	90.00000	0.00000	1
4	-6.61000	-10.00000	0.00000	-8.58679	0.00000	1
5	-8.12000	0.00000	0.00000			

400 HORSESHOE VORTICES USED ON THE LEFT HALF OF THE CONFIGURATION

PLANFORM	TOTAL	SPANWISE
1	160	10
2	240	15

16 HORSESHOE VORTICES IN EACH CHORDWISE ROW

MINIMUM FIELD LENGTH = 51000

APPENDIX D

X C/4	X 3C/4	Y	Z	S	C/4 SWEEP ANGLE	DIHEDRAL ANGLE	GAMMA/U AT CLDES= .2000
6.13964	6.08325	-6.39667	0.00000	.33333	52.35532	0.00000	.00409
6.02686	5.97047	-6.39667	0.00000	.33333	50.84486	0.00000	.00409
5.91408	5.85769	-6.39667	0.00000	.33333	49.22986	0.00000	.00409
5.80129	5.74490	-6.39667	0.00000	.33333	47.50192	0.00000	.00409
5.68851	5.63212	-6.39667	0.00000	.33333	45.65226	0.00000	.00409
5.57573	5.51934	-6.39667	0.00000	.33333	43.67183	0.00000	.00409
5.46294	5.40655	-6.39667	0.00000	.33333	41.55153	0.00000	.00409
5.35016	5.29377	-6.39667	0.00000	.33333	39.28245	0.00000	.00409
5.23738	5.18098	-6.39667	0.00000	.33333	36.85627	0.00000	.00409
5.12459	5.06820	-6.39667	0.00000	.33333	34.26574	0.00000	.00409
5.01181	4.95542	-6.39667	0.00000	.33333	31.50526	0.00000	.00367
4.89903	4.84263	-6.39667	0.00000	.33333	28.57167	0.00000	.00303
4.78624	4.72985	-6.39667	0.00000	.33333	25.46500	0.00000	.00239
4.67346	4.61707	-6.39667	0.00000	.33333	22.18933	0.00000	.00176
4.56067	4.50428	-6.39667	0.00000	.33333	18.75361	0.00000	.00112
4.44789	4.39150	-6.39667	0.00000	.33333	15.17224	0.00000	.00048
7.00393	6.92476	-5.73000	0.00000	.33333	52.35532	0.00000	.00871
6.84558	6.76641	-5.73000	0.00000	.33333	50.84486	0.00000	.00871
6.68723	6.60806	-5.73000	0.00000	.33333	49.22986	0.00000	.00871
6.52888	6.44971	-5.73000	0.00000	.33333	47.50192	0.00000	.00871
6.37053	6.29136	-5.73000	0.00000	.33333	45.65226	0.00000	.00871
6.21218	6.13301	-5.73000	0.00000	.33333	43.67183	0.00000	.00871
6.05383	5.97465	-5.73000	0.00000	.33333	41.55153	0.00000	.00871
5.89548	5.81630	-5.73000	0.00000	.33333	39.28245	0.00000	.00871
5.73713	5.65795	-5.73000	0.00000	.33333	36.85627	0.00000	.00871
5.57878	5.49960	-5.73000	0.00000	.33333	34.26574	0.00000	.00871
5.42043	5.34125	-5.73000	0.00000	.33333	31.50526	0.00000	.00782
5.26208	5.18290	-5.73000	0.00000	.33333	28.57167	0.00000	.00646
5.10373	5.02455	-5.73000	0.00000	.33333	25.46500	0.00000	.00510
4.94538	4.86620	-5.73000	0.00000	.33333	22.18933	0.00000	.00374
4.78702	4.70785	-5.73000	0.00000	.33333	18.75361	0.00000	.00238
4.62867	4.54950	-5.73000	0.00000	.33333	15.17224	0.00000	.00102
7.86822	7.76626	-5.06333	0.00000	.33333	52.35532	0.00000	.01329
7.66431	7.56235	-5.06333	0.00000	.33333	50.84486	0.00000	.01329
7.46039	7.35843	-5.06333	0.00000	.33333	49.22986	0.00000	.01329
7.25647	7.15451	-5.06333	0.00000	.33333	47.50192	0.00000	.01329
7.05255	6.95059	-5.06333	0.00000	.3233	45.65226	0.00000	.01329
6.84863	6.74668	-5.06333	0.00000	.33333	43.67183	0.00000	.01329
6.64472	6.54276	-5.06333	0.00000	.33333	41.55153	0.00000	.01329
6.44080	6.33884	-5.06333	0.00000	.33333	39.28245	0.00000	.01329
6.23688	6.13492	-5.06333	0.00000	.33333	36.85627	0.00000	.01329
6.03296	5.93100	-5.06333	0.00000	.33333	34.26574	0.00000	.01329
5.82905	5.72709	-5.06333	0.00000	.33333	31.50526	0.00000	.01194
5.62513	5.52317	-5.06333	0.00000	.33333	28.57167	0.00000	.00986

5.42121	5.31925	-5.06333	0.00000	.33333	25.46500	0.00000	.00779
5.21729	5.11533	-5.06333	0.00000	.33333	22.18933	0.00000	.00571
5.01337	4.91142	-5.06333	0.00000	.33333	18.75361	0.00000	.00363
4.80946	4.70750	-5.06333	0.00000	.33333	15.17224	0.00000	.00156
8.73251	8.60777	-4.39667	0.00000	.33333	52.35532	0.00000	.01794
8.48303	8.35829	-4.39667	0.00000	.33333	50.84486	0.00000	.01794
8.23354	8.10880	-4.39667	0.00000	.33333	49.22986	0.00000	.01794
7.98406	7.85932	-4.39667	0.00000	.33333	47.50192	0.00000	.01794
7.73457	7.60983	-4.39667	0.00000	.33333	45.65226	0.00000	.01794
7.48509	7.36035	-4.39667	0.00000	.33333	43.67183	0.00000	.01794
7.23560	7.11086	-4.39667	0.00000	.33333	41.55153	0.00000	.01794
6.98612	6.86138	-4.39667	0.00000	.33333	39.28245	0.00000	.01794
6.73663	6.61189	-4.39667	0.00000	.33333	36.85627	0.00000	.01794
6.48715	6.36241	-4.39667	0.00000	.33333	34.26574	0.00000	.01794
6.23766	6.11292	-4.39667	0.00000	.33333	31.50526	0.00000	.01612
5.98818	5.86344	-4.39667	0.00000	.33333	28.57167	0.00000	.01331
5.73869	5.61395	-4.39667	0.00000	.33333	25.46500	0.00000	.01051
5.48921	5.36447	-4.39667	0.00000	.33333	22.18933	0.00000	.00771
5.23972	5.11498	-4.39667	0.00000	.33333	18.75361	0.00000	.00490
4.99024	4.86550	-4.39667	0.00000	.33333	15.17224	0.00000	.00210
9.59680	9.44928	-3.73000	0.00000	.33333	52.35532	0.00000	.02248
9.30175	9.15422	-3.73000	0.00000	.33333	50.84486	0.00000	.02248
9.00670	8.85917	-3.73000	0.00000	.33333	49.22986	0.00000	.02248
8.71165	8.56412	-3.73000	0.00000	.33333	47.50192	0.00000	.02248
8.41659	8.26907	-3.73000	0.00000	.33333	45.65226	0.00000	.02248
8.12154	7.97402	-3.73000	0.00000	.33333	43.67183	0.00000	.02248
7.82649	7.67896	-3.73000	0.00000	.33333	41.55153	0.00000	.02248
7.53144	7.38391	-3.73000	0.00000	.33333	39.28245	0.00000	.02248
7.23639	7.08886	-3.73000	0.00000	.33333	36.85627	0.00000	.02248
6.94133	6.79381	-3.73000	0.00000	.33333	34.26574	0.00000	.02248
6.64628	6.49876	-3.73000	0.00000	.33333	31.50526	0.00000	.02019
6.35123	6.20370	-3.73000	0.00000	.33333	28.57167	0.00000	.01668
6.05618	5.90865	-3.73000	0.00000	.33333	25.46500	0.00000	.01317
5.76113	5.61360	-3.73000	0.00000	.33333	22.18933	0.00000	.00966
5.46607	5.31855	-3.73000	0.00000	.33333	18.75361	0.00000	.00615
5.17102	5.02350	-3.73000	0.00000	.33333	15.17224	0.00000	.00263
10.46109	10.29078	-3.06333	0.00000	.33333	52.35532	0.00000	.02669
10.12047	9.95016	-3.06333	0.00000	.33333	50.84486	0.00000	.02669
9.77985	9.60954	-3.06333	0.00000	.33333	49.22986	0.00000	.02669
9.43923	9.26892	-3.06333	0.00000	.33333	47.50192	0.00000	.02669
9.09861	8.92830	-3.06333	0.00000	.33333	45.65226	0.00000	.02669
8.75800	8.58769	-3.06333	0.00000	.33333	43.67183	0.00000	.02669
8.41738	8.24707	-3.06333	0.00000	.33333	41.55153	0.00000	.02669
8.07676	7.90645	-3.06333	0.00000	.33333	39.28245	0.00000	.02669
7.73614	7.56583	-3.06333	0.00000	.33333	36.85627	0.00000	.02669
7.39552	7.22521	-3.06333	0.00000	.33333	34.26574	0.00000	.02669
7.05490	6.88459	-3.06333	0.00000	.33333	31.50526	0.00000	.02398
6.71428	6.54397	-3.06333	0.00000	.33333	28.57167	0.00000	.01981
6.37366	6.20335	-3.06333	0.00000	.33333	25.46500	0.00000	.01564
6.03304	5.86273	-3.06333	0.00000	.33333	22.18933	0.00000	.01147
5.69242	5.52211	-3.06333	0.00000	.33333	18.75361	0.00000	.00730

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5.35180	5.18149	-3.06333	0.00000	.33333	15.17224	0.00000	.00313
11.32538	11.13229	-2.39667	0.00000	.33333	52.35532	0.00000	.03037
10.93919	10.74610	-2.39667	0.00000	.33333	50.84486	0.00000	.03037
10.55301	10.35991	-2.39667	0.00000	.33333	49.22986	0.00000	.03037
10.16682	9.97373	-2.39667	0.00000	.33333	47.50192	0.00000	.03037
9.78064	9.58754	-2.39667	0.00000	.33333	45.65226	0.00000	.03037
9.39445	9.20136	-2.39667	0.00000	.33333	43.67183	0.00000	.03037
9.00826	8.81517	-2.39667	0.00000	.33333	41.55153	0.00000	.03037
8.62208	8.42898	-2.39667	0.00000	.33333	39.28245	0.00000	.03037
8.23589	8.04280	-2.39667	0.00000	.33333	36.85627	0.00000	.03037
7.84970	7.65661	-2.39667	0.00000	.33333	34.26574	0.00000	.03037
7.46352	7.27042	-2.39667	0.00000	.33333	31.50526	0.00000	.02728
7.07733	6.88424	-2.39667	0.00000	.33333	28.57167	0.00000	.02254
6.69115	6.49805	-2.39667	0.00000	.33333	25.46500	0.00000	.01779
6.30496	6.11187	-2.39667	0.00000	.33333	22.18933	0.00000	.01305
5.91877	5.72568	-2.39667	0.00000	.33333	18.75361	0.00000	.00830
5.53259	5.33949	-2.39667	0.00000	.33333	15.17224	0.00000	.00356
12.18967	11.97379	-1.73000	0.00000	.33333	52.35532	0.00000	.03333
11.75792	11.54204	-1.73000	0.00000	.33333	50.84486	0.00000	.03333
11.32616	11.11029	-1.73000	0.00000	.33333	49.22986	0.00000	.03333
10.89441	10.67853	-1.73000	0.00000	.33333	47.50192	0.00000	.03333
10.46266	10.24678	-1.73000	0.00000	.33333	45.65226	0.00000	.03333
10.03090	9.81503	-1.73000	0.00000	.33333	43.67183	0.00000	.03333
9.59915	9.38327	-1.73000	0.00000	.33333	41.55153	0.00000	.03333
9.16740	8.95152	-1.73000	0.00000	.33333	39.28245	0.00000	.03333
8.73564	8.51977	-1.73000	0.00000	.33333	36.85627	0.00000	.03333
8.30389	8.08801	-1.73000	0.00000	.33333	34.26574	0.00000	.03333
7.87214	7.65626	-1.73000	0.00000	.33333	31.50526	0.00000	.02994
7.44038	7.22451	-1.73000	0.00000	.33333	28.57167	0.00000	.02473
7.00863	6.79275	-1.73000	0.00000	.33333	25.46500	0.00000	.01953
6.57688	6.36100	-1.73000	0.00000	.33333	22.18933	0.00000	.01432
6.14512	5.92925	-1.73000	0.00000	.33333	18.75361	0.00000	.00911
5.71337	5.49749	-1.73000	0.00000	.33333	15.17224	0.00000	.00391
13.05396	12.81530	-1.06333	0.00000	.33333	52.35532	0.00000	.03542
12.57664	12.33798	-1.06333	0.00000	.33333	50.84486	0.00000	.03542
12.09932	11.86066	-1.06333	0.00000	.33333	49.22986	0.00000	.03542
11.62200	11.38334	-1.06333	0.00000	.33333	47.50192	0.00000	.03542
11.14468	10.90602	-1.06333	0.00000	.33333	45.65226	0.00000	.03542
10.66736	10.42870	-1.06333	0.00000	.33333	43.67183	0.00000	.03542
10.19004	9.95138	-1.06333	0.00000	.33333	41.55153	0.00000	.03542
9.71272	9.47406	-1.06333	0.00000	.33333	39.28245	0.00000	.03542
9.23539	8.99673	-1.06333	0.00000	.33333	36.85627	0.00000	.03542
8.75807	8.51941	-1.06333	0.00000	.33333	34.26574	0.00000	.03542
8.28075	8.04209	-1.06333	0.00000	.33333	31.50526	0.00000	.03182
7.80343	7.56477	-1.06333	0.00000	.33333	28.57167	0.00000	.02629
7.32611	7.08745	-1.06333	0.00000	.33333	25.46500	0.00000	.02075
6.84879	6.61013	-1.06333	0.00000	.33333	22.18933	0.00000	.01522
6.37147	6.13281	-1.06333	0.00000	.33333	18.75361	0.00000	.00968
5.89415	5.65549	-1.06333	0.00000	.33333	15.17224	0.00000	.00415
13.95930	13.69678	-.36500	0.00000	.36500	52.35532	0.00000	.03657
13.43425	13.17172	-.36500	0.00000	.36500	50.84486	0.00000	.03657

12.90920	12.64667	-.36500	0.00000	.36500	49.22986	0.00000	.03657
12.38415	12.12162	-.36500	0.00000	.36500	47.50192	0.00000	.03657
11.85909	11.59657	-.36500	0.00000	.36500	45.65226	0.00000	.03657
11.33404	11.07152	-.36500	0.00000	.36500	43.67183	0.00000	.03657
10.80899	10.54646	-.36500	0.00000	.36500	41.55153	0.00000	.03657
10.28394	10.02141	-.36500	0.00000	.36500	39.28245	0.00000	.03657
9.75889	9.49636	-.36500	0.00000	.36500	36.85627	0.00000	.03657
9.23383	8.97131	-.36500	0.00000	.36500	34.26574	0.00000	.03657
8.70878	8.44626	-.36500	0.00000	.36500	31.50526	0.00000	.03286
8.18373	7.92120	-.36500	0.00000	.36500	28.57167	0.00000	.02714
7.65868	7.39615	-.36500	0.00000	.36500	25.46500	0.00000	.02143
7.13363	6.87110	-.36500	0.00000	.36500	22.18933	0.00000	.01571
6.60857	6.34605	-.36500	0.00000	.36500	18.75361	0.00000	.01000
6.08352	5.82100	-.36500	0.00000	.36500	15.17224	0.00000	.00429

SECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS

-4.16494	-4.24416	-9.66667	0.00000	.33333	43.72398	0.00000	.01971
-4.32338	-4.40260	-9.66667	0.00000	.33333	41.54445	0.00000	.01971
-4.48182	-4.56104	-9.66667	0.00000	.33333	39.20746	0.00000	.01971
-4.64026	-4.71947	-9.66667	0.00000	.33333	36.70395	0.00000	.01971
-4.79869	-4.87791	-9.66667	0.00000	.33333	34.02611	0.00000	.01971
-4.95713	-5.03635	-9.66667	0.00000	.33333	31.16804	0.00000	.01971
-5.11557	-5.19479	-9.66667	0.00000	.33333	28.12659	0.00000	.01971
-5.27401	-5.35322	-9.66667	0.00000	.33333	24.90235	0.00000	.01971
-5.43244	-5.51166	-9.66667	0.00000	.33333	21.50057	0.00000	.01971
-5.59088	-5.67010	-9.66667	0.00000	.33333	17.93207	0.00000	.01971
-5.74932	-5.82854	-9.66667	0.00000	.33333	14.21389	0.00000	.01971
-5.90776	-5.98697	-9.66667	0.00000	.33333	10.36951	0.00000	.01971
-6.06619	-6.14541	-9.66667	0.00000	.33333	6.42851	0.00000	.01971
-6.22463	-6.30385	-9.66667	0.00000	.33333	2.42556	0.00000	.01694
-6.38307	-6.46229	-9.66667	0.00000	.33333	-1.60118	0.00000	.01078
-6.54151	-6.62072	-9.66667	0.00000	.33333	-5.61219	0.00000	.00462
-3.52733	-3.62998	-9.00000	0.00000	.33333	43.72398	0.00000	.03316
-3.73264	-3.83530	-9.00000	0.00000	.33333	41.54445	0.00000	.03316
-3.93795	-4.04061	-9.00000	0.00000	.33333	39.20746	0.00000	.03316
-4.14327	-4.24592	-9.00000	0.00000	.33333	36.70395	0.00000	.03316
-4.34858	-4.45123	-9.00000	0.00000	.33333	34.02611	0.00000	.03316
-4.55389	-4.65655	-9.00000	0.00000	.33333	31.16804	0.00000	.03316
-4.75920	-4.86186	-9.00000	0.00000	.33333	28.12659	0.00000	.03316
-4.96452	-5.06717	-9.00000	0.00000	.33333	24.90235	0.00000	.03316
-5.16983	-5.27248	-9.00000	0.00000	.33333	21.50057	0.00000	.03316
-5.37514	-5.47780	-9.00000	0.00000	.33333	17.93207	0.00000	.03316
-5.58045	-5.68311	-9.00000	0.00000	.33333	14.21389	0.00000	.03316
-5.78577	-5.88842	-9.00000	0.00000	.33333	10.36951	0.00000	.03316
-5.99108	-6.09373	-9.00000	0.00000	.33333	6.42851	0.00000	.03316
-6.19639	-6.29905	-9.00000	0.00000	.33333	2.42556	0.00000	.02850
-6.40170	-6.50436	-9.00000	0.00000	.33333	-1.60118	0.00000	.01814
-6.60702	-6.70967	-9.00000	0.00000	.33333	-5.61219	0.00000	.00777
-2.88971	-3.01581	-8.33333	0.00000	.33333	43.72398	0.00000	.04089
-3.14190	-3.26799	-8.33333	0.00000	.33333	41.54445	0.00000	.04089

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-3.39409	-3.52018	-8.33333	0.00000	.33333	39.20746	0.00000	.04089
-3.64628	-3.77237	-8.33333	0.00000	.33333	36.70395	0.00000	.04089
-3.89846	-4.02456	-8.33333	0.00000	.33333	34.02611	0.00000	.04089
-4.15065	-4.27674	-8.33333	0.00000	.33333	31.16804	0.00000	.04089
-4.40284	-4.52893	-8.33333	0.00000	.33333	28.12659	0.00000	.04089
-4.65503	-4.78112	-8.33333	0.00000	.33333	24.90235	0.00000	.04089
-4.90721	-5.03331	-8.33333	0.00000	.33333	21.50057	0.00000	.04089
-5.15940	-5.28549	-8.33333	0.00000	.33333	17.93207	0.00000	.04089
-5.41159	-5.53768	-8.33333	0.00000	.33333	14.21389	0.00000	.04089
-5.66378	-5.78987	-8.33333	0.00000	.33333	10.36951	0.00000	.04089
-5.91596	-6.04206	-8.33333	0.00000	.33333	6.42851	0.00000	.04089
-6.16815	-6.29424	-8.33333	0.00000	.33333	2.42556	0.00000	.03514
-6.42034	-6.54643	-8.33333	0.00000	.33333	-1.60118	0.00000	.02236
-6.67253	-6.79862	-8.33333	0.00000	.33333	-5.61219	0.00000	.00958
-2.25210	-2.40163	-7.66667	0.00000	.33333	43.72398	0.00000	.04556
-2.55116	-2.70069	-7.66667	0.00000	.33333	41.54445	0.00000	.04556
-2.85022	-2.99976	-7.66667	0.00000	.33333	39.20746	0.00000	.04556
-3.14929	-3.29882	-7.66667	0.00000	.33333	36.70395	0.00000	.04556
-3.44835	-3.59788	-7.66667	0.00000	.33333	34.02611	0.00000	.04556
-3.74741	-3.89694	-7.66667	0.00000	.33333	31.16804	0.00000	.04556
-4.04647	-4.19601	-7.66667	0.00000	.33333	28.12659	0.00000	.04556
-4.34554	-4.49507	-7.66667	0.00000	.33333	24.90235	0.00000	.04556
-4.64460	-4.79413	-7.66667	0.00000	.33333	21.50057	0.00000	.04556
-4.94366	-5.09319	-7.66667	0.00000	.33333	17.93207	0.00000	.04556
-5.24272	-5.39226	-7.66667	0.00000	.33333	14.21389	0.00000	.04556
-5.54179	-5.69132	-7.66667	0.00000	.33333	10.36951	0.00000	.04556
-5.84085	-5.99038	-7.66667	0.00000	.33333	6.42851	0.00000	.04556
-6.13991	-6.28944	-7.66667	0.00000	.33333	2.42556	0.00000	.03916
-6.43897	-6.58851	-7.66667	0.00000	.33333	-1.60118	0.00000	.02492
-6.73804	-6.88757	-7.66667	0.00000	.33333	-5.61219	0.00000	.01068
-1.64477	-1.81663	-7.03167	0.00000	.30167	43.72398	0.00000	.04799
-1.98848	-2.16034	-7.03167	0.00000	.30167	41.54445	0.00000	.04799
-2.33219	-2.50405	-7.03167	0.00000	.30167	39.20746	0.00000	.04799
-2.67590	-2.84776	-7.03167	0.00000	.30167	36.70395	0.00000	.04799
-3.01961	-3.19147	-7.03167	0.00000	.30167	34.02611	0.00000	.04799
-3.36333	-3.53518	-7.03167	0.00000	.30167	31.16804	0.00000	.04799
-3.70704	-3.87889	-7.03167	0.00000	.30167	28.12659	0.00000	.04799
-4.05075	-4.22260	-7.03167	0.00000	.30167	24.90235	0.00000	.04799
-4.39446	-4.56631	-7.03167	0.00000	.30167	21.50057	0.00000	.04799
-4.73817	-4.91002	-7.03167	0.00000	.30167	17.93207	0.00000	.04799
-5.08188	-5.25374	-7.03167	0.00000	.30167	14.21389	0.00000	.04799
-5.42559	-5.59745	-7.03167	0.00000	.30167	10.36951	0.00000	.04799
-5.76930	-5.94116	-7.03167	0.00000	.30167	6.42851	0.00000	.04799
-6.11301	-6.28487	-7.03167	0.00000	.30167	2.42556	0.00000	.04124
-6.45672	-6.62858	-7.03167	0.00000	.30167	-1.60118	0.00000	.02625
-6.80044	-6.97229	-7.03167	0.00000	.30167	-5.61219	0.00000	.01125
-1.03744	-1.23162	-6.39667	0.00000	.33333	43.72398	0.00000	.04891
-1.42580	-1.61998	-6.39667	0.00000	.33333	41.54445	0.00000	.04891
-1.81416	-2.00834	-6.39667	0.00000	.33333	39.20746	0.00000	.04891
-2.20252	-2.39670	-6.39667	0.00000	.33333	36.70395	0.00000	.04891
-2.59088	-2.78506	-6.39667	0.00000	.33333	34.02611	0.00000	.04891

-2.97924	-3.17342	-6.39667	0.00000	.33333	31.16804	0.00000	.04891
-3.36760	-3.56178	-6.39667	0.00000	.33333	28.12659	0.00000	.04891
-3.75596	-3.95014	-6.39667	0.00000	.33333	24.90235	0.00000	.04891
-4.14432	-4.33850	-6.39667	0.00000	.33333	21.50057	0.00000	.04891
-4.53268	-4.72686	-6.39667	0.00000	.33333	17.93207	0.00000	.04891
-4.92104	-5.11522	-6.39667	0.00000	.33333	14.21389	0.00000	.04891
-5.30940	-5.50358	-6.39667	0.00000	.33333	10.36951	0.00000	.04891
-5.69776	-5.89194	-6.39667	0.00000	.33333	6.42851	0.00000	.04891
-6.08612	-6.28029	-6.39667	0.00000	.33333	2.42556	0.00000	.04204
-6.47447	-6.66865	-6.39667	0.00000	.33333	-1.60118	0.00000	.02675
-6.86283	-7.05701	-6.39667	0.00000	.33333	-5.61219	0.00000	.01146
-.39983	-.61745	-5.73000	0.00000	.33333	43.72398	0.00000	.04866
-.83506	-1.05268	-5.73000	0.00000	.33333	41.54445	0.00000	.04866
-1.27030	-1.48791	-5.73000	0.00000	.33333	39.20746	0.00000	.04866
-1.70553	-1.92315	-5.73000	0.00000	.33333	36.70395	0.00000	.04866
-2.14077	-2.35838	-5.73000	0.00000	.33333	34.02611	0.00000	.04866
-2.57600	-2.79362	-5.73000	0.00000	.33333	31.16804	0.00000	.04866
-3.01123	-3.22885	-5.73000	0.00000	.33333	28.12659	0.00000	.04866
-3.44647	-3.66409	-5.73000	0.00000	.33333	24.90235	0.00000	.04866
-3.88170	-4.09932	-5.73000	0.00000	.33333	21.50057	0.00000	.04866
-4.31694	-4.53456	-5.73000	0.00000	.33333	17.93207	0.00000	.04866
-4.75217	-4.96979	-5.73000	0.00000	.33333	14.21389	0.00000	.04866
-5.18741	-5.40502	-5.73000	0.00000	.33333	10.36951	0.00000	.04866
-5.62264	-5.84026	-5.73000	0.00000	.33333	6.42851	0.00000	.04866
-6.05788	-6.27549	-5.73000	0.00000	.33333	2.42556	0.00000	.04182
-6.49311	-6.71073	-5.73000	0.00000	.33333	-1.60118	0.00000	.02661
-6.92834	-7.14596	-5.73000	0.00000	.33333	-5.61219	0.00000	.01140
.23779	-.00327	-5.06333	0.00000	.33333	43.72398	0.00000	.04750
-.24432	-.48538	-5.06333	0.00000	.33333	41.54445	0.00000	.04750
-.72643	-.96749	-5.06333	0.00000	.33333	39.20746	0.00000	.04750
-1.20854	-1.44960	-5.06333	0.00000	.33333	36.70395	0.00000	.04750
-1.69065	-1.93171	-5.06333	0.00000	.33333	34.02611	0.00000	.04750
-2.17276	-2.41382	-5.06333	0.00000	.33333	31.16804	0.00000	.04750
-2.65487	-2.89592	-5.06333	0.00000	.33333	28.12659	0.00000	.04750
-3.13698	-3.37803	-5.06333	0.00000	.33333	24.90235	0.00000	.04750
-3.61909	-3.86014	-5.06333	0.00000	.33333	21.50057	0.00000	.04750
-4.10120	-4.34225	-5.06333	0.00000	.33333	17.93207	0.00000	.04750
-4.58331	-4.82436	-5.06333	0.00000	.33333	14.21389	0.00000	.04750
-5.06542	-5.30647	-5.06333	0.00000	.33333	10.36951	0.00000	.04750
-5.54753	-5.78858	-5.06333	0.00000	.33333	6.42851	0.00000	.04750
-6.02964	-6.27069	-5.06333	0.00000	.33333	2.42556	0.00000	.04082
-6.51175	-6.75280	-5.06333	0.00000	.33333	-1.60118	0.00000	.02598
-6.99385	-7.23491	-5.06333	0.00000	.33333	-5.61219	0.00000	.01113
.87540	.61091	-4.39667	0.00000	.33333	43.72398	0.00000	.04575
.34642	.08192	-4.39667	0.00000	.33333	41.54445	0.00000	.04575
-.18257	-.44706	-4.39667	0.00000	.33333	39.20746	0.00000	.04575
-.71155	-.97604	-4.39667	0.00000	.33333	36.70395	0.00000	.04575
-1.24054	-1.50503	-4.39667	0.00000	.33333	34.02611	0.00000	.04575
-1.76952	-2.03401	-4.39667	0.00000	.33333	31.16804	0.00000	.04575
-2.29851	-2.56300	-4.39667	0.00000	.33333	28.12659	0.00000	.04575
-2.82749	-3.09198	-4.39667	0.00000	.33333	24.90235	0.00000	.04575

APPENDIX D

-3.35647	-3.62097	-4.39667	0.00000	.33333	21.50057	0.00000	.04575
-3.88546	-4.14995	-4.39667	0.00000	.33333	17.93207	0.00000	.04575
-4.41444	-4.67894	-4.39667	0.00000	.33333	14.21389	0.00000	.04575
-4.94343	-5.20792	-4.39667	0.00000	.33333	10.36951	0.00000	.04575
-5.47241	-5.73690	-4.39667	0.00000	.33333	6.42851	0.00000	.04575
-6.00140	-6.26589	-4.39667	0.00000	.33333	2.42556	0.00000	.03932
-6.53038	-6.79487	-4.39667	0.00000	.33333	-1.60118	0.00000	.02502
-7.05937	-7.32386	-4.39667	0.00000	.33333	-5.61219	0.00000	.01072
1.51302	1.22509	-3.73000	0.00000	.33333	43.72398	0.00000	.04370
.93716	.64923	-3.73000	0.00000	.33333	41.54445	0.00000	.04370
.36130	.07337	-3.73000	0.00000	.33333	39.20746	0.00000	.04370
-.21456	-.50249	-3.73000	0.00000	.33333	36.70395	0.00000	.04370
-.79042	-1.07835	-3.73000	0.00000	.33333	34.02611	0.00000	.04370
-1.36628	-1.65421	-3.73000	0.00000	.33333	31.16804	0.00000	.04370
-1.94214	-2.23007	-3.73000	0.00000	.33333	28.12659	0.00000	.04370
-2.51800	-2.80593	-3.73000	0.00000	.33333	24.90235	0.00000	.04370
-3.09386	-3.38179	-3.73000	0.00000	.33333	21.50057	0.00000	.04370
-3.66972	-3.95765	-3.73000	0.00000	.33333	17.93207	0.00000	.04370
-4.24558	-4.53351	-3.73000	0.00000	.33333	14.21389	0.00000	.04370
-4.82144	-5.10937	-3.73000	0.00000	.33333	10.36951	0.00000	.04370
-5.39730	-5.68523	-3.73000	0.00000	.33333	6.42851	0.00000	.04370
-5.97316	-6.26109	-3.73000	0.00000	.33333	2.42556	0.00000	.03755
-6.54902	-6.83695	-3.73000	0.00000	.33333	-1.60118	0.00000	.02390
-7.12488	-7.41281	-3.73000	0.00000	.33333	-5.61219	0.00000	.01024
2.15063	1.83926	-3.06333	0.00000	.33333	43.72398	0.00000	.04158
1.52790	1.21653	-3.06333	0.00000	.33333	41.54445	0.00000	.04158
.90516	.59379	-3.06333	0.00000	.33333	39.20746	0.00000	.04158
.28243	-.02894	-3.06333	0.00000	.33333	36.70395	0.00000	.04158
-.34031	-.65167	-3.06333	0.00000	.33333	34.02611	0.00000	.04158
-.96304	-1.27441	-3.06333	0.00000	.33333	31.16804	0.00000	.04158
-1.58578	-1.89714	-3.06333	0.00000	.33333	28.12659	0.00000	.04158
-2.20851	-2.51988	-3.06333	0.00000	.33333	24.90235	0.00000	.04158
-2.83125	-3.14261	-3.06333	0.00000	.33333	21.50057	0.00000	.04158
-3.45398	-3.76535	-3.06333	0.00000	.33333	17.93207	0.00000	.04158
-4.07671	-4.38808	-3.06333	0.00000	.33333	14.21389	0.00000	.04158
-4.69945	-5.01082	-3.06333	0.00000	.33333	10.36951	0.00000	.04158
-5.32218	-5.63355	-3.06333	0.00000	.33333	6.42851	0.00000	.04158
-5.94492	-6.25628	-3.06333	0.00000	.33333	2.42556	0.00000	.03573
-6.56765	-6.87902	-3.06333	0.00000	.33333	-1.60118	0.00000	.02274
-7.19039	-7.50175	-3.06333	0.00000	.33333	-5.61219	0.00000	.00974
2.78824	2.45344	-2.39667	0.00000	.33333	43.72398	0.00000	.03961
2.11863	1.78383	-2.39667	0.00000	.33333	41.54445	0.00000	.03961
1.44903	1.11422	-2.39667	0.00000	.33333	39.20746	0.00000	.03961
.77942	.44461	-2.39667	0.00000	.33333	36.70395	0.00000	.03961
.10981	-.22500	-2.39667	0.00000	.33333	34.02611	0.00000	.03961
-.55980	-.89461	-2.39667	0.00000	.33333	31.16804	0.00000	.03961
-1.22941	-1.56422	-2.39667	0.00000	.33333	28.12659	0.00000	.03961
-1.89902	-2.23383	-2.39667	0.00000	.33333	24.90235	0.00000	.03961
-2.56863	-2.90344	-2.39667	0.00000	.33333	21.50057	0.00000	.03961
-3.23824	-3.57304	-2.39667	0.00000	.33333	17.93207	0.00000	.03961
-3.90785	-4.24265	-2.39667	0.00000	.33333	14.21389	0.00000	.03961

-4.57746	-4.91226	-2.39667	0.00000	.33333	10.36951	0.00000	.03961
-5.24707	-5.58187	-2.39667	0.00000	.33333	6.42851	0.00000	.03961
-5.91668	-6.25148	-2.39667	0.00000	.33333	2.42556	0.00000	.03404
-6.58629	-6.92109	-2.39667	0.00000	.33333	-1.60118	0.00000	.02166
-7.25590	-7.59070	-2.39667	0.00000	.33333	-5.61219	0.00000	.00928
3.42586	3.06762	-1.73000	0.00000	.33333	43.72398	0.00000	.03796
2.70937	2.35113	-1.73000	0.00000	.33333	41.54445	0.00000	.03796
1.99289	1.63465	-1.73000	0.00000	.33333	39.20746	0.00000	.03796
1.27641	.91816	-1.73000	0.00000	.33333	36.70395	0.00000	.03796
.55992	.20168	-1.73000	0.00000	.33333	34.02611	0.00000	.03796
-.15656	-.51481	-1.73000	0.00000	.33333	31.16804	0.00000	.03796
-.87305	-1.23129	-1.73000	0.00000	.33333	28.12659	0.00000	.03796
-1.58953	-1.94777	-1.73000	0.00000	.33333	24.90235	0.00000	.03796
-2.30602	-2.66426	-1.73000	0.00000	.33333	21.50057	0.00000	.03796
-3.02250	-3.38074	-1.73000	0.00000	.33333	17.93207	0.00000	.03796
-3.73898	-4.09723	-1.73000	0.00000	.33333	14.21389	0.00000	.03796
-4.45547	-4.81371	-1.73000	0.00000	.33333	10.36951	0.00000	.03796
-5.17195	-5.53020	-1.73000	0.00000	.33333	6.42851	0.00000	.03796
-5.88844	-6.24668	-1.73000	0.00000	.33333	2.42556	0.00000	.03262
-6.60492	-6.96316	-1.73000	0.00000	.33333	-1.60118	0.00000	.02076
-7.32141	-7.67965	-1.73000	0.00000	.33333	-5.61219	0.00000	.00890
4.06347	3.68179	-1.06333	0.00000	.33333	43.72398	0.00000	.03676
3.30011	2.91843	-1.06333	0.00000	.33333	41.54445	0.00000	.03676
2.53675	2.15508	-1.06333	0.00000	.33333	39.20746	0.00000	.03676
1.77340	1.39172	-1.06333	0.00000	.33333	36.70395	0.00000	.03676
1.01004	.62836	-1.06333	0.00000	.33333	34.02611	0.00000	.03676
.24668	-.13500	-1.06333	0.00000	.33333	31.16804	0.00000	.03676
-.51668	-.89836	-1.06333	0.00000	.33333	28.12659	0.00000	.03676
-1.28004	-1.66172	-1.06333	0.00000	.33333	24.90235	0.00000	.03676
-2.04340	-2.42508	-1.06333	0.00000	.33333	21.50057	0.00000	.03676
-2.80676	-3.18844	-1.06333	0.00000	.33333	17.93207	0.00000	.03676
-3.57012	-3.95180	-1.06333	0.00000	.33333	14.21389	0.00000	.03676
-4.33348	-4.71516	-1.06333	0.00000	.33333	10.36951	0.00000	.03676
-5.09684	-5.47852	-1.06333	0.00000	.33333	6.42851	0.00000	.03676
-5.86020	-6.24188	-1.06333	0.00000	.33333	2.42556	0.00000	.03159
-6.62356	-7.00524	-1.06333	0.00000	.33333	-1.60118	0.00000	.02011
-7.38692	-7.76860	-1.06333	0.00000	.33333	-5.61219	0.00000	.00862
4.73137	4.32514	-.36500	0.00000	.36500	43.72398	0.00000	.03610
3.91891	3.51268	-.36500	0.00000	.36500	41.54445	0.00000	.03610
3.10645	2.70022	-.36500	0.00000	.36500	39.20746	0.00000	.03610
2.29399	1.88776	-.36500	0.00000	.36500	36.70395	0.00000	.03610
1.48153	1.07530	-.36500	0.00000	.36500	34.02611	0.00000	.03610
.66907	.26284	-.36500	0.00000	.36500	31.16804	0.00000	.03610
-.14339	-.54962	-.36500	0.00000	.36500	28.12659	0.00000	.03610
-.95585	-1.36208	-.36500	0.00000	.36500	24.90235	0.00000	.03610
-1.76831	-2.17454	-.36500	0.00000	.36500	21.50057	0.00000	.03610
-2.58077	-2.98700	-.36500	0.00000	.36500	17.93207	0.00000	.03610
-3.39323	-3.79947	-.36500	0.00000	.36500	14.21389	0.00000	.03610
-4.20570	-4.61193	-.36500	0.00000	.36500	10.36951	0.00000	.03610
-5.01816	-5.42439	-.36500	0.00000	.36500	6.42851	0.00000	.03610
-5.83062	-6.23685	-.36500	0.00000	.36500	2.42556	0.00000	.03102
-6.64308	-7.04931	-.36500	0.00000	.36500	-1.60118	0.00000	.01974
-7.45554	-7.86177	-.36500	0.00000	.36500	-5.61219	0.00000	.00846

REF. CHORD	C AVERAGE	TRUE AREA	REFERENCE AREA	B/2	REF. AR	TRUE AR	MACH NUMBER
9.18000	11.23076	224.61520	160.00000	10.00000	2.50000	1.78082	.30000

FIRST PLANFORM SPAN LOADING

Y	CL*C
-6.39667	.10666
-5.73000	.22722
-5.06333	.34678
-4.39667	.46804
-3.73000	.58646
-3.06333	.69641
-2.39667	.79239
-1.73000	.86960
-1.06333	.92420
-.36500	.95424

CL DEVELOPED ON THIS PLANFORM= .050522
CM DEVELOPED ON THIS PLANFORM= .048956

SECOND PLANFORM SPAN LOADING

Y	CL*C
-9.66667	.57724
-9.00000	.97100
-8.33333	1.19736
-7.66667	1.33419
-7.03167	1.40524
-6.39667	1.43229
-5.73000	1.42484
-5.06333	1.39090
-4.39667	1.33971
-3.73000	1.27949
-3.06333	1.21745
-2.39667	1.15977
-1.73000	1.11150
-1.06333	1.07652
-.36500	1.05702

CL DEVELOPED ON THIS PLANFORM= .149512
CM DEVELOPED ON THIS PLANFORM= -.048933

CL DESIGN = .200000 CL COMPUTED= .200034 CM COMPUTED= .000023 CD V= .004948

LOCAL ELEVATION DATA

Y= -6.3967 Y/B/2= -.6397 CHORD= 1.8045

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0501 .0439 .0404 .0379 .0358 .0338 .0318 .0296 .0271 .0231 .0201 .0185 .0177 .0174 .0179 .0194

