DEVELOPMENT OF THEORETICAL METHOD FOR TWO-DIMENSIONAL MULTI-ELEMENT AIRFOIL ANALYSIS AND DESIGN

Part I: Viscous-Flow Analysis Method

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FOREWORD

This final report summarizes the work accomplished by the Fort Worth operation of the Convair Aerospace Division of General Dynamics Corporation, Fort Worth, Texas, under USAF Contract F33615-71-C-1597, Project 1366. The work was conducted under the direction of the Air Force Program Manager, Mr. Russell F. Osborn, AFFDL/FXM.

The results of this development are documented in two parts which constitute the Final Technical Report under the contract. In Part I, a method for the viscous flow analysis of multi-element airfoil systems is presented. In Part II, a semi-inverse method for the design of leading-edge slats is presented.

Mr. Ishwar C. Bhateley served as the General Dynamics Program Manager for this study and developed the viscous flow method. Dr. O. Wayne McGregor developed the slat design method. The computer programming task for both methods was performed by Jack W. McWhirter. Dr. R. G. Bradley served as a special consultant and counselor throughout the study.

The research and technical development for this report was accomplished between 24 May 1971 and 12 June 1972. This report was released by the authors in July 1972.

This technical report has been reviewed and is approved.

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ABSTRACT

A method has been developed for the analysis of arbitrary multi-element airfoils in viscous flow. The viscous solution is obtained through an inviscid analysis of an equivalent system defined from viscous considerations. An iterative procedure has been formulated to implement this analysis. The inviscid solution is obtained through a distributed singularity method. A finite-difference method is used to determine boundary-layer characteristics. Methods are included to predict laminar-flow bubbles and separation and transition points. The equivalent airfoil is defined for airfoils with attached flow as well as for airfoils with flow separation. The validity of the method is established through comparison of the predicted results with experimental data for several single- and multi-element airfoils. The comparisons show good agreement for lift coefficient and maximum lift coefficient and fair agreement for drag and pitching moment coefficients. Details of the computer program developed to implement this method are described, including input and output details, FORTRAN source deck listing, and a sample problem.

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NOMENCLATURE

A,B,D,E,I,J,P,T	Influence coefficients (Eqns. 21, 22, 3, 4, 26, 27, 30, 49)
C_d, C_D	Drag coefficient
C_ℓ, C_L	Lift coefficient
C_m	Pitching moment coefficient
C_p	Incompressible pressure coefficient (Eq. 37)
G	Vorticity strength
I_1, I_2, I_3	Integral (Eqns. 6, 7, 8)
K	Shape factor (Eq. 56)
$\bar{K}$	Mean shape factor (Eq. 59)
ℓ	Linear segment length (Eq. 5)
$(M)_{CR}$	Transition criteria (Eq. 58)
N	Total number of corner points
Ns	Number of source locations
R_x	Reynolds number based on developed length
R_θ	Reynolds number based on momentum thickness
u, v	Velocity components
U_∞	Freestream velocity
s, t	Coordinates of the source points
x, y	Coordinates of corner points
$\bar{x}$, $\bar{y}$	Coordinates of boundary points
α	Angle of attack

NOMENCLATURE (Cont'd)

θ	Local surface slope (Eq. 31)
ν	Kinematic viscosity

1. INTRODUCTION

The research conducted in this study is directed toward providing methods applicable to the analysis and design of high-lift systems for modern aircraft. These aircraft often have short takeoff and landing (STOL) performance requirements, which makes the design of the high-lift system critical. Many of these aircraft also have specialized wing sections optimized for cruise, maneuver, or other performance requirements. Empirical and semi-empirical methods for design and analysis currently available are not adequate as they are based on data obtained for high-lift systems of conventional airfoils. Also, the availability of deformable materials has contributed flexibility to the design of high-lift systems and, in order to utilize this potential, methods are required to predict the effect of contour change on aerodynamic performance.

The method described in this report for the analysis of multi-element airfoils in viscous flow (a two-dimensional method) provides only a partial solution to high-lift system design. Before the three-dimensional problem can be solved, it is necessary to develop the two-dimensional approach. Moreover, the optimum configuration arrived at through a two-dimensional analysis can be used to reduce significantly the problems associated with three-dimensional design.

Potential-flow methods for the analysis of two-dimensional multi-element airfoils have been available for some time (Refs. 1 through 4). These methods are based on modeling the flow by a distribution of various types of singularities distributed on the surface or camber line. Aerodynamic forces and moments as well as pressure distributions predicted by these methods show good agreement with experimental data for all cases where the viscous effects are small. But, since for most high-lift systems viscous effects are large because of steeply deflected surfaces and large incidence of onset flow, these methods are not adequate.

At present, no closed-form solution exists for viscous flow over multi-element airfoils, although finite-difference techniques for solving the Navier-Stokes equation hold some promise for the future. However, these methods in general require long computational times.

An approximate method for the analysis of multi-element airfoils in viscous flow is through the inviscid analysis of an equivalent system defined from viscous considerations.

Jacob (Ref. 5) has developed such a method for single-element airfoils that shows very good correlation with experimental data for several Reynolds numbers, including the prediction of C_{Lmax}. He uses a singularity approach and obtains a solution in an iterative manner to satisfy equal pressure conditions at the separation point and the trailing edge. However, this method cannot be directly extended to the analysis of the multi-element airfoil problem.

Stevens, Goradia, and Braden have also developed a method for the analysis of multi-element airfoils in viscous flow (Ref. 6). In this approach, the effect of slot flow as well as the effect of the wake of the forward element on the boundary-layer growth on the rear element (confluent-boundary layer) are taken into account. The precise impact of the mixing process on the airfoil system pressure distribution is not known. The equivalent body is defined in this approach as an airfoil with a sharp trailing edge, with a modification to the camber line and thickness distribution defined from viscous considerations. This model, however, does not permit the analysis of airfoils with separated flow. Results predicted by this approach compare favorably with experimental data below stall.

Callaghan and Beatley have also discussed an approach for the solution of the two-dimensional multi-element airfoil problem (Ref. 7). Their approach is based on semi-empirically defining the value of the boundary-layer displacement thickness past the separation point. This method is apparently still under development. The preliminary results show good agreement with experimental data.

The method developed in the present study is also based on the assumption that an approximate viscous solution can be obtained through an inviscid analysis of an equivalent system defined from viscous considerations. In the following sections, the methods used for the viscous analysis are described. The complex mixing phenomena associated with the interaction of the viscous wake shed from a forward element with the slot efflux and the boundary layer developing on the following element are not considered in this simplified method. The equivalent bodies are defined for two cases, depending on whether boundary-layer separation is present or not. The results calculated by this method are compared with experimental data for several single-element and multi-element airfoils. The FORTRAN listing of the computer procedure, input and output details, and a sample problem are included as appendixes to this report.

2. METHOD DESCRIPTION

The analytical method developed for the analysis of multi-element airfoils in viscous flow is based on the assumption that a viscid solution can be obtained through an inviscid analysis of an appropriate equivalent system. The success of this method depends on a good representation of the equivalent system as well as accurate calculations of the boundary-layer characteristics, including the values of the boundary-layer displacement thickness, the location of the separation and transition points, and the values of the skin friction coefficients. The method therefore can be divided into the following basic parts:

1. Inviscid-flow analysis methods
2. Viscid-flow analysis methods
3. Equivalent-body-definition methods
4. Iteration control scheme.

The iteration cycle used by the method is summarized below and depicted in Figure 1. The first step is to calculate the inviscid, potential-flow pressure distributions. The computed pressure distributions are then used to determine laminar and turbulent boundary-layer displacement thickness, transition-point locations, separation-point locations, and the existence of laminar flow bubbles through the use of boundary-layer prediction techniques. With these boundary-layer characteristics as a basis, an equivalent system is defined for each airfoil part, taking into account predicted separation points. The equivalent system is then analyzed in inviscid flow and the pressure distributions determined. These pressure distributions are compared with the pressure distributions obtained from the previous calculation (potential-flow results are used for the first comparison). If for any point the absolute value of the difference between the C_p calculated and C_p from the previous iteration is greater than 0.15 (arbitrarily chosen number) or greater than 10 percent (arbitrarily chosen) of the calculated C_p value, the iteration cycle is continued by calculating new boundary-layer characteristics based on the latest pressure distributions. When convergence is obtained, the final pressure distributions are integrated to determine the viscous forces and moments. Flow streamlines are also calculated if requested.

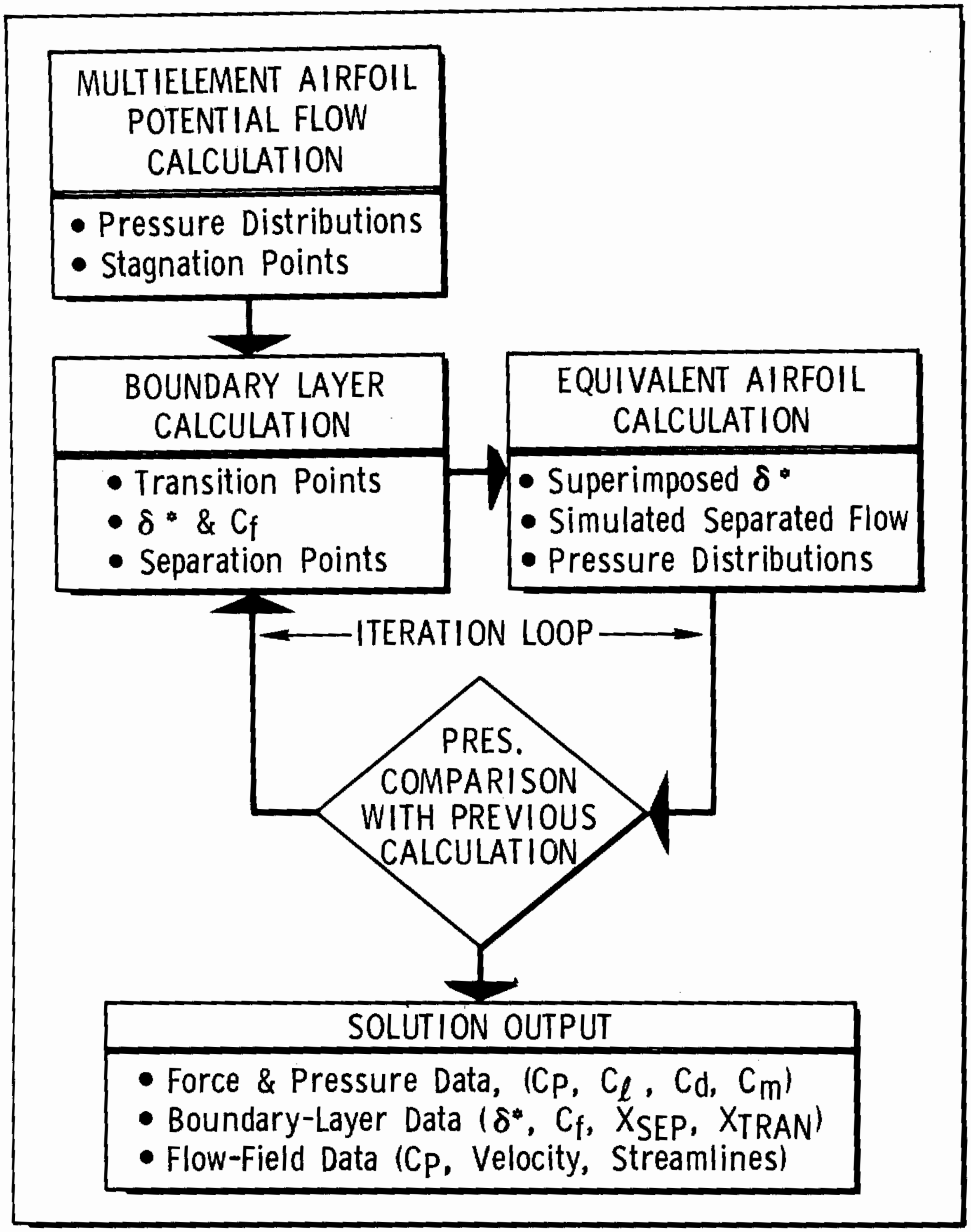

Figure 1 Procedure for the Analysis of Multi-Element Airfoils in Viscous Flow

3. INVISCID-FLOW ANALYSIS

The potential-flow method for the analysis of arbitrary multiple airfoils in viscous flow is described in this section. The extension of this technique to the analysis of airfoil systems with blunt bases is also described. These two methods form the nucleus of the viscous-flow-field analysis procedure, as will be described in later sections.

3.1 Airfoils with Sharp Trailing Edges

The potential flow about an arbitrary system of bodies can be exactly simulated by a vortex sheet of continuously varying vortex density lying on the surface of each body. The strength of the vortex sheet corresponding to each body is established by satisfying the condition of tangential flow everywhere on the body as well as the Kutta condition at the trailing edge of each body. An approximate solution of reasonable accuracy, as will be demonstrated, can be obtained by making the following simplifying assumptions:

1. The vortex sheet of continuously varying vortex density along the body contour can be approximated by a closed polygon formed by a connected series of straight line segments along each of which the vortex density is allowed to vary linearly. The assumed vortex sheet (polygon) is shown schematically in Figure 2. The vertices of the polygon are referred to as corner points.

2. The condition that the flow be parallel to the surface at all points on each body is reduced to the condition that flow be parallel to the surface at the mid-points of the straight line segments of the vortex sheet. These points are referred to as boundary points.

No restrictions are imposed on placing the corner points except that they should be chosen such that the polygon they describe is as close to the shape of the airfoil as possible. This requires that the corner points be closely spaced in regions of large curvature change, e.g., leading-edge regions.

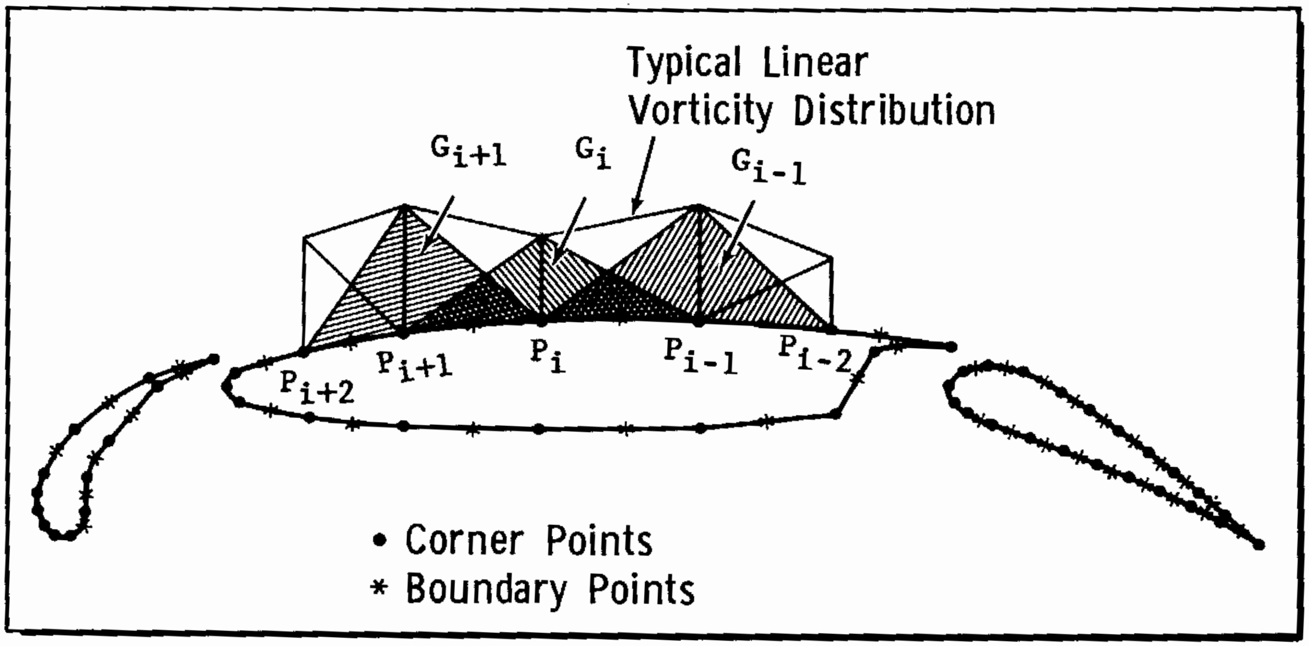

Figure 2 Distributed Singularity Model - Sharp Trailing Edge

As can be seen from Figure 2 the vortex sheet is completely defined in terms of the vorticity strength G_i at the corner points. The linear distribution of G over the ith segment can be considered as the sum of two triangular distributions of G_i and G_{i+1} over this segment. Thus the influence of G_i is spread over both ith and (i-1)th segments, except at the first and last corner points.

The velocity induced by a triangular distribution of vorticity between the ith and (i+1)th corner points (x_i, y_i) and (x_{i+1}, y_{i+1}), respectively, at any boundary point $\bar{x}_k$, $\bar{y}_k$ (not lying between the ith and (i+1)th corner points) can be expressed as a linear function of G_i by use of Biot-Savart's Law (Ref. 8) as

$$\bar{u}_{ki} = D_{ki}\, G_i \qquad (1)$$

$$\bar{v}_{ki} = E_{ki}\, G_i \qquad (2)$$

where

$$D_{ki} = -\frac{\ell_i}{2\pi}\left[(y_i-\bar{y}_k)I_1+(y_{i+1}-2y_i+\bar{y}_k)I_2-(y_{i+1}-y_i)I_3\right] \qquad (3)$$

and

$$E_{ki} = \frac{\ell_i}{2\pi}\left[(x_i-\bar{x}_k)+(x_{i+1}-2x_i+\bar{x}_k)I_2+(x_{i+1}-x_i)I_3\right] \qquad (4)$$

where ℓ_i is the length of the ith segment as shown in Figure 2 and expressed by

$$\ell_i = \left[(x_i-x_{i+1}) \;\; + (y_i-y_{i+1})^2\right]^{\frac{1}{2}} \qquad (5)$$

and I_1, I_2, and I_3 are definite integrals defined by

$$I_1 = \int_o^1 \frac{dp}{f(p)} \qquad (6)$$

$$I_2 = \int_o^1 \frac{pdp}{f(p)} \qquad (7)$$

$$I_3 = \int_o^1 \frac{p^2dp}{f(p)} \qquad (8)$$

where

$$f(p) = a_{ki}^2 + b_{ki}^2 p + \ell_i^2 p^2 \tag{9}$$

where the constants a_{ki} and b_{ki} are defined as

$$a_{ki} = \left[(x_i-\bar{x}_k)^2 + (y_i-\bar{y}_k)^2\right]^{\frac{1}{2}} \tag{10}$$

$$b_{ki} = (a_{k_{i+1}}^2 - a_{k_i}^2 - \ell_i^2)^{\frac{1}{2}} \tag{11}$$

and a_{ki+1} is defined as

$$a_{ki+1} = \left[(x_{i+1}-\bar{x}_k)^2 + (y_{i+1} - \bar{y}_k)^2\right]^{\frac{1}{2}}$$

The integrals given by Equations 6, 7 and 8 can be evaluated as

$$I_1 = \frac{2}{c_{ki}^2}\left[\tan^{-1}\left(\frac{d_{ki}^2}{c_{ki}^2}\right) - \tan^{-1}\left(\frac{b_{ki}^2}{c_{ki}^2}\right)\right] \tag{12}$$

where the constants c_{ki} and d_{ki} are defined as

$$c_{ki} = \left[4a_{ki}^2\ell_i^2 - b_{ki}^4\right]^{\frac{1}{2}} \tag{13}$$

and

$$d_{ki} = \left[2\ell_i^2 + b_{ki}^2\right]^{\frac{1}{2}} \tag{14}$$

and

$$I_2 = \frac{1}{2\ell_i^2}\left[\ell n \frac{a_{ki+1}^2}{a_{ki}^2} - b_{ki}^2 I_1\right] \tag{15}$$

and

$$I_3 = \frac{1}{2\ell_i^4}\left[2\ell_i^2 - \frac{b_{ki}^2}{\ell_i^2}\ell n \frac{a_{ki+1}^2}{a_{ki}^2} + (b_{ki}^4 - 2a_{ki}^2\ell_i^2)I_1\right] \tag{16}$$

Similarly, the velocity induced by the triangular distribution of G over the (i-1)th segment between the corner points (x_i, y_i) and (x_{i-1}, y_{i-1}) at the kth boundary point $(\bar{x}_k, \bar{y}_k)$ can be expressed as

$$\bar{\bar{u}}_{ki} = F_{ki} G_i \tag{17}$$

$$\bar{\bar{v}}_{ki} = H_{ki} G_i \tag{18}$$

where F_{ki} and H_{ki} are defined in a manner similar to D_{ki} and E_{ki}, respectively. Then the component of velocity at the kth boundary induced by G_i can be written as

$$u_{ki} = A_{ki} G_i \tag{19}$$

$$v_{ki} = B_{ki} G_i \tag{20}$$

where

$$A_{ki} = D_{ki} + F_{ki} \tag{21}$$

$$B_{ki} = E_{ki} + H_{ki} \tag{22}$$

The G's corresponding to the first corner point on any airfoil part F_{ki} and H_{ki} are assumed to be zero, and for the last corner point on any airfoil part D_{ki} and E_{ki} are assumed to be zero. For the condition when $(\bar{x}_k, \bar{y}_k)$ is at the midpoint of either the line joining points (x_i, y_i) and (x_{i+1}, y_{i+1}) or the line joining the points (x_i, y_i) and (x_{i-1}, y_{i-1}), a concentrated vortex is assumed at the point (x_i, y_i). The strength of this equivalent vortex G_E is assumed to be equal to the integrated value of G over the segment given by

$$G_E = \frac{1}{2} G_i \ell_j \tag{23}$$

where ℓ_j is the length of either the ith or (i-1)th linear segment of the airfoil. Under this condition, the induced velocity is given by using the formulas for concentrated vortices as

$$u_{ki} = I_{ki} G_i \tag{24}$$

$$v_{ki} = J_{ki} G_i \tag{25}$$

where

$$I_{ki} = -\frac{\ell_i}{4\pi}\left[\frac{y_i - \bar{y}_k}{(x_i-\bar{x}_k)^2 + (y_i-\bar{y}_k)^2}\right] \tag{26}$$

$$J_{ki} = \frac{\ell_i}{4\pi}\left[\frac{x_i - \bar{x}_k}{(x_i-\bar{x}_k)^2 + (y_i-\bar{y}_k)^2}\right] \tag{27}$$

The velocity at the kth boundary point can be expressed as the sum of the velocity induced by the vortex system and the freestream velocity, i.e., as

$$u_k = \sum_{i=1}^{N} A_{ki}G_i + U_\infty \cos\alpha \tag{28}$$

$$v_k = \sum_{i=1}^{N} B_{ki}G_i + U_\infty \sin\alpha \tag{29}$$

where the summation is carried out over the total number of corner points N of the system, α is the freestream flow inclination to the x axis (chosen to be parallel to the reference chord of the system), and U_∞ is the freestream velocity.

Satisfying the condition of zero normal flow at each boundary point gives the following equation:

$$\sum_{i=1}^{N} (A_{ki} \sin \theta_k - B_{ki} \cos \theta_k)G_i =$$

$$- U_\infty(\sin\alpha \cos \theta_k - \cos\alpha \sin \theta_k) \tag{30}$$

where θ_k is the local surface slope at the kth boundary point and assumed equal to the slope of the line joining the kth and (k+1)th corner points given by

$$\theta = \tan^{-1}\left[\frac{y_{k+1} - y_k}{x_{k+1} - x_k}\right] \tag{31}$$

Equation 30 can be written as

$$\sum_{i=1}^{N} P_{ki}G_i = B_k \tag{32}$$

where P_{ki} is referred to as the influence coefficient of the <u>ith</u> vortex at the k<u>th</u> boundary point. An equation of this type can be generated for each boundary point.

As can be seen from Figure 2, the number of boundary points on any airfoil part is one less than the number of corner points. Therefore, to obtain a square system of equations, one additional equation is required per airfoil part. The Kutta condition is used to give this equation, and it can be formed in either of the following two ways:

1. A pseudo boundary point is specified at a point very close (approximately 10^{-5} chord) to the trailing edge. A condition of tangential flow in a direction which is the average of the slope of the upper and lower surface slopes at the trailing edge is satisfied at this point. In this case an equation similar to Equation 32 results.

2. The net vorticity at the trailing edge is required to be zero. This gives an equation of the form

$$G_{F_j} + G_{L_j} = 0 \tag{33}$$

where G_{F_j} is the vortex strength at the first corner point and G_{L_j} is the vortex strength at the last corner point of airfoil part 'j'.

Equations of the type of Equation 32 obtained by satisfying the tangential flow condition at the boundary points coupled with the equations resulting from satisfying the Kutta condition can be written in matrix form as

$$[A][G] = [B] \tag{34}$$

where [A] is referred to as the influence coefficient matrix, [G] is the matrix of unknown vortex strengths, and [B] is the right-hand side matrix. This matrix can be readily inverted to give a solution for the G's.

The velocity at each boundary point can then be found as the sum of the freestream velocity, the velocity induced by the vortex system, and the velocity discontinuity induced by the local vortex sheet density in the tangential direction. This can be expressed as

$$u_k = U_\infty \cos\alpha + \sum_{i=1}^{N} A_{ki} G_i + \frac{1}{4}(G_k + G_{k+1}) \cos \theta_k \qquad (35)$$

$$v_k = U_\infty \sin\alpha + \sum_{i=1}^{N} B_{ki} G_i + \frac{1}{4}(G_k + G_{k+1}) \sin \theta_k \qquad (36)$$

The pressure coefficients can now be calculated from the incompressible relations given by

$$C_{p_k} = 1 - \left[\frac{u_k^{\,2} + v_k^{\,2}}{U_\infty^{\,2}} \right] \qquad (37)$$

The pressures are then numerically integrated and resolved to give force and moment coefficients as discussed in Subsection 4.5.

The validity of this method was evaluated by a comparison of results predicted by this method with experimental data. Typical comparisons for an NACA 23012 airfoil with single-slotted trailing-edge flap and leading-edge slat (Ref. 9) are shown in Figures 3 and 4. For a flap deflection of 20 degrees (Fig. 3), viscous effects are relatively small and good agreement is exhibited between experimental and theoretical pressure distributions. However, for a flap deflection of 40 degrees (Fig. 4), the viscous effects are significant and experimental data indicate separation on the upper surface of the flap trailing edge. In this case the agreement between experimental and theoretical results is only fair. It is to be noted that flow separation on the flap not only reduces the load carried by the flap but also reduces the load carried by the main airfoil and slat because of a decrease in the total flow circulation.

3.2 Airfoils with Blunt Trailing Edges

The method discussed above has been extended to permit the analysis of airfoils with finite-thickness trailing edges.

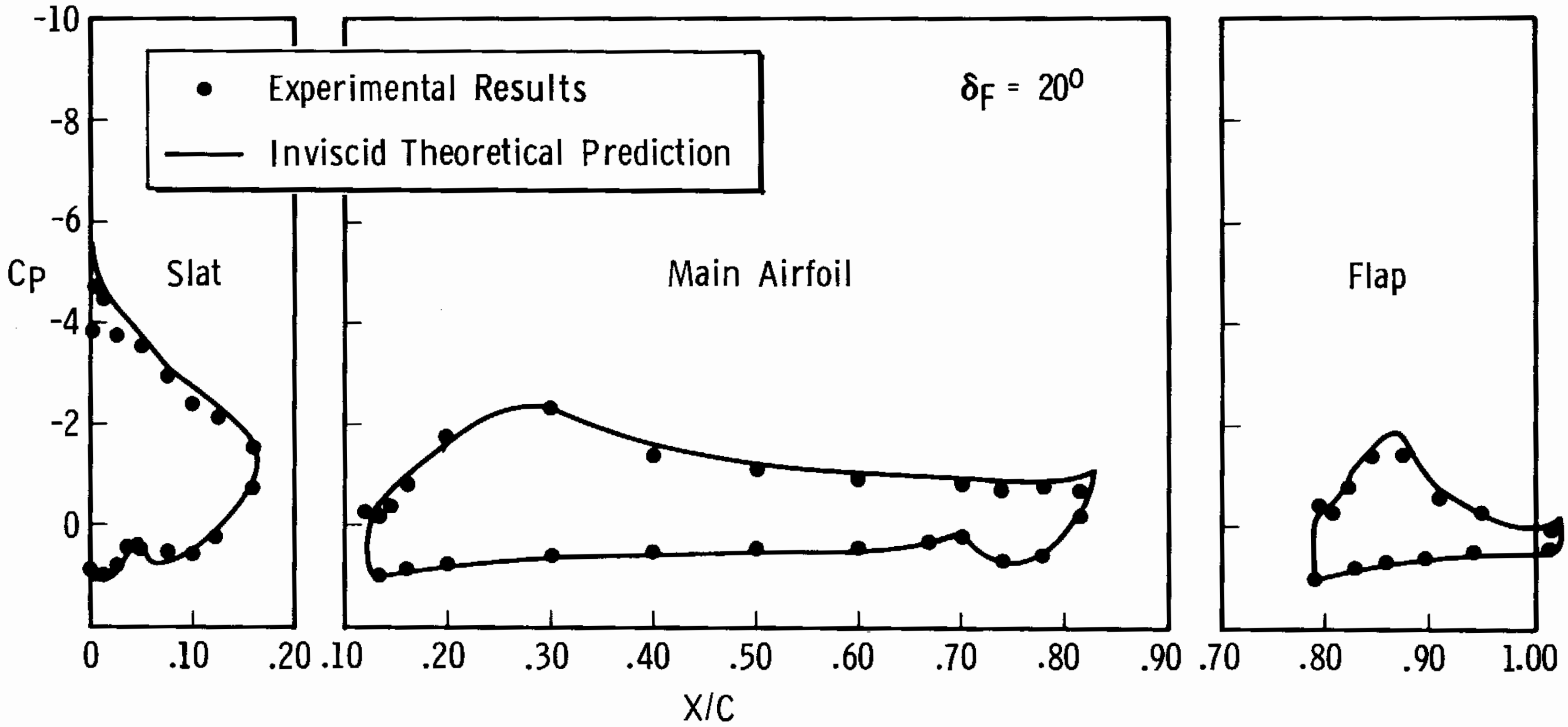

Figure 3 Comparison Between Experimental and Potential Flow Results. NACA 23012 Airfoil with Slat and Flap Deflected 20^o, $\alpha = 8^o$

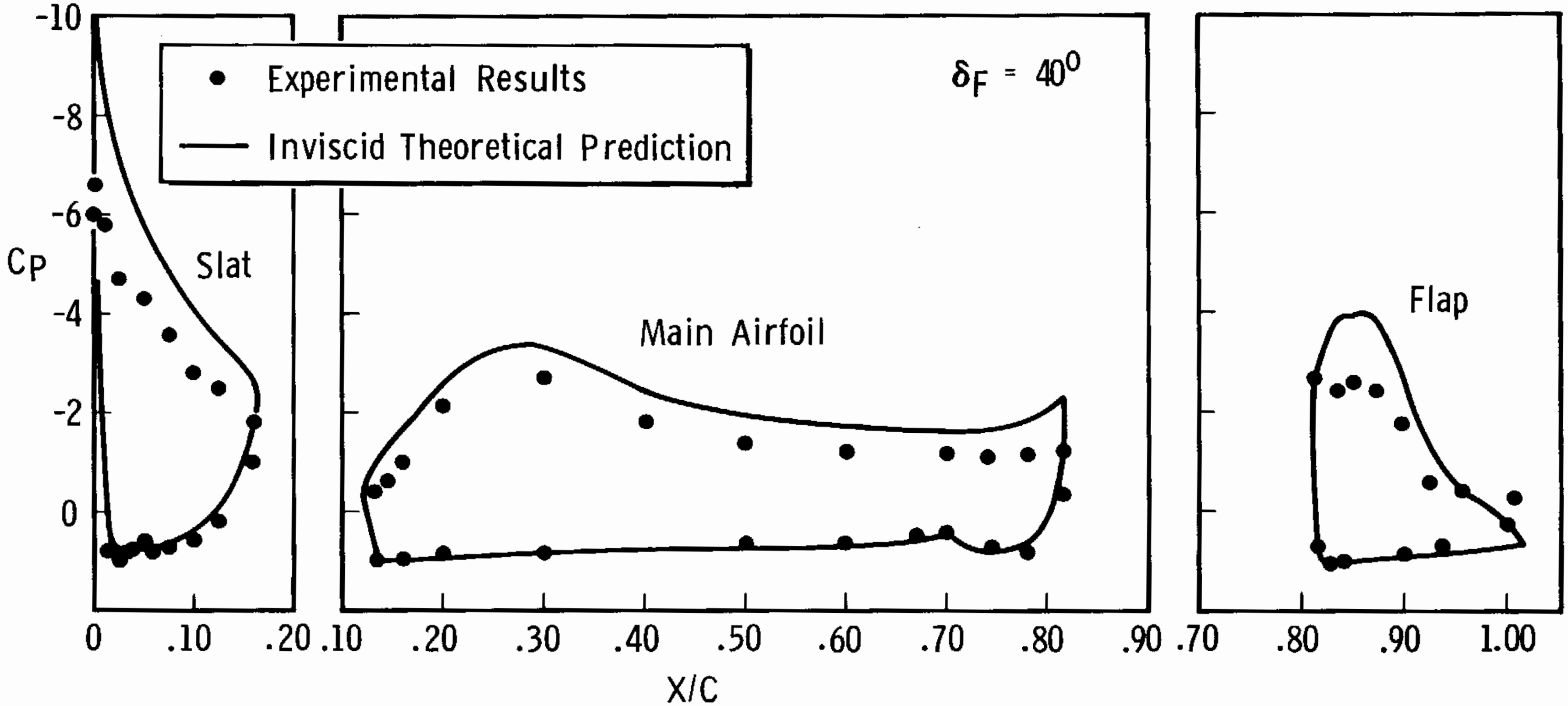

Figure 4 Comparison Between Experimental and Potential Flow Results, NACA 23012 Airfoil with Slat and Flap Deflected 40°, $\alpha = 8°$

The mathematical model used is illustrated in Figure 5. The model is similar to the model used for the potential-flow analysis of airfoils with sharp trailing edges except for the following differences:

1. The vortex sheet defining the airfoil is an open-sided polygon instead of a closed polygon, i.e., the vortex sheet does not span the blunt trailing edge.

2. A concentrated source singularity of unknown strength is embedded within the contour of each airfoil.

The velocity induced at any boundary point can be expressed as

$$u_k = \sum_{i=1}^{N} A_{ki} G_i + \sum_{j=1}^{N_s} R_{kj} M_j + U_\infty \cos\alpha \tag{38}$$

$$v_k = \sum_{i=1}^{N} B_{ki} G_i + \sum_{j=1}^{N} S_{kj} M_j + U_\infty \sin\alpha \tag{39}$$

where A_{ki} and B_{ki} are the same as defined in Equations 21 and 22 and M_j are the unknown source strengths, N_s is the number of airfoil parts, and R_{kj} and S_{kj} are given by

$$R_{kj} = \frac{1}{2\pi}\left[\frac{s_j - \bar{x}_k}{(s_j-\bar{x}_k)^2 + (t_j-\bar{y}_k)^2}\right] \tag{40}$$

$$S_{kj} = \frac{1}{2\pi}\left[\frac{t_j - \bar{y}_k}{(s_j-\bar{x}_k)^2 + (t_j-\bar{y}_k)^2}\right] \tag{41}$$

where (s_j, t_j) are the coordinates of the point where the source is located on airfoil part j.

If the vortex and source singularities are combined, these equations reduce to the form

$$u_k = \sum_{i=1}^{N+Ns} M_{ki} S_i + U_\infty \cos\alpha \tag{42}$$

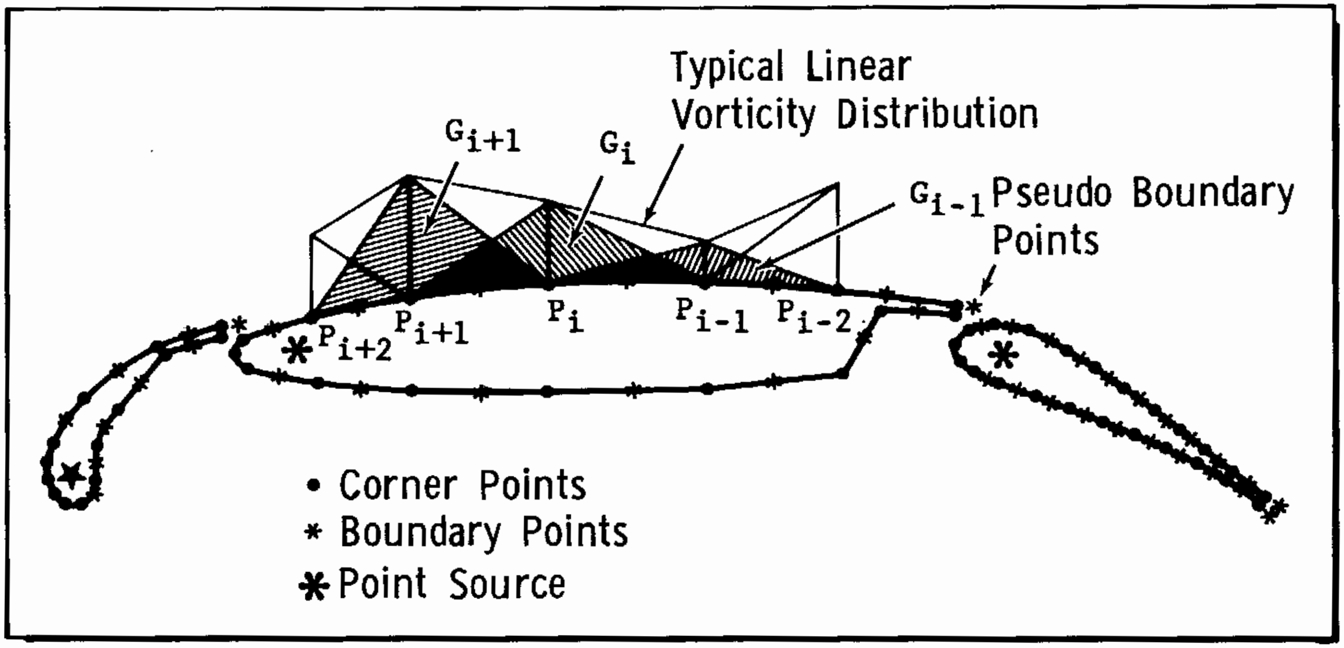

Figure 5   Distributed Singularity Model - Blunt Trailing Edge

$$v_k = \sum_{i=1}^{N+Ns} N_{ki} S_i + U_\infty \cos\alpha \tag{43}$$

where

$$S_i = G_i \text{ for } 1 \leq i \leq N \tag{44}$$

$$S_i = M_{i-N} \text{ for } N+1 \leq i \leq N+Ns \tag{45}$$

and

$$\left.\begin{aligned} M_{ki} &= A_{ki} \\ N_{ki} &= B_{ki} \end{aligned}\right\} \text{ for } 1 \leq i \leq N \tag{46}$$

and

$$\left.\begin{aligned} M_{ki} &= R_{ki-N} \\ N_{ki} &= S_{ki-N} \end{aligned}\right\} \text{ for } N+1 \leq i \leq N+Ns \tag{47}$$

Satisfying the condition of the tangential flow at the k<u>th</u> boundary point gives

$$\sum_{i=1}^{N+Ns} (M_{ki} \sin \theta_k - N_{ki} \cos \theta_k) S_i =$$

$$U_\infty (\cos\alpha \sin \theta_k - \sin\alpha \cos \theta_k) \tag{48}$$

where θ_k is the local surface slope. Equation 48 can be written as

$$\sum_{i=1}^{N+Ns} T_{ki} S_i = c_k \tag{49}$$

where T_{ki} is referred to as the influence coefficient associated with the i<u>th</u> singularity (vortex or source, depending on the value of i) at the k<u>th</u> boundary point. An equation of type of Equation 49 can be generated for each boundary point.

As can be seen from Figure 5, the number of unknown singularities on each airfoil part is equal to the number of corner points plus one, while the number of boundary points on each airfoil part is equal to one less than the number of corner points. Therefore to obtain a square system of linear equations two additional equations need to be generated per airfoil part. This is accomplished by specifying two pseudo boundary points just behind the trailing edge on both the upper and lower surfaces of each airfoil, as shown in Figure 5. The condition of continued tangential flow to the last surface element is satisfied at these pseudo boundary points and results in an equation of the same type as Equation 49. The resulting system can now be written in matrix form as

$$\left[\bar{A}\right]\left[S\right] = \left[\bar{B}\right] \qquad (50)$$

where $[\bar{A}]$ is the influence coefficient matrix, $[S]$ is the matrix of unknown singularity strengths, and $[\bar{B}]$ is the right-hand-side matrix. Solving this system of linear equations yields the singularity strengths. The velocity at each boundary point can then be found as

$$u_k = U_\infty \cos\alpha + \sum_{i=1}^{N} A_{ki}G_i + \sum_{j=1}^{N} R_{kj}M_j + \frac{1}{4}(G_k+G_{k+1}) \qquad (51)$$

$$v_k = U_\infty \sin\alpha + \sum_{i=1}^{N} B_{ki}G_i + \sum_{j=1}^{N} S_{kj}M_j + \frac{1}{4}(G_k+G_{k+1}) \qquad (52)$$

which again is similar to Equations 35 and 36 except that the velocity contributed by the source singularities is also taken into account. The pressures are calculated by use of the incompressible relationship given by Equation 37 and integrated to give forces, as discussed in Subsection 4.5.

This model for the analysis of airfoils with finite-thickness trailing edges has an additional feature in that wake boundaries are simulated by the outflow generated by the source located within each airfoil. It is pointed out that the internal wake conditions, i.e., the velocity defect in the wake, is not simulated through this analysis but, perhaps, could be approximated by imposing velocity conditions at certain points in the wake. Typical streamline traces, shown in Figure 6, depict the wake boundaries simulated by this method.

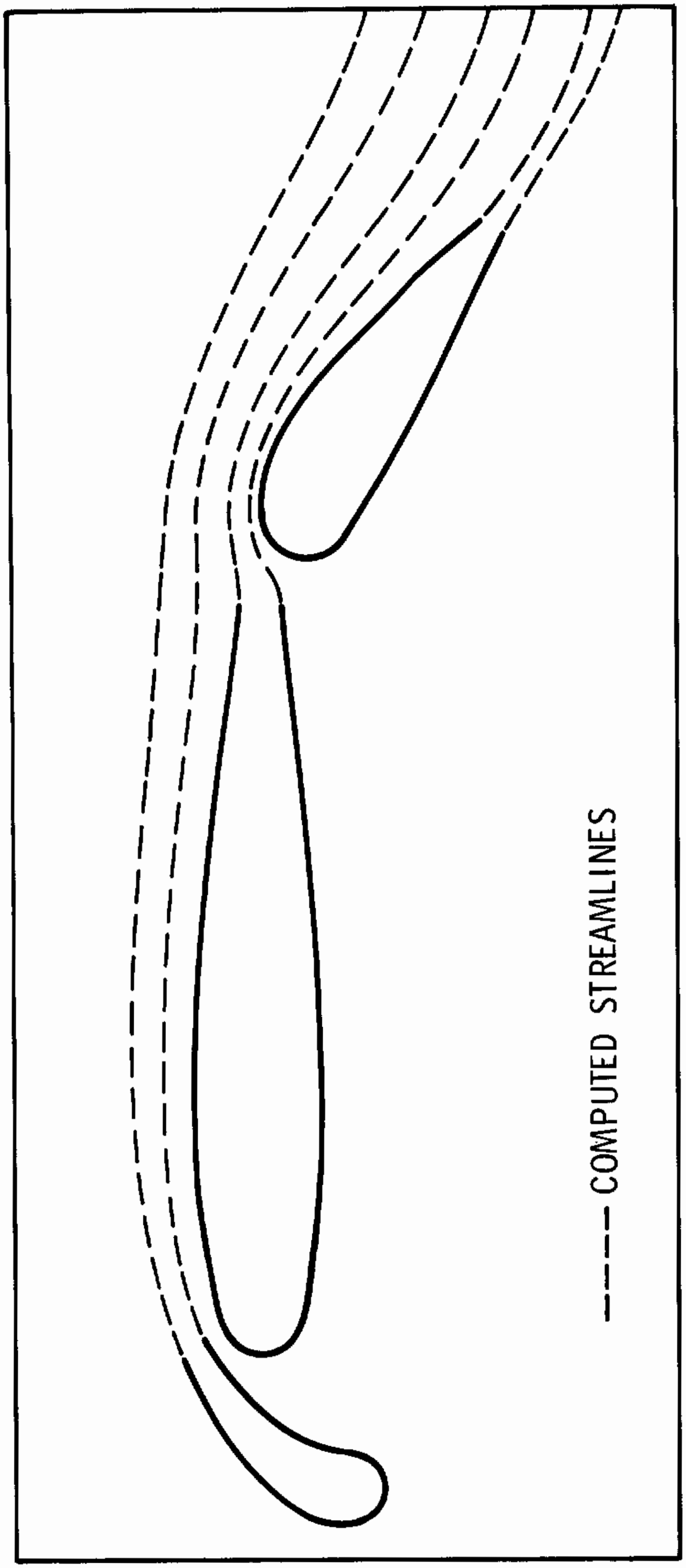

Figure 6 Wake Boundaries Simulated in the Blunt Trailing Edge Analysis

The blunt-trailing-edge-airfoil analysis approach has been evaluated by comparison of computed results with experimental data for an F-111 wing section at B.L. 189 (modified NACA 64A210 section), both with and without trailing-edge bluntness. In Figure 7, in which lift and moment data are compared, the incremental effect of trailing-edge thickness is predicted extremely well. In Figures 8, 9, and 10, in which the experimental and theoretical pressure distributions are compared for angles of attack of 4.1, 8.3, and 14.3 degrees, not only the incremental agreement is very good but also the general agreement is good for the lower angles of attack where viscous effects are small.

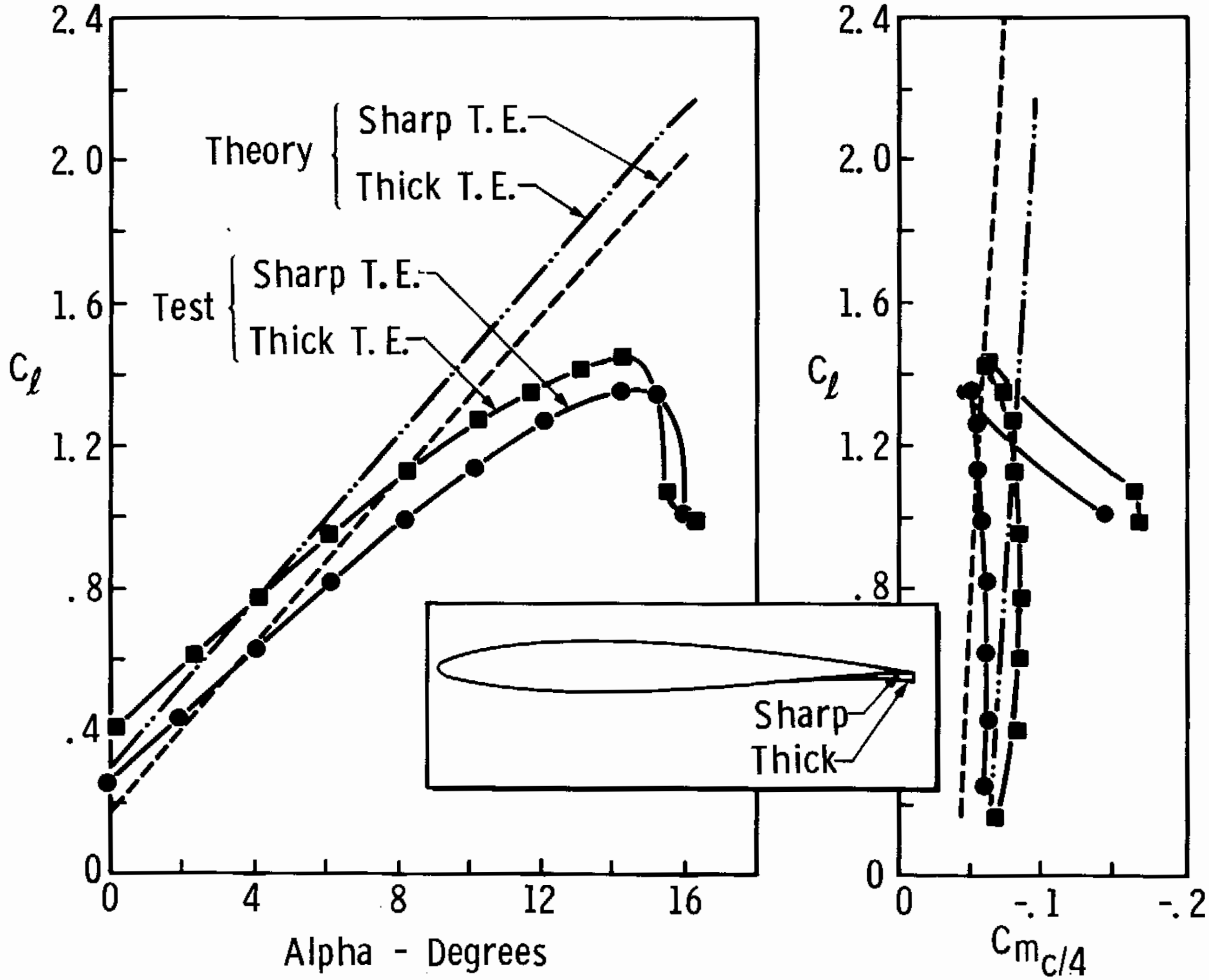

Figure 7   Effect of Trailing Edge Bluntness on Force Data

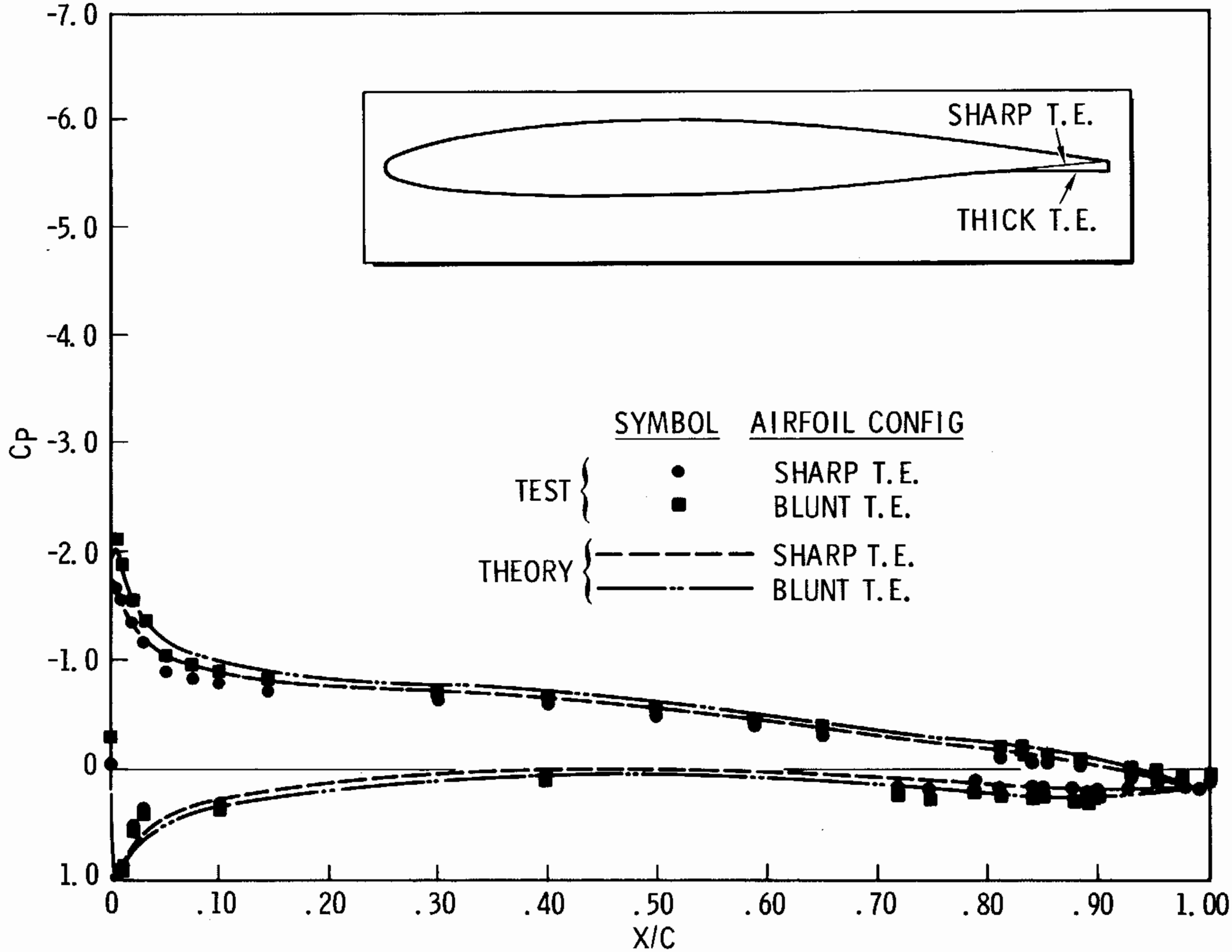

Figure 8 Effect of Trailing Edge Bluntness on Pressure Distributions; $\alpha = 4.1^{\circ}$

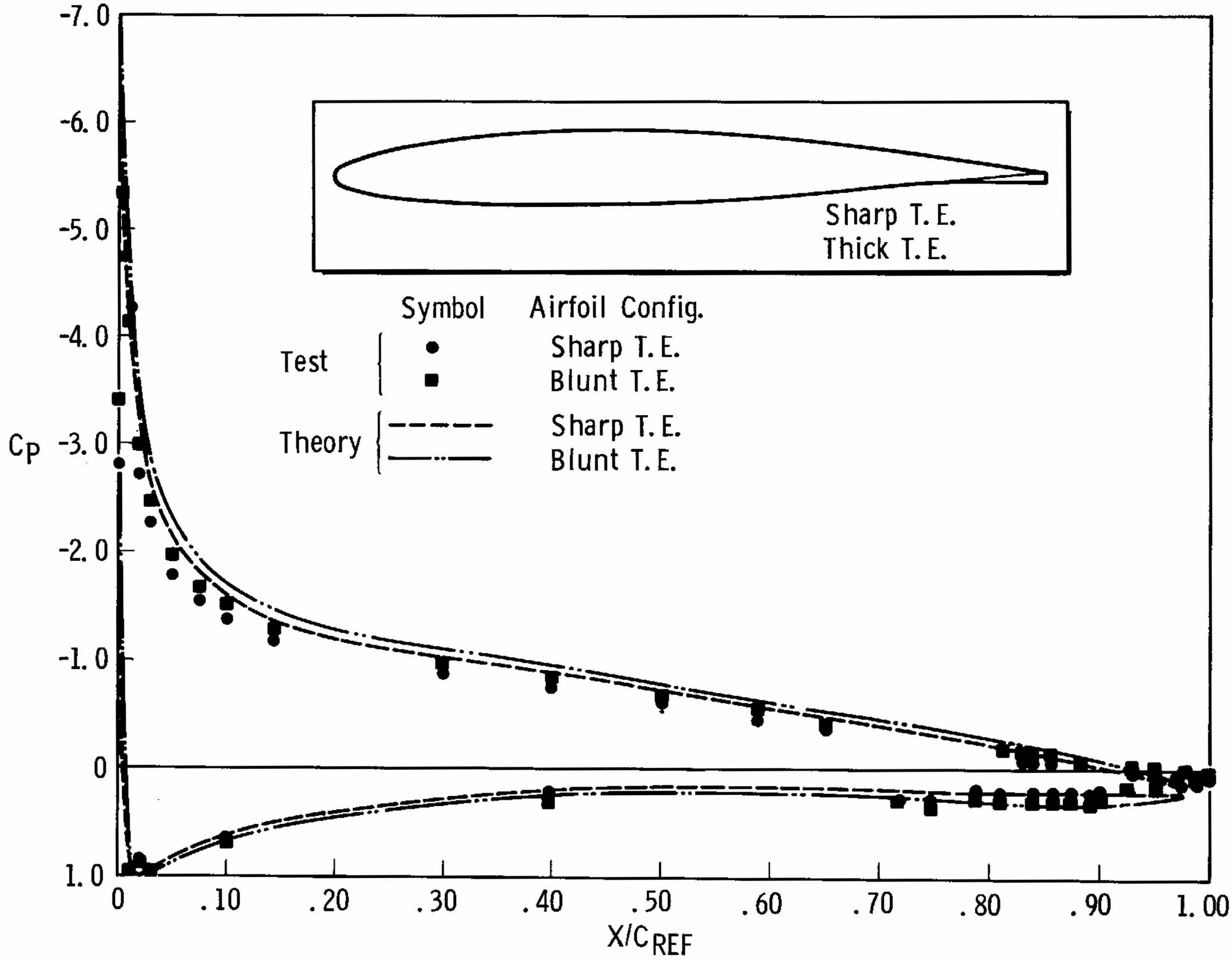

Figure 9 Effect of Trailing Edge Bluntness on Pressure Distributions; $\alpha = 8.3^{\circ}$

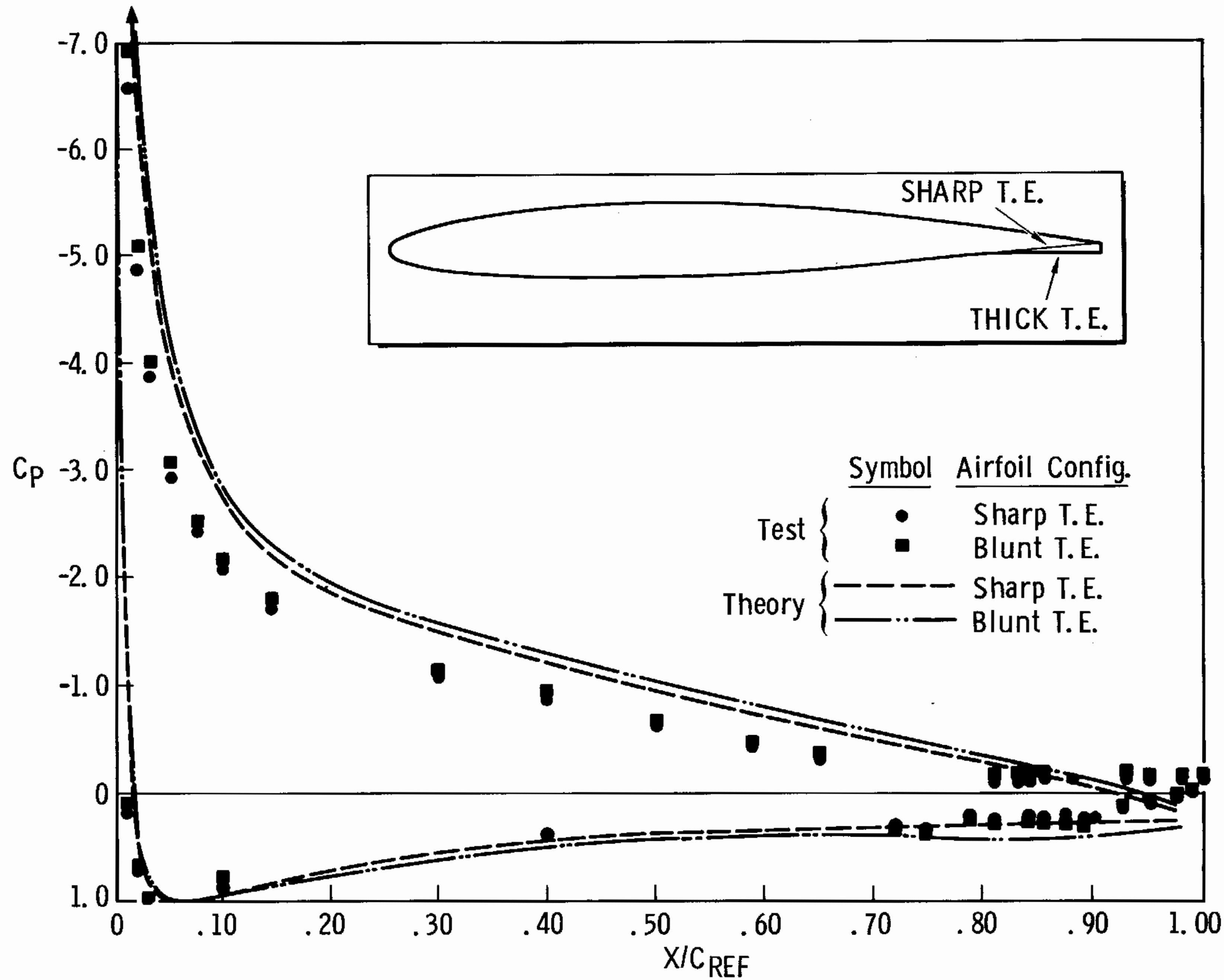

Figure 10 Effect of Trailing Edge Bluntness on Pressure Distributions; $\alpha = 14.3^{\circ}$

4. VISCID-FLOW ANALYSIS

In this section the methods used to predict the boundary-layer characteristics are briefly discussed. The basic method is discussed along with the modifications made to predict transition and separation points and laminar flow bubbles. Also, the method used to calculate aerodynamic forces, including the effects of friction forces, is discussed.

4.1 Boundary-Layer Characteristics

The basic technique used to predict the boundary-layer characteristics is the finite-difference program developed by Cebeci, Smith, and Wang (Ref. 10). In this method, a finite-difference approach is used for solving the laminar- and turbulent-boundary-layer equation for incompressible and compressible flows about two-dimensional and axisymmetric bodies. Currently, the use of the method is restricted to two-dimensional bodies in incompressible flow. In this method, the Reynolds shear-stress term is eliminated by an eddy viscosity concept, and the time mean of the product of fluctuating velocity and temperature appearing in the energy equation is eliminated by an eddy conductivity concept. The turbulent boundary layer is regarded as a composite layer consisting of inner and outer regions for which separate expressions for eddy viscosity are used. The eddy conductivity term is included in a turbulent Prandtl number, which is assumed constant.

In References 10, 11, and 12, the accuracy of this method for predicting the values of displacement and momentum thickness, skin friction coefficients, and separation points is demonstrated through comparison of the results obtained by this method with results from other analytical methods, numerical methods, and experiment. From these comparisons, this method was judged to be the best available.

4.2 Transition-Point Prediction

Two techniques have been incorporated into the method for predicting the location of the transition points on both the upper and lower surface of each airfoil part. The transition points can also be specified on each component of the multi-element systems, or can be assumed to exist at or near the location of the negative-pressure-coefficient peak on both the upper and lower surfaces. This allows the analysis of systems in which transition is artifically induced. However, mixed conditions, where the transition point is specified on some components and calculated on other components of a multi-element system, are not permissible in this analysis procedure to avoid programming complexity.

The first method for predicting transition is based on an extension of Michel's empirical transition correlation curve by Ward (Ref. 13). This method provides a simple, reasonably accurate approximation for the point of transition on an airfoil up to high subsonic speeds. A unique relationship at transition is assumed between the Reynolds number based on momentum thickness, R_θ, and the Reynolds number based on surface distance, R_x, from the stagnation point. The position of the point of transition is defined as that point on the surface where the Reynolds number based on momentum thickness, R_θ, for the laminar boundary layer reaches the transition value $R_{\theta_{tr}}$ as calculated from the empirical relation

$$R_{\theta_{tr}} = 700(R_x \cdot 10^{-6})^{0.435} \tag{53}$$

where the Reynolds numbers are based on the properties in the physical plane defined as

$$R_x = \frac{U_e x}{\nu_e} \tag{54}$$

$$R_\theta = \frac{U_e \theta}{\nu_w} \tag{55}$$

where U_e is the velocity at the edge of the boundary layer, ν_e and ν_w are the values of the kinematic viscosity at the edge of the boundary layer and at the wall, respectively, and x is the developed length measured from the stagnation point. As pointed out by Ward, the best results are obtained with this approximation for two-dimensional low-turbulence flows over smooth airfoils with velocity distributions that are reasonably smooth. Ward's empirical curve is compared with experimental data in Figure 11 (taken from Ref. 14).

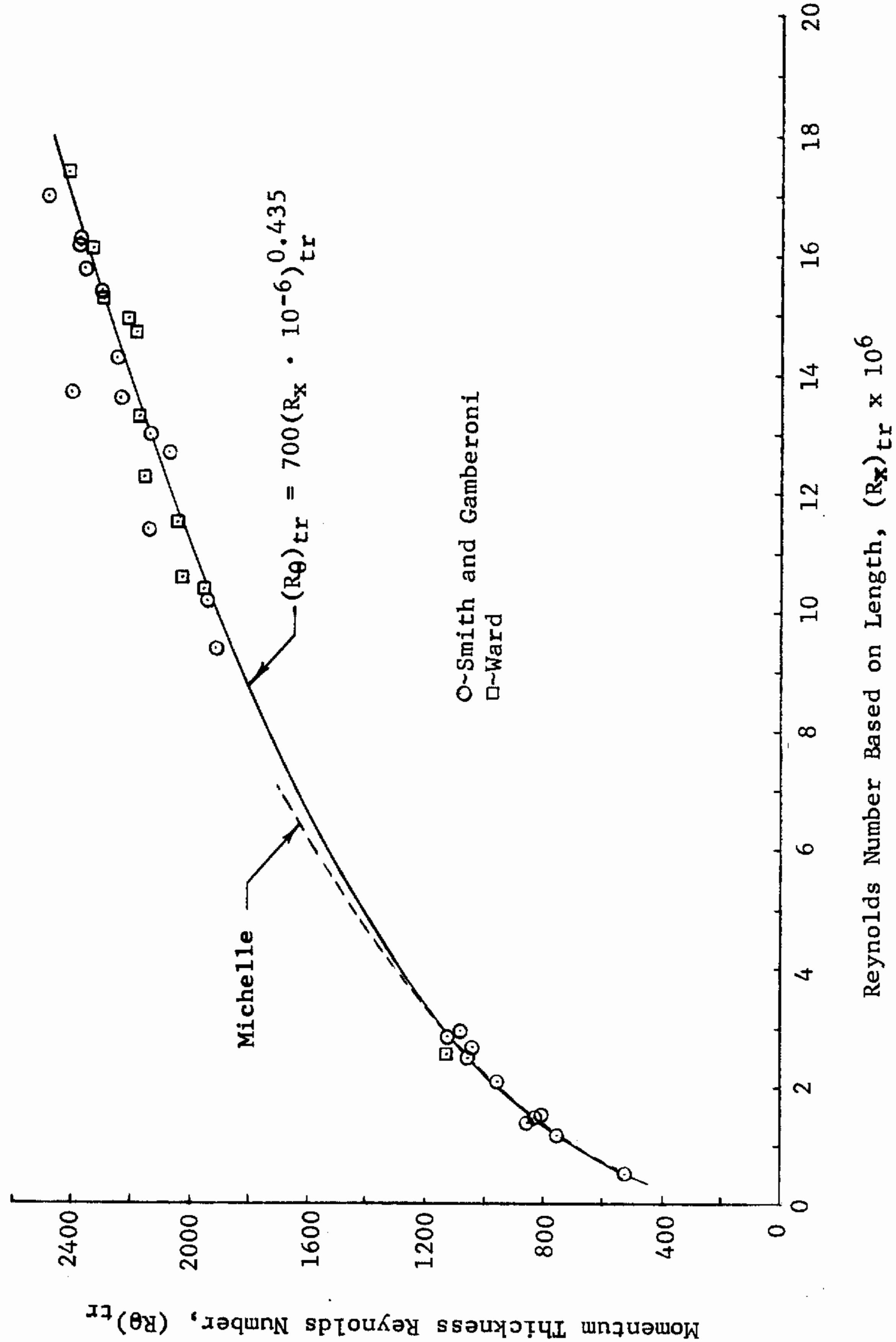

Figure 11 THE TRANSITION-CORRELATION CURVE DEVELOPED BY WARD

The second method for predicting the transition point is based on a theoretical approach due to Schlichting, Ulrich, and Granville (Ref. 15). The method first calculates the boundary layer instability point and then the transition to the turbulent boundary layer.

To predict the boundary layer instability point, the procedure uses the curve shown in Figure 12, derived from the curves of neutral stability calculated by Schlichting and Ulrich for various pressure gradients. It gives the critical Reynolds number based on local momentum thickness $(R_\theta)_{cr}$ as a function of the local shape factor K defined by

$$K = \frac{\theta^2}{\nu}\left(\frac{du_e}{ds}\right) \qquad (56)$$

A curve-fitting procedure was used to derive the following analytical function for $(R_\theta)_{cr}$

$$(R_\theta)_{cr} = \exp\,(5.46714 + 43.3220K + 235.246K^2 - 1934.43K^3 - 30387.9K^4) \qquad (57)$$

At each point downstream of the stagnation point the values of the local Reynolds number based on momentum thickness R_θ and shape factor K are calculated from the value of momentum thickness determined from laminar-boundary-layer calculations. When $R_\theta \geq (R_\theta)_{cr}$ the boundary layer is assumed to have become unstable to external disturbances.

To predict the transition point, the procedure uses the curve shown in Figure 13, which is based on a least-squares approximation of the results of P. S. Granville (Ref. 16). This figure correlates the value of $(M)_{CR}$ with $\bar{K}$, where $(M)_{CR}$ and $\bar{K}$ are defined by the following relations:

$$(M)_{CR} = \left(\frac{U_e\theta}{\nu}\right)_{transition} - \left(\frac{U_e\theta}{\nu}\right)_{stability} \qquad (58)$$

$$\bar{K} = \frac{1}{s/c-(s/c)_{instability}} \int_{(s/c)_{instability}}^{(s/c)} \frac{\theta^2}{\nu}\,\frac{du_e}{d(s/c)}\,d(s/c) \qquad (59)$$

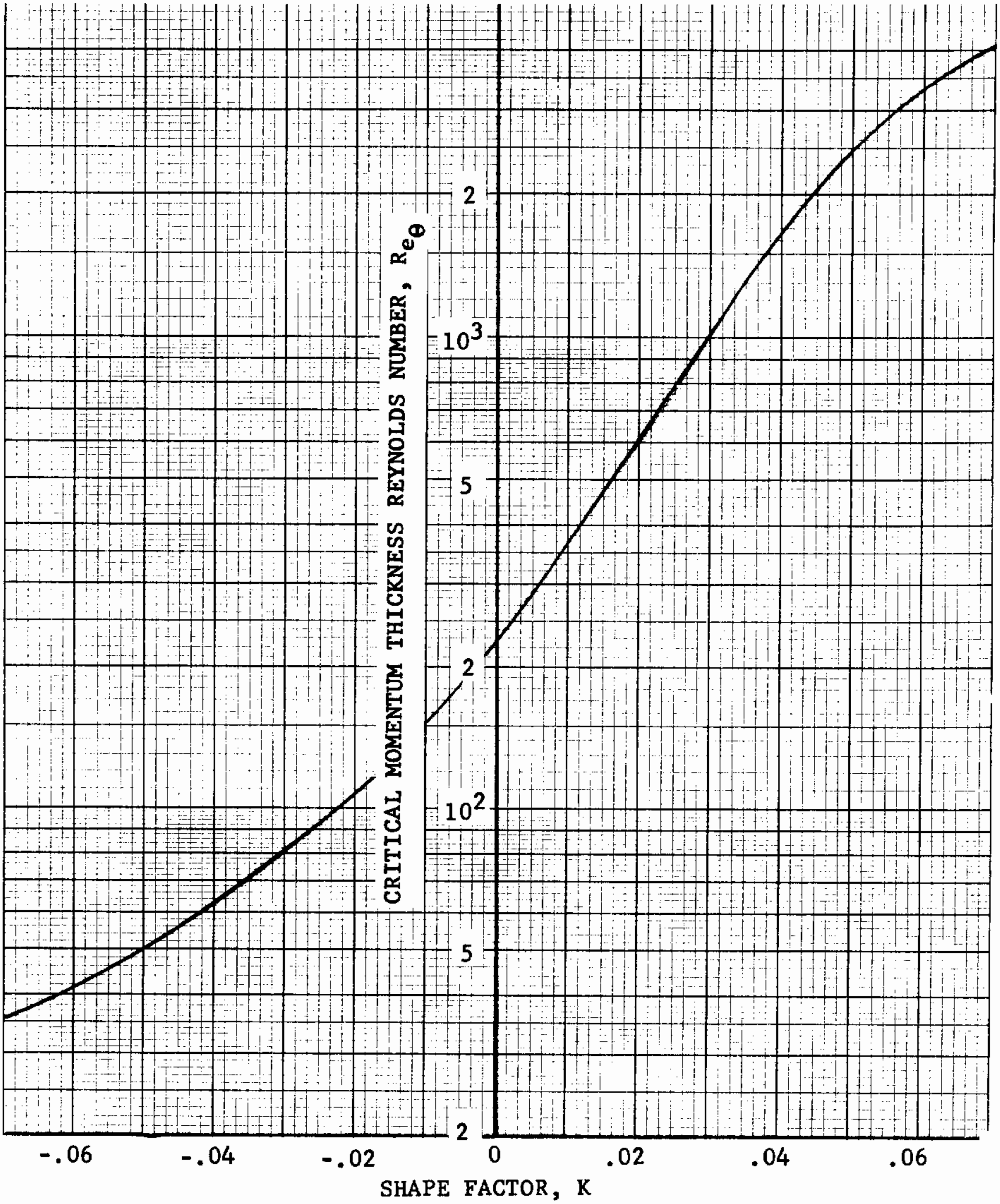

Figure 12 Criteria for Determining Boundary Layer Instability Point

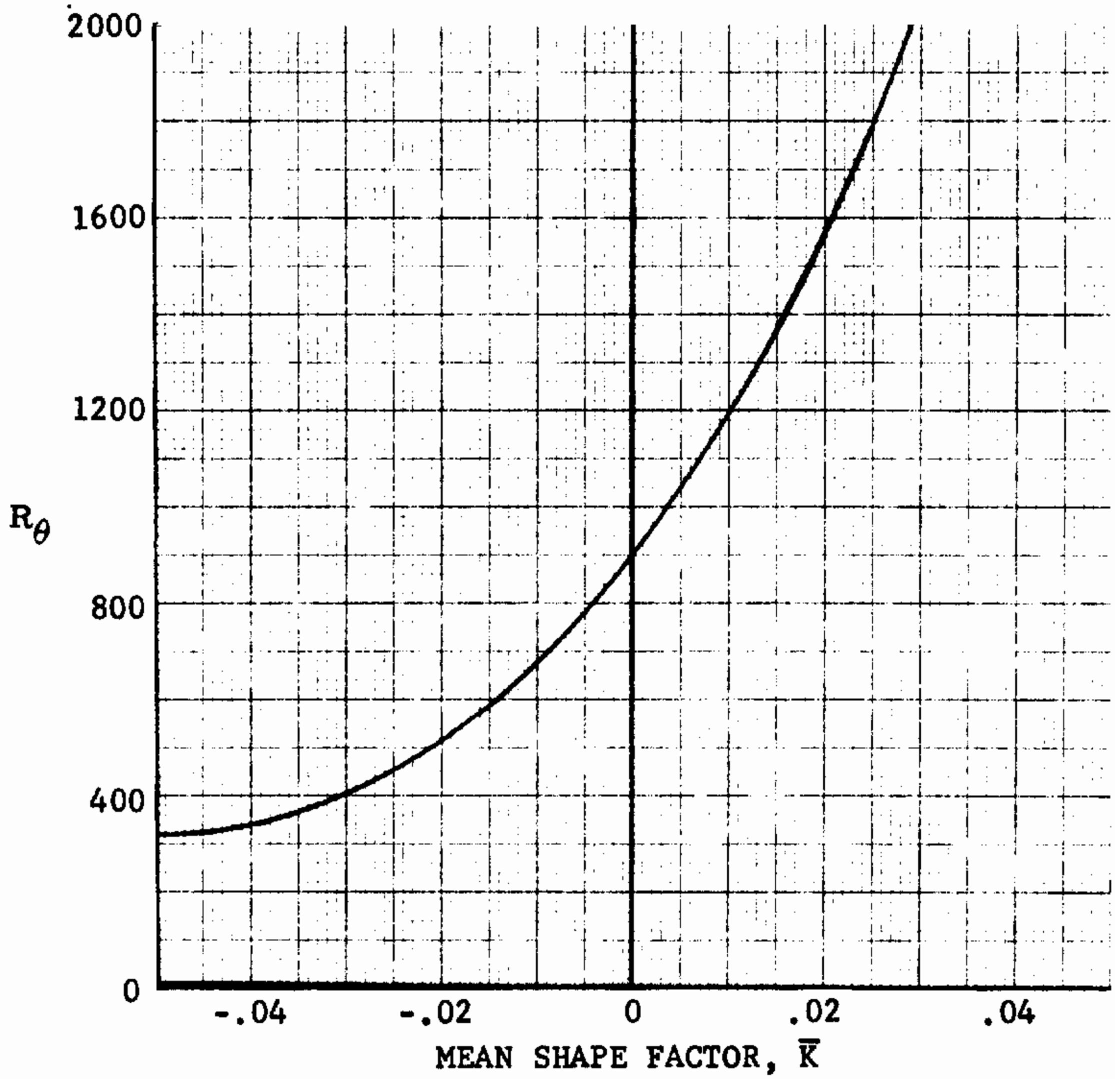

Figure 13 Criteria for Determining Boundary Layer Separation Point

A curve-fitting procedure was used to derive the following analytical function for $(M)_{CR}$

$$(M)_{CR} = \exp\,(6.81066 + 29.2795\bar{K} - 45.679\bar{K}^2 - 2615.87\bar{K}^3 + 38397.8\bar{K}^4) \quad (60)$$

At each point downstream of the instability point, the values of M (Eq. 58 applied to non-transition points) and $\bar{K}$ are calculated through use of the value of momentum thickness determined from laminar-boundary-layer calculations. When $M \geq (M)_{CR}$ the transition from laminar to turbulent boundary layer is assumed.

A detailed investigation of the accuracy of these two methods was not carried out during this study. However, for several cases, it was found that both methods predicted the transition point at the same location. Since the first method is simpler to apply and requires a smaller amount of computer time, it was used extensively in the analysis.

4.3 Separation-Point Prediction

Two techniques have been incorporated for the prediction of the separation point in this method. Separation points calculated by these techniques on the lower surface are ignored in this analysis so as to avoid the condition where separation is present on both the upper and lower surfaces of a body.

The first method for predicting the separation point uses the value of skin friction coefficient calculated by the finite-difference boundary-layer calculation procedure (Ref. 10). A value of skin friction can be specified below which separation will be assumed. Another criterion used by this technique to predict the separation point is based on the mean velocity profile in the boundary layer. Separation is assumed to occur when the velocity gradient at the wall tends to zero or a negative value. When laminar-boundary-layer separation is predicted by this method, a check is made to see if a laminar flow bubble exists by the method discussed below. If a laminar bubble is present, transition is assumed at the separation point and the turbulent-boundary-layer calculations are continued. Laminar separation is assumed only when a bubble burst is indicated.

Correlation between the separation point predicted by this method and experimentally measured separation has been shown to be excellent in Reference 12.

The second technique for predicting the separation point is the Stratford method (Refs. 17, 18, and 19). In this method, no boundary-layer calculations are carried out explicitly. The method relates the separation point to the magnitude of the adverse pressure gradients encountered downstream of the minimum-pressure-coefficient point. Preliminary calculations based on 2-D potential-flow pressure distributions for an airfoil with two highly different leading-edge geometries yield reasonable predictions for the separation locations. The two geometries considered were a fairly sharp leading-edge airfoil and one with a leading-edge Krueger flap. In the case of the sharp leading edge, a particularly good correlation was obtained between the incidence angle at which the theoretical separation point "jumps" from the trailing edge to the leading edge and the experimentally determined incidence angle for maximum lift. This correlation is shown in Figure 14, where the rapid movement of the separation point is evident as the maximum lift condition is approached. For the Krueger flap configuration, the gradual upstream movement of the predicted separation point with increasing incidence is shown in Figure 15. This appears to be consistent with the rather rounded experimental lift curve, which indicates a gradual growth of the separated region.

Both of these methods were evaluated in the viscous flow solution iteration cycle described in Section 1. In all cases, the separation point predicted by the boundary-layer method was downstream of the separation point predicted by the Stratford method. The separation point predicted by the boundary-layer technique was found to be consistent and reasonably accurate for most configurations. The separation point predicted by the Stratford method was found to be erratic and often inconsistent when used in this iterative scheme. For example, the separation point predicted for certain angles of attack was found to be downstream of the separation predicted for lower angles of attack. This discrepancy perhaps can be attributed to the inaccurate calculation of the value of the pressure gradient. When a boundary layer is superimposed on an airfoil contour, the resulting surface is not smoothed and therefore can cause local pressure waviness, which, in turn, can cause large changes in the value of pressure gradient. The method does

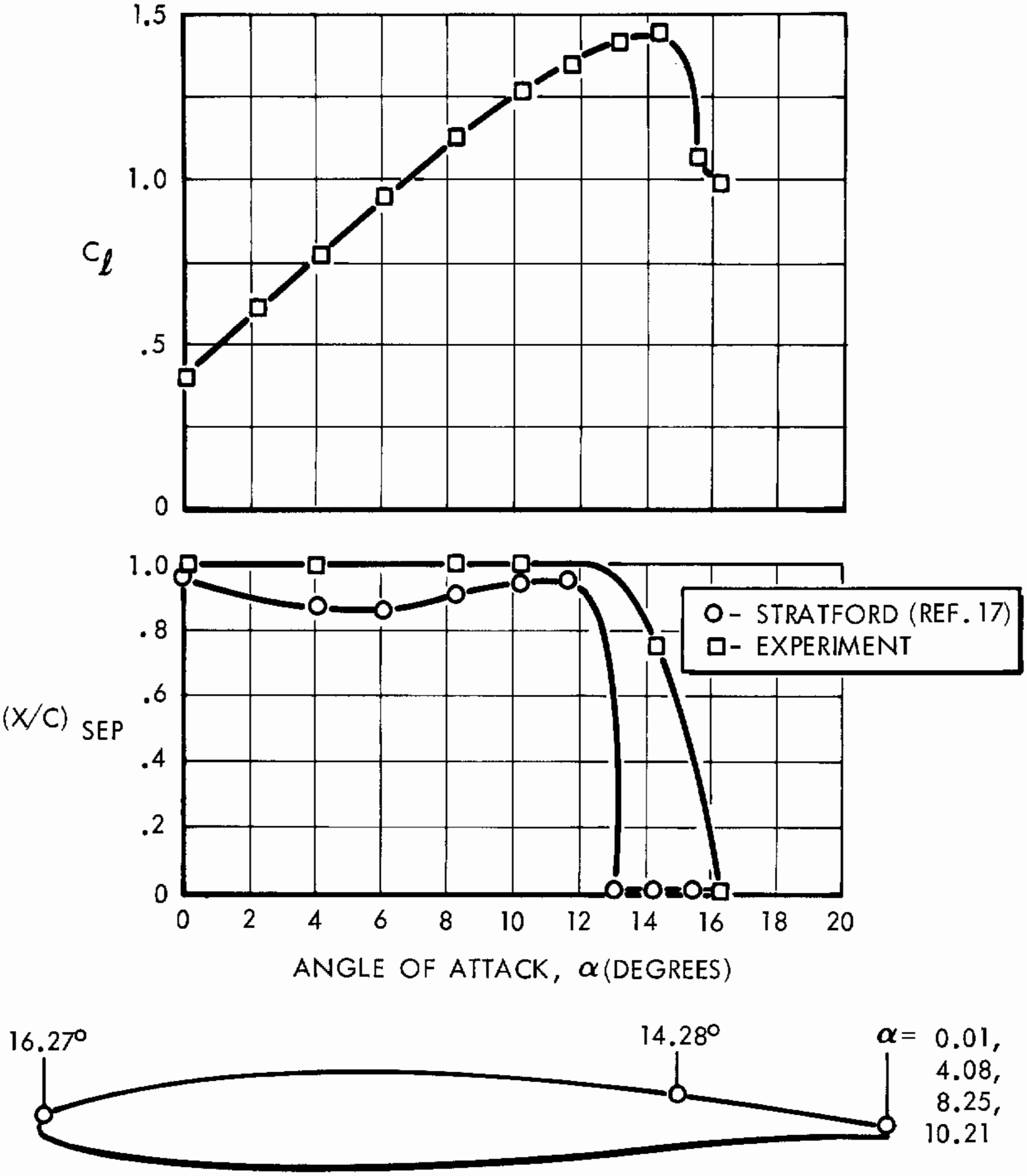

Figure 14 Correlation of Predicted Separation Point Using Stratford's Method for F-111 Wing Section

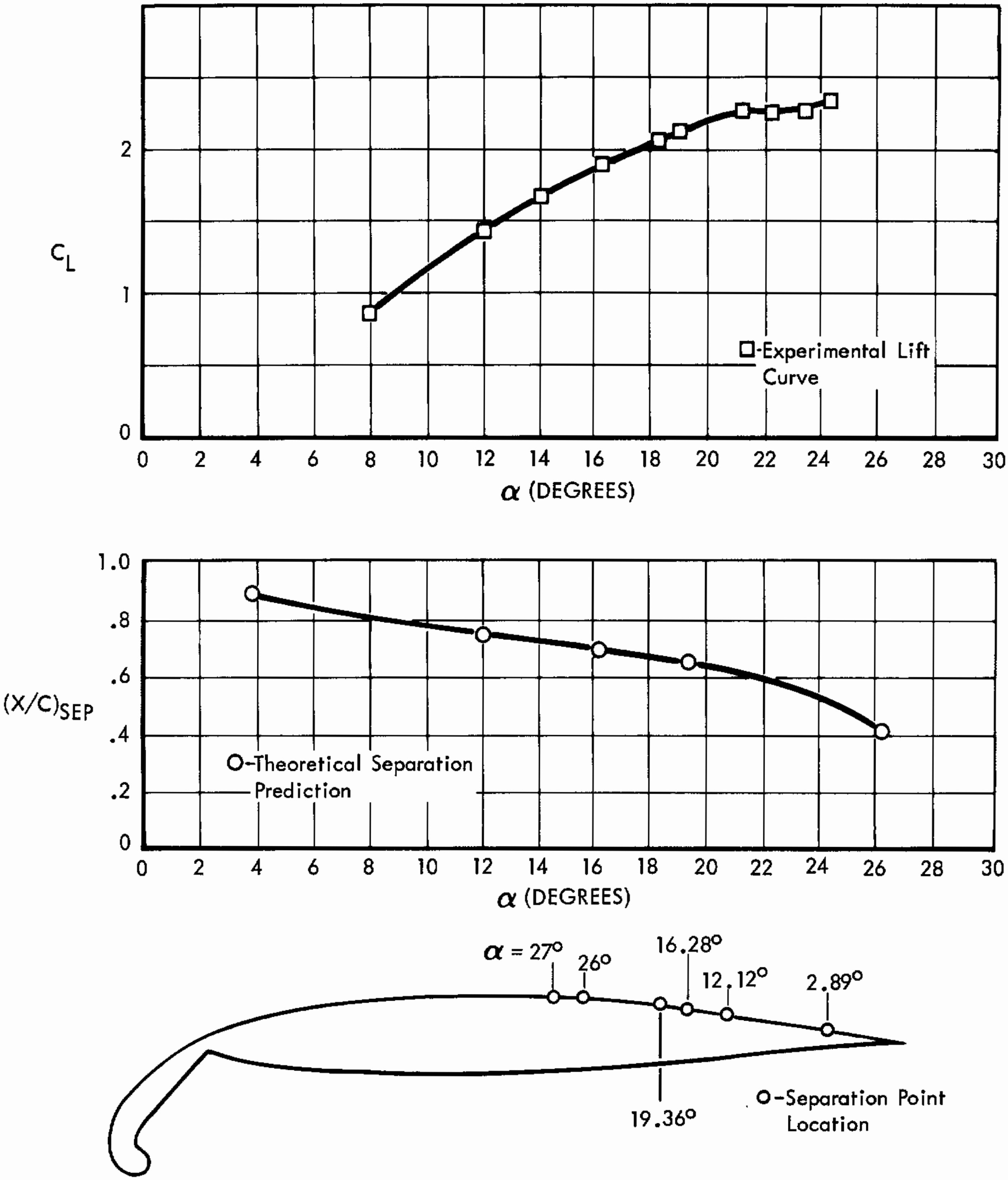

Figure 15 Correlation of Predicted Separation Point Using Stratford's Method for F-111 Wing Section with Leading Edge Flap

not use any technique to smooth either the pressure distribution or the calculated values of pressure gradients and, until such techniques are incorporated, the Stratford method for predicting the incipient separation point is not recommended for use.

4.4 Laminar-Flow-Bubble Prediction

A second type of flow separation has been observed on thin and moderately thin ($t/c \leq 10\%$) airfoils. It is called laminar separation or leading-edge separation, referring to the type and location of the boundary layer present. This separation is characterized by a laminar-boundary-layer separation with a subsequent re-attachment (normally with a turbulent shear layer). Leading-edge separation may be divided into two classes that distinguish the type of separation bubble that is present, a long bubble or a short bubble. The primary difference between the two classes is not the bubble length, but how the bubble changes with airfoil incidence. With increasing airfoil incidence, the short bubble becomes shorter but the long bubble becomes longer. The long bubble results in a significant loss in leading-edge suction (magnitude of Cp_{min} is reduced), while the short bubble produces a very localized effect (small effect on Cp_{min}). The flow characteristics (lift, drag, pressure, etc.) change uniformly with airfoil incidence in the case of the long bubble. The short bubble also yields uniform performance, but only at low and moderate angles of incidence. With increasing incidence, the short bubble reattachment criterion becomes more and more difficult for the flow to satisfy; ultimately, the bubble bursts and the airfoil stalls (typically 50% loss in lift).

The proposed model for separation bubbles is based primarily on the work of Gaster (Ref. 20). When laminar separation is indicated by the methods in Subsection 4.3, it will be assumed that either a short bubble exists or a short bubble has burst. The elimination of the possibility of having a long bubble is necessitated by the lack of information concerning such cases. Actually, this is an acceptable assumption, since long bubbles are normally associated with very thin airfoils (Ref. 21). The criterion is shown in Figure 16. It correlates the critical value of shape factor $(K)_{CR}$ required for a bubble burst to occur for a given value of the Reynolds number based on momentum thickness. The shape factor $(K)_{CR}$ is given by

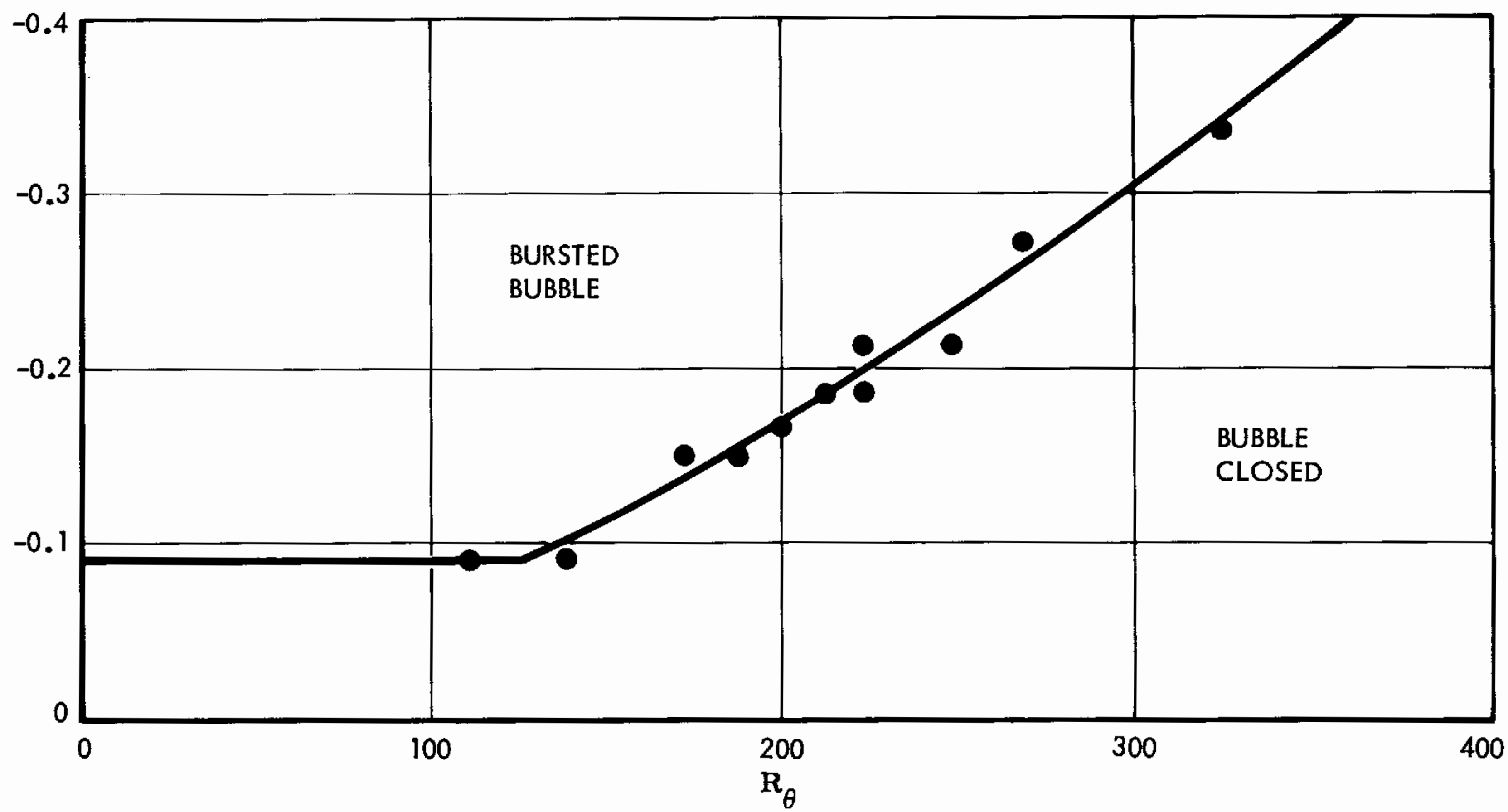

Figure 16 Empirical Criterion for Bursting of Short Laminar Bubbles

$$(K)_{CR} = \frac{\theta^2}{\nu}\left(\frac{du_e}{ds}\right) \qquad (61)$$

The value of θ at the separation point is used to calculate R_θ and K. If $K \geq (K)_{CR}$, a bursted-bubble condition is assumed. If $K < (K)_{CR}$, an attached laminar bubble is assumed.

Methods are available by which the length of the separation bubble and the pressure distribution over the separated region can be estimated (Ref. 22). From linearized theory, a shape can be computed which would approximate the calculated pressure field. However, in this analysis, the flow bubble could not be modeled because in most instances the length of the bubble was found to be smaller than the distance between two consecutive corner points used to define the airfoils. When an attached laminar bubble was indicated, transition was assumed at the separation point and calculation of the turbulent boundary layer was initiated.

When a bursted bubble is indicated, laminar separation is assumed and the flow is handled in the same manner as trailing-edge separation. The separation point is used to define the equivalent airfoil for the next iteration.

4.5 Aerodynamic Force Coefficients

The net force exerted on an airfoil is composed of two components, the pressure force and the friction force. Integrating these surface forces over the entire airfoil and resolving them into components parallel and normal to the freestream defines the airfoil drag and lift, respectively, as:

$$C_d = \oint C_p \cos(\theta-\alpha) + C_f \sin(\theta-\alpha) \quad d\ell \qquad (62)$$

$$C_\ell = \oint C_p \sin(\theta-\alpha) + C_f \cos(\theta-\alpha) \quad d\ell \qquad (63)$$

where

C_p is the local pressure coefficient
C_f is the local skin friction coefficient
α is the angle of incidence
θ is the local surface angle
ℓ is the arc length along the airfoil surface.

For multiple-element airfoils, the integrals for each element are evaluated. The total lift and drag of the system is also computed as the sum of the respective integrals. The pitching moment coefficients of the system and each of its elements are determined by integrating the moments calculated for each linear segment of the airfoil.

The forces are calculated by this method during the first and last iteration cycles only to conserve computer time. During the first iteration, the forces and moments corresponding to the potential-flow solution are obtained by integrating the pressure forces only (friction forces are not included).

The values of skin friction coefficient obtained from the finite-difference boundary-layer program are used to calculate the frictional forces. For those airfoil systems in which separation is indicated on one or more elements, pressures and forces are only calculated for regions where the flow is attached to the surface. A zero value of the skin friction coefficient is assumed over the separated regions of the airfoil. Further, the pressure downstream of the separation point is assumed to be constant and equal to the pressure obtained by linear extrapolation of the last two boundary-point pressures to the separation point.

The forces obtained by this method are compared with experimental data in Section 7. It was found that, although the accuracies of the lift values predicted were acceptable, those of drag were not. This was attributed to the inconsistency in the calculations for pressure drag, which is extremely sensitive to the shape of the pressure distribution--especially in the trailing-edge region. The contribution of friction forces to both lift and drag was found to be reasonable.

5. EQUIVALENT-BODY DEFINITION

The definition of the equivalent body that simulates the viscous phenomena constitutes a critical step in the iterative solution cycle. Two distinct cases occur, depending on whether boundary-layer separation occurs on any given airfoil of a system. The mathematical model for each case is described in the following subsections.

In the analysis of the resulting equivalent multi-element airfoil system, the complex mixing phenomena associated with the interaction of the viscous wake shed from a forward element with the slot efflux and boundary layer developing on the following element has not been considered. This confluent-boundary-layer problem has been investigated by Goradia, as reported in Reference 6. The precise impact of the mixing process on the airfoil-system pressure distribution is not known. Thus, in the interest of simplicity, the effect has been omitted in the present model.

5.1 Attached-Flow Model

The model used for the case when the boundary-layer-calculations predict no flow separation on the upper surface is shown schematically in Figure 17. The equivalent body is obtained by superimposing the boundary-layer displacement thickness normal to the airfoil contour.

The values of the local surface slope and the boundary-layer displacement thickness calculated at adjacent boundary points are linearly interpolated to obtain values of slope and displacement thickness at all the corner points except the first and last. The values of the slope and displacement thickness at the first and last corner points are obtained by linear extrapolation of the values at the first and last boundary points. In order to avoid large extrapolations, the computer program generates an additional corner point located within 5 percent of the first and last section length of the trailing edge. This then generates additional boundary points very close to the trailing edge.

If separation is predicted on the lower surface it is ignored in this analysis. The boundary-layer displacement-thickness values are assumed constant downstream of the separation point and equal to the value of displacement thickness determined at the separation point.

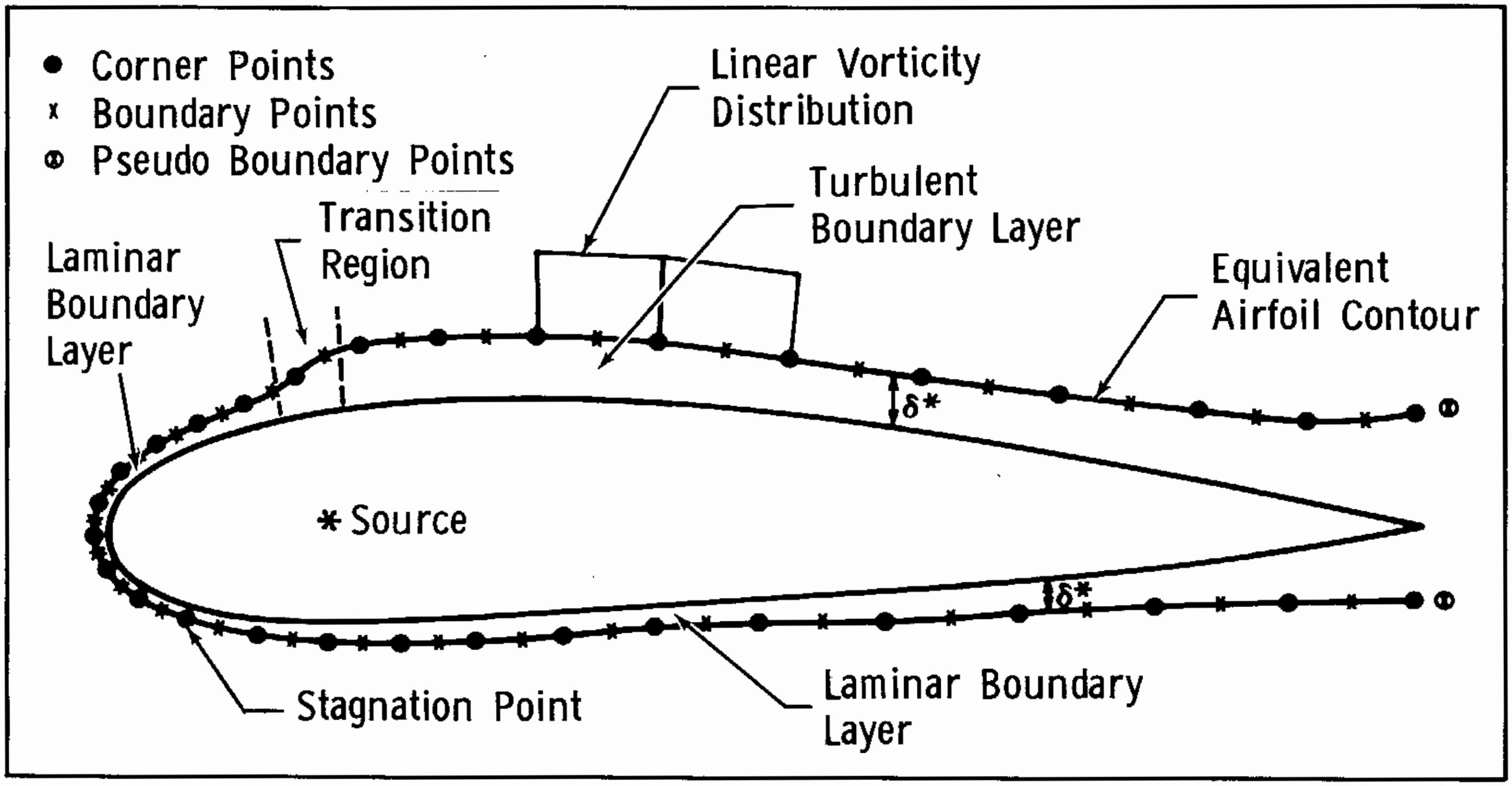

Figure 17 Equivalent Airfoil Model for Attached Flow

For all cases discussed above, the boundary-layer displacement thickness calculated at the trailing edge is finite, and therefore the resulting equivalent body is analogous to an airfoil with a finite-thickness trailing edge. The method for the analysis of airfoils with finite-thickness trailing edges described in Subsection 3.2 is therefore directly applicable.

