



**A COMPUTER PROGRAM FOR THE AERODYNAMIC
DESIGN OF AXISYMMETRIC AND PLANAR
NOZZLES FOR SUPERSONIC AND
HYPERSONIC WIND TUNNELS**

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FOR THE COMMANDER



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20. ABSTRACT (Continued)

expected at the nozzle exit. The continuous curvature is achieved through specification of a centerline distribution of velocity (or Mach number) which has first and second derivatives that 1) are compatible with a transonic solution near the throat and with radial flow near the inflection point and 2) approach zero at the design Mach number. The boundary-layer growth is calculated by solving a momentum integral equation by numerical integration.

PREFACE

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC). The results of the research were obtained by ARO, Inc., AEDC Division (a Sverdrup Corporation Company), operating contractor for the AEDC, AFSC, Arnold Air Force Station, Tennessee, under ARO Project Numbers V33A-A8A and V32A-P1A. The Air Force project manager was Mr. Elton R. Thompson. The manuscript was submitted for publication on September 12, 1978.

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1.0 INTRODUCTION

Supersonic and hypersonic wind tunnel nozzles can be placed in two general categories, planar (also called two-dimensional) and axisymmetric. Early supersonic nozzles (circa 1940) were planar for many reasons: the state of the art was new with regard to both the design and the fabrication; the expansion of the air - the usual medium - was in one plane only, thereby simplifying the calculations and requiring two contoured walls for each test Mach number and two flat walls which could be used for all the Mach numbers; and the relatively low stagnation temperature and pressure requirements did not create dimensional stability problems in the throat region. Dimensional stability would in later years become a primary factor in the development of axisymmetric nozzles.

Prandtl and Busemann, Ref. 1, laid the foundation for determining the inviscid nozzle contours by the method of characteristics. Foelsch, Ref. 2, simplified the calculation of the contour by assuming that the flow in the region of the inflection point was radial, as if the flow came from a theoretical source as illustrated in Fig. 1. The downstream boundary of the radial flow is the right-running characteristic AC from the inflection point, A, to the point, C, on the axis of symmetry where the design Mach number is first reached. The flow properties along this characteristic can be readily calculated; and inasmuch as all left-running characteristics downstream of the radial flow region are straight lines in planar flow, the entire downstream contour can be determined analytically. Upstream of the inflection point, it was assumed that the source flow could be produced by a contour which was a simple analytic curve. In the Foelsch design the Mach number gradient on the axis is discontinuous at the juncture of the radial flow region and the beginning of the parallel flow region. This discontinuity produces a discontinuity in curvature of the contour at the inflection point and at the theoretical exit of the nozzle.

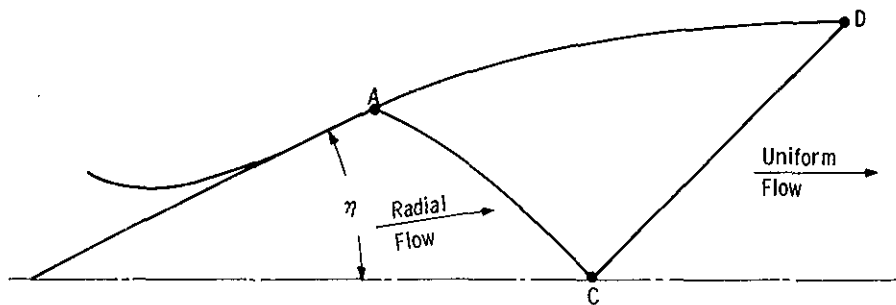


Figure 1. A Foelsch-type nozzle with radial flow at the inflection point.

As the state of the art progressed, it became desirable to cover a range of Mach numbers without fabricating different nozzle blocks for each Mach number. A limited range of Mach numbers could be covered by using blocks with unsymmetrical contours which could be translated relative to each other to vary the mean Mach number in the test section. The widest range of Mach numbers with acceptably uniform flow in the test section has been obtained in wind tunnels in which the contoured walls consist of flexible plates supported by jacks which can be adjusted to vary the contour to suit each Mach number. Inasmuch as the curvature of a plate so supported must be continuous, methods of calculating contours with continuous curvature were developed (Refs. 3, 4, and 5) by introducing a transition region, A B C J, downstream of the radial flow region (see Fig. 2). The shape of the wall between points A and J was controlled to give continuous curvature. The contours used for the von Kármán Gas Dynamics Facility 40- by 40-in. Supersonic Wind Tunnel (A) at AEDC were obtained by the method of Ref. 5. Not only is a continuous-curvature contour easier to match with a jack-supported plate, but it also satisfies the potential flow criterion for zero vorticity,

$$dq/dn = Kq \quad (1)$$

where q is the velocity measured along a streamline of curvature K and n is the distance normal to the streamline. Inasmuch as the inviscid contour is a streamline, this criterion implies that the flow will be disturbed where a contour has a discontinuity in curvature.

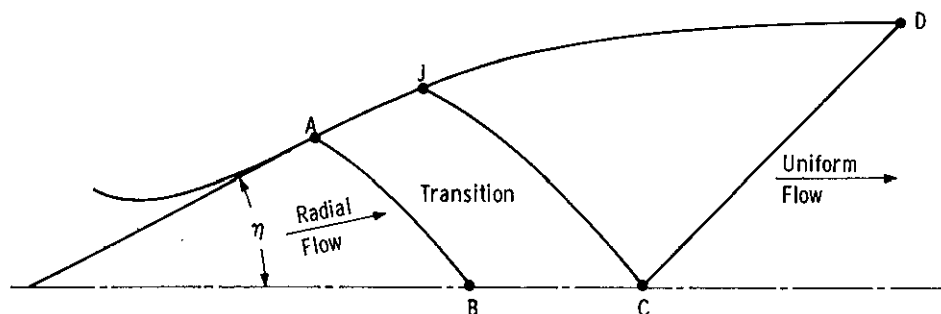


Figure 2. Nozzle with radial flow and a transition region to produce continuous curvature.

The usual wind tunnel criterion concerning temperature is that the constituents of the gas should not liquefy during the expansion process required to reach the test Mach number. For the usual pressure levels involved, ambient stagnation temperatures can be used up to a Mach number of about five. As the stagnation temperature is raised, dimensional stability becomes more difficult to maintain in a planar nozzle. Therefore, axisymmetric nozzles are used when elevated stagnation temperatures are involved. Axisymmetric nozzles have also been used for low-density tunnels (Ref. 6) because their boundary-layer growth is more uniform than that of planar nozzles, which inherently have transverse pressure gradients on the flat walls. The obvious disadvantage of axisymmetric nozzles is that each one must be designed for a particular Mach number. Moreover, disturbances created by imperfections in the contour tend to be focused on the centerline.

Before the advent of high-speed digital computers, it was extremely time consuming (Ref. 7) to calculate axisymmetric nozzle flow by the method of characteristics (Ref. 8). Inasmuch as the assumption of source flow saved time in designing a planar nozzle, it was logical to use source flow as a starting point in the design of an axisymmetric nozzle. In Ref. 9, Foelsch develops an approximate method of converting the radial flow to uniform flow. Beckwith et al., Ref. 7, show that Foelsch's approximations were quite inaccurate but utilized the idea of

This characteristic is also called a branch line. Between the theoretical location of the throat and the intersection of the branch line with the contour was a region which was not calculated but which increased in size as the throat curvature increased. This gap in the contour has been eliminated by the method described herein which utilizes a right-running characteristic originating at the throat as shown in Fig. 4 (where point I has been moved from the sonic line to the throat characteristic). With this latest improvement upon the method of Ref. 12, contours can be designed which have throat radii of curvature of the same order of magnitude as the throat radii although such an extreme curvature would not normally be recommended from other standpoints. A recent (1975) design of a Mach 6 nozzle utilized this method with a throat radius of curvature of about 5.5 times the throat radius.

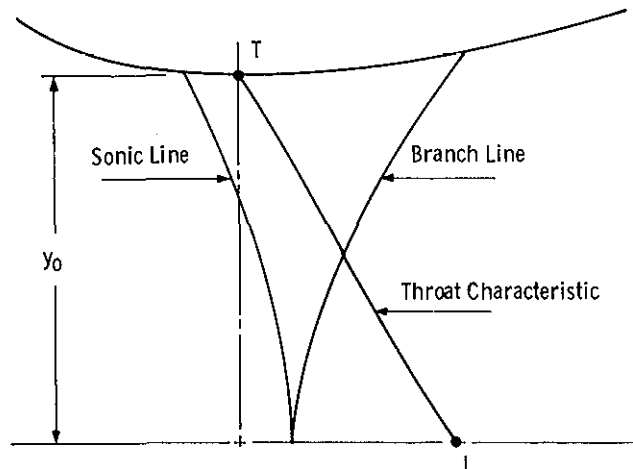


Figure 4. Nozzle throat region.

After the design method was developed for axisymmetric nozzles, it was adapted for planar nozzles having a prescribed centerline distribution of Mach number (or velocity). This approach to such a design is considerably different from that of Ref. 5. The current design method is incorporated into the computer program included herein. As an option in the program, a complete centerline Mach number distribution

can be used which does not include a radial flow region. Parts of the computer program are subroutines for computing the boundary-layer correction to the inviscid contour, for smoothing the contour, and for interpolating points at even axial positions by means of a cubic spline fit of the contour.

2.0 TRANSONIC SOLUTION

In many early nozzle designs, it was assumed that the flow at the throat was uniform ($M = 1$) and parallel. This assumption implies that the wall curvature is zero and that the acceleration of the flow is zero (i.e., the acceleration starts from zero at the beginning of the contraction, reaches a maximum in the contraction but is reduced to zero again at the throat, and must be increased again in the beginning of the supersonic contour and reduced to zero at the nozzle exit). A nozzle so designed therefore becomes considerably longer than one in which the flow reaches its maximum acceleration in the vicinity of the throat, where it is approximately proportional to the reciprocal of the square root of the radius of curvature. The above argument indicates the fallacy of some so-called "minimum length" nozzles, although some designers have combined a contraction having a relatively high throat curvature with the supersonic section having zero throat curvature.

For a throat with a finite radius of curvature there have been many transonic solutions. Hall, Ref. 13, developed a small perturbation transonic solution for irrotational, perfect gas flow, in both two-dimensional and axisymmetric nozzles, by means of expansions in inverse powers of R , the ratio of the throat radius of curvature to the throat half-height, or radius. His solution gives the normalized (with the velocity at the sonic point) axial and normal velocity components in the form

$$u = 1 + \frac{u_a(y, z)}{R} + \frac{u_b(y, z)}{R^2} + \frac{u_c(y, z)}{R^3} + \dots \quad (2)$$

$$v = \left[\frac{\gamma+1}{(1+\sigma)R} \right]^{\frac{1}{2}} \left[\frac{v_a(y, z)}{R} + \frac{v_b(y, z)}{R^2} + \frac{v_c(y, z)}{R^3} + \dots \right] \quad (3)$$

where

$$z = \left[\frac{(1+\sigma)R}{\gamma+1} \right]^{\frac{1}{2}} x \quad (4)$$

and x and y are coordinates normalized with the throat half-height or radius, y_0 . The value of σ is zero for two-dimensional flow and one for axisymmetric flow. Kliegel and Levine in Ref. 14 extended the applicability of Hall's axisymmetric solution to lower values of R essentially by making the substitution

$$R^{-1} = S^{-1} + S^{-2} + S^{-3} + \dots \quad (5)$$

where $S = R + 1$, into Eqs. (2) and (3). In the method used herein, the same substitution is made in Eq. (4) for two-dimensional flow as well as for axisymmetric flow and therefore becomes a special case of the general transonic solution described in Ref. 15. The complete general equations in terms of S are given in Appendix A.