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	.0295	.0000	.0532
.0250	.0282	.0451	.0510
.0500	.0270	.0902	.0487
.0750	.0258	.1353	.0465
.1000	.0246	.1805	.0444
.1250	.0235	.2256	.0424
.1500	.0225	.2707	.0405
.1750	.0214	.3158	.0387
.2000	.0205	.3609	.0369
.2250	.0195	.4060	.0352
.2500	.0185	.4511	.0335
.2750	.0176	.4962	.0318
.3000	.0167	.5414	.0302
.3250	.0158	.5865	.0286
.3500	.0150	.6316	.0270
.3750	.0141	.6767	.0255
.4000	.0133	.7218	.0240
.4250	.0125	.7669	.0226
.4500	.0117	.8120	.0212
.4750	.0110	.8572	.0198
.5000	.0102	.9023	.0185
.5250	.0095	.9474	.0172
.5500	.0088	.9925	.0159
.5750	.0082	1.0376	.0147
.6000	.0076	1.0827	.0136
.6250	.0070	1.1278	.0126
.6500	.0064	1.1729	.0116
.6750	.0059	1.2181	.0107
.7000	.0054	1.2632	.0098
.7250	.0050	1.3083	.0090
.7500	.0045	1.3534	.0081
.7750	.0041	1.3985	.0073
.8000	.0036	1.4436	.0065
.8250	.0032	1.4887	.0057
.8500	.0027	1.5339	.0049
.8750	.0023	1.5790	.0041
.9000	.0019	1.6241	.0034
.9250	.0014	1.6692	.0026
.9500	.0010	1.7143	.0017
.9750	.0005	1.7594	.0009
1.0000	0.0000	1.8045	0.0000

Y= -5.7300 Y/B/2= -.5730 CHORD= 2.5336

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0531 .0434 .0374 .0330 .0292 .0256 .0221 .0185 .0143 .0081 .0034 .0008-.0006-.0009-.0003 .0020

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	.0189	.0000	.0478
.0250	.0175	.0633	.0444
.0500	.0162	.1267	.0410
.0750	.0149	.1900	.0378
.1000	.0137	.2534	.0348
.1250	.0127	.3167	.0321
.1500	.0117	.3800	.0295
.1750	.0107	.4434	.0271
.2000	.0098	.5067	.0248
.2250	.0089	.5701	.0226
.2500	.0081	.6334	.0205
.2750	.0073	.6967	.0186
.3000	.0066	.7601	.0167
.3250	.0059	.8234	.0149
.3500	.0052	.8868	.0132
.3750	.0046	.9501	.0116
.4000	.0040	1.0134	.0101
.4250	.0034	1.0768	.0086
.4500	.0029	1.1401	.0073
.4750	.0024	1.2035	.0060
.5000	.0019	1.2668	.0049
.5250	.0015	1.3301	.0038
.5500	.0011	1.3935	.0028
.5750	.0008	1.4568	.0020
.6000	.0005	1.5202	.0014
.6250	.0004	1.5835	.0009
.6500	.0002	1.6468	.0005
.6750	.0001	1.7102	.0003
.7000	.0000	1.7735	.0001
.7250	.0000	1.8369	.0000
.7500	-.0000	1.9002	-.0000
.7750	-.0000	1.9635	-.0000
.8000	-.0000	2.0269	-.0000
.8250	.0000	2.0902	.0000
.8500	.0000	2.1536	.0001
.8750	.0001	2.2169	.0002
.9000	.0001	2.2802	.0002
.9250	.0001	2.3436	.0002
.9500	.0001	2.4069	.0002
.9750	.0001	2.4703	.0001
1.0000	0.0000	2.5336	0.0000

Y= -5.0633 Y/B/2= -.5063 CHORD= 3.2627

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0526 .0409 .0337 .0281 .0234 .0191 .0149 .0105 .0056-.0017-.0073-.0103-.0118-.0122-.0113-.0084

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	.0113	.0000	.0369
.0250	.0100	.0816	.0326
.0500	.0087	.1631	.0283
.0750	.0074	.2447	.0241
.1000	.0063	.3263	.0204
.1250	.0053	.4078	.0171
.1500	.0043	.4894	.0141
.1750	.0035	.5710	.0113
.2000	.0027	.6525	.0087
.2250	.0019	.7341	.0062
.2500	.0012	.8157	.0040
.2750	.0006	.8972	.0018
.3000	-.0000	.9788	-.0001
.3250	-.0006	1.0604	-.0019
.3500	-.0011	1.1419	-.0036
.3750	-.0016	1.2235	-.0052
.4000	-.0020	1.3051	-.0066
.4250	-.0024	1.3866	-.0078
.4500	-.0027	1.4682	-.0090
.4750	-.0030	1.5498	-.0099
.5000	-.0033	1.6313	-.0108
.5250	-.0035	1.7129	-.0115
.5500	-.0037	1.7945	-.0120
.5750	-.0038	1.8760	-.0123
.6000	-.0038	1.9576	-.0124
.6250	-.0037	2.0392	-.0122
.6500	-.0036	2.1207	-.0118
.6750	-.0035	2.2023	-.0113
.7000	-.0033	2.2839	-.0106
.7250	-.0030	2.3654	-.0099
.7500	-.0028	2.4470	-.0090
.7750	-.0025	2.5286	-.0081
.8000	-.0022	2.6101	-.0072
.8250	-.0019	2.6917	-.0062
.8500	-.0016	2.7733	-.0052
.8750	-.0013	2.8548	-.0042
.9000	-.0010	2.9364	-.0032
.9250	-.0007	3.0180	-.0023
.9500	-.0004	3.0996	-.0014
.9750	-.0002	3.1811	-.0007
1.0000	0.0000	3.2627	0.0000

APPENDIX D

Y= -4.3967 Y/B/2= -.4397 CHORD= 3.9918

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0501 .0369 .0287 .0223 .0169 .0119 .0071 .0022-.0034-.0115-.0177-.0209-.0226-.0230-.0219-.0187

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	.0033	.0000	.0133
.0250	.0021	.0993	.0083
.0500	.0008	.1996	.0032
.0750	-.0004	.2994	-.0015
.1000	-.0014	.3992	-.0057
.1250	-.0023	.4990	-.0094
.1500	-.0032	.5988	-.0126
.1750	-.0039	.6986	-.0156
.2000	-.0046	.7984	-.0183
.2250	-.0052	.8981	-.0207
.2500	-.0057	.9979	-.0229
.2750	-.0062	1.0977	-.0249
.3000	-.0067	1.1975	-.0266
.3250	-.0071	1.2973	-.0282
.3500	-.0074	1.3971	-.0295
.3750	-.0077	1.4969	-.0307
.4000	-.0079	1.5967	-.0317
.4250	-.0081	1.6965	-.0325
.4500	-.0083	1.7963	-.0331
.4750	-.0084	1.8961	-.0334
.5000	-.0084	1.9959	-.0336
.5250	-.0084	2.0957	-.0336
.5500	-.0084	2.1955	-.0334
.5750	-.0082	2.2953	-.0329
.6000	-.0080	2.3951	-.0320
.6250	-.0077	2.4948	-.0308
.6500	-.0074	2.5946	-.0294
.6750	-.0069	2.6944	-.0277
.7000	-.0065	2.7942	-.0258
.7250	-.0060	2.8940	-.0238
.7500	-.0054	2.9938	-.0217
.7750	-.0049	3.0936	-.0195
.8000	-.0043	3.1934	-.0173
.8250	-.0038	3.2932	-.0150
.8500	-.0032	3.3930	-.0127
.8750	-.0026	3.4928	-.0104
.9000	-.0020	3.5926	-.0081
.9250	-.0015	3.6924	-.0059
.9500	-.0010	3.7922	-.0038
.9750	-.0005	3.8920	-.0019
1.0000	0.0000	3.9918	0.0000

Y= -3.7300 Y/B/2= -.3730 CHORD= 4.7208

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0460 .0318 .0227 .0157 .0097 .0042-.0010-.0064-.0124-.0211-.0277-.0312-.0330-.0333-.0321-.0285

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0049	.0000	-.0232
.0250	-.0061	.1180	-.0286
.0500	-.0072	.2360	-.0341
.0750	-.0083	.3541	-.0392
.1000	-.0092	.4721	-.0436
.1250	-.0100	.5901	-.0473
.1500	-.0107	.7081	-.0505
.1750	-.0113	.8261	-.0533
.2000	-.0118	.9442	-.0558
.2250	-.0123	1.0622	-.0579
.2500	-.0126	1.1802	-.0597
.2750	-.0130	1.2982	-.0612
.3000	-.0132	1.4162	-.0625
.3250	-.0134	1.5343	-.0634
.3500	-.0136	1.6523	-.0642
.3750	-.0137	1.7703	-.0646
.4000	-.0137	1.8883	-.0648
.4250	-.0137	2.0064	-.0648
.4500	-.0137	2.1244	-.0645
.4750	-.0136	2.2424	-.0640
.5000	-.0134	2.3604	-.0632
.5250	-.0132	2.4784	-.0622
.5500	-.0129	2.5965	-.0608
.5750	-.0125	2.7145	-.0591
.6000	-.0121	2.8325	-.0570
.6250	-.0115	2.9505	-.0544
.6500	-.0109	3.0685	-.0515
.6750	-.0102	3.1866	-.0484
.7000	-.0095	3.3046	-.0450
.7250	-.0088	3.4226	-.0414
.7500	-.0080	3.5406	-.0377
.7750	-.0072	3.6586	-.0339
.8000	-.0064	3.7767	-.0300
.8250	-.0055	3.8947	-.0261
.8500	-.0047	4.0127	-.0222
.8750	-.0039	4.1307	-.0182
.9000	-.0030	4.2487	-.0143
.9250	-.0022	4.3668	-.0105
.9500	-.0014	4.4848	-.0068
.9750	-.0007	4.6028	-.0034
1.0000	0.0000	4.7208	0.0000

APPENDIX D

Y= -3.0633 Y/B/2= -.3063 CHORD= 5.4499

SLOPES,DZ/DX,AT SLOPE POINTS,FRCM FRONT TO REAR

.0407 .0257 .0160 .0085 .0021-.0037-.0093-.0150-.0213-.0303-.0371-.0407-.0425-.0427-.0413-.0374

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0131	.0000	-.0713
.0250	-.0141	.1362	-.0769
.0500	-.0151	.2725	-.0825
.0750	-.0161	.4087	-.0877
.1000	-.0169	.5450	-.0920
.1250	-.0175	.6812	-.0954
.1500	-.0180	.8175	-.0982
.1750	-.0184	.9537	-.1005
.2000	-.0188	1.0900	-.1024
.2250	-.0191	1.2262	-.1040
.2500	-.0193	1.3625	-.1051
.2750	-.0194	1.4987	-.1058
.3000	-.0195	1.6350	-.1062
.3250	-.0195	1.7712	-.1063
.3500	-.0195	1.9075	-.1061
.3750	-.0194	2.0437	-.1055
.4000	-.0192	2.1800	-.1047
.4250	-.0190	2.3162	-.1035
.4500	-.0187	2.4525	-.1020
.4750	-.0184	2.5887	-.1003
.5000	-.0180	2.7250	-.0982
.5250	-.0176	2.8612	-.0958
.5500	-.0171	2.9974	-.0930
.5750	-.0165	3.1337	-.0898
.6000	-.0158	3.2699	-.0861
.6250	-.0150	3.4062	-.0819
.6500	-.0142	3.5424	-.0773
.6750	-.0133	3.6787	-.0724
.7000	-.0123	3.8149	-.0672
.7250	-.0113	3.9512	-.0618
.7500	-.0103	4.0874	-.0562
.7750	-.0093	4.2237	-.0505
.8000	-.0082	4.3599	-.0448
.8250	-.0071	4.4962	-.0389
.8500	-.0061	4.6324	-.0331
.8750	-.0050	4.7687	-.0273
.9000	-.0039	4.9049	-.0215
.9250	-.0029	5.0412	-.0158
.9500	-.0019	5.1774	-.0103
.9750	-.0009	5.3137	-.0051
1.0000	0.0000	5.4499	0.0000

Y= -2.3967 Y/B/2= -.2397 CHORD= 6.1790

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0342 .0188 .0087 .0009-.0058-.0118-.0176-.0234-.0298-.0388-.0457-.0492-.0508-.0509-.0493-.0450

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0210	.0000	-.1297
.0250	-.0219	.1545	-.1351
.0500	-.0227	.3089	-.1404
.0750	-.0235	.4634	-.1453
.1000	-.0241	.6179	-.1491
.1250	-.0246	.7724	-.1519
.1500	-.0249	.9268	-.1540
.1750	-.0252	1.0813	-.1555
.2000	-.0253	1.2358	-.1565
.2250	-.0254	1.3903	-.1571
.2500	-.0254	1.5447	-.1572
.2750	-.0254	1.6992	-.1568
.3000	-.0253	1.8537	-.1561
.3250	-.0251	2.0082	-.1549
.3500	-.0248	2.1626	-.1534
.3750	-.0245	2.3171	-.1516
.4000	-.0242	2.4716	-.1493
.4250	-.0238	2.6261	-.1468
.4500	-.0233	2.7805	-.1438
.4750	-.0227	2.9350	-.1405
.5000	-.0222	3.0895	-.1369
.5250	-.0215	3.2440	-.1329
.5500	-.0208	3.3984	-.1284
.5750	-.0200	3.5529	-.1235
.6000	-.0191	3.7074	-.1180
.6250	-.0181	3.8619	-.1119
.6500	-.0171	4.0163	-.1054
.6750	-.0159	4.1708	-.0985
.7000	-.0148	4.3253	-.0913
.7250	-.0136	4.4798	-.0838
.7500	-.0123	4.6342	-.0762
.7750	-.0111	4.7887	-.0685
.8000	-.0098	4.9432	-.0606
.8250	-.0085	5.0977	-.0527
.8500	-.0073	5.2521	-.0449
.8750	-.0060	5.4066	-.0370
.9000	-.0047	5.5611	-.0292
.9250	-.0035	5.7156	-.0215
.9500	-.0023	5.8700	-.0141
.9750	-.0011	6.0245	-.0070
1.0000	0.0000	6.1790	0.0000

Y= -1.7300 Y/B/2= -.1730 CHORD= 6.9081

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0265 .0109 .0006-.0073-.0141-.0201-.0259-.0316-.0378-.0466-.0532-.0564-.0578-.0576-.0557-.0510

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0286	.0000	-.1978
.0250	-.0293	.1727	-.2024
.0500	-.0300	.3454	-.2071
.0750	-.0306	.5181	-.2112
.1000	-.0310	.6908	-.2141
.1250	-.0313	.8635	-.2159
.1500	-.0314	1.0362	-.2168
.1750	-.0314	1.2089	-.2171
.2000	-.0314	1.3816	-.2169
.2250	-.0313	1.5543	-.2161
.2500	-.0311	1.7270	-.2148
.2750	-.0308	1.8997	-.2129
.3000	-.0305	2.0724	-.2107
.3250	-.0301	2.2451	-.2080
.3500	-.0297	2.4178	-.2049
.3750	-.0291	2.5905	-.2013
.4000	-.0286	2.7632	-.1974
.4250	-.0280	2.9359	-.1931
.4500	-.0273	3.1086	-.1884
.4750	-.0265	3.2813	-.1833
.5000	-.0257	3.4540	-.1778
.5250	-.0249	3.6267	-.1719
.5500	-.0240	3.7994	-.1655
.5750	-.0230	3.9721	-.1586
.6000	-.0219	4.1448	-.1511
.6250	-.0207	4.3175	-.1430
.6500	-.0195	4.4902	-.1344
.6750	-.0181	4.6629	-.1253
.7000	-.0168	4.8356	-.1160
.7250	-.0154	5.0083	-.1064
.7500	-.0140	5.1810	-.0966
.7750	-.0126	5.3537	-.0867
.8000	-.0111	5.5264	-.0767
.8250	-.0097	5.6991	-.0667
.8500	-.0082	5.8718	-.0568
.8750	-.0068	6.0445	-.0468
.9000	-.0053	6.2172	-.0369
.9250	-.0039	6.3899	-.0272
.9500	-.0026	6.5627	-.0178
.9750	-.0013	6.7354	-.0088
1.0000	0.0000	6.9081	0.0000

Y= -1.0633 Y/B/2= -.1063 CHORD= 7.6371

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0166 .0009-.0094-.0173-.0239-.0298-.0352-.0405-.0462-.0543-.0601-.0628-.0636-.0629-.0605-.0552

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0366	.0000	-.2799
.0250	-.0371	.1909	-.2831
.0500	-.0375	.3819	-.2864
.0750	-.0378	.5728	-.2890
.1000	-.0380	.7637	-.2904
.1250	-.0380	.9546	-.2904
.1500	-.0379	1.1456	-.2895
.1750	-.0377	1.3365	-.2880
.2000	-.0374	1.5274	-.2858
.2250	-.0371	1.7184	-.2830
.2500	-.0366	1.9093	-.2797
.2750	-.0361	2.1002	-.2758
.3000	-.0355	2.2911	-.2714
.3250	-.0349	2.4821	-.2665
.3500	-.0342	2.6730	-.2612
.3750	-.0335	2.8639	-.2555
.4000	-.0326	3.0549	-.2493
.4250	-.0318	3.2458	-.2428
.4500	-.0309	3.4367	-.2358
.4750	-.0299	3.6276	-.2284
.5000	-.0289	3.8186	-.2206
.5250	-.0278	4.0095	-.2125
.5500	-.0267	4.2004	-.2038
.5750	-.0255	4.3913	-.1946
.6000	-.0242	4.5823	-.1848
.6250	-.0228	4.7732	-.1744
.6500	-.0214	4.9641	-.1634
.6750	-.0199	5.1551	-.1521
.7000	-.0184	5.3460	-.1404
.7250	-.0168	5.5369	-.1286
.7500	-.0153	5.7278	-.1166
.7750	-.0137	5.9188	-.1045
.8000	-.0121	6.1097	-.0924
.8250	-.0105	6.3006	-.0802
.8500	-.0089	6.4916	-.0682
.8750	-.0074	6.6825	-.0562
.9000	-.0058	6.8734	-.0443
.9250	-.0043	7.0643	-.0326
.9500	-.0028	7.2553	-.0213
.9750	-.0014	7.4462	-.0106
1.0000	0.0000	7.6371	0.0000

Y= -.3650 Y/B/2= -.0365 CHORD= 8.4008

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

-.0027-.0190-.0294-.0371-.0432-.0482-.0527-.0568-.0609-.0670-.0706-.0712-.0702-.0680-.0644-.0581

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0504	.0000	-.4231
.0250	-.0503	.2100	-.4227
.0500	-.0503	.4200	-.4222
.0750	-.0501	.6301	-.4210
.1000	-.0498	.8401	-.4184
.1250	-.0493	1.0501	-.4142
.1500	-.0487	1.2601	-.4090
.1750	-.0480	1.4701	-.4031
.2000	-.0472	1.6802	-.3965
.2250	-.0463	1.8902	-.3893
.2500	-.0454	2.1002	-.3814
.2750	-.0444	2.3102	-.3730
.3000	-.0433	2.5202	-.3641
.3250	-.0422	2.7303	-.3548
.3500	-.0411	2.9403	-.3450
.3750	-.0399	3.1503	-.3348
.4000	-.0386	3.3603	-.3243
.4250	-.0373	3.5704	-.3134
.4500	-.0360	3.7804	-.3021
.4750	-.0346	3.9904	-.2904
.5000	-.0331	4.2004	-.2785
.5250	-.0317	4.4104	-.2662
.5500	-.0302	4.6205	-.2536
.5750	-.0286	4.8305	-.2405
.6000	-.0270	5.0405	-.2268
.6250	-.0253	5.2505	-.2127
.6500	-.0236	5.4605	-.1982
.6750	-.0218	5.6706	-.1835
.7000	-.0201	5.8806	-.1686
.7250	-.0183	6.0906	-.1536
.7500	-.0165	6.3006	-.1387
.7750	-.0147	6.5106	-.1238
.8000	-.0130	6.7207	-.1090
.8250	-.0112	6.9307	-.0943
.8500	-.0095	7.1407	-.0799
.8750	-.0078	7.3507	-.0656
.9000	-.0061	7.5607	-.0516
.9250	-.0045	7.7708	-.0379
.9500	-.0029	7.9808	-.0247
.9750	-.0015	8.1908	-.0122
1.0000	0.0000	8.4008	0.0000

Y= -9.6667 Y/B/2= -.9667 CHORD= 2.5350

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0933 .0742 .0619 .0517 .0425 .0335 .0247 .0158 .0067-.0028-.0131-.0250-.0425-.0588-.0636-.0586
CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	.0111	0.0000	.0281
.0250	.0087	.0634	.0222
.0500	.0064	.1267	.0162
.0750	.0041	.1901	.0105
.1000	.0021	.2535	.0053
.1250	.0003	.3169	.0007
.1500	-.0014	.3802	-.0036
.1750	-.0030	.4436	-.0076
.2000	-.0045	.5070	-.0114
.2250	-.0059	.5704	-.0149
.2500	-.0071	.6337	-.0181
.2750	-.0083	.6971	-.0211
.3000	-.0094	.7605	-.0239
.3250	-.0104	.8239	-.0265
.3500	-.0114	.8872	-.0288
.3750	-.0122	.9506	-.0309
.4000	-.0129	1.0140	-.0327
.4250	-.0136	1.0774	-.0344
.4500	-.0141	1.1407	-.0358
.4750	-.0146	1.2041	-.0370
.5000	-.0150	1.2675	-.0380
.5250	-.0153	1.3309	-.0387
.5500	-.0155	1.3942	-.0392
.5750	-.0156	1.4576	-.0395
.6000	-.0156	1.5210	-.0396
.6250	-.0155	1.5844	-.0393
.6500	-.0153	1.6477	-.0389
.6750	-.0150	1.7111	-.0381
.7000	-.0147	1.7745	-.0371
.7250	-.0141	1.8379	-.0359
.7500	-.0135	1.9012	-.0342
.7750	-.0127	1.9646	-.0322
.8000	-.0117	2.0280	-.0297
.8250	-.0105	2.0914	-.0267
.8500	-.0092	2.1547	-.0232
.8750	-.0077	2.2181	-.0195
.9000	-.0061	2.2815	-.0155
.9250	-.0045	2.3449	-.0115
.9500	-.0030	2.4082	-.0075
.9750	-.0015	2.4716	-.0037
1.0000	0.0000	2.5350	0.0000

Y= -9.0000 Y/B/2= -.9000 CHORD= 3.2850

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0877 .0606 .0426 .0280 .0150 .0029-.0089-.0205-.0322-.0444-.0576-.0728-.0955-.1166-.1229-.1167

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9344

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0250	0.0000	-.0823
.0250	-.0273	.0821	-.0895
.0500	-.0295	.1642	-.0968
.0750	-.0315	.2464	-.1036
.1000	-.0333	.3285	-.1095
.1250	-.0348	.4106	-.1143
.1500	-.0361	.4927	-.1185
.1750	-.0372	.5749	-.1222
.2000	-.0382	.6570	-.1254
.2250	-.0390	.7391	-.1281
.2500	-.0397	.8212	-.1304
.2750	-.0402	.9034	-.1322
.3000	-.0406	.9855	-.1335
.3250	-.0409	1.0676	-.1345
.3500	-.0411	1.1497	-.1351
.3750	-.0412	1.2319	-.1353
.4000	-.0411	1.3140	-.1351
.4250	-.0409	1.3961	-.1345
.4500	-.0406	1.4782	-.1335
.4750	-.0402	1.5604	-.1322
.5000	-.0397	1.6425	-.1305
.5250	-.0391	1.7246	-.1283
.5500	-.0383	1.8067	-.1258
.5750	-.0374	1.8889	-.1230
.6000	-.0364	1.9710	-.1197
.6250	-.0353	2.0531	-.1160
.6500	-.0340	2.1352	-.1118
.6750	-.0327	2.2174	-.1073
.7000	-.0311	2.2995	-.1023
.7250	-.0295	2.3816	-.0968
.7500	-.0276	2.4637	-.0907
.7750	-.0256	2.5459	-.0839
.8000	-.0233	2.6280	-.0764
.8250	-.0207	2.7101	-.0681
.8500	-.0180	2.7922	-.0590
.8750	-.0150	2.8744	-.0494
.9000	-.0120	2.9565	-.0394
.9250	-.0089	3.0386	-.0293
.9500	-.0059	3.1207	-.0193
.9750	-.0029	3.2029	-.0096
1.0000	0.0000	3.2850	0.0000

Y= -8.3333 Y/B/2= -.8333 CHORD= 4.0350

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0812 .0535 .0352 .0206 .0080-.0035-.0145-.0252-.0360-.0473-.0595-.0738-.0956-.1161-.1218-.1153

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0288	.0000	-.1164
.0250	-.0309	.1009	-.1246
.0500	-.0329	.2018	-.1329
.0750	-.0348	.3026	-.1406
.1000	-.0365	.4035	-.1471
.1250	-.0378	.5044	-.1524
.1500	-.0389	.6052	-.1568
.1750	-.0398	.7061	-.1606
.2000	-.0406	.8070	-.1637
.2250	-.0412	.9079	-.1663
.2500	-.0417	1.0087	-.1683
.2750	-.0421	1.1096	-.1698
.3000	-.0423	1.2105	-.1708
.3250	-.0425	1.3114	-.1713
.3500	-.0425	1.4122	-.1714
.3750	-.0424	1.5131	-.1710
.4000	-.0422	1.6140	-.1701
.4250	-.0418	1.7149	-.1688
.4500	-.0414	1.8157	-.1671
.4750	-.0409	1.9166	-.1649
.5000	-.0402	2.0175	-.1623
.5250	-.0395	2.1184	-.1593
.5500	-.0386	2.2192	-.1558
.5750	-.0376	2.3201	-.1519
.6000	-.0366	2.4210	-.1475
.6250	-.0354	2.5219	-.1427
.6500	-.0340	2.6227	-.1374
.6750	-.0326	2.7236	-.1316
.7000	-.0310	2.8245	-.1252
.7250	-.0293	2.9254	-.1184
.7500	-.0275	3.0262	-.1108
.7750	-.0254	3.1271	-.1025
.8000	-.0231	3.2280	-.0932
.8250	-.0206	3.3289	-.0829
.8500	-.0178	3.4297	-.0719
.8750	-.0149	3.5306	-.0601
.9000	-.0119	3.6315	-.0479
.9250	-.0088	3.7324	-.0356
.9500	-.0058	3.8332	-.0235
.9750	-.0029	3.9341	-.0116
1.0000	0.0000	4.0350	0.0000

Y= -7.6667 Y/B/2= -.7667 CHORD= 4.7850

SLOPES,DZ/DX,AT SLOPE POINTS,FRCM FRONT TO REAR

.0787 .0522 .0348 .0211 .0093-.0013-.0112-.0209-.0307-.0407-.0517-.0647-.0847-.1036-.1087-.1024

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0237	.0000	-.1135
.0250	-.0257	.1196	-.1230
.0500	-.0277	.2392	-.1325
.0750	-.0295	.3589	-.1414
.1000	-.0311	.4785	-.1489
.1250	-.0324	.5981	-.1550
.1500	-.0335	.7177	-.1601
.1750	-.0344	.8374	-.1645
.2000	-.0352	.9570	-.1682
.2250	-.0358	1.0766	-.1713
.2500	-.0363	1.1962	-.1738
.2750	-.0367	1.3159	-.1756
.3000	-.0370	1.4355	-.1770
.3250	-.0371	1.5551	-.1778
.3500	-.0372	1.6747	-.1780
.3750	-.0372	1.7944	-.1778
.4000	-.0370	1.9140	-.1771
.4250	-.0368	2.0336	-.1760
.4500	-.0364	2.1532	-.1743
.4750	-.0360	2.2729	-.1722
.5000	-.0355	2.3925	-.1697
.5250	-.0348	2.5121	-.1666
.5500	-.0341	2.6317	-.1631
.5750	-.0333	2.7514	-.1592
.6000	-.0323	2.8710	-.1547
.6250	-.0313	2.9906	-.1498
.6500	-.0302	3.1102	-.1444
.6750	-.0289	3.2299	-.1384
.7000	-.0276	3.3495	-.1318
.7250	-.0261	3.4691	-.1247
.7500	-.0244	3.5887	-.1169
.7750	-.0226	3.7084	-.1081
.8000	-.0206	3.8280	-.0984
.8250	-.0183	3.9476	-.0876
.8500	-.0159	4.0672	-.0759
.8750	-.0133	4.1869	-.0635
.9000	-.0106	4.3065	-.0506
.9250	-.0078	4.4261	-.0375
.9500	-.0052	4.5457	-.0247
.9750	-.0026	4.6654	-.0123
1.0000	0.0000	4.7850	0.0000

Y= -7.0317 Y/B/2= -.7032 CHORD= 5.4994

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0965 .0720 .0553 .0432 .0325 .0229 .0140 .0053-.0033-.0122-.0220-.0335-.0516-.0687-.0732-.0672

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	.0032	.0000	.0176
.0250	.0008	.1375	.0042
.0500	-.0017	.2750	-.0091
.0750	-.0040	.4125	-.0218
.1000	-.0060	.5499	-.0330
.1250	-.0078	.6874	-.0428
.1500	-.0094	.8249	-.0515
.1750	-.0108	.9624	-.0594
.2000	-.0121	1.0999	-.0666
.2250	-.0133	1.2374	-.0732
.2500	-.0144	1.3748	-.0791
.2750	-.0153	1.5123	-.0843
.3000	-.0162	1.6498	-.0890
.3250	-.0169	1.7873	-.0931
.3500	-.0176	1.9248	-.0967
.3750	-.0181	2.0623	-.0998
.4000	-.0186	2.1998	-.1024
.4250	-.0190	2.3372	-.1045
.4500	-.0193	2.4747	-.1061
.4750	-.0195	2.6122	-.1073
.5000	-.0196	2.7497	-.1080
.5250	-.0197	2.8872	-.1082
.5500	-.0196	3.0247	-.1079
.5750	-.0195	3.1621	-.1071
.6000	-.0193	3.2996	-.1059
.6250	-.0189	3.4371	-.1041
.6500	-.0185	3.5746	-.1019
.6750	-.0180	3.7121	-.0991
.7000	-.0174	3.8496	-.0957
.7250	-.0167	3.9870	-.0917
.7500	-.0158	4.1245	-.0870
.7750	-.0148	4.2620	-.0813
.8000	-.0136	4.3995	-.0746
.8250	-.0122	4.5370	-.0669
.8500	-.0106	4.6745	-.0582
.8750	-.0088	4.8120	-.0486
.9000	-.0070	4.9494	-.0387
.9250	-.0052	5.0869	-.0286
.9500	-.0034	5.2244	-.0187
.9750	-.0017	5.3619	-.0093
1.0000	0.0000	5.4994	0.0000

Y= -6.3967 Y/B/2= -.6397 CHORD= 6.2137

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0610 .0388 .0242 .0130 .0035-.0049-.0127-.0202-.0276-.0353-.0438-.0538-.0698-.0849-.0887-.0832

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0218	0.0000	-.1355
.0250	-.0233	.1553	-.1451
.0500	-.0249	.3107	-.1547
.0750	-.0263	.4660	-.1635
.1000	-.0275	.6214	-.1709
.1250	-.0285	.7767	-.1768
.1500	-.0292	.9321	-.1816
.1750	-.0299	1.0874	-.1856
.2000	-.0304	1.2427	-.1889
.2250	-.0308	1.3981	-.1915
.2500	-.0311	1.5534	-.1935
.2750	-.0313	1.7088	-.1948
.3000	-.0315	1.8641	-.1955
.3250	-.0315	2.0195	-.1958
.3500	-.0315	2.1748	-.1954
.3750	-.0313	2.3302	-.1946
.4000	-.0311	2.4855	-.1933
.4250	-.0308	2.6408	-.1915
.4500	-.0305	2.7962	-.1892
.4750	-.0300	2.9515	-.1865
.5000	-.0295	3.1069	-.1833
.5250	-.0289	3.2622	-.1796
.5500	-.0282	3.4176	-.1755
.5750	-.0275	3.5729	-.1709
.6000	-.0267	3.7282	-.1659
.6250	-.0258	3.8836	-.1603
.6500	-.0248	4.0389	-.1542
.6750	-.0238	4.1943	-.1476
.7000	-.0226	4.3496	-.1405
.7250	-.0214	4.5050	-.1328
.7500	-.0200	4.6603	-.1243
.7750	-.0185	4.8157	-.1149
.8000	-.0168	4.9710	-.1045
.8250	-.0150	5.1263	-.0929
.8500	-.0129	5.2817	-.0805
.8750	-.0108	5.4370	-.0672
.9000	-.0086	5.5924	-.0535
.9250	-.0064	5.7477	-.0397
.9500	-.0042	5.9031	-.0261
.9750	-.0021	6.0584	-.0129
1.0000	0.0000	6.2137	0.0000

Y= -5.7300 Y/B/2= -.5730 CHORD= 6.9637

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0395 .0196 .0067-.0031-.0114-.0186-.0253-.0316-.0379-.0444-.0515-.0602-.0740-.0871-.0903-.0853

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0323	.0000	-.2281
.0250	-.0337	.1741	-.2350
.0500	-.0349	.3482	-.2420
.0750	-.0356	.5223	-.2483
.1000	-.0363	.6964	-.2530
.1250	-.0368	.8705	-.2563
.1500	-.0371	1.0446	-.2585
.1750	-.0373	1.2187	-.2599
.2000	-.0374	1.3927	-.2607
.2250	-.0374	1.5668	-.2607
.2500	-.0374	1.7409	-.2601
.2750	-.0372	1.9150	-.2589
.3000	-.0369	2.0891	-.2571
.3250	-.0366	2.2632	-.2548
.3500	-.0362	2.4373	-.2520
.3750	-.0357	2.6114	-.2487
.4000	-.0352	2.7855	-.2449
.4250	-.0346	2.9596	-.2407
.4500	-.0339	3.1337	-.2360
.4750	-.0332	3.3078	-.2309
.5000	-.0324	3.4819	-.2253
.5250	-.0315	3.6560	-.2194
.5500	-.0306	3.8301	-.2129
.5750	-.0296	4.0042	-.2060
.6000	-.0285	4.1782	-.1987
.6250	-.0274	4.3523	-.1909
.6500	-.0262	4.5264	-.1827
.6750	-.0250	4.7005	-.1739
.7000	-.0236	4.8746	-.1646
.7250	-.0222	5.0487	-.1547
.7500	-.0207	5.2228	-.1441
.7750	-.0190	5.3969	-.1327
.8000	-.0173	5.5710	-.1202
.8250	-.0153	5.7451	-.1066
.8500	-.0132	5.9192	-.0921
.8750	-.0110	6.0933	-.0769
.9000	-.0088	6.2674	-.0612
.9250	-.0065	6.4415	-.0454
.9500	-.0043	6.6156	-.0299
.9750	-.0021	6.7897	-.0149
1.0000	0.0000	6.9637	0.0000

APPENDIX D

Y= -5.0633 Y/B/2= -.5063 CHORD= 7.7137

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0248 .0073-.0039-.0124-.0194-.0255-.0310-.0363-.0415-.0468-.0527-.0600-.0719-.0831-.0857-.0810

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0371	.0000	-.2859
.0250	-.0377	.1928	-.2908
.0500	-.0383	.3857	-.2956
.0750	-.0389	.5785	-.2998
.1000	-.0392	.7714	-.3025
.1250	-.0394	.9642	-.3038
.1500	-.0394	1.1571	-.3040
.1750	-.0393	1.3499	-.3035
.2000	-.0392	1.5427	-.3024
.2250	-.0390	1.7356	-.3005
.2500	-.0386	1.9284	-.2981
.2750	-.0382	2.1213	-.2950
.3000	-.0378	2.3141	-.2915
.3250	-.0373	2.5070	-.2874
.3500	-.0367	2.6998	-.2829
.3750	-.0360	2.8927	-.2779
.4000	-.0353	3.0855	-.2725
.4250	-.0346	3.2783	-.2667
.4500	-.0338	3.4712	-.2605
.4750	-.0329	3.6640	-.2538
.5000	-.0320	3.8569	-.2468
.5250	-.0310	4.0497	-.2393
.5500	-.0300	4.2426	-.2315
.5750	-.0289	4.4354	-.2232
.6000	-.0278	4.6282	-.2146
.6250	-.0266	4.8211	-.2055
.6500	-.0254	5.0139	-.1959
.6750	-.0241	5.2068	-.1860
.7000	-.0227	5.3996	-.1755
.7250	-.0213	5.5925	-.1645
.7500	-.0198	5.7853	-.1528
.7750	-.0182	5.9782	-.1403
.8000	-.0164	6.1710	-.1268
.8250	-.0146	6.3638	-.1123
.8500	-.0126	6.5567	-.0970
.8750	-.0105	6.7495	-.0809
.9000	-.0083	6.9424	-.0644
.9250	-.0062	7.1352	-.0478
.9500	-.0041	7.3281	-.0315
.9750	-.0020	7.5209	-.0156
1.0000	0.0000	7.7137	0.0000

Y= -4.3967 Y/B/2= -.4397 CHORD= 8.4637

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

.0105-.0047-.0143-.0215-.0273-.0323-.0368-.0410-.0452-.0495-.0542-.0602-.0703-.0798-.0818-.0775

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
0.0000	-.0415	0.0000	-.3513
.0250	-.0418	.2116	-.3536
.0500	-.0421	.4232	-.3559
.0750	-.0422	.6348	-.3576
.1000	-.0423	.8464	-.3578
.1250	-.0421	1.0580	-.3567
.1500	-.0419	1.2696	-.3546
.1750	-.0416	1.4812	-.3518
.2000	-.0412	1.6927	-.3484
.2250	-.0407	1.9043	-.3444
.2500	-.0401	2.1159	-.3398
.2750	-.0395	2.3275	-.3346
.3000	-.0389	2.5391	-.3290
.3250	-.0382	2.7507	-.3230
.3500	-.0374	2.9623	-.3165
.3750	-.0366	3.1739	-.3096
.4000	-.0357	3.3855	-.3023
.4250	-.0348	3.5971	-.2947
.4500	-.0339	3.8087	-.2866
.4750	-.0329	4.0203	-.2783
.5000	-.0318	4.2319	-.2695
.5250	-.0308	4.4435	-.2605
.5500	-.0297	4.6551	-.2511
.5750	-.0285	4.8667	-.2413
.6000	-.0273	5.0782	-.2311
.6250	-.0261	5.2898	-.2206
.6500	-.0248	5.5014	-.2097
.6750	-.0234	5.7130	-.1984
.7000	-.0221	5.9246	-.1867
.7250	-.0206	6.1362	-.1744
.7500	-.0191	6.3478	-.1616
.7750	-.0175	6.5594	-.1480
.8000	-.0158	6.7710	-.1335
.8250	-.0139	6.9826	-.1180
.8500	-.0120	7.1942	-.1017
.8750	-.0100	7.4058	-.0848
.9000	-.0080	7.6174	-.0675
.9250	-.0059	7.8290	-.0501
.9500	-.0039	8.0406	-.0331
.9750	-.0019	8.2522	-.0164
1.0000	0.0000	8.4637	0.0000

Y= -3.7300 Y/B/2= -.3730 CHORD= 9.2137

SLOPES,DZ/DX,AT SLOPE POINTS,FRCM FRONT TO REAR

-.0031-.0161-.0243-.0302-.0350-.0390-.0425-.0458-.0489-.0523-.0560-.0608-.0693-.0773-.0787-.0748

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0460	.0000	-.4240
.0250	-.0460	.2303	-.4234
.0500	-.0459	.4607	-.4227
.0750	-.0457	.6910	-.4215
.1000	-.0455	.9214	-.4190
.1250	-.0451	1.1517	-.4151
.1500	-.0445	1.3821	-.4104
.1750	-.0440	1.6124	-.4050
.2000	-.0433	1.8427	-.3991
.2250	-.0426	2.0731	-.3926
.2500	-.0418	2.3034	-.3855
.2750	-.0410	2.5338	-.3781
.3000	-.0402	2.7641	-.3701
.3250	-.0393	2.9945	-.3618
.3500	-.0383	3.2248	-.3532
.3750	-.0374	3.4552	-.3442
.4000	-.0363	3.6855	-.3348
.4250	-.0353	3.9158	-.3251
.4500	-.0342	4.1462	-.3152
.4750	-.0331	4.3765	-.3049
.5000	-.0319	4.6069	-.2943
.5250	-.0308	4.8372	-.2834
.5500	-.0296	5.0676	-.2723
.5750	-.0283	5.2979	-.2608
.6000	-.0270	5.5282	-.2491
.6250	-.0257	5.7586	-.2370
.6500	-.0244	5.9889	-.2246
.6750	-.0230	6.2193	-.2118
.7000	-.0216	6.4496	-.1987
.7250	-.0201	6.6800	-.1851
.7500	-.0186	6.9103	-.1710
.7750	-.0170	7.1407	-.1562
.8000	-.0153	7.3710	-.1406
.8250	-.0135	7.6013	-.1241
.8500	-.0116	7.8317	-.1068
.8750	-.0097	8.0620	-.0890
.9000	-.0077	8.2924	-.0708
.9250	-.0057	8.5227	-.0526
.9500	-.0038	8.7531	-.0347
.9750	-.0019	8.9834	-.0172
1.0000	0.0000	9.2137	0.0000