5.2 Separated-Flow Model

The model used for the case when the boundary-layer calculations predict flow separation on the upper surface of any airfoil is shown schematically in Figure 18. The validity of this model is discussed in Subsection 5.3, and the evolution of the model is described in Subsection 5.4.

A model using the free-separation-streamline approach is used to simulate viscous effects for airfoils where flow separation is indicated. In this method, the conditions of tangential flow are satisfied on only that part of the airfoil having attached flow. The equivalent body is defined by superimposing the boundary-layer displacement thickness normal to the airfoil contour on the lower surface and upstream of the separation point on the upper surface. If flow separation is indicated on the lower surface, it is ignored, and the values of the displacement thickness are obtained in the same manner as described above in Subsection 5.1 for the attached-flow model. Again, to avoid large extrapolation to the values of boundary-layer displacement thickness, two additional corner points are generated very close to the separation point on the upper surface and at the trailing edge on the lower surface. Since no flow control is exercised at points downstream of the separation point on the upper surface, the separation streamline develops freely from the separation point. Two pseudo boundary points are generated very close to but downstream of the separation point on the upper surface and at the trailing edge on the lower surface as shown in Figure 18. The condition of continued tangential flow is satisfied at the pseudo boundary point on the lower surface. A condition on the flow direction, specified by the user, is also satisfied at the pseudo boundary point on the upper surface. This implies that, although the separation streamline is allowed to develop freely downstream of the separation point, the direction at which the flow leaves the surface is specified by the user.

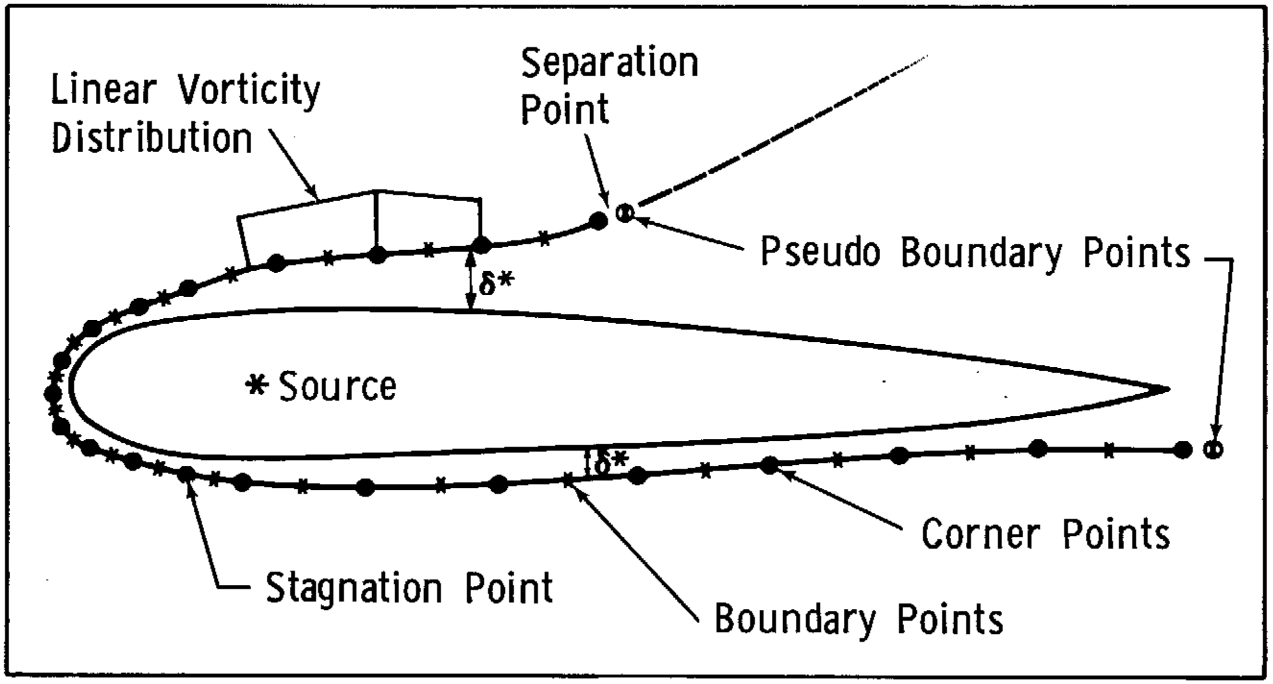

Figure 18 Equivalent Airfoil Model for Separated Flow

For laminar flow, Dobbina, Ingen, and Kooi (Ref. 23) have derived an expression for this angle. No such value of the angle was found for turbulent flows.

The model described above is mathematically identical to the model used to analyze airfoils with finite-thickness bases if the total separated region of the airfoil is considered as a finite-thickness base. The pseudo boundary point just downstream of the upper-surface trailing edge in the blunt-trailing-edge-airfoil analysis model is moved to a point just downstream of the separation point, and the condition of continued tangential flow in blunt-trailing-edge-airfoil analysis is replaced by the condition of flow in a specified direction. Since no boundary points exist in the separated region, no pressures are calculated. The pressure distribution downstream of the separation point is assumed constant and equal to that value of the pressure obtained by linear extrapolation of the last two boundary-point pressures to the separation point.

5.3 Mathematical Model Substantiation

The validity of the free-separation-streamline model was checked by comparing theoretically calculated pressure distributions with experimental data (Ref. 24). Meaningful comparisons require that true two-dimensional data be obtained. High-lift systems in general generate steep adverse pressure gradients and large amounts of flow circulation that tend to cause premature separations near wind tunnel walls due to the interference of model and wall boundary layers. Wall-interference effects on the experimental data used to substantiate the theoretical model were eliminated through use of the blowing-wall test technique. The data utilized in this study were obtained at the 6-ft by 9-ft low-speed tunnel of the National Aeronautical Establishment of the National Research Council, Ottawa, Canada, with a 2-foot-chord model, a nominal Mach number of 0.2, and a Reynolds number of 2.5 million (Ref. 25).

In the comparisons that follow, the equivalent-airfoil theoretical model is evaluated by calculating the pressure distributions with the separation-point location estimated from the experimental data. The specified separation point thus provides a true evaluation of the equivalent-body model independently of the viscous-separation prediction method. The validation of the complete viscous-flow analysis method is discussed in Section 7.

Comparison between experimental and theoretical results are presented for two single-element airfoils and two multi-element airfoils. In all these comparisons, the theoretical results are based on the assumption that the separation streamline leaves the surface in a direction parallel to the local surface slope at the separation point.

For the first comparison, the F-111 wing section at buttock line 189 was used. Excellent correlation between theoretical and experimental lift curves, including $C_{L_{max}}$, was obtained for this configuration, as shown in Figure 19. The location of the separation points used in this analysis are also shown in this figure. The comparisons between experimental and theoretical pressure distributions for this configuration are shown in Figures 20, 21, 22, and 23 for angles of attack of 8.3, 10.2, 14.3, and 15.2 degrees, respectively. The potential-flow pressure distributions are also shown on these figures to emphasize the improvement of the viscous-model solution over the potential-flow solution. For these comparisons, the effect of boundary-layer displacement thickness was not taken into account in the definition of the equivalent body. The displacement effect is small, as will be shown in a following comparison. Excellent correlation between experimental and theoretical results are noted for all angles of attack except in the separated region at the lower angles of attack. It is noted from Figure 19 that $C_{l_{max}}$ occurs at about the 14.5-degree angle of attack.

The comparisons between experimental and theoretical pressure distributions for the F-111 wing section at buttock line 189 with a 22-percent-chord leading-edge flap are shown in Figures 24, 25, and 26 for angles of attack of 18.5, 20.5, and 22.3 degrees, respectively. Potential-flow-analysis results are also shown on these figures. Again, the effect of boundary-layer displacement thickness is ignored in the definition of the equivalent body. Excellent agreement is obtained between experimental and theoretical results for angles of attack of 18.45 and 20.45 degrees except on the lower surface of the leading-edge flap. Here, experimental data seem to indicate a laminar-flow bubble on the lower surface of the leading-edge flap, which was not considered in the theoretical analysis. For the angle of attack of 22.31 degrees, the agreement between theoretical and experimental pressure distributions is only fair. At this angle of attack, the separation point is at 40-percent chord and poor agreement can perhaps be attributed to the large region of separated flow.

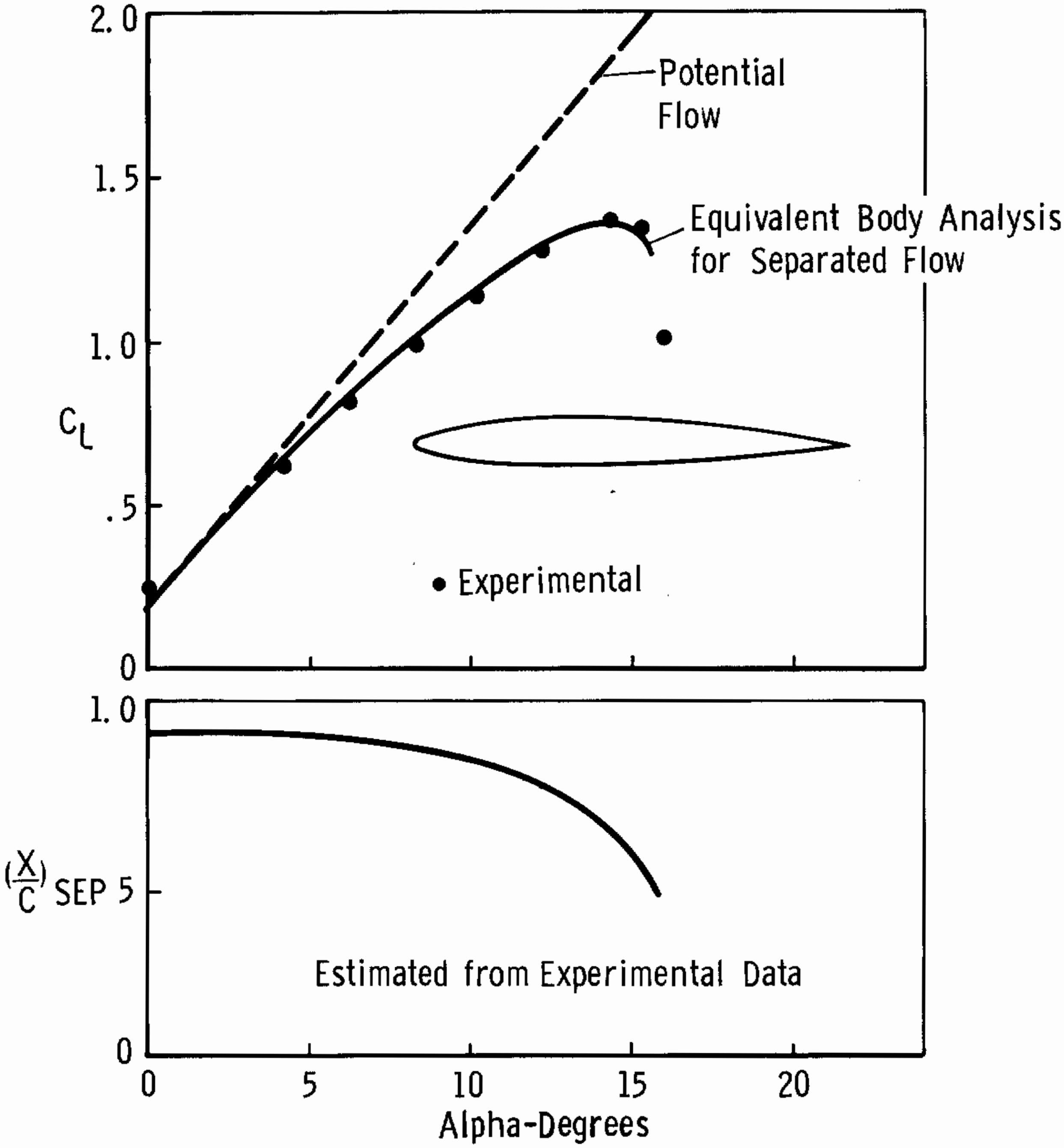

Figure 19 **Substantiation of the Equivalent Airfoil Model F-111 Cruise Section**

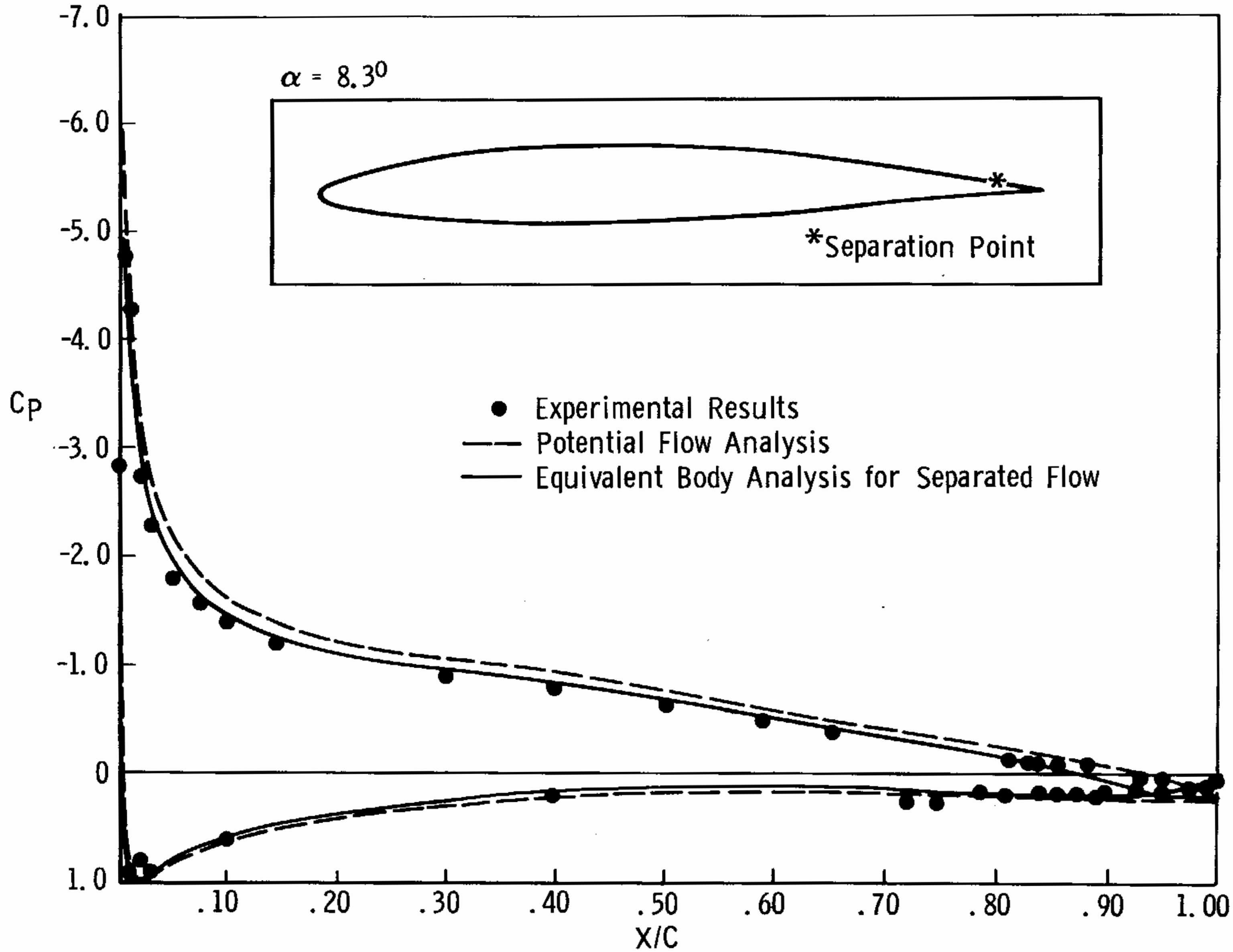

Figure 20 Substantiation of Equivalent Airfoil Model. F-111 Cruise Section - Pressure Distribution at $\alpha = 8.3^{\circ}$

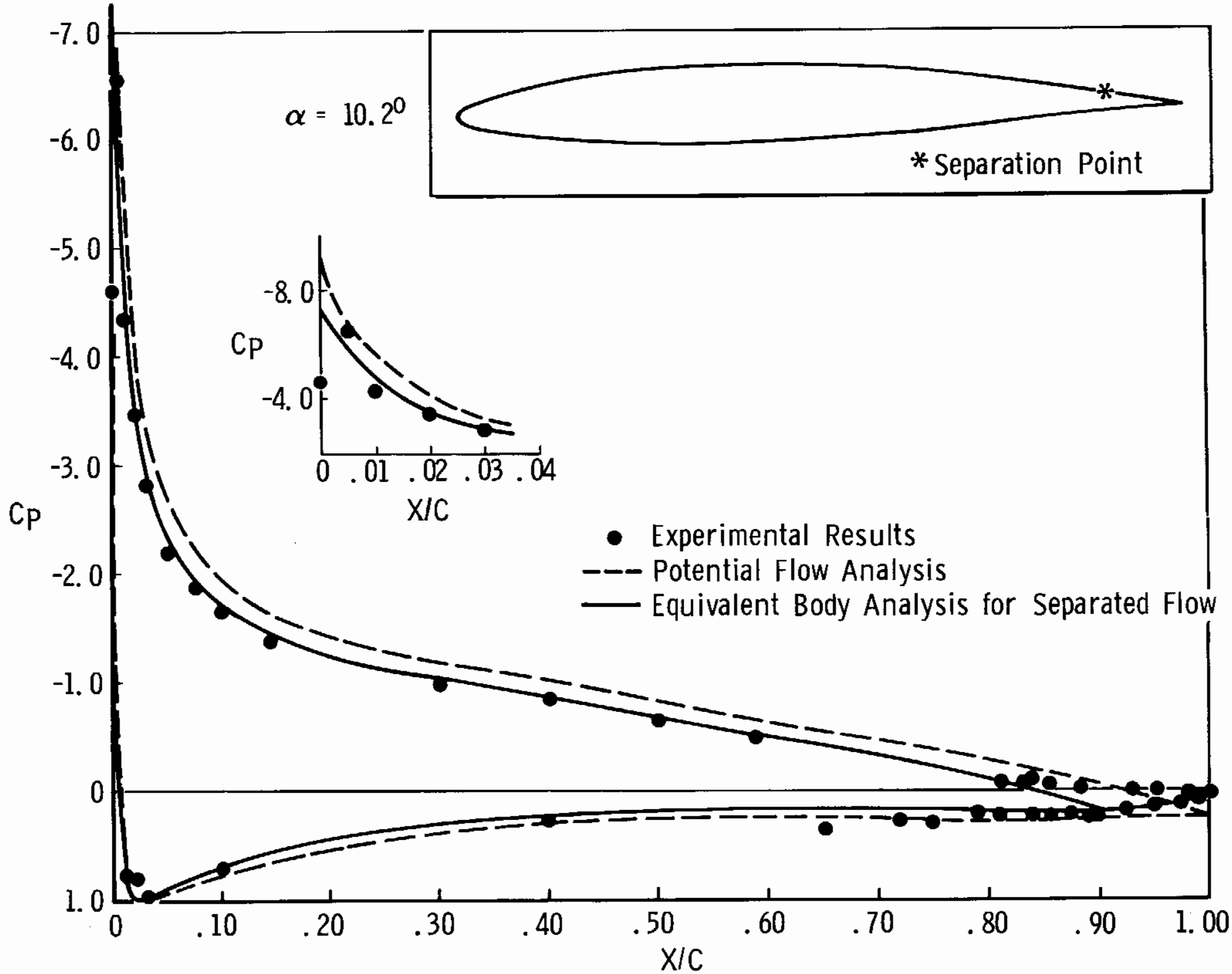

Figure 21 Substantiation of Equivalent Airfoil Model. F-111 Cruise Section - Pressure Distribution at $\alpha = 10.2^{\circ}$

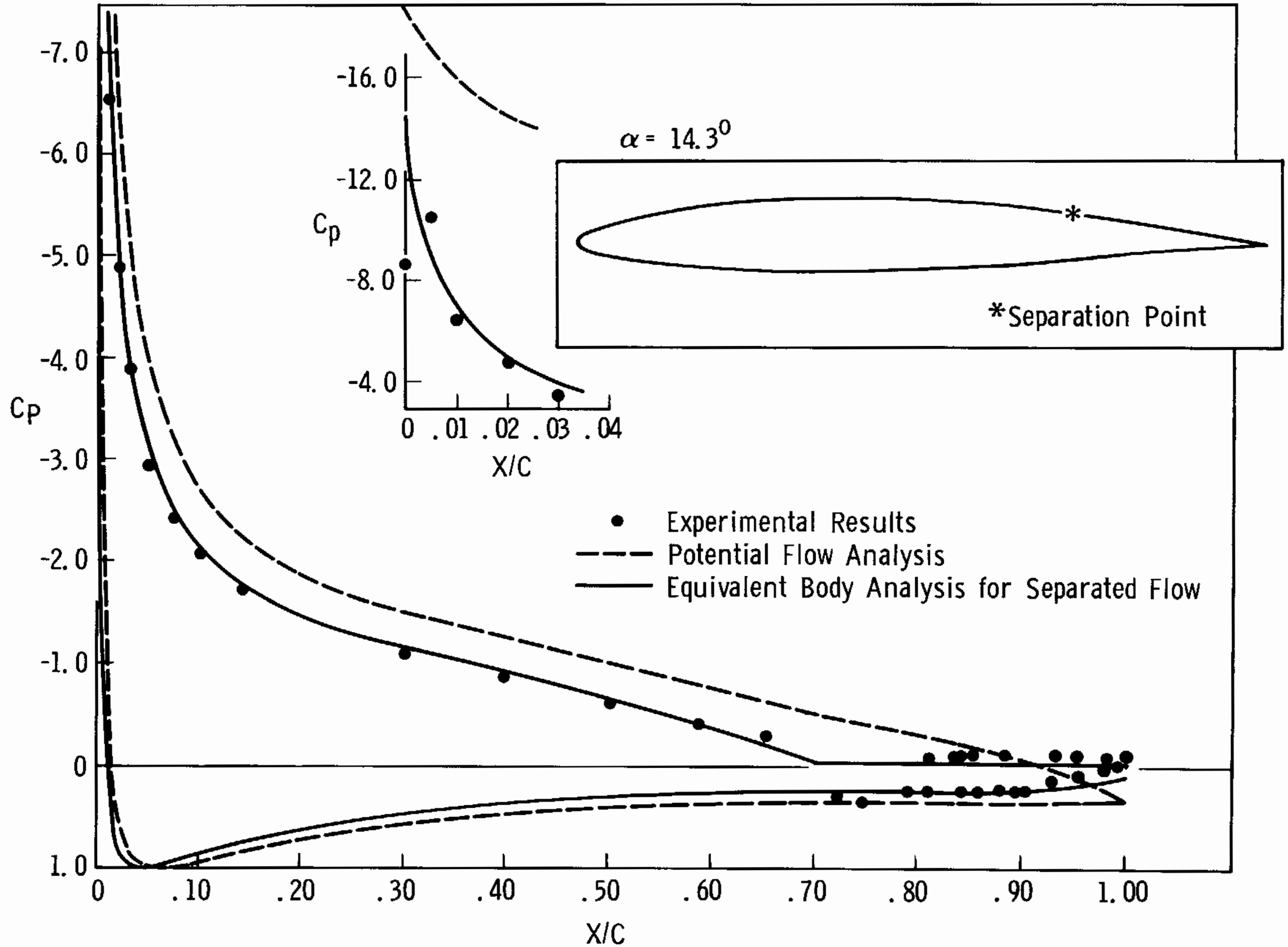

Figure 22 Substantiation of Equivalent Airfoil Model. F-111 Cruise Section - Pressure Distribution at $\alpha = 14.3^{o}$

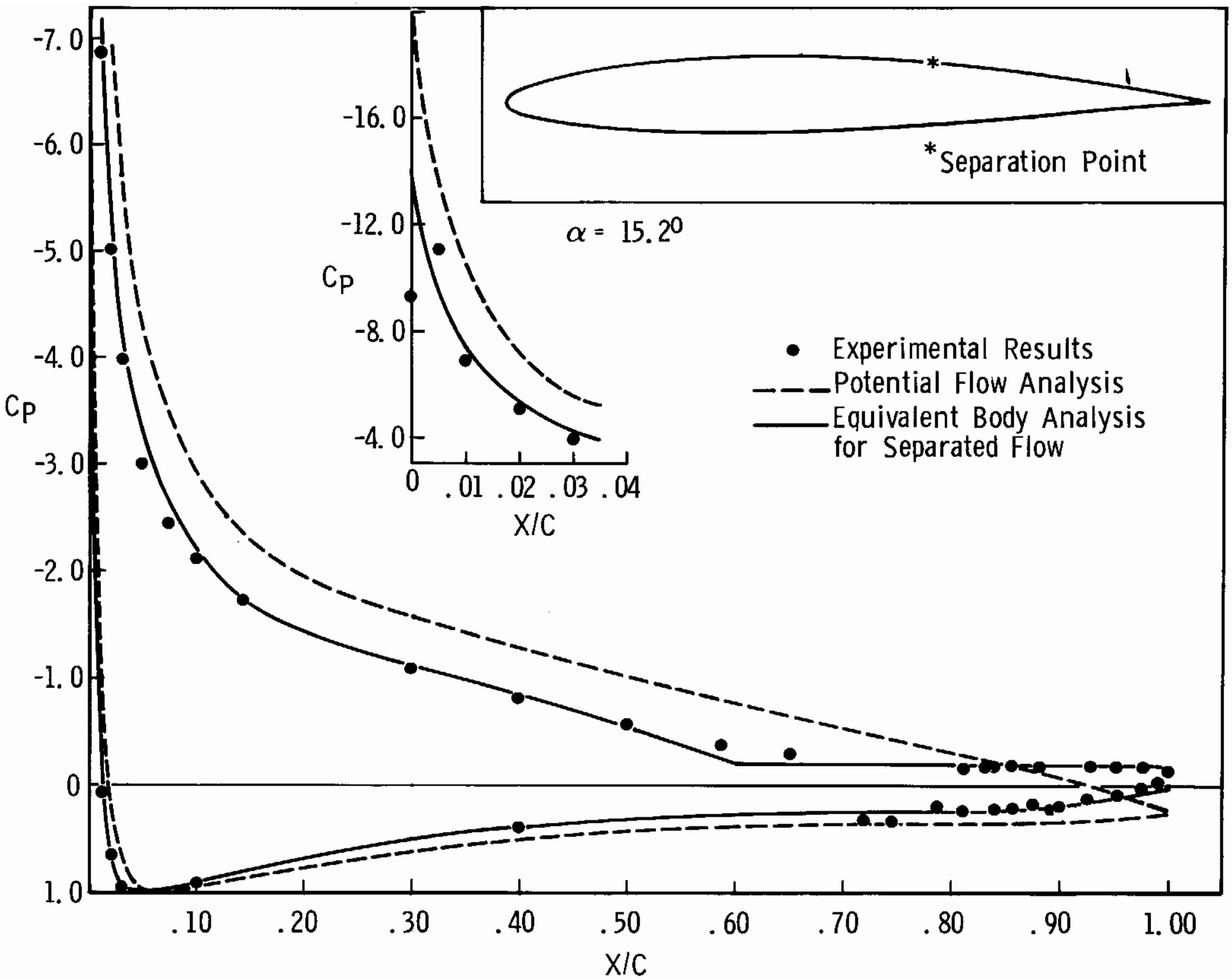

Figure 23 Substantiation of Equivalent Airfoil Model. F-111 Cruise Section - Pressure Distribution at $\alpha = 15.2^{o}$

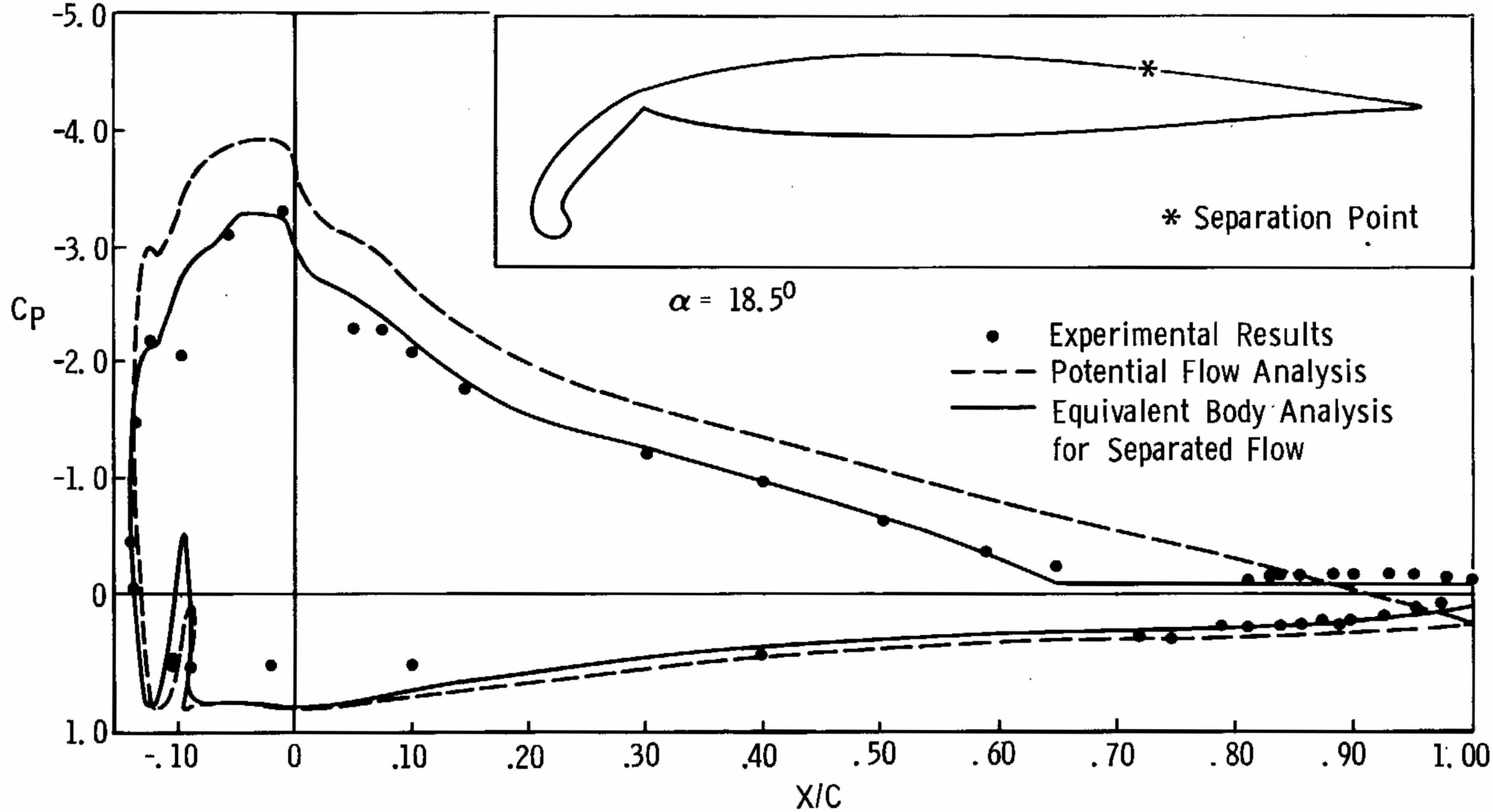

Figure 24 Substantiation of Equivalent Airfoil Model. F-111 Section with Leading Edge Flap. Pressure Distribution at $\alpha = 18.5^{o}$

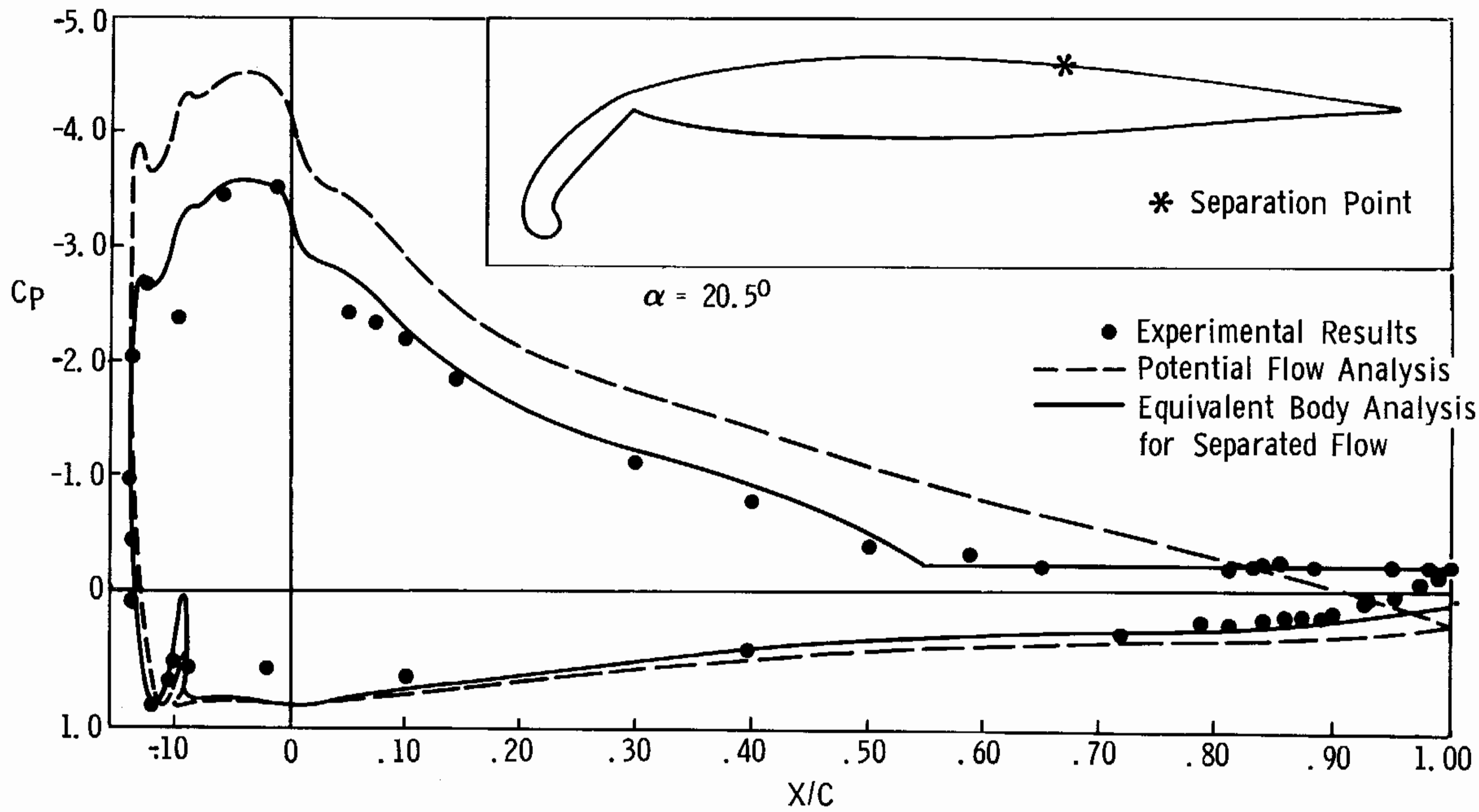

Figure 25 Substantiation of Equivalent Airfoil Model. F-111 Section with Leading Edge Flap. Pressure Distribution at $\alpha = 20.5^{o}$

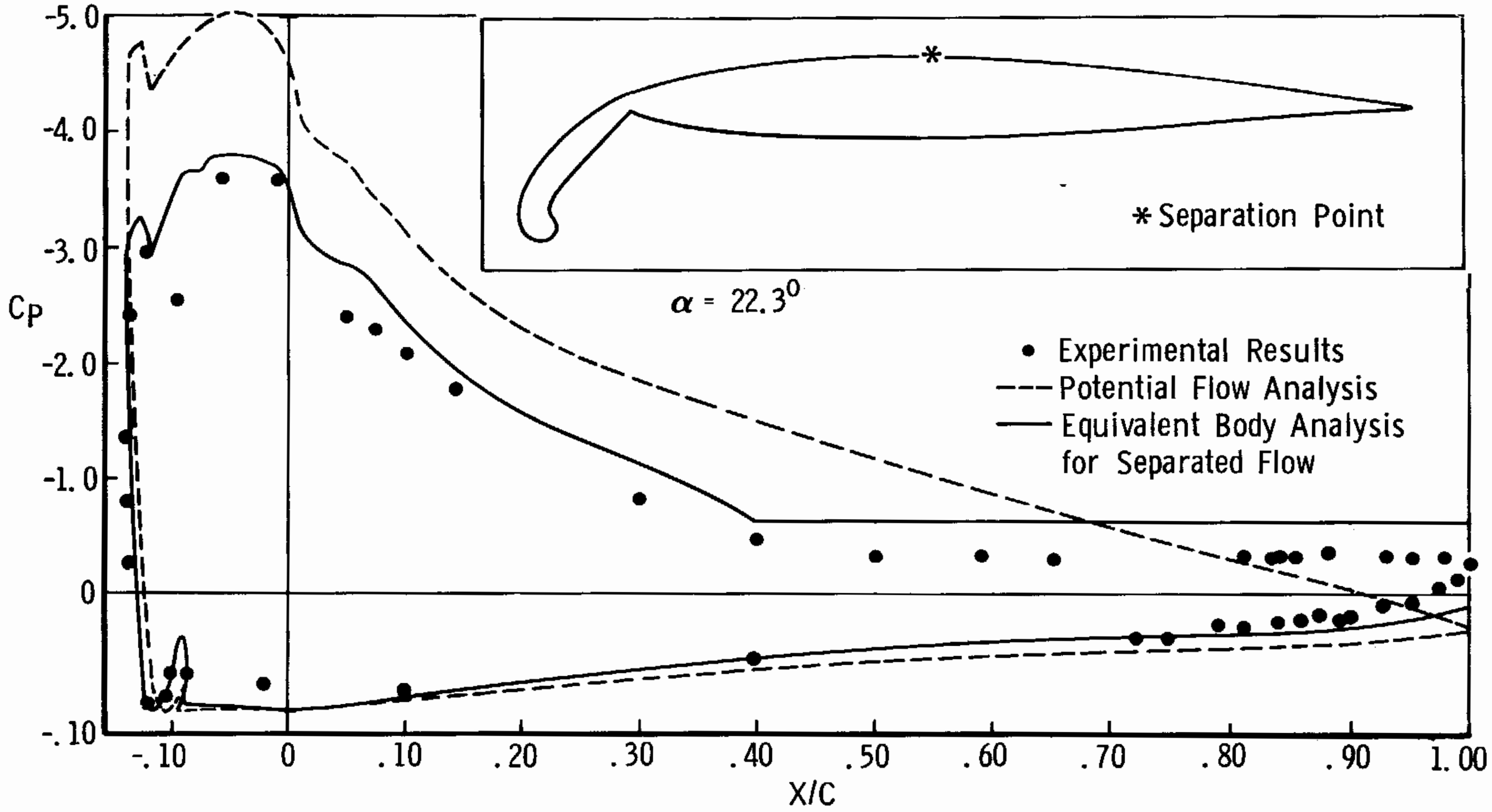

Figure 26 Substantiation of Equivalent Airfoil Model. F-111 Section with Leading Edge Flap. Pressure Distribution at $\alpha = 23.3^{\circ}$

The comparisons between experimental and theoretical pressure distributions for the F-111 wing section at buttock line 189 with a 22-percent-chord leading-edge slat are shown in Figures 27, 28, and 29 for angles of attack of 14.3, 21.5, and 23.2 degrees, respectively. Theoretical results for the equivalent system obtained by both neglecting and including the effects of boundary-layer displacement thickness are presented in these figures. The separation-point locations on each element are noted on the airfoil sketch in these figures. Also, potential-flow results are shown for comparison with the simulated viscous solution. These data show that the theoretical and experimental distributions are in very good agreement for angles of attack of 14.3 and 21.5 degrees. The effect of including the boundary-layer displacement thickness is seen to be small but tends to improve the agreement between experimental and theoretical pressure distributions. At the 23.2-degree angle of attack (experimental $C_{l_{max}}$) agreement between experimental and theoretical results is only fair, which, again, may be attributed to the large region of separated flow.

Comparisons of experimental and theoretical pressure distributions for the F-111 wing section at buttock line 189 with a 22-percent-chord leading-edge slat and 35-percent-chord trailing-edge single-slotted flap are shown in Figures 30, 31, and 32 for angles of attack of 18.7, 20.7, and 22.9 degrees, respectively. The potential-flow solution is shown for comparison, and the theoretical pressure distributions for the equivalent system with and without the effect of boundary-layer displacement thickness are presented. The experimental pressure distributions show a separation point on the flap that remains invariant over the angle-of-attack range analyzed. The effect of including the boundary-layer displacement thickness is again noted to be small. The experimental and theoretical pressure distributions over the flap are in good agreement, but the theoretical pressure distributions over the wing section and slat are only in fair agreement.

These comparisons between computed pressure distribution and experimental data show that the simplified mathematical model defined to represent airfoils with separated flow gives accurate predictions even near stall. Some discrepancies existing near the trailing edge of the airfoil elements point to the deficiencies of this simplified approach.

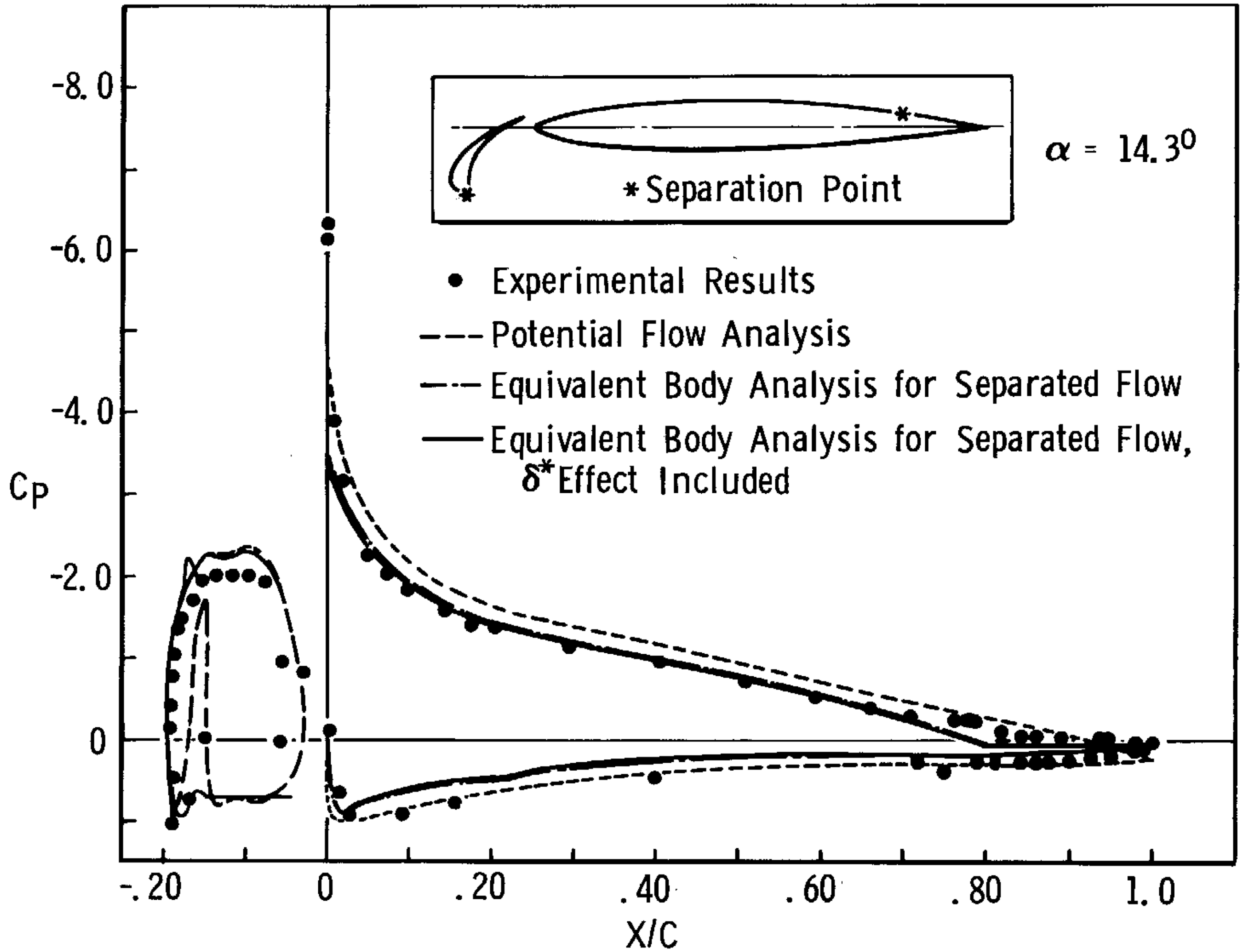

Figure 27 Substantiation of Equivalent Airfoil Model. F-111 Section with Leading Edge Slat. Pressure Distribution at $\alpha = 14.3^{o}$

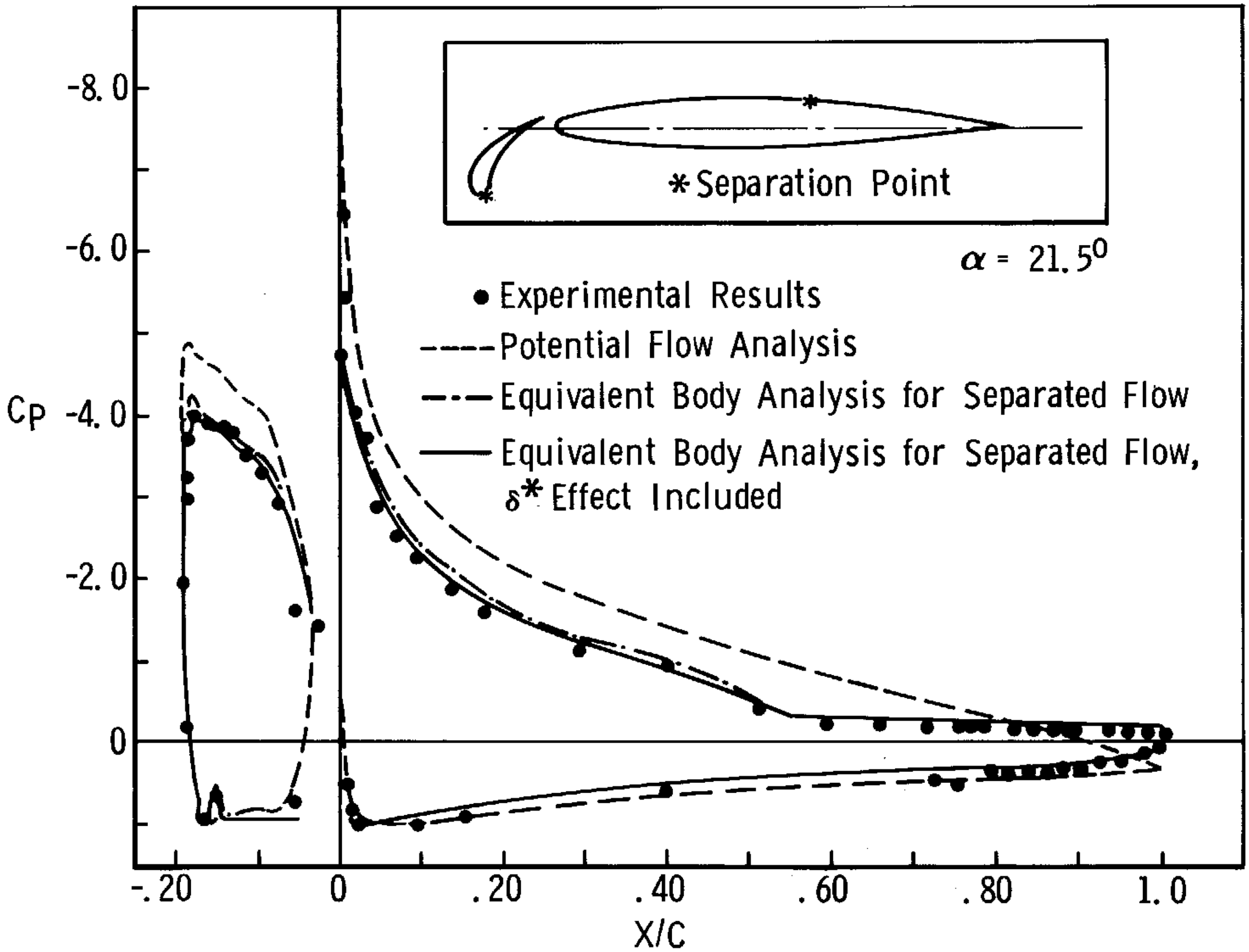

Figure 28 Substantiation of Equivalent Airfoil Model. F-111 Section with Leading Edge Slat. Pressure Distribution at $\alpha = 21.5^{o}$

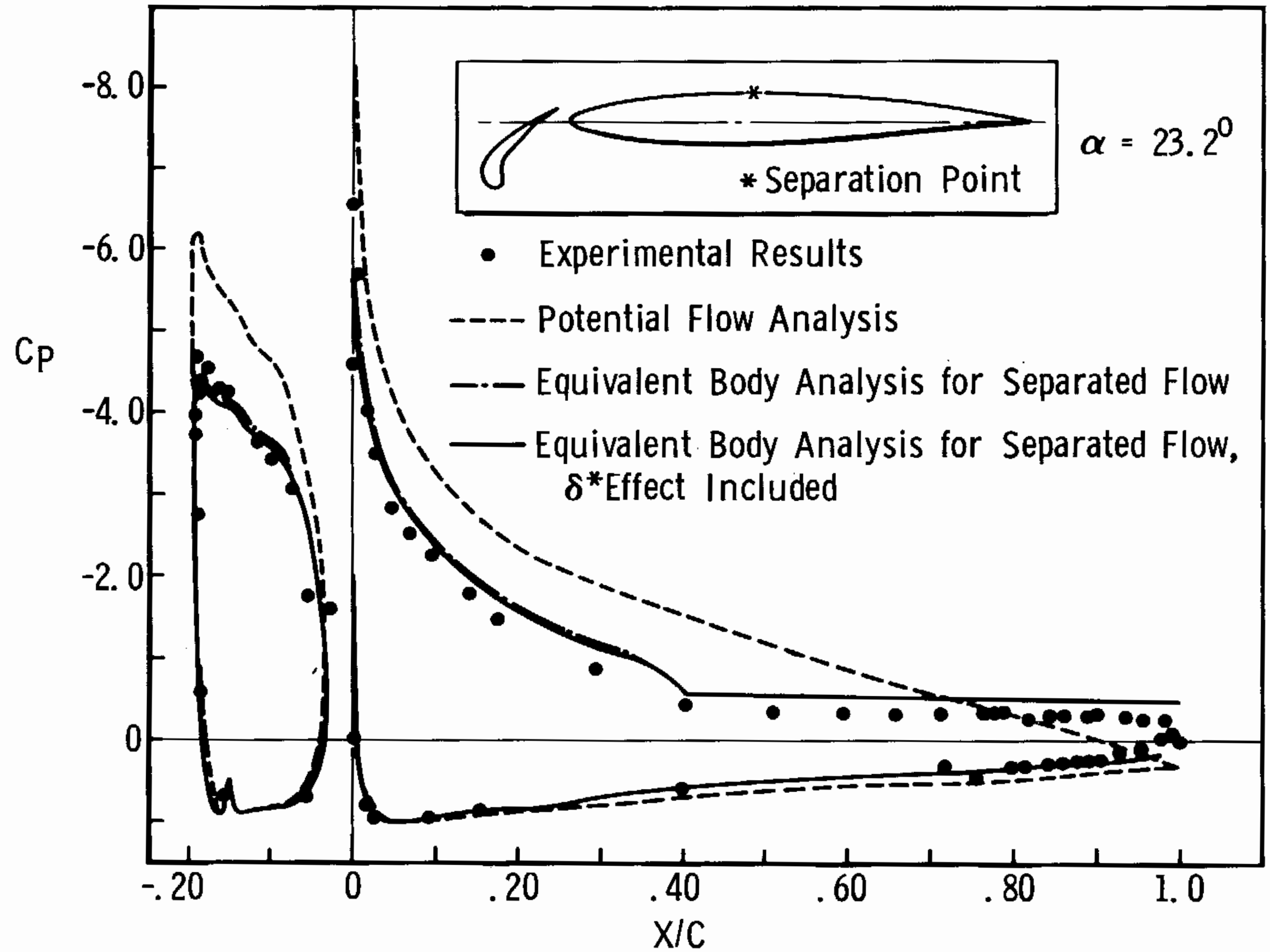

Figure 29 Substantiation of Equivalent Airfoil Model. F-111 Section with Leading Edge Slat. Pressure Distribution at $\alpha = 23.2^{o}$

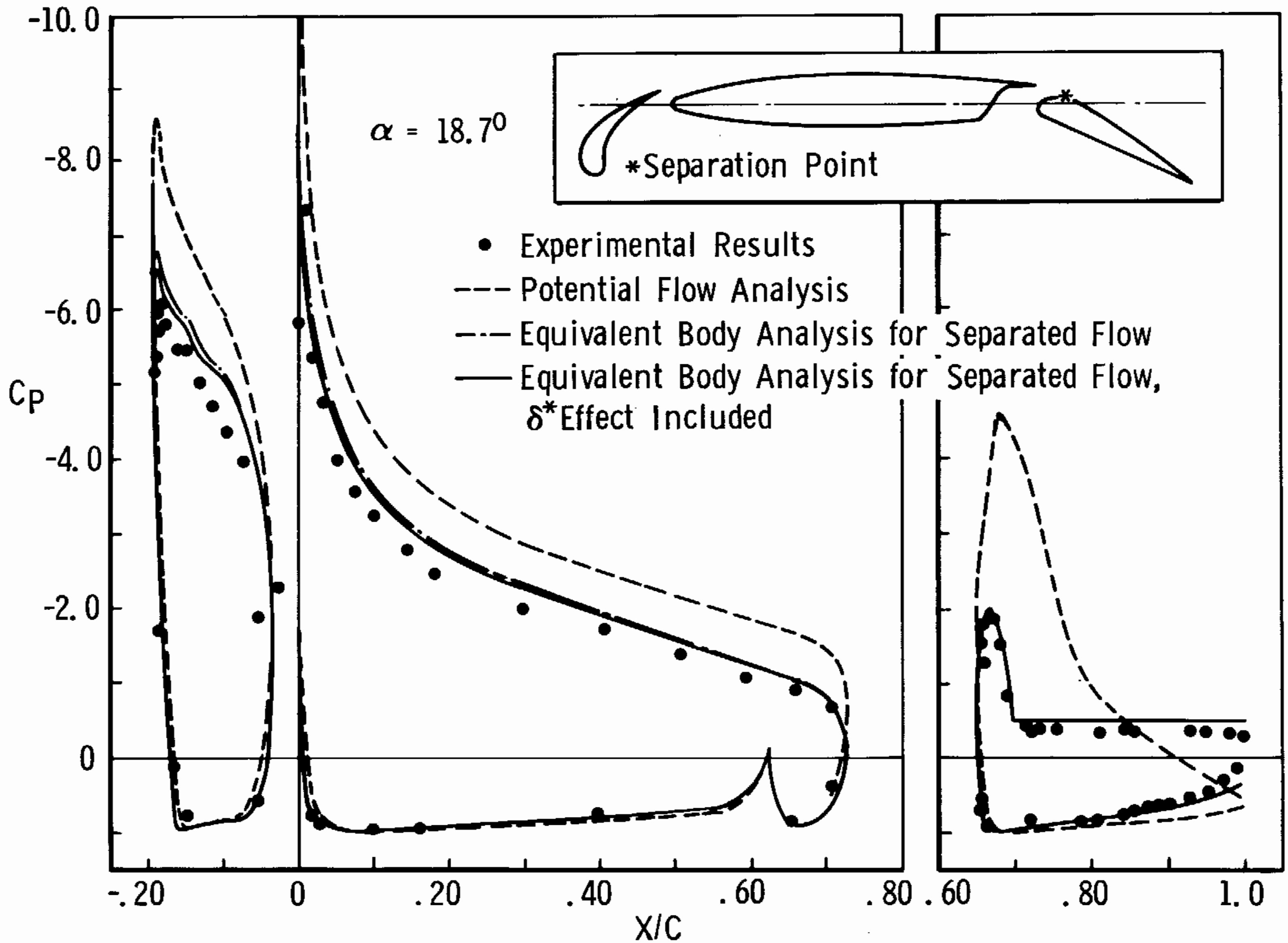

Figure 30 Substantiation of Equivalent Airfoil Model F-111 Section with Leading Edge Slat and Single Slotted Flap Deflected 30°. Pressure Distributions at $\alpha = 18.7°$

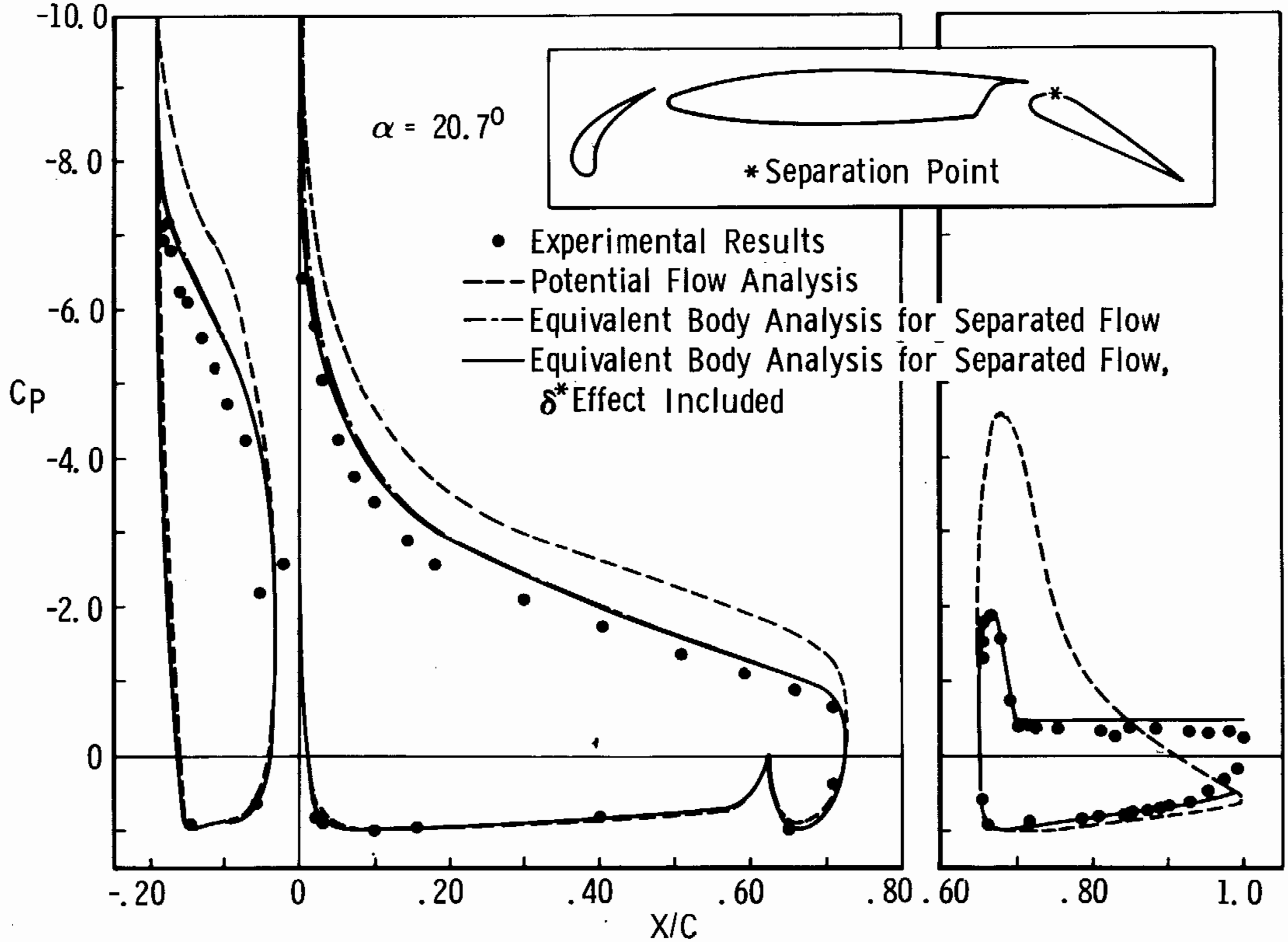

Figure 31 Substantiation of Equivalent Airfoil Model F-111 Section with Leading Edge Slat and Single Slotted Flap Deflected 30°. Pressure Distributions at $\alpha = 20.7°$

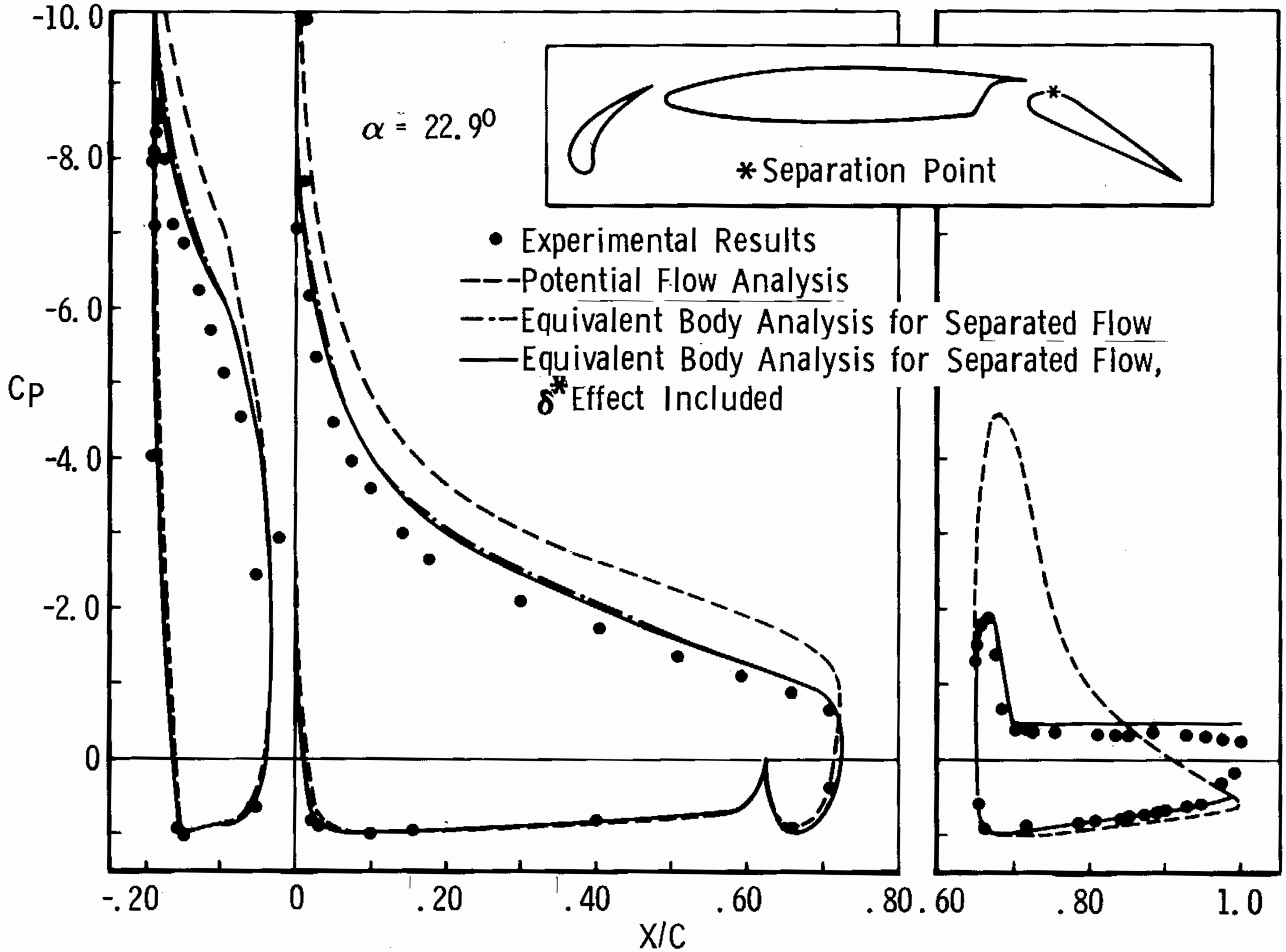

Figure 32 Substantiation of Equivalent Airfoil Model F-111 Section with Leading Edge Slat and Single Slotted Flap Deflected 30°. Pressure Distributions at = 22.9°

5.4 Evolution of the Separated-Flow Model

The evolution of the mathematical model for those airfoils where boundary-layer separation is indicated is presented for information purposes only. This model is necessary before the analysis of any meaningful high-lift system can be accomplished, as most high-lift systems operate with separation on one or more element. Furthermore the movement of the separation point with increase in incidence determines the nonlinear lift curve slope near stall as well as the maximum lift.

The boundary-layer calculation methods described in Section 4 predict the separation point but, of course, do not carry out calculations past the separation point. Therefore no values of boundary-layer displacement thickness are available downstream of the separation point to allow the definition of an equivalent body for the separated-flow condition in a manner similar to that for the attached-flow case. Callaghan and Beatty (Ref. 7) have used semi-empirical methods (details not revealed) to calculate boundary-layer displacement thickness past the separation point. For these reasons, alternate methods were sought.

Another approach is to allow the separation streamline to remain a free boundary and fix its position by specifying a constant pressure condition along the streamline from the separation point to the airfoil trailing-edge location. Experimental data tend to support such a constant-pressure separated-wake condition. Jacob (Ref. 5) approximated this condition for a single-element airfoil by assuming equal pressures at three discrete points: the airfoil trailing edge, the separation point, and the airfoil trailing-edge station on the separation streamline. Such an approach, however, requires the solution of a nonlinear system of equations within the framework of the distributed-singularity theory. The undesirability of a nonlinear inviscid solution for the equivalent system led to the search for a simpler approach.

One alternate approach to the problem is to define the separated-wake shape empirically (i.e., the inviscid streamline emanating from the separation point) and assume that the equivalent-body contour follows that streamline. The result is an open-base airfoil element defined by the displacement surface and this separation streamline. The analytical form of the separation streamline must then be established.

An attempt was made to determine the shape of the separated wake experimentally. Photographs of the approximate separation streamline were made during a 2-D wind tunnel test program (Ref. 25). An approximate chordwise position of the separation point was visually determined by tufts attached to the model. A long tuft (approximately 18 inches) attached to a tapered rod was inserted from the tunnel roof to this approximate separation point and photographed. Unfortunately, the separation streamline emanating from steeply deflected flaps and slats could not be photographed. Further, separation streamlines were not photographed for enough configurations to empirically define the separation streamline shape as a function of the separation-point location and incidence.

A brief analytical study was carried out to determine if the streamline emanating from the separation point could be approximated by an analytical function. The F-111 wing section at buttock line 189 was used in the analysis. The separation point used was predicted by applying Stratford's (Ref. 12) separation criteria for predicting incipient separation based on the potential-flow pressure distributions. The predicted lift curves for a linear and parabolic streamline assumption are shown in Figure 33. The linear streamline was aligned with the freestream direction, while the parabolic streamline was oriented so that it was tangential to the local surface at the separation point and parallel to the freestream direction at the trailing edge. The agreement between the calculated and the experimental lift curves is very poor, although the parabolic-streamline model shows some improvement over the linear-streamline model. Perhaps by a trial-and-error method a satisfactory analytical definition for the separation streamline could be obtained for the configuration under investigation, but it would have to be proved valid for a variety of multi-element airfoil configurations and locations of separation points.

As discussed in Subsection 5.3, the free-separation-streamline model for the equivalent body failed to predict the pressure distribution accurately on airfoils having large regions of separated flow. A systematic study was therefore conducted to determine if an improved equivalent-body model could be found. In this study it was assumed that the procedure would converge to the correct separation point, and therefore the separation point was specified and determined from experimental data for angles of attack greater than or equal to the stall angle.

Since a constant pressure is assumed over the separated region, an effort was made to impose the condition of equal pressure at the separation point and the lower-surface trailing-edge point. So that the number of conditions would be balanced with the number of unknowns, it was necessary to include an additional singularity into the problem. Both source- and vortex-type singularities, concentrated and distributed at a variety of positions within and external to the body, were investigated. In most instances it was found that the resulting system of linear equations became dependent and the inverse of the matrix could not be obtained. In some cases where solutions were obtained, the singularity strengths were such that the solutions were meaningless. From this analysis it was concluded that the additional singularities introduced were redundant and not linearly independent.

The next attempt was directed toward finding a method by which the equal-pressure condition could be imposed without introducing any new singularities into the problem. This could be accomplished by eliminating the flow-direction condition at either the pseudo boundary point located near but downstream of the separation point on the lower surface or at the pseudo boundary point located near but downstream of the trailing edge on the lower surface. Further refinement of the model was attempted by relocating and distributing the existing source singularity.

The best equivalent-body model to evolve from this study is shown schematically in Figure 34. It is similar to the free-separation-streamline model except for the following differences:

1. The condition of continued tangential flow at the pseudo boundary point on the lower surface is eliminated.

2. An equal-pressure condition is imposed at two boundary points located very close to the separation point on the upper surface and the trailing edge on the lower surface.

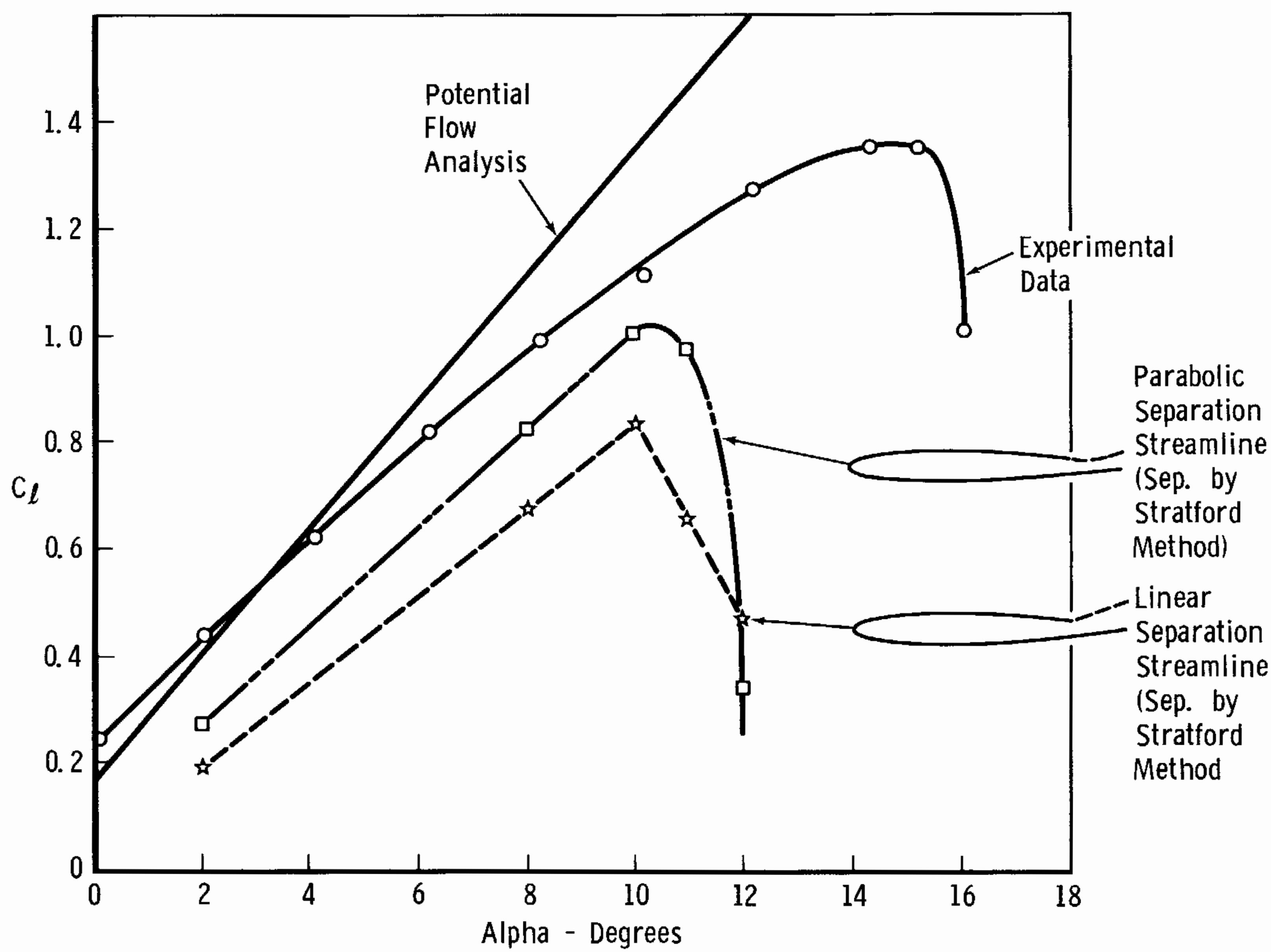

Figure 33 Effect of the Shape of the Separation Streamline

3. A triangular distributed source singularity is used, half embedded in the airfoil contour, with the apex of the triangular source distribution near the separation point (see Figure 34).

This model was used in the viscous analysis program during a preliminary checkout of the procedure. The results obtained were not satisfactory and this model was subsequently abandoned. The final equivalent-body model used has been discussed in Subsection 5.2.

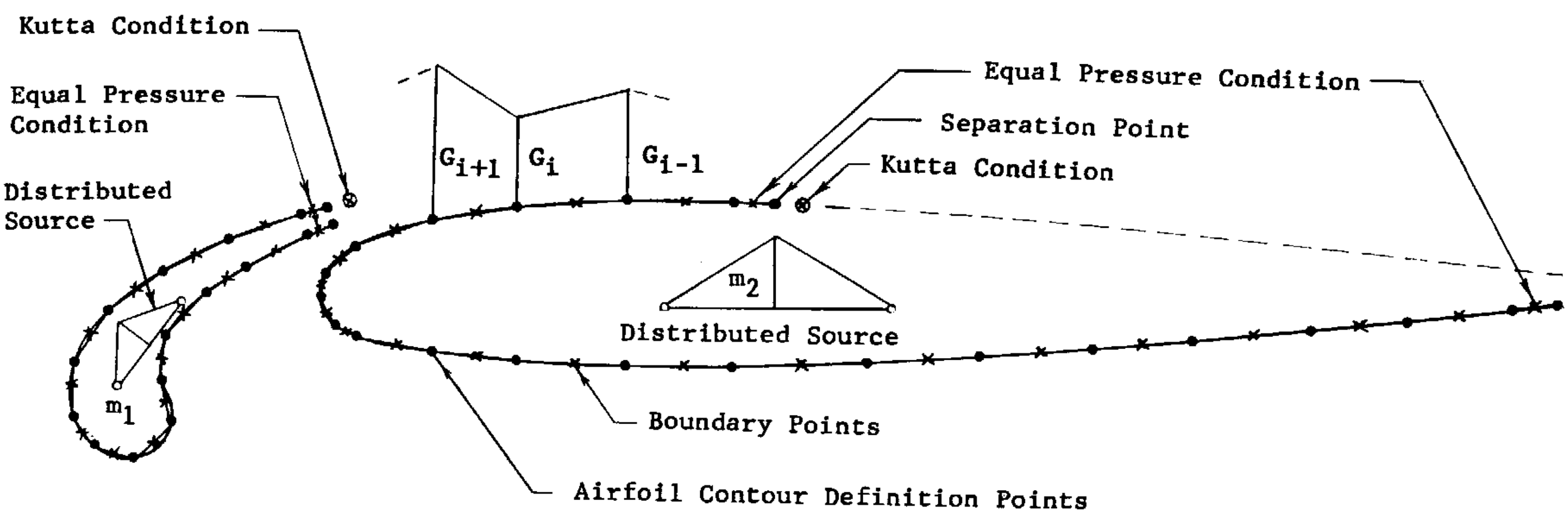

Figure 34 Alternate Equivalent Body Model for Separated Flow

6. ITERATION CYCLE

As discussed in Section 2, the viscous-flow analysis is based on an iterative process. The convergence of this process in reasonable computation time is of prime concern. In this subsection, first the criteria used to deduce convergence are described and, then, a unique method for achieving convergence is presented. This method assures convergence for most configurations.

6.1 Convergence Criteria

There are several techniques by which convergence can be deduced, some of which are

1. Comparison between the values of the aerodynamic coefficients, especially the lift coefficients for consecutive iterations.

2. Comparison between the values of the boundary-layer characteristics (including the values of boundary-layer displacement thicknesses and points of transition and separation) calculated for consecutive iterations.

3. Comparison between the chordwise pressure distributions calculated for consecutive iterations.

The last method was selected for inclusion in this procedure, since it imposes the most stringent criteria.

At the end of each iteration the values of C_p calculated are compared, point by point, with the values of C_p calculated during the previous iteration. Convergence is assumed when the following two criteria are satisfied:

1. The absolute value of the difference between the calculated value of the pressure coefficient at any boundary point and the value of the pressure coefficient calculated during the previous iteration at the same boundary point is less than 0.15 for all boundary points. The number 0.15 was arbitrarily chosen. This can be expressed as

$$\left| (C_{p_i})_{\text{Iter. No. } j} - (C_{p_i})_{\text{Iter. No. } j-1} \right| < 0.15 \quad (64)$$

for all i's, where i ranges over the complete set of boundary points.

2. The absolute value of the difference between the calculated value of the pressure coefficient at any boundary point and the value of the pressure coefficient calculated during the previous iteration at the same boundary point is less than 10 percent of the value of pressure coefficient calculated. Again, 10 percent was arbitrarily chosen. This can be expressed as

$$\left| (C_{p_i})_{\text{Iter. No. } j} - (C_{p_i})_{\text{Iter. No. } (j-1)} \right| < 0.1 \left| (C_{p_i})_{\text{Iter. No. } j} \right| \quad (65)$$

When both of these criteria are satisfied, the iteration is stopped and the final solution, including forces and flow streamlines, is calculated.

6.2 Effective Separation Point

In an iterative solution it is necessary to include schemes that will assure convergence. If these schemes are not included, the iteration cycle can oscillate and never reach convergence. As an example, the simple case of the analysis of a single-element airfoil at a moderate angle of attack will be considered. The potential-flow analysis is obtained and used to calculate boundary-layer characteristics. It is assumed that separation is predicted at the 80-percent-chord position. These boundary-layer characteristics are used to define and analyze an equivalent airfoil surface so that new pressure distributions can be calculated. These pressure distributions are then used to calculate a new set of boundary-layer characteristics. It is conceivable that now no flow separation is indicated, so that the next equivalent body is similar to the original airfoil (exactly the same as the airfoil with the boundary-layer displacement thickness superimposed). When the pressure distributions calculated for this equivalent body are analyzed, the separation point will again be predicted at the 80-percent-chord position and the whole process will repeat indefinitely. The probability of this condition occurring increases as the number of airfoils in a given system become larger.

In order to avoid the situation described above from occurring, the following scheme of defining an effective separation point was implemented. The effective separation point is assumed midway between the calculated separation point and the separation point used in the previous iteration. This method does tend to slow down convergence and an option is incorporated into the procedure whereby the effective separation point is the same as the predicted separation point. To assure convergence when the predicted separation point and the separation point used in the previous iteration are within two corner points of one another, the effective separation is assumed at the predicted separation point. In all cases, the separation point is not allowed to move downstream of the separation point used during the previous iteration. The use of an effective separation point reduces the possibility of an equivalent system in which the separation point chosen is upstream of the true separation point. This is further assured by not allowing the effective separation point to be more than four corner points (eight corner points when the effective-separation-point concept is not used) upstream of the separation point used in the previous iteration. This prevents the false prediction of leading-edge separation due to laminar bubble burst. It is noted that if laminar bubble burst is present the method will eventually allow the separation point to shift to the leading edge but will require several intermediate iterations.

7. METHOD SUBSTANTIATION

The results calculated from this viscous-flow analysis procedure were compared with experimental data (Refs. 25, 26, and 27) for several single- and multi-element airfoils. Based on the results of a preliminary study, the separation streamline was made to leave the surface in a direction parallel to the freestream direction. No other assumptions were made except that the transition point was specified at the minimum pressure point for the F-111 cruise wing section at buttock line 189. For all other configurations, the transition point was calculated by Ward's method (Ref. 10). For all cases, the separation point was deduced from either the value of skin friction coefficient, or the laminar bubble burst criteria. The results obtained are discussed in the following subsections.

7.1 Single-Element Airfoils

Comparisons between experimental and theoretical force and moment coefficients for the F-111 cruise wing section at buttock line 189 (modified NACA 64A210 section) are shown in Figure 35. The results calculated for both the potential-flow analysis and the viscous-flow analysis are shown in this figure. At low to moderate angles of attack, it can be seen that the results predicted for the lift coefficient and the pitching moment coefficient by the viscous-flow analysis method are close to the results obtained by the potential-flow analysis method, therby confirming the applicability of of potential-flow analysis schemes for the analysis of systems where viscous effects are small. The results show good agreement with experimental data. The drag coefficient predicted by the viscous-flow method is substantially higher than that calculated by the potential-flow method because of the inclusion of frictional forces. Also, the predicted drag shows good correlation with experimental data. At larger angles of attack, the lift coefficient calculated by the viscous-flow analysis procedure shows good correlation with experimental data (Fig. 35). At these angles a large improvement is shown by the viscid solution over the potential-flow solution. Also, the values of predicted maximum lift coefficient and stall angle show good correlation with experimental data. However, to predict $C_{L_{max}}$, it is necessary to carry out the analysis in fine increments of the angle of attack. As expected, the theoretical approach

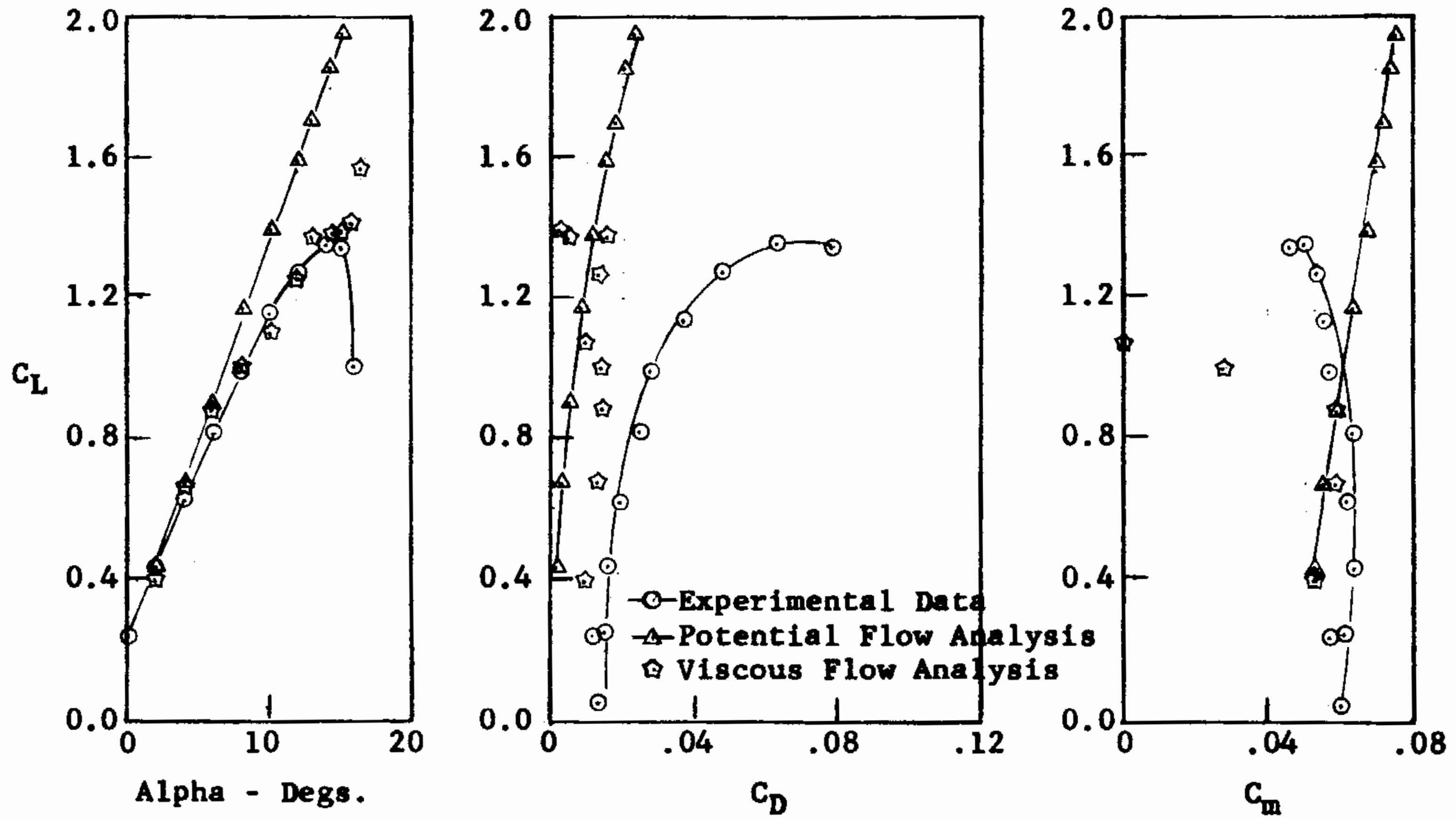

Figure 35 Substantiation of the Viscous Method F-111 Cruise Section

breaks down at angles of attack larger than the stall angle, and the theoretical method continues to predict large values for the lift coefficient. As can be seen from this figure, the value of $C_{L_{max}}$ can easily be missed if analysis is made in large increments of angle of attack. The values of drag and pitching moment coefficients predicted at large angles of attack show only fair agreement with experimental data. These values are extremely sensitive to the shape of the pressure distribution, especially in the trailing-edge region. As discussed in Subsection 5.3, the simplified equivalent body is not able to match the pressures in the separated regions at the trailing edge.

A comparison between experimental and theoretical pressure distributions for the same configuration are shown in Figures 36, 37, 38, and 39 for angles of attack of 8.3, 10.2, 14.3, and 15.2 degrees, respectively. Again the results calculated from the potential-flow analysis method and the viscous-flow analysis method are shown. It can be seen from these plots that the pressures calculated by the viscous-flow analysis method show good agreement with experimental data except in the regions of separated flow. A marked improvement is shown by the viscid solution over the potential-flow solution, especially for the higher angles of attack. The separation point calculated by this method is in all cases downstream of the separation point deduced from experimental data.

Comparisons between experimental and theoretical force and moment coefficients for the F-111 section with a 22-percent-chord leading-edge-flap are shown in Figure 40. Comparisons between experimental and theoretical pressure distributions for the same configuration at an angle of attack of 22.3 degrees are shown in Figure 41. The results calculated by both the potential-flow analysis method and the viscous-flow analysis method are shown in both these figures. The comparison between theoretical and experimental lift coefficient show fair agreement at low angles of attack, perhaps attributable to flow separation present on the underside of the slat, which is not taken into account in the theoretical analysis. Good agreement is exhibited at moderate angles of attack. The value of $C_{L_{max}}$ was not predicted because the analysis was not made in fine increments near the stall angle. The typical comparison between experimental and theoretical pressure distribution again shows fair agreement with experimental data. The separation point calculated was again upstream of the separation point deduced from experimental data.

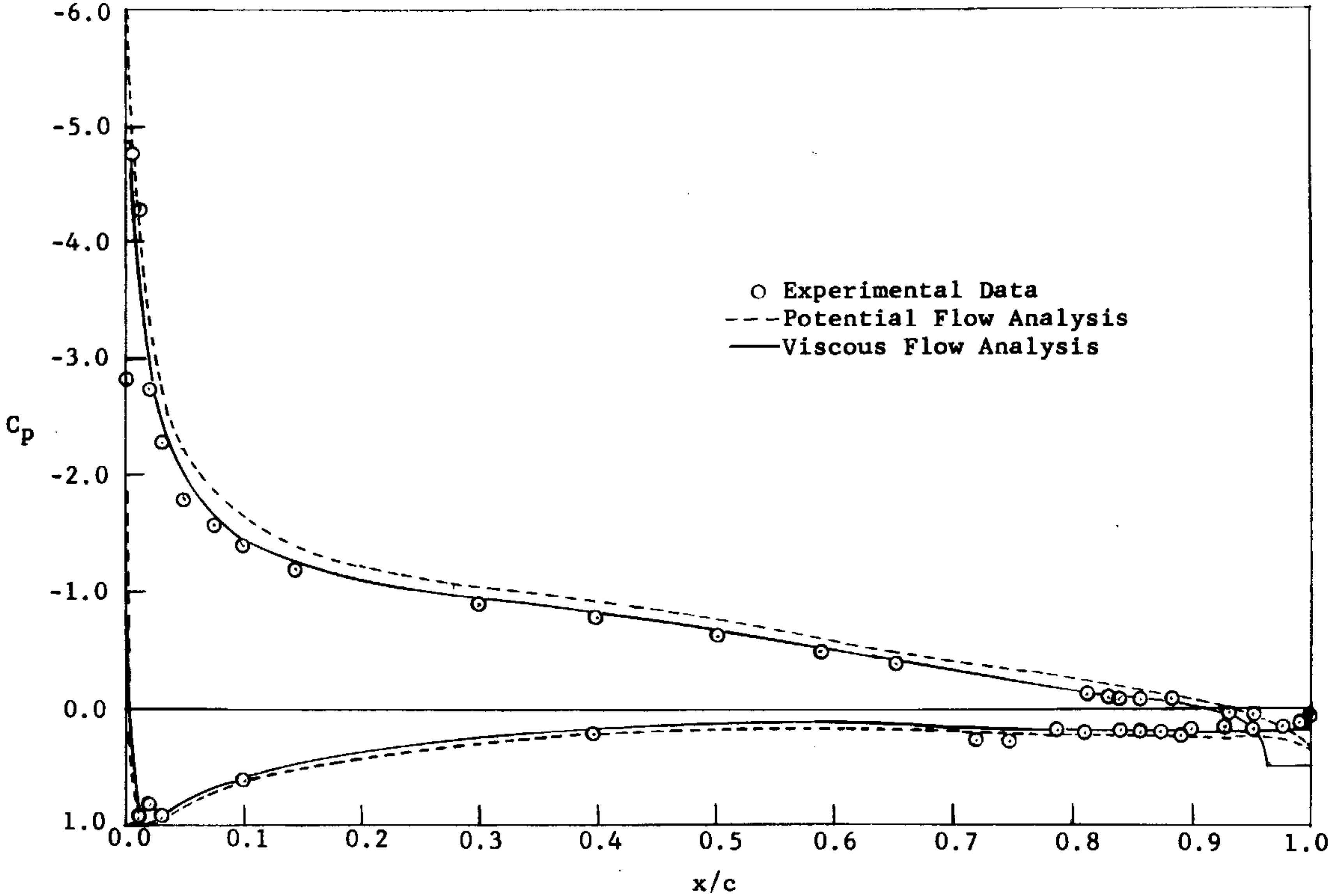

Figure 36 Substantiation of the Viscous Method F-111 Cruise Section. Pressure Distribution at $\alpha = 8.3^{o}$

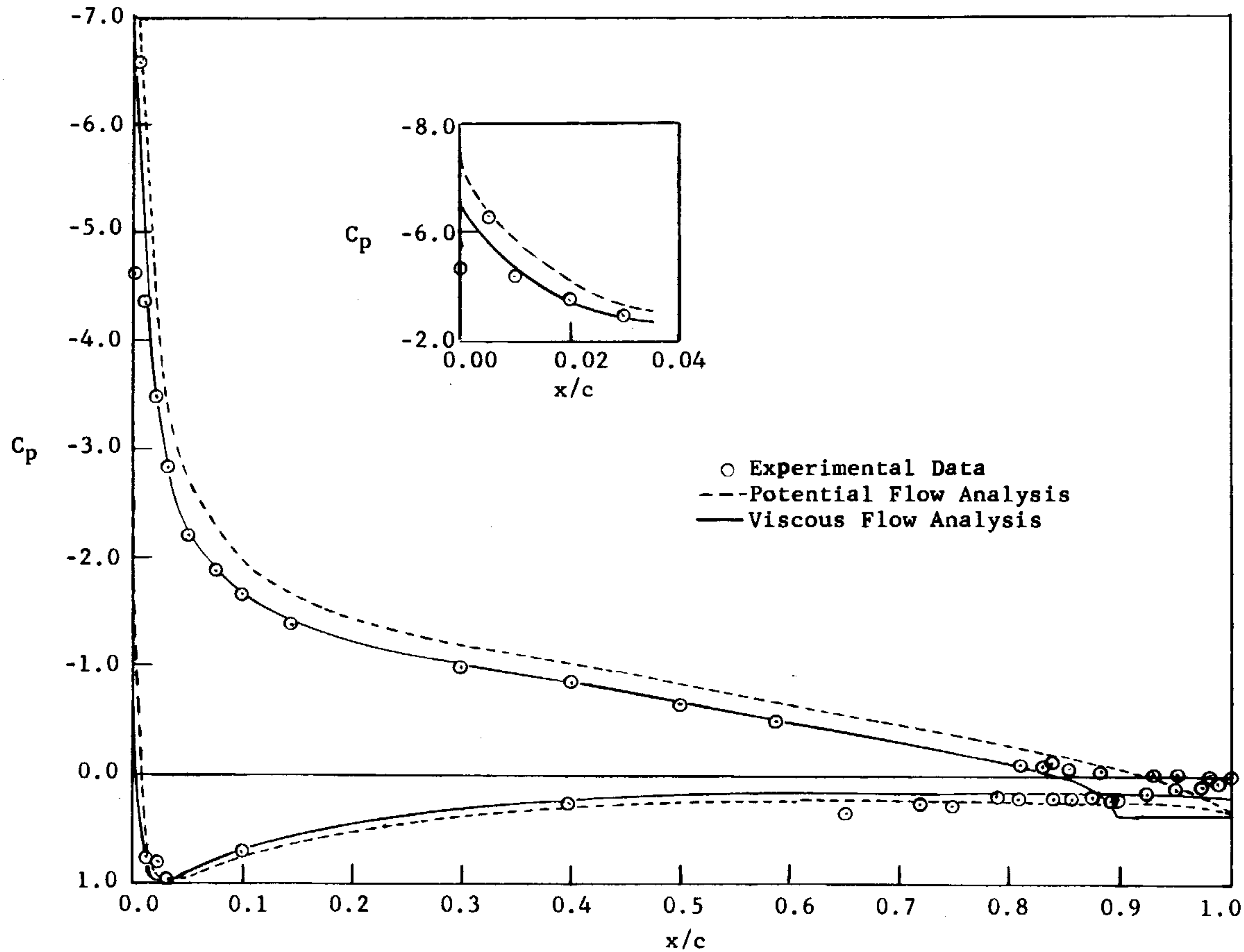

Figure 37 Substantiation of the Viscous Method F-111 Cruise Section. Pressure Distribution at $\alpha = 10.2^{\circ}$

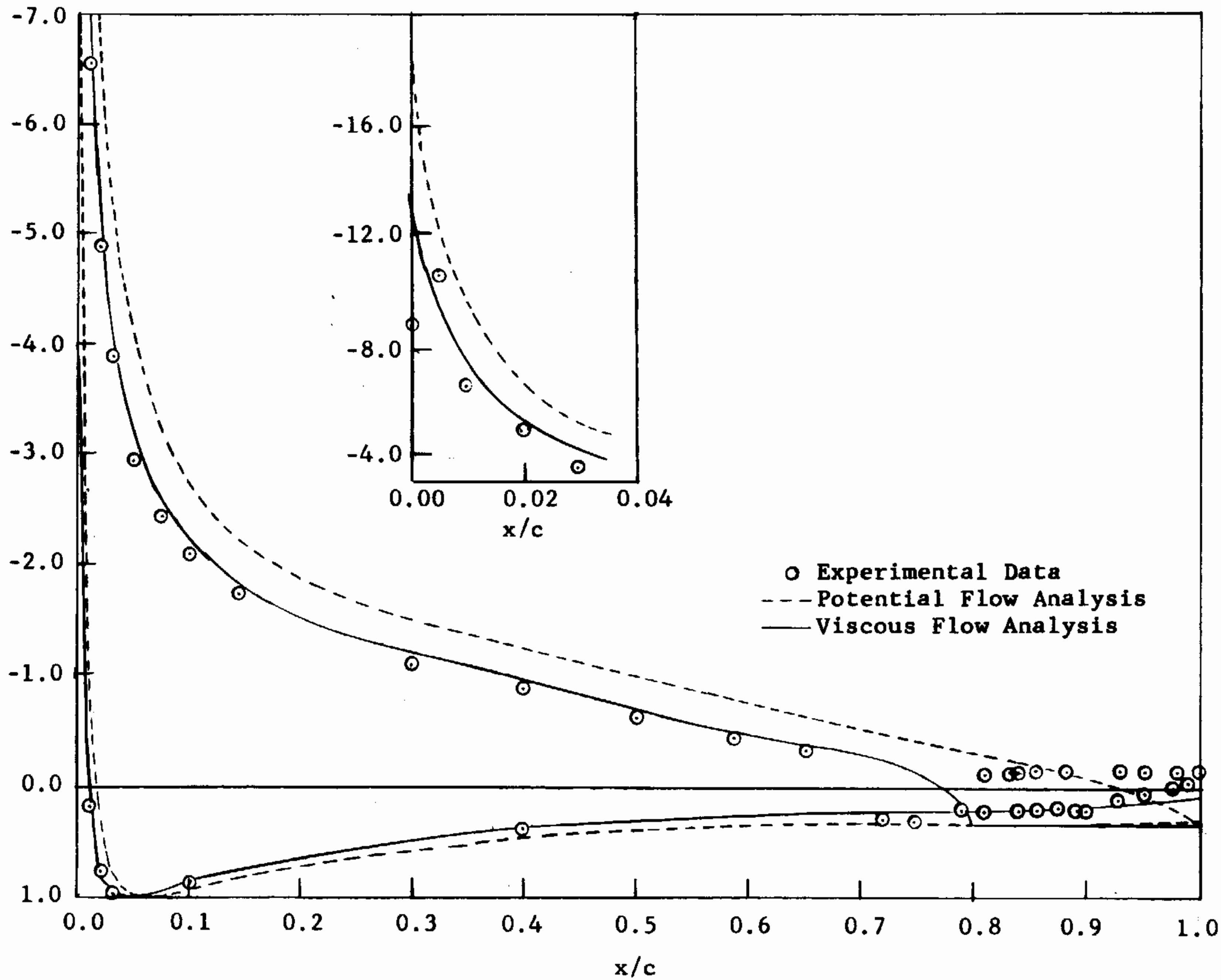

Figure 38 Substantiation of the Viscous Method F-111 Cruise Section. Pressure Distribution at $\alpha = 14.3^{o}$

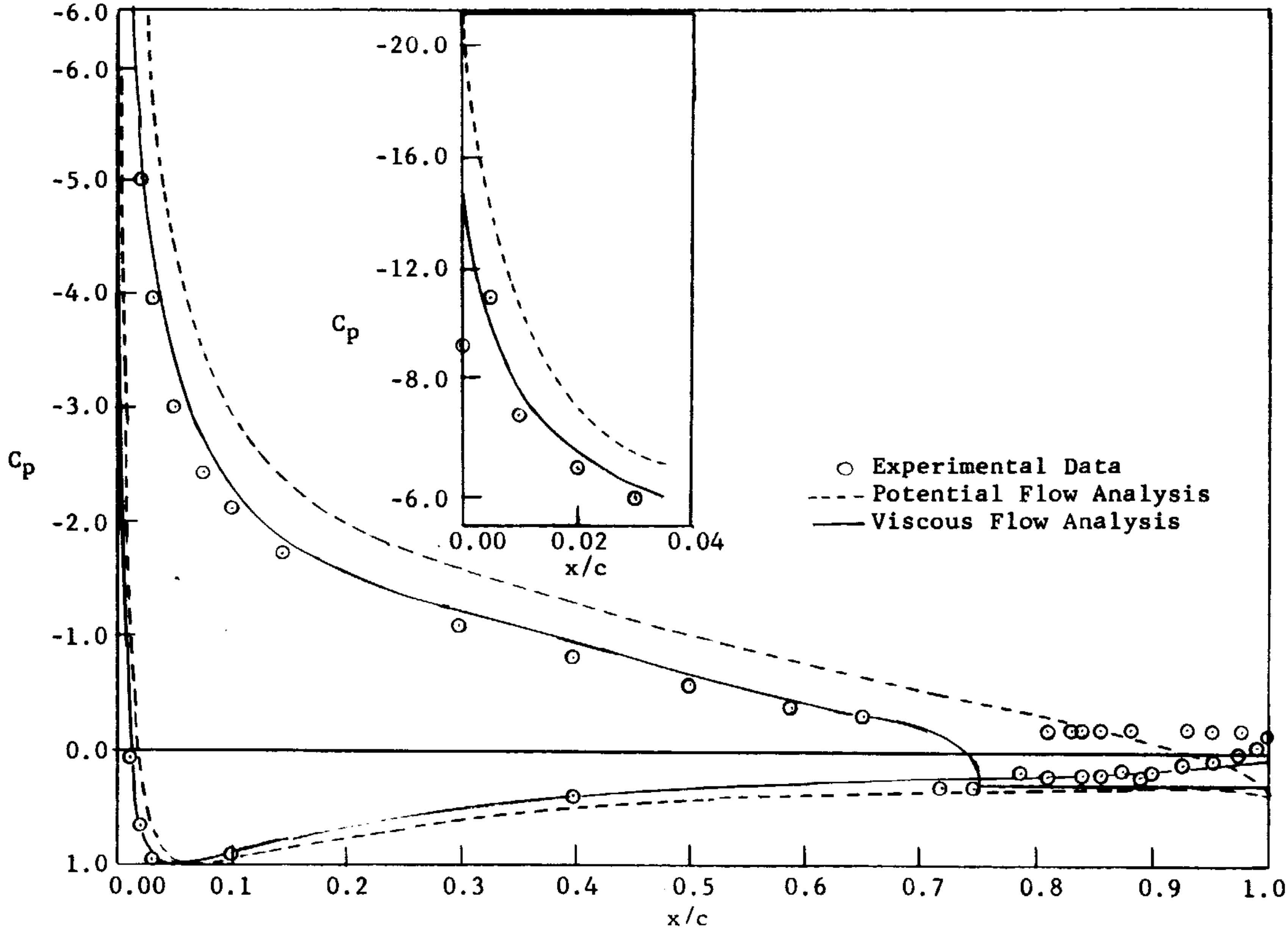

Figure 39 Substantiation of the Viscous Method F-111 Cruise Section. Pressure Distribution at $\alpha = 15.2^{o}$

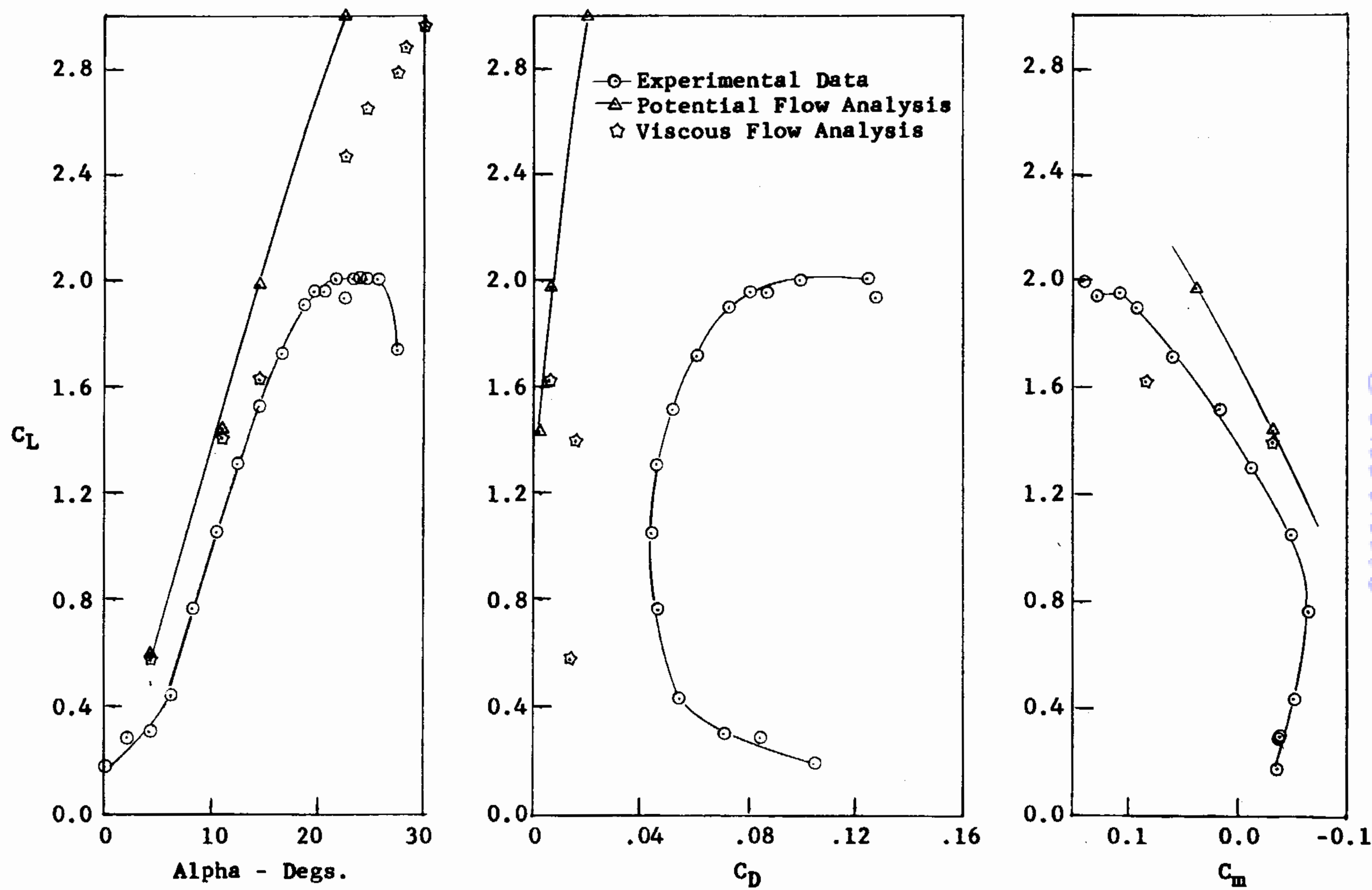

Figure 40 Substantiation of the Viscous Method F-111 Section with Leading-Edge Flap

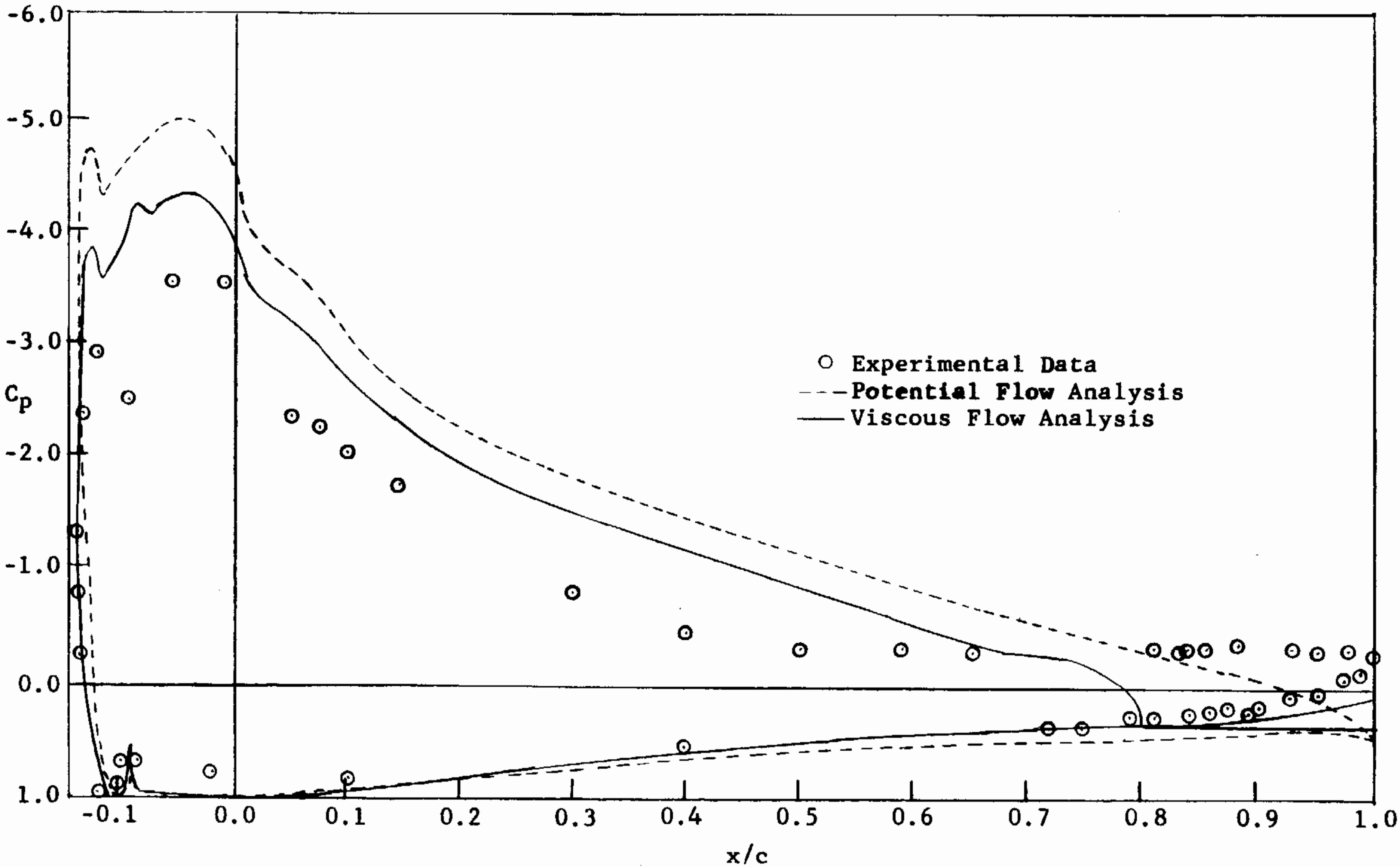

Figure 41 Substantiation of the Viscous Method F-111 Section with Leading-Edge Flap. Pressure Distribution at $\alpha = 22.3^{o}$

7.2 Multi-Element Airfoils

Comparisons between experimental and theoretical force and moment coefficients for the F-111 section with a 22-percent-chord leading-edge slat are shown in Figure 42. The results calculated by both the potential-flow analysis method and the viscous-flow analysis method are shown in these figures. The lift coefficients predicted by the viscous-flow analysis method at low angles of attack are slightly higher than the experimentally measured lift, perhaps due to separation on the lower side of the slat. Good agreement is exhibited between experimental and theoretical lift and pitching moment coefficient at moderate to high angles of attack. The value of $C_{L_{max}}$ is not defined as the analysis was made in large increments near the stall angle. The values calculated for the drag coefficient are erratic except at very low angles of attack where the separation point is at or near the trailing edge.