At the throat, $x = 0$, $y = y_0$, $v = 0$, for planar flow,

$$u = 1 + \frac{1}{3S} - \frac{(14\gamma-75)}{270S^2} + \frac{(274\gamma^2 - 861\gamma + 4464)}{17010S^3} + \dots \quad (6)$$

$$\frac{du}{dx/y_0} = \lambda \left[1 + \frac{1}{S} - \frac{(32\gamma^2 + 87\gamma - 561)}{540S^2} + \dots \right] \quad (7)$$

and, for axisymmetric flow,

$$u = 1 + \frac{1}{4S} - \frac{(14\gamma - 57)}{288S^2} + \frac{(2364\gamma^2 - 3915\gamma + 14337)}{82944S^3} + \dots \quad (8)$$

$$\frac{du}{dx/y_0} = \lambda \left[1 + \frac{7}{8S} - \frac{(64\gamma^2 + 117\gamma - 1026)}{1152S^2} + \dots \right] \quad (9)$$

where the derivatives are with respect to x nondimensionalized by the throat half-height or radius, respectively, and

$$\lambda = \left[\frac{1+\sigma}{(\gamma-1)S} \right]^{\frac{1}{2}} \quad (10)$$

On the axis, $y = 0$, $v = 0$, for planar flow,

$$\begin{aligned} u = & 1 - \frac{1}{6S} + \frac{\gamma-15}{270S^2} - \frac{782\gamma^2 + 3507\gamma + 7767}{272160S^3} + \dots \\ & + \frac{x\lambda}{y_0} \left(1 + \frac{134\gamma^2 + 429\gamma + 123}{4320S^2} + \dots \right) + \\ & \left(\frac{x\lambda}{y_0} \right)^2 \left(-\frac{2\gamma-3}{6} - \frac{5\gamma}{36S} + \dots \right) + \\ & \left(\frac{x\lambda}{y_0} \right)^3 (2\gamma^2 - 33\gamma + 9)/72 + \dots \end{aligned} \quad (11)$$

and, for axisymmetric flow,

$$\begin{aligned} u = & 1 - \frac{1}{4S} + \frac{10\gamma-15}{288S^2} - \frac{2708\gamma^2 + 2079\gamma + 2115}{82944S^3} + \dots \\ & + \frac{x\lambda}{y_0} \left(1 - \frac{1}{8S} + \frac{92\gamma^2 + 180\gamma - 9}{1152S^2} + \dots \right) + \\ & \left(\frac{x\lambda}{y_0} \right)^2 \left(-\frac{2\gamma-3}{6} - \frac{\gamma+1}{16S} + \dots \right) + \\ & \left(\frac{x\lambda}{y_0} \right)^3 (4\gamma^2 - 57\gamma + 27)/144 + \dots \end{aligned} \quad (12)$$

Because the sonic line is curved for finite values of R , the mass flow through the throat is reduced by the factor C_D (discharge coefficient), which is the ratio of actual mass flow to that which could flow if R were infinite and the sonic line were straight. For planar flow,

$$C_D = 1 - \frac{\gamma+1}{90S^2} \left[1 - \frac{4\gamma-24}{21S} + \frac{334\gamma^2 - 457\gamma + 4353}{3780S^2} + \dots \right] \quad (13)$$

and, for axisymmetric flow,

$$C_D = 1 - \frac{\gamma+1}{96S^2} \left[1 - \frac{8\gamma-27}{24S} + \frac{754\gamma^2-757\gamma+3615}{2880S^2} + \dots \right] \quad (14)$$

The flow which passes through the throat also passes through the sonic area of the source flow which is at a distance r_1 from the source. In planar flow,

$$y^* = y_o C_D = \eta r_1 \quad (15)$$

or

$$y_o/r_1 = \eta/C_D \quad (16)$$

where the inflection angle, η , is in radians.

In axisymmetric flow,

$$\pi y^{*2} = \pi y_o^2 C_D = 2\pi r_1^2 (1 - \cos \eta) \quad (17)$$

or

$$y_o/r_1 = 2 \sin (\eta/2)/C_D^{\frac{1}{2}} \quad (18)$$

In the calculation of the throat characteristic used herein, the value at $x = 0$, $y = y_o$, Eq. (6), is the starting point. The half-height or radius, y_o , is divided into 240 equally spaced values of y . Inasmuch as the characteristic is right running, its slope at each point is

$$dy/dx = \tan (\phi - \mu) \quad (19)$$

where

$$\sin \mu = 1/M \quad (20)$$

Also

$$W = M \left(\frac{2}{\gamma+1} + \frac{\gamma-1}{\gamma+1} M^2 \right)^{-\frac{1}{2}} \quad (21)$$

$$\sin \phi = v/W \quad (22)$$

and

$$d\psi + d\phi = \frac{\sigma \sin \phi \sin \mu}{y} d\xi \quad (23)$$

$$d\xi = dx/\cos(\phi - \mu) = dy/\sin(\phi - \mu) \quad (24)$$

The term ψ is the Prandtl-Meyer angle in two-dimensional flow,

$$\psi = \left(\frac{\gamma+1}{\gamma-1} \right)^{\frac{1}{2}} \tan^{-1} \left[\frac{\gamma-1}{\gamma+1} (M^2 - 1) \right]^{\frac{1}{2}} - \tan^{-1} (M^2 - 1)^{\frac{1}{2}} \quad (25)$$

Equations (19) and (23) are the characteristic equations and are solved by finite differences. If all values are known at point 1, the values at point 2 are found (y is known at both points) by

$$x_2 = x_1 + \frac{2(y_2 - y_1)}{\tan(\phi_1 - \mu_1) + \tan(\phi_2 - \mu_2)} \quad (26)$$

$$\Delta\xi = \left[(y_2 - y_1)^2 + (x_2 - x_1)^2 \right]^{\frac{1}{2}} \quad (27)$$

$$\psi_2 = \psi_1 + \phi_1 - \phi_2 + \frac{\alpha}{2} \left[\frac{v_1}{W_1 y_1 M_1} + \frac{v_2}{W_2 y_2 M_2} \right] \Delta\xi \quad (28)$$

At the starting point W is the value of u because $v = 0$. Values of v_2 are calculated at each point (x_2, y_2) from the transonic solution, and Eqs. (26) to (28) are iterated until convergence is reached. For evaluating the term in brackets in Eq. (28), the ratio v/y is defined by the transonic solution even on the axis where both v and y are zero. This fact eliminates the general problem in axisymmetric characteristics solutions of evaluating the indeterminate $\sin \phi/y$ in Eq. (23) on the axis of symmetry.

It may be noted that the value of W as calculated from the characteristic value from Eq. (21) differs from the value $(u^2 + v^2)^{1/2}$ calculated from the transonic equations, but the difference decreases with increasing R . For the final point of the throat characteristic which lies on the axis, the value of d^3u/dx^3 from the transonic solution for the axial distribution is "corrected" to make $u = W$ for the axisymmetric case for values of R less than 12. The correction is about 16 percent for $R = 1$ and decreases rapidly as R increases. This correction is made

so that values of du/dx and d^2u/dx^2 can be calculated from the transonic solution for later application. The correction is believed to be justified inasmuch as the accuracy of the transonic solution is limited, particularly for low values of R , because the series expression for u is truncated after the x^3 term.

3.0 CENTERLINE DISTRIBUTION

In the radial flow region, the distance r , measured from the source, is related to the local Mach number by

$$\left(\frac{r}{r_1}\right)^{1+\sigma} = M^{-1} \left(\frac{2}{\gamma+1} + \frac{\gamma-1}{\gamma+1} M^2 \right)^{\frac{\gamma+1}{2(\gamma-1)}} \quad (29)$$

or

$$\left(\frac{r}{r_1}\right)^{1+\sigma} = W^{-1} \left(\frac{\gamma+1}{2} - \frac{\gamma-1}{2} W^2 \right)^{\frac{-1}{\gamma-1}} \quad (30)$$

First, second, and third derivatives of W or M with respect to r/r_1 can be obtained as described in Ref. 12. Along the axis $x = r$ when x is measured from the source. Inasmuch as all coordinates must be normalized by the same factor, r_1 , the transonic equation in terms of x/y_0 and y/y_0 can be transformed by Eqs. (16) and (18), after which the distance from the source to the throat station must be taken into account. This latter distance is generally unknown until after the distance from point I to point E is determined.

In radial flow, the term on the right-hand side of Eq. (23) can be evaluated simply. Inasmuch as $\sin \phi = y/r$ and $d\xi = dr/\cos \mu$,

$$\frac{\sin \phi \sin \mu}{y} \frac{d\xi}{dr} = \tan \mu \frac{dr}{r}$$

but

$$\tan \mu = (M^2 - 1)^{-\frac{1}{2}}$$

and, from Eq. (29) for $\sigma = 1$,

$$\frac{dr}{r} = \frac{(M^2 - 1)}{2(1 + \frac{\gamma-1}{2} M^2)} \frac{dM}{M}$$

Thus

$$\tan \mu \frac{dr}{r} = \frac{(M^2 - 1)^{\frac{1}{2}}}{2(1 + \frac{\gamma-1}{2} M^2)} \frac{dM}{M}$$

From Eq. (25),

$$d\psi = \frac{(M^2 - 1)^{\frac{1}{2}}}{(1 + \frac{\gamma-1}{2} M^2)} \frac{dM}{M}$$

therefore, Eq. (23), in radial flow, becomes

$$d\psi + d\phi = \frac{\sigma}{2} d\psi \quad (31)$$

which applies for characteristic AB or GF. Similarly, for the left-running characteristic EG,

$$d\psi - d\phi = \frac{\sigma}{2} d\psi \quad (32)$$

Therefore,

$$\psi_B - \psi_A = (\sigma + 1) \eta = \psi_F - \psi_G \quad (33)$$

and

$$\psi_G - \psi_E = (\sigma + 1) \eta \quad (34)$$

and, from the design values η and M_B (and/or M_F), M_A , M_G , M_E , W_E , and the necessary derivatives can be calculated.

Within the accuracy of Eqs. (11) and (12), the second derivative of velocity ratio at the sonic point is negative for values of R less than 11.767 for planar flow and 10.525 for axisymmetric flow. The second derivative of Mach number at the sonic point is positive for all values of R . Inasmuch as the second derivative of either W or M is negative for source flow, it seems better to use a velocity distribution rather than a Mach number distribution between points I and E. On the other hand, a Mach number distribution between points B and C is preferable

because the velocity ratio approaches the constant value of $[(\gamma + 1)/(\gamma - 1)]^{1/2}$ as the Mach number increases to infinity; therefore, the change in velocity between points B and C becomes small relative to the change in Mach number.

The velocities and their first and second derivatives at points I and E are used to determine the coefficients of the general fifth degree polynomial

$$W = C_1 + C_2 X + C_3 X^2 + C_4 X^3 + C_5 X^4 + C_6 X^5 \quad (35)$$

where

$$X = (x - x_I)/(x_E - x_I) \quad (36)$$

Similarly, the Mach numbers and their first and second derivatives at points B and C are used to determine the coefficients of the polynomial

$$M = D_1 + D_2 X + D_3 X^2 + D_4 X^3 + D_5 X^4 + D_6 X^5 \quad (37)$$

where, in this case,

$$X = (x - x_B)/(x_C - x_B) \quad (38)$$

and the first and second derivatives at point C are usually set equal to zero.

In these equations, the lengths $(x_E - x_I)$ and $(x_C - x_B)$ must be specified, but can be determined by the conditions that C_6 and D_6 equal zero, thereby reducing the polynomials to fourth-degree ones. If the velocity at point E is determined by iteration, the third derivative at point I or E can be included as a criterion for the fourth-degree polynomial; or, by setting $C_5 = 0$, one can find a third-degree polynomial with a constant third derivative. In either case, the Mach number at point B is found from Eqs. (33) and (34) after the value at point E is found. All of these options are included in the program, but unless there are other factors involved, the preferred options are the cubic between points I and E and the quartic between points B and C.

For the cubic distribution for axisymmetric flow, the Mach number at point E is related to the radius ratio as shown in Fig. 5 for $\gamma = 1.4$ for various values of inflection angle. Cross plotted are lines of constant values of the ratio ψ_E/η . Such values for most axisymmetric nozzles lie in the range covered in this figure, and inasmuch as $\psi_F/\eta = \psi_E/\eta + 4$, values of M_F can also be obtained.

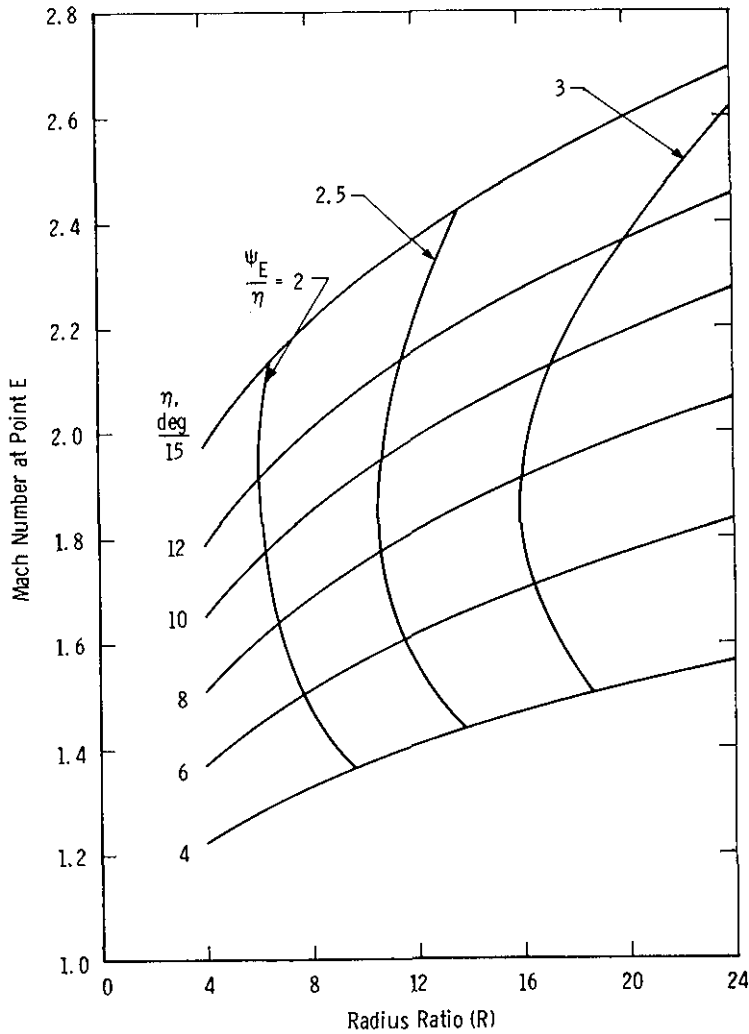


Figure 5. Relationships obtained from cubic distribution of velocity from sonic point to point E for axisymmetric nozzle.

