NASA TECHNICAL NOTE

NASA TN D-7921

NASA TN D-7921

CASE FILE COPY

SUBSONIC AERODYNAMIC CHARACTERISTICS OF INTERACTING LIFTING SURFACES WITH SEPARATED FLOW AROUND SHARP EDGES PREDICTED BY A VORTEX-LATTICE METHOD

John E. Lamar and Blair B. Gloss

Langley Research Center

Hampton, Va. 23665

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • SEPTEMBER 1975

1. Report No.
NASA TN D-7921

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
SUBSONIC AERODYNAMIC CHARACTERISTICS OF INTERACTING LIFTING SURFACES WITH SEPARATED FLOW AROUND SHARP EDGES PREDICTED BY A VORTEX-LATTICE METHOD

5. Report Date
September 1975

6. Performing Organization Code

7. Author(s)
John E. Lamar and Blair B. Gloss

8. Performing Organization Report No.
L-10001

10. Work Unit No.
505-06-14-01

9. Performing Organization Name and Address
NASA Langley Research Center
Hampton, Va. 23665

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
National Aeronautics and Space Administration
Washington, D.C. 20546

13. Type of Report and Period Covered
Technical Note

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract
Because the potential flow suction along the leading and side edges of a planform can be used to determine both leading- and side-edge vortex lift, the present investigation was undertaken to apply the vortex-lattice method to computing side-edge suction force for isolated or interacting planforms. Although there is a small effect of bound vortex sweep on the computation of the side-edge suction force, the results obtained for a number of different isolated planforms produced acceptable agreement with results obtained from a method employing continuous induced-velocity distributions. By using the method outlined in this report, better agreement between theory and experiment was noted for a wing in the presence of a canard than had previously been obtained.

17. Key Words (Suggested by Author(s))
Subsonic flow
Generalized suction analogy
Vortex lattice
Interacting lifting surfaces

18. Distribution Statement
Unclassified – Unlimited

Subject Category 02

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	90	$4.75

*For sale by the National Technical Information Service, Springfield, Virginia 22161

SUBSONIC AERODYNAMIC CHARACTERISTICS OF INTERACTING LIFTING SURFACES WITH SEPARATED FLOW AROUND SHARP EDGES PREDICTED BY A VORTEX-LATTICE METHOD

John E. Lamar and Blair B. Gloss
Langley Research Center

SUMMARY

Because the potential flow suction along the leading and side edges of a planform can be used to determine both leading- and side-edge vortex lift, the present investigation was undertaken to apply the vortex-lattice method to computing side-edge suction force for both isolated and interacting planforms. Although there is a small effect of bound vortex sweep on the computation of the side-edge suction force, the results obtained for a number of different isolated planforms produced acceptable agreement with results obtained from an application of the suction analogy to a method employing continuous induced-velocity distributions. The computed side-edge suction results generally remained within 1 percent of the converged ones for 6 singularities chordwise at each of 20 spanwise locations.

The lift characteristics obtained from the present method for several isolated wings agreed as closely with experimental data as did those obtained from the method employing continuous induced-velocity distributions. In addition, by using the method outlined in this report, better agreement between theory and experiment was noted for a wing in the presence of a canard than had previously been obtained.

INTRODUCTION

The development of methods for predicting the aerodynamic characteristics of aircraft, which during portions of their flight envelopes, develop separated flow with reattachment around the leading and side edges of the wing, has been the subject of studies for many years and has had varying degrees of success. Polhamus in references 1, 2, and 3 provided a method by which the effects of separated flow around a sharp leading edge on lift and drag could be estimated by an analogy that relates these forces to the attached flow leading-edge suction force. Hence, current lifting-surface computer programs which estimate leading-edge suction are useful in predicting the leading-edge separation effects on the forces.

The effects of side-edge separation on the aerodynamic characteristics have been estimated by determining the attached flow side force and then employing a "suction analogy" similar to that used at the leading edge. This concept was developed and correlated with experiment and other methods in reference 4. The procedure employed in reference 4 is based on a modified Multhopp method which is outlined in reference 5.

The technique of reference 4 is well suited to single, isolated planforms. However, for lifting planforms in combinations or for flat body-wing configurations, the vortex-lattice method (i.e., ref. 6) is better suited because its elemental panel representation provides a straightforward extension to the more complex configurations.

This paper is concerned with the extension of the vortex-lattice method of reference 6 to the computation of the attached flow side force. Others have published similar work recently (refs. 7, 8, and 9, for example) but they do not provide comparisons of alternate paneling arrangements or convergence studies with their analyses. Thus, the purposes of this paper are (1) to provide comparisons of alternate paneling arrangements, (2) to provide convergence studies, (3) to provide the details of side-force and pitching-moment computation, and (4) to present comparisons between experimental and theoretical results for single planform configurations and interacting planform configurations.

The program changes made in Langley computer program A2794 since the publication of reference 6 are discussed in appendix A. These changes include corrections, improvements, and the additions relating the the side-edge-suction computations. In addition, input and output data for a sample case are presented in appendix B, and a listing of the program is provided in appendix C.

SYMBOLS

A aspect ratio

b wing span

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

$C_{D,o}$ experimental value of 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, $\frac{\text{Pitching moment}}{q_\infty S_{ref} c_{ref}}$

$\Delta C_{m,i}$ contribution to pitching-moment coefficient from vortex system operating on an elemental panel

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

C_S total leading-edge suction-force coefficient, $\frac{2(\text{Leading-edge suction force on one panel})}{q_\infty S_{ref}}$

$C_{Y,se}$ twice total side-edge-suction-force coefficient of one wing panel,

$$\frac{2(\text{Side force along side edge on one wing panel})}{q_\infty S_{ref}} = 2 \sum_{i=1}^{N/2} \left(\Delta C_{Y,se}\right)_i$$

$\left(\Delta C_{Y,se}\right)_i$ contribution to side-edge-force coefficient from ith elemental panel

c_{ref} reference chord

c_t tip chord

$\Delta F_{Y,i}$ contribution to side force from ith elemental panel

K_p $= \frac{\partial C_N}{\partial(\sin \alpha \cos \alpha)}$

$K_{v,le}$ $= \frac{\partial C_S}{\partial \sin^2 \alpha}$

$K_{v,se}$ $= \frac{\partial C_{Y,se}}{\partial \sin^2 \alpha}$

l length of trailing filament between adjacent chordwise horseshoe vortices

Δl bound vortex filament length in chord direction

M Mach number

N	total number of horseshoe vortices that contribute to the side-edge suction force
$\overline{N}_c$	number of elemental panels in chordwise row
$\overline{N}_s$	number of chordwise rows on wing semispan
q_∞	free-stream dynamic pressure
S_{ref}	reference area
U	free-stream velocity
w	induced downwash velocity
X,Y,Z	axis system of a given horseshoe vortex (see fig. 1)
$\overline{X},\overline{Y},\overline{Z}$	body-axis system for planform input (see fig. 1)
$\overline{x},\overline{y}$	distance along $\overline{X}$- and $\overline{Y}$-axis, respectively
x_{ref}	moment reference point (taken to be zero herein)
Δx	distance along tip chord to centroid of side-edge force
$\Delta x'$	chordwise distance from midpoint of particular vortex filament to moment reference point
α	angle of attack, deg
β	$= \sqrt{1 - M^2}$
Γ	vortex strength
Γ'	chordwise sum of vortex strengths to a particular elemental panel, $\Sigma\Gamma$ (see fig. 1)
Λ	leading-edge sweep angle, positive for sweepback, deg

λ	taper ratio
ρ	density
ψ	sweep angle of bound vortex, deg

Subscripts:

B	bound vortex
c	centroid
i	particular horseshoe vortex
j	particular item of location
L	left
le	leading edge
p	potential or attached flow
R	right
se	side edge
tot	total
vle	vortex effect at leading edge
vse	vortex effect at side edge

THEORETICAL DEVELOPMENT

The attached flow side force is developed in accordance with the Kutta-Joukowski law for forces generated by a vortex filament. Figure 1 shows vortex filaments which have a streamwise component interacting with the net downwash at the filament midpoint to produce an elemental side force. The net side force on an elemental panel due to a swept horseshoe vortex system on the left wing panel is

$$\Delta F_{y,i} = \rho \left\{ \Gamma' \left[\left(w_L - U\alpha \right) l_L - \left(w_R - U\alpha \right) l_R \right] + \frac{|\tan \psi|}{\tan \psi} \Gamma \left(w_B - U\alpha \right) \Delta l \right\}_i \tag{1}$$

and the contribution to the side-force coefficient is

$$\left(\Delta C_{Y,se} \right)_i = \frac{2}{S_{ref}} \left\{ \frac{\Gamma'}{U} \left[\left(\frac{w_L}{U} - \alpha \right) l_L - \left(\frac{w_R}{U} - \alpha \right) l_R \right] + \frac{|\tan \psi|}{\tan \psi} \frac{\Gamma}{U} \left(\frac{w_B}{U} - \alpha \right) \Delta l \right\}_i \tag{2}$$

The side force is of order α^2, which is appropriate since it is associated with edge suction. If the trigonometric terms were retained, the side force is actually a function of $\sin^2 \alpha$ since the α term is really a $\sin \alpha$ term and Γ/U, Γ'/U, and w/U are all proportional to $\sin \alpha$ for the wind and body axes coincident. Hence, $K_{v,se}$ can be formulates as

$$K_{v,se} = \frac{\partial \left[2 \sum_{i=1}^{N/2} \left(\Delta C_{Y,se} \right)_i \right]}{\partial \sin^2 \alpha} \tag{3}$$

For small α the $\sin \alpha \approx \alpha$ which, for numerical purposes, is taken to be 1 radian in equations (2) and (3) and leads to

$$K_{v,se} = 2 \sum_{i=1}^{N/2} \left(\Delta C_{Y,se} \right)_i \tag{4}$$

This provides an additional contribution to the total lift, as indicated in the following equation:

$$C_{L,tot} = \overbrace{K_p \sin \alpha \cos^2 \alpha}^{C_{L,p}} + \overbrace{K_{v,le} |\sin \alpha| \sin \alpha \cos \alpha}^{C_{L,vle}} + \overbrace{K_{v,se} |\sin \alpha| \sin \alpha \cos \alpha}^{C_{L,vse}} \tag{5}$$

For planforms having sharp edges, the drag coefficient can be written as

$$C_D = C_{D,o} + C_{L,tot} \tan \alpha$$

In the numerical determination of the side force, it is realized that computational time savings could be made with the utilization of a swept horseshoe vortex system. The savings are due to the vortex filament length and the net downwash associated with the right trailing filament of a swept horseshoe vortex being the same as those for the left trailing filament on the adjoining inboard swept horseshoe vortex. However, the swept bound vortex may lead to local and overall errors in the side force, just as it did for leading-edge thrust[1] (ref. 10). This potential problem will be investigated although it should be less serious than that for thrust because in the side-force computation, the bound vortex interaction with the net downwash at its midpoint will only contribute a portion to the total side force, rather than the entire result.

To assess the importance of the inclusion of the swept bound vortex, numerical studies are presented in the next section. They are based on paneling the wing in various ways to emphasize the influence of the bound vortex differently.

The pitching-moment contribution about the $\bar{Y}$-axis associated with the side-edge-suction force is determined from each elemental horseshoe vortex by

$$\Delta C_{m,i} = \frac{2}{S_{ref}} \frac{1}{c_{ref}} \left\{ \frac{\Gamma'}{U} \left[-\left(\frac{w_L}{U} - \alpha\right) l_L \, \Delta x'_L + \left(\frac{w_R}{U} - \alpha\right) l_R \, \Delta x'_R \right] - \frac{|\tan \psi|}{\tan \psi} \frac{\Gamma}{U}\left(\frac{w_B}{U} - \alpha\right) \Delta l \, \Delta x'_B \right\}_i$$

The sign of each term is chosen with the realization that the overall rotation of the trailing flow field on the left wing panel is clockwise as viewed from the rear. This rotation causes the vortex elements behind the moment reference point to contribute a noseup moment if associated with the left trailing leg or a sweptback bound vortex and a nosedown moment for the vortex elements associated with the right trailing leg (fig. 1). The total pitching moment is obtained by using the following expression:

$$C_{m,tot} = \overbrace{K_p \sin \alpha \cos \alpha \frac{\tilde{x}_{c,p}}{c_{ref}}}^{C_{m,p}} + \overbrace{K_{v,le} \, |\sin \alpha| \sin \alpha \frac{\tilde{x}_{c,le}}{c_{ref}}}^{C_{m,vle}} + \overbrace{K_{v,se} \, |\sin \alpha| \sin \alpha \frac{\tilde{x}_{c,se}}{c_{ref}}}^{C_{m,vse} = \left(2 \sum_{i=1}^{N/2} \Delta C_{m,i}\right) |\sin \alpha| \sin \alpha}$$

when the particular $\tilde{x}_c$-terms equal $x_{ref} - x_{c,j}$.

Only those horseshoe vortices or portions thereof which would intersect the side edge if they were projected laterally to the local spanwise extent of the planform (those

[1]The leading-edge thrust problem and the program changes made to correct it are described in appendix A.

that do so are said to directly oppose the side edge) are included in the summation for the side force and pitching moment. This procedure is the same as that used for computing the leading-edge thrust, where all the distributed thrust along the chord is projected forward and assumed to act at the leading edge. One reason for computing the side-edge suction force in this manner, rather than with the method presented in reference 8, is that, in the application of the method of reference 8 to a cropped diamond wing, the entire side-edge suction force would be calculated over a wing panel with the only reduction coming from the removal of the contribution from the leading-edge suction. This retains the contribution to the side force from the aft part of the cropped delta wing from which no edge force is expected.

NUMERICAL STUDIES

Panel Arrangements

Table I presents a comparison of $K_{v,se}$ and the side-edge load centroid obtained by four different methods for the three wing planforms presented in figure 2. Method 1 is the continuous loading method of reference 4 and the results of this method are taken to be the standard. Method 2 is the present method, which was described previously. Method 3 is the same as method 2 except each planform is considered as two wings (the dashed lines in fig. 2 show break lines) and the side-edge suction force is computed only on the aft wing. Method 4 is the vortex-lattice method described in reference 7 with the results being supplied by R. G. Bradley of General Dynamics Corp.

The layout of the bound vortices directly opposing the side edge of a wing tip will have less sweep for method 3 than for method 2 because method 3 panels the wing as two planforms. In fact the cropped delta wing is a special case for method 3 since the bound vortices inboard of the wing tip have no sweep. By comparison, the results of method 3 agreed more closely with the continuous induced-velocity approach of reference 4 (method 1) than the results of method 2. The results from method 3 for the cropped delta wing agreed closest with method 1. This agreement indicates that there is an effect of bound vortex sweep on $K_{v,se}$; however, the maximum difference between the results of method 2 and those of method 1 for the configurations shown in table I was only about 4 percent for $K_{v,se}$ and about 4 percent for the centroid location. The table also shows that the results of method 4 (ref. 7) are somewhat higher than those of method 1.

In an effort to study further the effect of bound vortex sweep angle on $K_{v,se}$ and its chordwise centroid, results were obtained for a rectangular wing sheared to various sweep angles; these results are presented in table II. The reason for selecting this type of planform was to provide a critical evaluation of method 2, since the bound vortex sweep angles will all be (1) the same, (2) maximum for the planform, and (3) equal to that of the leading edge. For any other simple planform, discounting those with reversed taper, the bound vortex sweep angles would become less positive the closer the vortices are located to the trailing edge. Increasing the leading-edge sweep angle in this manner leads to a reduced number of horseshoe vortices that directly oppose the side edge and that can make a contribution to side force or its moment. Table II shows that, in general, the $K_{v,se}$ values and chordwise centroid locations of method 2 are smaller and more forward, respectively, than those of method 1. The maximum percent errors are 9.4 for $K_{v,se}$ and 9.8 for $\Delta x/c_t$ in terms of c_t. The highest sweep angle reported in this study was 75° because for higher sweep angles method 1 was unable to determine a suitable control point pattern to insure a valid logarithmic singular correction.

Method 2 is chosen in this paper as the method to be used in subsequent calculations and will be designated as present method because it allows the analysis of two wings in the presence of each other (for example, a canard-wing configuration), whereas method 3 does not. Another reason is that the values of $K_{v,se}$ presented in table I, as determined by the four methods, have only small differences and the effect on the total lift answer would amount to less than a 4-percent maximum error for angles of attack up to 30°.

Table III presents a comparison of K_p, $K_{v,le}$, and $K_{v,se}$ as computed by the present method and method 1 (ref. 4) for several different aspect-ratio rectangular wings and the three wing planforms shown in figure 2. There is seen to be good agreement between the two methods. As the aspect ratio for the rectangular wings approaches zero, $K_{v,se}$ is less than π for the present method and greater than π for method 1. Reference 4 shows for rectangular wings that as βA approaches zero, the theoretical value of $K_{v,se}$ should approach π.

Values of $\overline{N}_c$ and $\overline{N}_s$ of 6 and 25, respectively, were used in obtaining the results in table III because a preliminary investigation indicated this combination to be adequate. Subsequently, a convergence study was undertaken to determine the minimum requirements of $\overline{N}_c$ and $\overline{N}_s$. The results of this study are discussed in a subsequent section.

Effect of $\overline{N}_c$ and $\overline{N}_s$

The effect of varying $\overline{N}_c$ and $\overline{N}_s$ on $K_{v,se}$ and $\Delta x/c_t$ is examined herein. The solutions are from the present method and are presented in figures 3 and 4 for isolated planforms. For most of the wings considered in figures 3 and 4, there are many combinations of $\overline{N}_c$ and $\overline{N}_s$ which will yield results within 1 percent of what appears to be the converged values of $K_{v,se}$ and $\Delta x/c_t$. In particular the pattern for $\overline{N}_c = 6$ and $\overline{N}_s = 20$ gives good agreement with the converged result except for the wing with $A = 3.5$ and $\Lambda = 75°$. The vortex-lattice representation for this wing does not provide enough vortices that oppose the side edge for a converged result to be determined with method 2. This pattern is seen to be larger than the pattern for $\overline{N}_c = 4$ and $\overline{N}_s = 20$, which was determined in reference 6 to be generally adequate to yield acceptable $\partial C_m/\partial C_L$ solutions.

CORRELATION WITH EXPERIMENT

Figures 5 to 8 present the comparison of the theoretical results obtained by the present method with experimental data obtained from reference 4 for flat rectangular wings with sharp leading and side edges. These wings had aspect ratios of 0.20, 0.40, 1.00, and 3.00. Also, the comparison of theoretical results (present method) with experimental results (ref. 4) for the three swept wings presented in figure 2 is shown in figures 9 to 11. Since the values of $K_{v,se}$ and its chordwise centroid obtained by methods 1 and 2 and reported in table III closely agree, the theoretical results obtained by using the present method should agree as well with the experimental data as did the results of method 1 (ref. 4). As pointed out in reference 4, the reason for the disagreement between experiment and theory shown in figures 9 and 11 is that sweptback wings which have large amounts of area behind the point of maximum span develop lift values in excess of those predicted because of the additional induced effects associated with the actual shed-vortex system. These additional induced effects are the leading-edge vortex acting along the side edge and over the trailing triangular portion of a cropped diamond wing.

Figures 12 to 14 present a comparison of experimental lift (ref. 9) with the present theoretical lift on a wing in the presence of a canard for three different canard configurations: (1) in the wing chord plane, (2) above the wing chord plane, and (3) above the wing chord plane with 18.6° of anhedral. (Only the lift on the portion of the model drawn with solid lines in the sketches in figs. 12 to 14 is plotted.) The addition of the side-edge vortex lift gives better agreement between theory and experiment as compared with that shown in reference 11 for these particular models at angles of attack up to wing stall. The theoretical results presented in reference 11 are replotted in figures 12 to 14 as short dashed lines. It should be noted that the canard data are not presented in this report since the experimental data of reference 11 indicated the canard did not develop full leading-edge vortex lift.

CONCLUDING REMARKS

Because the potential flow suction along the leading and side edges of a planform can be used to determine both leading- and side-edge vortex lift, the present investigation was undertaken to apply the vortex-lattice method to computing side-edge suction force for isolated or interacting planforms. Although there is a small effect of bound vortex sweep on the computation of the side-edge suction force, the results obtained for a number of different isolated planforms produced acceptable agreement with results obtained from a method employing continuous induced-velocity distributions. The computed side-edge suction results generally remained within 1 percent of the converged ones for 6 singularities chordwise at each of 20 spanwise locations.

The lift characteristics obtained from the present method for several isolated wings agreed as closely with experimental data as did those obtained from the method employing continuous induced-velocity distributions. In addition, by using the method outlined in this report, better agreement between theory and experiment was noted for a wing in the presence of a canard than had previously been obtained.

Langley Research Center
National Aeronautics and Space Administration
Hampton, Va., 23665
June 19, 1975

APPENDIX A

CHANGES, IMPROVEMENTS, AND ADDITIONS TO LANGLEY COMPUTER PROGRAM A2794

The purpose of this appendix is to describe in some detail the changes, improvements, and additions to Langley computer program A2794 of reference 6.

Changes to the input cards of the computer program presented in reference 6 are as follows:

(1) On the configuration card an additional field of 5 has been added (columns 66 to 70) and has a specification of F5.1. This field is used to obtain entry into the tip-suction overlay. By putting a 1. in this field, a tip-suction computation will be made. If this option is not required, the field can be left blank or a 0. put in it.

(2) With the 1. specified in change (1), it is necessary to provide another input data card with a format of 4F10.5. This card contains the limits of "$\bar{y}$-integration" over which the leading-edge suction distribution is to be integrated. Normally these limits would be the plane of symmetry (0.) and the left wing tip (-b/2); however, others could be used. Four fields are provided for the two planforms since each planform would need a beginning (inboard) and ending (outboard) $\bar{y}$-location. The order is for the first planform beginning and ending $\bar{y}$-limits followed by the second planform $\bar{y}$-limits. This card then becomes the last card of the input deck for a configuration.

(3) With the 1. specified in change (1) and SCW specified as 0. the numbers in TBLSCW(I) must be the same on a given planform but can change with planform in order for the program to function properly. This restriction was placed on TBLSCW(I) to save computer execution time.

(4) With the 1. specified in change (1), SCW or TBLSCW(I) must be larger than 1.

Program Improvements

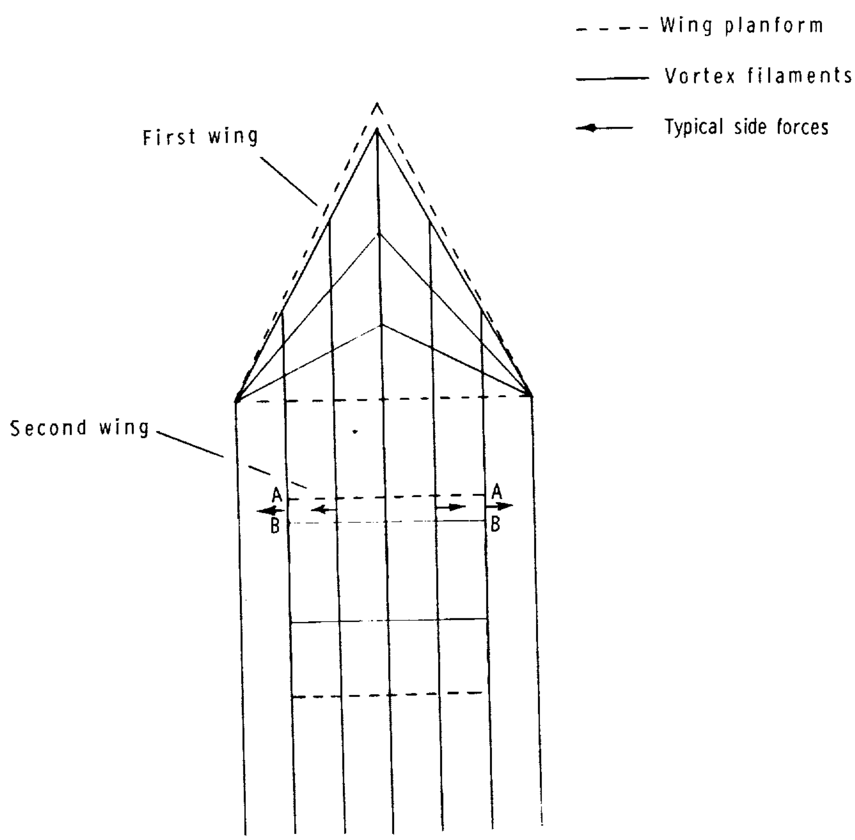
Improvements to the vortex-lattice computer program presented in reference 6 are detailed below. A listing of the complete revised computer program is presented in appendix B.

Since the leading-edge thrust and its distribution are obtained by the difference between Lift $\times \alpha$ and induced drag on an overall and local basis, improvements in the accuracy of these terms would yield necessarily more accurate thrust results. Reference 6 has determined ranges of $\overline{N}_c$ and $\overline{N}_s$ required for the convergence of lift for a wide assortment of planforms. A similar study for the near-field induced drag found convergence but not to the far-field values. Reference 10 relates this problem to the violation of the Munk stagger theorem (ref. 12) in two regards: The induced drag associated with the induced velocity from the bound vortices and from the near-field limit of the trailing vortices should sum to zero, and the bound vortices should be of uniform length.

To implement those ideas, a new overlay was developed (OVERLAY 4) to take the set of Γ/U already determined in OVERLAY 2 along with the original vortex lattice in OVERLAY 1 and to repanel the wing with a network of unswept horseshoe vortices of equal spacing whose values of Γ/U were determined by interpolation. It is with this setup that the near-field induced drag is now determined.

OVERLAY 5

The side-force computation is performed in OVERLAY 5 as outlined in the section of this paper entitled "Theoretical Development." Coplanar wings which have an unswept leading edge on the second wing require special attention in the computation of side force and pitching moment at the leading-edge region of the second wing. The side force acting on the trailing vortex filaments of the first wing which intersect the leading edge of the second wing is computed between lines A-A and B-B (shown in sketch (a)) of the second wing.



Sketch (a).

OVERLAY 5 computes $K_{v,le}$ by integrating the local leading-edge suction over the desired portion of the configuration to obtain the total leading-edge suction coefficient C_S. This was done to allow the program user the flexibility of choosing the leading-edge region of the wing over which vortex lift is assumed to exist. By making the small angle of attack approximation, which is done throughout the potential flow part of this computer program, $K_{v,le}$ is computed by using the following expression:

$$K_{v,le} = \frac{\partial C_S}{\partial \alpha^2}$$

The values of K_p and $K_{v,le}$ computed by this program in the manner outlined are appropriate only for untwisted or uncambered lifting surfaces. The lift and pitching-moment coefficients are then computed by using the expressions found in reference 4. The side-force computation on planforms with dihedral is performed in a manner similar to that for planforms with no dihedral. For reliable side-edge loading results the program should be restricted to planforms which do not have swept forward leading edges.

APPENDIX B

SAMPLE CASE

Input data, the sketch, and output data for a sample case with a canard-body-wing combination are presented in this appendix. The canard shown has 18.6° anhedral, and the leading-edge suction is integrated from the body-wing and body-canard intersections to the respective tips.

The following list contains the output variable names not defined in reference 6:

KP	K_p
KV LE	$K_{v,le}$
KV SE	$K_{v,se}$
ALPHA	α
CN	$C_{N,tot}$
CLP	$C_{L,p}$
CLVLE	$C_{L,vle}$
CLVSE	$K_{v,se} \|\sin\alpha\| \sin\alpha \cos\alpha$
CMP[2]	pitching-moment coefficient due to $C_{L,p}$
CMVLE[2]	pitching-moment coefficient due to $C_{L,vle}$
CMVSE[2]	pitching-moment coefficient due to $C_{L,vse}$
CM[2]	total pitching moment
CD	$C_{L,tot} \tan\alpha$
CL**2/(PI*AR)	$(C_{L,tot})^2/\pi A$

[2]Reference point is the origin of the $\bar{X},\bar{Y},\bar{Z}$ axis system.