Comparison between experimental and theoretical force and moment coefficients for the F-111 wing section with 35-percent-chord single-slotted flap deflected 20 degrees are shown in Figure 43. No flow separation is predicted for low to moderate angles of attack, and the calculated values of lift are higher than experimental values. The stall angle appears to be reasonably well predicted. The viscous effects are again seen to be small when flow is attached on all elements; however, the viscid solution tends to improve the potential-flow results at all angles of attack.

The comparisons between experimental and theoretical force and moment coefficients for the F-111 section with 22-percent-chord leading-edge flap and 35-percent-chord single-slotted flap deflected 30 degrees or 35-percent-chord double-slotted flap deflected 40 degrees are shown in Figures 44 and 45. The theoretical results calculated by both the potential-flow analysis method and viscous-flow analysis method are presented. For both these configurations a separation point was predicted on only the last element of the system. The viscous-flow results for both lift and pitching moment coefficient show a marked improvement over potential-flow results and a fair agreement with experimental data. The stall angle indicated for the double-slotted configuration shows fair correlation with experimental data.

Finally, comparisons between experimental and theoretical force and moment coefficients for the F-111 section with 22-percent-chord leading-edge flap and 35-percent-chord triple-slotted flap deflected 70 degrees is shown in Figure 46. Good correlation between experimental and theoretical lift curves is shown, including the predicted value of $C_{L_{max}}$. The pitching moment predicted shows fair agreement with experimental data. For this configuration, separation was predicted on the main airfoil as well as on each element of the triple-slotted flap system.

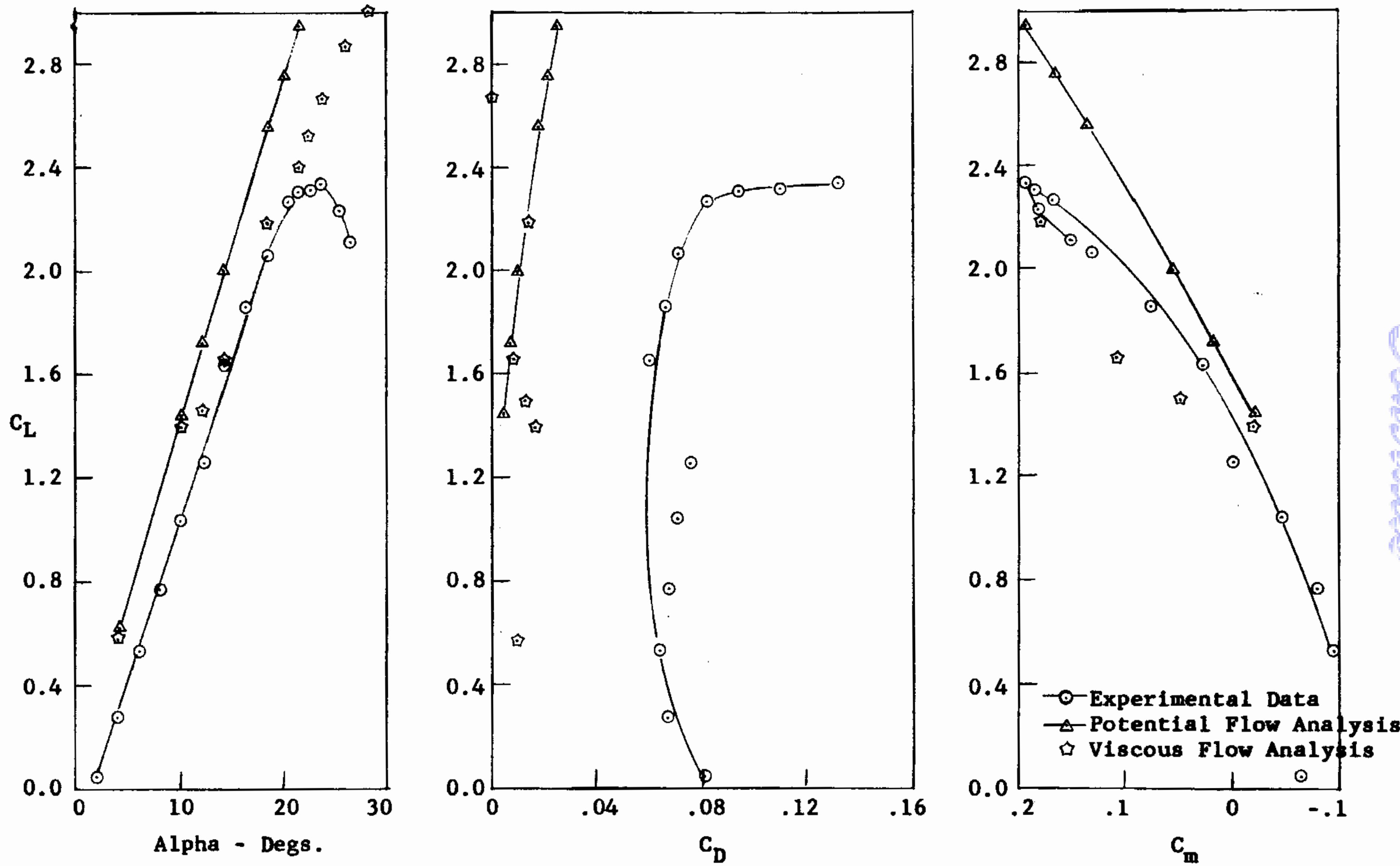

Figure 42 Substantiation of the Viscous Method F-111 Section with Leading-Edge Slat

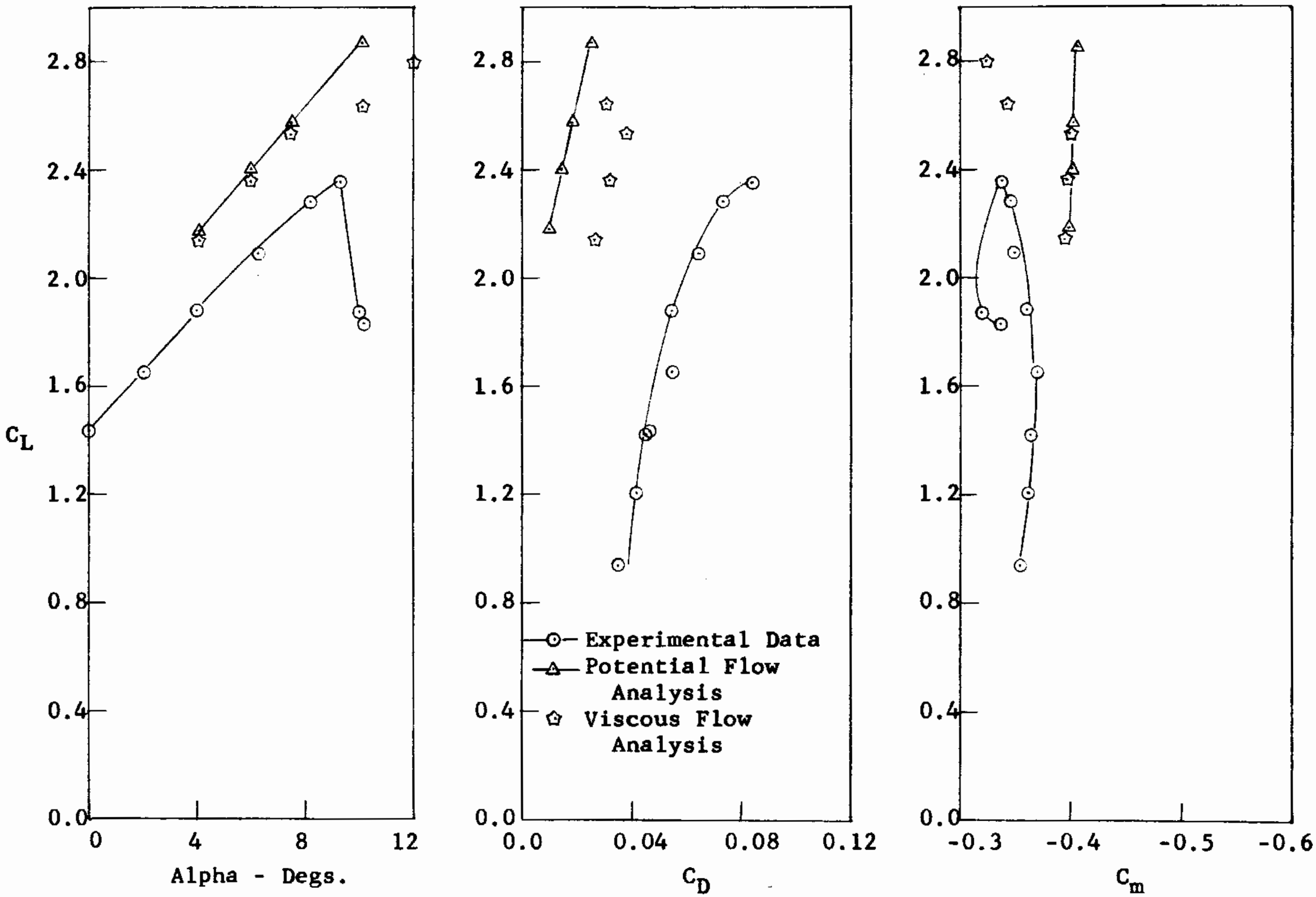

Figure 43 Substantiation of the Viscous Method F-111 Section with Single-Slotted Flap Deflected 20°

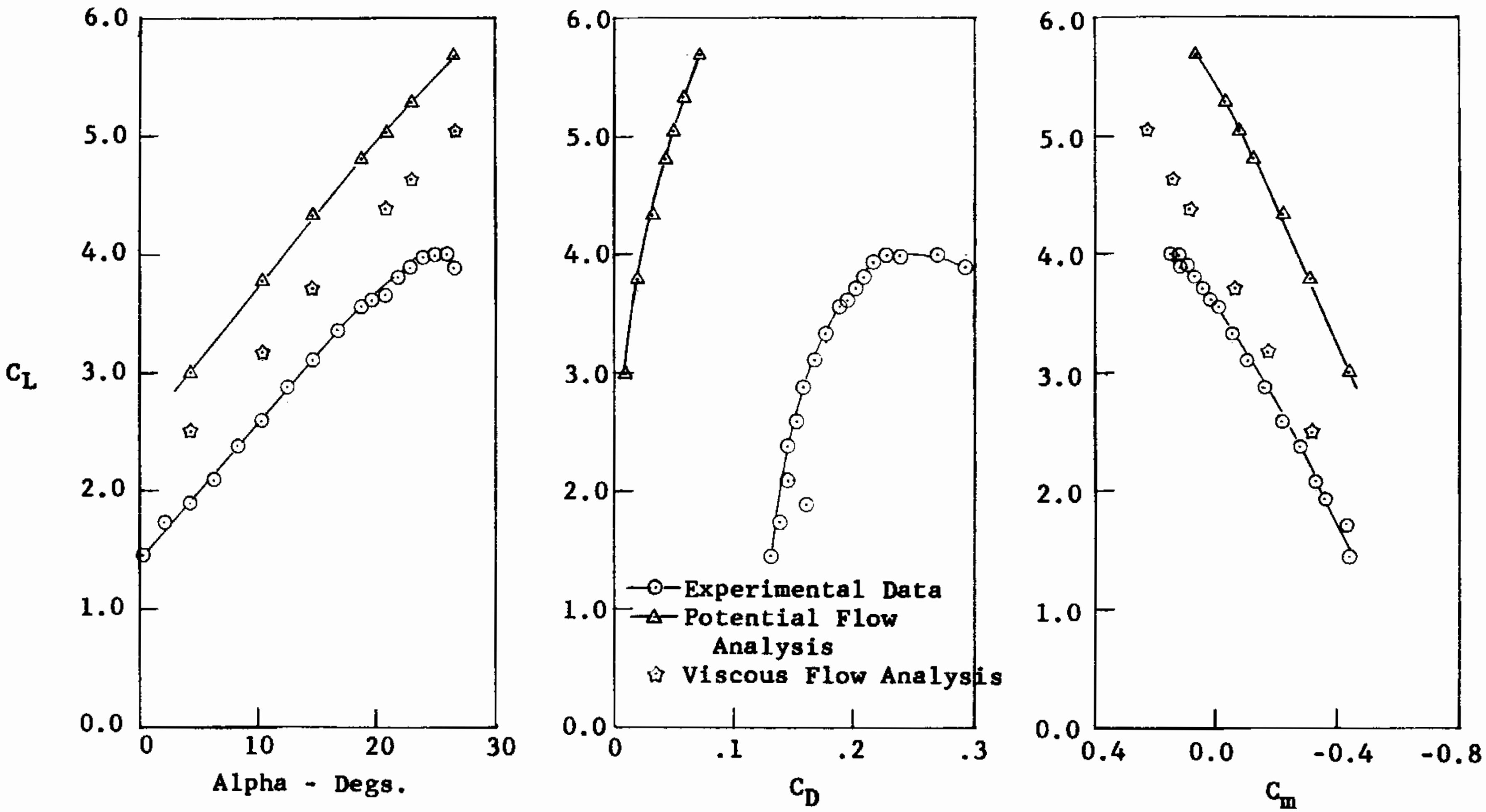

Figure 44 Substantiation of the Viscous Method F-111 Section with Slat and Single-Slotted Flap Deflected 30°

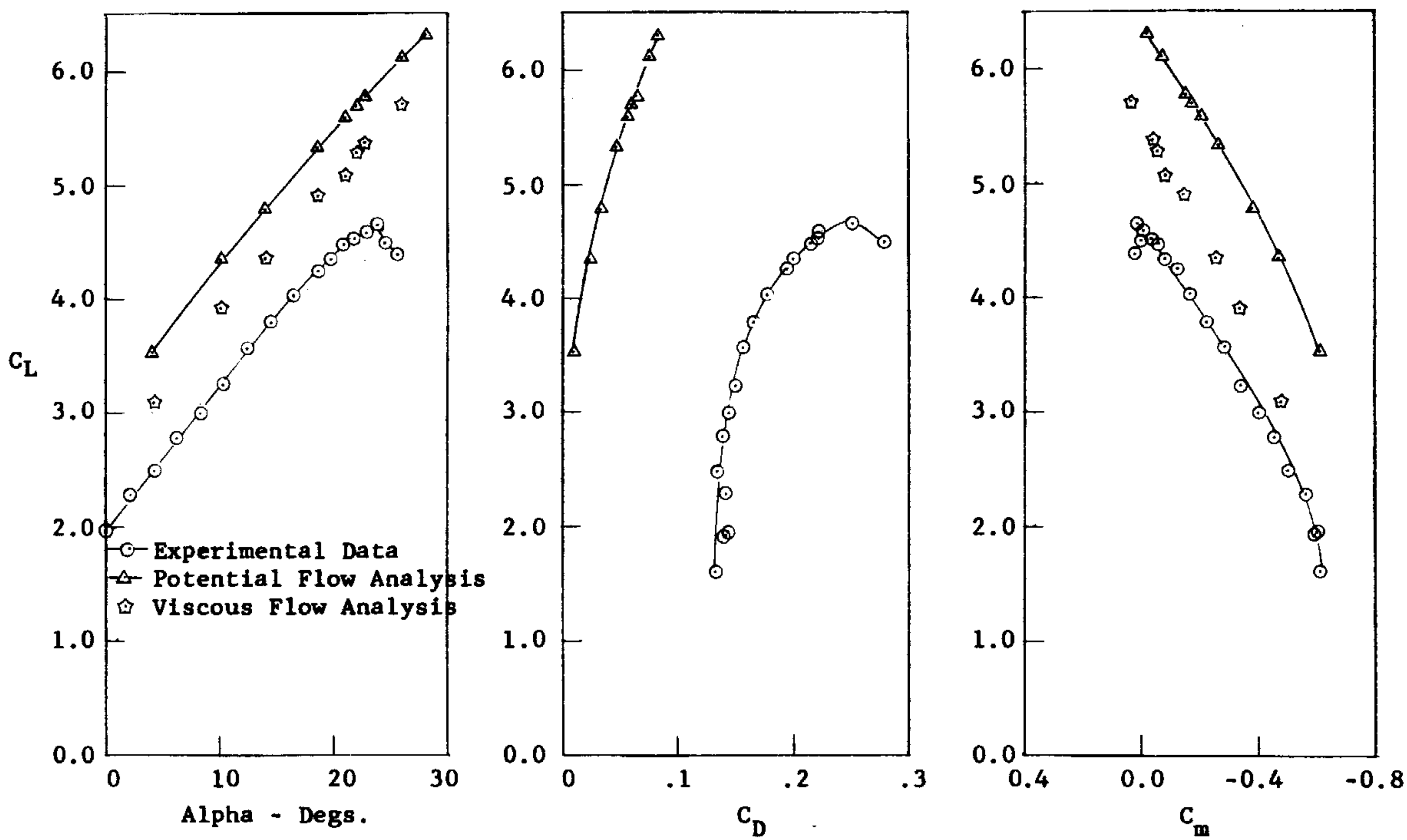

Figure 45 Substantiation of the Viscous Method F-111 Section with Slat and Double-Slotted Flap Deflected 40°

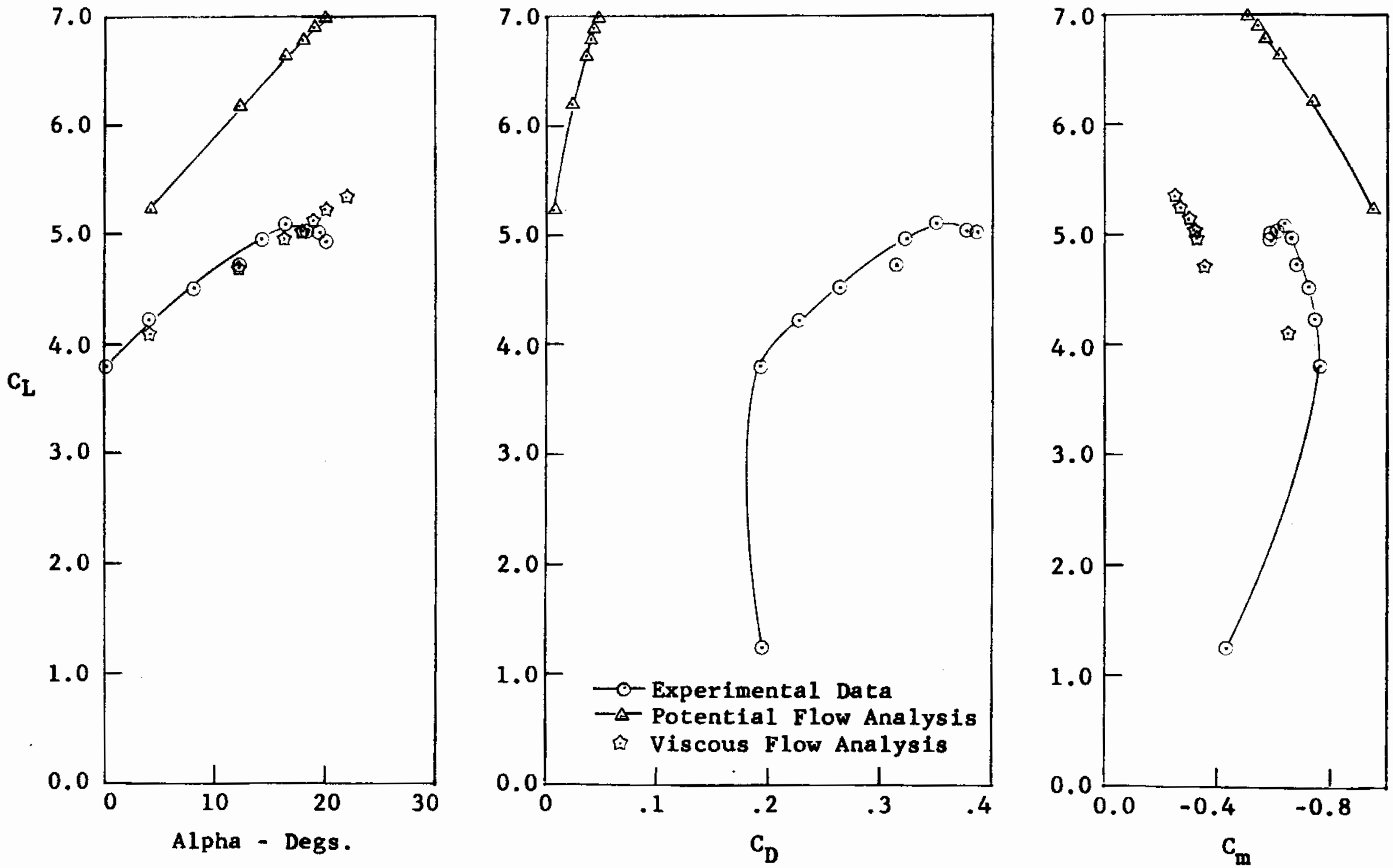

Figure 46 Substantiation of the Viscous Method F-111 Section with Slat and Triple-Slotted Flap Deflected 70°

8. CONCLUDING REMARKS

The method described for the analysis of multi-element airfoils in viscous flow calculates lift and pitching moment coefficients that correlate well with experimental data. For most configurations the value of $C_{L_{max}}$ can be predicted if the analysis is carried out in fine increments of angle of attack near the stall angle. The analysis is not valid after stall. The values of drag coefficient predicted for systems where substantial flow separation is predicted are erratic and unreliable and not recommended for use. The results obtained by this method are significantly better than those obtained from potential-flow methods. The method is recommended for the analysis of high-lift systems.

The separation point for several configurations was predicted downstream of the separation point indicated experimentally. The effect of the wake shed by the forward element on the separation point on the following element was not considered in this analysis. Inclusion of these effects into criteria for predicting the separation point is required.

The simplified mathematical model developed for the analysis of airfoil systems with separated flow predicts good results for airfoils with small regions of separated flow. Some discrepancies existing in the calculated pressure distributions in the separated region can be attributed to the model. This deficiency may possible be corrected by enforcing a base pressure condition in the separated region, perhaps determined empirically.

Including the effects of compressibility on both the pressure distributions calculated by inviscid analysis of the equivalent system and the boundary-layer characteristics calculated by the viscous analysis procedures should improve the results predicted by this method. Compressibility effects can be large for high-lift systems even at low free-stream Mach number as local Mach number can get high. Since most high-lift systems also operate in the vicinity of the ground, the inclusion of these effects in the analysis will significantly improve the applicability of this method.

APPENDIX I

COMPUTER PROGRAM DESCRIPTION

I-1 Procedure Description

The procedure X0P has been coded in FORTRAN Extended Language to operate on a CDC 6600 or a compatible model under the standard CDC-supplied operating system and utility programs. This procedure is an extension of the General Dynamics procedure AG0 (Ref. 1). The boundary-layer calculations in X0P use a number of subroutines (BNPUT, BN1CAL, BN1OUT, CSCNST, EDYVSC, ENERGY, FLPR, MOMTUM, STCNST, and STZERO) which have been taken from a procedure developed by Cebeci, Mosinskis, and Wang of Douglas Aircraft Company (Ref.10). Some modifications were made to these subroutines prior to their use in X0P. In particular, the calculation of the transition point was incorporated into subroutine BN1OUT. The values of constants and flags were fixed according to the incompressible problems solvable by X0P.

The main program, X0P00, controls the calling of seven overlays. In each overlay there is a program X0Pyz where y is the primary-level number and z is the secondary-level number of the overlay. These programs bring the desired subroutines into the core and direct the calling of the subroutines to make the necessary computations. Figure 47 shows the important subroutines called from these programs, while Figure 48 shows the flow of information and the calculations performed from the customer's viewpoint.

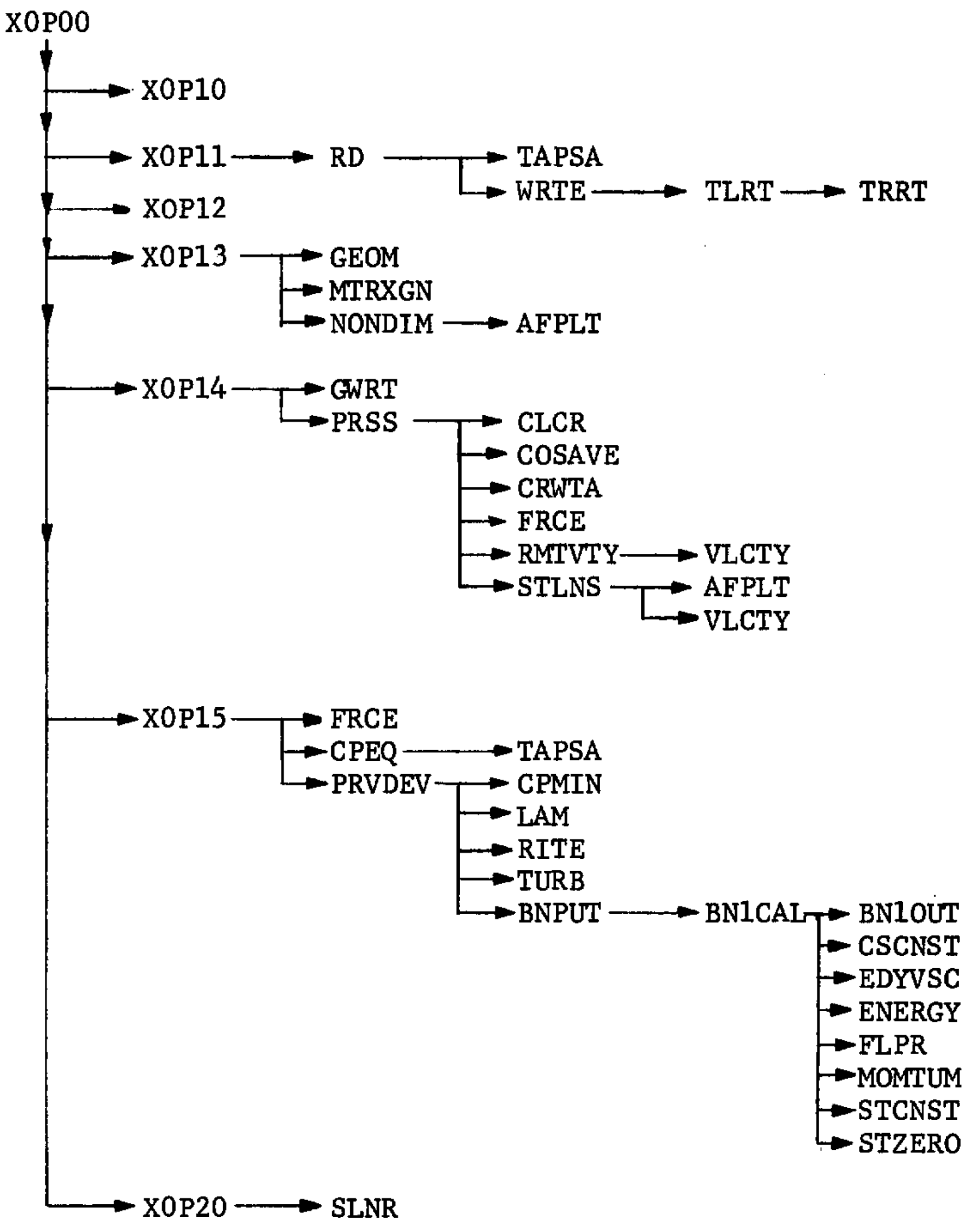

Figure 47 Flow Schematic of Procedure XOP

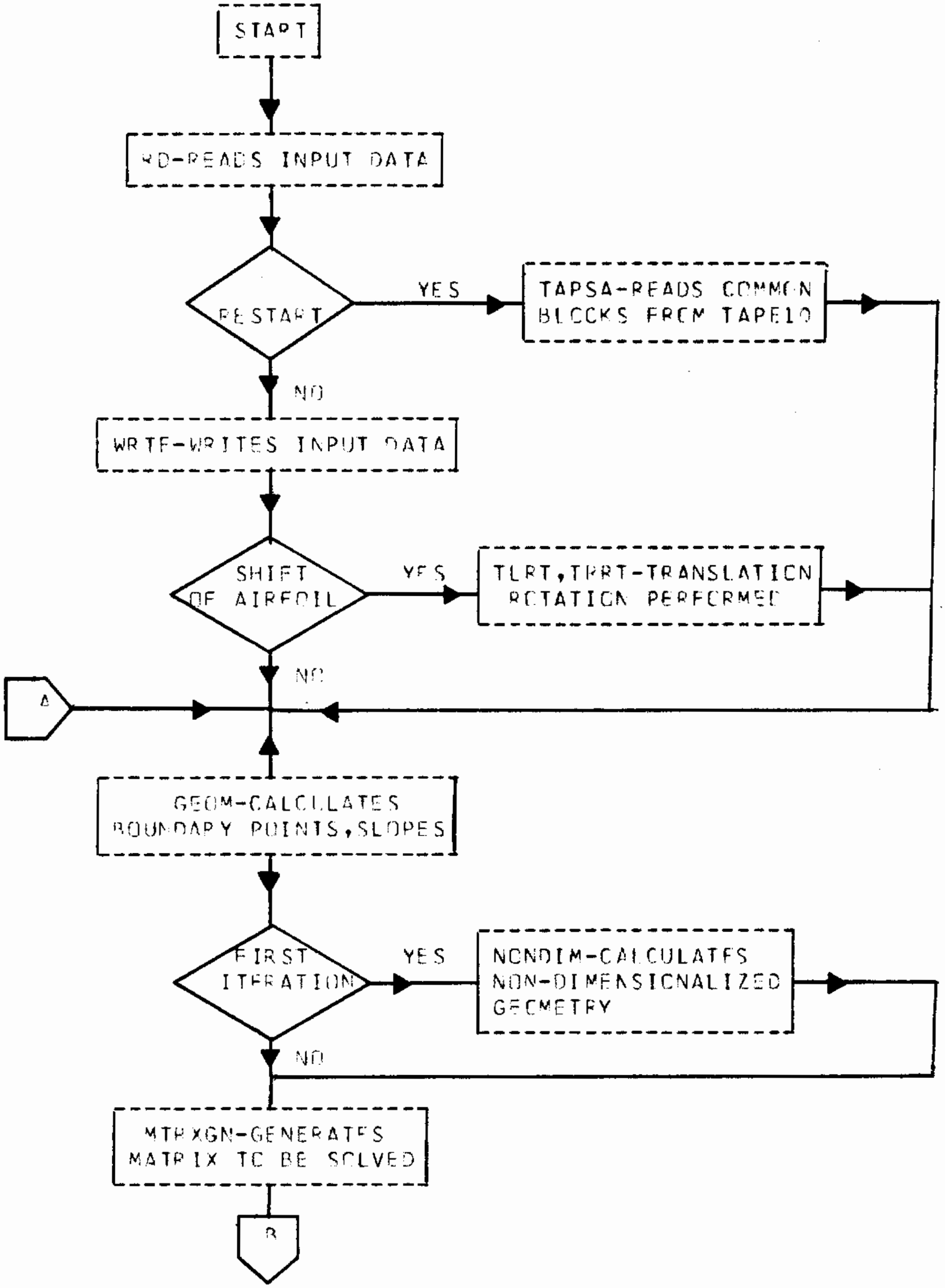

Figure 48 Flow Charts of Procedure XOP

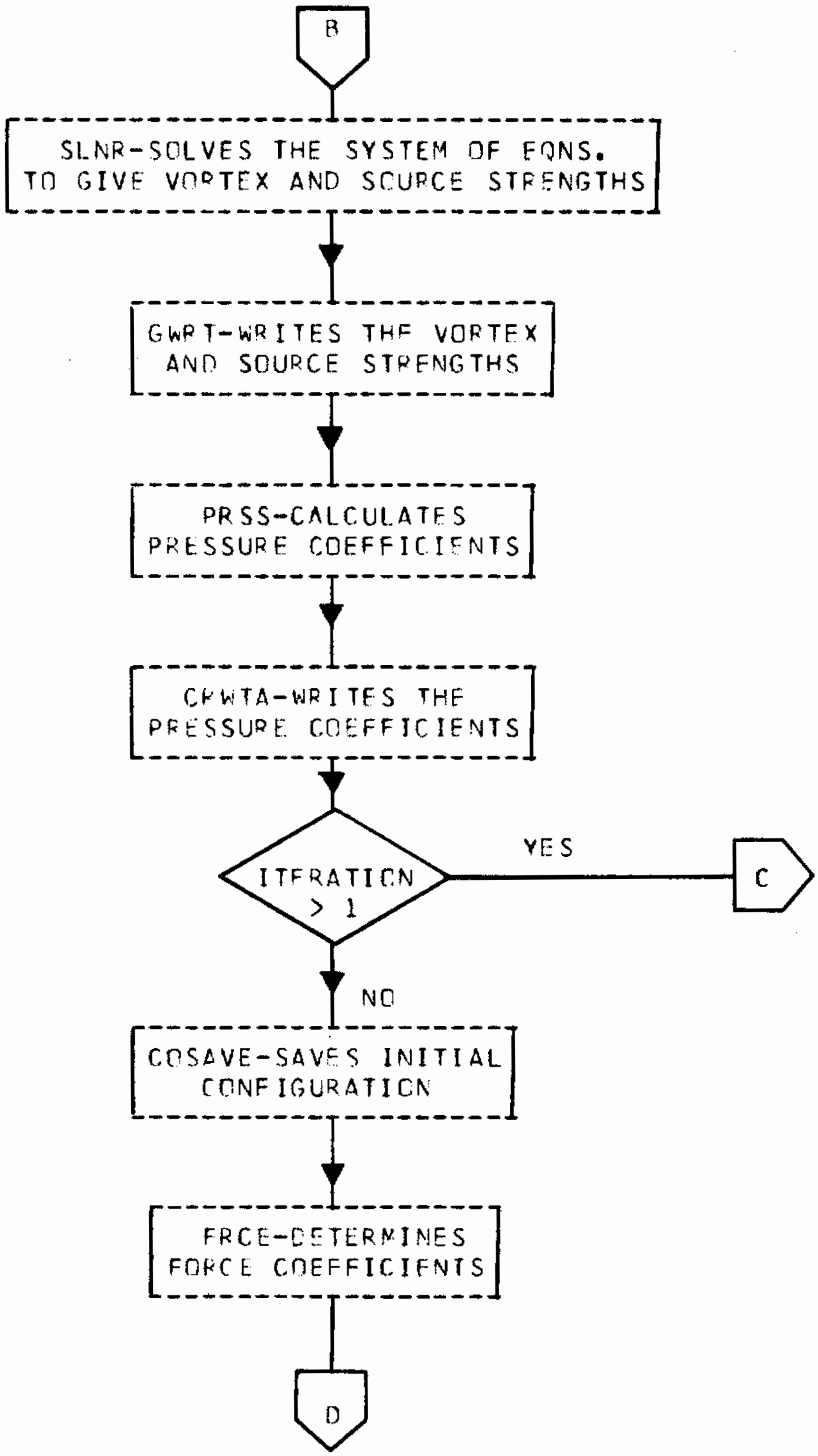

Figure 48 CONTINUED

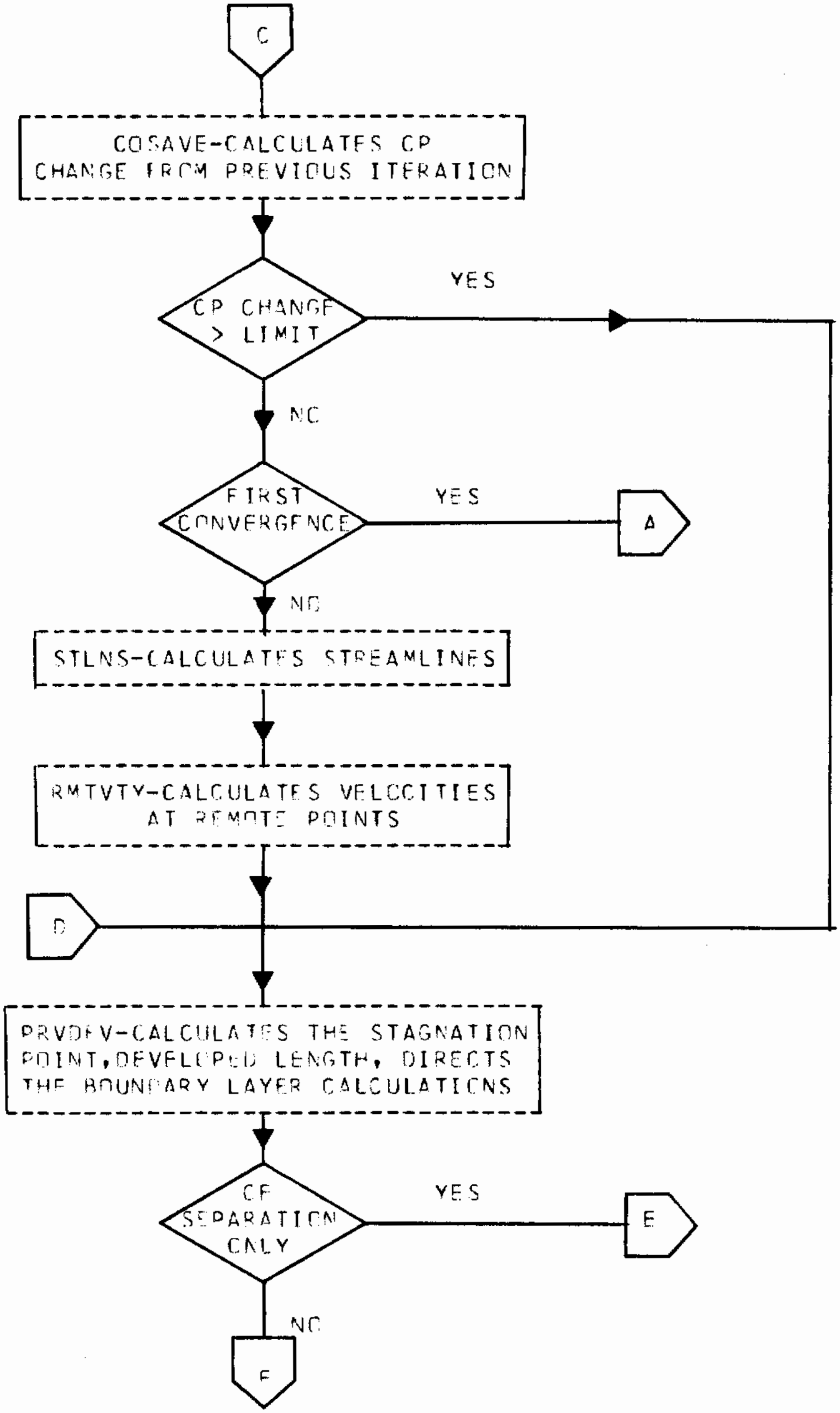

Figure 48 CONTINUED

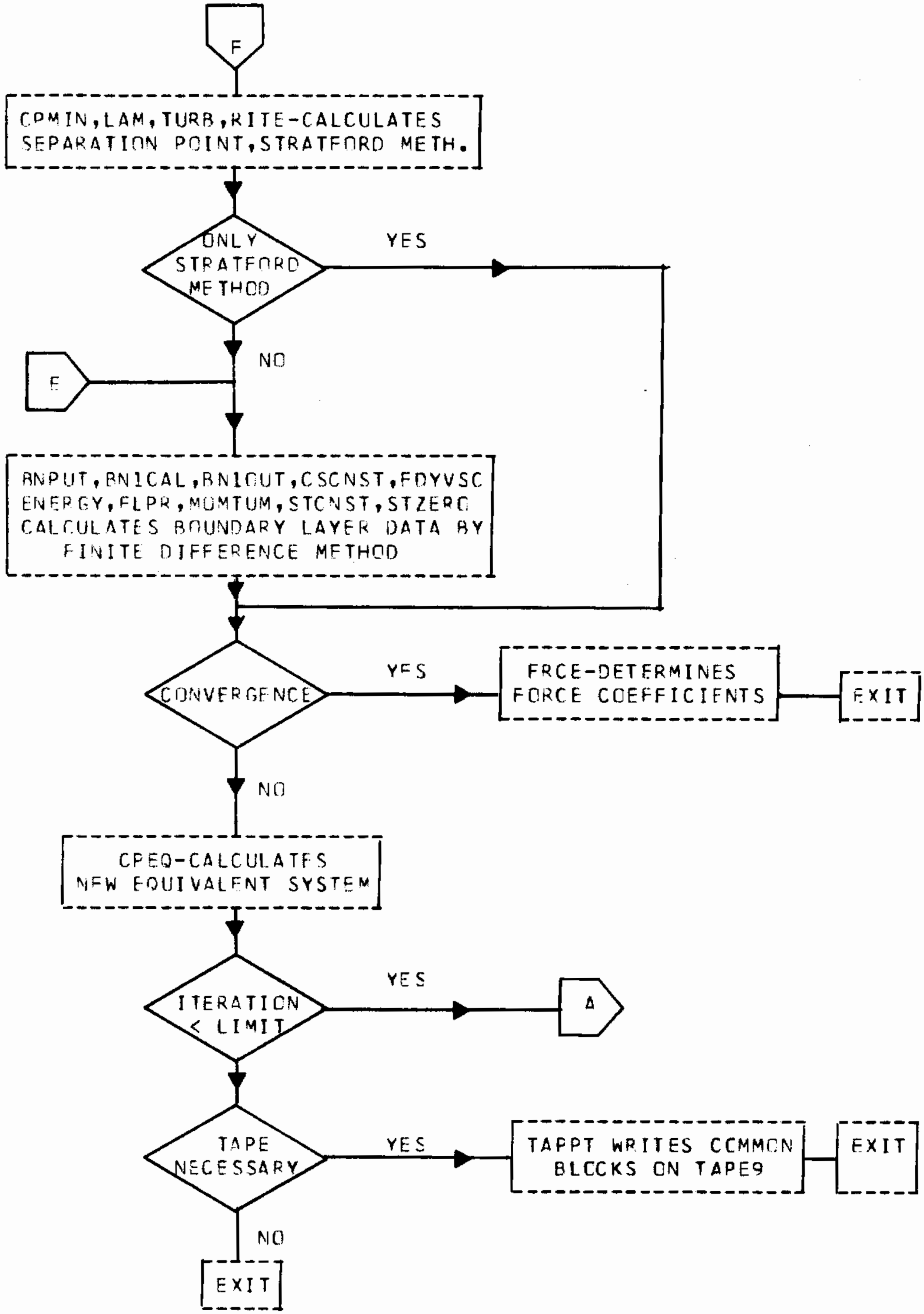

Figure 48 CONCLUDED

I-2 I/O Requirements

Card input occurs on file name TAPE5, and data output occurs on file name TAPE6. In addition to these files, there are four more file names, as listed below. Reading of TAPE10 and writing of TAPE9 is associated with the restart capability and will occur only once during a run if a restart is required. The reading and writing of TAPE1 and TAPE2 occur during every iteration and most of the I/O time is associated with TAPE1 and TAPE2 operations, if only the first and last (converged) solutions are printed.

Subroutine	File Name	Operation
MTRXGN	1	Write u, v velocity components
	2	Write linear equation coefficients
PRSS	1	Read u, v velocity components
SLNR	2	Read linear equation coefficients
TAPSA	9	Write common blocks to be saved for a restart at a later time
	10	Read common blocks written on TAPE9 for the restart

I-3 Deck Structure

The deck makeup for a run consists of a Job card, INPUT card, 7/8/9 card, binary object decks as listed below, 7/8/9 card, problem data deck, and 6/7/8/9 card. This is the deck required for a problem not involving a restart. If a tape is to be saved after the number of iterations specified by the input for a restart at a later time, a REQUEST (TAPE9) card is required after the Job card to obtain an output tape. On restarting a problem, the tape saved from a previous run is required as input. This requires a REQUEST (TAPE10) card after the Job card.

DECK STRUCTURE FOR OVERLAYS

```
OVERLAY (DUM,0,0)
    PROGRAM X0P00
        SUBROUTINE KEOF
OVERLAY (DUM,1,0)
    PROGRAM X0P10
        SUBROUTINE AFPLT
        SUBROUTINE DSTRBD
        SUBROUTINE DSTSQD
        SUBROUTINE FRCE
        SUBROUTINE HEADR
        SUBROUTINE TAPSA
OVERLAY (DUM,1,1)
    PROGRAM X0P11
        SUBROUTINE RD
        SUBROUTINE TLRT
        SUBROUTINE TRRT
        SUBROUTINE WRTE
OVERLAY (DUM,1,2)
    PROGRAM X0P12
OVERLAY (DUM,1,3)
    PROGRAM X0P13
        SUBROUTINE GEOM
        SUBROUTINE MTRXGN
        SUBROUTINE NONDIM
OVERLAY (DUM,1,4)
    PROGRAM X0P14
        SUBROUTINE CLCR
        SUBROUTINE COSAVE
        SUBROUTINE CRWTA
        SUBROUTINE GWRT
        SUBROUTINE PRSS
        SUBROUTINE RMTVTY
        SUBROUTINE STLNS
        SUBROUTINE VLCTY
OVERLAY (DUM,1,5)
    PROGRAM X0P15
        SUBROUTINE BNPUT
        SUBROUTINE BN1CAL
        SUBROUTINE BN1OUT
        SUBROUTINE CPEQ
        SUBROUTINE CPMIN
        SUBROUTINE CSCNST
        SUBROUTINE EDYVSC
        SUBROUTINE ENERGY
```

DECK STRUCTURE FOR OVERLAYS (Cont'd)

```
                SUBROUTINE FLPR
                SUBROUTINE LAM
                SUBROUTINE MOMTUM
                SUBROUTINE PRVDEV
                SUBROUTINE RITE
                SUBROUTINE STCNST
                SUBROUTINE STZERO
                SUBROUTINE TURB
        OVERLAY (DUM,2,0)
            PROGRAM XOP20
                SUBROUTINE SLNR
```

I-4 Function of Subroutines and Programs

SUBROUTINE AFPLT can be used with minor modifications to plot the airfoil system being analyzed.

SUBROUTINE BNPUT generates the grid size and determines the maximum number of points in the η-direction for the boundary-layer calculations.

SUBROUTINE BN1CAL controls the logic of the boundary-layer calculations.

SUBROUTINE BN1OUT calculates the transition point and prints the calculated boundary-layer characteristics.

SUBROUTINE CLCR calculates the incompressible pressure coefficients at any boundary point after the velocities have been calculated.

SUBROUTINE COSAVE saves the initial configuration and determines if convergence has occurred.

SUBROUTINE CPEQ calculates the coordinates of the equivalent airfoil system with the boundary layer superimposed.

SUBROUTINE CPMIN calculates the minimum pressure coefficient and the derivative of the pressure coefficient for the Stratford method.

SUBROUTINE CRWTA writes the pressure coefficients.

SUBROUTINE CSCNST calculates the constant coefficients of the finite-difference formulas in the y-direction.

SUBROUTINE DSTRBD calculates the components of velocity induced by a triangular distribution of vorticity at any boundary point.

SUBROUTINE DSTSQD calculates the distance between two specified points.

SUBROUTINE EDYVSC calculates quantities associated with the eddy viscosity.

SUBROUTINE ENERGY calculates the solution of the energy equation.

SUBROUTINE FLPR calculates the fluid properties.

SUBROUTINE FRCE calculates, numerically integrates, and prints out the force coefficients.

SUBROUTINE GEOM calculates and writes the boundary point coordinates and the local surface slope associated with each boundary point.

SUBROUTINE GWRT writes the vortex and source strengths computed.

SUBROUTINE HEADR writes the program title on top of a page.

SUBROUTINE KEOF writes the location of an unexpected end of file during a read operation.

SUBROUTINE LAM calculates the laminar separation points by Stratford's method.

SUBROUTINE MOMTUM calculates the solution of the momentum equation.

SUBROUTINE MTRXGN generates the matrix to be solved.

SUBROUTINE NONDIM calculates and writes the non-dimensionalized coordinates for the airfoil system.

SUBROUTINE PRSS directs the calculation and writing of the pressure coefficients.

SUBROUTINE PRVDEV calculates the stagnation point and directs the calculation of pressure vs developed length. It also adjusts indices to take into account the separation-point location.

SUBROUTINE RD reads the input data and checks for input errors.

SUBROUTINE RITE writes the calculated pressure gradient and the pressure gradient required for laminar or turbulent separation by Stratford's method.

SUBROUTINE RMTVTY directs the calculations and writing of the velocity at the remote points.

SUBROUTINE SLNR solves the system of equations for the vortex and source strengths.

SUBROUTINE STCNST calculates the coefficients of the finite-difference formulas in the x-direction.

SUBROUTINE STLNS calculates the streamlines for the airfoil system.

SUBROUTINE STZERO starts the boundary-layer calculations at the stagnation point.

SUBROUTINE TAPSA reads and/or writes a number of common blocks on tape for a restart of the calculations.

SUBROUTINE TLRT directs the translation and/or rotation on an airfoil part.

SUBROUTINE TRRT performs the translation and/or rotation about a point.

SUBROUTINE TURB calculates the turbulent separation point by Stratford's method.

SUBROUTINE VLCTY calculates the velocity at any point.

SUBROUTINE WRTE writes the input data and the coordinates after any translation and/or rotation.

PROGRAM XOP00 controls the logic of the calling of the overlays, writing of a tape for a restart, and the number of iterations performed to obtain a converged solution.

PROGRAM XOP10 permits the subroutines TAPSA, FRCE, AFPLT, DSTSQD, DSTRBD, and HEADR to be in overlay segment (1,0).

PROGRAM XOP11 directs the calling of subroutine RD.

PROGRAM XOP12 directs the calling of subroutine TAPSA.

PROGRAM XOP13 controls the calling of subroutines GEOM, NONDIM, and MTRXGN.

PROGRAM XOP14 directs the calling of subroutines GWRT and PRSS.

PROGRAM XOP15 controls the calling of subroutines PRVDEV, CPEQ, and FRCE.

PROGRAM XOP20 directs the calling of subroutine SLNR.

I-5 Definition of FORTRAN Variables

COMMON BLOCKA

ANGL(10)	Angles of attack, input
BEGIN	Logical variable, false during first iteration and true thereafter
IND(30)	Option indicators, input
ITER	Iteration number
ITMAX	Maximum acceptable iteration number, input
LIT	Logical variable, true if convergence occurs in subroutine COSAVE
NAFPTS	Number of airfoil parts, input
NANGLS	Number of angles of attack, input
NCPTS(10)	Number of corner points per airfoil part
NOANG	Index of angle of attack of problem being solved
NPTS	Total number of corner points
NPNTS	NPTS plus 1
NSTLNS	Number of streamlines
NVLPTS	Number of remote points at which the velocity is required, input
N1	NPTS plus NAFPTS
N2	N1 plus 1

COMMON BLOCKB

COSRF	Cosine of the angle made by reference chord with the X axis
CPUP(200)	Pressure coefficient
ISAVE(10)	Index associated with the stagnation points on each airfoil part
CREF	Reference chord length
CRFSQ	Square of the reference chord length
CRT	Maximum number of points on each streamline, input
CSTH(10)	Cosine of the angle made by the local chord of each airfoil part with the X axis
DLTALM	Maximum distance between two consecutive points on a streamline, input
DLTALN	Nominal starting distance between two consecutive points on a streamline, input
DLTLMN	Minimum distance between two consecutive points on a streamline, input
DS(10)	Local chord lengths
DXTGE	Distance behind the trailing edge at which the condition of continued tangential flow is satisfied, input
HEIGHT	Initial separation-streamline direction control factor, input
IDD(8)	Laminar or turbulent Stratford's separation analysis indicator and control for printout of iterations indicator, input

IDFO(10)	Logical variables; subscripts 1 to 8 are true if IDD variable equals zero, subscript 9 is true if convergence has occurred, and subscript 10 is true if the data should be printed for an iteration.
INDR(10)	Translation and/or rotation indicator for an airfoil part, input
JCPTS(10)	Number of corner points associated with airfoil part, iteration 1
JIBEG(10)	First corner point index associated with an airfoil part, iteration 1
JIEND(10)	Last corner point index associated with an airfoil part, iteration 1
JIE(10)	Last corner point index of the current equivalent body part
JIS(10)	First corner point index of the current equivalent body part
JIEE(10)	Equal to JIE associated with previous iteration
JISS(10)	Equal to JIS associated with previous iteration
JNPTS	Total number of corner points, iteration 1
REY	Reynolds number, input
SINRF	Sine of the angle made by the reference chord with the X axis
SNTH(10)	Sine of the angles made by the local chords with the X axis
TITLE(12)	Title of the problem, input
TOLLMT	Error acceptable in calculating streamlines, input

USUBI	Freestream velocity, set equal to 1.0
XLE(10)	X coordinate of leading edge of an airfoil part, input
XLR	X coordinate of reference leading edge, input
XMBAR	X coordinate of point about which moments are calculated, input
XSUBC	X coordinate value up to which the streamlines are calculated, input
XTE(10)	X coordinate of trailing edge of an airfoil part, input
XTR	X coordinate of reference trailing edge, input
YLE(10)	Y coordinate of leading edge of an airfoil part, input
YLR	Y coordinate of reference leading edge, input
YMBAR	Y coordinate of point about which moments are calculated, input
YTE(10)	Y coordinate of trailing edge of an airfoil
YTR	Y coordinate of reference trailing edge, input
ZD(3)	Not in use in the current version of the program
ZS(3)	Not in use in the current version of the program
RATIO(200)	Ratio of distances between corner points used to interpolate and extrapolate δ^* values

COMMON BLOCKC

CPCOS(200)	Cosine of the angle made by the local surface at each boundary point, initial array
CPJ(200)	Pressure coefficient array for total system, present iteration
CPK(200)	Pressure coefficient array for total system, previous iteration
CPSIN(200)	Sine of the angle made by the local surface at each boundary point, initial array
XJ(200)	X coordinate of corner points, initial array
YJ(200)	Y coordinate of corner points, initial array

COMMON BLOCKD

COSSLP(200)	Cosine of the angle made by the local surface at each boundary point of the equivalent system
CS	Cosine of the angle of attack
IE(10)	Boundary point index associated with the last boundary point on each airfoil part
IIS(10)	Boundary point index associated with the stagnation point on each airfoil part
IJS(10)	Not used in the current version of the program
IS(10)	Boundary point index associated with the first boundary point on each equivalent body part
SINSLP(200)	Sine of the angle made by the local surface at each boundary point of the equivalent system

SN	Sine of the angle of attack
XBP(200)	X coordinate of boundary points on the equivalent system
YBP(200)	Y coordinate of boundary points on the equivalent system

COMMON BLOCKE

ALPHA	Angle of attack, degrees
GAMMA(200)	Vortex and source strengths
SS(10)	Source strength
VSUBM	Mach number
X(200)	X coordinate of corner points of the equivalent system
XS(30)	X coordinate of streamline starting point
XSLOC1(10)	X coordinate of source location for an airfoil part
XV(100)	X coordinate of the point at which velocity is calculated
Y(200)	Y coordinate of corner point of the equivalent system
YS(30)	Y coordinate of streamline starting point
YSLOC1(10)	Y coordinate of source location for an airfoil part
YV(100)	Y coordinate of the point at which velocity is calculated

COMMON BLOCKF

U(200)	Velocity component in the X direction
V(200)	Velocity component in the Y direction

COMMON BLOCKH

AEPS	CF level below which separation will be assumed to occur, input
ACREF	Reference chord length
AUSUBI	Freestream velocity
AVSUBM	Freestream Mach number
GRIDK	Grid parameter used in the finite-difference boundary-layer calculation method
HETEM	Reference static temperature ^{o}R
ICFLAG	Compressibility indicator (not used in the current version of the program)
IIPR	Option indicator for detail print of boundary layer profiles
ISEPA	Index point associated with the separation point
RRO	Prandtl number
XRHOEO	Flow density
BPDE(200)	Calculated displacement thickness at the boundary point for each surface
ITRAN(20)	Transition point index
BPDEL(200)	Calculated displacement thickness at the boundary point for the complete system

COMMON BLOCKI

MBPU(10)	Lower limit of the index of boundary points for determining the stagnation point
MBPL(10)	Upper limit of the index of boundary points for determining the stagnation point

COMMON BLOCKJ

CFDE(200)	Calculated local skin-friction coefficient at the boundary point for each surface
CFF(200)	Calculated local skin-friction coefficient at the boundary point for the complete system

COMMON BLOCKL

IEQ(10)	Initial value of IE, used for restart
ISQ(10)	Initial value of IS, used for restart
QCOSSL(200)	Initial value of COSSLP, used for restart
QSINSL(200)	Initial value of SINSLP, used for restart
QX(200)	Initial value of X, used for restart
QXBP(200)	Initial value of XBP, used for restart
QY(200)	Initial value of Y, used for restart
QYBP(200)	Initial value of YBP, used for restart

COMMON B3

ETAE6	Transformed boundary-layer thickness for laminar flow, set to 8 in the current version of the program
ETAE9	Transformed boundary-layer thickness for turbulent flow, set to 100 in the current version of the program
IMX6	Number of points in the η-direction for laminar flow
IMX9	Number of points in the η-direction for turbulent flow

LTRAN	Logical variable to designate if transition has occurred
LL	Not in use in the current version
Q	Temperature
THETA	Momentum thickness
RTHETA	Reynolds number based on momentum thickness
INSTA	Index of point where instability occurs
IBUB	Index of point where bubble burst occurs
GPW1(200)	Input quantity related to the heat transfer rate at the wall, set to 0 in the current version of the program
TE1(200)	Absolute temperature array

<u>COMMON B4</u>

UE1(200)	Pressure coefficient array
X1(200)	Developed length array

APPENDIX II

PROGRAM UTILIZATION

II-1 Input

Card input is classified into three sections. The first section consists of the title for the problem and has two cards of alphanumeric information. The second section consists of integers and has a variable number of cards. The last section consists of floating-point constants and has a variable number of cards.

The input that is in the form of integers has a maximum of 15 input items per card. Columns 1 to 3 contain the first input item; columns 4 to 6 contain the second input item; ...; and columns 43 to 45 contain the 15th input item, if required. The numbers should be right-adjusted in each field, since leading, trailing and embedded blanks are treated as zeros. If additional input items are required, the 16th item appears in columns 1 to 3 on the next card with the additional items in the following 3 column fields.

The cards requiring floating-point constants have a maximum of 6 items per card. Each input item has a field length of 10 columns and must be right-adjusted or accompanied by a decimal point. If the decimal point is omitted, the decimal is placed after the digit in the 10th column. The first input item is in columns 1 to 10; the second input item, if required, is in columns 11 to 20; ...; and the sixth input item, if required, is in columns 51 to 60. If more input items for a card type are required, the input items appear on additional cards.

II-1.1 Card Description

A problem deck other than for the case of a restart should be assembled in the order given below. The problem deck for a restart consists of cards of type A and B only, with changes permitted in indicators input as B13, B14, B19, B20, B21, and B22.

A. Title Cards (2 required)

The first card contains the title in columns 1-60.

The second card is a continuation of the title in columns 1-40, with the job and deck identification appearing in columns 41-50 and the date in columns 51-60. Any combination of alphanumeric characters may be used (FORMAT 6A10/6A10).

B. Option Indicator Cards (2 required)

These cards have the following input items on Card 1:

B1, B2, B3, ..., B14, B15

and on Card 2:

B16, B17, B18, ..., B29, B30

with a FORMAT of 15I3/15I3, where

B1	= -1	Transition point is evaluated by the program using method specified by B15.
	= 0	Transition point is a constant number of points, given by B2, downstream of the C_p minimum location on each airfoil segment.
	= 1	Transition point index is read in for the upper and lower surfaces of each airfoil part.
B2	= 0	When B1 = -1 or 1
	= N	Number of points downstream of C_p minimum location where transition occurs.
B3	= 0 = 1 = 2	If B16=2 (i.e., using Stratford's method to calculate separation point) and the solution is near convergence, B16 is set equal to B3.
B4	= 0	The equivalent body used in the next iteration is obtained by removing all points downstream of the predicted separation point. The maximum number of points to be removed is 8 for one iteration.

	= 1	The equivalent body used in the next iteration is obtained by removing half the points between the predicted separation point and the current equivalent body.
B5	= N	Number of angles of attack, $1 \leq B5 \leq 10$
B6	= 0	Forces calculated with detailed output
	= 1	Forces calculated with no detailed output
	= 2	No forces calculated

<u>NOTE</u>: Force calculations are made only in the first (potential flow) and last (converged) iteration cycles.

B7	= 0	No streamlines
	= 1	Streamlines required; if B7 equals 1, C2 must be positive and/or B9 must equal 1.
B8	= 0	No translation and/or rotation of the system required.
	= 1	Translation and/or rotation of the system required to align the X axis with input reference chord.
B9	= 0	No streamlines from separation points
	= 1	Two streamlines evaluated for each airfoil segment, starting (1) from the separation point (if any) or the trailing edge of the upper surface and (2) from the trailing edge of the lower surface.
B10	= 0	All boundary points used in evaluating stagnation points
	= 1	Input range of boundary points used in evaluating stagnation points (use only for airfoils which have large regions of near-stagnation flow).

B11 = 0	Non-dimensionalized values for the input calculated
= 1	Non-dimensionalized values for the input not calculated
B12 = 0	Not in use in present version
B13 = N	Number of iterations permitted; calculations stop after N iterations and no tape is saved, $1 \leq N$
B14 = 1	Initial start of problem
= N	Iteration index number; add one to the iteration index for which calculations were saved
B15 = 0	Transition point calculation by Ward-Michelle method only if B1 = -1
= 1	Transition point calculation by Schlicting-Ulrich method only if B1 = -1
B16 = 0	Calculation of boundary-layer separation point by CF values
= 1	Calculation of boundary-layer separation point by Stratford's method. δ^* given by BN1.
= 2	Calculation of boundary-layer separation point by Stratford's method with δ^* set to zero, i.e., no boundary-layer calculations are made. Near convergence, B16 is set equal to B3. On a restart after "convergence," set B16 equal to B3 on input card.
B17 = 0	Not in use in present version
B18 = 0	Not in use in present version
B19 = 1	For initial calculation

= N — For a restart where N is the angle number at which the previous calculations were stopped.

B20 = 0 — Time limit specified on Job Card, or number of iterations specified in B13, or completion of job will terminate problem. No tape will be saved.

= 1 — When starting initial problem and a tape is to be saved after the number of iterations specified by B21. Tape 9 will be saved. REQUEST statement necessary for Tape 9.

= 2 — When restarting a problem using input data from Tape 10 and a tape is to be saved after the iteration index specified by B21 has been reached. Tape 9 will be saved. REQUEST statements necessary for Tape 9 and Tape 10.

NOTE: When B20 = 1 or 2, time limit specified should permit the number of calculations necessary for saving a tape. If job termination occurs due to exceeding time limit, no tape will be saved.

B21 = 0 — When B20 = 0

= N — Number of iterations permitted with B20 = 1 or 2. After N iterations data will be saved on Tape 9 for a future restart.

B22 = 0 — No matrix printout

= N — Influence coefficient matrix will be printed for iteration number N

B23 = 0 — Not in use in present version

⋮

B30 = 0 — Not in use in present version

C. Problem Dimension Card (1 required)

This card has the following input items:

C1, C2, C3, with a FORMAT of 3I3, where

C1 = Number of airfoil parts, $0 < C1 \leq 10$

C2 = Number of streamlines, $0 \leq C2 \leq 10$. Do not include those associated with indicator B9.

C3 = Number of remote points at which the velocity is required, $0 \leq C3 \leq 100$

D. Corner Point Card (1 required)

This card has the following input items:

D1, D2, ..., DA with a FORMAT of 10I3, where

D1 = Number of corner points on airfoil part number 1

D2 = Number of corner points on airfoil part number 2

⋮

DA = Number of corner points on airfoil part number A, and A = C1

The Di for any airfoil must be positive and the sum of Di must not exceed (200 - 3*C1).

E. Shift Indicator Card (1 required)

This card has the following input items:

E1, E2, ..., EA with a FORMAT of 10I3, where

E1 = 0 If no shift is required on airfoil part 1

= 1 If a shift is required on airfoil part 1

E2 = 0 If no shift is required on airfoil part 2

= 1 If a shift is required on airfoil part 2

⋮

EA = 0 If no shift is required on airfoil part A, and A = C1

= 1 If a shift is required on airfoil part A, and A = C1

F. Stratford Separation Card (1 required)

This card has the following input items:

F1, F2, F3, ..., F8 with a FORMAT 8I3, where

F1 = 0 Stratford's laminar boundary-layer analysis technique used to predict the separation point if B16 ≠ 0.

= 1 Stratford's turbulent boundary-layer analysis technique used to predict the separation point if B16 ≠ 0.

NOTE: If B16 = 0, set F1 = 1

F2 = 0 Print complete iteration cycle results

= 1 Print first and last (converged) iteration solution only

= N Print first, N, 2N, 3N, ..., and last (converged) iteration solution only

F3 = 0 Not in use in present version

⋮

F8 = 0 Not in use in present version

G. Transition Point Index Card (0, 1, or 2 required)

This card(s) is required only when B1 = 1 and has the following input items:

G1, G2, G3, G4, ..., GB with a FORMAT of 15I3/5I3, where

G1 = Boundary-point index at which transition is initiated on the upper surface of airfoil 1

G2 = Boundary-point index at which transition is initiated on the lower surface of airfoil 1

G3 = Boundary-point index at which transition is initiated on the upper surface of airfoil 2

G4 = Boundary-point index at which transition is initiated on the lower surface of airfoil 2

⋮

GB = Boundary-point index at which transition is initiated on the lower surface of airfoil A and A = C1, and B=2*C1.

NOTE: Laminar boundary layer is assumed at the boundary point whose index is input above.

Boundary points are points located midway between two consecutive airfoil corner points. The number of boundary points in each airfoil are one less than the number of airfoil corner points given by Di. They are indexed starting from the trailing edge on the upper surface to the leading edge and back to the trailing edge on the lower surface.

EXAMPLE:

The boundary point index associated with the tenth boundary point on airfoil J is given by

$$\text{Index} = \sum_{i=1}^{J-1} (\text{No. of boundary points on airfoil } i)$$

$$+ 2(J-1) + 10$$

H. <u>Stagnation Point Limit Card</u> (0, 1, or 2 required)

This card(s) is required only when B10 = 1 and has the following input items: H1, H2, H3, H4, ...HB with a FORMAT of 15I3/5I3, where

H1 = Boundary-point index above which the stagnation point is possible for airfoil 1.

H2 = Boundary-point index below which the stagnation point is possible for airfoil 1.

H3 = Boundary-point index above which the stagnation point is possible for airfoil 2.

H4 = Boundary-point index below which the stagnation point is possible for airfoil 2.

⋮

HB = Boundary-point index below which the stagnation point is possible for airfoil A and A = C1, and B=2*C1.

I. <u>Kutta Condition Card</u> (1 required)

This card has the following input item: I1 with a FORMAT of 1F10.0 where

I1 = distance behind the trailing edge at which the condition of continued tangential flow is satisfied; a typical value is 10^{-5} times the reference chord

J. <u>Moments Card</u> (1 required)

This card has the following input items: J1, J2 with a FORMAT of 2F10.0, where

J1 = X coordinate of a point about which moments are calculated.

J2 = Y coordinate of a point about which moments are calculated.

K. Reference Edge Card (1 required)

This card has the following input items: K1, K2, K3, K4 with a FORMAT of 4F10.0, where

K1 = X coordinate of the reference trailing edge of the system

K2 = Y coordinate of the reference trailing edge of the system

K3 = X coordinate of the reference leading edge of the system

K4 = Y coordinate of the reference leading edge of the system

Reference leading edge and trailing edge of the system must not be coincident.

L. Airfoil Edge Card (C1 required)

One card required for each airfoil part. Each card has the following input items: L1, L2, L3, L4 with a FORMAT OF 4F10.0, where

L1 = X coordinate of trailing edge of airfoil part i

L2 = Y coordinate of trailing edge of airfoil part i

L3 = X coordinate of leading edge of airfoil part i

L4 = Y coordinate of leading edge of airfoil part i

where i = 1, 2, ..., C1

Leading edge and trailing edge must not be coincident for any airfoil segment.

M. Source Location Card (C1 required)

One card required for each airfoil part. Each card has the following input items: M1, M2 with a FORMAT of 2F10.0, where

M1 = X coordinate of the source location in airfoil part i

M2 - Y coordinate of the source location in airfoil part i

where i = 1, 2, ..., C1

Sources must be located within the contour of each airfoil at approximately the quarter chord.

N. Incidence Card (B5 required)

One card for each angle of attack. Each card has the following input item: N1 with a FORMAT of 1F10.0, where

N1 = Angle of attack number i in degrees

where i = 1, 2, ..., B5 and B5 $\leq$ 10

P. Wake-Shape Control Card

This card has the following input item: P1 with a FORMAT of 1F10.0, where

P1 = Determines the angle made by the separation streamline with the local surface

(1) If P1 > 1.0, the separation streamline makes an angle of P1 degrees with the local surface slope.

(2) If P1 $\leq$ 1.0, the separation streamline makes an angle with the local surface slope which is fraction P1 of the angle between the local slope and the free-stream direction.

Q. Streamline Card (0 or 1 required)

This card is required only when B7 $\neq$ 0 and has the following input items: Q1, Q2, Q3, Q4, Q5, Q6 with a FORMAT OF 6F10.0, where

Q1 = Maximum X value to which the streamlines are calculated; a typical value is 2 chord lengths downstream of the trailing edge.

Q2 = Minimum distance between two consecutive points on a streamline; a typical 10^{-3} times the reference chord.

Q3 = Nominal value which is the starting distance between two consecutive points on a streamline; a typical value is 10^{-2} times reference chord.

Q4 = Maximum distance between two consecutive points on a streamline; a typical value is 10^{-1} times reference chord.

Q5 = Maximum error allowed in calculating streamlines; a typical value is 10^{-5} times the reference chord.

Q6 = Maximum number of points on each streamline, typically 500.

$Q2 \leq Q3 \leq Q4$

R. Streamline Coordinate Card ((C2)/3 required)

This card(s) is required only when C2 ≠ 0 and has the following input items: R1, R2, R3, R4, ..., RB with a FORMAT of 6F10.0, where

R1 = X coordinate of the starting point for the first streamline

R2 = Y coordinate of the starting point for the first streamline

R3 = X coordinate of the starting point for the second streamline

R4 = Y coordinate of the starting point for the second streamline

⋮

RB = Y coordinate of the starting point for the A^{th} streamline with A = C2, and B = 2*C2.

S. <u>Remote-Points Card</u> ((C3)/3 required)

This card(s) is required only when C3 ≠ 0 and has the following input items: S1, S2, S3, S4, ... SB with a FORMAT of 6F10.0, where

S1 = X coordinate of remote point 1 at which the velocity is required

S2 = Y coordinate of remote point 1 at which the velocity is required

S3 = X coordinate of remote point 2 at which the velocity is required

S4 = Y coordinate of remote point 2 at which the velocity is required

⋮

SB = Y coordinate of remote point A at which the velocity is required with A = C3, and B = 2*C3.

T. <u>Reynolds Number Card</u> (1 required)

This card has the following input item: T1 with a FORMAT of 1F10.0, where

T1 = Reynolds number based on reference chord

U. <u>Boundary-Layer-Characteristics Card</u> (1 required)

This card has the following input items: U1, U2, U3, U4, U5 with a FORMAT of 5F10.0, where

U1 = CF level below which separation can be assumed to occur. Data may be modified to check on dCF/ds value. Typical value is 0.0001.

U2 = Grid parameter. This is the factor by which each program-generated step in the normal direction is multiplied to give the length of the next step in the boundary-layer program. Typical value is 1.021066.

U3	=	Reference static temperature
	= 0.0	Reference static temperature is set to 519°R
U4	=	Velocity in ft/sec. Should be compatible with Reynolds number input in T1 for incompressible flow.
U5	= 0.0	(Will be used to input Prandtl number in the future).

V. Corner Point Card(s) (4, 5, ... or 67 required)

For each airfoil part these cards have the following format. The first card for each airfoil part has the word "POINTS" in columns 1-6. The succeeding cards have the X and Y coordinates of the corner points in 6F10.0 format. Typical i^{th} card where $i \geq 1$, has V1, V2, ... V6, where

V1	=	X coordinate of corner point J
V2	=	Y coordinate of corner point J
V3	=	X coordinate of corner point J+1
V4	=	Y coordinate of corner point J+1
V5	=	X coordinate of corner point J+2
V6	=	Y coordinate of corner point J+2

The corner points should be listed starting from the trailing edge along the top surface to the leading edge and then back to the trailing edge along the lower surface. The trailing-edge point on the upper surface is always the first point and the lower trailing-edge point is the last point listed for each airfoil part. These points should not be coincident. It will be necessary to modify the coordinates of the trailing edge of sharp airfoils to produce a small (10^{-4} x chord) blunt trailing edge system.

W. Shift Data Card (0, 1, ... or 10 required)

This card(s) is required only when any of Ei on the Shift Indicator Card is different from zero and has the following input items: W1, W2, W3, W4, W5 with a format of 5F10.0, where

W1 = Translation in the X direction

W2 = Translation in the Y direction

W3 = X coordinate of the point of rotation

W4 = Y coordinate of the point of rotation

W5 = Angle of rotation, measured positive clockwise in degrees

Each shift requires a card. This sequence is repeated for the number of airfoil parts to be shifted.

NOTE: The point of rotation is translated by W1 and W2 before rotation.

Table II-1 gives the card sequence and lists the possible number of input items for each card type and indicates if the card type may be omitted.

Table II-1

CARD SEQUENCE

TYPE	OPTIONAL	DESCRIPTION	FORMAT	ITEMS
A	No	Title	6A10/6A10	
B	"	Option Indicator	15I3/15I3	30
C	"	Problem Dimension	3I3	3
D	"	Corner Point	10I3	$1 \leq N \leq 10$
E	"	Shift Indicator	10I3	$1 \leq N \leq 10$
F	"	Stratford Separation	8I3	8
G	Yes	Transition Point Index	15I3/5I3	$2 \leq N \leq 20$
H	"	Stagnation Point Limit	15I3/5I3	$2 \leq N \leq 20$
I	No	Kutta Condition	1F10.0	1
J	"	Moments	2F10.0	2
K	"	Reference Edge	4F10.0	4
L	"	Airfoil Edge	4F10.0	$4 \leq N \leq 40$
M	"	Source Location	2F10.0	$2 \leq N \leq 20$
N	"	Incidence	1F10.0	$1 \leq N \leq 10$
P	"	Wake Shape Control	1F10.0	1
Q	Yes	Streamline	6F10.0	6
R	"	Streamline Coordinate	6F10.0	$2 \leq N \leq 20$
S	"	Remote Points	6F10.0	$2 \leq N \leq 200$
T	No	Reynolds Number	1F10.0	1
U	"	B.L. Characteristics	5F10.0	5
V	"	Corner Point	6F10.0	$8 \leq N \leq 400-6*C1$
W	Yes	Shift Data	5F10.0	$5 \leq N \leq 50$

II-1.2 Restrictions

Maximum of 10 airfoil sections

Maximum of 10 angles of attack

Maximum of 10 input points for streamlines

Maximum of 100 points at which the velocity is calculated

Maximum of (200-3*number of airfoil parts) corner points.

II-2 Output Description

The first iteration has an output consisting of the following items:

1. A listing of the Option Indicator Array and the resulting options chosen, the angles of attack, the streamline-starting coordinates, the point about which moments are taken, the reference leading edge, reference trailing edge, reference chord, and the remote points at which the velocity is calculated.

2. For each airfoil part for which a translation and/or rotation is required, a listing of the translation and rotation values, as well as the coordinates of the corner points before and after the transformation is made.

3. For each airfoil part, a listing of the leading edge, trailing edge, and chord.

4. For each airfoil part, the set of corner points, the set of boundary points, and the slope at each boundary point.

5. The input values for the corner points, non-dimensionalized with respect to both the reference chord and the local chord for all airfoil parts.

6. A set of vortex and source strengths.

7. For each airfoil part, the pressure versus the boundary points, and the boundary points non-dimensionalized with respect to both the reference chord and the local chord.

8. If B6 is equal to 0 or 1, a listing of the pitching moment coefficient, the force coefficients normal and parallel to the local and reference chords for each airfoil part, obtained by integration of pressure distribution.

9. If B6 is equal to 0, a listing of the force coefficients normal and parallel to the reference chord and pitching moment coefficient for each segment of the surface lying between consecutive corner points.

10. For each airfoil part the stagnation point and a listing of the pressure versus developed length measured from the stagnation point.

11. If B16 is equal to 1 or 2, a listing of the calculated derivatives of the pressure coefficients with respect to the developed length and the derivatives of the pressure coefficient to cause separation as predicted by Stratford's method for the lower and the upper surface of each airfoil part.

12. If B16 is equal to 0 or 1, the existence of laminar flow bubble, transition point, and separation point are evaluated for the upper and lower surfaces of each airfoil part.

13. If B16 is equal to 0 or 1, a listing of the momentum thickness, total enthalpy, local skin-friction coefficient, local Reynolds number, Stanton number, and displacement thickness as calculated as boundary-layer parameters for the lower and upper surface of each airfoil part.

Depending upon the indicators selected on the Option Indicator Card, the second, third, ... and the converged solution iterations have items 4, 6, 7, 10, 11, 12 and 13.

The converged solution iteration in addition to the items listed above has:

1. If B7 is equal to 1, a listing of the non-dimensionalized coordinates of the points defining the streamlines requested.

2. If C3 is positive, a listing of the modulus, magnitude, and components of the velocity vector at each remote point at which the velocity is calculated. Also listed are the non-dimensionalized coordinate of each remote point with respect to the reference chord.

3. For each airfoil part, components of forces described in items 8 and 9 due to pressure distribution plus the same components due to frictional forces.

II-3 Sample Test Problem

II-3.1 Input

The input for the test problem is presented in the following pages to illustrate the method of card input:

- Cards 1 and 2 are the title cards. Job identification is 5CP/22.9 and the date is 6-06-72.

- Cards 3 and 4 are the option indicator cards. Indicator 1 indicates that the transition point is evaluated by the Ward-Michelle method, indicator 15. Indicator 5 indicates one angle of attack. Indicators 7 and 9 indicate streamlines to be calculated from the separation points on the converged solution. Indicator 13 is set at a large number to permit sufficient iterations to obtain a converged solution. Indicators 14 and 19 indicate that this is the initial start of the problem. Indicator 16 indicates that separation is determined from the calculated CF values.

- Card 5 indicates 3 airfoil parts, no additional streamlines or remote points.

*** CARD INPUT ***

```
1        10         20         30         40         50         60
F-111 AIRFOIL AT B.L. 189 WITH .22C KRUEGER LE SLAT AND .35C                  P050001
 SINGLE SLOTTED T.E. FLAP DEF=30 RUN 95   5CP/22.9    6-06-72                 P050002
 -1  0  0  0  1  0  1  0  1  0  0  0 20  1  0                                 P050003
  0  0  0  1  0  0  0  0  0  0  0  0  0  0  0                                 P050004
  3  0  0                                                                     P050005
 31 58 46                                                                     P050006
  0  0  1                                                                     P050007
  1  0  0  0  0  0  0  0                                                      P050008
    .00002                                                                    P050009
      0.50       0.0                                                          P050010
       2.0       0.0        0.0        0.0                                    P050011
     -0.05     0.044     -0.376     -0.270                                    P050012
   1.47067   0.08300        0.0        0.0                                    P050013
       2.0       0.0    1.30283        0.0                                    P050014
    -0.335     -0.23                                                          P050015
       0.5       0.0                                                          P050016
      1.40      0.01                                                          P050017
      22.9                                                                    P050018
       1.0                                                                    P050019
       3.0      .002        .02         .2      .0002        300              P050020
  2560000.                                                                    P050021
    0.0001  1.021066        0.0      201.7        0.0                         P050022
POINTS                                                                        P050023
  -0.05000   0.04400   -0.10868    0.02794   -0.16706    0.00432              P050024
  -0.19434  -0.00874   -0.23304   -0.03238   -0.26934   -0.05746              P050025
  -0.30414  -0.08666   -0.33424   -0.11912   -0.35864   -0.15138              P050026
  -0.37472  -0.18104   -0.38388   -0.20948   -0.38580   -0.23188              P050027
  -0.38274  -0.25252   -0.37552   -0.27024   -0.36356   -0.28536              P050028
  -0.35314  -0.29308   -0.33916   -0.30022   -0.32640   -0.30268              P050029
  -0.31468  -0.30060   -0.30472   -0.29492   -0.29602   -0.28590              P050030
  -0.29198  -0.26874   -0.29000   -0.23000   -0.28200   -0.19000              P050031
  -0.26384  -0.14372   -0.23524   -0.10814   -0.19956   -0.06366              P050032
  -0.17802  -0.03700   -0.15970   -0.01382   -0.10370    0.01590              P050033
  -0.05000   0.04160                                                          P050034
1        10         20         30         40         50         60
```

1 … 10	20	30	40	50	60	
POINTS						P050035
1.47067	0.08300	1.40126	0.09192	1.33333	0.10017	P050036
1.26667	0.10700	1.20162	0.11378	1.10176	0.12224	P050037
1.00188	0.12874	0.90198	0.13298	0.80202	0.13444	P050038
0.70204	0.13274	0.60200	0.12824	0.50190	0.12118	P050039
0.40178	0.11132	0.30156	0.09810	0.25146	0.09000	P050040
0.20130	0.08070	0.16116	0.07226	0.12102	0.06228	P050041
0.08080	0.05010	0.06068	0.04298	0.04054	0.03468	P050042
0.02542	0.02688	0.01530	0.02012	0.00770	0.01328	P050043
0.00258	0.00622	0.00000	0.00000	-0.00020	-0.00322	P050044
0.00022	-0.00652	0.00228	-0.01206	0.00718	-0.01824	P050045
0.01456	-0.02376	0.02448	-0.02898	0.03940	-0.03460	P050046
0.05930	-0.04034	0.07924	-0.04500	0.11912	-0.05198	P050047
0.15902	-0.05778	0.19896	-0.06260	0.24888	-0.06760	P050048
0.29882	-0.07182	0.39876	-0.07858	0.49870	-0.08334	P050049
0.59868	-0.08638	0.69868	-0.08778	0.79872	-0.08712	P050050
0.89878	-0.08408	0.99888	-0.07894	1.09898	-0.07228	P050051
1.19912	-0.06450	1.24000	-0.06175	1.25000	-0.05508	P050052
1.26667	-0.02625	1.30000	0.03125	1.31667	0.06000	P050053
1.33333	0.07700	1.35000	0.08175	1.40000	0.08175	P050054
1.47067	0.08175					P050055
POINTS						P050056
2.00000	0.00000	1.95008	0.00817	1.90025	0.01650	P050057
1.85033	0.02475	1.80042	0.03292	1.75050	0.04100	P050058
1.70067	0.04908	1.65075	0.05692	1.62500	0.06092	P050059
1.60083	0.06458	1.55942	0.07092	1.49825	0.07942	P050060
1.47625	0.08108	1.43617	0.08017	1.39617	0.07317	P050061
1.36617	0.06258	1.33858	0.04650	1.31758	0.02633	P050062
1.30542	0.00625	1.30167	-0.00375	1.29958	-0.01375	P050063
1.29942	-0.01883	1.29975	-0.02383	1.30333	-0.03375	P050064
1.31100	-0.04375	1.32683	-0.05183	1.33792	-0.05292	P050065
1.35000	-0.05175	1.36667	-0.05008	1.38333	-0.04850	P050066
1.39942	-0.04670	1.41692	-0.04517	1.44942	-0.04200	P050067
1.48192	-0.03883	1.49950	-0.03733	1.52083	-0.03525	P050068
1.54958	-0.03283	1.59967	-0.02858	1.64967	-0.02467	P050069
1.69975	-0.02108	1.74975	-0.01758	1.79983	-0.01417	P050070
1.84983	-0.01083	1.89992	-0.00742	1.94992	-0.00392	P050071
2.00000	-0.00240					P050072
.17725	.01775	1.29942	-0.01883	30.0		P050073
1 … 10	20	30	40	50	60	

- Card 6 indicates the number of corner points on each part.
- Card 7 indicates a shift on the third airfoil part.
- Card 8 indicates that all iterations are printed.
- Card 9 indicates the distance behind the trailing edge at which the Kutta condition is satisfied.
- Card 10 indicates the coordinates of the point about which moments are calculated.
- Card 11 indicates the coordinates of the reference trailing and leading edges of the system.
- Cards 12, 13, and 14 indicate coordinates of the trailing and leading edges of the three airfoil parts. These are used to non-dimensionalize the coordinates of the boundary points in the pressure coefficient output.
- Cards 15, 16, and 17 indicate the source location for the three airfoil parts.
- Card 18 indicates a 22.9^{o} angle of attack.
- Card 19 indicates the separation streamline leaves the surface in a direction parallel to the free-stream equal to 22.9^{o}.
- Card 20 indicates the input required to calculate streamlines.
- Card 21 indicates Reynolds number to be 2.56×10^{6}.
- Card 22 indicates the constants necessary for boundary-layer calculations.
- Cards 23 through 72 indicate the coordinates of the corner points for the 3 airfoil parts.
- Card 73 indicates a translation in the X direction of 0.17725 and in the Y direction of 0.01775 followed by a rotation of 30^{o} about the point (1.29942, -0.01883).

II.3-2 Output

An abbreviated sample-problem output listing is shown on the following pages (131-241). Iterations one, two, and the final converged solution are presented.

TWO-DIMENSIONAL POTENTIAL FLOW ANALYSIS BY THE METHOD OF DISTRIBUTED SINGULARITIES

F-111 AIRFOIL AT B.L. 189 WITH .220 KRUEGER LE SLAT AND .350 SINGLE SLOTTED T.E. FLAP DEF=30 RUN 95

XSUBC = 3.0000   DLTLMN = .00200   DLTALN = .02000   DLTALM = .20000   TCLLMT = .00020

POINT ABOUT WHICH MOMENTS ARE TAKEN (.5000, 0.0000)

REFERENCE LEADING EDGE (0.0000, 0.0000)
REFERENCE TRAILING EDGE (2.0000, 0.0000)

REFERENCE CHORD 2.0000

AFPT	XLE	YLE	XTE	YTE	CHORD	X-SOURCE1	Y-SOURCE1
1	-.3760	-.2700	-.0500	.0440	0.1000	-.3350	-.2300
2	0.0000	0.0000	1.4707	.0830	0.0000	.5000	0.0000
3	1.3028	0.0000	2.0000	0.0000	0.1000	1.4000	.0100

AIRFOIL PART NUMBER 3,

TRANSLATION IN THE X-DIRECTION .1772,

TRANSLATION IN THE Y-DIRECTION .0178,

ROTATED 30.0000 DEGREES ABOUT (1.2994, -.0188)

UNTRANSFORMED COORDINATES

INDEX	X	Y
94	2.0000	0.0000
95	1.9975	.0004
96	1.9501	.0082
97	1.9002	.0165
98	1.8503	.0248
99	1.8004	.0329
100	1.7505	.0410
101	1.7007	.0491
102	1.6508	.0569
103	1.6250	.0609
104	1.6008	.0646
105	1.5594	.0709
106	1.4982	.0794
107	1.4763	.0811
108	1.4362	.0802
109	1.3962	.0732
110	1.3662	.0626
111	1.3386	.0465
112	1.3176	.0263
113	1.3054	.0063
114	1.3017	-.0038
115	1.2956	-.0137
116	1.2994	-.0188
117	1.2998	-.0238
118	1.3033	-.0337
119	1.3110	-.0437
120	1.3268	-.0518
121	1.3379	-.0529

122	1.3500	-.0517
123	1.3667	-.0501
124	1.3833	-.0485
125	1.3994	-.0467
126	1.4169	-.0452
127	1.4494	-.0420
128	1.4819	-.0388
129	1.4995	-.0373
130	1.5208	-.0353
131	1.5496	-.0328
132	1.5997	-.0286
133	1.6497	-.0247
134	1.6998	-.0211
135	1.7497	-.0176
136	1.7998	-.0142
137	1.8498	-.0108
138	1.8999	-.0074
139	1.9499	-.0039
140	1.9975	-.0025
141	2.0000	-.0024

```
OPEN AIRFOIL ANALYSIS 3 AIRFOIL PARTS...

   OPTION INDICATORS...
                          1. -1     2.  0     3.  0     4.  0     5.  1     6.  0     7.  1     8.  0     9.  1    10.  0
                         11.  0    12.  0    13. 20    14.  1    15.  0    16.  0    17.  1    18.  0    19.  1    20.  0
                         21.  0    22.  0    23.  0    24.  0    25.  0    26.  0    27.  0    28.  0    29.  0    30.  0
   SEPARATION STREAMLINE MAKES AN ANGLE EQUAL TO  1.000 * 100 PERCENT OF ALPHA WITH LOCAL SURFACE AT SEPARATION POINT ...
   PRESSURES CALCULATED...
   SEPARATION METHOD BY CF DATA...
   FORCES CALCULATED...
    6 STREAMLINES CALCULATED
   KUTTA CONDITION USED - 1 PSEUDO BOUNDARY POINT  SPECIFIED .000020 DOWNSTREAM OF SEPARATION POINT
   ANGLES OF ATTACK =   22.9000

         XSUBC =   3.0000     DLTLMN =   .00200     DLTALN =   .02000     DLTALM =   .20000     TOLLMT =   .00020

            POINT ABOUT WHICH MOMENTS ARE TAKEN  (   .5000,  0.0000)

            REFERENCE LEADING EDGE  (  0.0000,  0.0000)
            REFERENCE TRAILING EDGE  (  2.0000,  0.0000)

            REFERENCE CHORD   2.0000

AFPT     XLE        YLE        XTE        YTE       CHORD     X-SOURCE1  Y-SOURCE1
  1    -.3760     -.2700     -.0500      .0440      .4526     -.3350     -.2300
  2    0.0000     0.0000     1.4707      .0830     1.4730      .5000     0.0000
  3    1.4890      .0135     2.0928     -.3351      .6972     1.5782     -.0264
```

ANGLE OF ATTACK = 22.900

AIRFOIL PART 1, 33 DEFINING POINTS...

ITERATION 1...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
1.	- 1 -	-.05000	.04400	-.05147	.04360	15.30633
2.	- 2 -	-.05293	.04320	-.08081	.03557	15.30633
3.	- 3 -	-.10868	.02794	-.13787	.01613	22.02779
4.	- 4 -	-.16706	.00432	-.18070	-.00221	25.58226
5.	- 5 -	-.19434	-.00874	-.21369	-.02056	31.41879
6.	- 6 -	-.23304	-.03238	-.25119	-.04492	34.64095
7.	- 7 -	-.26934	-.05746	-.28674	-.07206	39.99935
8.	- 8 -	-.30414	-.08666	-.31919	-.10289	47.16039
9.	- 9 -	-.33424	-.11912	-.34644	-.13525	52.89779
10.	- 10 -	-.35864	-.15138	-.36668	-.16621	61.53592
11.	- 11 -	-.37472	-.18104	-.37930	-.19526	72.14721
12.	- 12 -	-.38388	-.20946	-.38484	-.22068	85.10091
13.	- 13 -	-.38580	-.23188	-.38427	-.24220	-81.56700
14.	- 14 -	-.38274	-.25252	-.37913	-.26138	-67.83160
15.	- 15 -	-.37552	-.27024	-.36954	-.27780	-51.65582
16.	- 16 -	-.36356	-.28536	-.35835	-.28922	-36.53412
17.	- 17 -	-.35314	-.29308	-.34615	-.29665	-27.05475
18.	- 18 -	-.33916	-.30022	-.33278	-.30145	-10.91217
19.	- 19 -	-.32640	-.30268	-.32054	-.30164	10.06375
20.	- 20 -	-.31468	-.30060	-.30970	-.29775	29.69530
21.	- 21 -	-.30472	-.29492	-.30037	-.29041	46.03457
22.	- 22 -	-.29602	-.28590	-.29400	-.27732	76.75204
23.	- 23 -	-.29198	-.26874	-.29099	-.24937	87.07416
24.	- 24 -	-.29000	-.23000	-.28600	-.21000	78.69007
25.	- 25 -	-.28200	-.19000	-.27292	-.16686	68.57525
26.	- 26 -	-.26384	-.14372	-.24954	-.12593	51.20690
27.	- 27 -	-.23524	-.10814	-.21740	-.08590	51.26487
28.	- 28 -	-.19956	-.06366	-.18879	-.05033	51.06345
29.	- 29 -	-.17802	-.03700	-.16886	-.02541	51.67940
30.	- 30 -	-.15970	-.01382	-.13170	.00104	27.95553
31.	- 31 -	-.10370	.01590	-.07819	.02811	25.57507
32.	- 32 -	-.05268	.04031	-.05134	.04096	25.57507
33.	- 33 -	-.05000	.04160	-.04998	.04401	15.30633
34.	- 34 -			-.04998	.04161	25.57507

ANGLE OF ATTACK = 22.900

AIRFOIL PART 2, 60 DEFINING POINTS...