In determining the length of the segment between points B and C, using the fourth-degree polynomial distribution, there is a minimum value of the Mach number at point B for the design Mach number at point C. As given in Ref. 12,

$$M_{B_{\min}} = M_C + 0.75 \frac{M_C'^2}{M_B''} \quad (39)$$

where the primes indicate derivatives with respect to r/r_1 . This relationship is shown in Fig. 6. For an axisymmetric nozzle designed for a Mach number greater than about 3.4, the minimum Mach number at

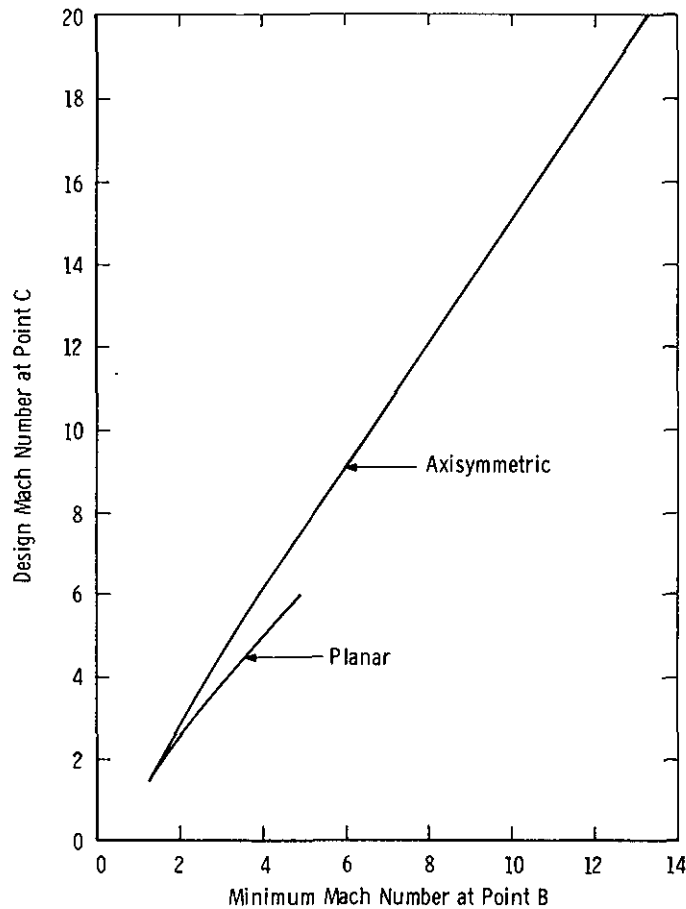


Figure 6. Limitations of fourth-degree distribution of Mach number from Eq. (39).

point B is about two-thirds of the design Mach number. Using such a value usually causes the length to be excessive, and more realistic

values of M_B are 75 to 80 percent of M_C . It is important, however, as illustrated in Ref. 16, that the distance between points B and C be sufficient to allow for accurate machining of the contour between points A and J, which lie on the characteristics through points B and C, respectively.

4.0 INVISCID CONTOUR

The flow properties are determined at a desired number of points along the key characteristics (i.e., the throat characteristic, TI, as described earlier (a sub-multiple of 240 is used for subsequent calculations), the characteristics EG and AB bounding the radial flow region by Eqs. (33) and (34) for equal increments in η , and the final characteristic CD along which the Mach number is constant and the flow angle is zero). The flow properties are also determined at axial points from Eqs. (35) and (37). The network of characteristics is then calculated in the region TIEG starting at point E and progressing upstream and in the region ABCD starting at point B and progressing downstream.

The equations for a right-running characteristic were given previously.

$$dy/dx = \tan(\phi - \mu) \quad (19)$$

$$d\psi + d\phi = \frac{\sigma \sin \phi \sin \mu}{y} d\xi \quad (23)$$

where

$$d\xi = dx/\cos(\phi - \mu) = dy/\sin(\phi - \mu) \quad (24)$$

For a left-running characteristic, the equations are

$$dy/dx = \tan(\phi + \mu) \quad (40)$$

$$d\psi - d\phi = \frac{\sigma \sin \phi \sin \mu}{y} d\xi \quad (41)$$

where

$$d\xi = dx/\cos(\phi + \mu) = dy/\sin(\phi + \mu) \quad (42)$$

Also

$$d\psi = \frac{\cot \mu}{(1 + \frac{\gamma-1}{2} M^2)} \frac{dM}{M} = \cot \mu \frac{dW}{W} \quad (43)$$

Values of x , y , ϕ , and M are known at the general point 1 on the right-running characteristic, ξ , and at the general point 2 on the left-running characteristic, ζ . The characteristics intersect at the general point 3 where the values are calculated by numerical integration of Eqs. (23) and (41) along the respective characteristics.

$$\psi_3 - \psi_2 - (\phi_3 - \phi_2) = P_2 =$$

$$\frac{\sigma}{2} \left(\frac{\sin \phi_3 \sin \mu_3}{y_3} + \frac{\sin \phi_2 \sin \mu_2}{y_2} \right) \Delta \zeta \quad (44)$$

where

$$\Delta \zeta = (x_3 - x_2) \sec \beta \quad (45)$$

and

$$\frac{y_3 - y_2}{x_3 - x_2} = \tan \beta = \frac{1}{2} \tan (\phi_3 + \mu_3) + \frac{1}{2} \tan (\phi_2 + \mu_2) \quad (46)$$

$$\psi_3 - \psi_1 + (\phi_3 - \phi_1) = P_1 =$$

$$\frac{\sigma}{2} \left(\frac{\sin \phi_3 \sin \mu_3}{y_3} + \frac{\sin \phi_1 \sin \mu_1}{y_1} \right) \Delta \xi \quad (47)$$

where

$$\Delta \xi = (x_3 - x_1) \sec \alpha \quad (48)$$

and

$$\frac{y_3 - y_1}{x_3 - x_1} = \tan \alpha = \frac{1}{2} \tan (\phi_3 - \mu_3) + \frac{1}{2} \tan (\phi_1 - \mu_1) \quad (49)$$

Adding, subtracting, and rearranging gives

$$\psi_3 = \frac{1}{2} (\psi_2 + \psi_1 - \phi_2 + \phi_1 + P_2 + P_1) \quad (50)$$

$$\phi_3 = \frac{1}{2} (\psi_1 - \psi_2 + \phi_1 + \phi_2 + P_1 - P_2) \quad (51)$$

In planar flow, $P_1 = P_2 = 0$ because $\sigma = 0$ and Eqs. (50) and (51) can be solved directly, M_3 is obtained from ψ_3 by the inverse application of Eq. (25), and $\mu_3 = \sin^{-1}(1/M_3)$. In axisymmetric flow, the equations must be solved by iteration. A useful first approximation for P_1 and P_2 is the radial flow values, $P_1 = (\psi_3 - \psi_1)/2$ and $P_2 = (\psi_3 - \psi_2)/2$.

At all points except on the axis in axisymmetric flow, Eqs. (44) and (47) are defined because y_2 and y_1 are nonzero. On the axis, the terms $\sin \phi_2/y_2$ and $\sin \phi_1/y_1$ are indeterminate with the form zero/zero. These indeterminates can be evaluated by assuming that the general points 1 and 2 on the axis are very close together and that $\mu_1 \approx \mu_2 \approx \mu_3$ and $W_1 \approx W_2 \approx W_3$. Equation (41) can be written

$$\cot \mu \frac{dW}{W} = d\phi + \frac{\sin \phi \sin \mu dx}{y \cos (\phi + \mu)} \quad (52)$$

and Eq. 23 can be written

$$\cot \mu \frac{dW}{W} = -d\phi + \frac{\sin \phi \sin \mu dx}{y \cos (\phi - \mu)} \quad (53)$$

as

$$\phi \rightarrow 0, \quad \phi \rightarrow \sin \phi, \quad \phi \pm \mu \rightarrow \pm \mu$$

and

$$\tan \mu_3 = \frac{y_3}{x_3 - x_2} = \frac{y_3}{x_1 - x_3}$$

In finite-difference form,

$$\begin{aligned} \frac{\cot \mu_3}{W_3} (W_3 - W_2) &= \phi_3 + \frac{\sin \phi_3 \tan \mu_3 (x_3 - x_2)}{y_3} \\ &\rightarrow \frac{\phi_3 \tan \mu_3 (x_3 - x_2)}{y_3} + \frac{\sin \phi_3 \tan \mu_3 (x_3 - x_2)}{y_3} \end{aligned} \quad (54)$$

$$\rightarrow 2 \sin \phi_3 \tan \mu_3 (x_3 - x_2)/y_3 \quad (55)$$

Similarly

$$\frac{\cot \mu_3}{W_3} (W_1 - W_3) = \phi_3 + \sin \phi_3 \tan \mu_3 (x_1 - x_3)/y_3 \quad (56)$$

$$\rightarrow 2 \sin \phi_3 \tan \mu_3 (x_1 - x_3)/y_3 \quad (57)$$

Adding Eqs. (55) and (57) and rearranging,

$$\lim_{y \rightarrow 0} \frac{\sin \phi}{y} = \frac{1}{2} \frac{\cot^2 \mu}{W} \frac{dW}{dx} \quad (58)$$

and

$$\frac{\sin \phi_2 \sin \mu_2}{y_2} \approx \frac{(M_2^2 - 1)}{2M_2 W_2} \left(\frac{dW}{dx} \right)_2 \quad (59)$$

for use in Eq. (44) when point 2 is on the axis, and

$$\frac{\sin \phi_1 \sin \mu_1}{\gamma_1} = \frac{(M_1^2 - 1)}{2W_1 W_1} \left(\frac{dW}{dx} \right)_1 \quad (60)$$

for use in Eq. (47) when point 1 is on the axis.

In starting the calculation of the network of characteristics in the region TIEG, point E becomes point 1 and the first axis point upstream of point E becomes point 2. The complete left-running characteristic approximately parallel to EG is calculated, and the point on the contour is determined from mass flow considerations as described in Ref. 17. The flow properties along this characteristic are then used to calculate the next left-running characteristic, again starting on the axis. This process is repeated until point I is reached, after which the starting point for each left-running characteristic is a point on the throat characteristic as illustrated in Fig. 7. The process in region ABCD is similar except that right-running characteristics are calculated for each point on the contour.

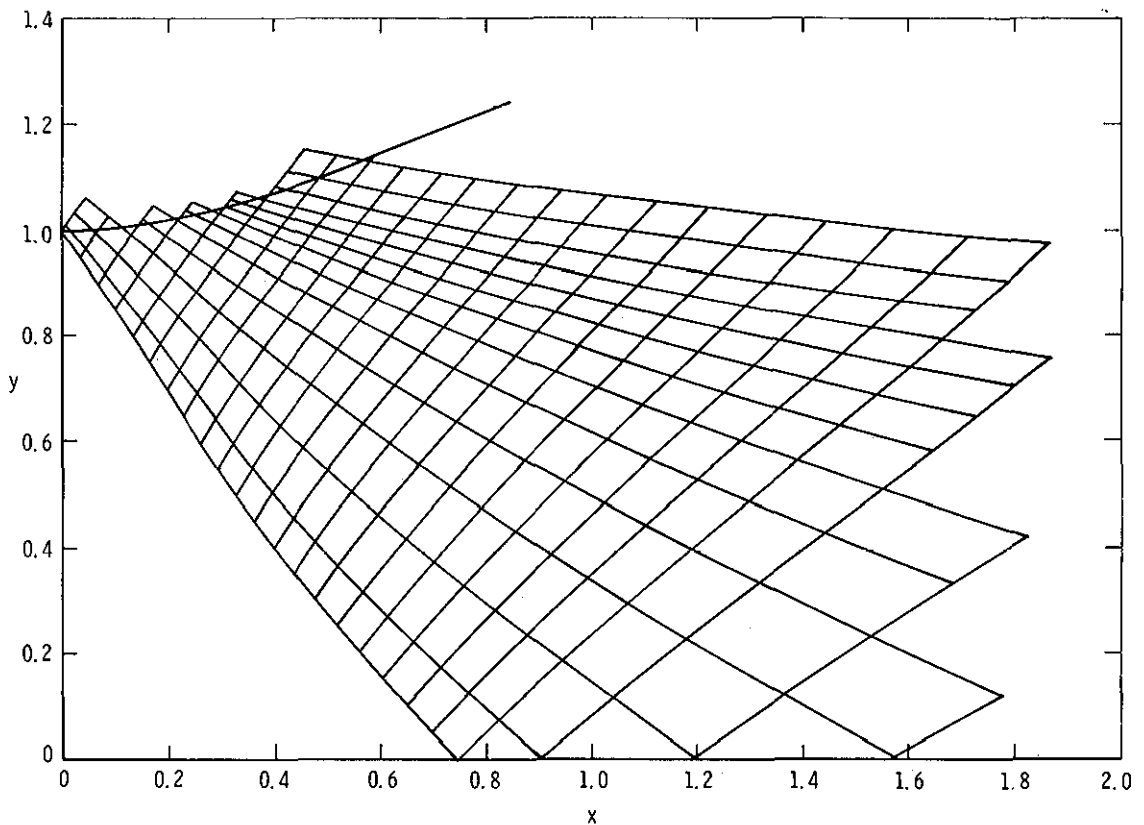


Figure 7. Characteristics near throat of nozzle with $R = 1$.