Y= -3.0633 Y/B/2= -.3063 CHORD= 9.9637

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

-.0156-.0267-.0335-.0384-.0421-.0452-.0479-.0503-.0526-.0551-.0579-.0617-.0687-.0754-.0764-.0727

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0504	.0000	-.5021
.0250	-.0500	.2491	-.4983
.0500	-.0496	.4982	-.4945
.0750	-.0492	.7473	-.4901
.1000	-.0486	.9964	-.4845
.1250	-.0480	1.2455	-.4778
.1500	-.0472	1.4946	-.4702
.1750	-.0464	1.7437	-.4620
.2000	-.0455	1.9927	-.4534
.2250	-.0446	2.2418	-.4442
.2500	-.0436	2.4909	-.4346
.2750	-.0426	2.7400	-.4246
.3000	-.0416	2.9891	-.4142
.3250	-.0405	3.2382	-.4035
.3500	-.0394	3.4873	-.3925
.3750	-.0383	3.7364	-.3812
.4000	-.0371	3.9855	-.3696
.4250	-.0359	4.2346	-.3578
.4500	-.0347	4.4837	-.3457
.4750	-.0335	4.7328	-.3334
.5000	-.0322	4.9819	-.3208
.5250	-.0309	5.2310	-.3080
.5500	-.0296	5.4801	-.2950
.5750	-.0283	5.7292	-.2818
.6000	-.0269	5.9782	-.2683
.6250	-.0255	6.2273	-.2545
.6500	-.0241	6.4764	-.2405
.6750	-.0227	6.7255	-.2261
.7000	-.0212	6.9746	-.2115
.7250	-.0197	7.2237	-.1965
.7500	-.0182	7.4728	-.1811
.7750	-.0166	7.7219	-.1650
.8000	-.0149	7.9710	-.1482
.8250	-.0131	8.2201	-.1306
.8500	-.0113	8.4692	-.1123
.8750	-.0094	8.7183	-.0935
.9000	-.0075	8.9674	-.0743
.9250	-.0055	9.2165	-.0552
.9500	-.0037	9.4656	-.0365
.9750	-.0018	9.7147	-.0181
1.0000	0.0000	9.9637	0.0000

Y= -2.3967 Y/B/2= -.2397 CHORD= 10.7137

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

-.0269-.0363-.0419-.0458-.0487-.0510-.0529-.0545-.0561-.0578-.0599-.0627-.0685-.0741-.0746-.0711

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0545	.0000	-.5838
.0250	-.0538	.2678	-.5767
.0500	-.0532	.5357	-.5696
.0750	-.0524	.8035	-.5619
.1000	-.0516	1.0714	-.5532
.1250	-.0507	1.3392	-.5434
.1500	-.0497	1.6071	-.5328
.1750	-.0487	1.8749	-.5217
.2000	-.0476	2.1427	-.5102
.2250	-.0465	2.4106	-.4983
.2500	-.0454	2.6784	-.4860
.2750	-.0442	2.9463	-.4734
.3000	-.0430	3.2141	-.4604
.3250	-.0417	3.4820	-.4472
.3500	-.0405	3.7498	-.4338
.3750	-.0392	4.0177	-.4201
.4000	-.0379	4.2855	-.4062
.4250	-.0366	4.5533	-.3921
.4500	-.0353	4.8212	-.3778
.4750	-.0339	5.0890	-.3634
.5000	-.0326	5.3569	-.3487
.5250	-.0312	5.6247	-.3339
.5500	-.0298	5.8926	-.3190
.5750	-.0284	6.1604	-.3038
.6000	-.0269	6.4282	-.2885
.6250	-.0255	6.6961	-.2730
.6500	-.0240	6.9639	-.2573
.6750	-.0225	7.2318	-.2413
.7000	-.0210	7.4996	-.2252
.7250	-.0195	7.7675	-.2087
.7500	-.0179	8.0353	-.1918
.7750	-.0163	8.3032	-.1744
.8000	-.0146	8.5710	-.1563
.8250	-.0128	8.8388	-.1375
.8500	-.0110	9.1067	-.1181
.8750	-.0092	9.3745	-.0982
.9000	-.0073	9.6424	-.0781
.9250	-.0054	9.9102	-.0581
.9500	-.0036	10.1781	-.0383
.9750	-.0018	10.4459	-.0191
1.0000	0.0000	10.7137	0.0000

Y= -1.7300 Y/B/2= -.1730 CHORD= 11.4637

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

-.0369-.0449-.0495-.0526-.0547-.0563-.0575-.0585-.0594-.0604-.0617-.0638-.0665-.0731-.0733-.0699

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0583	.0000	-.6684
.0250	-.0574	.2866	-.6578
.0500	-.0565	.5732	-.6473
.0750	-.0555	.8598	-.6363
.1000	-.0545	1.1464	-.6243
.1250	-.0533	1.4330	-.6114
.1500	-.0521	1.7196	-.5978
.1750	-.0509	2.0062	-.5837
.2000	-.0497	2.2928	-.5693
.2250	-.0484	2.5793	-.5545
.2500	-.0471	2.8659	-.5394
.2750	-.0457	3.1525	-.5241
.3000	-.0444	3.4391	-.5084
.3250	-.0430	3.7257	-.4926
.3500	-.0416	4.0123	-.4767
.3750	-.0402	4.2989	-.4605
.4000	-.0387	4.5855	-.4442
.4250	-.0373	4.8721	-.4278
.4500	-.0359	5.1587	-.4112
.4750	-.0344	5.4453	-.3946
.5000	-.0330	5.7319	-.3778
.5250	-.0315	6.0185	-.3609
.5500	-.0300	6.3051	-.3439
.5750	-.0285	6.5917	-.3268
.6000	-.0270	6.8782	-.3096
.6250	-.0255	7.1648	-.2923
.6500	-.0240	7.4514	-.2748
.6750	-.0224	7.7380	-.2572
.7000	-.0209	8.0246	-.2394
.7250	-.0193	8.3112	-.2214
.7500	-.0177	8.5978	-.2031
.7750	-.0161	8.8844	-.1843
.8000	-.0144	9.1710	-.1648
.8250	-.0126	9.4576	-.1448
.8500	-.0108	9.7442	-.1243
.8750	-.0090	10.0308	-.1033
.9000	-.0072	10.3174	-.0821
.9250	-.0053	10.6040	-.0610
.9500	-.0035	10.8906	-.0403
.9750	-.0017	11.1772	-.0200
1.0000	0.0000	11.4637	0.0000

Y= -1.0633 Y/B/2= -.1063 CHORD= 12.2137

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

-.0463-.0532-.0569-.0592-.0607-.0616-.0622-.0625-.0627-.0630-.0636-.0650-.0687-.0724-.0722-.0689

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0621	.0000	-.7585
.0250	-.0610	.3053	-.7444
.0500	-.0598	.6107	-.7304
.0750	-.0586	.9160	-.7158
.1000	-.0573	1.2214	-.7004
.1250	-.0560	1.5267	-.6841
.1500	-.0546	1.8321	-.6672
.1750	-.0532	2.1374	-.6499
.2000	-.0518	2.4427	-.6324
.2250	-.0503	2.7481	-.6145
.2500	-.0488	3.0534	-.5964
.2750	-.0473	3.3588	-.5781
.3000	-.0458	3.6641	-.5596
.3250	-.0443	3.9695	-.5410
.3500	-.0428	4.2748	-.5222
.3750	-.0412	4.5802	-.5034
.4000	-.0397	4.8855	-.4845
.4250	-.0381	5.1908	-.4655
.4500	-.0366	5.4962	-.4465
.4750	-.0350	5.8015	-.4275
.5000	-.0334	6.1069	-.4084
.5250	-.0319	6.4122	-.3893
.5500	-.0303	6.7176	-.3701
.5750	-.0287	7.0229	-.3509
.6000	-.0272	7.3282	-.3317
.6250	-.0256	7.6336	-.3125
.6500	-.0240	7.9389	-.2931
.6750	-.0224	8.2443	-.2737
.7000	-.0208	8.5496	-.2543
.7250	-.0192	8.8550	-.2346
.7500	-.0176	9.1603	-.2148
.7750	-.0159	9.4657	-.1945
.8000	-.0142	9.7710	-.1737
.8250	-.0125	10.0763	-.1524
.8500	-.0107	10.3817	-.1306
.8750	-.0089	10.6870	-.1085
.9000	-.0071	10.9924	-.0862
.9250	-.0052	11.2977	-.0641
.9500	-.0035	11.6031	-.0423
.9750	-.0017	11.9084	-.0210
1.0000	0.0000	12.2137	0.0000

Y = -.3650   Y/B/2= -.0365   CHORD= 12.9994

SLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR

-.0596-.0656-.0685-.0700-.0705-.0704-.0699-.0691-.0682-.0674-.0668-.0670-.0694-.0719-.0712-.0679

CORRESPONDING X/C LOCATIONS FROM FRONT TO REAR

.0469 .1094 .1719 .2344 .2969 .3594 .4219 .4844 .5469 .6094 .6719 .7344 .7969 .8594 .9219 .9844

LOCAL ELEVATION

X/C	Z/C	DELTA X	DELTA Z
.0000	-.0682	.0000	-.8867
.0250	-.0667	.3250	-.8674
.0500	-.0652	.6500	-.8481
.0750	-.0637	.9750	-.8284
.1000	-.0621	1.2999	-.8078
.1250	-.0605	1.6249	-.7864
.1500	-.0588	1.9499	-.7645
.1750	-.0571	2.2749	-.7423
.2000	-.0554	2.5999	-.7199
.2250	-.0536	2.9249	-.6973
.2500	-.0519	3.2498	-.6745
.2750	-.0501	3.5748	-.6517
.3000	-.0484	3.8998	-.6288
.3250	-.0466	4.2248	-.6059
.3500	-.0448	4.5498	-.5830
.3750	-.0431	4.8748	-.5601
.4000	-.0413	5.1997	-.5373
.4250	-.0396	5.5247	-.5146
.4500	-.0378	5.8497	-.4920
.4750	-.0361	6.1747	-.4694
.5000	-.0344	6.4997	-.4470
.5250	-.0327	6.8247	-.4246
.5500	-.0310	7.1497	-.4024
.5750	-.0293	7.4746	-.3803
.6000	-.0276	7.7996	-.3583
.6250	-.0259	8.1246	-.3364
.6500	-.0242	8.4496	-.3146
.6750	-.0225	8.7746	-.2929
.7000	-.0209	9.0996	-.2712
.7250	-.0192	9.4245	-.2495
.7500	-.0175	9.7495	-.2277
.7750	-.0158	10.0745	-.2057
.8000	-.0141	10.3995	-.1833
.8250	-.0123	10.7245	-.1605
.8500	-.0106	11.0495	-.1373
.8750	-.0088	11.3745	-.1139
.9000	-.0070	11.6994	-.0905
.9250	-.0052	12.0244	-.0672
.9500	-.0034	12.3494	-.0444
.9750	-.0017	12.6744	-.0221
1.0000	0.0000	12.9994	0.0000

APPENDIX E

FORTRAN PROGRAM LISTING

This program was written in FORTRAN IV language, version 2.3 for the Control Data Corporation series 6000 computer system with SCOPE 3.0 operating system and library tape. Minor modifications may be required prior to use on other computers. The program is written using UPDATE and PROGRAM stepping. These features allow the program storage requirements to vary from 51000_8 to 112000_8 words, depending on the matrix conditioning and the solution technique for the aerodynamic characteristics. The solution technique for configurations without dihedral uses PROGRAM CIRCUL1 and 51000_8 words; the solution technique for configurations with dihedral uses PROGRAM CIRCUL2 and 63000_8 words for a well-conditioned matrix and uses PROGRAM CIRCUL3 and 112000_8 words for an ill-conditioned matrix. The selection takes place automatically and is dependent on the geometry of the configuration and the vortex-lattice layout.

This computer program consists of four basic PROGRAM steps, three OVERLAYS and seven SUBROUTINES. Each PROGRAM, OVERLAY, and SUBROUTINE is identified in columns 73 to 75 by a three-letter abbreviation. In addition, each of these parts is sequenced with a three-digit number in columns 77 to 79. The following table is an index to the program listing:

[a]The PROGRAM DUMMY is for default purposes of PROGRAM GEOMTRY.

```
JOB,1,1000,063000,1000.             A4062    R4310       100110           B1212 R101
USER.LAMAR, JOHN E                        000503400N 38510
NORFL.
UPDATE(F,I,N,C,L=0)
REWIND(NEWPL)
UPDATE(Q,P=NEWPL,C,L=0)
RUN(S,,,COMPILE)
SETINDF.
LGO.
REWIND(NEWPL)
REWIND(TAPE50)
UPDATE(Q,I=TAPE50,P=NEWPL,L=0)
RUN(S,,,COMPILE,,GLO)
SETINDF.
GLO.
EXIT.
```

APPENDIX E

```
*DECK VLMCGEOM
      PROGRAM GEOMTRY(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE25,TAPE5
     10)
      DIMENSION XREF(25), YREF(25), SAR(25), A(25), RSAR(25), X(25), Y(2
     15), BOTSV(2), SA(2), VBORD(51), SPY(50,2), KFX(2), IYL(50,2), IYT(
     250,2)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(4
     100),S(400),PSI(400),PHI(50),ZH(50),NSSW
      COMMON /MAINONE/ ICODEOF,TOTAL,AAN(2),XS(2),YS(2),KFCTS(2),XREG(25
     1,2),YREG(25,2),AREG(25,2),DIH(25,2),MCD(25,2),XX(25,2),YY(25,2),AS
     2(25,2),TTWD(25,2),MMCD(25,2),AN(2),ZZ(25,2),IFLAG
      COMMON /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTC
     1DHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50)
      COMMON /CCRRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA
      REAL MACH
      REWIND 50
C
C       PART ONE - GEOMETRY COMPUTATION
C
C                   SECTION ONE - INPUT OF REFERENCE WING POSITION
C
C
      ICODEOF=0
      TOTAL=PTEST=QTEST=TWIST(1)=TWIST(2)=0.
      IF (TOTAL.EQ.0.) RTCDHT(1)=RTCDHT(2)=0.0
      YTOL=1.E-10
      AZY=1.E+13
      PIT=1.5707963
      RAD=57.29578
      IF (TOTAL.GT.0.) GO TO 7
C
C
C     SET PLAN EQUAL TO 1. FOR A WING ALONE COMPUTAION - EVEN FOR A
C     VARIABLE SWEEP WING
C     SET PLAN EQUAL TO 2. FOR A WING - TAIL COMBINATION
C
C     SET TOTAL EQUAL TO THE NUMBER OF SETS
C       OF GROUP TWO DATA PROVIDED
C
      READ (5,98) PLAN,TOTAL,CREF,SREF
      IF(ENDFILE 5) 93,1
1     IPLAN=PLAN
C
C
C     SET AAN(IT) EQUAL TO THE MAXIMUM NUMBER OF CURVES REQUIRED TO
C     DEFINE THE PLANFORM PERIMETER OF THE (IT) PLANFORM.
C
C     SET RTCDHT(IT) EQUAL TO THE ROOT CHORD HEIGHT OF THE LIFTING
C     SURFACE (IT),WHOSE PERIMETER POINTS ARE BEING READ IN, WITH
C     RESPECT TO THE WING ROOT CHORD HEIGHT
C
      WRITE (6,96)
      DO 6 IT=1,IPLAN
      READ (5,98) AAN(IT),XS(IT),YS(IT),RTCDHT(IT)
      N=AAN(IT)
      N1=N+1
      MAK=0
      IF (IPLAN.EQ.1) PRTCON=10H
      IF (IPLAN.EQ.2.AND.IT.EQ.1) PRTCON=10H    FIRST
      IF (IPLAN.EQ.2.AND.IT.EQ.2) PRTCON=10H   SECOND
```

```
      WRITE (6,97) PRTCON,N,RTCDHT(IT),XS(IT),YS(IT)
      WRITE (6,109)
      DO 5 I=1,N1
      READ (5,98) XREG(I,IT),YREG(I,IT),DIH(I,IT),AMCD
      MCD(I,IT)=AMCD
      IF (I.EQ.1) GO TO 5
      IF (MAK.NE.0.OR.MCD(I-1,IT).NE.2) GO TO 2
      MAK=I-1
2     IF (ABS(YREG(I-1,IT)-YREG(I,IT)).LT.YTOL) GO TO 3
      AREG(I-1,IT)=(XREG(I-1,IT)-XREG(I,IT))/(YREG(I-1,IT)-YREG(I,IT))
      ASWP=ATAN(AREG(I-1,IT))*RAD
      GO TO 4
3     YREG(I,IT)=YREG(I-1,IT)
      AREG(I-1,IT)=AZY
      ASWP=90.
4     J=I-1
C
C     WRITE PLANFORM PERIMETER POINTS AND ANGLES
C
      WRITE (6,106) J,XREG(J,IT),YREG(J,IT),ASWP,DIH(J,IT),MCD(J,IT)
      DIH(J,IT)=TAN(DIH(J,IT)/RAD)
5     CONTINUE
      KFCTS(IT)=MAK
      WRITE (6,106) N1,XREG(N1,IT),YREG(N1,IT)
6     CONTINUE
C
C                        PART 1 - SECTION 2
C         READ GROUP 2 DATA AND COMPUTE DESIRED WING POSITION
C
C
C     SET SA(1),SA(2) EQUAL TO THE SWEEP ANGLE,IN DEGREES, FOR THE FIRST
C     CURVE(S) THAT CAN CHANGE SWEEP FOR EACH PLANFORM
C
7     READ(5,105) CONFIG,SCW,VIC,MACH,CLDES,SA(1),SA(2)
C
      WRITE (6,99) CONFIG
      IF(ENDFILE 5) 93,8
8     IF (PTEST.NE.0..AND.QTEST.NE.0.) GO TO 95
      IF (SCW.EQ.0.) GO TO 10
      DO 9 I=1,50
9     TBLSCW(I)=SCW
      GO TO 11
10    READ (5,98) STA
      NSTA=STA
      READ (5,98) (TBLSCW(I),TBLSCW(I+1),TBLSCW(I+2),TBLSCW(I+3),TBLSCW(
     1I+4),TBLSCW(I+5),TBLSCW(I+6),TBLSCW(I+7),I=1,NSTA,8)
11    DO 37 IT=1,IPLAN
      N=AAN(IT)
      N1=N+1
      DO 12 I=1,N
      XREF(I)=XREG(I,IT)
      YREF(I)=YREG(I,IT)
      A(I)=AREG(I,IT)
      RSAR(I)=ATAN(A(I))
      IF (A(I).EQ.AZY) RSAR(I)=PIT
12    CONTINUE
      XREF(N1)=XREG(N1,IT)
      YREF(N1)=YREG(N1,IT)
      IF (KFCTS(IT).GT.0) GO TO 13
      K=1
```

```
      SA(IT)=RSAR(1)*RAD
      GO TO 14
13    K=KFCTS(IT)
14    WRITE (6,102) K,SA(IT),IT
      SB=SA(IT)/RAD
      IF (ABS(SB-RSAR(K)).GT.(.1/RAD)) GO TO 17
C     REFERENCE PLANFORM COORDINATES ARE STORED UNCHANGED FOR WINGS
C             WITHOUT CHANGE IN SWEEP
      DO 16 I=1,N
      X(I)=XREF(I)
      Y(I)=YREF(I)
      IF (RSAR(I).EQ.PIT) GO TO 15
      A(I)=TAN(RSAR(I))
      GO TO 16
15    A(I)=AZY
16    SAR(I)=RSAR(I)
      X(N1)=XREF(N1)
      Y(N1)=YREF(N1)
      GO TO 35
C
C     CHANGES IN WING SWEEP ARE MADE HERE
C
17    IF (MCD(K,IT).NE.2) GO TO 94
      KA=K-1
      DO 18 I=1,KA
      X(I)=XREF(I)
      Y(I)=YREF(I)
18    SAR(I)=RSAR(I)
C     DETERMINE LEADING EDGE INTERSECTION BETWEEN FIXED AND VARIABLE
C             SWEEP WING SECTIONS
      SAR(K)=SB
      A(K)=TAN(SB)
      SAI=SB-RSAR(K)
      X(K+1)=XS(IT)+(XREF(K+1)-XS(IT))*COS(SAI)+(YREF(K+1)-YS(IT))*SIN(S
     1AI)
      Y(K+1)=YS(IT)+(YREF(K+1)-YS(IT))*COS(SAI)-(XREF(K+1)-XS(IT))*SIN(S
     1AI)
      IF (ABS(SB-SAR(K-1)).LT.(.1/RAD)) GO TO 19
      Y(K)=X(K+1)-X(K-1)-A(K)*Y(K+1)+A(K-1)*Y(K-1)
      Y(K)=Y(K)/(A(K-1)-A(K))
      X(K)=A(K)*X(K-1)-A(K-1)*X(K+1)+A(K-1)*A(K)*(Y(K+1)-Y(K-1))
      X(K)=X(K)/(A(K)-A(K-1))
      GO TO 20
C     ELIMINATE EXTRANEOUS BREAKPOINTS
19    X(K)=XREF(K-1)
      Y(K)=YREF(K-1)
      SAR(K)=SAR(K-1)
20    K=K+1
C     SWEEP THE BREAKPOINTS ON THE VARIABLE SWEEP PANEL
C        (IT ALSO KEEPS SWEEP ANGLES IN FIRST OR FOURTH QUADRANTS)
21    K=K+1
      SAR(K-1)=SAI+RSAR(K-1)
22    IF (SAR(K-1).LE.PIT) GO TO 23
      SAR(K-1)=SAR(K-1)-3.1415927
      GO TO 22
23    IF (SAR(K-1).GE.(-PIT)) GO TO 24
      SAR(K-1)=SAR(K-1)+3.1415927
      GO TO 23
24    IF ((SAR(K-1)).LT..0) GO TO 25
      IF (SAR(K-1)-PIT) 28,26,26
```

```
25     IF (SAR(K-1)+PIT) 27,27,28
26     A(K-1)=AZY
       GO TO 29
27     A(K-1)=-AZY
       GO TO 29
28     A(K-1)=TAN(SAR(K-1))
29     KK=MCD(K,IT)
       GO TO (31,30), KK
30     Y(K)=YS(IT)+(YREF(K)-YS(IT))*COS(SAI)-(XREF(K)-XS(IT))*SIN(SAI)
       X(K)=XS(IT)+(XREF(K)-XS(IT))*COS(SAI)+(YREF(K)-YS(IT))*SIN(SAI)
       GO TO 21
C      DETERMINE THE TRAILING EDGE INTERSECTION
C         BETWEEN FIXED AND VARIABLE SWEEP WING SECTIONS
31     IF (ABS(RSAR(K)-SAR(K-1)).LT.(.1/RAD)) GO TO 32
       Y(K)=XREF(K+1)-X(K-1)-A(K)*YREF(K+1)+A(K-1)*Y(K-1)
       Y(K)=Y(K)/(A(K-1)-A(K))
       X(K)=A(K)*X(K-1)-A(K-1)*XREF(K+1)+A(K-1)*A(K)*(YREF(K+1)-Y(K-1))
       X(K)=X(K)/(A(K)-A(K-1))
       GO TO 33
32     X(K)=XREF(K+1)
       Y(K)=YREF(K+1)
33     K=K+1
C      STORE REFERENCE PLANFORM COORDINATES ON INBOARD FIXED TRAILING
C      EDGE
       DO 34 I=K,N1
       X(I)=XREF(I)
       Y(I)=YREF(I)
34     SAR(I-1)=RSAR(I-1)
35     DO 36 I=1,N
       XX(I,IT)=X(I)
       YY(I,IT)=Y(I)
       MMCD(I,IT)=MCD(I,IT)
       TTWD(I,IT)=DIH(I,IT)
36     AS(I,IT)=A(I)
       XX(N1,IT)=X(N1)
       YY(N1,IT)=Y(N1)
       AN(IT)=AAN(IT)
37     CONTINUE
C
C        LINE UP BREAKPOINTS AMONG PLANFORMS
C
       BOTSV(1)=BOTSV(2)=0.
       WRITE (6,108)
       DO 49 IT=1,IPLAN
       NIT=AN(IT)+1
       DO 43 ITT=1,IPLAN
       IF (ITT.EQ.IT) GO TO 43
       NITT=AN(ITT)+1
       DO 42 I=1,NITT
       JPSV=0
       DO 38 JP=1,NIT
       IF (YY(JP,IT).EQ.YY(I,ITT)) GO TO 42
38     CONTINUE
       DO 39 JP=1,NIT
       IF (YY(JP,IT).LT.YY(I,ITT)) GO TO 40
39     CONTINUE
       GO TO 42
40     IF(JP.EQ.1) GO TO 42
       JPSV=JP
       IND=NIT-(JPSV-1)
       DO 41 JP=1,IND
```

```
      K2=NIT-JP+2
      K1=NIT-JP+1
      XX(K2,IT)=XX(K1,IT)
      YY(K2,IT)=YY(K1,IT)
      MMCD(K2,IT)=MMCD(K1,IT)
      AS(K2,IT)=AS(K1,IT)
41    TTWD(K2,IT)=TTWD(K1,IT)
      YY(JPSV,IT)=YY(I,ITT)
      AS(JPSV,IT)=AS(JPSV-1,IT)
      TTWD(JPSV,IT)=TTWD(JPSV-1,IT)
      XX(JPSV,IT)=(YY(JPSV,IT)-YY(JPSV-1,IT))*AS(JPSV-1,IT)+XX(JPSV-1,IT
     1)
      MMCD(JPSV,IT)=MMCD(JPSV-1,IT)
      AN(IT)=AN(IT)+1.
      NIT=NIT+1
42    CONTINUE
43    CONTINUE
C
C     SEQUENCE WING COORDINATES FROM TIP TO ROOT
C
      N1=AN(IT)+1.
      DO 44 I=1,N1
44    Q(I)=YY(I,IT)
      DO 48 J=1,N1
      HIGH=1.
      DO 45 I=1,N1
      IF ((Q(I)-HIGH).GE.0.) GO TO 45
      HIGH=Q(I)
      IH=I
45    CONTINUE
      IF (J.NE.1) GO TO 46
      BOTSV(IT)=HIGH
      KFX(IT)=IH
46    Q(IH)=1.
      SPY(J,IT)=HIGH
      IF (IH.GT.KFX(IT)) GO TO 47
      IYL(J,IT)=1
      IYT(J,IT)=0
      GO TO 48
47    IYL(J,IT)=0
      IYT(J,IT)=1
48    CONTINUE
49    CONTINUE
C
C     SELECT MAXIMUM B/2 AS THE WING SEMISPAN.   IF BOTH FIRST AND
C     SECOND PLANFORMS HAVE SAME SEMISPAN THEN THE SECOND PLANFORM IS
C     TAKEN TO BE THE WING.
C
      KBOT=1
      IF (BOTSV(1).GE.BOTSV(2)) KBOT=2
      BOT=BOTSV(KBOT)
C
C     COMPUTE NOMINAL HORSESHOE VORTEX WIDTH ALONG WING SURFACE
C
      TSPAN=0
      ISAVE=KFX(KBOT)-1
      I=KFX(KBOT)-2
50    IF (I.EQ.0) GO TO 51
      IF (TTWD(I,KBOT).EQ.TTWD(ISAVE,KBOT)) GO TO 52
51    CTWD=COS(ATAN(TTWD(ISAVE,KBOT)))
```

```
      TLGTH=(YY(ISAVE+1,KBOT)-YY(I+1,KBOT))/CTWD
      TSPAN=TSPAN+TLGTH
      IF (I.EQ.0) GO TO 53
      ISAVE=I
52    I=I-1
      GO TO 50
53    VI=TSPAN/VIC
      VSTOL=VI/2
C
      TSPANA=0.
      KBIT=2
      IF (IPLAN.EQ.1) GO TO 57
      IF (KBOT.EQ.2) KBIT=1
      ISAVEA=KFX(KBIT)-1
      IA=KFX(KBIT)-2
54    IF (IA.EQ.0) GO TO 55
      IF (TTWD(IA,KBIT).EQ.TTWD(ISAVEA,KBIT)) GO TO 56
55    CTWDA=COS(ATAN(TTWD(ISAVEA,KBIT)))
      TLGTHA=(YY(ISAVEA+1,KBIT)-YY(IA+1,KBIT))/CTWDA
      TSPANA=TSPANA+TLGTHA
      IF (IA.EQ.0) GO TO 57
      ISAVEA=IA
56    IA=IA-1
      GO TO 54
57    CONTINUE
C     ELIMINATE PLANFORM BREAKPOINTS WHICH ARE WITHIN (B/2)/2000 UNITS
C     LATERALLY
C
      DO 59 IT=1,IPLAN
      N=AN(IT)
      N1=N+1
      DO 59 J=1,N
      AA=ABS(SPY(J,IT)-SPY(J+1,IT))
      IF (AA.EQ.0..OR.AA.GT.ABS(TSPAN/2000.)) GO TO 59
      IF (AA.GT.YTOL) WRITE (6,111) SPY(J+1,IT),SPY(J,IT)
      DO 58 I=1,N1
      IF (YY(I,IT).NE.SPY(J+1,IT)) GO TO 58
      YY(I,IT)=SPY(J,IT)
58    CONTINUE
      SPY(J+1,IT)=SPY(J,IT)
59    CONTINUE
C
C     COMPUTE Z COORDINATES
C
      DO 63 IT=1,IPLAN
      JM=N1=AN(IT)+1.
      DO 60 JZ=1,N1
60    ZZ(JZ,IT)=RTCDHT(IT)
      JZ=1
61    JZ=JZ+1
      IF (JZ.GT.KFX(IT)) GO TO 62
      ZZ(JZ,IT)=ZZ(JZ-1,IT)+(YY(JZ,IT)-YY(JZ-1,IT))*TTWD(JZ-1,IT)
      GO TO 61
62    JM=JM-1
      IF (JM.EQ.KFX(IT)) GO TO 63
      ZZ(JM,IT)=ZZ(JM+1,IT)+(YY(JM,IT)-YY(JM+1,IT))*TTWD(JM,IT)
      GO TO 62
63    CONTINUE
C
C     WRITE PLANFORM PERIMETER POINTS ACTUALLY USED IN THE COMPUTATIONS
```

```
C
      WRITE (6,100)
      DO 65 IT=1,IPLAN
      N=AN(IT)
      N1=N+1
      IF (IT.EQ.2) WRITE (6,110)
      DO 64 KK=1,N
      TOUT=ATAN(TTWD(KK,IT))*RAD
      AOUT=ATAN(AS(KK,IT))*RAD
      IF (AS(KK,IT).EQ.AZY) AOUT=90.
      WRITE (6,101) KK,XX(KK,IT),YY(KK,IT),ZZ(KK,IT),AOUT,TOUT,MMCD(KK,I
     1T)
64    CONTINUE
      WRITE (6,101) N1,XX(N1,IT),YY(N1,IT),ZZ(N1,IT)
65    CONTINUE
C
C     PART ONE - SECTION THREE - LAY OUT YAWED HORSESHOE VORTICES
C
      STRUE=0.
      NSSWSV(1)=NSSWSV(2)=MSV(1)=MSV(2)=0
      DO 74 IT=1,IPLAN
      N1=AN(IT)+1.
      I=0
      J=1
      YIN=BOTSV(IT)
      ILE=ITE=KFX(IT)
C     DETERMINE SPANWISE BORDERS OF HORSESHOE VORTICES
66    IXL=IXT=0
      I=I+1
      IF (YIN.GE.(SPY(J,IT)+VSTOL)) GO TO 67
C     BORDER IS WITHIN VORTEX SPACING TOLERANCE (VSTOL) OF BREAKPOINT
C     THEREFORE USE THE NEXT BREAKPOINT INBOARD FOR THE BORDER
      VBORD(I)=YIN
      GO TO 70
C     USE NOMINAL VORTEX SPACING TO DETERMINE THE BORDER
67    VBORD(I)=SPY(J,IT)
C     COMPUTE SUBSCRIPTS ILE AND ITE TO INDICATE WHICH
C     BREAKPOINTS ARE ADJACENT AND WHETHER THEY ARE ON THE WING LEADING
C       EDGE OR THE TRAILING EDGE
68    IF (J.GE.N1) GO TO 69
      IF (SPY(J,IT).NE.SPY(J+1,IT)) GO TO 69
      IXL=IXL+IYL(J,IT)
      IXT=IXT+IYT(J,IT)
      J=J+1
      GO TO 68
69    YIN=SPY(J,IT)
      IXL=IXL+IYL(J,IT)
      IXT=IXT+IYT(J,IT)
      J=J+1
70    CPHI=COS(ATAN(TTWD(ILE,IT)))
      IPHI=ILE-IXL
      IF (J.GE.N1) IPHI=1
      YIN=YIN-VI*COS(ATAN(TTWD(IPHI,IT)))
      IF (I.NE.1) GO TO 72
71    ILE=ILE-IXL
      ITE=ITE+IXT
      GO TO 66
C     COMPUTE COORDINATES FOR CHORDWISE ROW OF HORSESHOE VORTICES
72    YQ=(VBORD(I-1)+VBORD(I))/2.
      HW=(VBORD(I)-VBORD(I-1))/2.
```

```
      IM1=I-1+NSSWSV(1)
      ZH(IM1)=ZZ(ILE,IT)+(YQ-YY(ILE,IT))*TTWD(ILE,IT)
      PHI(IM1)=TTWD(ILE,IT)
      SSWWA(IM1)=AS(ILE,IT)
      XLE=XX(ILE,IT)+AS(ILE,IT)*(YQ-YY(ILE,IT))
      XET=XX(ITE,IT)+AS(ITE,IT)*(YQ-YY(ITE,IT))
      XLOCAL=(XLE-XET)/TBLSCW(IM1)
C
C     COMPUTE WING AREA PROJECTED TO THE X - Y PLANE
C
      STRUE=STRUE+XLOCAL*TBLSCW(IM1)*(HW*2.)*2.
C
      NSCW=TBLSCW(IM1)
      DO 73 JCW=1,NSCW
      AJCW=JCW-1
      XLEL=XLE-AJCW*XLOCAL
      NTS=JCW+MSV(1)+MSV(2)
      PN(NTS)=XLEL-.25*XLOCAL
      PV(NTS)=XLEL-.75*XLOCAL
      PSI(NTS)=((XLE-PN(NTS))*AS(ITE,IT)+(PN(NTS)-XET)*AS(ILE,IT))/(XLE-
     1XET)*CPHI
      S(NTS)=HW/CPHI
      Q(NTS)=YQ
   73 CONTINUE
      MSV(IT)=MSV(IT)+NSCW
C
C     TEST TO DETERMINE WHEN WING ROOT IS REACHED
      IF(VBORD(I).LT.YREG(1,IT)) GO TO 71
C
      NSSWSV(IT)=I-1
   74 CONTINUE
      M=MSV(1)+MSV(2)
C
C     COMPUTE ASPECT RATIO  AND  AVERAGE CHORD
C
      BOT=-BOT
      AR=4.*BOT*BOT/SREF
      ARTRUE=4.*BOT*BOT/STRUE
      CAVE=STRUE/(2.*BOT)
      BETA=(1.-MACH*MACH)**.5
      WRITE (6,114) M
      WRITE (6,115) (IT,MSV(IT),NSSWSV(IT),IT=1,IPLAN)
      IF (SCW.NE.0.) WRITE (6,112) SCW
      IF (SCW.EQ.0.) WRITE (6,113) (TBLSCW(I),I=1,NSTA)
C
C     APPLY PRANDTL-GLAUERT CORRECTION
C
      DO 75 NV=1,M
      PSI(NV)=ATAN(PSI(NV)/BETA)
      PN(NV)=PN(NV)/BETA
   75 PV(NV)=PV(NV)/BETA
      NSSW=NSSWSV(1)+NSSWSV(2)
      JN=0
      DO 77 JSSW=1,NSSW
      CHORD(JSSW)=0.
      NSCW=TBLSCW(JSSW)
      DO 76 JSCW=1,NSCW
      JN=JN+1
      CHORD(JSSW)=CHORD(JSSW)-2.*(PV(JN)-PN(JN))*BETA
   76 CONTINUE
```

```
 77    XTE(JSSW)=(PV(JN)+(PV(JN)-PN(JN))/2.)*BETA
       PHISUM=0.
       DO 78 IKY=1,NSSW
       PHISUM=PHISUM+PHI(IKY)
 78    CONTINUE
       IFLAG=1
       IF (IPLAN.EQ.1.AND.PHISUM.NE.0.) IFLAG=2
       IF (IPLAN.EQ.2.AND.PHISUM.NE.0.) GO TO 79
       GO TO 83
 79    DO 81 IP=1,IPLAN
       IA=1+(IP-1)*NSSWSV(1)
       IB=NSSWSV(1)+(IP-1)*NSSWSV(2)
       IC=1-(IP-2)*NSSWSV(1)
       ID=NSSWSV(1)-(IP-2)*NSSWSV(2)
       DO 80 IU=IA,IB
       DO 80 IZ=IC,ID
       IF (ZH(IU).EQ.ZH(IZ)) GO TO 82
 80    CONTINUE
 81    CONTINUE
       IFLAG=2
       GO TO 83
 82    IFLAG=3
 83    CONTINUE
       READ (5,122) XCFW,XCFT
       IF (M.GT.400) GO TO 86
       NSW=NSSWSV(1)+NSSWSV(2)
       IF (NSW.GT.50) GO TO 85
       ITSV=0
       DO 84 IT=1,IPLAN
       IF (AN(IT).LE.25.) GO TO 84
       WRITE (6,118) IT,AN(IT)
       ITSV=1
 84    CONTINUE
       IF (ITSV.GT.0) GO TO 91
       GO TO 87
 85    WRITE (6,117) NSW
       GO TO 91
 86    WRITE (6,116) M
       GO TO 91
 87    REWIND 25
       WRITE (25) BOT,M,BETA,PTEST,QTEST,TBLSCW,Q,PN,PV,S,PSI,PHI,ZH,NSSW
      1,TWIST,CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTCDHT,CONFIG,NSSWSV,M
      2SV,KBOT,PLAN,IPLAN,MACH,SSWWA,CHORD,XTE,KBIT,TSPAN,TSPANA,XCFW,XCF
      3T,IFLAG,YREG(1,1),YREG(1,2)
       END FILE 25
       GO TO (88,89,90), IFLAG
 88    WRITE (6,119)
       WRITE (50,123)
       GO TO 92
 89    WRITE (6,120)
       WRITE (50,124)
       GO TO 92
 90    WRITE (6,121)
       WRITE (50,125)
       GO TO 92
 91    TOTAL=TOTAL-1.
       WRITE (50,126)
 92    CONTINUE
       END FILE 50
       STOP
```

```
93    ICODEOF=1
      WRITE (6,103) CONFIG
      GO TO 91
94    ICODEOF=2
      WRITE (6,104) K,IT
      GO TO 91
95    ICODEOF=3
      WRITE (6,107) PTEST,QTEST
      GO TO 91
C
C
96    FORMAT (1H1//63X,13HGEOMETRY DATA)
97    FORMAT (///45X,A10,22HREFERENCE PLANFORM HAS,I3,7H CURVES//12X,19H
     1ROOT CHORD HEIGHT =,F12.5,4X,29HVARIABLE SWEEP PIVOT POSITION,4X,6
     2HX(S) =,F12.5,5X,6HY(S) =,F12.5//46X,40HBREAK POINTS FOR THE REFER
     3ENCE PLANFORM /)
98    FORMAT (8F10.4)
99    FORMAT (1H1//47X,17HCONFIGURATION NO.,F8.0/)
100   FORMAT (22X,5HPOINT,6X,1HX,11X,1HY,11X,1HZ,10X,5HSWEEP,7X,8HDIHEDR
     1AL,4X,4HMOVE/68X,5HANGLE,8X,5HANGLE,6X,4HCODE/)
101   FORMAT (20X,I5,3F12.5,2F14.5,I6)
102   FORMAT (/40X,5HCURVE,I3,9H IS SWEPT,F12.5,20H DEGREES ON PLANFORM,
     1I3)
103   FORMAT (1H1///41X,43HEND OF FILE ENCOUNTERED AFTER CONFIGURATION,F
     17.0)
104   FORMAT (1H1///18X,45HTHE FIRST VARIABLE SWEEP CURVE SPECIFIED (K =
     1,I3,44H ) DOES NOT HAVE AN M CODE OF 2 FOR PLANFORM,I4)
 105  FORMAT(5F5.1,2F10.4)
106   FORMAT (26X,I5,2F12.5,2F16.5,4X,I4)
107   FORMAT (1H1///1X,38HERROR - PROGRAM CANNOT PROCESS PTEST =,F5.1,12
     1H AND QTEST =,F5.1)
108   FORMAT (//48X,35HBREAK POINTS FOR THIS CONFIGURATION//)
109   FORMAT (28X,5HPOINT,6X,1HX,11X,1HY,11X,5HSWEEP,10X,8HDIHEDRAL,7X,4
     1HMOVE/38X,3HREF,9X,3HREF,10X,5HANGLE,11X,5HANGLE,9X,4HCODE/)
110   FORMAT (/52X,28HSECOND PLANFORM BREAK POINTS/)
111   FORMAT (////25X,34HTHE BREAKPOINT LOCATED SPANWISE AT,F11.5,3X,20H
     1HAS BEEN ADJUSTED TO,F9.5////)
112   FORMAT (/43X,F5.0,41H HORSESHOE VORTICES IN EACH CHORDWISE ROW)
113   FORMAT (/23X,98HTABLE OF HORSESHOE VORTICES IN EACH CHORDWISE ROW
     1(FROM TIP TO ROOT BEGINNING WITH FIRST PLANFORM)//25F5.0/25F5.0)
114   FORMAT (///33XI5,62H HORSESHOE VORTICES USED ON THE LEFT HALF OF T
     1HE CONFIGURATION//50X,36HPLANFORM       TOTAL        SPANWISE/)
115   FORMAT (52X,I4,10X,I3,11X,I4)
116   FORMAT (1H1//10X,I6,93HHORSESHOE VORTICES LAIDOUT, THIS IS MORE TH
     1AN THE 400 MAXIMUM. THIS CONFIGURATION IS ABORTED.)
117   FORMAT (1H1//10X,I6,101H ROWS OF HORSESHOE VORTICES LAIDOUT. THIS
     1IS MORE THAN THE 50 MAXIMUM. THIS CONFIGURATION IS ABORTED.)
118   FORMAT (1H1//10X,8HPLANFORM,I6,4H HAS,I6,74H BREAKPOINTS. THE MAXI
     1MUM DIMENSIONED IS 25. THE CONFIGURATION IS ABORTED.)
119   FORMAT (///20X,28HMINIMUM FIELD LENGTH = 51000)
120   FORMAT (///20X,28HMINIMUM FIELD LENGTH = 63000)
121   FORMAT (///20X,29HMINIMUM FIELD LENGTH = 112000)
122   FORMAT (6F10.4)
123   FORMAT (35H*COMPILE VLMCDRAGS,VLMCCIR1,VLMCZOC)
124   FORMAT (35H*COMPILE VLMCDRAGS,VLMCCIR2,VLMCZOC)
125   FORMAT (35H*COMPILE VLMCDRAGS,VLMCCIR3,VLMCZOC)
126   FORMAT (18H*COMPILE VLMCDUMMY)
      END
```