APPENDIX B

Sample Input Data and Sketch

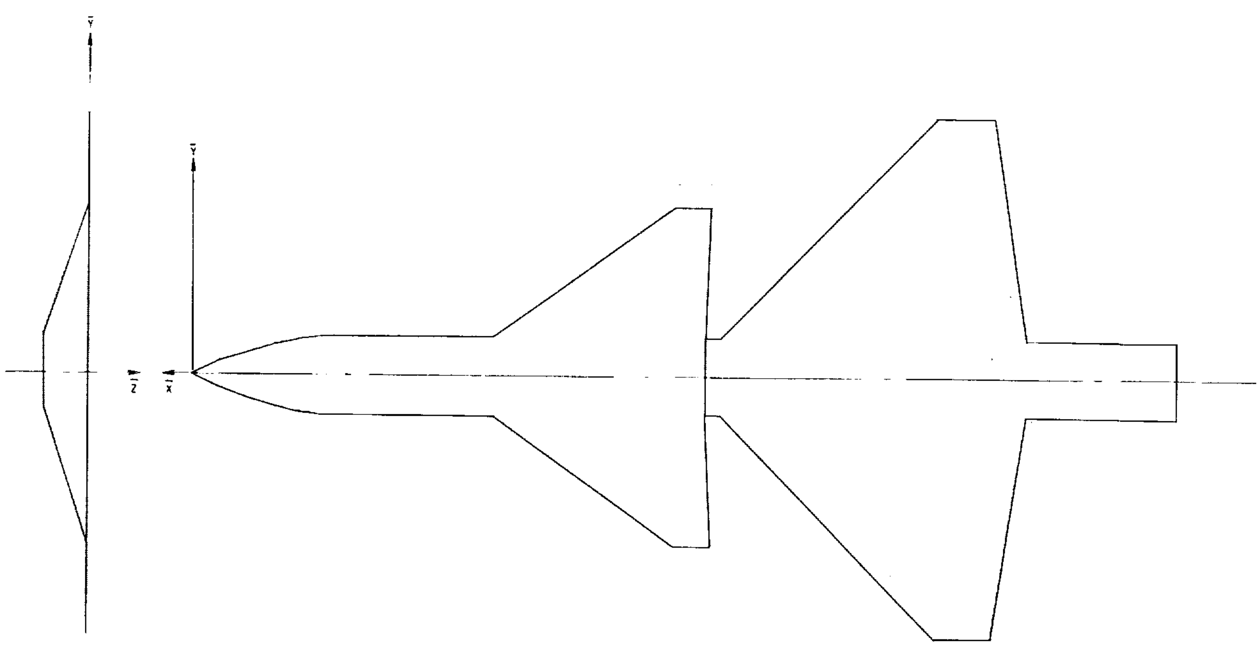
```
                         C O L U M N   N U M B E R S   F O R   I N P U T   D A T A
00000000011111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

GROUP ONE DATA

```
2.        1.        9.1756    159.99696
10.       0.        0.        -1.69
0.0       0.0       0.0       1.
-1.2      -.55      0.        1.
-2.2      -.9       0.        1.
-3.2      -1.2      0.        1.
-4.2      -1.42     0.        1.
-5.       -1.5      0.        1.
-11.65    -1.5      -18.62    1.
-18.60    -6.51     0.        1.
-20.00    -6.51     -18.62    1.
-18.85    -1.5      0.        1.
-18.85    0.0
7.        0.        0.        0.0
-18.85    0.0       0.        1.
-18.85    -1.5      0.        1.
-20.4     -1.5      0.        1.
-28.7     -10.      0.        1.
-30.9     -10.      0.        1.
-32.2     -1.5      0.        1.
-38.      -1.5      0.        1.
-38.      0.0
```

GROUP TWO DATA

```
  1.    6. 13.   .30 1.    0.    0.    0.              0.              1.
-1.5      -15.      -1.5      -15.
```



Sample Output Data

GEOMETRY DATA

FIRST REFERENCE PLANFORM HAS 10 CURVES

ROOT CHORD HEIGHT = -1.69000 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	0.00000	0.00000	65.37644	0.00000	1
2	-1.20000	-.55000	70.70995	0.00000	1
3	-2.20000	-.90000	73.30076	0.00000	1
4	-3.20000	-1.20000	77.59258	0.00000	1
5	-4.20000	-1.42000	84.28941	0.00000	1
6	-5.00000	-1.50000	90.00000	0.00000	1
7	-11.65000	-1.50000	54.21355	-18.62000	1
8	-18.60000	-6.51000	90.00000	0.00000	1
9	-20.00000	-6.51000	12.92778	-18.62000	1
10	-18.85000	-1.50000	0.00000	0.00000	1
11	-18.85000	0.00000			

SECOND REFERENCE PLANFORM HAS 7 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	-18.85000	0.00000	0.00000	0.00000	1
2	-18.85000	-1.50000	90.00000	0.00000	1
3	-20.40000	-1.50000	44.31794	0.00000	1
4	-28.70000	-10.00000	90.00000	0.00000	1
5	-30.90000	-10.00000	-8.69550	0.00000	1
6	-32.20000	-1.50000	90.00000	0.00000	1
7	-38.00000	-1.50000	0.00000	0.00000	1
8	-38.00000	0.00000			

CONFIGURATION NO. 1

CURVE 1 IS SWEPT 65.37644 DEGREES ON PLANFORM 1

CURVE 1 IS SWEPT 0.00000 DEGREES ON PLANFORM 2

BREAK POINTS FOR THIS CONFIGURATION

POINT	X	Y	Z	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	0.00000	0.00000	-1.69000	65.37644	0.00000	1
2	-1.20000	-.55000	-1.69000	70.70995	0.00000	1
3	-2.20000	-.90000	-1.69000	73.30076	0.00000	1
4	-3.20000	-1.20000	-1.69000	77.59258	0.00000	1
5	-4.20000	-1.42000	-1.69000	84.28941	0.00000	1
6	-5.00000	-1.50000	-1.69000	90.00000	0.00000	1
7	-11.65000	-1.50000	-1.69000	54.21355	-18.62000	1
8	-18.60000	-6.51000	-.00200	90.00000	0.00000	1
9	-20.00000	-6.51000	-.00200	12.92778	-18.62000	1
10	-18.85000	-1.50000	-1.69000	0.00000	0.00000	1
11	-18.85000	0.00000	-1.69000			

SECOND PLANFORM BREAK POINTS

POINT	X	Y	Z	SWEEP ANGLE	DIHEDRAL ANGLE	MOVE CODE
1	-18.85000	0.00000	0.00000	0.00000	0.00000	1
2	-18.85000	-.55000	0.00000	0.00000	0.00000	1
3	-18.85000	-.90000	0.00000	0.00000	0.00000	1
4	-18.85000	-1.20000	0.00000	0.00000	0.00000	1
5	-18.85000	-1.42000	0.00000	0.00000	0.00000	1
6	-18.85000	-1.50000	0.00000	90.00000	0.00000	1
7	-20.40000	-1.50000	0.00000	44.31794	0.00000	1
8	-25.29212	-6.51000	0.00000	44.31794	0.00000	1
9	-28.70000	-10.00000	0.00000	90.00000	0.00000	1
10	-30.90000	-10.00000	0.00000	-8.69550	0.00000	1
11	-32.20000	-1.50000	0.00000	90.00000	0.00000	1
12	-38.00000	-1.50000	0.00000	0.00000	0.00000	1
13	-38.00000	0.00000	0.00000			

174 HORSESHOE VORTICES USED ON THE LEFT HALF OF THE CONFIGURATION

PLANFORM TOTAL SPANWISE

AERODYNAMIC DATA

CONFIGURATION NO. 1

STATIC LONGITUDINAL AERODYNAMIC COEFFICIENTS ARE COMPUTED

X C/4	X 3C/4	Y	Z	S	C/4 SWEEP ANGLE	DIHEDRAL ANGLE	LOCAL ALPHA IN RADIANS	DELTA CP AT DESIRED CL = 1.00000
-18.17029	-18.32212	-6.14552	-.12481	.38462	53.24644	-18.62000	0.00000	3.72658
-18.47395	-18.62578	-6.14552	-.12481	.38462	48.89306	-18.62000	0.00000	1.69346
-18.77761	-18.92944	-6.14552	-.12481	.38462	43.62423	-18.62000	0.00000	1.04381
-19.08127	-19.23310	-6.14552	-.12481	.38462	37.24015	-18.62000	0.00000	.66053
-19.38493	-19.53676	-6.14552	-.12481	.38462	29.56186	-18.62000	0.00000	.41117
-19.68859	-19.84042	-6.14552	-.12481	.38462	20.51844	-18.62000	0.00000	.22533
-17.19422	-17.41637	-5.41655	-.37041	.38462	53.24644	-18.62000	0.00000	3.41634
-17.63853	-17.86068	-5.41655	-.37041	.38462	48.89306	-18.62000	0.00000	1.60920
-18.08284	-18.30500	-5.41655	-.37041	.38462	43.62423	-18.62000	0.00000	1.06980
-18.52715	-18.74931	-5.41655	-.37041	.38462	37.24015	-18.62000	0.00000	.74750
-18.97146	-19.19362	-5.41655	-.37041	.38462	29.56186	-18.62000	0.00000	.50397
-19.41577	-19.63793	-5.41655	-.37041	.38462	20.51844	-18.62000	0.00000	.29033
-16.21814	-16.51062	-4.68758	-.61602	.38462	53.24644	-18.62000	0.00000	3.06694
-16.80310	-17.09558	-4.68758	-.61602	.38462	48.89306	-18.62000	0.00000	1.45406
-17.38807	-17.68055	-4.68758	-.61602	.38462	43.62423	-18.62000	0.00000	.99044
-17.97303	-18.26551	-4.68758	-.61602	.38462	37.24015	-18.62000	0.00000	.71586
-18.55799	-18.85048	-4.68758	-.61602	.38462	29.56186	-18.62000	0.00000	.50163
-19.14296	-19.43544	-4.68758	-.61602	.38462	20.51844	-18.62000	0.00000	.29981
-15.24206	-15.60487	-3.95862	-.86163	.38462	53.24644	-18.62000	0.00000	2.75671
-15.96768	-16.33048	-3.95862	-.86163	.38462	48.89306	-18.62000	0.00000	1.31328
-16.69329	-17.05610	-3.95862	-.86163	.38462	43.62423	-18.62000	0.00000	.90859
-17.41891	-17.78172	-3.95862	-.86163	.38462	37.24015	-18.62000	0.00000	.66947
-18.14452	-18.50733	-3.95862	-.86163	.38462	29.56186	-18.62000	0.00000	.47964
-18.87014	-19.23295	-3.95862	-.86163	.38462	20.51844	-18.62000	0.00000	.29326
-14.26598	-14.69911	-3.22965	-1.10724	.38462	53.24644	-18.62000	0.00000	2.48005
-15.13225	-15.56538	-3.22965	-1.10724	.38462	48.89306	-18.62000	0.00000	1.18951
-15.99852	-16.43165	-3.22965	-1.10724	.38462	43.62423	-18.62000	0.00000	.83349
-16.86479	-17.29792	-3.22965	-1.10724	.38462	37.24015	-18.62000	0.00000	.62596
-17.73105	-18.16419	-3.22965	-1.10724	.38462	29.56186	-18.62000	0.00000	.45656
-18.59732	-19.03046	-3.22965	-1.10724	.38462	20.51844	-18.62000	0.00000	.28069
-13.28990	-13.79336	-2.50068	-1.35284	.38462	53.24644	-18.62000	0.00000	2.22473
-14.29682	-14.80028	-2.50068	-1.35284	.38462	48.89306	-18.62000	0.00000	1.08091
-15.30374	-15.80720	-2.50068	-1.35284	.38462	43.62423	-18.62000	0.00000	.76725

-16.31066	-16.81413	-2.50068	-1.35284	.38462	37.24015	-18.62000	0.00000	.58092
-17.31759	-17.82105	-2.50068	-1.35284	.38462	29.56186	-18.62000	0.00000	.44657
-18.32451	-18.82797	-2.50068	-1.35284	.38462	20.51844	-18.62000	0.00000	.26158
-12.37593	-12.94524	-1.81810	-1.58282	.33567	53.24644	-18.62000	0.00000	2.05972
-13.51455	-14.08387	-1.81810	-1.58282	.33567	48.89306	-18.62000	0.00000	.87773
-14.65318	-15.22249	-1.81810	-1.58282	.33567	43.62423	-18.62000	0.00000	.80396
-15.79180	-16.36111	-1.81810	-1.58282	.33567	37.24015	-18.62000	0.00000	.46991
-16.93043	-17.49974	-1.81810	-1.58282	.33567	29.56186	-18.62000	0.00000	.49827
-18.06905	-18.63836	-1.81810	-1.58282	.33567	20.51844	-18.62000	0.00000	.22120
-5.19375	-6.38125	-1.46000	-1.69000	.04000	84.04287	0.00000	0.00000	.26730
-7.56875	-8.75625	-1.46000	-1.69000	.04000	82.80077	0.00000	0.00000	.03916
-9.94375	-11.13125	-1.46000	-1.69000	.04000	80.90972	0.00000	0.00000	.05710
-12.31875	-13.50625	-1.46000	-1.69000	.04000	77.69198	0.00000	0.00000	1.05621
-14.69375	-15.88125	-1.46000	-1.69000	.04000	71.07536	0.00000	0.00000	.69435
-17.06875	-18.25625	-1.46000	-1.69000	.04000	51.34019	0.00000	0.00000	.40845
-4.33125	-5.59375	-1.31000	-1.69000	.11000	77.07090	0.00000	0.00000	.40797
-6.85625	-8.11875	-1.31000	-1.69000	.11000	74.46967	0.00000	0.00000	.06902
-9.38125	-10.64375	-1.31000	-1.69000	.11000	70.60793	0.00000	0.00000	.08068
-11.90625	-13.16875	-1.31000	-1.69000	.11000	64.35899	0.00000	0.00000	.72423
-14.43125	-15.69375	-1.31000	-1.69000	.11000	52.97327	0.00000	0.00000	.69555
-16.95625	-18.21875	-1.31000	-1.69000	.11000	29.60445	0.00000	0.00000	.41693
-3.37292	-4.71875	-1.05000	-1.69000	.15000	72.61761	0.00000	0.00000	.48129
-6.06458	-7.41042	-1.05000	-1.69000	.15000	69.24593	0.00000	0.00000	.10972
-8.75625	-10.10208	-1.05000	-1.69000	.15000	64.35899	0.00000	0.00000	.09115
-11.44792	-12.79375	-1.05000	-1.69000	.15000	56.79343	0.00000	0.00000	.52299
-14.13958	-15.48542	-1.05000	-1.69000	.15000	44.19307	0.00000	0.00000	.65413
-16.83125	-18.17708	-1.05000	-1.69000	.15000	22.61987	0.00000	0.00000	.41141
-2.41458	-3.84375	-.72500	-1.69000	.17500	69.93693	0.00000	0.00000	.50002
-5.27292	-6.70208	-.72500	-1.69000	.17500	66.14953	0.00000	0.00000	.14697
-8.13125	-9.56042	-.72500	-1.69000	.17500	60.75117	0.00000	0.00000	.09444
-10.98958	-12.41875	-.72500	-1.69000	.17500	52.63333	0.00000	0.00000	.40121
-13.84792	-15.27708	-.72500	-1.69000	.17500	39.80557	0.00000	0.00000	.61283
-16.70625	-18.13542	-.72500	-1.69000	.17500	19.65382	0.00000	0.00000	.40307
-1.36042	-2.88125	-.27500	-1.69000	.27500	64.44004	0.00000	0.00000	.48819
-4.40208	-5.92292	-.27500	-1.69000	.27500	59.93142	0.00000	0.00000	.17141
-7.44375	-8.96458	-.27500	-1.69000	.27500	53.74616	0.00000	0.00000	.09460
-10.48542	-12.00625	-.27500	-1.69000	.27500	45.00000	0.00000	0.00000	.32584
-13.52708	-15.04792	-.27500	-1.69000	.27500	32.47119	0.00000	0.00000	.56958
-16.56875	-18.08958	-.27500	-1.69000	.27500	15.25512	0.00000	0.00000	.39267

SECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS

-28.43420	-28.65373	-9.61538	0.00000	.38462	42.90475	0.00000	0.00000	4.03015
-28.87327	-29.09280	-9.61538	0.00000	.38462	36.54497	0.00000	0.00000	1.54306
-29.31233	-29.53186	-9.61538	0.00000	.38462	28.94001	0.00000	0.00000	.79538
-29.75140	-29.97093	-9.61538	0.00000	.38462	20.03721	0.00000	0.00000	.45779
-30.19046	-30.40999	-9.61538	0.00000	.38462	10.00798	0.00000	0.00000	.27680
-30.62952	-30.84906	-9.61538	0.00000	.38462	-.67404	0.00000	0.00000	.15319
-27.71927	-28.01120	-8.84615	0.00000	.38462	42.90475	0.00000	0.00000	4.06426
-28.30313	-28.59506	-8.84615	0.00000	.38462	36.54497	0.00000	0.00000	1.72615
-28.88699	-29.17892	-8.84615	0.00000	.38462	28.94001	0.00000	0.00000	1.01160

-29.47085	-29.76278	-8.84615	0.00000	.38462	20.03721	0.00000	0.00000	.62038
-30.05471	-30.34664	-8.84615	0.00000	.38462	10.00798	0.00000	0.00000	.37816
-30.63857	-30.93051	-8.84615	0.00000	.38462	-.67404	0.00000	0.00000	.20487
-27.00434	-27.36867	-8.07692	0.00000	.38462	42.90475	0.00000	0.00000	3.90372
-27.73299	-28.09732	-8.07692	0.00000	.38462	36.54497	0.00000	0.00000	1.67207
-28.46165	-28.82598	-8.07692	0.00000	.38462	28.94001	0.00000	0.00000	1.01718
-29.19031	-29.55464	-8.07692	0.00000	.38462	20.03721	0.00000	0.00000	.64912
-29.91897	-30.28330	-8.07692	0.00000	.38462	10.00798	0.00000	0.00000	.40451
-30.64762	-31.01195	-8.07692	0.00000	.38462	-.67404	0.00000	0.00000	.21969
-26.28940	-26.72613	-7.30769	0.00000	.38462	42.90475	0.00000	0.00000	3.75602
-27.16286	-27.59959	-7.30769	0.00000	.38462	36.54497	0.00000	0.00000	1.55480
-28.03631	-28.47304	-7.30769	0.00000	.38462	28.94001	0.00000	0.00000	.95388
-28.90977	-29.34649	-7.30769	0.00000	.38462	20.03721	0.00000	0.00000	.62259
-29.78322	-30.21995	-7.30769	0.00000	.38462	10.00798	0.00000	0.00000	.39546
-30.65667	-31.09340	-7.30769	0.00000	.38462	-.67404	0.00000	0.00000	.21653
-25.73998	-26.23234	-6.71654	0.00000	.20654	42.90475	0.00000	0.00000	3.75572
-26.72471	-27.21707	-6.71654	0.00000	.20654	36.54497	0.00000	0.00000	1.38093
-27.70944	-28.20180	-6.71654	0.00000	.20654	28.94001	0.00000	0.00000	.87260
-28.69417	-29.18653	-6.71654	0.00000	.20654	20.03721	0.00000	0.00000	.58406
-29.67890	-30.17126	-6.71654	0.00000	.20654	10.00798	0.00000	0.00000	.37780
-30.66363	-31.15599	-6.71654	0.00000	.20654	-.67404	0.00000	0.00000	.20889
-25.19055	-25.73856	-6.12538	0.00000	.38462	42.90475	0.00000	0.00000	1.55688
-26.28656	-26.83456	-6.12538	0.00000	.38462	36.54497	0.00000	0.00000	1.12328
-27.38257	-27.93057	-6.12538	0.00000	.38462	28.94001	0.00000	0.00000	.78078
-28.47857	-29.02657	-6.12538	0.00000	.38462	20.03721	0.00000	0.00000	.54240
-29.57458	-30.12258	-6.12538	0.00000	.38462	10.00798	0.00000	0.00000	.35835
-30.67058	-31.21859	-6.12538	0.00000	.38462	-.67404	0.00000	0.00000	.20024
-24.47562	-25.09602	-5.35615	0.00000	.38462	42.90475	0.00000	0.00000	1.20203
-25.71642	-26.33683	-5.35615	0.00000	.38462	36.54497	0.00000	0.00000	.80400
-26.95723	-27.57763	-5.35615	0.00000	.38462	28.94001	0.00000	0.00000	.64956
-28.19803	-28.81843	-5.35615	0.00000	.38462	20.03721	0.00000	0.00000	.48163
-29.43883	-30.05923	-5.35615	0.00000	.38462	10.00798	0.00000	0.00000	.32869
-30.67963	-31.30003	-5.35615	0.00000	.38462	-.67404	0.00000	0.00000	.18653
-23.76069	-24.45349	-4.58692	0.00000	.38462	42.90475	0.00000	0.00000	1.07099
-25.14629	-25.83909	-4.58692	0.00000	.38462	36.54497	0.00000	0.00000	.64833
-26.53189	-27.22469	-4.58692	0.00000	.38462	28.94001	0.00000	0.00000	.54302
-27.91749	-28.61029	-4.58692	0.00000	.38462	20.03721	0.00000	0.00000	.42692
-29.30308	-29.99588	-4.58692	0.00000	.38462	10.00798	0.00000	0.00000	.30159
-30.68868	-31.38148	-4.58692	0.00000	.38462	-.67404	0.00000	0.00000	.17359
-23.04576	-23.81095	-3.81769	0.00000	.38462	42.90475	0.00000	0.00000	.97541
-24.57615	-25.34135	-3.81769	0.00000	.38462	36.54497	0.00000	0.00000	.56518
-26.10655	-26.87175	-3.81769	0.00000	.38462	28.94001	0.00000	0.00000	.47066
-27.63694	-28.40214	-3.81769	0.00000	.38462	20.03721	0.00000	0.00000	.38345
-29.16734	-29.93254	-3.81769	0.00000	.38462	10.00798	0.00000	0.00000	.27953
-30.69773	-31.46293	-3.81769	0.00000	.38462	-.67404	0.00000	0.00000	.16170
-22.33083	-23.16842	-3.04846	0.00000	.38462	42.90475	0.00000	0.00000	.88966
-24.00602	-24.84361	-3.04846	0.00000	.38462	36.54497	0.00000	0.00000	.51438
-25.68121	-26.51880	-3.04846	0.00000	.38462	28.94001	0.00000	0.00000	.42166
-27.35640	-28.19400	-3.04846	0.00000	.38462	20.03721	0.00000	0.00000	.35200
-29.03159	-29.86919	-3.04846	0.00000	.38462	10.00798	0.00000	0.00000	.26443
-30.70678	-31.54438	-3.04846	0.00000	.38462	-.67404	0.00000	0.00000	.14966

-21.61589	-22.52589	-2.27923	0.00000	.38462	42.90475	0.00000	0.00000	.80015
-23.43588	-24.34587	-2.27923	0.00000	.38462	36.54497	0.00000	0.00000	.49118
-25.25587	-26.16586	-2.27923	0.00000	.38462	28.94001	0.00000	0.00000	.37956
-27.07586	-27.98585	-2.27923	0.00000	.38462	20.03721	0.00000	0.00000	.33268
-28.89584	-29.80584	-2.27923	0.00000	.38462	10.00798	0.00000	0.00000	.25925
-30.71583	-31.62583	-2.27923	0.00000	.38462	-.67404	0.00000	0.00000	.13259
-21.07505	-22.03981	-1.69731	0.00000	.19731	42.90475	0.00000	0.00000	.71316
-23.00457	-23.96934	-1.69731	0.00000	.19731	36.54497	0.00000	0.00000	.52206
-24.93410	-25.89886	-1.69731	0.00000	.19731	28.94001	0.00000	0.00000	.30040
-26.86363	-27.82839	-1.69731	0.00000	.19731	20.03721	0.00000	0.00000	.35297
-28.79315	-29.75792	-1.69731	0.00000	.19731	10.00798	0.00000	0.00000	.27534
-30.72268	-31.68744	-1.69731	0.00000	.19731	-.67404	0.00000	0.00000	.09532
-19.64792	-21.24375	-1.46000	0.00000	.04000	0.00000	0.00000	0.00000	.39401
-22.83958	-24.43542	-1.46000	0.00000	.04000	0.00000	0.00000	0.00000	.37683
-26.03125	-27.62708	-1.46000	0.00000	.04000	0.00000	0.00000	0.00000	.36901
-29.22292	-30.81875	-1.46000	0.00000	.04000	0.00000	0.00000	0.00000	.21472
-32.41458	-34.01042	-1.46000	0.00000	.04000	0.00000	0.00000	0.00000	.03357
-35.60625	-37.20208	-1.46000	0.00000	.04000	0.00000	0.00000	0.00000	.00860
-19.64792	-21.24375	-1.31000	0.00000	.11000	0.00000	0.00000	0.00000	.38667
-22.83958	-24.43542	-1.31000	0.00000	.11000	0.00000	0.00000	0.00000	.40078
-26.03125	-27.62708	-1.31000	0.00000	.11000	0.00000	0.00000	0.00000	.35211
-29.22292	-30.81875	-1.31000	0.00000	.11000	0.00000	0.00000	0.00000	.21240
-32.41458	-34.01042	-1.31000	0.00000	.11000	0.00000	0.00000	0.00000	.05136
-35.60625	-37.20208	-1.31000	0.00000	.11000	0.00000	0.00000	0.00000	.01443
-19.64792	-21.24375	-1.05000	0.00000	.15000	0.00000	0.00000	0.00000	.40181
-22.83958	-24.43542	-1.05000	0.00000	.15000	0.00000	0.00000	0.00000	.40029
-26.03125	-27.62708	-1.05000	0.00000	.15000	0.00000	0.00000	0.00000	.33914
-29.22292	-30.81875	-1.05000	0.00000	.15000	0.00000	0.00000	0.00000	.21200
-32.41458	-34.01042	-1.05000	0.00000	.15000	0.00000	0.00000	0.00000	.06333
-35.60625	-37.20208	-1.05000	0.00000	.15000	0.00000	0.00000	0.00000	.01950
-19.64792	-21.24375	-.72500	0.00000	.17500	0.00000	0.00000	0.00000	.42072
-22.83958	-24.43542	-.72500	0.00000	.17500	0.00000	0.00000	0.00000	.39237
-26.03125	-27.62708	-.72500	0.00000	.17500	0.00000	0.00000	0.00000	.33066
-29.22292	-30.81875	-.72500	0.00000	.17500	0.00000	0.00000	0.00000	.21129
-32.41458	-34.01042	-.72500	0.00000	.17500	0.00000	0.00000	0.00000	.07126
-35.60625	-37.20208	-.72500	0.00000	.17500	0.00000	0.00000	0.00000	.02322
-19.64792	-21.24375	-.27500	0.00000	.27500	0.00000	0.00000	0.00000	.43575
-22.83958	-24.43542	-.27500	0.00000	.27500	0.00000	0.00000	0.00000	.38501
-26.03125	-27.62708	-.27500	0.00000	.27500	0.00000	0.00000	0.00000	.32522
-29.22292	-30.81875	-.27500	0.00000	.27500	0.00000	0.00000	0.00000	.21049
-32.41458	-34.01042	-.27500	0.00000	.27500	0.00000	0.00000	0.00000	.07638
-35.60625	-37.20208	-.27500	0.00000	.27500	0.00000	0.00000	0.00000	.02574

REF. CHORD	C AVERAGE	TRUE AREA	REFERENCE AREA	B/2	REF. AR	TRUE AR	MACH NUMBER
9.17560	13.51260	270.25200	159.99696	10.00000	2.50005	1.48010	.30000

COMPLETE CONFIGURATION		WING-BODY CHARACTERISTICS		
		LIFT	INDUCED DRAG (FAR FIELD SOLUTION)	
DESIRED CL	COMPUTED ALPHA	CL(WB)	CDI AT CL(WB)	CDI/(CL(WB)**2) (1/(PI*AR) = .12732)
1.00000	17.90535	.59724	.06733	.18876

COMPLETE CONFIGURATION CHARACTERISTICS

CL ALPHA PER RADIAN	CL ALPHA PER DEGREE	CL(TWIST)	ALPHA AT CL=0	Y CP	CM/CL	CMO
3.19992	.05585	0.00000	-0.00000	-.41849	-2.33969	0.00000

STATION	2Y/B	ADDITIONAL LOADING WITH CL BASED ON S(TRUE) SL COEF	CL RATIO	C RATIO	LOAD DUE TO TWIST	ADD. LOAD AT CL= 0.00000	BASIC LOAD AT CL=0	SPAN LOAD AT DESIRED CL	-AT CL DES- X LOCATON OF LOCAL CENT PR
1	-.61455	.29459	2.18482	.13483	0.00000	0.00000	0.00000	.17440	-18.50420
2	-.54165	.42417	2.14999	.19729	0.00000	0.00000	0.00000	.25112	-17.74451
3	-.46876	.51395	1.97871	.25974	0.00000	0.00000	0.00000	.30428	-16.97449
4	-.39586	.58240	1.80761	.32220	0.00000	0.00000	0.00000	.34480	-16.20531
5	-.32296	.63523	1.65146	.38465	0.00000	0.00000	0.00000	.37608	-15.44203
6	-.25007	.67490	1.50949	.44710	0.00000	0.00000	0.00000	.39956	-14.68937
7	-.18181	.70180	1.38810	.50558	0.00000	0.00000	0.00000	.41549	-13.99110
8	-.14600	.74890	.71015	1.05457	0.00000	0.00000	0.00000	.44337	-12.85910
9	-.13100	.75574	.67406	1.12118	0.00000	0.00000	0.00000	.44742	-11.99776
10	-.10500	.76401	.63924	1.19518	0.00000	0.00000	0.00000	.45231	-11.11893
11	-.07250	.77124	.60767	1.26919	0.00000	0.00000	0.00000	.45660	-10.36793
12	-.02750	.77651	.57494	1.35059	0.00000	0.00000	0.00000	.45972	-9.67063

CONTRIBUTION OF THE SECOND PLANFORM TO SPAN LOAD DISTRIBUTION

STATION	2Y/B	SL COEF	CL RATIO	C RATIO	LOAD DUE TO TWIST	ADD. LOAD AT CL= 0.00000	BASIC LOAD AT CL=0	SPAN LOAD AT DESIRED CL	X LOCATON OF LOCAL CENT PR
13	-.96154	.39826	2.04280	.19496	0.00000	0.00000	0.00000	.23578	-28.82026
14	-.88462	.58427	2.25367	.25925	0.00000	0.00000	0.00000	.34590	-28.31349
15	-.80769	.71649	2.21450	.32355	0.00000	0.00000	0.00000	.42418	-27.77968
16	-.73077	.81880	2.11118	.38784	0.00000	0.00000	0.00000	.48475	-27.22058
17	-.67165	.88381	2.02130	.43725	0.00000	0.00000	0.00000	.52324	-26.75954
18	-.61254	.62500	1.28426	.48666	0.00000	0.00000	0.00000	.37002	-26.81144
19	-.53562	.56651	1.02823	.55095	0.00000	0.00000	0.00000	.33539	-26.44443
20	-.45869	.54809	.89085	.61525	0.00000	0.00000	0.00000	.32449	-25.98917
21	-.38177	.54252	.79836	.67954	0.00000	0.00000	0.00000	.32119	-25.51920
22	-.30485	.54273	.72963	.74384	0.00000	0.00000	0.00000	.32131	-25.05822
23	-.22792	.54496	.67435	.80813	0.00000	0.00000	0.00000	.32263	-24.61574
24	-.16973	.54492	.63602	.85677	0.00000	0.00000	0.00000	.32261	-24.28605
25	-.14600	.55725	.39321	1.41720	0.00000	0.00000	0.00000	.32991	-24.07250
26	-.13100	.56563	.39912	1.41720	0.00000	0.00000	0.00000	.33487	-24.19489

27	-.10500	.57294	.40428	1.41720	0.00000	0.00000	0.00000	.33920	-24.23822
28	-.07250	.57830	.40806	1.41720	0.00000	0.00000	0.00000	.34237	-24.24694
29	-.02750	.58193	.41062	1.41720	0.00000	0.00000	0.00000	.34452	-24.24557

INDUCED DRAG, LEADING EDGE THRUST AND SUCTION COEFFICIENT CHARACTERISTICS
COMPUTED AT THE DESIRED CL FROM A NEAR FIELD SOLUTION

SECTION COEFFICIENTS

STATION	2Y/B	L. E. SWEEP ANGLE	CDII C/2B	CT C/2B	CS C/2B
1	-.61455	54.21355	-.00351	.02261	.03866
2	-.54165	54.21355	-.00450	.03094	.05292
3	-.46876	54.21355	-.00070	.03272	.05595
4	-.39586	54.21355	.00393	.03234	.05530
5	-.32296	54.21355	.00881	.03082	.05271
6	-.25007	54.21355	.01540	.02672	.04569
7	-.18181	54.21355	.02575	.01890	.10663
8	-.14600	84.28941	.02279	.02402	.23456
9	-.13100	77.59258	.02687	.02025	.18165
10	-.10500	73.30076	.03394	.01370	.08992
11	-.07250	70.70995	.04300	.00512	.01812
12	-.02750	65.37644	.05588	-.00735	-.01808
	CONTRIBUTION OF THE SECOND PLANFORM TO THE CHORD OR DRAG FORCE				
13	-.96154	44.31794	-.01214	.03563	.04979
14	-.88462	44.31794	-.00759	.04391	.06137
15	-.80769	44.31794	-.00567	.05030	.07031
16	-.73077	44.31794	.00017	.05097	.07123
17	-.67165	44.31794	.03605	.01768	.02471
18	-.61254	44.31794	.06006	-.01999	-.02793
19	-.53562	44.31794	.03478	.00107	.00149
20	-.45869	44.31794	.02943	.00496	.00693
21	-.38177	44.31794	.02890	.00501	.00700
22	-.30485	44.31794	.02974	.00420	.00587
23	-.22792	44.31794	.03063	.00341	.00476
24	-.16973	44.31794	.03376	.00075	.00124
25	-.14600	0.00000	.03551	-.00070	-.00070
26	-.13100	0.00000	.03483	.00029	.00029
27	-.10500	0.00000	.03365	.00200	.00200
28	-.07250	0.00000	.03295	.00314	.00314
29	-.02750	0.00000	.03312	.00325	.00325

TOTAL COEFFICIENTS

CDII/CL**2 = .15956 CT= .15098 CS= .29455

APPENDIX B

KP , KV AND RESPECTIVE CHORDWISE CENTROIDS FOR EACH PLANFORM

PLANFORM NO. 1

KP=	1.28879	CENTROID AT -14.39074
KV LE=	1.55287	CENTROID AT -14.70269
KV SE=	.22241	CENTROID AT -19.26927

PLANFORM NO. 2

KP=	1.91113	CENTROID AT -26.24069
KV LE=	1.04260	CENTROID AT -26.77147
KV SE=	.45948	CENTROID AT -29.83309

PERFORMANCE CHARACTERISTICS FOR PLANFORM 1

ALPHA	CN	CLP	CLP+CLVLE	CLP+CLVSE	CL	CMP	CMP+CMVLE	CMP+CMVSE	CM	CD	CL**2/(PI*AR)
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.0000	.0471	.0449	.0468	.0452	.0471	-.0705	-.0735	-.0711	-.0741	.0016	.0003
4.0000	.0983	.0895	.0970	.0905	.0981	-.1407	-.1528	-.1429	-.1550	.0069	.0012
6.0000	.1534	.1332	.1501	.1357	.1525	-.2101	-.2373	-.2152	-.2424	.0160	.0030
8.0000	.2120	.1759	.2057	.1802	.2099	-.2786	-.3268	-.2876	-.3358	.0295	.0056
10.0000	.2739	.2170	.2632	.2237	.2698	-.3457	-.4207	-.3597	-.4348	.0476	.0093
12.0000	.3388	.2564	.3220	.2658	.3314	-.4111	-.5186	-.4313	-.5388	.0704	.0140
14.0000	.4064	.2935	.3817	.3062	.3944	-.4745	-.6201	-.5018	-.6474	.0983	.0198
16.0000	.4764	.3282	.4417	.3445	.4579	-.5356	-.7246	-.5711	-.7601	.1313	.0267
18.0000	.5483	.3602	.5013	.3804	.5215	-.5940	-.8317	-.6386	-.8763	.1694	.0346
20.0000	.6219	.3892	.5599	.4137	.5844	-.6496	-.9407	-.7043	-.9953	.2127	.0435
22.0000	.6968	.4150	.6171	.4440	.6460	-.7021	-1.0512	-.7676	-1.1168	.2610	.0531
24.0000	.7726	.4375	.6722	.4711	.7058	-.7511	-1.1627	-.8283	-1.2400	.3142	.0634
26.0000	.8489	.4564	.7246	.4948	.7630	-.7964	-1.2746	-.8862	-1.3643	.3722	.0741
28.0000	.9255	.4717	.7739	.5150	.8172	-.8379	-1.3863	-.9408	-1.4892	.4345	.0850
30.0000	1.0019	.4833	.8195	.5315	.8677	-.8753	-1.4973	-.9920	-1.6141	.5009	.0959
32.0000	1.0777	.4912	.8610	.5441	.9139	-.9084	-1.6071	-1.0395	-1.7383	.5711	.1064
34.0000	1.1526	.4953	.8979	.5530	.9555	-.9371	-1.7151	-1.0831	-1.8612	.6445	.1163
36.0000	1.2262	.4958	.9299	.5580	.9920	-.9612	-1.8209	-1.1226	-1.9822	.7207	.1253
38.0000	1.2982	.4927	.9565	.5591	1.0230	-.9806	-1.9238	-1.1577	-2.1008	.7992	.1332
40.0000	1.3681	.4861	.9776	.5565	1.0480	-.9953	-2.0234	-1.1883	-2.2164	.8794	.1398
42.0000	1.4357	.4763	.9929	.5503	1.0669	-1.0051	-2.1192	-1.2142	-2.3283	.9607	.1449
44.0000	1.5007	.4633	1.0023	.5405	1.0795	-1.0100	-2.2107	-1.2354	-2.4361	1.0424	.1484
46.0000	1.5626	.4474	1.0055	.5273	1.0855	-1.0100	-2.2976	-1.2517	-2.5393	1.1241	.1500
48.0000	1.6213	.4288	1.0027	.5110	1.0849	-1.0051	-2.3793	-1.2631	-2.6372	1.2049	.1498
50.0000	1.6764	.4079	.9937	.4918	1.0776	-.9953	-2.4555	-1.2694	-2.7296	1.2842	.1478

PERFORMANCE CHARACTERISTICS FOR PLANFORM 2

ALPHA	CN	CLP	CLP+CLVLE	CLP+CLVSE	CL	CMP	CMP+CMVLE	CMP+CMVSE	CM	CD	CL**2/(PI*AR)
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.0000	.0685	.0666	.0679	.0672	.0684	-.1906	-.1943	-.1924	-.1962	.0024	.0006
4.0000	.1403	.1327	.1377	.1349	.1400	-.3803	-.3951	-.3876	-.4024	.0098	.0025
6.0000	.2151	.1976	.2089	.2026	.2139	-.5682	-.6014	-.5845	-.6177	.0225	.0058
8.0000	.2925	.2608	.2808	.2696	.2896	-.7533	-.8122	-.7822	-.8411	.0407	.0107
10.0000	.3721	.3219	.3528	.3355	.3665	-.9347	-1.0264	-.9797	-1.0714	.0646	.0171
12.0000	.4536	.3802	.4243	.3996	.4437	-1.1115	-1.2430	-1.1761	-1.3076	.0943	.0251
14.0000	.5365	.4353	.4945	.4614	.5206	-1.2830	-1.4610	-1.3704	-1.5484	.1298	.0345
16.0000	.6205	.4868	.5629	.5203	.5965	-1.4481	-1.6793	-1.5616	-1.7928	.1710	.0453
18.0000	.7051	.5342	.6289	.5759	.6706	-1.6063	-1.8968	-1.7489	-2.0394	.2179	.0573
20.0000	.7899	.5772	.6918	.6277	.7423	-1.7566	-2.1124	-1.9313	-2.2872	.2702	.0702
22.0000	.8746	.6155	.7511	.6752	.8109	-1.8983	-2.3252	-2.1080	-2.5349	.3276	.0837
24.0000	.9586	.6487	.8063	.7182	.8757	-2.0308	-2.5341	-2.2780	-2.7812	.3899	.0976
26.0000	1.0417	.6768	.8569	.7562	.9362	-2.1534	-2.7380	-2.4405	-3.0251	.4566	.1116
28.0000	1.1233	.6995	.9024	.7889	.9918	-2.2656	-2.9360	-2.5948	-3.2653	.5273	.1252
30.0000	1.2031	.7167	.9424	.8162	1.0419	-2.3666	-3.1271	-2.7401	-3.5006	.6015	.1382
32.0000	1.2807	.7284	.9766	.8378	1.0861	-2.4562	-3.3104	-2.8757	-3.7299	.6786	.1502
34.0000	1.3557	.7345	1.0048	.8536	1.1239	-2.5338	-3.4850	-3.0009	-3.9521	.7581	.1608
36.0000	1.4278	.7352	1.0266	.8637	1.1551	-2.5990	-3.6500	-3.1152	-4.1661	.8392	.1699
38.0000	1.4965	.7306	1.0420	.8679	1.1793	-2.6516	-3.8046	-3.2178	-4.3709	.9214	.1771
40.0000	1.5617	.7209	1.0509	.8663	1.1963	-2.6912	-3.9481	-3.3085	-4.5654	1.0038	.1822
42.0000	1.6229	.7062	1.0531	.8591	1.2060	-2.7178	-4.0798	-3.3867	-4.7487	1.0859	.1852
44.0000	1.6798	.6870	1.0489	.8465	1.2084	-2.7311	-4.1990	-3.4520	-4.9199	1.1669	.1859
46.0000	1.7322	.6634	1.0382	.8285	1.2033	-2.7311	-4.3052	-3.5041	-5.0782	1.2461	.1844
48.0000	1.7799	.6359	1.0212	.8057	1.1910	-2.7178	-4.3978	-3.5428	-5.2228	1.3227	.1806
50.0000	1.8225	.6049	.9982	.7782	1.1715	-2.6912	-4.4764	-3.5679	-5.3530	1.3961	.1747

TOTAL PERFORMANCE CHARACTERISTICS

ALPHA	CN	CLP	CLP+CLVLE	CLP+CLVSE	CL	CMP	CMP+CMVLE	CMP+CMVSE	CM	CD	CL**2/(PI*AR)
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2.0000	.1156	.1115	.1147	.1124	.1155	-.2611	-.2679	-.2635	-.2703	.0040	.0017
4.0000	.2386	.2221	.2347	.2254	.2380	-.5210	-.5479	-.5305	-.5574	.0166	.0072
6.0000	.3685	.3308	.3590	.3382	.3664	-.7783	-.8387	-.7997	-.8602	.0385	.0171
8.0000	.5045	.4367	.4865	.4498	.4996	-1.0318	-1.1389	-1.0698	-1.1769	.0702	.0318
10.0000	.6460	.5389	.6160	.5592	.6362	-1.2803	-1.4471	-1.3395	-1.5062	.1122	.0515
12.0000	.7924	.6365	.7463	.6654	.7751	-1.5226	-1.7616	-1.6074	-1.8464	.1648	.0765
14.0000	.9429	.7288	.8762	.7675	.9149	-1.7574	-2.0811	-1.8722	-2.1959	.2281	.1066
16.0000	1.0969	.8150	1.0046	.8648	1.0544	-1.9837	-2.4039	-2.1327	-2.5529	.3023	.1415
18.0000	1.2534	.8944	1.1301	.9563	1.1920	-2.2003	-2.7284	-2.3876	-2.9157	.3873	.1809
20.0000	1.4118	.9664	1.2517	1.0414	1.3267	-2.4062	-3.0531	-2.6356	-3.2825	.4829	.2241
22.0000	1.5713	1.0305	1.3682	1.1192	1.4569	-2.6004	-3.3765	-2.8756	-3.6516	.5886	.2703
24.0000	1.7312	1.0862	1.4785	1.1893	1.5815	-2.7819	-3.6968	-3.1063	-4.0212	.7041	.3185
26.0000	1.8906	1.1332	1.5815	1.2510	1.6993	-2.9498	-4.0126	-3.3267	-4.3894	.8288	.3676
28.0000	2.0488	1.1712	1.6763	1.3039	1.8090	-3.1034	-4.3223	-3.5356	-4.7545	.9618	.4166
30.0000	2.2049	1.2000	1.7619	1.3476	1.9095	-3.2419	-4.6245	-3.7321	-5.1147	1.1025	.4643
32.0000	2.3584	1.2195	1.8376	1.3819	2.0000	-3.3646	-4.9175	-3.9152	-5.4682	1.2497	.5093
34.0000	2.5083	1.2298	1.9027	1.4066	2.0795	-3.4708	-5.2001	-4.0840	-5.8133	1.4026	.5506
36.0000	2.6540	1.2310	1.9565	1.4216	2.1471	-3.5602	-5.4709	-4.2377	-6.1484	1.5600	.5870
38.0000	2.7947	1.2233	1.9986	1.4270	2.2022	-3.6322	-5.7284	-4.3755	-6.4717	1.7206	.6175
40.0000	2.9298	1.2070	2.0285	1.4228	2.2443	-3.6865	-5.9715	-4.4968	-6.7818	1.8832	.6413
42.0000	3.0586	1.1825	2.0461	1.4094	2.2730	-3.7229	-6.1990	-4.6009	-7.0770	2.0466	.6578
44.0000	3.1805	1.1502	2.0511	1.3869	2.2878	-3.7411	-6.4098	-4.6874	-7.3560	2.2093	.6664
46.0000	3.2949	1.1108	2.0437	1.3559	2.2888	-3.7411	-6.6028	-4.7559	-7.6175	2.3701	.6670
48.0000	3.4012	1.0647	2.0238	1.3167	2.2758	-3.7229	-6.7771	-4.8059	-7.8601	2.5276	.6594
50.0000	3.4989	1.0128	1.9918	1.2700	2.2490	-3.6865	-6.9318	-4.8373	-8.0826	2.6803	.6440

THIS CASE IS FINISHED

APPENDIX C

FORTRAN PROGRAM LISTING

This program was written in FORTRAN IV language, version 2.3, for the Control Data series 6000 computer systems with SCOPE 3.0 operating system and library tape. Minor modifications may be required prior to use with other computers. The program requires 53000_8 words of storage on the Control Data 6600 computer system and consists of a main program, five overlays, and five subroutines. Each program or subroutine is identified in columns 73 to 75 by a 3-character identification. In addition, each of these parts is sequenced with a 4-digit number in columns 76 to 79. The following table is an index to the program listing:

Program or subroutine	Identification	Page
WINGAL	MAI	30
INFSUB	INF	31
GEOMTRY	GEO	32
MATXSOL	MAT	42
SSLESO	SSL	43
AERODYN	AER	44
FTLUP	TLU	49
CDICLS	CDI	51
CDRAGNF	DRA	53
FTLUP	TLU	57
TIPSUCT	TIP	59
WRTANS	WRT	65

The execution time for this program is similar to that for the program presented in reference 6.

APPENDIX C