5.0 BOUNDARY-LAYER CORRECTION

To each ordinate of the inviscid contour must be added a correction for the boundary-layer growth to obtain the viscous or physical contour of the nozzle. Except for very low stagnation pressures, the boundary layer is assumed to be turbulent. Generally, the boundary-layer correction will be made for one design condition of stagnation pressure and temperature although it is theoretically possible to reshape a flexible-plate type of planar nozzle to account for different boundary-layer thicknesses corresponding to different stagnation conditions. The correction for a planar nozzle is usually applied to the contoured walls only, but the correction also allows for the growth of the boundary layer on the parallel walls in order to maintain a constant Mach number along the test section centerline. Therefore, the correction applied is greater than the displacement thickness on the contoured walls, and the flow in the test section is diverging in the longitudinal plane normal to the contoured walls. In the longitudinal plane normal to the parallel walls, the flow is converging because of the boundary-layer growth; moreover, there is a tendency for the boundary layer to be thicker on the wall centerline because of the transverse pressure gradients present on the parallel walls. Although these physical effects make a true correction impossible for a planar nozzle, the calculations described herein are made as if the cross section were circular, with the circumference at each station equal to the periphery of the actual rectangular cross section.

The method of calculating the boundary-layer growth is based on obtaining a solution to the von Kármán momentum equation written for axisymmetric flow.

$$\frac{d\theta}{dx} + \theta \left[\frac{2 - M^2 + H}{M \left[1 + (\gamma - 1) M^2 / 2 \right]} \frac{dM}{dx} + \frac{1}{r_w} \frac{dr_w}{dx} \right] = \frac{C_f}{2} \sec \phi_w \quad (61)$$

The term $\left[(1/r_w) (dr_w/dx) \right]$ becomes an effective one for planar flow as just described. For either type of nozzle, the inviscid value is used

as a first approximation. The entire solution is iterated several times with new values of r_w and $dr_w/dx = \tan \phi_w$ obtained each time by adding vectorially the displacement thickness to the inviscid contour.

The value of momentum thickness used in Eq. (61) is defined by

$$\theta = \int_0^{\delta} \left(1 - \frac{z \cos \phi_w}{r_w} \right) \left(\frac{\rho q}{\rho_e q_e} \right) \left(1 - \frac{q}{q_e} \right) dz \quad (62)$$

where z is measured normal to the wall.

Also

$$\delta^* = H\theta = \int_0^{\delta} \left(1 - \frac{z \cos \phi_w}{r_w} \right) \left(1 - \frac{\rho q}{\rho_e q_e} \right) dz \quad (63)$$

The quantities δ^* and θ may be considered to be the displacement and momentum thicknesses when the boundary-layer thickness is small with respect to the radius, r_w . These values are related to total values δ_a^* and θ_a , obtained from mass-defect and momentum-defect considerations by

$$\delta^* = \delta_a^* - \delta_a^{*2} \cos \phi_w / 2r_w \quad (64)$$

and

$$\theta = \theta_a - \theta_a^2 \cos \phi_w / 2r_w \quad (65)$$

Because $r_w = \delta_a^* \cos \phi_w + y$, where y is the inviscid radius, Eq. (64) may be rearranged to give

$$\delta_a^* = \delta^* + (\delta^{*2} + y^2 \sec^2 \phi_w)^{\frac{1}{2}} - y \sec \phi_w \quad (66)$$

For the final correction, the value $\delta_a^* \sec \phi_w$ is added to the inviscid radius in order that no correction be made to the longitudinal location.

The integrations of Eqs. (62) and (63) are performed numerically using Gauss' 16-point formula, with the assumption of the power-law velocity distribution

$$q/q_e = (z/\delta)^{1/N} \quad (67)$$

and

$$\rho/\rho_e = T_e/T \quad (68)$$

where

$$T = T_w + \alpha (T_{aw} - T_w) q/q_e + [T_e - \alpha (T_{aw} - T_w) - T_w] (q/q_e)^2 \quad (69)$$

which is Crocco's quadratic temperature distribution if $\alpha = 1$. However, as shown in Ref. 12, a value of $\alpha = 0$ gives a parabolic distribution which agrees better with data obtained in hypersonic wind tunnels with water-cooled walls. The same distribution is obtained if $T_w = T_{aw}$, which is likely to be the case for planar, flexible-plate nozzles. Before using the Gaussian integration, one must replace the values of z and dz with $\delta(q/q_e)^N$ and $N\delta(q/q_e)^{N-1} d(q/q_e)$, respectively, in order to avoid the infinite slope, dq/dz , when q and z equal zero.

The value of the compressible skin friction coefficient, C_f , in Eq. (61) is assumed to be related to an incompressible value, C_{f_i} , by a factor F_c , introduced by Spalding and Chi, Ref. 18,

$$F_c C_f = C_{f_i} \quad (70)$$

and C_{f_i} is related to an incompressible Reynolds number, R_{θ_i} , which is related to the compressible value, R_{θ_c} , by a factor F_{R_δ} ,

$$F_{R_\delta} R_{\theta_c} = R_{\theta_i} \quad (71)$$

The factor F_c , also used by van Driest, Ref. 19, is given by

$$F_c = \left[\int_0^1 (\rho/\rho_e)^{\frac{1}{2}} d(q/q_e) \right]^{-2} \quad (72)$$

which uses Eqs. (68) and (69). In Refs. 18 and 19, a value of $\alpha = 1$ was implied, but Eq. (72) is used herein with $\alpha = 0$ also, to give a "modified" value of F_c . The factor F_c may be considered to be the ratio of a reference temperature to the free-stream temperature. The factor F_{R_δ} , as used by van Driest, is

$$F_{R_\delta} = \mu_e/\mu_w \quad (73)$$

The compressible momentum thickness, θ_c , upon which R_{θ_c} is based is the flat-plate value

$$\theta_c = \int_0^{\delta} \left(1 - \frac{q}{q_e} \right) \frac{\rho q}{\rho_e q_e} dz \quad (74)$$

because the values of F_c and F_{R_δ} were developed to correlate flat-plate data.

The equation used herein for incompressible skin-friction coefficient is that of Ref. 20,

$$C_{f_i} = \frac{0.0773}{(\log R_{\theta_i} + 4.561) (\log R_{\theta_i} - 0.546)} \quad (75)$$

This equation is believed to agree with experimental data slightly better than the von Kármán-Schoenherr equation,

$$C_{f_i} = \frac{(0.242)^2}{(\log R_{\theta_i} + 1.1696) (\log R_{\theta_i} + 0.3010)} \quad (76)$$

at high Reynolds numbers. Also as shown in Ref. 20, Eq. (75) agrees with the equation, Ref. 21, based on Coles' law of the wall and law of the wake,

$$\kappa (2/C_{f_i})^{\frac{1}{2}} = \ln R_\delta + 0.5 \ln (C_{f_i}/2) + \kappa C + 2\Pi \quad (77)$$

if Π varies as shown in Fig. 8 from about 0.41 at $R_{\theta_i} = 400$ to a maximum of 0.5885 at $R_{\theta_i} = 50,000$ and then decreases to about 0.49 at $R_{\theta_i} = 10^7$. In order for Eq. (76) to agree with Eq. (77), Π must continually increase with increasing R_{θ_i} as shown in Fig. 8. The data shown in Fig. 8 were computed by Coles in Ref. 21 from Wiegardt's flat plate data, Ref. 22. A comparison of friction coefficients from Eqs. (75) and (76) is shown in Fig. 9 together with Wiegardt's values as recomputed by Coles. The constants κ and C are 0.41 and 5.0, respectively. The relationship between θ_i and δ is obtained from the logarithmic velocity profile by neglecting the laminar sublayer, representing the wake function by a sine² distribution, and integrating to obtain

$$\frac{\delta_i^*}{\delta} = \frac{1 + \Pi}{\kappa} \left(\frac{C_{f_i}}{2} \right)^{\frac{1}{2}} \quad (78)$$

and

$$\frac{\theta_i}{\delta} = \frac{\delta_i^*}{\delta} - \frac{C_{f_i}}{2\kappa} (2 + 3.179 \Pi + 1.5 \Pi^2) \quad (79)$$

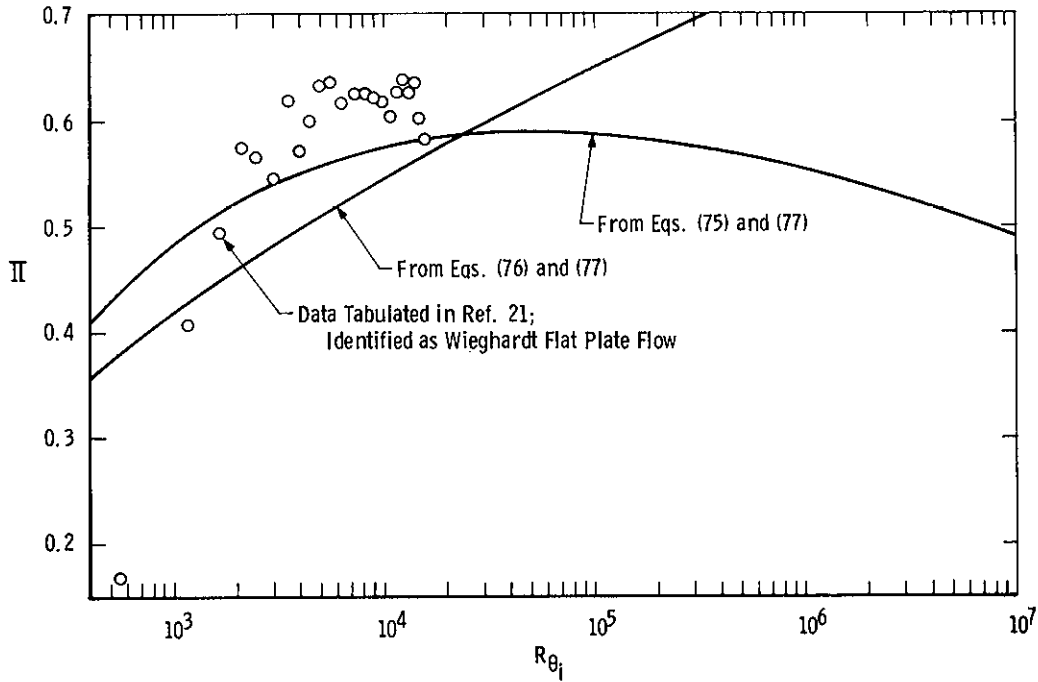


Figure 8. Variation of wake parameter, Π , with Reynolds number (incompressible).

The value of N in Eq. (67) is assumed to be a function of Reynolds number based on the actual boundary thickness, not corrected by F_{R_δ} , and is evaluated through the use of the kinematic momentum thickness

$$\theta_k = \int_0^\delta \frac{q}{q_e} \left(1 - \frac{q}{q_e}\right) dz \quad (80)$$

from which

$$\theta_k/\delta = N/(N^2 + 3N + 2) \quad (81)$$

or

$$N = \frac{1}{2} \left\{ \frac{\delta}{\theta_k} - 3 + \left[\frac{\delta}{\theta_k} \left(\frac{\delta}{\theta_k} - 6 \right) + 1 \right]^{\frac{1}{2}} \right\} \quad (82)$$

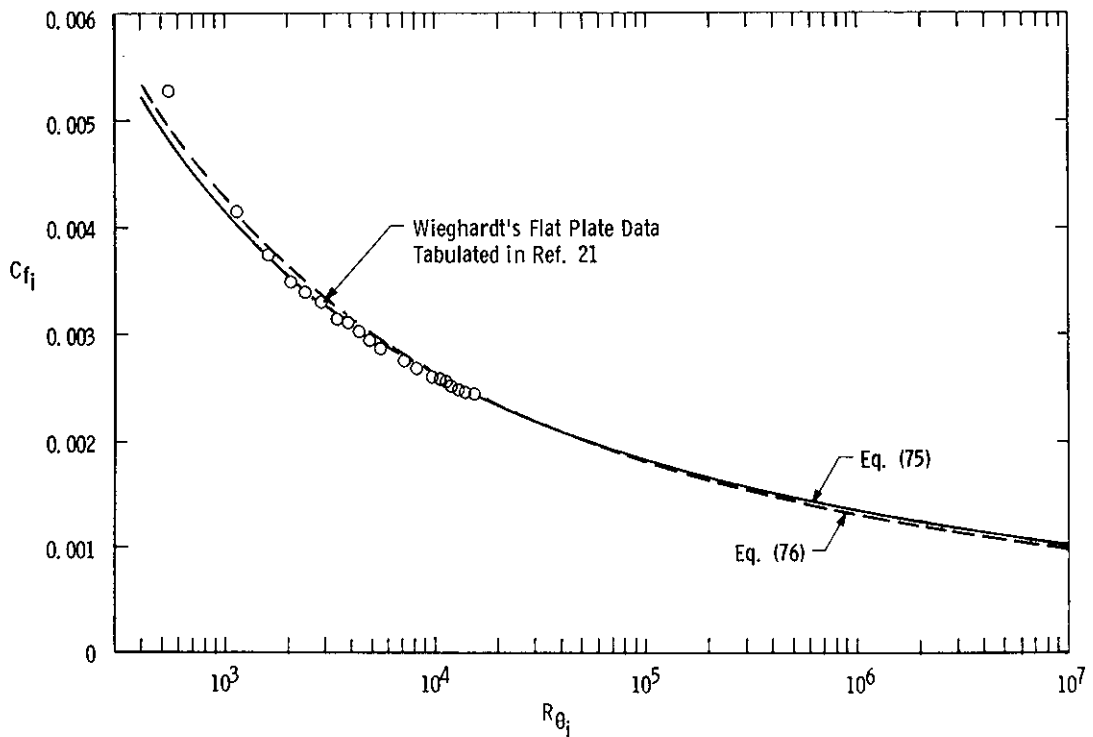


Figure 9. Variation of skin-friction coefficient with Reynolds number (incompressible).