APPENDIX E

```
*DECK VLMCDRAGS
      OVERLAY(WINGTL,0,0)                                                DG0
      PROGRAM WINGAL(OUTPUT,TAPE6=OUTPUT,TAPE10,TAPE20,TAPE25)           DG0
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(4DG0
     100),S(400),PSI(400),PHI(50),ZH(50),NSSW                            DG0
      COMMON /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTCDG0
     1DHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50),XCFWDG0
     2,XCFT,YREG(1,2)                                                    DG0
      COMMON /TOTHRE/ CIR(400)                                           DG0
      COMMON /CCRRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA                DG0
      REAL MACH                                                          DG0
C                                                                        DG0
C                                                                        DG0
C        VORTEX LATTICE AERODYNAMIC COMPUTATION                          DG0
C                                                                        DG0
      REWIND 25                                                          DG0
      READ (25) BOT,M,BETA,PTEST,QTEST,TBLSCW,Q,PN,PV,S,PSI,PHI,ZH,NSSW,DG0
     1TWIST,CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTCDHT,CONFIG,NSSWSV,MSDG0
     2V,KBOT,PLAN,IPLAN,MACH,SSWWA,CHORD,XTE,KBIT,TSPAN,TSPANA,XCFW,XCFTDG0
     3 ,IFLAG,YREG(1,1),YREG(1,2)                                        DG0
C                                                                        DG0
C                                                                        DG0
C                                                                        DG0
      WINGTL=6LWINGTL                                                    DG0
      RECALL=6HRECALL                                                    DG0
C                                                                        DG0
C                                                                        DG0
C                                                                        DG0
      CALL OVERLAY (WINGTL,1,0,RECALL)                                   DG0
C                                                                        DG0
      CALL OVERLAY (WINGTL,2,0,RECALL)                                   DG0
      STOP                                                               DG0
      END                                                                DG0
```

```
      SUBROUTINE FTLUP (X,Y,M,N,VARI,VARD)
C     ***DOCUMENT DATE 09-12-69    SUBROUTINE REVISED 07-07-69 *********
C        MODIFICATION OF LIBRARY INTERPOLATION SUBROUTINE  FTLUP
      DIMENSION VARI(1), VARD(1), V(3), YY(2)
      DIMENSION II(43)
C
C      INITIALIZE ALL INTERVAL POINTERS TO -1.0   FOR MONOTONICITY CHECK
      DATA (II(J),J=1,43)/43*-1/
      MA=IABS(M)
C
C             ASSIGN INTERVAL POINTER FOR GIVEN VARI TABLE
C      THE SAME POINTER WILL BE USED ON A GIVEN VARI TABLE EVERY TIME
      LI=MOD(LOCF(VARI(1)),43)+1
      I=II(LI)
      IF (I.GE.0) GO TO 6
      IF (N.LT.2) GO TO 6
C
C     MONOTONICITY CHECK
      IF (VARI(2)-VARI(1)) 2,2,4
C     ERROR IN MONOTONICITY
1     K=LOCF(VARI(1))
      PRINT 17, J,K,(VARI(J),J=1,N),(VARD(J),J=1,N)
      STOP
C     MONOTONIC DECREASING
2     DO 3 J=2,N
      IF (VARI(J)-VARI(J-1)) 3,1,1
3     CONTINUE
      GO TO 6
C     MONOTONIC INCREASING
4     DO 5 J=2,N
      IF (VARI(J)-VARI(J-1)) 1,1,5
5     CONTINUE
C
C     INTERPOLATION
6     IF (I.LE.0) I=1
      IF (I.GE.N) I=N-1
      IF (N.LE.1) GO TO 7
      IF (MA.NE.0) GO TO 8
C     ZERO ORDER
7     Y=VARD(1)
      GO TO 16
C     LOCATE I INTERVAL (X(I).LE.X.LT.X(I+1))
8     IF ((VARI(I)-X)*(VARI(I+1)-X)) 11,11,9
C     IN GIVES DIRECTION FOR SEARCH OF INTERVALS
9     IN=SIGN(1.0,(VARI(I+1)-VARI(I))*(X-VARI(I)))
C     IF X OUTSIDE ENDPOINTS, EXTRAPOLATE FROM END INTERVAL
10    IF ((I+IN).LE.0) GO TO 11
      IF ((I+IN).GE.N) GO TO 11
      I=I+IN
      IF ((VARI(I)-X)*(VARI(I+1)-X)) 11,11,10
11    IF (MA.EQ.2) GO TO 12
C
C     FIRST ORDER
      Y=(VARD(I)*(VARI(I+1)-X)-VARD(I+1)*(VARI(I)-X))/(VARI(I+1)-VARI(I)
     1)
      GO TO 16
C
C     SECOND ORDER
12    IF (N.EQ.2) GO TO 1
      IF (I.EQ.(N-1)) GO TO 14
```

```
      IF (I.EQ.1) GO TO 13
C     PICK THIRD POINT
      SK=VARI(I+1)-VARI(I)
      IF ((SK*(X-VARI(I-1))).LT.(SK*(VARI(I+2)-X))) GO TO 14
13    L=I
      GO TO 15
14    L=I-1
15    V(1)=VARI(L)-X
      V(2)=VARI(L+1)-X
      V(3)=VARI(L+2)-X
      YY(1)=(VARD(L)*V(2)-VARD(L+1)*V(1))/(VARI(L+1)-VARI(L))
      YY(2)=(VARD(L+1)*V(3)-VARD(L+2)*V(2))/(VARI(L+2)-VARI(L+1))
      Y=(YY(1)*V(3)-YY(2)*V(1))/(VARI(L+2)-VARI(L))
16    II(LI)=I
      RETURN
C
C
17    FORMAT (1H1,50H TABLE BELOW OUT OF ORDER FOR FTLUP  AT POSITION ,
     1I5,/31H X TABLE IS STORED IN LOCATION ,O6,//(8G15.8))
      END
```

APPENDIX E

```
      SUBROUTINE SIMEQ (A,N,B,M,DETERM,IPIVOT,NMAX,ISCALE)
C     SOLUTION OF SIMULTANEOUS LINEAR EQUATIONS
C     *** DOCUMENT DATE 08-01-68   SUBROUTINE REVISED 08-01-68 *********
C
      DIMENSION IPIVOT(N), A(NMAX,N), B(NMAX,M)
      EQUIVALENCE (IROW,JROW), (ICOLUM,JCOLUM), (AMAX,T,SWAP)
C
C     INITIALIZATION
C
1     ISCALE=0
      R1=10.0**100
      R2=1.0/R1
      DETERM=1.0
      DO 2 J=1,N
2     IPIVOT(J)=0
      DO 38 I=1,N
C
C     SEARCH FOR PIVOT ELEMENT
C
      AMAX=0.0
      DO 7 J=1,N
      IF (IPIVOT(J)-1) 3,7,3
3     DO 6 K=1,N
      IF (IPIVOT(K)-1) 4,6,39
4     IF (ABS(AMAX)-ABS(A(J,K))) 5,6,6
5     IROW=J
      ICOLUM=K
      AMAX=A(J,K)
6     CONTINUE
7     CONTINUE
      IF (AMAX) 9,8,9
8     DETERM=0.0
      ISCALE=0
      GO TO 39
9     IPIVOT(ICOLUM)=IPIVOT(ICOLUM)+1
C
C     INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
      IF (IROW-ICOLUM) 10,14,10
10    DETERM=-DETERM
      DO 11 L=1,N
      SWAP=A(IROW,L)
      A(IROW,L)=A(ICOLUM,L)
11    A(ICOLUM,L)=SWAP
      IF (M) 14,14,12
12    DO 13 L=1,M
      SWAP=B(IROW,L)
      B(IROW,L)=B(ICOLUM,L)
13    B(ICOLUM,L)=SWAP
14    PIVOT=A(ICOLUM,ICOLUM)
      IF (PIVOT) 15,8,15
C
C     SCALE THE DETERMINANT
C
15    PIVOTI=PIVOT
      IF (ABS(DETERM)-R1) 18,16,16
16    DETERM=DETERM/R1
      ISCALE=ISCALE+1
      IF (ABS(DETERM)-R1) 21,17,17
17    DETERM=DETERM/R1
```

APPENDIX E

```
      ISCALE=ISCALE+1
      GO TO 21
18    IF (ABS(DETERM)-R2) 19,19,21
19    DETERM=DETERM*R1
      ISCALE=ISCALE-1
      IF (ABS(DETERM)-R2) 20,20,21
20    DETERM=DETERM*R1
      ISCALE=ISCALE-1
21    IF (ABS(PIVOTI)-R1) 24,22,22
22    PIVOTI=PIVOTI/R1
      ISCALE=ISCALE+1
      IF (ABS(PIVOTI)-R1) 27,23,23
23    PIVOTI=PIVOTI/R1
      ISCALE=ISCALE+1
      GO TO 27
24    IF (ABS(PIVOTI)-R2) 25,25,27
25    PIVOTI=PIVOTI*R1
      ISCALE=ISCALE-1
      IF (ABS(PIVOTI)-R2) 26,26,27
26    PIVOTI=PIVOTI*R1
      ISCALE=ISCALE-1
27    DETERM=DETERM*PIVOTI
C
C     DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
      DO 29 L=1,N
      IF (IPIVOT(L)-1) 28,29,39
28    A(ICOLUM,L)=A(ICOLUM,L)/PIVOT
29    CONTINUE
      IF (M) 32,32,30
30    DO 31 L=1,M
31    B(ICOLUM,L)=B(ICOLJM,L)/PIVOT
C
C     REDUCE NON-PIVOT ROWS
C
32    DO 38 L1=1,N
      IF (L1-ICOLUM) 33,38,33
33    T=A(L1,ICOLUM)
      DO 35 L=1,N
      IF (IPIVOT(L)-1) 34,35,39
34    A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
35    CONTINUE
      IF (M) 38,38,36
36    DO 37 L=1,M
37    B(L1,L)=B(L1,L)-B(ICOLUM,L)*T
38    CONTINUE
39    RETURN
      END
```

APPENDIX E

```
SUBROUTINE DRAGSUB (R,A,Y,Z,S,IS,JS,WNK)
REAL IS,JS
ZP=Z+S*SIN(A)
YP=Y+S*COS(A)
ZM=Z-S*SIN(A)
YM=Y-S*COS(A)
RL=SQRT(ZP**2+YP**2)
RR=SQRT(ZM**2+YM**2)
ZPOYP=ZP/YP
ZMOYM=ZM/YM
PHILTLJ=ATAN(ZPOYP)
PHIRTLJ=ATAN(ZMOYM)
PLMPI=PHILTLJ-R
PRMPI=PHIRTLJ-R
COSPLI=COS(PLMPI)
COSPRI=COS(PRMPI)
WNK=IS*COSPLI/RL-JS*COSPRI/RR
RETURN
END
```

APPENDIX E

```
*DECK VLMCCIR1
      OVERLAY(WINGTL,1,0)                                               DG1
      PROGRAM CIRCUL1                                                   DG1
      DIMENSION A0(2), B0(2), A1(2), B1(2), C1(2), D1(2), ISUM(2), ISUMPDG1
     1(2), ISUMP2(2), PPP(100), WN(2), YY(2), ZZH(50), ZHH(100), YB(50),DG1
     2 Y(100), PPHI(50), XTT(50), XTA(100), CHD(100), A(8,8), CDRAG(8), DG1
     3IPIVOT(8), GAM(100,6), NMA(2), YQ(100), YQQ(50), YC(100), YA(100) DG1
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(4DG1
     100),S(400),PSI(400),PHI(50),ZH(50),NSSW                           DG1
      COMMON /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTCDG1
     1DHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50),XCFWDG1
     2,XCFT,YREG(1,2)                                                   DG1
      COMMON /TOTHRE/ CIR(400)                                          DG1
      COMMON /CCRRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA               DG1
      REAL ISIGN,JSIGN                                                  DG1
C                                                                       DG1
C                                                                       DG1
      TOLC=(BOT*15.E-05)**2                                             DG1
C                                                                       DG1
C                                                                       DG1
      NMA(1)=NMA(2)=0                                                   DG1
      PI=4.*ATAN(1.)                                                    DG1
      RAD=180./PI                                                       DG1
      BOTL=ABS(TSPAN)                                                   DG1
      BOL=ABS(TSPANA)                                                   DG1
      SNN=BOTL/(2.*NSSWSV(KBOT))                                        DG1
      DELTYB=2.*SNN                                                     DG1
      NMA(KBOT)=BOTL/DELTYB                                             DG1
      NMA(KBIT)=BOL/DELTYB                                              DG1
      NMAX=NMA(1)+NMA(2)                                                DG1
      LM=1                                                              DG1
      IF (IPLAN.EQ.2) LM=6                                              DG1
      IL=LM+1                                                           DG1
      JM=LM+2                                                           DG1
      IF (LM.EQ.1) JM=IL                                                DG1
      IM=LM+2                                                           DG1
      DO 1 I=1,IM                                                       DG1
      CDRAG(I)=0.                                                       DG1
      DO 1 J=1,IM                                                       DG1
1     A(I,J)=0.                                                         DG1
      DO 2 I=1,NMAX                                                     DG1
      DO 2 J=1,LM                                                       DG1
      GAM(I,J)=0.                                                       DG1
2     CONTINUE                                                          DG1
      CDRAG(IL)=CLDES                                                   DG1
      CDRAG(IM)=0.0                                                     DG1
C                                                                       DG1
      SCWMIN=20.                                                        DG1
      DO 3 I=1,NSSW                                                     DG1
3     SCWMIN=AMIN1(SCWMIN,TBLSCW(I))                                    DG1
      NSCWMIN=SCWMIN                                                    DG1
      II=1                                                              DG1
      DO 15 I=1,IPLAN                                                   DG1
      BOTT=BOTL                                                         DG1
      IF (I.EQ.KBIT) BOTT=BOL                                           DG1
      IB=NSSWSV(I)                                                      DG1
      IC=MSV(1)+(I-1)*MSV(2)                                            DG1
      ID=IC+1                                                           DG1
      IZ=NSSWSV(1)+(I-1)*NSSWSV(2)                                      DG1
      D=XCFW                                                            DG1
      IF (I.EQ.2) D=XCFT                                                DG1
      AI=NSCWMIN*D+0.75                                                 DG1
```

```
      IMAX=INT(AI)
      IF (D.EQ.1.) GO TO 4
      B0(I)=-1./(NSCWMIN*(1.-D))
      A0(I)=IMAX-B0(I)*(NSCWMIN+0.75)*(NSCWMIN-IMAX)
      GO TO 5
4     B0(I)=0.
      A0(I)=IMAX
5     ISUM(I)=ISUMP(I)=ISUMP2(I)=0
      IF (IMAX.EQ.0) GO TO 7
      DO 6 IN=1,IMAX
6     ISUM(I)=ISUM(I)+IN
7     IMM=IMAX+1
      IF (IMM.GT.NSCWMIN) GO TO 9
      DO 8 IN=IMM,NSCWMIN
      ISUMP(I)=ISUMP(I)+IN
8     ISUMP2(I)=ISUMP2(I)+IN**2
9     IAMM=NMA(I)
      IUZ=NSSWSV(I)
      YCAT=YREG(1,I)
      DO 11 J=1,IUZ
      JJ=J+(I-1)*NSSWSV(1)
      ZZH(J)=ZH(JJ)
      PPHI(J)=PHI(JJ)
      XTT(J)=XTE(JJ)
      CIR(J)=CHORD(JJ)
      YQQ(J)=Q(II)
      YA(JJ)=YQQ(J)
      II=II+TBLSCW(JJ)
      IE=IB-J+1
      ITL=TBLSCW(IZ)
      ID=ID-ITL
      IA=ID+ITL
      IF (IA.GT.IC) YCAT=YCAT-S(ID)
      IF (IA.GT.IC) GO TO 10
      YCAT=YCAT-S(ID)-S(IA)
10    IZ=IZ-1
      YB(IE)=YCAT
11    CONTINUE
      DO 12 J=1,IUZ
      JJ=J+(I-1)*NSSWSV(1)
      YC(JJ)=YB(J)
12    CONTINUE
      YOB=-NMA(I)*2.*SNN-SNN+YREG(1,I)
      DO 14 K=1,IAMM
      KK=K+(I-1)*NMA(1)
      YOB=YOB+DELTYB
      Y(KK)=YOB
      CALL FTLUP (YOB,YQ(KK),+1,IUZ,YB,YQQ)
      CALL FTLUP (YOB,XTA(KK),+1,IUZ,YB,XTT)
      CALL FTLUP (YOB,CHD(KK),+1,IUZ,YB,CIR)
      CALL FTLUP (YOB,PPP(KK),+1,IUZ,YB,PPHI)
      CALL FTLUP (YOB,ZHH(KK),+1,IUZ,YB,ZZH)
      B1(I)=-CHD(KK)/NSCWMIN
      A1(I)=((XTA(KK)+CHD(KK))-0.75*B1(I))*A0(I)
      C1(I)=B0(I)*(XTA(KK)+2.*CHD(KK)-1.5*B1(I))
      D1(I)=B1(I)*B0(I)
C
C     THE FACTOR  8  IS USED INSTEAD OF THE FACTOR  4  TO TAKE INTO
C     ACCOUNT BOTH SIDES OF THE WING
C
```

```
      RB=A0(I)+B0(I)*ISUMP(I)
      CNNSTA=8.*SNN*COS(ATAN(PPP(KK)))/SREF
      RL=CNNSTA*RB
      RM=CNNSTA/CREF*(A1(I)+B1(I)*ISUM(I)+C1(I)*ISUMP(I)+D1(I)*ISUMP2(I)
     1)
      YBT=-YQ(KK)/BOTT
      SYT=SQRT(1.-YBT**2)
      DO 13 JZ=1,3
      IF (IPLAN.EQ.1.AND.JZ.GT.1) GO TO 13
      JR=JZ+(I-1)*3
      SRU=SYT*YBT**(2*(JZ-1))
      GAM(KK,JR)=RB*SRU
      A(JR,IL)=A(JR,IL)+RL*SRU
      A(JR,IM)=A(JR,IM)+RM*SRU
13    CONTINUE
14    CONTINUE
15    CONTINUE
C
C
      DO 16 K=1,LM
      A(IL,K)=A(K,IL)
      A(IM,K)=A(K,IM)
16    CONTINUE
C
C
C     THE -A- MATRIX STANDS FOR THE DRAG MATRIX -CDV-
C
C
      DO 21 I=1,NMAX
      RPHI=ATAN(PPP(I))
      DO 20 J=1,NMAX
      SPHI=ATAN(PPP(J))
      YY(1)=YQ(I)-YQ(J)
      YY(2)=YQ(I)+YQ(J)
      ZZ=ZHH(I)-ZHH(J)
      DO 18 K=1,2
      ISIGN=JSIGN=1.
      IF (K.EQ.2) GO TO 17
      IF (YY(1).LT.TOLC) JSIGN=-1.
      IF (YY(1).LT.(-TOLC)) ISIGN=-1.
17    YYY=YY(K)
      CALL DRAGSUB (RPHI,SPHI,YYY,ZZ,SNN,ISIGN,JSIGN,WN(K))
      SPHI=-SPHI
18    CONTINUE
      DO 19 KP=1,LM
      DO 19 KG=1,LM
      A(KP,KG)=A(KP,KG)+GAM(I,KP)*GAM(J,KG)*SNN*(WN(1)-WN(2))/(PI*SREF)
19    CONTINUE
20    CONTINUE
21    CONTINUE
C
C
      REWIND 10
      WRITE (10) ((A(I,J),I=1,JM),J=1,JM)
      END FILE 10
      REWIND 20
      DO 23 I=1,LM
      DO 22 J=1,LM
      XTA(J)=A(I,J)+A(J,I)
22    CONTINUE
```

```
      WRITE (20) (XTA(IK),IK=1,LM)
   23 CONTINUE
      END FILE 20
      REWIND 20
      DO 24 I=1,LM
      READ (20) (A(I,J),J=1,LM)
   24 CONTINUE
      CALL SIMEQ (A,JM,CDRAG,1,DETERM,IPIVOT,8,ISCALE)
      REWIND 10
      READ (10) ((A(I,J),I=1,JM),J=1,JM)
      CD=0.
      DO 25 I=1,LM
      DO 25 J=1,LM
   25 CD=CD+CDRAG(I)*A(I,J)*CDRAG(J)*2.
      JK=0
      DO 28 I=1,IPLAN
      BOTT=BOTL
      IF (I.EQ.KBIT) BOTT=BOL
      KA=1+(I-1)*NSSWSV(1)
      KB=NSSWSV(1)+(I-1)*NSSWSV(2)
      D=XCFW
      IF (I.EQ.2) D=XCFT
      DO 27 J=KA,KB
      YBT=-YA(J)/BOTT
      SYT=SQRT(1.-YBT**2)
      RJ=0.
      DO 26 JZ=1,3
      JR=JZ+(I-1)*3
      IF (IPLAN.EQ.1.AND.JZ.GT.1) GO TO 26
      SRJ=SYT*YBT**(2*(JZ-1))
      RJ=RJ+CDRAG(JR)*SRJ
   26 CONTINUE
      NSCW=TBLSCW(J)
      AI=NSCW*D+0.75
      IMAX=INT(AI)
      DO 27 K=1,NSCW
      JK=JK+1
      E=1.
      IF (K.GT.IMAX) E=(1.-(K-.75)/NSCW)/(1.-D)
      CIR(JK)=E*RJ
   27 CONTINUE
   28 CONTINUE
      WRITE (6,36) CLDES
      NR=0
      DO 29 NV=1,NSSW
      NSCW=TBLSCW(NV)
      NP=NR+1
      NR=NR+NSCW
      PHIPR=ATAN(PHI(NV))*RAD
      IF (NV.EQ.(NSSWSV(1)+1)) WRITE (6,37)
      DO 29 I=NP,NR
      PNPR=PN(I)*BETA
      PVPR=PV(I)*BETA
      PSIPR=ATAN(BETA*TAN(PSI(I)))*RAD
      WRITE (6,38) PNPR,PVPR,Q(I),ZH(NV),S(I),PSIPR,PHIPR,CIR(I)
   29 CONTINUE
      WRITE (6,34)
      WRITE (6,35) CREF,CAVE,STRUE,SREF,BOT,AR,ARTRUE,MACH
      CLTOT=CMTOT=0.
      DO 31 I=1,NSSW
```

APPENDIX E

```
      IF (I.EQ.1) WRITE (6,41)                                          DG1 241
      IF (I.EQ.(NSSWSV(1)+1)) WRITE (6,42)                              DG1 242
      SPANLD=0.                                                         DG1 243
      DO 30 IJ=1,NSCWMIN                                                DG1 244
      IK=(I-1)*NSCWMIN+IJ                                               DG1 245
      SPANLD=SPANLD+2.*CIR(IK)*COS(ATAN(PHI(I)))                        DG1 246
      CLTOT=CLTOT+8.*S(IK)*CIR(IK)/SREF*COS(ATAN(PHI(I)))               DG1 247
      CMTOT=CMTOT+8.*S(IK)*CIR(IK)*PN(IK)*BETA*COS(ATAN(PHI(I)))/(SREF*CDG1 247A
     1REF)                                                              DG1 247B
30    CONTINUE                                                          DG1 248
      WRITE (6,44) Q(IK),SPANLD                                         DG1 249
      IF (I.EQ.NSSWSV(1)) CL1=CLTOT                                     DG1 250
      IF (I.EQ.NSSWSV(1)) CM1=CMTOT                                     DG1 250A
      IF (I.EQ.NSSWSV(1)) WRITE (6,43) CL1,CM1                          DG1 251
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) CL2=CLTOT-CL1                       DG1 252
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) CM2=CMTOT-CM1                       DG1 252A
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) WRITE (6,43) CL2,CM2                DG1 253
31    CONTINUE                                                          DG1 254
C                                                                       DG1 255
      WRITE(6,39) CLDES,CLTOT,CMTOT,CD                                  DG1 256
C                                                                       DG1 257
32    CONTINUE                                                          DG1 258
33    CONTINUE                                                          DG1 259
      RETURN                                                            DG1 260
34    FORMAT (////4X,11H REF. CHORD,6X,25HC AVERAGE     TRUE AREA  ,2X,1DG1 261
     14HREFERENCE AREA,9X,3HB/2,8X,7HREF. AR,8X,7HTRUE AR,4X,11HMACH NUMDG1 262
     2BER/)                                                             DG1 263
35    FORMAT (8F15.5)                                                   DG1 264
36    FORMAT (1H1,///25X,1HX11X,1HX,11X,1HY,11X,1HZ,12X,1HS,5X,9HC/4 SWEDG1 265
     1EP,4X,8HDIHEDRAL,3X,10HGAMMA/U AT/24X,3HC/4,9X,4H3C/4,42X,5HANGLE,DG1 266
     27X,5HANGLE,4X,6HCLDES=,F7.4/)                                     DG1 267
37    FORMAT (/45X,45HSECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS/)   DG1 268
38    FORMAT (17X,8F12.5)                                               DG1 269
39    FORMAT (/////15X,11HCL DESIGN =,F10.6,5X,12HCL COMPUTED=,F10.6,5X,DG1 270
     112HCM COMPUTED=,F10.6,5X,5HCD V=,F10.6)                           DG1 271
40    FORMAT (/////15X,7HCL DES=,F10.6,5X,12HCL COMPUTED=,F10.6,5X,29HNODG1 272
     1 PITCHING MOMENT CONSTRAINT,5X,5HCD V=,F10.6)                     DG1 273
41    FORMAT (////40X,56HF I R S T    P L A N F O R M    S P A N    L O DG1 274
     1A D I N G//60X,1HY,11X,4HCL*C)                                    DG1 275
42    FORMAT (////40X,58HS E C O N D    P L A N F O R M    S P A N    L DG1 276
     1O A D I N G//60X,1HY,11X,4HCL*C)                                  DG1 277
43    FORMAT (//50X,30HCL DEVELOPED ON THIS PLANFORM=,F10.6/            DG1 278
     1            50X,30HCM DEVELOPED ON THIS PLANFORM=,F10.6)          DG1 278A
44    FORMAT (55XF10.5,3XF10.5)                                         DG1 279
      END                                                               DG1 280-
```

```
*DECK VLMCCIR2
      OVERLAY(WINGTL,1,0)                                               DG2
      PROGRAM CIRCUL2                                                   DG2
      DIMENSION A0(2), B0(2), A1(2), B1(2), C1(2), D1(2), ISUM(2), ISUMPDG2
     1(2), ISUMP2(2), PPP(100), WN(2), YY(2), ZZH(50), ZHH(100), YB(50),DG2
     2 Y(100), PPHI(50), XTT(50), XTA(102), CHD(100), A(102,102), CDRAG(DG2
     3102), IPIVOT(102), NMA(2), YQ(100), YQQ(50), YC(100)             DG2
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(4DG2
     100),S(400),PSI(400),PHI(50),ZH(50),NSSW                           DG2
      COMMON /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTCDG2
     1DHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50),XCFWDG2
     2,XCFT,YREG(1,2)                                                   DG2
      COMMON /TOTHRE/ CIR(400)                                          DG2
      COMMON /CCRRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA               DG2
      REAL ISIGN,JSIGN                                                  DG2
C                                                                       DG2
C                                                                       DG2
      TOLC=(BOT*15.E-05)**2                                             DG2
C                                                                       DG2
C                                                                       DG2
      NMA(1)=NMA(2)=0                                                   DG2
      PI=4.*ATAN(1.)                                                    DG2
      RAD=180./PI                                                       DG2
      BOTL=ABS(TSPAN)                                                   DG2
      BOL=ABS(TSPANA)                                                   DG2
      SNN=BOTL/100.                                                     DG2
      DELTYB=2.*SNN                                                     DG2
      NMA(KBOT)=BOTL/DELTYB                                             DG2
      NMA(KBIT)=BOL/DELTYB                                              DG2
      NMAX=NMA(1)+NMA(2)                                                DG2
      LM=NMAX                                                           DG2
      IL=LM+1                                                           DG2
      JM=LM+2                                                           DG2
      IF (LM.EQ.NMA(1)) JM=IL                                           DG2
      IM=LM+2                                                           DG2
      DO 1 I=1,IM                                                       DG2
      CDRAG(I)=0.                                                       DG2
      DO 1 J=1,IM                                                       DG2
1     A(I,J)=0.                                                         DG2
      CDRAG(IL)=CLDES                                                   DG2
      CDRAG(IM)=0.0                                                     DG2
C                                                                       DG2
      SCWMIN=20.                                                        DG2
      DO 2 I=1,NSSW                                                     DG2
2     SCWMIN=AMIN1(SCWMIN,TBLSCW(I))                                    DG2
      NSCWMIN=SCWMIN                                                    DG2
      II=1                                                              DG2
      DO 13 I=1,IPLAN                                                   DG2
      IB=NSSWSV(I)                                                      DG2
      IC=MSV(1)+(I-1)*MSV(2)                                            DG2
      ID=IC+1                                                           DG2
      IZ=NSSWSV(1)+(I-1)*NSSWSV(2)                                      DG2
      D=XCFW                                                            DG2
      IF (I.EQ.2) D=XCFT                                                DG2
      AI=NSCWMIN*D+0.75                                                 DG2
      IMAX=INT(AI)                                                      DG2
      IF (D.EQ.1.) GO TO 3                                              DG2
      B0(I)=-1./(NSCWMIN*(1.-D))                                        DG2
      A0(I)=IMAX-B0(I)*(NSCWMIN+0.75)*(NSCWMIN-IMAX)                    DG2
      GO TO 4                                                           DG2
3     B0(I)=0.                                                          DG2
      A0(I)=IMAX                                                        DG2
```

```
4     ISUM(I)=ISUMP(I)=ISUMP2(I)=0
      IF (IMAX.EQ.0) GO TO 6
      DO 5 IN=1,IMAX
5     ISUM(I)=ISUM(I)+IN
6     IMM=IMAX+1
      IF (IMM.GT.NSCWMIN) GO TO 8
      DO 7 IN=IMM,NSCWMIN
      ISUMP(I)=ISUMP(I)+IN
7     ISUMP2(I)=ISUMP2(I)+IN**2
8     IAMM=NMA(I)
      IUZ=NSSWSV(I)
      YCAT=YREG(1,I)
      DO 10 J=1,IUZ
      JJ=J+(I-1)*NSSWSV(1)
      ZZH(J)=ZH(JJ)
      PPHI(J)=PHI(JJ)
      XTT(J)=XTE(JJ)
      CIR(J)=CHORD(JJ)
      YQQ(J)=Q(II)
      II=II+TBLSCW(JJ)
      IE=IB-J+1
      ITL=TBLSCW(IZ)
      ID=ID-ITL
      IA=ID+ITL
      IF (IA.GT.IC) YCAT=YCAT-S(ID)
      IF (IA.GT.IC) GO TO 9
      YCAT=YCAT-S(ID)-S(IA)
9     IZ=IZ-1
      YB(IE)=YCAT
10    CONTINUE
      DO 11 J=1,IUZ
      JJ=J+(I-1)*NSSWSV(1)
      YC(JJ)=YB(J)
11    CONTINUE
      YOB=-NMA(I)*2.*SNN-SNN+YREG(1,I)
      DO 12 K=1,IAMM
      KK=K+(I-1)*NMA(1)
      YOB=YOB+DELTYB
      Y(KK)=YOB
      CALL FTLUP (YOB,YQ(KK),+1,IUZ,YB,YQQ)
      CALL FTLUP (YOB,XTA(KK),+1,IUZ,YB,XTT)
      CALL FTLUP (YOB,CHD(KK),+1,IUZ,YB,CIR)
      CALL FTLUP (YOB,PPP(KK),+1,IUZ,YB,PPHI)
      CALL FTLUP (YOB,ZHH(KK),+1,IUZ,YB,ZZH)
      B1(I)=-CHD(KK)/NSCWMIN
      A1(I)=((XTA(KK)+CHD(KK))-0.75*B1(I))*A0(I)
      C1(I)=B0(I)*(XTA(KK)+2.*CHD(KK)-1.5*B1(I))
      D1(I)=B1(I)*B0(I)
C
C     THE FACTOR  8  IS USED INSTEAD OF THE FACTOR  4  TO TAKE INTO
C     ACCOUNT BOTH SIDES OF THE WING
C
      CNNSTA=8.*SNN*COS(ATAN(PPP(KK)))/SREF
      A(KK,IL)=CNNSTA*(A0(I)+B0(I)*ISUMP(I))
      A(KK,IM)=CNNSTA/CREF*(A1(I)+B1(I)*ISUM(I)+C1(I)*ISUMP(I)+D1(I)*ISU
     1MP2(I))
12    CONTINUE
13    CONTINUE
C
C
```

```
      DO 14 K=1,LM
      A(IL,K)=A(K,IL)
      A(IM,K)=A(K,IM)
14    CONTINUE
C
C
C     THE -A- MATRIX STANDS FOR THE DRAG MATRIX -CDV-
C
C
      DO 17 I=1,LM
      RPHI=ATAN(PPP(I))
      CSR=A(I,IL)*SREF/(8.*SNN*COS(RPHI))
      DO 17 J=1,LM
      SPHI=ATAN(PPP(J))
      CSS=A(J,IL)*SREF/(8.*SNN*COS(SPHI))
      YY(1)=YQ(I)-YQ(J)
      YY(2)=YQ(I)+YQ(J)
      ZZ=ZHH(I)-ZHH(J)
      DO 16 K=1,2
      ISIGN=JSIGN=1.
      IF (K.EQ.2) GO TO 15
      IF (YY(1).LT.TOLC) JSIGN=-1.
      IF (YY(1).LT.(-TOLC)) ISIGN=-1.
15    YYY=YY(K)
      CALL DRAGSUB (RPHI,SPHI,YYY,ZZ,SNN,ISIGN,JSIGN,WN(K))
      SPHI=-SPHI
16    CONTINUE
      A(I,J)=SNN*CSR*CSS*(WN(1)-WN(2))/(PI*SREF)
17    CONTINUE
C
C
      REWIND 10
      WRITE (10) ((A(I,J),I=1,JM),J=1,JM)
      END FILE 10
      REWIND 20
      DO 19 I=1,LM
      DO 18 J=1,LM
      XTA(J)=A(I,J)+A(J,I)
18    CONTINUE
      WRITE (20) (XTA(IK),IK=1,LM)
19    CONTINUE
      END FILE 20
      REWIND 20
      DO 20 I=1,LM
      READ (20) (A(I,J),J=1,LM)
20    CONTINUE
      CALL SIMEQ (A,JM,CDRAG,1,DETERM,IPIVOT,102,ISCALE)
      WRITE (6,45)
      WRITE (6,47)
      REWIND 10
      READ (10) ((A(I,J),I=1,JM),J=1,JM)
      CD=0.
      DO 21 I=1,LM
      DO 21 J=1,LM
21    CD=CD+CDRAG(I)*A(I,J)*CDRAG(J)*2.
      DO 23 I=1,LM
      CRPHI=COS(ATAN(PPP(I)))
      WNII=0.
      DO 22 J=1,LM
      SPHI=ATAN(PPP(J))
```

```
      CSS=A(J,IL)*SREF/(8.*SNN*COS(SPHI))
      WNII=WNII+CDRAG(J)*A(I,J)*PI*SREF/(SNN*CSS*CRPHI)
22    CONTINUE
      WRITE (6,46) Y(I),CDRAG(I),WNII
      IF (I.EQ.NMA(1).AND.IPLAN.EQ.2) WRITE (6,48)
23    CONTINUE
      DO 26 I=1,IPLAN
      IUZ=NMA(I)
      DO 24 J=1,IUZ
      JJ=J+(I-1)*NMA(1)
      ZZH(J)=Y(JJ)
      XTT(J)=CDRAG(JJ)
24    CONTINUE
      IUU=NSSWSV(I)
      DO 25 J=1,IUU
      JJ=J+(I-1)*NSSWSV(1)
      CALL FTLUP (YC(JJ),PPP(JJ),+1,IUZ,ZZH,XTT)
25    CONTINUE
26    CONTINUE
      JK=0
      DO 28 I=1,IPLAN
      KA=1+(I-1)*NSSWSV(1)
      KB=NSSWSV(1)+(I-1)*NSSWSV(2)
      D=XCFW
      IF (I.EQ.2) D=XCFT
      DO 27 J=KA,KB
      NSCW=TBLSCW(J)
      AI=NSCW*D+0.75
      IMAX=INT(AI)
      DO 27 K=1,NSCW
      JK=JK+1
      E=1.
      IF (K.GT.IMAX) E=(1.-(K-.75)/NSCW)/(1.-D)
      CIR(JK)=PPP(J)*E
27    CONTINUE
28    CONTINUE
      WRITE (6,36) CLDES
      NR=0
      DO 29 NV=1,NSSW
      NSCW=TBLSCW(NV)
      NP=NR+1
      NR=NR+NSCW
      PHIPR=ATAN(PHI(NV))*RAD
      IF (NV.EQ.(NSSWSV(1)+1)) WRITE (6,37)
      DO 29 I=NP,NR
      PNPR=PN(I)*BETA
      PVPR=PV(I)*BETA
      PSIPR=ATAN(BETA*TAN(PSI(I)))*RAD
      WRITE (6,38) PNPR,PVPR,Q(I),ZH(NV),S(I),PSIPR,PHIPR,CIR(I)
29    CONTINUE
      WRITE (6,34)
      WRITE (6,35) CREF,CAVE,STRUE,SREF,BOT,AR,ARTRUE,MACH
      CLTOT=CMTOT=0.
      DO 31 I=1,NSSW
      IF (I.EQ.1) WRITE (6,41)
      IF (I.EQ.(NSSWSV(1)+1)) WRITE (6,42)
      SPANLD=0.
      DO 30 IJ=1,NSCWMIN
      IK=(I-1)*NSCWMIN+IJ
      SPANLD=SPANLD+2.*CIR(IK)*COS(ATAN(PHI(I)))
```

```
      CLTOT=CLTOT+8.*S(IK)*CIR(IK)/SREF*COS(ATAN(PHI(I)))              DG2 241
      CMTOT=CMTOT+8.*S(IK)*CIR(IK)*PN(IK)*BETA*COS(ATAN(PHI(I)))/(SREF*CDG2 241A
     1REF)                                                              DG2 241B
   30 CONTINUE                                                          DG2 242
      WRITE (6,44) Q(IK),SPANLD                                         DG2 243
      IF (I.EQ.NSSWSV(1)) CL1=CLTOT                                     DG2 244
      IF (I.EQ.NSSWSV(1)) CM1=CMTOT                                     DG2 244A
      IF (I.EQ.NSSWSV(1)) WRITE (6,43) CL1,CM1                          DG2 245
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) CL2=CLTOT-CL1                       DG2 246
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) CM2=CMTOT-CM1                       DG2 246A
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) WRITE (6,43) CL2,CM2                DG2 247
   31 CONTINUE                                                          DG2 248
C                                                                       DG2 249
      WRITE(6,39) CLDES,CLTOT,CMTOT,CD                                  DG2 250
C                                                                       DG2 251
   32 CONTINUE                                                          DG2 252
   33 CONTINUE                                                          DG2 253
      RETURN                                                            DG2 254
   34 FORMAT (////4X,11H REF. CHORD,6X,25HC AVERAGE      TRUE AREA  ,2X,1DG2 255
     14HREFERENCE AREA,9X,3HB/2,8X,7HREF. AR,8X,7HTRUE AR,4X,11HMACH NUMDG2 256
     2BER/)                                                             DG2 257
   35 FORMAT (8F15.5)                                                   DG2 258
   36 FORMAT (1H1,///25X,1HX11X,1HX,11X,1HY,11X,1HZ,12X,1HS,5X,9HC/4 SWEDG2 259
     1EP,4X,8HDIHEDRAL,3X,10HGAMMA/U AT/24X,3HC/4,9X,4H3C/4,42X,5HANGLE,DG2 260
     27X,5HANGLE,4X,6HCLDES=,F7.4/)                                     DG2 261
   37 FORMAT (/45X,45HSECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS/)   DG2 262
   38 FORMAT (17X,8F12.5)                                               DG2 263
   39 FORMAT (/////15X,11HCL DESIGN =,F10.6,5X,12HCL COMPUTED=,F10.6,5X,DG2 264
     112HCM COMPUTED=,F10.6,5X,5HCD V=,F10.6)                           DG2 265
   40 FORMAT (/////15X,7HCL DES=,F10.6,5X,12HCL COMPUTED=,F10.6,5X,29HNODG2 266
     1 PITCHING MOMENT CONSTRAINT,5X,5HCD V=,F10.6)                     DG2 267
   41 FORMAT (////40X,56HF I R S T    P L A N F O R M    S P A N   L O DG2 268
     1A D I N G//60X,1HY,11X,4HCL*C)                                    DG2 269
   42 FORMAT (////40X,58HS E C O N D    P L A N F O R M    S P A N    L DG2 270
     10 A D I N G//60X,1HY,11X,4HCL*C)                                  DG2 271
   43 FORMAT (//50X,30HCL DEVELOPED ON THIS PLANFORM=,F10.6/            DG2 272
     1           50X,30HCM DEVELOPED ON THIS PLANFORM=,F10.6)           DG2 272A
   44 FORMAT (55XF10.5,3XF10.5)                                         DG2 273
   45 FORMAT(/////2X, 127HS P A N W I S E    S C A L E    F A C T O R S DG2 274
     1 A N D    ( N O R M A L    W A S H ) /( U  *  C O S I N E ( D I DG2 275
     2H E D R A L ) )//30X,23HDISTANCE ALONG PLANFORM,5X,7HFACTORS,5X,15DG2 276
     3HWN/(U*COS(PHI)))                                                 DG2 277
   46 FORMAT (36XF10.5,10XF10.5,3XF10.5)                                DG2 278
   47 FORMAT (10X,14HFIRST PLANFORM)                                    DG2 279
   48 FORMAT (10X,15HSECOND PLANFORM)                                   DG2 280
      END                                                               DG2 281-
```