```
      OVERLAY(WINGTL,0,0)
      PROGRAM WINGAL(INPUT=201,OUTPUT=1001,TAPE5=INPUT,TAPE6=OUTPUT,TAPE
     110=401)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      COMMON /TOTHRE/ CIR(200,2)
      COMMON /THREFOR/ CCAV(2,50),CLT,CLNT,NSSW,ALPD
      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),XL(2
     2),XT(2),CLWB,CMCL,CLA(2),BLAIR(50),CLAMAR(2)
      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),ITIPCOD
      COMMON /CCRRDD/ TSPAN,TSPANA,KBIT
C
C         VORTEX LATTICE AERODYNAMIC COMPUTATION
C               NASA-LRC PROGRAM NO. A2794
C
C
      ICODEOF=TOTAL=0
      WINGTL=6LWINGTL
      RECALL=6HRECALL
10    CALL OVERLAY (WINGTL,1,0,RECALL)
      IF (ICODEOF.GT.0) GO TO 70
      IF (M.GT.200) GO TO 40
      NSW=NSSWSV(1)+NSSWSV(2)
      IF (NSW.GT.50) GO TO 30
      ITSV=0
      DO 20 IT=1,IPLAN
      IF (AN(IT).LE.25.) GO TO 20
      WRITE (6,100) IT,AN(IT)
      ITSV=1
20    CONTINUE
      IF (ITSV.GT.0) GO TO 60
      GO TO 50
30    WRITE (6,90) NSW
      GO TO 60
40    WRITE (6,80) M
      GO TO 60
50    CALL OVERLAY (WINGTL,2,0,RECALL)
      CALL OVERLAY (WINGTL,3,0,RECALL)
      IF (PTEST.EQ.1..OR.QTEST.EQ.1.) GO TO 60
      CALL OVERLAY (WINGTL,4,0,RECALL)
      IF (ITIPCOD.EQ.1) CALL OVERLAY (WINGTL,5,0,RECALL)
60    TOTAL=TOTAL-1.
      GO TO 10
70    STOP
C
C
C
80    FORMAT (1H1//10X,I6,93HHORSESHOE VORTICES LAIDOUT, THIS IS MORE TH
     1AN THE 200 MAXIMUM. THIS CONFIGURATION IS ABORTED.)
90    FORMAT (1H1//10X,I6,101H ROWS OF HORSESHOE VORTICES LAIDOUT. THIS
     1IS MORE THAN THE 50 MAXIMUM. THIS CONFIGURATION IS ABORTED.)
100   FORMAT (1H1//10X,8HPLANFORM,I6,4H HAS,I6,74H BREAKPOINTS. THE MAXI
     1MUM DIMENSIONED IS 25. THE CONFIGURATION IS ABORTED.)
      END
```

APPENDIX C

```
      SUBROUTINE INFSUB (BOT,FVI,FWI)
      COMMON /INSUB23/ PSII,APHII,XXX,YYY,ZZZ,SNN,TOLRNC
      FC=COS(PSII)
      FS=SIN(PSII)
      FT=FS/FC
C
C
      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 10
      FVONE=(XXX*FPS-ZZZ*FT*FPC)*FFF/FFA
      FWONE=(YYY*FT-XXX)*FFF/FFA*FPC
      GO TO 20
10    FVONE=FWONE=0.
C
20    IF (ABS(FFD).LT.TOLRNC) GO TO 30
      FVTWO=F6*(1.-F4/FFC)/FFD
      FWTWO=-F5*(1.-F4/FFC)/FFD
      GO TO 40
30    FVTWO=FWTWO=0.
C
40    IF (ABS(FFE).LT.TOLRNC) GO TO 50
      FVTHRE=-F3*(1.-F1/FFB)/FFE
      FWTHRE=F2*(1.-F1/FFB)/FFE
      GO TO 60
50    FVTHRE=FWTHRE=0.
C
60    FVI=FVONE+FVTWO+FVTHRE
      FWI=FWONE+FWTWO+FWTHRE
      RETURN
      END
```

```
      OVERLAY(WINGTL,1,0)
      PROGRAM GEOMTRY
      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(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      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),XL(2
     2),XT(2),CLWB,CMCL,CLA(2),BLAIR(50),CLAMAR(2)
      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),ITIPCOD
      COMMON /CCRRDD/ TSPAN,TSPANA,KBIT
      REAL MACH
C
C
C       PART ONE - GEOMETRY COMPUTATION
C
C                   SECTION ONE - INPUT OF REFERENCE WING POSITION
C
C
      IF (TOTAL.EQ.0.0) RTCDHT(1)=RTCDHT(2)=XL(2)=XT(2)=0.0
      YTOL=1.E-10
      AZY=1.E+13
      PIT=1.5707963
      RAD=57.29578
      IF (TOTAL.GT.0.) GO TO 70
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 (5,880) PLAN,TOTAL,CREF,SREF
      IF (ENDFILE 5) 830,10
10    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 (6,860)
      DO 60 IT=1,IPLAN
      READ (5,880) 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 (6,870) PRTCON,N,RTCDHT(IT),XS(IT),YS(IT)
      WRITE (6,990)
```

```
      DO 50 I=1,N1
      READ (5,880) XREG(I,IT),YREG(I,IT),DIH(I,IT),AMCD
      MCD(I,IT)=AMCD
      IF (I.EQ.1) GO TO 50
      IF (MAK.NE.0.OR.MCD(I-1,IT).NE.2) GO TO 20
      MAK=I-1
20    IF (ABS(YREG(I-1,IT)-YREG(I,IT)).LT.YTOL) GO TO 30
      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 40
30    YREG(I,IT)=YREG(I-1,IT)
      AREG(I-1,IT)=AZY
      ASWP=90.
40    J=I-1
C
C     WRITE PLANFORM PERIMETER POINTS AND ANGLES
C
      WRITE (6,960) J,XREG(J,IT),YREG(J,IT),ASWP,DIH(J,IT),MCD(J,IT)
      DIH(J,IT)=TAN(DIH(J,IT)/RAD)
50    CONTINUE
      KFCTS(IT)=MAK
      WRITE (6,960) N1,XREG(N1,IT),YREG(N1,IT)
60    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
C     IF A PARTICULAR VALUE OF CL IS DESIRED AT WHICH THE LOADINGS ARE
C     TO BE COMPUTED, SET CLDES EQUAL TO THIS VALUE
C     SET CLDES EQUAL TO 11. FOR A DRAG POLAR AT CL VALUES OF-.1 TO  1.0
C
C     IF PTEST IS SET EQUAL TO ONE THE PROGRAM WILL COMPUTE  CLP
C     IF QTEST IS SET EQUAL TO ONE THE PROGRAM WILL COMPUTE  CMQ AND CLQ
C     DO NOT SET BOTH PTEST AND QTEST TO ONE FOR A SINGLE CONFIGURATION
C
C     SET TWIST(1) OR TWIST(2) EQUAL TO 0. FOR A FLAT PLANFORM AND TO 1.
C     FOR A PLANFORM THAT HAS TWIST AND/OR CAMBER
C
C     SET ATPCOD TO ONE IF THE CONTRIBUTIONS TO LIFT,DRAG AND MOMENT
C     FROM SEPERATED FLOW AROUND THE LEADING AND/OR SIDE EDGES IS
C     DESIRED.   OTHERWISE SET ATPCOD TO ZERO.
C
C
70    READ (5,950) CONFIG,SCW,VIC,MACH,CLDES,PTEST,QTEST,TWIST(1),SA(1),
     1TWIST(2),SA(2),ATPCOD
      ITIPCOD=ATPCOD
      IF (ITIPCOD.NE.1) GO TO 110
      DO 100 IT=1,IPLAN
      NBBG=AAN(IT)
      DO 90 IBBG=2,NBBG
      IF (YREG(IBBG,IT).EQ.YREG(IBBG+1,IT)) GO TO 80
      GO TO 90
80    IF (YREG(IBBG+2,IT).LT.YREG(IBBG+1,IT)) GO TO 90
      IF (YREG(IBBG-1,IT).LT.YREG(IBBG,IT)) GO TO 90
      XL(IT)=XREG(IBBG,IT)
      XT(IT)=XREG(IBBG+1,IT)
```

```
      GO TO 100                                                         GE01210
   90 CONTINUE                                                          GE01220
      XL(IT)=0.0                                                        GE01230
      XT(IT)=0.0                                                        GE01240
  100 CONTINUE                                                          GE01250
  110 CONTINUE                                                          GE01260
      WRITE (6,890) CONFIG                                              GE01270
      IF (ENDFILE 5) 830,120                                            GE01280
  120 IF (PTEST.NE.0..AND.QTEST.NE.0.) GO TO 850                        GE01290
      IF (SCW.EQ.0.) GO TO 140                                          GE01300
      DO 130 I=1,50                                                     GE01310
  130 TBLSCW(I)=SCW                                                     GE01320
      GO TO 150                                                         GE01330
  140 READ (5,880) STA                                                  GE01340
      NSTA=STA                                                          GE01350
      READ (5,880) (TBLSCW(I),TBLSCW(I+1),TBLSCW(I+2),TBLSCW(I+3),TBLSCWGE01360
     1(I+4),TBLSCW(I+5),TBLSCW(I+6),TBLSCW(I+7),I=1,NSTA,8)             GE01370
  150 DO 410 IT=1,IPLAN                                                 GE01380
      N=AAN(IT)                                                         GE01390
      N1=N+1                                                            GE01400
      DO 160 I=1,N                                                      GE01410
      XREF(I)=XREG(I,IT)                                                GE01420
      YREF(I)=YREG(I,IT)                                                GE01430
      A(I)=AREG(I,IT)                                                   GE01440
      RSAR(I)=ATAN(A(I))                                                GE01450
      IF (A(I).EQ.AZY) RSAR(I)=PIT                                      GE01460
  160 CONTINUE                                                          GE01470
      XREF(N1)=XREG(N1,IT)                                              GE01480
      YREF(N1)=YREG(N1,IT)                                              GE01490
      IF (KFCTS(IT).GT.0) GO TO 170                                     GE01500
      K=1                                                               GE01510
      SA(IT)=RSAR(1)*RAD                                                GE01520
      GO TO 180                                                         GE01530
  170 K=KFCTS(IT)                                                       GE01540
  180 WRITE (6,920) K,SA(IT),IT                                         GE01550
      SB=SA(IT)/RAD                                                     GE01560
      IF (ABS(SB-RSAR(K)).GT.(.1/RAD)) GO TO 210                        GE01570
C     REFERENCE PLANFORM COORDINATES ARE STORED UNCHANGED FOR WINGS     GE01580
C            WITHOUT CHANGE IN SWEEP                                    GE01590
      DO 200 I=1,N                                                      GE01600
      X(I)=XREF(I)                                                      GE01610
      Y(I)=YREF(I)                                                      GE01620
      IF (RSAR(I).EQ.PIT) GO TO 190                                     GE01630
      A(I)=TAN(RSAR(I))                                                 GE01640
      GO TO 200                                                         GE01650
  190 A(I)=AZY                                                          GE01660
  200 SAR(I)=RSAR(I)                                                    GE01670
      X(N1)=XREF(N1)                                                    GE01680
      Y(N1)=YREF(N1)                                                    GE01690
      GO TO 390                                                         GE01700
C                                                                       GE01710
C     CHANGES IN WING SWEEP ARE MADE HERE                               GE01720
C                                                                       GE01730
  210 IF (MCD(K,IT).NE.2) GO TO 840                                     GE01740
      KA=K-1                                                            GE01750
      DO 220 I=1,KA                                                     GE01760
      X(I)=XREF(I)                                                      GE01770
      Y(I)=YREF(I)                                                      GE01780
  220 SAR(I)=RSAR(I)                                                    GE01790
C     DETERMINE LEADING EDGE INTERSECTION BETWEEN FIXED AND VARIABLE    GE01800
```

```
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 230
      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 240
C     ELIMINATE EXTRANEOUS BREAKPOINTS
230   X(K)=XREF(K-1)
      Y(K)=YREF(K-1)
      SAR(K)=SAR(K-1)
240   K=K+1
C     SWEEP THE BREAKPOINTS ON THE VARIABLE SWEEP PANEL
C        (IT ALSO KEEPS SWEEP ANGLES IN FIRST OR FOURTH QUADRANTS)
250   K=K+1
      SAR(K-1)=SAI+RSAR(K-1)
260   IF (SAR(K-1).LE.PIT) GO TO 270
      SAR(K-1)=SAR(K-1)-3.1415927
      GO TO 260
270   IF (SAR(K-1).GE.(-PIT)) GO TO 280
      SAR(K-1)=SAR(K-1)+3.1415927
      GO TO 270
280   IF ((SAR(K-1)).LT..0) GO TO 290
      IF (SAR(K-1)-PIT) 320,300,300
290   IF (SAR(K-1)+PIT) 310,310,320
300   A(K-1)=AZY
      GO TO 330
310   A(K-1)=-AZY
      GO TO 330
320   A(K-1)=TAN(SAR(K-1))
330   KK=MOD(K,IT)
      GO TO (350,340), KK
340   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 250
C     DETERMINE THE TRAILING EDGE INTERSECTION
C        BETWEEN FIXED AND VARIABLE SWEEP WING SECTIONS
350   IF (ABS(RSAR(K)-SAR(K-1)).LT.(.1/RAD)) GO TO 360
      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 370
360   X(K)=XREF(K+1)
      Y(K)=YREF(K+1)
370   K=K+1
C     STORE REFERENCE PLANFORM COORDINATES ON INBOARD FIXED TRAILING
C     EDGE
      DO 380 I=K,N1
      X(I)=XREF(I)
      Y(I)=YREF(I)
380   SAR(I-1)=RSAR(I-1)
390   DO 400 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)
 400  AS(I,IT)=A(I)
      XX(N1,IT)=X(N1)
      YY(N1,IT)=Y(N1)
      AN(IT)=AAN(IT)
 410  CONTINUE
C
C       LINE UP BREAKPOINTS AMONG PLANFORMS
C
      BOTSV(1)=BOTSV(2)=0.
      WRITE (6,980)
      DO 530 IT=1,IPLAN
      NIT=AN(IT)+1
      DO 470 ITT=1,IPLAN
      IF (ITT.EQ.IT) GO TO 470
      NITT=AN(ITT)+1
      DO 460 I=1,NITT
      JPSV=0
      DO 420 JP=1,NIT
      IF (YY(JP,IT).EQ.YY(I,ITT)) GO TO 460
 420  CONTINUE
      DO 430 JP=1,NIT
      IF (YY(JP,IT).LT.YY(I,ITT)) GO TO 440
 430  CONTINUE
      GO TO 460
 440  JPSV=JP
      IND=NIT-(JPSV-1)
      DO 450 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)
 450  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
 460  CONTINUE
 470  CONTINUE
C
C     SEQUENCE WING COORDINATES FROM TIP TO ROOT
C
      N1=AN(IT)+1.
      DO 480 I=1,N1
 480  Q(I)=YY(I,IT)
      DO 520 J=1,N1
      HIGH=1.
      DO 490 I=1,N1
      IF ((Q(I)-HIGH).GE.0.) GO TO 490
      HIGH=Q(I)
      IH=I
```