The value of θ_k/δ is obtained from Eq. (79), where the value of Π is evaluated from Eqs. (75) and (77) with θ_k used instead of θ_i . The resulting variation of N with R_δ is shown in Fig. 10.

Two options contained in the program subroutine for the boundary layer utilize Coles' law of corresponding stations (Ref. 23),

$$\frac{C_{f_i} R_{\theta_i}}{C_{f_c} R_{\theta_c}} = \frac{T_w \mu_e}{T_e \mu_w} \quad (83)$$

If $C_{f_i}/C_{f_c} = F_c$ is calculated from Eq. (72) for $\alpha = 0$ or $\alpha = 1$, then one option gives

$$F_{R_\delta} = T_w \mu_e / (F_c T_e \mu_w) \quad (84)$$

The second option divides Eq. (83) into the two parts,

$$C_{f_i}/C_{f_c} = T_w \mu_e / T_e \mu_w \quad (85)$$

and

$$R_{\theta_i}/R_{\theta_c} = \mu_e/\mu_c \quad (86)$$

where μ_c is evaluated at the temperature

$$T_c = T_w + 17.2 (C_{f_i}/2)^{\frac{1}{2}} \alpha (T_{aw} - T_w) - 305 (C_{f_i}/2) [\alpha (T_{aw} - T_w) + T_w - T_e] \quad (87)$$

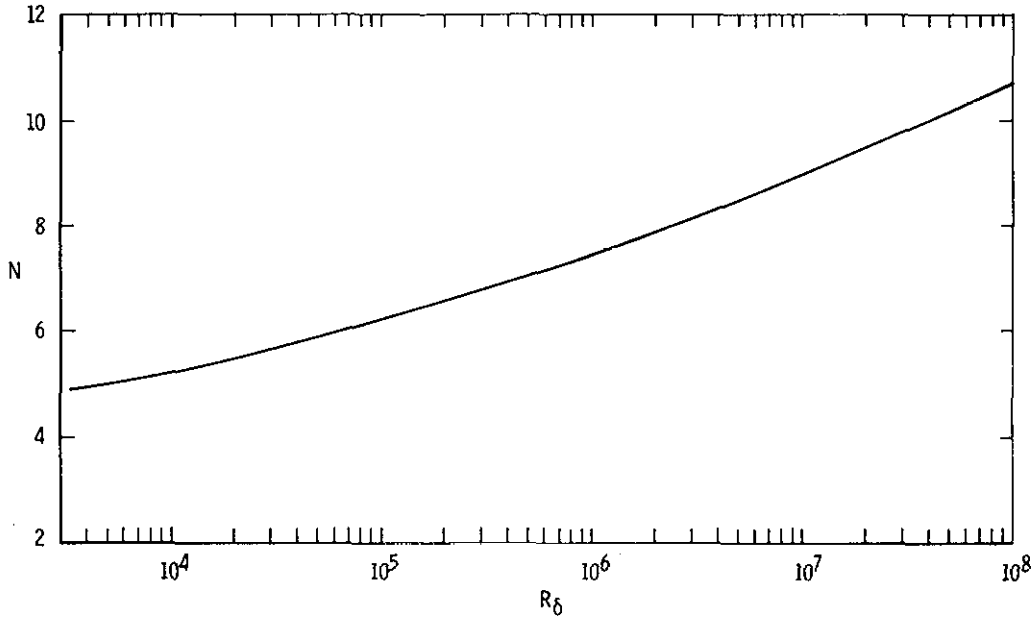


Figure 10. Variation of velocity profile exponent with Reynolds number based on boundary-layer thickness.

Still another option defines the incompressible skin-friction coefficient as

$$C_{f_i} = \frac{0.0888}{(\log R_{\delta_i} + 4.6221)(\log R_{\delta_i} - 1.4402)} \quad (88)$$

where

$$R_{\delta_i}/R_{\delta} = T_e^{\frac{1}{2}} \mu_e / (F_c^{\frac{1}{2}} T_w^{\frac{1}{2}} \mu_w) \quad (89)$$

and F_c is calculated from Eq. (72).

The wall temperature in the above equations can be the adiabatic wall temperature or can be allowed to vary between a throat wall temperature, T_{wT} , and a nozzle-exit wall temperature, T_{wD} , both of which are input to the program. Two options are available for the variation of wall temperature,

$$T_w = T_{wD} + \frac{(T_{wT} - T_{wD})}{(A_c/A^*)^m - 1} \left[\left(\frac{A_c/A^*}{A/A^*} \right)^m - 1 \right] \quad (90)$$

where m can be $1/2$ or 1 , A/A^* is the area ratio corresponding to local Mach number, and A_c/A^* is the area ratio corresponding to the design Mach number at the nozzle exit. Equation (90) is used in lieu of more accurate values and approximates the way the heat transfer decreases as the Mach number increases from 1 at the throat to the design value at the exit. For a water-cooled throat, the value of T_{wT} can also be calculated by the program,

$$T_{wT} = \frac{h_a T_{aw} + Q(T_{wD} - 15)}{h_a + Q} \quad (91)$$

where h_a is the airside heat-transfer coefficient at the throat as calculated by Reynolds analogy from the throat skin-friction coefficient

$$h_a = \rho_c q_c C_p P_r^{-2/3} C_f/2 \quad (92)$$

with a constant specific heat based on the thermochemical BTU

$$C_p = \frac{\gamma R_g}{(\gamma - 1) 777.64885} \quad (93)$$

and Q is an input which is a function of the properties of the throat material, the cooling water, and the geometry and would be a constant if the properties were constant. The assumption is made that the bulk temperature of the water is 15°F less than T_{wD} and that $P_r^{2/3}$ is the square of the recovery factor used to obtain the adiabatic wall temperature, T_{aw} .

For the integration of Eq. (61), the values of x , y , dy/dx , M , and dM/dx are obtained from the inviscid contour at unevenly spaced points as a result of the characteristics solution. With the inputs of stagnation pressure and temperature, gas constant, and recovery factor, the unit Reynolds number and static and adiabatic wall temperatures can be calculated at the same points as functions of Mach number with Sutherland's equation used for viscosity. With the inputs of T_{w_T} and T_{w_D} , the wall temperatures can also be calculated as functions of Mach number, although T_{w_T} may need to be obtained by iteration if the option to input a value of Q is exercised. Sutherland's equation is also used with wall temperatures to obtain the viscosities at the wall. For any static temperature below the Sutherland temperature, 198.72°R as used herein, the viscosity variation with temperature is assumed to be linear.

The integration of Eq. (61) is started at the throat where it is assumed that $d\theta/dx = 0$ in order to obtain a value of θ . Iteration is involved at each point because C_f is a function of Reynolds number based upon θ , and the relations θ/δ and δ^*/δ depend upon the value of N , which is a function of Reynolds number based upon δ . After all iterations converge within specified tolerances, the value of δ_a^* is calculated from the value of δ^* , and the values of θ and $d\theta/dx$ are used in the calculation at subsequent points. The values of $d\theta/dx$ are integrated numerically to obtain the increment in θ to be added to a previously determined value of θ . The trapezoidal rule is used to determine the second point, the parabolic rule for the third point, and cubic integration for the fourth and subsequent points.

For convenience, Eq. (61) may be written $\theta' + \theta P = Q$. The general integration for the n th point is

$$\theta_n = \theta_{n-3} + G_{n-3} \theta'_{n-3} + G_{n-2} \theta'_{n-2} + G_{n-1} \theta'_{n-1} + G_n \theta'_n \quad (94)$$

where the G 's are functions of the spacings s , t , and u between the points and are given in Appendix B. Except for θ_n and θ'_n , the other values in Eq. (94) are known from previous calculations. Inasmuch as

$$\theta'_n = Q_n - P_n \theta_n \quad (95)$$

Eq. (92) can be rearranged to give

$$\theta_n = \frac{(\theta_{n-3} + G_{n-3} \theta'_{n-3} + G_{n-2} \theta'_{n-2} + G_{n-1} \theta'_{n-1} + G_n Q_n)}{(1 + G_n P_n)} \quad (96)$$

After convergence of the iterations, Eq. (95) is used to obtain $d\theta/dx$. Inasmuch as Eq. (94) depends upon the knowledge of θ_{n-3} , the value of θ_{n-2} is calculated by

$$\theta_{n-2} = \theta_{n-3} + F_{n-3} \theta'_{n-3} + F_{n-2} \theta'_{n-2} + F_{n-1} \theta'_{n-1} + F_n \theta_n \quad (97)$$

which becomes the θ_{n-3} for the next point to be calculated. The values of the F 's are also given in Appendix B. The values of θ_2 and θ_3 obtained from Eq. (95) are used in the calculation of δ^* and δ_a^* instead of the initial values obtained by the trapezoidal or parabolic integration.

The success of the above type of integration depends upon the spacing of the points. The values of the increments s , t , and u must be of the same order of magnitude, although t is usually larger than s and smaller than u if the parameters involved in the characteristics solution are selected with care.

After the values of $\delta_a^* \sec \phi_w$ are calculated, the values of $d(\delta_a^* \sec \phi_w)/dx$ are obtained by parabolic differentiation and added to the inviscid values of dy/dx to obtain dr_w/dx . This procedure is believed to be more accurate than differentiating the value $(\delta_a^* \sec \phi_w + y)$ because dy/dx is obtained directly from the characteristics solution and not by differentiating y with respect to x .

In general, the boundary-layer correction at the throat will have a gradient such that the viscous throat will be slightly upstream of the

inviscid throat. This displacement and the value of the viscous curvature at the throat are calculated using the assumption that both the inviscid throat and the boundary-layer correction are parabolic in shape.

6.0 DESCRIPTION OF PROGRAM

The computer program is written in Fortran IV for use with the IBM 370/165 Computer. The program consists of a main section, three functions, and 16 subroutines arranged so that the program can be overlaid to conserve computer storage. The four overlays consist of AXIAL, CONIC, SORCE, and TORIC; PERFC; BOUND and HEAT; SPLIND and XYZ. The input data cards are described in Appendix C, and a listing of the program is given in Appendix D.

Program MAIN. MAIN calls for the various overlays. The title card is read in with the designation as to whether the nozzle is planar or axisymmetric. A card defining the gas properties and a few pertinent dimensions is then read in. The first subroutine called is AXIAL, in which the upstream axial distribution is defined. PERFC is called to calculate the upstream contour. AXIAL is recalled to define the downstream distribution, and PERFC is recalled to calculate the downstream contour. BOUND is called to calculate the boundary-layer growth. SPLIND is called to determine the coefficients of cubic equations to fit the unevenly spaced points along the contour, and XYZ uses these coefficients to obtain ordinates at evenly spaced points along the axis or, in the case of the planar nozzle, at discrete points along the surface of the flexible plate at which the supporting jacks are located.

Subroutine AXIAL. In this subroutine, cards are read in with the parameters used to define the axial distributions of velocity and/or Mach number and with integers which define the number and spacing of the points on the axis and on the key characteristics and the sequence of

subsequent calculations. If the throat characteristic is called for, the upstream end of the upstream distribution starts at the intersection of the throat characteristic and the axis. An option can be exercised to not use the throat characteristic and thereby start the distribution at the point where $M = 1$. This option would normally be used for a nozzle with a large throat radius of curvature, e.g. a planar nozzle, or if it were desired to repeat a calculation as in Ref. 13. Another option is to avoid a radial flow section altogether by using a polynomial distribution from the throat to the beginning of the test cone or rhombus. Other options will be described in Appendix C when the input cards are discussed.