APPENDIX E

```
*DECK VLMCCIR3
      OVERLAY(WINGTL,1,0)
      PROGRAM CIRCUL3
      DIMENSION A0(2), B0(2), A1(2), B1(2), C1(2), D1(2), ISUM(2), ISUMP
     1(2), ISUMP2(2), PPP(100), WN(2), YY(2), ZZH(50), ZHH(100), YB(50),
     2 Y(100), PPHI(50), XTT(50), XTA(102), CHD(100), A(102,102), CDRAG(
     3102), NMA(2), YQ(100), YQQ(50), YC(100), V(102,102)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(4
     100),S(400),PSI(400),PHI(50),ZH(50),NSSW
      COMMON /ONETHRE/ TWIST(2),CREF,SREF,CAVE,CLDES,STRUE,AR,ARTRUE,RTC
     1DHT(2),CONFIG,NSSWSV(2),MSV(2),KBOT,PLAN,IPLAN,MACH,SSWWA(50),XCFW
     2,XCFT,YREG(1,2)
      COMMON /TOTHRE/ CIR(400)
      COMMON /CCRRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA
      REAL ISIGN,JSIGN
C
C
      TOLC=(BOT*15.E-05)**2
C
C
      NMA(1)=NMA(2)=0
      PI=4.*ATAN(1.)
      RAD=180./PI
      BOTL=ABS(TSPAN)
      BOL=ABS(TSPANA)
      SNN=BOTL/100.
      DELTYB=2.*SNN
      NMA(KBOT)=BOTL/DELTYB
      NMA(KBIT)=BOL/DELTYB
      NMAX=NMA(1)+NMA(2)
      LM=NMAX
      IL=LM+1
      JM=LM+2
      IF (LM.EQ.NMA(1)) JM=IL
      IM=LM+2
      DO 1 I=1,IM
      CDRAG(I)=0.
      DO 1 J=1,IM
    1 A(I,J)=0.
      CDRAG(IL)=CLDES
      CDRAG(IM)=0.0
C
      SCWMIN=20.
      DO 2 I=1,NSSW
    2 SCWMIN=AMIN1(SCWMIN,TBLSCW(I))
      NSCWMIN=SCWMIN
      II=1
      DO 13 I=1,IPLAN
      IB=NSSWSV(I)
      IC=MSV(1)+(I-1)*MSV(2)
      ID=IC+1
      IZ=NSSWSV(1)+(I-1)*NSSWSV(2)
      D=XCFW
      IF (I.EQ.2) D=XCFT
      AI=NSCWMIN*D+0.75
      IMAX=INT(AI)
      IF (D.EQ.1.) GO TO 3
      B0(I)=-1./(NSCWMIN*(1.-D))
      A0(I)=IMAX-B0(I)*(NSCWMIN+0.75)*(NSCWMIN-IMAX)
      GO TO 4
    3 B0(I)=0.
      A0(I)=IMAX
```

```
4       ISUM(I)=ISUMP(I)=ISUMP2(I)=0
        IF (IMAX.EQ.0) GO TO 6
        DO 5 IN=1,IMAX
5       ISUM(I)=ISUM(I)+IN
6       IMM=IMAX+1
        IF (IMM.GT.NSCWMIN) GO TO 8
        DO 7 IN=IMM,NSCWMIN
        ISUMP(I)=ISUMP(I)+IN
7       ISUMP2(I)=ISUMP2(I)+IN**2
8       IAMM=NMA(I)
        IUZ=NSSWSV(I)
        YCAT=YREG(1,I)
        DO 10 J=1,IUZ
        JJ=J+(I-1)*NSSWSV(1)
        ZZH(J)=ZH(JJ)
        PPHI(J)=PHI(JJ)
        XTT(J)=XTE(JJ)
        CIR(J)=CHORD(JJ)
        YQQ(J)=Q(II)
        II=II+TBLSCW(JJ)
        IE=IB-J+1
        ITL=TBLSCW(IZ)
        ID=ID-ITL
        IA=ID+ITL
        IF (IA.GT.IC) YCAT=YCAT-S(ID)
        IF (IA.GT.IC) GO TO 9
        YCAT=YCAT-S(ID)-S(IA)
9       IZ=IZ-1
        YB(IE)=YCAT
10      CONTINUE
        DO 11 J=1,IUZ
        JJ=J+(I-1)*NSSWSV(1)
        YC(JJ)=YB(J)
11      CONTINUE
        YOB=-NMA(I)*2.*SNN-SNN+YREG(1,I)
        DO 12 K=1,IAMM
        KK=K+(I-1)*NMA(1)
        YOB=YOB+DELTYB
        Y(KK)=YOB
        CALL FTLUP (YOB,YQ(KK),+1,IUZ,YB,YQQ)
        CALL FTLUP (YOB,XTA(KK),+1,IUZ,YB,XTT)
        CALL FTLUP (YOB,CHD(KK),+1,IUZ,YB,CIR)
        CALL FTLUP (YOB,PPP(KK),+1,IUZ,YB,PPHI)
        CALL FTLUP (YOB,ZHH(KK),+1,IUZ,YB,ZZH)
        B1(I)=-CHD(KK)/NSCWMIN
        A1(I)=((XTA(KK)+CHD(KK))-0.75*B1(I))*A0(I)
        C1(I)=B0(I)*(XTA(KK)+2.*CHD(KK)-1.5*B1(I))
        D1(I)=B1(I)*B0(I)
C
C       THE FACTOR  8  IS USED INSTEAD OF THE FACTOR  4  TO TAKE INTO
C       ACCOUNT BOTH SIDES OF THE WING
C
        CNNSTA=8.*SNN*COS(ATAN(PPP(KK)))/SREF
        A(KK,IL)=CNNSTA*(A0(I)+B0(I)*ISUMP(I))
        A(KK,IM)=CNNSTA/CREF*(A1(I)+B1(I)*ISUM(I)+C1(I)*ISUMP(I)+D1(I)*ISU
       1MP2(I))
12      CONTINUE
13      CONTINUE
C
C
```

```
      DO 14 K=1,LM
      A(IL,K)=A(K,IL)
      A(IM,K)=A(K,IM)
14    CONTINUE
C
C
C     THE -A- MATRIX STANDS FOR THE DRAG MATRIX -CDV-
C
C
      DO 17 I=1,LM
      RPHI=ATAN(PPP(I))
      CSR=A(I,IL)*SRFF/(8.*SNN*COS(RPHI))
      DO 17 J=1,LM
      SPHI=ATAN(PPP(J))
      CSS=A(J,IL)*SREF/(8.*SNN*COS(SPHI))
      YY(1)=YQ(I)-YQ(J)
      YY(2)=YQ(I)+YQ(J)
      ZZ=ZHH(I)-ZHH(J)
      DO 16 K=1,2
      ISIGN=JSIGN=1.
      IF (K.EQ.2) GO TO 15
      IF (YY(1).LT.TOLC) JSIGN=-1.
      IF (YY(1).LT.(-TOLC)) ISIGN=-1.
15    YYY=YY(K)
      CALL DRAGSUB (RPHI,SPHI,YYY,ZZ,SNN,ISIGN,JSIGN,WN(K))
      SPHI=-SPHI
16    CONTINUE
      A(I,J)=SNN*CSR*CSS*(WN(1)-WN(2))/(PI*SREF)
17    CONTINUE
C
C
      REWIND 10
      WRITE (10) ((A(I,J),I=1,JM),J=1,JM)
      END FILE 10
      REWIND 20
      DO 19 I=1,LM
      DO 18 J=1,LM
      XTA(J)=A(I,J)+A(J,I)
18    CONTINUE
      WRITE (20) (XTA(IK),IK=1,LM)
19    CONTINUE
      END FILE 20
      REWIND 20
      DO 20 I=1,LM
      READ (20) (A(I,J),J=1,LM)
20    CONTINUE
      CALL GIASOS (3,102,102,JM,JM,A,1,CDRAG,15,XTA,V,IRANK,AP,IERR)
      WRITE (6,34) IRANK,IERR
      WRITE (6,46)
      WRITE (6,48)
      REWIND 10
      READ (10) ((A(I,J),I=1,JM),J=1,JM)
      CD=0.
      DO 21 I=1,LM
      DO 21 J=1,LM
21    CD=CD+CDRAG(I)*A(I,J)*CDRAG(J)*2.
      DO 23 I=1,LM
      CRPHI=COS(ATAN(PPP(I)))
      WNII=0.
      DO 22 J=1,LM
```

```
      SPHI=ATAN(PPP(J))
      CSS=A(J,IL)*SREF/(8.*SNN*COS(SPHI))
      WNII=WNII+CDRAG(J)*A(I,J)*PI*SREF/(SNN*CSS*CRPHI)
   22 CONTINUE
      WRITE (6,47) Y(I),CDRAG(I),WNII
      IF (I.EQ.NMA(1).AND.IPLAN.EQ.2) WRITE (6,49)
   23 CONTINUE
      DO 26 I=1,IPLAN
      IUZ=NMA(I)
      DO 24 J=1,IUZ
      JJ=J+(I-1)*NMA(1)
      ZZH(J)=Y(JJ)
      XTT(J)=CDRAG(JJ)
   24 CONTINUE
      IUU=NSSWSV(I)
      DO 25 J=1,IUU
      JJ=J+(I-1)*NSSWSV(1)
      CALL FTLUP (YC(JJ),PPP(JJ),+1,IUZ,ZZH,XTT)
   25 CONTINUE
   26 CONTINUE
      JK=0
      DO 28 I=1,IPLAN
      KA=1+(I-1)*NSSWSV(1)
      KB=NSSWSV(1)+(I-1)*NSSWSV(2)
      D=XCFW
      IF (I.EQ.2) D=XCFT
      DO 27 J=KA,KB
      NSCW=TBLSCW(J)
      AI=NSCW*D+0.75
      IMAX=INT(AI)
      DO 27 K=1,NSCW
      JK=JK+1
      E=1.
      IF (K.GT.IMAX) E=(1.-(K-.75)/NSCW)/(1.-D)
      CIR(JK)=PPP(J)*E
   27 CONTINUE
   28 CONTINUE
      WRITE (6,37) CLDES
      NR=0
      DO 29 NV=1,NSSW
      NSCW=TBLSCW(NV)
      NP=NR+1
      NR=NR+NSCW
      PHIPR=ATAN(PHI(NV))*RAD
      IF (NV.EQ.(NSSWSV(1)+1)) WRITE (6,38)
      DO 29 I=NP,NR
      PNPR=PN(I)*BETA
      PVPR=PV(I)*BETA
      PSIPR=ATAN(BETA*TAN(PSI(I)))*RAD
      WRITE (6,39) PNPR,PVPR,Q(I),ZH(NV),S(I),PSIPR,PHIPR,CIR(I)
   29 CONTINUE
      WRITE (6,35)
      WRITE (6,36) CREF,CAVE,STRUE,SREF,BOT,AR,ARTRUE,MACH
      CLTOT=CMTOT=0.
      DO 31 I=1,NSSW
      IF (I.EQ.1) WRITE (6,42)
      IF (I.EQ.(NSSWSV(1)+1)) WRITE (6,43)
      SPANLD=0.
      DO 30 IJ=1,NSCWMIN
      IK=(I-1)*NSCWMIN+IJ
```

```
      SPANLD=SPANLD+2.*CIR(IK)*COS(ATAN(PHI(I)))
      CLTOT=CLTOT+8.*S(IK)*CIR(IK)/SREF*COS(ATAN(PHI(I)))
      CMTOT=CMTOT+8.*S(IK)*CIR(IK)*PN(IK)*BETA*COS(ATAN(PHI(I)))/(SREF*C
     1REF)
   30 CONTINUE
      WRITE (6,45) Q(IK),SPANLD
      IF (I.EQ.NSSWSV(1)) CL1=CLTOT
      IF (I.EQ.NSSWSV(1)) CM1=CMTOT
      IF (I.EQ.NSSWSV(1)) WRITE (6,44) CL1,CM1
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) CL2=CLTOT-CL1
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) CM2=CMTOT-CM1
      IF (I.EQ.NSSW.AND.IPLAN.EQ.2) WRITE (6,44) CL2,CM2
   31 CONTINUE
C
      WRITE(6,40) CLDES,CLTOT,CMTOT,CD
C
   32 CONTINUE
   33 CONTINUE
      RETURN
   34 FORMAT (10XI10,10XI10)
   35 FORMAT (////4X,11H REF. CHORD,6X,25HC AVERAGE      TRUE AREA   ,2X,1
     14HREFERENCE AREA,9X,3HB/2,8X,7HREF. AR,8X,7HTRUE AR,4X,11HMACH NUM
     2BER/)
   36 FORMAT (8F15.5)
   37 FORMAT (1H1,///25X,1HX11X,1HX,11X,1HY,11X,1HZ,12X,1HS,5X,9HC/4 SWE
     1EP,4X,8HDIHEDRAL,3X,10HGAMMA/U AT/24X,3HC/4,9X,4H3C/4,42X,5HANGLE,
     27X,5HANGLE,4X,6HCLDES=,F7.4/)
   38 FORMAT (/45X,45HSECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS/)
   39 FORMAT (17X,8F12.5)
   40 FORMAT (/////15X,11HCL DESIGN =,F10.6,5X,12HCL COMPUTED=,F10.6,5X,
     112HCM COMPUTED=,F10.6,5X,5HCD V=,F10.6)
   41 FORMAT (/////15X,7HCL DES=,F10.6,5X,12HCL COMPUTED=,F10.6,5X,29HNO
     1 PITCHING MOMENT CONSTRAINT,5X,5HCD V=,F10.6)
   42 FORMAT (////40X,56HF I R S T    P L A N F O R M    S P A N    L O 
     1A D I N G//60X,1HY,11X,4HCL*C)
   43 FORMAT (////40X,58HS E C O N D    P L A N F O R M    S P A N    L 
     1O A D I N G//60X,1HY,11X,4HCL*C)
   44 FORMAT (//50X,30HCL DEVELOPED ON THIS PLANFORM=,F10.6/
     1          50X,30HCM DEVELOPED ON THIS PLANFORM=,F10.6)
   45 FORMAT (35XF10.5,3XF10.5)
   46 FORMAT(/////2X, 127HS P A N W I S E    S C A L E    F A C T O R S 
     1 A N D    ( N O R M A L    W A S H ) /( U  *  C O S I N E ( D I 
     2H E D R A L ) )//30X,23HDISTANCE ALONG PLANFORM,5X,7HFACTORS,5X,15
     3HWN/(U*COS(PHI)))
   47 FORMAT (36XF10.5,10XF10.5,3XF10.5)
   48 FORMAT (10X,14HFIRST PLANFORM)
   49 FORMAT (10X,15HSECOND PLANFORM)
      END
```

APPENDIX E

```
      SUBROUTINE GIASOS(IOP,MD,ND,M,N,A,NOS,B,IAC,Q,V,IRANK,APLUS,IERR)
C*********************************************************************
C
C PURPOSE      TO COMPUTE THE SINGULAR VALUE DECOMPOSITION OF A REAL M X
C              N MATRIX A:BY PERFORMING THE A=UQV (T) FACTORIZATION,
C              WITH OPTIONS FOR THE RANK,THE SINGULAR VALUES, AN
C              ORTHOGONAL BASIS FOR THE HOMOGENOUS SOLUTION , AND THE
C              PSEUDO INVERSE OF A AND A LEAST SQUARES SOLUTION FOR THE
C              MATRIX PROBLEM AX=B.
C
C USE
C
C     CALL GIASOS(IOP,MD,ND,M,N,A,NOS,B,IAC,Q,V,IRANK,APLUS,IERR)
C
C        IOP   OPTION CODE
C
C          IOP=1  RANK WILL BE RETURNED TO THE CALLING PROGRAM IN
C                 IRANK. THE ORDERED SINGULAR VALUES WILL BE RETURNED IN Q
C
C          IOP=2  IN ADDITION TO THE OPTIONS IN IOP=1 AN ORTHOGONAL
C                 BASIS FOR THE HOMOGENOUS SOLUTION WILL BE RETURNED IN
C                 THE LAST N-IRANK COLUMNS OF THE V MATRIX.  THE U
C                 TRANSFORMATION MATRIX WILL BE RETURNED IN MATRIX A.
C
C          IOP=3  SAME AS IOP=2.  IN ADDITION THE LEAST SQUARES SOLUTIONS
C                 WILL BE RETURNED IN MATRIX B.
C
C          IOP=4  SAME AS IOP=2.  IN ADDITION THE PSEUDO INVERSE WILL BE
C                 RETURNED IN APLUS.
C
C          IOP=5  SAME AS IOP=4.  IN ADDITION THE LEAST SQUARES SOLUTIONS
C                 WILL BE RETURNED IN MATRIX B.
C
C        MD    INPUT INTEGER SPECIFING THE MAXIMUM ROW DIMENSION FOR A.
C
C        ND    INPUT INTEGER SPECIFING THE MAXIMUM ROW DIMENSION FOR V
C
C        M     INPUT INTEGER SPECIFING THE NUMBER OF ROWS IN A.
C
C        N     INPUT INTEGER SPECIFING THE NUMBER OF COLUMNS IN A.
C
C        A     AN INPUT/OUTPUT TWO-DIMENSIONAL REAL ARRAY WITH ROW DIMEN-
C              SION MD AND COLUMN DIMENSION AT LEAST N.  ON INPUT, A
C              CONTAINS THE INPUT MATRIX A WHICH IS DESTROYED.  ON OUTPUT
C              A CONTAINS THE ISOMETRIC MATRIX U EXCEPT WHEN IOP=1.
C
C        NOS   NUMBER OF RIGHT HAND SIDES TO BE SOLVED.
C
C        B     AN INPUT/OUTPUT TWO-DIMENSIONAL ARRAY(MD X NOS) USED FOR

C              IOP=3 OR IOP=5.  ON INPUT,B CONTAINS THE RIGHT  HAND SIDES
C              FOR THE SYSTEM OF EQUATIONS TO BE SOLVED.  ON OUTPUT, B
C              CONTAINS THE LEAST SQUARES SOLUTIONS FOR THE EQUATIONS.
C              B NEED NOT BE DIMENSIONED FOR OTHER OPTIONS.
C
C        IAC   AN INPUT INTEGER SPECIFING THE NUMBER OF DECIMAL DIGITS OF
C              ACCURACY  IN THE ELEMENTS OF THE INPUT A MATRIX.  THIS
C              VALUE IS USED TO DETERMINE THE TEST FOR ZERO SINGULAR
C              VALUES. THUS DETERMINING RANK.
C
C              IF IAC.GT.13  THE ZERO TEST WILL BE COMPUTED USING THE
```

```
C                            E-NORM OF A MULTIPLIED BY 2**(-48) .
C
C              IF IAC.LT.13  THE ZERO TEST WILL BE COMPUTED USING THE
C                            E-NORM OF A MULTIPLIED BY 10**(-IAC).
C
C        Q     A ONE DIMENSIONAL ARRAY OF SIZE N WHICH WILL CONTAIN THE
C              ORDERED SINGULAR VALUES.
C
C        V     AN OUTPUT TWO DIMENSIONAL ARRAY (ND X N) WHICH CONTAINS THE
C              ORTHOGONAL V MATRIX EXCEPT WHEN     IOP=1.  THE V MATRIX
C              UPON RETURN FROM THE SUBROUTINE WILL CONTAIN AN ORTHOGONAL
C              BASIS FOR THE HOMOGENOUS SOLUTIONS IN THE LAST N-IRANK
C              COLUMNS FOR ALL OPTIONS EXCEPT 1 .
C
C        IRANK RANK OF THE MATRIX A (OUTPUT)
C
C        APLUS AN OUTPUT TWO DIMENSIONAL ARRAY (ND X M) WHICH CONTAINS
C              THE PSEUDO INVERSE OF MATRIX A. IF IOP DOES NOT EQUAL
C              4 OR 5 THIS ARRAY NEED NOT BE DIMENSIONED BUT A DUMMY
C              PARAMETER MUST APPEAR IN THE CALLING SEQUENCE.
C
C        IERR  ERROR INDICATOR
C
C              K=0     IMPLIES NORMAL RETURN
C
C              K.GT.0 IMPLIES KTH SINGULAR VALUE NOT FOUND AFTER 30 ITER.
C              K=-1    IMPLIES THAT USING THE GIVEN IAC(ACCURACY REQUIRE-
C                      MENT), THIS MATRIX IS CLOSE TO A MATRIX WHICH IS OF
C                      LOWER RANK THAN IRANK AND IF THE ACCURACY IS
C                      REDUCED THE RANK OF THE MATRIX MAY ALSO BE REDUCED.
C
C
C*********************************************************************
C
      LOGICAL WITHU,WITHV
      DIMENSION A(MD,N),        V(ND,N),Q(N),E(256)
      DIMENSION B(MD,NOS),APLUS(ND,M)
C
      TOL=1.0E-60
      SIZE=0.0
      NP1=N+1
C
C     COMPUTE THE E-NORM OF MATRIX A AS ZERO TEST FOR SINGULAR VALUES
C
      SUM=0.0
      DO 500 I=1,M
      DO 500 J=1,N
  500 SUM = SUM + A(I,J)**2
      ZTEST = SQRT(SUM)


      IF (IAC.GT.13)  GO TO 505
      ZTEST = ZTEST*10.**(-IAC)
      GO TO 510
  505 ZTEST = ZTEST * 2.0**(-48)
      ZTEST =SQRT(SUM)*2.0**(-48)
C
  510 IF (IOP.NE.1 ) GO TO 515
      WITHU=.FALSE.
      WITHV=.FALSE.
      GO TO 520
  515 WITHU=.TRUE.
```

```
      WITHV=.TRUE.
  520 CONTINUE
      G = 0.0
      X = 0.0
      DO 30 I = 1,N
C
C     HOUSEHOLDER REDUCTION TO BIDIAGONAL FORM.
C
      E(I) = G
      S = 0.0
      L = I+1
C
C     ANNIHILATE THE I-TH COLUMN BELOW DIAGONAL.
C
      DO 3 J = I,M
    3 S = S + A(J,I)**2
      G = 0.0
      IF(S .LT. TOL)    GO TO 10
      G = SQRT(S)
      F = A(I,I)
      IF(F .GE. 0.0)   G = -G
      H = F*G -S
      A(I,I) = F-G
      IF(I .EQ. N)   GO TO 10
        DO 9 J = L,N
        S = 0.0
        DO 7 K = I,M
    7   S = S +A(K,I)*A(K,J)
        F = S/H
        DO 8 K = I,M
    8   A(K,J) =A(K,J) + F*A(K,I)
    9   CONTINUE
   10 Q(I) = G
      IF(I .EQ. N)   GO TO 20
C
C     ANNIHILATE THE I-TH ROW TO RIGHT OF SUPER-DIAG.
C
      S = 0.0
      DO 11 J = L,N
   11 S = S + A(I,J)**2
      G = 0.0
      IF (S .LT. TOL)    GO TO 20
        G = SQRT(S)
        F = A(I,I+1)
        IF(F .GE. 0.0)    G = -G
        H = F*G -S
        A(I,I+1) = F - G
        DO 15 J = L,N
   15   E(J) = A(I,J)/H


        DO 19 J = L,M
        S = 0.0
        DO 16 K = L,N
   16   S = S + A(J,K) * A(I,K)
        DO 17 K = L,N
   17   A(J,K) = A(J,K) + S*E(K)
   19   CONTINUE
   20 Y = ABS(Q(I)) + ABS(E(I))
      IF(Y .GT. SIZE)    SIZE = Y
   30 CONTINUE
      IF(.NOT. WITHV)    GO TO 41
```

APPENDIX E

```
C
C     ACCUMULATION OF RIGHT TRANSFORMATIONS.
C
      DO 40 II = 1,N
      I = NP1 - II
      IF(I .EQ. N)    GO TO 39
      IF(G .EQ. 0.0)    GO TO 37
      H = A(I,I+1)*G
      DO 32 J = L,N
   32 V(J,I) = A(I,J)/H
      DO 36 J = L,N
      S = 0.0
      DO 33 K = L,N
   33 S = S + A(I,K)*V(K,J)
      DO 34 K = L,N
   34 V(K,J) = V(K,J) + S*V(K,I)
   36 CONTINUE
   37 DO 38 J = L,N
      V(I,J) = 0.0
   38 V(J,I) = 0.0
   39 V(I,I) = 1.0
      G = E(I)
   40 L = I
   41 CONTINUE
      IF(.NOT. WITHU)    GO TO 53
C
C     ACCUMULATION OF LEFT TRANSFORMATIONS.
C
      DO 52 II = 1,N
      I = NP1 -II
      L = I + 1
      G = Q(I)
      IF(I .EQ. N)    GO TO 43
      DO 42 J = L,N
   42 A(I,J) = 0.0
   43 CONTINUE
      IF(G .EQ. 0.0)    GO TO 49
      IF(I .EQ. N)    GO TO 47
        H = A(I,I)*G
        DO 46 J = L,N
        S = 0.0
        DO 44 K = L,M
   44   S = S + A(K,I)*A(K,J)
        F = S/H
        DO 45 K = I,M
   45   A(K,J) = A(K,J) +  F*A(K,I)
   46   CONTINUE
   47 DO 48 J = I,M
   48 A(J,I) = A(J,I)/G


      GO TO 51
   49 DO 50 J = I,M
   50 A(J,I) = 0.0
   51 A(I,I) = A(I,I) + 1.0
   52 CONTINUE
   53 CONTINUE
C
C     DIAGONALIZATION OF BIDIAGONAL FORM.
C
      DO 100 KK=1,N
        K=NP1-KK
```

```
      ITCNT=0                                                           GIA0241
      KP1=K+1                                                           GIA0242
C                                                                       GIA0243
C     TEST F SPLITTING.                                                 GIA0244
C                                                                       GIA0245
   59 CONTINUE                                                          GIA0246
      DO 60 LL=1,K                                                      GIA0247
        L=KP1-LL                                                        GIA0248
        IF((SIZE+ABS(E(L))).EQ.SIZE)     GO TO 64                       GIA0249
        LM1=L-1                                                         GIA0250
        IF((SIZE+ABS(Q(LM1))).EQ.SIZE)     GO TO 61                     GIA0251
   60 CONTINUE                                                          GIA0252
C                                                                       GIA0253
C     CANCELLATION OF E(L) IF L .GT. 1.                                 GIA0254
C                                                                       GIA0255
   61 C=0.0                                                             GIA0256
      S=1.0                                                             GIA0257
      L1=L-1                                                            GIA0258
      DO 63 I=L,K                                                       GIA0259
        F=S*E(I)                                                        GIA0260
        E(I)=C*E(I)                                                     GIA0261
        IF((SIZE+ABS(F)).EQ.SIZE)    GO TO 64                           GIA0262
        G=Q(I)                                                          GIA0263
        Q(I)=SQRT(F*F+G*G)                                              GIA0264
        H=Q(I)                                                          GIA0265
        C=G/H                                                           GIA0266
        S=-F/H                                                          GIA0267
        IF(.NOT.WITHU)    GO TO 63                                      GIA0268
          DO 62 J=1,M                                                   GIA0269
            Y=A(J,L1)                                                   GIA0270
            Z=A(J,I)                                                    GIA0271
            A(J,L1)=Y*C+Z*S                                             GIA0272
            A(J,I)= -Y*S+Z*C                                            GIA0273
   62     CONTINUE                                                      GIA0274
C                                                                       GIA0275
   63 CONTINUE                                                          GIA0276
C                                                                       GIA0277
C     TEST F CONVERGENCE.                                               GIA0278
C                                                                       GIA0279
   64 Z=Q(K)                                                            GIA0280
      IF(L.EQ.K)    GO TO 75                                            GIA0281
      IF(ITCNT .LE. 30)    GO TO 65                                     GIA0282
      IERR = KK                                                         GIA0283
      RETURN                                                            GIA0284
   65 ITCNT = ITCNT + 1                                                 GIA0285
C                                                                       GIA0286
C     SHIFT FROM LOWER 2X2.                                             GIA0287
C                                                                       GIA0288
      X=Q(L)                                                            GIA0289

      Y=Q(K-1)                                                          GIA0290
      G=E(K-1)                                                          GIA0291
      H=E(K)                                                            GIA0292
      F=((Y-Z)*(Y+Z)+(G-H)*(G+H))/(2.0*H*Y)                             GIA0293
      G=SQRT(F*F+1.0)                                                   GIA0294
      IF(F.LT.0.0)   G=-G                                               GIA0295
      F = ((X-Z)*(X+Z)+H*(Y/(F+G)-H))/X                                 GIA0296
C                                                                       GIA0297
C                                                                       GIA0298
C     NEXT QR TRANSFORMATION.                                           GIA0299
C                                                                       GIA0300
```

```
      C=1.0
      S=1.0
      LP1=L+1
      DO 73 I=LP1,K
        G=E(I)
        Y=Q(I)
        H=S*G
        G=C*G
        Z=SQRT(F*F+H*H)
        E(I-1)=Z
        C=F/Z
        S=H/Z
        F=X*C+G*S
        G=-X*S+G*C
        H=Y*S
        Y=Y*C
        IF(.NOT.WITHV)   GO TO 70
          DO 68 J=1,N
            X=V(J,I-1)
            Z=V(J,I)
            V(J,I-1)=X*C+Z*S
            V(J,I)=-X*S+Z*C
   68     CONTINUE
C
   70   Z=SQRT(F*F+H*H)
        Q(I-1)=Z
        C=F/Z
        S=H/Z
        F=C*G+S*Y
        X=-S*G+C*Y
        IF(.NOT.WITHU)   GO TO 73
          DO 72 J=1,M
            Y=A(J,I-1)
            Z=A(J,I)
            A(J,I-1)=Y*C+Z*S
            A(J,I)=-Y*S+Z*C
   72     CONTINUE
C
C
   73   E(L) = 0.0
        E(K)=F
        Q(K)=X
        GO TO 59
C
C       CONVERGENCE.
C
   75   CONTINUE
        IF(Z.GE.0.0)   GO TO 100
          Q(K)=-Z


          IF(.NOT.WITHV)   GO TO 100
          DO 76 J=1,N
   76     V(J,K)=-V(J,K)
  100   CONTINUE
C
       IERR = 0
       DO 280  II=2,N
       I= II-1
       K=I
       P=Q(I)
C
```

```
      DO 250  J=II,N
      IF (Q(J).LE.P) GO TO 250
      K=J
      P=Q(J)
  250 CONTINUE
C
      IF (K.EQ.I) GO TO 280
      Q(K) = Q(I)
      Q(I) = P
C
      IF(IOP.EQ.1) GO TO 280
C
      DO 260  J=1,N
      P= V(J,I)
      V(J,I)= V(J,K)
      V(J,K)= P
  260 CONTINUE
C
      DO 270  J=1,M
      P = A(J,I)
      A(J,I)= A(J,K)
      A(J,K)= P
  270 CONTINUE
C
  280 CONTINUE
C
      J=N
  290 IF (Q(J).GT.ZTEST) GO TO 300
      Q(J)=0.0
      J=J-1
      GO TO 290
  300 IRANK =J
      TEMP = ZTEST/Q(J)
      IF (TEMP.GT..0625)     IERR=-1
C
      IF (IOP.LT. 3)  RETURN
      IF(IOP.GT.3) GO TO 170
      DO 160  L=1,NOS
      DO 130  J=1,IRANK
      SUM=0.0
      DO 120  I=1,M
  120 SUM =SUM + A(I,J)*B(I,L)
  130 F(J)= SUM/Q(J)
C
      DO 150  K=1,N
      SUM=0.0
      DO 140  I=1,IRANK
  140 SUM =SUM  + V(K,I)*F(I)
  150 B(K,L)=SUM


  160 CONTINUE
      RETURN
  170 DO 200  J=1,M
      DO 190  I=1,N
      SUM=0.0
      DO 180  K=1,IRANK
  180 SUM =SUM + V(I,K)*A(J,K)/Q(K)
  190 APLUS(I,J)= SUM
  200 CONTINUE
C
      IF( IOP .EQ.4) RETURN
```

```
      DO 230  K=1,NOS
      DO 220  I=1,N
      SUM=0.0
      DO 210  J=1,M
  210 SUM=SUM+ APLUS(I,J)*B(J,K)
  220 E(I)=SUM
      DO 225  I=1,N
  225 B(I,K)=E(I)
  230 CONTINUE
      RETURN
      END
```

APPENDIX E

```
*DECK VLMCZOC
      OVERLAY(WINGTL,2,0)                                               ZOC
      PROGRAM ZOCDFTM                                                   ZOC
      DIMENSION YY(2), FV(2), FW(2), DZDX(400), XXCC(20), WOU(20)       ZOC
      DIMENSION X3C4(22), ALOC(22,1), T(41), SS(41,1), SS1(41,1), SS2(41ZOC
     1,1), S2(22,1), S3(22,1), DELY(22,1), H(22), PSUM(41,1)           ZOC
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(400),PN(400),PV(4ZOC
     100),S(400),PSI(400),PHI(50),ZH(50),NSSW                          ZOC
      COMMON /TOTHRE/ CIR(400)  .                                       ZOC
      COMMON /CCRRDD/ CHORD(50),XTE(50),KBIT,TSPAN,TSPANA               ZOC
      COMMON /INSUB23/ APSI,APHI,XX,YYY,ZZ,SNN,TOLC                     ZOC
C                                                                       ZOC
C                                                                       ZOC
C     PART 3 - COMPUTE Z/C VERSUS X/C                                   ZOC
C                                                                       ZOC
C                                                                       ZOC
C     THE TOLERANCE SET AT THIS POINT IN THE PROGRAM MAY NEED TO BE     ZOC
C     CHANGED FOR COMPUTERS OTHER THAN THE CDC 6000 SERIES              ZOC
C                                                                       ZOC
C                                                                       ZOC
      WRITE (6,12)                                                      ZOC
      TOLC=(BOT*15.E-05)**2                                             ZOC
      IZZ=1                                                             ZOC
      NNV=TBLSCW(IZZ)                                                   ZOC
      DO 3 NV=1,M                                                       ZOC
      DZDX(NV)=0.                                                       ZOC
      IZ=1                                                              ZOC
      NNN=TBLSCW(IZ)                                                    ZOC
      DO 2 NN=1,M                                                       ZOC
      APHI=ATAN(PHI(IZ))                                                ZOC
      APSI=PSI(NN)                                                      ZOC
      XX=PV(NV)-PN(NN)                                                  ZOC
      YY(1)=Q(NV)-Q(NN)                                                 ZOC
      YY(2)=Q(NV)+Q(NN)                                                 ZOC
      ZZ=ZH(IZZ)-ZH(IZ)                                                 ZOC
      SNN=S(NN)                                                         ZOC
      DO 1 I=1,2                                                        ZOC
      YYY=YY(I)                                                         ZOC
      CALL INFSUB (BOT,FV(I),FW(I))                                     ZOC
      APHI=-APHI                                                        ZOC
      APSI=-APSI                                                        ZOC
    1 CONTINUE                                                          ZOC
      FVN=FW(1)+FW(2)-(FV(1)+FV(2))*PHI(IZZ)                            ZOC
      DZDX(NV)=DZDX(NV)+FVN*CIR(NN)/12.5663704                          ZOC
      IF (NN.LT.NNN.OR.NN.EQ.M) GO TO 2                                 ZOC
      IZ=IZ+1                                                           ZOC
      NNN=NNN+TBLSCW(IZ)                                                ZOC
    2 CONTINUE                                                          ZOC
      IF (NV.LT.NNV.OR.NV.EQ.M) GO TO 3                                 ZOC
      IZZ=IZZ+1                                                         ZOC
      NNV=NNV+TBLSCW(IZZ)                                               ZOC
    3 CONTINUE                                                          ZOC
C                                                                       ZOC
C                                                                       ZOC
C       INTEGRATE DZ/DX TO OBTAIN Z/C VERSUS X/C AT THE VARIOUS Y LOCATIZOC
C                                                                       ZOC
C                                                                       ZOC
      LA=1                                                              ZOC
      LB=0                                                              ZOC
      DO 9 I=1,NSSW                                                     ZOC
      IN=TBLSCW(I)                                                      ZOC
      IF (I.EQ.1) GO TO 4                                               ZOC
```