ITERATION 1...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
35.	- 1 -	1.47067	.08300	1.46893	.18322	-7.32304
36.	- 2 -	1.46720	.08345	1.43423	.18768	-7.32304
37.	- 3 -	1.40126	.09192	1.36729	.19604	-6.92458
38.	- 4 -	1.33333	.10017	1.30000	.10358	-5.85012
39.	- 5 -	1.26667	.10700	1.23414	.11039	-5.95031
40.	- 6 -	1.20162	.11378	1.15169	.11801	-4.84246
41.	- 7 -	1.10176	.12224	1.05182	.12549	-3.72345
42.	- 8 -	1.00188	.12874	.95193	.13086	-2.43031
43.	- 9 -	.90198	.13298	.85200	.13371	-.83679
44.	- 10 -	.80202	.13444	.75203	.13359	.97413
45.	- 11 -	.70204	.13274	.65202	.13049	2.57554
46.	- 12 -	.60200	.12824	.55195	.12471	4.03436
47.	- 13 -	.50190	.12118	.45184	.11625	5.62446
48.	- 14 -	.40178	.11132	.35167	.10471	7.51449
49.	- 15 -	.30156	.09810	.27651	.09405	9.18392
50.	- 16 -	.25146	.09000	.22638	.08535	10.50375
51.	- 17 -	.20130	.08070	.18123	.07648	11.87427
52.	- 18 -	.16116	.07226	.14109	.06727	13.96233
53.	- 19 -	.12102	.06228	.10091	.05619	16.84812
54.	- 20 -	.08080	.05010	.07074	.04654	19.48769
55.	- 21 -	.06068	.04298	.05061	.03883	22.39730
56.	- 22 -	.04054	.03468	.03298	.03078	27.28799
57.	- 23 -	.02542	.02688	.02036	.02350	33.74230
58.	- 24 -	.01530	.02012	.01150	.01670	41.98721
59.	- 25 -	.00770	.01328	.00514	.00975	54.04991
60.	- 26 -	.00258	.00622	.00129	.00311	67.47177
61.	- 27 -	0.00000	0.00000	-.00010	-.00161	86.44582
62.	- 28 -	-.00020	-.00322	.00001	-.00487	-82.74681
63.	- 29 -	.00022	-.00652	.00125	-.00929	-69.60279
64.	- 30 -	.00228	-.01206	.00473	-.01515	-51.58580
65.	- 31 -	.00718	-.01824	.01087	-.02100	-36.79529
66.	- 32 -	.01456	-.02376	.01952	-.02637	-27.75378
67.	- 33 -	.02448	-.02898	.03194	-.03179	-20.64017
68.	- 34 -	.03940	-.03460	.04935	-.03747	-16.08979
69.	- 35 -	.05930	-.04034	.06927	-.04267	-13.15400
70.	- 36 -	.07924	-.04500	.09918	-.04849	-9.92764
71.	- 37 -	.11912	-.05198	.13907	-.05488	-8.27078
72.	- 38 -	.15902	-.05778	.17899	-.06019	-6.88124
73.	- 39 -	.19896	-.06260	.22392	-.06510	-5.71968
74.	- 40 -	.24888	-.06760	.27385	-.06971	-4.83010
75.	- 41 -	.29882	-.07182	.34879	-.07520	-3.86967
76.	- 42 -	.39876	-.07858	.44873	-.08096	-2.72686
77.	- 43 -	.49870	-.08334	.54869	-.08485	-1.74160
78.	- 44 -	.59868	-.08638	.64868	-.08709	-.80209
79.	- 45 -	.69868	-.08778	.74870	-.08745	.37800
80.	- 46 -	.79872	-.08712	.84875	-.08560	1.74021
81.	- 47 -	.89878	-.08408	.94883	-.08151	2.93948
82.	- 48 -	.99888	-.07894	1.04893	-.07561	3.80648
83.	- 49 -	1.09898	-.07228	1.14905	-.06839	4.44246
84.	- 50 -	1.19912	-.06450	1.21956	-.06312	3.84849
85.	- 51 -	1.24000	-.06175	1.24500	-.05841	33.70329
86.	- 52 -	1.25000	-.05508	1.25833	-.04066	59.96276

87.	- 53 -	1.26667	-.02625	1.28333	.00250	59.90118
88.	- 54 -	1.30000	.03125	1.30833	.14563	59.89372
89.	- 55 -	1.31667	.06000	1.32500	.16850	45.57873
90.	- 56 -	1.33333	.07700	1.34166	.17937	15.90453
91.	- 57 -	1.35000	.08175	1.37500	.08175	0.00000
92.	- 58 -	1.40000	.08175	1.43357	.08175	-.00000
93.	- 59 -	1.46714	.08175	1.45890	.18175	.00000
94.	- 60 -	1.47067	.08175	1.47069	.18300	-7.32304
95.	- 61 -			1.47069	.08175	.00000

ANGLE OF ATTACK = 22.900

AIRFOIL PART 3, 48 DEFINING POINTS...

ITERATION 1...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
96.	- 1 -	2.09281	-.33506	2.09183	-.33426	-39.29473
97.	- 2 -	2.05085	-.33346	2.07225	-.31824	-39.29473
98.	- 3 -	2.05366	-.30303	2.03416	-.28696	-39.49029
99.	- 4 -	2.01467	-.27090	1.99512	-.25485	-39.38413
100.	- 5 -	1.97556	-.23879	1.95599	-.22278	-39.29656
101.	- 6 -	1.93642	-.20676	1.91683	-.19078	-39.19410
102.	- 7 -	1.89723	-.17481	1.87767	-.15885	-39.21042
103.	- 8 -	1.85812	-.14289	1.83846	-.12702	-38.92547
104.	- 9 -	1.81881	-.11114	1.80866	-.10297	-38.82974
105.	- 10 -	1.79851	-.09480	1.78895	-.08718	-38.61073
106.	- 11 -	1.77940	-.07955	1.76306	-.06645	-38.70457
107.	- 12 -	1.74671	-.05335	1.72235	-.03438	-37.91099
108.	- 13 -	1.69799	-.01541	1.68888	-.00919	-34.31505
109.	- 14 -	1.67976	-.00297	1.66218	.00666	-28.69935
110.	- 15 -	1.64460	.01628	1.62553	.02325	-20.07375
111.	- 16 -	1.60646	.03022	1.59082	.03313	-10.55697
112.	- 17 -	1.57518	.03605	1.55922	.03598	.23448
113.	- 18 -	1.54325	.03592	1.52911	.03243	13.84506
114.	- 19 -	1.51498	.02895	1.50469	.02329	28.80184
115.	- 20 -	1.49441	.01764	1.49028	.01425	39.44396
116.	- 21 -	1.48616	.01085	1.48275	.00705	48.19511
117.	- 22 -	1.47935	.00324	1.47801	.00108	58.19601
118.	- 23 -	1.47667	-.00108	1.47556	-.00333	63.77605
119.	- 24 -	1.47446	-.00558	1.47353	-.01077	79.84386
120.	- 25 -	1.47260	-.01596	1.47342	-.02220	-82.51179
121.	- 26 -	1.47424	-.02845	1.47907	-.03591	-57.04082
122.	- 27 -	1.48391	-.04336	1.48844	-.04661	-35.61339
123.	- 28 -	1.49297	-.04985	1.49849	-.05237	-24.46791
124.	- 29 -	1.50401	-.05488	1.51165	-.05832	-24.27920
125.	- 30 -	1.51929	-.06177	1.52689	-.06525	-24.58239
126.	- 31 -	1.53450	-.06873	1.54192	-.07197	-23.61682
127.	- 32 -	1.54934	-.07522	1.55730	-.07893	-25.00342
128.	- 33 -	1.56526	-.08264	1.58012	-.08939	-24.42908
129.	- 34 -	1.59499	-.09615	1.60985	-.10290	-24.42903
130.	- 35 -	1.62472	-.10965	1.63271	-.11340	-25.12309
131.	- 36 -	1.64069	-.11714	1.65045	-.12157	-24.43040
132.	- 37 -	1.66021	-.12601	1.67326	-.13214	-25.18853
133.	- 38 -	1.68631	-.13828	1.70907	-.14897	-25.15022
134.	- 39 -	1.73182	-.15965	1.75445	-.17046	-25.52857
135.	- 40 -	1.77708	-.18126	1.79966	-.19223	-25.89975
136.	- 41 -	1.82224	-.20319	1.84477	-.21418	-25.99583
137.	- 42 -	1.86729	-.22516	1.88983	-.23621	-26.10468
138.	- 43 -	1.91237	-.24725	1.93495	-.25830	-26.17832
139.	- 44 -	1.95734	-.26936	1.97988	-.28040	-26.10545
140.	- 45 -	2.00242	-.29145	2.02495	-.30243	-25.99583
141.	- 46 -	2.04747	-.31342	2.06844	-.32469	-28.26152
142.	- 47 -	2.08940	-.33596	2.09050	-.33655	-28.26152
143.	- 48 -	2.09161	-.33714	2.09282	-.33508	-39.29473
144.	- 49 -			2.09162	-.33715	-28.26152

NON-DIMENSIONALIZED INPUT GEOMETRY

INDEX	NO.	X	Y	X/CREF	Y/CREF	XT/C-LCC	YT/C-LCC
1	1	-.05000	.04400	-.025000	.022000	1.000000	0.000000
2	2	-.05293	.04320	-.026467	.021598	.994101	.003219
3	3	-.10868	.02794	-.054340	.013970	.882012	.064381
4	4	-.16706	.00432	-.083530	.002160	.752914	.116273
5	5	-.19434	-.00874	-.097170	-.004370	.689488	.137303
6	6	-.23304	-.03239	-.116520	-.016190	.591675	.159000
7	7	-.26934	-.05745	-.134670	-.028730	.495474	.174728
8	8	-.30414	-.08666	-.152070	-.043330	.395345	.181600
9	9	-.33424	-.11912	-.167120	-.059560	.297698	.176082
10	10	-.35864	-.15138	-.179320	-.075690	.209429	.162146
11	11	-.37472	-.18104	-.187360	-.090520	.138383	.139595
12	12	-.38388	-.20948	-.191940	-.104740	.080218	.108379
13	13	-.38580	-.23189	-.192900	-.115940	.042831	.075678
14	14	-.38274	-.25252	-.191370	-.126260	.016066	.038145
15	15	-.37552	-.27024	-.187760	-.135120	.000396	-.001118
16	16	-.36356	-.28536	-.181780	-.142680	-.003747	-.043508
17	17	-.35314	-.29308	-.176570	-.146540	.001002	-.071762
18	18	-.33916	-.30022	-.169580	-.150110	.012304	-.104551
19	19	-.32640	-.30269	-.163200	-.151340	.028838	-.128022
20	20	-.31468	-.30060	-.157340	-.150300	.050675	-.142675
21	21	-.30472	-.29492	-.152360	-.147460	.075229	-.148902
22	22	-.29602	-.28590	-.148010	-.142950	.102898	-.147883
23	23	-.29198	-.26874	-.145990	-.134370	.135627	-.126769
24	24	-.29000	-.23000	-.145000	-.115000	.198153	-.068160
25	25	-.28200	-.19000	-.141000	-.095000	.272189	-.016771
26	26	-.26384	-.14372	-.131920	-.071860	.372018	.029038
27	27	-.23524	-.10814	-.117620	-.054070	.472060	.041820
28	28	-.19956	-.06366	-.099780	-.031830	.597008	.057913
29	29	-.17802	-.03700	-.089010	-.018500	.672144	.067321
30	30	-.15970	-.01382	-.079850	-.005910	.736823	.076128
31	31	-.10370	.01590	-.051850	.007950	.871483	.037590
32	32	-.05268	.04031	-.026342	.020157	.990080	-.001749
33	33	-.05000	.04160	-.025000	.020800	.996322	-.003819
34	1	1.47067	.08300	.735335	.041500	1.000000	0.000000
35	2	1.46720	.08345	.733600	.041723	.997665	.000435
36	3	1.40126	.09192	.700630	.045960	.953295	.008701
37	4	1.33333	.10017	.666665	.050085	.907567	.016892
38	5	1.26667	.10700	.633335	.053500	.862646	.024071
39	6	1.20162	.11378	.600810	.056890	.818814	.031155
40	7	1.10176	.12224	.550880	.061120	.751453	.040709
41	8	1.00188	.12874	.500940	.064370	.684002	.048935
42	9	.90198	.13298	.450990	.065490	.616452	.055631
43	10	.80202	.13444	.401010	.067220	.548755	.060444
44	11	.70204	.13274	.351020	.066370	.480923	.063116
45	12	.60200	.12824	.301000	.064120	.412943	.063893
46	13	.50190	.12118	.250950	.060590	.344825	.062937
47	14	.40178	.11132	.200890	.055660	.276586	.060084
48	15	.30156	.09810	.150780	.049050	.208151	.054957
49	16	.25146	.09000	.125730	.045000	.173883	.051383
50	17	.20130	.08070	.100650	.040350	.139529	.046998
51	18	.16116	.07226	.080580	.036130	.111999	.042813
52	19	.12102	.06229	.060510	.031140	.084410	.037584
53	20	.08080	.05010	.040400	.025050	.056683	.030867
54	21	.06068	.04298	.030340	.021490	.042773	.026811

55	22	.04054	.03463	.020270	.017340	.028805	.021955
56	23	.02542	.02688	.012710	.013440	.018258	.017247
57	24	.01530	.02012	.007650	.010060	.011140	.013052
58	25	.00770	.01328	.003850	.005640	.005727	.008707
59	26	.00258	.00622	.001290	.003110	.001987	.004117
60	27	0.00000	0.00000	0.000000	0.000000	0.000000	0.000000
61	28	-.00020	-.00322	-.000100	-.001610	-.000259	-.002175
62	29	.00022	-.00652	.000110	-.003260	-.000100	-.004428
63	30	.00228	-.01205	.001140	-.005030	.001084	-.008262
64	31	.00718	-.01824	.003590	-.009120	.004169	-.012638
65	32	.01456	-.02376	.007280	-.011880	.008960	-.016662
66	33	.02448	-.02899	.012240	-.014490	.015484	-.020579
67	34	.03940	-.03460	.019700	-.017300	.025382	-.024959
68	35	.05930	-.04034	.029650	-.020170	.038651	-.029611
69	36	.07924	-.04500	.039620	-.022500	.051988	-.033532
70	37	.11912	-.05198	.059560	-.025990	.078752	-.039789
71	38	.15902	-.05778	.079510	-.028890	.105574	-.045246
72	39	.19896	-.06260	.099480	-.031300	.132461	-.050041
73	40	.24888	-.06760	.124440	-.033800	.166106	-.055740
74	41	.29882	-.07182	.149410	-.035910	.199794	-.060111
75	42	.39876	-.07858	.199380	-.039290	.267275	-.068516
76	43	.49870	-.08334	.249350	-.041670	.334832	-.075565
77	44	.59868	-.08638	.299340	-.043190	.402483	-.081450
78	45	.69868	-.08778	.349340	-.043890	.470210	-.086224
79	46	.79872	-.08712	.399360	-.043560	.538042	-.089604
80	47	.89878	-.08408	.449390	-.042040	.605980	-.091371
81	48	.99888	-.07894	.499440	-.039470	.674024	-.091716
82	49	1.09898	-.07228	.549490	-.035140	.742127	-.091031
83	50	1.19912	-.06450	.599560	-.032250	.810300	-.089588
84	51	1.24000	-.06175	.620000	-.030875	.838114	-.089288
85	52	1.25000	-.05508	.625000	-.027540	.845147	-.085150
86	53	1.26667	-.02625	.633335	-.013125	.857549	-.066246
87	54	1.30000	.03125	.650000	.015625	.882340	-.028548
88	55	1.31667	.06000	.658335	.030000	.894738	-.009698
89	56	1.33333	.07700	.666665	.038500	.906681	.001187
90	57	1.35000	.08175	.675000	.040875	.918162	.003769
91	58	1.40000	.08175	.700000	.040875	.952052	.001856
92	59	1.46714	.08175	.733568	.040875	.997557	-.000712
93	60	1.47067	.08175	.735335	.040875	.999952	-.000847
94	1	2.09281	-.33505	1.046403	-.167531	1.000000	0.000000
95	2	2.09085	-.33345	1.045424	-.165730	.996420	.000586
96	3	2.05366	-.30303	1.026829	-.151514	.928396	.011719
97	4	2.01467	-.27091	1.007335	-.135449	.856922	.023667
98	5	1.97556	-.23873	.987781	-.119397	.785318	.035501
99	6	1.93642	-.20676	.968212	-.103382	.713728	.047219
100	7	1.89723	-.17481	.948616	-.087403	.642125	.058809
101	8	1.85812	-.14289	.929059	-.071447	.570650	.070399
102	9	1.81881	-.11114	.909403	-.055572	.499046	.081644
103	10	1.79851	-.09481	.899253	-.047402	.462111	.087382
104	11	1.77940	-.07955	.889702	-.039775	.427442	.092632
105	12	1.74671	-.05335	.873356	-.026677	.368045	.101726
106	13	1.69799	-.01541	.848993	-.007704	.280305	.113918
107	14	1.67976	-.00297	.839882	-.001485	.248749	.116299
108	15	1.64460	.01628	.822299	.008141	.191259	.114993
109	16	1.60646	.03022	.803229	.015110	.133884	.104953
110	17	1.57518	.03605	.787591	.018024	.090853	.089763
111	18	1.54325	.03592	.771624	.017959	.051279	.066698
112	19	1.51498	.02895	.757489	.014475	.021157	.037767
113	20	1.49441	.01764	.747203	.008820	.003715	.008965
114	21	1.48616	.01085	.743079	.005427	-.001664	-.005379
115	22	1.47935	.00324	.739674	.001620	-.004662	-.019723
116	23	1.47667	-.00109	.738335	-.000540	-.004891	-.027009
117	24	1.47446	-.00558	.737229	-.002788	-.004418	-.034181
118	25	1.47260	-.01596	.736298	-.007978	.000717	-.048410
119	26	1.47424	-.02845	.737119	-.014226	.011719	-.062754

120	27	1.48391	-.04336	.741954	-.021682	.034425	-.074343
121	28	1.49297	-.04985	.746483	-.024926	.050332	-.075907
122	29	1.50401	-.05488	.752007	-.027440	.067659	-.074229
123	30	1.51929	-.06177	.759643	-.030884	.091570	-.071833
124	31	1.53450	-.06873	.767252	-.034365	.115467	-.069567
125	32	1.54934	-.07522	.774669	-.037608	.138546	-.066985
126	33	1.56526	-.08264	.782629	-.041321	.163647	-.064791
127	34	1.59499	-.09615	.797494	-.048073	.210264	-.060244
128	35	1.62472	-.10965	.812360	-.054825	.256881	-.055697
129	36	1.64069	-.11714	.820347	-.058571	.282098	-.053545
130	37	1.66021	-.12601	.830103	-.063003	.312693	-.050562
131	38	1.68631	-.13828	.843157	-.069142	.353931	-.047090
132	39	1.73182	-.15965	.865910	-.079824	.425779	-.040994
133	40	1.77708	-.18126	.888538	-.090631	.497497	-.035386
134	41	1.82224	-.20319	.911120	-.101597	.569330	-.030237
135	42	1.86729	-.22516	.933646	-.112581	.641049	-.025216
136	43	1.91237	-.24725	.956184	-.123625	.712882	-.020325
137	44	1.95734	-.26936	.978670	-.134678	.784601	-.015524
138	45	2.00242	-.29145	1.001212	-.145724	.856448	-.010643
139	46	2.04747	-.31342	1.023737	-.156709	.928167	-.005623
140	47	2.08940	-.33596	1.044699	-.167978	.996408	-.003552
141	48	2.09161	-.33714	1.045803	-.168571	1.000000	-.003442

GAMMA DISTRIBUTION FOR ALPHA = 22.9000

INDEX	-1-
1.	-.14270
2.	-.77617
3.	-2.32590
4.	-2.59239
5.	-2.85075
6.	-2.87369
7.	-3.04892
8.	-3.20805
9.	-3.24912
10.	-3.47523
11.	-3.65540
12.	-3.81695
13.	-3.79762
14.	-3.61790
15.	-3.37376
16.	-2.93880
17.	-2.45926
18.	-2.18010
19.	-1.83933
20.	-1.32659
21.	-.84778
22.	-.48106
23.	-.09014
24.	.03218
25.	.05242
26.	.06759
27.	.15930
28.	.22615
29.	.24184
30.	.07327
31.	.37823
32.	.27623
33.	.05016
34.	-.09873
35.	-.58752
36.	-1.43681
37.	-1.58715
38.	-1.64637
39.	-1.70372
40.	-1.75242
41.	-1.80702
42.	-1.86548
43.	-1.92444
44.	-1.97218
45.	-2.02458
46.	-2.09500
47.	-2.18335
48.	-2.28859
49.	-2.35531
50.	-2.43504
51.	-2.53076
52.	-2.63046
53.	-2.73929
54.	-2.83657
55.	-2.98927
56.	-3.14801

57.	-3.29332
58.	-3.46136
59.	-3.51286
60.	-3.77227
61.	-3.44579
62.	-3.13030
63.	-2.63644
64.	-1.97398
65.	-1.43108
66.	-1.06842
67.	-.77003
68.	-.56672
69.	-.44272
70.	-.28894
71.	-.19851
72.	-.13022
73.	-.06352
74.	-.00865
75.	.07851
76.	.14190
77.	.19540
78.	.24803
79.	.29465
80.	.33570
81.	.37502
82.	.42301
83.	.52627
84.	.91381
85.	.89825
86.	.54228
87.	.38732
88.	.22845
89.	.10292
90.	.14552
91.	.39931
92.	.31346
93.	.03156
94.	-.04142
95.	-.21314
96.	-.67401
97.	-.81626
98.	-.91410
99.	-.99973
100.	-1.08163
101.	-1.17298
102.	-1.26740
103.	-1.32586
104.	-1.37765
105.	-1.50149
106.	-1.81397
107.	-1.97202
108.	-2.17472
109.	-2.32915
110.	-2.39705
111.	-2.35328
112.	-2.13762
113.	-1.84580
114.	-1.74660
115.	-1.68826
116.	-1.58628
117.	-1.59146
118.	-1.27485
119.	-.97075
120.	-.54758
121.	-.32453
122.	-.16963

123.	-.07586
124.	-.01653
125.	.02422
126.	.05992
127.	.11045
128.	.14937
129.	.17107
130.	.18851
131.	.21583
132.	.25244
133.	.28523
134.	.31674
135.	.34493
136.	.37116
137.	.39466
138.	.40981
139.	.38060
140.	.12947
141.	.01968

SOURCE STRENGTHS FOR ALPHA = 22.9000

INDEX	-1-
1.	.00474
2.	.00201
3.	.00162

INCOMPRESSIBLE PRESSURE DISTRIBUTION

POTENTIAL FLOW ANALYSIS

ALPHA = 22.9000 DEGREES

NO.	XBP	YBP	X/CREF	Y/CREF	XTR/CR	YTR/CR	CP-INNER	CP
1	-.0515	.0436	-.0257	.0218	.9971	.0016	-1.2176	-2.7971
2	-.0809	.0356	-.0404	.0178	.9381	.0338	.4805	-4.1611
3	-.1379	.0161	-.0689	.0081	.8175	.0903	.9456	-6.2491
4	-.1807	-.0022	-.0903	-.0011	.7212	.1268	.9742	-7.3073
5	-.2137	-.0206	-.1068	-.0103	.6406	.1482	.9938	-7.6484
6	-.2512	-.0449	-.1256	-.0225	.5436	.1669	.9970	-8.0952
7	-.2867	-.0721	-.1434	-.0360	.4454	.1782	.9995	-8.9302
8	-.3192	-.1029	-.1596	-.0514	.3465	.1788	.9998	-9.5073
9	-.3464	-.1352	-.1732	-.0676	.2536	.1691	1.0000	-10.2844
10	-.3667	-.1662	-.1833	-.0831	.1739	.1509	.9994	-11.5421
11	-.3793	-.1953	-.1896	-.0976	.1093	.1240	.9969	-12.5432
12	-.3848	-.2207	-.1924	-.1103	.0615	.0920	.9969	-13.0739
13	-.3843	-.2422	-.1921	-.1211	.0294	.0569	.9948	-12.2174
14	-.3791	-.2614	-.1896	-.1307	.0082	.0185	.9941	-10.6885
15	-.3695	-.2778	-.1848	-.1389	-.0017	-.0223	.9905	-8.3553
16	-.3583	-.2892	-.1792	-.1446	-.0014	-.0576	.9989	-6.1092
17	-.3461	-.2966	-.1731	-.1483	.0067	-.0882	.9973	-4.1435
18	-.3328	-.3014	-.1664	-.1507	.0206	-.1163	.9970	-2.8213
19	-.3205	-.3016	-.1603	-.1508	.0398	-.1353	.9973	-1.3445
20	-.3097	-.2978	-.1548	-.1489	.0630	-.1458	.9990	-.1139
21	-.3004	-.2904	-.1502	-.1452	.0891	-.1484	.9998	.5788
22	-.2940	-.2773	-.1470	-.1387	.1193	-.1373	.9991	.9348
23	-.2910	-.2494	-.1455	-.1247	.1669	-.0975	.9992	1.0000
24	-.2860	-.2100	-.1430	-.1050	.2352	-.0425	.9975	.9916
25	-.2729	-.1669	-.1365	-.0834	.3221	.0061	.9954	.9838
26	-.2495	-.1259	-.1248	-.0630	.4220	.0354	.9952	.9667
27	-.2174	-.0859	-.1087	-.0430	.5345	.0499	.9937	.9261
28	-.1888	-.0503	-.0944	-.0252	.6346	.0626	.9885	.8835
29	-.1689	-.0254	-.0844	-.0127	.7045	.0717	.9666	.8843
30	-.1317	.0010	-.0658	.0005	.8042	.0569	.9312	.7617
31	-.0782	.0281	-.0391	.0141	.9308	.0179	.4981	-.0727
32	-.0513	.0410	-.0257	.0205	.9932	-.0028	-1.0244	-1.5154
35	1.4689	.0832	.7345	.0416	.9988	.0002	-.1564	-1.0121
36	1.4342	.0877	.7171	.0438	.9755	.0046	.7478	-1.2933
37	1.3673	.0960	.6836	.0480	.9304	.0128	.9844	-1.6796
38	1.3000	.1036	.6500	.0518	.8851	.0205	.9984	-1.7439
39	1.2341	.1104	.6171	.0552	.8407	.0276	.9998	-1.8555
40	1.1517	.1180	.5758	.0590	.7851	.0359	1.0000	-2.0044
41	1.0519	.1255	.5259	.0627	.7177	.0448	1.0000	-2.1807
42	.9519	.1309	.4760	.0654	.6502	.0523	1.0000	-2.3816
43	.8520	.1337	.4260	.0669	.5826	.0580	1.0000	-2.5954
44	.7520	.1336	.3760	.0668	.5148	.0618	1.0000	-2.7977
45	.6520	.1305	.3260	.0652	.4469	.0635	1.0000	-2.9970
46	.5519	.1247	.2760	.0624	.3789	.0634	1.0000	-3.2387
47	.4518	.1162	.2259	.0581	.3107	.0615	1.0000	-3.5470
48	.3517	.1047	.1758	.0524	.2424	.0575	.9998	-3.9433
49	.2765	.0940	.1383	.0470	.1910	.0532	1.0000	-4.3700
50	.2264	.0854	.1132	.0427	.1567	.0492	.9999	-4.6984
51	.1812	.0765	.0906	.0382	.1258	.0449	.9999	-5.1224
52	.1411	.0673	.0705	.0336	.0982	.0402	.9998	-5.5874

53	.1009	.0562	.0505	.0281	.0705	.0342	.9995	-6.0930
54	.0707	.0465	.0354	.0233	.0497	.0288	.9999	-6.7235
55	.0506	.0388	.0253	.0194	.0358	.0244	.9993	-7.3348
56	.0330	.0308	.0165	.0154	.0235	.0196	.9987	-8.1930
57	.0204	.0235	.0102	.0117	.0147	.0151	.9983	-9.1124
58	.0115	.0167	.0057	.0083	.0084	.0109	.9961	-9.9859
59	.0051	.0097	.0026	.0049	.0039	.0064	.9932	-10.5909
60	.0013	.0031	.0006	.0016	.0010	.0021	.9852	-11.3968
61	-.0001	-.0016	-.0000	-.0008	-.0001	-.0011	.9995	-11.8716
62	.0000	-.0049	.0000	-.0024	-.0002	-.0033	.9998	-9.7312
63	.0013	-.0093	.0006	-.0046	.0005	-.0063	.9948	-6.9041
64	.0047	-.0151	.0024	-.0076	.0026	-.0104	.9941	-3.9649
65	.0109	-.0210	.0054	-.0105	.0066	-.0146	.9981	-1.7538
66	.0195	-.0264	.0098	-.0132	.0122	-.0186	.9996	-.5123
67	.0319	-.0318	.0160	-.0159	.0204	-.0228	.9998	.1819
68	.0494	-.0375	.0247	-.0187	.0320	-.0273	1.0000	.5624
69	.0693	-.0427	.0346	-.0213	.0453	-.0316	1.0000	.7454
70	.0992	-.0485	.0496	-.0242	.0654	-.0367	1.0000	.8688
71	.1391	-.0549	.0695	-.0274	.0922	-.0425	1.0000	.9403
72	.1790	-.0602	.0895	-.0301	.1190	-.0476	1.0000	.9726
73	.2279	-.0651	.1120	-.0326	.1493	-.0527	1.0000	.9904
74	.2738	-.0697	.1369	-.0349	.1829	-.0577	1.0000	.9986
75	.3489	-.0752	.1744	-.0376	.2335	-.0643	1.0000	.9989
76	.4487	-.0810	.2244	-.0405	.3011	-.0720	1.0000	.9880
77	.5487	-.0849	.2743	-.0424	.3687	-.0785	1.0000	.9696
78	.6487	-.0871	.3243	-.0435	.4363	-.0838	1.0000	.9477
79	.7487	-.0875	.3743	-.0437	.5041	-.0879	1.0000	.9228
80	.8487	-.0856	.4244	-.0428	.5720	-.0905	1.0000	.8966
81	.9488	-.0815	.4744	-.0408	.6400	-.0915	1.0000	.8690
82	1.0489	-.0756	.5245	-.0378	.7081	-.0914	1.0000	.8352
83	1.1490	-.0684	.5745	-.0342	.7762	-.0903	1.0000	.7707
84	1.2196	-.0631	.6098	-.0316	.8242	-.0894	.9988	.5310
85	1.2450	-.0584	.6225	-.0292	.8416	-.0872	.9993	.1319
86	1.2583	-.0407	.6292	-.0203	.8513	-.0757	.9994	.5152
87	1.2833	.0025	.6417	.0012	.8699	-.0474	.9997	.7689
88	1.3083	.0456	.6542	.0228	.8885	-.0191	.9988	.8832
89	1.3250	.0685	.6625	.0342	.9007	-.0043	.9946	.9428
90	1.3417	.0794	.6708	.0397	.9124	.0025	.9885	.9463
91	1.3750	.0817	.6875	.0409	.9351	.0028	.9791	.8258
92	1.4336	.0817	.7168	.0409	.9748	.0006	.7578	.2800
93	1.4689	.0817	.7345	.0409	.9988	-.0008	-.1676	-.5702
96	2.0918	-.3343	1.0459	-.1671	.9982	.0003	.7648	.6251
97	2.0723	-.3182	1.0361	-.1591	.9624	.0062	.9334	.5077
98	2.0342	-.2870	1.0171	-.1435	.8927	.0177	.9931	.3141
99	1.9951	-.2548	.9976	-.1274	.8211	.0296	.9977	.1656
100	1.9560	-.2228	.9780	-.1114	.7495	.0414	.9988	.0175
101	1.9168	-.1908	.9584	-.0954	.6779	.0530	.9993	-.1395
102	1.8777	-.1588	.9388	-.0794	.6064	.0646	.9995	-.3198
103	1.8385	-.1270	.9192	-.0635	.5348	.0760	.9997	-.5325
104	1.8087	-.1030	.9043	-.0515	.4806	.0845	.9997	-.7245
105	1.7890	-.0872	.8945	-.0436	.4448	.0900	.9997	-.8707
106	1.7631	-.0665	.8815	-.0332	.3977	.0972	.9998	-1.1154
107	1.7223	-.0344	.8612	-.0172	.3242	.1078	1.0000	-1.7349
108	1.6889	-.0092	.8444	-.0046	.2645	.1151	.9998	-2.6312
109	1.6622	.0067	.8311	.0033	.2200	.1156	.9995	-3.2106
110	1.6255	.0233	.8128	.0116	.1626	.1100	.9989	-3.9203
111	1.5909	.0331	.7954	.0166	.1124	.0974	.9990	-4.4376
112	1.5592	.0360	.7796	.0180	.0711	.0782	.9976	-4.4104
113	1.5291	.0324	.7646	.0162	.0362	.0522	.9967	-3.7866
114	1.5047	.0233	.7523	.0116	.0124	.0234	.9971	-2.7542
115	1.4903	.0142	.7451	.0071	.0010	.0018	.9999	-2.2004
116	1.4828	.0070	.7414	.0035	-.0032	-.0126	.9993	-1.8572
117	1.4780	.0011	.7390	.0005	-.0048	-.0234	1.0000	-1.7000
118	1.4756	-.0033	.7378	-.0017	-.0047	-.0306	1.0000	-1.5441

119	1.4735	-.0108	.7368	-.0054	-.0019	-.0413	.9980	-.9277
120	1.4734	-.0222	.7367	-.0111	.0062	-.0556	.9990	-.1854
121	1.4791	-.0359	.7395	-.0180	.0231	-.0685	.9977	.4944
122	1.4884	-.0466	.7442	-.0233	.0424	-.0751	.9999	.8196
123	1.4985	-.0524	.7492	-.0262	.0590	-.0751	1.0000	.9419
124	1.5116	-.0583	.7558	-.0292	.0796	-.0730	1.0000	.9853
125	1.5269	-.0652	.7634	-.0326	.1035	-.0707	1.0000	.9980
126	1.5419	-.0720	.7710	-.0360	.1270	-.0683	1.0000	.9999
127	1.5573	-.0789	.7786	-.0395	.1511	-.0659	1.0000	.9977
128	1.5801	-.0894	.7901	-.0447	.1870	-.0625	.9999	.9909
129	1.6099	-.1029	.8049	-.0514	.2336	-.0580	.9999	.9798
130	1.6327	-.1134	.8164	-.0567	.2695	-.0546	.9999	.9703
131	1.6505	-.1216	.8252	-.0608	.2974	-.0521	.9998	.9630
132	1.6733	-.1321	.8366	-.0661	.3333	-.0488	.9998	.9537
133	1.7091	-.1490	.8545	-.0745	.3899	-.0440	.9998	.9382
134	1.7544	-.1705	.8772	-.0852	.4616	-.0382	.9997	.9185
135	1.7997	-.1922	.8998	-.0961	.5334	-.0328	.9996	.8976
136	1.8448	-.2142	.9224	-.1071	.6052	-.0277	.9995	.8753
137	1.8898	-.2362	.9449	-.1181	.6770	-.0228	.9993	.8516
138	1.9349	-.2583	.9674	-.1292	.7487	-.0179	.9988	.8256
139	1.9799	-.2804	.9899	-.1402	.8205	-.0131	.9977	.7965
140	2.0249	-.3024	1.0125	-.1512	.8923	-.0081	.9928	.7696
141	2.0684	-.3247	1.0342	-.1623	.9623	-.0046	.9331	.7360
142	2.0905	-.3365	1.0453	-.1683	.9982	-.0035	.7620	.6837

--- FORCE COEFFICIENTS ---

ALPHA = 22.9000 DEGREES

POTENTIAL FLOW ANALYSIS

AIRFOIL PART NUMBER 1 ...

NO.	PR-N	PR-C	PR-M
1	.0046	-.0012	.0012
2	.1231	-.0337	.0352
3	.1776	-.0719	.0562
4	.0979	-.0469	.0334
5	.1484	-.0907	.0539
6	.1478	-.1021	.0578
7	.1548	-.1299	.0656
8	.1434	-.1546	.0667
9	.1260	-.1666	.0646
10	.0924	-.1704	.0542
11	.0571	-.1773	.0424
12	.0124	-.1444	.0214
13	-.0186	-.1253	.0070
14	-.0382	-.0939	-.0046
15	-.0504	-.0637	-.0131
16	-.0322	-.0238	-.0104
17	-.0295	-.0151	-.0102
18	-.0180	-.0035	-.0070
19	-.0081	.0014	-.0036
20	-.0009	.0005	-.0004
21	.0024	-.0025	.0013
22	.0018	-.0078	.0018
23	.0010	-.0193	.0028
24	.0040	-.0198	.0036
25	.0089	-.0227	.0053
26	.0138	-.0171	.0062
27	.0165	-.0206	.0068
28	.0096	-.0119	.0036
29	.0079	-.0100	.0028
30	.0188	-.0100	.0060
31	.0005	-.0002	.0002
32	-.0016	.0008	-.0004

```
--- COEFFICIENTS FOR AIRFOIL NUMBER  1 ---

--- PRESSURE FORCE COEFFICIENTS ---

      NORMAL FORCE COEFFICIENT (LOCAL)     =  9.1107

      CHORDWISE FORCE COEFFICIENT (LOCAL) = -1.9861

      NORMAL FORCE COEFFICIENT             =  1.1732

      LIFT COEFFICIENT                     =  1.7633

      CHORDWISE FORCE COEFFICIENT          = -1.7541

      DRAG COEFFICIENT                     = -1.1593

      PITCHING MOMENT COEFFICIENT          =   .5505

      POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5100,  0.0000)
```

--- FORCE COEFFICIENTS ---

ALPHA = 22.9000 DEGREES

POTENTIAL FLOW ANALYSIS

AIRFOIL PART NUMBER 2 ...

NO.	PR-N	PR-C	PR-M
1	.0019	.0002	-.0009
2	.0441	.0057	-.0204
3	.0557	.0068	-.0238
4	.0583	.0060	-.0230
5	.0606	.0063	-.0219
6	.1004	.0085	-.0322
7	.1091	.0071	-.0296
8	.1190	.0051	-.0265
9	.1296	.0019	-.0227
10	.1398	-.0024	-.0177
11	.1502	-.0068	-.0118
12	.1625	-.0115	-.0049
13	.1781	-.0175	.0033
14	.1969	-.0260	.0133
15	.1087	-.0176	.0113
16	.1180	-.0219	.0152
17	.1028	-.0216	.0156
18	.1123	-.0279	.0192
19	.1223	-.0370	.0234
20	.0674	-.0238	.0139
21	.0740	-.0305	.0161
22	.0618	-.0319	.0139
23	.0459	-.0307	.0107
24	.0378	-.0340	.0089
25	.0271	-.0374	.0065
26	.0146	-.0352	.0036
27	.0012	-.0185	.0003
28	-.0020	-.0157	-.0005
29	-.0069	-.0187	-.0016
30	-.0098	-.0123	-.0023
31	-.0068	-.0051	-.0016
32	-.0027	-.0014	-.0006
33	.0012	.0005	.0003
34	.0054	.0016	.0012
35	.0074	.0017	.0016
36	.0173	.0030	.0034
37	.0187	.0027	.0033
38	.0194	.0023	.0030
39	.0247	.0025	.0033
40	.0249	.0021	.0027
41	.0498	.0034	.0036
42	.0493	.0023	.0012
43	.0484	.0015	-.0012
44	.0474	.0007	-.0035
45	.0462	-.0003	-.0057
46	.0448	-.0014	-.0078
47	.0435	-.0022	-.0097
48	.0416	-.0028	-.0113
49	.0381	-.0030	-.0123

50	.0113	-.0008	-.0040
51	.0014	-.0009	-.0005
52	.0044	-.0077	-.0015
53	.0126	-.0218	-.0050
54	.0073	-.0125	-.0032
55	.0078	-.0079	-.0035
56	.0077	-.0022	-.0033
57	.0189	0.0000	-.0082
58	.0110	.0000	-.0051
59	-.0007	.0000	.0003

```
--- COEFFICIENTS FOR AIRFOIL NUMBER  2 ---

--- PRESSURE FORCE COEFFICIENTS ---

    NORMAL FORCE COEFFICIENT (LOCAL)     =  4.0787

    CHORDWISE FORCE COEFFICIENT (LOCAL) =  -.4185

    NORMAL FORCE COEFFICIENT            =  2.9919

    LIFT COEFFICIENT                    =  2.9325

    CHORDWISE FORCE COEFFICIENT         =  -.4770

    DRAG COEFFICIENT                    =   .7209

    PITCHING MOMENT COEFFICIENT         =  -.1288

    POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5300,  0.0000)
```

--- FORCE COEFFICIENTS ---

ALPHA = 22.9000 DEGREES

POTENTIAL FLOW ANALYSIS

AIRFOIL PART NUMBER 3 ...

NO.	PR-N	PR-C	PR-M
1	-.0006	-.0005	.0005
2	-.0090	-.0074	.0083
3	-.0062	-.0051	.0055
4	-.0032	-.0027	.0029
5	-.0003	-.0003	.0003
6	.0028	.0023	-.0022
7	.0063	.0052	-.0048
8	.0103	.0083	-.0074
9	.0072	.0058	-.0050
10	.0085	.0068	-.0058
11	.0194	.0155	-.0127
12	.0422	.0328	-.0263
13	.0233	.0159	-.0139
14	.0571	.0313	-.0331
15	.0742	.0271	-.0414
16	.0682	.0127	-.0370
17	.0693	-.0003	-.0367
18	.0531	-.0131	-.0275
19	.0294	-.0161	-.0149
20	.0093	-.0076	-.0047
21	.0064	-.0072	-.0032
22	.0023	-.0037	-.0011
23	.0016	-.0033	-.0008
24	.0008	-.0046	-.0004
25	-.0001	-.0011	.0001
26	.0022	.0034	-.0011
27	.0036	.0025	-.0018
28	.0052	.0023	-.0026
29	.0075	.0034	-.0039
30	.0076	.0035	-.0040
31	.0074	.0032	-.0040
32	.0079	.0037	-.0043
33	.0147	.0067	-.0082
34	.0146	.0066	-.0084
35	.0078	.0036	-.0046
36	.0094	.0043	-.0057
37	.0124	.0058	-.0077
38	.0213	.0100	-.0136
39	.0208	.0099	-.0139
40	.0203	.0098	-.0141
41	.0197	.0096	-.0143
42	.0192	.0094	-.0144
43	.0186	.0091	-.0145
44	.0180	.0088	-.0145
45	.0173	.0084	-.0145
46	.0155	.0083	-.0135
47	.0008	.0004	-.0007

```
--- COEFFICIENTS FOR AIRFOIL NUMBER  3 ---

--- PRESSURE FORCE COEFFICIENTS ---

     NORMAL FORCE COEFFICIENT (LOCAL)      =  2.1588
     CHORDWISE FORCE COEFFICIENT (LOCAL)   = -.5104
     NORMAL FORCE COEFFICIENT              =   .7437
     LIFT COEFFICIENT                      =   .5979
     CHORDWISE FORCE COEFFICIENT           =   .2239
     DRAG COEFFICIENT                      =   .4956
     PITCHING MOMENT COEFFICIENT           =  -.4459
     POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,  0.0000)


--- FORCE COEFFICIENTS FOR THE TOTAL SYSTEM ---

--- PRESSURE FORCE COEFFICIENTS ---

     NORMAL FORCE COEFFICIENT              =  4.8988
     LIFT COEFFICIENT                      =  5.2937
     CHORDWISE FORCE COEFFICIENT           = -2.0072
     DRAG COEFFICIENT                      =   .0572
     PITCHING MOMENT COEFFICIENT           =  -.0242
     POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,  0.0000)
```

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 1 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 1 ... STAGNATION POINT = (-.29099 , -.24937)

UPPER SURFACE

NO.	XRP	YRP	LENGTH	CP
1	-.29099	-.24937	0.0010	1.0000
2	-.29400	-.27732	.0231	.9348
3	-.30037	-.29041	.0427	.5788
4	-.30970	-.29776	.0545	-.1139
5	-.32054	-.30164	.0661	-1.3445
6	-.33278	-.30145	.0733	-2.8213
7	-.34615	-.29665	.0925	-4.1435
8	-.35835	-.28922	.1058	-6.1092
9	-.36954	-.27780	.1228	-8.3553
10	-.37913	-.26138	.1418	-10.6885
11	-.38427	-.24220	.1617	-12.2174
12	-.38484	-.22068	.1832	-13.0739
13	-.37930	-.19526	.2092	-12.5432
14	-.36668	-.16621	.2439	-11.5421
15	-.34644	-.13525	.2779	-10.2844
16	-.31919	-.10289	.3212	-9.5073
17	-.28674	-.07206	.3649	-8.9302
18	-.25119	-.04492	.4036	-8.0952
19	-.21369	-.02056	.4544	-7.6484
20	-.18070	-.00221	.4921	-7.3073
21	-.13787	.01613	.5387	-6.2491
22	-.08081	.03557	.5930	-4.1611
23	-.05147	.04360	.6234	-2.7971

LOWER SURFACE

NO.	XBF	YBP	LENGTH	CP
1	-.29099	-.24937	0.0000	1.0000
2	-.28600	-.21000	.0337	.9916
3	-.27292	-.16686	.0848	.9838
4	-.24954	-.12593	.1319	.9667
5	-.21740	-.08590	.1832	.9261
6	-.18879	-.05033	.2239	.8835
7	-.16886	-.02541	.2618	.8343
8	-.13170	.00104	.3064	.7617
9	-.07819	.02811	.3654	-.0727
10	-.05134	.04096	.3951	-1.5154

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 23 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .1021066E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1 0.00000	.123199529E+01 0.	.100000000E+01 0.	0. 0.	0. 0.	0. 0.
2 .02811	.177210092E+01 .689213829E-04	.100000000E+01 .210582226E+01	0. .368994019E-01	.918969401E+04 0.	.145136182E-03 .225304217E+02
3 .04267	.155281124E+01 .443889614E-04	.100000000E+01 .222119891E+01	0. .192314695E-01	.754461577E+05 0.	.985967126E-04 .368747514E+02
4 .05455	.145149241E+01 .410705700E-04	.100000000E+01 .223425005E+01	0. .127316200E-01	.736895346E+05 0.	.917619231E-04 .554841380E+02
5 .06606	.133258731E+01 .403288765E-04	.100000000E+01 .223847235E+01	0. .887850597E-02	.129471631E+06 0.	.902750748E-04 .790408675E+02
6 .07830	.118586900E+01 .434293507E-04	.100000000E+01 .226230537E+01	0. .623425422E-02	.195922736E+06 0.	.982504523E-04 .108667037E+03
7 .09251	.114794331E+01 .485029301E-04	.100000000E+01 .225682232E+01	0. .487808543E-02	.268544283E+06 0.	.109462495E-03 .140802044E+03
8 .10679	.116745562E+01 .495456782E-04	.100000000E+01 .223616009E+01	0. .418195448E-02	.364466082E+06 0.	.110792068E-03 .169093227E+03
9 .12278	.112606273E+01 .514358047E-04	.100000000E+01 .224556233E+01	0. .343887957E-02	.480690425E+06 0.	.115502305E-03 .201373975E+03
10 .14180	.102898978E+01 .556737890E-04	.100000000E+01 .228272891E+01	0. .268711753E-02	.620513885E+06 0.	.127088168E-03 .243635284E+03
11 .16165	.904618861E+00 .628257526E-04	.100000000E+01 .233872084E+01	0. .206738955E-02	.752254887E+06 0.	.146930961E-03 .292360304E+03
12 .18318	.723264206E+00 .736257522E-04	.100000000E+01 .243986165E+01	0. .146917514E-02	.879617989E+06 0.	.179636649E-03 .353546429E+03
13 .20920	.441258431E+00 .946561850E-04	.100000000E+01 .266962020E+01	0. .800013035E-03	.985427779E+06 0.	.252696063E-03 .445881624E+03
14 .24087	.197090758E+01 .168837176E-03	.100000000E+01 .166602811E+01	0. .320816100E-02	.109188442E+07 0.	.281287481E-03 .765355921E+03
15 .27786	.247952821E+01 .263669098E-03	.100000000E+01 .150178646E+01	0. .365946326E-02	.119473613E+07 0.	.395974682E-03 .113372606E+04
16 .32015	.254673337E+01 .373095113E-03	.100000000E+01 .147030047E+01	0. .343885054E-02	.132839453E+07 0.	.548561921E-03 .154801450E+04
17 .36492	.252498537E+01 .495107402E-03	.100000000E+01 .146058177E+01	0. .315618438E-02	.147194526E+07 0.	.723144846E-03 .199705017E+04
18	.251467724E+01	.100000000E+01	0.	.158135141E+07	.925429189E-03

```
 .40965     .635967927E-03    .145515072E+01    .294662706E-02    0.                          .245499903E+04

 19         .256672088E+01    .100000000E+01    0.                          .171034443E+07    .110550331E-02
 .45437     .764752155E-03    .144557070E+01    .284573469E-02    0.                          .287870779E+04

 20         .250127213E+01    .100000000E+01    0.                          .181555363E+07    .130288758E-02
 .49212     .898112587E-03    .145069515E+01    .266053197E-02    0.                          .331338259E+04

 21         .199326956E+01    .100000000E+01    0.                          .185654113E+07    .188540164E-02
 .53871     .124687968E-02    .151209589E+01    .202701974E-02    0.                          .429709946E+04

                              FLOW SEPARATION INDICATED

                         FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR FLOW BUBBLE EXISTS

TRANSITION IS CALCULATED TO OCCUR AT INDEX  13  XBP =   -.37930  YBP =   -.19526  LENGTH =   .2092


*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  10 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .1021066E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
```

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1	.123199525E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.107165174E+01	.100000000E+01	0.	.466380402E+04	.417206255E-03
.03968	.184379749E-03	.226275530E+01	.312148467E-01	0.	.216684295E+02
3	.109697667E+01	.100000000E+01	0.	.138306944E+05	.583397045E-03
.08476	.260545599E-03	.223913606E+01	.166477333E-01	0.	.425123133E+02
4	.129406650E+01	.100000000E+01	0.	.308103347E+05	.530673327E-03
.13190	.245251697E-03	.216379064E+01	.136275105E-01	0.	.572874666E+02
5	.130773294E+01	.100000000E+01	0.	.637635506E+05	.460129266E-03
.18324	.210792323E-03	.218285591E+01	.101864796E-01	0.	.733522909E+02
6	.983394817E+00	.100000000E+01	0.	.999987747E+05	.528414687E-03
.22889	.228403730E-03	.231351164E+01	.616572016E-02	0.	.997883499E+02
7	.122577397E+01	.100000000E+01	0.	.113560105E+05	.557560906E-03
.26079	.252546105E-03	.220775888E+01	.681014765E-02	0.	.109968309E+03
8	.200447146E+01	.100000000E+01	0.	.191437230E+05	.334866352E-03
.30641	.167894861E-03	.199450031E+01	.950350046E-02	0.	.104897517E+03
9	.219937356E+01	.100000000E+01	0.	.485703179E+05	.155892035E-03
.36637	.726072896E-04	.214705763E+01	.810001904E-02	0.	.962564737E+02
10	.199817079E+01	.100000000E+01	0.	.804196392E+05	.124110246E-03
.39614	.559954965E-04	.221682854E+01	.636026202E-02	0.	.113655790E+03

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 1 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 2 ... STAGNATION POINT = (.34879 , -.07520)

UPPER SURFACE

NO.	XPP	YPP	LENGTH	CP
1	.34879	-.07520	0.0000	1.0000
2	.27385	-.06971	.0751	.9986
3	.22392	-.06510	.1253	.9904
4	.17899	-.06019	.1795	.9726
5	.13907	-.05488	.2138	.9403
6	.09918	-.04849	.2512	.8588
7	.06927	-.04267	.2816	.7454
8	.04935	-.03747	.3022	.5624
9	.03194	-.03179	.3235	.1819
10	.01952	-.02637	.3341	-.5123
11	.01087	-.02100	.3443	-1.7538
12	.00473	-.01515	.3527	-3.9649
13	.00125	-.00929	.3596	-6.9041
14	.00001	-.00487	.3641	-9.7312
15	-.00010	-.00161	.3674	-11.8716
16	.00129	.00311	.3723	-11.3968
17	.00514	.00975	.3800	-10.5909
18	.01150	.01670	.3834	-9.9859
19	.02036	.02350	.4036	-9.1124
20	.03298	.03078	.4152	-8.1930
21	.05061	.03883	.4345	-7.3348
22	.07074	.04654	.4551	-6.7235
23	.10091	.05619	.4878	-6.0930
24	.14109	.06727	.5295	-5.5874
25	.18123	.07648	.5716	-5.1224
26	.22638	.08535	.6156	-4.6984
27	.27651	.09405	.6675	-4.3700
28	.35167	.10471	.7434	-3.9433
29	.45184	.11625	.8443	-3.5470
30	.55195	.12471	.9447	-3.2387
31	.65202	.13049	1.0450	-2.9970
32	.75203	.13359	1.1450	-2.7977
33	.85200	.13371	1.2450	-2.5954
34	.95193	.13086	1.3450	-2.3816
35	1.05182	.12549	1.4450	-2.1807
36	1.15169	.11801	1.5452	-2.0044
37	1.23414	.11039	1.6290	-1.8555
38	1.30000	.10358	1.6942	-1.7439
39	1.36729	.09604	1.7619	-1.6796
40	1.43423	.08768	1.8293	-1.2933
41	1.46893	.08322	1.8643	-1.0121

LOWER SURFACE

NO.	XPP	YEP	LENGTH	CP
1	.34879	-.07520	0.0000	1.0000
2	.44873	-.08096	.1001	.9880
3	.54869	-.08486	.2011	.9596
4	.64868	-.08708	.3012	.9477
5	.74870	-.08745	.4012	.9228
6	.84875	-.08560	.5002	.8966
7	.94883	-.08151	.6014	.8690
8	1.04893	-.07561	.7017	.8352
9	1.14905	-.06839	.8011	.7707
10	1.21956	-.06312	.8718	.5310
11	1.24500	-.05841	.8976	.1319
12	1.25833	-.04066	.9138	.5152
13	1.28333	.00250	.9637	.7689
14	1.30833	.04563	1.0136	.8832
15	1.32500	.06850	1.0479	.9428
16	1.34166	.07937	1.0678	.9463
17	1.37500	.08175	1.1012	.8258
18	1.43357	.08175	1.1538	.2800
19	1.46890	.08175	1.1951	-.5702

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 41 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .1021066E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.160395444E+01	.100000000E+01	0.	.365679308E+04	.671937762E-03
.07514	.314897954E-03	.213382702E+01	.523645037E-01	0.	.153247804E+02
3	.148085767E+01	.100000000E+01	0.	.157188249E+05	.474261625E-03
.12528	.213594453E-03	.222038362E+01	.265069597E-01	0.	.267989161E+02
4	.144001866E+01	.100000000E+01	0.	.360977307E+05	.434218626E-03
.17048	.195080494E-03	.222584338E+01	.172965716E-01	0.	.413065167E+02
5	.149413229E+01	.100000000E+01	0.	.658856068E+05	.389069543E-03
.21075	.177692337E-03	.218956849E+01	.135213939E-01	0.	.555503686E+02
6	.161357392E+01	.100000000E+01	0.	.116425706E+06	.321226931E-03
.25115	.149485026E-03	.214889036E+01	.113955153E-01	0.	.692965967E+02
7	.175572721E+01	.100000000E+01	0.	.181890565E+06	.257523765E-03
.28162	.121333153E-03	.212245177E+01	.103998123E-01	0.	.783652149E+02
8	.192149017E+01	.100000000E+01	0.	.255888394E+06	.205743232E-03
.30221	.979114231E-04	.210132001E+01	.101014445E-01	0.	.829041044E+02
9	.212220845E+01	.100000000E+01	0.	.371093077E+06	.154264502E-03
.32052	.739608520E-04	.208575886E+01	.996434587E-02	0.	.856300604E+02
10	.228320919E+01	.100000000E+01	0.	.525852565E+06	.115738123E-03
.33407	.555615676E-04	.208306080E+01	.976985276E-02	0.	.874573511E+02
11	.235046952E+01	.100000000E+01	0.	.731234572E+06	.891961904E-04
.34425	.425977048E-04	.209392010E+01	.928897859E-02	0.	.904821147E+02
12	.226361308E+01	.100000000E+01	0.	.100603443E+07	.725189770E-04
.35274	.341783497E-04	.212178111E+01	.828884855E-02	0.	.974798018E+02
13	.214554054E+01	.100000000E+01	0.	.129388622E+07	.638544070E-04
.35955	.297889246E-04	.214356201E+01	.733459288E-02	0.	.107198906E+03
14	.199931849E+01	.100000000E+01	0.	.152687709E+07	.605178993E-04
.36414	.279333025E-04	.216651430E+01	.650326346E-02	0.	.117126714E+03
15	.160966252E+01	.100000000E+01	0.	.168721399E+07	.646874670E-04
.36740	.287613814E-04	.224910849E+01	.504806428E-02	0.	.132079849E+03
16	.866039997E+00	.100000000E+01	0.	.167797632E+07	.959142128E-04
.37232	.385207525E-04	.248993611E+01	.257780718E-02	0.	.173603950E+03
17	.542985311E+00	.100000000E+01	0.	.165596898E+07	.135794730E-03
.38000	.498883300E-04	.272194657E+01	.150667192E-02	0.	.217406549E+03
18	.366769136E+00	.100000000E+01	0.	.165213839E+07	.180715954E-03

.38942	.621530929E-04	.290759390E+01	.946569124E-03	0.	.263688187E+03
19 .40059	.141732512E+01 .984498585E-04	.100000000E+01 .186407918E+01	0. .340418187E-02	.163055798E+07 0.	.183518331E-03 .400730524E+03
20 .41516	.189109897E+01 .144805180E-03	.100000000E+01 .162016701E+01	0. .420444467E-02	.161120824E+07 0.	.234608575E-03 .561981741E+03
21 .43454	.192197622E+01 .210779251E-03	.100000000E+01 .156592374E+01	0. .393128402E-02	.160578074E+07 0.	.330064233E-03 .778906437E+03
22 .45610	.189344036E+01 .283016930E-03	.100000000E+01 .154556622E+01	0. .359046493E-02	.162245410E+07 0.	.437421407E-03 .100676818E+04
23 .48777	.191507276E+01 .386031773E-03	.100000000E+01 .152265899E+01	0. .331723920E-02	.166280082E+07 0.	.587794748E-03 .131597461E+04
24 .52945	.197904133E+01 .516091928E-03	.100000000E+01 .149992460E+01	0. .311739693E-02	.173936502E+07 0.	.774098980E-03 .169547912E+04
25 .57063	.202878643E+01 .652297774E-03	.100000000E+01 .148558389E+01	0. .296101801E-02	.180729191E+07 0.	.969043065E-03 .206593621E+04
26 .61665	.208978497E+01 .806607473E-03	.100000000E+01 .147347655E+01	0. .284112180E-02	.188418523E+07 0.	.118851720E-02 .246461742E+04
27 .66753	.215899494E+01 .972786734E-03	.100000000E+01 .146258044E+01	0. .274718655E-02	.198000509E+07 0.	.142277885E-02 .288546506E+04
28 .74344	.223895441E+01 .122856643E-02	.100000000E+01 .145279028E+01	0. .262422197E-02	.211573491E+07 0.	.178484937E-02 .349635144E+04
29 .84427	.233965969E+01 .156216758E-02	.100000000E+01 .144332067E+01	0. .251058346E-02	.230436962E+07 0.	.225470876E-02 .426381227E+04
30 .94474	.243139202E+01 .189476201E-02	.100000000E+01 .143567788E+01	0. .242749161E-02	.248964861E+07 0.	.272026791E-02 .499323016E+04
31 1.04497	.251844562E+01 .222373405E-02	.100000000E+01 .142900030E+01	0. .236561739E-02	.267412873E+07 0.	.317771661E-02 .569061972E+04
32 1.14503	.258299806E+01 .256032475E-02	.100000000E+01 .142523045E+01	0. .230130826E-02	.285618461E+07 0.	.364905281E-02 .638651000E+04
33 1.24500	.260179214E+01 .293822186E-02	.100000000E+01 .142701154E+01	0. .221255545E-02	.302173617E+07 0.	.419287651E-02 .713133690E+04
34 1.34497	.258357043E+01 .337314501E-02	.100000000E+01 .143348741E+01	0. .210787559E-02	.316579571E+07 0.	.483536090E-02 .793970439E+04
35 1.44501	.255629245E+01 .384796427E-02	.100000000E+01 .144137626E+01	0. .200950862E-02	.329867083E+07 0.	.554636434E-02 .878415500E+04
36 1.54516	.251262390E+01 .436095504E-02	.100000000E+01 .145103450E+01	0. .190971839E-02	.342816265E+07 0.	.632789623E-02 .967543337E+04
37 1.62796	.245681422E+01 .483715458E-02	.100000000E+01 .146105227E+01	0. .182028973E-02	.352121859E+07 0.	.705733570E-02 .104625689E+05
38 1.69417	.245852795E+01 .520698825E-02	.100000000E+01 .146447636E+01	0. .178711596E-02	.359212556E+07 0.	.762551120E-02 .110403130E+05
39 1.76189	.206937357E+01 .583245648E-02	.100000000E+01 .150636148E+01	0. .147665389E-02	.369165272E+07 0.	.879578779E-02 .122206632E+05

FLOW SEPARATION INDICATED

```
                    FFPW IS NEGATIVE - ITERATIONS DIVERGE
LAMINAR FLOW BUBBLE EXISTS
TRANSITION IS CALCULATED TO OCCUR AT INDEX  18  XBP =    .01150  YBP =    .01670  LENGTH =   .3894



*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  19 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .1021066E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
```

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.113036213E+01	.100000000E+01	0.	.140332764E+05	.584171634E-03
.10011	.260224502E-03	.224487560E+01	.189974066E-01	0.	.364794101E+02
3	.109638385E+01	.100000000E+01	0.	.446805860E+05	.716550851E-03
.20014	.318710540E-03	.224828100E+01	.975600706E-02	0.	.711503867E+02
4	.110340132E+01	.100000000E+01	0.	.878840977E+05	.776923919E-03
.30016	.346824007E-03	.224010998E+01	.690540739E-02	0.	.101548061E+03
5	.110640260E+01	.100000000E+01	0.	.142301644E+06	.814770865E-03
.40018	.363985062E-03	.223847336E+01	.541513430E-02	0.	.129431835E+03
6	.110447230E+01	.100000000E+01	0.	.205874845E+06	.849309191E-03
.50024	.379038500E-03	.224069373E+01	.447419495E-02	0.	.155992758E+03
7	.112913839E+01	.100000000E+01	0.	.278160137E+06	.869177278E-03
.60041	.389405721E-03	.223206088E+01	.392299817E-02	0.	.180405944E+03
8	.127429210E+01	.100000000E+01	0.	.364067224E+06	.827941259E-03
.70068	.379989385E-03	.217885365E+01	.388686928E-02	0.	.197438725E+03
9	.297671644E+01	.100000000E+01	0.	.490956134E+06	.588660899E-03
.80106	.297597850E-03	.197804151E+01	.563331875E-02	0.	.182392331E+03
10	.320929377E+01	.100000000E+01	0.	.764169898E+06	.299245861E-03
.87177	.157636797E-03	.189832492E+01	.796788886E-02	0.	.139180469E+03
11	.974920603E+00	.100000000E+01	0.	.107053254E+07	.438608621E-03
.89764	.191306298E-03	.229270351E+01	.232642762E-02	0.	.228153344E+03

LAMINAR BUBBLE BURST HAS OCCURRED

FLOW SEPARATION INDICATED

FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR BOUNDARY LAYER DISPLACEMENT THICKNESS USED IN EXTRAPOLATION

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 1 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 3 ... STAGNATION POINT = (1.54192 , -.07197)

UPPER SURFACE

NO.	XBP	YBP	LENGTH	CP
1	1.54192	-.07197	0.0000	1.0000
2	1.52689	-.06525	.0155	.9980
3	1.51165	-.05832	.0332	.9853
4	1.49849	-.05237	.0477	.9419
5	1.48844	-.04661	.0592	.8196
6	1.47907	-.03591	.0735	.4944
7	1.47342	-.02220	.0883	-.1894
8	1.47353	-.01077	.0937	-.9277
9	1.47556	-.00333	.1074	-1.5441
10	1.47801	.00108	.1125	-1.7000
11	1.48275	.00705	.1201	-1.8572
12	1.49028	.01425	.1315	-2.2004
13	1.50469	.02329	.1475	-2.7542
14	1.52911	.03243	.1736	-3.7866
15	1.55922	.03598	.2039	-4.4104
16	1.59082	.03313	.2356	-4.4376
17	1.62553	.02325	.2717	-3.9203
18	1.66218	.00666	.3120	-3.2106
19	1.68888	-.00919	.3430	-2.6312
20	1.72235	-.03438	.3849	-1.7349
21	1.76306	-.06645	.4357	-1.1154
22	1.78895	-.08718	.4699	-.8707
23	1.80866	-.10297	.4952	-.7245
24	1.83846	-.12702	.5334	-.5325
25	1.87767	-.15885	.5840	-.3198
26	1.91683	-.19078	.6345	-.1395
27	1.95599	-.22278	.6850	.0175
28	1.99512	-.25485	.7336	.1656
29	2.03416	-.28696	.7852	.3141
30	2.07225	-.31824	.8335	.5077
31	2.09183	-.33426	.8618	.6251

LOWER SURFACE

NO.	XBF	YBF	LENGTH	CP
1	1.54192	-.07197	0.0000	1.0000
2	1.55730	-.07893	.0159	.9977
3	1.58012	-.08939	.0420	.9909
4	1.60985	-.10290	.0746	.9798
5	1.63271	-.11340	.0938	.9703
6	1.65045	-.12157	.1133	.9630
7	1.67326	-.13214	.1445	.9537
8	1.70907	-.14897	.1840	.9382
9	1.75445	-.17046	.2342	.9185
10	1.79966	-.19223	.2844	.8975
11	1.84477	-.21418	.3346	.8753
12	1.88983	-.23621	.3847	.8516
13	1.93485	-.25830	.4349	.8256
14	1.97988	-.28040	.4851	.7969
15	2.02495	-.30243	.5352	.7696
16	2.06844	-.32469	.5841	.7360
17	2.09050	-.33655	.6091	.6837

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 31 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .1021066E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1 0.00000	.123199529E+01 0.	.100000000E+01 0.	0. 0.	0. 0.	0. 0.
2 .01646	.139657301E+01 .147600110E-03	.100000000E+01 .217561129E+01	0. .899891098E-01	.942758662E+03 0.	.321120465E-03 .845288948E+01
3 .03321	.152787577E+01 .106141322E-03	.100000000E+01 .218476082E+01	0. .454511267E-01	.515093606E+04 0.	.231893402E-03 .164647015E+02
4 .04765	.164619378E+01 .789139157E-04	.100000000E+01 .218069866E+01	0. .310863850E-01	.147005025E+05 0.	.172087470E-03 .243452316E+02
5 .05924	.156030348E+01 .630532795E-04	.100000000E+01 .219823454E+01	0. .214888518E-01	.322006714E+05 0.	.138605897E-03 .342757134E+02
6 .07346	.147818486E+01 .559188338E-04	.100000000E+01 .219995432E+01	0. .144688862E-01	.668571005E+05 0.	.123018880E-03 .508956999E+02
7 .08828	.139115333E+01 .518531302E-04	.100000000E+01 .220517374E+01	0. .100958576E-01	.123235905E+05 0.	.114345161E-03 .723846841E+02
8 .09972	.134627474E+01 .509933849E-04	.100000000E+01 .220787871E+01	0. .803672250E-02	.177219505E+05 0.	.112587209E-03 .906246213E+02
9 .10743	.114801060E+01 .530226162E-04	.100000000E+01 .227044354E+01	0. .609954196E-02	.219333695E+05 0.	.120384856E-03 .108252038E+03
10 .11247	.980225364E+00 .584218100E-04	.100000000E+01 .233797713E+01	0. .486194731E-02	.236557509E+05 0.	.136588856E-03 .122876166E+03
11 .12010	.917881071E+00 .655923641E-04	.100000000E+01 .236420935E+01	0. .415592972E-02	.259842579E+05 0.	.155074080E-03 .141917939E+03
12 .13051	.949442237E+00 .709475168E-04	.100000000E+01 .233349775E+01	0. .386392581E-02	.298858063E+05 0.	.165555871E-03 .162460753E+03
13 .14753	.985742315E+00 .767714610E-04	.100000000E+01 .229444505E+01	0. .347067627E-02	.365883843E+05 0.	.176147898E-03 .190401750E+03
14 .17360	.967054453E+00 .823211327E-04	.100000000E+01 .228910678E+01	0. .285057175E-02	.486158402E+05 0.	.188441863E-03 .230533264E+03
15 .20391	.797275621E+00 .961407120E-04	.100000000E+01 .237405018E+01	0. .200024989E-02	.607114189E+05 0.	.228242875E-03 .286241043E+03
16 .23565	.512157936E+00 .122017670E-03	.100000000E+01 .258047907E+01	0. .112795075E-02	.703352722E+05 0.	.314864043E-03 .364196119E+03
17 .27173	.171704390E+01 .218191227E-03	.100000000E+01 .169806567E+01	0. .337574713E-02	.771529525E+05 0.	.370503033E-03 .619505584E+03
18	.193721964E+01	.100000000E+01	0.	.819399993E+05	.575910870E-03

```
 .31197     .369422756E-03    .155894801E+01    .345879733E-02    0.                                 .970303983E+03

  19        .168052018E+01    .100000000E+01    0.                   .836644336E+05    .866021409E-03
 .34301     .548821279E-03    .157796617E+01    .282847211E-02    0.                                 .133863790E+04

  20        .110905312E+01    .100000000E+01    0.                   .814768000E+05    .162560574E-02
 .38491     .974107336E-03    .166881583E+01    .175198256E-02    0.                                 .206198970E+04

  21        .728945522E+00    .100000000E+01    0.                   .813044830E+05    .287034851E-02
 .43673     .161439389E-02    .177797286E+01    .108391890E-02    0.                                 .300546297E+04

  22        .595271660E+00    .100000000E+01    0.                   .822660452E+05    .376867273E-02
 .46990     .205741893E-02    .183174787E+01    .857217429E-03    0.                                 .360196252E+04

  23        .488145565E+00    .100000000E+01    0.                   .832293107E+05    .454833816E-02
 .49515     .242438000E-02    .187608302E+01    .687673976E-03    0.                                 .407511200E+04

  24        .246234885E+00    .100000000E+01    0.                   .845278839E+05    .614115517E-02
 .53345     .309775103E-02    .198245602E+01    .336598121E-03    0.                                 .490858104E+04

                                   FLOW SEPARATION INDICATED

                               FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR FLOW BUBBLE EXISTS

TRANSITION IS CALCULATED TO OCCUR AT INDEX  16   XBP =   1.59082   YBP =    .03313   LENGTH =   .2356



*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  17 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .1021066E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
```

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.116710879E+01	.100000000E+01	0.	.103654954E+04	.356567443E-03
.01688	.159614359E-03	.223393086E+01	.717574834E-01	0.	.980298397E+01
3	.112405804E+01	.100000000E+01	0.	.511997277E+04	.431499295E-03
.04199	.192660519E-03	.223968718E+01	.298762966E-01	0.	.234930813E+02
4	.110391435E+01	.100000000E+01	0.	.135691846E+05	.488108889E-03
.07464	.217882647E-03	.224023756E+01	.176878979E-01	0.	.396090541E+02
5	.108815843E+01	.100000000E+01	0.	.219945605E+05	.520569576E-03
.09979	.231796282E-03	.224580641E+01	.135767784E-01	0.	.510896555E+02
6	.107532213E+01	.100000000E+01	0.	.293643469E+05	.545904814E-03
.11933	.242451781E-03	.225160158E+01	.115271708E-01	0.	.596629748E+02
7	.107120393E+01	.100000000E+01	0.	.398056875E+05	.573920789E-03
.14447	.254687589E-03	.225343053E+01	.978657779E-02	0.	.701745867E+02
8	.107026842E+01	.100000000E+01	0.	.585502159E+05	.607673063E-03
.18403	.269677970E-03	.225332853E+01	.801021520E-02	0.	.857999502E+02
9	.107193059E+01	.100000000E+01	0.	.855753590E+05	.643726183E-03
.23424	.285831256E-03	.225211964E+01	.659327133E-02	0.	.104423150E+03
10	.108210711E+01	.100000000E+01	0.	.116493799E+06	.668363879E-03
.28442	.297362198E-03	.224764238E+01	.569106828E-02	0.	.121794440E+03
11	.109398827E+01	.100000000E+01	0.	.151235079E+06	.685533745E-03
.33459	.305651008E-03	.224286434E+01	.504839718E-02	0.	.138156250E+03
12	.111006651E+01	.100000000E+01	0.	.189721082E+06	.696828027E-03
.38475	.311507644E-03	.223695322E+01	.457742930E-02	0.	.153607036E+03
13	.113101975E+01	.100000000E+01	0.	.232500259E+06	.701337184E-03
.43490	.314562304E-03	.222956526E+01	.422397625E-02	0.	.168167411E+03
14	.112947271E+01	.100000000E+01	0.	.279827125E+06	.707710990E-03
.48506	.317117508E-03	.223169952E+01	.385968535E-02	0.	.182943409E+03
15	.114954193E+01	.100000000E+01	0.	.328809579E+06	.713366060E-03
.53522	.320536813E-03	.222553551E+01	.362478915E-02	0.	.196919485E+03
16	.154982239E+01	.100000000E+01	0.	.384100575E+06	.623939423E-03
.58407	.298612333E-03	.208946300E+01	.454832376E-02	0.	.196374967E+03
17	.183493499E+01	.100000000E+01	0.	.438529451E+06	.527248798E-03
.60912	.261063699E-03	.201961744E+01	.519548541E-02	0.	.187948860E+03

PROBLEM 5CP/4-23 6600 PROCEDURE VISCOUS FLOW ANALYSIS OF ARBITRARY MULTI-ELEMENT AIRFOILS DATE 6-06-72 PAGE 28

ANGLE OF ATTACK = 22.900

AIRFOIL PART 1, 33 DEFINING POINTS...

ITERATION 2...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
1.	- 1 -	-.05070	.04655	-.05216	.04614	15.30633
2.	- 2 -	-.05363	.04574	-.08152	.03792	15.66724
3.	- 3 -	-.10941	.03010	-.13853	.01789	22.73857
4.	- 4 -	-.16765	.00569	-.18129	-.00099	26.08942
5.	- 5 -	-.19493	-.00767	-.21426	-.01960	31.68246
6.	- 6 -	-.23359	-.03153	-.25172	-.04417	34.88598
7.	- 7 -	-.26984	-.05680	-.28721	-.07150	40.24031
8.	- 8 -	-.30458	-.08620	-.31959	-.10251	47.37385
9.	- 9 -	-.33460	-.11882	-.34676	-.13501	53.08954
10.	- 10 -	-.35892	-.15120	-.36694	-.16607	61.64987
11.	- 11 -	-.37496	-.18093	-.37953	-.19518	72.25218
12.	- 12 -	-.38409	-.20944	-.38502	-.22066	85.22196
13.	- 13 -	-.38596	-.23188	-.38442	-.24222	-81.49625
14.	- 14 -	-.38287	-.25256	-.37925	-.26143	-67.78553
15.	- 15 -	-.37562	-.27030	-.36963	-.27787	-51.63188
16.	- 16 -	-.36364	-.28544	-.35842	-.28931	-36.52730
17.	- 17 -	-.35320	-.29317	-.34620	-.29675	-27.02780
18.	- 18 -	-.33919	-.30032	-.33280	-.30155	-10.87061
19.	- 19 -	-.32640	-.30277	-.32053	-.30173	10.07634
20.	- 20 -	-.31465	-.30069	-.30966	-.29784	29.67374
21.	- 21 -	-.30466	-.29499	-.30029	-.29047	45.95258
22.	- 22 -	-.29591	-.28595	-.29390	-.27735	76.80401
23.	- 23 -	-.29188	-.26875	-.29084	-.24939	86.92176
24.	- 24 -	-.28980	-.23003	-.29566	-.21008	78.28641
25.	- 25 -	-.28153	-.19014	-.27244	-.16707	68.50649
26.	- 26 -	-.26336	-.14400	-.24910	-.12622	51.26936
27.	- 27 -	-.23485	-.10845	-.21701	-.08621	51.26138
28.	- 28 -	-.19917	-.06398	-.18838	-.05066	50.99444
29.	- 29 -	-.17760	-.03734	-.16851	-.02578	51.82882
30.	- 30 -	-.15942	-.01422	-.13150	.00073	28.17483
31.	- 31 -	-.10359	.01569	-.07811	.02794	25.69109
32.	- 32 -	-.05263	.04020	-.05129	.04085	25.63624
33.	- 33 -	-.04995	.04149	-.05068	.04655	15.30633
34.	- 34 -			-.04993	.04150	25.63624

ANGLE OF ATTACK = 22.900

AIRFOIL PART 2, 60 DEFINING POINTS...

ITERATION 2...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
35.	- 1 -	1.47194	.09286	1.47020	.09308	-7.32304
36.	- 2 -	1.46847	.09331	1.43544	.09726	-6.83239
37.	- 3 -	1.40242	.10122	1.36833	.10477	-5.94427
38.	- 4 -	1.33424	.10832	1.30083	.11131	-5.11888
39.	- 5 -	1.26742	.11430	1.23483	.11742	-5.45314
40.	- 6 -	1.20224	.12053	1.15222	.12434	-4.36359
41.	- 7 -	1.10220	.12816	1.05218	.13104	-3.29678
42.	- 8 -	1.00216	.13392	.95213	.13571	-2.04303
43.	- 9 -	.90211	.13749	.85206	.13793	-.49729
44.	- 10 -	.80202	.13836	.75197	.13726	1.26448
45.	- 11 -	.70193	.13615	.65188	.13367	2.84093
46.	- 12 -	.60183	.13118	.55176	.12742	4.29764
47.	- 13 -	.50169	.12366	.45162	.11849	5.89051
48.	- 14 -	.40155	.11333	.35145	.10648	7.78435
49.	- 15 -	.30134	.09963	.27629	.09546	9.45197
50.	- 16 -	.25124	.09129	.22617	.08652	10.77211
51.	- 17 -	.20109	.08175	.18103	.07743	12.14635
52.	- 18 -	.16096	.07311	.14090	.06802	14.22582
53.	- 19 -	.12084	.06294	.10075	.05675	17.11173
54.	- 20 -	.08065	.05056	.07060	.04695	19.76569
55.	- 21 -	.06054	.04334	.05048	.03914	22.68083
56.	- 22 -	.04043	.03493	.03287	.03099	27.52863
57.	- 23 -	.02532	.02706	.02025	.02366	33.84932
58.	- 24 -	.01519	.02026	.01139	.01683	42.13081
59.	- 25 -	.00758	.01339	.00503	.00983	54.32990
60.	- 26 -	.00248	.00628	.00121	.00315	67.79336
61.	- 27 -	-.00007	.00002	-.00017	-.00160	86.63240
62.	- 28 -	-.00026	-.00322	-.00005	-.00488	-82.72434
63.	- 29 -	.00016	-.00654	.00119	-.00932	-69.65080
64.	- 30 -	.00222	-.01209	.00467	-.01520	-51.68021
65.	- 31 -	.00712	-.01830	.01082	-.02107	-36.92653
66.	- 32 -	.01451	-.02385	.01947	-.02647	-27.90882
67.	- 33 -	.02443	-.02910	.03189	-.03193	-20.80176
68.	- 34 -	.03935	-.03477	.04929	-.03767	-16.24229
69.	- 35 -	.05924	-.04056	.06921	-.04292	-13.28547
70.	- 36 -	.07919	-.04527	.09913	-.04880	-10.03560
71.	- 37 -	.11906	-.05233	.13901	-.05526	-8.35099
72.	- 38 -	.15897	-.05819	.17894	-.06062	-6.93872
73.	- 39 -	.19891	-.06305	.22387	-.06561	-5.85798
74.	- 40 -	.24883	-.06817	.27381	-.07022	-4.68688
75.	- 41 -	.29879	-.07227	.34877	-.07557	-3.78062
76.	- 42 -	.39874	-.07887	.44871	-.08143	-2.93191
77.	- 43 -	.49867	-.08399	.54867	-.08556	-1.79680
78.	- 44 -	.59866	-.08713	.64867	-.08785	-.83021
79.	- 45 -	.69868	-.08858	.74871	-.08826	.35729
80.	- 46 -	.79874	-.08795	.84878	-.08645	1.72464
81.	- 47 -	.89882	-.08494	.94887	-.08236	2.94556
82.	- 48 -	.99893	-.07979	1.04898	-.07639	3.88653
83.	- 49 -	1.09903	-.07299	1.14909	-.06893	4.62799
84.	- 50 -	1.19915	-.06488	1.21961	-.06352	3.81891
85.	- 51 -	1.24007	-.06215	1.24523	-.05876	33.37991
86.	- 52 -	1.25038	-.05536	1.25876	-.04095	59.80602

87.	- 53 -	1.26715	-.02653	1.29382	.10222	59.90119
88.	- 54 -	1.30048	.03097	1.30880	.14532	59.89895
89.	- 55 -	1.31712	.05967	1.32538	.16810	45.59625
90.	- 56 -	1.33364	.07653	1.34184	.17886	15.86027
91.	- 57 -	1.35004	.08119	1.37502	.18119	-.00162
92.	- 58 -	1.40000	.08119	1.43357	.18119	-.00000
93.	- 59 -	1.46714	.08119	1.46890	.18119	.00000
94.	- 60 -	1.47067	.08119	1.47196	.19286	-7.32304
95.	- 61 -			1.47069	.18119	.00000

ANGLE OF ATTACK = 22.900

AIRFOIL PART 3, 44 DEFINING POINTS...

ITERATION 2...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
96.	- 1 -	1.94360	-.20198	1.94262	-.20118	-39.19410
97.	- 2 -	1.94164	-.20038	1.92204	-.18440	-39.19410
98.	- 3 -	1.90244	-.16842	1.88255	-.15286	-38.01941
99.	- 4 -	1.86265	-.13731	1.84233	-.12225	-36.54475
100.	- 5 -	1.82200	-.10718	1.81155	-.09938	-36.75564
101.	- 6 -	1.80110	-.09157	1.79133	-.08422	-36.95114
102.	- 7 -	1.78155	-.07687	1.76486	-.06418	-37.24144
103.	- 8 -	1.74818	-.05149	1.72340	-.03303	-36.70439
104.	- 9 -	1.69863	-.01456	1.68939	-.00844	-33.53091
105.	- 10 -	1.68015	-.00231	1.66247	.00720	-28.28544
106.	- 11 -	1.64479	.01671	1.62567	.02363	-19.88477
107.	- 12 -	1.60655	.03055	1.59088	.03343	-10.43579
108.	- 13 -	1.57521	.03632	1.55922	.03622	.34974
109.	- 14 -	1.54322	.03612	1.52907	.03262	13.89499
110.	- 15 -	1.51491	.02512	1.50461	.02345	28.82902
111.	- 16 -	1.49432	.01778	1.49018	.01438	39.48535
112.	- 17 -	1.48605	.01097	1.48264	.00715	48.29149
113.	- 18 -	1.47924	.00333	1.47790	.00116	58.34730
114.	- 19 -	1.47656	-.00102	1.47545	-.00328	63.91852
115.	- 20 -	1.47434	-.00554	1.47341	-.01075	79.87420
116.	- 21 -	1.47248	-.01596	1.47331	-.02223	-82.51941
117.	- 22 -	1.47413	-.02850	1.47897	-.03597	-57.08996
118.	- 23 -	1.48381	-.04345	1.48835	-.04672	-35.74007
119.	- 24 -	1.49289	-.04999	1.49841	-.05252	-24.67184
120.	- 25 -	1.50393	-.05506	1.51155	-.05854	-24.55047
121.	- 26 -	1.51917	-.06202	1.52680	-.06545	-24.17625
122.	- 27 -	1.53444	-.06887	1.54185	-.07212	-23.66319
123.	- 28 -	1.54927	-.07537	1.55718	-.07918	-25.69406
124.	- 29 -	1.56510	-.08299	1.57995	-.08978	-24.56423
125.	- 30 -	1.59480	-.09656	1.60965	-.10334	-24.51572
126.	- 31 -	1.62451	-.11011	1.63249	-.11387	-25.19723
127.	- 32 -	1.64047	-.11762	1.65022	-.12207	-24.49945
128.	- 33 -	1.65997	-.12651	1.67302	-.13266	-25.24492
129.	- 34 -	1.68607	-.13881	1.70881	-.14951	-25.19523
130.	- 35 -	1.73155	-.16021	1.75417	-.17103	-25.56321
131.	- 36 -	1.77679	-.18185	1.79937	-.19283	-25.92362
132.	- 37 -	1.82194	-.20380	1.84447	-.21479	-26.01208
133.	- 38 -	1.86699	-.22578	1.88952	-.23683	-26.11371
134.	- 39 -	1.91206	-.24788	1.93454	-.25893	-26.18454
135.	- 40 -	1.95703	-.26999	1.97957	-.28104	-26.11233
136.	- 41 -	2.00211	-.29209	2.02464	-.30305	-25.94647
137.	- 42 -	2.04717	-.31401	2.06816	-.32522	-28.09864
138.	- 43 -	2.08915	-.33642	2.09025	-.33701	-28.04038
139.	- 44 -	2.09136	-.33760	1.94362	-.20197	22.90000
140.	- 45 -			2.09138	-.33761	-28.04038

GAMMA DISTRIBUTION FOR ALPHA = 22.9000

INDEX	-1-
1.	-.11788
2.	-.59534
3.	-2.06222
4.	-2.34242
5.	-2.64309
6.	-2.70423
7.	-2.88973
8.	-3.04901
9.	-3.08935
10.	-3.30611
11.	-3.48001
12.	-3.63368
13.	-3.60744
14.	-3.42739
15.	-3.18028
16.	-2.74822
17.	-2.28241
18.	-1.99610
19.	-1.65160
20.	-1.15829
21.	-.70875
22.	-.36193
23.	-.03018
24.	.02651
25.	.01622
26.	.01085
27.	.10384
28.	.14415
29.	.13370
30.	-.11534
31.	.14074
32.	.07177
33.	.00646
34.	-.04843
35.	-.25115
36.	-.83183
37.	-1.15955
38.	-1.45558
39.	-1.56358
40.	-1.63242
41.	-1.63328
42.	-1.75529
43.	-1.81433
44.	-1.86286
45.	-1.91710
46.	-2.00831
47.	-2.12511
48.	-2.23213
49.	-2.29709
50.	-2.37424
51.	-2.46610
52.	-2.55176
53.	-2.66490
54.	-2.75629
55.	-2.89843
56.	-3.04483

57.	-3.18792
58.	-3.34910
59.	-3.38703
60.	-3.61856
61.	-3.29860
62.	-2.93709
63.	-2.52106
64.	-1.88116
65.	-1.35771
66.	-1.00757
67.	-.71935
68.	-.52217
69.	-.40120
70.	-.25135
71.	-.16240
72.	-.09511
73.	-.02939
74.	.02510
75.	.11362
76.	.13963
77.	.15931
78.	.21566
79.	.26221
80.	.30103
81.	.33653
82.	.37992
83.	.48510
84.	.89776
85.	.87779
86.	.48176
87.	.25004
88.	-.03020
89.	-.37694
90.	-.38171
91.	-.19231
92.	-.06909
93.	-.01548
94.	1.47603
95.	.21534
96.	-.29083
97.	-.49891
98.	-.63292
99.	-.71588
100.	-.79681
101.	-.96393
102.	-1.32949
103.	-1.50490
104.	-1.74832
105.	-1.99937
106.	-2.18511
107.	-2.21504
108.	-2.03016
109.	-1.75409
110.	-1.65710
111.	-1.59564
112.	-1.49342
113.	-1.49129
114.	-1.18507
115.	-.88574
116.	-.47731
117.	-.26985
118.	-.13724
119.	-.07151
120.	-.06237
121.	-.11034
122.	-.16916

123.	-.23039
124.	-.22322
125.	-.20299
126.	-.20429
127.	-.19029
128.	-.19678
129.	-.21626
130.	-.24794
131.	-.30946
132.	-.38031
133.	-.37136
134.	-.32218
135.	-.28055
136.	-.07145
137.	-.01561

SOURCE STRENGTHS FOR ALPHA = 22.9000

INDEX	-1-
1.	.00394
2.	.01567
3.	.04858

INCOMPRESSIBLE PRESSURE DISTRIBUTION

ALPHA = 22.9000 DEGREES

NO.	XBP	YBP	X/CREF	Y/CREF	XTR/CR	YTR/CR	CP-INNER	CP
1	-.0522	.0461	-.0261	.0231	.9998	.0067	-1.4972	-2.7515
2	-.0815	.0379	-.0408	.0190	.9405	.0386	.1506	-4.0644
3	-.1385	.0179	-.0693	.0089	.8191	.0941	.8139	-5.9262
4	-.1813	-.0010	-.0906	-.0005	.7221	.1296	.9075	-6.8227
5	-.2143	-.0196	-.1071	-.0098	.6411	.1506	.9678	-7.1400
6	-.2517	-.0442	-.1259	-.0221	.5439	.1689	.9833	-7.5632
7	-.2872	-.0715	-.1436	-.0358	.4455	.1798	.9928	-8.3272
8	-.3196	-.1025	-.1598	-.0512	.3465	.1801	.9956	-8.8325
9	-.3468	-.1350	-.1734	-.0675	.2534	.1700	.9981	-9.5068
10	-.3669	-.1661	-.1835	-.0830	.1737	.1515	.9998	-10.6191
11	-.3795	-.1952	-.1898	-.0976	.1091	.1245	.9994	-11.4787
12	-.3850	-.2207	-.1925	-.1103	.0613	.0923	.9988	-11.8626
13	-.3844	-.2422	-.1922	-.1211	.0292	.0571	.9967	-10.9697
14	-.3792	-.2614	-.1896	-.1307	.0080	.0186	.9954	-9.4721
15	-.3696	-.2779	-.1848	-.1389	-.0019	-.0223	.9919	-7.2618
16	-.3584	-.2893	-.1792	-.1447	-.0016	-.0577	.9991	-5.1737
17	-.3462	-.2967	-.1731	-.1484	.0064	-.0882	.9977	-3.3732
18	-.3328	-.3015	-.1664	-.1508	.0204	-.1164	.9974	-2.1446
19	-.3205	-.3017	-.1603	-.1509	.0396	-.1355	.9978	-.8432
20	-.3097	-.2978	-.1548	-.1489	.0629	-.1460	.9991	.1821
21	-.3003	-.2905	-.1501	-.1452	.0891	-.1486	.9998	.7279
22	-.2939	-.2774	-.1469	-.1387	.1194	-.1375	.9992	.9717
23	-.2908	-.2494	-.1454	-.1247	.1671	-.0977	.9983	.9984
24	-.2857	-.2101	-.1428	-.1050	.2356	-.0431	.9910	.9865
25	-.2724	-.1671	-.1362	-.0835	.3225	.0051	.9836	.9799
26	-.2491	-.1262	-.1246	-.0631	.4223	.0343	.9813	.9623
27	-.2170	-.0862	-.1085	-.0431	.5347	.0488	.9757	.9217
28	-.1884	-.0507	-.0942	-.0253	.6347	.0615	.9571	.8802
29	-.1685	-.0258	-.0843	-.0129	.7045	.0706	.8926	.8865
30	-.1315	.0007	-.0658	.0004	.8040	.0551	.7826	.7706
31	-.0781	.0279	-.0391	.0140	.9307	.0175	.1768	-.0273
32	-.0513	.0408	-.0256	.0204	.9931	-.0030	-1.3040	-1.4242
35	1.4702	.0931	.7351	.0465	1.0001	.0069	-.6619	-1.0705
36	1.4354	.0973	.7177	.0486	.9767	.0110	.0521	-1.2954
37	1.3683	.1048	.6842	.0524	.9315	.0187	.6188	-1.6021
38	1.3008	.1113	.6504	.0557	.8860	.0257	.9198	-1.5305
39	1.2348	.1174	.6174	.0587	.8415	.0323	.9834	-1.6840
40	1.1522	.1243	.5761	.0622	.7857	.0402	.9928	-1.8317
41	1.0522	.1310	.5261	.0655	.7182	.0486	.9950	-2.0053
42	.9521	.1357	.4761	.0679	.6506	.0556	.9958	-2.1999
43	.8521	.1379	.4260	.0690	.5828	.0609	.9963	-2.4068
44	.7520	.1373	.3760	.0686	.5149	.0643	.9964	-2.6042
45	.6519	.1337	.3259	.0668	.4470	.0657	.9965	-2.8001
46	.5518	.1274	.2759	.0637	.3789	.0653	.9978	-3.0405
47	.4516	.1185	.2258	.0592	.3106	.0630	.9998	-3.3251
48	.3514	.1065	.1757	.0532	.2423	.0587	.9999	-3.7064
49	.2763	.0955	.1381	.0477	.1909	.0541	1.0000	-4.1111
50	.2262	.0865	.1131	.0433	.1566	.0500	.9999	-4.4201
51	.1810	.0774	.0905	.0387	.1257	.0456	.9999	-4.8177
52	.1409	.0680	.0705	.0340	.0981	.0407	.9998	-5.2519
53	.1007	.0568	.0504	.0284	.0705	.0346	.9996	-5.7207
54	.0706	.0470	.0353	.0235	.0496	.0291	.9990	-6.3009

55	.0505	.0391	.0252	.0196	.0357	.1246	.9994	-6.8536
56	.0329	.0310	.0164	.0155	.0235	.1198	.9988	-7.6248
57	.0203	.0237	.0101	.0118	.0146	.1153	.9985	-8.4693
58	.0114	.0168	.0057	.0084	.0084	.1110	.9962	-9.2859
59	.0050	.0098	.0025	.0049	.0038	.1065	.9936	-9.8100
60	.0012	.0071	.0006	.0016	.0009	.1021	.9865	-10.4697
61	-.0002	-.0016	-.0001	-.0008	-.0002	-.1011	.9996	-10.8179
62	-.0001	-.0049	-.0000	-.0024	-.0002	-.1032	.9999	-8.8355
63	.0012	-.0093	.0006	-.0047	.0005	-.1064	.9953	-6.2393
64	.0047	-.0152	.0023	-.0076	.0026	-.1105	.9946	-3.5269
65	.0108	-.0211	.0054	-.0105	.0065	-.1147	.9983	-1.4915
66	.0195	-.0265	.0097	-.0132	.0122	-.1187	.9996	-.3541
67	.0319	-.0319	.0159	-.0160	.0204	-.1229	.9998	.2787
68	.0493	-.0377	.0246	-.0198	.0320	-.1274	1.0000	.6227
69	.0692	-.0429	.0346	-.0215	.0453	-.1317	1.0000	.7869
70	.0991	-.0488	.0496	-.0244	.0653	-.1369	1.0000	.8957
71	.1390	-.0553	.0695	-.0276	.0921	-.1428	1.0000	.9570
72	.1789	-.0606	.0895	-.0303	.1190	-.1479	1.0000	.9831
73	.2239	-.0656	.1119	-.0328	.1492	-.1530	1.0000	.9959
74	.2738	-.0702	.1369	-.0351	.1829	-.1581	1.0000	1.0000
75	.3489	-.0756	.1744	-.0378	.2335	-.1646	1.0000	.9957
76	.4487	-.0814	.2244	-.0407	.3010	-.0724	.9999	.9815
77	.5487	-.0856	.2743	-.0428	.3686	-.0790	.9965	.9564
78	.6487	-.0879	.3243	-.0439	.4363	-.0844	.9951	.9337
79	.7487	-.0883	.3744	-.0441	.5041	-.0885	.9955	.9065
80	.8488	-.0864	.4244	-.0432	.5720	-.0911	.9956	.8788
81	.9489	-.0824	.4744	-.0412	.6400	-.0921	.9954	.8503
82	1.0490	-.0764	.5245	-.0382	.7081	-.0919	.9950	.8163
83	1.1491	-.0689	.5745	-.0345	.7762	-.0907	.9958	.7523
84	1.2195	-.0635	.6098	-.0318	.8242	-.0897	1.0000	.5129
85	1.2452	-.0588	.6226	-.0294	.8418	-.0875	.9976	.1216
86	1.2588	-.0409	.6294	-.0205	.8516	-.0759	.9997	.5134
87	1.2878	.0022	.6419	.0011	.8703	-.0476	.9888	.7777
88	1.3088	.0453	.6544	.0227	.8888	-.0193	.9535	.8941
89	1.3254	.0681	.6627	.0341	.9010	-.0045	.8282	.9559
90	1.3418	.0789	.6709	.0394	.9125	.0021	.6422	.9521
91	1.3750	.0812	.6875	.0406	.9351	.0024	.5419	.8481
92	1.4335	.0812	.7168	.0406	.9748	.0002	.0905	.3227
93	1.4689	.0812	.7345	.0406	.9987	-.0012	-.5637	-.4597

96	1.9426	-.2012	.9713	-.1006	.7174	.0586	-.6043	.8228
97	1.9220	-.1844	.9610	-.0922	.6798	.0647	.3164	.2525
98	1.8825	-.1529	.9413	-.0764	.6081	.0755	.5698	-.1041
99	1.8423	-.1222	.9212	-.0611	.5362	.0847	.6614	-.3175
100	1.8116	-.0994	.9058	-.0497	.4816	.0911	.7090	-.4734
101	1.7913	-.0842	.8957	-.0421	.4456	.0954	.7389	-.6062
102	1.7649	-.0642	.8824	-.0321	.3984	.1013	.7752	-.8348
103	1.7234	-.0330	.8617	-.0165	.3245	.1103	.8379	-1.4003
104	1.6894	-.0084	.8447	-.0042	.2646	.1164	.8660	-2.1799
105	1.6625	.0072	.8312	.0036	.2200	.1165	.9043	-2.7479
106	1.6257	.0236	.8128	.0118	.1625	.1105	.9447	-3.4478
107	1.5909	.0334	.7954	.0167	.1122	.0978	.9837	-3.9272
108	1.5592	.0362	.7796	.0181	.0709	.0785	.9998	-3.9068
109	1.5291	.0326	.7645	.0163	.0360	.0524	.9985	-3.3412
110	1.5046	.0235	.7523	.0117	.0122	.0235	.9976	-2.3966
111	1.4902	.0144	.7451	.0072	.0008	.0019	.9999	-1.8827
112	1.4825	.0071	.7413	.0036	-.0034	-.0125	.9993	-1.5577
113	1.4779	.0012	.7389	.0006	-.0050	-.0234	1.0000	-1.3974
114	1.4754	-.0033	.7377	-.0016	-.0048	-.0306	1.0000	-1.2397
115	1.4734	-.0107	.7367	-.0054	-.0020	-.0414	.9981	-.6769
116	1.4733	-.0222	.7367	-.0111	.0061	-.0557	.9990	-.0074
117	1.4790	-.0360	.7395	-.0180	.0230	-.0687	.9978	.5973
118	1.4883	-.0467	.7442	-.0234	.0423	-.0753	.9997	.8721
119	1.4984	-.0525	.7492	-.0263	.0590	-.0753	.9997	.9650
120	1.5116	-.0585	.7558	-.0293	.0796	-.0734	.9993	.9940

121	1.5268	-.0654	.7634	-.0327	.1035	-.3710	.9962	1.0000
122	1.5419	-.0721	.7709	-.0361	.1270	-.1585	.9832	.9981
123	1.5572	-.0792	.7786	-.0396	.1511	-.1663	.9502	.9930
124	1.5799	-.0898	.7900	-.0449	.1870	-.1631	.8877	.9817
125	1.6097	-.1033	.8048	-.0517	.2336	-.1587	.8372	.9688
126	1.6325	-.1139	.8162	-.0569	.2696	-.1554	.8239	.9573
127	1.6502	-.1221	.8251	-.0610	.2975	-.1528	.8148	.9486
128	1.6730	-.1327	.8365	-.0663	.3334	-.1496	.8005	.9378
129	1.7088	-.1495	.8544	-.0748	.3899	-.1449	.7729	.9199
130	1.7542	-.1710	.8771	-.0855	.4617	-.1391	.7220	.8972
131	1.7994	-.1928	.8997	-.0964	.5335	-.1338	.6533	.8727
132	1.8445	-.2148	.9222	-.1074	.6053	-.1287	.5513	.8470
133	1.8895	-.2368	.9448	-.1184	.6770	-.1238	.4028	.8169
134	1.9345	-.2589	.9673	-.1295	.7488	-.1189	.2929	.7837
135	1.9796	-.2810	.9898	-.1405	.8206	-.1141	.2803	.7484
136	2.0245	-.3030	1.0123	-.1515	.8924	-.1091	.2969	.7115
137	2.0682	-.3252	1.0341	-.1626	.9623	-.1054	.3919	.6354
138	2.0903	-.3370	1.0451	-.1685	.9982	-.1043	.4903	.5506

MAX. CP DIFFERENCE AFTER ITERATION 2 IS 1.248 AND R.M.S. DEVIATION IS .408685

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 2 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 1 ... STAGNATION POINT = (-.29099 , -.24937)

UPPER SURFACE

NO.	XPP	YPP	LENGTH	CP
1	-.29099	-.24937	0.0000	1.0000
2	-.29400	-.27732	.0281	.9717
3	-.30037	-.29041	.0427	.7279
4	-.30970	-.29776	.0545	.1821
5	-.32054	-.30164	.0651	-.8432
6	-.33278	-.30145	.0733	-2.1446
7	-.34615	-.29665	.0925	-3.3732
8	-.35835	-.28922	.1058	-5.1737
9	-.36954	-.27780	.1228	-7.2618
10	-.37913	-.26138	.1418	-9.4721
11	-.38427	-.24220	.1617	-10.9697
12	-.38484	-.22068	.1832	-11.8526
13	-.37930	-.19526	.2092	-11.4787
14	-.36668	-.16621	.2409	-10.6191
15	-.34644	-.13525	.2779	-9.5068
16	-.31919	-.10289	.3232	-8.8326
17	-.28674	-.07206	.3649	-8.3272
18	-.25119	-.04492	.4096	-7.5632
19	-.21369	-.02056	.4544	-7.1400
20	-.18070	-.00221	.4921	-6.8227
21	-.13787	.01613	.5397	-5.9362
22	-.08081	.03557	.5990	-4.0644
23	-.05147	.04360	.6294	-2.7515

LOWER SURFACE

NO.	XRF	YRF	LENGTH	CP
1	-.29099	-.24937	0.0000	1.0000
2	-.28600	-.21000	.0337	.9865
3	-.27292	-.16686	.0848	.9799
4	-.24954	-.12593	.1319	.9623
5	-.21740	-.08590	.1832	.9217
6	-.18879	-.05033	.2239	.8802
7	-.16886	-.02541	.2638	.8865
8	-.13170	.00104	.3054	.7706
9	-.07819	.02811	.3554	-.0273
10	-.05134	.04096	.3951	-1.4242