Subroutine BOUND. This subroutine is used to calculate the turbulent boundary-layer correction to the inviscid contour. The stagnation conditions are input, as are the parameters to describe the wall temperature distribution, the temperature distribution in the boundary layer, and the factors relating the compressible skin-friction coefficients to incompressible values.

Subroutine CONIC. This subroutine is used within AXIAL to give the derivatives of Mach number with respect to r/r_1 in radial flow from Eq. (29).

Function CUBIC. This subroutine is used to obtain the smallest positive root of a cubic equation.

Function FMV. This subroutine determines the Mach number for a given Prandtl-Meyer angle.

Subroutine FVDGE. This subroutine is used within PERFC in conjunction with NEO to smooth the inviscid coordinates as desired.

Subroutine HEAT. This subroutine is a dummy called by BOUND but is included so that with a more elaborate subroutine a heat balance can be made to determine the wall temperature if the material conductivity is specified and the cooling water passage geometry and quantity of flow are specified.

Subroutine NEO. This subroutine is used with PERFC in conjunction with FVDGE to smooth the inviscid coordinates as desired by modifying the ordinate such that the second derivative is more nearly linear after smoothing than beforehand.

Subroutine OFELD. This subroutine is used within PERFC to calculate the properties at the intersection of a left- and a right-running characteristic.

Subroutine OREZ. This subroutine is used to make all values of an array equal to zero prior to a new calculation.

Subroutine PERFC. In this subroutine, the properties along the key characteristics are first calculated to go with those along the axis. The intermediate characteristics are then calculated and the contour points obtained by integrating the mass flow crossing each characteristic. If desired, certain designated intermediate characteristics may be printed out. If smoothing of the ordinates is desired, the inputs associated with the smoothing are read and the smoothing applied. Inasmuch as the wall angle is interpolated from mass-flow considerations, independently of the coordinates, the wall slopes are integrated from the inflection point toward the throat for comparison with the interpolated ordinates. Parabolic integration is used for this purpose as well as for the mass flow. Also calculated for comparison are the ordinates of a parabola and a hyperbola which have the same radius ratio, R , inasmuch as the transonic solution should be equally applicable to these shapes for the number of terms retained in the series,

Eqs. (2) and (3). Finally, the scale factor, the value of r_1 in inches, is applied to obtain the inviscid coordinates in inches, and the abscissas are also shifted as desired.

Subroutine PLATE. This subroutine is also a dummy to allow additional calculations to be made for a flexible plate contour after the coordinates at each jack location have been interpolated by SPLIND and XYZ.

Subroutine SCND. This subroutine is used in BOUND, NEO, and PERFC for parabolic differentiation of coordinates to obtain the slopes, or of slopes and abscissas to obtain second derivatives. Three points at a time are used to establish the parabola, and the slope is obtained at the center point. The slopes at the first and last point are also obtained, but with less accuracy.

Subroutine SORCE. This subroutine is used within AXIAL to give the derivatives of velocity ratio, W , with respect to r/r_1 in radial flow from Eq. (30).

Subroutine SPLIND. This subroutine computes the coefficients of cubic equations that fit the unevenly spaced points obtained from the characteristics solution. The initial and final slopes are used together with the coordinates to determine the cubic coefficients.

Function TORIC. If the velocity gradient is known at the axial point where $M = 1$, this function gives the value of radius ratio, R , which would produce such a gradient from the transonic theory used. This function is used in AXIAL if the option is exercised of specifying the Mach number at point F but not specifying the value of R . It is also used to determine the value of R for calculating streamlines other than the contour itself.

Subroutine TRANS. This subroutine calculates the throat characteristic from the transonic theory. In AXIAL, at the point where the throat characteristic intersects the axis, the derivatives of velocity and Mach number are used to determine the coefficients of the polynomial describing the axial distribution. In PERFC, the flow properties along this key characteristic are used at the number of points specified as one plus a submultiple of 240.

Subroutine TWIXT. This subroutine is used in PERFC and BOUND to interpolate the ordinate and other properties at a specified point. A four-point Lagrangian interpolation is used with two points on either side of the specified point.

Subroutine XYZ. This subroutine uses the cubic coefficients obtained in SPLIND for calculating the ordinate, slope, and second derivative at specified values of the abscissa read as inputs in the MAIN section of the program. The points may be at even intervals in the abscissa or at arbitrary uneven intervals. The points may be the same points as those input to SPLIND if a comparison is desired between the derivatives so determined and those obtained elsewhere in the program.

7.0 SAMPLE NOZZLE DESIGN

The design of a Mach 4 axisymmetric nozzle is selected to illustrate use of the computer program. The input cards for the sample design are given in Table 1. An axisymmetric nozzle is specified by leaving JD blank ($JD = 0$) on Card 1. Leaving SFOA blank on Card 2 specifies that the upstream axial velocity distribution is not a fifth-degree polynomial. Leaving FMACH blank on Card 3 specifies that the value of FMACH will be computed by the program, and leaving IX blank on Card 4 specifies a cubic distribution. The computed value of FMACH is 3.0821543, which is greater than the value of BMACH specified on Card 3;

therefore, BMACH also becomes 3.0821543. The negative value of SF means that the inviscid exit radius of the nozzle is 12.25 in. The value of PP means that the inflection point will be 60 in. downstream of an arbitrary point. Leaving XC blank specifies the downstream axial distribution will be a fourth-degree polynomial, and the positive value of IN on Card 4 specifies a Mach number distribution. The values of MT, NT, MD, ND, NF, and LR determine the number of points on the key characteristics and are all odd numbers because each includes both end points of each distribution which is divided into an even number of increments. The negative value of NF specifies the contour points to be smoothed according to Card 5, and the negative value of LR specifies that the transonic distribution be printed as the first page of the sample output. The NX value of 13 specifies the spacing of the axial points between points I and E to be close together near Point I with the last increment about 3.17 times as large as the first increment, $(20^{1.3} - 19^{1.3})$. The JC value of 10 specifies that every 10th left-running characteristic will be printed for the upstream contour together with the right-running characteristic through Point E. The smoothing integers on Card 5 are used to control the smoothing subroutine.

Table 1. Input Cards for Sample Design

CARD 1															
ITLE JU															
M A C H 4															
CARD 2															
GAM		AR		ZO		RO		VISC		VISM		SFOA		XBL	
1.4		1716.563		1.		0.896		2.26968E-8		198.72				1000.	
CARD 3															
8.67		6.				3.		4.		-12.25		60.			
ETAD		RC		FMACH		BMACH		CMC		SF		PP		XC	
CARD 4															
MT		NT		IX		IN		IQ		MD		ND		NF	
41		21				10				41		49		-61	
										MP		MQ		JB	
														1	
												JX		JC	
														10	
												IT		LR	
														-21	
														NX	
														13	
CARD 5															
NOUP		NPCT		NODD											
50		85		50											
CARD 6															
PPQ		TO		TWT		TWAT		QFUN		ALPH		IHT		IR	
200.		1638.		900.		540.		.38							
												ID		LV	
														5	
CARD 7															
XST		XLOW		XEND		XINC		BJ		XMID		XINC2		CN	
1000.		46.		172.		2.									

For the boundary-layer calculations for stagnation conditions of 200 psia and 1638R, the value of QFUN of 0.38 overrides the specified throat temperature of 900R and produces the throat temperature of 866R as indicated on the output. Leaving ALPH blank causes the temperature distribution in the boundary to be parabolic for both the calculation of the boundary-layer parameters and the calculation of the reference temperature. Leaving IHT blank causes the longitudinal distribution of wall temperature to vary as a square-root function of the area ratio corresponding to the local Mach number; $m = 1/2$ in Eq. (90). Leaving IR blank causes the transformation from incompressible to compressible values of skin friction coefficient to be calculated using a modified Spalding-Chi reference temperature and a Van Driest reference Reynolds number. Specifying ID = 1 takes into account that the boundary-layer thickness is not negligible relative to the radius of the inviscid core, and its positive value causes the boundary-layer calculations to be printed for the first and last iteration; the number of iterations is specified by the absolute value of LV (LV = 5 for the example).

For the final coordinates, interpolated at even intervals, specifying XST = 1,000 (the same value as XBL on Card 2) keeps the X-coordinates consistent with the location of the inviscid inflection point at 60 in. downstream of an arbitrary point.

The main parameters selected for the sample problem were the inflection angle, the curvature ratio, and the Mach number at the point B. The selected values of 8.67 deg, 6, and 3.0821543 (computed), respectively, are not necessarily optimum but result in a nozzle with an upstream length of about 14 in. from the throat to the inflection point, a length of about 31 in. from the inflection point to point J (see Fig. 3), and nearly 120 in. from the inflection point to the theoretical end of the nozzle. Such downstream lengths are probably conservative and could be reduced to some degree although experience with Mach 4 axisymmetric nozzles is very limited.

The number of points used on the key characteristics should be consistent with the number of points used in the axial distributions in order that the individual nets in the characteristics network should not become too elongated (e.g., see Fig. 7). The spacing of the points on the final contour should also progress in an orderly manner. Several trials may be necessary to optimize the various inputs to the program.

8.0 SUMMARY

A method and computer program have been presented for the aerodynamic design of planar and axisymmetric supersonic wind tunnel nozzles. The method uses the well-known analytical solution for radial source flow and connects this radial flow region to the throat and test section regions via the method of characteristics. Continuous curvature over the entire contour is attained by specifying polynomial distributions of the centerline velocity or Mach number and matching various derivatives of these polynomials at the extremities of the radial flow region, the test section, and a throat characteristic. The inviscid contour is obtained by initiating characteristics outward from the centerline and then integrating the mass flux along these characteristics to compute the inviscid nozzle boundary. The final wall contour is then obtained by adding to the inviscid coordinates a boundary-layer correction based on displacement thickness computed by integrating the von Kármán momentum equation. To illustrate the method, a sample design calculation was presented along with the associated input and output data. A listing of the computer program and an input description are included.

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APPENDIX A TRANSONIC EQUATIONS

When Eq. (5) is substituted into Eqs. (2), (3) and (4), Eq. (2) can be written as:

$$\begin{aligned}
 u = 1 & - \frac{1}{2(3 - \sigma)S} - \frac{GR}{S^2} - \frac{GS}{S^3} + \dots \\
 & + \lambda x \left(1 - \frac{\sigma}{8S} + \frac{GT}{S^2} + \dots \right) \\
 & + \frac{\lambda^2 x^2}{2} \left(1 - \frac{2\gamma}{3} - \frac{GV}{S} + \dots \right) + \frac{\lambda^3 x^3}{3} GK + \dots \\
 & + \frac{y^2}{2S} + \frac{U_{42} y^4 - U_{22} y^2}{S^2} + \frac{U_{63} y^6 - U_{43} y^4 + U_{23} y^2}{S^3} \\
 & + \lambda x \left(\frac{y^2}{S} + \frac{U_{P2} y^4 - U_{P0} y^2}{S^2} + \dots \right) \\
 & + \frac{\lambda^2 x^2 y^2}{2} \left(\frac{3\sigma - (10 - 3\sigma)\gamma}{4S} \right) + \dots
 \end{aligned} \tag{A-1}$$

where the coefficients are written in the terminology of the program and x and y are normalized with respect to y_0 . For planar flow,

$$GR = (15 - \gamma)/270 \tag{A-2}$$

$$GS = (782 \gamma^2 + 3507 \gamma + 7767)/272160 \tag{A-3}$$

$$GT = (134 \gamma^2 + 429 \gamma + 123)/4320 \tag{A-4}$$

$$GV = 5 \gamma/18 \tag{A-5}$$

$$GK = (2\gamma^2 - 33\gamma + 9)/24 \tag{A-6}$$

$$U_{42} = (\gamma + 6)/18 \tag{A-7}$$

$$U_{22} = \gamma/9 \tag{A-8}$$

$$U_{63} = (362 \gamma^2 + 1449 \gamma + 3177)/12960 \quad (A-9)$$

$$U_{43} = (194 \gamma^2 + 549 \gamma - 63)/2592 \quad (A-10)$$

$$U_{23} = (854 \gamma^2 + 807 \gamma + 279)/12960 \quad (A-11)$$

$$U_{P2} = (26 \gamma^2 + 27 \gamma + 237)/288 \quad (A-12)$$

$$U_{P0} = (26 \gamma^2 + 51 \gamma - 27)/144 \quad (A-13)$$

For axisymmetric flow,

$$GR = (15 - 10 \gamma)/288 \quad (A-14)$$

$$GS = (2708 \gamma^2 + 2079 \gamma + 2115)/82944 \quad (A-15)$$

$$GT = (92 \gamma^2 + 180 \gamma - 9)/1152 \quad (A-16)$$

$$GV = (\gamma + 1)/8 \quad (A-17)$$

$$GK = (4 \gamma^2 - 57 \gamma + 27)/48 \quad (A-18)$$

$$U_{42} = (2 \gamma + 9)/24 \quad (A-19)$$

$$U_{22} = (4 \gamma + 3)/24 \quad (A-20)$$

$$U_{63} = (556 \gamma^2 + 1737 \gamma + 3069)/10368 \quad (A-21)$$

$$U_{43} = (388 \gamma^2 + 777 \gamma + 153)/2304 \quad (A-22)$$

$$U_{23} = (304 \gamma^2 + 255 \gamma - 54)/1728 \quad (A-23)$$

$$U_{P2} = (52 \gamma^2 + 51 \gamma + 327)/384 \quad (A-24)$$

$$U_{P0} = (52 \gamma^2 + 75 \gamma - 9)/192 \quad (A-25)$$

The first part of Eq. (A-1), which is independent of y , can be recognized as Eq. (11) for planar flow or Eq. (12) for axisymmetric flow inasmuch as x and y are normalized here with the value of y_0 .