APPENDIX E

```
      LA=LA+TBLSCW(I-1)
4     LB=LB+TBLSCW(I)
      DO 5 J=LA,LB
      N=J-LA+1
      WOU(N)=-DZDX(J)
      XXCC(N)=(N-0.25)/IN
      K=IN+1+LA-J
      X3C4(K)=PV(J)*BETA
5     ALOC(K)=-DZDX(J)
      Y=Q(LA)/BOT
      WRITE (6,10) Q(LA),Y,CHORD(I)
      WRITE (6,13)
      WRITE (6,17) (WOU(IJ),IJ=1,IN)
      WRITE (6,14)
      WRITE (6,17) (XXCC(IJ),IJ=1,IN)
      WRITE (6,15)
      WRITE (6,16)
      K1=IN+2
      K2=IN+1
      ALOC(1)=ALOC(2)
      ALOC(K1)=ALOC(K2)
      X3C4(1)=XTE(I)
      X3C4(K1)=XTE(I)+CHORD(I)
      D1=D2=0.
      DO 6 L=1,41
6     T(L)=XTE(I)+CHORD(I)*(L-1)*.025
      IW=0
      CALL SPLINE (22,1,41,K1,1,41,X3C4,ALOC,T,A,SS,SS1,SS2,S2,S3,DELY,H
     1,IW,D1,D2,1,PSUM)
      DO 7 L=1,40
      K=42-L
      J=41-L
7     PSUM(K)=PSUM(J)
      PSUM(1)=0.
      DO 8 L=1,41
      K=42-L
      XOC=1.+(XTE(I)-T(K))/CHORD(I)
      ZOC=PSUM(K)/CHORD(I)
      X=XOC*CHORD(I)
      WRITE (6,11) XOC,ZOC,X,PSUM(K)
8     CONTINUE
      WRITE (6,18)
9     CONTINUE
      RETURN
10    FORMAT (35X,2HY=,F10.4,11X,6HY/B/2=,F10.4,11X,6HCHORD=,F10.4//)
11    FORMAT (38XF9.4,3(5XF9.4))
12    FORMAT (1H1,55X,20HLOCAL ELEVATION DATA///)
13    FORMAT (41X,47HSLOPES,DZ/DX,AT SLOPE POINTS,FROM FRONT TO REAR/)
14    FORMAT (42X,46HCORRESPONDING X/C LOCATIONS FROM FRONT TO REAR/)
15    FORMAT (////58X,15HLOCAL ELEVATION//)
16    FORMAT (43X,3HX/C,11X,3HZ/C,8X,7HDELTA X,7X,7HDELTA Z/)
17    FORMAT (5X,20F6.4)
18    FORMAT (1H1)
      END
```

```
      SUBROUTINE INFSUB (BOT,FVI,FWI)
      COMMON /INSUB23/ PSII,APHII,XXX,YYY,ZZZ,SNN,TOLRNC
      FC=COS(PSII)
      FS=SIN(PSII)
      FT=FS/FC
      FPC=COS(APHII)
      FPS=SIN(APHII)
      FPT=FPS/FPC
      F1=XXX+SNN*FT*FPC
      F2=YYY+SNN*FPC
      F3=ZZZ+SNN*FPS
      F4=XXX-SNN*FT*FPC
      F5=YYY-SNN*FPC
      F6=ZZZ-SNN*FPS
      FFA=(XXX**2+(YYY*FPS)**2+FPC**2*((YYY*FT)**2+(ZZZ/FC)**2-2.*XXX*YY
     1Y*FT)-2.*ZZZ*FPC*(YYY*FPS+XXX*FT*FPS))
      FFB=(F1*F1+F2*F2+F3*F3)**.5
      FFC=(F4*F4+F5*F5+F6*F6)**.5
      FFD=F5*F5+F6*F6
      FFE=F2*F2+F3*F3
      FFF=(F1*FPC*FT+F2*FPC+F3*FPS)/FFB-(F4*FPC*FT+F5*FPC+F6*FPS)/FFC
C
C
C     THE TOLERANCE SET AT THIS POINT IN THE PROGRAM MAY NEED TO BE
C     CHANGED FOR COMPUTERS OTHER THAN THE CDC 6000 SERIES
C
C
      IF (ABS(FFA).LT.(BOT*15.E-5)**2) GO TO 1
      FVONE=(XXX*FPS-ZZZ*FT*FPC)*FFF/FFA
      FWONE=(YYY*FT-XXX)*FFF/FFA*FPC
      GO TO 2
1     FVONE=FWONE=0.
C
2     IF (ABS(FFD).LT.TOLRNC) GO TO 3
      FVTWO=F6*(1.-F4/FFC)/FFD
      FWTWO=-F5*(1.-F4/FFC)/FFD
      GO TO 4
3     FVTWO=FWTWO=0.
C
4     IF (ABS(FFE).LT.TOLRNC) GO TO 5
      FVTHRE=-F3*(1.-F1/FFB)/FFE
      FWTHRE=F2*(1.-F1/FFB)/FFE
      GO TO 6
5     FVTHRE=FWTHRE=0.
C
6     FVI=FVONE+FVTWO+FVTHRE
      FWI=FWONE+FWTWO+FWTHRE
      RETURN
      END
```

APPENDIX E

```
      SUBROUTINE SPLINE (MNPTS,MNCVS,MMAX,N,NCVS,M,X,Y,T,PROXIN,SS,SS1,S
     1S2,S2,S3,DELY,H,IW,D1,D2,KAB,PSUM)
      DIMENSION TH(50), DELH(50,1), CT(50), TH2(50), DELSQH(50), ST2(50,
     11)
      DIMENSION PSUM(MMAX,MNCVS)
      DIMENSION X(MNPTS), Y(MNPTS,MNCVS), T(MMAX), DELY(MNPTS,MNCVS), S2
     1(MNPTS,MNCVS), S3(MNPTS,MNCVS), SS1(MMAX,MNCVS), SS(MMAX,MNCVS), H
     2(MNPTS), SS2(MMAX,MNCVS), PROXIN(MNCVS), DELSQY(50), H2(50), C(50)
     3, D(50)
      DIMENSION D1(NCVS), D2(NCVS), KAB(NCVS)
      IF (IW) 9,1,9
1     N1=N-1
      IW=2
      DO 8 K=1,NCVS
      DO 2 I=1,N1
      H(I)=X(I+1)-X(I)
      II=I+1
      DELY(I,K)=(Y(II,K)-Y(I,K))/H(I)
2     C(I)=H(I)
      DO 3 I=2,N1
      H2(I)=(H(I-1)+H(I))*2.
      DELSQY(I)=(DELY(I,K)-DELY(I-1,K))*6.
3     CONTINUE
      IF (KAB(K).EQ.0) GO TO 4
      H2(1)=2.*H(1)
      H2(N)=2.*H(N1)
      DELSQY(1)=6.*(DELY(1,K)-D1(K))
      DELSQY(N)=(D2(K)-DELY(N1,K))*6.
      GO TO 5
4     H2(1)=1.0
      H2(N)=1.0
      C(1)=0.0
      H(N1)=0.0
      DELSQY(1)=0.0
      DELSQY(N)=0.0
5     CALL TRIMAT (H,H2,C,DELSQY,D,N)
      DO 6 I=1,N
6     S2(I,K)=D(I)
      H(N1)=C(N1)
      DO 7 I=1,N1
      II=I+1
7     S3(I,K)=(S2(II,K)-S2(I,K))/H(I)
8     CONTINUE
9     CONTINUE
      J=0
10    J=J+1
      I=1
      IF (T(J)-X(1)) 14,17,11
11    IF (T(J)-X(N)) 13,15,14
12    IF (T(J)-X(I)) 16,17,13
13    I=I+1
      GO TO 12
14    CONTINUE
      PRINT 25, J
      PRINT 26, (X(I),I=1,N)
      PRINT 26, (Y(I,1),I=1,N)
      GO TO 19
15    I=N
16    CONTINUE
      IW=-I
```

```
      I=I-1
17    DO 18 K=1,NCVS
      HT1=T(J)-X(I)
      II=I+1
      HT2=T(J)-X(II)
      PROD=HT1*HT2
      SS2(J,K)=S2(I,K)+HT1*S3(I,K)
      DELSQS=(S2(I,K)+S2(II,K)+SS2(J,K))/6.
      SS(J,K)=Y(I,K)+HT1*DELY(I,K)+PROD*DELSQS
      SS1(J,K)=DELY(I,K)+(HT1+HT2)*DELSQS+PROD*S3(I,K)/6.0
18    CONTINUE
19    CONTINUE
      IF (J.LT.M) GO TO 10
      M1=M-1
      DO 24 K=1,NCVS
      DO 20 I=1,M1
      TH(I)=T(I+1)-T(I)
      II=I+1
      DELH(I,K)=(SS(II,K)-SS(I,K))/TH(I)
      CT(I)=TH(I)
20    CONTINUE
      DO 21 I=2,M1
      TH2(I)=(TH(I-1)+TH(I))*2.
      DELSQH(I)=(DELH(I,K)-DELH(I-1,K))*6.
21    CONTINUE
      TH2(1)=TH2(M)=1.
      CT(1)=0
      TH(M1)=0
      DELSQH(1)=DELSQH(M)=0.
      CALL TRIMAT (TH,TH2,CT,DELSQH,D,M)
      DO 22 I=1,M
      ST2(I,K)=D(I)
22    CONTINUE
      TH(M1)=CT(M1)
      PROXIN(K)=0.0
      DO 23 I=1,M1
      II=I+1
      PROXIN(K)=PROXIN(K)+.5*TH(I)*(SS(I,K)+SS(II,K))-TH(I)**3*(ST2(I,K)
     1+ST2(II,K))/24.
      PSUM(I,K)=PROXIN(K)
23    CONTINUE
24    CONTINUE
      RETURN
C
25    FORMAT (I4,24HTH ARGUMENT OUT OF RANGE)
26    FORMAT (10F10.3)
      END
```

APPENDIX E

```
      SUBROUTINE TRIMAT (A,B,C,D,T,N)
      DIMENSION A(1), B(1), C(1), D(1), T(1), W(50), SV(50), G(50)
C
C     THIS ROUTINE SOLVES THE TRIDIAGONAL (EXCEPT TWO ELEMENTS)   MATRIX
C
      W(1)=B(1)
      SV(1)=C(1)/B(1)
      G(1)=D(1)/W(1)
      NM1=N-1
      DO 2 K=2,N
      KM1=K-1
      W(K)=B(K)-A(KM1)*SV(KM1)
      IF (K.EQ.N) GO TO 1
      SV(K)=C(K)/W(K)
1     G(K)=(D(K)-A(KM1)*G(KM1))/W(K)
2     CONTINUE
      T(N)=G(N)
      DO 3 K=1,NM1
      KK=N-K
      T(KK)=G(KK)-SV(KK)*T(KK+1)
3     CONTINUE
      RETURN
      END
```

```
*DECK VLMCDUMMY
      PROGRAM DUMMY
      URDUMB=0.
      STOP
      END
```

APPENDIX F

ROOT-BENDING-MOMENT CONSTRAINT

If the root bending moment is to be constrained instead of the pitching moment in equation (21), then it is also necessary to change from computing the C_m contributions (eq. (8)) to computing those of C_B. Thus the contribution to root bending moment[1] from the jth chordwise row would be

$$C_{B,j} = \frac{C_{N,j}\left[\left(\bar{y}_j - \bar{y}_r\right) \cos \phi_j + \left(\bar{z}_j - \bar{z}_r\right) \sin \phi_j\right]}{b/2} \tag{F1}$$

where ϕ_j is the horseshoe vortex dihedral angle. To reflect the change in the moment constraint which occurs in equation (21), it is necessary to rewrite the equation as

$$\phi_2 = \sum_{k=1}^{\bar{N}_s} \delta_k C_{B,k} - C_B = 0 \tag{F2}$$

for the dihedral solution technique. If the constraint is that of an elliptic span loading at $C_{L,d}$, then equation (F2) becomes

$$\phi_2 = \sum_{k=1}^{\bar{N}_s} \delta_k C_{B,k} - \frac{(-0.424414)C_{L,d}}{2} \tag{F3}$$

or

$$\phi_2 = 2 \sum_{k=1}^{\bar{N}_s} \delta_k C_{B,k} - (-0.424414)C_{L,d} \tag{F4}$$

with the number in parentheses being the fractional semispan distance of the loading centroid from the plane of symmetry. If the semispan employed in the preceding constraint is different from that of the wing under consideration, as could occur in a wing with a winglet added on, then the fractional location must be ratioed appropriately.

---

[1]The example of using the root-bending-moment constraint given in the text employed $\phi_j = 0$.

APPENDIX F

If there is an upper and a lower winglet on a wing to be represented, the upper winglet should be defined with the wing as one planform, and the lower winglet should become a second planform. For this two-planform configuration, the pitching-moment constraint should be made inoperative and in its place, the user may want to incorporate the root-bending-moment constraint just described.

The changes to the computer program listed in appendix E in order to implement the change to a root-bending-moment constraint are minor. The necessary change details will be given for the solution technique associated with the configuration having dihedral and a well-conditioned solution matrix. This is the part denoted by OVERLAY 1 CIRCUL2 and on the cards by DG2. The changes are given in the order of their occurrence in the program:

(1) Remove DG2 32

(2) Replace DG2 39 with

```
      CDRAG(IM) = -0.424414*CLDES                                     DG2  39
```

(3) Replace DG2 115 with

```
      APP = ATAN(PPP(KK))                                             DG2 115
```

and DG2 116 with

```
      A(KK,IM) = A(KK,IL)*((YQ(KK) - YREG(1,1))*                      DG2 116
     1 COS(APP) + (ZHH(KK) - RTCDHT(1))*SIN(APP))/BOT                 DG2 116A
```

Similar changes could be made in OVERLAY 1 CIRCUL1 and OVERLAY 1 CIRCUL3 if needed.

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1. Lamar, John E.: A Modified Multhopp Approach for Predicting Lifting Pressures and Camber Shape for Composite Planforms in Subsonic Flow. NASA TN D-4427, 1968.
2. Carlson, Harry W.; and Middleton, Wilbur D.: A Numerical Method for the Design of Camber Surfaces of Supersonic Wings With Arbitrary Planforms. NASA TN D-2341, 1964.
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11. Henderson, William P.: Pressure Distributions on a Cambered Wing-Body Configuration at Subsonic Mach Numbers. NASA TN D-7946, 1975.
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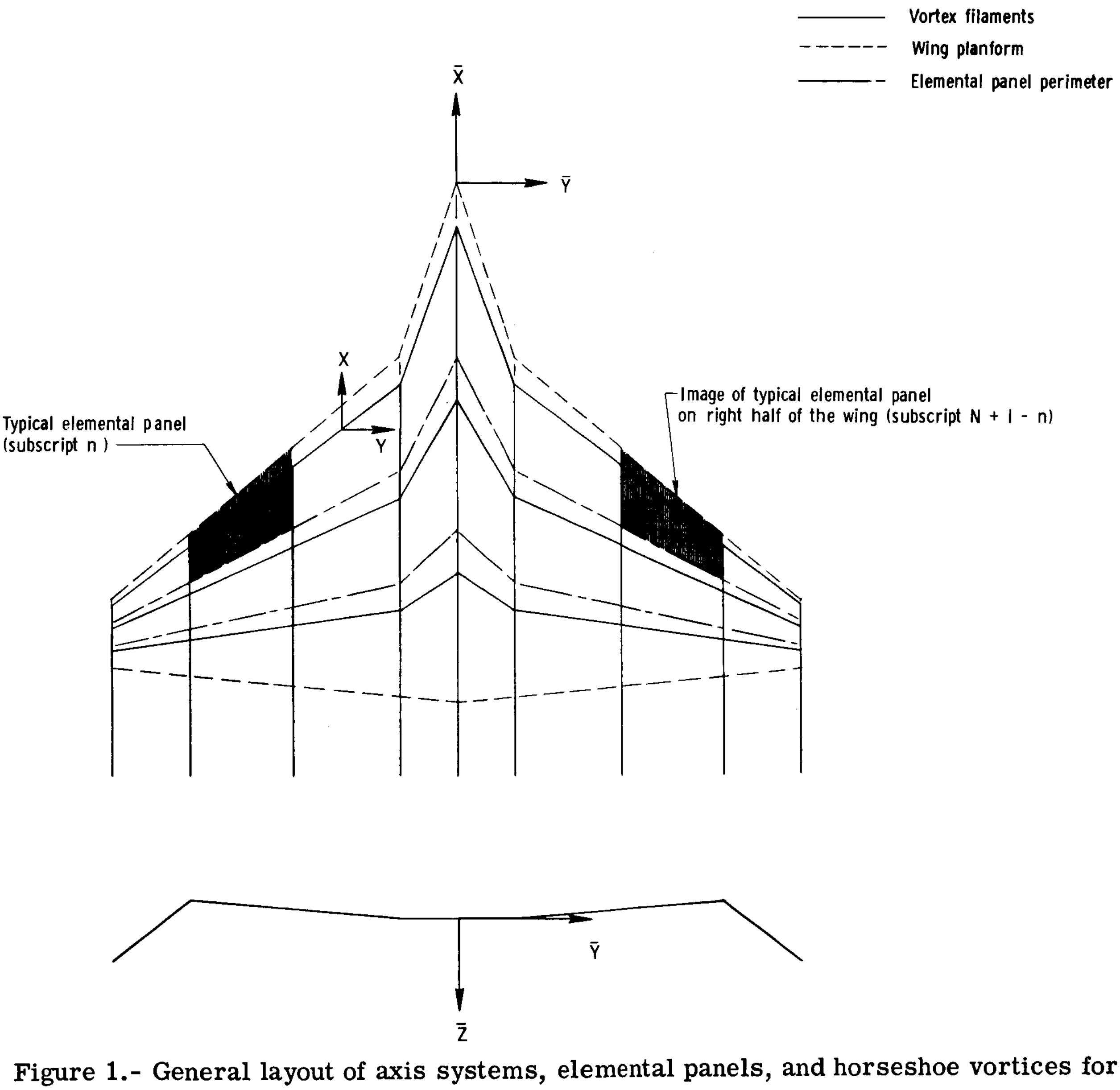


Figure 1.- General layout of axis systems, elemental panels, and horseshoe vortices for a typical wing planform.

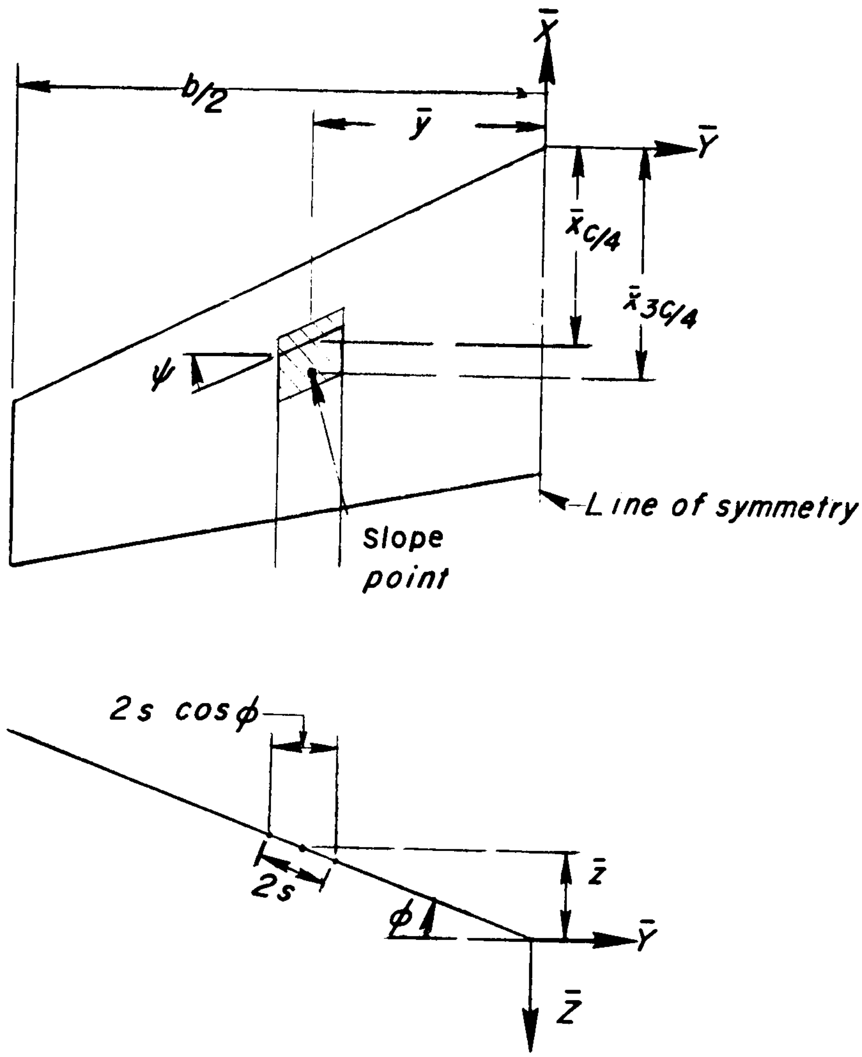
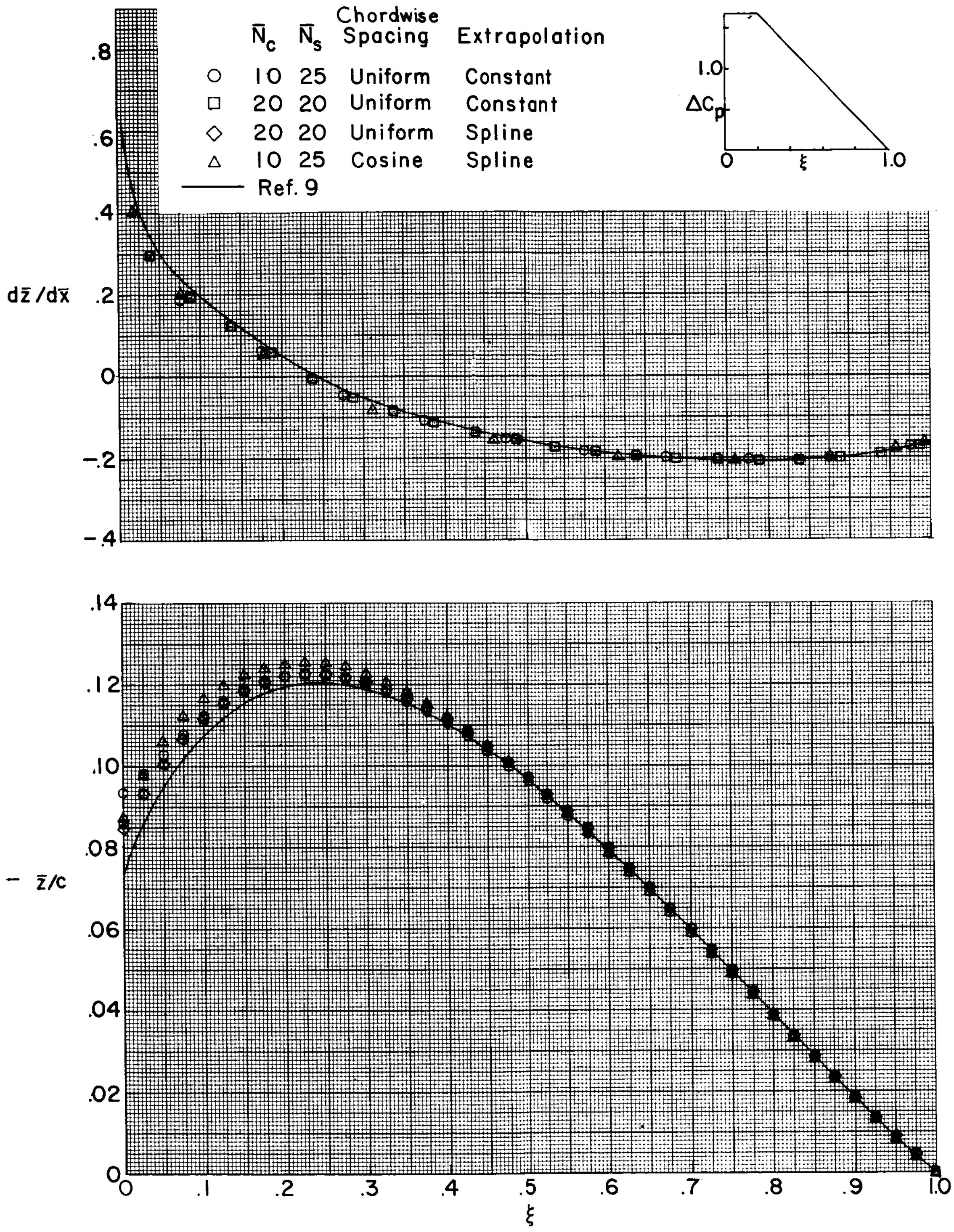
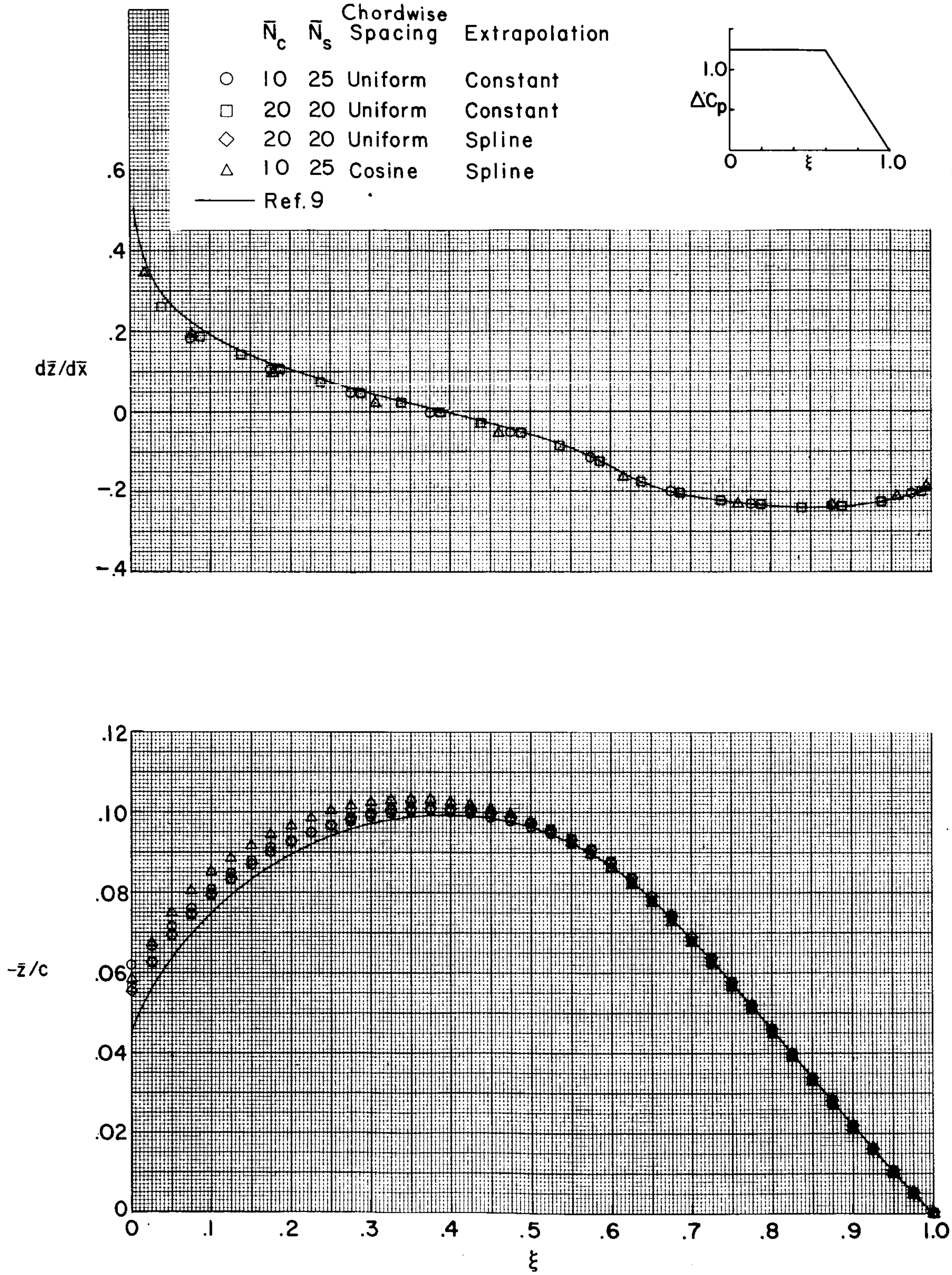


Figure 2.- Geometry of horseshoe vortex for typical panel. (See appendix C for variable names used in program and their description.



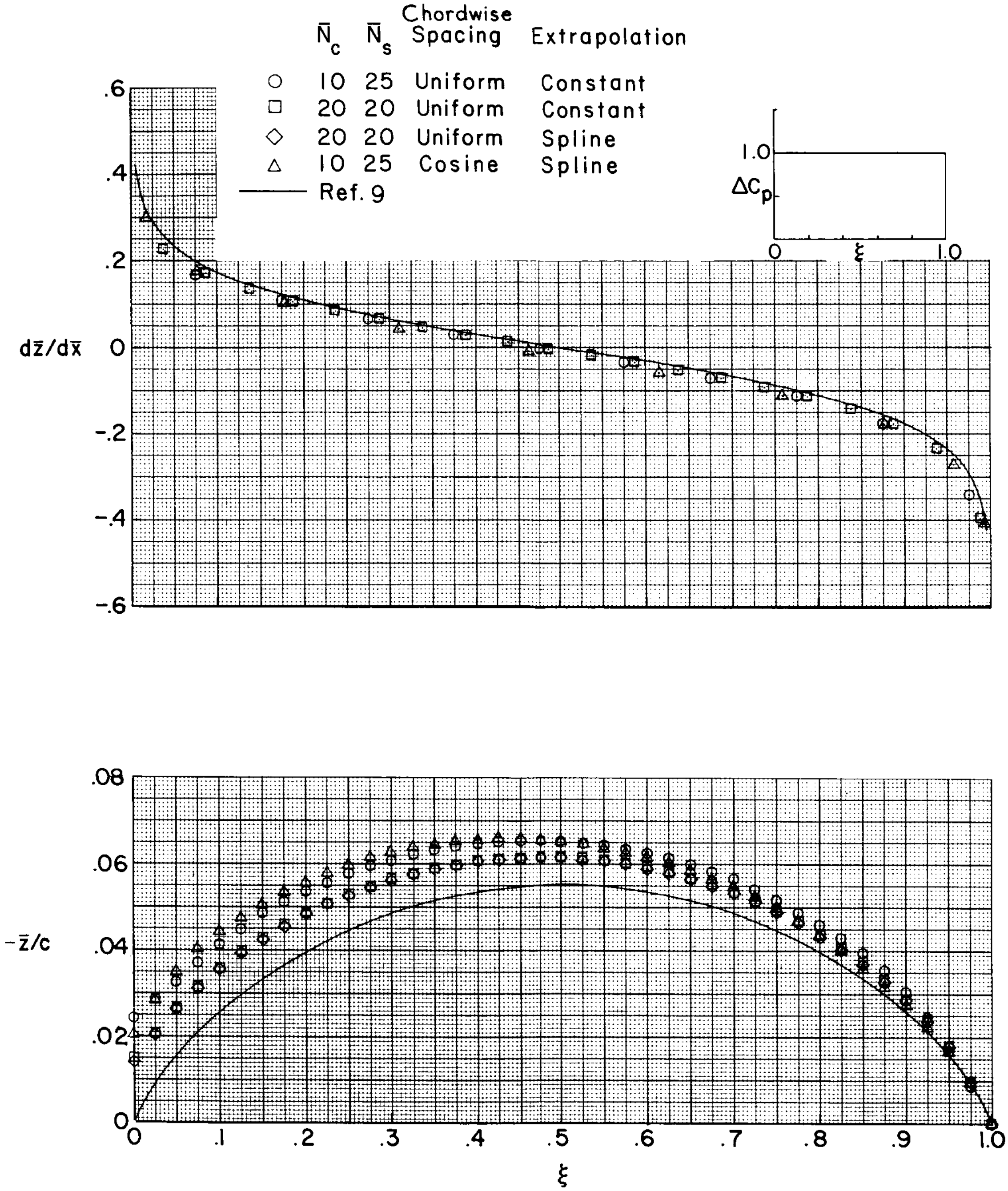
(a) a = 0.2.

Figure 3.- Solution from two-dimensional analytical method (ref. 9) and solutions from present method for local slopes and elevations for various values of a. $M_\infty = 0$; $C_{L,d} = 1.0$. (It should be noted that the diamond symbol does not appear in the upper part of the figure since it is coincident with the square symbol.)



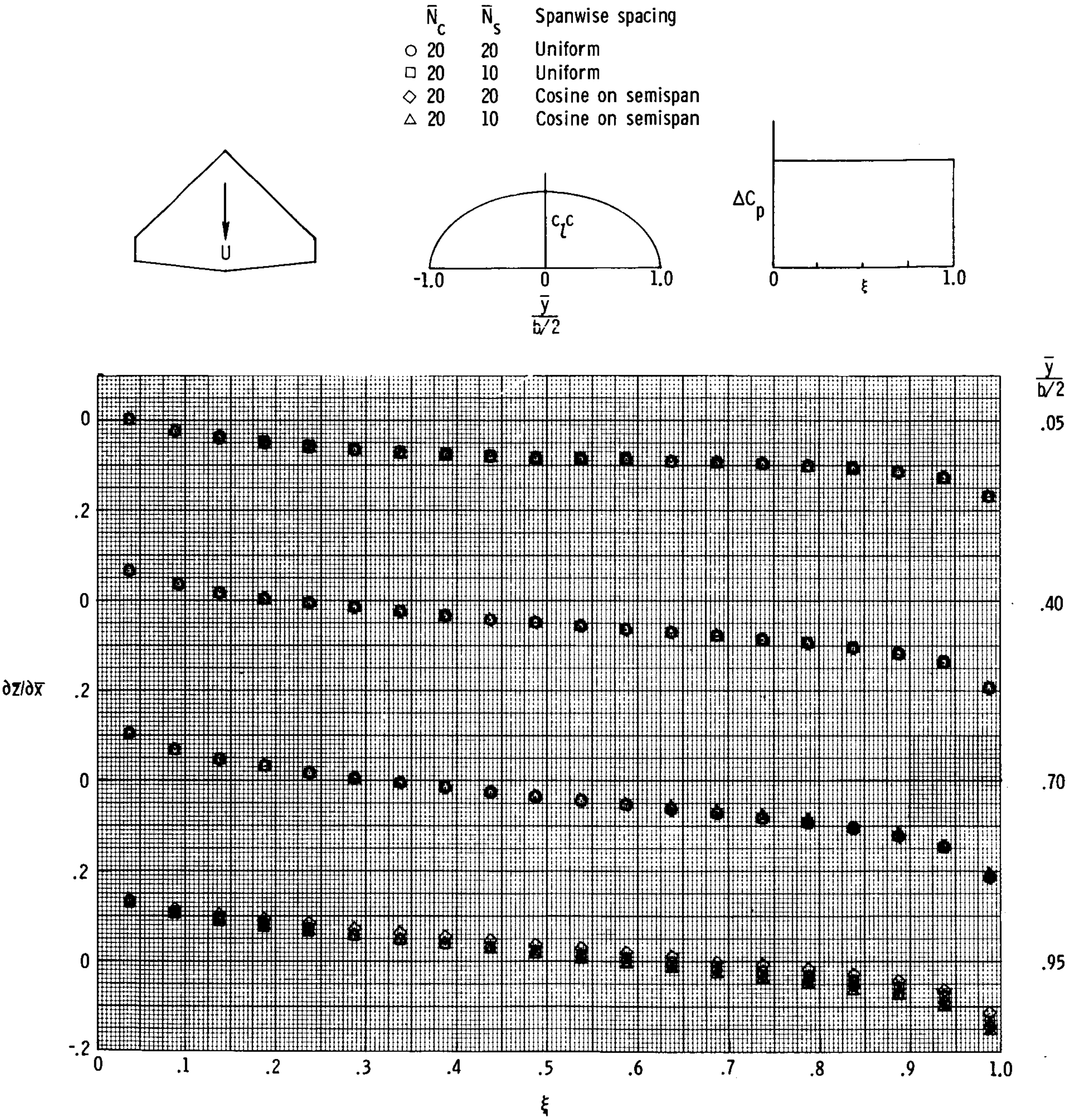
(b) a = 0.6.

Figure 3.- Continued.



(c) a = 1.0.

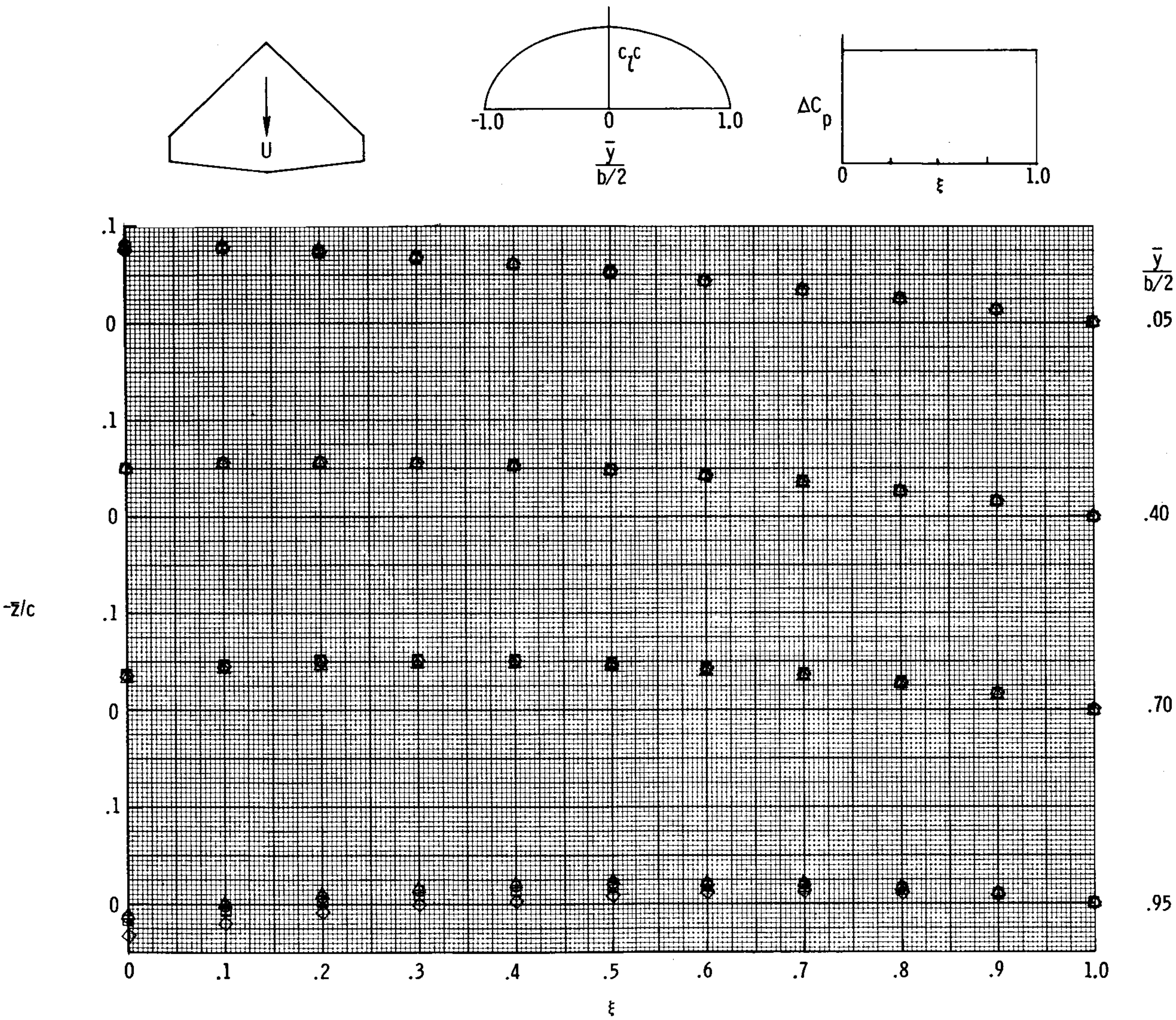
Figure 3.- Concluded.



(a) Local slopes.

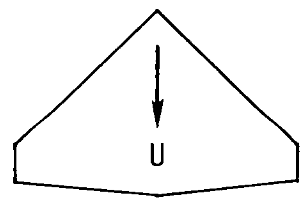
Figure 4.- Effect of number and spanwise distribution of chordwise rows of horseshoe vortices on local slopes and elevations for trapezoidal wing at $C_{L,d} = 0.35$ and $M_\infty = 0.40$. $\Lambda = 44.03^o$.

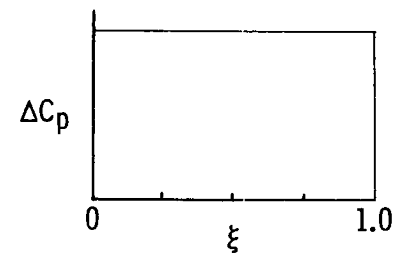
	$\bar{N}_c$	$\bar{N}_s$	Spanwise spacing
○	20	20	Uniform
□	20	10	Uniform
◇	20	20	Cosine on semispan
△	20	10	Cosine on semispan



(b) Local elevations.

Figure 4.- Concluded.