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 23 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .1021066E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GFW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.201197854E+01	.100000000E+01	0.	.605538827E+04	.161601722E-03
.02811	.779552861E-04	.207300531E+01	.515579700E-01	0.	.167919778E+02
3	.162155241E+01	.100000000E+01	0.	.284913973E+05	.972737902E-04
.04267	.429800717E-04	.226323006E+01	.235604100E-01	0.	.286989384E+02
4	.146831595E+01	.100000000E+01	0.	.631417323E+05	.916962838E-04
.05455	.404230090E-04	.226841806E+01	.145693400E-01	0.	.467926273E+02
5	.133660427E+01	.100000000E+01	0.	.114797895E+05	.913131749E-04
.06606	.405233368E-04	.225334787E+01	.982936767E-02	0.	.704206588E+02
6	.119309885E+01	.100000000E+01	0.	.177729573E+05	.994545329E-04
.07830	.439287197E-04	.226399798E+01	.680323346E-02	0.	.997098113E+02
7	.115728194E+01	.100000000E+01	0.	.247620309E+05	.110505565E-03
.09251	.490507392E-04	.225288278E+01	.526458123E-02	0.	.131297631E+03
8	.117393465E+01	.100000000E+01	0.	.339639984E+05	.111740838E-03
.10679	.500498044E-04	.223259289E+01	.446136512E-02	0.	.159178539E+03
9	.113328292E+01	.100000000E+01	0.	.451725882E+05	.116288916E-03
.12278	.518693297E-04	.224195911E+01	.364518869E-02	0.	.190834962E+03
10	.103896022E+01	.100000000E+01	0.	.587340137E+05	.127611576E-03
.14180	.560195041E-04	.227798475E+01	.283992901E-02	0.	.232042129E+03
11	.918985110E+00	.100000000E+01	0.	.715868374E+05	.147025013E-03
.16165	.630689991E-04	.233117721E+01	.218815109E-02	0.	.279297834E+03
12	.744506440E+00	.100000000E+01	0.	.840914910E+05	.178702669E-03
.18318	.736663123E-04	.242583975E+01	.156981878E-02	0.	.338176629E+03
13	.476014974E+00	.100000000E+01	0.	.945909376E+05	.247766382E-03
.20920	.940599349E-04	.263413304E+01	.892922795E-03	0.	.425304504E+03
14	.196964539E+01	.100000000E+01	0.	.105053676E+07	.277759588E-03
.24087	.166874337E-03	.166448354E+01	.330790417E-02	0.	.725089614E+03
15	.245116851E+01	.100000000E+01	0.	.115283932E+07	.392067965E-03
.27786	.260647323E-03	.150420868E+01	.372391764E-02	0.	.108143134E+04
16	.251575446E+01	.100000000E+01	0.	.128502959E+07	.542270113E-03
.32016	.368258165E-03	.147252706E+01	.349010418E-02	0.	.147806625E+04
17	.249781249E+01	.100000000E+01	0.	.142655430E+07	.713618907E-03
.36492	.498103647E-03	.146202330E+01	.320272854E-02	0.	.190808737E+04
18	.248822528E+01	.100000000E+01	0.	.153440260E+07	.913289680E-03

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 .40965     .627175999E-03     .145628649E+01      .298717490E-02     0.                        .234903115E+04

  19        .253807942E+01     .100000000E+01     0.                         .165931530E+07      .109321118E-02
 .45437     .755600887E-03     .144681035E+01      .288020725E-02     0.                        .275940013E+04

  20        .249269832E+01     .100000000E+01     0.                         .176179980E+07      .128154073E-02
 .49212     .884052556E-03     .144962051E+01      .271203508E-02     0.                        .316494636E+04

  21        .207110209E+01     .100000000E+01     0.                         .181603183E+07      .179161618E-02
 .53871     .119480902E-02     .149950004E+01      .215255002E-02     0.                        .402780299E+04

                                          FLOW SEPARATION INDICATED

                                       FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR FLOW BUBBLE EXISTS

TRANSITION IS CALCULATED TO OCCUR AT INDEX  13  XBP =   -.37930  YBP =   -.19526  LENGTH =   .2092


*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  10 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .102106FF+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000F-03 ...
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*** CALCULATED STATION DATA ***

N S	FPPW THETA	CW H	CFW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.103103545E+01	.100000000E+01	0.	.591124996E+04	.379933373E-03
.03968	.166921112E-03	.227612535E+01	.267058194E-01	0.	.248636289E+02
3	.101593831E+01	.100000000E+01	0.	.153805647E+05	.605234687E-03
.08476	.266711537E-03	.226924824E+01	.140694344E-01	0.	.483950668E+02
4	.125556433E+01	.100000000E+01	0.	.327598491E+05	.552216295E-03
.13190	.254997543E-03	.216557496E+01	.123839577E-01	0.	.633328552E+02
5	.129510324E+01	.100000000E+01	0.	.656184382E+05	.475974325E-03
.18324	.218769738E-03	.217568632E+01	.963637094E-02	0.	.783428806E+02
6	.926227227E+00	.100000000E+01	0.	.101387593E+06	.558342913E-03
.22889	.239472561E-03	.233155277E+01	.561561320E-02	0.	.106077321E+03
7	.116851855E+01	.100000000E+01	0.	.112478496E+06	.600201999E-03
.26079	.270061713E-03	.222246238E+01	.632059053E-02	0.	.116475238E+03
8	.202631637E+01	.100000000E+01	0.	.187834083E+06	.352037352E-03
.30641	.178057531E-03	.197709892E+01	.943882024E-02	0.	.109153122E+03
9	.224699135E+01	.100000000E+01	0.	.475310391E+06	.156803506E-03
.36637	.729530699E-04	.214937502E+01	.821990943E-02	0.	.946454317E+02
10	.203318336E+01	.100000000E+01	0.	.789486419E+06	.123789382E-03
.39614	.555287177E-04	.222928579E+01	.645501488E-02	0.	.110666511E+03

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 2 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 2 ... STAGNATION POINT = (.27385 , -.06971)

UPPER SURFACE

NO.	XBP	YBP	LENGTH	CP
1	.27385	-.06971	0.0000	1.0000
2	.22392	-.06510	.0501	.9959
3	.17859	-.06019	.0953	.9831
4	.13907	-.05488	.1356	.9570
5	.09918	-.04849	.1750	.8957
6	.06927	-.04267	.2055	.7869
7	.04935	-.03747	.2271	.6227
8	.03194	-.03179	.2434	.2783
9	.01952	-.02637	.2539	-.3541
10	.01087	-.02100	.2631	-1.4915
11	.00473	-.01515	.2776	-3.5269
12	.00125	-.00929	.2844	-6.2393
13	.00001	-.00487	.2880	-8.8355
14	-.00010	-.00161	.2923	-10.8179
15	.00129	.00311	.2972	-10.4697
16	.00514	.00975	.3049	-9.8100
17	.01150	.01570	.3143	-9.2859
18	.02036	.02350	.3234	-8.4693
19	.03298	.03078	.3410	-7.6249
20	.05061	.03883	.3534	-6.8536
21	.07074	.04654	.3810	-6.3009
22	.10091	.05619	.4136	-5.7203
23	.14109	.06727	.4543	-5.2519
24	.18123	.07648	.4955	-4.8177
25	.22638	.08535	.5415	-4.4201
26	.27651	.09405	.5924	-4.1111
27	.35167	.10471	.6683	-3.7064
28	.45184	.11625	.7631	-3.3251
29	.55195	.12471	.8636	-3.0405
30	.65202	.13049	.9638	-2.8001
31	.75203	.13359	1.0699	-2.6042
32	.85200	.13371	1.1539	-2.4068
33	.95193	.13086	1.2638	-2.1999
34	1.05182	.12549	1.3639	-2.0053
35	1.15169	.11801	1.4730	-1.8317
36	1.23414	.11039	1.5528	-1.6840
37	1.30000	.10358	1.6130	-1.5305
38	1.36729	.09604	1.6857	-1.6021
39	1.43423	.08768	1.7542	-1.2954
40	1.46893	.08322	1.7832	-1.0705

LOWER SURFACE

NO.	XBF	YBF	LENGTH	CP
1	.27385	-.06971	0.0000	1.0000
2	.34879	-.07520	.0751	.9957
3	.44873	-.08096	.1752	.9815
4	.54869	-.08486	.2753	.9564
5	.64868	-.08708	.3753	.9337
6	.74870	-.08745	.4753	.9065
7	.84875	-.08560	.5754	.8788
8	.94883	-.08151	.6755	.8503
9	1.04893	-.07561	.7758	.8163
10	1.14905	-.06839	.8752	.7523
11	1.21556	-.06312	.9459	.5129
12	1.24500	-.05841	.9728	.1216
13	1.25833	-.04066	.9950	.5134
14	1.28333	.00250	1.0449	.7777
15	1.30833	.04563	1.0947	.8941
16	1.32500	.06850	1.1230	.9555
17	1.34166	.07937	1.1429	.9521
18	1.37500	.08175	1.1753	.8481
19	1.43357	.08175	1.2349	.3227
20	1.46890	.08175	1.2702	-.4597

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 40 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .1021066E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	EPPW THETA	GW H	GEW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.127616679E+01	.100000000E+01	0.	.408568973E+04	.499907000E-03
.05014	.226791210E-03	.220426091E+01	.396205122E-01	0.	.184793532E+02
3	.133886540E+01	.100000000E+01	0.	.158530781E+05	.453151305E-03
.09534	.206664280E-03	.219269293E+01	.216142451E-01	0.	.343640646E+02
4	.143015090E+01	.100000000E+01	0.	.360103483E+05	.394260249E-03
.13561	.181276292E-03	.217491347E+01	.158082832E-01	0.	.491362133E+02
5	.155811145E+01	.100000000E+01	0.	.727422354E+05	.320936398E-03
.17601	.149031682E-03	.215347767E+01	.127048156E-01	0.	.615924986E+02
6	.169770313E+01	.100000000E+01	0.	.122002085E+06	.257185718E-03
.20648	.120524368E-03	.213388979E+01	.112705900E-01	0.	.712134456E+02
7	.185562177E+01	.100000000E+01	0.	.178539699E+06	.206188992E-03
.22707	.975743128E-04	.211314829E+01	.107533387E-01	0.	.767208364E+02
8	.204800325E+01	.100000000E+01	0.	.266830479E+06	.155359899E-03
.24538	.741377644E-04	.209555684E+01	.104571574E-01	0.	.806181475E+02
9	.220489640E+01	.100000000E+01	0.	.385681496E+06	.116995283E-03
.25893	.559733682E-04	.209019551E+01	.101611281E-01	0.	.833725734E+02
10	.227354026E+01	.100000000E+01	0.	.543723166E+06	.903755510E-04
.26911	.430611029E-04	.209877465E+01	.960574631E-02	0.	.870014559E+02
11	.219404139E+01	.100000000E+01	0.	.755996007E+06	.735931303E-04
.27759	.346319394E-04	.212500748E+01	.853527400E-02	0.	.943159169E+02
12	.208172208E+01	.100000000E+01	0.	.979499894E+06	.649306836E-04
.28441	.302535355E-04	.214621804E+01	.752225805E-02	0.	.104192229E+03
13	.194576876E+01	.100000000E+01	0.	.116013402E+07	.615969775E-04
.28900	.284103202E-04	.216811979E+01	.666822733E-02	0.	.114047337E+03
14	.157759143E+01	.100000000E+01	0.	.128603627E+07	.655676598E-04
.29226	.292081330E-04	.224826626E+01	.520095950E-02	0.	.128523811E+03
15	.880055871E+00	.100000000E+01	0.	.128827867E+07	.957381148E-04
.29718	.386599385E-04	.247641664E+01	.274545196E-02	0.	.167589504E+03
16	.569110170E+00	.100000000E+01	0.	.128298573E+07	.134434805E-03
.30486	.499479992E-04	.269149529E+01	.164875598E-02	0.	.210204269E+03
17	.386553898E+00	.100000000E+01	0.	.129016809E+07	.179211316E-03
.31428	.623796412E-04	.287291354E+01	.103784006E-02	0.	.256078588E+03
18	.139590126E+01	.100000000E+01	0.	.128198635E+07	.183747624E-03

.32545	.985579956E-04	.186436039E+01	.347688347E-02	0.	.388203703E+03
19	.184974369E+01	.100000000E+01	0.	.127816260E+07	.235433559E-03
.34002	.144947482E-03	.162426802E+01	.425228457E-02	0.	.544873567E+03
20	.188529813E+01	.100000000E+01	0.	.128920027E+07	.329901907E-03
.35940	.210257533E-03	.156903727E+01	.397615649E-02	0.	.754216494E+03
21	.186324623E+01	.100000000E+01	0.	.131756291E+07	.435880128E-03
.38095	.281654075E-03	.154757260E+01	.363468686E-02	0.	.974124823E+03
22	.188863522E+01	.100000000E+01	0.	.136919562E+07	.584845034E-03
.41263	.383762032E-03	.152397836E+01	.335732393E-02	0.	.127340563E+04
23	.195446430E+01	.100000000E+01	0.	.145400936E+07	.769787044E-03
.45431	.512877907E-03	.150091675E+01	.315245320E-02	0.	.164145592E+04
24	.200552195E+01	.100000000E+01	0.	.152975857E+07	.963339504E-03
.49549	.648103487E-03	.148639766E+01	.299259744E-02	0.	.200092118E+04
25	.206731542E+01	.100000000E+01	0.	.161368410E+07	.118136458E-02
.54151	.801376062E-03	.147417004E+01	.286986033E-02	0.	.238809619E+04
26	.213658036E+01	.100000000E+01	0.	.171423863E+07	.141453768E-02
.59239	.966709897E-03	.146325092E+01	.277308826E-02	0.	.279745352E+04
27	.221527895E+01	.100000000E+01	0.	.185576149E+07	.177646009E-02
.66830	.122208958E-02	.145362510E+01	.264542048E-02	0.	.339355981E+04
28	.231642780E+01	.100000000E+01	0.	.204743252E+07	.224649143E-02
.76913	.155566491E-02	.144407154E+01	.252992381E-02	0.	.414119809E+04
29	.240694988E+01	.100000000E+01	0.	.223742149E+07	.270994158E-02
.86960	.188646368E-02	.143651935E+01	.244410208E-02	0.	.485376114E+04
30	.248599183E+01	.100000000E+01	0.	.241993247E+07	.317961218E-02
.96983	.222229147E-02	.143078089E+01	.237371951E-02	0.	.554507107E+04
31	.254454235E+01	.100000000E+01	0.	.259987415E+07	.366421300E-02
1.06989	.256639537E-02	.142776637E+01	.230368673E-02	0.	.623643165E+04
32	.255868297E+01	.100000000E+01	0.	.276386271E+07	.422293311E-02
1.16985	.295280807E-02	.143014141E+01	.221051838E-02	0.	.697617272E+04
33	.253625911E+01	.100000000E+01	0.	.290753580E+07	.488291068E-02
1.26983	.339752955E-02	.143719447E+01	.210184160E-02	0.	.777932631E+04
34	.250210953E+01	.100000000E+01	0.	.303968552E+07	.561969820E-02
1.36987	.388639412E-02	.144599287E+01	.199763769E-02	0.	.862377225E+04
35	.244637858E+01	.100000000E+01	0.	.316634732E+07	.644500194E-02
1.47002	.442266572E-02	.145726635E+01	.188836156E-02	0.	.952621911E+04
36	.231230644E+01	.100000000E+01	0.	.325626191E+07	.735010131E-02
1.55282	.497780915E-02	.147657355E+01	.173984055E-02	0.	.104384439E+05
37	.241906231E+01	.100000000E+01	0.	.329658693E+07	.787021959E-02
1.61903	.535155447E-02	.147064178E+01	.178591112E-02	0.	.108965770E+05
38	.232525992E+01	.100000000E+01	0.	.348273125E+07	.830196060E-02
1.68674	.560777114E-02	.148043855E+01	.168507533E-02	0.	.115787322E+05
39	.985345018E+00	.100000000E+01	0.	.340190830E+07	.122692195E-01
1.75420	.748555194E-02	.163905342E+01	.701515105E-03	0.	.145166867E+05

FLOW SEPARATION INDICATED

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                                   FFPW IS NEGATIVE - ITERATIONS DIVERGE
LAMINAR FLOW BUBBLE EXISTS
TRANSITION IS CALCULATED TO OCCUR AT INDEX  17  XRP =    .01150  YRP =    .01670  LENGTH =   .3143



*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  20 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .10210666E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
```

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GFW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.119304961E+01	.100000000E+01	0.	.631870180E+04	.631508265E-03
.07514	.283631574E-03	.222650905E+01	.297916228E-01	0.	.238509934E+02
3	.120647354E+01	.100000000E+01	0.	.304985065E+05	.685433268E-03
.17525	.309298046E-03	.221609311E+01	.134354553E-01	0.	.538277170E+02
4	.114843628E+01	.100000000E+01	0.	.735817775E+05	.705297777E-03
.27528	.315461790E-03	.223576294E+01	.830962122E-02	0.	.843214518E+02
5	.111403464E+01	.100000000E+01	0.	.123664975E+06	.780692544E-03
.37530	.347400380E-03	.224724148E+01	.603964468E-02	0.	.114472583E+03
6	.111281380E+01	.100000000E+01	0.	.186053640E+06	.817502141E-03
.47532	.364158592E-03	.224490691E+01	.487764677E-02	0.	.142542517E+03
7	.110140754E+01	.100000000E+01	0.	.256444131E+06	.855944991E-03
.57539	.380841477E-03	.224750991E+01	.407670166E-02	0.	.169737715E+03
8	.111815804E+01	.100000000E+01	0.	.334601065E+06	.881006440E-03
.67555	.393405901E-03	.223943372E+01	.359843753E-02	0.	.194854990E+03
9	.125609269E+01	.100000000E+01	0.	.425635748E+06	.846035326E-03
.77582	.387044662E-03	.218588553E+01	.758553830E-02	0.	.212342464E+03
10	.207033031E+01	.100000000E+01	0.	.558174507E+06	.608353162E-03
.87620	.308756449E-03	.197033346E+01	.530192598E-02	0.	.196689688E+03
11	.324703171E+01	.100000000E+01	0.	.845959161E+06	.311296159E-03
.94691	.165659226E-03	.187913566E+01	.766328709E-02	0.	.147998364E+03
12	.843072328E+00	.100000000E+01	0.	.116697909E+07	.499438386E-03
.97278	.216513870E-03	.230672698E+01	.191870032E-02	0.	.259736929E+03

LAMINAR BUBBLE BURST HAS OCCURRED

FLOW SEPARATION INDICATED

FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR BOUNDARY LAYER DISPLACEMENT THICKNESS USED IN EXTRAPOLATION

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 2 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 3 ... STAGNATION POINT = (1.52689 , -.06525)

UPPER SURFACE

NO.	XBF	YBF	LENGTH	CP
1	1.52689	-.06525	0.0000	1.0000
2	1.51165	-.05832	.0157	.9940
3	1.49849	-.05237	.0312	.9650
4	1.48844	-.04661	.0428	.8721
5	1.47907	-.03591	.0570	.5973
6	1.47342	-.02220	.0718	-.0074
7	1.47353	-.01077	.0833	-.6769
8	1.47556	-.00333	.0910	-1.2397
9	1.47801	.00108	.0950	-1.3974
10	1.48275	.00705	.1036	-1.5577
11	1.49028	.01425	.1141	-1.8827
12	1.50469	.02329	.1311	-2.3966
13	1.52911	.03243	.1571	-3.3412
14	1.55922	.03598	.1875	-3.9068
15	1.59082	.03313	.2132	-3.9272
16	1.62553	.02325	.2553	-3.4478
17	1.66218	.00666	.2955	-2.7479
18	1.68888	-.00919	.3255	-2.1799
19	1.72235	-.03438	.3634	-1.4003
20	1.76306	-.06645	.4233	-.8348
21	1.78855	-.08718	.4534	-.6062
22	1.80866	-.10297	.4737	-.4734
23	1.83846	-.12702	.5170	-.3175
24	1.87767	-.15885	.5675	-.1041
25	1.91683	-.19078	.6130	.2525
26	1.95599	-.22278	.6636	.8228
27	1.99512	-.25485	.7132	.8228
28	2.03416	-.28696	.7637	.8228
29	2.07225	-.31824	.8130	.8228
30	2.09183	-.33426	.8443	.8228

LOWER SURFACE

NO.	XBP	YBP	LENGTH	CP
1	1.52689	-.06525	0.0000	1.0000
2	1.54192	-.07197	.0155	.9981
3	1.55730	-.07893	.0333	.9930
4	1.58012	-.08939	.0534	.9817
5	1.60985	-.10290	.0911	.9688
6	1.63271	-.11340	.1153	.9573
7	1.65045	-.12157	.1338	.9486
8	1.67326	-.13214	.1619	.9378
9	1.70907	-.14897	.2015	.9199
10	1.75445	-.17046	.2537	.8972
11	1.79966	-.19223	.3019	.8727
12	1.84477	-.21418	.3510	.8470
13	1.88987	-.23621	.4012	.8169
14	1.93485	-.25830	.4514	.7837
15	1.97988	-.28040	.5015	.7484
16	2.02495	-.30243	.5517	.7115
17	2.06844	-.32469	.6005	.6354
18	2.09050	-.33655	.6236	.5506

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 30 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .1021066E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1 0.00000	.123199529E+01 0.	.100000000E+01 0.	0. 0.	0. 0.	0. 0.
2 .01674	.139905008E+01 .112724364E-03	.100000000E+01 .217506117E+01	0. .683720065E-01	.165339428E+04 0.	.245182387E-03 .111309951E+02
3 .03119	.156433401E+01 .826538997E-04	.100000000E+01 .216919685E+01	0. .386298358E-01	.746711157E+04 0.	.179292579E-03 .197885729E+02
4 .04277	.151004949E+01 .640518222E-04	.100000000E+01 .220182934E+01	0. .249637891E-01	.195788103E+05 0.	.141031181E-03 .293181914E+02
5 .05699	.144897786E+01 .559204698E-04	.100000000E+01 .220951582E+01	0. .160271953E-01	.462916347E+05 0.	.123557163E-03 .454200423E+02
6 .07182	.137179286E+01 .519103280E-04	.100000000E+01 .221276251E+01	0. .108635343E-01	.922669667E+05 0.	.114865227E-03 .666902902E+02
7 .08326	.133097043E+01 .512589939E-04	.100000000E+01 .221254229E+01	0. .852779095E-02	.138002439E+06 0.	.113412692E-03 .849639080E+02
8 .09097	.114604557E+01 .537186412E-04	.100000000E+01 .226994335E+01	0. .648320115E-02	.174260830E+06 0.	.121030295E-03 .102137300E+03
9 .09601	.988584851E+00 .586219175E-04	.100000000E+01 .233229638E+01	0. .519877871E-02	.190282126E+06 0.	.136723686E-03 .116182796E+03
10 .10363	.925679158E+00 .658225875E-04	.100000000E+01 .235741126E+01	0. .442112751E-02	.212145144E+06 0.	.155170909E-03 .134743642E+03
11 .11405	.951047169E+00 .713524099E-04	.100000000E+01 .233004032E+01	0. .406156865E-02	.247859257E+06 0.	.166253992E-03 .155065319E+03
12 .13107	.981867124E+00 .775443879E-04	.100000000E+01 .229468511E+01	0. .360678567E-02	.309184935E+06 0.	.177939264E-03 .182927731E+03
13 .15714	.950696491E+00 .835777595E-04	.100000000E+01 .229126452E+01	0. .293870564E-02	.419084872E+06 0.	.191498756E-03 .222897403E+03
14 .18745	.791417025E+00 .980080720E-04	.100000000E+01 .237678631E+01	0. .205326582E-02	.531492643E+06 0.	.232944244E-03 .277888334E+03
15 .21918	.505333676E+00 .124831838E-03	.100000000E+01 .258612174E+01	0. .114848547E-02	.622755620E+06 0.	.322830331E-03 .354677450E+03
16 .25527	.165985683E+01 .222914916E-03	.100000000E+01 .170861294E+01	0. .336311781E-02	.689104823E+06 0.	.380875311E-03 .601756142E+03
17 .29551	.183957952E+01 .386187465E-03	.100000000E+01 .157058046E+01	0. .338311307E-02	.732275965E+06 0.	.606538487E-03 .956984231E+03
18	.156267377E+01	.100000000E+01	0.	.745398419E+06	.931035794E-03

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 .32655     .583516403E-03    .159556062E+01    .270956171E-02    0.                   .133189245E+04

  19        .990443474E+00    .100000000E+01    0.                  .730655435E+05     .176474411E-02
 .36844     .104565151E-02    .168769814E+01    .161247464E-02    0.                   .207361672E+04

  20        .551681292E+00    .100000000E+01    0.                  .728668865E+05     .329939532E-02
 .42027     .182274055E-02    .181012889E+01    .845798068E-03    0.                   .316030609E+04

  21        .364892318E+00    .100000000E+01    0.                  .735564043E+05     .452967716E-02
 .45344     .237771466E-02    .190505499E+01    .541981503E-03    0.                   .385712419E+04

  22        .237527783E+00    .100000000E+01    0.                  .743735043E+05     .559861252E-02
 .47869     .282895495E-02    .197903912E+01    .345251458E-03    0.                   .439532543E+04

                                        FLOW SEPARATION INDICATED

                                   FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR FLOW BUBBLE EXISTS

TRANSITION IS CALCULATED TO OCCUR AT INDEX  15  XBP =   1.59082  YBP =    .03313  LENGTH =   .2192


*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  18 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .1021066E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
```

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1 0.00000	.123199529E+01 0.	.100000000E+01 0.	0. 0.	0. 0.	0. 0.
2 .01646	.121702779E+01 .162597690E-03	.100000000E+01 .222000585E+01	0. .798040099E-01	.909204103E+03 0.	.360967823E-03 .898035981E+01
3 .03334	.119565850E+01 .168795074E-03	.100000000E+01 .222525257E+01	0. .395002251E-01	.356081891E+04 0.	.375611671E-03 .180282295E+02
4 .05845	.112284145E+01 .183516166E-03	.100000000E+01 .224755310E+01	0. .217120126E-01	.101277640E+05 0.	.412462328E-03 .317985260E+02
5 .09110	.107987099E+01 .215548462E-03	.100000000E+01 .225789031E+01	0. .140171260E-01	.206018513E+05 0.	.486684783E-03 .487433008E+02
6 .11625	.107545998E+01 .229196982E-03	.100000000E+01 .225534895E+01	0. .113242687E-01	.307381223E+05 0.	.516919172E-03 .606016388E+02
7 .13579	.106153184E+01 .239592097E-03	.100000000E+01 .225920382E+01	0. .980221062E-02	.393996356E+05 0.	.541287380E-03 .695181697E+02
8 .16093	.105599520E+01 .252092514E-03	.100000000E+01 .226002783E+01	0. .846596507E-02	.513585639E+05 0.	.569736098E-03 .804515884E+02
9 .20049	.105912376E+01 .266533812E-03	.100000000E+01 .225675088E+01	0. .709302747E-02	.726234856E+05 0.	.601500416E-03 .965459259E+02
10 .25070	.106524240E+01 .281559074E-03	.100000000E+01 .225288125E+01	0. .595527523E-02	.102909084E+05 0.	.634319159E-03 .115575271E+03
11 .30088	.107820528E+01 .291751937E-03	.100000000E+01 .224718483E+01	0. .520722154E-02	.137388720E+05 0.	.655620529E-03 .133219478E+03
12 .35105	.110485595E+01 .298288960E-03	.100000000E+01 .223658407E+01	0. .471627315E-02	.175774061E+05 0.	.667148336E-03 .149356947E+03
13 .40121	.113600479E+01 .299785437E-03	.100000000E+01 .222523988E+01	0. .435550895E-02	.219754276E+05 0.	.667094510E-03 .164202282E+03
14 .45136	.115241224E+01 .300159106E-03	.100000000E+01 .222104251E+01	0. .401563235E-02	.268672671E+05 0.	.666666133E-03 .178669792E+03
15 .50152	.115738598E+01 .301154461E-03	.100000000E+01 .222199768E+01	0. .369953101E-02	.321973391E+05 0.	.669164514E-03 .193339877E+03
16 .55168	.130742504E+01 .294064375E-03	.100000000E+01 .216922661E+01	0. .386301149E-02	.379289143E+05 0.	.637892266E-03 .202172799E+03
17 .60053	.171926569E+01 .254729810E-03	.100000000E+01 .205155355E+01	0. .472529051E-02	.464156429E+05 0.	.522591846E-03 .196882164E+03
18	.192979856E+01	.100000000E+01	0.	.536806335E+05	.442689891E-03

.62559 .2198028884E-03 .201403131F+01 .511042729E-02 0. .188609760E+03

ANGLE OF ATTACK = 22.900

AIRFOIL PART 1, 33 DEFINING POINTS...

ITERATION 3...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
1.	- 1 -	-.05065	.04636	-.05211	.14596	15.30633
2.	- 2 -	-.05358	.04556	-.08147	.03776	15.62267
3.	- 3 -	-.10937	.02996	-.13850	.01781	22.65010
4.	- 4 -	-.16763	.00565	-.18128	-.00102	26.03832
5.	- 5 -	-.19493	-.00769	-.21426	-.01961	31.67553
6.	- 6 -	-.23359	-.03154	-.25171	-.04418	34.88421
7.	- 7 -	-.26983	-.05681	-.28720	-.07151	40.23658
8.	- 8 -	-.30457	-.08621	-.31958	-.10251	47.37020
9.	- 9 -	-.33459	-.11882	-.34676	-.13501	53.08764
10.	- 10 -	-.35892	-.15120	-.36694	-.16607	61.65083
11.	- 11 -	-.37496	-.18094	-.37952	-.19519	72.24909
12.	- 12 -	-.38408	-.20944	-.38502	-.22066	85.21629
13.	- 13 -	-.38596	-.23188	-.38442	-.24222	-81.49821
14.	- 14 -	-.38287	-.25256	-.37925	-.26143	-67.78653
15.	- 15 -	-.37563	-.27030	-.36963	-.27787	-51.63257
16.	- 16 -	-.36364	-.28544	-.35842	-.28931	-36.52781
17.	- 17 -	-.35320	-.29317	-.34620	-.29675	-27.02829
18.	- 18 -	-.33920	-.30032	-.33280	-.30155	-10.87053
19.	- 19 -	-.32640	-.30278	-.32053	-.30173	10.07936
20.	- 20 -	-.31465	-.30069	-.30966	-.29784	29.67936
21.	- 21 -	-.30466	-.29499	-.30029	-.29047	45.92331
22.	- 22 -	-.29591	-.28595	-.29389	-.27735	76.78677
23.	- 23 -	-.29187	-.26875	-.29084	-.24939	86.96523
24.	- 24 -	-.28982	-.23002	-.28568	-.21008	78.27582
25.	- 25 -	-.28154	-.19014	-.27244	-.16707	68.46945
26.	- 26 -	-.26334	-.14401	-.24909	-.12624	51.27239
27.	- 27 -	-.23484	-.10846	-.21699	-.08623	51.25572
28.	- 28 -	-.19915	-.06399	-.18836	-.05068	50.97420
29.	- 29 -	-.17757	-.03736	-.16848	-.02580	51.83586
30.	- 30 -	-.15940	-.01424	-.13149	.00072	28.19807
31.	- 31 -	-.10359	.01568	-.07811	.02794	25.70004
32.	- 32 -	-.05263	.04020	-.05129	.04085	25.63861
33.	- 33 -	-.04995	.04149	-.05063	.04637	15.30633
34.	- 34 -			-.04993	.04150	25.63861

ANGLE OF ATTACK = 22.900

AIRFOIL PART 1, 33 DEFINING POINTS...

ITERATION 8...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
1.	- 1 -	-.05060	.04621	-.05207	.04580	15.30633
2.	- 2 -	-.05354	.04540	-.08143	.03761	15.60608
3.	- 3 -	-.10932	.02982	-.13845	.01768	22.61765
4.	- 4 -	-.16759	.00555	-.18123	-.00111	26.01635
5.	- 5 -	-.19488	-.00777	-.21421	-.01970	31.66597
6.	- 6 -	-.23353	-.03162	-.25166	-.04425	34.87381
7.	- 7 -	-.26978	-.05688	-.28715	-.07157	40.21814
8.	- 8 -	-.30452	-.08626	-.31955	-.10255	47.31933
9.	- 9 -	-.33457	-.11884	-.34677	-.13501	52.96765
10.	- 10 -	-.35896	-.15117	-.36698	-.16604	61.66436
11.	- 11 -	-.37500	-.18092	-.37954	-.19518	72.33951
12.	- 12 -	-.38408	-.20944	-.38502	-.22066	85.21178
13.	- 13 -	-.38596	-.23188	-.38442	-.24222	-81.49913
14.	- 14 -	-.38287	-.25256	-.37925	-.26143	-67.78715
15.	- 15 -	-.37563	-.27030	-.36963	-.27787	-51.63315
16.	- 16 -	-.36364	-.28544	-.35842	-.28931	-36.52818
17.	- 17 -	-.35320	-.29318	-.34620	-.29675	-27.02807
18.	- 18 -	-.33920	-.30032	-.33280	-.30155	-10.86862
19.	- 19 -	-.32640	-.30278	-.32053	-.30173	10.08570
20.	- 20 -	-.31465	-.30069	-.30966	-.29784	29.69136
21.	- 21 -	-.30466	-.29499	-.30029	-.29047	45.89647
22.	- 22 -	-.29591	-.28596	-.29388	-.27735	76.76532
23.	- 23 -	-.29186	-.26875	-.29084	-.24939	86.99192
24.	- 24 -	-.28983	-.23002	-.28569	-.21008	78.27449
25.	- 25 -	-.28155	-.19014	-.27244	-.16707	68.45000
26.	- 26 -	-.26333	-.14401	-.24908	-.12624	51.26783
27.	- 27 -	-.23483	-.10847	-.21698	-.08624	51.25382
28.	- 28 -	-.19914	-.06400	-.18835	-.05069	50.97177
29.	- 29 -	-.17755	-.03737	-.16847	-.02581	51.84136
30.	- 30 -	-.15939	-.01426	-.13149	.00071	28.20540
31.	- 31 -	-.10359	.01567	-.07811	.02794	25.70400
32.	- 32 -	-.05263	.04020	-.05129	.04084	25.64054
33.	- 33 -	-.04995	.04149	-.05058	.04621	15.30633
34.	- 34 -			-.04993	.04150	25.64054

ANGLE OF ATTACK = 22.900

AIRFOIL PART 2, 60 DEFINING POINTS...

ITERATION 8...

INDEX	POINT NUMBER	X	Y	X3P	Y3P	SLOPE
35.	- 1 -	1.47188	.09244	1.47015	.09267	-7.32304
36.	- 2 -	1.46841	.09289	1.43540	.09694	-6.99501
37.	- 3 -	1.40239	.10099	1.36833	.10473	-6.26912
38.	- 4 -	1.33426	.10848	1.30086	.11157	-5.29203
39.	- 5 -	1.26746	.11466	1.23487	.11777	-5.44241
40.	- 6 -	1.20228	.12087	1.15225	.12466	-4.32867
41.	- 7 -	1.10222	.12845	1.05220	.13130	-3.25910
42.	- 8 -	1.00217	.13414	.95214	.13589	-2.00121
43.	- 9 -	.90211	.13764	.85206	.13805	-.46724
44.	- 10 -	.80202	.13846	.75197	.13733	1.28587
45.	- 11 -	.70193	.13621	.65188	.13371	2.85714
46.	- 12 -	.60183	.13121	.55176	.12744	4.30697
47.	- 13 -	.50169	.12367	.45162	.11850	5.89465
48.	- 14 -	.40155	.11333	.35145	.10648	7.78753
49.	- 15 -	.30134	.09963	.27629	.09546	9.45358
50.	- 16 -	.25124	.09129	.22617	.08652	10.77246
51.	- 17 -	.20109	.08175	.18103	.07743	12.14611
52.	- 18 -	.16097	.07311	.14090	.06802	14.22530
53.	- 19 -	.12084	.06294	.10075	.05675	17.11080
54.	- 20 -	.08065	.05057	.07060	.04695	19.76390
55.	- 21 -	.06054	.04334	.05048	.03914	22.67891
56.	- 22 -	.04042	.03493	.03287	.03100	27.52970
57.	- 23 -	.02532	.02706	.02025	.02366	33.85648
58.	- 24 -	.01519	.02026	.01139	.01682	42.13564
59.	- 25 -	.00759	.01338	.00503	.00983	54.32527
60.	- 26 -	.00248	.00628	.00120	.00315	67.78262
61.	- 27 -	-.00007	.00002	-.00017	-.00160	86.62468
62.	- 28 -	-.00026	-.00322	-.00005	-.00488	-82.72510
63.	- 29 -	.00016	-.00654	.00119	-.00932	-69.65098
64.	- 30 -	.00222	-.01210	.00467	-.01520	-51.68111
65.	- 31 -	.00712	-.01830	.01081	-.02107	-36.92783
66.	- 32 -	.01451	-.02385	.01947	-.02647	-27.90937
67.	- 33 -	.02443	-.02910	.03189	-.03194	-20.80077
68.	- 34 -	.03934	-.03477	.04929	-.03767	-16.23980
69.	- 35 -	.05924	-.04057	.06921	-.04292	-13.28164
70.	- 36 -	.07919	-.04527	.09913	-.04880	-10.03204
71.	- 37 -	.11906	-.05233	.13901	-.05526	-8.35604
72.	- 38 -	.15897	-.05819	.17894	-.06064	-6.99935
73.	- 39 -	.19891	-.06309	.22388	-.06549	-5.47673
74.	- 40 -	.24885	-.06788	.27383	-.06995	-4.72517
75.	- 41 -	.29881	-.07201	.34876	-.07561	-4.12028
76.	- 42 -	.39872	-.07921	.44870	-.08162	-2.76848
77.	- 43 -	.49867	-.08404	.54867	-.08559	-1.77058
78.	- 44 -	.59866	-.08713	.64867	-.08786	-.83311
79.	- 45 -	.69868	-.08859	.74871	-.08828	.35573
80.	- 46 -	.79874	-.08797	.84878	-.08646	1.72031
81.	- 47 -	.89882	-.08496	.94887	-.08239	2.93966
82.	- 48 -	.99893	-.07982	1.04898	-.07642	3.88300
83.	- 49 -	1.09903	-.07302	1.14909	-.06897	4.63407
84.	- 50 -	1.19915	-.06491	1.21961	-.06349	3.96214
85.	- 51 -	1.24006	-.06208	1.24516	-.05868	33.64183
86.	- 52 -	1.25027	-.05528	1.25862	-.04085	59.94567

87.	- 53 -	1.26697	-.02642	1.28363	.00233	59.90119
88.	- 54 -	1.30030	.03108	1.30862	.04544	59.89694
89.	- 55 -	1.31695	.05980	1.32523	.06825	45.58948
90.	- 56 -	1.33352	.07671	1.34177	.07906	15.87746
91.	- 57 -	1.35002	.08141	1.37501	.08141	-.00100
92.	- 58 -	1.40000	.08141	1.43357	.08141	-.00000
93.	- 59 -	1.46714	.08141	1.46890	.08141	.00000
94.	- 60 -	1.47067	.08141	1.47190	.09244	-7.32304
95.	- 61 -			1.47069	.08141	.00000

ANGLE OF ATTACK = 22.900

AIRFOIL PART 3, 38 DEFINING POINTS...

ITERATION 8...

INDEX	POINT NUMBER	X	Y	XBP	YBP	SLOPE
96.	- 1 -	1.75037	-.05370	1.74914	-.05276	-37.41451
97.	- 2 -	1.74792	-.05183	1.72338	-.03305	-37.41451
98.	- 3 -	1.69883	-.01428	1.68956	-.00818	-33.32669
99.	- 4 -	1.68029	-.00209	1.66256	.00734	-28.00680
100.	- 5 -	1.64482	.01678	1.62569	.02367	-19.82723
101.	- 6 -	1.60656	.03057	1.59088	.03346	-10.41815
102.	- 7 -	1.57521	.03634	1.55922	.03624	.36445
103.	- 8 -	1.54322	.03613	1.52907	.03263	13.90194
104.	- 9 -	1.51491	.02913	1.50461	.02346	28.83435
105.	- 10 -	1.49431	.01779	1.49018	.01438	39.49042
106.	- 11 -	1.48605	.01097	1.48264	.00715	48.29433
107.	- 12 -	1.47923	.00333	1.47789	.00116	58.34419
108.	- 13 -	1.47655	-.00102	1.47545	-.00328	63.91456
109.	- 14 -	1.47434	-.00554	1.47341	-.01075	79.87371
110.	- 15 -	1.47248	-.01595	1.47330	-.02223	-82.51534
111.	- 16 -	1.47413	-.02850	1.47897	-.03597	-57.08019
112.	- 17 -	1.48381	-.04345	1.48835	-.04672	-35.73024
113.	- 18 -	1.49289	-.04999	1.49841	-.05253	-24.80176
114.	- 19 -	1.50392	-.05508	1.51157	-.05849	-24.02404
115.	- 20 -	1.51922	-.06190	1.52683	-.06529	-24.59224
116.	- 21 -	1.53444	-.06887	1.54182	-.07219	-24.26017
117.	- 22 -	1.54920	-.07552	1.55715	-.07925	-25.17186
118.	- 23 -	1.56510	-.08299	1.57995	-.08978	-24.55375
119.	- 24 -	1.59480	-.09656	1.60965	-.10334	-24.54010
120.	- 25 -	1.62450	-.11012	1.63249	-.11388	-25.18257
121.	- 26 -	1.64047	-.11763	1.65022	-.12207	-24.49219
122.	- 27 -	1.65997	-.12651	1.67302	-.13266	-25.23688
123.	- 28 -	1.68607	-.13881	1.70881	-.14951	-25.18710
124.	- 29 -	1.73156	-.16021	1.75418	-.17102	-25.55830
125.	- 30 -	1.77680	-.18184	1.79937	-.19281	-25.91670
126.	- 31 -	1.82195	-.20378	1.84448	-.21477	-26.00524
127.	- 32 -	1.86700	-.22576	1.88954	-.23680	-26.10520
128.	- 33 -	1.91207	-.24785	1.93456	-.25890	-26.17304
129.	- 34 -	1.95705	-.26995	1.97959	-.28099	-26.08383
130.	- 35 -	2.00214	-.29203	2.02468	-.30297	-25.90745
131.	- 36 -	2.04722	-.31392	2.06821	-.32513	-28.09924
132.	- 37 -	2.08919	-.33633	2.09030	-.33692	-28.07564
133.	- 38 -	2.09140	-.33751	1.75039	-.05370	22.90000
134.	- 39 -			2.09142	-.33752	-28.07564

GAMMA DISTRIBUTION FOR ALPHA = 22.5000

INDEX	-1-
1.	-.11742
2.	-.59566
3.	-2.04671
4.	-2.32285
5.	-2.61098
6.	-2.66294
7.	-2.83979
8.	-2.99095
9.	-3.02560
10.	-3.24038
11.	-3.40042
12.	-3.53262
13.	-3.50041
14.	-3.31380
15.	-3.06119
16.	-2.62868
17.	-2.17016
18.	-1.87905
19.	-1.53285
20.	-1.05135
21.	-.61943
22.	-.28507
23.	.01049
24.	.04979
25.	.03780
26.	.03072
27.	.12256
28.	.16261
29.	.15430
30.	-.08233
31.	.17058
32.	.08753
33.	.00961
34.	-.04722
35.	-.24352
36.	-.82688
37.	-1.15245
38.	-1.42595
39.	-1.52715
40.	-1.59545
41.	-1.65717
42.	-1.71950
43.	-1.77924
44.	-1.82861
45.	-1.88311
46.	-1.97183
47.	-2.08470
48.	-2.19007
49.	-2.25409
50.	-2.33006
51.	-2.42037
52.	-2.51435
53.	-2.61558
54.	-2.70526
55.	-2.84472
56.	-2.98809

57.	-3.12747
58.	-3.28407
59.	-3.31939
60.	-3.54359
61.	-3.22817
62.	-2.53047
63.	-2.45069
64.	-1.83110
65.	-1.31696
66.	-.97288
67.	-.63975
68.	-.49570
69.	-.37636
70.	-.22869
71.	-.14062
72.	-.07423
73.	-.00875
74.	.04426
75.	.13252
76.	.16140
77.	.18399
78.	.23900
79.	.28442
80.	.32209
81.	.35628
82.	.39779
83.	.49869
84.	.50324
85.	.87522
86.	.47874
87.	.25349
88.	-.00835
89.	-.32556
90.	-.32910
91.	-.15362
92.	-.06023
93.	-.01391
94.	1.86969
95.	.27145
96.	-.60878
97.	-.79987
98.	-1.10987
99.	-1.52162
100.	-1.89591
101.	-2.04905
102.	-1.91383
103.	-1.66094
104.	-1.56892
105.	-1.50858
106.	-1.41014
107.	-1.40510
108.	-1.11007
109.	-.81825
110.	-.42629
111.	-.23434
112.	-.12505
113.	-.09966
114.	-.16848
115.	-.33897
116.	-.55504
117.	-.78468
118.	-.82069
119.	-.79958
120.	-.82031
121.	-.80586
122.	-.79779

123.	-.75719
124.	-.69538
125.	-.62979
126.	-.55728
127.	-.47697
128.	-.39038
129.	-.32356
130.	-.08138
131.	-.01776

SOURCE STRENGTHS FOR ALPHA = 22.9000

INDEX	-1-
1.	.00821
2.	.01407
3.	.12107

INCOMPRESSIBLE PRESSURE DISTRIBUTION

ALPHA = 22.9000 DEGREES

NO.	XRP	YRP	X/CREF	Y/CREF	XTR/CR	YTR/CR	CP-INNER	CP
1	-.0521	.0458	-.0260	.0229	.9995	.0060	-1.3715	-2.5968
2	-.0814	.0376	-.0407	.0188	.9402	.0380	.2211	-3.8565
3	-.1385	.0177	-.0692	.0088	.8189	.0937	.8412	-5.6734
4	-.1812	-.0011	-.0906	-.0006	.7220	.1293	.9221	-6.5408
5	-.2142	-.0197	-.1071	-.0098	.6411	.1503	.9735	-6.8379
6	-.2517	-.0442	-.1258	-.0221	.5439	.1686	.9863	-7.2289
7	-.2872	-.0716	-.1436	-.0358	.4455	.1796	.9943	-7.9448
8	-.3195	-.1025	-.1598	-.0513	.3465	.1799	.9965	-8.4079
9	-.3468	-.1350	-.1734	-.0675	.2534	.1700	.9986	-9.0480
10	-.3670	-.1660	-.1835	-.0830	.1737	.1516	.9999	-10.0918
11	-.3795	-.1952	-.1898	-.0976	.1090	.1245	.9993	-10.8331
12	-.3850	-.2207	-.1925	-.1103	.0613	.0923	.9988	-11.1226
13	-.3844	-.2422	-.1922	-.1211	.0292	.1571	.9968	-10.2237
14	-.3792	-.2614	-.1896	-.1307	.0080	.0186	.9957	-8.7452
15	-.3696	-.2779	-.1848	-.1389	-.0019	-.0223	.9925	-6.6093
16	-.3584	-.2893	-.1792	-.1447	-.0016	-.0577	.9991	-4.6169
17	-.3462	-.2967	-.1731	-.1484	.0064	-.0882	.9980	-2.9178
18	-.3328	-.3015	-.1664	-.1508	.0204	-.1164	.9978	-1.7515
19	-.3205	-.3017	-.1603	-.1509	.0396	-.1355	.9981	-.5583
20	-.3097	-.2978	-.1548	-.1489	.0629	-.1460	.9993	.3459
21	-.3003	-.2905	-.1501	-.1452	.0891	-.1486	.9999	.8056
22	-.2939	-.2774	-.1469	-.1387	.1194	-.1376	.9994	.9872
23	-.2908	-.2494	-.1454	-.1247	.1671	-.0977	.9986	.9954
24	-.2857	-.2101	-.1428	-.1050	.2355	-.0431	.9923	.9827
25	-.2724	-.1671	-.1362	-.0835	.3225	.0051	.9860	.9767
26	-.2491	-.1262	-.1245	-.0631	.4223	.0342	.9842	.9591
27	-.2170	-.0862	-.1085	-.0431	.5347	.1487	.9796	.9185
28	-.1883	-.0507	-.0942	-.0253	.6347	.0614	.9639	.8786
29	-.1685	-.0258	-.0842	-.0129	.7045	.0705	.9087	.8856
30	-.1315	.0007	-.0657	.0004	.8040	.0560	.8131	.7731
31	-.0781	.0279	-.0391	.0140	.9307	.1175	.2453	.0044
32	-.0513	.0408	-.0256	.0204	.9931	-.0030	-1.1913	-1.3375
35	1.4701	.0927	.7351	.0463	1.0000	.0066	-.4887	-.8646
36	1.4354	.0969	.7177	.0485	.9766	.0108	.1720	-1.0884
37	1.3683	.1047	.6842	.0524	.9315	.0186	.6849	-1.4056
38	1.3009	.1116	.6504	.0558	.8860	.0259	.9357	-1.3803
39	1.2349	.1178	.6174	.0589	.8415	.0326	.9868	-1.5331
40	1.1523	.1247	.5761	.0623	.7858	.0404	.9943	-1.6793
41	1.0522	.1313	.5261	.0656	.7182	.0487	.9960	-1.8536
42	.9521	.1359	.4761	.0679	.6506	.0557	.9967	-2.0475
43	.8521	.1380	.4260	.0690	.5828	.0610	.9971	-2.2525
44	.7520	.1373	.3760	.0687	.5149	.0643	.9972	-2.4486
45	.6519	.1337	.3259	.0669	.4470	.0657	.9972	-2.6427
46	.5518	.1274	.2759	.0637	.3789	.1653	.9982	-2.8786
47	.4516	.1185	.2258	.0593	.3106	.0630	.9999	-3.1582
48	.3514	.1065	.1757	.0532	.2423	.1587	.9999	-3.5287
49	.2763	.0955	.1381	.0477	.1909	.0541	1.0000	-3.9206
50	.2262	.0865	.1131	.0433	.1566	.0500	.9999	-4.2196
51	.1810	.0774	.0905	.0387	.1257	.0456	.9999	-4.6035
52	.1409	.0680	.0705	.0340	.0981	.1407	.9998	-5.0224
53	.1007	.0568	.0504	.0284	.0705	.1346	.9996	-5.4739
54	.0706	.0470	.0353	.0235	.0496	.0291	.9999	-6.0331

55	.0505	.0391	.0252	.0196	.0357	.1246	.9994	-6.5653
56	.0329	.0310	.0164	.0155	.0235	.1198	.9988	-7.3071
57	.0203	.0237	.0101	.0118	.0146	.1153	.9985	-8.1166
58	.0114	.0168	.0057	.0084	.0084	.1110	.9964	-8.8952
59	.0050	.0098	.0025	.0049	.0038	.1065	.9938	-9.3889
60	.0012	.0031	.0006	.0016	.0009	.1021	.9871	-10.0079
61	-.0002	-.0016	-.0001	-.0008	-.0002	-.1011	.9996	-10.3258
62	-.0001	-.0049	-.0000	-.0024	-.0002	-.1033	.9999	-8.4119
63	.0012	-.0093	.0006	-.0047	.0005	-.1064	.9955	-5.9101
64	.0047	-.0152	.0023	-.0076	.0026	-.1105	.9949	-3.3023
65	.0108	-.0211	.0054	-.0105	.0065	-.1147	.9984	-1.3535
66	.0195	-.0265	.0097	-.0132	.0122	-.1187	.9997	-.2690
67	.0319	-.0319	.0159	-.0160	.0204	-.1229	.9998	.3311
68	.0493	-.0377	.0246	-.0188	.0320	-.1274	1.0000	.6560
69	.0692	-.0429	.0346	-.0215	.0453	-.1317	1.0000	.8099
70	.0991	-.0488	.0496	-.0244	.0653	-.1369	1.0000	.9104
71	.1390	-.0553	.0695	-.0276	.0921	-.1428	1.0000	.9657
72	.1789	-.0606	.0895	-.0303	.1190	-.1479	1.0000	.9882
73	.2239	-.0655	.1119	-.0327	.1492	-.1530	1.0000	.9982
74	.2738	-.0699	.1369	-.0350	.1829	-.1579	1.0000	.9998
75	.3488	-.0756	.1744	-.0378	.2335	-.1646	1.0000	.9928
76	.4487	-.0816	.2243	-.0408	.3010	-.1725	.9999	.9759
77	.5487	-.0856	.2743	-.0428	.3686	-.1790	.9972	.9490
78	.6487	-.0879	.3243	-.0439	.4363	-.1844	.9961	.9249
79	.7487	-.0883	.3744	-.0441	.5041	-.1885	.9964	.8967
80	.8488	-.0865	.4244	-.0432	.5720	-.1911	.9965	.8684
81	.9489	-.0824	.4744	-.0412	.6400	-.1921	.9963	.8399
82	1.0490	-.0764	.5245	-.0382	.7081	-.1919	.9961	.8065
83	1.1491	-.0690	.5745	-.0345	.7762	-.1907	.9967	.7439
84	1.2196	-.0635	.6098	-.0317	.8242	-.1897	1.0000	.5065
85	1.2452	-.0587	.6226	-.0293	.8417	-.1874	.9978	.1241
86	1.2586	-.0409	.6293	-.0204	.8515	-.1758	.9998	.5240
87	1.2836	.0023	.6418	.0012	.8701	-.1475	.9910	.7876
88	1.3086	.0454	.6543	.0227	.8887	-.1193	.9626	.9002
89	1.3252	.0683	.6626	.0341	.9009	-.1044	.8612	.9577
90	1.3418	.0791	.6709	.0395	.9125	.1023	.7095	.9552
91	1.3750	.0814	.6875	.0407	.9351	.1026	.6196	.8591
92	1.4336	.0814	.7168	.0407	.9748	.1003	.2064	.3855
93	1.4689	.0814	.7345	.0407	.9987	-.1010	-.4031	-.3167
96	1.7491	-.0528	.8746	-.0264	.3706	.1042	-1.8558	.6164
97	1.7234	-.0331	.8617	-.0165	.3245	.1102	-.2133	-.6133
98	1.6895	-.0082	.8448	-.0041	.2647	.1168	.1804	-1.5910
99	1.6626	.0073	.8313	.0037	.2200	.1168	.3269	-2.1517
100	1.6257	.0237	.8128	.0118	.1625	.1106	.5754	-2.8707
101	1.5909	.0335	.7954	.0167	.1122	.1978	.8609	-3.3336
102	1.5592	.0362	.7796	.0181	.0709	.1785	.9871	-3.3515
103	1.5291	.0326	.7645	.0163	.0360	.1524	.9999	-2.8806
104	1.5046	.0235	.7523	.0117	.0122	.1235	.9982	-2.0443
105	1.4902	.0144	.7451	.0072	.0008	.1019	.9999	-1.5812
106	1.4826	.0072	.7413	.0036	-.0034	-.1125	.9992	-1.2838
107	1.4779	.0012	.7389	.0006	-.0050	-.1234	1.0000	-1.1334
108	1.4754	-.0033	.7377	-.0016	-.0048	-.1306	1.0000	-.9858
109	1.4734	-.0107	.7367	-.0054	-.0020	-.1414	.9981	-.4743
110	1.4733	-.0222	.7367	-.0111	.0061	-.1557	.9989	.1328
111	1.4790	-.0360	.7395	-.0180	.0230	-.1687	.9976	.6710
112	1.4883	-.0467	.7442	-.0234	.0423	-.1753	.9994	.9061
113	1.4984	-.0525	.7492	-.0263	.0590	-.1753	.9989	.9784
114	1.5115	-.0585	.7558	-.0292	.0796	-.1733	.9955	.9979
115	1.5269	-.0654	.7634	-.0327	.1035	-.1709	.9756	.9995
116	1.5418	-.0722	.7709	-.0361	.1270	-.1686	.8965	.9954
117	1.5571	-.0793	.7786	-.0396	.1511	-.1664	.6926	.9885
118	1.5799	-.0898	.7900	-.0449	.1870	-.1631	.3023	.9726
119	1.6097	-.1033	.8048	-.0517	.2336	-.1587	-.0036	.9604
120	1.6325	-.1139	.8162	-.0569	.2696	-.1554	-.0780	.9480

121	1.6502	-.1221	.8251	-.0610	.2975	-.1528	-.1194	.9385
122	1.6730	-.1327	.8365	-.0663	.3334	-.1496	-.1734	.9273
123	1.7088	-.1495	.8544	-.0748	.3899	-.1449	-.2261	.9070
124	1.7542	-.1710	.8771	-.0855	.4617	-.1391	-.2530	.8831
125	1.7994	-.1928	.8997	-.0964	.5335	-.1337	-.2201	.8569
126	1.8445	-.2148	.9222	-.1074	.6053	-.1287	-.1592	.8285
127	1.8895	-.2368	.9448	-.1184	.6770	-.1237	-.0876	.7981
128	1.9346	-.2589	.9673	-.1294	.7488	-.1189	-.0069	.7635
129	1.9796	-.2810	.9898	-.1405	.8206	-.1140	.0788	.7232
130	2.0247	-.3030	1.0123	-.1515	.8924	-.1090	.1538	.6831
131	2.0682	-.3251	1.0341	-.1626	.9623	-.1053	.3003	.5980
132	2.0903	-.3369	1.0451	-.1685	.9982	-.0041	.4281	.5006

STREAMLINE 1, ALPHA = 22.9000

X	Y	X	Y	X	Y	X	Y	X	Y
-.0487	.0467	-.0468	.0475	-.0450	.0483	-.0427	.0493	-.0399	.0507
-.0243	.0234	-.0234	.0237	-.0225	.0241	-.0214	.0247	-.0200	.0254 1
-.0364	.0525	-.0321	.0549	-.0268	.0579	-.0202	.0616	-.0119	.0664
-.0182	.0263	-.0161	.0274	-.0134	.0289	-.0101	.0308	-.0060	.0332
-.0041	.0707	.0033	.0747	.0102	.0783	.0190	.0827	.0273	.0867
-.0021	.0354	.0016	.0374	.0051	.0392	.0095	.0414	.0137	.0433
.0352	.0903	.0451	.0946	.0544	.0985	.0632	.1020	.0743	.1062
.0176	.0451	.0225	.0473	.0272	.0492	.0316	.0510	.0372	.0531
.0848	.1100	.0946	.1134	.1070	.1175	.1196	.1212	.1296	.1245
.0424	.0550	.0473	.0567	.0535	.0588	.0593	.0606	.0648	.0623
.1473	.1286	.1562	.1322	.1684	.1355	.1836	.1394	.1979	.1429
.0716	.0643	.0781	.0661	.0842	.0677	.0918	.0697	.0989	.0715
.2158	.1472	.2326	.1510	.2485	.1545	.2683	.1586	.2869	.1623
.1079	.0736	.1163	.0755	.1242	.0772	.1341	.0793	.1434	.0811
.3044	.1656	.3263	.1696	.3468	.1731	.3661	.1763	.3842	.1791
.1522	.0828	.1631	.0848	.1734	.0865	.1830	.0881	.1921	.0895
.4068	.1825	.4281	.1855	.4480	.1882	.4730	.1914	.4964	.1943
.2034	.0913	.2140	.0928	.2240	.0941	.2365	.0957	.2482	.0971
.5184	.1967	.5390	.1990	.5648	.2016	.5890	.2038	.6117	.2058
.2592	.0984	.2695	.0995	.2824	.1008	.2945	.1019	.3058	.1029
.6330	.2075	.6596	.2095	.6845	.2112	.7080	.2126	.7299	.2139
.3165	.1038	.3298	.1048	.3423	.1056	.3540	.1063	.3650	.1069
.7505	.2149	.7763	.2160	.8004	.2169	.8231	.2175	.8443	.2180
.3753	.1074	.3881	.1080	.4002	.1084	.4115	.1088	.4221	.1090
.8708	.2185	.8957	.2188	.9191	.2190	.9482	.2189	.9756	.2188
.4354	.1093	.4479	.1094	.4595	.1095	.4741	.1095	.4878	.1094
1.0012	.2184	1.0252	.2180	1.0553	.2173	1.0834	.2164	1.1098	.2155
.5006	.1092	.5126	.1090	.5276	.1086	.5417	.1082	.5549	.1077
1.1428	.2142	1.1737	.2127	1.2026	.2112	1.2388	.2092	1.2728	.2071
.5714	.1071	.5868	.1064	.6013	.1056	.6194	.1046	.6364	.1036
1.3046	.2050	1.3443	.2022	1.3815	.1995	1.4281	.1959	1.4862	.1912
.6523	.1025	.6721	.1011	.6908	.0997	.7140	.0979	.7431	.0956
1.5169	.1888	1.5385	.1870	1.5536	.1856	1.5678	.1842	1.5811	.1827
.7585	.0944	.7692	.0935	.7768	.0928	.7839	.0921	.7906	.0914
1.5936	.1813	1.6091	.1793	1.6237	.1773	1.6373	.1753	1.6500	.1732
.7968	.0906	.8046	.0897	.8118	.0887	.8186	.0876	.8250	.0866
1.6619	.1711	1.6768	.1684	1.6907	.1657	1.7038	.1630	1.7200	.1595
.8310	.0856	.8384	.0842	.8454	.0828	.8519	.0815	.8600	.0797

1.7352	.1560	1.7542	.1516	1.7778	.1458	1.8074	.1384	1.8442	.1289
.8676	.0780	.8771	.0759	.8889	.0729	.9037	.0692	.9221	.0645
1.8902	.1170	1.9226	.1087	1.9530	.1010	1.9815	.0940	2.0083	.0875
.9451	.0585	.9613	.0543	.9765	.0505	.9908	.0470	1.0042	.0438
2.0335	.0816	2.0571	.0763	2.0793	.0714	2.1001	.0669	2.1196	.0629
1.0167	.0408	1.0285	.0381	1.0396	.0357	1.0530	.0335	1.0598	.0314
2.1441	.0579	2.1670	.0535	2.1886	.0495	2.2088	.0459	2.2278	.0426
1.0720	.0290	1.0835	.0267	1.0943	.0247	1.1044	.0229	1.1139	.0213
2.2456	.0397	2.2679	.0362	2.2888	.0330	2.3085	.0303	2.3269	.0278
1.1228	.0199	1.1340	.0181	1.1444	.0165	1.1542	.0151	1.1635	.0139
2.3500	.0248	2.3716	.0222	2.3919	.0200	2.4110	.0180	2.4348	.0156
1.1750	.0124	1.1858	.0111	1.1960	.0100	1.2055	.0090	1.2174	.0078
2.4572	.0136	2.4782	.0119	2.4979	.0104	2.5225	.0087	2.5456	.0073
1.2286	.0068	1.2391	.0060	1.2489	.0052	1.2612	.0044	1.2728	.0037
2.5672	.0062	2.5875	.0052	2.6129	.0042	2.6367	.0033	2.6590	.0027
1.2836	.0031	1.2938	.0026	1.3064	.0021	1.3184	.0017	1.3295	.0014
2.6800	.0023	2.7061	.0019	2.7307	.0016	2.7537	.0015	2.7824	.0016
1.3400	.0011	1.3531	.0009	1.3653	.0008	1.3768	.0008	1.3912	.0008
2.8094	.0018	2.8346	.0022	2.8583	.0027	2.8879	.0035	2.9157	.0043
1.4047	.0009	1.4173	.0011	1.4292	.0014	1.4440	.0017	1.4578	.0022
2.9417	.0053	2.9742	.0067	3.0046	.0081				
1.4708	.0026	1.4871	.0033	1.5023	.0041				

STREAMLINE 2, ALPHA = 22.9000

X	Y	X	Y	X	Y	X	Y	X	Y
-.0442	.0442	-.0403	.0463	-.0354	.0489	-.0294	.0524	-.0219	.0568
-.0221	.0221	-.0201	.0231	-.0177	.0245	-.0147	.0262	-.0109	.0284
-.0125	.0624	-.0037	.0675	.0046	.0721	.0126	.0763	.0201	.0800
-.0063	.0312	-.0019	.0337	.0023	.0360	.0063	.0381	.0100	.0400
.0271	.0834	.0361	.0875	.0445	.0912	.0525	.0946	.0625	.0986
.0136	.0417	.0180	.0438	.0223	.0456	.0262	.0473	.0313	.0493
.0720	.1022	.0809	.1055	.0921	.1094	.1026	.1130	.1159	.1173
.0360	.0511	.0404	.0527	.0460	.0547	.0513	.0565	.0579	.0586
.1283	.1211	.1401	.1245	.1548	.1287	.1686	.1324	.1816	.1358
.0642	.0605	.0700	.0623	.0774	.0643	.0843	.0662	.0908	.0679
.1979	.1398	.2132	.1434	.2276	.1467	.2456	.1506	.2626	.1541
.0990	.0699	.1066	.0717	.1138	.0733	.1228	.0753	.1313	.0771
.2785	.1573	.2984	.1611	.3170	.1646	.3346	.1676	.3565	.1713
.1392	.0787	.1492	.0806	.1585	.0823	.1673	.0838	.1783	.0857
.3772	.1746	.3965	.1775	.4147	.1802	.4374	.1833	.4587	.1861
.1885	.0873	.1982	.0888	.2073	.0901	.2187	.0916	.2293	.0930
.4787	.1886	.5037	.1915	.5272	.1941	.5492	.1964	.5699	.1984
.2393	.0943	.2518	.0958	.2636	.0971	.2746	.0982	.2849	.0992
.5957	.2007	.6199	.2028	.6427	.2045	.6640	.2061	.6907	.2078
.2978	.1004	.3100	.1014	.3213	.1023	.3320	.1030	.3453	.1039
.7157	.2097	.7391	.2105	.7611	.2115	.7817	.2123	.8075	.2132
.3578	.1048	.3696	.1053	.3806	.1057	.3909	.1062	.4038	.1066
.8317	.2138	.8544	.2143	.8756	.2146	.9022	.2149	.9271	.2149
.4159	.1069	.4272	.1072	.4378	.1073	.4511	.1074	.4636	.1075
.9505	.2149	.9797	.2146	1.0071	.2142	1.0327	.2136	1.0568	.2130
.4752	.1074	.4898	.1073	.5035	.1071	.5164	.1068	.5284	.1065
1.0868	.2120	1.1150	.2110	1.1414	.2099	1.1744	.2083	1.2053	.2067
.5434	.1060	.5575	.1055	.5707	.1049	.5872	.1042	.6027	.1033
1.2343	.2050	1.2706	.2027	1.3045	.2004	1.3470	.1974	1.3867	.1944
.6172	.1025	.6353	.1014	.6523	.1002	.6735	.0987	.6934	.0972
1.4364	.1905	1.4985	.1855	1.5231	.1835	1.5403	.1821	1.5565	.1806
.7182	.0953	.7493	.0928	.7615	.0918	.7702	.0910	.7783	.0903
1.5717	.1791	1.5859	.1775	1.5992	.1759	1.6116	.1743	1.6233	.1726
.7858	.0895	.7929	.0888	.7996	.0880	.8058	.0871	.8116	.0863
1.6378	.1704	1.6514	.1682	1.6641	.1659	1.6760	.1636	1.6909	.1607
.8189	.0852	.8257	.0841	.8321	.0829	.8380	.0818	.8454	.0803
1.7048	.1577	1.7221	.1539	1.7383	.1501	1.7595	.1453	1.7837	.1389
.8524	.0789	.8611	.0770	.8692	.0751	.8793	.0726	.8919	.0695

1.8152	.1308	1.8545	.1204	1.8913	.1107	1.9259	.1017	1.9502	.0955
.9076	.0654	.9272	.0602	.9457	.0553	.9629	.0508	.9751	.0477
1.9730	.0897	2.0016	.0827	2.0284	.0763	2.0536	.0705	2.0773	.0651
.9865	.0449	1.0008	.0414	1.0142	.0381	1.0268	.0352	1.0386	.0326
2.0995	.0603	2.1203	.0559	2.1399	.0519	2.1583	.0483	2.1812	.0439
1.0497	.0302	1.0602	.0280	1.0699	.0260	1.0791	.0241	1.0906	.0219
2.2028	.0399	2.2231	.0364	2.2421	.0332	2.2600	.0303	2.2823	.0268
1.1014	.0200	1.1115	.0182	1.1211	.0166	1.1300	.0151	1.1412	.0134
2.3033	.0238	2.3230	.0211	2.3414	.0186	2.3645	.0158	2.3862	.0133
1.1516	.0119	1.1615	.0105	1.1707	.0093	1.1823	.0079	1.1931	.0066
2.4065	.0111	2.4256	.0092	2.4495	.0069	2.4719	.0050	2.4929	.0034
1.2033	.0055	1.2128	.0046	1.2248	.0035	1.2360	.0025	1.2465	.0017
2.5126	.0020	2.5373	.0004	2.5604	-.0009	2.5821	-.0020	2.6024	-.0029
1.2563	.0010	1.2686	.0002	1.2802	-.0005	1.2910	-.0010	1.3012	-.0015
2.6278	-.0039	2.6516	-.0046	2.6740	-.0051	2.6950	-.0055	2.7211	-.0058
1.3139	-.0019	1.3258	-.0023	1.3370	-.0026	1.3475	-.0027	1.3606	-.0029
2.7457	-.0060	2.7687	-.0060	2.7975	-.0058	2.8245	-.0055	2.8498	-.0050
1.3729	-.0030	1.3844	-.0030	1.3988	-.0029	1.4122	-.0027	1.4249	-.0025
2.8735	-.0045	2.9031	-.0036	2.9309	-.0027	2.9569	-.0016	2.9895	-.0002
1.4368	-.0022	1.4516	-.0018	1.4655	-.0013	1.4785	-.0008	1.4947	-.0001
3.0200	.0014								
1.5100	.0007								

STREAMLINE 3, ALPHA = 22.9000

X	Y	X	Y	X	Y	X	Y	X	Y
1.4745	.0921	1.4779	.0919	1.4821	.0918	1.4873	.0917	1.4938	.0918
.7373	.0461	.7389	.0459	.7410	.0459	.7436	.0459	.7469	.0459
1.5019	.0919	1.5121	.0922	1.5248	.0926	1.5338	.0927	1.5422	.0927
.7510	.0460	.7561	.0461	.7624	.0463	.7669	.0463	.7711	.0463
1.5500	.0926	1.5574	.0923	1.5643	.0920	1.5729	.0914	1.5810	.0907
.7750	.0463	.7787	.0462	.7822	.0460	.7865	.0457	.7905	.0454
1.5886	.0899	1.5956	.0890	1.6044	.0877	1.6127	.0863	1.6204	.0849
.7943	.0449	.7978	.0445	.8022	.0439	.8063	.0432	.8102	.0424
1.6275	.0834	1.6365	.0814	1.6448	.0794	1.6526	.0773	1.6623	.0746
.8139	.0417	.8182	.0407	.8224	.0397	.8263	.0386	.8312	.0373
1.6714	.0718	1.6798	.0691	1.6903	.0656	1.7001	.0622	1.7122	.0577
.8357	.0359	.8399	.0346	.8451	.0328	.8500	.0311	.8561	.0288
1.7236	.0533	1.7377	.0477	1.7553	.0406	1.7773	.0316	1.7980	.0233
.8618	.0267	.8689	.0239	.8777	.0203	.8887	.0158	.8990	.0116
1.8174	.0156	1.8356	.0086	1.8528	.0022	1.8743	-.0057	1.8946	-.0130
.9087	.0078	.9178	.0043	.9264	.0011	.9372	-.0029	.9473	-.0065
1.9136	-.0196	1.9374	-.0277	1.9598	-.0352	1.9809	-.0421	2.0007	-.0484
.9568	-.0098	.9687	-.0139	.9799	-.0176	.9905	-.0210	1.0003	-.0242
2.0193	-.0541	2.0367	-.0595	2.0586	-.0660	2.0791	-.0719	2.0984	-.0773
1.0096	-.0271	1.0184	-.0297	1.0293	-.0330	1.0396	-.0359	1.0492	-.0386
2.1165	-.0822	2.1336	-.0867	2.1496	-.0908	2.1646	-.0945	2.1834	-.0990
1.0583	-.0411	1.0668	-.0433	1.0748	-.0454	1.0823	-.0472	1.0917	-.0495
2.2011	-.1030	2.2177	-.1067	2.2333	-.1100	2.2480	-.1129	2.2663	-.1165
1.1006	-.0515	1.1089	-.0533	1.1167	-.0550	1.1240	-.0565	1.1332	-.0582
2.2836	-.1197	2.2997	-.1225	2.3149	-.1250	2.3339	-.1280	2.3518	-.1307
1.1418	-.0598	1.1499	-.0612	1.1575	-.0625	1.1670	-.0640	1.1759	-.0654
2.3685	-.1331	2.3843	-.1351	2.4039	-.1376	2.4224	-.1398	2.4397	-.1416
1.1843	-.0665	1.1921	-.0676	1.2020	-.0688	1.2112	-.0699	1.2199	-.0708
2.4614	-.1438	2.4817	-.1457	2.5008	-.1473	2.5187	-.1486	2.5411	-.1502
1.2307	-.0719	1.2409	-.0728	1.2504	-.0736	1.2593	-.0743	1.2705	-.0751
2.5621	-.1515	2.5817	-.1525	2.6064	-.1537	2.6294	-.1546	2.6511	-.1553
1.2810	-.0757	1.2909	-.0763	1.3032	-.0769	1.3147	-.0773	1.3255	-.0777
2.6714	-.1559	2.6968	-.1564	2.7206	-.1567	2.7429	-.1569	2.7708	-.1569
1.3357	-.0779	1.3484	-.0782	1.3603	-.0783	1.3714	-.0784	1.3854	-.0784
2.7969	-.1567	2.8214	-.1564	2.8444	-.1560	2.8731	-.1554	2.9000	-.1546
1.3984	-.0784	1.4107	-.0782	1.4222	-.0780	1.4365	-.0777	1.4500	-.0773
2.9252	-.1537	2.9568	-.1524	2.9863	-.1511	3.0140	-.1496		
1.4626	-.0768	1.4784	-.0762	1.4932	-.0755	1.5070	-.0748		

STREAMLINE 4, ALPHA = 22.9000

X	Y	X	Y	X	Y	X	Y	X	Y
1.4754	.0814	1.4814	.0816	1.4888	.0820	1.4980	.0825	1.5096	.0833
.7377	.0407	.7407	.0408	.7444	.0410	.7490	.0413	.7548	.0417
1.5204	.0840	1.5281	.0843	1.5352	.0846	1.5442	.0847	1.5526	.0847
.7602	.0420	.7640	.0422	.7676	.0423	.7721	.0424	.7763	.0423
1.5604	.0845	1.5678	.0841	1.5747	.0836	1.5811	.0831	1.5892	.0822
.7802	.0422	.7839	.0421	.7873	.0418	.7906	.0415	.7946	.0411
1.5967	.0812	1.6038	.0802	1.6104	.0790	1.6186	.0775	1.6262	.0759
.7984	.0406	.8019	.0401	.8052	.0395	.8093	.0387	.8131	.0379
1.6334	.0742	1.6422	.0720	1.6505	.0697	1.6583	.0674	1.6679	.0644
.8167	.0371	.8211	.0360	.8253	.0349	.8291	.0337	.8339	.0322
1.6768	.0615	1.6852	.0585	1.6956	.0547	1.7053	.0510	1.7173	.0462
.8384	.0307	.8426	.0293	.8478	.0274	.8526	.0255	.8587	.0231
1.7323	.0400	1.7509	.0320	1.7742	.0220	1.7906	.0151	1.8060	.0087
.8661	.0200	.8755	.0160	.8871	.0110	.8953	.0075	.9030	.0043
1.8206	.0029	1.8388	-.0043	1.8559	-.0109	1.8774	-.0189	1.8976	-.0262
.9103	.0014	.9194	-.0022	.9279	-.0054	.9387	-.0094	.9488	-.0131
1.9166	-.0330	1.9404	-.0413	1.9627	-.0489	1.9837	-.0558	2.0035	-.0622
.9583	-.0165	.9702	-.0206	.9814	-.0244	.9919	-.0279	1.0017	-.0311
2.0220	-.0681	2.0394	-.0735	2.0613	-.0802	2.0818	-.0862	2.1010	-.0917
1.0110	-.0341	1.0197	-.0368	1.0306	-.0401	1.0409	-.0431	1.0505	-.0458
2.1192	-.0967	2.1362	-.1013	2.1522	-.1054	2.1672	-.1092	2.1860	-.1137
1.0596	-.0483	1.0681	-.0506	1.0761	-.0527	1.0836	-.0546	1.0930	-.0569
2.2037	-.1178	2.2203	-.1215	2.2359	-.1248	2.2505	-.1278	2.2688	-.1314
1.1018	-.0589	1.1101	-.0608	1.1179	-.0624	1.1253	-.0639	1.1344	-.0657
2.2861	-.1346	2.3022	-.1374	2.3174	-.1400	2.3364	-.1430	2.3543	-.1457
1.1430	-.0673	1.1511	-.0687	1.1587	-.0700	1.1682	-.0715	1.1771	-.0728
2.3710	-.1480	2.3868	-.1501	2.4064	-.1525	2.4249	-.1547	2.4422	-.1565
1.1855	-.0740	1.1934	-.0750	1.2032	-.0763	1.2124	-.0773	1.2211	-.0783
2.4639	-.1587	2.4842	-.1605	2.5033	-.1621	2.5212	-.1635	2.5436	-.1650
1.2319	-.0794	1.2421	-.0803	1.2517	-.0811	1.2606	-.0817	1.2718	-.0825
2.5646	-.1663	2.5843	-.1673	2.6089	-.1685	2.6320	-.1694	2.6536	-.1701
1.2823	-.0831	1.2921	-.0837	1.3044	-.0842	1.3160	-.0847	1.3268	-.0850
2.6739	-.1706	2.6993	-.1711	2.7231	-.1713	2.7454	-.1715	2.7733	-.1715
1.3370	-.0853	1.3496	-.0855	1.3615	-.0857	1.3727	-.0857	1.3866	-.0857
2.7994	-.1713	2.8239	-.1710	2.8469	-.1705	2.8756	-.1698	2.9025	-.1690
1.3997	-.0856	1.4120	-.0855	1.4235	-.0853	1.4378	-.0849	1.4513	-.0845
2.9279	-.1681	2.9593	-.1668	2.9888	-.1654	3.0165	-.1640		
1.4639	-.0841	1.4796	-.0834	1.4944	-.0827	1.5093	-.0820		

STREAMLINE 5, ALPHA = 22.9000

X	Y	X	Y	X	Y	X	Y	X	Y	
1.7522	-.0529	1.7541	-.0535	1.7560	-.0542	1.7583	-.0552	1.7612	-.0565	
.8761	-.0265	.8771	-.0268	.8780	-.0271	.8792	-.0276	.8806	-.0282	1
1.7647	-.0581	1.7692	-.0601	1.7747	-.0627	1.7816	-.0659	1.7903	-.0698	
.8824	-.0290	.8846	-.0301	.8874	-.0313	.8908	-.0329	.8952	-.0349	
1.8012	-.0748	1.8148	-.0809	1.8318	-.0884	1.8532	-.0976	1.8733	-.1061	
.9006	-.0374	.9074	-.0404	.9159	-.0442	.9266	-.0488	.9366	-.0530	
1.8985	-.1165	1.9222	-.1262	1.9445	-.1351	1.9654	-.1433	1.9850	-.1509	
.9492	-.0583	.9611	-.0631	.9722	-.0675	.9827	-.0717	.9925	-.0755	
2.0035	-.1579	2.0266	-.1666	2.0484	-.1745	2.0698	-.1818	2.0881	-.1885	
1.0017	-.0790	1.0133	-.0833	1.0242	-.0873	1.0344	-.0909	1.0440	-.0942	
2.1062	-.1945	2.1232	-.2000	2.1392	-.2050	2.1543	-.2095	2.1684	-.2135	
1.0531	-.0973	1.0616	-.1000	1.0696	-.1025	1.0771	-.1047	1.0842	-.1068	
2.1818	-.2172	2.1943	-.2205	2.2100	-.2245	2.2247	-.2281	2.2386	-.2312	
1.0909	-.1086	1.0971	-.1103	1.1050	-.1122	1.1124	-.1140	1.1193	-.1156	
2.2516	-.2341	2.2680	-.2375	2.2833	-.2405	2.2977	-.2432	2.3113	-.2455	
1.1258	-.1170	1.1340	-.1187	1.1417	-.1202	1.1489	-.1216	1.1556	-.1228	
2.3282	-.2484	2.3441	-.2508	2.3591	-.2530	2.3777	-.2556	2.3953	-.2579	
1.1641	-.1242	1.1721	-.1254	1.1795	-.1265	1.1889	-.1278	1.1976	-.1289	
2.4118	-.2598	2.4272	-.2615	2.4466	-.2635	2.4647	-.2652	2.4817	-.2667	
1.2059	-.1299	1.2136	-.1308	1.2233	-.1318	1.2323	-.1326	1.2409	-.1334	
2.5030	-.2684	2.5230	-.2698	2.5417	-.2710	2.5651	-.2723	2.5871	-.2734	
1.2515	-.1342	1.2615	-.1349	1.2709	-.1355	1.2826	-.1362	1.2936	-.1367	
2.6077	-.2742	2.6270	-.2749	2.6512	-.2755	2.6738	-.2760	2.6951	-.2763	
1.3039	-.1371	1.3135	-.1374	1.3256	-.1378	1.3369	-.1380	1.3475	-.1381	
2.7216	-.2765	2.7465	-.2765	2.7698	-.2764	2.7917	-.2762	2.8190	-.2757	
1.3608	-.1382	1.3732	-.1383	1.3849	-.1382	1.3959	-.1381	1.4095	-.1379	
2.8447	-.2751	2.8687	-.2744	2.8987	-.2734	2.9269	-.2723	2.9532	-.2711	
1.4223	-.1376	1.4343	-.1372	1.4494	-.1367	1.4634	-.1362	1.4766	-.1356	
2.9862	-.2695	3.0171	-.2578							
1.4931	-.1347	1.5085	-.1339							

STREAMLINE 6, ALPHA = 22.9000

X	Y	X	Y	X	Y	X	Y	X	Y
2.0946	-.3392	2.0986	-.3411	2.1037	-.3433	2.1101	-.3459	2.1183	-.3490
1.0473	-.1696	1.0493	-.1705	1.0519	-.1716	1.0551	-.1730	1.0591	-.1745
2.1259	-.3518	2.1356	-.3550	2.1447	-.3579	2.1532	-.3605	2.1640	-.3636
1.0630	-.1759	1.0678	-.1775	1.0723	-.1790	1.0766	-.1802	1.0820	-.1818
2.1741	-.3663	2.1868	-.3696	2.1988	-.3725	2.2100	-.3750	2.2241	-.3781
1.0871	-.1832	1.0934	-.1848	1.0994	-.1862	1.1050	-.1875	1.1120	-.1890
2.2373	-.3807	2.2498	-.3831	2.2653	-.3860	2.2800	-.3884	2.2937	-.3906
1.1187	-.1904	1.1249	-.1916	1.1327	-.1930	1.1400	-.1942	1.1468	-.1953
2.3109	-.3932	2.3270	-.3954	2.3422	-.3974	2.3612	-.3997	2.3790	-.4017
1.1554	-.1966	1.1635	-.1977	1.1711	-.1987	1.1806	-.1998	1.1895	-.2008
2.3957	-.4034	2.4165	-.4053	2.4361	-.4070	2.4545	-.4084	2.4718	-.4096
1.1978	-.2017	1.2083	-.2027	1.2181	-.2035	1.2273	-.2042	1.2359	-.2048
2.4934	-.4109	2.5136	-.4120	2.5326	-.4129	2.5563	-.4139	2.5785	-.4146
1.2467	-.2055	1.2568	-.2060	1.2663	-.2064	1.2781	-.2069	1.2893	-.2073
2.5954	-.4151	2.6255	-.4156	2.6500	-.4159	2.6729	-.4160	2.6944	-.4160
1.2997	-.2076	1.3127	-.2078	1.3250	-.2080	1.3364	-.2080	1.3472	-.2080
2.7212	-.4159	2.7464	-.4156	2.7700	-.4151	2.7996	-.4144	2.8272	-.4136
1.3606	-.2079	1.3732	-.2078	1.3850	-.2076	1.3998	-.2072	1.4136	-.2068
2.8532	-.4127	2.8775	-.4117	2.9078	-.4103	2.9363	-.4088	2.9630	-.4073
1.4265	-.2063	1.4387	-.2058	1.4539	-.2051	1.4681	-.2044	1.4815	-.2036
2.9963	-.4052	3.0276	-.4032						
1.4982	-.2026	1.5138	-.2016						

MAX. CP DIFFERENCE AFTER ITERATION 8 IS 0.000 AND R.M.S. DEVIATION IS 0.000000

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 8 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 1 ... STAGNATION POINT = (-.29099 , -.24937)

UPPER SURFACE

NO.	XBP	YBP	LENGTH	CP
1	-.29099	-.24937	0.0010	1.0000
2	-.29400	-.27732	.0231	.9872
3	-.30037	-.29041	.0427	.8056
4	-.30970	-.29776	.0545	.3459
5	-.32054	-.30164	.0651	-.5583
6	-.33278	-.30145	.0783	-1.7515
7	-.34615	-.29665	.0925	-2.9178
8	-.35835	-.28922	.1068	-4.6169
9	-.36954	-.27780	.1228	-6.6093
10	-.37913	-.26138	.1418	-8.7457
11	-.38427	-.24220	.1617	-10.2237
12	-.38484	-.22068	.1832	-11.1226
13	-.37930	-.19526	.2092	-10.8331
14	-.36668	-.16621	.2419	-10.0918
15	-.34644	-.13525	.2779	-9.0480
16	-.31919	-.10289	.3212	-8.4079
17	-.28674	-.07206	.3649	-7.9448
18	-.25119	-.04492	.4096	-7.2289
19	-.21369	-.02056	.4544	-6.8379
20	-.18070	-.00221	.4931	-6.5408
21	-.13787	.01613	.5397	-5.6734
22	-.08081	.03557	.5930	-3.8565
23	-.05147	.04360	.6234	-2.5968

LOWER SURFACE

NO.	XBF	YBP	LENGTH	CP
1	-.29099	-.24937	0.0000	1.0000
2	-.28600	-.21900	.0337	.9827
3	-.27292	-.16686	.0848	.9767
4	-.24954	-.12593	.1319	.9591
5	-.21740	-.08590	.1832	.9185
6	-.18879	-.05033	.2299	.8786
7	-.16886	-.02541	.2608	.8856
8	-.13170	.00104	.3054	.7731
9	-.07819	.02811	.3654	.0044
10	-.05134	.04096	.3951	-1.3375

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 23 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .102106GE+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FFPW THETA	GW H	GFW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.231552967E+01	.100000000E+01	0.	.407219883E+04	.175477913E-03
.02811	.859852706E-04	.204079132E+01	.722529401E-01	0.	.124556708E+02
3	.169149588E+01	.100000000E+01	0.	.240817622E+05	.916712968E-04
.04267	.389435017E-04	.235355619E+01	.281593683E-01	0.	.219790145E+02
4	.147876382E+01	.100000000E+01	0.	.564665909E+05	.893749303E-04
.05455	.383477784E-04	.233064167E+01	.161751651E-01	0.	.396975840E+02
5	.133537097E+01	.100000000E+01	0.	.105553860E+05	.911110019E-04
.06606	.399773366E-04	.227906633E+01	.105779362E-01	0.	.638776500E+02
6	.119410556E+01	.100000000E+01	0.	.166251914E+05	.100022945E-03
.07830	.440553692E-04	.227039171E+01	.722379027E-02	0.	.935395245E+02
7	.116058460E+01	.100000000E+01	0.	.234372179E+05	.111244500E-03
.09251	.494143291E-04	.225125994E+01	.554152230E-02	0.	.125194149E+03
8	.117639500E+01	.100000000E+01	0.	.323962104E+05	.112435157E-03
.10679	.504248373E-04	.222975746E+01	.465945196E-02	0.	.152968509E+03
9	.113695172E+01	.100000000E+01	0.	.433520380E+05	.116829453E-03
.12278	.521839396E-04	.223880094E+01	.379020505E-02	0.	.184254760E+03
10	.104484951E+01	.100000000E+01	0.	.566591878E+05	.127930801E-03
.14180	.562520033E-04	.227424435E+01	.294629717E-02	0.	.224774085E+03
11	.926846415E+00	.100000000E+01	0.	.693200415E+05	.147110352E-03
.16165	.632346530E-04	.232641985E+01	.226880054E-02	0.	.271164234E+03
12	.756560069E+00	.100000000E+01	0.	.816367864E+05	.178297943E-03
.18318	.737498990E-04	.241760254E+01	.163563421E-02	0.	.328677472E+03
13	.502833355E+00	.100000000E+01	0.	.921112397E+05	.243637673E-03
.20920	.933346880E-04	.261036575E+01	.964890591E-03	0.	.410961828E+03
14	.204911141E+00	.100000000E+01	0.	.102681513E+07	.378021201E-03
.24087	.125776478E-03	.300549997E+01	.351318472E-03	0.	.536179752E+03
15	.173915737E+01	.100000000E+01	0.	.112738750E+07	.387235096E-03
.27786	.225918163E-03	.171480934E+01	.269277351E-02	0.	.916239453E+03
16	.252518187E+01	.100000000E+01	0.	.125657835E+07	.480041857E-03
.32016	.321019178E-03	.149536816E+01	.356554553E-02	0.	.126033837E+04
17	.261909895E+01	.100000000E+01	0.	.139700404E+07	.632447377E-03
.36492	.433265091E-03	.145972383E+01	.341457465E-02	0.	.165862902E+04
18	.258552639E+01	.100000000E+01	0.	.150415699E+07	.822104924E-03

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 .40965     .565432908E-03     .145353876E+01     .315354104E-02     0.                      .207616535E+04

  19        .260859774E+01     .100000000E+01     0.                  .162823683E+07         .995606949E-03
 .45437     .688527589E-03     .144599427E+01     .300551608E-02     0.                      .246735831E+04

  20        .254979234E+01     .100000000E+01     0.                  .172975911E+07         .117634143E-02
 .49212     .811756673E-03     .144913059E+01     .281524955E-02     0.                      .285327219E+04

  21        .212350269E+01     .100000000E+01     0.                  .178129732E+07         .165905173E-02
 .53871     .110808616E-02     .149722268E+01     .223866401E-02     0.                      .366400635E+04
                                               FLOW SEPARATION INDICATED

                                          FPFW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR FLOW BUBBLE EXISTS

TRANSITION IS CALCULATED TO OCCUR AT INDEX  14  XBP =   -.36668  YBP =   -.15621  LENGTH =   .2409



*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  10 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .10210666E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
```

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1 0.00000	.123199529E+01 0.	.100000000E+01 0.	0. 0.	0. 0.	0. 0.
2 .03968	.101689864E+01 .158105998E-03	.100000000E+01 .228093875E+01	0. .247956964E-01	.667684264E+04 0.	.360630097E-03 .266007210E+02
3 .08476	.966761472E+00 .266295648E-03	.100000000E+01 .229083989E+01	0. .127184749E-01	.165459485E+05 0.	.610040694E-03 .519807747E+02
4 .13190	.122320016E+01 .260410498E-03	.100000000E+01 .217168639E+01	0. .115954559E-01	.341376373E+05 0.	.565529934E-03 .673973973E+02
5 .18324	.127723133E+01 .224635993E-03	.100000000E+01 .217389175E+01	0. .923231038E-02	.669515753E+05 0.	.488334311E-03 .820779545E+02
6 .22889	.907756867E+00 .246209638E-03	.100000000E+01 .233484695E+01	0. .538663804E-02	.102093697E+05 0.	.574861824E-03 .109821142E+03
7 .26079	.115228645E+01 .277292452E-03	.100000000E+01 .222444489E+01	0. .612344243E-02	.112884906E+05 0.	.616821779E-03 .120025912E+03
8 .30641	.202957178E+01 .183141667E-03	.100000000E+01 .197120394E+01	0. .933203402E-02	.186841272E+05 0.	.361009575E-03 .111676394E+03
9 .36637	.226605410E+01 .741531032E-04	.100000000E+01 .214679248E+01	0. .824225816E-02	.467926571E+05 0.	.159191324E-03 .947078143E+02
10 .39614	.205129632E+01 .560841238E-04	.100000000E+01 .223146810E+01	0. .649800189E-02	.775226283E+05 0.	.125149933E-03 .109754501E+03

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 8 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 2 ... STAGNATION POINT = (.27385 , -.06971)

UPPER SURFACE

NO.	XBP	YBP	LENGTH	CP
1	.27385	-.06971	0.0030	1.0000
2	.22392	-.06510	.0511	.9982
3	.17899	-.06019	.0953	.9882
4	.13907	-.05488	.1356	.9657
5	.09918	-.04849	.1750	.9104
6	.06927	-.04267	.2065	.8099
7	.04935	-.03747	.2271	.6560
8	.03194	-.03179	.2454	.3311
9	.01952	-.02637	.2599	-.2690
10	.01087	-.02100	.2631	-1.3535
11	.00473	-.01515	.2776	-3.3023
12	.00125	-.00929	.2844	-5.9101
13	.00001	-.00487	.2890	-8.4119
14	-.00010	-.00161	.2923	-10.3258
15	.00129	.00311	.2972	-10.0079
16	.00514	.00975	.3049	-9.3889
17	.01150	.01670	.3143	-8.8952
18	.02036	.02350	.3254	-8.1166
19	.03298	.03078	.3400	-7.3071
20	.05061	.03883	.3534	-6.5653
21	.07074	.04654	.3810	-6.0331
22	.10091	.05619	.4126	-5.4739
23	.14109	.06727	.4543	-5.0224
24	.18123	.07648	.4955	-4.6035
25	.22638	.08535	.5415	-4.2196
26	.27651	.09405	.5924	-3.9206
27	.35167	.10471	.6613	-3.5287
28	.45184	.11625	.7631	-3.1582
29	.55195	.12471	.8636	-2.8786
30	.65202	.13049	.9638	-2.6427
31	.75203	.13359	1.0639	-2.4486
32	.85200	.13371	1.1639	-2.2525
33	.95193	.13086	1.2638	-2.0475
34	1.05182	.12549	1.3639	-1.8536
35	1.15169	.11801	1.4710	-1.6793
36	1.23414	.11039	1.5528	-1.5331
37	1.30000	.10358	1.6190	-1.3803
38	1.36729	.09604	1.6857	-1.4056
39	1.43423	.08768	1.7542	-1.0884
40	1.46893	.08322	1.7832	-.8646

LOWER SURFACE

NO.	XBP	YBP	LENGTH	CP
1	.27385	-.06971	0.0000	1.0000
2	.34879	-.07520	.0751	.9928
3	.44873	-.08096	.1752	.9759
4	.54869	-.08486	.2753	.9490
5	.64868	-.08708	.3753	.9249
6	.74870	-.08745	.4753	.8967
7	.84875	-.08560	.5754	.8684
8	.94883	-.08151	.6755	.8399
9	1.04893	-.07561	.7758	.8065
10	1.14905	-.06839	.8752	.7439
11	1.21956	-.06312	.9459	.5065
12	1.24500	-.05841	.9728	.1241
13	1.25833	-.04066	.9950	.5240
14	1.28333	.00250	1.0449	.7876
15	1.30833	.04563	1.0947	.9002
16	1.32500	.06850	1.1230	.9577
17	1.34166	.07937	1.1429	.9552
18	1.37500	.08175	1.1753	.8591
19	1.43357	.08175	1.2349	.3855
20	1.46890	.08175	1.2732	-.3167

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 40 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .10210666E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1 0.00000	.123199529E+01 0.	.100000000E+01 0.	0. 0.	0. 0.	0. 0.
2 .05014	.141284663E+01 .261772772E-03	.100000000E+01 .217202403E+01	0. .533079451E-01	.274555785E+04 0.	.568576750E-03 .143334335E+02
3 .09534	.141245088E+01 .199239524E-03	.100000000E+01 .220393697E+01	0. .262644538E-01	.132550245E+05 0.	.439111353E-03 .277001130E+02
4 .13561	.145329109E+01 .175250640E-03	.100000000E+01 .219797882E+01	0. .177819481E-01	.321619649E+05 0.	.385197196E-03 .415628938E+02
5 .17601	.155308864E+01 .147212921E-03	.100000000E+01 .216802195E+01	0. .136508819E-01	.674313029E+05 0.	.319160844E-03 .563988253E+02
6 .20648	.168180675E+01 .120482463E-03	.100000000E+01 .213993512E+01	0. .118584132E-01	.115238377E+05 0.	.257824655E-03 .672420358E+02
7 .22707	.183303227E+01 .978627738E-04	.100000000E+01 .211626196E+01	0. .111865210E-01	.170463063E+05 0.	.207103266E-03 .734667521E+02
8 .24538	.201926043E+01 .744708490E-04	.100000000E+01 .209773728E+01	0. .107810868E-01	.256872187E+05 0.	.156220277E-03 .779581063E+02
9 .25893	.217233113E+01 .562636321E-04	.100000000E+01 .209214420E+01	0. .104141695E-01	.373363722E+05 0.	.117711632E-03 .811283874E+02
10 .26911	.224000998E+01 .433027350E-04	.100000000E+01 .210050180E+01	0. .980616156E-02	.528448085E+05 0.	.909574727E-04 .850317642E+02
11 .27759	.216322108E+01 .348363182E-04	.100000000E+01 .212635814E+01	0. .868966410E-02	.737009670E+05 0.	.740744886E-04 .924898577E+02
12 .28441	.205450781E+01 .304366453E-04	.100000000E+01 .214720158E+01	0. .764456301E-02	.956964677E+05 0.	.653536128E-04 .102411208E+03
13 .28900	.192197658E+01 .285839035E-04	.100000000E+01 .216885638E+01	0. .676996664E-02	.113487136E+07 0.	.619943813E-04 .112245524E+03
14 .29226	.156049585E+01 .293845796E-04	.100000000E+01 .224857541E+01	0. .528111679E-02	.125897575E+07 0.	.660734430E-04 .126579516E+03
15 .29718	.876237801E+00 .388508696E-04	.100000000E+01 .247459187E+01	0. .280139868E-02	.126207793E+07 0.	.961400461E-04 .164991950E+03
16 .30486	.570341020E+00 .502067215E-04	.100000000E+01 .268654474E+01	0. .168594162E-02	.125774751E+07 0.	.134882604E-03 .207136645E+03
17 .31428	.390474725E+00 .627100936E-04	.100000000E+01 .286450236E+01	0. .107029400E-02	.126542945E+07 0.	.179633182E-03 .252498856E+03
18	.138058326E+01	.100000000E+01	0.	.125778733E+07	.184537121E-03

.32545	.988868486F-04	.186614422E+01	.350516816E-02	0.	.382176554E+03
19	.182576403E+01	.100000000E+01	0.	.125440009E+07	.236573796E-03
.34002	.145428531E-03	.162673578F+01	.427205576E-02	0.	.536518441E+03
20	.186163415E+01	.100000000E+01	0.	.126531532E+07	.331509386E-03
.35940	.210982650E-03	.157126373E+01	.399101313E-02	0.	.742796043E+03
21	.184113138E+01	.100000000E+01	0.	.129317074E+07	.437998768E-03
.38095	.282655586F-03	.154958469E+01	.364707242E-02	0.	.959490440E+03
22	.186759750E+01	.100000000E+01	0.	.134385561E+07	.587673478E-03
.41263	.385163476E-03	.152577675E+01	.336780557E-02	0.	.125440266E+04
23	.193385541E+01	.100000000E+01	0.	.142707057E+07	.773529773E-03
.45431	.514812366E-03	.150254700E+01	.316140558E-02	0.	.161712074E+04
24	.198491375E+01	.100000000E+01	0.	.150133507E+07	.968141606E-03
.49549	.650650657E-03	.148755916E+01	.300014329E-02	0.	.197146118E+04
25	.204633730F+01	.100000000E+01	0.	.158355009E+07	.118754282E-02
.54151	.804724386F-03	.147571372E+01	.287613195E-02	0.	.235329243E+04
26	.211490421F+01	.100000000E+01	0.	.168199131E+07	.142245607E-02
.59239	.971084002E-03	.146481259E+01	.277813010E-02	0.	.275725183E+04
27	.219224824E+01	.100000000E+01	0.	.182039284E+07	.178769344E-02
.66830	.122841631E-02	.145528305E+01	.264855728E-02	0.	.334611608E+04
28	.229027472E+01	.100000000E+01	0.	.200752177E+07	.226414430E-02
.76913	.156576353E-02	.144603208E+01	.252984557E-02	0.	.408683206E+04
29	.237665991E+01	.100000000E+01	0.	.219211118E+07	.273721173E-02
.86960	.190228976E-02	.143890367E+01	.244039996E-02	0.	.479536194E+04
30	.245104832E+01	.100000000E+01	0.	.236930169E+07	.321886178E-02
.96983	.224523498E-02	.143364139E+01	.236638553E-02	0.	.548510585E+04
31	.250337235E+01	.100000000E+01	0.	.254315222E+07	.372049360E-02
1.06989	.259938608E-02	.143129704E+01	.229156164E-02	0.	.617878983E+04
32	.250981766E+01	.100000000E+01	0.	.270056332E+07	.430367145E-02
1.16986	.299991380F-02	.143459837E+01	.219241408E-02	0.	.692514191E+04
33	.247767134E+01	.100000000E+01	0.	.283747177E+07	.499856804E-02
1.26983	.346416761E-02	.144293481E+01	.207625872E-02	0.	.774076926E+04
34	.243074167E+01	.100000000E+01	0.	.296200660E+07	.578540702E-02
1.36987	.398034138F-02	.145349518E+01	.196257139E-02	0.	.860653083E+04
35	.236138419E+01	.100000000E+01	0.	.307991647E+07	.667716561E-02
1.47002	.455208249F-02	.146683757E+01	.184359434E-02	0.	.953733334E+04
36	.221013444F+01	.100000000E+01	0.	.316340810E+07	.766484513E-02
1.55282	.514764493E-02	.148900036E+01	.168220899E-02	0.	.104867761E+05
37	.225978435E+01	.100000000E+01	0.	.319730911E+07	.833223000E-02
1.61903	.559362255E-02	.148959461E+01	.168784003E-02	0.	.110464666E+05
38	.206232956E+01	.100000000E+01	0.	.334868515E+07	.909982630E-02
1.68674	.601269248F-02	.151343617E+01	.151233940E-02	0.	.119369693E+05

WARNING-FPPW DOES NOT CONVERGE AFTER 18 ITERATIONS

39	.793717568E-01	.100000000E+01	0.	.324484692E+07	.162407818F-01

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1.75420      .900263551E-02      .180400303E+01      .572181134E-04      0.                  .166527113E+05
                                           FLOW SEPARATION INDICATED

                                      FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR FLOW BUBBLE EXISTS

TRANSITION IS CALCULATED TO OCCUR AT INDEX  17  XBP =    .01150  YBP =    .01670  LENGTH =   .3143



*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  20 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .1021066E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
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*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1 0.00000	.123109525E+01 0.	.100000000E+01 0.	0. 0.	0. 0.	0. 0.
2 .07514	.115253249E+01 .253931658E-03	.100000000E+01 .223820998E+01	0. .253758261E-01	.815518795E+04 0.	.568352370E-03 .275597237E+02
3 .17525	.115509435E+01 .307781248E-03	.100000000E+01 .222677540E+01	0. .116986817E-01	.348022497E+05 0.	.685359713E-03 .611222998E+02
4 .27528	.112112429E+01 .320749561E-03	.100000000E+01 .223669998E+01	0. .756846469E-02	.795525963E+05 0.	.717420535E-03 .926918320E+02
5 .37530	.109726627E+01 .350380162E-03	.100000000E+01 .224621455E+01	0. .563332148E-02	.131654794E+06 0.	.787029019E-03 .122913806E+03
6 .47532	.109735932E+01 .366982396E-03	.100000000E+01 .224576211E+01	0. .459629545E-02	.195586675E+06 0.	.824155159E-03 .151008080E+03
7 .57539	.108567346E+01 .384058351E-03	.100000000E+01 .225018211E+01	0. .386485013E-02	.267149985E+06 0.	.864201229E-03 .178317396E+03
8 .67555	.110023578E+01 .397712634E-03	.100000000E+01 .224371752E+01	0. .342222987E-02	.345951226E+06 0.	.892354802E-03 .203670253E+03
9 .77582	.123494787E+01 .393105395E-03	.100000000E+01 .219050290E+01	0. .342101856E-02	.436827065E+06 0.	.861098509E-03 .221338120E+03
10 .87620	.205748692E+01 .316160752E-03	.100000000E+01 .196754864E+01	0. .513252231E-02	.567599037E+06 0.	.622061656E-03 .204807172E+03
11 .94691	.325332940E+01 .170749529E-03	.100000000E+01 .186990319E+01	0. .750236227E-02	.851456461E+06 0.	.319285089E-03 .153537282E+03
12 .97278	.277832532E+01 .194203712E-03	.100000000E+01 .170997714E+01	0. .618768582E-02	.116536519E+07 0.	.332083908E-03 .232650755E+03

FLOW SEPARATION INDICATED

FPPW IS NEGATIVE - ITERATIONS DIVERGE

LAMINAR FLOW BUBBLE EXISTS

TRANSITION IS CALCULATED TO OCCUR AT INDEX 11 XBP = 1.21956 YBP = -.06312 LENGTH = .9469

PRESSURES VS. DEVELOPED LENGTH MEASURED FROM THE STAGNATION POINT

ITERATION = 8 ...

ALPHA = 22.9000

REYNOLDS NUMBER = 2.560 MILLION

AIRFOIL PART NUMBER 3 ... STAGNATION POINT = (1.52689 , -.06525)

UPPER SURFACE

NO.	XRP	YRP	LENGTH	CP
1	1.52689	-.06525	0.0000	1.0000
2	1.51165	-.05832	.0157	.9979
3	1.49849	-.05237	.0312	.9784
4	1.48844	-.04661	.0428	.9061
5	1.47907	-.03591	.0570	.6710
6	1.47342	-.02220	.0718	.1328
7	1.47353	-.01077	.0833	-.4743
8	1.47556	-.00333	.0910	-.9858
9	1.47801	.00108	.0950	-1.1334
10	1.48275	.00705	.1036	-1.2838
11	1.49028	.01425	.1141	-1.5812
12	1.50469	.02329	.1311	-2.0443
13	1.52911	.03243	.1571	-2.8806
14	1.55922	.03598	.1875	-3.3515
15	1.59082	.03313	.2132	-3.3336
16	1.62553	.02325	.2553	-2.8707
17	1.66218	.00666	.2935	-2.1517
18	1.68888	-.00919	.3255	-1.5910
19	1.72235	-.03438	.3634	-.6133
20	1.76306	-.06645	.4213	.6164
21	1.78895	-.08718	.4534	.6164
22	1.80866	-.10297	.4737	.6164
23	1.83846	-.12702	.5170	.6164
24	1.87767	-.15885	.5675	.6164
25	1.91683	-.19078	.6130	.6164
26	1.95599	-.22278	.6636	.6164
27	1.99512	-.25485	.7132	.6164
28	2.03416	-.28696	.7637	.6164
29	2.07225	-.31824	.8130	.6164
30	2.09183	-.33426	.8443	.6164

LOWER SURFACE

NO.	XPP	YPP	LENGTH	CP
1	1.52689	-.06525	0.0000	1.0000
2	1.54192	-.07197	.0165	.9954
3	1.55730	-.07893	.0333	.9886
4	1.58012	-.08939	.0584	.9726
5	1.60985	-.10290	.0911	.9604
6	1.63271	-.11340	.1163	.9480
7	1.65045	-.12157	.1358	.9385
8	1.67326	-.13214	.1609	.9273
9	1.70907	-.14897	.2005	.9070
10	1.75445	-.17046	.2507	.8831
11	1.79966	-.19223	.3009	.8569
12	1.84477	-.21418	.3510	.8285
13	1.88983	-.23621	.4012	.7981
14	1.93485	-.25830	.4514	.7635
15	1.97988	-.28040	.5015	.7232
16	2.02495	-.30243	.5517	.6831
17	2.06844	-.32469	.6005	.5980
18	2.09050	-.33655	.6236	.5006

*** CASE DATA ***

-- INCOMPRESSIBLE FLOW ...

-- FREE STREAM VELOCITY = .2017E+03(FT/SEC)

-- TOTAL NUMBER OF X-STATIONS = 30 ...
-- STATIC TEMPERATURE = .5190E+03 ...
-- GRID PARAMETER = .1021066E+01 ...
-- REFERENCE CHORD = .2000E+01 ...
-- CF SEPARATION LEVEL = .1000E-03 ...

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.161568437E+01	.100000000E+01	0.	.973082921E+03	.288042439E-03
.01674	.135122075E-03	.213172008E+01	.102466237E+00	0.	.785264423E+01
3	.166148289E+01	.100000000E+01	0.	.586802805E+04	.169980162E-03
.03119	.760506898E-04	.223509033E+01	.492536001E-01	0.	.143084907E+02
4	.153345120E+01	.100000000E+01	0.	.167738613E+05	.136900809E-03
.04277	.604648974E-04	.226413696E+01	.288836346E-01	0.	.237113213E+02
5	.143952151E+01	.100000000E+01	0.	.418411703E+05	.124229576E-03
.05699	.556013525E-04	.223429055E+01	.174280423E-01	0.	.408190962E+02
6	.135652638E+01	.100000000E+01	0.	.856078686E+05	.117313101E-03
.07182	.529448965E-04	.221575842E+01	.114806448E-01	0.	.631103196E+02
7	.131870260E+01	.100000000E+01	0.	.129395352E+06	.115936576E-03
.08326	.524578866E-04	.221008857E+01	.892574073E-02	0.	.815280600E+02
8	.113899140E+01	.100000000E+01	0.	.164084633E+06	.123482734E-03
.09097	.544799865E-04	.226657056E+01	.677200352E-02	0.	.982676170E+02
9	.986733346E+00	.100000000E+01	0.	.179497036E+06	.139139653E-03
.09601	.597626172E-04	.232820548E+01	.543860712E-02	0.	.111730231E+03
10	.924720104E+00	.100000000E+01	0.	.200463497E+06	.157854003E-03
.10363	.670660158E-04	.235371077E+01	.461397518E-02	0.	.129729292E+03
11	.947961595E+00	.100000000E+01	0.	.234542889E+06	.169382812E-03
.11405	.727499181E-04	.232828870E+01	.421583783E-02	0.	.149608292E+03
12	.975063066E+00	.100000000E+01	0.	.292710409E+06	.182013319E-03
.13107	.792794113E-04	.229584600E+01	.371718677E-02	0.	.177056190E+03
13	.948618099E+00	.100000000E+01	0.	.396230133E+06	.197263885E-03
.15714	.859193490E-04	.229591922E+01	.300274865E-02	0.	.216646050E+03
14	.771870963E+00	.100000000E+01	0.	.500515906E+06	.242654663E-03
.18745	.101632809E-03	.238756230E+01	.206924633E-02	0.	.271370743E+03
15	.468774265E+00	.100000000E+01	0.	.584040959E+06	.343611647E-03
.21918	.131166979E-03	.261965055E+01	.110044043E-02	0.	.349509011E+03
16	.155606286E+01	.100000000E+01	0.	.642845316E+06	.409694253E-03
.25527	.237492641E-03	.172508198E+01	.325720273E-02	0.	.598071013E+03
17	.166685407E+01	.100000000E+01	0.	.671510553E+06	.688285652E-03
.29551	.433552206E-03	.158754965E+01	.317042689E-02	0.	.985203782E+03
18	.112223629E+01	.100000000E+01	0.	.672805063E+06	.122672943E-02

```
    .32655      .741707473E-03      .165352621E+01      .201547129E-02     0.                      .152817411E+04
                                                  FLOW SEPARATION INDICATED
                                             FPPW IS NEGATIVE - ITERATIONS DIVERGE
LAMINAR FLOW BUBBLE EXISTS
TRANSITION IS CALCULATED TO OCCUR AT INDEX  15  XBP =   1.59082  YBP =    .03313  LENGTH =   .2192


*** CASE DATA ***


  -- INCOMPRESSIBLE FLOW ...