In a similar manner, Eq. (3) can be written as

$$\begin{aligned}
 v = \frac{y}{\lambda S} \left\{ \frac{(y^2 - 1)}{2(3 - \sigma)S} + \frac{V_{42} y^4 - V_{22} y^2 + V_{02}}{S^2} \right. \\
 + \frac{V_{63} y^6 - V_{43} y^4 + V_{23} y^2 - V_{03}}{S^3} + \dots \\
 + \lambda x \left[1 + \frac{(2\gamma + 12 - 3\sigma)y^2 - 2\gamma - 1.5\sigma}{(9 - 3\sigma)S} \right. \\
 + \frac{6 U_{63} y^4 - 4 U_{43} y^2 + 2 U_{23}}{S^2} + \dots \left. \right] \\
 + \frac{\lambda^2 x^2}{2} \left(2 + \frac{4 U_{P2} y^2 - 2 U_{P0}}{S} + \dots \right) \\
 \left. + \frac{\lambda^3 x^3}{3} \left(\frac{3\sigma - 10\gamma - 3\sigma \gamma}{4} + \dots \right) + \dots \right\} \quad (A-26)
 \end{aligned}$$

For planar flow,

$$V_{42} = (22 \gamma + 75)/360 \quad (A-27)$$

$$V_{22} = (10 \gamma + 15)/108 \quad (A-28)$$

$$V_{02} = (34 \gamma - 75)/1080 \quad (A-29)$$

$$V_{63} = (6574 \gamma^2 + 26481 \gamma + 40059)/181440 \quad (A-30)$$

$$V_{43} = (2254 \gamma^2 + 6153 \gamma + 2979)/25920 \quad (A-31)$$

$$V_{23} = (5026 \gamma^2 + 7551 \gamma - 4923)/77760 \quad (A-32)$$

$$V_{03} = (7570 \gamma^2 + 3087 \gamma + 23157)/544320 \quad (A-33)$$

For axisymmetric flow,

$$V_{42} = (\gamma + 3)/9 \quad (A-34)$$

$$V_{22} = (20 \gamma + 27)/96 \quad (A-35)$$

$$V_{02} = (28 \gamma - 15)/288 \quad (A-36)$$

$$V_{63} = (6836 \gamma^2 + 23031 \gamma + 30627)/82944 \quad (A-37)$$

$$V_{43} = (3380 \gamma^2 + 7551 \gamma + 3771)/13824 \quad (A-38)$$

$$V_{23} = (3424 \gamma^2 + 4071 \gamma - 972)/13824 \quad (A-39)$$

$$V_{03} = (7100 \gamma^2 + 2151 \gamma + 2169)/82944 \quad (A-40)$$

APPENDIX B CUBIC INTEGRATION FACTORS

If a curve through four points with ordinates a , b , c , and d , spaced at uneven increments in abscissa, s , t , and u , is defined by a cubic equation, the area under each section of the curve can be found in the following manner:

$$\text{Area}_{a-b} = F_{as} a + F_{bs} b + F_{cs} c + F_{ds} d \quad (\text{B-1})$$

$$\text{Area}_{b-c} = F_{at} a + F_{bt} b + F_{ct} c + F_{dt} d \quad (\text{B-2})$$

$$\text{Area}_{c-d} = F_{au} a + F_{bu} b + F_{cu} c + F_{du} d \quad (\text{B-3})$$

$$\text{Area}_{\text{total}} = G_a a + G_b b + G_c c + G_d d \quad (\text{B-4})$$

where

$$F_{as} = \frac{s}{2} - \frac{s^2(3s + 4t + 2u)}{12(s+t)(s+t+u)} \quad (\text{B-5})$$

$$F_{bs} = \frac{s}{2} + \frac{s^2(s + 4t + 2u)}{12t(t+u)} \quad (\text{B-6})$$

$$F_{cs} = -\frac{s^3(s + 2t + 2u)}{12tu(s+t)} \quad (\text{B-7})$$

$$F_{ds} = \frac{s^3(s + 2t)}{12(s+t+u)(t+u)u} \quad (\text{B-8})$$

$$F_{at} = -\frac{t^3(t + 2u)}{12s(s+t)(s+t+u)} \quad (\text{B-9})$$

$$F_{bt} = \frac{t}{2} + \frac{t^2(t + 2u - 2s)}{12s(t+u)} \quad (\text{B-10})$$

$$F_{ct} = \frac{t}{2} + \frac{t^2(2s + t - 2u)}{12u(s+t)} \quad (\text{B-11})$$

$$F_{dt} = - \frac{t^3(2s + t)}{12u(t + u)(s + t + u)} \quad (B-12)$$

$$F_{au} = \frac{u^3(2t + u)}{12s(s + t)(s + t + u)} \quad (B-13)$$

$$F_{bu} = - \frac{u^3(2s + 2t + u)}{12st(t + u)} \quad (B-14)$$

$$F_{cu} = \frac{u}{2} + \frac{u^2(2s + 4t + u)}{12t(s + t)} \quad (B-15)$$

$$F_{du} = \frac{u}{2} - \frac{u^2(2s + 4t + 3u)}{12(t + u)(s + t + u)} \quad (B-16)$$

$$G_a = F_{as} + F_{at} + F_{au} \quad (B-17)$$

$$G_b = F_{bs} + F_{bt} + F_{bu} \quad (B-18)$$

$$G_c = F_{cs} + F_{ct} + F_{cu} \quad (B-19)$$

$$G_d = F_{ds} + F_{dt} + F_{du} \quad (B-20)$$

If all increments are equal, then

$$s = t = u = h \quad (B-21)$$

$$F_{ds} = -F_{at} = -F_{dt} = F_{au} = h/24 \quad (B-22)$$

$$F_{cs} = F_{bu} = -5h/24 \quad (B-23)$$

$$F_{bs} = F_{cu} = 19h/24 \quad (B-24)$$

$$F_{as} = F_{du} = 9h/24 \quad (B-25)$$

$$F_{bt} = F_{ct} = 13h/24 \quad (B-26)$$

$$G_a = G_d = 3h/8 \quad (B-27)$$

$$G_b = G_c = 9h/8 \quad (B-28)$$

The values of G 's in Eq. (96) correspond to those in Eq. (B-4).
The value of F 's in Eq. (97) correspond to those in Eq. (B-1).

APPENDIX C INPUT DATA CARDS

Input	Columns	
<u>Card 1</u>		
ITLE	2-12	Title
JD	14-15	Blank (0) for axisymmetric contour, -1 for planar.
<u>Card 2</u>		
GAM	1-10	Specific heat ratio.
AR	11-20	Gas constant, $\text{ft}^2/\text{sec}^2 \text{ R}$.
ZO	21-30	Compressibility factor for an axisym- metric nozzle, constant for entire contour. Or, for a planar nozzle, ZO is half the distance (in.) between the parallel walls, and the compressibility factor is one.
RO	31-40	Turbulent boundary-layer recovery factor.
VISC	41-50	Constant in viscosity law.
VISM	51-60	Constant in viscosity law. If VISM is equal to or less than one, $\mu = \text{VISC} * T^{\text{VISM}} \text{ lb-sec/ft}^2$ If VISM is greater than one, $\mu = \frac{\text{VISC} * T^{1.5}}{T + \text{VISM}} \text{ lb-sec/ft}^2. \text{ If}$ $T \text{ is greater than VISM,}$ $\mu = \frac{\text{VISC} * T}{2 \text{ VISM}^{1/2}}; T \leq \text{VISM}.$
SFOA	61-70	Used for nozzle with radial flow region if 5th-deg axial velocity distribution is desired. If positive, the distance, in inches, from the throat to Point A

on the characteristic diagram. If negative, absolute value is distance from the throat to Point G. If Blank, 3rd- or 4th-deg distribution is used depending on value of IX on Card 4.

XBL 71-80

Station (in.) where interpolation is desired (e.g., the end of a truncated nozzle). If XBL=1000., the spline fit subroutines are used to obtain values at increments evenly spaced in length.

Card 3

ETAD 1-10

Inflection angle in degrees if radial flow region is desired. Two characteristic solutions are obtained, one upstream and one downstream of Point A. If ETAD = 60., the entire centerline velocity distribution is specified and only one solution is obtained and the inflection point must be interpolated. If ETAD = 60., IQ = 1, IX = 0, on Card 4.

RC 11-20

Ratio of throat radius of curvature to throat radius. Must be given if ETAD = 60. or FMACH = 0. If FMACH is given, RC is calculated. If LR = 0, IX = 0 gives third-deg equation between Mach 1 and EMACH, matching first and second derivations at each end. If LR ≠ 0, the value of RC found for LR = 0 is used with given value of FMACH to define a fourth-deg equation. If IX = ±1 and FMACH is given, RC is calculated to define a fourth-deg equation. If LR ≠ 0, a new value of FMACH is found, compatible with the value of RC calculated for LR = 0.

FMACH 21-30

Mach number at Point F if ETAD ≠ 60. Negative value specifies Prandtl-Meyer angle at Point F as |FMACH| * ETAD (usually around -7). If FMACH and RC are given, IX = 0 and 4th-deg distribution is used. If FMACH = 0 and IX = 0, a 3rd-deg distribution is used. If FMACH = 0. and IX = ±1, a 4th-deg distribution is used. FMACH is calculated if not given. If ETAD = 60., Point F is not defined.

BMACH	31-40	Mach No. at Point B if ETAD $\neq$ 60.
CMC	41-50	Absolute value is design Mach No. at Point C. If ETAD $\neq$ 60, positive CMC gives $d^2M/dx^2 = 0$, and negative CMC gives $d^2M/dx^2 \neq 0$. If ETAD = 60., CMC is positive.
SF	51-60	Scale factor by which nondimension coordinates are multiplied to give dimensions in inches. If SF = 0, nozzle will have an inviscid throat radius (or half-height) of 1 in. If negative, nozzle will have an inviscid exit radius (or half-height) of $ SF $ in.
PP	61-70	Station (in.) at Point A. PP = 0 gives coordinates relative to geometric throat. Negative PP gives coordinates relative to source or radial flow (ETAD $\neq$ 60.).
XC	71-80	Nondimensional distance from source to Point C. XC = 1. requires centerline Mach No. distribution from Point B to Point C to be read in as input data on Unit 9. Otherwise, positive XC gives 5th-deg distribution if CMC positive and 4th-deg if CMC negative. XC = 0 gives 4th-deg distribution if CMC positive and 3rd-deg if CMC negative. Negative XC and IN gives 3rd-deg distribution with d^2W/dx^2 not matching source flow at Point B. If ETAD = 60. and XC > 1, XC is ratio of length, from throat to Point C, to throat height. Negative XC gives 3rd-deg distribution in M; XC = 0 gives 4th-deg distribution; XC > 1 gives 5th-deg distribution. XC = 1. requires centerline Mach No. distribution to be read in as input data on Unit 9.

Card 4

MT	1-5	Number of points on characteristic EG if ETAD $\neq$ 60. or CD if ETAD = 60. Maximum value about 125. Use odd number. A zero or negative value stops calculation after centerline distribution is calculated if NT positive.
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NT	6-10	Number of points on axis IE. Maximum value is 149-LR. Use odd number. A zero or negative value stops calculation before center-line distribution is calculated but after parameters and coefficients of distribution are calculated.
IX	11-15	Determines if third derivative of velocity distribution is matched. IX = 1 matches third derivative with transonic solution. IX = -1 matches third derivative with source flow value. IX = 0 does not match third derivative but gives constant third derivative if RC = 0 or FMACH = 0.
IN	16-20	Determines type of distribution from Point B to Point C, positive for Mach No. distribution, negative for velocity distribution. IN = 0 for throat only. If XC is greater than 1., the downstream value of the second derivative at Point B is $0.1 * IN $ times the radial flow value. Similarly, if ETAD = 60., the second derivative at Point I is $0.1 * IN$ times the transonic value.
IQ	21-25	Zero for a complete contour if ETAD $\neq$ 60., 1 for throat only or if ETAD = 60., -1 for downstream only.
MD	26-30	Number of points on characteristic AB. Maximum value about 125. Use odd number. A zero or negative value stops calculation similarly to MT.
ND	31-35	Number of points on axis BC. Maximum value is 150. A zero or negative value acts like NT.
NF	36-40	Absolute value is number of points on characteristic CD for ETAD $\neq$ 60. Maximum value is 149 or $200 - ND - MP - MQ $ - number of points on upstream contour. Negative value calls for smoothing subroutine.
MP	41-45	Number of points on conical section GA if FMACH $\neq$ BMACH. Use value to give desired increments in contour - usually not known for initial calculation.