Technique For wings with		C_L	$C_{D,v}$
○	No Dihedral	.350	.0153
□	Dihedral	.351	.0161

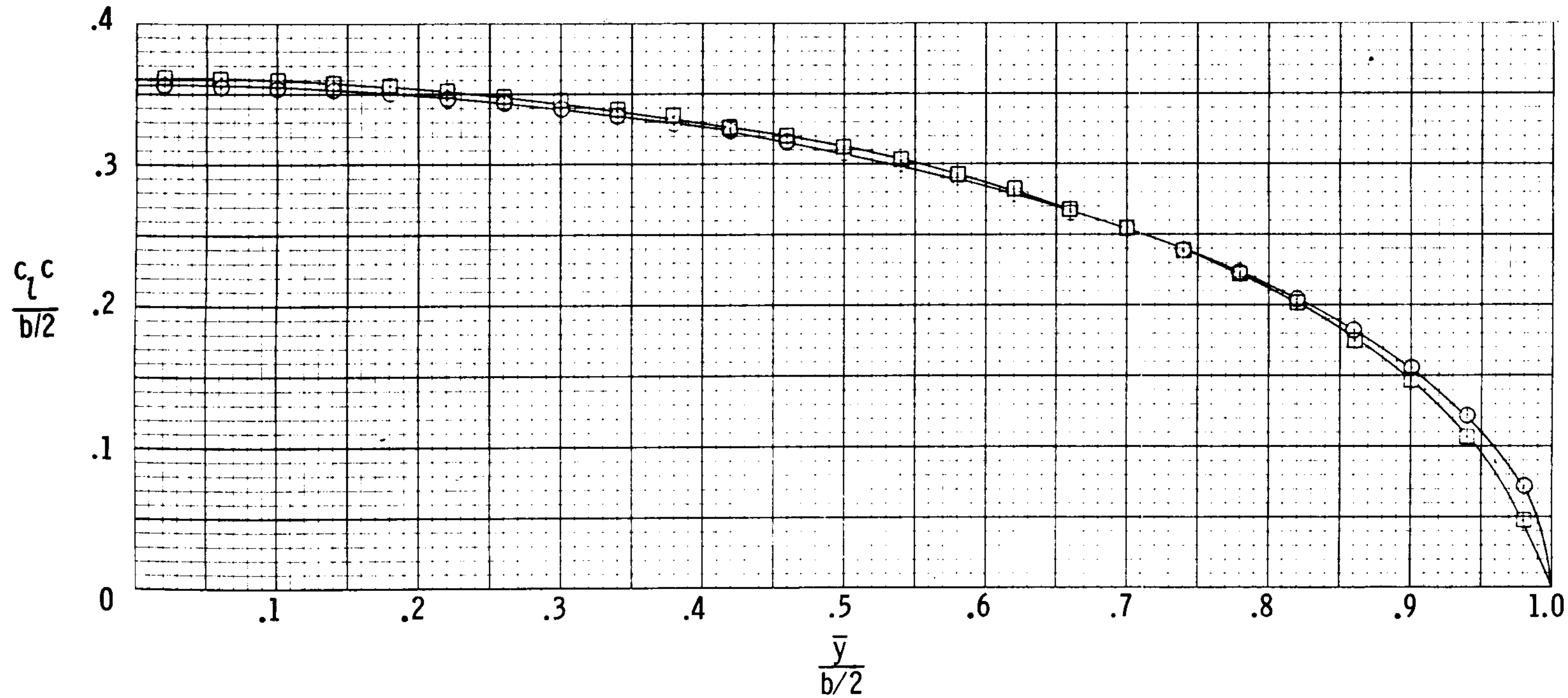


Figure 5.- Effect of solution technique on aerodynamic results for wing with no dihedral. $\overline{N}_c = 16$; $\overline{N}_s = 25$; $M_\infty = 0$. $\Lambda = 44.03^\circ$.

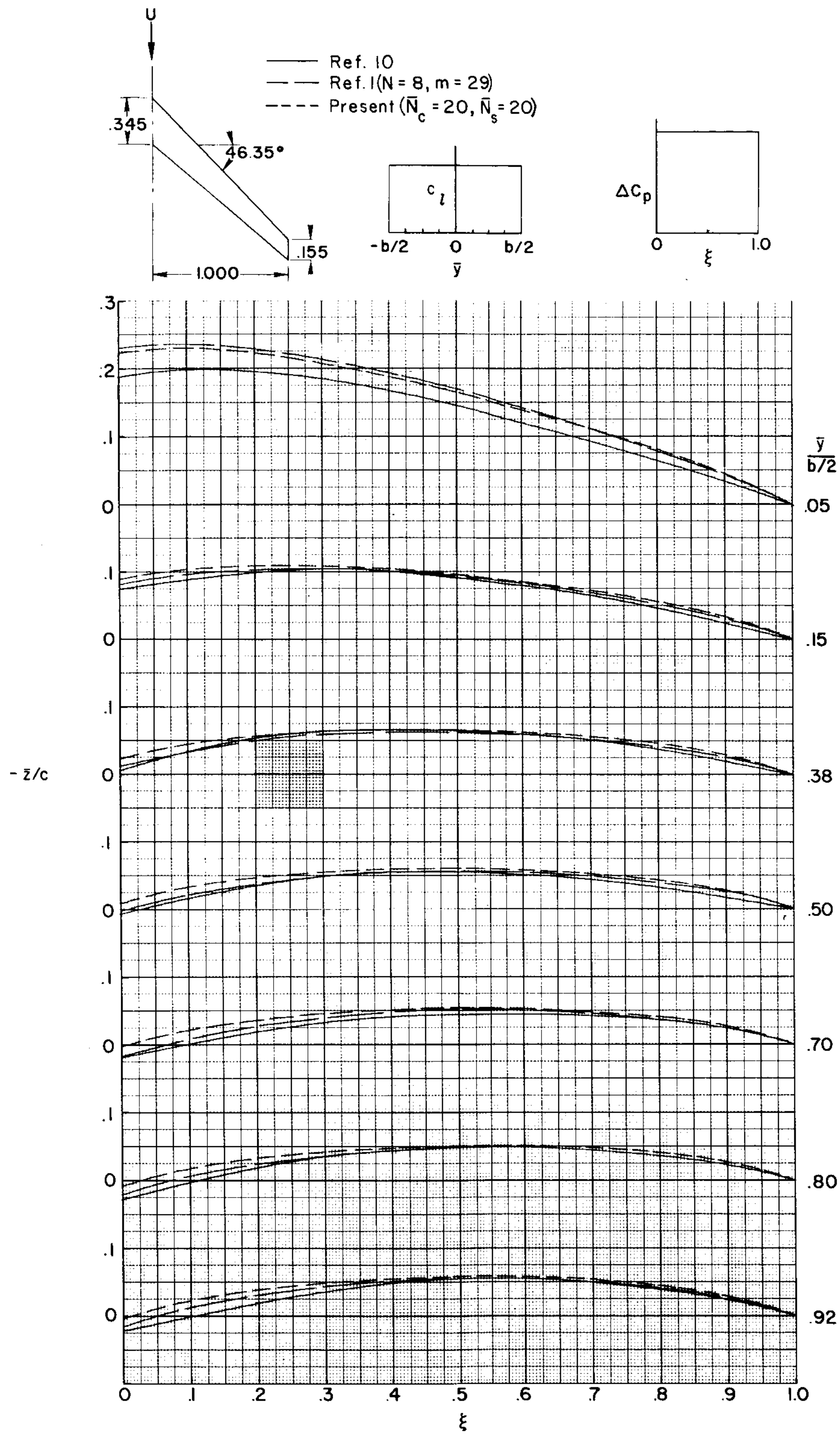
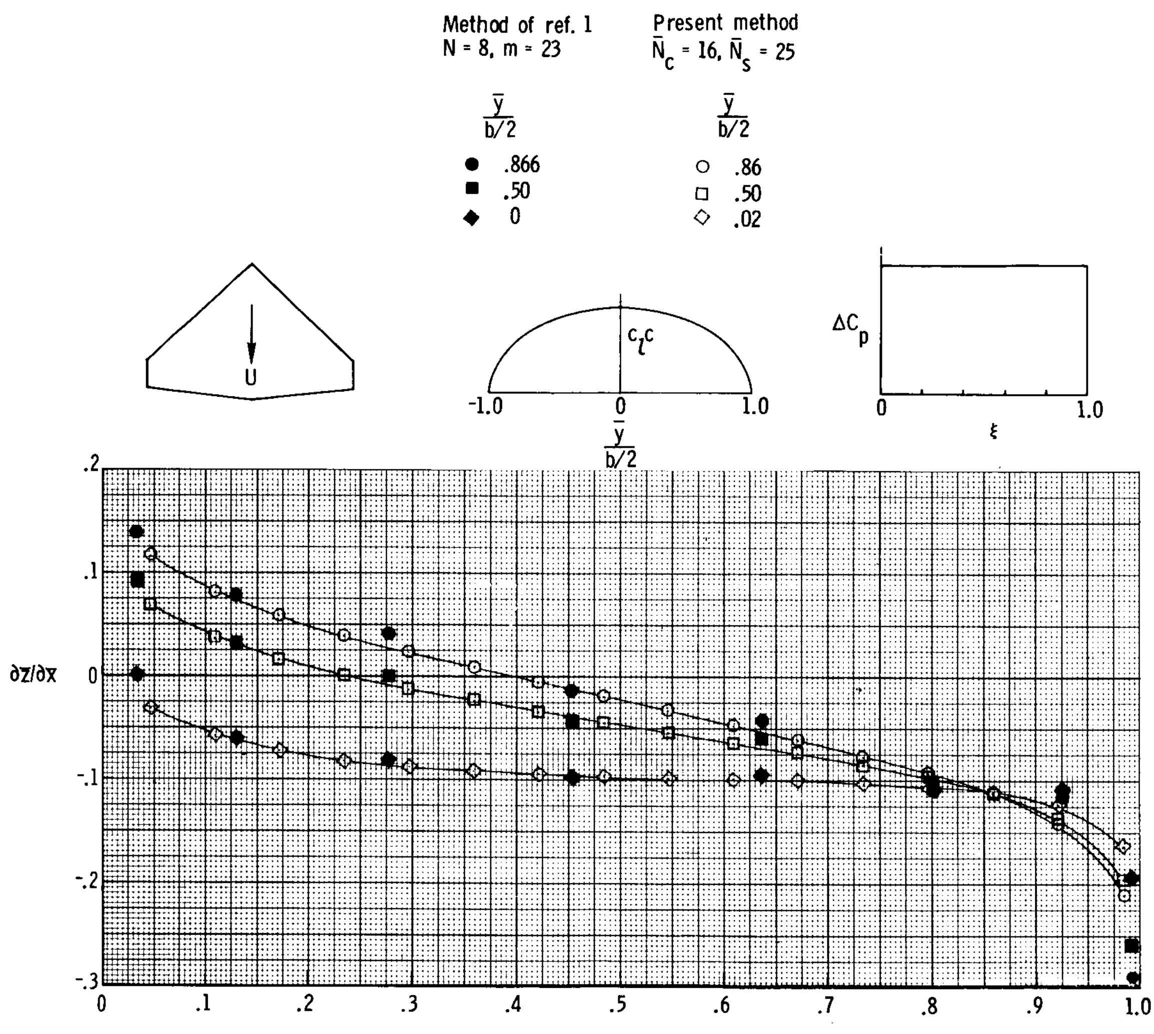
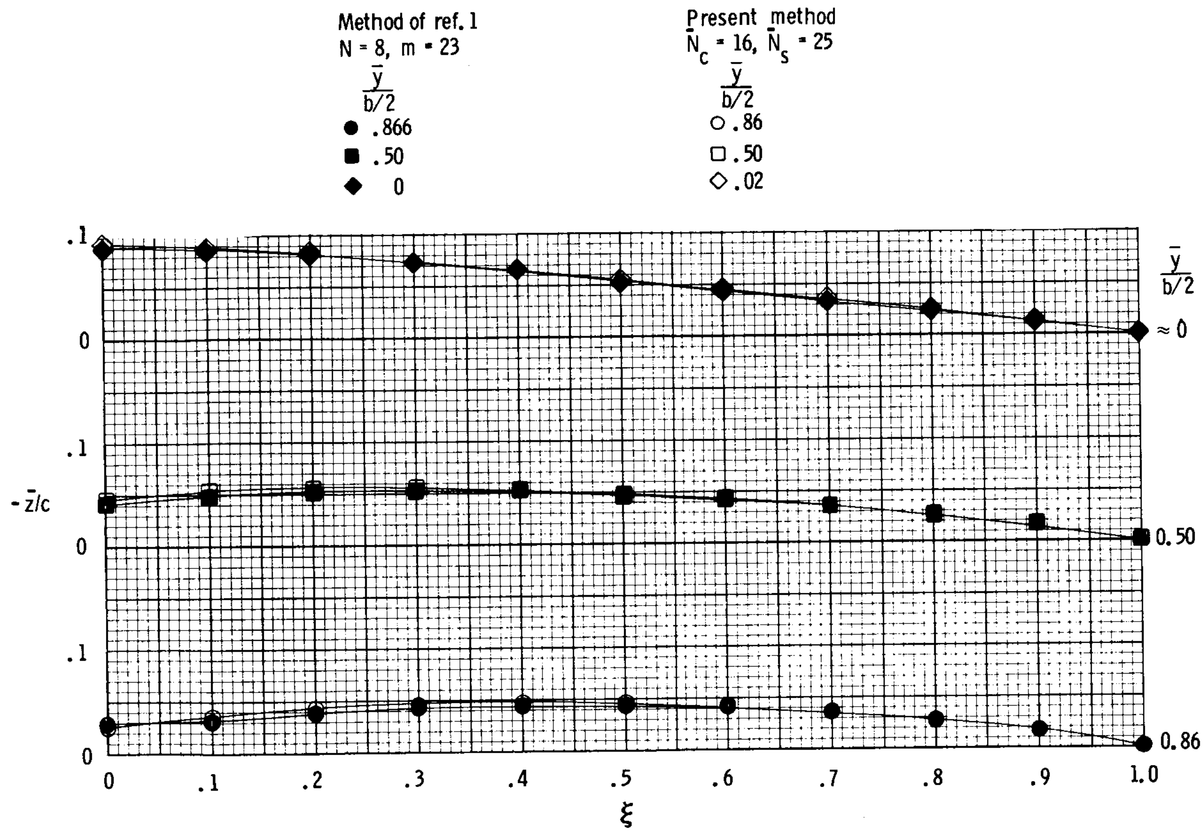


Figure 6.- Local elevations obtained from three theoretical methods for high-aspect-ratio wing at $C_{L,d} = 1.0$ and $M_\infty = 0.90$.



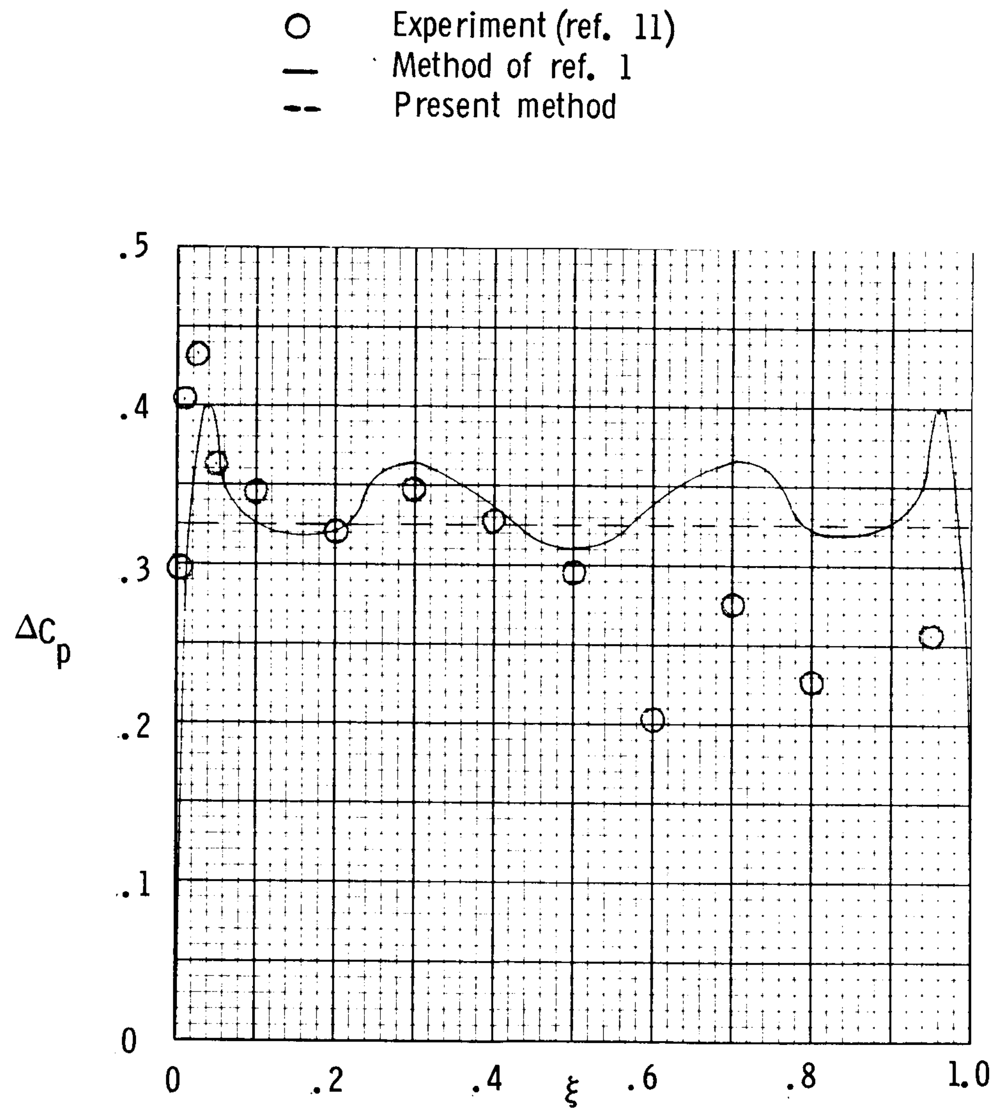
(a) Local slopes.

Figure 7.- Local slopes, elevations, and lifting pressure distribution for trapezoidal wing for $C_{L,d} = 0.35$ and $M_\infty = 0.40$. $\Lambda = 44.03^\circ$.



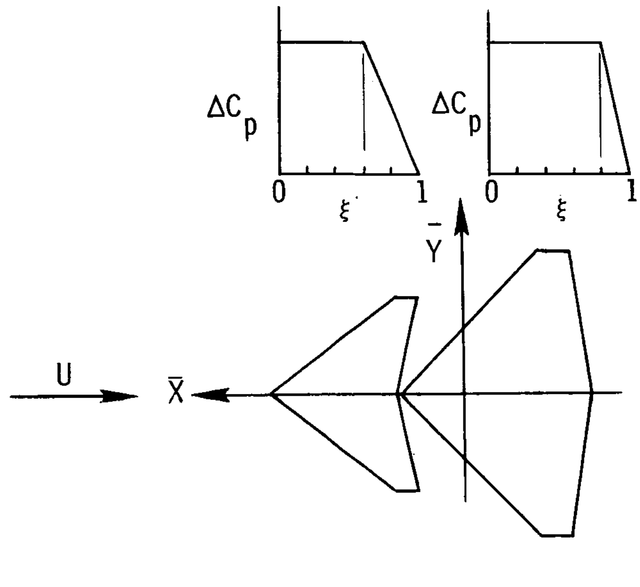
(b) Local elevations.

Figure 7.- Continued.



(c) Lifting pressure distributions at $\frac{\bar{y}}{b/2} = 0.259$.

Figure 7.- Concluded.



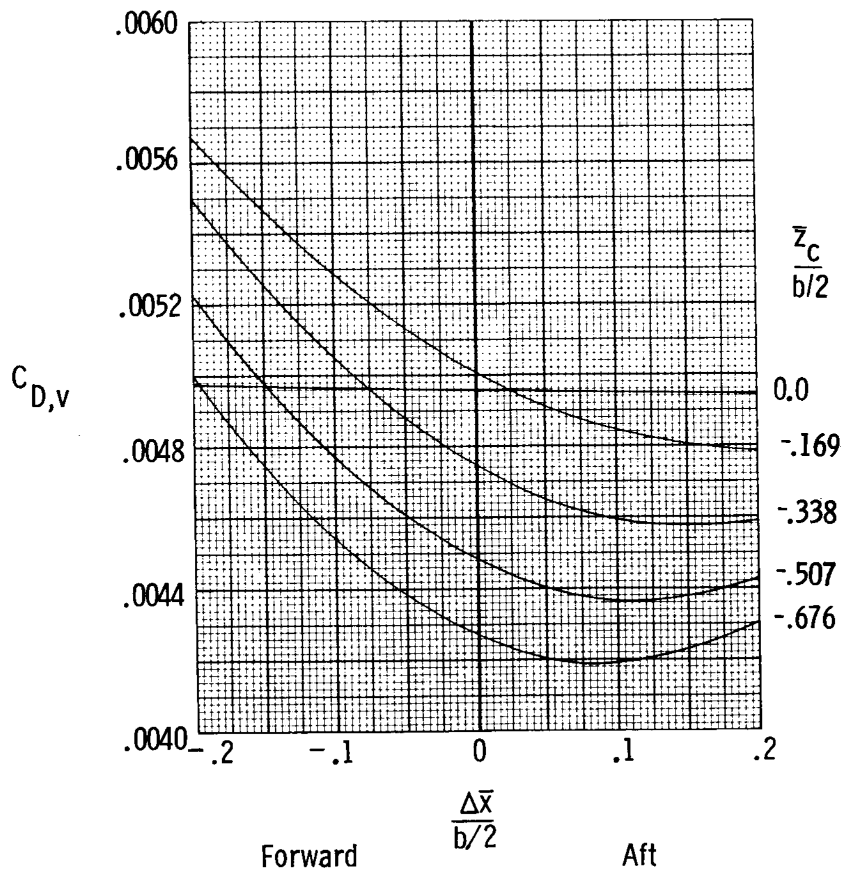
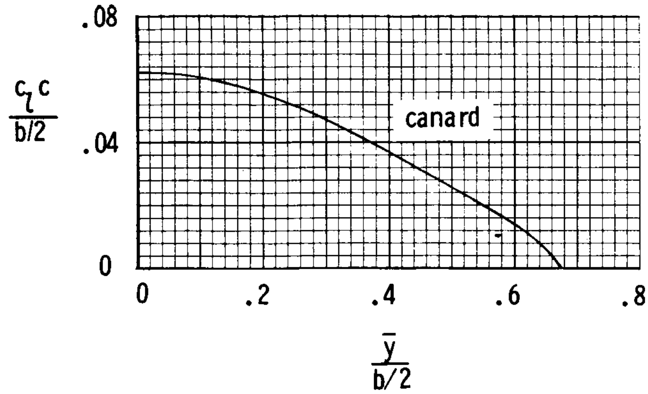
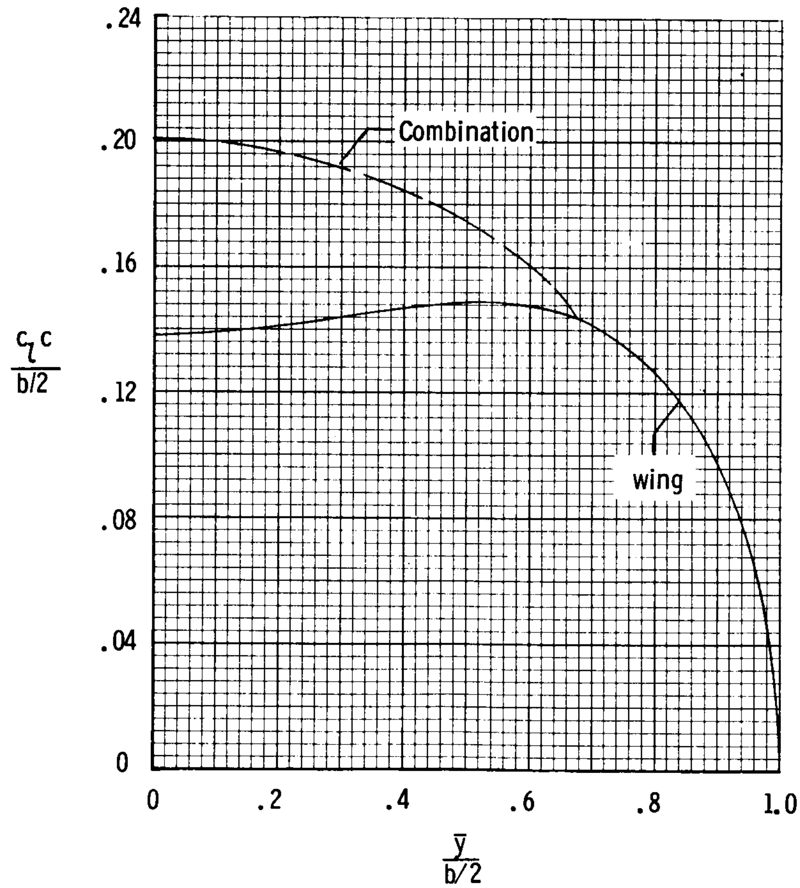


Figure 8.- Vortex drag for a wing-canard configuration over a range of moment trim points and vertical separations for $C_{L,d} = 0.2$ and $M_\infty = 0.30$.

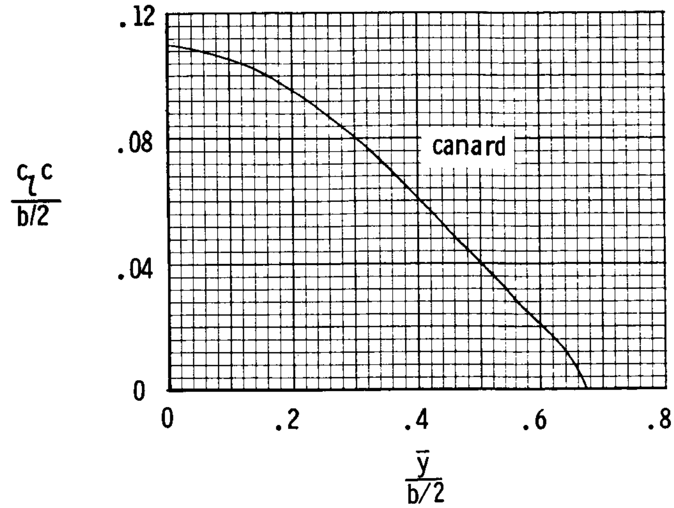


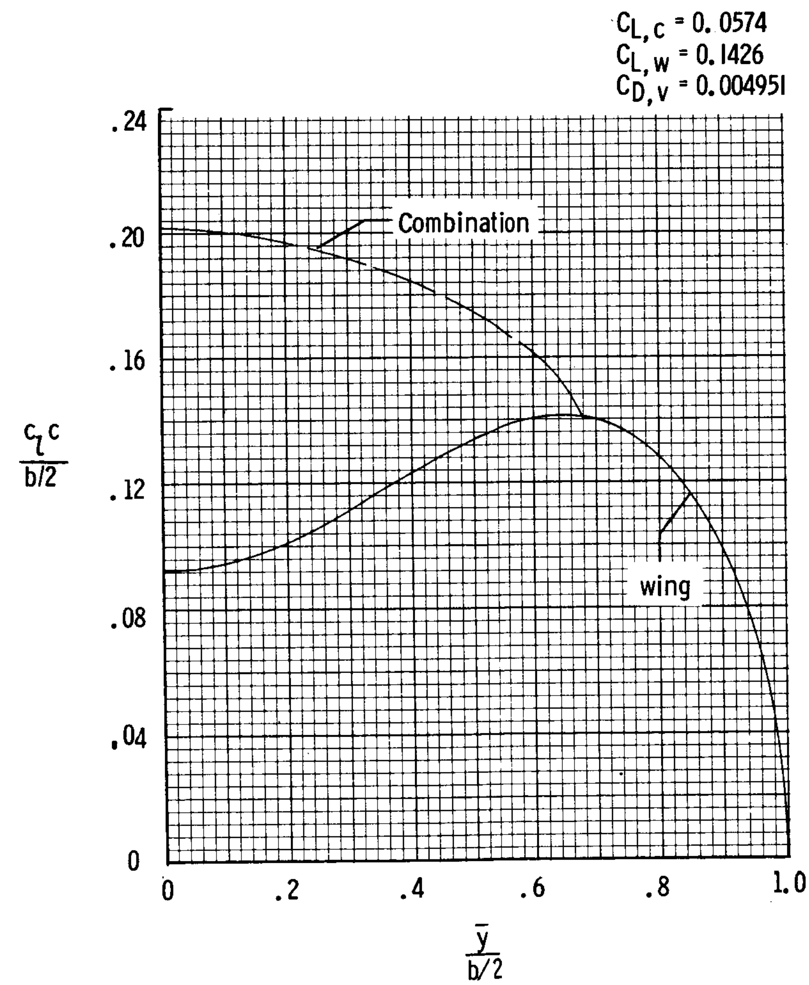
$C_{L,c}$ = 0.0338
$C_{L,w}$ = 0.1662
$C_{D,v}$ = 0.004943



(a) $a_c = a_w = 0$.

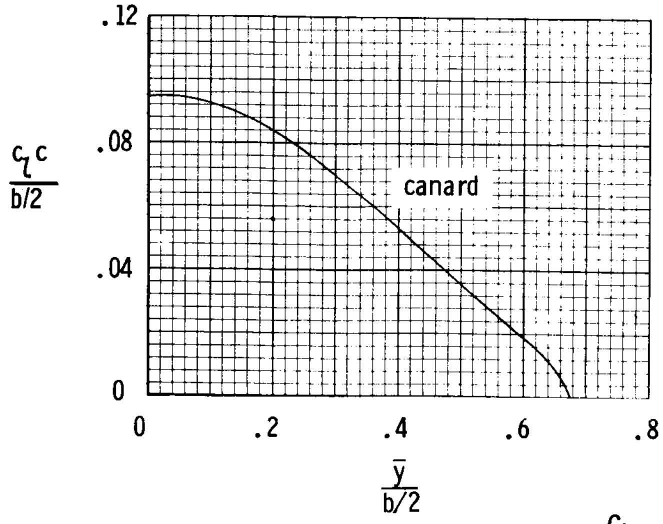
Figure 9.- Effect of location of chord loading change on optimum span loading, C_L division, and $C_{D,v}$ with pitching-moment constraint for wing-canard configuration of figure 8. $\frac{\Delta\bar{x}}{b/2} = 0.1$; $\frac{\bar{z}_c}{b/2} = 0$; $M_\infty = 0.30$.

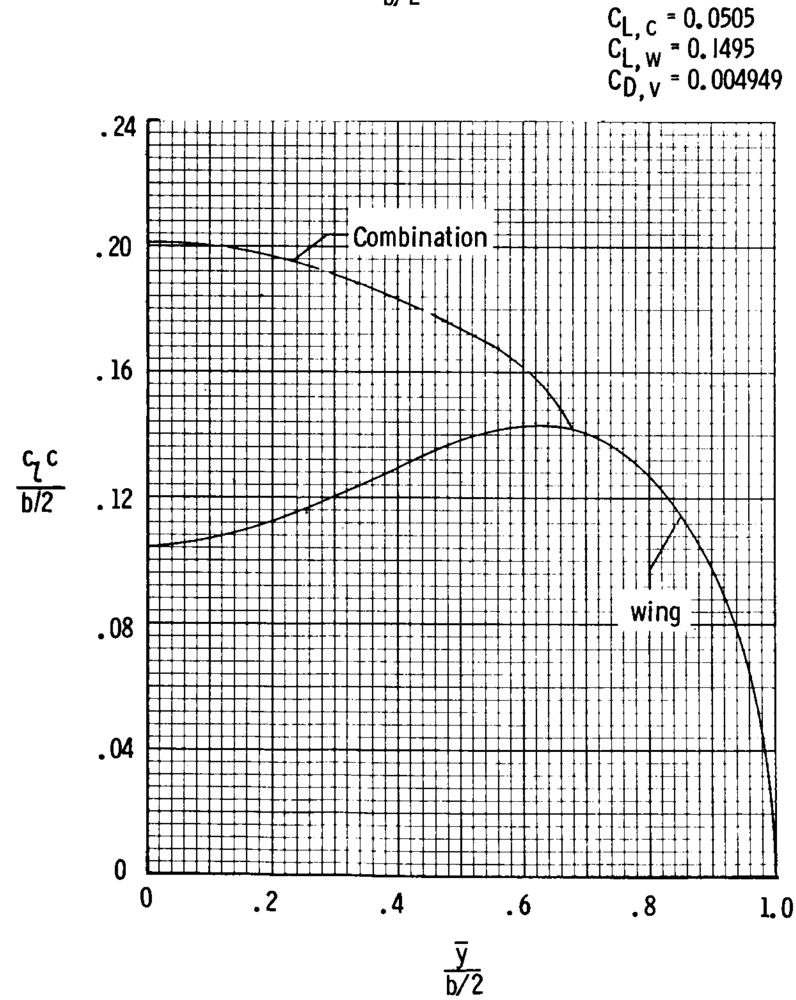




(b) $a_c = a_w = 1.0$.

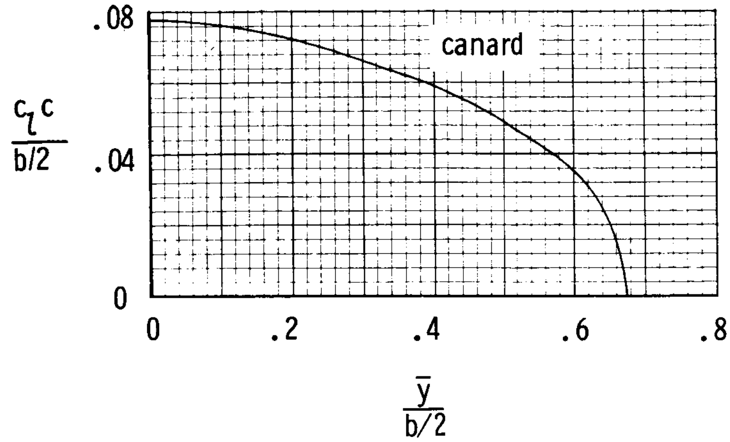
Figure 9.- Continued.

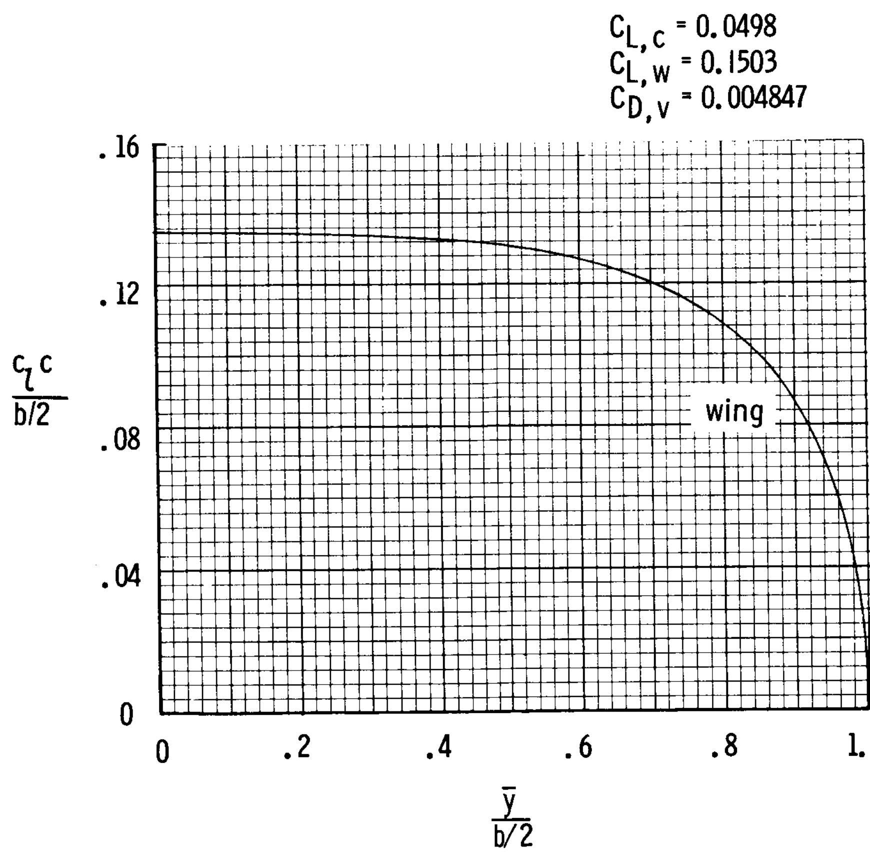




(c) $a_c = 0.6$, $a_w = 0.8$.

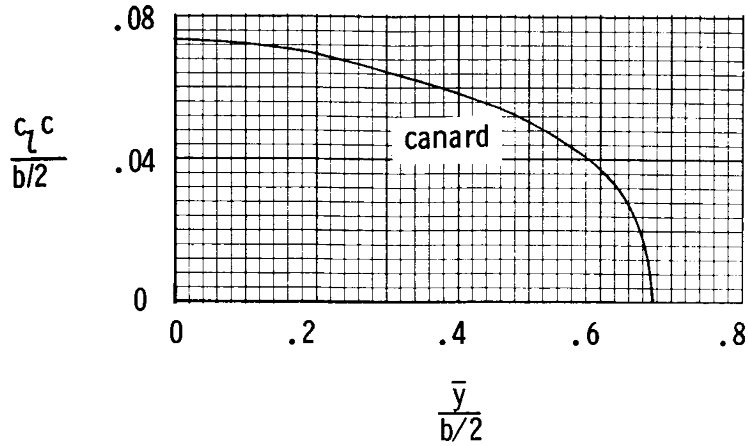
Figure 9.- Concluded.

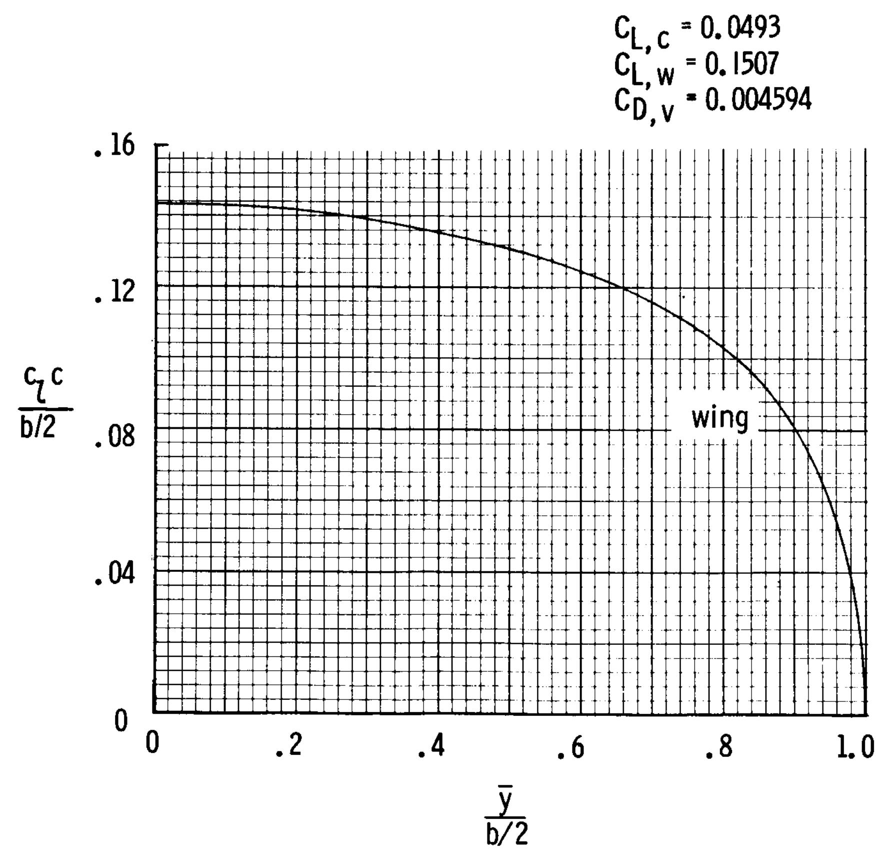




(a) $\frac{\bar{z}_c}{b/2} = -0.169$.

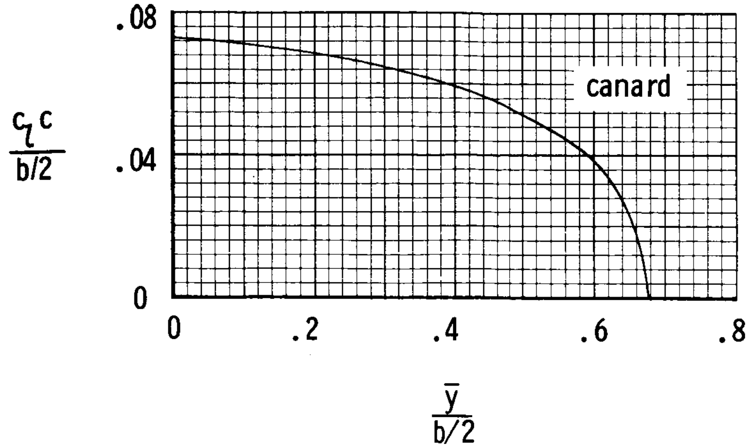
Figure 10.- Effect on span loading, C_L division, and $C_{D,v}$ of vertical separation of wing-canard configuration of figure 8 with pitching-moment constraint. $\frac{\Delta\bar{x}}{b/2} = 0.1$; $a_c = 0.6$; $a_w = 0.8$; $M_\infty = 0.30$.