  -- FREE STREAM VELOCITY =    .2017E+03(FT/SEC)

  -- TOTAL NUMBER OF X-STATIONS =  18 ...
  -- STATIC TEMPERATURE =    .5190E+03 ...
  -- GRID PARAMETER =    .102106E+01 ...
  -- REFERENCE CHORD =    .2000E+01 ...
  -- CF SEPARATION LEVEL =    .1000E-03 ...
```

*** CALCULATED STATION DATA ***

N S	FPPW THETA	GW H	GPW CF	REX ST	DELS RTHETA
1	.123199529E+01	.100000000E+01	0.	0.	0.
0.00000	0.	0.	0.	0.	0.
2	.112545237E+01	.100000000E+01	0.	.143218195E+04	.302433168E-03
.01646	.134631456E-03	.224637820E+01	.590454534E-01	0.	.117128536E+02
3	.112009320E+01	.100000000E+01	0.	.458408261E+04	.370588609E-03
.03334	.165559614E-03	.223839982E+01	.309406006E-01	0.	.227640884E+02
4	.106483668E+01	.100000000E+01	0.	.123746379E+05	.405997599E-03
.05845	.180145261E-03	.225372345E+01	.179919755E-01	0.	.381394504E+02
5	.102313159E+01	.100000000E+01	0.	.232171089E+05	.500740514E-03
.09110	.220751888E-03	.226834080E+01	.119654182E-01	0.	.562569685E+02
6	.104685073E+01	.100000000E+01	0.	.339474972E+05	.525776233E-03
.11625	.233045828E-03	.225610661E+01	.100968679E-01	0.	.680529934E+02
7	.103815838E+01	.100000000E+01	0.	.431185669E+05	.547046594E-03
.13579	.242102413E-03	.225956688E+01	.886087725E-02	0.	.768771142E+02
8	.103980139E+01	.100000000E+01	0.	.555487617E+05	.574030918E-03
.16093	.254038640E-03	.225962050E+01	.777352695E-02	0.	.876871515E+02
9	.105145851E+01	.100000000E+01	0.	.782608644E+05	.598470099E-03
.20049	.265392328E-03	.225503918E+01	.662795210E-02	0.	.103594705E+03
10	.105455433E+01	.100000000E+01	0.	.109709378E+05	.632242412E-03
.25070	.280448272E-03	.225439938E+01	.559228808E-02	0.	.122726459E+03
11	.107551630E+01	.100000000E+01	0.	.145687965E+05	.650779473E-03
.30088	.289715173E-03	.224627335E+01	.495445835E-02	0.	.140280667E+03
12	.109434530E+01	.100000000E+01	0.	.186062450E+05	.662223396E-03
.35105	.295719170E-03	.223936580E+01	.447347800E-02	0.	.156737053E+03
13	.111944982E+01	.100000000E+01	0.	.230749450E+05	.667497210E-03
.40121	.299243146E-03	.223061821E+01	.412348770E-02	0.	.172106079E+03
14	.115604731E+01	.100000000E+01	0.	.280965996E+05	.663302395E-03
.45136	.299057578E-03	.221797555E+01	.388122404E-02	0.	.186159279E+03
15	.116977927E+01	.100000000E+01	0.	.337746795E+05	.659402319E-03
.50152	.297216910E-03	.221522496E+01	.361055034E-02	0.	.200159823E+03
16	.132207400E+01	.100000000E+01	0.	.397511619E+05	.625593415E-03
.55168	.289212640E-03	.216309154E+01	.377810908E-02	0.	.208390055E+03
17	.175745960E+01	.100000000E+01	0.	.487342009E+05	.507353040E-03
.60057	.248443844E-03	.204212361E+01	.467764410E-02	0.	.201615688E+03
18	.197654087E+01	.100000000E+01	0.	.565877379E+05	.426197548E-03

.62559   .212542789E-03   .200523175E+01   .507123740E-02   0.   .192256863E+03

--- FORCE COEFFICIENTS ---

ALPHA = 22.9000 DEGREES

VISCOUS FLOW ANALYSIS

AIRFOIL PART NUMBER 1 ...

NO.	PR-N	PR-C	PR-M	FR-N	FR-C	FR-M
1	.0042	-.0012	.0011	.0000	.0000	.0000
2	.1137	-.0311	.0325	.0001	.0003	.0000
3	.1613	-.0653	.0510	.0002	.0004	.0001
4	.0878	-.0420	.0299	.0001	.0003	.0000
5	.1327	-.0810	.0482	.0003	.0005	.0001
6	.1320	-.0912	.0516	.0003	.0005	.0001
7	.1377	-.1155	.0583	.0004	.0005	.0002
8	.1268	-.1367	.0590	.0005	.0005	.0002
9	.1108	-.1465	.0568	.0004	.0003	.0002
10	.0807	-.1488	.0474	.0001	.0001	.0000
11	.0493	-.1531	.0366	.0002	.0001	.0001
12	.0105	-.1229	.0182	.0002	.0000	.0001
13	-.0156	-.1049	.0058	.0003	-.0000	.0001
14	-.0313	-.0768	-.0037	.0003	-.0001	.0001
15	-.0399	-.0505	-.0104	.0002	-.0002	.0001
16	-.0244	-.0181	-.0079	.0001	-.0001	.0001
17	-.0208	-.0106	-.0072	.0001	-.0002	.0001
18	-.0113	-.0022	-.0044	.0000	-.0001	.0000
19	-.0035	.0006	-.0015	-.0000	-.0001	.0000
20	.0014	-.0008	.0007	-.0000	-.0001	-.0000
21	.0034	-.0035	.0019	-.0000	-.0000	-.0000
22	.0020	-.0083	.0019	-.0000	-.0000	-.0000
23	.0010	-.0152	.0028	-.0000	-.0000	-.0000
24	.0039	-.0157	.0036	.0000	.0000	.0000
25	.0089	-.0226	.0053	.0000	.0000	.0000
26	.0137	-.0170	.0062	.0000	.0000	.0000
27	.0164	-.0204	.0068	.0000	.0000	.0000
28	.0095	-.0118	.0036	.0000	.0000	.0000
29	.0079	-.0100	.0028	.0000	.0000	.0000
30	.0194	-.0103	.0061	.0000	.0001	.0000
31	.0023	-.0011	.0007	.0001	.0002	.0000
32	-.0014	.0007	-.0004	.0000	.0000	.0000

```
--- COEFFICIENTS FOR AIRFOIL NUMBER  1 ---

--- PRESSURE FORCE COEFFICIENTS ---

        NORMAL FORCE COEFFICIENT (LOCAL)     =  8.1324

        CHORDWISE FORCE COEFFICIENT (LOCAL) = -1.5689

        NORMAL FORCE COEFFICIENT             =  1.0890

        LIFT COEFFICIENT                     =  1.6032

        CHORDWISE FORCE COEFFICIENT          = -1.5419

        DRAG COEFFICIENT                     =  -.9966

        PITCHING MOMENT COEFFICIENT          =   .5034

        POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,  0.0000)


--- FRICTIONAL FORCE COEFFICIENTS ---

        NORMAL FORCE COEFFICIENT (LOCAL)     =   .0037

        CHORDWISE FORCE COEFFICIENT (LOCAL) =   .0211

        NORMAL FORCE COEFFICIENT             =   .0039

        LIFT COEFFICIENT                     =   .0025

        CHORDWISE FORCE COEFFICIENT          =   .0129

        DRAG COEFFICIENT                     =   .0042

        PITCHING MOMENT COEFFICIENT          =   .0016

        POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,  0.0000)
```

--- FORCE COEFFICIENTS ---

ALPHA = 22.9000 DEGREES

VISCOUS FLOW ANALYSIS

AIRFOIL PART NUMBER 2 ...

NO.	PR-N	PR-C	PR-M	FR-N	FR-C	FR-M
1	.0016	.0002	-.0008	-.0000	.0000	.0000
2	.0371	.0048	-.0171	-.0000	.0000	.0000
3	.0463	.0056	-.0198	-.0000	.0001	.0000
4	.0467	.0048	-.0184	-.0000	.0001	.0000
5	.0500	.0052	-.0180	-.0000	.0001	.0000
6	.0842	.0071	-.0270	-.0000	.0002	.0000
7	.0927	.0060	-.0252	-.0000	.0003	.0000
8	.1023	.0043	-.0228	-.0000	.0003	.0000
9	.1125	.0016	-.0197	-.0000	.0004	.0000
10	.1224	-.0021	-.0155	.0000	.0004	.0000
11	.1325	-.0060	-.0104	.0000	.0004	.0000
12	.1443	-.0102	-.0047	.0000	.0005	.0000
13	.1587	-.0156	.0030	.0001	.0005	.0000
14	.1761	-.0232	.0119	.0001	.0006	.0000
15	.0975	-.0158	.0102	.0001	.0003	.0000
16	.1060	-.0196	.0137	.0001	.0004	.0000
17	.0924	-.0194	.0140	.0001	.0003	.0000
18	.1009	-.0251	.0173	.0001	.0004	.0000
19	.1099	-.0333	.0210	.0001	.0004	.0000
20	.0604	-.0214	.0125	.0001	.0003	.0000
21	.0663	-.0273	.0144	.0001	.0003	.0000
22	.0551	-.0284	.0124	.0001	.0003	.0000
23	.0409	-.0273	.0095	.0001	.0002	.0000
24	.0336	-.0303	.0080	.0000	.0001	.0000
25	.0240	-.0231	.0058	.0001	.0000	.0000
26	.0128	-.0309	.0032	.0001	.0000	.0000
27	.0010	-.0161	.0003	.0001	.0000	.0000
28	-.0017	-.0136	-.0004	.0001	-.0000	.0000
29	-.0059	-.0160	-.0014	.0001	-.0001	.0000
30	-.0081	-.0103	-.0019	.0001	-.0001	.0000
31	-.0053	-.0039	-.0013	.0001	-.0001	.0000
32	-.0015	-.0008	-.0004	.0000	-.0001	.0000
33	.0024	.0009	.0005	.0000	-.0001	.0000
34	.0064	.0018	.0014	.0000	-.0000	.0000
35	.0080	.0019	.0017	.0000	-.0000	.0000
36	.0181	.0032	.0036	.0000	-.0000	.0000
37	.0192	.0028	.0034	.0000	-.0000	.0000
38	.0197	.0024	.0031	.0000	-.0000	.0000
39	.0249	.0025	.0034	.0000	-.0000	.0000
40	.0249	.0021	.0027	-.0000	.0000	-.0000
41	.0495	.0034	.0036	-.0000	.0000	-.0000
42	.0487	.0023	.0012	-.0000	.0000	-.0000
43	.0475	.0014	-.0012	-.0000	.0000	-.0000
44	.0462	.0006	-.0035	-.0000	.0000	-.0000
45	.0449	-.0003	-.0056	.0000	.0000	-.0000
46	.0434	-.0013	-.0075	.0000	.0000	-.0000
47	.0420	-.0022	-.0093	.0000	.0000	-.0000
48	.0402	-.0027	-.0109	.0000	.0000	-.0000
49	.0768	-.0029	-.0118	.0000	.0001	-.0000

50	.0108	-.0007	-.0038	.0000	.0001	-.0000
51	.0014	-.0009	-.0005	.0000	.0000	-.0000
52	.0045	-.0078	-.0016	.0000	.0000	-.0000
53	.0129	-.0223	-.0051	.0001	.0000	-.0000
54	.0074	-.0128	-.0033	.0000	.0000	-.0000
55	.0079	-.0081	-.0035	.0000	.0000	-.0000
56	.0078	-.0022	-.0034	.0000	.0000	-.0000
57	.0199	0.0000	-.0087	0.0000	.0001	.0000
58	.0143	.0000	-.0067	-.0000	.0001	.0000
59	-.0007	.0000	.0001	.0000	.0000	.0000

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--- COEFFICIENTS FOR AIRFOIL NUMBER 2 ---

--- PRESSURE FORCE COEFFICIENTS ---

```
     NORMAL FORCE COEFFICIENT (LOCAL)     =  3.6865
     CHORDWISE FORCE COEFFICIENT (LOCAL) =  -.3751
     NORMAL FORCE COEFFICIENT             =  2.6952
     LIFT COEFFICIENT                     =  2.6497
     CHORDWISE FORCE COEFFICIENT          =  -.4288
     DRAG COEFFICIENT                     =   .6538
     PITCHING MOMENT COEFFICIENT          =  -.1093
     POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,   0.0000)
```

--- FRICTIONAL FORCE COEFFICIENTS ---

```
     NORMAL FORCE COEFFICIENT (LOCAL)     =   .0022
     CHORDWISE FORCE COEFFICIENT (LOCAL) =   .0099
     NORMAL FORCE COEFFICIENT             =   .0020
     LIFT COEFFICIENT                     =  -.0010
     CHORDWISE FORCE COEFFICIENT          =   .0372
     DRAG COEFFICIENT                     =   .0074
     PITCHING MOMENT COEFFICIENT          =   .0007
     POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,   0.0000)
```

--- FORCE COEFFICIENTS ---

ALPHA = 22.9000 DEGREES

VISCOUS FLOW ANALYSIS

AIRFOIL PART NUMBER 3 ...

NO.	PR-N	PR-C	PR-M	FR-N	FR-C	FR-M
1	-.0006	-.0005	.0006	0.0000	0.0000	0.0000
2	-.0115	-.0094	.0105	0.0000	0.0000	0.0000
3	-.0120	-.0099	.0106	0.0000	0.0000	0.0000
4	-.0121	-.0099	.0103	0.0000	0.0000	0.0000
5	-.0121	-.0099	.0099	0.0000	0.0000	0.0000
6	-.0121	-.0098	.0095	0.0000	0.0000	0.0000
7	-.0121	-.0098	.0091	0.0000	0.0000	0.0000
8	-.0121	-.0098	.0087	0.0000	0.0000	0.0000
9	-.0063	-.0050	.0044	0.0000	0.0000	0.0000
10	-.0059	-.0047	.0040	0.0000	0.0000	0.0000
11	-.0071	-.0057	.0047	-.0000	.0000	.0000
12	.0135	.0105	-.0084	-.0001	.0001	.0000
13	.0137	.0093	-.0082	-.0000	.0001	.0000
14	.0385	.0211	-.0223	-.0001	.0002	.0001
15	.0540	.0197	-.0302	-.0001	.0002	.0000
16	.0512	.0095	-.0277	-.0000	.0001	.0000
17	.0526	-.0002	-.0279	.0000	.0001	.0000
18	.0403	-.0099	-.0209	.0000	.0002	-.0000
19	.0218	-.0120	-.0111	.0001	.0001	-.0000
20	.0067	-.0065	-.0034	.0000	.0000	-.0000
21	.0045	-.0050	-.0022	.0000	.0000	-.0000
22	.0015	-.0025	-.0007	.0000	.0000	-.0000
23	.0010	-.0021	-.0005	.0000	.0000	-.0000
24	.0004	-.0022	-.0002	.0001	.0000	-.0000
25	.0001	.0009	-.0001	.0001	-.0000	-.0000
26	.0031	.0048	-.0016	.0000	-.0000	-.0000
27	.0040	.0029	-.0020	.0000	-.0000	-.0000
28	.0054	.0024	-.0027	.0000	-.0000	-.0000
29	.0076	.0034	-.0039	.0000	-.0000	-.0000
30	.0076	.0035	-.0040	-.0000	.0000	.0000
31	.0074	.0032	-.0040	-.0000	.0000	.0000
32	.0079	.0037	-.0043	-.0000	.0000	.0000
33	.0145	.0066	-.0081	-.0000	.0000	.0000
34	.0147	.0065	-.0083	-.0000	.0000	.0000
35	.0076	.0036	-.0045	-.0000	.0000	.0000
36	.0092	.0042	-.0055	-.0000	.0000	.0000
37	.0121	.0057	-.0075	-.0000	.0000	.0000
38	.0206	.0097	-.0132	-.0000	.0000	.0000
39	.0200	.0095	-.0173	-.0000	.0000	.0000
40	.0193	.0094	-.0135	-.0000	.0000	.0000
41	.0187	.0091	-.0135	-.0000	.0000	.0000
42	.0180	.0088	-.0135	-.0000	.0000	.0000
43	.0172	.0084	-.0134	-.0000	.0000	.0000
44	.0163	.0080	-.0132	-.0000	.0000	.0000
45	.0153	.0074	-.0128	-.0000	.0000	.0000
46	.0127	.0068	-.0111	-.0000	.0000	.0000
47	.0006	.0003	-.0005	-.0000	.0000	.0000

```
--- COEFFICIENTS FOR AIRFOIL NUMBER  3 ---
--- PRESSURE FORCE COEFFICIENTS ---
      NORMAL FORCE COEFFICIENT (LOCAL)     =  1.2385
      CHORDWISE FORCE COEFFICIENT (LOCAL)  =  -.4563
      NORMAL FORCE COEFFICIENT             =   .4551
      LIFT COEFFICIENT                     =   .3900
      CHORDWISE FORCE COEFFICIENT          =   .0751
      DRAG COEFFICIENT                     =   .2463
      PITCHING MOMENT COEFFICIENT          =  -.2559
      POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,  0.0000)

--- FRICTIONAL FORCE COEFFICIENTS ---
      NORMAL FORCE COEFFICIENT (LOCAL)     =   .0020
      CHORDWISE FORCE COEFFICIENT (LOCAL)  =   .0033
      NORMAL FORCE COEFFICIENT             =   .0000
      LIFT COEFFICIENT                     =  -.0005
      CHORDWISE FORCE COEFFICIENT          =   .0013
      DRAG COEFFICIENT                     =   .0012
      PITCHING MOMENT COEFFICIENT          =   .0000
      POINT ABOUT WHICH MOMENTS ARE TAKEN (   .5000,  0.0000)
```

--- FORCE COEFFICIENTS FOR THE TOTAL SYSTEM ---

--- PRESSURE FORCE COEFFICIENTS ---

NORMAL FORCE COEFFICIENT	= 4.2394
LIFT COEFFICIENT	= 4.6429
CHORDWISE FORCE COEFFICIENT	= -1.8957
DRAG COEFFICIENT	= -.0966
PITCHING MOMENT COEFFICIENT	= .1383
POINT ABOUT WHICH MOMENTS ARE TAKEN	(.5000, 0.0000)

--- FRICTIONAL FORCE COEFFICIENTS ---

NORMAL FORCE COEFFICIENT	= .0059
LIFT COEFFICIENT	= .0010
CHORDWISE FORCE COEFFICIENT	= .0114
DRAG COEFFICIENT	= .0128
PITCHING MOMENT COEFFICIENT	= .0023
POINT ABOUT WHICH MOMENTS ARE TAKEN	(.5000, 0.0000)

--- TOTAL FORCE COEFFICIENTS ---

NORMAL FORCE COEFFICIENT	= 4.2454
LIFT COEFFICIENT	= 4.6440
CHORDWISE FORCE COEFFICIENT	= -1.8842
DRAG COEFFICIENT	= -.0838
PITCHING MOMENT COEFFICIENT	= .1406
POINT ABOUT WHICH MOMENTS ARE TAKEN	(.5000, 0.0000)

APPENDIX III

PROGRAM LISTING

```
      SUBROUTINE  AFPLT                                                 XOPD0010
C  **                                                                   XOPD0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS  XOPD0030
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPD0040
     2     , KPAGE                                                      XOPD0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPD0060
     1     , CREF, CRFSQ, CRT, CSTH(10), DLTALM                         XOPD0070
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)   XOPD0080
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPD0090
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)  XOPD0100
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR    XOPD0110
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR                          XOPD0120
     7     , ZC(3), ZS(3),     RAIO(200)                                XOPD0130
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPD0140
     1     , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)           XOPD0150
     2     , XSLOC1(10), YSLOC1(10)                                     XOPD0160
C  **                                                                   XOPD0170
C  **              SUBROUTINE  AFPLT  PREPARES AIRFOIL  SYSTEM          XOPD0180
C  **         FOR ILLUSTRATION                                          XOPD0190
C  **                                                                   XOPD0200
      K = 0                                                             XOPD0210
C     WRITE (        ) NAFPTS            ***                    ***     XOPD0220
C  **                                                                   XOPD0230
      DO 20  I = 1, NAFPTS                                              XOPD0240
C  **                                                                   XOPD0250
      NN = NCPTS(I)                                                     XOPD0260
C     WRITE (        ) NN                ***                    ***     XOPD0270
C  **                                                                   XOPD0280
      DO 10  IA = 1, NN                                                 XOPD0290
C  **                                                                   XOPD0300
      K = K + 1                                                         XOPD0310
C  **                                                                   XOPD0320
      XA = (X(K) - XLR)/CREF                                            XOPD0330
      YA = (Y(K) - YLR)/CREF                                            XOPD0340
C  **                                                                   XOPD0350
C     WRITE (        ) XA, YA            ***                    ***     XOPD0360
10    CONTINUE                                                          XOPD0370
C  **                                                                   XOPD0380
20    CONTINUE                                                          XOPD0390
C  **                                                                   XOPD0400
      RETURN                                                            XOPD0410
C  **                                                                   XOPD0420
      END                                                               XOPD0430
```

```
      SUBROUTINE    BNPUT (INMAX, ITBFLA, LWRT, AX1, AUE1)
C
      COMMON/AQ/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)
     1     , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3)
     2     /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)
     3     , RHO(300) /A9/ RK(300), ROROE(300) /A10/T(300), TEMP(300)
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3
     1     , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE
     2     , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE
     3     , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17
     4     , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2
     5     , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3
     6     , CV3, DV3, EV3, AV4, BV4, CV4, DV4, FV4, AV5, BV5, CV5, DV5
     7     , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1
     8     , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3
     9     , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3
     .     , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB
      COMMON/B1/ BETA1(200), DUDX1(200),         IPN(200), MUE1(200)
     1      /B2/ PE1(200), RHOE1(200), SQUI11(200)
     2      /B3/ ETAE6, ETAE9, IMX6, IMX9, LTRAN, LL, Q, THETA, RTHETA
     3     , INSTA, IBUB, GPW1(200), TE1(200)
     4      /B4/ UE1(200), X1(200)
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK
     1     , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)
     2     , ITRAN(20),                                   BPDEL(200)
      LOGICAL LINCO, LTRAN, LWRT
      REAL MUEO, MUE1
      DIMENSION AX1(200), AUE1(200), XY(200)
      DIMENSION A(25)
      DATA IZERO, IONE, ITWO, ITHREE, ZERO, ONE /0, 1, 2, 3, 0.0, 1.0/
      DATA A / 0.1557982 E-13, 0.6348393 E-07, 0.14964577 E-06, 0.1 E-05
     1          , 0.002378, C.005, 0.2 , 0.28465
     2          , 0.28571, 0.5, 0.500662, 0.999999
     3          , 1.238522, 1.436156, 1.5, 2.0
     4          , 3.5, 3.5165, 7.99999, 49.1
     5          , 99.99999, 5000., 6035., 1.194930 E+06, 3.7E+07 /
      LINCO = ICFLAG .EQ. IONE
      BETA1(1) = ONE
      NMAX = INMAX
      NN = NMAX + IONE
      ISEPTB = ITBFLA
      LTRAN = .TRUE.
      IF  (ISEPTB .GE. IZERO) GO  TO 10
      ISEPTB = NN
      LTRAN = .FALSE.
10    CONTINUE
      HE = HETEM
      GK = GRIDK
      PRO = RRO
      RHOEO = XRHOEO
      MUEO = AVSUBM
      A0 = AUSUBI
      CHORD = ACREF
      DO 20 I = 1, NN
      X1(I) = AX1(I)
      UE1(I) = AUE1(I)
```

```
      GPW1(I) = ZERO                                                    XOPS0570
      PE1(I) = ZERO                                                     XOPS0580
20    CONTINUE                                                          XOPS0590
      IPRNT = IIPR                                                      XOPS0600
      IF  (LINCO) UE1(1) = A(12)                                        XOPS0610
C                                                                       XOPS0620
      IPN(1) = IZERO                                                    XOPS0630
      IPN(2) = ITWO                                                     XOPS0640
      DO 30 I = 3, NN                                                   XOPS0650
      IPN(I) = ITHREE                                                   XOPS0660
30    CONTINUE                                                          XOPS0670
      T1 = ZERO                                                         XOPS0680
      VEL = A0                                                          XOPS0690
      REY = RHOEO                                                       XOPS0700
C                                                                       XOPS0710
C                                                                       XOPS0720
      AO = A(23) * HE                                                   XOPS0730
      IF  (MUEO .EQ. ZERO) GO  TO 40                                    XOPS0740
      VEL = A(20) * MUEO *  SQRT(HE)                                    XOPS0750
      GMEO = A(7) * MUEO * MUEO                                         XOPS0760
      GO  TO 50                                                         XOPS0770
40    CONTINUE                                                          XOPS0780
      GMEO = A(11) * VEL * VEL / AO                                     XOPS0790
50    CONTINUE                                                          XOPS0800
      HE = AO * (ONE + GMEO)                                            XOPS0810
      MUEO = A(4) * ( A(3) * AO + A(13) - SQRT(A(1) * AO * AO + A(2) *  XOPS0820
     1       AO + A(14) ) )                                             XOPS0830
      RHOEO = REY   * MUEO / (VEL * CHORD)                              XOPS0840
      IF  (LINCO) GO  TO 70                                             XOPS0850
      PEO = A(8) * RHOEO * AO                                           XOPS0860
      IF  (AO .GT. ZERO) AO = MUEO * (AO + A(24)) / AO ** A(15)         XOPS0870
      DO 60 I = 1, NN                                                   XOPS0880
C                                                                       XOPS0890
C     IF CP-FLAG NE 0 CALCULATE VELOCITIES FROM CP DISTRIBUTION         XOPS0900
C                                                                       XOPS0910
      UE1(I) = SQRT (ONE -(((ONE + A(17) * GMEO * UE1(I)) ** A(9))      XOPS0920
     1         - ONE) / GMEO)                                           XOPS0930
      UE1(I) = UE1(I) * VEL                                             XOPS0940
      Q = HE - UE1(I) * UE1(I) * A(10)                                  XOPS0950
      IF  ( ( Q .LT. A(22)) .OR. (Q .GT. A(25))) GO  TO 250             XOPS0960
      T1 = Q                                                            XOPS0970
      TE1(I) = T1                                                       XOPS0980
      PE1(I) = (ONE + GMEO * (ONE - (UE1(I)*UE1(I)/(VEL*VEL))))** A(17) XOPS0990
      PE1(I) = PE1(I) * PEO                                             XOPS1000
      RHOE1(I) = A(18) * PE1(I) / TE1(I)                                XOPS1010
      MUE1(I) = AO * Q ** A(15) / (Q + A(24))                           XOPS1020
60    CONTINUE                                                          XOPS1030
      GO  TO 90                                                         XOPS1040
70    DO 80 I= 1,NN                                                     XOPS1050
C                                                                       XOPS1060
C     IF CP-FLAG NE 0 CALCULATE VELOCITIES FROM CP DISTRIBUTION         XOPS1070
C                                                                       XOPS1080
      UE1(I) = VEL * SQRT (ONE - UE1(I))                                XOPS1090
      RHOE1(I) = RHOEO                                                  XOPS1100
      MUE1(I) = MUEO                                                    XOPS1110
      TE1(I) = T1                                                       XOPS1120
```

```
80    CONTINUE
90    CONTINUE
C
C     IF F-FLAG=0 CALCULATE FW AND SQUIG
C
      FP = RHOE1(1) * UE1(1) * MUE1(1)
        SQUI11(1) = RHOE1(1) * MUE1(1) * UE1(1) * X1(1)
      DO 100 I = 2, NN
      F2 = RHOE1(I) * UE1(I) * MUE1(I)
      W = X1(I) - X1(I-1)
      SQUI11(I) = SQUI11(I-1) + (FP+F2) * A(10) * W
      FP = F2
100   CONTINUE
C
C     IF B-FLAG =0 CALCULATE BETA
C
      DO 150 I = 2, NN
      IF  (UE1(I-1).NE.UE1(I)) GO  TO 110
      IF (I.EQ.NN) GO  TO 130
      IF  (UE1(I).EQ.UE1(I+1)) GO  TO 130
110   IF (I.EQ.NN) GO  TO 120
      SQ1 =X1(I-1)
      SQ2 =X1(I)
      SQ3 =X1(I+1)
      FK10 = -(SQ2-SQ3)/(SQ1-SQ2)/(SQ3-SQ1)
      FK11 = -(SQ2+SQ2-SQ3-SQ1) / (SQ2-SQ3) / (SQ1-SQ2)
      FK12 = (SQ1-SQ2)/(SQ2-SQ3)/(SQ3-SQ1)
      DUDX1(I) = FK10 * UE1(I-1) + FK11 * UE1(I) + FK12 * UE1(I+1)
      GO  TO 140
120   FK10 = (SQ3-SQ2)/(SQ1-SQ2)/(SQ1-SQ3)
      FK11 = (SQ3-SQ1)/(SQ2-SQ1)/(SQ2-SQ3)
      FK12 = (SQ3+SQ3-SQ1-SQ2) / (SQ3-SQ1) / (SQ3-SQ2)
      I2 = I- ITWO
      IM = I- IONE
      DUDX1(I   )=FK10 * UE1(I2 ) + FK11 * UE1(IM)+ FK12 * UE1(I   )
      GO  TO 140
130   DUDX1(I) = ZERO
140   CONTINUE
      BETA1(I) = SQUI11(I) * DUDX1(I)  / UE1(I)
      BETA1(I) = BETA1(I) +  BETA1(I)
      BETA1(I)=BETA1(I)/ (UE1(I)*RHOE1(I)*MUE1(I))
150   CONTINUE
C
C     CALCULATE ETAE
C
      I = IONE
      E(1) = ZERO
      DH(1) = A(6)
160   I = I + IONE
      DH(I) = DH(I-1) * GK
      E(I) = E(I-1) + DH(I-1)
      IF  (E(I) .LT. A(19)) GO  TO 160
      ETAE6 = E(I)
      IMX6 = I
170   CONTINUE
      I = I + IONE
```

```
      DH(I) = DH(I-1) * GK
      E(I) = E(I-1) + DH(I-1)
      IF  (E(I) .LT. A(21)) GO  TO 170
      ETAE9 = E(I)
      IMX9 = I
      IMAX = IMX6
      I = I + IONE
      E(I) = E(I-1) + DH(I-1)
      DH(I) = DH(I-1) * GK
C
C     OUTPUT CASE DATA
C
      T1 = HE - VEL * VEL * A(10)
      Q = T1 / A(23)
      IF  (LWRT) GO  TO 180
      GO  TO 220
180   CONTINUE
      WRITE  (6,270)
      IF  (LINCO) GO  TO 190
      WRITE  (6,280)  RRO, AVSUBM
      GO  TO 200
190   CONTINUE
      WRITE  (6,290)  AUSUBI
200   CONTINUE
      IF  (ISEPTB .NE. NN) WRITE (6,300)  ISEPTB
      WRITE  (6,310)  NN, HETEM, GRIDK, ACREF, AEPS
C
C     OUTPUT STATION DATA
C
      IF  (IPRNT .EQ. IZERO) GO  TO 220
      CALL  HEADR
      WRITE  (6,320)
      WRITE  (6,330)
      LCMAX = 40
      LC = IONE
      DO 210 I = 1, NN
      XY(I) = X1(I) / CHORD
      TE1(I) = TE1(I) / A(23)
      WRITE  (6,340)  I  , X1(I), UE1(I), MUE1(I), IMX6  , XY(I)
      WRITE  (6,350)  BETA1(I), PE1(I),        RHOE1(I), IPN(I)
      WRITE  (6,360)  SQUI11(I), ETAE6  , GPW1(I), TE1(I)
      TE1(I) = TE1(I) * A(23)
      IF  (I .EQ. NN) GO  TO 210
      LC = LC + 4
      IF  (LC.LE.LCMAX) GO  TO 210
      CALL  HEADR
      WRITE  (6,320)
      WRITE  (6,330)
      LC = IONE
210   CONTINUE
220   CONTINUE
      NN = NMAX + IONE
      DO 240 I=2,NN
      IF (X1(I) .GT. X1(I-1)) GO  TO 230
      WRITE  (6,370)  I
      CALL  EXIT
```

```
230   CONTINUE                                                    XOPS2250
240   CONTINUE                                                    XOPS2260
      CALL  BN1CAL  (IPRNT, LWRT)                                 XOPS2270
      ITBFLA = ISEPTB                                             XOPS2280
      RETURN                                                      XOPS2290
C                                                                 XOPS2300
C     WRITE OUT FATAL INPUT ERROR MESSAGES                        XOPS2310
C                                                                 XOPS2320
250   CONTINUE                                                    XOPS2330
      WRITE  (6,260)  Q,I                                         XOPS2340
      CALL  EXIT                                                  XOPS2350
      RETURN                                                      XOPS2360
C                                                                 XOPS2370
260   FORMAT  (1H0, 54H *** IN SUBROUTINE BNPUT, TEMPERATURE IS OUT OF RXOPS2380
     1ANGE,  E13.6, 5X, 12HCHECK HE,UE(, I3,  6H ) *** )         XOPS2390
270   FORMAT  (1H0 // 1H0, 17H*** CASE DATA ***  // )             XOPS2400
280   FORMAT  (1H0, 26H  -- COMPRESSIBLE FLOW ... /               XOPS2410
     1         1H0, 37H  -- PRANDTL NUMBER = , E12.4, 4H ... /    XOPS2420
     2          1H , 19H  -- MACH NUMBER = , E12.4, 4H ... )      XOPS2430
290   FORMAT  (1H0, 28H  -- INCOMPRESSIBLE FLOW ... /             XOPS2440
     1          1H0, 28H  -- FREE STREAM VELOCITY = , E12.4,  8H(FT/SEC)/XOPS2450
     2)                                                           XOPS2460
300   FORMAT  (1H , 37H  -- FLOW IS TURBULENT AFTER STATION ,I3,4H ... )XOPS2470
310   FORMAT  (1H , 34H  -- TOTAL NUMBER OF X-STATIONS = , I3, 4H ... / XOPS2480
     1          1H , 26H  -- STATIC TEMPERATURE = , E12.4, 4H ... /   XOPS2490
     2          1H , 22H  -- GRID PARAMETER = , E15.7, 4H ... /       XOPS2500
     3          1H , 23H  -- REFERENCE CHORD = , E12.4, 4H ... /      XOPS2510
     4          1H , 27H  -- CF SEPARATION LEVEL = , E12.4, 4H ... )  XOPS2520
320   FORMAT  (1H0, 20H*** STATION DATA ***/)                     XOPS2530
330   FORMAT  (1H0,          7X, 1HN, 11X, 1HS, 16X, 2HFW, 17X, 1HR, 16XXOPS2540
     1,    2HUE, 16X, 3HMUE, 9X, 4HIMAX,  9X, 3HX/C /             XOPS2550
     2     18X, 4HBETA, 13X, 5HRHOVW, 15X,                        XOPS2560
     3     2HPE, 15X, 4HCOSA, 14X, 4HRHOE, 9X, 3HIPN / 17X, 5HSQUIG, 14XXOPS2570
     4,    4HETAE, 15X, 2HGW, 15X, 3HGPW, 14X, 5HTEMPE, 8X, 6HIPRINT/// XOPS2580
     5)                                                           XOPS2590
340   FORMAT  (1H , 4X, I4, E18.7, 5X, 3H0.0, 15X, 3H0.0, 10X, 2E18.7,  XOPS2600
     1          I7, E18.7 )                                       XOPS2610
350   FORMAT  (1H , 8X, E18.7, 5X, 3H0.0, 10X, E18.7, 5X, 3H0.0, 10X,   XOPS2620
     1          E18.7, I6 )                                       XOPS2630
360   FORMAT  (1H , 8X, 2E18.7, 5X, 3H0.0, 10X, 2E18.7, 5X, 1H0 / )     XOPS2640
370   FORMAT  (1H0, 75H *** IN SUBROUTINE BNPUT, DEVELOPED LENGTH IS NOTXOPS2650
     1 IN ASCENDING ORDER AT I = , I3, 4H *** )                   XOPS2660
      END                                                         XOPS2670
```

```
      SUBROUTINE  BN1CAL  (IPRNT, LWRT)                                 XOPT0010
C                                                                       XOPT0020
C                                                                       XOPT0030
      COMMON/AQ/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)       XOPT0040
     1    , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3)  XOPT0050
     2    /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)XOPT0060
     3    , RHO(300) /A9/ RK(300), RORDE(300) /A10/T(300), TEMP(300)    XOPT0070
     4    /A11/ PHIP(300, 3)                                            XOPT0080
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3             XOPT0090
     1    , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE      XOPT0100
     2    , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE       XOPT0110
     3    , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17    XOPT0120
     4    , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2XOPT0130
     5    , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3  XOPT0140
     6    , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5  XOPT0150
     7    , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1  XOPT0160
     8    , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3   XOPT0170
     9    , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3  XOPT0180
     .    , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB      XOPT0190
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK                  XOPT0200
     1    , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)          XOPT0210
     2    , ITRAN(20),                                     BPDEL(200)   XOPT0220
     3    /B3/ ETAE6, ETAE9, IMX6, IMX9, LTRAN, LL, Q, THETA, RTHETA    XOPT0230
     4    , INSTA, IBUB, GPW1(200), TE1(200)                            XOPT0240
     5     /B4/ UE1(200), X1(200)                                       XOPT0250
      COMMON/BLOCKJ/CFF(200), CFDE(200)                                 XOPT0260
      LOGICAL LINCO, LTRAN, LWRT                                        XOPT0270
      DIMENSION A(7), SPHIPP(300), SPHPPP(300)                          XOPT0280
      DIMENSION SPHI (300, 3), SPHIP(300, 3), SPSI(300, 3)              XOPT0290
      DATA  IZERO, IONE, ITWO, IFOUR, I18, I36, ZERO, ONE               XOPT0300
     1    /0, 1, 2, 4, 18, 36, 0.0, 1.0 /                               XOPT0310
      DATA  A / - 0.09,  0.005,  0.01,  0.0671429, 0.1257143, 125.0,    XOPT0320
     1      6346.39 /                                                   XOPT0330
C                                                                       XOPT0340
      EPS1 = A(2)                                                       XOPT0350
      PHI (1,2) = ZERO                                                  XOPT0360
      PHI (1,3) = ZERO                                                  XOPT0370
      PHIP(1,2) = ZERO                                                  XOPT0380
      PHIP(1,3) = ZERO                                                  XOPT0390
      PSI (1,1) = ONE                                                   XOPT0400
      CALL  CSCNST (IPRNT)                                              XOPT0410
      ISTN = IZERO                                                      XOPT0420
      IBUB = IZERO                                                      XOPT0430
      DELS = ZERO                                                       XOPT0440
      CALL  STCNST ( 1, IPRNT)                                          XOPT0450
      IMMTM = ITWO                                                      XOPT0460
      CALL  FLPR  (IMMTM)                                               XOPT0470
      CALL  EDYVSC                                                      XOPT0480
      CALL  STZERO (IPRNT)                                              XOPT0490
      DO 10 I = 2, IMAX                                                 XOPT0500
      PHI (I,2) = ZERO                                                  XOPT0510
      PHI (I,3) = ZERO                                                  XOPT0520
      PHIP(I,2) = ZERO                                                  XOPT0530
      PHIP(I,3) = ZERO                                                  XOPT0540
      PSI (I,1) = ZERO                                                  XOPT0550
      PSI (I,2) = ZERO                                                  XOPT0560
```

```
      PSI (I,3) = ZERO                                                  XOPT0570
10    CONTINUE                                                          XOPT0580
      PHIPPW = PHIPP(1)                                                 XOPT0590
      NMAX1 = NMAX + IONE                                               XOPT0600
      IXS = IONE                                                        XOPT0610
      IF  (.NOT. LWRT) GO  TO 20                                        XOPT0620
      CALL  HEADR                                                       XOPT0630
      WRITE  (6,300)                                                    XOPT0640
C  **                                                                   XOPT0650
20    CONTINUE                                                          XOPT0660
C  **                                                                   XOPT0670
      IS = IXS                                                          XOPT0680
      DO 180 IX = IS, NMAX1                                             XOPT0690
      IXS = IX                                                          XOPT0700
      MEAN = IZERO                                                      XOPT0710
      IF  (ISTN .EQ. IZERO) GO  TO 40                                   XOPT0720
      CALL  STCNST (IX, IPRNT)                                          XOPT0730
      CALL  EDYVSC                                                      XOPT0740
      IF  (LWRT) GO  TO 30                                              XOPT0750
      GO  TO 40                                                         XOPT0760
30    CONTINUE                                                          XOPT0770
      IF  (IPRINT .NE. IZERO) WRITE  (6,290)  ISTN, X                   XOPT0780
C                                                                       XOPT0790
C     Q  -  L  O  O  P                                                  XOPT0800
C                                                                       XOPT0810
40    DO 140 K = 1, 2                                                   XOPT0820
      IF  (IPRNT .EQ. IZERO ) GO  TO 50                                 XOPT0830
      IF  (LWRT) WRITE  (6,320)  K                                      XOPT0840
50    CONTINUE                                                          XOPT0850
      IF  (ISTN .LT. ISEPTB) GO  TO 110                                 XOPT0860
      GO  TO 70                                                         XOPT0870
60    CALL  ENERGY                                                      XOPT0880
      IMMTM = IONE                                                      XOPT0890
      CALL  FLPR  (IMMTM)                                               XOPT0900
      CALL  EDYVSC                                                      XOPT0910
C                                                                       XOPT0920
C     CONVERGENCE CRITERION FOR FPPW                                    XOPT0930
C                                                                       XOPT0940
      IF (ABS((PHIPP(1)-PHIPPW)/(PHIPP(1)+PHIPPW)) .LT. EPS1) GO  TO 150XOPT0950
      PHIPPW = PHIPP(1)                                                 XOPT0960
      GO  TO 110                                                        XOPT0970
70    CONTINUE                                                          XOPT0980
      KD = IONE                                                         XOPT0990
      KDMAX = I36                                                       XOPT1000
80    CALL  MOMTUM   (MEAN)                                             XOPT1010
      IF  (PHIPP(1) .LT. ZERO) GO  TO 190                               XOPT1020
      X2 = DELS                                                         XOPT1030
      CALL  EDYVSC                                                      XOPT1040
      IF  (LINCO) GO  TO 90                                             XOPT1050
      GO  TO 60                                                         XOPT1060
90    CONTINUE                                                          XOPT1070
C                                                                       XOPT1080
C     CONVERGENCE CRITERION FOR DELS                                    XOPT1090
C                                                                       XOPT1100
      IF  (ABS((X2 - DELS) / (X2 + DELS)) .LT. EPS1) GO  TO 100         XOPT1110
      IF  (KD .GT. KDMAX ) GO  TO 100                                   XOPT1120
```

```
      KD = KD + IONE
      GO  TO 80
100   PHIPPW = PHIPP(1)
      IF  (KD .GT. KDMAX ) WRITE  (6,330)  KD
C
C     K   -   L   O   O   P
C
110   DO 130 K1 = 1, 9
      CALL  MOMTUM    (MEAN)
      IF  (PHIPP(1) .LT. ZERO) GO  TO 190
C
      CALL  EDYVSC
      IF  (LINCO) GO  TO 120
      GO  TO 60
120   CONTINUE
C
C     CONVERGENCE CRITERION FOR FPPW
C
      IF  (ABS ((PHIPP(1) - PHIPPW) / (PHIPP(1) + PHIPPW)) .LT. EPS1) GO
     1 TO 150
130   PHIPPW = PHIPP(1)
140   CONTINUE
      KQMAX = I18
      WRITE  (6,340)  KQMAX
150   CALL  BN1OUT (IX, LWRT)
      DO 170 J = 1, IMAX
      DO 160 IR= 1, 2
      II = IFOUR - IR
      PHI(J,II) = PHI(J,II-1)
      SPHI(J, II) = PHI(J, II-1)
      SPHIP(J, II) = PHIP(J, II-1)
      SPSI(J, II) = PSI(J, II-1)
      PHIP(J,II) = PHIP(J,II-1)
160   PSI(J,II) = PSI(J,II-1)
      SPHIPP(J) = PHIPP(J)
      SPHPPP(J) = PHIPPP(J)
170   CONTINUE
      ISTN = ISTN + IONE
      SP1 = X
180   CONTINUE
      RETURN
190   CONTINUE
      IF  (LTRAN) GO  TO 250
      IF  (IXS .GT. ISEPTB) GO  TO 250
C
C     LAMINAR BUBBLE BURST EVALUATION
C
      Y = THETA
      Y = Y * Y
      Y = Y * A(7)
      W = X
      SP1 = W - SP1
      BB = Y * ( UE1(IXS) - UE1(IXS-1)) / SP1
      IF  (RTHETA .LT. A(6)) GO  TO 200
      BX = RTHETA
      BX = BX * A(3)
```

```
      BX = A(4) - A(5) * BX                                             XOPT1690
      IF  ( BB .LT. BX) GO  TO 240                                      XOPT1700
      GO  TO 210                                                        XOPT1710
200   CONTINUE                                                          XOPT1720
      IF  ( BB .LT. A(1)) GO  TO 240                                    XOPT1730
210   CONTINUE                                                          XOPT1740
      LTRAN = .TRUE.                                                    XOPT1750
      ISEPTB = IXS - IONE                                               XOPT1760
      IBUB = IXS                                                        XOPT1770
      DO 230 J = 1, IMAX                                                XOPT1780
      DO 220 II = 2, 3                                                  XOPT1790
      PHI(J, II) = SPHI(J, II)                                          XOPT1800
      PHIP(J, II) = SPHIP(J, II)                                        XOPT1810
      PSI(J, II) = SPSI(J, II)                                          XOPT1820
220   CONTINUE                                                          XOPT1830
      PHI (J, 1) = SPHI (J, 2)                                          XOPT1840
      PHIP(J, 1) = SPHIP(J, 2)                                          XOPT1850
      PSI (J, 1) = SPSI (J, 2)                                          XOPT1860
      PHIPP (J) = SPHIPP(J)                                             XOPT1870
      PHIPPP(J) = SPHPPP(J)                                             XOPT1880
230   CONTINUE                                                          XOPT1890
      GO  TO 20                                                         XOPT1900
240   CONTINUE                                                          XOPT1910
      WRITE  (6,270)                                                    XOPT1920
C  **                                                                   XOPT1930
250   CONTINUE                                                          XOPT1940
C  **                                                                   XOPT1950
      WRITE  (6,350)                                                    XOPT1960
      ISEPA = IXS                                                       XOPT1970
      IXS = IXS - IONE                                                  XOPT1980
      IF  (IXS .LT. ISEPTB) WRITE  (6,310)                              XOPT1990
      BPDE(IXS+1) = BPDE(IXS-1) + (BPDE(IXS) - BPDE(IXS-1)) *           XOPT2000
     1     (X1(IXS+1) - X1(IXS-1)) / (X1(IXS) - X1(IXS-1))              XOPT2010
      IA = IXS + ITWO                                                   XOPT2020
      IB = IXS + IONE                                                   XOPT2030
      DO 260 I = IA, NMAX1                                              XOPT2040
      BPDE (I) = BPDE(IB)                                               XOPT2050
260   CONTINUE                                                          XOPT2060
      CFDE(ISEPA) = CFDE(IXS)                                           XOPT2090
      RETURN                                                            XOPT2100
C                                                                       XOPT2110
270   FORMAT  (1H0, 34H LAMINAR BUBBLE BURST HAS OCCURRED )             XOPT2120
290   FORMAT  (1H0,        11HSTATION NO. , I4, 92X, 3HX =, F9.4 // )   XOPT2160
300   FORMAT  (1H0, 31H*** CALCULATED STATION DATA *** // )             XOPT2170
310   FORMAT  (1H0, 29X, 67HLAMINAR BOUNDARY LAYER DISPLACEMENT THICKNESXOPT2180
     1S USED IN EXTRAPOLATION )                                         XOPT2190
320   FORMAT  (1H0, 28X, 3HQ =, I2)                                     XOPT2200
330   FORMAT  (1H0, 40X, 36HWARNING-DELS DOES NOT CONVERGE AFTER  ,1X,  XOPT2210
     1    I3,  12H ITERATIONS  /       )                                XOPT2220
340   FORMAT  (1H0, 40X, 36HWARNING-FPPW DOES NOT CONVERGE AFTER  ,1X,  XOPT2230
     1    I3,  12H ITERATIONS  /       )                                XOPT2240
350   FORMAT  (1H0, 46X, 25HFLOW SEPARATION INDICATED  /                XOPT2250
     1        1H0, 40X, 37HFPPW IS NEGATIVE - ITERATIONS DIVERGE )      XOPT2260
      END                                                               XOPT2270
```

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      SUBROUTINE  BN1OUT (IK, LWRT)                                     XOP10010
C                                                                       XOP10020
C     CALCULATE  AND  PRINT  PROFILE  DATA                              XOP10030
C                                                                       XOP10040
      COMMON/AQ/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)       XOP10050
     1      , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3) XOP10060
     2      /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)XOP10070
     3      , RHO(300) /A9/ RK(300), ROROE(300) /A10/T(300), TEMP(300)   XOP10080
     4      /A11/ PHIP(300, 3)                                          XOP10090
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS  XOP10100
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOP10110
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3             XOP10120
     1      , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE     XOP10130
     2      , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE      XOP10140
     3      , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17   XOP10150
     4      , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2XOP10160
     5      , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3 XOP10170
     6      , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5 XOP10180
     7      , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1 XOP10190
     8      , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3  XOP10200
     9      , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3 XOP10210
     .      , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB     XOP10220
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK                  XOP10230
     1      , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)         XOP10240
     2      , ITRAN(20),                                  BPDEL(200)     XOP10250
     3       /B3/ ETAE6, ETAE9, IMX6, IMX9, LTRAN ,LL, Q, THETA, RTHETA  XOP10260
     4      , INSTA, IBUB, GPW1(200), TE1(200)                          XOP10270
     5       /B4/ UE1(200), X1(200)                                     XOP10280
      COMMON/BLOCKJ/CFF(200), CFDE(200)                                 XOP10290
      LOGICAL LINCO, LINSTA, LTRAN, LWARD, LWRT                         XOP10300
      REAL MU, MUE, NUS                                                 XOP10310
      DIMENSION A(5), B(5)                                              XOP10320
      DIMENSION HD(22)                                                  XOP10330
      DATA  HD / 10H        N    , 10H            , 10H FPPW      ,     XOP10340
     1           10H             , 10H  GW        , 10H           ,     XOP10350
     2           10H GPW         , 10H            , 10H  REX      ,     XOP10360
     3           10H             , 10H DELS       , 10H        S  ,     XOP10370
     4           10H             , 10H THETA      , 10H           ,     XOP10380
     5           10H  H          , 10H            , 10H CF        ,     XOP10390
     6           10H             , 10H  ST        , 10H           ,     XOP10400
     7           10H RTHETA    /                                        XOP10410
      DATA  A / 5.46714219557, 43.3219502720, 235.246325555             XOP10420
     1      , 1934.42113442, 30387.8829816 /, B / 6.81065800504         XOP10430
     2      , 29.2794787857, 45.6794795736, 2615.87876671, 38397.7592236 XOP10440
     3      /, HALF / 0.5 /                                             XOP10450
      IPRT = IMAX / 30                                                  XOP10460
      IF  ( IMAX .LT. 30) IPRT = 1                                      XOP10470
      IF  (IK .NE. 1) GO  TO 30                                         XOP10480
      LINSTA = .FALSE.                                                  XOP10490
      V = 6346.3857                                                     XOP10500
      TRINT = 0.0                                                       XOP10510
      NMAX1 = NMAX + 1                                                  XOP10520
      IF  (LWRT) GO  TO 10                                              XOP10530
      GO  TO 20                                                         XOP10540
10    CONTINUE                                                          XOP10550
      WRITE  (6,170)  HD                                                XOP10560
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20    CONTINUE                                                              XOP10570
      A1= 0.                                                                XOP10580
      CF= 0.                                                                XOP10590
      E1= 0.                                                                XOP10600
      H = 0.                                                                XOP10610
      ST  =0.                                                               XOP10620
      LWARD = IND(15) .EQ. 0                                                XOP10630
      INSTA = 0                                                             XOP10640
      GO TO 40                                                              XOP10650
30    CONTINUE                                                              XOP10660
      IF  (LINCO) NUS = E(IMAX)                                             XOP10670
40    A5 =  NUS - PHI(IMAX,1) + PHI(1,1)                                    XOP10680
      DELS = A1 * A5                                                        XOP10690
C                                                                           XOP10700
C     CALCULATE  STATION  DATA (THETA, H, CF, ST)                           XOP10710
C     AND PRINT STATION DATA                                                XOP10720
C     ( PHIPPW, GW, GPW, REX, DELS, THETA, H, CF, ST )                      XOP10730
C                                                                           XOP10740
      SUM = 0.0                                                             XOP10750
      FA = 0.                                                               XOP10760
      IPMX = 1 + (IMAX/IPRT) * IPRT                                         XOP10770
      IF  (IPRT .LE.1 ) IPMX = IMAX                                         XOP10780
      IF  (PHIP(IMAX,1) .LT. 0.995  ) WRITE  (6,210)  E(IPMX)               XOP10790
      IF (PHIPP(IMAX)  .GT.  0.1E-02      ) WRITE (6,210)  E(IPMX)          XOP10800
      DO 50 I = 2, IMAX                                                     XOP10810
      F2 = -PHIP(I,1) * (PHIP(I,1)-1.00)                                    XOP10820
      SUM = SUM + (FA + F2) * HALF * DH(I-1)                                XOP10830
      FA = F2                                                               XOP10840
50    CONTINUE                                                              XOP10850
      THETA = A1 * SUM                                                      XOP10860
      IF  ( X .EQ. 0.0) GO  TO 60                                           XOP10870
      H = DELS / THETA                                                      XOP10880
      CF = 2.00/SQTSQ      * RHO(1) / RHOE * MU(1) * PHIPP(1)               XOP10890
      PRO = PR(1)                                                           XOP10900
      ST = 0.                                                               XOP10910
      IF  ( ( PRO .NE. 0.00) .AND. ( PSI(1,1) .NE. 1.00) ) ST = RHO(1)*MXOP10920
     1U(1)*PSIP(1)/(PRO*RHOE*SQTSQ*(1.00-PSI(1,1)))                         XOP10930
60    CONTINUE                                                              XOP10940
      E1 = THETA * UE * RHOE / MUE                                          XOP10950
      IF  (LTRAN) GO  TO 110                                                XOP10960
      IF  (LWARD) GO  TO 80                                                 XOP10970
C                                                                           XOP10980
C     TRANSITION POINT - SCHLICTING, ULRICH METHOD                          XOP10990
C                                                                           XOP11000
      IF  (LINSTA) GO  TO 70                                                XOP11010
      IF  (IK .EQ. 1) GO  TO 110                                            XOP11020
      IF  (IK .GE. NMAX1) GO  TO 110                                        XOP11030
      TRK = THETA * THETA * V * (UE1(IK+1)-UE1(IK))/(X1(IK+1)-X1(IK))       XOP11040
      IF  (TRK .GT. 0.06) GO  TO 110                                        XOP11050
      TRK2 = TRK * TRK                                                      XOP11060
      TRK3 = TRK * TRK2                                                     XOP11070
      TRK4 = TRK * TRK3                                                     XOP11080
      TREOR =      (A(1) + A(2)*TRK + A(3)*TRK2 - A(4)*TRK3 - A(5)*TRK4)    XOP11090
      IF  (E1 .LE. 0.0) GO  TO 110                                          XOP11100
      IF  (ALOG(E1) .LT. TREOR) GO  TO 110                                  XOP11110
      INSTA = IK                                                            XOP11120
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      LINSTA = .TRUE.                                                   XOP11130
      TUESP  = TRK                                                      XOP11140
      TMINS = E1                                                        XOP11150
      GO  TO 110                                                        XOP11160
C                                                                       XOP11170
70    CONTINUE                                                          XOP11180
C                                                                       XOP11190
      TUES = THETA * THETA * V *(UE1(IK+1)-UE1(IK))/ (X1(IK+1)-X1(IK))  XOP11200
      TRINT = TRINT + HALF * (TUES + TUESP) * (X1(IK) - X1(IK-1))       XOP11210
      TUESP = TUES                                                      XOP11220
      TKBAR = ACREF * TRINT / (X1(IK) - X1(INSTA))                      XOP11230
      TKBAR2 = TKBAR * TKBAR                                            XOP11240
      TKBAR3 = TKBAR * TKBAR2                                           XOP11250
      TKBAR4 = TKBAR * TKBAR3                                           XOP11260
      TMT =      (B(1)+B(2)*TKBAR-B(3)*TKBAR2-B(4)*TKBAR3+B(5)*TKBAR4)  XOP11270
      TM = E1 - TMINS                                                   XOP11280
      IF  (TM .LE. 0.0) GO  TO 110                                      XOP11290
      TM = ALOG (TM)                                                    XOP11300
      IF  (TM .LT. TMT) GO  TO 110                                      XOP11310
      LTRAN = .TRUE.                                                    XOP11320
      ISEPTB = IK                                                       XOP11330
      GO  TO 110                                                        XOP11340
80    CONTINUE                                                          XOP11350
C                                                                       XOP11360
C     TRANSITION POINT - WARD, MICHELLE METHOD                          XOP11370
C                                                                       XOP11380
      IF  (LINCO) GO  TO 90                                             XOP11390
      TW = MU(IK)* Q / (1.0 + 0.2 * AVSUBM * AVSUBM)                    XOP11400
      TS = TE1(IK) / 6035.0                                             XOP11410
      TT = TS / TW                                                      XOP11420
      TU = E1 *  TT ** 2.5 * (TW+199.0) / (TS+199.0)                    XOP11430
      IF  (TU .LT. 1.7183    * REX ** 0.435) GO  TO 110                 XOP11440
      GO  TO 100                                                        XOP11450
90    CONTINUE                                                          XOP11460
      IF  (E1 .LT. 1.7183    * REX ** 0.435) GO  TO 110                 XOP11470
100   CONTINUE                                                          XOP11480
      IF  (IK .EQ. 1) GO  TO 110                                        XOP11490
      ISEPTB = IK                                                       XOP11500
      LTRAN = .TRUE.                                                    XOP11510
110   CONTINUE                                                          XOP11520
      IF  (LWRT) WRITE (6,200) IK  ,PHIPP(1),PSI(1,1),PSIP(1), REX, DELSXOP11530
     1,X,THETA,       H, CF, ST, E1                                     XOP11540
      RTHETA = E1                                                       XOP11550
      BPDE(IK) = DELS                                                   XOP11560
      CFDE (IK) = CF                                                    XOP11570
      NN = NMAX + 1                                                     XOP11580
      IF  (IK .NE. NN) RETURN                                           XOP11590
      DO 120 I = 2, NN                                                  XOP11600
      ISEPA = I                                                         XOP11610
      IF  (CFDE(I) .LE. AEPS) GO  TO 130                                XOP11620
120   CONTINUE                                                          XOP11630
130   CONTINUE                                                          XOP11640
      IF  (ISEPA .EQ. NN) RETURN                                        XOP11650
      IF  (LWRT) WRITE  (6,190)  ISEPA                                  XOP11660
      MS = ISEPA - 1                                                    XOP11670
      IF  (MS .GE. 2) GO  TO 140                                        XOP11680
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      WRITE  (6,160)                                                    XOP11690
      CALL   EXIT                                                       XOP11700
  140 CONTINUE                                                          XOP11710
      IF   (MS .LT. ISEPTB) WRITE  (6,180)                              XOP11720
      MSP1 = MS + 1                                                     XOP11730
      DO 150 I = MSP1, NN                                               XOP11740
      BPDE(I) = BPDE(MS)                                                XOP11750
  150 CONTINUE                                                          XOP11760
      RETURN                                                            XOP11770
C                                                                       XOP11780
  160 FORMAT  (1H0, 87H *** IN SUBROUTINE BN1OUT THE SEPARATION POINT ISXOP11790
     1 TOO CLOSE TO THE STAGNATION POINT *** )                          XOP11800
  170 FORMAT  (1H0, 11A10 / 1X, 11A10 )                                 XOP11810
  180 FORMAT  (1H0, 29X, 67HLAMINAR BOUNBARY LAYER DISPLACEMENT THICKNESXOP11820
     1S USED IN EXTRAPOLATION )                                         XOP11830
  190 FORMAT  (1H0, 5X, 42HSEPARATION INDICATED BY CF VALUE AT INDEX ,  XOP11840
     1         I3 )                                                     XOP11850
  200 FORMAT  (1H0, I8,3X,5E20.9 /1H , F11.5, 5E20.9     )              XOP11860
  210 FORMAT ( 1H0/ 30X, 44HWARNING-ETAE IS TOO SMALL.CHECK FP,FPP AT ETXOP11870
     1,     3HA= ,F11.5                                                 XOP11880
     2)                                                                 XOP11890
      END                                                               XOP11900
```