```
490   CONTINUE
      IF (J.NE.1) GO TO 500
      BOTSV(IT)=HIGH
      KFX(IT)=IH
500   Q(IH)=1.
      SPY(J,IT)=HIGH
      IF (IH.GT.KFX(IT)) GO TO 510
      IYL(J,IT)=1
      IYT(J,IT)=0
      GO TO 520
510   IYL(J,IT)=0
      IYT(J,IT)=1
520   CONTINUE
530   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
540   IF (I.EQ.0) GO TO 550
      IF (TTWD(I,KBOT).EQ.TTWD(ISAVE,KBOT)) GO TO 560
550   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 570
      ISAVE=I
560   I=I-1
      GO TO 540
570   VI=TSPAN/VIC
      VSTOL=VI/2
      TSPANA=0.
      KBIT=2
      IF (IPLAN.EQ.1) GO TO 610
      IF (KBOT.EQ.2) KBIT=1
      ISAVEA=KFX(KBIT)-1
      IA=KFX(KBIT)-2
580   IF (IA.EQ.0) GO TO 590
      IF (TTWD(IA,KBIT).EQ.TTWD(ISAVEA,KBIT)) GO TO 600
590   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 610
      ISAVEA=IA
600   IA=IA-1
      GO TO 580
610   CONTINUE
C
C     ELIMINATE PLANFORM BREAKPOINTS WHICH ARE WITHIN (B/2)/2000 UNITS
C     LATERALLY
C
      DO 630 IT=1,IPLAN
```

```
      N=AN(IT)                                                          GE03610
      N1=N+1                                                            GE03620
      DO 630 J=1,N                                                      GE03630
      AA=ABS(SPY(J,IT)-SPY(J+1,IT))                                     GE03640
      IF (AA.EQ.0..OR.AA.GT.ABS(TSPAN/2000.)) GO TO 630                 GE03650
      IF (AA.GT.YTOL) WRITE (6,1010) SPY(J+1,IT),SPY(J,IT)              GE03660
      DO 620 I=1,N1                                                     GE03670
      IF (YY(I,IT).NE.SPY(J+1,IT)) GO TO 620                            GE03680
      YY(I,IT)=SPY(J,IT)                                                GE03690
  620 CONTINUE                                                          GE03700
      SPY(J+1,IT)=SPY(J,IT)                                             GE03710
  630 CONTINUE                                                          GE03720
C                                                                       GE03730
C     COMPUTE Z COORDINATES                                             GE03740
C                                                                       GE03750
      DO 670 IT=1,IPLAN                                                 GE03760
      JM=N1=AN(IT)+1.                                                   GE03770
      DO 640 JZ=1,N1                                                    GE03780
  640 ZZ(JZ,IT)=RTCDHT(IT)                                              GE03790
      JZ=1                                                              GE03800
  650 JZ=JZ+1                                                           GE03810
      IF (JZ.GT.KFX(IT)) GO TO 660                                      GE03820
      ZZ(JZ,IT)=ZZ(JZ-1,IT)+(YY(JZ,IT)-YY(JZ-1,IT))*TTWD(JZ-1,IT)       GE03830
      GO TO 650                                                         GE03840
  660 JM=JM-1                                                           GE03850
      IF (JM.EQ.KFX(IT)) GO TO 670                                      GE03860
      ZZ(JM,IT)=ZZ(JM+1,IT)+(YY(JM,IT)-YY(JM+1,IT))*TTWD(JM,IT)         GE03870
      GO TO 660                                                         GE03880
  670 CONTINUE                                                          GE03890
C                                                                       GE03900
C     WRITE PLANFORM PERIMETER POINTS ACTUALLY USED IN THE COMPUTATIONS GE03910
C                                                                       GE03920
      WRITE (6,900)                                                     GE03930
      DO 690 IT=1,IPLAN                                                 GE03940
      N=AN(IT)                                                          GE03950
      N1=N+1                                                            GE03960
      IF (IT.EQ.2) WRITE (6,1000)                                       GE03970
      DO 680 KK=1,N                                                     GE03980
      TOUT=ATAN(TTWD(KK,IT))*RAD                                        GE03990
      AOUT=ATAN(AS(KK,IT))*RAD                                          GE04000
      IF (AS(KK,IT).EQ.AZY) AOUT=90.                                    GE04010
      WRITE (6,910) KK,XX(KK,IT),YY(KK,IT),ZZ(KK,IT),AOUT,TOUT,MMCD(KK,IGE04020
     1T)                                                                GE04030
  680 CONTINUE                                                          GE04040
      WRITE (6,910) N1,XX(N1,IT),YY(N1,IT),ZZ(N1,IT)                    GE04050
  690 CONTINUE                                                          GE04060
C                                                                       GE04070
C     PART ONE - SECTION THREE - LAY OUT YAWED HORSESHOE VORTICES       GE04080
C                                                                       GE04090
      STRUE=0.                                                          GE04100
      NSSWSV(1)=NSSWSV(2)=MSV(1)=MSV(2)=0                               GE04110
      DO 780 IT=1,IPLAN                                                 GE04120
      N1=AN(IT)+1.                                                      GE04130
      I=0                                                               GE04140
      J=1                                                               GE04150
      YIN=BOTSV(IT)                                                     GE04160
      ILE=ITE=KFX(IT)                                                   GE04170
C     DETERMINE SPANWISE BORDERS OF HORSESHOE VORTICES                  GE04180
  700 IXL=IXT=0                                                         GE04190
      I=I+1                                                             GE04200
```

```
      IF (YIN.GE.(SPY(J,IT)+VSTOL)) GO TO 710
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 740
C     USE NOMINAL VORTEX SPACING TO DETERMINE THE BORDER
710   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
720   IF (J.GE.N1) GO TO 730
      IF (SPY(J,IT).NE.SPY(J+1,IT)) GO TO 730
      IXL=IXL+IYL(J,IT)
      IXT=IXT+IYT(J,IT)
      J=J+1
      GO TO 720
730   YIN=SPY(J,IT)
      IXL=IXL+IYL(J,IT)
      IXT=IXT+IYT(J,IT)
      J=J+1
740   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 760
750   ILE=ILE-IXL
      ITE=ITE+IXT
      GO TO 700
C     COMPUTE COORDINATES FOR CHORDWISE ROW OF HORSESHOE VORTICES
760   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))
      XTE=XX(ITE,IT)+AS(ITE,IT)*(YQ-YY(ITE,IT))
      XLOCAL=(XLE-XTE)/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 770 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)-XTE)*AS(ILE,IT))/(XLE-
     1XTE)
      S(NTS)=HW/CPHI
      Q(NTS)=YQ
770   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 750
C
```

```
      NSSWSV(IT)=I-1                                                    GE04810
  780 CONTINUE                                                          GE04820
      M=MSV(1)+MSV(2)                                                   GE04830
C                                                                       GE04840
C     COMPUTE ASPECT RATIO  AND  AVERAGE CHORD                          GE04850
C                                                                       GE04860
      BOT=-BOT                                                          GE04870
      AR=4.*BOT*BOT/SREF                                                GE04880
      ARTRUE=4.*BOT*BOT/STRUE                                           GE04890
      CAVE=STRUE/(2.*BOT)                                               GE04900
      BETA=(1.-MACH*MACH)**.5                                           GE04910
      NVTWO=0                                                           GE04920
      DO 810 IT=1,IPLAN                                                 GE04930
      NVONE=1+(IT-1)*MSV(1)                                             GE04940
      NVTWO=NVTWO+MSV(IT)                                               GE04950
      IF (TWIST(IT).LE.0.) GO TO 790                                    GE04960
      READ (5,880) (ALP(NV),ALP(NV+1),ALP(NV+2),ALP(NV+3),ALP(NV+4),ALP(GE04970
     1NV+5),ALP(NV+6),ALP(NV+7),NV=NVONE,NVTWO,8)                       GE04980
      GO TO 810                                                         GE04990
  790 DO 800 NV=NVONE,NVTWO                                             GE05000
  800 ALP(NV)=0.                                                        GE05010
  810 CONTINUE                                                          GE05020
      WRITE (6,1040) M                                                  GE05030
      WRITE (6,1050) (IT,MSV(IT),NSSWSV(IT),IT=1,IPLAN)                 GE05040
      IF (SCW.NE.0.) WRITE (6,1020) SCW                                 GE05050
      IF (SCW.EQ.0.) WRITE (6,1030) (TBLSCW(I),I=1,NSTA)                GE05060
C                                                                       GE05070
C     APPLY PRANDTL-GLAUERT CORRECTION                                  GE05080
C                                                                       GE05090
      DO 820 NV=1,M                                                     GE05100
      PSI(NV)=ATAN(PSI(NV)/BETA)                                        GE05110
      PN(NV)=PN(NV)/BETA                                                GE05120
  820 PV(NV)=PV(NV)/BETA                                                GE05130
      RETURN                                                            GE05140
  830 ICODEOF=1                                                         GE05150
      WRITE (6,930) CONFIG                                              GE05160
      RETURN                                                            GE05170
  840 ICODEOF=2                                                         GE05180
      WRITE (6,940) K,IT                                                GE05190
      RETURN                                                            GE05200
  850 ICODEOF=3                                                         GE05210
      WRITE (6,970) PTEST,QTEST                                         GE05220
      RETURN                                                            GE05230
C                                                                       GE05240
C                                                                       GE05250
C                                                                       GE05260
  860 FORMAT (1H1//63X,13HGEOMETRY DATA)                                GE05270
  870 FORMAT (///45X,A10,22HREFERENCE PLANFORM HAS,I3,7H CURVES//12X,19HGE05280
     1ROOT CHORD HEIGHT =,F12.5,4X,29HVARIABLE SWEEP PIVOT POSITION,4X,6GE05290
     2HX(S) =,F12.5,5X,6HY(S) =,F12.5//46X,40HBREAK POINTS FOR THE REFERGE05300
     3ENCE PLANFORM /)                                                  GE05310
  880 FORMAT (8F10.4)                                                   GE05320
  890 FORMAT (1H1//47X,17HCONFIGURATION NO.,F8.0/)                      GE05330
  900 FORMAT (22X,5HPOINT,6X,1HX,11X,1HY,11X,1HZ,10X,5HSWEEP,7X,8HDIHEDRGE05340
     1AL,4X,4HMOVE/68X,5HANGLE,8X,5HANGLE,6X,4HCODE/)                   GE05350
  910 FORMAT (20X,I5,3F12.5,2F14.5,I6)                                  GE05360
  920 FORMAT (/40X,5HCURVE,I3,9H IS SWEPT,F12.5,20H DEGREES ON PLANFORM,GE05370
     1I3)                                                               GE05380
  930 FORMAT (1H1///41X,43HEND OF FILE ENCOUNTERED AFTER CONFIGURATION,FGE05390
     17.0)                                                              GE05400
```

```
940   FORMAT (1H1///18X,45HTHE FIRST VARIABLE SWEEP CURVE SPECIFIED (K =GE05410
     1,I3,44H ) DOES NOT HAVE AN M CODE OF 2 FOR PLANFORM,I4)             GE05420
950   FORMAT (8F5.1,F10.4,F5.1,F10.4,F5.1)                                GE05430
960   FORMAT (26X,I5,2F12.5,2F16.5,4X,I4)                                 GE05440
970   FORMAT (1H1//30X,38HERROR - PROGRAM CANNOT PROCESS PTEST =,F5.1,12GE05450
     1H AND QTEST =,F5.1)                                                 GE05460
980   FORMAT (//48X,35HBREAK POINTS FOR THIS CONFIGURATION//)             GE05470
990   FORMAT (28X,5HPOINT,6X,1HX,11X,1HY,11X,5HSWEEP,10X,8HDIHEDRAL,7X,4GE05480
     1HMOVE/38X,3HREF,9X,3HREF,10X,5HANGLE,11X,5HANGLE,9X,4HCODE/)        GE05490
1000  FORMAT (/52X,28HSECOND PLANFORM BREAK POINTS/)                      GE05500
1010  FORMAT (////25X,34HTHE BREAKPOINT LOCATED SPANWISE AT,F11.5,3X,20HGE05510
     1HAS BEEN ADJUSTED TO,F9.5////)                                      GE05520
1020  FORMAT (/43X,F5.0,41H HORSESHOE VORTICES IN EACH CHORDWISE ROW)    GE05530
1030  FORMAT (/23X,98HTABLE OF HORSESHOE VORTICES IN EACH CHORDWISE ROW GE05540
     1(FROM TIP TO ROOT BEGINNING WITH FIRST PLANFORM)//25F5.0/25F5.0)   GE05550
1040  FORMAT (///33XI5,62H HORSESHOE VORTICES USED ON THE LEFT HALF OF TGE05560
     1HE CONFIGURATION//50X,36HPLANFORM        TOTAL          SPANWISE/)  GE05570
1050  FORMAT (52X,I4,10X,I3,11X,I4)                                       GE05580
      END                                                                 GE05590-
```

```
      OVERLAY(WINGTL,2,0)
      PROGRAM MATXSOL
      DIMENSION YY(2), FV(2), FW(2), FVN(200)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      COMMON /TOTHRE/ CIR(200,2)
      COMMON /INSUB23/ APSI,APHI,XX,YYY,ZZ,SNN,TOLC
C
C
C     PART 2 - COMPUTE CIRCULATION TERMS
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
      TOLC=(BOT*15.E-05)**2
      DO 10 NV=1,M
      CIR(NV,1)=12.5663704*ALP(NV)
      CIR(NV,2)=12.5663704
      IF (PTEST.NE.0.) CIR(NV,2)=-1.0964155*Q(NV)/BOT
      IF (QTEST.NE.0.) CIR(NV,2)=-1.0964155*PV(NV)*BETA
10    CONTINUE
      IZZ=1
      NNV=TBLSCW(IZZ)
      REWIND 10
      DO 70 NV=1,M
      DO 20 I=1,M
20    FVN(I)=0.
      IZ=1
      NNN=TBLSCW(IZ)
      DO 60 NN=1,M
      APHI=ATAN(PHI(IZ))
      APSI=PSI(NN)
      XX=PV(NV)-PN(NN)
      YY(1)=Q(NV)-Q(NN)
      YY(2)=Q(NV)+Q(NN)
      ZZ=ZH(IZZ)-ZH(IZ)
      SNN=S(NN)
      DO 30 I=1,2
      YYY=YY(I)
      CALL INFSUB (BOT,FV(I),FW(I))
      APHI=-APHI
      APSI=-APSI
30    CONTINUE
      IF (PTEST.NE.0.) GO TO 40
      FVN(NN)=FW(1)+FW(2)-(FV(1)+FV(2))*PHI(IZZ)
      GO TO 50
40    FVN(NN)=FW(1)-FW(2)-(FV(1)-FV(2))*PHI(IZZ)
50    IF (NN.LT.NNN.OR.NV.EQ.M) GO TO 60
      IZ=IZ+1
      NNN=NNN+TBLSCW(IZ)
60    CONTINUE
      DUMB=-CIR(NV,1)
      DUMY=-CIR(NV,2)
      WRITE (10) (FVN(I),I=1,M),DUMB,DUMY
      IF (NV.LT.NNV.OR.NV.EQ.M) GO TO 70
      IZZ=IZZ+1
      NNV=NNV+TBLSCW(IZZ)
70    CONTINUE
      CALL SSLESO (M,2)
      RETURN
      END
```

APPENDIX C

```
      SUBROUTINE SSLESO (NT,NCFLG)
      COMMON /TOTHRE/ CIR(200,2)
      DIMENSION RV(205), CV(205), R(205), V(10350)
      REWIND 10
      N1=NT+NCFLG
      J=N1-1
      READ (10) (R(I),I=1,N1)
      DO 10 I=1,J
 10   V(I)=-R(I+1)/R(1)
      IN=1
 20   READ (10) (R(I),I=1,N1)
      I2=0
      DO 40 I=1,J
      RV(I)=0.
      DO 30 II=1,IN
      I2=I2+1
 30   RV(I)=RV(I)+R(II)*V(I2)
      N2=I+IN
 40   RV(I)=RV(I)+R(N2)
      I2=IN+1
      NN=J*IN+1
      KK=J*I2
      J=J-1
      DO 60 I=1,J
      DO 50 II=1,IN
      NN=NN-1
      KK=KK-1
 50   V(KK)=V(NN)
 60   KK=KK-1
      DO 70 I=1,IN
 70   R(I)=V(I)
      K=0
      DO 90 I=1,J
      CC=-RV(I+1)/RV(1)
      DO 80 II=1,IN
      CV(II)=CC*R(II)
      NN=K+II
      I2=I2+1
 80   V(NN)=CV(II)+V(I2)
      K=NN+1
      I2=I2+1
 90   V(K)=CC
      IN=IN+1
      IF (J.EQ.NCFLG) GO TO 100
      GO TO 20
 100  K=1
      DO 110 J=1,NCFLG
      DO 110 I=1,NT
      CIR(I,J)=V(K)
      K=K+1
 110  CONTINUE
      RETURN
      END
```

```
      OVERLAY(WINGTL,3,0)
      PROGRAM AERODYN
C
C
      DIMENSION YCP(2), CLCC(200,2), CH(2,50), SUM(2), AC(2), CLCL(2,50)
     1, CP(200), P(200), SMOAD(2,50), SLDT(50), SMLD(2,50)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      COMMON /TOTHRE/ CIR(200,2)
      COMMON /THREFOR/ CCAV(2,50),CLT,CLNT,NSSW,ALPD
      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),XL(2
     2),XT(2),CLWB,CMCL,CLA(2),BLAIR(50),CLAMAR(2)
      COMMON /THRECDI/ SLOAD(3,50)
      COMMON /INSUB23/ APSI,APHI,XX,YYY,ZZ,SNN,TOLCSQ
C
C
C     PART 3 - COMPUTE OUTPUT TERMS
C
C
      RAD=57.29578
      TWST=TWIST(1)+TWIST(2)
      ALREF=1
      QINF=1.
      NSSW=NSSWSV(1)+NSSWSV(2)
C
C                           PART 3 - SECTION 1
C                  COMPUTE LIFT AND PITCHING MOMENT HERE
C
      IZ=1
      NNN=TBLSCW(IZ)
      DO 10 I=1,M
      P(I)=S(I)*COS(ATAN(PHI(IZ)))
      IF (I.LT.NNN.OR.I.EQ.M) GO TO 10
      IZ=IZ+1
      NNN=NNN+TBLSCW(IZ)
10    CONTINUE
      DO 20 NV=1,2
      SUM(NV)=0
      DO 20 I=1,M
      SUM(NV)=SUM(NV)+CIR(I,NV)*P(I)
      IF (NV.EQ.1.AND.I.EQ.MSV(1)) CLWNGT=SUM(1)*8./SREF
      IF (NV.EQ.2.AND.I.EQ.MSV(1)) CLWING=SUM(2)*8./SREF
20    CONTINUE
      CLT=8.*SUM(1)/SREF
      CLNT=8.*SUM(2)/SREF
      IF (KBOT.EQ.1) GO TO 30
      CLWNGT=CLT-CLWNGT
      CLWING=CLNT-CLWING
30    CRL=0.
      DO 40 I=1,M
      CRL=CRL+(Q(I)*CIR(I,2)*2.*P(I))*2.
      CLCC(I,1)=CIR(I,1)*2*P(I)/(CAVE*S(I))
40    CLCC(I,2)=CIR(I,2)*2*P(I)/(CAVE*S(I))
C
C     COMPUTE CLP
C
      CLP=CRL/(SREF*BOT*0.08725)
      CLA(2)=CLNT
      DO 120 IXX=1,2
```

```
      SA=SB=SC=0.
      I=0
      JB=NSSWSV(1)
      JA=1
50    CONTINUE
      DO 70 JSSW=JA,JB
      SD=SE=0.
      SLOAD(IXX,JSSW)=0
      NSCW=TBLSCW(JSSW)
      DO 70 JSCW=1,NSCW
      IF (TWST.EQ.0..AND.IXX.EQ.1) GO TO 60
      I=I+1
      SA=SA+CIR(I,IXX)*P(I)
      SB=SB+CIR(I,IXX)*Q(I)*P(I)
      SC=SC+CIR(I,IXX)*PN(I)*P(I)*BETA
      SLOAD(IXX,JSSW)=SLOAD(IXX,JSSW)+(BOT*CIR(I,IXX)*P(I)/S(I))/(2.*SUM
     1(IXX))
      SD=SD+CIR(I,IXX)
      SE=SE+CIR(I,IXX)*PN(I)*BETA
      IF (JSCW.NE.NSCW) GO TO 70
      SMOAD(IXX,JSSW)=SE
      SMLD(IXX,JSSW)=SD
      GO TO 70
60    SLOAD(1,JSSW)=SMOAD(1,JSSW)=SMLD(1,JSSW)=0.
70    CONTINUE
      IF (JSSW.GE.NSSW) GO TO 80
      JA=NSSWSV(1)+1
      JB=NSSW
      IF (IXX.EQ.1) GO TO 50
      SC2=SC
      SA2=SA
      CLAMAR(1)=SC/(SA*CREF)
      GO TO 50
80    CONTINUE
      IF (IXX.EQ.1) GO TO 100
      IF (IPLAN.EQ.1) GO TO 90
      SC3=SC-SC2
      SA3=SA-SA2
      CLAMAR(2)=SC3/(SA3*CREF)
      GO TO 100
90    CLAMAR(1)=SC/(SA*CREF)
100   CONTINUE
      IF (TWST.EQ.0..AND.IXX.EQ.1) GO TO 110
      YCP(IXX)=SB/(SA*BOT)
      AC(IXX)=SC/(SA*CREF)
      GO TO 120
110   YCP(1)=AC(1)=0.
120   CONTINUE
      CMCL=AC(2)
      CMO=(AC(1)-AC(2))*CLT
C
C                             PART 3 - SECTION 2
C          COMPUTE OTHER-  AND PRINT ALL FINAL-  OUTPUT DATA HERE
C
      DO 140 IXX=1,2
      JN=0
      DO 140 JSSW=1,NSSW
      CH(IXX,JSSW)=0
      NSCW=TBLSCW(JSSW)
      DO 130 JSCW=1,NSCW
```

```
      JN=JN+1                                                          AER1210
      CH(IXX,JSSW)=(-2.0)*(PV(JN)-PN(JN))*BETA+CH(IXX,JSSW)            AER1220
  130 CONTINUE                                                         AER1230
      CCAV(IXX,JSSW)=CH(IXX,JSSW)/CAVE                                 AER1240
      CLCL(IXX,JSSW)=SLOAD(IXX,JSSW)/CCAV(IXX,JSSW)                    AER1250
  140 CONTINUE                                                         AER1260
      CLD=CLDES                                                        AER1270
      IF (CLDES.EQ.11) CLD=1.                                          AER1280
      DO 150 I=1,M                                                     AER1290
      CP(I)=(CLCC(I,1)+CLCC(I,2)*(CLD-CLT)/CLNT)*CAVE/(2.*(PN(I)-PV(I))*AER1300
     1BETA)                                                            AER1310
  150 CONTINUE                                                         AER1320
      WRITE (6,240) CONFIG                                             AER1330
      IF (PTEST.NE.0.) WRITE (6,350)                                   AER1340
      IF (QTEST.NE.0.) WRITE (6,330)                                   AER1350
      IF (PTEST.EQ.0..AND.QTEST.EQ.0.) WRITE (6,340)                   AER1360
      WRITE (6,360) CLD                                                AER1370
      HEAD=8HDESIRED                                                   AER1380
      IF (CLDES.EQ.11.) HEAD=8H                                        AER1390
      IEND=11                                                          AER1400
      IF (CLDES.NE.11.) IEND=1                                         AER1410
      DO 190 IUTK=1,IEND                                               AER1420
      IF (IEND.EQ.11) CLDES=(FLOAT(IUTK)-1.)/10.                       AER1430
      IF (CLDES.EQ.0.) CLDES=-.1                                       AER1440
      NR=0                                                             AER1450
      DO 160 NV=1,NSSW                                                 AER1460
      NSCW=TBLSCW(NV)                                                  AER1470
      NP=NR+1                                                          AER1480
      NR=NR+NSCW                                                       AER1490
      PHIPR=ATAN(PHI(NV))*RAD                                          AER1500
      SLOAD(3,NV)=0.                                                   AER1510
      IF (NV.EQ.(NSSWSV(1)+1).AND.IEND.EQ.1) WRITE (6,230)             AER1520
      DO 160 I=NP,NR                                                   AER1530
      IF (IUTK.GT.1) GO TO 160                                         AER1540
      PNPR=PN(I)*BETA                                                  AER1550
      PVPR=PV(I)*BETA                                                  AER1560
      PSIPR=ATAN(BETA*TAN(PSI(I)))*RAD                                 AER1570
      WRITE (6,370) PNPR,PVPR,Q(I),ZH(NV),S(I),PSIPR,PHIPR,ALP(I),CP(I) AER1580
  160 SLOAD(3,NV)=SLOAD(3,NV)+CLCC(I,2)*CLDES/CLNT+CLCC(I,1)-CLCC(I,2)*CAER1590
     1LT/CLNT                                                          AER1600
      IF (IUTK.GT.1) GO TO 170                                         AER1610
      WRITE (6,270)                                                    AER1620
      WRITE (6,280) CREF,CAVE,STRUE,SREF,BOT,AR,ARTRUE,MACH             AER1630
  170 CONTINUE                                                         AER1640
C                                                                      AER1650
C                                                                      AER1660
      IF (PTEST.NE.0.) WRITE (6,380) CLP                               AER1670
      IF (PTEST.NE.0.) GO TO 220                                       AER1680
C                                                                      AER1690
C     COMPUTE CMQ,CLQ                                                  AER1700
C                                                                      AER1710
      CMQ=2.0*CMCL*CLNT/(0.08725*CREF)                                 AER1720
      CLQ=2.0*CLNT/(0.08725*CREF)                                      AER1730
      IF (QTEST.NE.0.) WRITE (6,390) CMQ,CLQ                           AER1740
      IF (QTEST.NE.0.) GO TO 220                                       AER1750
C                                                                      AER1760
C        COMPUTE INDUCED DRAG FOR FLAT WING-BODY WITH NO DIHEDRAL      AER1770
C                                                                      AER1780
      NSV=NSSWSV(1)+1                                                  AER1790
      MTOT=MSV(1)+1                                                    AER1800
```

```
      IF (KBOT.EQ.1) GO TO 180
      NSV=NSV+NSSWSV(2)
      MTOT=MTOT+MSV(2)
180   CALL CDICLS (AR,ARTRUE,NSSWSV(KBOT),MTOT,NSV,CDI,CDIT)
      CLAPD=CLA(2)/57.29578
      ALPO=-(CLT/CLA(2))*57.29578
      ALPD=CLDES/CLAPD+ALPO
      ALPW=1./CLAPD
      CLWB=CLWING*ALPD/57.29578+CLWNGT
      CDIWB=CDI/(CLWB*CLWB)
      IF (IUTK.EQ.1) WRITE (6,250) HEAD,CDIT
190   WRITE (6,260) CLDES,ALPD,CLWB,CDI,CDIWB
      WRITE (6,290) CLA(2),CLAPD,CLT,ALPO,YCP(2),CMCL,CMO
      WRITE (6,300) CLT
      NR=J=0
      DO 210 NV=1,NSSW
      BCLCC=BADLAE=BASLD=0.
      NSCW=TBLSCW(NV)
      NP=NR+1
      NR=NR+NSCW
      DO 200 I=NP,NR
      ADLAE=CLCC(I,2)*CLT/CLNT
      BSLD=CLCC(I,1)-ADLAE
      BCLCC=BCLCC+CLCC(I,1)
      BADLAE=BADLAE+ADLAE
      BASLD=BASLD+BSLD
200   CONTINUE
      SLDT(NV)=(SMOAD(1,NV)+SMOAD(2,NV)*(CLDES-CLT)/CLNT)/(SMLD(1,NV)+SM
     1LD(2,NV)*(CLDES-CLT)/CLNT)
      J=J+NSCW
      YQ=Q(J)/BOT
      IF (NV.EQ.(NSSWSV(1)+1)) WRITE (6,310)
210   WRITE (6,320) NV,YQ,SLOAD(2,NV),CLCL(2,NV),CCAV(2,NV),BCLCC,BADLAE
     1,BASLD,SLOAD(3,NV),SLDT(NV)
220   CONTINUE
      RETURN
C
C
C
230   FORMAT (/12X,45HSECOND PLANFORM HORSESHOE VORTEX DESCRIPTIONS/)
240   FORMAT (1H1///58X,16HAERODYNAMIC DATA///54X,17HCONFIGURATION NO.,F
     17.0//)
250   FORMAT (1H1,18X,22HCOMPLETE CONFIGURATION,31X,25HWING-BODY CHARACT
     1ERISTICS/64X,4HLIFT,9X,33HINDUCED DRAG (FAR FIELD SOLUTION)//16XA8
     2,21H CL     COMPUTED ALPHA,19X,6HCL(WB),7X,13HCDI AT CL(WB),4X,15HC
     3DI/(CL(WB)**2)/88X,12H(1/(PI*AR) =F8.5,2H ))
260   FORMAT (11X,2F15.5,15X,3F15.5)
270   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/)
280   FORMAT (8F15.5)
290   FORMAT (///47X,38HCOMPLETE CONFIGURATION CHARACTERISTICS//36X,8HCL
     1 ALPHA,8X,53HCL(TWIST)  ALPHA AT CL=0     Y CP        CM/CL       CMO
     2/27X,23HPER RADIAN   PER DEGREE/24X,7F12.5)
300   FORMAT (//25X,18HADDITIONAL LOADING/24X,24HWITH CL BASED ON S(TRUE
     1)71X,11H-AT CL DES-/67X,34HLOAD DUE  ADD. LOAD AT  BASIC LOAD3X,27
     2HSPAN LOAD AT   X LOCATON OF/8H STATION6X,5H 2Y/B9X,9H SL COEF ,4X
     3,8HCL RATIO4X,7HC RATIO,7X,14HTO TWIST   CL=,F9.5,3X,7HAT CL=05X,2
     46HDESIRED CL   LOCAL CENT PR/)
310   FORMAT (/47X,61HCONTRIBUTION OF THE SECOND PLANFORM TO SPAN LOAD D
```