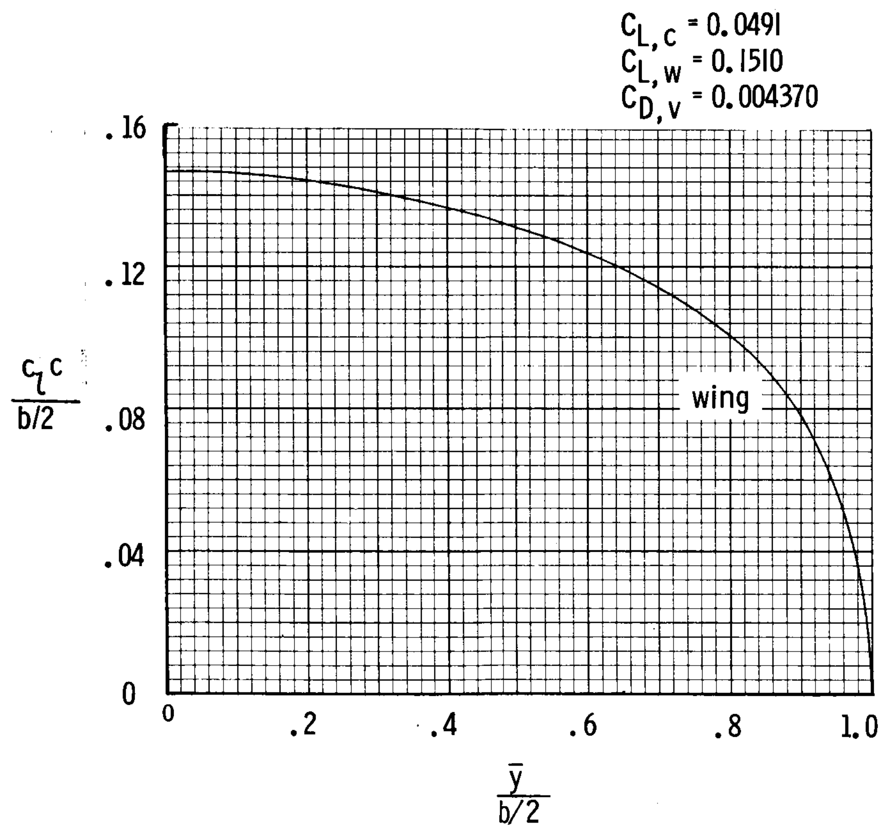




(b) $\frac{\bar{z}_c}{b/2} = -0.338.$

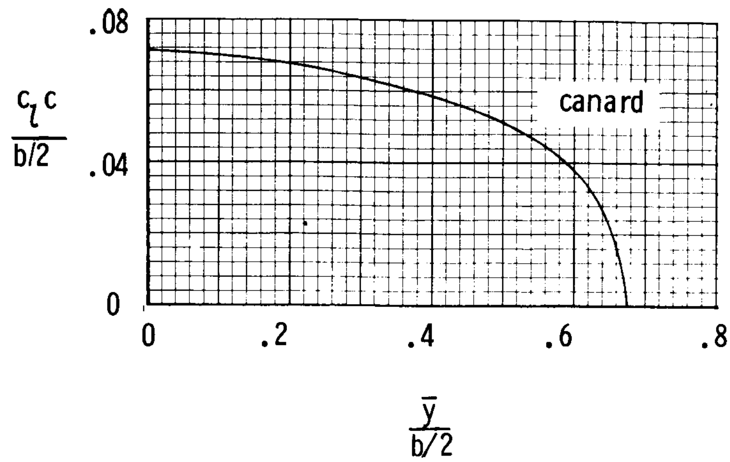
Figure 10.- Continued.

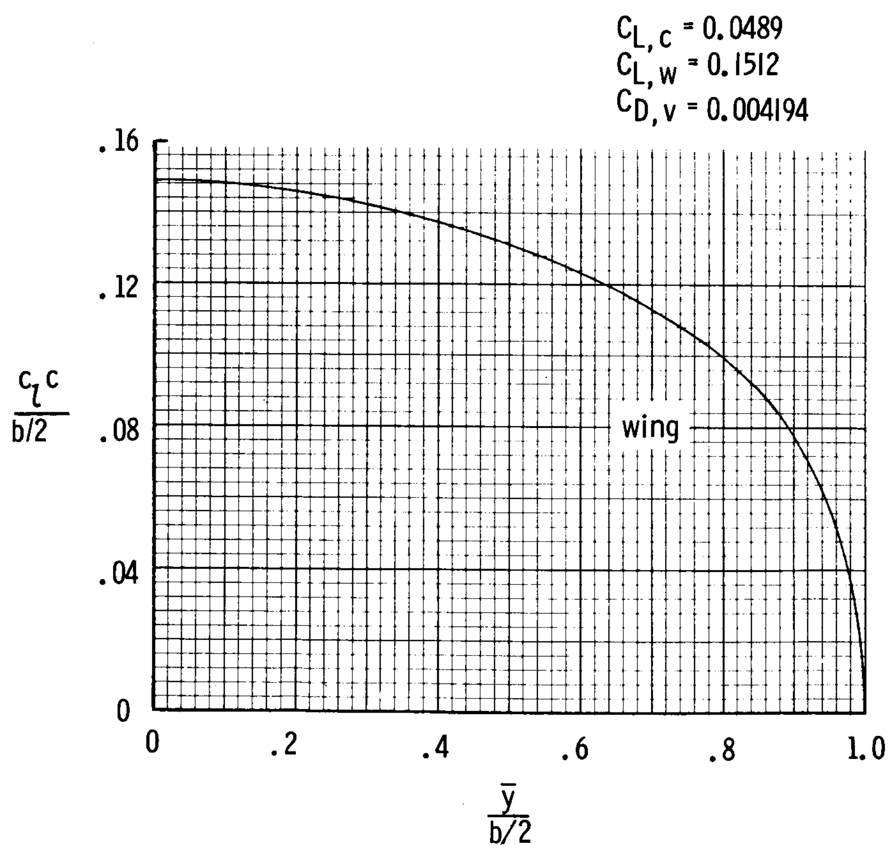




(c) $\frac{\bar{z}_c}{b/2} = -0.507.$

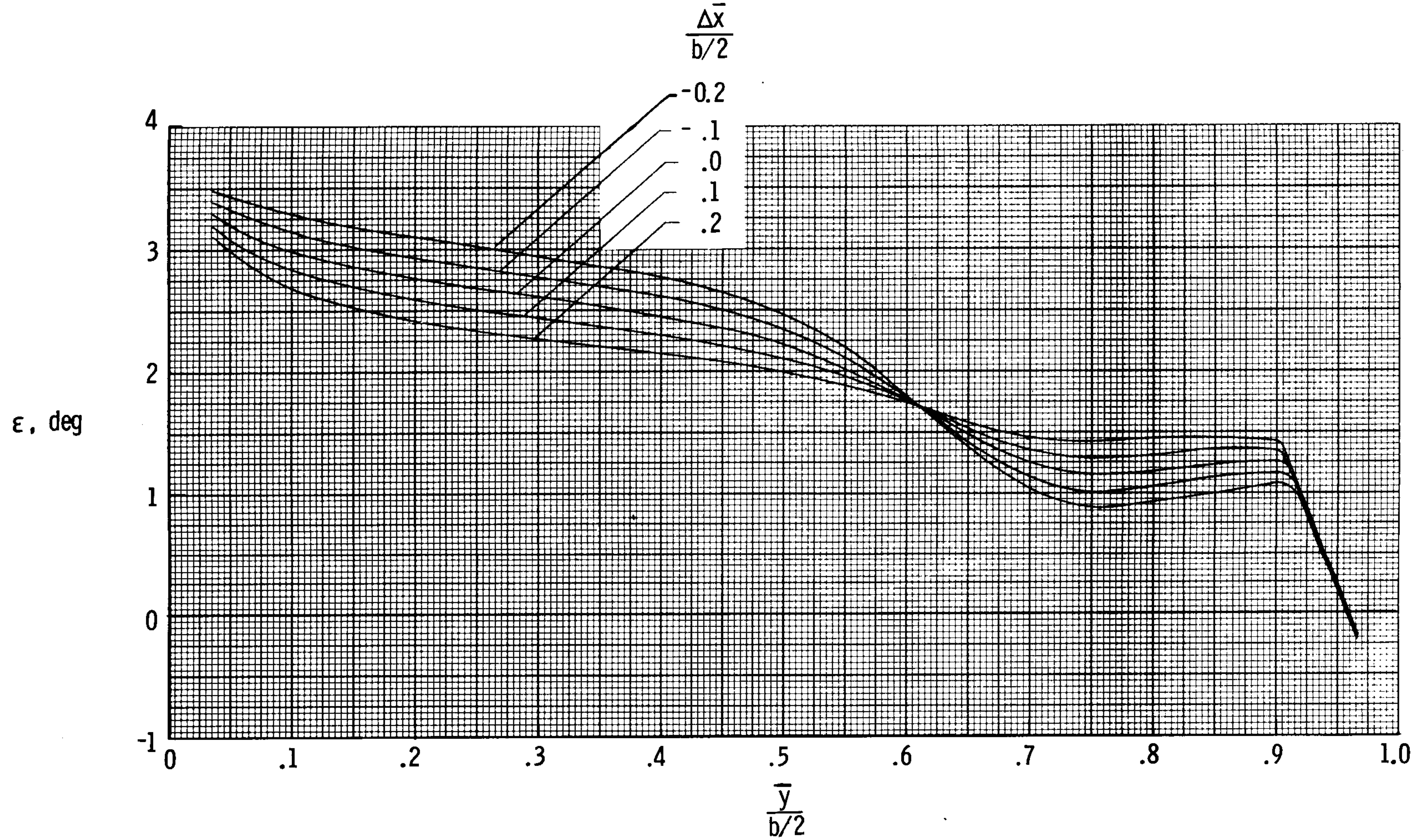
Figure 10.- Continued.





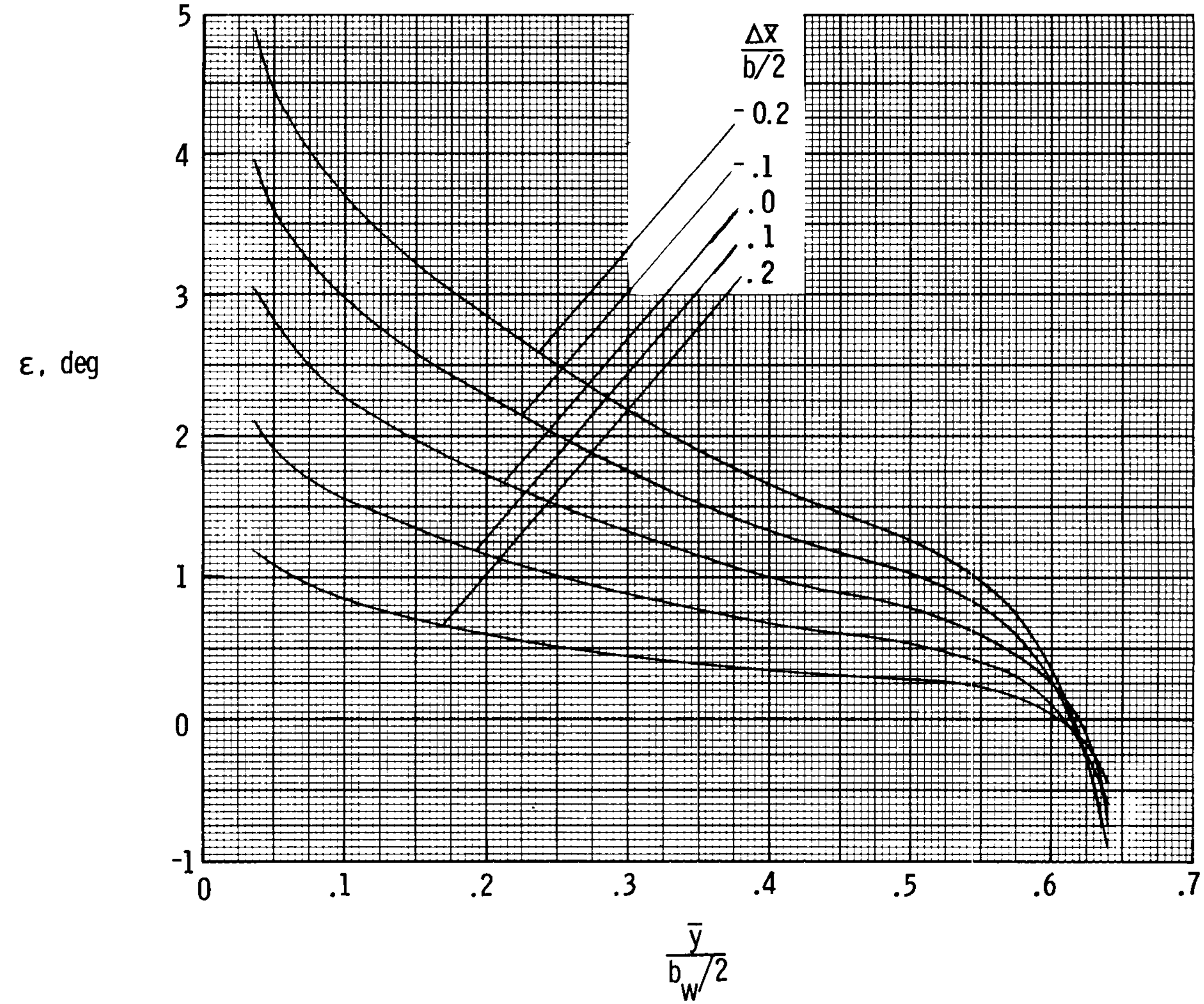
(d) $\frac{\bar{z}_c}{b/2} = -0.676.$

Figure 10.- Concluded.



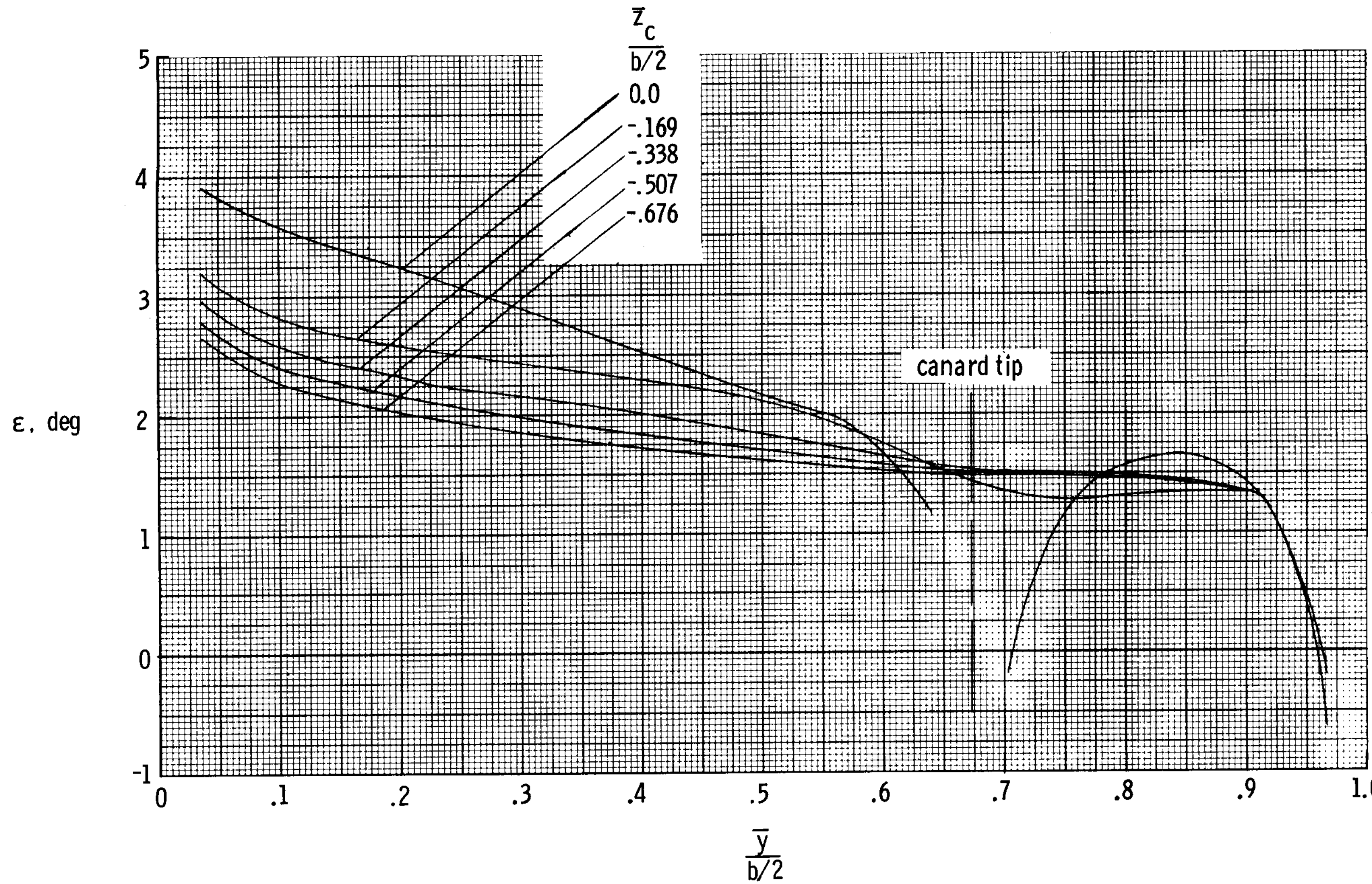
(a) Wing.

Figure 11.- Effect on incidence-angle distribution of moment trim point of wing-canard configuration of figure 8. $\frac{\bar{z}_c}{b/2} = -0.169$.



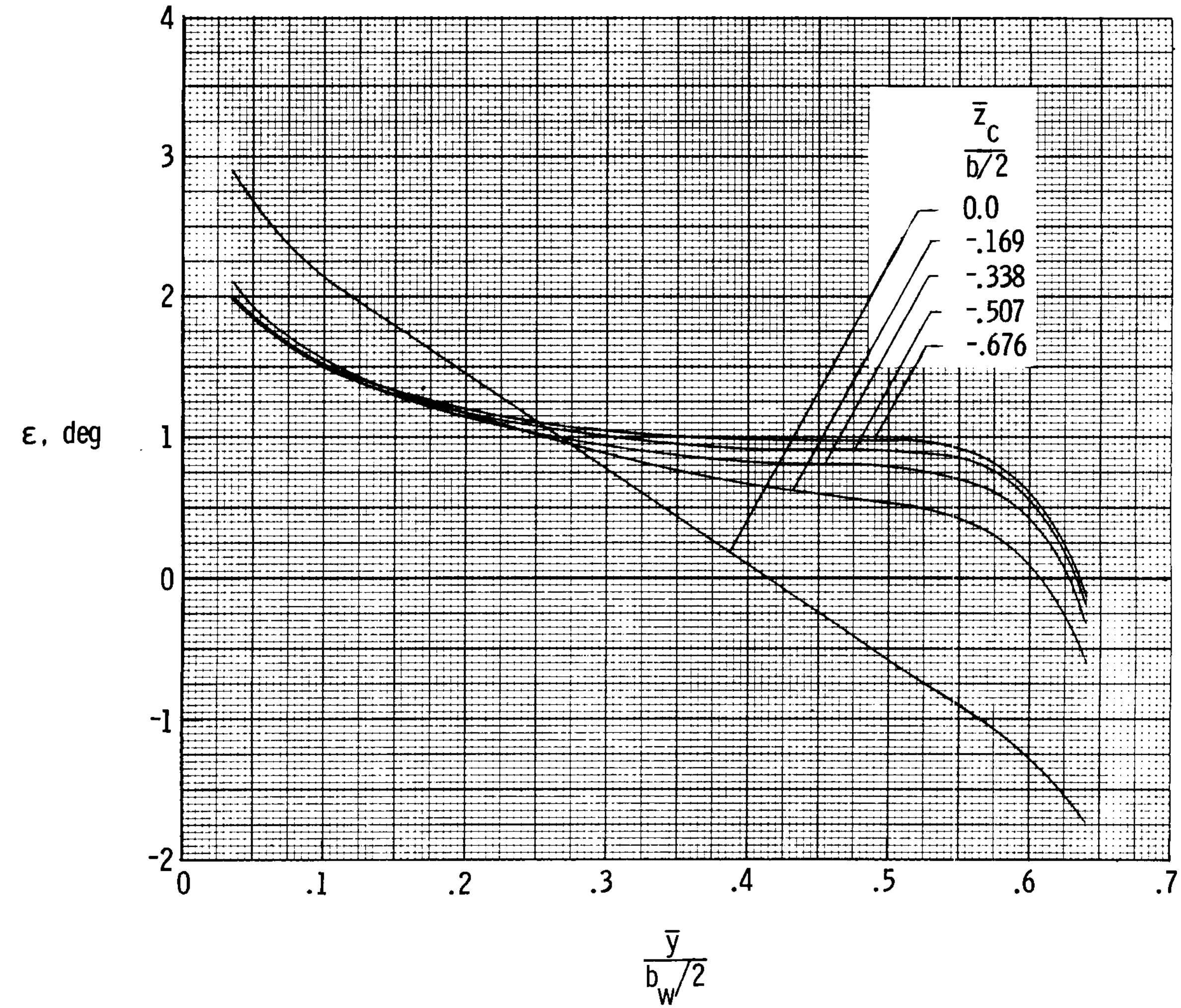
(b) Canard.

Figure 11.- Concluded.



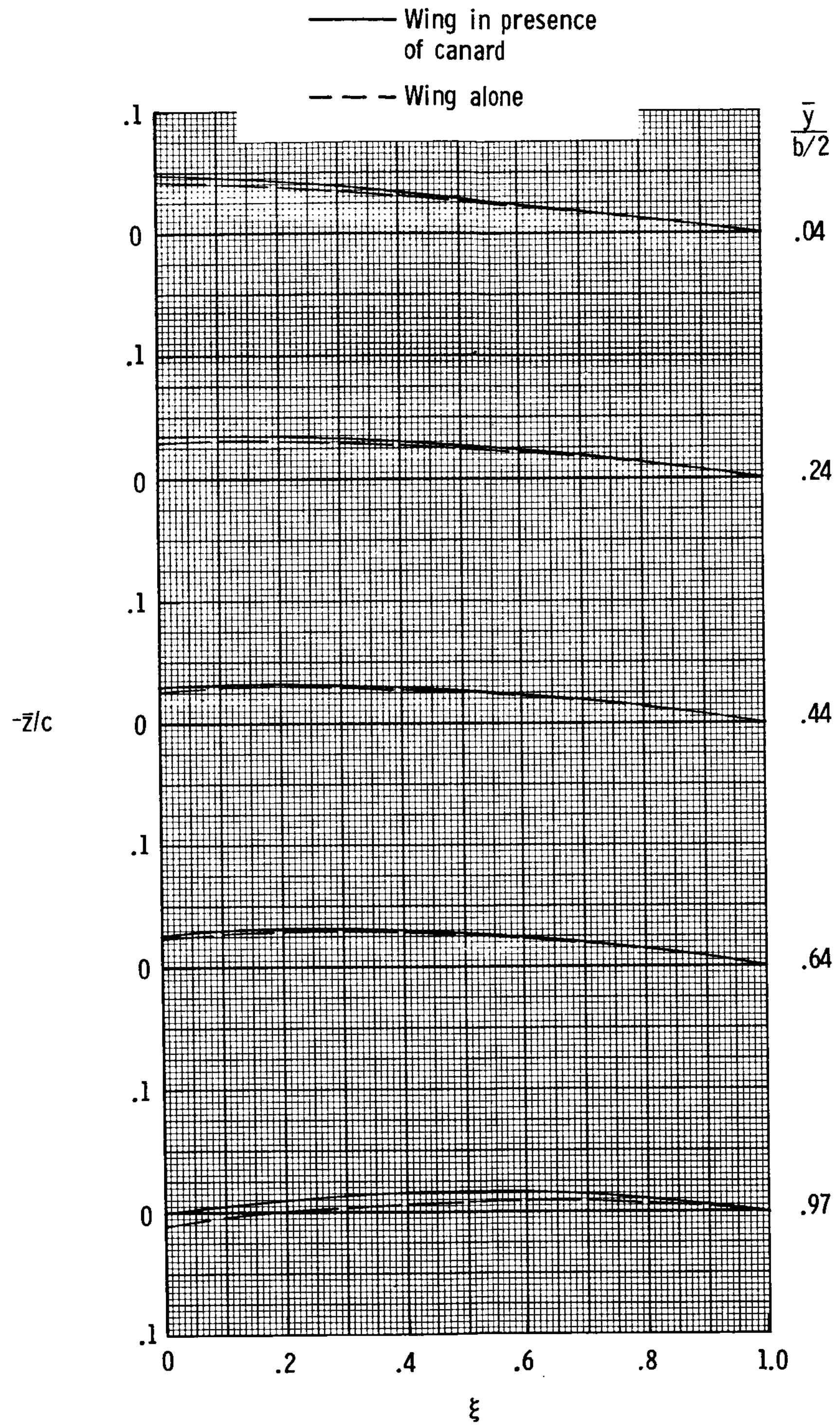
(a) Wing.

Figure 12.- Effect on incidence-angle distribution of vertical separation of wing-canard configuration of figure 8. $\frac{\Delta \bar{x}}{b/2} = 0.1$.



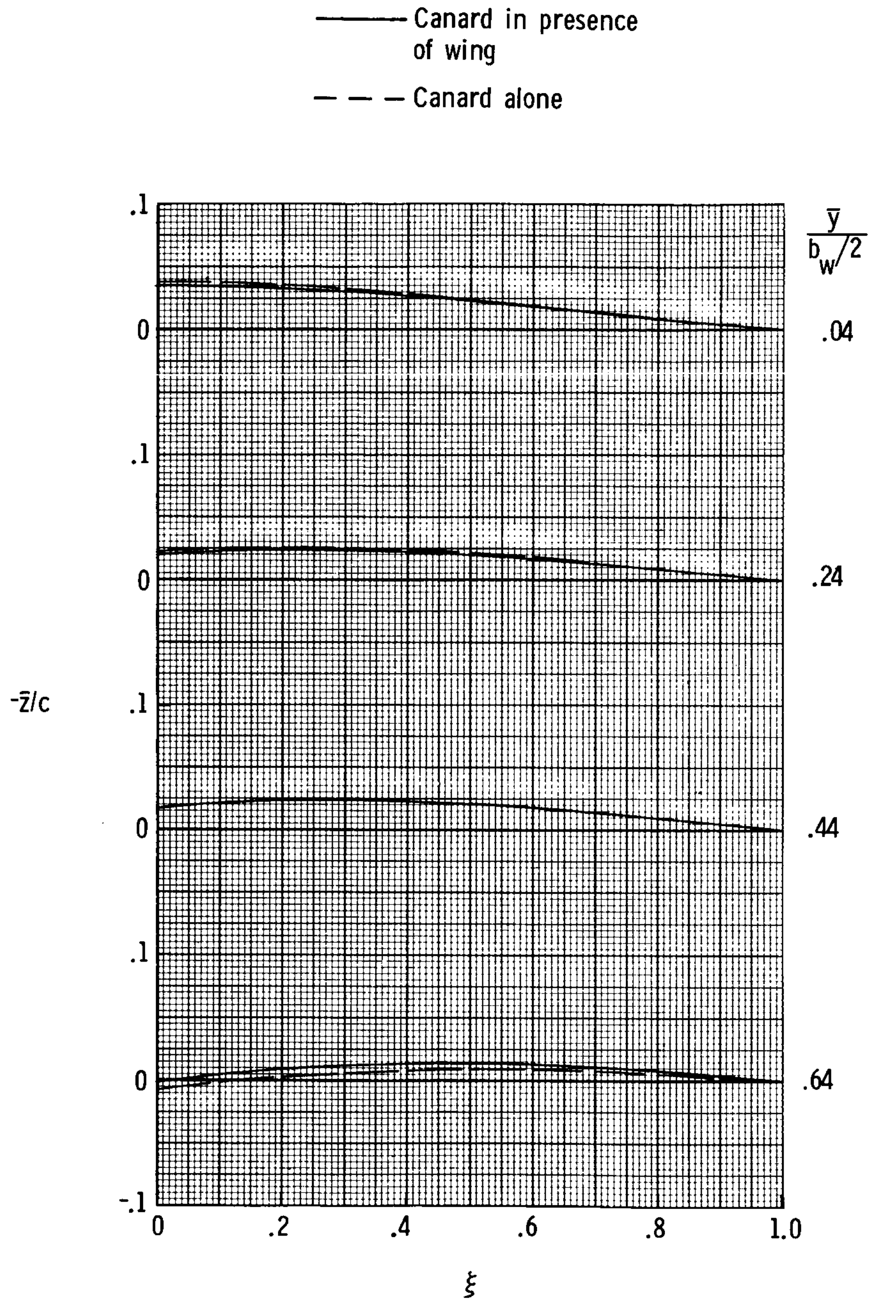
(b) Canard.

Figure 12.- Concluded.



(a) Wing.

Figure 13.- Local elevations for wing-canard configuration of figure 8 designed separately and in the presence of each other. $C_{L,d} = 0.2$; $M_\infty = 0.30$; $\frac{\Delta\bar{x}}{b/2} = 0.1$; $\frac{\bar{z}_c}{b/2} = -0.676$.



(b) Canard.

Figure 13.- Concluded.

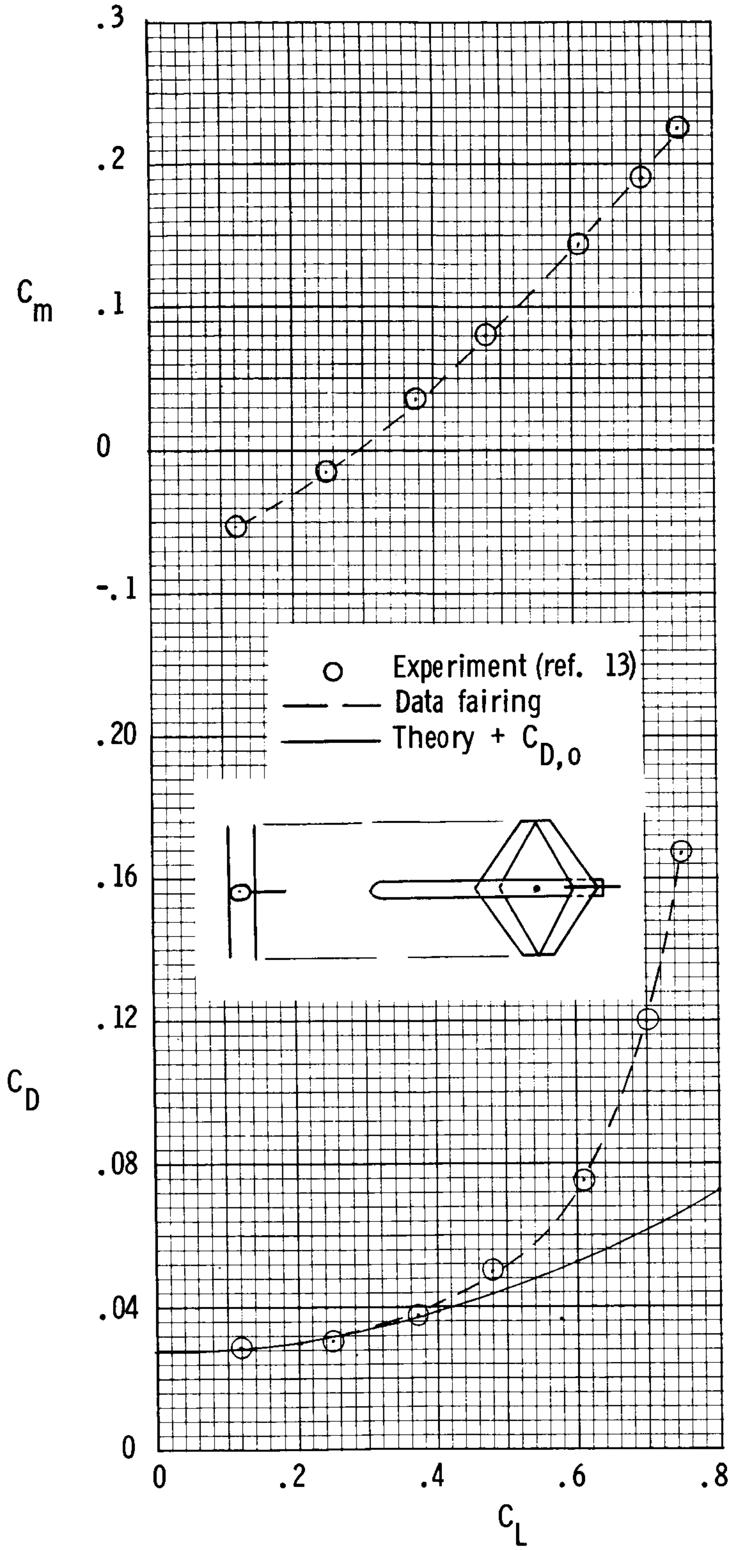
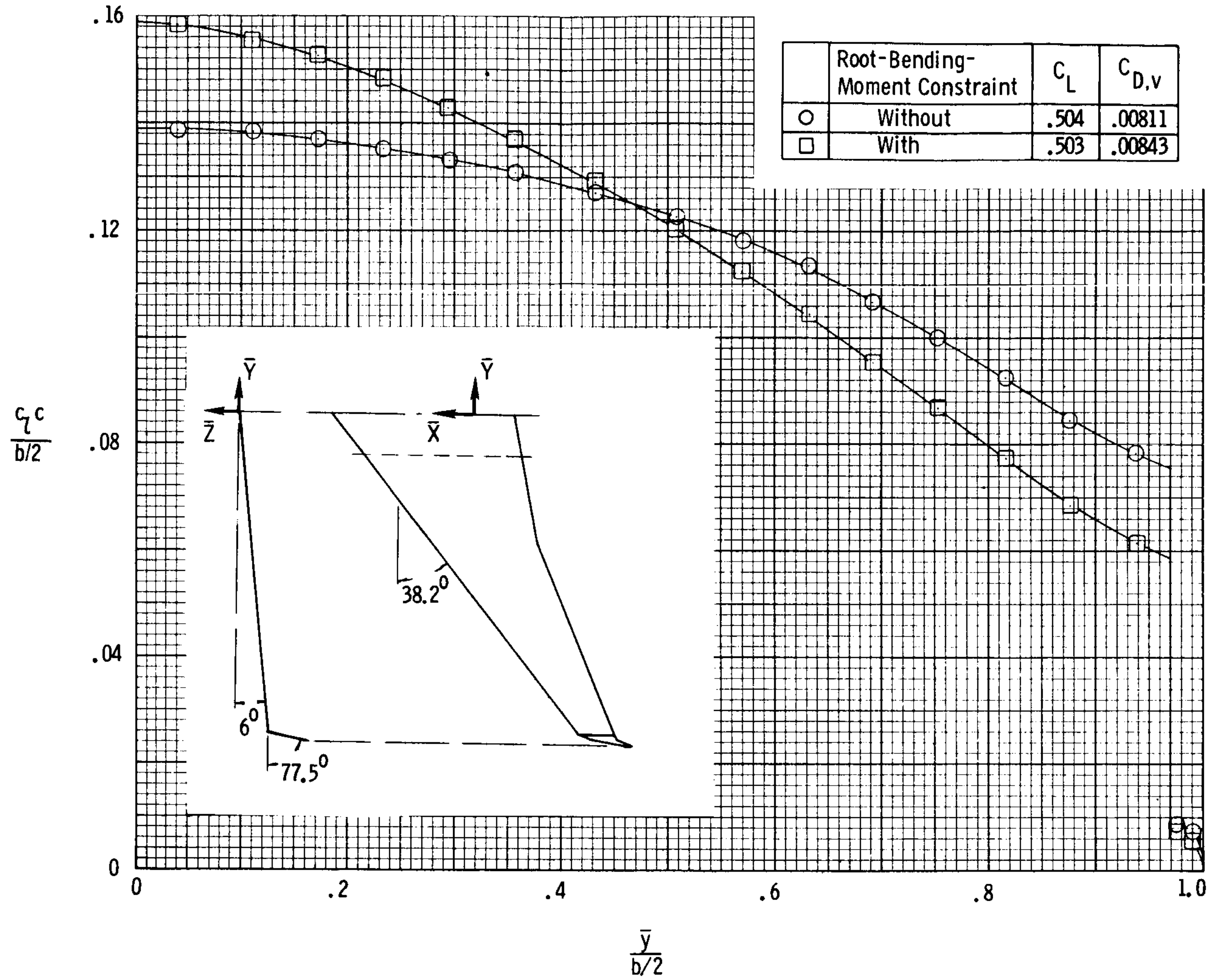
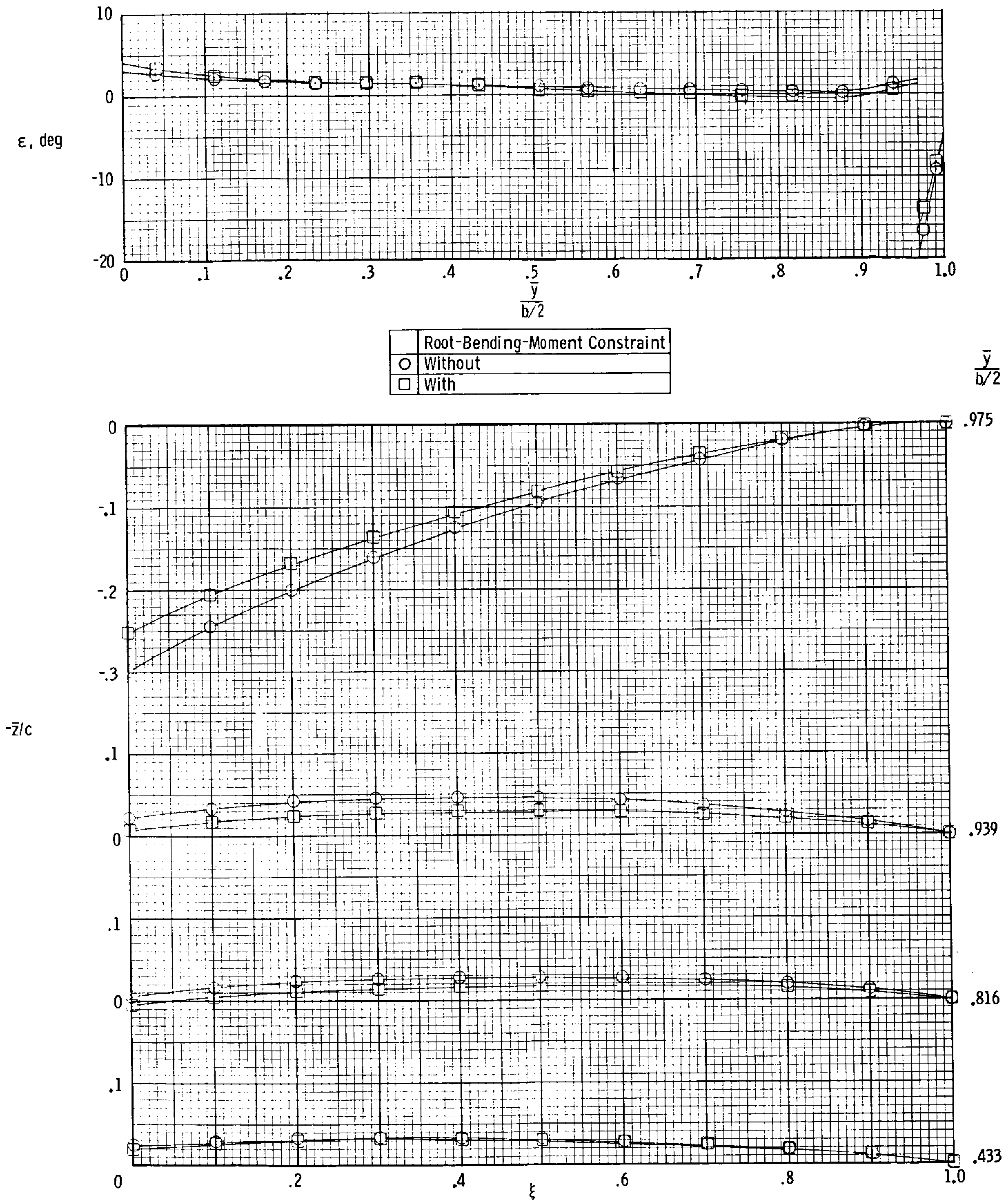


Figure 14.- Longitudinal aerodynamic characteristics of a tandem wing designed for $C_{L,d} = 0.35$ at $M_\infty = 0.30$.



(a) Aerodynamic characteristics.

Figure 15.- Effect of root-bending-moment constraint on aerodynamic characteristics, incidence-angle distribution, and local elevations of aspect-ratio-6.67 wing-winglet combination. $\overline{N}_C = 20$; $\overline{N}_S = 17$; $M_\infty = 0.80$.



(b) Incidence-angle distribution and local elevations.

Figure 15.- Concluded.