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      SUBROUTINE CLCR(C1, C2, C3, C4, C5, C6, C7, C8)                      XOPPB01
C   **                                                                  XOPPB02
C   **              SUBROUTINE 'CLCR' CALCULATES THE UPPER AND LOWER     XOPPB03
C   **          INCOMPRESSIBLE PRESSURE COEFFICIENTS...                  XOPPB04
C   **                                                                  XOPPB05
      GVG = (C1 + C2)/4.                                                XOPPB06
C   **                                                                  XOPPB07
      G1 = GVG * C5                                                     XOPPB08
C   **                                                                  XOPPB09
      G2 = GVG * C6                                                     XOPPB10
C   **                                                                  XOPPB11
      C7 = 1.0 - (C3-G1)*(C3-G1) - (C4-G2)*(C4-G2)                      XOPPB12
C   **                                                                  XOPPB13
      C8 = 1.0 - (C3+G1)*(C3+G1) - (C4+G2)*(C4+G2)                      XOPPB14
C   **                                                                  XOPPB15
      RETURN                                                            XOPPB16
      END                                                               XOPPB17
```

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      SUBROUTINE  COSAVE
C  **
C  **               SUBROUTINE  COSAVE  SAVES THE INITIAL CONFIGURATION
C  **            AND DETERMINES IF CONVERGENCE HAS OCCURRED
C  **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NDANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR
     7      , ZD(3), ZS(3),     RAIO(200)
      COMMON/BLOCKC/CPCOS(200), CPJ(200), CPK(200), CPSIN(200)
     1      , XJ(200), YJ(200)
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)
     1      , SINSLP(200), SN, XBP(200), YBP(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
      COMMON/BLOCKL/IEQ(10), ISQ(10), QCOSSL(200), QSINSL(200)
     1      , QX(200), QXBP(200), QY(200), QYBP(200)
      LOGICAL BEGIN, IDFO, LIT, LCONV
      DIMENSION CP(200)
      EQUIVALENCE (CP(1), CPUP(1))
      IF  (ITER .GT. 1) GO  TO 50
      IF  (NDANG .GT. 1) RETURN
C  **
      JNPTS = NPTS
      JJ = 0
      CPDIF = 1.0
      DO 10 I = 1, NAFPTS
      JCPTS(I) = NCPTS(I)
      JIBEG(I) = JJ + 1
      JIEND(I) = JJ + JCPTS(I)
      JJ = JIEND(I)
      J = JJ + I
      CP(J) = 0.0
      CP(J-1) = 0.0
C  **
10    CONTINUE
C  **
      DO 20 I = 1, NPTS
      XJ(I) = X(I)
      YJ(I) = Y(I)
C  **
20    CONTINUE
C  **
      IMAX = JNPTS + NAFPTS
      DO 30 I = 1, IMAX
      CPJ(I) = 0.0
      QCOSSL(I) = COSSLP(I)
      QSINSL(I) = SINSLP(I)
```

```
      QX(I) = X(I)
      QXBP(I) = XBP(I)
      QY(I) = Y(I)
      QYBP(I) = YBP(I)
30    CONTINUE
      DO 40  I = 1, NAFPTS
      IEQ(I) = IE(I)
      ISQ(I) = IS(I)
C  **
40    CONTINUE
C  **
C  **
      RETURN
C
50    CONTINUE
C
      ISM = 1
      CC2 = 0.0
C
      DO 90  J = 1, NAFPTS
C
      JM1 = J -1
      K1 = JIBEG(J) + JM1
      K3 = JIS(J) + JM1
      IF  (K3 .NE. K1) K3 = K3 - 1
      K2 = K3 - 1
      K4 = JIE(J) + JM1 - 1
      K6 = JIEND(J) + JM1 - 1
C
      IF  (K3 .EQ. K1) GO  TO 70
      DO 60  K = K1, K2
      CPJ(K) = CP(ISM)
60    CONTINUE
70    CONTINUE
C
      DO 80  K = K3, K4
      CPJ(K) = CP(ISM)
      ISM = ISM + 1
80    CONTINUE
C
      ISM = ISM + 2
      CPJ(K6 + 1) = 0.0
      CPJ(K6 + 2) = 0.0
C
90    CONTINUE
C
      LCONV = .TRUE.
      CPDIF = ABS(CPJ(1) - CPK(1))
      IMAX = JNPTS + NAFPTS
      DO 110  I = 1, IMAX
      CCC = ABS(CPJ(I) - CPK(I))
      IF  ( CCC .LT. CPDIF) GO  TO 100
      CPDIF = CCC
100   CONTINUE
      IF  (CCC .GT. ABS( 0.1  * CPJ(I))) LCONV = .FALSE.
      CPK(I) = CPJ(I)
```

```
      CP(I) = CPJ(I)
      IF  (CCC .GT. 20.0) GO  TO 110
      CC2 = CC2 + CCC * CCC
110   CONTINUE
      XIMA = JNPTS - NAFPTS
      CC2 = (CC2 / XIMA) ** 0.5
      WRITE  (6,170)  ITER, CPDIF, CC2
      IF  (LCONV) GO  TO 120
      IF  (CPDIF .LT. 0.15) GO  TO 120
      GO  TO 130
120   CONTINUE
      LIT = .TRUE.
      IF  (IND(16) .NE. 2) GO  TO 130
      IF  (IND(3) .EQ. 2) GO  TO 130
      IND(16) = IND(3)
      LIT = .FALSE.
130   CONTINUE
      IF  (IDFO(9)) GO  TO 140
      IF  (LIT) RETURN
C  **
140   CONTINUE
C  **
      ALPHA = ANGL(NOANG)
      DO 150 I = 1, NAFPTS
      NCPTS(I) = JCPTS(I)
      IE(I) = IEQ(I)
      IS(I) = ISQ(I)
150   CONTINUE
      IMAX = JNPTS + NAFPTS
      DO 160 I = 1, IMAX
      COSSLP(I) = QCOSSL(I)
      SINSLP(I) = QSINSL(I)
      X(I) = QX(I)
      XBP(I) = QXBP(I)
      Y(I) = QY(I)
      YBP(I) = QYBP(I)
160   CONTINUE
      RETURN
C
170   FORMAT  (1H0, 35HMAX. CP DIFFERENCE AFTER ITERATION , I3, 4H IS ,
     1         F10.3, 25H AND R.M.S. DEVIATION IS , F9.6 )
      END
```

```
      SUBROUTINE  CPEQ                                                  XOPR0010
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS   XOPR0020
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPR0030
     2      , KPAGE                                                     XOPR0040
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPR0050
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM                        XOPR0060
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)  XOPR0070
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPR0080
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12) XOPR0090
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR   XOPR0100
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR                         XOPR0110
     7      , ZD(3), ZS(3),       RAIO(200)                             XOPR0120
      COMMON/BLOCKC/CPCOS(200), CPJ(200), CPK(200), CPSIN(200)          XOPR0130
     1      , XJ(200), YJ(200)                                          XOPR0140
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPR0150
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)          XOPR0160
     2      , XSLOC1(10), YSLOC1(10)                                    XOPR0170
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK                  XOPR0180
     1      , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)        XOPR0190
     2      , ITRAN(20),                                   BPDEL(200)   XOPR0200
      LOGICAL BEGIN, LIT                                                XOPR0210
      DIMENSION CPDEL(200), DIST(200)                                   XOPR0220
C   **                                                                  XOPR0230
C   **                                                                  XOPR0240
      IF  (ITER .GT. 1) GO  TO 60                                       XOPR0250
      IF  (NOANG .GT. 1) GO  TO 60                                      XOPR0260
C   **                                                                  XOPR0270
      DO 30 J = 1, NAFPTS                                               XOPR0280
      IMAX = JIEND(J)                                                   XOPR0290
      IMAXM1 = IMAX - 1                                                 XOPR0300
      IBEG = JIBEG(J)                                                   XOPR0310
      IBEGP1 = IBEG + 1                                                 XOPR0320
      JISS(J) = JIBEG(J)                                                XOPR0330
      JIEE(J) = JIEND(J)                                                XOPR0340
C   **                                                                  XOPR0350
      DO 10 I = IBEG, IMAXM1                                            XOPR0360
      DELX = XJ(I) - XJ(I+1)                                            XOPR0370
      DELY = YJ(I+1) - YJ(I)                                            XOPR0380
      DELX2 = DELX * DELX                                               XOPR0390
      DELY2 = DELY * DELY                                               XOPR0400
      DIST(I) = SQRT (DELX2 + DELY2)                                    XOPR0410
10    CONTINUE                                                          XOPR0420
C   **                                                                  XOPR0430
      DELX = XJ(IBEG) - XJ(IBEGP1)                                      XOPR0440
      DELY =-YJ(IBEG) + YJ(IBEGP1)                                      XOPR0450
      DELX2 = DELX * DELX                                               XOPR0460
      DELY2 = DELY * DELY                                               XOPR0470
      DIS = SQRT (DELX2 + DELY2)                                        XOPR0480
      CPCOS(IBEG) = DELX / DIS                                          XOPR0490
      CPSIN(IBEG) = DELY / DIS                                          XOPR0500
      DELX = XJ(IMAXM1) - XJ(IMAX)                                      XOPR0510
      DELY =-YJ(IMAXM1) + YJ(IMAX)                                      XOPR0520
      DELX2 = DELX * DELX                                               XOPR0530
      DELY2 = DELY * DELY                                               XOPR0540
      DIS = SQRT (DELX2 + DELY2)                                        XOPR0550
      CPCOS(IMAX) = DELX / DIS                                          XOPR0560
```

```
      CPSIN(IMAX) = DELY / DIS
C  **
      XBP1 = (XJ(IBEG) + XJ(IBEGP1)) * 0.5
      YBP1 = (YJ(IBEG) + YJ(IBEGP1)) * 0.5
      DO 20 I = IBEGP1, IMAXM1
      XBP2 = (XJ(I) + XJ(I+1)) * 0.5
      YBP2 = (YJ(I) + YJ(I+1)) * 0.5
      DELX = XBP1 - XBP2
      DELY =-YBP1 + YBP2
      DELX2 = DELX * DELX
      DELY2 = DELY * DELY
      DIS = SQRT (DELX2 + DELY2)
      CPCOS(I) = DELX / DIS
      CPSIN(I) = DELY / DIS
      XBP1 = XBP2
      YBP1 = YBP2
      RAIO (I) = DIST(I-1) / (DIST(I) + DIST(I-1))
20    CONTINUE
C  **
C  **
30    CONTINUE
C  **
      IEND = JNPTS + NAFPTS
      DO 40 I = 1, IEND
      CPK(I) = CPUP(I)
40    CONTINUE
      IF  (IND(16) .NE. 2) GO  TO 60
      IEND = JNPTS + NAFPTS
      DO 50 I = 1, IEND
      BPDEL(I) = 0.0
50    CONTINUE
C  **
60    CONTINUE
C  **
      NPTS = 0
      ISM = 1
      ILA = 1
      DO 160 J = 1, NAFPTS
      JM1 = J - 1
      JM2 = JM1 - 1
      IBEG = JIBEG(J)
      IBEGP1 = IBEG + 1
      IMAX = JIEND(J)
      IMAXM1 = IMAX - 1
      IF (JIS(J) .GT. JIBEG(J)) JIS(J) = JIS(J) - 1
      IF ((JISS(J) .NE. JIBEG(J)).AND.(JIS(J)-JISS(J) .LE. 1)) JIS(J) =
     1JIS(J) + 1
      IF  (JIS(J)   .LE. JISS(J)) GO  TO 80
      IF ((JIS(J)-JISS(J)).GT.8) JIS(J)=JISS(J)+8
      IF  (IND(4) .EQ. 0) GO  TO 70
      JIS(J) = (JIS(J) + JISS(J) + 1) / 2
70    CONTINUE
      JISS(J) = JIS(J)
      GO  TO 90
80    CONTINUE
      JIS(J) = JISS(J)
```

```
90     CONTINUE
       JIE(J) = JIEE(J)
C  **
       DO 100  I = IBEGP1,  IMAXM1
       K = I + JM2
       CPDEL(I) = BPDEL(K) + RAIO (I) * (BPDEL(K+1) - BPDEL(K))
       IF  (CPDEL(I) .LT. 0.0) CPDEL(I) = 0.0
100    CONTINUE
       K = IBEG + JM1
       CPDEL(IBEG) = BPDEL(K) + BPDEL(K) - CPDEL(IBEGP1)
       IF  (CPDEL(IBEG) .LT. 0.0) CPDEL(IBEG) = 0.0
       K = IMAX + JM2
       CPDEL(IMAX) = BPDEL(K) + BPDEL(K) - CPDEL(IMAXM1)
       IF  (CPDEL(IMAX) .LT. 0.0) CPDEL(IMAX) = 0.0
C  **
110    CONTINUE
C  **
C           IF ANY SEPARATION, ADD POINT ON UPPER SURFACE
C           AT 0.95 * Z(SEP. INDEX = I) + 0.05 * Z(I-1)
C  **
       IF  (ILA .EQ. (JIS(J) - 1)) GO  TO 120
       IF  (ILA .LT. JIS(J)) GO  TO 140
       IF  (ILA .LE. JIE(J)) GO  TO 130
       IF  (ILA .LE. IMAX) GO  TO 140
       GO  TO 150
120    CONTINUE
       X(ISM+1) = XJ(ILA+1) + CPDEL(ILA+1) * CPSIN(ILA+1)
       Y(ISM+1) = YJ(ILA+1) + CPDEL(ILA+1) * CPCOS(ILA+1)
       X(ISM+2) = XJ(ILA+2) + CPDEL(ILA+2) * CPSIN(ILA+2)
       Y(ISM+2) = YJ(ILA+2) + CPDEL(ILA+2) * CPCOS(ILA+2)
       X(ISM) = 1.05 * X(ISM+1) - 0.05 * X(ISM+2)
       Y(ISM) = 1.05 * Y(ISM+1) - 0.05 * Y(ISM+2)
       ILA = ILA + 3
       ISM = ISM + 3
       GO  TO 110
130    CONTINUE
       X(ISM) = XJ(ILA) + CPDEL(ILA) * CPSIN(ILA)
       Y(ISM) = YJ(ILA) + CPDEL(ILA) * CPCOS(ILA)
       ISM = ISM + 1
140    CONTINUE
       ILA = ILA + 1
       GO  TO 110
150    CONTINUE
       ISM = ISM - 1
       NCPTS(J) = ISM - NPTS
       NPTS = ISM
       ISM = ISM + 1
160    CONTINUE
       IF  (IND(20) .EQ. 0) RETURN
       IF  (LIT) RETURN
       CALL  TAPSA
       RETURN
       END
```

```
      SUBROUTINE  CPMIN (ILUM, NLU, XLUM, CPLUM, XLU, CPLU, USULU, DCPLU
     1        , N)
C
      DIMENSION  XLU(200), CPLU(200), USULU(200), DCPLU(200)
      DATA EPS /1.0E-06/
C                           ***  MINIMUM CP   ***
      IF  (N .EQ. 1) GO  TO 90
      CPLUM = CPLU(2)
      XLUM  = XLU(2)
      ILUM  = 2
      DO 20 I = 3, NLU
      IF  (CPLU(I) .GE. CPLUM) GO  TO 10
      CPLUM = CPLU(I)
      XLUM  = XLU(I)
      ILUM  = I
   10 CONTINUE
   20 CONTINUE
C                           *** DERIVATIVE OF CP ***
      IF  (ILUM .EQ. NLU) GO  TO 80
      DELCP = 1.0 - CPLUM
C                                                         ERROR 119
      IF  (ABS(DELCP) .GE. EPS) GO  TO 30
      WRITE  (6,120)
      CALL  EXIT
   30 CONTINUE
      DELCP = SQRT (1.0 / DELCP)
      DO 50 I = 2, ILUM
      IF  (CPLU(I) .GT. 1.0) GO  TO 40
      USULU(I) = DELCP * SQRT(1.0 - CPLU(I))
      GO  TO 50
   40 CONTINUE
      USULU(I) = 0.0
      WRITE  (6,130)  I
   50 CONTINUE
      DCPLU(ILUM) = 0.0
      IBEG =  ILUM + 1
      DO 70 I = IBEG, NLU
      DELX = XLU(I) - XLU(I-1)
C                                                         ERROR 120
      IF  (ABS(DELX) .GE. EPS) GO  TO 60
      WRITE  (6,140)
      CALL  EXIT
   60 CONTINUE
      DCPLU(I) = (CPLU(I) - CPLU(I-1)) / DELX
   70 CONTINUE
   80 CONTINUE
      RETURN
   90 CONTINUE
      DO 100 I = 3, NLU
      ILUM = I
      IF  (CPLU(I) .GT. CPLU(I-1)) GO  TO 110
  100 CONTINUE
      RETURN
  110 CONTINUE
      ILUM = ILUM - 1
      RETURN
```

```
C                                                                        XOPRA570
120    FORMAT  (1H0, 59H *** IN SUBROUTINE CPMIN, MINIMUM CP MUST NOT EQUXOPRA580
      1AL ONE *** )                                                      XOPRA590
130    FORMAT  (1H0, 18H THE CP FOR INDEX , I3, 20H IS GREATER THAN 1.0 )XOPRA600
140    FORMAT  (1H0, 87H *** IN SUBROUTINE CPMIN, THE DEVELOPED LENGTH OFXOPRA610
      1 ADJACENT POINTS MUST NOT BE EQUAL *** )                          XOPRA620
       END                                                               XOPRA630
```

```
      SUBROUTINE  CRWTA (K, C1, C2,     M, B1, B2, IK, IJ, IL, IM, IULT)XOPM0010
C  **                                                                    XOPM0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS   XOPM0030
     1    , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPM0040
     2    , KPAGE                                                        XOPM0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                          XOPM0060
     1    , CREF, CRFSQ, CRT, CSTH(10), DLTALM                           XOPM0070
     2    , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)     XOPM0080
     3    , INOR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPM0090
     4    , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)    XOPM0100
     5    , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR      XOPM0110
     6    , YLE(10), YLR, YMBAR, YTE(10), YTR                            XOPM0120
     7    , ZD(3), ZS(3),      RAIO(200)                                 XOPM0130
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)    XOPM0140
     1    , SINSLP(200), SN, XBP(200), YBP(200)                          XOPM0150
      DIMENSION XPP(200), XPT(200), YPP(200), YPT(200)                   XOPM0160
     1    , C1(M), C2(M), HD(13), IULT(10)                               XOPM0170
      LOGICAL  IDFO                                                      XOPM0180
      DATA  HD / 10H        NO , 10H.          , 10HXBP        ,         XOPM0190
     1          10H    YBP     , 10H      X/CR , 10HEF         ,         XOPM0200
     2          10HY/CREF      , 10H    XTR/CR , 10H        YT ,         XOPM0210
     3          10HR/CR        , 10H  CP-INNER , 10H         C ,         XOPM0220
     4          10HP           /                                         XOPM0230
C  **                                                                    XOPM0240
C  **                SUBROUTINE  CRWTA  WRITES THE INCOMPRESSIBLE        XOPM0250
C  **           PRESSURE COEFFICIENTS                                    XOPM0260
C  **                                                                    XOPM0270
C  **                                                                    XOPM0280
      IF  (IDFO(10)) GO  TO  10                                          XOPM0290
      GO  TO 20                                                          XOPM0300
10    CONTINUE                                                           XOPM0310
C  **                                                                    XOPM0320
      WRITE  (6,70)  HD                                                  XOPM0330
C  **                                                                    XOPM0340
20    CONTINUE                                                           XOPM0350
C  **                                                                    XOPM0360
      IZ = 0                                                             XOPM0370
C  **                                                                    XOPM0380
      DO 60  I = 1, NAFPTS                                               XOPM0390
C  **                                                                    XOPM0400
      NN = NCPTS(I) - 1                                                  XOPM0410
C  **                                                                    XOPM0420
C     WRITE (        ) NN               ***                    ***       XOPM0430
C  **                                                                    XOPM0440
      DO 50  J = 1, NN                                                   XOPM0450
C  **                                                                    XOPM0460
      IZ = IZ + 1                                                        XOPM0470
C  **                                                                    XOPM0480
      XPP(IZ) = (XBP(IZ) - XLR)/CREF                                     XOPM0490
      YPP(IZ) = (YBP(IZ) - YLR)/CREF                                     XOPM0500
C  **                                                                    XOPM0510
      XA = XBP(IZ) - XLE(I)                                              XOPM0520
      YA = YBP(IZ) - YLE(I)                                              XOPM0530
C  **                                                                    XOPM0540
      XPT(IZ) = (XA * CSTH(I) + YA * SNTH(I))/DS(I)                      XOPM0550
      YPT(IZ) = (YA * CSTH(I) - XA * SNTH(I))/DS(I)                      XOPM0560
```

```
C   **                                                                      XOPM0570
C   **                                                                      XOPM0580
C      WRITE (       ) XPP(IZ), C1(IZ)    ***                  ***          XOPM0590
C   **                                                                      XOPM0600
       IF  (K.EQ.2) GO  TO 30                                               XOPM0610
       IF  (IDFO(10)) WRITE  (6,80)  IZ, XBP(IZ), YBP(IZ), XPP(IZ), YPP(IXOPM0620
     1Z),                            XPT(IZ), YPT(IZ),  C2(IZ),  C1(IXOPM0630
     2Z)                                                                    XOPM0640
C   **                                                                      XOPM0650
       GO  TO 40                                                            XOPM0660
C   **                                                                      XOPM0670
30     CONTINUE                                                             XOPM0680
C   **                                                                      XOPM0690
       C1(IZ) = C1(IZ)/(B1 + B2 * C1(IZ))                                   XOPM0700
C   **                                                                      XOPM0710
       IF  (IDFO(10)) WRITE  (6,90)  IZ, XBP(IZ), YBP(IZ), XPP(IZ), YPP(IXOPM0720
     1Z),XPT(IZ),                YPT(IZ), C1(IZ)                            XOPM0730
C   **                                                                      XOPM0740
40     CONTINUE                                                             XOPM0750
C   **                                                                      XOPM0760
50     CONTINUE                                                             XOPM0770
C   **                                                                      XOPM0780
       IZ = IZ + 2                                                          XOPM0790
C   **                                                                      XOPM0800
       WRITE  (6,100)                                                       XOPM0810
C   **                                                                      XOPM0820
60     CONTINUE                                                             XOPM0830
C   **                                                                      XOPM0840
       RETURN                                                               XOPM0850
C   **                                                                      XOPM0860
C                                                                           XOPM0870
70     FORMAT  (1H0, 13A10 )                                                XOPM0880
80     FORMAT  (8X, I3, 6(6X, F8.4), 1X, 2(6X, F8.4))                       XOPM0890
90     FORMAT  (1H , 7X, I3, 6(6X, F8.4), 21X, F8.4)                        XOPM0900
100    FORMAT  (1H0 )                                                       XOPM0910
       END                                                                  XOPM0920
```

```
      SUBROUTINE  CSCNST  (IPRNT)
C
C     CALCULATE  CASE CONSTANTS
C
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3
     1     , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE
     2     , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE
     3     , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17
     4     , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2
     5     , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3
     6     , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5
     7     , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1
     8     , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3
     9     , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3
     .     , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB
      LOGICAL LINCO
      REAL I1, INN, IN1, IN2, IN3, INM1, INM2, INM3, K, K2, K3, K4, K5
     1     , K6, M1, MNN, MN1, MN2, MN3, MNM1, MNM2, MNM3
      DATA C005, ONE, TWO, THREE, SIX / 0.005, 1.0, 2.0, 3.0, 6.0 /
C
C     CALCULATE  CONSTANT COEFFICIENTS OF
C                5-POINT FINITE-DIFFERENCE FORMULAS WITH VARIABLE GRID
C
      K = GK
      CC = C005
      K2 = K * K
      K3 = K * K2
      K4  = K3*K
      K5 = K4 * K
      K6 = K5 * K
      S1 = ONE + K
      S2 = S1 + K2
      S3 = S2 + K3
      S1SQ = S1 * S1
      S12  = S1 * S2
      S13  = S1 * S3
      S23  = S2 * S3
      S123 = S12 * S3
      S1K  = S1 * K
      S1K2 = S1 * K2
      S2K  = S2 * K
      S2K2 = S2 * K2
      S1MK2= S1 - K2
      S2MK3= S2 - K3
      S1KM1 = S1K - ONE
      S1MK2S = S1 - K2 * S1
      DKOEK = -S3
      CKOEK = K * S23/S1
      BKOEK = -K3 * S3
      AKOEK = K6
      RN1 = SIX * (S1MK2 + K)
      RN2 =       K * (S1MK2 - S1K)
      RN2 = RN2 + RN2
      RN3 = -K3 * S1
      FN1 = DKOEK * SIX * (S1MK2S + K)
      FN2 = - DKOEK *        S1K * (S1KM1 + K2)
```

```
FN2 = FN2 + FN2
FN3 = -DKOEK * K3 * S1SQ
GN1 = CKOEK * (RN1 - SIX * S1K2)
GN2 = CKOEK * (RN2 - RN1 / THREE * S1K2 )
GN3 =-CKOEK * RN3 * (S1KM1 - S1MK2)
GN4 = K6 * S123
IN1 = BKOEK * SIX * (S1MK2S - K2)
IN2 = - BKOEK *        S1K2 * (ONE + S1MK2)
IN2 = IN2 + IN2
IN3 = BKOEK * S1K2 * S1K2
MN1 = - AKOEK * SIX * K * (S1KM1 + K)
MN2 = AKOEK *        K3 * (S1KM1 - S1)
MN2 = MN2 + MN2
MN3 = AKOEK * K5 * S1
F1  = DKOEK * S3 / S2
G1  = CKOEK * S3 / S1
I1  = BKOEK * S3
M1 = AKOEK * (ONE + S3 / S2 + S3 / S1 + S3)
RNM1 = SIX * (S2 + S1K + K2)
RNM2 =        (S12 + S2K + S1K2) * K
RNM2 = RNM2 + RNM2
RNM3= K3 * S12
FNM1 = DKOEK * (RNM1 - SIX * K3)
FNM2 = DKOEK * (RNM2 - K3 * RNM1 / THREE )
FNM3= DKOEK * K3 * (S12 - K * S12 - S2K2 + RN3)
FNM4 = GN4
GNM1 = CKOEK * SIX * (S2MK3 + S1K)
GNM2 = CKOEK *        K * (S12 - S2K2 + RN3)
GNM2 = GNM2 + GNM2
GNM3 =-CKOEK * K4 * S12
INM1 = BKOEK * SIX * (S2MK3 + K2)
INM2 = BKOEK *        K2 * (S2MK3 - S2K)
INM2 = INM2 + INM2
INM3 = -K5 * S2   * BKOEK
MNM1 = AKOEK * K * RN1
MNM2 = AKOEK * K2 * RN2
MNM3 =-AKOEK * K6 * S1
RNN1 = K3 * S12
RNN2 = K2 * S13
RNN4 = S123
RNN3 = K * S23
RNN= RNN1 + RNN2 + RNN3 + RNN4
FNN = DKOEK * S123 /RNN
GNN = CKOEK * RNN3  /RNN
INN = BKOEK * RNN2   /RNN
MNN = AKOEK * RNN1    /RNN
AK = ONE / S123
BK = - ONE / (K3 * S12)
CK = ONE / (K5 * S1SQ)
DK = BK / K3
EK = AK / K6
AV1 =-AK * (S12 + S13 + S23 + S123)
BV1 =-BK * S123
CV1 =-CK * S23
DV1 =-DK * S13
EV1 =-EK * S12
```

```
      AV2 =-AK * RNN1                                                   XOPU1130
      BV2 = BK * (S1 + S2 * (S1 - S1KM1)) *K2                           XOPU1140
      CV2 = CK * K2 * S12                                               XOPU1150
      DV2 = DK * S2K2                                                   XOPU1160
      EV2 = EK * S1K2                                                   XOPU1170
      AV3 = MN3 * EK                                                    XOPU1180
      BV3 = IN3 * EK                                                    XOPU1190
      CV3 = GN3 * EK                                                    XOPU1200
      DV3 = FN3 * EK                                                    XOPU1210
      EV3 = RN3 * EK                                                    XOPU1220
      AV4 = MNM3 * EK                                                   XOPU1230
      BV4 = INM3 * EK                                                   XOPU1240
      CV4 = GNM3 * EK                                                   XOPU1250
      DV4 = FNM3 * EK                                                   XOPU1260
      EV4 = RNM3     * EK                                               XOPU1270
      AV5 = AK * K6 * S12                                               XOPU1280
      BV5 = BK * K5 * S13                                               XOPU1290
      CV5 = CK * K4 * S23                                               XOPU1300
      DV5 = DK * K3 * S123                                              XOPU1310
      EV5 = EK * K3 * RNN                                               XOPU1320
C                                                                       XOPU1330
C     CALCULATE  CONSTANT COEFFICIENTS OF 3-POINT FINITE-DIFFERENCE     XOPU1340
C     FORMULAS WITH VARIABLE-GRID-SIZE                                  XOPU1350
C                                                                       XOPU1360
      AA = ONE + K                                                      XOPU1370
      A2 = ONE - K                                                      XOPU1380
      A4 = TWO + K                                                      XOPU1390
      A5 = ONE / AA                                                     XOPU1400
      A45= A5 * A4                                                      XOPU1410
      A6 = - ONE / K                                                    XOPU1420
      B7 = - A5 * A6                                                    XOPU1430
      B6 = A6 * A2                                                      XOPU1440
      B5 = - A5 * K                                                     XOPU1450
      Q16 = - AA                                                        XOPU1460
      Q17 = - K * Q16                                                   XOPU1470
      Q18 = ONE / B7                                                    XOPU1480
      Q19 = AA * AA / K / A4                                            XOPU1490
      Q20 = ONE / K / A4                                                XOPU1500
      Q21 = CC * AA / A4                                                XOPU1510
      Q22 = K                                                           XOPU1520
      Q23 = - K2                                                        XOPU1530
      Q24 = - CC / A45                                                  XOPU1540
      Q25 = - A6 * AA / A45                                             XOPU1550
      Q26 = - B7 / A45                                                  XOPU1560
      Q27 = - A45 / CC                                                  XOPU1570
      Q28 = - A6 * AA / CC                                              XOPU1580
      Q29 = -B7 / CC                                                    XOPU1590
      IF  (IPRNT .EQ. 0) RETURN                                         XOPU1600
      CALL  HEADR                                                       XOPU1610
      WRITE  (6,10)   RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, XOPU1620
     1          IN1, IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2,XOPU1630
     2          RNM3, FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1,   XOPU1640
     3          INM2, INM3, MNM1, MNM2, MNM3, RNN1, RNN2, RNN3, RNN4    XOPU1650
     4     , RNN, FNN, GNN, INN, MNN                                    XOPU1660
     5                 ,AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2XOPU1670
     6,         AV3, BV3, CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BVXOPU1680
```

```
75          , CV5, DV5, EV5                                          XOPU1690
8    ,B5, B6, B7, V1,V2, V3, Q4, Q16, Q17, Q18, Q19,                 XOPU1700
9      Q20, Q21, Q22, Q23, Q24, Q25, Q26, Q27, Q28,Q29               XOPU1710
      RETURN                                                         XOPU1720
C                                                                    XOPU1730
10    FORMAT  (1HO, 28H*** CASE CONSTANT VALUES *** //(1H ,4X,8E14.7)) XOPU1740
      END                                                            XOPU1750
```

```
      SUBROUTINE  DSTRBD (X1, Y1, X2, Y2, U, V, A, X3, Y3)
C  **
C  **              SUBROUTINE 'DSTRBD' COMPUTES THE 'DISTRIBUTED'
C  **         COMPONENTS OF VELOCITY...
C  **
      CALL  DSTSQD (X2, Y2, X1, Y1, X4, Y4, B, B1, 1)
      CALL  DSTSQD (X2, Y2, X3, Y3, X5, Y5, C, B1, 0)
C  **
      BSQ = A - B - C
      DSQ = 2. * B  +  BSQ
      CSQ = 2. * (X4 * Y5  -  X5 * Y4)
C  **
      IF  (ABS(CSQ).LT.1.E-9) GO  TO 10
C  **
      D = (ATAN(DSQ/CSQ) - ATAN(BSQ/CSQ)) / CSQ
C  **
      GO  TO 20
C  **
10    CONTINUE
C  **
      D = 1./BSQ  -  1./DSQ
C  **
20    CONTINUE
C  **
      E = ALOG(A/C)
C  **
      BIK = (0.5 * E  -  BSQ * D)/B
C  **
      FIK = (B - 0.5 * BSQ * E + (BSQ * BSQ - 2. * B * C) * D)/(B * B)
C  **
      SQBP = B1/6.283184
C  **
      U = SQBP * (Y5 * BIK - Y4 * FIK)
C  **
      V = SQBP * (X4 * FIK - X5 * BIK)
C  **
      RETURN
C  **
      END
```

```
      SUBROUTINE  DSTSQD (X1, Y1, X2, Y2, X3, Y3, S1, S2, K)
C  **
C  **                SUBROUTINE 'DSTSQD' CALCULATES THE FOLLOWING, USING
C  **           ANY TWO POINTS IN TWO-SPACE--
C  **                     -- THE DIFFERENCE BETWEEN THE ABSCISSAS...
C  **                     -- THE DIFFERENCE BETWEEN THE ORDINATES...
C  **                     -- THE SQUARE OF THE DISTANCE BETWEEN THE
C  **                        POINTS...
C  **                     -- THE DISTANCE BETWEEN THE POINTS, IF K.NE.0...
C  **
      X3 = X1 - X2
      Y3 = Y1 - Y2
C  **
      S1 = X3 * X3  +  Y3 * Y3
C  **
      IF  (K.NE.0) S2 = SQRT(S1)
C  **
      RETURN
C  **
      END
```

```
      SUBROUTINE  EDYVSC
C
C     CALCULATE  EDDY-VISCOSITY  EPS, CT, CTP
C
      COMMON/A0/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)
     1     , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3)
     2     /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)
     3     , RHO(300) /A9/ RK(300), RDRDE(300) /A10/T(300), TEMP(300)
     4     /A11/ PHIP(300, 3)
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3
     1     , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE
     2     , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE
     3     , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17
     4     , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2
     5     , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3
     6     , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5
     7     , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1
     8     , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3
     9     , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3
     .     , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB
      LOGICAL LINCO
      REAL INT, MU, MUE
      DIMENSION A(5)
      DATA ZERO, ONE, TWO, THREE, IZERO, IONE, ITHREE, ISIX, A /
     1      0.0, 1.0, 2.0, 3.0, 0, 1, 3, 6, 0.0084, 0.16, 0.2, 5.5, 26./
     2     , HALF /0.5/
      F (A, B, C, D, E, Z1, Z2, Z3, Z4, Z5) = DH3 * (A * Z1 + B * Z2 +
     1          C * Z3 + D * Z4 + E * Z5)
      IF  (ISTN .GE. ISEPTB) GO  TO 50
C
C     CALCULATE  EPS, CT, CTP FOR LAMINAR FLOWS
C
      DO 10 I = 1, IMAX
      EPS(I) = ZERO
      CTP(I) = ZERO
      S = ONE + T(I)
      CT(I) = C(I) * S * S
10    CONTINUE
      IF  (LINCO) GO  TO 40
20    CONTINUE
C
C     CALCULATE  CTP FROM CT WITH 5-POINT FINITE DIFFERENCE FORMULAS
C
      I = ITHREE
      DH3 = ONE / DH(1)
      CTP(1)   = F (AV1,BV1,CV1,DV1,EV1,CT(I-2),CT(I-1),CT(I),CT(I+1)
     1    , CT(I+2) )
      IF  (LINCO) CTP(1) = ZERO
      CTP(2)   = F (AV2,BV2,CV2,DV2,EV2,CT(I-2),CT(I-1),CT(I),CT(I+1)
     1    , CT(I+2) )
      DO 30 I = 3, MT
      DH3 = ONE / DH (I - 2)
30    CTP(I)   = F (AV3,BV3,CV3,DV3,EV3,CT(I-2),CT(I-1),CT(I),CT(I+1)
     1    , CT(I+2) )
      I=MT
      CTP(IO   )=F (AV4,BV4,CV4,DV4,EV4,CT(I-2),CT(I-1),CT(I),CT(I+1)
```

```
     1    , CT(I+2) )                                                    XOPX0570
      CTP(IMAX)=F (AV5,BV5,CV5,DV5,EV5,CT(I-2),CT(I-1),CT(I),CT(I+1)     XOPX0580
     1    , CT(I+2) )                                                    XOPX0590
 40   RETURN                                                             XOPX0600
C                                                                        XOPX0610
C     CALCULATE  DELS AND EPS                                            XOPX0620
C                                                                        XOPX0630
 50   ICT = IZERO                                                        XOPX0640
      A3 = - SQTSQ / (A(5) * RHOE)                                       XOPX0650
      SUM = ZERO                                                         XOPX0660
      FP = ZERO                                                          XOPX0670
      DO 60  I = 2, IMAX                                                 XOPX0680
      F2 = RHOE / RHO(I) * (ONE - PHIP(I,1)) / (ONE + T(I))              XOPX0690
      SUM = SUM + (FP + F2) * HALF * DH(I-1)                             XOPX0700
 60   FP = F2                                                            XOPX0710
      DELS =  ABS(SUM) * A1                                              XOPX0720
      EO = A(1) * UE * DELS                                              XOPX0730
      EI = A(2) * SQTSQ / (RHOE * RHOE)                                  XOPX0740
      A6 = BETA * RHOE            * MUE    / SQTSQ                       XOPX0750
      INOUT = IZERO                                                      XOPX0760
      IF  (IPRINT .EQ. IONE) WRITE  (6,100)  ISTN, X                     XOPX0770
      AW = ABS (PHIPP(1))* RHO(1) * MU(1) / SQTSQ                        XOPX0780
      DO 80  I = 1, IMAX                                                 XOPX0790
      AWRO =  RHO(I) / MU(I)                                             XOPX0800
      EO1 = EO * AWRO * (TWO / (ONE + A(4) * (INT(I)/INT(IMAX))**ISIX ))XOPX0810
      IF  (INOUT .EQ. IONE) GO  TO 70                                    XOPX0820
      DUDY = ABS (( AW - A6 * INT(I)) / RHO(I))                          XOPX0830
      DUDY = SQRT (DUDY)                                                 XOPX0840
      G = A3 * AWRO * INT(I) * DUDY                                      XOPX085
      IF (G .GT. -600.0) GO TO  62                                       XOPX0851
      EX = 1.0                                                           XOPX0852
      GO TO 65                                                           XOPX0853
 62   CONTINUE                                                           XOPX0854
      EX = 1.0 - EXP(G)                                                  XOPX0855
 65   CONTINUE                                                           XOPX0856
C                                                                        XOPX0857
      EI1 = EI *(ONE + T(I)) * AWRO * RHO(I) * ABS(PHIPP(I)) * INT(I)    XOPX0860
     1          * INT(I) * EX * EX                                       XOPX0870
C                                                                        XOPX0880
C     TEST FOR INNER AND OUTER REGIONS                                   XOPX0890
C                                                                        XOPX0900
      IF  (EI1 .GT. EO1) GO  TO 70                                       XOPX0910
      EPS(I) = EI1                                                       XOPX0920
      IF  (IPRINT.EQ.IONE) WRITE  (6,110)  E(I), EI1, EO1, EX,EPS(I),CT(XOPX0930
     1I)                                                                 XOPX0940
      GO  TO 80                                                          XOPX0950
 70   EPS(I) = EO1                                                       XOPX0960
      IF  (IPRINT.EQ.IONE) WRITE  (6,110)  E(I), EI1, EO1, EX,EPS(I),CT(XOPX0970
     1I)                                                                 XOPX0980
      INOUT = IONE                                                       XOPX0990
      ICT = ICT + IONE                                                   XOPX1000
 80   CONTINUE                                                           XOPX1010
      ICT = IMAX - ICT + IONE                                            XOPX1020
      IF  (IPRINT.NE.IZERO) WRITE (6,120)  E(ICT), ICT                   XOPX1030
C                                                                        XOPX1040
C     CALCULATE  CT WITH 5-POINT MEAN OF EPS                             XOPX1050
```

```
C
      CT(1) = C(1)
      I = ITHREE
      CT(2)=(( EPS(I-2) + EPS(I-1) + EPS(I) ) /THREE + ONE    )*C(2)
      DO 90  I =3, MT
90    CT(I)= ((EPS(I-2) + EPS(I-1) + EPS(I) + EPS(I+1) + EPS(I+2) )*
     1            A(3) + ONE) * C(I)
      I = IMAX
      CT(IO)=((EPS(I-2)+ EPS(I-1) + EPS(I) ) /THREE + ONE )*C(IO)
      CT(I)=(ONE + EPS(I))*C(I)
      GO  TO 20
C
100   FORMAT  (1HO/1H , 7HSTATION, I4, 94X, 3HX =, E11.4)
110   FORMAT (1H , F11.5, 5E20.9)
120   FORMAT  (1H , 40X, 7HETA-K =, E14.7, 5X, 5HICT =, I5)
      END
```

```
      SUBROUTINE   ENERGY
C
C     ENERGY   EQ. IS SOLVED BY THE CHOLESKI METHOD
C     DERIVATIVES OF DEPENDENT VARIABLES ARE OBTAINED BY THE FIRST-
C     DERIVATIVE 3-POINT FINITE-DIFFERENCE FORMULAS WITH VARIABLE GRID
C
      COMMON/AQ/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)
     1      , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3)
     2      /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)
     3      , RHO(300) /A9/ RK(300), RORDE(300) /A10/T(300), TEMP(300)
     4      /A11/ PHIP(300, 3)
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3
     1      , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE
     2      , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE
     3      , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17
     4      , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2
     5      , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3
     6      , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5
     7      , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1
     8      , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3
     9      , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3
     .      , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB
      LOGICAL LINCO
      REAL L, LL
      DIMENSION  L(300), LL(300), U(300), XK2(300), Y(300), Z(300)
      FP(Z1, Z2, Z3, H) = (Z1 * B5 + Z2 * B6 + Z3 * B7) / H
      WX(Z1, Z2, C1, C2) = (Z1 * C1 + Z2 * C2) / DD
      V1P1 = V1 + 1.
      L(2) = 0.
      IF  (IPRINT .EQ. 1) WRITE  (6,140)   ISTN, X
      IF  (IPRINT .EQ. 1) WRITE  (6,150)   L(2), L(2), L(2), L(2), L(2),
     1       L(2), L(2), L(2)
C
C     CALCULATE  THE COEFFICIENTS OF THE DIFFERENTIAL ENERGY  EQ.
C
      DO 10 I = 1, IMAX
       LL(I) = C(I) * PHIPP(I) *(1.00-1.00/PR(I)) * Q4   * PHIP(I,1)
10    XK2(I)= C(I) / PR(I) * (1.00+EPS(I)         * PR(I) / PRT(I))
      DO 50 I = 2, IO
      XK22 = XK2(I) + XK2(I)
      DH2Q18 = Q18 * DH(I-1) * DH(I-1)
      XK1  = FP(XK2(I-1), XK2(I), XK2(I+1), DH(I-1)) + PHI(I,1) * V1P1
     1      + PHI(I,2) * V2 + PHI(I,3) * V3
      XK0  = - V1 * PHIP(I,1)
      XJ0  =-FP( LL(I-1),  LL(I),  LL(I+1), DH(I-1)) + PHIP(I,1) *
     1      ( PSI(I,2) * V2 + PSI(I,3) * V3)
      XK1DH= XK1    * DH(I-1)
C
C     CALCULATE  A, L, AND U-MATRICES
C
      DD    = XK22 + XK1DH
      W0    = WX(XK1DH, XK0, Q17, DH2Q18) + Q16
      X0    = WX(XK22, XK1DH, Q22, Q23)
      Z(I) = XJ0 * DH2Q18 / DD
      IF  (I .GT. 3) GO  TO 30
      IF  (I .EQ. 3) GO  TO 20
```

```
C
C     WALL BOUNDARY CONDITION, WALL HEAT TRANSFER IS GIVEN
C
      U(2) = W0 + X0 * Q19
      U23 =1.00- X0 * Q20
      Z (2) = Z (2) + Q21 * X0 * PSIP(1)
      GO  TO 40
C
C     WALL BOUNDARY CONDITION, WALL ENTHALPY RATIO IS GIVEN
C
20    L(3) = X0 / U(2)
      U(3) = W0 - L(3) * U23
      GO  TO 40
30    L(I) = X0    / U(I-1)
      U(I) = W0    - L(I)
40    IF  (IPRINT .EQ. 1) WRITE  (6,150)  E(I),XK2(I),XK1,XK0,XJ0,DD,W0,
     1X0
50    CONTINUE
C
C     EDGE BOUNDARY CONDITION ON G
C
      PSI(IMAX,1) = 1.
      Z(IO) = Z(IO) - PSI(IMAX, 1)
      Y(2) = Z (2)
      DO 60 I = 3, IO
60    Y(I) = Z (I) - L(I) * Y(I-1)
      IF  (IPRINT .EQ. 1) GO  TO 70
      GO  TO 90
70    CONTINUE
      WRITE  (6,160)   ISTN, X
      DO 80 I = 2, IO
80    WRITE  (6,170)  E(I), L(I), U(I), Z(I), Y(I)
      WRITE  (6,180)   U23
C
C     CALCULATE  PERTURBATION QUANTITIES PSI  FROM Y.AND U-MATRICES
C
90    PSI(IO,1) = Y(IO) / U(IO)
      DO 100 I = 4, IO
      IA = IO - I + 3
100   PSI(IA,1) = (Y(IA) - PSI(IA+1,1)) / U(IA)
      PSI(2,1) = (Y(2) - U23 * PSI(3,1)) / U(2)
      PSI(1,1) = Q24 * PSIP(1) + Q25 * PSI(2,1) + Q26 * PSI(3,1)
      IF  (IPRINT .NE. 0) WRITE  (6,210)  PSI(1,1), PSIP(1)
      IF  (IPRINT .EQ. 1) GO  TO 110
      GO  TO 130
110   CONTINUE
      WRITE  (6,190)   ISTN, X
      DO 120 I = 1, IMAX
120   WRITE  (6,200)  E(I), PSI(I,1),   XK2(I), LL(I)
130   RETURN
C
140   FORMAT  (1H0/1H , 7HSTATION, I4, 94X, 3HX =, E11.4
     1              /  / 1H0, 4X, 3HETA,10X, 2HK2, 15X, 2HK1 , 15X, 2HK0,
     2      15X, 1HJ, 16X, 2HDD, 15X, 1HW, 16X, 1HX  /// )
150   FORMAT  (1H , F9.5, 7E17.9)
160   FORMAT  (1H0/1H , 7HSTATION, I4, 94X, 3HX =, E11.4
```

```
     1          /    / 1HO, 4X, 3HETA, 13X, 1HL, 19X, 1HU, 19X, 1HZ,    XOPY1130
     2        19X, 1HY///)                                             XOPY1140
170   FORMAT  (1H , F9.5, 4E20.9)                                      XOPY1150
180   FORMAT  (1HO,  50X, 5HU23 =, E17.9)                              XOPY1160
190   FORMAT  (1HO/1H , 7HSTATION, I4, 94X, 3HX =, E11.4               XOPY1170
     1 // 1HO, 4X, 3HETA, 13X, 3H  G, 16X, 4H XK2, 17X, 2HLL  /// )    XOPY1180
200   FORMAT  (1H , F9.5, 3E20.9)                                      XOPY1190
210   FORMAT  (1H , 33X, 6H  GW =, E17.9, 6X, 7H  GPW =, E17.9)        XOPY1200
      END                                                              XOPY1210
```

```
      SUBROUTINE  FLPR  (IMMTM)
C
C     CALCULATE  FLUID PROPERTIES TEMP,RHO,RORQE,MU,C,PR,PRT,INT,T,RK
C
      COMMON/AQ/C(300), CT(300) /A2/CTP(3CC), DH(300) /A3/ E(300)
     1     , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3)
     2     /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)
     3     , RHO(300) /A9/ RK(300), RORQE(300) /A10/T(300), TEMP(300)
     4     /A11/ PHIP(300, 3)
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3
     1     , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE
     2     , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE
     3     , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17
     4     , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2
     5     , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3
     6     , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5
     7     , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1
     8     , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3
     9     , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3
     .     , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB
      LOGICAL LINCO
      REAL INT, MU, MUE, NUS
      DIMENSION A(7)
      DATA  IZERO, IONE, A / 0, 1, 0.5, 0.9, 1.0, 1.5, 5000.,
     1      0.119493 E07 , 0.37 E08 /
      DATA ZERO, ONE / 0.0, 1.0 /
      IF  (IPRINT .EQ. IONE) WRITE  (6,140)  ISTN, X
      T1 = TEMPE
      DO 70 I = 1, IMAX
      IF  (LINCO) GO  TO 30
      IF  (ISTN .GT. IZERO) GO  TO 10
      IF  (IMMTM .EQ.IONE) GO  TO 10
      T1 = TEMPE
      Q = T1
      GO  TO 20
10    Q = PSI(I,1) * HE - A(1) * UE * UE * PHIP(I,1) * PHIP(I,1)
      T1 = Q
      IF  ((Q .LT. A(5)) .OR. (Q .GT. A(7))) GO  TO 120
20    TEMP(I) = T1
      RORQE(I) = TEMPE / T1
      MU(I) = A0 * Q ** A(4) / (Q + A(6))
      GO  TO 40
30    RORQE(I) = ONE
      MU(I) = MUE
40    RHO(I) = RORQE(I) * RHOE
      IF  (LINCO) GO  TO 50
      C (I) = RORQE(I) * MU(I) / MUE
      GO  TO 60
50    C(I) = ONE
60    PR(I) = PRO
      PRT(I) = A(2)
70    CONTINUE
      INT(1) = ZERO
      RK(1)  = R
      ORHO1=RHOE/ RHO(1)
      DO 80 I = 2, IMAX
```

```
      ORHO =RHOE/ RHO(I)                                                 XOPW0570
      INT(I) = INT(I-1) + (ORHO + ORHO1) * A(I) * DH(I-1)                XOPW0580
80    ORHO1= ORHO                                                        XOPW0590
      NUS = INT(IMAX)                                                    XOPW0600
      DO 90 I = 1, IMAX                                                  XOPW0610
90    T(I) = ZERO                                                        XOPW0620
      IF (IPRINT .EQ. IONE) GO TO 100                                    XOPW0630
      RETURN                                                             XOPW0640
100   CONTINUE                                                           XOPW0650
      DO 110 I = 1, IMAX                                                 XOPW0660
110   WRITE (6,150) E(I),TEMP(I),ROROE(I),MU(I), RHO(I), C(I), PR(I),    XOPW0670
     1    PRT(I), INT(I), T(I)                                           XOPW0680
      RETURN                                                             XOPW0690
120   CONTINUE                                                           XOPW0700
      WRITE (6,130)                                                      XOPW0710
      CALL EXIT                                                          XOPW0720
      RETURN                                                             XOPW0730
C                                                                        XOPW0740
130   FORMAT (1H0, 68H *** IN SUBROUTINE FLPR,TEMPERATURE IS OUT OF RANXOPW0750
     1GE , IMMTM = 3 *** )                                               XOPW0760
140   FORMAT (1H0/1H , 7HSTATION, I4, 94X, 3HX =, E11.4                  XOPW0770
     1          / / 1H0, 4X, 3HETA, 12X, 4HTEMP, 16X, 5HROROE, 16X, XOPW0780
     2    2HMU, 18X, 3HRHO, 18X, 1HC, 18X, 2HPR / 1H , 19X, 3HPRT, 17X, XOPW0790
     3    3HINT, 18X, 1HT///)                                            XOPW0800
150   FORMAT (1H , F9.5, 6E20.9/ 10X, 6E20.9)                            XOPW0810
      END                                                                XOPW0820
```

```
      SUBROUTINE  FRCE
C  **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR
     7      , ZD(3), ZS(3),     RAIO(200)
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)
     1      , SINSLP(200), SN, XBP(200), YBP(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
      COMMON/BLOCKJ/CFF(200), CFDE(200)
C  **
      LOGICAL BEGIN
      DIMENSION HD(12), HG(9)
      DATA  HD/  10H          , 10H   NO.     , 10H      PR-N  ,
     1           10H         P , 10HR-C        , 10H    PR-M     ,
     2           10H          , 10H           , 10H FR-N      ,
     3           10H     FR-C , 10H          F , 10HR-M         /
      DATA  HG /  10H          , 10H          , 10H           ,
     1           10H          , 10H NO.       , 10H        PR- ,
     2           10HN         , 10H PR-C      , 10H     PR-M  /
C  **
C  **          SUBROUTINE 'FRCE' COMPUTES THE FORCE COEFFICIENTS
C  **
C  **
      APHA = ALPHA / 57.29578
      SN = SIN (APHA)
      CS = COS (APHA)
      SCREF = 1.0 / CREF
      SCRFSQ = 1.0 / CRFSQ
      LMP1 = 1
      ICP1 = 1
      CL = 0.
      CD = 0.
      CN1 = 0.
      CC1 = 0.
      CM1 = 0.
      IF  ((BEGIN) .AND. (IND(16) .EQ. 0)) GO  TO 80
C  **
      DO 70  I = 1, NAFPTS
C  **
      CALL  HEADR
      WRITE  (6,190)  ALPHA
      WRITE  (6,160)
C  **
      IF  (IND(18) .NE. 0) WRITE (6,210)   VSUBM
C  **
      NN = NCPTS(I) - 1
```

```
C   **
      CN2 = 0.
      CC2 = 0.
      CM2 = 0.
C   **
      WRITE  (6,220)    I
C   **
      IF  (IND(6).EQ.1) GO  TO 10
C   **
      WRITE  (6,170)    HG
C   **
C   **
10    CONTINUE
C   **
      DO 60 J = 1, NN
C   **
      LM = LMP1
      LMP1 = LM + 1
      IC = ICP1
      ICP1 = IC + 1
C   **
      IF  (J.EQ.1) GO  TO 20
C   **
      CP1 = CP2
      S1 = S2
C   **
      GO  TO 30
C   **
20    CONTINUE
C   **
      CALL  DSTSQD (XBP(IC), YBP(IC), X(LM), Y(LM), XDF, YDF, S1, S1, 1)
      CP1 = CPUP(IC) + ((CPUP(IC) - CPUP(ICP1)) / (XBP(IC) - XBP(ICP1)))
     1                * (X(LM) - XBP(IC))
C   **
30    CONTINUE
C   **
      A = 0.5 * (- S1)
C   **
      IF  (J.EQ.NN) GO  TO 40
C   **
      CALL  DSTSQD (XBP(ICP1), YBP(ICP1), X(LMP1), Y(LMP1), XDF, YDF,
     1                S2, S2, 1)
      CP2 = (S1 * CPUP(IC) + S2 * CPUP(ICP1)) / (S1 + S2)
      GO  TO 50
C   **
40    CONTINUE
C   **
      CP2 = CPUP(IC) + ((CPUP(IC) - CPUP(IC-1)) / (XBP(IC) - XBP(IC-1)))
     1                * (X(LMP1) - XBP(IC))
C   **
50    CONTINUE
      DF1 = A * (CP1 + CPUP(IC))
      DF2 = A * (CP2 + CPUP(IC))
C   **
      DFN1 = DF1 * COSSLP(IC)
      DFN2 = DF2 * COSSLP(IC)
```

```
C  **
       DFC1 = - DF1 * SINSLP(IC)
       DFC2 = - DF2 * SINSLP(IC)
C  **
       DFN = (DFN1 + DFN2)/CREF
       DFC = (DFC1 + DFC2)/CREF
       DM = (DFN1 * (XMBAR - (XBP(IC) + X(LM))/2.)
     1     - DFC1 * (YMBAR - (YBP(IC) + Y(LM))/2.)
     2     + DFN2 * (XMBAR - (XBP(IC) + X(LMP1))/2.)
     3     - DFC2 * (YMBAR - (YBP(IC) + Y(LMP1))/2.))/CRFSQ
C  **
       IF  (INC(6).EQ.0) WRITE  (6,180)    J, DFN, DFC, DM
C  **
       CN2 = CN2 + DFN
       CC2 = CC2 + DFC
       CM2 = CM2 + DM
C  **
60     CONTINUE
C  **
C  **
       LMP1 = LMP1 + 1
       ICP1 = ICP1 + 2
C  **
       CN1 = CN1 + CN2
       CC1 = CC1 + CC2
       CM1 = CM1 + CM2
C  **
       DV = CREF/DS(I)
       CN = (CN2 * CSTH(I)  -  CC2 * SNTH(I)) * DV
       CC = (CN2 * SNTH(I)  +  CC2 * CSTH(I)) * DV
C  **
       CALL  HEADR
       WRITE  (6,250)   I
C  **
       CL1 = CN2 * CS      - CC2 * SN
       CD1 = CN2 * SN      + CC2 * CS
       CL = CL + CL1
       CD = CD + CD1
C  **
       WRITE  (6,260)
       WRITE  (6,270)  CN, CC
       WRITE  (6,280)  CN2, CL1, CC2, CD1, CM2, XMBAR, YMBAR
C  **
70     CONTINUE
C  **
       WRITE  (6,300)
       WRITE  (6,260)
C  **
       WRITE  (6,280)  CN1, CL, CC1, CD, CM1, XMBAR, YMBAR
C  **
       RETURN
C  **
C  **
80     CONTINUE
C  **
       FCL = 0.0
```

```
      FCD = 0.0
      FN1 = 0.0
      FC1 = 0.0
      FM1 = 0.0
      DO 150 I = 1, NAFPTS
      CALL  HEADR
      WRITE  (6,190)  ALPHA
      WRITE  (6,200)
      IF  (IND(18) .NE. 0) WRITE (6,210)   VSUBM
      NN = NCPTS(I) - 1
      CN2 = 0.0
      CC2 = 0.0
      CM2 = 0.0
      FN2 = 0.0
      FC2 = 0.0
      FM2 = 0.0
      WRITE  (6,220)  I
      IF  (IND(6) .EQ. 1) GO  TO  90
      WRITE  (6,230)  HD
90    CONTINUE
C   **
      DO 140 J = 1, NN
C   **
      LM = LMP1
      LMP1 = LM + 1
      IC = ICP1
      ICP1 = IC + 1
      IF  (J .EQ. 1) GO  TO 100
      CF1 = CF2
      CP1 = CP2
      S1 = S2
      GO  TO 110
100   CONTINUE
      CALL  DSTSQD  (XBP(IC), YBP(IC), X(LM), Y(LM), XDF, YDF, S1, S1, 1
     1)
      R = (X(LM) - XBP(IC)) / (XBP(IC) - XBP(ICP1))
      CP1 = CPUP(IC) +  (CPUP(IC) - CPUP(ICP1)) * R
      CF1 = CFF(IC) + (CFF(IC) - CFF(ICP1)) * R
110   CONTINUE
      A = 0.5 * S1
      IF  (J .EQ. NN) GO  TO 120
      CALL  DSTSQD  (XBP(ICP1),YBP(ICP1), X(LMP1), Y(LMP1), XDF, YDF,
     1              S2, S2, 1)
      R = S1 + S2
      R1 = S1 / R
      R2 = S2 / R
      CP2 = R1 * CPUP(IC) + R2 * CPUP(ICP1)
      CF2 = R1 * CFF(IC) + R2 * CFF(ICP1)
      GO  TO 130
120   CONTINUE
      R = (X(LMP1) - XBP(IC)) / (XBP(IC) - XBP(IC-1))
      CP2 = CPUP(IC) + (CPUP(IC) - CPUP(IC-1)) * R
      CF2 = CFF(IC) + (CFF(IC) - CFF(IC-1)) * R
130   CONTINUE
      DF1 = - A * (CP1 + CPUP(IC))
      DF2 = - A * (CP2 + CPUP(IC))
```

```
      FF1 =  A * (CF1 + CFF(IC))
      FF2 =  A * (CF2 + CFF(IC))
C  **
      DFN1 = DF1 * COSSLP(IC)
      DFN2 = DF2 * COSSLP(IC)
      FFN1 = FF1 * SINSLP(IC)
      FFN2 = FF2 * SINSLP(IC)
C  **
      DFC1 = - DF1 * SINSLP(IC)
      DFC2 = - DF2 * SINSLP(IC)
      FFC1 = FF1 * COSSLP(IC)
      FFC2 = FF2 * COSSLP(IC)
C  **
      DFN = (DFN1 + DFN2) * SCREF
      DFC = (DFC1 + DFC2) * SCREF
      FFN = (FFN1 + FFN2) * SCREF
      FFC = (FFC1 + FFC2) * SCREF
C  **
      R  = XMBAR - (XBP(IC) + X(LM)) * 0.5
      R1 = YMBAR - (YBP(IC) + Y(LM)) * 0.5
      R2 = XMBAR - (XBP(IC) + X(LMP1)) * 0.5
      R3 = YMBAR - (YBP(IC) + Y(LMP1)) * 0.5
      DM = (DFN1 * R - DFC1 * R1 + DFN2 * R2 - DFC2 * R3) * SCRFSQ
      FM = (FFN1 * R - FFC1 * R1 + FFN2 * R2 - FFC2 * R3) * SCRFSQ
C  **
      IF  (IND(6) .EQ. 0) WRITE  (6,240)  J, DFN, DFC, DM, FFN, FFC, FM
C  **
      CN2 = CN2 + DFN
      CC2 = CC2 + DFC
      CM2 = CM2 + DM
      FN2 = FN2 + FFN
      FC2 = FC2 + FFC
      FM2 = FM2 + FM
C  **
140   CONTINUE
C  **
      LMP1 = LMP1 + 1
      ICP1 =  ICP1 + 2
C  **
      CN1 = CN1 + CN2
      CC1 = CC1 + CC2
      CM1 = CM1 + CM2
      FN1 = FN1 + FN2
      FC1 = FC1 + FC2
      FM1 = FM1 + FM2
C  **
      DV = CREF / DS(I)
      CN = (CN2 * CSTH(I) - CC2 * SNTH(I)) * DV
      CC = (CN2 * SNTH(I) + CC2 * CSTH(I)) * DV
      FN = (FN2 * CSTH(I) - FC2 * SNTH(I)) * DV
      FC = (FN2 * SNTH(I) + FC2 * CSTH(I)) * DV
C  **
      CALL  HEADR
      WRITE  (6,250)  I
C  **
      CL1 = CN2 * CS - CC2 * SN
```

```
      CD1 = CN2 * SN + CC2 * CS                                         XOPC2810
      CL = CL + CL1                                                     XOPC2820
      CD = CD + CD1                                                     XOPC2830
      FCL1 = FN2 * CS - FC2 * SN                                        XOPC2840
      FCD1 = FN2 * SN + FC2 * CS                                        XOPC2850
      FCL = FCL + FCL1                                                  XOPC2860
      FCD = FCD + FCD1                                                  XOPC2870
C  **                                                                   XOPC2880
      WRITE  (6,260)                                                    XOPC2890
      WRITE  (6,270)  CN, CC                                            XOPC2900
      WRITE  (6,280)  CN2, CL1, CC2, CD1, CM2, XMBAR, YMBAR             XOPC2910
      WRITE  (6,290)                                                    XOPC2920
      WRITE  (6,270)  FN, FC                                            XOPC2930
      WRITE  (6,280)  FN2, FCL1, FC2, FCD1, FM2, XMBAR, YMBAR           XOPC2940
C  **                                                                   XOPC2950
150   CONTINUE                                                          XOPC2960
C  **                                                                   XOPC2970
      CALL  HEADR                                                       XOPC2980
      WRITE  (6,300)                                                    XOPC2990
      WRITE  (6,260)                                                    XOPC3000
      WRITE  (6,280)  CN1, CL, CC1, CD, CM1, XMBAR, YMBAR               XOPC3010
      WRITE  (6,290)                                                    XOPC3020
      WRITE  (6,280)  FN1, FCL, FC1, FCD, FM1,XMBAR, YMBAR              XOPC3030
C  **                                                                   XOPC3040
      CN1 = CN1 + FN1                                                   XOPC3050
      CL  = CL  + FCL                                                   XOPC3060
      CC1 = CC1 + FC1                                                   XOPC3070
      CD  = CD  + FCD                                                   XOPC3080
      CM1 = CM1 + FM1                                                   XOPC3090
C  **                                                                   XOPC3100
      WRITE  (6,310)                                                    XOPC3110
      WRITE  (6,280)  CN1, CL, CC1, CD, CM1, XMBAR, YMBAR               XOPC3120
C  **                                                                   XOPC3130
      RETURN                                                            XOPC3140
C                                                                       XOPC3150
160   FORMAT  (1H0, 5X, 23HPOTENTIAL FLOW ANALYSIS )                    XOPC3160
170   FORMAT  (1H0, 9A10)                                               XOPC3170
180   FORMAT  (41X, I3, 5X, 3(5X, F9.4))                                XOPC3180
190   FORMAT  (1H0,  5X, 26H--- FORCE COEFFICIENTS ---, // 1H0, 5X,     XOPC3190
     1         8HALPHA = , F8.4, 8H DEGREES)                            XOPC3200
200   FORMAT  (1H0, 5X, 21HVISCOUS FLOW ANALYSIS)                       XOPC3210
210   FORMAT  (1H0, 5X, 14HMACH NUMBER = , F8.4, 4H ...)                XOPC3220
220   FORMAT  (1H0, 5X, 20HAIRFOIL PART NUMBER , I3, 4H ...)            XOPC3230
230   FORMAT  (1H0, 12A10)                                              XOPC3240
240   FORMAT  (1H , 13X, I3, 3F14.4, 14X, 3F14.4)                       XOPC3250
250   FORMAT  (1H0, 5X, 36H--- COEFFICIENTS FOR AIRFOIL NUMBER , I2,    XOPC3260
     1         4H ---)                                                  XOPC3270
260   FORMAT  (1H0, 5X, 35H--- PRESSURE FORCE COEFFICIENTS ---)         XOPC3280
270   FORMAT  (1H0, 12X, 37HNORMAL FORCE COEFFICIENT (LOCAL)     =, F8.4/XOPC3290
     1         1H0, 12X, 37HCHORDWISE FORCE COEFFICIENT (LOCAL) =, F8.4)XOPC3300
280   FORMAT  (1H0, 12X, 37HNORMAL FORCE COEFFICIENT             =, F8.4/XOPC3310
     1         1H0, 12X, 37HLIFT COEFFICIENT                     =, F8.4/XOPC3320
     2         1H0, 12X, 37HCHORDWISE FORCE COEFFICIENT          =, F8.4/XOPC3330
     3         1H0, 12X, 37HDRAG COEFFICIENT                     =, F8.4/XOPC3340
     4         1H0, 12X, 37HPITCHING MOMENT COEFFICIENT          =, F8.4/XOPC3350
     5         1H0, 12X, 37HPOINT ABOUT WHICH MOMENTS ARE TAKEN (, F8.4,XOPC3360
```

```
      6            1H, F8.4, 1H1 //)                                          XOPC3370
290    FORMAT  (1HO, 5X, 37H--- FRICTIONAL FORCE COEFFICIENTS ---)              XOPC3380
300    FORMAT  (1HO, 5X, 47H--- FORCE COEFFICIENTS FOR THE TOTAL SYSTEM -XOPC3390
      1--)                                                                    XOPC3400
310    FORMAT  (1HO, 5X, 32H--- TOTAL FORCE COEFFICIENTS ---)                   XOPC3410
       END                                                                    XOPC3420
```

```
      SUBROUTINE   GEOM                                                  XOPH0010
C  **                                                                    XOPH0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS   XOPH0030
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPH0040
     2      , KPAGE                                                      XOPH0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                          XOPH0060
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM                         XOPH0070
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)   XOPH0080
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPH0090
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)  XOPH0100
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR    XOPH0110
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR                          XOPH0120
     7      , ZC(3), ZS(3),      RAIO(200)                               XOPH0130
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)    XOPH0140
     1      , SINSLP(200), SN, XBP(200), YBP(200)                        XOPH0150
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                     XOPH0160
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)           XOPH0170
     2      , XSLOC1(10), YSLOC1(10)                                     XOPH0180
C  **                                                                    XOPH0190
      DIMENSION HD(12)                                                   XOPH0200
      DIMENSION SLPE(200)                                                XOPH0210
      LOGICAL IDFO, LIT, BEGIN                                           XOPH0220
C  **                                                                    XOPH0230
      DATA HD / 10H              , 10H        IND , 10HEX  POINT  ,      XOPH0240
     1          10HNUMBER        , 10H      X     , 10H           ,      XOPH0250
     2          10HY             , 10H      XBP   , 10H           ,      XOPH0260
     3          10HYBP           , 10H        SLO , 10HPE         /      XOPH0270
      DATA  RADIAN /57.2957795 /                                         XOPH0280
C  **                                                                    XOPH0290
C  **              SUBROUTINE 'GEOM' CALCULATES AND WRITES THE BOUNDARY  XOPH0300
C  **         POINT COORDINATES, AND THE SLOPE ASSOCIATED WITH EACH      XOPH0310
C  **         BOUNDARY POINT.  THE COORDINATES OF THE POINT ASSOCIATED   XOPH0320
C  **         WITH EACH BOUNDARY POINT ARE ALSO WRITTEN...               XOPH0330
C  **                                                                    XOPH0340
C  **                                                                    XOPH0350
      IB = 0                                                             XOPH0360
      IC = 0                                                             XOPH0370
      ANGR = ANGL(NOANG) / 57.29578                                      XOPH0380
      IDFO(9) = .FALSE.                                                  XOPH0390
      IDFO(10) = .TRUE.                                                  XOPH0400
      IF  (LIT) GO  TO  20                                               XOPH0410
      IF  (IDFO(2)) GO  TO  30                                           XOPH0420
      IF  (ITER .EQ. 1) GO  TO  30                                       XOPH0430
      IF  (ITER .EQ. IND(13)) GO  TO  30                                 XOPH0440
      IF  (IDD(2) .EQ. 1) GO  TO  10                                     XOPH0450
      DD = MOD (ITER, IDD(2))                                            XOPH0460
      DD = DD / IDD(2)                                                   XOPH0470
      IDFO(10) = DD .LT. 0.01                                            XOPH0480
      GO  TO  30                                                         XOPH0490
10    CONTINUE                                                           XOPH0500
      IDFO(10) = .FALSE.                                                 XOPH0510
      GO  TO  30                                                         XOPH0520
20    CONTINUE                                                           XOPH0530
      IDFO(9) = .TRUE.                                                   XOPH0540
30    CONTINUE                                                           XOPH0550
      IF  ( NOANG .EQ. 1 ) GO  TO  40                                    XOPH0560
```

```
      IF  ( IND (9) .EQ. 0 ) GO  TO 40
      IF  ( .NOT. IDFO(9)) GO  TO 40
      NSTLNS = NSTLNS - NAFPTS - NAFPTS
40    CONTINUE
C  **
      DO 140 I = 1, NAFPTS
C  **
      IF  (IDFO(10)) GO  TO 50
      GO  TO 60
50    CONTINUE
      CALL  HEADR
      APHA = ANGL (NOANG)
      WRITE  (6,150)  APHA
      WRITE  (6,160)   I, NCPTS(I), ITER
C  **
      WRITE  (6,170)   HD
C  **
60    CONTINUE
C  **
      NBP = NCPTS(I) - 1
      ICP1 = IC + 1
      IS(I) = IB + 1
      DO 110 J = 1, NBP
C  **
      ICJ = IC + J
      IBJ = IB + J
      XBP(IBJ) = (X(ICJ  ) + X(ICP1+J))  / 2.0
      YBP(IBJ) = (Y(ICJ  ) + Y(ICP1+J))  / 2.0
      DX = X(ICJ  ) - X(ICP1+J)
      DY = Y(ICJ  ) - Y(ICP1+J)
      D = SQRT (DX * DX + DY * DY)
C  **
      IF  (D .NE. 0.0) GO  TO 70
      WRITE  (6,180)
      CALL  EXIT
70    CONTINUE
C  **
      COSSLP(IBJ) = DX / D
      SINSLP(IBJ) = DY / D
      IF  (DX .EQ. 0.0) GO  TO 80
      IF  (DY .EQ. 0.0) GO  TO 90
      SLPE(IBJ) = ATAN (DY/DX) * 57.29578
      GO  TO 100
80    CONTINUE
      SLPE(IBJ) = 90.0
      IF  (DY .LT. 0.0) SLPE(IBJ) = - SLPE(IBJ)
      GO  TO 100
90    CONTINUE
      SLPE(IBJ) = 0.0
C  **
100   CONTINUE
C  **
C  **
      IF  (IDFO(10)) WRITE  (6,190)  IBJ, J, X(ICJ), Y(ICJ), XBP(IBJ),
     1                               YBP(IBJ), SLPE(IBJ)
C  **
```

```
110   CONTINUE
C  **
      IE(I) = IBJ
C  **
      IBJ = IBJ + 1
      ICJ = ICJ + 1
C  **
      IF  (.NOT. BEGIN) GO  TO 120
      IF  (JIS(I) .LE.  JIBEG(I) + 1) GO  TO 120
      IF  (ABS(HEIGHT) .LT. 0.001) GO  TO 120
      AA = SLPE(IS(I)) / RADIAN
      AB = AA + (ANGR - AA) * HEIGHT
      IF  (HEIGHT .GT. 1.0) AB = AA + HEIGHT / RADIAN
      COSSLP(IBJ) = COS(AB)
      SINSLP(IBJ) = SIN(AB)
      SLPE (IBJ) = AB * RADIAN
      GO  TO 130
120   CONTINUE
      COSSLP(IBJ) = COSSLP(IS(I))
      SINSLP(IBJ) = SINSLP(IS(I))
      SLPE(IBJ) = SLPE(IS(I))
130   CONTINUE
      XBP(IBJ) = X(ICP1) + DXTGE * COSSLP(IBJ)
      YBP(IBJ) = Y(ICP1) + DXTGE * SINSLP(IBJ)
C  **
      IF  (IDFO(10)) WRITE  (6,190)  IBJ, NCPTS(I), X(ICJ), Y(ICJ),
     1                               XBP(IBJ), YBP(IBJ), SLPE(IBJ)
C  **
C  **
      IBJ = IBJ + 1
      COSSLP(IBJ) = COSSLP(IBJ-2)
      SINSLP(IBJ) = SINSLP(IBJ-2)
      SLPE(IBJ) = SLPE(IBJ-2)
      XBP(IBJ) = X(ICJ) - DXTGE * COSSLP(IBJ)
      YBP(IBJ) = Y(ICJ) - DXTGE * SINSLP(IBJ)
      II = NCPTS(I) + 1
      IF  (IDFO(10)) WRITE  (6,200)    IBJ, II, XBP(IBJ), YBP(IBJ),
     1                                 SLPE(IBJ)
      IC = IC + NCPTS(I)
      IB = IB + II
C  **
      IF  (.NOT. IDFO(9)) GO  TO 140
      IF  (INC(9) .EQ. 0) GO  TO 140
      NSTLNS = NSTLNS + 1
      XS(NSTLNS) = XBP(IBJ-1)
      YS(NSTLNS) = YBP(IBJ-1)
      NSTLNS = NSTLNS + 1
      XS(NSTLNS) = XBP(IBJ)
      YS(NSTLNS) = YBP(IBJ)
C  **
140   CONTINUE
C  **
      RETURN
C  **
C
150   FORMAT  (1H0, 18HANGLE OF ATTACK = , F6.3)
```

```
160    FORMAT  (1H0, 13HAIRFOIL PART  , I2, 2H,  , I3, 19H DEFINING POINTXOPH1690
      1S... /   1H0, 10HITERATION   , I2, 3H... )                         XOPH1700
170    FORMAT  (1H0, 12A10)                                                XOPH1710
180    FORMAT  (1H0, 78H *** IN SUBROUTINE GEOM, TWO ADJACENT CORNER POINXOPH1720
      1TS MUST NOT BE COINCIDENT *** )                                     XOPH1730
190    FORMAT  (1H , 18X, I3, 6H.     - , I3, 2H -, 8X, 4(F10.5, 5X), 4X, XOPH1740
      1         F9.5)                                                      XOPH1750
200    FORMAT  (1H , 18X, I3, 6H.     - , I3, 2H -, 38X, 2(F10.5, 5X), 4X,XOPH1760
      1         F9.5)                                                      XOPH1770
       END                                                                 XOPH1780
```

```
      SUBROUTINE  GWRT
C  **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR
     7      , ZD(3), ZS(3),       RAID(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
      LOGICAL IDFO
      DIMENSION HD(2)
      DATA HD / 10H INDEX     , 10H   -1-      /
      DATA KNSUB /4HGWRT /
C  **
C  **              SUBROUTINE 'GWRT' PRINTS THE GAMMAS WHICH HAVE BEEN
C  **         COMPUTED...
C  **
C  **
C  **
      IF  (.NOT. IDFO(10)) GO  TO 10
      CALL  HEADR
      WRITE  (6,50)  ALPHA
      WRITE  (6,60)  HD
10    CONTINUE
C  **
      M = 0
      I = 0
C  **
      DO 30  I1 = 1, NAFPTS
      N = NCPTS(I1)
C  **
      DO 20  K = 1, N
C  **
      M = M + 1
      I = I + 1
C  **
      IF  (IDFO(10)) WRITE  (6,70)  M, GAMMA(I)
C  **
20    CONTINUE
C  **
      I = I + 1
C  **
      SS(I1   ) = GAMMA(I)
C  **
30    CONTINUE
C  **
      IF  (.NOT. IDFO(10)) RETURN
C  **
      CALL  HEADR
```

```
      WRITE  (6,80)  ALPHA
      WRITE  (6,60)  HD
C  **
      DO 40  I = 1, NAFPTS
C  **
      WRITE  (6,70)   I, SS(I)
C  **
40    CONTINUE
C  **
      RETURN
C  **
C
50    FORMAT  (1H0, 46X, 31HGAMMA DISTRIBUTION FOR ALPHA =   , F9.4 )
60    FORMAT  (1H0, 2A10)
70    FORMAT  (1H , 3X, I3, 4H.    , F9.5)
80    FORMAT  (1H0, 47X, 29HSOURCE STRENGTHS FOR ALPHA =   , F9.4)
      END
```

```
      SUBROUTINE  HEADR                                                 XOPDC010
C  **                                                                   XOPDC020
C          PRINT THE PROGRAM TITLE                                      XOPDC030
C  **                                                                   XOPDC040
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS   XOPDC050
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPDC060
     2     , KPAGE                                                      XOPDC070
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPDC080
     1     , CREF, CRFSQ, CRT, CSTH(10), DLTALM                         XOPDC090
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDO(10), IDFO(10)   XOPDC100
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPDC110
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)  XOPDC120
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR    XOPDC130
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR                          XOPDC140
     7     , ZD(3), ZS(3),      RAIO(200)                               XOPDC150
C  **                                                                   XOPDC160
      WRITE  (6,10)  TITLE(11) , TITLE(12), KPAGE                       XOPDC170
      KPAGE = KPAGE + 1                                                 XOPDC180
      RETURN                                                            XOPDC190
C                                                                       XOPDC200
10    FORMAT  (1H1 / 1H , 10H PROBLEM   , A10, 5X, 72H6600 PROCEDURE VISCXOPDC210
     1OUS FLOW ANALYSIS OF ARBITRARY MULTI-ELEMENT AIRFOILS, 7X, 4HDATE,XOPDC220
     2 A10, 2X, 5HPAGE , I4 /  )                                        XOPDC230
      END                                                               XOPDC240
```

```
      SUBROUTINE  KEOF (TAPENO, KIND, KSUBR, KSTMT)
C
      IF   (KIND .NE. 0) GO  TO 10
      WRITE  (6,30)
      GO  TO 20
10    CONTINUE
      WRITE  (6,40)  TAPENO, KSUBR, KSTMT
20    CONTINUE
      CALL  EXIT
      RETURN
C
30    FORMAT  (22H THIS JOB IS COMPLETE. )
40    FORMAT  (32H UNEXPECTED END OF FILE ON UNIT , I3 /
     1         15H IN SUBROUTINE , A6, 11H STATEMENT , I6 )
      END
```

```
      SUBROUTINE  LAM (IXM, NX, XXM, CPXM, XX, CPX, USUMX, DCPX,
     1                    DDCPX, XSEP, IXXS, RATIO)
C  **
C             *** LAMINAR SEPARATION ***
C  **
      DIMENSION XX(200), CPX(200), USUMX(200), DCPX(200), DDCPX(200)
      EQUIVALENCE (U5, PY, A)
      DATA EPS /1.0E-06/, COEF /0.102/, XTWO /2.0/,NTWO /2/
C  **
C             *** EQUIVALENT LEADING EDGE CALCULATION ***
C  **
      XSEP = 0.0
      SAVE = USUMX(2) ** 5
      XOPX = XX(2) *  SAVE
      DO 10 I = 3, IXM
      U5 = USUMX(I) ** 5
      XOPX = XOPX + (U5 + SAVE) * (XX(I) - XX(I-1))
      SAVE = U5
10    CONTINUE
      XOPX = XOPX / XTWO
C  **
C            ***  DDCP CALCULATION AT INDEX OF CPMIN + 1 ***
C  **
      IBEG = IXM + NTWO
      XXO = XOPX - XXM
      SAVE = ABS (1.0 - CPXM)
      SQCP = SAVE * SQRT(SAVE)
      SAVE = ABS( CPX(IXM+1) -CPXM)
C                                                        ERROR  121
      IF  (SAVE .GE. EPS) GO  TO 20
      WRITE  (6,100)
      CALL  EXIT
20    CONTINUE
      PY = SQCP / SQRT(SAVE)
      SAVE = XX(IXM+1) + XXO
C                                                        ERROR  122
      IF  (ABS(SAVE) .GE. EPS) GO  TO 30
      WRITE  (6,110)
      CALL  EXIT
30    CONTINUE
      DDCPX(IXM+1)=( COEF * PY) / SAVE
      IF  (DCPX(IXM+1) .LT. DDCPX(IXM+1)) GO  TO 40
      IXXS = IXM+1
      XSEP = XX(IXM+1)
      RATIO = 0.0
      RETURN
40    CONTINUE
C  **
C            ***  DDCP CALCULATION TILL SEPARATION ***
C  **
      DO 80 I = IBEG, NX
      IXXS = I
      PY = SQCP / SQRT(ABS(CPX(I) - CPXM))
      SAVE = XX(I) + XXO
C                                                        ERRCR  123
      IF  (ABS(SAVE) .GE. EPS) GO  TO 50
```

```
      WRITE  (6,120)                                                    XOPRB570
      CALL   EXIT                                                       XOPRB580
50    CONTINUE                                                          XOPRB590
      DDCPX(I) = (COEF * PY) / SAVE                                     XOPRB600
      IF  (DCPX(I) .LT. DDCPX(I)) GO  TO 70                             XOPRB610
      SAVE1= 1.0 / (XX(I-1) - XX(I))                                    XOPRB620
      A = (DDCPX(I-1) - DDCPX(I)) * SAVE1                               XOPRB630
      B = (DCPX (I-1) - DCPX (I)) * SAVE1                               XOPRB640
      SAVE = B - A                                                      XOPRB650
C                                                          ERROR  124   XOPRB660
      IF  (ABS(SAVE) .GE. EPS) GO  TO 60                                XOPRB670
      WRITE  (6,130)                                                    XOPRB680
      CALL   EXIT                                                       XOPRB690
60    CONTINUE                                                          XOPRB700
      XSEP = XX(I) + (DDCPX(I) - DCPX(I)) / SAVE                        XOPRB710
      RATIO = (XSEP - XX(I)) * SAVE1                                    XOPRB720
      GO  TO 90                                                         XOPRB730
70    CONTINUE                                                          XOPRB740
80    CONTINUE                                                          XOPRB750
90    CONTINUE                                                          XOPRB760
      RETURN                                                            XOPRB770
C                                                                       XOPRB780
100   FORMAT   (1HO, 74H *** IN SUBROUTINE LAM, CP VALUES MUST NOT BE EQUXOPRB790
     1AL AT ADJACENT POINTS *** )                                       XOPRB800
110   FORMAT   (1HO, 89H *** IN SUBROUTINE LAM, INITIAL DELTA EQUIVALENT XOPRB810
     1DISTANCE OF THE LEADING EDGE IS ZERO *** )                        XOPRB820
120   FORMAT   (1HO, 93H *** IN SUBROUTINE LAM, DELTA EQUIVALENT DISTANCEXOPRB830
     1 OF THE LEADING EDGE MUST NOT EQUAL ZERO *** )                    XOPRB840
130   FORMAT   (1HO, 75H *** IN SUBROUTINE LAM, SLOPE OF DCPX MUST NOT EQXOPRB850
     1UAL THE SLOPE OF DDCPX *** )                                      XOPRB860
      END                                                               XOPRB870
```

```
      SUBROUTINE  MOMTUM  (MEAN)                                        XOPZ0010
C                                                                       XOPZ0020
C     MOMENTUM EQ. IS SOLVED BY THE CHOLESKI METHOD                     XOPZ0030
C     DERIVATIVES OF DEPENDENT VARIABLES ARE OBTAINED BY THE FIRST-     XOPZ0040
C     DERIVATIVE 5-POINT FINITE-DIFFERENCE FORMULAS WITH VARIABLE GRID  XOPZ0050
C                                                                       XOPZ0060
      COMMON/AQ/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)       XOPZ0070
     1      , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3) XOPZ0080
     2      /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)XOPZ0090
     3      , RHO(300) /A9/ RK(300), RUROE(300) /A10/T(300), TEMP(300)  XOPZ0100
     4      /A11/ PHIP(300, 3)                                          XOPZ0110
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3             XOPZ0120
     1      , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE    XOPZ0130
     2      , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE     XOPZ0140
     3      , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17  XOPZ0150
     4      , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2XOPZ0160
     5      , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3 XOPZ0170
     6      , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5 XOPZ0180
     7      , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1 XOPZ0190
     8      , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3  XOPZ0200
     9      , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3 XOPZ0210
     .      , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB    XOPZ0220
      LOGICAL  LINCO, LMN, LNMN, LNPR, LPR                              XOPZ0230
      REAL I1, I3, I4, I5, INM, INN, IN1, IN2, IN3, INM1, INM2, INM3, JOXOPZ0240
     1      , K00, K10, K20, K30, L11, L11M, L111, MN, M1, M3, M4, M5   XOPZ0250
     2      , MNN, MN1, MN2, MN3, MNM1, MNM2, MNM3, MNM, IN, L1, L2, N  XOPZ0260
      DIMENSION  DEL(300),DELP(300),L1(300),L2(300),N(300),U(300),Y(300)XOPZ0270
     1           , U1(300),J0(300),K00(300),K10(300),K20(300),K30(300)  XOPZ0280
      EQUIVALENCE  (DEL(1),L1(1),CT(1)),  (DELP(1),L2(1),CTP(1)),       XOPZ0290
     1             (K30(1),Y(1),EPS(1))                                 XOPZ0300
      DATA  ZERO, C5, ONE, IZERO, IONE /0.0, 0.5, 1.0, 0, 1/            XOPZ0310
      DENOM (R1, R2, R3, Z1, Z2,H)=R1 + R2 * Z2 *  H   + R3 * Z1 * DETA2XOPZ0320
      F ( F1, F2, F3, F4, Z2, Z1, Z0,H)= (F1 + F2 * Z2 *  H   + F3 * Z1 XOPZ0330
     1    * DETA2 + F4 * Z0 * DETA3) / DD                               XOPZ0340
      FP (A, B, C, D, E, FM2, FM1, F, FP1, FP2,H)=(A * FM2 + B * FM1 +  XOPZ0350
     1         C * F + D * FP1 + E * FP2) / H                           XOPZ0360
C                                                                       XOPZ0370
C     CALCULATE  THE COEFFICIENTS OF THE DIFFERENTIAL MOMENTUM  EQ.     XOPZ0380
C                                                                       XOPZ0390
      LPR = IPRINT .EQ. IONE                                            XOPZ0400
      LNPR = .NOT. LPR                                                  XOPZ0410
      LMN = MEAN .EQ. IZERO                                             XOPZ0420
      LNMN = .NOT. LMN                                                  XOPZ0430
      V1B = BETA + V1                                                   XOPZ0440
      BROE = BETA * RHOE                                                XOPZ0450
      DO 10  I= 1, IMAX                                                 XOPZ0460
      PHIM1 = PHI(I,1) - E(I)                                           XOPZ0470
      PHIM2 = PHI(I,2) - E(I)                                           XOPZ0480
      PHIM3 = PHI(I,3) - E(I)                                           XOPZ0490
      PHIPM1 = PHIP(I,1) - ONE                                          XOPZ0500
      PHIPM2 = PHIP(I,2) - ONE                                          XOPZ0510
      PHIPM3 = PHIP(I,3) - ONE                                          XOPZ0520
      K30(I) = CT(I)                                                    XOPZ0530
      K20(I) = (CTP(I) + PHI(I,1)) / K30(I)                             XOPZ0540
      K10(I) = -(BETA + V1B*PHIP(I,1))/ K30(I)                          XOPZ0550
      K00(I) =(V1 * PHIPP(I)   ) / K30(I)                               XOPZ0560
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10    JO(I)  = ( PHIP(I,1)*(V2*PHIPM2+V3*PHIPM3)-PHIPP(I)*(V2*PHIM2      XOPZ0570
     1        + V3*PHIM3) + BETA - BROE / RHO(I) ) / K30(I)              XOPZ0580
      DO 20 I = 1, IMAX                                                   XOPZ0590
      PHIM1 = PHI (I,1) - F(I)                                            XOPZ0600
      PHIPM1= PHIP(I,1) - ONE                                             XOPZ0610
20    JO(I)=JO(I)-(PHIPPP(I)+K20(I)*PHIPP(I)+K10(I)*PHIPM1+K00(I)*PHIM1)XOPZ0620
C                                                                         XOPZ0630
C     WALL BOUNDARY CONDITION ON DEL                                      XOPZ0640
C                                                                         XOPZ0650
      DEL(1) = DELW                                                       XOPZ0660
      IF  ( LPR) WRITE  (6,140)   ISTN, X                                 XOPZ0670
C                                                                         XOPZ0680
C     CALCULATE  A, L, AND U-MATRICES                                     XOPZ0690
C                                                                         XOPZ0700
      DD = S12                                                            XOPZ0710
      IF  ( LPR) WRITE  (6,150) E(1),K30(1),K20(1),K10(1),           K00(1XOPZ0720
     1), JO(1), DD, F1, G1, I1, M1                                        XOPZ0730
      DELP(1) = ZERO                                                      XOPZ0740
      DETA2 = DH(1) * DH(1)                                               XOPZ0750
      DETA3 = DETA2 * DH(1)                                               XOPZ0760
      L1(2) = ZERO                                                        XOPZ0770
      L2(2) =  ZERO                                                       XOPZ0780
      U(2) = I1                                                           XOPZ0790
      U1(2) = G1                                                          XOPZ0800
      U23 = F1                                                            XOPZ0810
      GK2 = GK * GK                                                       XOPZ0820
      GK3 = GK * GK2                                                      XOPZ0830
      GK6 = GK3 * GK3                                                     XOPZ0840
      N(2) = -M1 * DEL(1) - DELP(1) * DH(1)* GK6 *                        XOPZ0850
     1       ( ONE + GK  + GK2 + GK3)                                     XOPZ0860
      DD = DENOM (RN1, RN2, RN3, K10(3), K20(3) , DH(1) )                 XOPZ0870
      F3 = F (FN1, FN2, FN3,ZERO, K20(3), K10(3),ZERO , DH(1) )           XOPZ0880
      I3 = F (IN1, IN2, IN3,ZERO, K20(3), K10(3),ZERO , DH(1) )           XOPZ0890
      M3 = F (MN1, MN2, MN3,ZERO, K20(3), K10(3),ZERO , DH(1) )           XOPZ0900
      G3 = F (GN1, GN2, GN3, GN4, K20(3), K10(3), K00(3) , DH(1) )        XOPZ0910
      EDETA3 = DETA3 * GN4 / DD                                           XOPZ0920
      IF  ( LPR) WRITE  (6,150) E(3),K30(3),K20(3),K10(3),           K00(3XOPZ0930
     1), JO(3), DD, F3, G3, I3, M3                                        XOPZ0940
      L1(3) = ZERO                                                        XOPZ0950
      L2(3) = I3 / U(2)                                                   XOPZ0960
      U(3) = G3 - L2(3) * U1(2)                                           XOPZ0970
      U1(3) = F3 - L2(3) * U23                                            XOPZ0980
      U34 =ONE - L2(3)                                                    XOPZ0990
      N(3) = JO(3) * EDETA3 - M3 * DEL(1)                                 XOPZ1000
      DETA2 = DH(2) * DH(2)                                               XOPZ1010
      DETA3 = DETA2 * DH(2)                                               XOPZ1020
      DD = DENOM (RN1, RN2, RN3, K10(4), K20(4) , DH(2) )                 XOPZ1030
      G4 = F (GN1, GN2, GN3, GN4, K20(4), K10(4), K00(4) , DH(2) )        XOPZ1040
      F4 = F (FN1, FN2, FN3,ZERO, K20(4), K10(4),ZERO , DH(2) )           XOPZ1050
      I4 = F (IN1, IN2, IN3,ZERO, K20(4), K10(4),ZERO , DH(2) )           XOPZ1060
      M4 = F (MN1, MN2, MN3,ZERO, K20(4), K10(4),ZERO , DH(2) )           XOPZ1070
      EDETA3 = DETA3 * GN4 / DD                                           XOPZ1080
      IF  ( LPR) WRITE  (6,150) E(4),K30(4),K20(4),K10(4),           K00(4XOPZ1090
     1), JO(4), DD, F4, G4, I4, M4                                        XOPZ1100
      L1(4) = M4 / U(2)                                                   XOPZ1110
      L2(4) = (I4 - L1(4) * U1(2))/ U(3)                                  XOPZ1120
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      U(4) = G4 - L1(4) * U23 - L2(4) * U1(3)
      U1(4) = F4 - L1(4) - L2(4) * U34
      N(4) = JO(4) * EDETA3
      DETA2 = DH(3) * DH(3)
      DETA3 = DETA2 * DH(3)
      DD = DENOM (RN1, RN2, RN3, K10(5), K20(5) , DH(3) )
      F5 = F (FN1, FN2, FN3,ZERO, K20(5), K10(5),ZERO , DH(3) )
      I5 = F (IN1, IN2, IN3,ZERO, K20(5), K10(5),ZERO , DH(3) )
      M5 = F (MN1, MN2, MN3,ZERO, K20(5), K10(5),ZERO , DH(3) )
      G5 = F (GN1, GN2, GN3, GN4, K20(5), K10(5), K00(5) , DH(3) )
      EDETA3 = DETA3 * GN4 / DD
      IF  ( LPR) WRITE  (6,150) E(5),K30(5),K20(5),K10(5),         K00(5
     1), JO(5), DD, F5, G5, I5, M5
      L1(5) = M5 / U(3)
      L2(5) = (I5 - L1(5) * U1(3)) / U(4)
      U(5) = G5 - L1(5)* U34 - L2(5) * U1(4)
      U1(5) = F5 - L2(5)
      N(5) = JO(5) * EDETA3
      DO 30 M = 6, MT
      DETA2 = DH( M-2) * DH(M-2)
      DETA3 = DETA2 * DH(M-2)
      DD = DENOM (RN1, RN2, RN3, K10(M), K20(M) , DH(M-2) )
      GN = F (GN1, GN2, GN3, GN4, K20(M), K10(M), K00(M) , DH(M-2) )
      MN = F (MN1, MN2, MN3,ZERO, K20(M), K10(M),ZERO , DH(M-2) )
      IN = F (IN1, IN2, IN3,ZERO, K20(M), K10(M),ZERO , DH(M-2) )
      FN = F (FN1, FN2, FN3,ZERO, K20(M), K10(M),ZERO , DH(M-2) )
      EDETA3 = DETA3 * GN4 / DD
      IF  ( LPR) WRITE  (6,150) E(M),K30(M),K20(M),K10(M),         K00(M
     1), JO(M), DD, FN, GN, IN, MN
      L1(M) = MN / U(M-2)
      L2(M) = (IN - L1(M) * U1(M-2)) / U(M-1)
      U (M) = GN - L1(M) - L2(M) * U1(M-1)
      U1(M) = FN - L2(M)
      N (M) = JO(M   )*EDETA3
30    CONTINUE
      DD = DENOM (RNM1, RNM2, RNM3, K10(IMAX-1), K20(IMAX-1),DH(IMAX-4))
      FNM = F (FNM1, FNM2, FNM3, FNM4, K20(IMAX-1), K10(IMAX-1), K00(IMA
     1        X-1) , DH(IMAX-4) )
      MNM = F (MNM1, MNM2, MNM3,ZERO, K20(IMAX-1), K10(IMAX-1),ZERO ,
     1  DH(IMAX-4) )
      INM = F (INM1, INM2, INM3,ZERO, K20(IMAX-1), K10(IMAX-1),ZERO ,
     1  DH(IMAX-4) )
      GNM = F (GNM1, GNM2, GNM3,ZERO, K20(IMAX-1), K10(IMAX-1),ZERO ,
     1  DH(IMAX-4) )
      EDETA3 = DETA3 * GN4 / DD
      IF  ( LPR) WRITE (6,150) E(IMAX-1),K30(IMAX-1),K20(IMAX-1),     K1
     10(IMAX-1), K00(IMAX-1), JO(IMAX-1), DD, FNM, GNM, INM, MNM
      L11M = MNM / U(IMAX-4)
      L1(IMAX-1) = (INM - L11M * U1(IMAX-4)) / U(IMAX-3)
      L2(IMAX-1) = (GNM - L11M - L1(IMAX-1) * U1(IMAX-3)) / U(IMAX-2)
      U(IMAX-1) =  FNM - L1(IMAX-1) - L2(IMAX-1) * U1(IMAX-2)
      U1(IMAX-1) =ONE - L2(IMAX-1)
      N(IMAX-1) = JO(IMAX-1) * EDETA3
      DD = RNN
      IF  ( LPR) WRITE (6,150) E(IMAX),K30(IMAX),K20(IMAX),        K10(
     1IMAX), K00(IMAX), JO(IMAX), DD, FNN, GNN, INN, MNN
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      L111 = MNN / U(IMAX-4)                                            XOPZ1690
      L11 = (INN - L111 * U1(IMAX-4)) / U(IMAX-3)                       XOPZ1700
      L1(IMAX) = (GNN - L111 - L11 * U1(IMAX-3)) / U(IMAX-2)            XOPZ1710
      L2(IMAX) = (FNN - L11 - L1(IMAX) * U1(IMAX-2)) / U(IMAX-1)        XOPZ1720
      U(IMAX) =ONE - L1(IMAX) - L2(IMAX) * U1(IMAX-1)                   XOPZ1730
      N(IMAX) = ZERO                                                    XOPZ1740
C                                                                       XOPZ1750
C     CALCULATE Y-MATRIX                                                XOPZ1760
C                                                                       XOPZ1770
      Y(2) = N(2)                                                       XOPZ1780
      Y(3) = N(3) - L2(3) * Y(2)                                        XOPZ1790
      DO 40 M = 4, MT                                                   XOPZ1800
40    Y(M) = N(M) - L1(M) * Y(M-2) - L2(M) * Y(M-1)                     XOPZ1810
      Y(IMAX-1) = N(IMAX-1) - L11M * Y(IMAX-4) - L1(IMAX-1) * Y(IMAX-3) XOPZ1820
     1         - L2(IMAX-1) * Y(IMAX-2)                                 XOPZ1830
      Y(IMAX) = - L111 * Y(IMAX-4) - L11 * Y(IMAX-3) - L1(IMAX) * Y(IMAXXOPZ1840
     1        -2) - L2(IMAX) * Y(IMAX-1) + N(IMAX)                      XOPZ1850
      IF  ( LNPR) GO  TO 60                                             XOPZ1860
      WRITE  (6,160)   ISTN, X                                          XOPZ1870
      DO 50 I = 1, IMAX                                                 XOPZ1880
50    WRITE  (6,170)  E(I),L1(I), L2(I), U(I), U1(I), N(I), Y(I)        XOPZ1890
C                                                                       XOPZ1900
C     CALCULATE  PERTURBATION QUANTITIES DEL  FROM Y.AND U-MATRICES     XOPZ1910
C                                                                       XOPZ1920
60    DEL(IMAX) = Y(IMAX) / U(IMAX)                                     XOPZ1930
      DEL(IMAX-1) = (Y(IMAX-1) - U1(IMAX-1) * DEL(IMAX)) / U(IMAX-1)    XOPZ1940
      I44= IMAX - 4                                                     XOPZ1950
      DO 70 M = 2, I44                                                  XOPZ1960
      IT = IMAX-M                                                       XOPZ1970
70    DEL(IT) = (Y(IT) - DEL(IT+2) - U1(IT) * DEL(IT+1)) / U(IT)        XOPZ1980
      DEL(3) = (Y(3) - U34 * DEL(5) - U1(3) * DEL(4))/ U(3)             XOPZ1990
      DEL(2) = (Y(2) - DEL(5) - U23 * DEL(4) - U1(2) * DEL(3)) / U(2)   XOPZ2000
C                                                                       XOPZ2010
C     WALL BOUNDARY CONDITION ON DELP                                   XOPZ2020
C                                                                       XOPZ2030
C                                                                       XOPZ2040
C     CALCULATE  PERTURBATION QUANTITIES DELP  FROM DEL  BY THE FIRST-  XOPZ2050
C     DERIVATIVE 5-POINT FINITE-DIFFERENCE FORMULAS WITH VARIABLE GRID  XOPZ2060
C                                                                       XOPZ2070
      DELP(2) = FP (AV2, BV2, CV2, DV2, EV2, DEL(1), DEL(2), DEL(3), DELXOPZ2080
     1       (4), DEL(5) , DH(1) )                                      XOPZ2090
      DO 80 I = 3, MT                                                   XOPZ2100
      DELP(I) = FP (AV3, BV3, CV3, DV3, EV3, DEL(I-2), DEL(I-1), DEL(I),XOPZ2110
     1       DEL(I+1), DEL(I+2) , DH(I-2) )                             XOPZ2120
80    CONTINUE                                                          XOPZ2130
      DELP(IMAX-1) = FP (AV4, BV4, CV4, DV4, EV4, DEL(IMAX-4), DEL(IMAX-XOPZ2140
     1           3), DEL(IMAX-2), DEL(IMAX-1), DEL(IMAX) ,DH(IMAX-4)) XOPZ2150
C                                                                       XOPZ2160
C     EDGE BOUNDARY CONDITION ON DELP                                   XOPZ2170
C                                                                       XOPZ2180
      DELP(IMAX) = ZERO                                                 XOPZ2190
C                                                                       XOPZ2200
C     CALCULATE  PERTURBATION QUANTITIES DELPP FROM DELP BY THE FIRST-  XOPZ2210
C     DERIVATIVE 5-POINT FINITE-DIFFERENCE FORMULAS WITH VARIABLE GRID  XOPZ2220
C     CALCULATE  PHIPP =  DELPP  + PHIPPO                               XOPZ2230
C     CALCULATE GAMMAP FROM THE MOMENTUM EQ.                            XOPZ2240
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C     CALCULATE PHIPPP = GAMMAP + PHIPPPO                                XOPZ2250
C     ( 2-POINT MEAN OF F AND ITS DERIVATIVES IN X-DIRECTION ARE USED    XOPZ2260
C     FOR TURBULENT FLOW, EXCEPT THE FIRST ITERATION )                   XOPZ2270
C                                                                        XOPZ2280
      DELPP   = FP (AV1, BV1, CV1, DV1, EV1, DELP(1), DELP(2), DELP(3),  XOPZ2290
     1 DELP(4), DELP(5) , DH(1) )                                        XOPZ2300
      PHIPP(1) =(PHIPP(1) + DELPP + PHIPP(1) ) * C5                      XOPZ2310
      IF  (LMN) PHIPP(1)    = PHIPP(1)     + C5  * DELPP                 XOPZ2320
      GAMMAP = (JO(1) - KOO(1) * DEL(1) - K10(1) * DELP(1) - K20(1)      XOPZ2330
     1     * DELPP)                                                      XOPZ2340
      PHIPPP(1) = PHIPPP(1) + GAMMAP                                     XOPZ2350
      IF  ( LNPR ) GO  TO 90                                             XOPZ2360
                            WRITE  (6,180)   ISTN, X                     XOPZ2370
                         WRITE (6,190)  E(1),DEL(1), DELP(1), DELPP,GAMMAXOPZ2380
     1P                                                                  XOPZ2390
90    CONTINUE                                                           XOPZ2400
      DELPP   = FP (AV2, BV2, CV2, DV2, EV2, DELP(1), DELP(2), DELP(3),  XOPZ2410
     1 DELP(4), DELP(5) , DH(1) )                                        XOPZ2420
      PHIPP(2) =(PHIPP(2) + DELPP + PHIPP(2) ) *  C5                     XOPZ2430
      IF  (LMN) PHIPP(2)    = PHIPP(2)     + C5  * DELPP                 XOPZ2440
      GAMMAP = (JO(2) - KOO(2) * DEL(2) - K10(2) * DELP(2) - K20(2)      XOPZ2450
     1     * DELPP)                                                      XOPZ2460
      PHIPPP(2) =(PHIPPP(2) + GAMMAP  + PHIPPP(2) ) *  C5                XOPZ2470
      IF  (LMN) PHIPPP(2)   = PHIPPP(2)     + C5  * GAMMAP               XOPZ2480
      IF  ( LPR) WRITE (6,190)  E(2),DEL(2), DELP(2), DELPP,GAMMAP       XOPZ2490
      DO 100  I =  3, MT                                                 XOPZ2500
      DELPP   = FP (AV3, BV3, CV3, DV3, EV3, DELP(I-2), DELP(I-1),       XOPZ2510
     1   DELP(I), DELP(I+1), DELP(I+2)   , DH(I-2) )                     XOPZ2520
      PHIPP(I) =(PHIPP(I) + DELPP + PHIPP(I) ) * C5                      XOPZ2530
      IF  (LMN) PHIPP(I)    = PHIPP(I)     + C5  * DELPP                 XOPZ2540
      GAMMAP =(JO(I) -KOO(I) * DEL(I  )-K10(I) * DELP(I   )-K20(I)       XOPZ2550
     1     * DELPP)                                                      XOPZ2560
      PHIPPP(I) =(PHIPPP(I) + GAMMAP  + PHIPPP(I) ) *  C5                XOPZ2570
      IF  (LMN) PHIPPP(I)   = PHIPPP(I)     + C5  * GAMMAP               XOPZ2580
      IF  ( LPR) WRITE (6,190)  E(I),DEL(I  ), DELP(I  ), DELPP,    GAMMXOPZ2590
     1AP                                                                 XOPZ2600
100   CONTINUE                                                           XOPZ2610
      DELPP   = FP (AV4, BV4, CV4, DV4, EV4, DELP(IMAX-4),DELP(IMAX-3),  XOPZ2620
     1  DELP(IMAX-2), DELP(IMAX-1), DELP(IMAX), DH(IMAX-4) )             XOPZ2630
      PHIPP(IMAX-1) =(PHIPP(IMAX-1) + DELPP + PHIPP(IMAX-1) ) * C5       XOPZ2640
      IF  (LMN) PHIPP(IO)   = PHIPP(IO)    + C5  * DELPP                 XOPZ2650
      GAMMAP = (JO(IO) - KOO(IO) * DEL(IO) - K10(IO) * DELP(IO)          XOPZ2660
     1     - K20(IO) * DELPP)                                            XOPZ2670
      PHIPPP(IO) =(PHIPPP(IO) + GAMMAP  + PHIPPP(IO) ) *  C5             XOPZ2680
      IF  (LMN) PHIPPP(IO)  = PHIPPP(IO)    + C5  * GAMMAP               XOPZ2690
      IF  ( LPR) WRITE (6,190) E(IO),DEL(IO),DELP(IO),DELPP,GAMMAP       XOPZ2700
      DELPP   = FP (AV5, BV5, CV5, DV5, EV5, DELP(IMAX-4),DELP(IMAX-3),  XOPZ2710
     1  DELP(IMAX-2), DELP(IMAX-1), DELP(IMAX), DH(IMAX-4) )             XOPZ2720
      PHIPP(IMAX   ) =(PHIPP(IMAX   ) + DELPP + PHIPP(IMAX   ) ) *  C5   XOPZ2730
      IF  (LMN) PHIPP(IMAX) = PHIPP(IMAX) + C5  * DELPP                  XOPZ2740
      GAMMAP = (JO(IMAX) - KOO(IMAX) * DEL(IMAX) - K10(IMAX) *DELP(IMAX)XOPZ2750
     1     - K20(IMAX) * DELPP)                                          XOPZ2760
      PHIPPP(IMAX) =(PHIPPP(IMAX) + GAMMAP  + PHIPPP(IMAX) )  *  C5      XOPZ2770
      IF  (LMN) PHIPPP(IMAX)= PHIPPP(IMAX) + C5  * GAMMAP                XOPZ2780
      PHI(1,1) = DELW    + PHI(1,1)                                      XOPZ2790
      IF  ( LNPR ) GO  TO 110                                            XOPZ2800
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                    WRITE (6,190) E(IMAX),DEL(IMAX), DELP(IMAX), DELPPXOPZ2810
     1,    GAMMAP                                                       XOPZ2820
                       WRITE  (6,200)   ISTN, X                         XOPZ2830
C                                                                       XOPZ2840
C     CALCULATE  PHIP  =  DELP   +  PHIPO                               XOPZ2850
C     CALCULATE  PHI   =  DEL    +  PHIO                                XOPZ2860
C                                                                       XOPZ2870
                        WRITE (6,190) E(1),PHI(1,1),PHIP(1,1),          XOPZ2880
     1       PHIPP(1), PHIPPP(1)                                        XOPZ2890
110   CONTINUE                                                          XOPZ2900
      DO 120 I = 2, IMAX                                                XOPZ2910
      PHI(I,1) =(PHI(I,1) + DEL(I) + PHI(I,1) ) *  C5                   XOPZ2920
      PHIP(I,1) =(PHIP(I,1) + DELP(I)   + PHIP(I,1) ) *  C5             XOPZ2930
      IF  (LNMN) GO  TO 120                                             XOPZ2940
                      PHI (I,1) = PHI (I,1) + C5  * DEL (I)             XOPZ2950
                      PHIP(I,1) = PHIP(I,1) + C5  * DELP(I)             XOPZ2960
120   CONTINUE                                                          XOPZ2970
      IF  (ISTN .GE. ISEPTB) MEAN = IONE                                XOPZ2980
      IF  ( LNPR ) RETURN                                               XOPZ2990
      DO 130 I = 1, IMAX                                                XOPZ3000
130                     WRITE (6,190) E(I),PHI(I,1),PHIP(I,1),          XOPZ3010
     1       PHIPP(I), PHIPPP(I)                                        XOPZ3020
      WRITE  (6,210)   PHIPP(1), DELS                                   XOPZ3030
      RETURN                                                            XOPZ3040
C                                                                       XOPZ3050
140   FORMAT  (1H0//1H , 7HSTATION, I4, 94X, 3HX =, E11.4               XOPZ3060
     1          /    / 1H0, 4X, 3HETA, 13X, 2HK3, 18X, 2HK2, 18X, 2HK1XOPZ3070
     2,    18X, 2HK0, 18X, 2HJ0 /18X,8H(H**3)DD,15X, 1HF, 19X, 1HG, 19X,XOPZ3080
     3     1HI, 19X, 1HM   /// )                                        XOPZ3090
150   FORMAT  ( 1H , F9.5, 5E20.9 / 10X, 5E20.9 /  )                    XOPZ3100
160   FORMAT  (1H0//1H , 7HSTATION, I4, 94X, 3HX =, E11.4               XOPZ3110
     1        / / 1H0, 4X, 3HETA, 12X, 2HL1, 16X, 2HL2, 16X, 1HU, 17X,  XOPZ3120
     2       2HU1, 16X, 1HN, 17X, 1HY /// )                             XOPZ3130
170   FORMAT  (1H , F9.5, 6E18.9)                                       XOPZ3140
180   FORMAT  (1H0//1H , 7HSTATION, I4, 94X, 3HX =, E11.4               XOPZ3150
     1          /    / 1H0, 4X, 3HETA,13X, 3HDEL, 17X, 4HDELP, 15X,     XOPZ3160
     2     5HDELPP, 15X, 6HGAMMAP///)                                   XOPZ3170
190   FORMAT  (1H , F9.5, 4E20.9)                                       XOPZ3180
200   FORMAT  (1H0//1H , 7HSTATION, I4, 94X, 3HX =, E11.4               XOPZ3190
     1          /    / 1H0, 4X, 3HETA, 13X, 3HPHI, 17X, 4HPHIP, 15X,    XOPZ3200
     2       5HPHIPP, 14X, 8H PHIPPP /// )                              XOPZ3210
210   FORMAT  (1H , 39X, 6HFPPW =, E17.9,  5X, 6HDELS =, E17.9)         XOPZ3220
      END                                                               XOPZ3230
```

```
      SUBROUTINE  MTRXGN                                                XOPJ0010
C  **                                                                   XOPJ0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS  XOPJ0030
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPJ0040
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPJ0050
     1     , CREF, CRFSQ, CRT, CSTH(10), DLTALM                         XOPJ0060
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)   XOPJ0070
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPJ0080
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)  XOPJ0090
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR    XOPJ0100
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR                          XOPJ0110
     7     , ZD(3), ZS(3),      RAIO(200)                               XOPJ0120
      COMMON/BLOCKC/CPCOS(200), CPJ(200), CPK(200), CPSIN(200)          XOPJ0130
     1     , XJ(200), YJ(200)                                           XOPJ0140
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)   XOPJ0150
     1     , SINSLP(200), SN, XBP(200), YBP(200)                        XOPJ0160
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPJ0170
     1     , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)           XOPJ0180
     2     , XSLOC1(10), YSLOC1(10)                                     XOPJ0190
      COMMON/BLOCKF/U(200), V(200)                                      XOPJ0200
      DIMENSION AA(201), B(2048)                                        XOPJ0210
C  **                                                                   XOPJ0220
C  **              SUBROUTINE 'MTRXGN' GENERATES THE MATRIX SYSTEM TO   XOPJ0230
C  **         BE SOLVED...  (AX = B)...                                 XOPJ0240
C  **                                                                   XOPJ0250
      ALPHA = ANGL(NOANG)                                               XOPJ0260
      APHA = ALPHA / 57.29578                                           XOPJ0270
      SN = SIN(APHA)                                                    XOPJ0280
      CS = COS(APHA)                                                    XOPJ0290
      IZ = 0                                                            XOPJ0300
      IV = 0                                                            XOPJ0310
      NPNTS = NPTS + 1                                                  XOPJ0320
      N1 = NPTS + NAFPTS                                                XOPJ0330
      N2 = NPNTS + NAFPTS                                               XOPJ0340
      MMAX = 2048 - N2                                                  XOPJ0350
      M = 0                                                             XOPJ0360
C  **                                                                   XOPJ0370
C  **                                                                   XOPJ0380
      DO 150 K = 1, NAFPTS                                              XOPJ0390
      IB = NCPTS(K)                                                     XOPJ0400
      IB = IB + 1                                                       XOPJ0410
C  **                                                                   XOPJ0420
      DO 140 II = 1, IB                                                 XOPJ0430
      IW = 0                                                            XOPJ0440
      IY = 0                                                            XOPJ0450
      IZ = IZ + 1                                                       XOPJ0460
      IF  (II .EQ. IB) GO  TO 10                                        XOPJ0470
      IV = IV + 1                                                       XOPJ0480
10    CONTINUE                                                          XOPJ0490
C  **                                                                   XOPJ0500
      AA(N2 ) = USUBI * (SN    * COSSLP(IZ) - CS    * SINSLP(IZ))       XOPJ0510
C  **                                                                   XOPJ0520
      DO 90 IJ = 1, NAFPTS                                              XOPJ0530
      NN = NCPTS(IJ)                                                    XOPJ0540
C  **                                                                   XOPJ0550
      DO 80 IK = 1, NN                                                  XOPJ0560
```

```
      IYM1 = IY
      IW = IW + 1
      IY = IY + 1
      IYP1 = IY + 1
      CALL  DSTSQD (X(IY), Y(IY), XBP(IZ), YBP(IZ), X1, Y1, A, A1, 1)
      IF  (IK.EQ.1) GO  TO 20
      IF  (IK.EQ.NN) GO  TO 30
      IF  (IV.EQ.IY) GO  TO 40
      IF  (IV.EQ.IYM1) GO  TO 50
      CALL  DSTRBD (X(IY), Y(IY), X(IYP1), Y(IYP1), U1, V1, A, XBP(IZ),
     1              YBP(IZ))
      CALL  DSTRBD (X(IY), Y(IY), X(IYM1), Y(IYM1), U2, V2, A, XBP(IZ),
     1              YBP(IZ))
      GO  TO 70
C  **
20    CONTINUE
      U2 = 0.
      V2 = 0.
      IF  (IV.EQ.IY) GO  TO 60
      U1 = 0.
      V1 = 0.
      CALL  DSTRBD (X(IY), Y(IY), X(IYP1), Y(IYP1), U2, V2, A, XBP(IZ),
     1              YBP(IZ))
      GO  TO 70
C  **
30    CONTINUE
      U2 = 0.
      V2 = 0.
      IF  (IV.EQ.IYM1) GO  TO 60
      U1 = 0.
      V1 = 0.
      CALL  DSTRBD (X(IY), Y(IY), X(IYM1), Y(IYM1), U2, V2, A, XBP(IZ),
     1              YBP(IZ))
      GO  TO 70
C  **
40    CONTINUE
      CALL  DSTRBD (X(IY), Y(IY), X(IYM1), Y(IYM1), U2, V2, A, XBP(IZ),
     1              YBP(IZ))
      GO  TO 60
C  **
50    CONTINUE
      CALL  DSTRBD (X(IY), Y(IY), X(IYP1), Y(IYP1), U2, V2, A, XBP(IZ),
     1              YBP(IZ))
60    CONTINUE
      B1 = 6.283184 * A1
      U1 = Y1/B1
      V1 = - X1/B1
70    CONTINUE
      U(IW) = U1 + U2
      V(IW) = V1 + V2
      AA(IW) = U(IW) * SINSLP(IZ) - V(IW) * COSSLP(IZ)
C  **
80    CONTINUE
C  **
      IW = IW + 1
      CALL  DSTSQD  (XBP(IZ), YBP(IZ), XSLOC1(IJ), YSLOC1(IJ)
```

```
     1          , XXX, YYY, DD, DDD, O)                                    XOPJ1130
      DD = 6.283184 * DD                                                   XOPJ1140
      U(IW) = XXX / DD                                                     XOPJ1150
      V(IW) = YYY / DD                                                     XOPJ1160
      AA(IW) = U(IW) * SINSLP(IZ) - V(IW) * COSSLP(IZ)                     XOPJ1170
C  **                                                                      XOPJ1180
90    CONTINUE                                                             XOPJ1190
C  **                                                                      XOPJ1200
      WRITE  (1)  U, V                                                     XOPJ1210
C  **                                                                      XOPJ1220
      DO 100 J = 1, N2                                                     XOPJ1230
      B(M+J) = AA(J)                                                       XOPJ1240
100   CONTINUE                                                             XOPJ1250
      M = M + N2                                                           XOPJ1260
      IF  (II .LT. IB) GO  TO 110                                          XOPJ1270
      IF (K .EQ. NAFPTS) GO TO 120                                         XOPJ1280
110   CONTINUE                                                             XOPJ1300
      IF (M .LE. MMAX) GO TO 130                                           XOPJ1310
120   CONTINUE                                                             XOPJ1320
      WRITE  (2)  B                                                        XOPJ1330
      M = 0                                                                XOPJ1340
130   CONTINUE                                                             XOPJ1350
      IF  (ITER .NE. IND(22)) GO  TO 140                                   XOPJ1360
      WRITE  (6,160)  II                                                   XOPJ1370
      WRITE  (6,170)  (U(J), J = 1, N1)                                    XOPJ1380
      WRITE  (6,180)  II                                                   XOPJ1390
      WRITE  (6,170)  (V(J), J = 1, N1)                                    XOPJ1400
      WRITE  (6,190)  II                                                   XOPJ1410
      WRITE  (6,170)  (AA(J), J = 1, N2)                                   XOPJ1420
C  **                                                                      XOPJ1430
140   CONTINUE                                                             XOPJ1440
C  **                                                                      XOPJ1450
C  **                                                                      XOPJ1460
150   CONTINUE                                                             XOPJ1470
C  **                                                                      XOPJ1480
      END  FILE  1                                                         XOPJ1490
      REWIND  1                                                            XOPJ1500
      END  FILE  2                                                         XOPJ1510
      REWIND  2                                                            XOPJ1520
C  **                                                                      XOPJ1530
      RETURN                                                               XOPJ1540
C  **                                                                      XOPJ1550
C                                                                          XOPJ1560
160   FORMAT  (1H0, 20H *** U ROW FOR II = , I3, 4H ***  / )               XOPJ1570
170   FORMAT  (1X, 1P10E13.4 )                                             XOPJ1580
180   FORMAT  (1H0, 20H *** V ROW FOR II = , I3, 4H ***  / )               XOPJ1590
190   FORMAT  (1H0, 28H *** AA MATRIX ROW FOR II = , I3, 4H *** / )        XOPJ1600
      END                                                                  XOPJ1610
```

```
      SUBROUTINE  NONDIM                                                XOPI0010
C  **                                                                   XOPI0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS   XOPI0030
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPI0040
     2     , KPAGE                                                      XOPI0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPI0060
     1     , CREF, CRFSQ, CRT, CSTH(10), DLTALM                         XOPI0070
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)   XOPI0080
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIFF(10),JIEND(10)XOPI0090
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)  XOPI0100
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR    XOPI0110
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR                          XOPI0120
     7     , ZD(3), ZS(3),      RAIO(200)                               XOPI0130
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPI0140
     1     , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)           XOPI0150
     2     , XSLOC1(10), YSLOC1(10)                                     XOPI0160
      DIMENSION HD(4), HDG(13)                                          XOPI0170
      DATA  HD / 10HNON-DIMENS , 10HIONALIZED  , 10HINPUT GEOM ,        XOPI0180
     1          10HETRY        /                                        XOPI0190
      DATA  HDG/ 10H           , 10H INDEX     , 10H NO.       ,        XOPI0200
     1          10H    X       , 10H           , 10HY          ,        XOPI0210
     2          10H       X/CR , 10HEF         , 10H     Y/CREF ,       XOPI0220
     3          10H          X , 10HT/C-LOC    , 10H        YT/C ,      XOPI0230
     4          10H-LOC        /                                        XOPI0240
C  **                                                                   XOPI0250
C  **                 SUBROUTINE 'NONDIM' COMPUTES AND WRITES THE       XOPI0260
C  **           NON-DIMENSIONALIZED INPUT GEOMETRY...                   XOPI0270
C  **                                                                   XOPI0280
      CALL   AFPLT                                                      XOPI0290
C  **                                                                   XOPI0300
      CALL   HEADR                                                      XOPI0310
      WRITE (6,30)    HD                                                XOPI0320
C  **                                                                   XOPI0330
      WRITE  (6,40)    HDG                                              XOPI0340
C  **                                                                   XOPI0350
C  **                                                                   XOPI0360
      K=0                                                               XOPI0370
C  **                                                                   XOPI0380
      DO 20 I = 1, NAFPTS                                               XOPI0390