```
     1ISTRIBUTION/)                                                     AER2410
 320  FORMAT (4X,I4,F12.5,5X,3F12.5,3X,3F12.5,3X,2F12.5)                AER2420
 330  FORMAT (/54X,24HCMQ AND CLQ ARE COMPUTED//)                       AER2430
 340  FORMAT (/38X,57HSTATIC LONGITUDINAL AERODYNAMIC COEFFICIENTS ARE CAER2440
     1OMPUTED//)                                                        AER2450
 350  FORMAT (/59X,15HCLP IS COMPUTED//)                                AER2460
 360  FORMAT (/20X,1HX,11X,1HX,11X,1HY,11X,1HZ,12X,1HS,5X,9HC/4 SWEEP,4XAER2470
     1,8HDIHEDRAL,2X,11HLOCAL ALPHA,2X,19HDELTA CP AT DESIRED/19X,3HC/4,AER2480
     29X,4H3C/4,42X,5HANGLE,7X,5HANGLE,4X,10HIN RADIANS,4X,4HCL =,F10.5/AER2490
     3)                                                                 AER2500
 370  FORMAT (12X,9F12.5)                                               AER2510
 380  FORMAT (//////////56X,4HCLP=,F9.5////)                            AER2520
 390  FORMAT (//////////42X,4HCMQ=,F9.5,10X,4HCLQ=,F9.5////)            AER2530
      END                                                               AER2540-
```

APPENDIX C

```
      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 60
      IF (N.LT.2) GO TO 60
C
C     MONOTONICITY CHECK
      IF (VARI(2)-VARI(1)) 20,20,40
C     ERROR IN MONOTONICITY
10    K=LOCF(VARI(1))
      PRINT 170, J,K,(VARI(J),J=1,N),(VARD(J),J=1,N)
      STOP
C     MONOTONIC DECREASING
20    DO 30 J=2,N
      IF (VARI(J)-VARI(J-1)) 30,10,10
30    CONTINUE
      GO TO 60
C     MONOTONIC INCREASING
40    DO 50 J=2,N
      IF (VARI(J)-VARI(J-1)) 10,10,50
50    CONTINUE
C
C     INTERPOLATION
60    IF (I.LE.0) I=1
      IF (I.GE.N) I=N-1
      IF (N.LE.1) GO TO 70
      IF (MA.NE.0) GO TO 80
C     ZERO ORDER
70    Y=VARD(1)
      GO TO 160
C     LOCATE I INTERVAL (X(I).LE.X.LT.X(I+1))
80    IF ((VARI(I)-X)*(VARI(I+1)-X)) 110,110,90
C     IN GIVES DIRECTION FOR SEARCH OF INTERVALS
90    IN=SIGN(1.0,(VARI(I+1)-VARI(I))*(X-VARI(I)))
C     IF X OUTSIDE ENDPOINTS, EXTRAPOLATE FROM END INTERVAL
100   IF ((I+IN).LE.0) GO TO 110
      IF ((I+IN).GE.N) GO TO 110
      I=I+IN
      IF ((VARI(I)-X)*(VARI(I+1)-X)) 110,110,100
110   IF (MA.EQ.2) GO TO 120
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 160
C
C     SECOND ORDER
120   IF (N.EQ.2) GO TO 10
      IF (I.EQ.(N-1)) GO TO 140
```

```
      IF (I.EQ.1) GO TO 130
C     PICK THIRD POINT
      SK=VARI(I+1)-VARI(I)
      IF ((SK*(X-VARI(I-1))).LT.(SK*(VARI(I+2)-X))) GO TO 140
130   L=I
      GO TO 150
140   L=I-1
150   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))
160   II(LI)=I
      RETURN
C
C
170   FORMAT (1H1,50H TABLE BELOW OUT OF ORDER FOR FTLUP  AT POSITION ,
     1I5,/31H X TABLE IS STORED IN LOCATION ,O6,//(8G15.8))
      END
```

```
      SUBROUTINE CDICLS (AR,ARTRUE,ISEMSP,MTOT,NSV,CDI,CDIT)
      DIMENSION ETAN(51), GAMPR(51,1), ETA(41), GAMMA(41), VE(41), B(41)
     1, FVN(41,41)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      COMMON /THRECDI/ SLOAD(3,50)
      DO 10 I=1,41
      DO 10 J=1,41
   10 FVN(I,J)=0
      SPAN=2.*BOT
      CAVB=SPAN/ARTRUE
      PI=.314159265E+01
      NST=ISEMSP+1
      NN=MTOT
      DO 20 N=1,ISEMSP
      NM=NSV-N
      NSCW=TBLSCW(NM)
      NN=NN-NSCW
      ETAN(N)=ASIN(-Q(NN)*2./SPAN)
      GAMPR(N,1)=SLOAD(3,NM)*CAVB/(2.*SPAN)
   20 CONTINUE
      ETAN(NST)=PI/2.
      GAMPR(NST,1)=0
      DO 30 NP=1,41
      ANP=NP
   30 ETA(NP)=(ANP-21.)*PI/42.
C
      DO 40 JK=21,41
      CALL FTLUP (ETA(JK),GAMMA(JK),1,NST,ETAN,GAMPR)
   40 CONTINUE
      DO 50 NY=22,41
      ETA(NY)=SIN(ETA(NY))
      NR=42-NY
      ETA(NR)=-ETA(NY)
   50 GAMMA(NR)=GAMMA(NY)
      DO 90 NU=21,41
      ANU=NU
      DO 80 N=1,41
      AN=N
      NNUD=IABS(N-NU)
      VE(N)=COS(((AN-21.)*PI)/42.)
      IF (NNUD.NE.0) GO TO 60
      B(N)=(42.)/(4.0*COS(((ANU-21.)*PI)/42.))
      GO TO 80
   60 IF (MOD(NNUD,2).EQ.0) GO TO 70
      B(N)=VE(N)/((42.)*(ETA(N)-ETA(NU))**2)
      GO TO 80
   70 B(N)=0.0
   80 CONTINUE
      DO 90 NP=21,41
      NUST=IABS(NU-21)
      IF (NUST.EQ.0) GO TO 90
      IF (MOD(NUST,2).EQ.0) GO TO 90
      NPST=IABS(NP-20)
      IF (MOD(NPST,2).EQ.0) GO TO 90
      NPNUD=IABS(NP-NU)
      IF (NPNUD.EQ.0) GO TO 90
      IF (MOD(NPNUD,2).EQ.0) GO TO 90
      FVN(NU,NP)=2.0*B(NP)/21.*COS((ANU-21.)*PI/42.)
      IT=42-NU
```

```
      ITT=42-NP
      FVN(NU,ITT)=2.0*B(ITT)/21.*COS((ANU-21.)*PI/42.)
      FVN(IT,NP)=FVN(NU,ITT)
      FVN(IT,ITT)=FVN(NU,NP)
90    CONTINUE
C
      CCC=0.0
      DO 100 N=1,41
100   CCC=CCC+(GAMMA(N)*GAMMA(N))
      DO 110 NUP=1,41
      DO 110 N=1,41
      CCD=CCD-2.0*FVN(NUP,N)*(GAMMA(NUP)*GAMMA(N))
110   CONTINUE
      CDI=PI*AR/4.*(CCC+CCD)
      CDIT=1./(PI*AR)
      RETURN
      END
```

```
      OVERLAY(WINGTL,4,0)
      PROGRAM CDRAGNF
      DIMENSION GAM(1000), XC4(1000), YQ(1000), CCR(20), FW(2), FV(2), X
     1XCC(20), CCC(200), CRR(200), YB(50), CRI(51), NMA(2), XCC4(200), C
     2HD(50), XC44(50), YY(2), PPHI(50), ZZH(50), Z(1000), PHII(1000), S
     3A(50), SSA(1000), ALOP(200), ALLP(50), ALPPD(1000), ALO(20), YC(51
     4), YQQ(50)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      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),XL(2
     2),XT(2),CLWB,CMCL,CLA(2),BLAIR(50),CLAMAR(2)
      COMMON /TOTHRE/ CIR(200,2)
      COMMON /INSUB23/ APSI,APHI,XX,YYY,ZZ,SNN,TOLCSQ
      COMMON /THREFOR/ CCAV(2,50),CLT,CLNT,NSSW,ALPD
      COMMON /CCRRDD/ TSPAN,TSPANA,KBIT
C
C
      WRITE (6,250)
      APSI=TOLCSQ=TBLS=0.
      PI=4.*ATAN(1.)
      FPI=4.*PI
      BOTL=ABS(TSPAN)
      BOL=ABS(TSPANA)
      SNN=BOTL/(2.*NSSWSV(KBOT))
      DELTYB=2.*SNN
      NMA(KBOT)=BOTL/DELTYB
      NMA(KBIT)=BOL/DELTYB
      NMAX=NMA(1)+NMA(2)
      DO 10 I=1,M
      CRR(I)=CIR(I,1)+CIR(I,2)*(CLDES-CLT)/CLNT
10    CONTINUE
      SCWMIN=20.
      DO 20 I=1,NSSW
20    SCWMIN=AMIN1(SCWMIN,TBLSCW(I))
      NSCWMIN=SCWMIN
      MM=NSCWMIN*NMAX
      DELTXOC=1./SCWMIN
      DO 100 LA=1,NSSW
      CHD(LA)=CCAV(2,LA)*CAVE/BETA
      DELTXX=1./TBLSCW(LA)
      XC=-.75*DELTXX
      ITBL=TBLSCW(LA)
      DO 30 LB=1,ITBL
      XC=XC+DELTXX
      XXCC(LB)=XC
      LC=LB+TBLS
30    ALO(LB)=ALP(LC)
      XLE=PN(LC)+CHD(LA)*(1.-.75/TBLSCW(LA))
      XOC=-.75*DELTXOC
      KCODE=LB=0
      DO 90 K=1,NSCWMIN
      J=K+(LA-1)*NSCWMIN
      XOC=XOC+DELTXOC
      XCC4(J)=-XOC*CHD(LA)+XLE
      CALL FTLUP (XOC,ALOP(J),+1,ITBL,XXCC,ALO)
      AXMN=K*DELTXOC
      CAT=0.
      IF (KCODE.EQ.2) CAT=CCR(LB)-CUT
      KCODE=0
```

```
40    LB=LB+1
      LC=LB+TBLS
      CCR(LB)=CRR(LC)
      AXITBL=LB*DELTXX
      IF (AXMN-AXITBL) 50,60,70
50    CUT=CCR(LB)*(AXMN-(LB-1)*DELTXX)/DELTXX
      KCODE=2
      GO TO 80
60    KCODE=1
70    CUT=CCR(LB)
80    CAT=CAT+CUT
      IF (KCODE.GE.1) GO TO 90
      IF (LB.LT.ITBL) GO TO 40
90    CCC(J)=CAT
      TBLS=TBLS+TBLSCW(LA)
100   CONTINUE
      II=1
      DO 150 I=1,IPLAN
      BOTT=BOTL
      IF (I.EQ.KBIT) BOTT=BOL
      IUZ=NSSWSV(I)
      IUX=IUZ+1
      IC=MSV(1)+(I-1)*MSV(2)
      ID=IC+1
      IZ=NSSWSV(1)+(I-1)*NSSWSV(2)
      YCAT=0.
      IAMM=NMA(I)
      DO 140 LA=1,NSCWMIN
      YC(1)=-PI/2.
      CRI(1)=0.
      DO 120 J=1,IUZ
      L=J+1
      LU=LA+(J-1+(I-1)*NSSWSV(1))*NSCWMIN
      ALLP(J)=ALOP(LU)
      XC44(J)=XCC4(LU)
      CRI(L)=CCC(LU)
      IF (LA.NE.1) GO TO 120
      JJ=J+(I-1)*NSSWSV(1)
      ZZH(J)=ZH(JJ)
      SA(J)=SSWWA(JJ)
      PPHI(J)=PHI(JJ)
      YQQ(J)=Q(II)
      II=II+TBLSCW(JJ)
      IE=IUZ-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 110
      YCAT=YCAT-S(ID)-S(IA)
110   IZ=IZ-1
      YB(IE)=YCAT
120   CONTINUE
      DO 130 JP=1,IUZ
      JZ=JP+1
      YC(JZ)=ASIN(YB(JP)/BOTT)
130   CONTINUE
      YOB=-NMA(I)*2.*SNN-SNN
      DO 140 K=1,IAMM
      KP=LA+(K-1+(I-1)*NMA(1))*NSCWMIN
```

```
      YOB=YOB+DELTYB
      YOC=ASIN(YOB/BOTT)
      CALL FTLUP (YOB,YQ(KP),+1,IUZ,YB,YQQ)
      CALL FTLUP (YOB,ALPPD(KP),+1,IUZ,YB,ALLP)
      CALL FTLUP (YOB,SSA(KP),+1,IUZ,YB,SA)
      CALL FTLUP (YOB,XC4(KP),+1,IUZ,YB,XC44)
      CALL FTLUP (YOB,Z(KP),+1,IUZ,YB,ZZH)
      CALL FTLUP (YOB,PHII(KP),+1,IUZ,YB,PPHI)
      CALL FTLUP (YOC,GAM(KP),+1,IUX,YC,CRI)
      IF (YOB.GT.YB(IUZ)) GAM(KP)=CRI(IUX)
  140 CONTINUE
  150 CONTINUE
      CDRAG=CTHRUST=CSUCT=0.
      CONST=16.*SNN*BOT/SREF
      DO 190 LI=1,NMAX
      LA=(LI-1)*NSCWMIN+1
      LB=LI*NSCWMIN
      CDRAGIT=CTT=0.
      DO 180 NV=LA,LB
      CPT=COS(ATAN(PHII(NV)))
      VELIN=0.
      DO 170 NN=1,MM
      XX=XC4(NV)-XC4(NN)
      YY(1)=YQ(NV)-YQ(NN)
      YY(2)=YQ(NV)+YQ(NN)
      ZZ=Z(NV)-Z(NN)
      APHI=ATAN(PHII(NN))
      DO 160 I=1,2
      YYY=YY(I)
      CALL INFSUB (BOT,FV(I),FW(I))
      APHI=-APHI
  160 CONTINUE
      VELIN=((FW(1)+FW(2))-(FV(1)+FV(2))*PHII(NV))*GAM(NN)/FPI+VELIN
  170 CONTINUE
      CTT=CTT+GAM(NV)*(ALPD/57.29578+ALPPD(NV))*CPT/(2.*BOT)
  180 CDRAGIT=CDRAGIT+VELIN*GAM(NV)*CPT/(2.*BOT)
      CTT=CTT-CDRAGIT
      SWLE=ATAN(SSA(LA))
      CST=CTT/COS(SWLE)
      CCC(LI)=CDRAGIT
      CRR(LI)=CTT
      XCC4(LI)=CST
      CDRAG=CDRAG+CDRAGIT*CONST
      CTHRUST=CTHRUST+CTT*CONST
      CSUCT=CSUCT+CST*CONST
  190 CONTINUE
      TBLE=II=0
      LI=0
      LBLR=0
      DO 220 I=1,2
      IAMM=NMA(I)
      DO 200 J=1,IAMM
      JJ=J+(I-1)*NMA(1)
      LA=1+(J-1+(I-1)*NMA(1))*NSCWMIN
      GAM(J)=CCC(JJ)
      XC4(J)=CRR(JJ)
      Z(J)=XCC4(JJ)
      PHII(J)=YQ(LA)
  200 CONTINUE
      IUZ=NSSWSV(I)
```

```
      DO 210 LBLAIR=1,IUZ
      LI=LI+1
      LU=1+TBLE
      LBLR=LBLR+1
      YBB=Q(LU)
      II=II+1
      TBLE=TBLE+TBLSCW(II)
      YOOB=YBB/BOT
      CALL FTLUP (YBB,CDRAGIT,+1,IAMM,PHII,GAM)
      CALL FTLUP (YBB,CTT,+1,IAMM,PHII,XC4)
      CALL FTLUP (YBB,CST,+1,IAMM,PHII,Z)
      LL=LBLAIR+(I-1)*NSSWSV(1)
      SWALE=ATAN(SSWWA(LL))*57.29578
      IF (II.EQ.(NSSWSV(1)+1)) WRITE (6,240)
      WRITE (6,260) LI,YOOB,SWALE,CDRAGIT,CTT,CST
      BLAIR(LBLR)=CST
  210 CONTINUE
      IF (NSSWSV(2).EQ.0) GO TO 230
  220 CONTINUE
  230 CDCL2=CDRAG/CLDES**2
      WRITE (6,270) CDCL2,CTHRUST,CSUCT
      RETURN
C
C
C
  240 FORMAT (/37X,62HCONTRIBUTION OF THE SECOND PLANFORM TO THE CHORD O
     1R DRAG FORCE/)
  250 FORMAT (////30X,73HINDUCED DRAG, LEADING EDGE THRUST AND SUCTION C
     1OEFFICIENT CHARACTERISTICS/40X,53HCOMPUTED AT THE DESIRED CL FROM
     2A NEAR FIELD SOLUTION//58X,20HSECTION COEFFICIENTS/48X,11HL. E. SW
     3EEP/25X,7HSTATION,9X,5H 2Y/B,5X,5HANGLE,7X,9HCDII C/2B,5X,7HCT C/2
     4B,5X,7HCS C/2B)
  260 FORMAT (20X,I10,5X,5F12.5)
  270 FORMAT (///57X,18HTOTAL COEFFICIENTS//36X,12HCDII/CL**2 =F10.5,5X,
     13HCT=,F10.5,5X,3HCS=,F10.5)
      END
```

APPENDIX C

```
      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 60
      IF (N.LT.2) GO TO 60
C
C     MONOTONICITY CHECK
      IF (VARI(2)-VARI(1)) 20,20,40
C     ERROR IN MONOTONICITY
10    K=LOCF(VARI(1))
      PRINT 170, J,K,(VARI(J),J=1,N),(VARD(J),J=1,N)
      STOP
C     MONOTONIC DECREASING
20    DO 30 J=2,N
      IF (VARI(J)-VARI(J-1)) 30,10,10
30    CONTINUE
      GO TO 60
C     MONOTONIC INCREASING
40    DO 50 J=2,N
      IF (VARI(J)-VARI(J-1)) 10,10,50
50    CONTINUE
C
C     INTERPOLATION
60    IF (I.LE.0) I=1
      IF (I.GE.N) I=N-1
      IF (N.LE.1) GO TO 70
      IF (MA.NE.0) GO TO 80
C     ZERO ORDER
70    Y=VARD(1)
      GO TO 160
C     LOCATE I INTERVAL (X(I).LE.X.LT.X(I+1))
80    IF ((VARI(I)-X)*(VARI(I+1)-X)) 110,110,90
C     IN GIVES DIRECTION FOR SEARCH OF INTERVALS
90    IN=SIGN(1.0,(VARI(I+1)-VARI(I))*(X-VARI(I)))
C     IF X OUTSIDE ENDPOINTS, EXTRAPOLATE FROM END INTERVAL
100   IF ((I+IN).LE.0) GO TO 110
      IF ((I+IN).GE.N) GO TO 110
      I=I+IN
      IF ((VARI(I)-X)*(VARI(I+1)-X)) 110,110,100
110   IF (MA.EQ.2) GO TO 120
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 160
C
C     SECOND ORDER
120   IF (N.EQ.2) GO TO 10
      IF (I.EQ.(N-1)) GO TO 140
```