      WRITE  (6,50)                                                     XOPI0400
C  **                                                                   XOPI0410
      N = NCPTS(I)                                                      XOPI0420
C  **                                                                   XOPI0430
      DO 10 J=1,N                                                       XOPI0440
C  **                                                                   XOPI0450
      K = K + 1                                                         XOPI0460
C  **                                                                   XOPI0470
      XX = (X(K) - XLR)/CREF                                            XOPI0480
      YY = (Y(K) - YLR)/CREF                                            XOPI0490
C  **                                                                   XOPI0500
      XX1 = X(K) - XLE(I)                                               XOPI0510
      YY1 = Y(K) - YLE(I)                                               XOPI0520
C  **                                                                   XOPI0530
      XXX = (XX1 * CSTH(I) + YY1 * SNTH(I))/DS(I)                       XOPI0540
      YYY = (YY1 * CSTH(I) - XX1 * SNTH(I))/DS(I)                       XOPI0550
C  **                                                                   XOPI0560
```

```
      WRITE  (6,60)   K, J, X(K), Y(K), XX, YY, XXX, YYY
C     WRITE (       ) XXX, YYY          ***                    ***
C  **
10    CONTINUE
C  **
20    CONTINUE
C  **
C  **
      RETURN
C  **
C
30    FORMAT  (1H0, 47X, 4A10)
40    FORMAT  (1H0, 13A10)
50    FORMAT  (1H )
60    FORMAT  (12X, I3, 6X, I3, 5X, F10.5, 7X, F10.5, 8X, 4(F10.6, 7X))
      END
```

```
      SUBROUTINE  PRSS                                                  XOPL0010
C  **                                                                   XOPL0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS  XOPL0030
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPL0040
     2      , KPAGE                                                     XOPL0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPL0060
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM                        XOPL0070
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)  XOPL0080
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPL0090
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12) XOPL0100
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR   XOPL0110
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR                        XOPL0120
     7      , ZD(3), ZS(3),      RAIO(200)                              XOPL0130
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)   XOPL0140
     1      , SINSLP(200), SN, XBP(200), YBP(200)                      XOPL0150
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPL0160
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)         XOPL0170
     2      , XSLOC1(10), YSLOC1(10)                                    XOPL0180
      COMMON/BLOCKF/U(200), V(200)                                      XOPL0190
      COMMON/BLOCKI/ MBPU(10), MBPL(10)                                 XOPL0200
      COMMON/BLOCKJ/CFF(200), CFDE(200)                                 XOPL0210
      DIMENSION CPLR(200), IULT(10)                                     XOPL0220
      LOGICAL BEGIN, BLIP, I180FG, LIT                                  XOPL0230
     1      , IDFO, LSTAG                                               XOPL0240
      DATA KNSUB /4HPRSS /                                              XOPL0250
C  **                                                                   XOPL0260
C  **               SUBROUTINE  PRSS  DIRECTS THE COMPUTATION OF        XOPL0270
C  **          INCOMPRESSIBLE PRESSURE COEFFICIENTS                     XOPL0280
C  **                                                                   XOPL0300
      I180FG = IND(18) .EQ. 0                                           XOPL0310
      IJ = 0                                                            XOPL0320
      IV = 0                                                            XOPL0330
      IZ = 0                                                            XOPL0340
C  **                                                                   XOPL0350
C  **                                                                   XOPL0360
      TESTA    = 1.                                                     XOPL0370
C  **                                                                   XOPL0380
      DO 90 L = 1, NAFPTS                                               XOPL0390
C  **                                                                   XOPL0400
      IF  (.NOT. BEGIN) GO  TO 10                                       XOPL0410
      IF  (JIS(L) .EQ. JIBEG(L)) GO  TO 10                              XOPL0420
      IJ = IJ + JIS(L) - JIBEG(L) - 1                                   XOPL0430
10    CONTINUE                                                          XOPL0440
C  **                                                                   XOPL0450
      ISAVE(L) = 0                                                      XOPL0460
C  **                                                                   XOPL0470
      BLIP = .TRUE.                                                     XOPL0480
      LSTAG = .FALSE.                                                   XOPL0490
      IB = NCPTS(L) - 1                                                 XOPL0500
C  **                                                                   XOPL0510
      DO 60 I = 1, IB                                                   XOPL0520
C  **                                                                   XOPL0530
      IV = IV + 1                                                       XOPL0540
      IZ = IZ + 1                                                       XOPL0550
      IY = IZ + 1                                                       XOPL0560
C  **                                                                   XOPL0570
```

```
      READ  (1)  U, V
      IF  (EOF(1) .NE. 0.0) CALL  KEOF  (1, 1, KNSUB, 1)
      UVT = USUBI * CS
      VVT = USUBI * SN
C  **
C  **
      DO 20 K = 1, N1
C  **
      UVT = UVT + U(K) * GAMMA(K)
      VVT = VVT + V(K) * GAMMA(K)
C  **
20    CONTINUE
C  **
      CALL  CLCR (GAMMA(IZ), GAMMA(IY), UVT, VVT,
     1             COSSLP(IZ), SINSLP(IZ), CPUP(IZ), CPLR(IZ))
C  **
      IF  (IND(10) .EQ. 0) GO  TO 30
      M = IJ + IZ
      IF  (M .LE. MBPU(L)) GO  TO 40
      IF  (M .GE. MBPL(L)) GO  TO 40
C  **
30    CONTINUE
C  **
      IF  (LSTAG) GO  TO 40
      IF (I .LT. 4) GO TO 40
      IF  (CPUP(IZ-1) .LT. 0.9) GO  TO 40
      IF  (CPUP(IZ-1) .LT. CPUP(IZ)) GO  TO 40
      ISAVE(L) = IZ - 1
      LSTAG = .TRUE.
C  **
40    CONTINUE
C  **
      IF  (XBP(IZ).LE.X(IV)) GO  TO 50
C  **
C  **
      IF  (BLIP) IULT(L) = IZ
      BLIP = .FALSE.
C  **
50    CONTINUE
      IF  (TESTA .GT. CPUP(IZ)) TESTA = CPUP(IZ)
C  **
60    CONTINUE
C  **
      IF  (LSTAG) GO  TO 80
      IM = IZ - IB
      CPMAXI = CPUP(IM+1)
      ISAVE(L) = IM+1
      DO 70 I = 2, IB
      IF  (CPUP(IM+I) .LE. CPMAXI) GO  TO 70
      CPMAXI = CPUP(IM+I)
      ISAVE(L) = IM+I
70    CONTINUE
80    CONTINUE
      IF  (ITER .GT. 1) ISAVE(L) = ISAVE(L)+ IJ
      IF  (BEGIN) IJ = IJ + JIEND(L) - JIE(L)
C  **
```

```
      IV = IV + 1
      IZ = IZ + 1
C  **
      READ  (1)
      IF  (EOF(1) .NE. 0.0) CALL  KEOF  (1, 1, KNSUB, 2)
C  **
      IZ = IZ + 1
      READ  (1)
      IF  (EOF(1) .NE. 0.0) CALL  KEOF  (1, 1, KNSUB, 3)
C  **
90    CONTINUE
C  **
      REWIND  1
C  **
      IF  (I180FG) GO  TO 100
C  **
C  **
      VMSQ = VSUBM * VSUBM
      BETA1     = SQRT(1. - VMSQ)
      BETA2     = 0.5 * (1. - BETA1)
      CPTST     = 1.428571 * ((0.8333333 * (1. + 0.2 * VMSQ)) ** 3.5
     1              - 1.)/VMSQ
C  **
C  **
      GO  TO 120
100   CONTINUE
      IF  (IDFO(10)) GO  TO 110
      GO  TO 160
110   CONTINUE
C  **
      CALL  HEADR
      WRITE  (6,200)
C  **
C  **
      IF  (ITER .EQ. 1) WRITE  (6,210)
      WRITE  (6,220)   ALPHA
C  **
C  **
      CALL  CRWTA (0, CPUP, CPLR, NPTS, BETA1, BETA2, 1, 1, 1, 1, IULT)
C  **
      GO  TO 160
C  **
120   CONTINUE
C  **
      IF  (TESTA .LE. CPTST) GO  TO 130
C  **
      TESTAC = TESTA /(BETA1 + BETA2 * TESTA)
C  **
      IF  (TESTAC.GT.CPTST   ) GO  TO 140
130   CONTINUE
C  **
      WRITE  (6,230)   VSUBM   , CPTST
C  **
140   CONTINUE
C  **
      IF  (IDFO(10)) GO  TO 150
```

```
      GO  TO 160
150   CONTINUE
C  **
      CALL  HEADR
      WRITE  (6,240)
C  **
C  **
      IF  (ITER .EQ. 1) WRITE  (6,210)
      WRITE  (6,220)    ALPHA
C  **
      WRITE  (6,250)    VSUBM
C  **
C  **
      CALL  CRWTA (2, CPUP, CPLR, NPTS, BETA1, BETA2, 1, 0, 2, 1, IULT)
C  **
160   CONTINUE
C  **
      IF  (BEGIN) GO  TO 170
      IF  (INC(6) .EQ. 2) GO  TO 170
      CALL  FRCE
C  **
170   CONTINUE
C  **
      V1 = VSUBM
      IF  (I180FG) V1 = 0.0
      IF  (.NOT. IDFO(9)) GO  TO 190
C  **
C     IF (.NOT. IDFO(9)) GO TO 321 REMOVE FOR STLNS ON IT=1
C  **
      IF  (IND(7) .EQ. 1) CALL  STLNS
      IF  (NVLPTS .GT. 0) CALL  RMTVTY
      DO 180 I = 1, N2
      CFF(I) = 0.0
180   CONTINUE
190   CONTINUE
      CALL  COSAVE
      RETURN
C
200   FORMAT  (1H0, 48X, 37HINCOMPRESSIBLE PRESSURE DISTRIBUTION )
210   FORMAT  (1H0, 5X, 23HPOTENTIAL FLOW ANALYSIS )
220   FORMAT  (1H0, 5X, 8HALPHA = , F8.4, 8H DEGREES)
230   FORMAT  (////// 1H0, 44X, 38HSONIC VELOCITY EXCEEDED AT MACH NUMB
     1ER , F6.4 /  1H0, 48X, 30HCRITICAL PRESSURE COEFFICIENT  , F8.4 )
240   FORMAT  (1H0, 49X, 34HCOMPRESSIBLE PRESSURE DISTRIBUTION  )
250   FORMAT  (1H0, 5X, 14HMACH NUMBER =  , F6.4)
      END
```

```
      SUBROUTINE  PRVDEV
C  **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEF(10),JIEND(10)
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR
     7      , ZO(3), ZS(3),      RAIO(200)
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)
     1      , SINSLP(200), SN, XBP(200), YBP(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK
     1      , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)
     2      , ITRAN(20),                                      BPDEL(200)
     3       /B3/ ETAE6, ETAE9, IMX6, IMX9, LTRAN, LL, Q, THETA, RTHETA
     4      , INSTA, IBUB, GPW1(200), TE1(200)
      COMMON/BLOCKJ/CFF(200), CFDE(200)
      LOGICAL BEGIN, IDFO, I181FG, LIT
      DIMENSION DCPLU(200), DDCPLU(200), ILPT(10), ISEPL(10)
     1      , ISEPU(10), IUPT(10), USULU(200)
     2      , CPPL(200), CPPU(200), DEVL(200), DEVU(200)
     3      , HD(12), UX(150), UY(150), BX(150), BY(150)
      DATA  HD / 10H           , 10H       NO.  , 10H          ,
     1           10H          X , 10HBP        , 10H          ,
     2           10H     YBP    , 10H           , 10H      LENG ,
     3           10HTH          , 10H           , 10H CP        /
      DATA EPS /1.0 E-07/, IONE / 1/
C  **
C  **
      I181FG = IND(18) .EQ. IONE
      DO 500 J = 1, NAFPTS
C  **
      IF  (IDFO(10)) GO  TO 10
      GO  TO 20
10    CONTINUE
      CALL  HEADR
      WRITE  (6,510)
C  **
      WRITE  (6,520)  ITER
      IF  (I181FG) WRITE  (6,530)  VSUBM
C  **
      WRITE  (6,540)    ALPHA
C  **
C  **
      REYM = REY / 1000000.
      WRITE  (6,550)  REYM
C  **
20    CONTINUE
      M = 1
```

```
      N = 1
      II = ISAVE(J    ) - 1
C  **
      XST = XBP(II+1)
C  **
      DEVU(1) = 0
      DEVL(1) = 0
      CPPU(1) = 1.0
      CPPL(1) = 1.0
C  **
      IF  (XST.NE.XBP(II)) GO  TO 40
C  **
30    CONTINUE
C  **
      IJ = II
      YST = YBP(II)
      GO  TO 70
C  **
40    CONTINUE
C  **
      II = II + 1
      IF  (XST.EQ.XBP(II)) GO  TO 30
C  **
      II = II + 1
      IF  (XST.EQ.XBP(II)) GO  TO 30
C  **
      II = II - 1
      IF  (XST.LT.XBP(II)) II = II - 1
      IJ = II + 1
C  **
      DELTAX = XBP(II) - XBP(IJ)
      DELTAY = YBP(II) - YBP(IJ)
C  **
      IF  (ABS(DELTAX) .LT. EPS) GO  TO 50
      YST = YBP(II) - (DELTAY/DELTAX) * (XBP(II) - XST)
      GO  TO 60
50    CONTINUE
      YST = 0.5 * (YBP(II) + YBP(IJ))
60    CONTINUE
C  **
      CALL  DSTSQD (XST, YST, XBP(II), YBP(II), A, B, C, DEVU(2), 1)
      CALL  DSTSQD (XST, YST, XBP(IJ), YBP(IJ), A, B, C, DEVL(2), 1)
C  **
      UX(2) = XBP(II)
      UY(2) = YBP(II)
      BX(2) = XBP(IJ)
      BY(2) = YBP(IJ)
C  **
      N = N + 1
      M = M + 1
C  **
      CPPU(2) = CPUP(II)
      CPPL(2) = CPUP(IJ)
C  **
70    CONTINUE
C  **
```

```
      IIS(J    ) =  II
      IJS(J    ) =  IJ
C   **
      UX(1) = XST
      UY(1) = YST
      BX(1) = XST
      BY(1) = YST
C   **
80    CONTINUE
C   **
      IIP1 = II
      II = II - 1
      NM1 = N
      N = N + 1
C   **
      UX(N) = XBP(II)
      UY(N) = YBP(II)
C   **
      CALL  DSTSQD (XBP(II), YBP(II), XBP(IIP1), YBP(IIP1), A, B, C, P,
     11)
C   **
      DEVU(N) = DEVU(NM1) + P
      CPPU(N) = CPUP(II)
C   **
      IF  (II.GT.IS(J)) GO  TO 80
      IUPT(J) = N
C   **
90    CONTINUE
C   **
      IJM1 = IJ
      IJ = IJ + 1
      MM1 = M
      M = M + 1
C   **
      BX(M) = XBP(IJ)
      BY(M) = YBP(IJ)
C   **
      CALL  DSTSQD (XBP(IJ), YBP(IJ), XBP(IJM1), YBP(IJM1), A, B, C, P,
     11)
C   **
      DEVL(M) = DEVL(MM1) + P
      CPPL(M) = CPUP(IJ)
C   **
      IF  (IJ.LT.IE(J)) GO  TO 90
      ILPT(J) = M
      IF  (IDFO(10)) GO  TO 100
      GO  TO 110
100   CONTINUE
      WRITE  (6,560)   J, XST, YST
      WRITE  (6,570)  HD
C   **
      WRITE  (6,580)   (K, UX(K), UY(K), DEVU(K), CPPU(K), K=1, N)
C   **
      CALL  HEADR
      WRITE  (6,590)
C   **
```

```
      WRITE  (6,570)  HD
      WRITE  (6,580)   (L, BX(L), BY(L), DEVL(L), CPPL(L), L=1, M)
C  **
110   CONTINUE
C  **
      IF  (INC(16) .EQ. 0) GO  TO 300
C  **
      KALP = ALPHA
C                        ****  UPPER SURFACE  ****
      CALL  CPMIN (ILUM, N, XLUM, CPLUM, DEVU, CPPU, USULU, DCPLU, 0)
      IF  (ILUM .GE. (N-3)) GO  TO 190
      IF   (IDFO(1)) GO  TO 120
      GO  TO 150
120   CONTINUE
      CALL  LAM (ILUM, N, XLUM, CPLUM, DEVU, CPPU, USULU, DCPLU,
     1            DDCPLU, XSEP, IXXS, RATIO)
      IF  (XSEP .EQ. 0.0) GO  TO 130
      SEPX = UX(IXXS) + RATIO * (UX(IXXS - 1) - UX(IXXS))
      SEPY = UY(IXXS) + RATIO * (UY(IXXS - 1) - UY(IXXS))
130   CONTINUE
      IF  (IDFO(10)) GO  TO 140
      GO  TO 200
140   CONTINUE
      CALL  RITE (ILUM, IXXS, DEVU, CPPU, DCPLU, DDCPLU, XSEP, 1,
     1              SEPX, SEPY)
C     IF (IDFO(6)) CALL FPLOT(ILUM, N, IXXS, 1, IDFO, ZS, ZD, CREF,
C    1                           DEVU, DCPLU, DDCPLU, AM1, KALP, J )
      GO  TO 200
C  **
150   CONTINUE
      IF  (CPLUM .GE. 0.0) GO  TO 180
      CALL  TURB (ILUM, N, XLUM, CPLUM, DEVU, CPPU, USULU, DCPLU,
     1              DDCPLU, XSEP, IXXS, CREF, REY, RATIO)
      IF  (XSEP .EQ. 0.0) GO  TO 160
      SEPX = UX(IXXS) + RATIO * (UX(IXXS - 1) - UX(IXXS))
      SEPY = UY(IXXS) + RATIO * (UY(IXXS - 1) - UY(IXXS))
160   CONTINUE
      IF  (IDFO(10)) GO  TO 170
      GO  TO 200
170   CONTINUE
      CALL  RITE (ILUM, IXXS, DEVU, CPPU, DCPLU, DDCPLU, XSEP, 3,
     1              SEPX, SEPY)
C     IF (IDFO(6)) CALL FPLOT(ILUM, N, IXXS, 3, IDFO, ZS, ZD, CREF,
C    1                           DEVU, DCPLU, DDCPLU, AM1, KALP, J )
      GO  TO 200
180   CONTINUE
      IF  (IDFO(10)) WRITE  (6,600)
      IXXS = N
      GO  TO 200
190   CONTINUE
      IXXS = N
      IF  (IDFO(10)) WRITE  (6,610)
C                        ****  LOWER SURFACE  ****
200   CONTINUE
      ISEPU(J) = IXXS
      CALL  CPMIN (ILUM, M, XLUM, CPLUM, DEVL, CPPL, USULU, DCPLU, 0)
```

```
      IF  (ILUM .GE. (M-3)) GO  TO 280                                  XOPQ2250
      IF  (IDFO(1)) GO  TO 210                                          XOPQ2260
      GO  TO 240                                                        XOPQ2270
210   CONTINUE                                                          XOPQ2280
      CALL  LAM (ILUM, M, XLUM, CPLUM, DEVL, CPPL, USULU, DCPLU,        XOPQ2290
     1            DDCPLU, XSEP, IXXS, RATIO)                            XOPQ2300
      IF  (XSEP .EQ. 0.0) GO  TO 220                                    XOPQ2310
      SEPX = BX(IXXS) + RATIO * (BX(IXXS - 1) - BX(IXXS))               XOPQ2320
      SEPY = BY(IXXS) + RATIO * (BY(IXXS - 1) - BY(IXXS))               XOPQ2330
220   CONTINUE                                                          XOPQ2340
      IF  (IDFO(10)) GO  TO 230                                         XOPQ2350
      GO  TO 290                                                        XOPQ2360
230   CONTINUE                                                          XOPQ2370
      CALL  RITE (ILUM, IXXS, DEVL, CPPL, DCPLU, DDCPLU, XSEP, 2,       XOPQ2380
     1             SEPX, SEPY)                                          XOPQ2390
C     IF (IDFO(6)) CALL FPLOT(ILUM, M, IXXS, 2, IDFO, ZS,  ZD, CREF,    XOPQ2400
C    1                         DEVL, DCPLU, DDCPLU, AM1, KALP, J )      XOPQ2410
      GO  TO 290                                                        XOPQ2420
240   CONTINUE                                                          XOPQ2430
      IF  (CPLUM .GE. 0.0) GO  TO 270                                   XOPQ2440
      CALL  TURB (ILUM, M, XLUM, CPLUM, DEVL, CPPL, USULU, DCPLU,       XOPQ2450
     1             DDCPLU, XSEP, IXXS, CREF, REY, RATIO)                XOPQ2460
      IF  (XSEP .EQ. 0.0) GO  TO 250                                    XOPQ2470
      SEPX = BX(IXXS) + RATIO * (BX(IXXS - 1) - BX(IXXS))               XOPQ2480
      SEPY = BY(IXXS) + RATIO * (BY(IXXS - 1) - BY(IXXS))               XOPQ2490
250   CONTINUE                                                          XOPQ2500
      IF  (IDFO(10)) GO  TO 260                                         XOPQ2510
      GO  TO 290                                                        XOPQ2520
260   CONTINUE                                                          XOPQ2530
      CALL  RITE (ILUM, IXXS, DEVL, CPPL, DCPLU, DDCPLU, XSEP, 4,       XOPQ2540
     1             SEPX, SEPY)                                          XOPQ2550
C     IF (IDFO(6)) CALL FPLOT(ILUM, M, IXXS, 4, IDFO, ZS, ZD, CREF,     XOPQ2560
C    1                         DEVL, DCPLU, DDCPLU, AM1, KALP, J )      XOPQ2570
      GO  TO 290                                                        XOPQ2580
270   CONTINUE                                                          XOPQ2590
      IF  (IDFO(10)) WRITE  (6,600)                                     XOPQ2600
      IXXS = M                                                          XOPQ2610
      GO  TO 290                                                        XOPQ2620
280   CONTINUE                                                          XOPQ2630
      IF  (IDFO(10)) WRITE  (6,610)                                     XOPQ2640
      IXXS = M                                                          XOPQ2650
290   CONTINUE                                                          XOPQ2660
      ISEPL(J) = M                                                      XOPQ2670
      IF  (IND(16) .EQ. 2) GO  TO 490                                   XOPQ2680
300   CONTINUE                                                          XOPQ2690
      IF  (IND(1) .EQ. 0) GO  TO 310                                    XOPQ2700
      IF  (IND(1) .GT. 0) GO  TO 320                                    XOPQ2710
C  **             CALL (TRANSITION POINT CALCULATION)                   XOPQ2720
      ITBFLA = - 1                                                      XOPQ2730
      GO  TO 330                                                        XOPQ2740
310   CONTINUE                                                          XOPQ2750
      CALL  CPMIN  (ILUM, N, XLUM, CPLUM, DEVU, CPPU, USULU, DCPLU, 1)  XOPQ2760
      ITBFLA = ILUM + IND(2)                                            XOPQ2770
      GO  TO 330                                                        XOPQ2780
320   CONTINUE                                                          XOPQ2790
      ITBFLA = IIS(J) - ITRAN(J+J-1) + 1                                XOPQ2800
```

```
      IF  (IIS(J) .NE. IJS(J)) ITBFLA = ITBFLA + 1                      XOPQ2810
      IF  (ITBFLA .LE. 0) GO  TO 310                                    XOPQ2820
330   CONTINUE                                                          XOPQ2830
      CALL  BNPUT  (NM1, ITBFLA, IDFO(10), DEVU, CPPU)                  XOPQ2840
      IF  (IND(1) .GE. 0) GO  TO 350                                    XOPQ2850
      IF  (.NOT. IDFO(10)) GO  TO 350                                   XOPQ2860
      IF  (INSTA .EQ. 0) GO  TO 340                                     XOPQ2870
      WRITE  (6,620)  INSTA, UX(INSTA), UY(INSTA), DEVU(INSTA)          XOPQ2880
340   CONTINUE                                                          XOPQ2890
      IF  (IBUB .NE. 0) WRITE  (6,630)                                  XOPQ2900
      IF  (ITBFLA .GE. N) GO  TO 350                                    XOPQ2910
      WRITE  (6,640)  ITBFLA, UX(ITBFLA), UY(ITBFLA), DEVU(ITBFLA)      XOPQ2920
350   CONTINUE                                                          XOPQ2930
      IF  (IND(16) .EQ. 0) ISFPU(J) = ISEPA                             XOPQ2940
      L = JIBEG(J) + N + J - 1                                          XOPQ2950
      DO 360 K = 1, N                                                   XOPQ2960
      BPDEL(L-K) = BPDE(K)                                              XOPQ2970
360   CONTINUE                                                          XOPQ2980
      IF  (.NOT. IDFO(9)) GO  TO 390                                    XOPQ2990
      KMAX = ISEPU(J)                                                   XOPQ3000
      IF  (ISEPU(J) .GT. ISEPA) KMAX = ISEPA                            XOPQ3010
      DO 370 K = 2, KMAX                                                XOPQ3020
      CFF(L-K) = CFDE(K) * (1.0 - CPPU(K))                              XOPQ3030
370   CONTINUE                                                          XOPQ3040
      CFF(L-1) = 0.0                                                    XOPQ3050
      IF  (ISEPU(J) .LE. ISEPA) GO  TO 390                              XOPQ3060
      KMAX = ISEPU(J)                                                   XOPQ3070
      JJ = ISEPA + 1                                                    XOPQ3080
      I = L - ISEPA                                                     XOPQ3090
      DO 380 K = JJ, KMAX                                               XOPQ3100
      CFF(L-K) = CFF(I)                                                 XOPQ3110
380   CONTINUE                                                          XOPQ3120
390   CONTINUE                                                          XOPQ3130
      IF  (IND(1) .EQ. 0) GO  TO 400                                    XOPQ3140
      IF  (IND(1) .GT. 0) GO  TO 410                                    XOPQ3150
C **              CALL (TRANSITION POINT CALCULATION)                   XOPQ3160
      ITBFLA = - 1                                                      XOPQ3170
      GO  TO 420                                                        XOPQ3180
400   CONTINUE                                                          XOPQ3190
      CALL  CPMIN  (ILUM, M, XLUM, CPLUM, DEVL, CPPL, USULU, DCPLU, 1)  XOPQ3200
      ITBFLA = ILUM + IND(2)                                            XOPQ3210
      GO  TO 420                                                        XOPQ3220
410   CONTINUE                                                          XOPQ3230
      ITBFLA = ITRAN(J+J) - IJS(J) + 1                                  XOPQ3240
      IF  (IIS(J) .NE. IJS(J)) ITBFLA = ITBFLA + 1                      XOPQ3250
      IF  (ITBFLA .LE. 0) GO  TO 400                                    XOPQ3260
420   CONTINUE                                                          XOPQ3270
      CALL  BNPUT  (MM1, ITBFLA, IDFO(10), DEVL, CPPL)                  XOPQ3280
      IF  (IND(1) .GE. 0) GO  TO 430                                    XOPQ3290
      IF  (.NOT. IDFO(10)) GO  TO 430                                   XOPQ3300
      IF  (INSTA .GT. 0) WRITE  (6,620)  INSTA, BX(INSTA), BY(INSTA),   XOPQ3310
     1      DEVL(INSTA)                                                 XOPQ3320
      IF  (IBUB .NE. 0) WRITE  (6,630)                                  XOPQ3330
      IF  (ITBFLA .LT. M) WRITE (6,640)  ITBFLA, BX(ITBFLA), BY(ITBFLA),XOPQ3340
     1      DEVL(ITBFLA)                                                XOPQ3350
430   CONTINUE                                                          XOPQ3360
```

```
      IF  (IND(16) .EQ.  0) ISEPL(J) = ISEPA
      IF  ((IUPT(J) + ILPT(J)) .EQ. (JCPTS(J) + 1)) GO  TO 440
      L = L + 1
440   CONTINUE
      L = L - 3
      DO 450 K = 2, M
      BPDEL(L+K) = BPDE(K)
450   CONTINUE
      IF  (.NOT.  IDFO(9)) GO  TO 480
      DO 460 K = 2, ISEPA
      CFF(L+K) = CFDE(K) * (CPPL(K) - 1.0)
460   CONTINUE
      IF  (ISEPA .GE. M) GO  TO 480
      A  = CFF (L  + ISEPA)
      JJ = ISEPA + 1
      DO 470 K = JJ, M
      CFF (L+K) = A
470   CONTINUE
480   CONTINUE
490   CONTINUE
      JJ = JIBEG(J) + IUPT(J)
      JIS(J) = JJ - ISEPU(J)
      JIE(J) = JJ + M - 2
      IF  ((IUPT(J) + ILPT(J)).NE.(JCPTS(J) + 1)) JIE(J)= JIE(J)+1
C  **
500   CONTINUE
C  **
      RETURN
C
510   FORMAT  (1H0, 33X, 65HPRESSURES VS. DEVELOPED LENGTH MEASURED FROM
     1 THE STAGNATION POINT )
520   FORMAT  (1H0, 12HITERATION = , I2, 4H ...)
530   FORMAT  (1H0, 14HMACH NUMBER = , F6.4)
540   FORMAT  (1H0, 8HALPHA = , F9.4)
550   FORMAT  (1H0, 18HREYNOLDS NUMBER  = , F8.3 ,  8H MILLION )
560   FORMAT  (1H0, 20HAIRFOIL PART NUMBER , I2, 4H ..., 10X, 20HSTAGNAT
     1ION POINT = (, F9.5, 2H ,, F9.5, 2H ) / 1H0, 17X, 13HUPPER SURFACE
     2)
570   FORMAT  (1H0, 12A10)
580   FORMAT  (17X, I3, 15X, F10.5, 15X, F10.5, 15X, F8.4, 15X, F8.4)
590   FORMAT  (1H0, 17X, 13HLOWER SURFACE )
600   FORMAT  (1H0, 20X, 61H**** A POSITIVE MINIMUM CP PREVENTS A TURBUL
     1ENT ANALYSIS **** )
610   FORMAT  (1H0, 20X, 70H**** MINIMUM CP OCCURS NEAR EXTERMITY - NO S
     1EPARATION CALCULATION ****  // )
620   FORMAT  (1H0,39HUNSTABLE CONDITIONS EXIST AFTER INDEX =, I3,
     1       7H  XBP =, F10.5, 7H  YBP =, F10.5, 10H  LENGTH =, F8.4)
630   FORMAT  (1H0, 26HLAMINAR FLOW BUBBLE EXISTS )
640   FORMAT  (1H0,43HTRANSITION IS CALCULATED TO OCCUR AT INDEX , I3,
     1       7H  XBP =, F10.5, 7H  YBP =, F10.5, 10H  LENGTH =, F8.4)
      END
```

```
      SUBROUTINE  RD                                                    XOPE0010
C  **                                                                   XOPE0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS  XOPE0030
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPE0040
     2      , KPAGE                                                     XOPE0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPE0060
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM                        XOPE0070
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)  XOPE0080
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPE0090
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12) XOPE0100
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR   XOPE0110
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR                         XOPE0120
     7      , ZD(3), ZS(3),      RAIO(200)                              XOPE0130
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPE0140
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)          XOPE0150
     2      , XSLOC1(10), YSLOC1(10)                                    XOPE0160
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK                  XOPE0170
     1      , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)        XOPE0180
     2      , ITRAN(20),                                     BPDEL(200) XOPE0190
      COMMON/BLOCKI/ MBPU(10), MBPL(10)                                 XOPE0200
      DIMENSION IB(30), PX(200), PY(200)                                XOPE0210
      LOGICAL BEGIN,IDFO                                                XOPE0220
      DATA EPS /1.0E-07/, KNSUB / 2HRD /                                XOPE0230
     1      , KPOINT / 6HPOINTS /                                       XOPE0240
C  **                                                                   XOPE0250
C  **                                                                   XOPE0260
C  **           SUBROUTINE 'RD' PERFORMS THE INPUT FUNCTIONS FOR        XOPE0270
C  **       EACH PROBLEM.  THE NECESSARY VARIABLES ARE CHECKED FOR      XOPE0280
C  **       RANGE, AND ERRORS CAUSE PROBLEM REJECTION...                XOPE0290
C  **                                                                   XOPE0300
C  **                -- IND 1 - TRANSITION POINT INDEX ...              XOPE0310
C  **                           (0=CALCULATED, 1=INPUT)                 XOPE0320
C  **                -- IND 2 - NO. OF POINTS DOWNSTREAM OF             XOPE0330
C  **                           CPMIN LOCATION IS TRANSITION PT         XOPE0340
C  **                       5 - NO. OF ANGLES OF ATTACK        T        XOPE0350
C  **                       6 - FORCES REQUIRED WITH DETAILED OUTPUT,XOPE0360
C  **                           FORCES REQUIRED WITH OUT DETAILED       XOPE0370
C  **                           OUTPUT, NO FORCES REQUIRED... (0,1,2)XOPE0380
C  **                       7 - STREAMLINES REQUIRED... (1,0)           XOPE0390
C  **                       8 - ROTATE INPUT POINTS ABOUT THE ORIGIN XOPE0400
C  **                           DUE TO CREF... (1,0)                    XOPE0410
C  **                       9 - STREAMLINES FROM SEPARATION             XOPE0420
C  **                           POINTS (0=NO, 1=YES)                    XOPE0430
C  **                      10 - BOUNDARY PT RANGE FOR STAGNATION PT     XOPE0440
C  **                           (0=ALL , 1=INPUT RANGE)                 XOPE0450
C  **                      11 - NON-DIMENSIONALIZED INPUT GEOMETRY      XOPE0460
C  **                           AND LARGE PLOTS OF AIRFOIL... (0,1)     XOPE0470
C  **                      13 - NO. OF ITERATIONS PERMITTED             XOPE0480
C  **                      16 - BND. LAYER THKNESS AND SEP. PT. CALC XOPE0490
C  **                           BY BN1 = 0, BND. THK CALC BY BN1 SEP XOPE0500
C  **                           PT BY STRATFORD = 1, STRAT. SEP = 2     XOPE0510
C  **                      18 - INCOMPRESSIBLE = 0, COMPRESSIBLE = 1 XOPE0520
C  **                -- INDR - ROTATION/TRANSLATION INDICATORS FOR      XOPE0530
C  **                          EACH AIRFOIL PART... (1,0)               XOPE0540
C  **                -- NSTLNS - NUMBER OF STREAMLINES...               XOPE0550
C  **                -- NVLPTS - NUMBER OF POINTS AT WHICH VELOCITY     XOPE0560
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C   **                                IS REQUIRED...                           XOPF0570
C   **                     -- NAFPTS - NUMBER OF AIRFOIL PARTS...              XOPF0580
C   **                     -- NPTS - TOTAL NUMBER OF CORNER POINTS...          XOPF0590
C   **                     -- TITLE - PROBLEM INPUT TITLE...                   XOPF0600
C   **                     -- DXTGE - DELTA-X FOR THE TRAILING EDGE...         XOPF0610
C   **                     -- HEIGHT - HEIGHT FOR GROUND EFFECT...             XOPF0620
C   **                     -- XMBAR, YMBAR - COORDINATES ABOUT WHICH           XOPF0630
C   **                                 MOMENTS ARE CALCULATED...               XOPF0640
C   **                     -- USUBI - FREE STREAM VELOCITY...                  XOPF0650
C   **                     -- XLR, YLR - REFERENCE POSITION OF THE LEADING XOPF0660
C   **                              EDGE OF THE SYSTEM...                      XOPF0670
C   **                     -- XTR, YTR - REFERENCE POSITION OF THE TRAILINGXOPF0680
C   **                              EDGE OF THE SYSTEM...                      XOPF0690
C   **                     -- CREF - REFERENCE CHORD...                        XOPF0700
C   **                     -- XTE, YTE - REFERENCE TRAILING EDGE               XOPF0710
C   **                              COORDINATES FOR EACH AIRFOIL               XOPF0720
C   **                              PART...                                    XOPF0730
C   **                     -- XLE, YLE - REFERENCE LEADING EDGE                XOPF0740
C   **                              COORDINATES FOR EACH AIRFOIL               XOPF0750
C   **                              PART...                                    XOPF0760
C   **                     -- XSUBC - X-VALUE TO WHICH STREAMLINES ARE         XOPF0770
C   **                            CALCULATED...                                XOPF0780
C   **                     -- DLTLMN - MINIMUM DELTA-L...                      XOPF0790
C   **                     -- DLTALN - NOMINAL DELTA-L...                      XOPF0800
C   **                     -- DLTALM - MAXIMUM DELTA-L...                      XOPF0810
C   **                     -- TOLLMT - TOLERANCE USED IN CALCULATING           XOPF0820
C   **                             STREAMLINES...                              XOPF0830
C   **                     -- ALPHA - ANGLE/S OF ATTACK...                     XOPF0840
C   **                     -- VSUBM - MACH NUMBER/S...                         XOPF0850
C   **                     -- XS, YS - COORDINATES AT WHICH STREAMLINES        XOPF0860
C   **                             BEGIN...                                    XOPF0870
C   **                     -- XV, YV - COORDINATES AT WHICH VELOCITY IS TO XOPF0880
C   **                             BE CALCULATED...                            XOPF0890
C   **                     -- X, Y - COORDINATES OF CORNER POINTS...           XOPF0900
C   **                                                                         XOPF0910
      READ  (5,280)  (TITLE(I), I = 1, 6), IIPR, (TITLE(I), I = 7, 12)         XOPF0920
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 0, KNSUB, 101 )                    XOPF0930
C   **                                                                         XOPF0940
C   **                                                                         XOPF0950
C   **                                                                         XOPF0960
      READ  (5,290)  IND                                                       XOPF0970
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 103)                     XOPF0980
C   **                                                                         XOPF0990
      IF  (IND(20) .NE. 2) GO  TO 30                                           XOPF1000
      DO 10 I = 1, 30                                                          XOPF1010
      IB(I) = IND(I)                                                           XOPF1020
10    CONTINUE                                                                 XOPF1030
      CALL  TAPWR                                                              XOPF1040
      DO 20 I = 1, 30                                                          XOPF1050
      IND(I) = IB(I)                                                           XOPF1060
20    CONTINUE                                                                 XOPF1070
      RETURN                                                                   XOPF1080
30    CONTINUE                                                                 XOPF1090
      READ  (5,290)  NAFPTS, NSTLNS, NVLPTS                                    XOPF1100
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 104)                     XOPF1110
      IF  ((NAFPTS .GE. 1) .AND. (NAFPTS .LE. 10)) GO  TO 40                   XOPF1120
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      WRITE  (6,300)
      CALL   EXIT
40    CONTINUE
      READ  (5,290)  (NCPTS(I), I = 1, NAFPTS)
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 105)
C  **
      READ  (5,290)  (INDR (I), I = 1, NAFPTS)
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 106)
C  **
      READ  (5,290)  (IDD(I), I = 1, 8)
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 107)
C  **
      DO 50 I = 1, 8
      IDFO(I) = IDD(I) .EQ. 0
50    CONTINUE
      IDFO(9)  = .FALSE.
      IDFO(10) = .TRUE.
      IF  (IND(1) .LE. 0) GO  TO 60
      IMAX = NAFPTS + NAFPTS
      READ  (5,290) (ITRAN(I), I = 1, IMAX)
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 108)
C  **
60    CONTINUE
      IF  (IND(10) .NE. 1) GO  TO 70
      READ  (5,290)  (MBPU(I), MBPL(I), I = 1, NAFPTS )
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 109)
C  **
70    CONTINUE
      READ  (5,310)  DXTGE
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 110)
C  **
      READ  (5,310)  XMBAR, YMBAR
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 111)
C  **
      USUBI = 1.0
C  **
      READ  (5,310)  XTR, YTR, XLR, YLR
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 113)
C  **
      DO 80 I = 1, NAFPTS
      READ  (5,310)   XTE(I), YTE(I), XLE(I), YLE(I)
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 114)
80    CONTINUE
C  **
      DO 90 I = 1, NAFPTS
      READ  (5,310)  XSLOC1(I), YSLOC1(I)
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 115)
90    CONTINUE
C  **
      IF  ((IND(5) .GE. 1) .AND. (IND(5) .LE. 10)) GO  TO 100
      WRITE  (6,320)
      CALL   EXIT
100   CONTINUE
      NANGLS = IND(5)
      DO 110 I = 1, NANGLS
      READ  (5,310)  ANGL(I)
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      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 116)                  XOPE1700
110   CONTINUE                                                              XOPE1710
      READ  (5,310)  HEIGHT                                                 XOPE1720
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 117)                  XOPE1730
C  **                                                                       XOPE1740
      IF  (IND(7) .NE. 1) GO  TO 130                                        XOPE1750
      READ  (5,310)  XSUBC, DLTLMN, DLTALN, DLTALM, TOLLMT, CRT             XOPE1760
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 118)                  XOPE1770
C  **                                                                       XOPE1780
      IF  ( NSTLNS .EQ. 0) GO  TO 130                                       XOPE1790
      IF  ((NSTLNS .GE. 1) .AND. (NSTLNS .LE. 10)) GO  TO 120               XOPE1800
      WRITE  (6,330)                                                        XOPE1810
      CALL  EXIT                                                            XOPE1820
120   CONTINUE                                                              XOPE1830
      READ  (5,310)  (XS(I), YS(I), I = 1, NSTLNS)                          XOPE1840
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 119)                  XOPE1850
130   CONTINUE                                                              XOPE1860
C  **                                                                       XOPE1870
      IF  (NVLPTS .EQ. 0 ) GO  TO 150                                       XOPE1880
      IF  ((NVLPTS .GE. 1) .AND. (NVLPTS .LE. 100)) GO  TO 140              XOPE1890
      WRITE  (6,340)                                                        XOPE1900
      CALL  EXIT                                                            XOPE1910
140   CONTINUE                                                              XOPE1920
      READ  (5,310)  (XV(I), YV(I), I = 1, NVLPTS)                          XOPE1930
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 120)                  XOPE1940
150   CONTINUE                                                              XOPE1950
C  **                                                                       XOPE1960
      READ  (5,310)  REY                                                    XOPE1970
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 121)                  XOPE1980
      READ  (5,310)  AEPS, GRIDK, HETEM, ALSUBI, RRO                        XOPE1990
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 122)                  XOPE2000
      II = 1                                                                XOPE2010
      NPTS = 0                                                              XOPE2020
      DO 170 J = 1, NAFPTS                                                  XOPE2030
      NPTS = NPTS + NCPTS(J)                                                XOPE2040
C  **                                                                       XOPE2050
C  **                                                                       XOPE2060
      READ  (5,350)  MPOINT                                                 XOPE2070
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 122)                  XOPE2080
C  **                                                                       XOPE2090
      IF  (MPOINT .EQ. KPOINT) GO  TO 160                                   XOPE2100
      WRITE  (6,360)  J                                                     XOPE2110
      CALL  EXIT                                                            XOPE2120
160   CONTINUE                                                              XOPE2130
      READ  (5,310)  (PX(I), PY(I), I = II, NPTS)                           XOPE2140
      IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 123)                  XOPE2150
      II = NPTS + 1                                                         XOPE2160
170   CONTINUE                                                              XOPE2170
C  **                                                                       XOPE2180
      IF  (NPTS .LE. (200 - 3 * NAFPTS)) GO TO 180                          XOPE2190
      WRITE  (6,370)                                                        XOPE2200
      CALL  EXIT                                                            XOPE2210
180   CONTINUE                                                              XOPE2220
C  **                                                                       XOPE2230
      IF  (IND(7) .EQ. 0) GO  TO 190                                        XOPE2240
      IF  (IND(9) .EQ. 1) GO  TO 190                                        XOPE2250
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      IF  (NSTLNS .GT. 0) GO  TO 190                                     XOPE2260
      WRITE  (6,380)                                                    XOPE2270
      CALL  EXIT                                                        XOPE2280
190   CONTINUE                                                          XOPE2290
      NOPT = 0                                                          XOPE2300
      DO 200 I = 1, NAFPTS                                              XOPE2310
      NOPT = NOPT + INDR(I)                                             XOPE2320
      DS(I) = 0.0                                                       XOPE2330
200   CONTINUE                                                          XOPE2340
C  **                                                                   XOPE2350
      IF  (IND(7).EQ. 0) GO  TO 220                                     XOPE2360
      IF  (DLTLMN .GT. DLTALN) GO  TO 210                               XOPE2370
      IF  (DLTALN .GT. DLTALM) GO  TO 210                               XOPE2380
      GO  TO 220                                                        XOPE2390
210   CONTINUE                                                          XOPE2400
      WRITE  (6,390)                                                    XOPE2410
      CALL  EXIT                                                        XOPE2420
220   CONTINUE                                                          XOPE2430
C  **                                                                   XOPE2440
C  **                                                                   XOPE2460
      XRHOFO = REY                                                      XOPE2470
      IF  (IND(18) .EQ. 0) GO  TO 230                                   XOPE2480
      ICFLAG = 0                                                        XOPE2490
      AVSUBM = VSUBM                                                    XOPE2500
      GO  TO 240                                                        XOPE2510
C  **                                                                   XOPE2520
230   CONTINUE                                                          XOPE2530
C  **                                                                   XOPE2540
      ICFLAG = 1                                                        XOPE2550
      AVSUBM = 0.0                                                      XOPE2560
240   CONTINUE                                                          XOPE2570
C  **                                                                   XOPE2580
      CALL  DSTSQD  (XTR, YTR, XLR, YLR, XDF, YDF, CRFSQ, CREF, 1)      XOPE2590
C  **                                                                   XOPE2600
      AA = CREF / 1000.                                                 XOPE2610
      IF ((DXTGE .LE. AA) .AND.(CREF .GT. EPS)) GO  TO 250              XOPE2620
      WRITE  (6,400)                                                    XOPE2630
      CALL  EXIT                                                        XOPE2640
250   CONTINUE                                                          XOPE2650
C  **                                                                   XOPE2660
      COSRF = XDF / CREF                                                XOPE2670
      SINRF = YDF / CREF                                                XOPE2680
      IF  (HETEM .EQ. 0.0) HETEM = 519.0                                XOPE2690
      ACREF = CREF                                                      XOPE2700
C  **                                                                   XOPE2710
C  **                                                                   XOPE2720
C  **                                                                   XOPE2730
C          ADD NEW POINTS ON LOWER AND UPPER  SURFACE AT                XOPE2740
C          0.05 * Z(END-1) + 0.95 * Z(END)                              XOPE2750
C  **                                                                   XOPE2760
      J = 1                                                             XOPE2770
      K = 1                                                             XOPE2780
      DO 270 I = 1, NAFPTS                                              XOPE2790
      X(J) = PX(K)                                                      XOPE2800
      Y(J) = PY(K)                                                      XOPE2810
      J = J + 1                                                         XOPE2820
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      X(J) = 0.95 * PX(K) + 0.05 * PX(K+1)                              XOPE2830
      Y(J) = 0.95 * PY(K) + 0.05 * PY(K+1)                              XOPE2840
      LIMIT = NCPTS(I) - 2                                              XOPE2850
      DO 260 L = 1, LIMIT                                               XOPE2860
      J = J + 1                                                         XOPE2870
      K = K + 1                                                         XOPE2880
      X(J) = PX(K)                                                      XOPE2890
      Y(J) = PY(K)                                                      XOPE2900
260   CONTINUE                                                          XOPE2910
      J = J + 1                                                         XOPE2920
      X(J) = 0.05 * PX(K) + 0.95 * PX(K+1)                              XOPE2930
      Y(J) = 0.05 * PY(K) + 0.95 * PY(K+1)                              XOPE2940
      NCPTS(I) = NCPTS(I) + 2                                           XOPE2950
      NPTS = NPTS + 2                                                   XOPE2960
      J = J + 1                                                         XOPE2970
      K = K + 1                                                         XOPE2980
      X(J) = PX(K)                                                      XOPE2990
      Y(J) = PY(K)                                                      XOPE3000
      J = J + 1                                                         XOPE3010
      K = K + 1                                                         XOPE3020
C  **                                                                   XOPE3030
270   CONTINUE                                                          XOPE3040
C  **                                                                   XOPE3050
      CALL  WRTE (NOPT)                                                 XOPE3060
C  **                                                                   XOPE3070
      RETURN                                                            XOPE3080
C                                                                       XOPE3090
280   FORMAT  (6A10, 4X, I1 / 6A10)                                     XOPE3100
290   FORMAT  (15I3)                                                    XOPE3110
300   FORMAT  (1HO, 84H *** IN SUBROUTINE RD, NUMBER OF AIRFOIL PARTS MUXOPE3120
     1ST BE POSITIVE AND LESS THAN 11 *** )                             XOPE3130
310   FORMAT  (6F10.0)                                                  XOPE3140
320   FORMAT  (1HO, 87H *** IN SUBROUTINE RD, NUMBER OF ANGLES OF ATTACKXOPE3150
     1 MUST BE POSITIVE AND LESS THAN 11 *** )                          XOPE3160
330   FORMAT  (1HO, 53H *** IN SUBROUTINE RD, AN ERROR EXISTS IN NSTLNS XOPE3170
     1 *** )                                                            XOPE3180
340   FORMAT  (1HO, 70H *** IN SUBROUTINE RD, AN ERROR EXISTS IN THE NC.XOPE3190
     1 OF REMOTE POINTS *** )                                           XOPE3200
350   FORMAT  ( A6 )                                                    XOPE3210
360   FORMAT  (1HO, 81H *** IN SUBROUTINE RD, AN INPUT ERROR EXISTS PRIOXOPE3220
     1R TO THE READING OF AIRFOIL PART , I3, 4H *** )                   XOPE3230
370   FORMAT  (1HO, 80H *** IN SUBROUTINE RD, THE NUMBER OF POINTS MUST XOPE3240
     1BE LESS THAN (200-3*NAFPTS) ***  )                                XOPE3250
380   FORMAT  (1HO, 79H *** IN SUBROUTINE RD, AN ERROR EXISTS IN THE INPXOPE3260
     1UT OF STREAMLINES REQUIRED *** )                                  XOPE3270
390   FORMAT  (1HO, 65H *** IN SUBROUTINE RD, AN ERROR EXISTS ON THE STRXOPE3280
     1EAMLINE CARD *** )                                                XOPE3290
400   FORMAT  (1HO, 60H *** IN SUBROUTINE RD, AN ERROR EXISTS IN CREF ORXOPE3300
     1 DXTGE  *** )                                                     XOPE3310
      END                                                               XOPE3320
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      SUBROUTINE  RITE (IXM, IXXS, XX, CPX, DCPX, DDCPX, XXSEP, K,       XOPRD010
     1                SEPX, SEPY)                                        XOPRD020
C  **                                                                    XOPRD030
C           ***  PRINT OUTPUT FOR LAMINAR AND TURBULENT ***              XOPRD040
C  **                                                                    XOPRD050
      DIMENSION XX(200), CPX(200), DCPX(200), DDCPX(200)                 XOPRD060
      DIMENSION HD(7)                                                    XOPRD070
      DATA  HD /  10H          , 10H          , 10H I.      LE ,         XOPRD080
     1            10HNGTH      , 10HCP        , 10HDCPX        ,         XOPRD090
     2            10HDDCPX     /                                         XOPRD100
C  **                                                                    XOPRD110
C           ***  K=1(LAM,UP),2(LAM,LO),3(TUR,UP),4(TUR,LO)  ***          XOPRD120
C  **                                                                    XOPRD130
      GO  TO  (10,20,30,40),  K                                          XOPRD140
10    CONTINUE                                                           XOPRD150
      CALL  HEADR                                                        XOPRD160
      WRITE  (6,80)                                                      XOPRD170
      WRITE  (6,90)                                                      XOPRD180
      GO  TO 50                                                          XOPRD190
20    CONTINUE                                                           XOPRD200
      CALL  HEADR                                                        XOPRD210
      WRITE  (6,80)                                                      XOPRD220
      WRITE  (6,100)                                                     XOPRD230
      GO  TO 50                                                          XOPRD240
30    CONTINUE                                                           XOPRD250
      CALL  HEADR                                                        XOPRD260
      WRITE  (6,110)                                                     XOPRD270
      WRITE  (6,90)                                                      XOPRD280
      GO  TO 50                                                          XOPRD290
40    CONTINUE                                                           XOPRD300
      CALL  HEADR                                                        XOPRD310
      WRITE  (6,110)                                                     XOPRD320
      WRITE  (6,100)                                                     XOPRD330
50    CONTINUE                                                           XOPRD340
      WRITE  (6,120)   HD                                                XOPRD350
C  **                                                                    XOPRD360
C               *** WRITE DCP AND DDCP ***                               XOPRD370
C  **                                                                    XOPRD380
      IXP = IXM +1                                                       XOPRD390
      WRITE  (6,130)  ( I, XX(I), CPX(I), DCPX(I), DDCPX(I),I=IXP,IXXS) XOPRD400
      IF  (XXSEP .EQ. 0.0) GO  TO 60                                     XOPRD410
      WRITE  (6,140)  SEPX, SEPY, XXSEP                                  XOPRD420
      GO  TO 70                                                          XOPRD430
60    CONTINUE                                                           XOPRD440
      WRITE  (6,150)                                                     XOPRD450
70    CONTINUE                                                           XOPRD460
      RETURN                                                             XOPRD470
C                                                                        XOPRD480
80    FORMAT  (1H0, 21X, 11H*** LAMINAR )                                XOPRD490
90    FORMAT  (1H+, 33X, 30HANALYSIS FOR UPPER SURFACE *** )             XOPRD500
100   FORMAT  (1H+, 33X, 30HANALYSIS FOR LOWER SURFACE *** )             XOPRD510
110   FORMAT  (1H0, 19X, 13H*** TURBULENT )                              XOPRD520
120   FORMAT  (1H0, 7A10)                                                XOPRD530
130   FORMAT  (1H , 20X, I3, 4F11.4)                                     XOPRD540
140   FORMAT  (1H0, 48HTHE STRATFORD METHOD PREDICTS SEPARATION AT X = ,XOPRD550
     1        F10.4/1H0, 44X, 4HY = , F10.4 /1H0, 44X, 19HDEVELOPED LENXOPRD560
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      2GTH = , F10.4 // )                                                 XOPRD570
150    FORMAT  (1HO, 48HTHE STRATFORD METHOD DOES NOT PREDICT SEPARATION XOPRD580
      1)                                                                  XOPRD590
       END                                                                XOPRD600
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      SUBROUTINE  RMTVTY
C   **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NDANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR
     7      , ZD(3), ZS(3),      RAIO(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
C   **
      DIMENSION HD(12)
      DATA  HD / 10H       NO. , 10H         X , 10HV         ,
     1           10H    YV     , 10H      XV/C , 10HREF       ,
     2           10HYV/CREF    , 10H    MODULU , 10HS     MAGN ,
     3           10HITUDE      , 10H    U      , 10H         V /
C   **
C   **             SUBROUTINE 'RMTVTY' FINDS THE VELOCITY AT ALL
C   **          REMOTE POINTS... THE COORDINATES, VELOCITY COMPONENTS,
C   **          MODULUS AND MAGNITUDE ARE WRITTEN...
C   **
      CALL  HEADR
      WRITE  (6,20)   ALPHA
C   **
C   **
      WRITE  (6,30)   HD
C   **
C   **
      DO 10 J = 1, NVLPTS
C   **
      CALL  VLCTY  (U0, V0,     XV(J), YV(J), VL)
C   **
      XL = (XV(J) - XLR)/CREF
      YL = (YV(J) - YLR)/CREF
C   **
      TN = ATAN (V0 / U0) * 57.29578
C   **
      WRITE  (6,40)   J, XV(J), YV(J), XL, YL, TN, VL, U0, V0
C   **
10    CONTINUE
C   **
C   **
      RETURN
C   **
C
20    FORMAT  (1H0, 53X, 25HVELOCITY AT REMOTE POINTS //
     1         1H , 4X, 8HALPHA = , F8.4, 4H ... // )
30    FORMAT  (1H , 12A10)
40    FORMAT  (8X, I3, 5X, 2(F9.4, 6X), 6(F8.4, 6X)  )
      END
```

```
      SUBROUTINE   SLNR
C  **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
C  **
      DATA EPSLN, IONE, IZERO, ONE, ZERO / 1.0 E-10, 1, 0, 1.0, 0.0/
      DIMENSION A(200, 201), IPIVO(200), B(2048)
      DATA  KNSUB / 4HSLNR /
C  **
C  **              SUBROUTINE 'SLNR' PRODUCES THE GAMMAS REQUIRED FOR
C  **         THE SOLUTION OF THE CURRENT PROBLEM...
C  **
C  **
C  **
      JROW = 0
      MROW = 2048 / N2
      MRD = N1 / MROW
      MLAS = N1 - MRD * MROW
      IF  (MLAS .EQ. 0) GO  TO 10
      MRD = MRD + 1
      GO  TO 20
10    CONTINUE
      MLAS = MROW
20    CONTINUE
C  **
      DO 50 M = 1, MRD
      READ  (2)  B
      IF  (EOF(2) .NE. 0.0) CALL  KEOF  (2, 1, KNSUB, 105)
      IF  ( M .EQ. MRD) MROW = MLAS
      DO 40 J = 1, MROW
      K = JROW + J
      N = N2 * (J - 1)
      DO 30 I = 1, N2
      A(K, I) = B(N + I)
30    CONTINUE
40    CONTINUE
      JROW = JROW + MROW
50    CONTINUE
C  **
      CONTINUE
C  **
      REWIND  2
C  **
C
C          ZERO THE PIVOT INDEX ARRAY
C
      DO 60 I = 1, N1
      IPIVO(I) = IZERO
60    CONTINUE
C
      DO 150 I = 1, N1
      T = ZERO
```

```
C
C        THE FOLLOWING SELECTS THE PIVOT ELEMENT WHICH HAS
C        THE LARGEST MAGNITUDE.
C
      DO 80 J = 1, N1
      IF  (IPIVO(J) .NE. IZERO) GO  TO 80
      DO 70 K = 1, N1
      IF  (IPIVO(K) .NE. IZERO) GO  TO 70
      TE = ABS (A(J,K))
      IF  (TE .LE. T) GO  TO 70
      T = TE
      JROW = J
      KCOL = K
70    CONTINUE
80    CONTINUE
C
C        IF A SELECTED PIVOT ELEMENT IS LESS THAN THE SINGULARITY
C        CRITERION, CALL ERROR(112)
      IF  (T  .GE. EPSLN) GO  TO 90
      WRITE  (6,170)
      CALL  EXIT
90    CONTINUE
C
      IPIVO(KCOL) = IONE
      IF  (JROW .EQ. KCOL  ) GO  TO 110
C        PUT A(JROW, KCOL) ON DIAGONAL
      DO 100 J = 1, N2
      TE = A (KCOL, J)
      A(KCOL, J) = A(JROW, J)
      A(JROW, J) = TE
100   CONTINUE
110   CONTINUE
C     JNRO(I) = JROW
C     KNCO(I) = KROW
C
C        DIVISION DOWN THE PIVOT ROW BY ITS MAIN DIAGONAL ELEMENT
C
      TE = ONE / A(KCOL, KCOL)
      A(KCOL, KCOL) = ONE
      DO 120 K = 1, N2
      A(KCOL, K) = A(KCOL, K) * TE
120   CONTINUE
C
C        REPLACE EACH ROW BY LINEAR COMBINATION WITH PIVOT ROW
C
      DO 140 J = 1, N1
      IF  (J .EQ. KCOL) GO  TO 140
      TE = A(J, KCOL)
      A(J, KCOL) = ZERO
      DO 130 K = 1, N2
      A(J, K) = A(J, K) - A(KCOL, K) * TE
130   CONTINUE
140   CONTINUE
150   CONTINUE
C
      DO 160 I = 1, N1
```

```
      GAMMA(I) = A(I, N2)                                               XOP21130
C                                                                       XOP21140
C  **                                                                   XOP21150
160   CONTINUE                                                          XOP21160
C  **                                                                   XOP21170
      RETURN                                                            XOP21180
C                                                                       XOP21190
170   FORMAT  (1HO, 78H *** IN SUBROUTINE SLNR THE PIVOT ELMENT MUST BE XOP21200
     1GREATER THAN (10 ** -10)   *** )                                  XOP21210
      END                                                               XOP21220
```

```
      SUBROUTINE  STCNST (IX, IPRNT)                                    XOPV0010
C                                                                       XOPV0020
C     CALCULATE STATION DATA,                                           XOPV0030
C     CALCULATE  QUANTITIES FOR WHICH E IS LARGER THAN ETAE OF PREVIOUS XOPV0040
C     STATION                                                           XOPV0050
C                                                                       XOPV0060
      COMMON/AQ/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)       XOPV0070
     1     , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3) XOPV0080
     2     /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)XOPV0090
     3     , RHO(300) /A9/ RK(300), ROROE(300) /A10/T(300), TEMP(300)   XOPV0100
     4     /A11/ PHIP(300, 3)                                           XOPV0110
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3             XOPV0120
     1     , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE     XOPV0130
     2     , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE      XOPV0140
     3     , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17   XOPV0150
     4     , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2XOPV0160
     5     , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3 XOPV0170
     6     , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5 XOPV0180
     7     , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1 XOPV0190
     8     , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3  XOPV0200
     9     , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3 XOPV0210
     .     , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB     XOPV0220
      COMMON/B1/ BETA1(200), DUDX1(200),          IPN(200), MUE1(200)   XOPV0230
     1      /B2/ PE1(200), RHOE1(200), SQUI11(200)                      XOPV0240
     2      /B3/ ETAE6, ETAE9, IMX6, IMX9, LTRAN, LL, Q, THETA, RTHETA  XOPV0250
     3     , INSTA, IBUB, GPW1(200), TE1(200)                           XOPV0260
     4      /B4/ UE1(200), X1(200)                                      XOPV0270
      LOGICAL LINCO, LTRAN                                              XOPV0280
      REAL INT, MU, MUE, MUE1, NUS                                      XOPV0290
      DATA ZERO, ONE, IZERO, IONE / 0.0, 1.0, 0, 1 /                    XOPV0300
C  **                                                                   XOPV0310
      I = IX                                                            XOPV0320
      IF  (ISTN .GE. ISEPTB) GO  TO 10                                  XOPV0330
      IMAX = IMX6                                                       XOPV0340
      GO  TO 20                                                         XOPV0360
10    CONTINUE                                                          XOPV0370
      IMAX = IMX9                                                       XOPV0380
      ETAE = ETAE6                                                      XOPV0350
      ETAE = ETAE9                                                      XOPV0390
20    CONTINUE                                                          XOPV0400
      BETA = BETA1(I)                                                   XOPV0410
      COSA = ZERO                                                       XOPV0420
      FW = ZERO                                                         XOPV0430
      GPW  = GPW1 (I)                                                   XOPV0440
      IPAR = IPN  (I)                                                   XOPV0450
      IPRINT = IPRNT                                                    XOPV0460
      MUE = MUE1(I)                                                     XOPV0470
      PE = ZERO                                                         XOPV0480
      R = ZERO                                                          XOPV0490
      RHOE = RHOE1(I)                                                   XOPV0500
      RHOVW = ZERO                                                      XOPV0510
      SQUIG = SQUI11(I)                                                 XOPV0520
      SQUIG1 = SQUI11(I-1)                                              XOPV0530
      SQUIG2 = SQUI11(I-2)                                              XOPV0540
      TEMPE =    TE1(I)                                                 XOPV0550
      UE =    UE1(I)                                                    XOPV0560
```

```
      X =       XI(I)
      SQTSQ = SQRT (SQUIG + SQUIG)
      IO = IMAX - IONE
      MT = IO - IONE
      REX = RHOE * UE * X / MUE
      SQREX = SQRT (REX)
      PHI (1,1) = FW
      PHIP(1,1) = RHOVW
      DELW  = FW
      PHIP (1, 1) = ZERO
      PSIP(1) = GPW
      A1 = SQTSQ /(RHOE * UE)
      IF  (ISTN .GT. IZERO) GO  TO 30
      IMXX = IMAX
      GO  TO 60
30    CONTINUE
C
C     ESTABLISH ALL QUANTITIES ( PHI0, PHI1, PHI2, PHIP0, PHIP1, PHIP2,
C     PHIPP, PHIPPP, PR, PRT, C, PSI0, PSI1, PSI2, PSIP, MU, RHO, ROROE,
C     TEMP, INT, T, RK ) FOR WHICH E IS LARGER THAN ETAE OF PREVIOUS
C     STATION
C
      IM = IMXX + IONE
      PHIXX1   = PHI(IMXX,1) - E(IMXX)
      PHIXX2   = PHI(IMXX,2) - E(IMXX)
      PHIXX3   = PHI(IMXX,3) - E(IMXX)
      DO 40 I = IM , IMAX
      PHI(I,1) = PHIXX1      + E(I)
      PHI(I,2) = PHIXX2      + E(I)
      PHI(I,3) = PHIXX3      + E(I)
      PHIP (I, 1) = ONE
      PHIP (I, 2) = ONE
      PHIP (I, 3) = ONE
      PHIPP(I) = ZERO
      PHIPPP(I) = ZERO
      PSI (I, 1) = ONE
      PSI (I, 2) = ONE
      PSI (I, 3) = ONE
      PSIP (I) = ZERO
      PR(I) = PR(IMXX)
      PRT(I) = PRT(IMXX)
      C(I) = ONE
      MU(I) = MU(IMXX)
      RHO(I) = RHO(IMXX)
      ROROE (I) = ONE
      TEMP(I) = TEMP(IMXX)
      INT(I) = INT(I-1) + DH(I-1)
      T(I) = ZERO
40    CONTINUE
      NUS = INT(IMAX)
C
C     CALCULATE  COEFFICIENTS OF THE FIRST-DERIVATIVE FORMULA IN X
C
      IF  (IPAR .EQ. IZERO) GO  TO 60
      IF (IPAR .GE. 3) GO  TO 50
C
```

```
C     2-POINT
C
      A = ONE / (SQUIG - SQUIG1)
      B = - A
      C1 = ZERO
      GO  TO 70
C
C     3-POINT
C
50    CONTINUE
      A = ONE / (SQUIG - SQUIG1) + ONE / (SQUIG - SQUIG2)
      B = -(SQUIG - SQUIG2) / ((SQUIG - SQUIG1) * (SQUIG1 - SQUIG2))
      C1= (SQUIG - SQUIG1) / ((SQUIG - SQUIG2) * (SQUIG1 - SQUIG2))
      GO  TO 70
C
C     0-POINT
C
60    A = ZERO
      B = ZERO
      C1= ZERO
70    V0 = SQUIG + SQUIG
      V1 = V0 * A
      V2 = V0 * B
      V3 = V0 * C1
      IF  (HE .NE. ZERO) Q4 = UE * UE / HE
      IMXX = IMAX
      IF  (IPRINT .NE. IONE) RETURN
      WRITE (6,80) ISTN,DELW,PHIP(1,1), PSI(1,1), A1, A, B, C1,
     1    V1, V2, V3, Q4, SQUIG, TEMPE, UE, X, ETAE, SQUIG1, SQUIG2
      RETURN
C
80    FORMAT  (1H0/1H0,25HSTCNST VALUES FOR STATION, I4//(1H ,4X,8E14.7)
     1)
      END
```

```
      SUBROUTINE  STLNS                                                 XOPN0010
C  **                                                                   XOPN0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS   XOPN0030
     1      , NANGLS, NCPTS(10), NDANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPN0040
     2      , KPAGE                                                     XOPN0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPN0060
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM                        XOPN0070
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10) , IDFO(10)  XOPN0080
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10) , JIEE(10),JIEND(10)XOPN0090
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)  XOPN0100
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR    XOPN0110
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR                         XOPN0120
     7      , ZD(3), ZS(3),       RAIO(200)                             XOPN0130
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPN0140
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)          XOPN0150
     2      , XSLOC1(10), YSLOC1(10)                                    XOPN0160
C  **                                                                   XOPN0170
      LOGICAL BLAP                                                      XOPN0180
      DIMENSION ERR1(5), ERR2(5), HD(12), XX(5, 2), YY(5, 2)            XOPN0190
      DATA  HD / 10H             , 10H X          , 10H   Y        ,    XOPN0200
     1           10H      X      , 10H       Y    , 10H          X ,    XOPN0210
     2           10H             , 10HY           , 10H    X       ,    XOPN0220
     3           10H     Y       , 10H        X   , 10H         Y  /    XOPN0230
      DATA BLANK / 1H /, ERR1 / 1H1, 1H2, 1H3, 1H4, 1H5/                XOPN0240
C  **                                                                   XOPN0250
C  **             SUBROUTINE 'STLNS' CALCULATES AND PLOTS STREAMLINES   XOPN0260
C  **        FOR THE GIVEN AIRFOIL SYSTEM.  IF THE ITERATIONS REQUIRED XOPN0270
C  **        FOR A GIVEN STREAMLINE EXCEED 'CRT' BEFORE THE CUTOFF      XOPN0280
C  **        VALUE FOR 'X' IS ACHIEVED, THE NEXT STREAMLINE IS TO BE    XOPN0290
C  **        ATTEMPTED...                                               XOPN0300
C  **                                                                   XOPN0310
      IK = 0                                                            XOPN0320
      SAVE = DLTALN                                                     XOPN0330
C  **                                                                   XOPN0340
      CALL  AFPLT                                                       XOPN0350
C  **                                                                   XOPN0360
      BLAP = .TRUE.                                                     XOPN0370
C     WRITE (       ) NSTLNS              ***                 ***       XOPN0380
C  **                                                                   XOPN0390
      DO 80  J = 1, NSTLNS                                              XOPN0400
C  **                                                                   XOPN0410
      IL = 0                                                            XOPN0420
      DLTALN = SAVE                                                     XOPN0430
      XA = XS(J)                                                        XOPN0440
      YA = YS(J)                                                        XOPN0450
C  **                                                                   XOPN0460
      X1 = (XA - XLR)/CREF                                              XOPN0470
      Y1 = (YA - YLR)/CREF                                              XOPN0480
C  **                                                                   XOPN0490
C     WRITE (       ) X1, Y1                                  ***       XOPN0500
C  **                                                                   XOPN0510
      CALL  HEADR                                                       XOPN0520
      WRITE  (6,90)    J, ALPHA                                         XOPN0530
C  **                                                                   XOPN0540
      WRITE  (6,100)   HD                                               XOPN0550
C  **                                                                   XOPN0560
```

```
      CALL   VLCTY  (UA, VA,     XA, YA, DA)
C  **
10    CONTINUE
C  **
      SNA = VA/DA
      CSA = UA/DA
C  **
20    CONTINUE
C  **
      VL1 = DLTALN * CSA
      VL2 = DLTALN * SNA
C  **
      XB = XA + VL1
      YB = YA + VL2
C  **
      XC = XB + VL1
      YC = YB + VL2
C  **
      CALL   VLCTY  (UB, VB,     XB, YB, DB)
C  **
      CT  = DLTALN/DB
      XD = XB + UB * CT
      YD = YB + VB * CT
C  **
      CALL   DSTSQD (XC, YC, XD, YD, XE, YE, S1, S2, 1)
C  **
      IF   (S2.GE.TOLLMT) GO  TO  50
C  **
      IF   (BLAP) DLTALN = 1.25 * DLTALN
      BLAP = .TRUE.
C  **
      IF   (DLTALN.GT.DLTALM) DLTALN = DLTALM
C  **
30    CONTINUE
C  **
      IK = IK + 1
      IL = IL + 1
      ERR2(IK) = BLANK
      IF   (.NOT.BLAP) ERR2(IK) = ERR1(IK)
C  **
      XX(IK, 1) = XB
      XX(IK, 2) = (XB - XLR)/CREF
      YY(IK, 1) = YB
      YY(IK, 2) = (YB - YLR)/CREF
C  **
C     WRITE (        ) XX(IK,2), YY(IK,2)                        ***
C  **
      IF   (IK.NE.5) GO  TO  40
      IK = 0
C  **
      WRITE  (6,110)   (XX(IA, 1), YY(IA, 1),  IA = 1, 5)
      WRITE  (6,110)   (XX(IA, 2), YY(IA, 2),  IA = 1, 5)
C  **
      WRITE  (6,120)   ERR2
C  **
40    CONTINUE
```

```
C     **
C     **
      IF  ((IL.GT. CRT).OR.(XB.GT.XSUBC)) GO  TO 60
C     **
C     **
      XA = XB
      YA = YB
      UA = UB
      VA = VB
      DA = DB
C     **
      GO  TO 10
C     **
50    CONTINUE
C     **
      IF  (DLTALN.EQ.DLTLMN) GO  TO 30
C     **
      BLAP = .TRUE.
C     **
      DLTALN = 0.75 * DLTALN
C     **
      IF  (DLTALN.GT.DLTLMN) GO  TO 20
C     **
      BLAP = .FALSE.
      DLTALN = DLTLMN
C     **
      GO  TO 20
C     **
60    CONTINUE
C     **
      IF  (IK.EQ.0) GO  TO 70
C     **
      WRITE  (6,130)  (XX(IA, 1), YY(IA, 1), IA = 1, IK)
      WRITE  (6,130)  (XX(IA, 2), YY(IA, 2), IA = 1, IK)
C     **
      WRITE  (6,120)  (ERR2(IA), IA = 1, IK)
C     **
      IK = 0
C     **
70    CONTINUE
C     **
80    CONTINUE
      RETURN
C
90    FORMAT  (1H0, 8X, 11HSTREAMLINE , I2, 1H,, 9X, 8HALPHA = , F8.4)
100   FORMAT  (1H0, 12A10)
110   FORMAT  (4X, 5(4X, F9.4, 2X, F9.4))
120   FORMAT  (1H+, 125X, 5A1 / )
130   FORMAT  (4X, 4(4X, F9.4, 2X, F9.4) )
      END
```

```
      SUBROUTINE  STZERO (IPRNT)                                        XOP1A010
      COMMON/AQ/C(300), CT(300) /A2/CTP(300), DH(300) /A3/ E(300)       XOP1A020
     1     , EPS(300) /A4/INT(300), MU(300) /A5/PHIPPP(300), PHI(300,3) XOP1A030
     2     /A6/PHIPP(300), PR(300) /A7/PRT(300), PSI(300,3)/A8/PSIP(300)XOP1A040
     3     , RHO(300) /A9/ RK(300), ROROE(300) /A10/T(300), TEMP(300)   XOP1A050
     4     /A11/ PHIP(300, 3)                                           XOP1A060
      COMMON/BLOCKG/A0, B5, B6, B7, HE, GK, PRO, V1, V2, V3             XOP1A070
     1     , LINCO, NMAX,  A1, BETA, COSA, DELS, DELW, ETAE,MUE, UE     XOP1A080
     2     , NUS, PE, R, REX, RHOE, RHOVW, SQUIG, SQREX, SQTSQ, TE      XOP1A090
     3     , TEMPE, X, IMAX, IMXX, IO, IPRINT, ISTN, MT, Q4, Q16, Q17   XOP1A100
     4     , Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, SQUIG1, SQUIG2XOP1A110
     5     , AV1, BV1, CV1, DV1, EV1, AV2, BV2, CV2, DV2, EV2, AV3, BV3 XOP1A120
     6     , CV3, DV3, EV3, AV4, BV4, CV4, DV4, EV4, AV5, BV5, CV5, DV5 XOP1A130
     7     , EV5, RN1, RN2, RN3, FN1, FN2, FN3, GN1, GN2, GN3, GN4, IN1 XOP1A140
     8     , IN2, IN3, MN1, MN2, MN3, F1, G1, I1, M1, RNM1, RNM2, RNM3  XOP1A150
     9     , FNM1, FNM2, FNM3, FNM4, GNM1, GNM2, GNM3, INM1, INM2, INM3 XOP1A160
     .     , MNM1, MNM2, MNM3, RNN, FNN, GNN, INN, MNN, S12, ISEPTB     XOP1A170
C                                                                       XOP1A180
C     LINEAR      VELOCITY  PROFILE                                     XOP1A190
C                                                                       XOP1A200
      ETAMAX =1.00/ E(IMAX)                                             XOP1A210
      ETAMA2 = ETAMAX * 0.500                                           XOP1A220
      DO 10 I = 1, IMAX                                                 XOP1A230
      PHI(I,1)  =    ETAMA2 * E(I)    *E(I)                             XOP1A240
      PHIP(I,1) =   ETAMAX * E(I)                                       XOP1A250
      PHIPP(I) = ETAMAX                                                 XOP1A260
10    PHIPPP(I) = 0.                                                    XOP1A270
      PHIPPP(1) = - BETA                                                XOP1A280
      IF  (IPRNT .EQ. 0) GO  TO 20                                      XOP1A290
      WRITE   (6,50)  (E(I), PHI(I,1), PHIP(I,1), PHIPP(I),PHIPPP(I),   XOP1A300
     1  I = 1, IMAX, 10 )                                               XOP1A310
20    CONTINUE                                                          XOP1A320
      EPHI = E(IMAX) + PHI(1,1) - PHI(IMAX,1)                           XOP1A330
      DELS = A1 * EPHI                                                  XOP1A340
      IF  (IPRNT .EQ. 0) GO  TO 30                                      XOP1A350
      WRITE  (6,40)   PHIPP(1), DELS                                    XOP1A360
30    CONTINUE                                                          XOP1A370
      RETURN                                                            XOP1A380
C                                                                       XOP1A390
40    FORMAT  (1H , 39X, 6HFPPW =, E17.9,  5X, 6HDELS =, E17.9)         XOP1A400
50    FORMAT  (         10X, 3HETA, 20X, 3HPHI, 19X, 4HPHIP, 18X, 5HPHIPP,XOP1A410
     1          17X, 6HPHIPPP/// (F16.5,  3X, 4E24.8) )                 XOP1A420
      END                                                               XOP1A430
```

```
      SUBROUTINE  TAPSA
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR
     7      , ZC(3), ZS(3),      RAIO(200)
      COMMON/BLOCKC/CPCOS(200), CPJ(200), CPK(200), CPSIN(200)
     1      , XJ(200), YJ(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK
     1      , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)
     2      , ITRAN(20),                                    BPDEL(200)
      COMMON/BLOCKI/ MBPU(10), MBPL(10)
      COMMON/BLOCKJ/CFF(200), CFDE(200)
      COMMON/BLOCKL/IEQ(10), ISQ(10), QCOSSL(200), QSINSL(200)
     1      , QX(200), QXBP(200), QY(200), QYBP(200)
      DOUBLE PRECISION X1(32), X2(310), X3(600), X4(446), X5(216)
     1    , X6(10), X7(610)
      EQUIVALENCE (X1(1), ANGL(1)), (X2(1), COSRF), (X3(1), CPCOS(1))
     1            , (X4(1), ALPHA), (X5(1), AEPS), (X6(1), MBPU(1))
     2    , (X7(1), IEQ(1))
      DATA  KNSUB /5HTAPSA /
C  **
      IF  (ITER .LT. IND(21)) RETURN
C  **
C  **
      REWIND   9
C  **
C  **
      WRITE  (9)   X1, X2, X3, X4, X5, X6, X7
C  **
      END  FILE  9
      REWIND   9
      WRITE  (6,20)   IND(21)
      CALL   EXIT
      RETURN
C  **
      ENTRY  TAPWR
C  **
      REWIND  10
C  **
      READ  (10)  X1, X2, X3, X4, X5, X6, X7
      IF  (EOF(10) .NE. 0.0) CALL  KEOF  (10, 1, KNSUB, 1)
      REWIND  10
C  **
      WRITE  (6,30)
C  **
      WRITE  (6,40)  TITLE
```

```
C   **                                                                  XOPB0570
      RETURN                                                            XOPB0580
      ENTRY TAPPT                                                       XOPB0590
      NPTS = JNPTS                                                      XOPB0600
      DO 10 I = 1, NAFPTS                                               XOPB0610
      NCPTS(I) = JCPTS(I)                                               XOPB0620
      JISS(I) = JIBEG(I)                                                XOPB0630
      JIEE(I) = JIEND(I)                                                XOPB0640
10    CONTINUE                                                          XOPB0650
      RETURN                                                            XOPB0660
C                                                                       XOPB0670
20    FORMAT  (1H0, 10X, 60H*** A TAPE ON UNIT NO. 9 HAS BEEN SAVED FOR XOPB0680
     1A RESTART AFTER , I3, 15H ITERATIONS *** )                        XOPB0690
30    FORMAT  (1H1, 24X, 82HTWO-DIMENSIONAL POTENTIAL FLOW ANALYSIS BY TXOPB0700
     1HE METHOD OF DISTRIBUTED SINGULARITIES //// 1H0, 32X, 15H*** RESTAXOPB0710
     2RT *** )                                                          XOPB0720
40    FORMAT  (1H0, 12A10)                                              XOPB0730
      END                                                               XOPB0740
```

```
      SUBROUTINE  TLRT (L)
C   **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(3C), ITER, ITMAX, LIT, NAFPTS
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2     , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1     , CREF, CRFSQ, CRT, CSTH(1C), DLTALM
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFC(10)
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR
     7     , ZD(3), ZS(3),      RAIO(20C)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1     , X(200), XS(30), XV(100), Y(20C), YS(30), YV(100)
     2     , XSLOC1(10), YSLOC1(10)
      DATA  KNSUB /4HTLRT /
C   **
C   **             SUBROUTINE 'TLRT' INSURES THAT THE TRANSLATICNS
C   **          AND/OR ROTATIONS ARE PERFORMED ON THE INPUT DATA...
C   **
      IF  (L.NE.0) GO  TO 50
C   **
      X1 = 0.
      Y1 = 0.
C   **
      XR = 0.
      YR = 0.
C   **
      XT = 0.
      YT = 0.
C   **
      YSUBC = 0.
C   **
C   **
C   **
      SINL = SINRF
      COSL = COSRF
      ANGLE =  ASIN(SINL) * 57.29578
C   **
      IF  (IND(6).NE.2) CALL  TRRT (X1, Y1, XR, YR, SINL, COSL, XMBAR, Y
     1MBAR)
C   **
      IF  (NSTLNS.EQ.0) GO  TO 20
C   **
      CALL  TRRT (X1, Y1, XR, YR, SINL, COSL, XSUBC, YSUBC)
C   **
      DO 10 I = 1, NSTLNS
C   **
      CALL  TRRT (X1, Y1, XR, YR, SINL, COSL, XS(I), YS(I))
C   **
10    CONTINUE
C   **
20    CONTINUE
C   **
      IF  (NVLPTS.EQ.0) GO  TO 40
```

```
C   **
       DO 30 I = 1, NVLPTS
C   **
       CALL   TRRT (X1, Y1, XR, YR, SINL, COSL, XV(I), YV(I))
C   **
30     CONTINUE
C   **
40     CONTINUE
C   **
       CALL   TRRT (X1, Y1, XR, YR, SINL, COSL, XTR, YTR)
       CALL   TRRT (X1, Y1, XR, YR, SINL, COSL, XLR, YLR)
C   **
C   **
50     CONTINUE
C   **
       K = 0
C   **
       DO 90 I = 1, NAFPTS
C   **
       NN = NCPTS(I)
C   **
       IF  (L.EQ.0) GO  TO 70
C   **
       IF  (INDR(I).NE.0) GO  TO 60
C   **
       K = K + NN
C   **
       GO  TO 90
C   **
60     CONTINUE
C   **
       READ  (5,100)   XT, YT, XR, YR, ANGLE
C   **
C              A POSITIVE ANGLE YIELDS A CLOCKWISE ROTATION
C   **
C   **
       IF  (EOF(5) .NE. 0.0) CALL  KEOF  (5, 1, KNSUB, 221)
       ANG  = ANGLE/57.29578
       SINL = SIN(ANG )
       COSL = COS(ANG )
C   **
       X1 = XT + XR
       Y1 = YT + YR
C   **
70     CONTINUE
C   **
       CALL   TRRT (X1, Y1, XR, YR, SINL, COSL, XTE(I), YTE(I))
       CALL   TRRT (X1, Y1, XR, YR, SINL, COSL, XLE(I), YLE(I))
C   **
       CALL   TRRT (X1, Y1, XR, YR, SINL, COSL, XSLOC1(I), YSLOC1(I))
C   **
       WRITE  (6,110)   I, XT, YT, ANGLE, XR, YR
C   **
       DO 80 J = 1, NN
C   **
       K = K + 1
```

```
C   **                                                                   XOPG1130
      WRITE  (6,120)   K, X(K), Y(K)                                     XOPG1140
C   **                                                                   XOPG1150
      CALL  TRRT (X1, Y1, XR, YR, SINL, COSL, X(K), Y(K))                XOPG1160
C   **                                                                   XOPG1170
80    CONTINUE                                                           XOPG1180
C   **                                                                   XOPG1190
90    CONTINUE                                                           XOPG1200
C   **                                                                   XOPG1210
      RETURN                                                             XOPG1220
C   **                                                                   XOPG1230
C                                                                        XOPG1240
100   FORMAT ( 5F10.0)                                                   XOPG1250
110   FORMAT  (1H0, 5X, 20HAIRFOIL PART NUMBER , I2, 1H, /               XOPG1260
     1          1H0, 5X, 31HTRANSLATION IN THE X-DIRECTION , F9.4, 1H, / XOPG1270
     2          1H0, 5X, 31HTRANSLATION IN THE Y-DIRECTION , F9.4, 1H, / XOPG1280
     3          1H0, 5X,  8HROTATED , F8.4, 17H DEGREES ABOUT ( , F9.4,  XOPG1290
     4          1H,, F9.4, 2H ) /                                        XOPG1300
     5          1H0, 53X, 26HUNTRANSFORMED COORDINATES  /                XOPG1310
     6          1H0, 45X, 5HINDEX, 8X, 1HX, 18X, 1HY / )                 XOPG1320
120   FORMAT  (47X, I3, 5X, F9.4, 10X, F9.4)                             XOPG1330
      END                                                                XOPG1340
```

```
      SUBROUTINE TRRT(X1, Y1, XR, YR, SINZ, COSZ, X2, Y2)                      XOPGA01
C  **                                                                          XOPGA02
C  **                 SUBROUTINE 'TRRT' TRANSLATES AND ROTATES THE PCINT       XOPGA03
C  **          (X2, Y2)--WHERE X1 = XT + XR, Y1 = YT + YR, AND (XT, YT)        XOPGA04
C  **                                ARE THE TRANSLATIONS...                   XOPGA05
C  **                            (XR, YR) IS THE POINT OF ROTATION...          XOPGA06
C  **                            (SINZ, COSZ) IMPLIES THAT 'Z' IS THE          XOPGA07
C  **                                   ANGLE OF ROTATION...                   XOPGA08
C  **                                                                          XOPGA09
      X3 = X2 - XR                                                             XOPGA10
      Y3 = Y2 - YR                                                             XOPGA11
C  **                                                                          XOPGA12
      X2 = X3 * COSZ  +  Y3 * SINZ  +  X1                                      XOPGA13
      Y2 = Y3 * COSZ  -  X3 * SINZ  +  Y1                                      XOPGA14
C  **                                                                          XOPGA15
      RETURN                                                                   XOPGA16
C  **                                                                          XOPGA17
      END                                                                      XOPGA18
```

```
      SUBROUTINE  TURB (IXM, NX, XXM, CPXM, XX, CPX, USUMX, DCPX,
     1                  DDCPX, XSEP, IXXS, CREF, REY, RATIO)
C  **
C          ***  TURBULENT SEPARATION ***
C  **
      DIMENSION XX(200), CPX(200), USUMX(200), DCPX(200), DDCPX(200)
      DATA EPS /1.0E-06/, COEF /.0377312/, XTWO/2.0/, NTWO/2/
C  **
C           *** EQUIVALENT LEADING EDGE CALCULATION ***
C  **
      XSEP = 0.0
      SAVE = USUMX(2) ** 3
      XOPX = XX(2) *  SAVE
      DO 10 I = 3, IXM
      U3 = USUMX(I) ** 3
      XOPX = XOPX + (U3 + SAVE) * (XX(I) - XX(I-1))
      SAVE = U3
10    CONTINUE
      XOPX = XOPX / XTWO
C  **
C          ***  DDCP CALCULATION AT INDEX OF CPMIN + 1 ***
C  **
      IBEG = IXM + NTWO
      XXO = XOPX - XXM
      XKAP = REY * SQRT(ABS(1.0 - CPXM))
      XKAPC = XKAP / CREF
      CPXMO = 1.0 - CPXM
      CPXMM = - CPXM
      CPKAP = CPXMM * XKAP / CREF
      XN = ALOG10(XKAPC * (XX(IXM+1) + XXO))
      XNS2 = XN / XTWO
      XM = (COEF * CPXMO ** XNS2) / (CPXMM ** XNS2 * 10.0 **
     1      (0.8 * XN) * XTWO ** (XNS2 - 1.0))
      W = XM * CPKAP
      DDCPX(IXM+1) = W * (1.0 -CPX(IXM+1)/ CPXM) ** (1.0 - XNS2)
      IF  (DCPX(IXM+1) .LT. DDCPX(IXM+1)) GO  TO 20
      IXXS = IXM+1
      XSEP = XX(IXM+1)
      RATIO = 0.0
      RETURN
20    CONTINUE
C  **
C          ***  DDCP CALCULATION TILL SEPARATION ***
C  **
      DO 50 I = IBEG, NX
      IXXS = I
      XN = ALOG10 (XKAPC * (XX(I) + XXO))
      XNS2 = XN / XTWO
      XM   = (COEF * CPXMO ** XNS2) / (CPXMM ** XNS2 * 10.0 **
     1      (0.8 * XN) * XTWO ** (XNS2 - 1.0))
      W = XM * CPKAP
      DDCPX(I) = W * (1.0 - CPX(I)  / CPXM) ** (1.0 - XNS2)
      IF  (DCPX(I) .LT. DDCPX(I)) GO  TO 40
      SAVE1= 1.0 / ( XX(I-1) - XX(I))
      A = (DDCPX(I-1) - DDCPX(I)) * SAVE1
      B = (DCPX(I-1) - DCPX(I)) * SAVE1
```

```
      SAVE = B - A                                                      XOPRC570
C                                                     ERROR  125        XOPRC580
      IF  (ABS(SAVE) .GE. EPS) GO  TO 30                                XOPRC590
      WRITE  (6,70)                                                     XOPRC600
      CALL   EXIT                                                       XOPRC610
30    CONTINUE                                                          XOPRC620
      XSEP = XX(I) + (DDCPX(I) - DCPX(I)) / SAVE                        XOPRC630
      RATIO = (XSEP - XX(I)) * SAVE1                                    XOPRC640
      GO  TO 60                                                         XOPRC650
40    CONTINUE                                                          XOPRC660
50    CONTINUE                                                          XOPRC670
60    CONTINUE                                                          XOPRC680
      RETURN                                                            XOPRC690
C                                                                       XOPRC700
70    FORMAT  (1HO, 77H *** IN SUBROUTINE TURB, SLOPE OF DCPX MUST NOT EXOPRC710
     1QUAL THE SLOPE OF DDCPX  *** )                                    XOPRC720
      END                                                               XOPRC730
```

```
      SUBROUTINE  VLCTY (UO, VO,     XA, YA, DA)
C  **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2      , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1      , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2      , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDO(10), IDFO(10)
     3      , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4      , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5      , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6      , YLE(10), YLR, YMBAR, YTE(10), YTR
     7      , ZC(3), ZS(3),      RAIO(200)
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)
     1      , SINSLP(200), SN, XBP(200), YBP(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1      , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2      , XSLOC1(10), YSLOC1(10)
      COMMON/BLOCKF/U(200), V(200)
C  **
C  **              SUBROUTINE 'VLCTY' COMPUTES THE VELOCITY REQUIRED
C  **         FOR EXTERNAL POINTS AND STREAMLINES...
C  **
      UO = USUBI * CS
      VO = USUBI * SN
C  **
      II = 0
      IZP1 = 1
C  **
      DO 60  I = 1, NAFPTS
C  **
      IA = NCPTS(I)
C  **
      DO 50  J = 1, IA
C  **
      II = II + 1
      IZM1 = IZ
      IZ = IZP1
      IZP1 = IZ + 1
C  **
      CALL  DSTSQD (X(IZ), Y(IZ), XA, YA, XB, YB, A, S2, 0)
C  **
      IF  (J.EQ.1) GO  TO 10
C  **
      CALL  DSTRBD (X(IZ), Y(IZ), X(IZM1), Y(IZM1), U1, V1, A, XA, YA)
C  **
      IF  (J.EQ.IA) GO  TO 30
C  **
      GO  TO 20
C  **
10    CONTINUE
C  **
      U1 = 0.
      V1 = 0.
C  **
20    CONTINUE
```

```
C   **                                                                   XOP00570
      CALL  DSTRBD (X(IZ), Y(IZ), X(IZP1), Y(IZP1), U2, V2, A, XA, YA)   XOP00580
C   **                                                                   XOP00590
      GO  TO 40                                                          XOP00600
C   **                                                                   XOP00610
30    CONTINUE                                                           XOP00620
C   **                                                                   XOP00630
      U2 = 0.                                                            XOP00640
      V2 = 0.                                                            XOP00650
C   **                                                                   XOP00660
40    CONTINUE                                                           XOP00670
C   **                                                                   XOP00680
      GMA = GAMMA(II)                                                    XOP00690
C   **                                                                   XOP00700
      U0 = U0 + (U1 + U2) * GMA                                          XOP00710
      V0 = V0 + (V1 + V2) * GMA                                          XOP00720
C   **                                                                   XOP00730
50    CONTINUE                                                           XOP00740
C   **                                                                   XOP00750
      II = II + 1                                                        XOP00760
C   **                                                                   XOP00770
      CALL DSTSQD (XA, YA, XSLOC1(I), YSLOC1(I), XXX, YYY, DD, DDD, 0)   XOP00780
      DD = 6.283184 * DD                                                 XOP00800
      U0 = U0 + XXX * GAMMA(II) / DD                                     XOP00810
      V0 = V0 + YYY * GAMMA(II) / DD                                     XOP00820
C   **                                                                   XOP00860
60    CONTINUE                                                           XOP00870
C   **                                                                   XOP00880
      DA = SQRT(U0 * U0  +  V0 * V0)                                     XOP00890
C   **                                                                   XOP00900
      RETURN                                                             XOP00910
C   **                                                                   XOP00920
      END                                                                XOP00930
```

```
      SUBROUTINE  WRTE (NOPT)                                           XOPF0010
C  **                                                                   XOPF0020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS  XOPF0030
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPF0040
     2     , KPAGE                                                      XOPF0050
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                         XOPF0060
     1     , CREF, CRFSQ, CRT, CSTH(10), DLTALM                         XOPF0070
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)   XOPF0080
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPF0090
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)  XOPF0100
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR    XOPF0110
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR                          XOPF0120
     7     , ZD(3), ZS(3),     RAIO(200)                                XOPF0130
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM                    XOPF0140
     1     , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)           XOPF0150
     2     , XSLOC1(10), YSLOC1(10)                                     XOPF0160
C  **                                                                   XOPF0170
      KPAGE = 1                                                         XOPF0180
C  **                                                                   XOPF0190
      CALL  HEADR                                                       XOPF0200
      WRITE  (6,180)                                                    XOPF0210
C  **                                                                   XOPF0220
      WRITE  (6,190)  (TITLE(I), I = 1, 10)                             XOPF0230
C  **                                                                   XOPF0240
      IF  (NOPT.EQ.0) GO  TO 20                                         XOPF0250
C  **                                                                   XOPF0260
      ASSIGN 10 TO  LCTN                                                XOPF0270
      GO  TO 130                                                        XOPF0280
C  **                                                                   XOPF0290
10    CONTINUE                                                          XOPF0300
C  **                                                                   XOPF0310
      CALL  TLRT (1)                                                    XOPF0320
C  **                                                                   XOPF0330
20    CONTINUE                                                          XOPF0340
C  **                                                                   XOPF0350
      IF  (IND(8).NE.1) GO  TO 40                                       XOPF0360
C  **                                                                   XOPF0370
      ASSIGN 30 TO  LCTN                                                XOPF0380
      GO  TO 130                                                        XOPF0390
C  **                                                                   XOPF0400
30    CONTINUE                                                          XOPF0410
C  **                                                                   XOPF0420
      CALL  TLRT (0)                                                    XOPF0430
C  **                                                                   XOPF0440
40    CONTINUE                                                          XOPF0450
      ASSIGN 170 TO  LCTN                                               XOPF0460
C  **                                                                   XOPF0470
      DO 60 I = 1, NAFPTS                                               XOPF0480
C  **                                                                   XOPF0490
      CALL  DSTSQD (XTE(I), YTE(I), XLE(I), YLE(I), XDF, YDF, S, DS(I), XOPF0500
     11)                                                                XOPF0510
C  **                                                                   XOPF0520
C  **        ERROR 113...                                               XOPF0530
C  **                                                                   XOPF0540
      IF  (DS(I) .NE. 0.0) GO  TO 50                                    XOPF0550
      WRITE  (6,200)                                                    XOPF0560
```

```
      CALL   EXIT
50    CONTINUE
C  **
      CSTH(I) = XDF/DS(I)
      SNTH(I) = YDF/DS(I)
C  **
60    CONTINUE
C  **
C  **
      CALL   HEADR
      WRITE  (6,210)   NAFPTS
      WRITE   (6,211)  ( I,  IND(I),  I = 1, 30)
      IF ( ABS(HEIGHT) .GT. 0.01)  GO TO 63
      WRITE   (6,212)
      GO TO 65
63    CONTINUE
      IF ( HEIGHT  .GT.  1.01)    GO TO 64
      WRITE   (6,213)  HEIGHT
      GO TO   65
64    CONTINUE
      WRITE     (6,214) HEIGHT
65    CONTINUE
      IF  (NVLPTS.NE.0) WRITE  (6,220)   NVLPTS
C  **
C  **
C  **
      WRITE  (6,230)
C  **
C  **
      IF  (IND(16) .EQ. 0) GO  TO 70
C  **
      WRITE  (6,240)
      GO  TO 80
C  **
70    CONTINUE
C  **
      WRITE  (6,250)
C  **
80    CONTINUE
C  **
      IF  (IND(6).EQ.2) GO  TO 90
C  **
      WRITE  (6,260)
C  **
      GO  TO 100
C  **
90    CONTINUE
C  **
      WRITE  (6,270)
C  **
100   CONTINUE
C  **
      IF  (IND(7).EQ.0) GO  TO 110
C  **
      IF  (NSTLNS .NE. 0) WRITE (6,280)  NSTLNS
      J = NAFPTS + NAFPTS
```

```
      IF  (IND(9) .EQ. 1) WRITE (6,280)  J
C  **
C  **
      GO  TO 120
C  **
110   CONTINUE
C  **
      WRITE  (6,290)
C  **
120   CONTINUE
C  **
      WRITE  (6,300)  DXTGE
C  **
      WRITE  (6,310) (ANGL(I), I = 1, NANGLS)
C  **
      IF  (IND(18) .EQ. 1) WRITE (6,320)  VSUBM
C  **
C  **
130   CONTINUE
C  **
      IF  (IND(7) .EQ. 0) GO  TO 140
C  **
      WRITE  (6,330)   XSUBC, DLTLMN, DLTALN, DLTALM, TOLLMT
C  **
      IF  (NSTLNS .EQ. 0) GO  TO 140
      WRITE  (6,340)   NSTLNS, (I, XS(I), YS(I), I = 1, NSTLNS)
C  **
140   CONTINUE
C  **
      IF  (IND(6) .NE. 2) WRITE  (6,350)  XMBAR, YMBAR
      WRITE  (6,360)  XLR, YLR, XTR, YTR, CREF
C  **
      WRITE  (6,370)
C  **
      WRITE  (6,380)
C  **
      DO 150  I=1, NAFPTS
C  **
      WRITE  (6,390)   (I, XLE(I), YLE(I), XTE(I), YTE(I), DS(I))
C  **
      WRITE  (6,400)  XSLOC1(I), YSLOC1(I)
C  **
150   CONTINUE
C  **
      IF  (NVLPTS.EQ.0) GO  TO 160
C  **
      WRITE  (6,410)   (I, XV(I), YV(I), I = 1, NVLPTS)
C  **
160   CONTINUE
C  **
C  **
      GO  TO LCTN,  (10,30,170)
C  **
C  **
170   CONTINUE
C  **
```

```
C  **                                                                     XOPF1590
      RETURN                                                              XOPF1600
C  **                                                                     XOPF1610
C                                                                         XOPF1620
180   FORMAT  (1HO, 24X, 82HTWO-DIMENSIONAL POTENTIAL FLOW ANALYSIS BY TXOPF1630
     1HE METHOD OF DISTRIBUTED SINGULARITIES )                            XOPF1640
190   FORMAT  (1HO, 10A10 )                                               XOPF1650
200   FORMAT  (1HO, 81H *** IN SUBROUTINE WRTE, LEADING EDGE AND TRAILINXOPF1660
     1GEDGE MUST NOT BE COINCIDENT *** )                                  XOPF1670
210   FORMAT  (1HO /1HO, 21HOPEN AIRFOIL ANALYSIS, I2, 17H AIRFOIL PARTSXOPF1680
     1... )                                                               XOPF1690
211   FORMAT  (1HO, 23H   OPTION INDICATORS...   / 26X, 10 (I2, 1H., I3, XOPF1691
     1         4X)  / 26X, 10(I2, 1H., I3, 4X) / 26X, 10(I2, 1H.,I3,4X)) XOPF1692
212   FORMAT  (1H , 73H   SEPARATION STREAMLINE PARALLEL TO LOCAL SURFACXOPF1693
     1E AT SEPARATION POINT... )                                          XOPF1694
213   FORMAT  (1H , 49H   SEPARATION STREAMLINE MAKES AN ANGLE EQUAL TO XOPF1695
     1 , F6.3 , 66H * 100 PERCENT OF ALPHA WITH LOCAL SURFACE AT SEPARATXOPF1696
     2ION POINT ... )                                                     XOPF1697
214   FORMAT  (1H , 40H   SEPARATION STREAMLINE MAKES AN ANGLE , F6.2 , XOPF1698
     1 58H DEGREES WITH THE LOCAL SURFACE AT THE SEPARATION POINT...)    XOPF1699
220   FORMAT  (1H , 25H   VELOCITY CALCULATED AT, I3, 17H REMOTE POINTS.XOPF1700
     1.. )                                                                XOPF1710
230   FORMAT  (1H , 26H   PRESSURES CALCULATED... )                       XOPF1720
240   FORMAT  (1H , 33H   SEPARATION METHOD STRATFORD... )                XOPF1730
250   FORMAT  (1H , 34H   SEPARATION METHOD BY CF DATA... )               XOPF1740
260   FORMAT  (1H , 23H   FORCES CALCULATED... )                          XOPF1750
270   FORMAT  (1H , 27H   NO FORCE CALCULATIONS... )                      XOPF1760
280   FORMAT  (1H , 3H    , I2, 23H STREAMLINES CALCULATED )              XOPF1770
290   FORMAT  (1H , 32H   NO STREAMLINE CALCULATIONS... )                 XOPF1780
300   FORMAT  (1H , 61H   KUTTA CONDITION USED - 1 PSEUDO BOUNDARY POINTXOPF1790
     1  SPECIFIED , F7.6, 31H DOWNSTREAM OF SEPARATION POINT )            XOPF1800
310   FORMAT  (1H , 22H   ANGLES OF ATTACK = , F9.4 / (23X, F9.4))        XOPF1810
320   FORMAT  (1H , 37H   COMPRESSIBLE FLOW - MACH NUMBER = , F6.4 )      XOPF1820
330   FORMAT  (1HO, 13X, 8HXSUBC = , F8.4, 5X, 9HDLTLMN = , F8.5, 5X,     XOPF1830
     1         9HDLTALN = , F8.5, 5X, 9HDLTALM = , F8.5, 5X,              XOPF1840
     2         9HTOLLMT = , F8.5 / )                                      XOPF1850
340   FORMAT  (17X, I2, 32H STREAMLINE STARTING COORDINATES /             XOPF1860
     1        (54X, I2, 1H., 2X, 1H(, F8.4, 1H, F8.4, 1H) ))              XOPF1870
350   FORMAT  (1HO, 16X, 38HPOINT ABOUT WHICH MOMENTS ARE TAKEN  (, F8.4XOPF1880
     1,        1H,, F8.4, 1H) )                                           XOPF1890
360   FORMAT  (1HO, 16X, 25HREFERENCE LEADING EDGE  (, F8.4,              XOPF1900
     1         1H,, F8.4, 1H) / 17X, 26HREFERENCE TRAILING EDGE  (, F8.4XOPF1910
     2,        1H,, F8.4, 1H) // 17X, 16HREFERENCE CHORD , F8.4)          XOPF1920
370   FORMAT  (1HO, 1X, 4HAFPT, 4X, 3HXLE, 8X, 3HYLE, 8X, 3HXTE, 8X,      XOPF1930
     1         3HYTE, 7X, 5HCHORD)                                        XOPF1940
380   FORMAT  (1H+, 62X, 20HX-SOURCE1  Y-SOURCE1 )                        XOPF1950
390   FORMAT  ( 3X, I2, 2X, 5(F8.4, 3X))                                  XOPF1960
400   FORMAT  (1H+, 59X, 2F11.4)                                          XOPF1970
410   FORMAT  (1HO, 2X, 5(3HNO., 5X, 2HXV, 8X, 2HYV, 6X) /                XOPF1980
     1         (5(3X, I3, 2X, F8.4, 2H, , F8.4)))                         XOPF1990
      END                                                                 XOPF2000
```

```
      PROGRAM XOPOO (INPUT=512, OUTPUT=512, TAPE5=INPUT, TAPE6=OUTPUT
     1     , TAPE1=448, TAPE2=2048, TAPE9=512, TAPE10=512               )
C  **
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2
     2     , KPAGE
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)
     1     , CREF, CRFSQ, CRT, CSTH(10), DLTALM
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12)
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR
     7     , ZD(3), ZS(3),     RAIO(200)
      COMMON/BLOCKC/CPCOS(200), CPJ(200), CPK(200), CPSIN(200)
     1     , XJ(200), YJ(200)
      COMMON/BLOCKD/COSSLP(200), CS, IE(10), IIS(10), IJS(10), IS(10)
     1     , SINSLP(200), SN, XBP(200), YBP(200)
      COMMON/BLOCKE/ALPHA, GAMMA(200), SS(10), VSUBM
     1     , X(200), XS(30), XV(100), Y(200), YS(30), YV(100)
     2     , XSLOC1(10), YSLOC1(10)
      COMMON/BLOCKH/AEPS, ACREF, AUSUBI, AVSUBM, GRIDK
     1     , HETEM, ICFLAG, IIPR, ISEPA, RRO, XRHOEO, BPDE(200)
     2     , ITRAN(20),                                      BPDEL(200)
      COMMON/BLOCKI/MBPU(10), MBPL(10)
      COMMON/BLOCKF/U(200), V(200)
      COMMON/BLOCKL/IEQ(10), ISQ(10), QCOSSL(200), QSINSL(200)
     1     , QX(200), QXBP(200), QY(200), QYBP(200)
      DOUBLE PRECISION  X1(310), X2(466)
      EQUIVALENCE (X1(1), COSRF), (X2(1), AEPS)
      LOGICAL BEGIN,LIT
C  **
C  **             THE MAIN PROGRAM FOR PROCEDURE XOP ACTS AS A DRIVER
C  **        TO THE PROBLEM SOLUTION...
C  **             TWO-DIMENSIONAL POTENTIAL FLOW ANALYSIS BY THE METHOD
C  **        OF DISTRIBUTED SINGULARITIES...
C  **
C  **
111   CONTINUE
C  **
      CALL  OVERLAY  (3HDUM, 1, 0)
      CALL  OVERLAY  (3HDUM, 1, 1)
      ITMAX = IND(13)
      NS = IND(19)
      IF  (NS .EQ. 0) NS = 1
      JS = IND(14)
      IF  (JS .EQ. 0) JS = 1
      ISFLAG = 0
C  **
      DO 151 N = NS, NANGLS
C  **
      ILIT = 0
      NOANG = N
      BEGIN = .FALSE.
      LIT = .FALSE.
      IF  (ISFLAG .EQ. 1) JS = 1
```

```
      ISFLAG = 1
C  **
      DO 131 I = JS, ITMAX
C  **
      REWIND  1
      REWIND  2
      ITER = I
      IF ((IND(20).EQ.2).AND.(I.NE.1)) BEGIN = .TRUE.
      IF  (N .EQ. 1) GO  TO 121
      IF  (I .GT. 1) GO  TO 121
      CALL  OVERLAY  (3HDUM, 1, 2)
C  **
121   CONTINUE
C  **
      CALL  OVERLAY  (3HDUM, 1, 3)
      CALL  OVERLAY  (3HDUM, 2, 0)
      CALL  OVERLAY  (3HDUM, 1, 0)
      CALL  OVERLAY  (3HDUM, 1, 4)
      CALL  OVERLAY  (3HDUM, 1, 5)
      IF  (LIT) ILIT = ILIT + 1
      IF  (ILIT .GT. 1) GO  TO 141
      BEGIN = .TRUE.
      IF  (ITER .NE. IND(13)) GO  TO 131
      WRITE  (6,191)
      GO TO 111
C  **
C  **
131   CONTINUE
C  **
141   CONTINUE
C  **
151   CONTINUE
C  **
      IF  (ILIT .GT. 100) GO  TO 161
      GO  TO 111
C  **   STATEMENTS BELOW RESULT IN ENDFIL, IFEND, INPUTB, OUTPUTB
C  **   IN MAIN OVERLAY SEGMENT
C  **
161   CONTINUE
      END  FILE  2
      REWIND   2
      IF  (EOF(2)) 171,181
171   WRITE (2)  ANGL
181   READ (2)  ANGL
      GO  TO 111
C
191   FORMAT  (1H0, 87H *** IN SUBROUTINE XOP00, CP CONVERGENCE HAS  NOT
     1OCCURRED IN (B13-INPUT) ITERATIONS *** )
      END
```

```
PROGRAM XOP10                                        XOPAZ010
A = 0.0                                              XOPAZ02
END                                                  XOPAZ03
```

```
PROGRAM XOP11                                                   XOPDZ010
CALL RD                                                         XOPDZ02
END                                                             XOPDZ03
```

```
      PROGRAM XOP12                                                    XOPGM010
      CALL TAPPT                                                       XOPGM02
      ENC                                                              XOPGM03
```

```
      PROGRAM XOP13                                                     XOPGZ010
C  **                                                                   XOPGZ020
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS  XOPGZ030
     1      , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPGZ040
     2      , KPAGE                                                     XOPGZ050
      LOGICAL BEGIN                                                     XOPGZ060
C  **                                                                   XOPGZ070
      CALL  GEOM                                                        XOPGZ080
      IF  (BEGIN) GO  TO 10                                             XOPGZ090
      IF  (IND(11) .EQ. 0) CALL  NONDIM                                 XOPGZ100
C  **                                                                   XOPGZ110
10    CONTINUE                                                          XOPGZ120
C  **                                                                   XOPGZ130
      CALL  MTRXGN                                                      XOPGZ140
      END                                                               XOPGZ150
```

```
      PROGRAM XOP14                                                XOPJZ010
      CALL GWRT                                                    XOPJZ03
      CALL PRSS                                                    XOPJZ04
      END                                                          XOPJZ05
```

```
      PROGRAM XOP15                                                    XOPPZ010
      COMMON/BLOCKA/ANGL(10), BEGIN, IND(30), ITER, ITMAX, LIT, NAFPTS XOPPZ020
     1     , NANGLS, NCPTS(10), NOANG, NPNTS, NPTS, NSTLNS, NVLPTS,N1,N2XOPPZ030
     2     , KPAGE                                                     XOPPZ040
      COMMON/BLOCKB/COSRF, CPUP(200), ISAVE(10)                        XOPPZ050
     1     , CREF, CRFSQ, CRT, CSTH(10), DLTALM                        XOPPZ060
     2     , DLTALN, DLTLMN, DS(10), DXTGE, HEIGHT, IDD(10), IDFO(10)  XOPPZ070
     3     , INDR(10), JCPTS(10), JIBEG(10), JIE(10), JIEE(10),JIEND(10)XOPPZ080
     4     , JIS(10), JISS(10), JNPTS, REY, SINRF, SNTH(10), TITLE(12) XOPPZ090
     5     , TOLLMT, USUBI, XLE(10), XLR, XMBAR, XSUBC, XTE(10), XTR   XOPPZ100
     6     , YLE(10), YLR, YMBAR, YTE(10), YTR                         XOPPZ110
     7     , ZD(3), ZS(3),     RAIO(200)                               XOPPZ120
      LOGICAL IDFO, LIT                                                XOPPZ130
C                                                                      XOPPZ140
      IF  (IDFO(9)) GO  TO 10                                          XOPPZ150
      IF  (LIT) GO  TO 30                                              XOPPZ160
10    CONTINUE                                                         XOPPZ170
      CALL  PRVDEV                                                     XOPPZ180
      IF  (IDFO(9)) GO  TO 20                                          XOPPZ190
      CALL  CPEQ                                                       XOPPZ200
      GO  TO 30                                                        XOPPZ210
20    CONTINUE                                                         XOPPZ220
      IF  (IND(6) .EQ. 2) GO  TO 30                                    XOPPZ230
      CALL  FRCE                                                       XOPPZ240
30    CONTINUE                                                         XOPPZ250
      END                                                              XOPPZ260
```

```
PROGRAM XOP20                                                   XOP1Z010
CALL SLNR                                                       XOP1Z02
END                                                             XOP1Z03
```

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13. ABSTRACT

A method has been developed for the analysis of arbitrary multi-element airfoils in viscous flow. The viscous solution is obtained through an inviscid analysis of an equivalent system defined from viscous considerations. An iterative procedure has been formulated to implement this analysis. The inviscid solution is obtained through a distributed singularity method. A finite-difference method is used to determine boundary-layer characteristics. Methods are included to predict laminar-flow bubbles and separation and transition points. The equivalent airfoil is defined for airfoils with attached flow as well as for airfoils with flow separation. The validity of the method is established through comparison of the predicted results with experimental data for several single- and multi-element airfoils. The comparisons show good agreement for lift coefficient and maximum lift coefficient and fair agreement for drag and pitching moment coefficients. Details of the computer program developed to implement this method are described, including input and output details, FORTRAN source deck listing, and a sample problem.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Two-dimensional airfoil theory						
High-lift devices						
Airfoil pressure distributions						
Aerodynamics						
Multiple-element airfoil theory						
Distributed singularity model						
Potential flow theory						
Viscous flow analysis						
Blunt-base airfoil analysis						
Free-streamline separation model						
Boundary-layer transition						
Boundary-layer separation						
Incompressible flow						

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