```
      IF (I.EQ.1) GO TO 130
C     PICK THIRD POINT
      SK=VARI(I+1)-VARI(I)
      IF ((SK*(X-VARI(I-1))).LT.(SK*(VARI(I+2)-X))) GO TO 140
130   L=I
      GO TO 150
140   L=I-1
150   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))
160   II(LI)=I
      RETURN
C
C
170   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 C

```
      OVERLAY(WINGTL,5,0)
      PROGRAM TIPSUCT
      DIMENSION YY(2), WVOU(60), FV(2), FW(2), XTLEG(60), CIRSUM(50), YL
     1EGSV(50), ZLEGSV(50)
      COMMON /ALL/ BOT,M,BETA,PTEST,QT5ST,TBLSCW(50),Q(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      COMMON /TOTHRE/ CIR(200,2)
      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),XL(2
     2),XT(2),CLWB,CMCL,CLA(2),BLAIR(50),CLAMAR(2)
      COMMON /THREFOR/ CCAV(2,50),CLT,CLNT,NSSW,ALPD
      COMMON /INSUB23/ APSI,APHI,XX,YYY,ZZ,SNN,TOLCSQ
      DIMENSION XKVSEW(2), CENTR(2)
      XKVSEW(1)=XKVSEW(2)=CENTR(1)=CENTR(2)=0.0
      IF (IPLAN.EQ.1.AND.XL(1).EQ.XT(1)) GO TO 540
      IF (XL(1).EQ.XT(1).AND.XL(2).EQ.XT(2)) GO TO 540
      BLAMAR=1./BETA
      XT(1)=XT(1)*BLAMAR
      XT(2)=XT(2)*BLAMAR
      XL(1)=XL(1)*BLAMAR
      XL(2)=XL(2)*BLAMAR
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
      TOLC=.0100*BOT
      TOLCSQ=TOLC*TOLC
C
C
      TIPSU=PITCH=0.
      NSSW=NSSWSV(1)+NSSWSV(2)
C
C
C     GEOMETRY FOR TIP TRAILING LEGS
C
      ITT=1
      IM=IMM=NSSW1=0
      CCIRS=0.
      NSSW2=NSSW3=NSSWSV(1)
      L=1
      NSCW=MSV(1)/NSSWSV(1)
      GO TO 20
   10 NSSW1=NSSWSV(1)
      NSSW2=NSSW$NSSW3=NSSWSV(2)
      L=NSSWSV(1)+1
      NSCW=MSV(2)/NSSWSV(2)
      IF (XL(2).EQ.XT(2)) GO TO 500
   20 I=IMM+1
      J=IMM+2
      IUU=2
      APHI=ATAN(PHI(IM+1))
      SA=SIN(APHI)
      CA=COS(APHI)
      TLX1=PN(I)-S(I)*TAN(PSI(I))*CA
      TLX2=PN(J)-S(J)*TAN(PSI(J))*CA
      CLFTLG=TLX1-TLX2
      XTLEG(1)=TLX1/2.+TLX2/2.
      YLEG=Q(I)-S(I)*CA
      IF (NSSW1.EQ.0) YLEGSV(1)=YLEG
      ZLEG=ZH(IM+1)-S(I)*SA
```

```
      IF (NSSW1.EQ.0) ZLEGSV(1)=ZLEG
      IF (XL(ITT).EQ.XT(ITT)) GO TO 100
      DO 30 NV=2,NSCW
      NVT=NV-1
30    XTLEG(NV)=XTLEG(NVT)-CLFTLG
      NCTL=0
      NA=1
      NB=NSCW
40    DO 70 NV=NA,NB
C
C
C     THE RATIO OF W/U IS INITIALIZED TO -1 BECAUSE IN THE TERM
C     -U*ALPHA/U,USED IN THIS SUMMATION, ALPHA IS SET TO 1 RADIAN
C     SO THAT THE RESULTING TIP SUCTION CAN BE USED DIRECTLY TO FIND
C     KV SIDE EDGE
C
C
      WVOU(NV)=-1.
      IZ=1
      NNN=TBLSCW(IZ)
      DO 60 NN=1,M
      APHI=ATAN(PHI(IZ))
      APSI=PSI(NN)
      XX=XTLEG(NV)-PN(NN)
      YY(1)=YLEG-Q(NN)
      YY(2)=YLEG+Q(NN)
      ZZ=ZLEG-ZH(IZ)
      SNN=S(NN)
      DO 50 I=1,2
      YYY=YY(I)
      CALL INFSUB (BOT,FV(I),FW(I))
      APHI=-APHI$APSI=-APSI
50    CONTINUE
      WVOU(NV)=WVOU(NV)+(FW(1)+FW(2))*CIR(NN,2)/12.5663704
      IF (NN.LT.NNN.OR.NN.EQ.M) GO TO 60
      IZ=IZ+1
      NNN=NNN+TBLSCW(IZ)
60    CONTINUE
70    CONTINUE
      NCTL=NCTL+1
      IF (NCTL-2) 80,100,150
C
C     GEOMETRY FOR SPANWISE BOUND VORTICES
C
80    NA=NSCW+1
      NB=2*NSCW
      JA=IMM+1
      YLEG=Q(JA)
      ZLEG=ZH(IM+1)
      DO 90 J=1,NSCW
      JK=IMM+J
      NV=J+NSCW
90    XTLEG(NV)=PN(JK)
      GO TO 40
C
C     GEOMETRY ALONG RIGHT TRAILING LEGS
C
100   NA=2*NSCW+1
      NB=3*NSCW
      CCIRS=0.
```

```
      JK=IMM+1
      APHI=ATAN(PHI(IM+1))
      SA=SIN(APHI)
      CA=COS(APHI)
      YLEG=Q(JK)+S(JK)*CA
      IF (NSSW1.EQ.0) YLEGSV(IUU)=YLEG
      ZLEG=ZH(IM+1)+S(JK)*SA
      IF (NSSW1.EQ.0) ZLEGSV(IUU)=ZLEG
      IF (XL(ITT).EQ.XT(ITT)) GO TO 150
      TLX1=PN(JK)+S(JK)*TAN(PSI(JK))*CA
      JK=JK+1
      TLX2=PN(JK)+S(JK)*TAN(PSI(JK))*CA
      CRTTLG=TLX1-TLX2
      XTLEG(NA)=TLX1/2.+TLX2/2.
      NAA=NA+1
      IF (NSSW1.EQ.NSSWSV(1)) GO TO 110
      GO TO 130
  110 DO 120 IT=2,L
      IQ=IT-1
      IF ((ABS(YLEGSV(IT)-YLEG).LT.TOLC).AND.(ABS(ZLEGSV(IT)-ZLEG).LT.TO
     1LC)) CCIRS=CIRSUM(IQ)
      IF (CCIRS.NE.0.) GO TO 130
  120 CONTINUE
  130 DO 140 NV=NAA,NB
      NVT=NV-1
  140 XTLEG(NV)=XTLEG(NVT)-CRTTLG
      GO TO 40
C
C
  150 CONTINUE
      IF (CCIRS.NE.0.) GO TO 160
      GO TO 270
  160 IJ=2*NSCW+1
      XLT=XTLEG(1)+CLFTLG/2.
      XRT=XTLEG(IJ)+CRTTLG/2.
      XLL=XLT+CLFTLG/4.
      XRL=XRT+CRTTLG/4.
      IF (XLL.GE.XL(ITT).AND.XLT.LE.XT(ITT)) GO TO 170
      IF (XLL.LE.XL(ITT).AND.XLT.GE.XT(ITT)) GO TO 190
      IF (XLL.GT.XL(ITT).AND.XLT.GE.XL(ITT)) GO TO 200
      IF (XLL.LE.XT(ITT)) GO TO 200
      IF (XLL.GT.XL(ITT).AND.XLT.LT.XL(ITT)) GO TO 180
      CON4=(XT(ITT)-XLL)/(XLT-XLL)
      GO TO 210
  170 CON4=(XL(ITT)-XT(ITT))/(XLL-XLT)
      GO TO 210
  180 CON4=(XL(ITT)-XLT)/(XLL-XLT)
      GO TO 210
  190 CON4=1.
      GO TO 210
  200 CON4=0.0
  210 CONTINUE
      IF (XRL.GE.XL(ITT).AND.XRT.LE.XT(ITT)) GO TO 220
      IF (XRL.LE.XL(ITT).AND.XRT.GE.XT(ITT)) GO TO 240
      IF (XRL.GT.XL(ITT).AND.XRT.GE.XL(ITT)) GO TO 250
      IF (XRL.LE.XT(ITT)) GO TO 250
      IF (XRL.GT.XL(ITT).AND.XRT.LT.XL(ITT)) GO TO 230
      CON5=(XT(ITT)-XRL)/(XRT-XRL)
      GO TO 260
  220 CON5=(XL(ITT)-XT(ITT))/(XRL-XRT)
```

```
      GO TO 260
230   CON5=(XL(ITT)-XRT)/(XRL-XRT)
      GO TO 260
240   CON5=1.
      GO TO 260
250   CON5=0.0
260   CONTINUE
      TIPSU=TIPSU+CCIRS*0.25*(CON4*WVOU(1)*CLFTLG-CON5*WVOU(IJ)*CRTTLG)*
     12./SREF*BETA
      PITCH=PITCH+CCIRS*0.25*(-CON4*WVOU(1)*CLFTLG*XTLEG(1)+CON5*WVOU(IJ
     1)*CRTTLG*XTLEG(IJ))*2./(SREF*CREF)*BETA**2
270   CIRCUS=CCIRS
      DO 460 NPOS=1,NSCW
      JK=IMM+NPOS
      JN=2*NSCW+NPOS
      NPIS=NSCW+NPOS
      CIRCUS=CIRCUS+CIR(JK,2)
      IF (XL(ITT).EQ.XT(ITT)) GO TO 460
      XLLEG=XTLEG(NPOS)
      XRLEG=XTLEG(JN)
      XLL=XTLEG(NPOS)+CLFTLG/2.
      XLT=XTLEG(NPOS)-CLFTLG/2.
      XRL=XTLEG(JN)+CRTTLG/2.
      XRT=XTLEG(JN)-CRTTLG/2.
      IF (XLL.GE.XL(ITT).AND.XLT.LE.XT(ITT)) GO TO 280
      IF (XLL.LE.XL(ITT).AND.XLT.GE.XT(ITT)) GO TO 300
      IF (XLL.GT.XL(ITT).AND.XLT.GE.XL(ITT)) GO TO 310
      IF (XLL.LE.XT(ITT)) GO TO 310
      IF (XLL.GT.XL(ITT).AND.XLT.LT.XL(ITT)) GO TO 290
      CON1=(XT(ITT)-XLL)/(XLT-XLL)
      XLLEG=XT(ITT)+CON1*CLFTLG/2.
      GO TO 320
280   CON1=(XL(ITT)-XT(ITT))/(XLL-XLT)
      XLLEG=(XL(ITT)+XT(ITT))/2.
      GO TO 320
290   CON1=(XL(ITT)-XLT)/(XLL-XLT)
      XLLEG=XLT+CON1*CLFTLG/2.
      GO TO 320
300   CON1=1.
      GO TO 320
310   CON1=0.0
320   CONTINUE
      IF (NPOS.EQ.NSCW.AND.CON1.EQ.1.) GO TO 360
      IF (XRL.GE.XL(ITT).AND.XRT.LE.XT(ITT)) GO TO 330
      IF (XRL.LE.XL(ITT).AND.XRT.GE.XT(ITT)) GO TO 350
      IF (XRL.GT.XL(ITT).AND.XRT.GE.XL(ITT)) GO TO 370
      IF (XRL.LE.XT(ITT)) GO TO 370
      IF (XRL.GT.XL(ITT).AND.XRT.LT.XL(ITT)) GO TO 340
      CON2=(XT(ITT)-XRL)/(XRT-XRL)
      XRLEG=XT(ITT)+CON2*CRTTLG/2.
      GO TO 380
330   CON2=(XL(ITT)-XT(ITT))/(XRL-XRT)
      XRLEG=(XL(ITT)+XT(ITT))/2.
      GO TO 380
340   CON2=(XL(ITT)-XRT)/(XRL-XRT)
      XRLEG=XRT+CON2*CRTTLG/2.
      GO TO 380
350   CON2=1.
      GO TO 380
360   CON1=.75
```

```
      CON2=.75
      GO TO 380
370   CON2=0.0
380   IF (XRL.GT.XLL) GO TO 390
      XSIGN=-1.0
      XBLL=XLL
      XBLT=XRL
      GO TO 400
390   XBLL=XRL
      XBLT=XLL
      XSIGN=1.
400   BVDLG=ABS(XBLL-XBLT)
      IF (XBLT.GE.XL(ITT)) GO TO 440
      IF (XBLL.LE.XT(ITT)) GO TO 440
      IF (XBLL.GE.XL(ITT).AND.XBLT.LE.XT(ITT)) GO TO 430
      IF (XBLL.LE.XL(ITT).AND.XBLT.GE.XT(ITT)) GO TO 420
      IF (XBLL.GT.XL(ITT).AND.XBLT.GE.XT(ITT)) GO TO 410
      CON3=(XT(ITT)-XBLL)/(XBLT-XBLL)
      XTLEG(NPIS)=XT(ITT)+CON3*BVDLG/2.
      CON3=CON3*XSIGN
      GO TO 450
410   CON3=(XL(ITT)-XBLT)/(XBLL-XBLT)
      XTLEG(NPIS)=XBLT+CON3*BVDLG/2.
      CON3=CON3*XSIGN
      GO TO 450
420   CON3=1.*XSIGN
      GO TO 450
430   CON3=(XL(ITT)-XT(ITT))/(XBLL-XBLT)
      XTLEG(NPIS)=(XL(ITT)+XT(ITT))/2.
      CON3=CON3*XSIGN
      GO TO 450
440   CON3=0.0
450   TIPSU=TIPSU+(CIRCUS*(WVOU(NPOS)*CLFTLG*CON1-CON2*WVOU(JN)*CRTILG)+
     1CIR(JK,2)*(WVOU(NPIS)*CON3*BVDLG))*2./SREF*BETA
      PITCH=PITCH+(CIRCUS*(-WVOU(NPOS)*CLFTLG*CON1*XLLEG+WVOU(JN)*CON2*C
     1RTTLG*XRLEG)-CIR(JK,2)*(WVOU(NPIS)*CON3*BVDLG*XTLEG(NPIS)))*2./(S
     2EF*CREF)*BETA**2
460   CONTINUE
      IM=IM+1
      IMM=IMM+TBLSCW(IM)
      IF (NSSW1.EQ.0) CIRSUM(IM)=CIRCUS
      IF (NSSW1.EQ.0) IUU=IM+2
      IF (IM.EQ.NSSWSV(1)) GO TO 470
      IF (XL(ITT).EQ.XT(ITT)) GO TO 100
      GO TO 480
470   CTSW=TIPSU
      CMW=PITCH
      IF (NSSW2.EQ.NSSW) GO TO 520
      ITT=2
      GO TO 10
480   IF (IM.EQ.NSSW) GO TO 500
      NCTL=1
      DO 490 NV=1,NSCW
      CLFTLG=CRTTLG
      NY=NV+2*NSCW
      XTLEG(NV)=XTLEG(NY)
490   WVOU(NV)=WVOU(NY)
      GO TO 80
500   XKVSEW(2)=2.*ABS(TIPSU-CTSW)
      IF (XKVSEW(2).LT.0.000001) GO TO 510
```

```
      CENTR(2)=(PITCH-CMW)*CREF/ABS(TIPSU-CTSW)
      GO TO 520
510   CENTR(2)=0.0
520   XKVSEW(1)=2.*ABS(CTSW)
      IF (XKVSEW(1).LT.0.000001) GO TO 530
      CENTR(1)=CMW*CREF/ABS(CTSW)
      GO TO 540
530   CENTR(1)=0.0
540   CALL WRTANS (XKVSEW,CENTR)
      RETURN
      END
```

```
      SUBROUTINE WRTANS (XKVSEW,CENTR)
      COMMON /ALL/ BOT,M,BETA,PTEST,QTEST,TBLSCW(50),Q(200),PN(200),PV(2
     100),ALP(200),S(200),PSI(200),PHI(50),ZH(50)
      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),XL(2
     2),XT(2),CLWB,CMCL,CLA(2),BLAIR(50),CLAMAR(2)
      COMMON /THREFOR/ CCAV(2,50),CLT,CLNT,NSSW,ALPD
      DIMENSION XKV(2), XKP(2), YCHLO(2), YCHHI(2), CENTR(2), CENT(2), X
     1KVSEW(2)
      LCH=0
      LAMAR=NSSWSV(1)
      SUMY=SUM=0.0
      CONV=3.1415926536/180.
      CINV=1./(3.1415926536*AR)
      DELTA=2.*CONV
      CONST=16.*BOT/SREF
      ALPHA=ALPD*CONV
      S22=ALPHA**2
      KBT=1
      IF (KBOT.EQ.1) KBT=2
      IF (IPLAN.EQ.1) GO TO 10
      XKP(KBOT)=CLWB/ALPHA
      XKP(KBT)=(CLDES-CLWB)/ALPHA
      GO TO 20
10    XKP(1)=CLA(2)
20    READ (5,180) YCHLO(1),YCHHI(1),YCHLO(2),YCHHI(2)
      NCH=1
      NC1=NSSWSV(1)
      DO 40 J=1,NC1
      IF (Q(NCH).GT.YCHLO(1)) GO TO 30
      IF (Q(NCH).LT.YCHHI(1)) GO TO 30
      SUM=SUM+(PN(NCH)+(PN(NCH)-PN(NCH+1))/4.)*BETA*BLAIR(J)*S(NCH)*CONS
     1T
      SUMY=SUMY+BLAIR(J)*S(NCH)*CONST
      IF (J.EQ.NC1) GO TO 40
30    NCH=NCH+TBLSCW(J)
40    CONTINUE
      XKV(1)=SUMY/S22
      IF (XKV(1).LT.0.000001) GO TO 50
      CENT(1)=SUM/SUMY
      GO TO 60
50    CENT(1)=0.0
60    CONTINUE
      IF (IPLAN.EQ.1) GO TO 100
      SUMY=SUM=0.0
      NCH=MSV(1)+1
      NC2=NSSWSV(2)
      DO 80 J=1,NC2
      IF (Q(NCH).GT.YCHLO(2)) GO TO 70
      IF (Q(NCH).LT.YCHHI(2)) GO TO 70
      SUM=SUM+(PN(NCH)+(PN(NCH)-PN(NCH+1))/4.)*BETA*BLAIR(NC1+J)*S(NCH)*
     1CONST
      SUMY=SUMY+BLAIR(NC1+J)*S(NCH)*CONST
      IF (J.EQ.NC2) GO TO 80
70    NCH=NCH+TBLSCW(J+LAMAR)
80    CONTINUE
      XKV(2)=SUMY/S22
      IF (XKV(2).LT.0.000001) GO TO 90
      CENT(2)=SUM/SUMY
      GO TO 100
```

```
90      CENT(2)=0.0
100     CONTINUE
        WRITE (6,190)
        DO 110 IK=1,IPLAN
        CENTPM=CLAMAR(IK)*CREF
        WRITE (6,200) IK
        WRITE (6,210) XKP(IK),CENTPM
        WRITE (6,220) XKV(IK),CENT(IK)
110     WRITE (6,230) XKVSEW(IK),CENTR(IK)
120     CONTINUE
        DO 160 IK=1,IPLAN
        IF (LCH.EQ.1) GO TO 130
        WRITE (6,240) IK
130     WRITE (6,250)
        ALPHA=0.0
        DO 160 J=1,26
        V=SIN(ALPHA)
        C=COS(ALPHA)
        C2=C**2
        S2=V**2
        CLP=XKP(IK)*V*C2
        CLVL=CLP+XKV(IK)*S2*C
        CLSL=CLP+XKVSEW(IK)*C*S2
        CLTOT=CLVL+XKVSEW(IK)*C*S2
        IF (LCH.EQ.0) GO TO 140
        CMP=V*C*(XKP(2)*CLAMAR(2)+(XKP(1)-XKP(2))*CLAMAR(1))
        CMPL=CMP+S2/CREF*(CENT(2)*XKV(2)+(XKV(1)-XKV(2))*CENT(1))
        CMPS=CMP+S2/CREF*(CENTR(2)*XKVSEW(2)+(XKVSEW(1)-XKVSEW(2))*CENTR(1
       1))
        CMTOT=CMPL+CMPS-CMP
        GO TO 150
140     CMP=CLAMAR(IK)*XKP(IK)*V*C
        CMPL=CMP+CENT(IK)*XKV(IK)*S2/CREF
        CMPS=CMP+XKVSEW(IK)*CENTR(IK)*S2/CREF
        CMTOT=CMPL+XKVSEW(IK)*CENTR(IK)*S2/CREF
150     CDI=CLTOT*TAN(ALPHA)
        CDII=(CLTOT**2)*CINV
        ALPH1=ALPHA/CONV
        CNTT=CLTOT/C
        WRITE (6,260) ALPH1,CNTT,CLP,CLVL,CLSL,CLTOT,CMP,CMPL,CMPS,CMTOT,C
       1DI,CDII
160     ALPHA=ALPHA+DELTA
        IF (IPLAN.EQ.1) GO TO 170
        IPLAN=1
        LCH=1
        WRITE (6,280)
        XKP(1)=XKP(1)+XKP(2)
        XKV(1)=XKV(1)+XKV(2)
        XKVSEW(1)=XKVSEW(1)+XKVSEW(2)
        GO TO 120
170     WRITE (6,270)
        IPLAN=PLAN
        RETURN
C
C
C
180     FORMAT (4F10.5)
190     FORMAT (1H1,////,31X,60HKP , KV AND RESPECTIVE CHORDWISE CENTROIDS
       1 FOR EACH PLANFORM)
200     FORMAT (///,52X,12HPLANFORM NO.,I2)
```

```
210   FORMAT (40X,3HKP=,F10.5,10X,11HCENTROID AT,F10.5)                       WRT1210
220   FORMAT (37X,6HKV LE=,F10.5,10X,11HCENTROID AT,F10.5)                    WRT1220
230   FORMAT (37X,6HKV SE=,F10.5,10X,11HCENTROID AT,F10.5)                    WRT1230
240   FORMAT (1H1,////,43X,40HPERFORMANCE CHARACTERISTICS FOR PLANFORM,IWRT1240
     12)                                                                       WRT1250
250   FORMAT (//7X,5HALPHA,6X,2HCN,8X,3HCLP,4X,9HCLP+CLVLE,1X,9HCLP+CLVSWRT1260
     1E,4X,2HCL,8X,3HCMP,4X,9HCMP+CMVLE,1X,9HCMP+CMVSE,4X,2HCM,8X,2HCD,3WRT1270
     2X,13HCL**2/(PI*AR)/)                                                     WRT1280
260   FORMAT (3X,12F10.4)                                                      WRT1290
270   FORMAT (///,50X,21HTHIS CASE IS FINISHED)                                WRT1300
280   FORMAT (1H1,////,48X,33HTOTAL PERFORMANCE CHARACTERISTICS)               WRT1310
      END                                                                      WRT1320-
```

REFERENCES

1. Polhamus, Edward C.: A Concept of the Vortex Lift of Sharp-Edge Delta Wings Based on a Leading-Edge-Suction Analogy. NASA TN D-3767, 1966.
2. Polhamus, Edward C.: Charts for Predicting the Subsonic Vortex-Lift Characteristics of Arrow, Delta, and Diamond Wings. NASA TN D-6243, 1971.
3. Polhamus, Edward C.: Predictions of Vortex-Lift Characteristics by a Leading-Edge Suction Analogy. J. Aircraft, vol. 8, no. 4, Apr. 1971, pp. 193-199.
4. Lamar, John E.: Extension of Leading-Edge-Suction Analogy to Wings With Separated Flow Around the Side Edges at Subsonic Speeds. NASA TR R-428, 1974.
5. 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.
6. Margason, Richard J.; and Lamar, John E.: Vortex-Lattice FORTRAN Program for Estimating Subsonic Aerodynamic Characteristics of Complex Planforms. NASA TN D-6142, 1971.
7. Bradley, R. G.; Smith, C. W.; and Bhateley, I. C.: Vortex-Lift Prediction for Complex Wing Planforms. J. Aircraft, vol. 10, no. 6, June 1973, pp. 379-381.
8. Smith, C. W.; Bradley, R. G.; and Bhateley, I. C.: Vortex Lift, Drag, and Pitching-Moment Predictions for Sharp-Edged Wings With Camber. ERR-FW-1470, Convair Aerospace Div., General Dynamics, Dec. 31, 1973.
9. Mendenhall, Michael R.; and Nielsen, Jack N.: Effect of Symmetrical Vortex Shedding on the Longitudinal Aerodynamic Characteristics of Wing-Body-Tail Combinations. NASA CR-2473, 1975.
10. Tulinius, J.; Clever, W.; Niemann, A.; Dunn, K.; and Gaither, B.: Theoretical Prediction of Airplane Stability Derivatives at Subcritical Speeds. NASA CR-132 681, 1975.
11. Gloss, Blair B.: The Effect of Canard Leading-Edge Sweep and Dihedral Angle on the Longitudinal and Lateral Aerodynamic Characteristics of a Close-Coupled Canard-Wing Configuration. NASA TN D-7814, 1974.
12. Munk, Max M.: The Minimum Induced Drag of Aerofoils. NACA Rep. 121, 1921.

TABLE I.- $K_{v,se}$ AND ITS CHORDWISE CENTROID OBTAINED BY FOUR METHODS FOR THREE PLANFORMS

[M = 0; for method 2, $\overline{N}_c = 6$ and $\overline{N}_s = 25$; for method 3, $\overline{N}_c = 3$ and $\overline{N}_s = 25$; for method 4, $\overline{N}_c = 11$ and $\overline{N}_s = 11$]

Method	Cropped diamond planform		Cropped arrow planform		Cropped delta planform	
	$K_{v,se}$	$\Delta x/c_t$	$K_{v,se}$	$\Delta x/c_t$	$K_{v,se}$	$\Delta x/c_t$
1	1.200	0.5367	1.693	0.5320	1.397	0.5373
2	1.232	.5207	1.726	.5098	1.456	.5182
3	1.200	.5451	1.688	.5350	1.412	.5441
4	1.300	-----	1.742	-----	1.60	-----

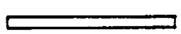
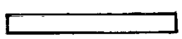
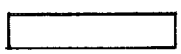
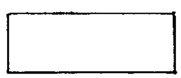
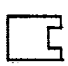
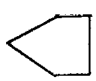
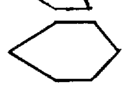
TABLE II.- EFFECT OF BOUND VORTEX SWEEP ANGLE ON $K_{v,se}$ AND $\Delta x/c_t$

[A = 3.5; λ = 1.0; M = 0.30; for method 2, $\overline{N}_c = 6$ and $\overline{N}_s = 30$]

Λ, deg	Method 1		Method 2	
	$K_{v,se}$	$\Delta x/c_t$	$K_{v,se}$	$\Delta x/c_t$
0	1.0968	0.6004	1.1037	0.5956
20	1.3050	.5777	1.3869	.5325
40	1.4149	.5486	1.3630	.5270
50	1.3631	.5418	1.3076	.5164
60	1.2431	.5464	1.1698	.5066
70	.9446	.5956	.9243	.4980
75	.8335	.5729	.7556	.4916

TABLE III.- POTENTIAL AND VORTEX LIFT FACTORS OBTAINED FROM THE PRESENT METHOD AND METHOD 1

[M = 0; for method 2, $\overline{N}_c = 6$ and $\overline{N}_s = 25$]

A	Type	Present method (method 2)			Method 1		
		K_p	$K_{v,le}$	$K_{v,se}$	K_p	$K_{v,le}$	$K_{v,se}$
0.05		0.0798	0.0399	2.9816	0.07844	0.0393	3.1799
.10		.1596	.0798	2.9477	.1571	.0785	3.0188
.20		.3188	.1597	2.8533	.3138	.1571	2.7913
.30		.4769	.2395	2.7497	.4693	.2356	2.7208
.40		.6329	.3194	2.6467	.6227	.3141	2.6341
1.00		1.4862	.7969	2.1157	1.4614	.7816	2.1255
1.00		1.4475	.7923	2.3581	1.4335	.7787	2.3863
[a].873		1.3064	1.5345	1.4563	1.2789	1.5041	1.3967
[a]1.069		1.5049	1.8575	1.7256	1.4868	1.8241	1.6929
[a].738		1.1298	1.3000	1.2321	1.1066	1.2744	1.2001

[a]Same wings as presented in figure 2.

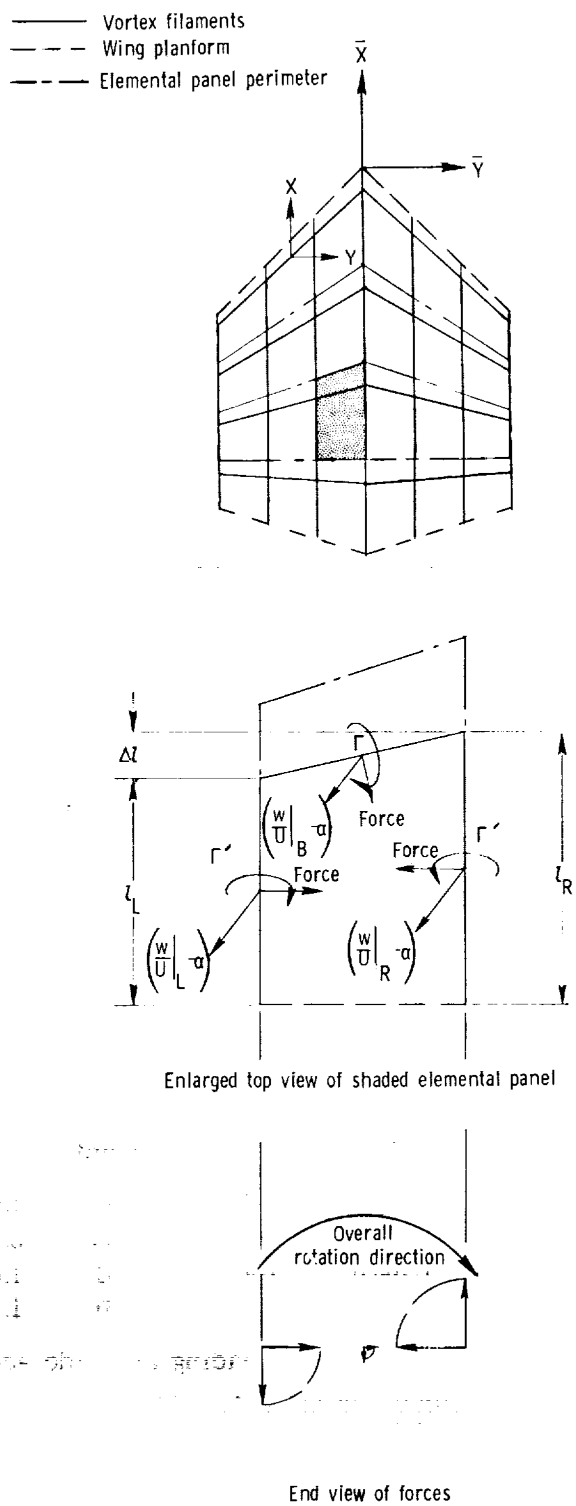
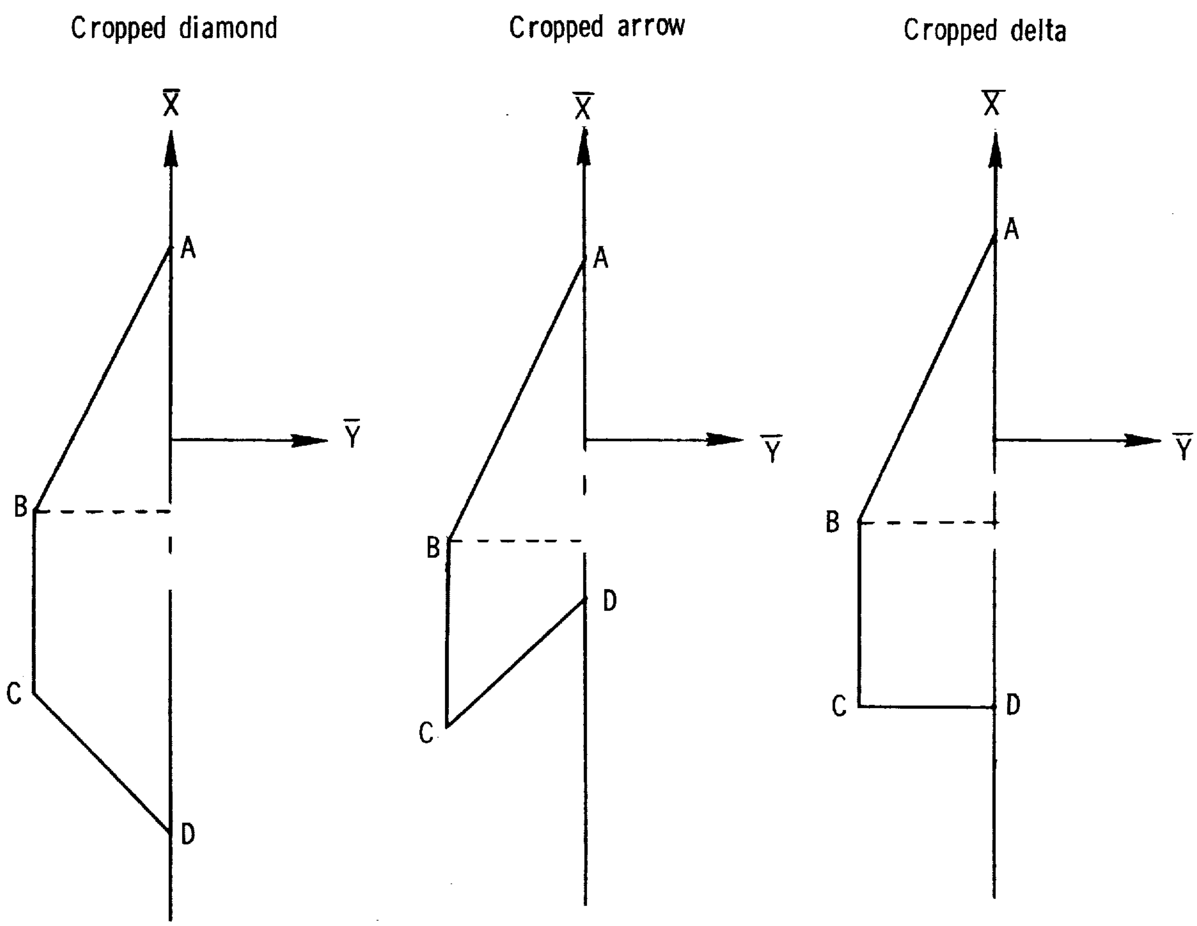


Figure 1.- General layout of axis systems, elemental panels, and horseshoe vortices for a typical wing.

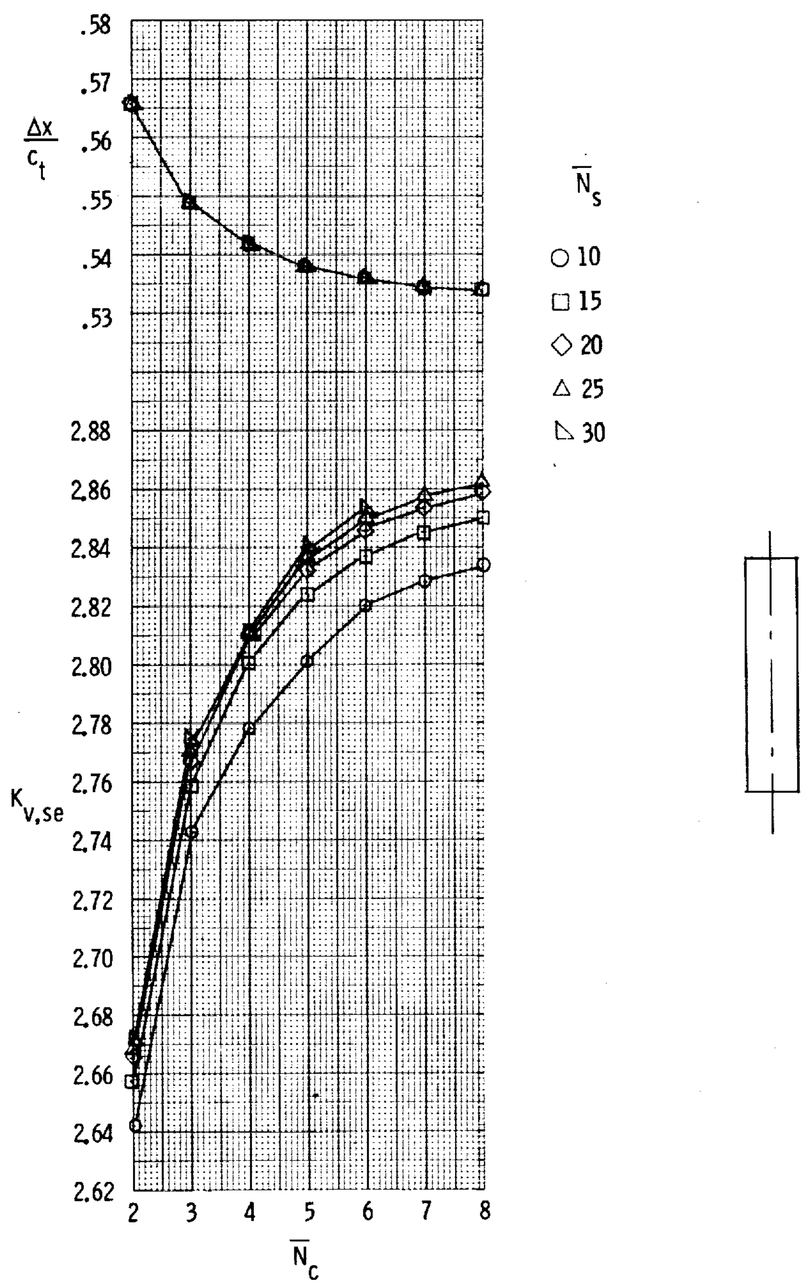


Point	$\bar{x}$	$\bar{y}$
A	1.54985	0.0
B	-0.41276	-1.0
C	-1.72117	-1.0
D	-2.56025	0.0

Point	$\bar{x}$	$\bar{y}$
A	1.36465	0.0
B	-0.59796	-1.0
C	-1.90637	-1.0
D	-1.06725	0.0

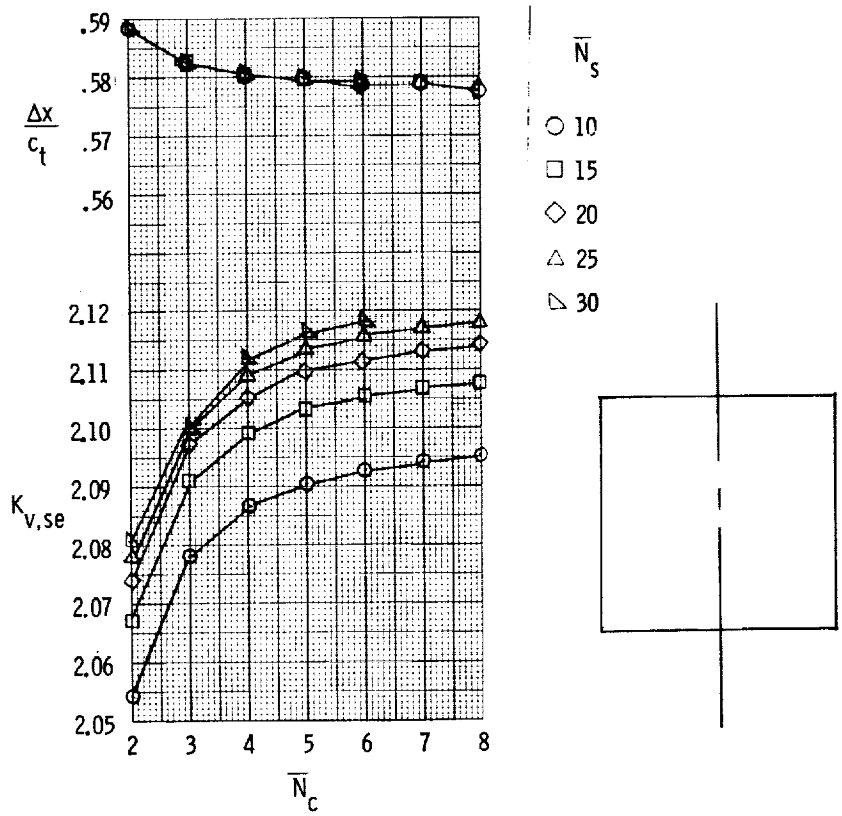
Point	$\bar{x}$	$\bar{y}$
A	1.44858	0.0
B	-0.51403	-1.0
C	-1.8224	-1.0
D	-1.8224	0.0

Figure 2. - Drawings of cropped planforms. Leading and side edges are sharp. All dimensions are in centimeters.



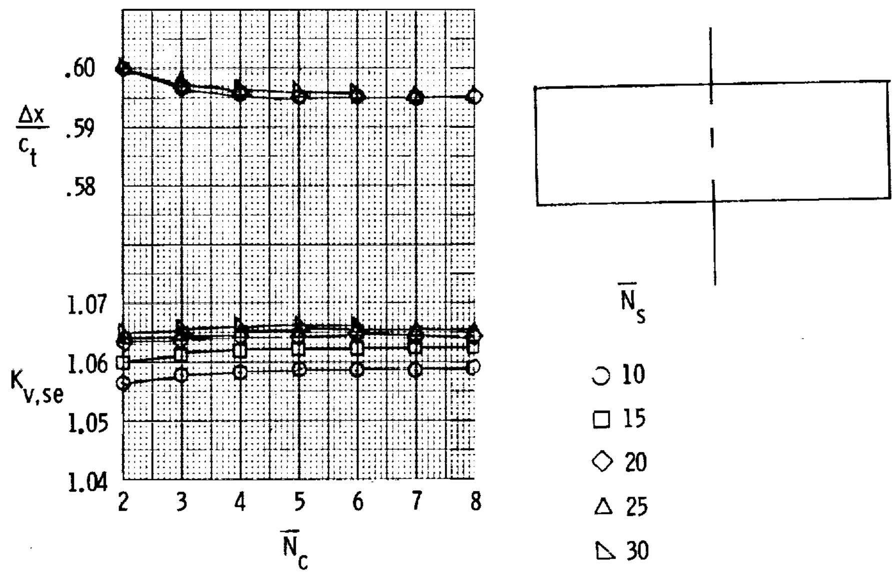
(a) $A = 0.20$; $\Lambda = 0^{\circ}$; $\lambda = 1.0$.

Figure 3.- Variation of $K_{v,se}$ and $\Delta x/c_t$ with $\overline{N}_s$ for simple planforms at $M = 0$.



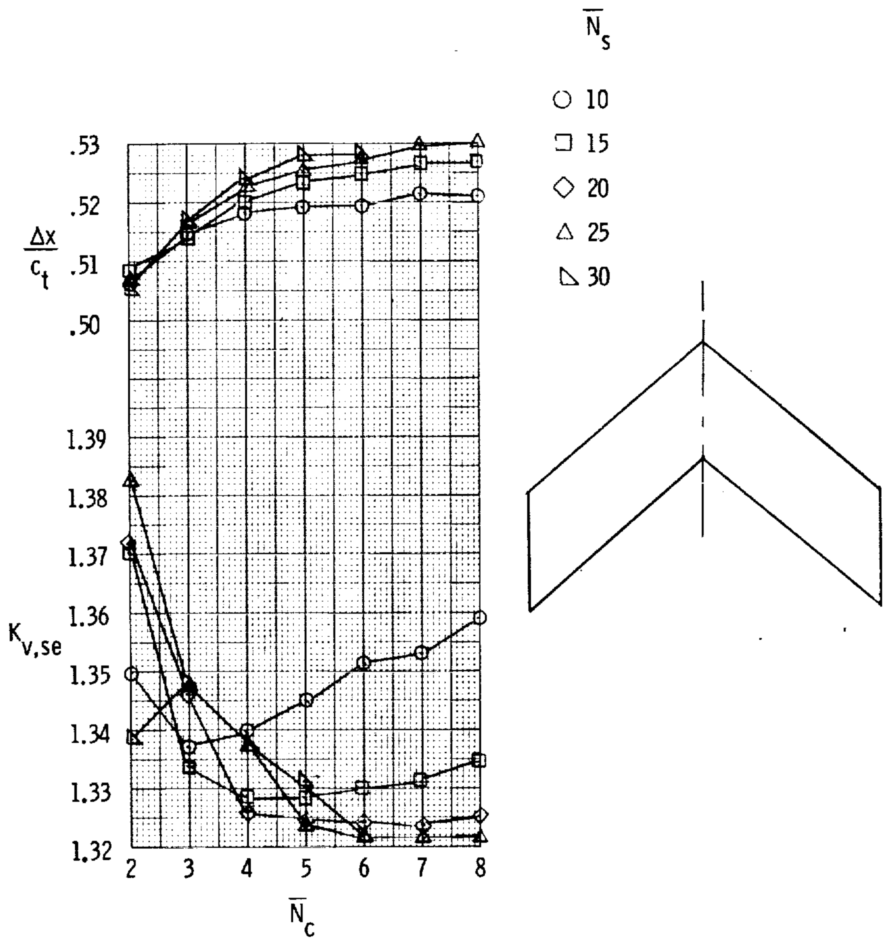
(b) A = 1.00; $\Lambda = 0^{\circ}$; $\lambda = 1.0$.

Figure 3.- Continued.



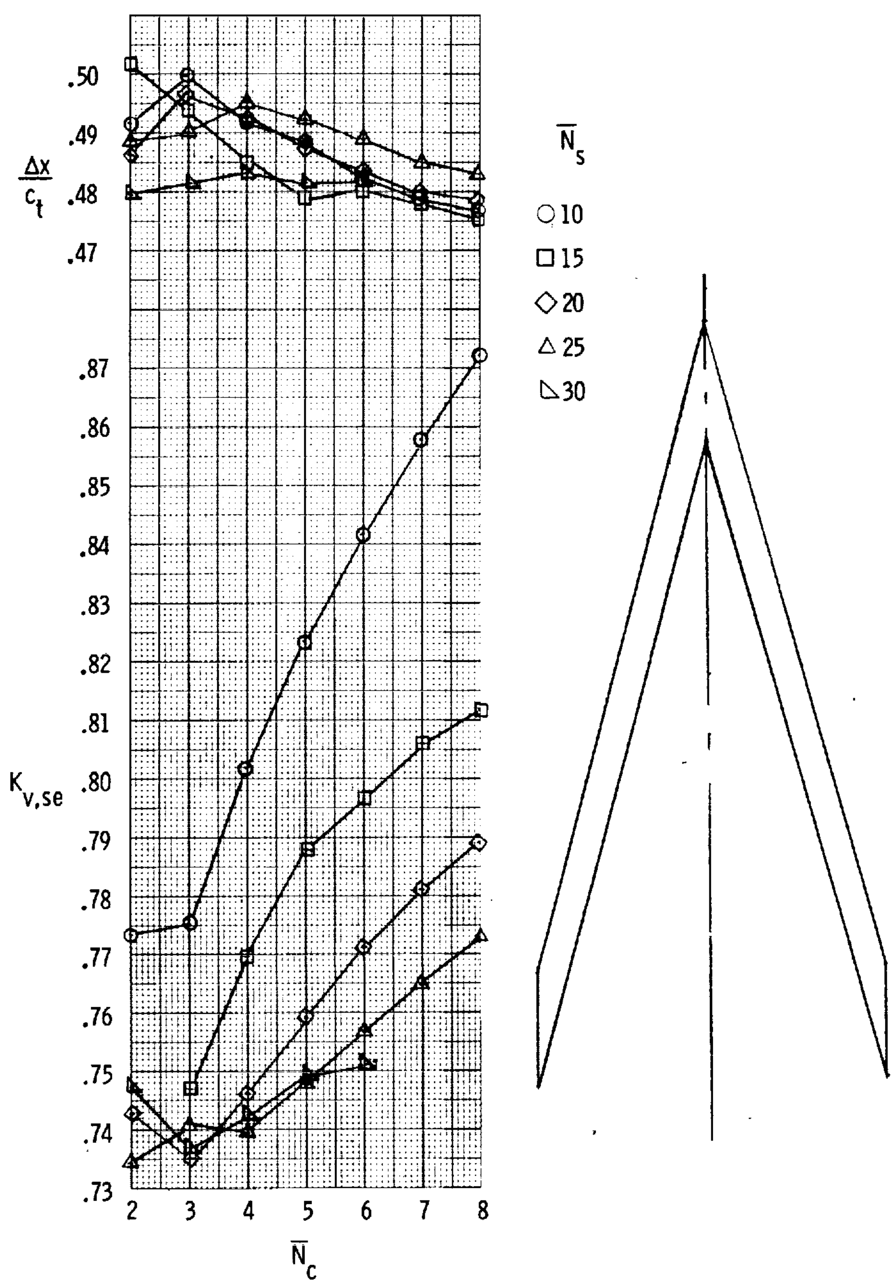
(c) $A = 3.50$; $\Lambda = 0^{o}$; $\lambda = 1.0$.

Figure 3.- Continued.



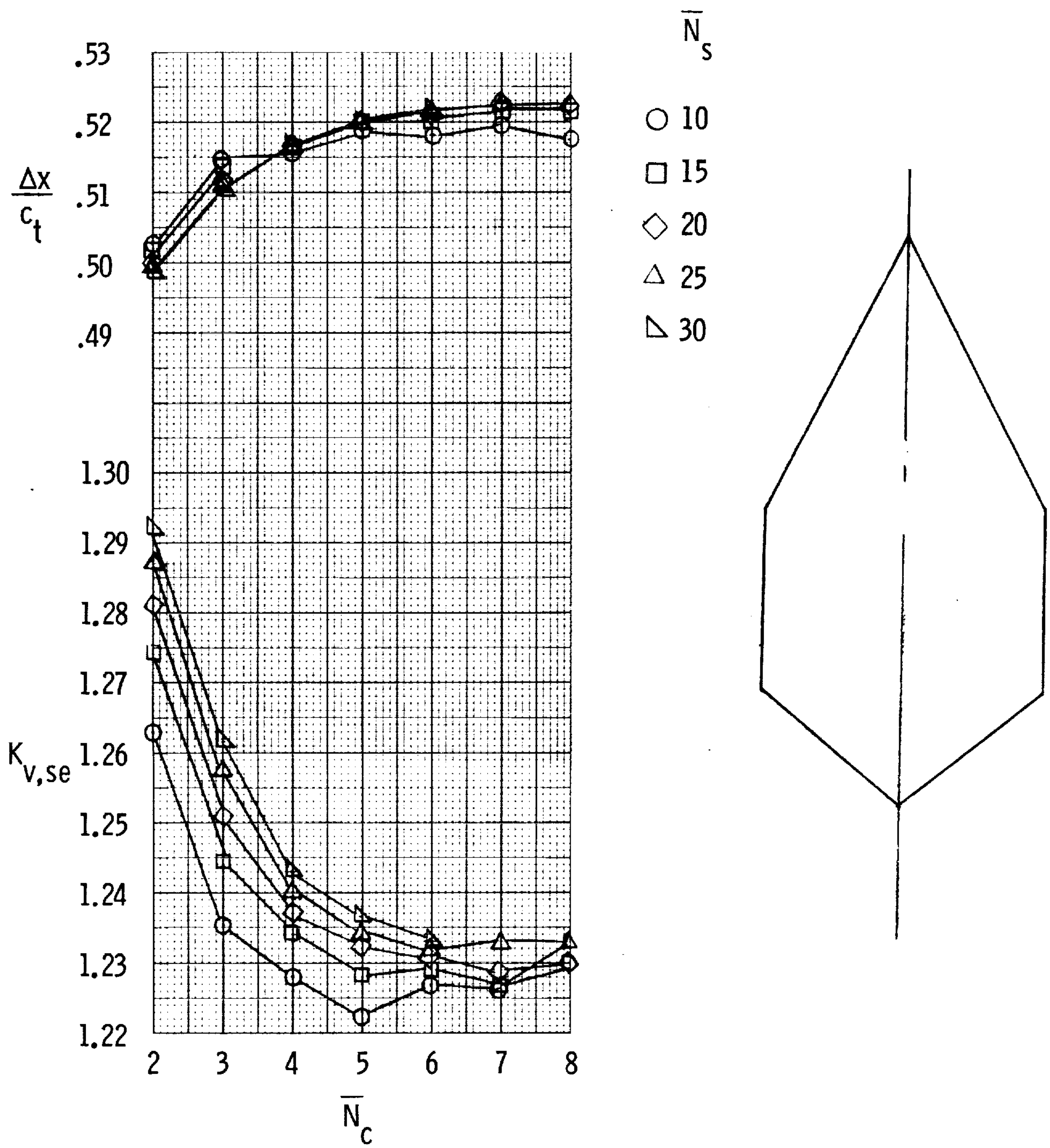
(d) $A = 3.50$; $\Lambda = 40^o$; $\lambda = 1.0$.

Figure 3.- Continued.



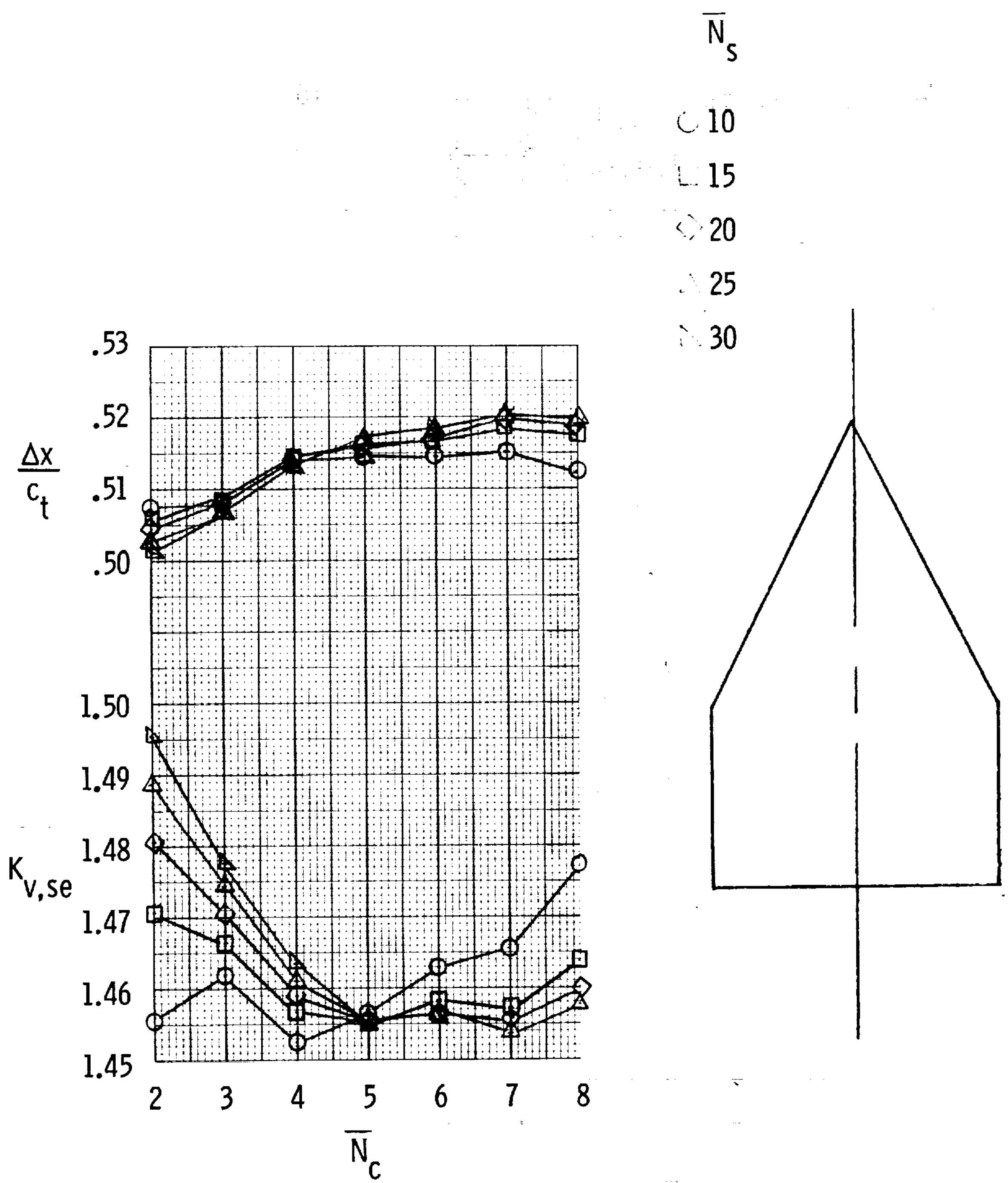
(e) $A = 3.50$; $\Lambda = 75^{\circ}$; $\lambda = 1.0$.

Figure 3.- Concluded.



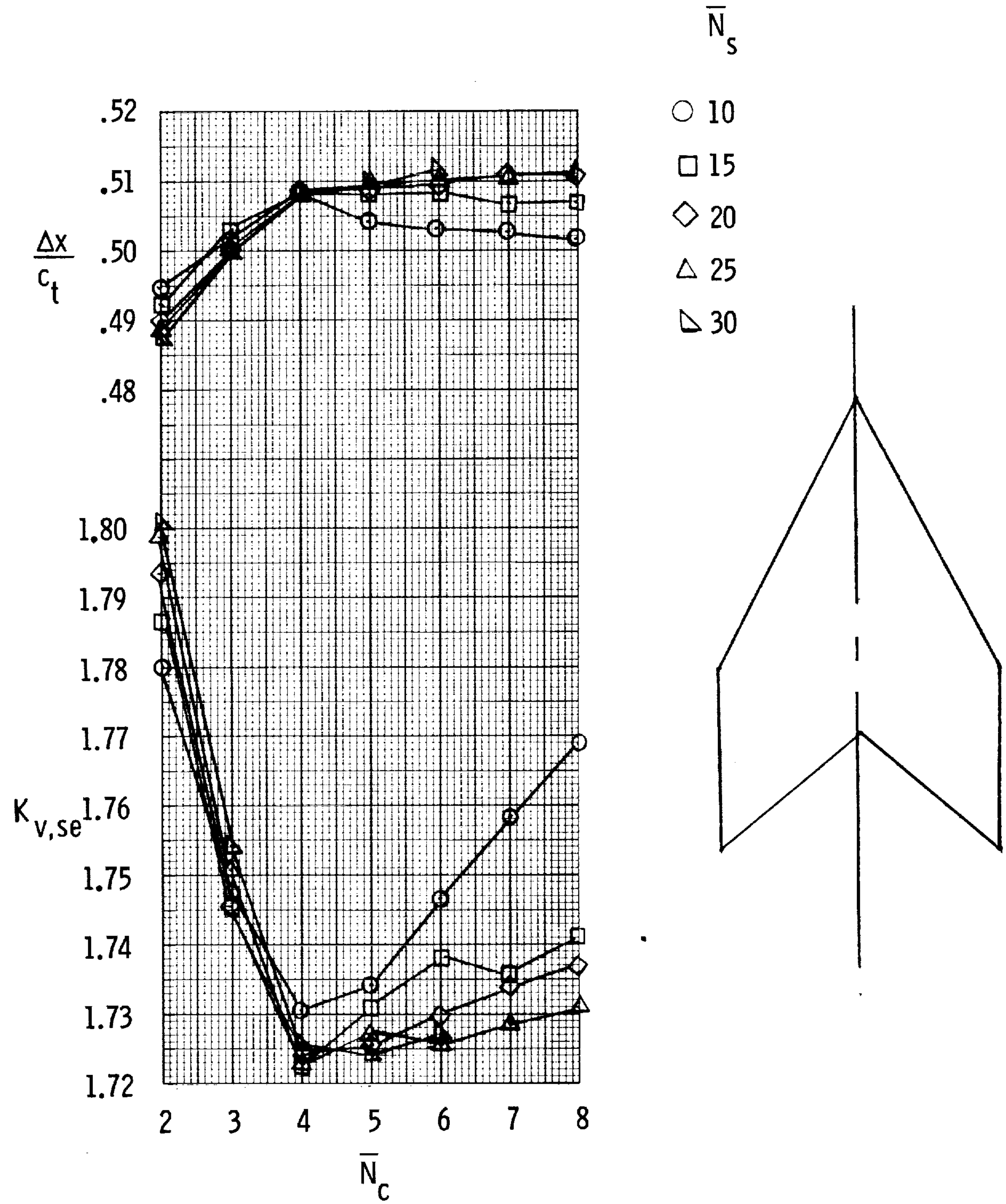
(a) Diamond; $A = 0.74$; $\Lambda = 63^{o}$; $\lambda = 0.32$.

Figure 4.- Variation of $K_{v,se}$ and $\Delta x/c_t$ with $\overline{N}_s$ for three cropped planforms at $M = 0$.



(b) Delta; A = 0.87; Λ = 63°; λ = 0.4.

Figure 4.- Continued.



(c) Arrow; A = 1.07; Λ = 63°; λ = 0.53.

Figure 4.- Concluded.

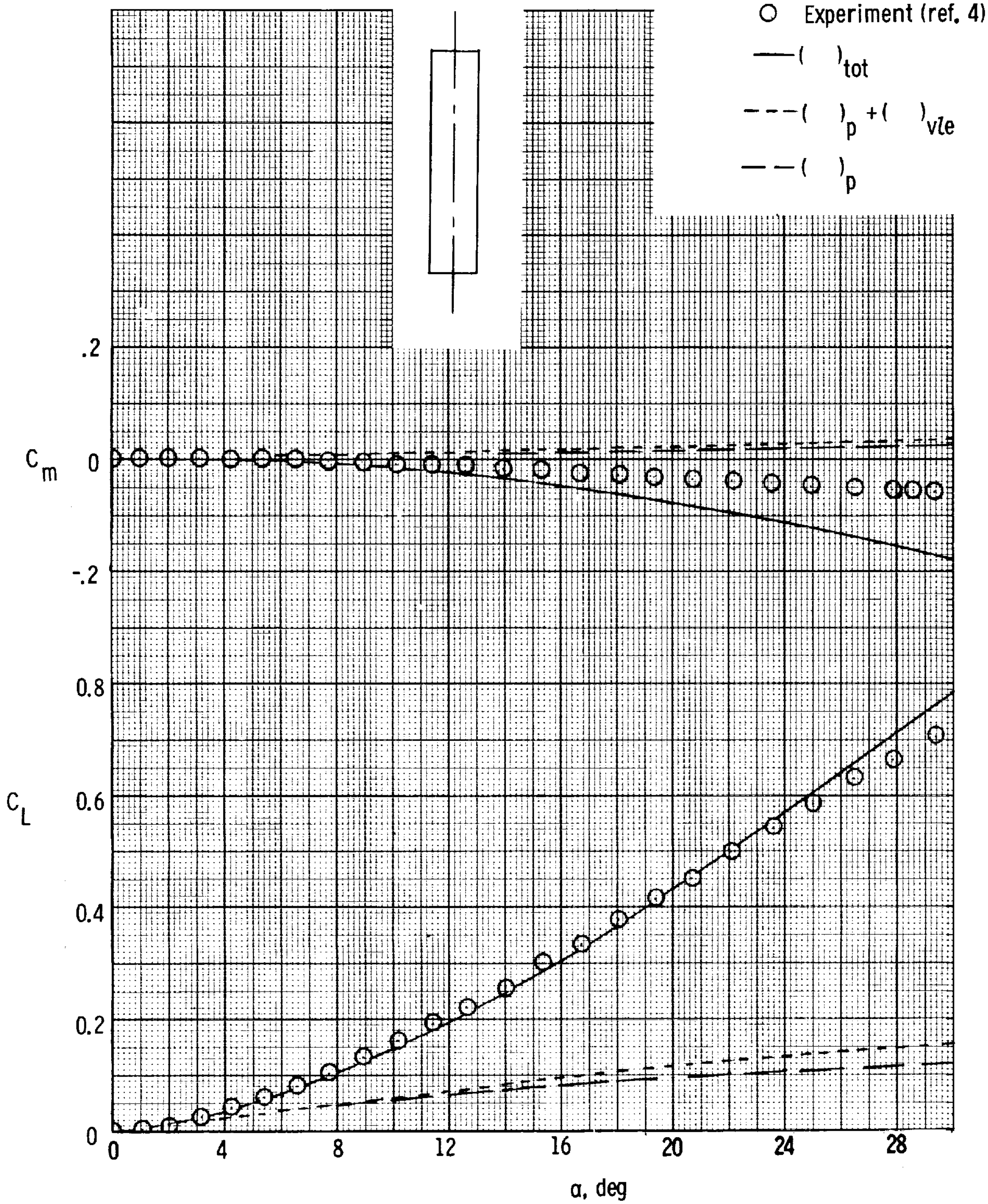


Figure 5.- Theoretical and experimental results for 0.2-aspect-ratio rectangular flat wing with sharp leading and side edges at M = 0.20 with $\overline{N}_c = 6$ and $\overline{N}_s = 25$.

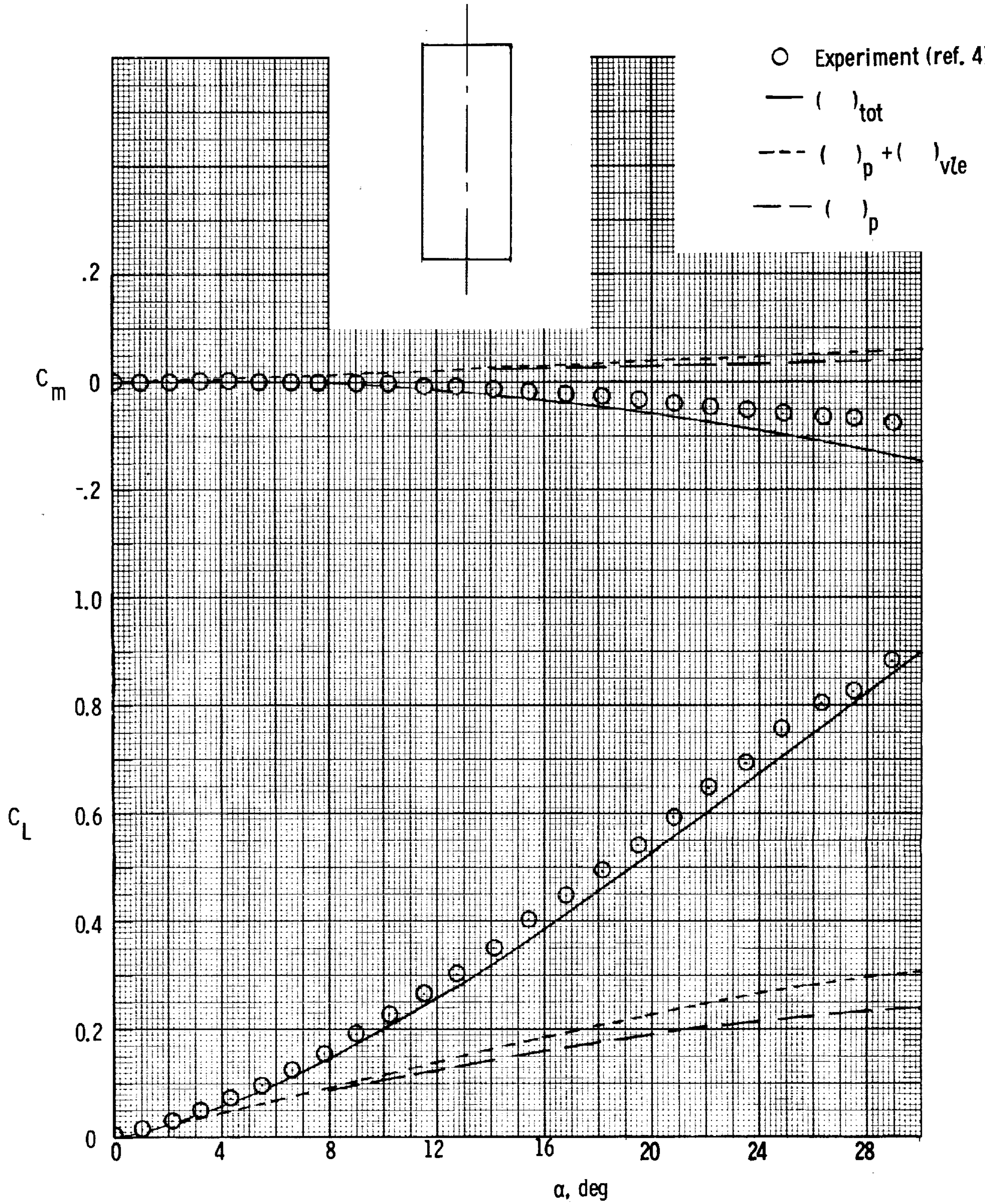


Figure 6.- Theoretical and experimental results for 0.4-aspect-ratio rectangular flat wing with sharp leading and side edges at M = 0.20 with $\overline{N}_c = 6$ and $\overline{N}_s = 25$.

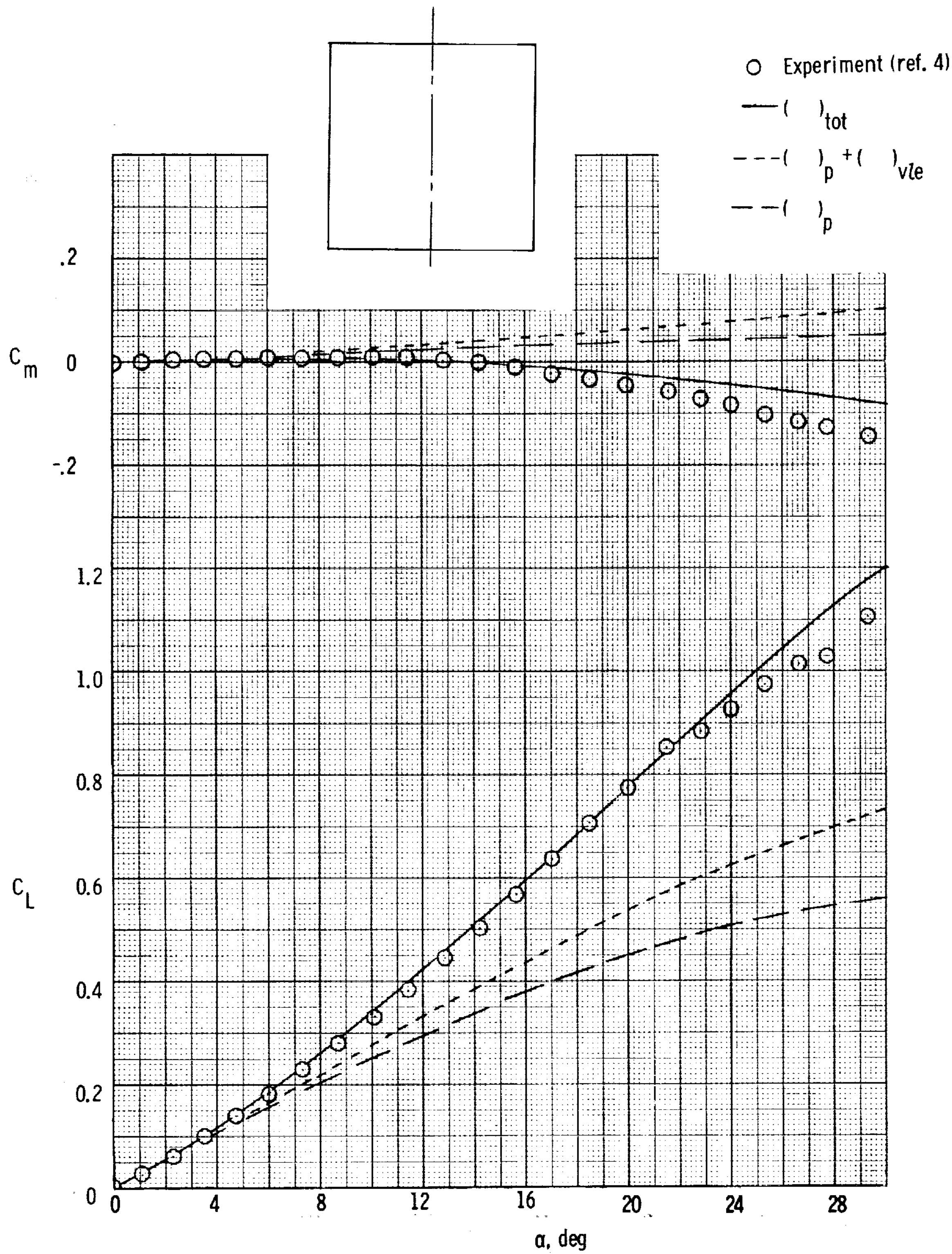


Figure 7.- Theoretical and experimental results for 1.0-aspect-ratio rectangular flat wing with sharp leading and side edges at M = 0.20 with $\overline{N}_c = 6$ and $\overline{N}_s = 25$.

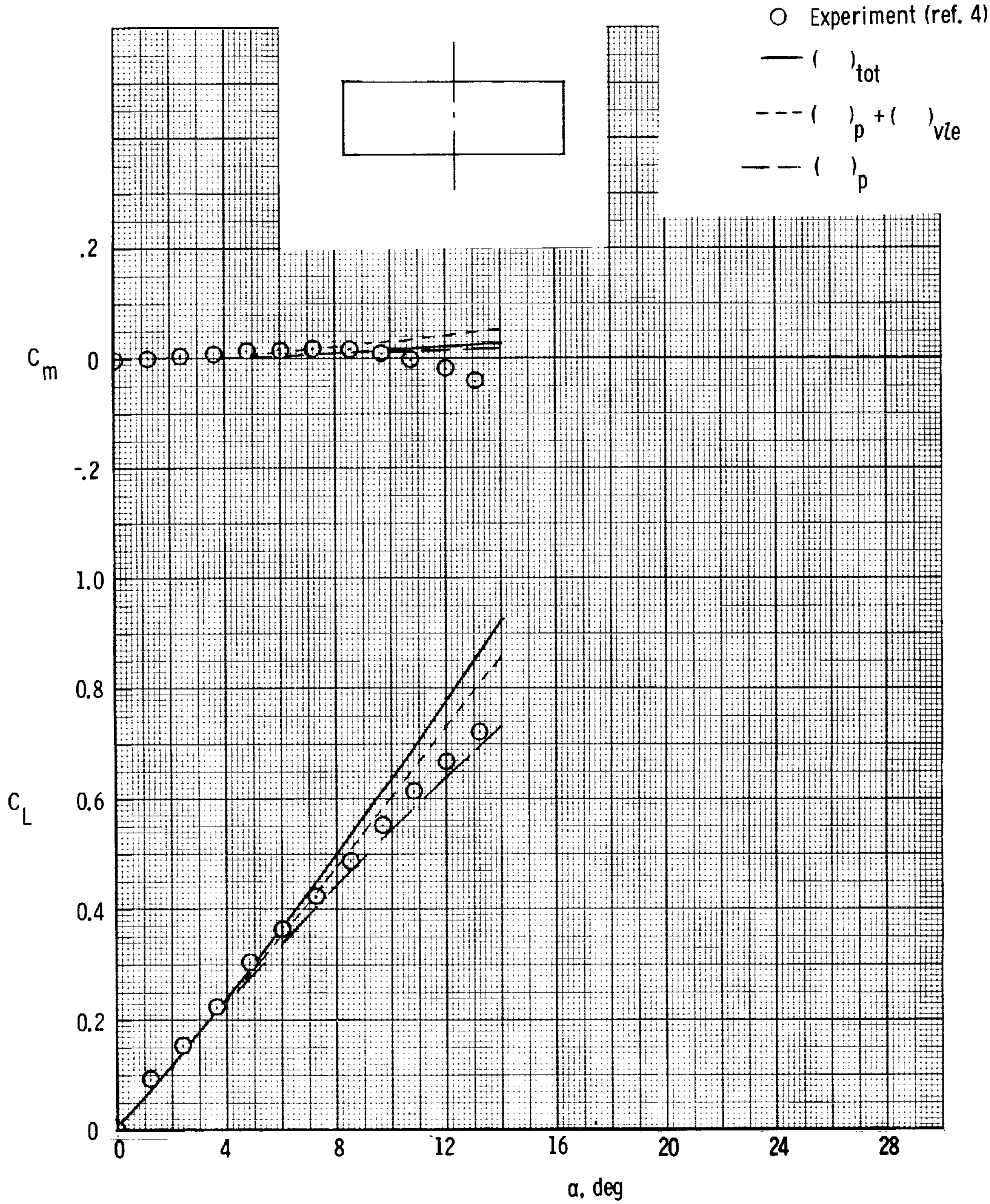


Figure 8.- Theoretical and experimental results for 3.0-aspect-ratio rectangular flat wing with sharp leading and side edges at $M = 0.20$ with $\overline{N}_c = 6$ and $\overline{N}_s = 25$.

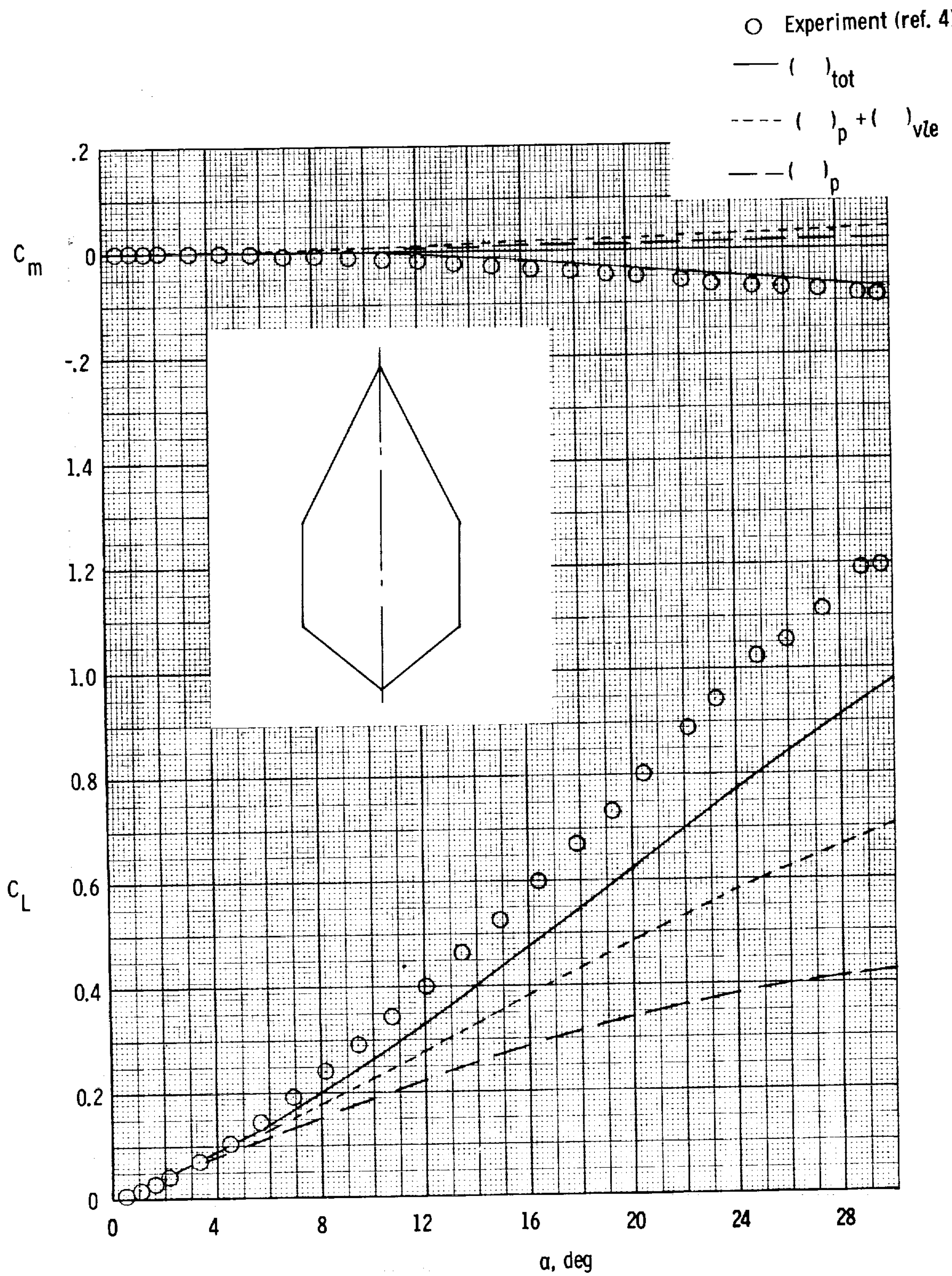


Figure 9.- Theoretical and experimental results for 0.738-aspect-ratio cropped diamond wing at $M = 0.20$ with $\overline{N}_c = 6$ and $\overline{N}_s = 25$.

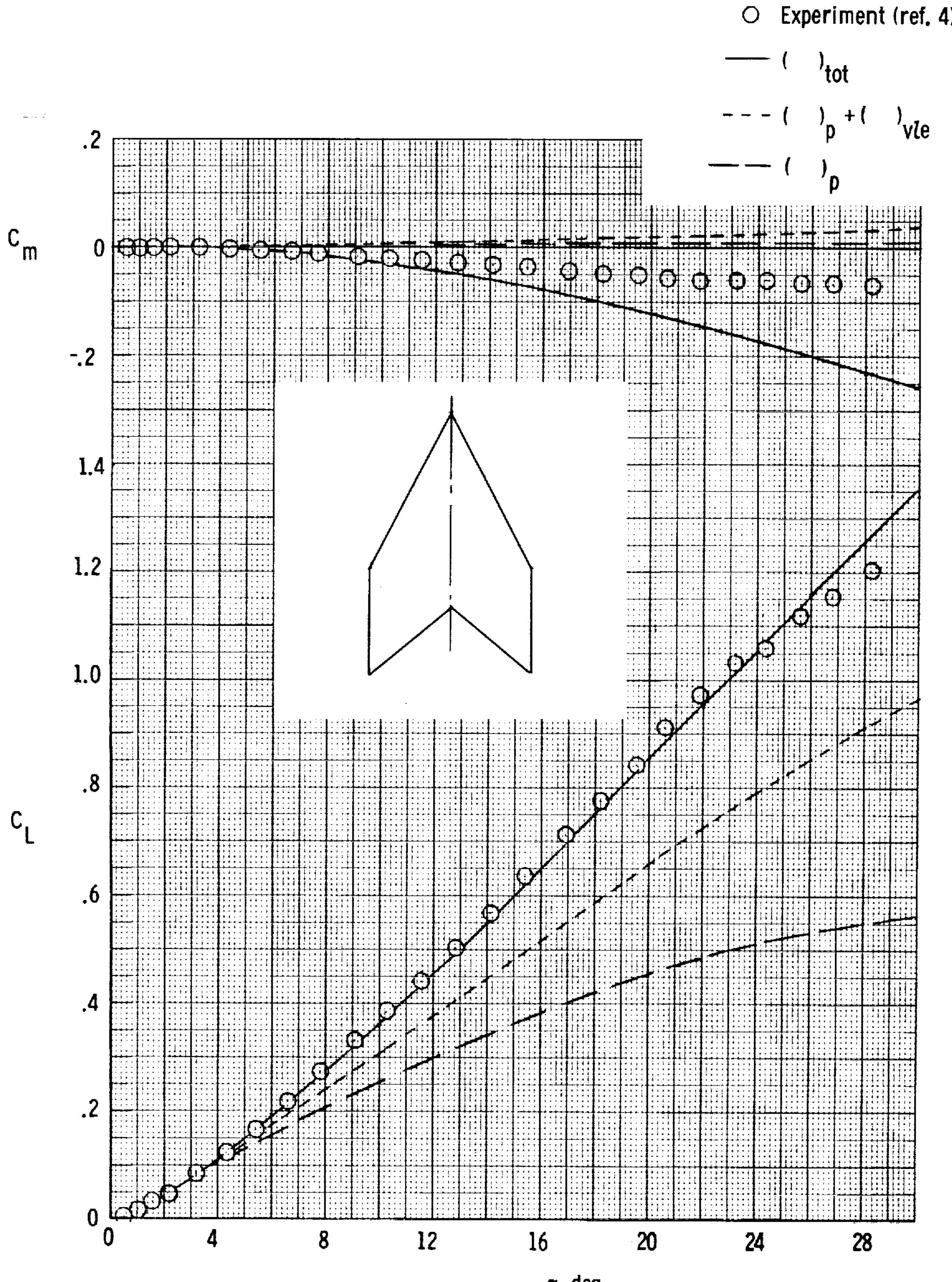


Figure 10.- Theoretical and experimental results for 1.069-aspect-ratio cropped arrow wing at M = 0.20 with $\overline{N}_c = 6$ and $\overline{N}_s = 25$.

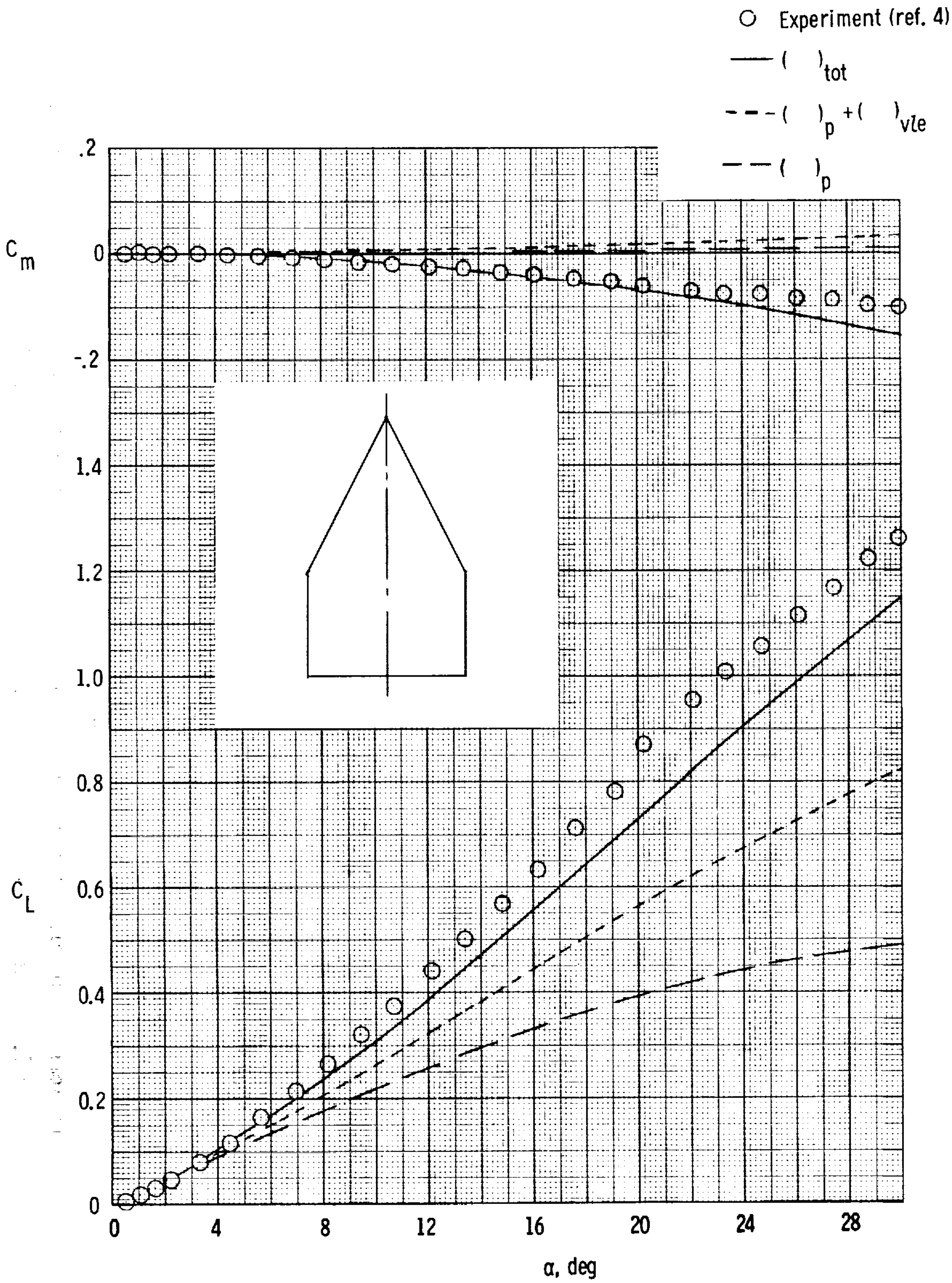


Figure 11.- Theoretical and experimental results for 0.873-aspect-ratio cropped delta wing at $M = 0.20$ with $\overline{N}_c = 6$ and $\overline{N}_s = 25$.

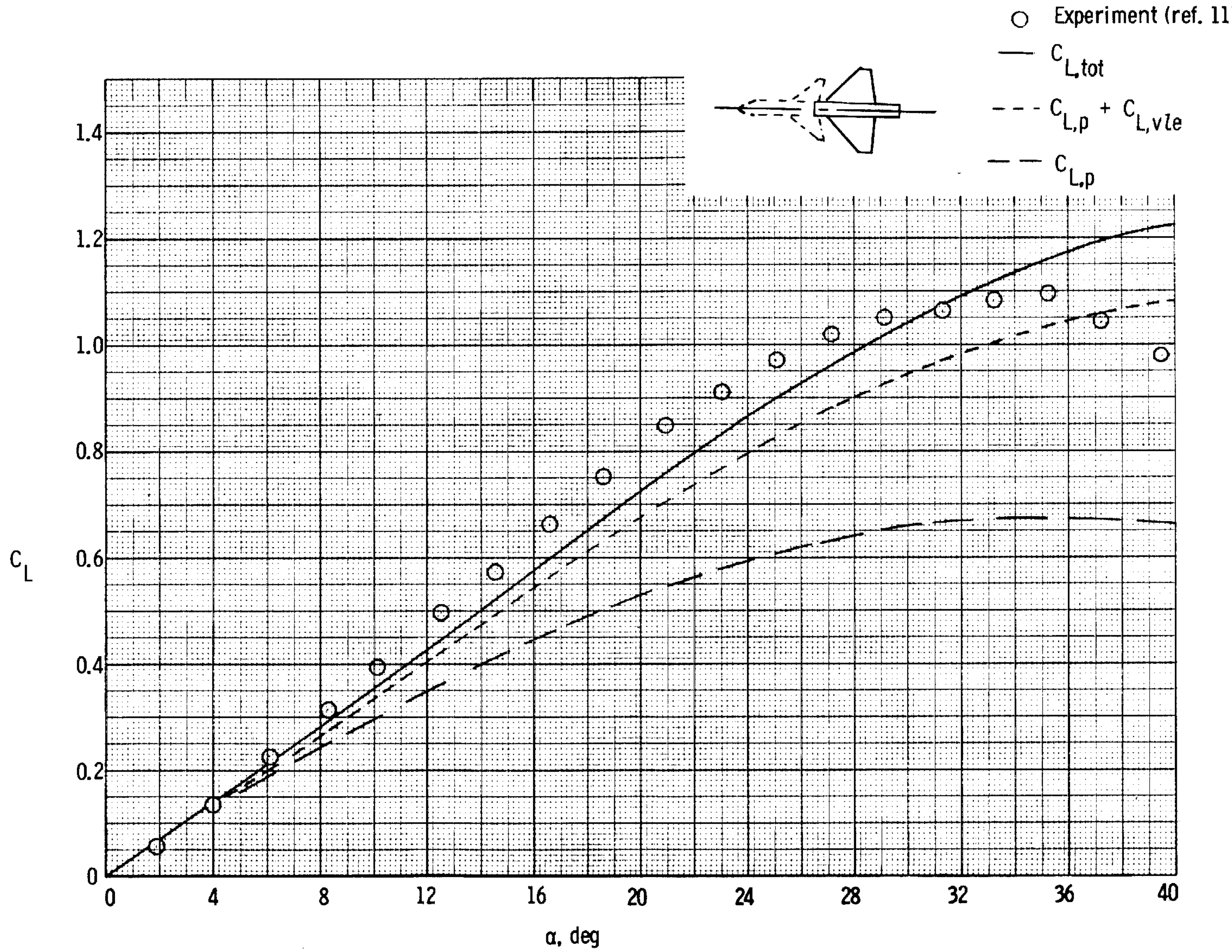


Figure 12.- Theoretical and experimental results on 44° swept wing in presence of canard in wing chord plane. M = 0.30 with $\overline{N}_c = 6$ and $\overline{N}_s = 12$ for canard and $\overline{N}_s = 17$ for wing.

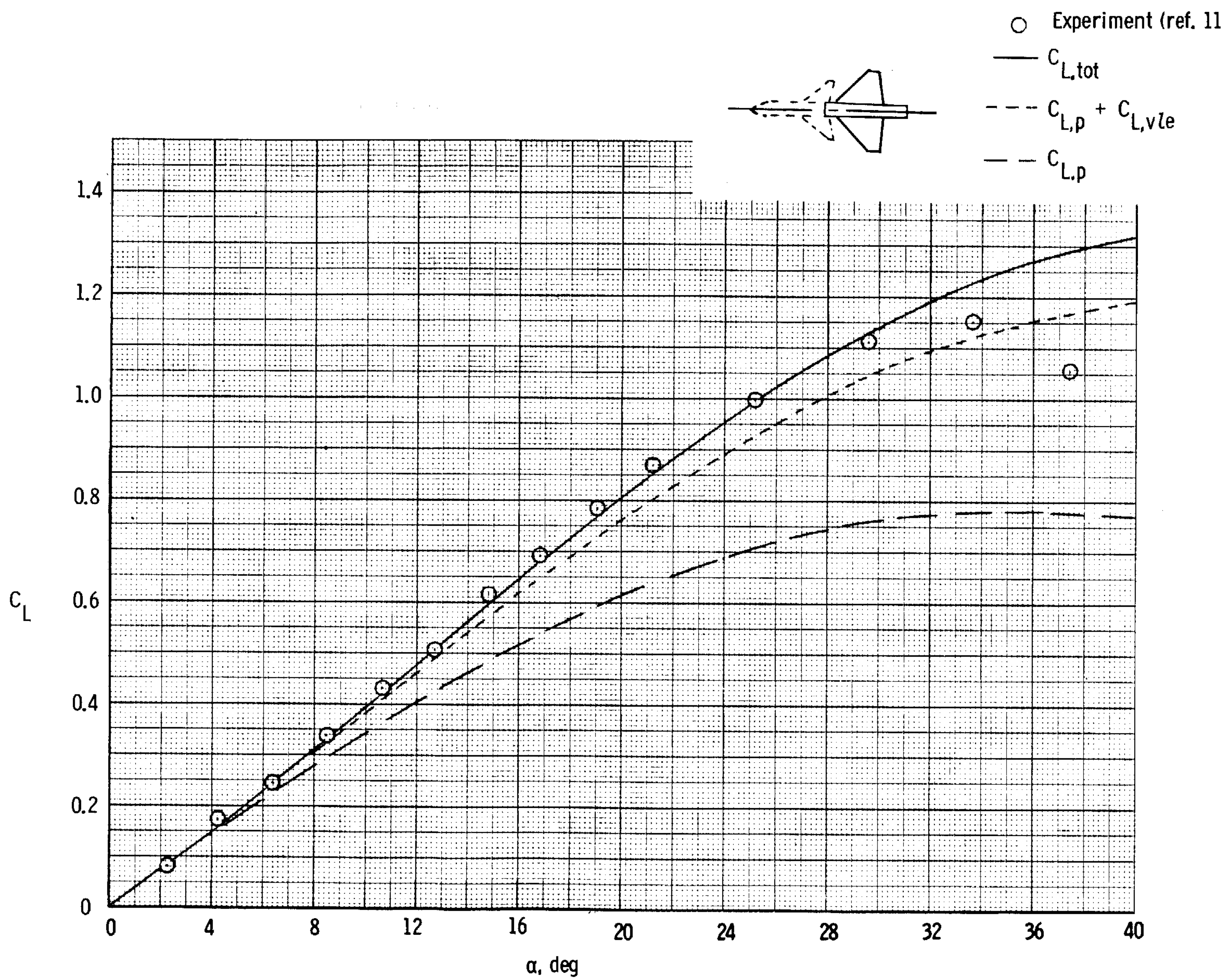


Figure 13.- Theoretical and experimental results on 44° swept wing in presence of canard above wing chord plane. M = 0.30 with $\overline{N}_c = 6$ and $\overline{N}_s = 12$ for canard and $\overline{N}_s = 17$ for wing.

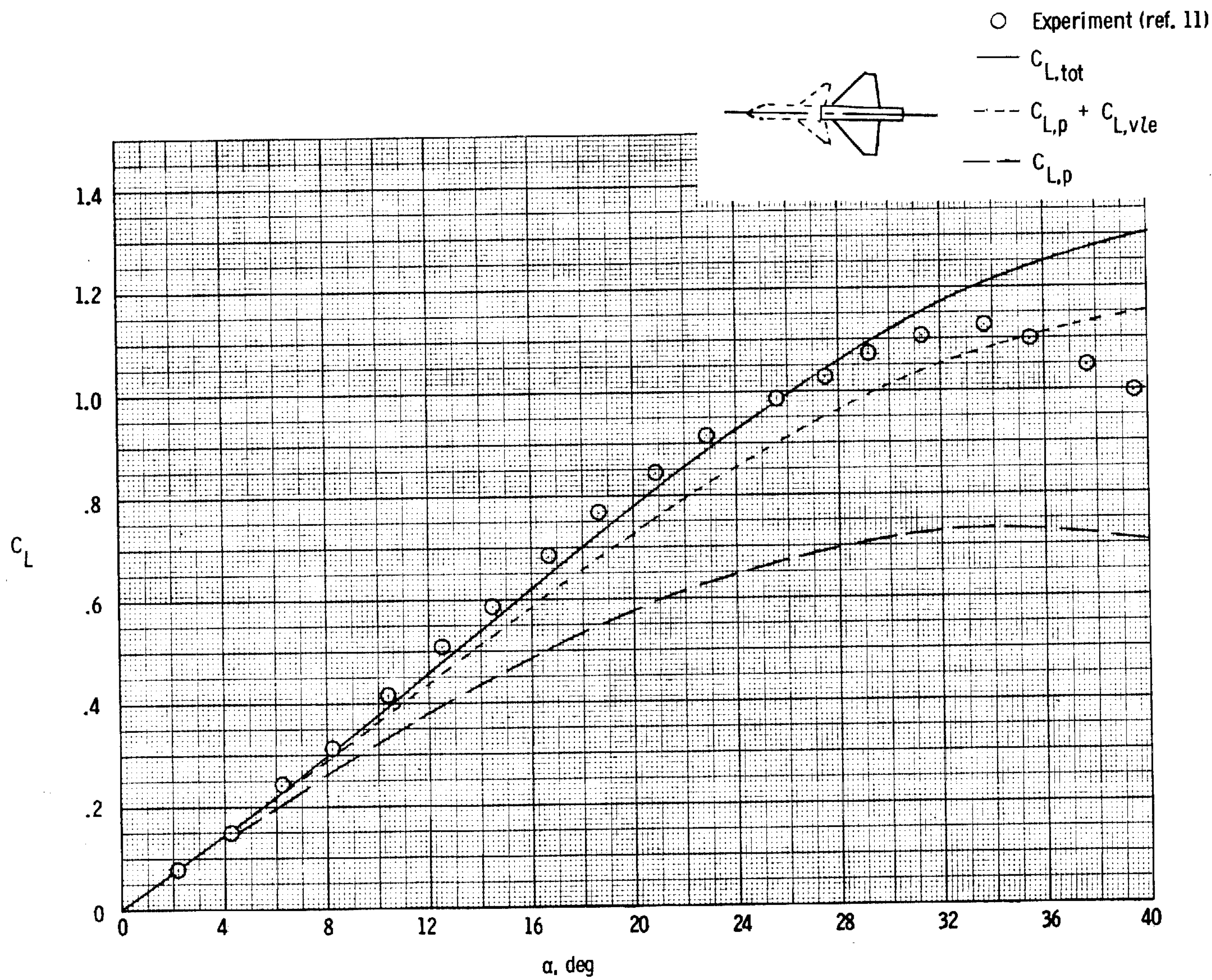


Figure 14.- Theoretical and experimental results on 44° swept wing in presence of canard with 18.6° anhedral above wing chord plane. M = 0.30 with $\overline{N}_c = 6$ and $\overline{N}_s = 12$ for canard and $\overline{N}_s = 17$ for wing.

NASA-Langley, 1975 L-10001