MQ	46-50	Number of points downstream of Point D if parallel inviscid contour desired. A negative value can be used to eliminate the inviscid printout.
JB	51-55	Positive number if boundary-layer calculation is desired before spline fit. Negative number transfers control of program to JX. Absolute values greater than one are used to approximately halve the number of points on the upstream contour even though $LR + NT - 1$ points are calculated from characteristic network if $LR > 2$, or $(NT + 1)$ points if $LR = 0$.
JX	56-60	Positive number calls for calculation of streamlines, zero calls for repeat of inviscid calculations requiring new cards 3 and 4, or, if $XBL = 1000.$, for spline fit after inviscid calculation, negative number calls for repeat of calculations requiring new cards 1, 2, 3, and 4.
JC	61-65	If not zero, calls for printout of intermediate characteristics within upstream contour if JC is positive and downstream contour if JC is negative. Characteristics are $(NT - 1)/JC$ or $(ND - 1)/(-JC)$. Opposite running characteristic through Point E (or B) is also printed.
IT	66-70	Number of points at which spline fit is desired if points are not evenly spaced, such as jack locations for a flexible plate. Used only for a planar nozzle, inasmuch as a nonzero value calculates distance along curved plate surface. Positive value of IT requires additional cards to be read in (8 points per card) after boundary layer is calculated.
LR	71-75	Absolute value is number of points on throat characteristic used in characteristics solution. Negative values give printout of transonic solution. $LR = 0$ gives $M = 1$ at Point I.
NX	76-80	Number from 10 to 20 determines spacing of points on axis for upstream contour. $NX = 10$ gives linear spacing. $NX > 10$ gives closer spacing of points at upstream end than at downstream end. $NX = 0$ same as $NX = 20$. Ratio of downstream

increment to upstream increment is $(NT - 1)^{NX/10} - (NT - 2)^{NX/10}$. Optimum values, usually 13 to 15, determined by trial and error for specific contour desired. Negative NX used with negative LR limits printout to transonic solution.

NOTE: A zero value of MT, NT, MD, or ND will allow a repeat of calculations for parameters specified by new cards Nos. 3 and 4. A negative value will allow a repeat of calculations for new cards Nos. 1, 2, 3, and 4.

Card 5

NOUP	1-5	If smoothing is desired, negative NF. Number of times upstream contour is smoothed.
NPCT	6-10	Smoothing factor in percent. Smoothing factor = NPCT/100.
NODO	11-15	Number of times downstream contour is smoothed.

Card 5

or

If boundary-layer calculation is desired using inviscid points calculated from characteristics solution. (No smoothing).

Card 6

or

If boundary-layer calculation is desired using evenly spaced points interpolated from spline fit of points from characteristics solution.

Card 7

If boundary-layer calculation is desired using evenly spaced points interpolated from spline fit of smoothed points.

PPQ	1-10	Stagnation pressure (psia).
TO	11-20	Stagnation temperature, Rankine.
TWT	21-30	Throat wall temperature, Rankine, if QFUN = 0. If TWT = 0, the wall temperature is assumed to be the adiabatic value.
TWAT	31-40	Wall temperature, Rankine, at Point D. For water-cooled wall, the bulk water temperature is assumed to be 15° lower than specified TWAT. The cooled wall temperature distribution is assumed to be

$$TW = TWAT + \frac{(TWT - TWAT)}{\sqrt{Ac/A^*} - 1} \times \left(\sqrt{\frac{Ac/A^*}{A/A^*}} - 1 \right)$$

where A/A^* is the area ratio corresponding to local value of Mach number and Ac refers to Point C.

For negative IHT

$$TW = TWAT + \frac{(TWT - TWAT)}{Ac/A^* - 1} \times \left(\frac{Ac/A^*}{A/A^*} - 1 \right)$$

QFUN 41-50 Heat-transfer function at the throat.

$$QFUN = \frac{ha(Taw - TWT)}{TWT - TWAT + 15}$$

where ha has dimensions of BTU/sec/sq ft/R and is obtained by Reynolds analogy from the skin-friction coefficient. If QFUN is specified, input value of TWT is ignored and TWT is calculated from QFUN.

ALPH 51-60 Parameter specifying temperature distribution in boundary layer. ALPH = 1, uses quadratic distribution both in the calculation of the reference temperature T_P and the calculation of boundary-layer shape parameters. ALPH = 0 uses parabolic distribution in both calculations. ALPH = -1, uses quadratic distribution for T_P and parabolic in the calculation of boundary-layer shape parameters. Within boundary layer,

$$T = Tw + \alpha(Taw - Tw) \left(\frac{U}{U_e} \right) + \left[Te - \alpha(Taw - Tw) - Tw \right] \left(\frac{U}{U_e} \right)^2$$

where $\alpha = 1$ for quadratic dist.

$\alpha = 0$ for parabolic dist.

IHT 61-65 Integer which determines temperature distribution (see TWAT). If nonzero, IHT determines how often subroutine HEAT is called. An absolute value of IHT greater than KO , the number of points on the upstream contour, will prevent HEAT from being called but will allow the choice of temperature distribution to be made.

NOTE: HEAT is a special purpose subroutine for determining heat-transfer values for the upstream contour. The subroutine HEAT incorporated in this program is a dummy.

IR 66-70 Integer, parameter specifying transformation from incompressible to compressible values. If IR = 2, Coles' transformation is used for C_f and Re_{θ_i} . If IR = 1, TP is calculated by a modification of the Spalding-Chi (Van Driest) method. If IR = 0, the Van Driest value of Re_{θ_i} is used, but if IR = -1, Coles' law of corresponding stations is used.

$$C_f = C_{f_i} * TE/TP, Re_{\theta_i} = FRD * Re_{\theta}$$

ID 71-75 Integer. If ID = ± 1 , axisymmetric effects are included in momentum equation and in calculation of boundary-layer parameters (δ not negligible relative to coordinate normal to axis). If ID = 0, these effects are omitted. Negative ID suppresses the printout of the boundary-layer calculations.

LV 76-80 Integer. Absolute value, usually 5, determines number of times boundary-layer solution is iterated so that radius terms in momentum equation refer to viscid radius instead of inviscid radius. Value of 0 or absolute value of 1 uses inviscid radius. Positive LV repeats boundary-layer calculations for new set of parameters on a new card if XBL $\neq$ 1000.

Card 5 If streamlines are desired, JX positive. (No smoothing.)

ETAD 1-10 Inflection angle in degrees for streamline desired if ETAD $\neq$ 60. for Card 3. If ETAD = 60. on Card 3, use ETAD = 60 on this card.

QM 11-20 Fraction of contour desired if ETAD = 60. Otherwise, QM = ETAD on Card 5 divided by ETAD on Card 3.

XJ 21-30 Value to update JX for subsequent calculation, JX = XJ.

<u>Card 5</u>		If SPLIND used after inviscid calculation (JX zero or negative and JB zero or negative). (No smoothing.)
or		
<u>Card 6</u>		If SPLIND used after viscid contour (JB positive and LV zero or negative). No smoothing of inviscid contour. Or, if inviscid contour is smoothed before SPLIND is used.
or		
<u>Card 7</u>		If inviscid contour is smoothed, boundary layer is added and SPLINE is desired.
XST	1-10	Station (in.) for throat value of X. If XST = 1000., program uses value previously determined by specifying PP on Card 3. Otherwise, value of XST is used to shift contour points by desired increments for arbitrary Station 0.
XLOW	11-20	Starting value for interpolation. Second value of interpolated $X = XLOW + XINC$.
XEND	21-30	End value for interpolation. If zero, SPLIND is used to calculate slope and d^2y/dx^2 at same points as previously defined.
XINC	31-40	Increment in X for interpolation. If zero, and BJ > 10, contour is divided into BJ increments.
BJ	41-50	Value to update JB for subsequent calculation. JB = BJ. If negative and XEND = 0, interpolation is made at discrete points read in on subsequent cards similar to case when IT > 0.
XMID	51-60	Intermediate value for interpolation. Distance (XMID-XLOW) is divided into increments defined by XINC, and distance (XEND-XMID) is divided into increments defined by XINC2.
XINC2	61-70	Increments in X between XMID and XEND if different than XINC.
CN	71-80	Number of copies desired of final tabulation of coordinates if more than one copy is desired.

APPENDIX D COMPUTER PROGRAM

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C      MAIN PART OF                                MAI 1
C      PROGRAM CONTUR(INPUT,OUTPUT,TAPES=INPUT,TAPE6=OUTPUT) MAI 2
C
C      NOZZLE CONTOUR PROGRAM VEV00028 FOR AXISYMMETRIC OR PLANAR FLOW MAI 3
C      WITH RADIAL FLOW REGION AND/OR WITH CENTER-LINE VELOCITY OR MACH MAI 4
C      NUMBER DISTRIBUTIONS DEFINED BY POLYNOMIALS. MAI 5
C
C      CORRECTION APPLIED FOR GROWTH OF TURBULENT BOUNDARY LAYER. MAI 6
C      PERFECT GAS IS ASSUMED WITH CONSTANT SPECIFIC HEAT RATIO, GAM, MAI 7
C      COMPRESSIBILITY FACTOR, Z0, AND RECOVERY FACTOR, R0, AS INPUTS. MAI 8
C      ALSO INPUT IS GAS CONSTANT, AR, IN SQ FT PER SQ SECOND PER DEG R. MAI 9
C      IF VISM IS SUTHERLANDS TEMPERATURE, VISCOSITY FOLLOWS SUTHERLANDS MAI 10
C      LAW ABOVE VISM, BUT IS LINEAR WITH TEMPERATURE BELOW VISM. MAI 11
C      IF(VISM.LE.1.D+0) VISCOSITY=VISC*TEMPERATURE**VISM MAI 12
C
C      IMPLICIT REAL*8(A-H,O-Z) MAI 13
C      COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,RGA,QT MAI 14
C      COMMON /COORD/ S(200),FS(200),WALTAN(200),SD(200),WMN(200),TTR(200) MAI 15
C      1),DMDX(200),SPR(200),DPX(200),SREF(200),XBIN,XCIN,GMA,GMB,GMC,GMD MAI 16
C      COMMON /CORR/ DLA(200),RCO(200),DAX(200),DRX(200),SL(200),DR2 MAI 17
C      COMMON /PROP/ AR,Z0,R0,VISC,VISM,SFOA,XBL,CONV MAI 18
C      COMMON /PARAM/ ETAD,RC,AMACH,BMACH,CMACH,EMACH,GMACH,FRC,SF,WWO,WMMAI 19
C      1OP,QM,WE,CBET,XE,ETA,EPSI,BPSI,XO,YO,RRR,SDO,XB,XC,AM,PP,SE,TYE,XAMAI 20
C      COMMON /JACK/ SJ(30),XJ(30),YJ(30),AJ(30) MAI 21
C      COMMON /CONTR/ ITLE(3),IE,LR,IT,JB,JQ,JX,KAT,KBL,KING,KO,LV,NOCON MAI 22
C      DATA ZRO/0.0D+0/,ONE/1.D+0/,TWO/2.D+0/,DC7/8H CURVATUR/ MAI 23
C      DATA DC1/8H DZY/DX2/,DC2/8H //,DC3/8H ANGLE/ MAI 24
C      DATA DC4/8H DY/DX/,DC5/8H DY/DS/,DC6/8H DX/DS/ MAI 25
C      DATA L1/4H X/,L2/4H Y/,L3/4H S/,L4/4H //,L5/4H DIFF/ MAI 26
C      CONV=90.D+0/DARSIN(ONE) MAI 27
C      IT=0 MAI 28
C      NC=0 MAI 29
C      LA=L1 MAI 30
C      LB=L4 MAI 31
C      DCA=DC4 MAI 32
C      DCB=DC2 MAI 33
C      JJ=1000 MAI 34
C      OCC=DC1 MAI 35
C
C      READ (5,30,END=24) ITLE,JD MAI 36
C      IF (ITLE(1).EQ.L4) GO TO 24 MAI 37
C      IE=1-JD MAI 38
C      QT=ONE/(1+IE) MAI 39
C
C      READ (5,28) GAM,AR,Z0,R0,VISC,VISM,SFOA,XBL MAI 40
C      FOR GAMMA=1.4, G9=5, G8=.2, G7=1.2, G6=5/6, G5=1/6, G4=1/SQRT(6), MAI 41
C      G3=1.5, G2=SQRT(6), G1=2.5 MAI 42
C      GM=GAM-ONE MAI 43
C      G1=ONE/GM MAI 44
C      G9=TWO*G1 MAI 45
C      G8=ONE/G9 MAI 46
C      G7=ONE*G8 MAI 47
C      G6=ONE/G7 MAI 48
C      G5=G8*G6 MAI 49
C      RGA=TWO*G5 MAI 50
C      GA=ONE/RGA MAI 51

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	G4=DSQRT(G5)	MAI	57
	G3=GA/TWO	MAI	58
	G2=ONE/G4	MAI	59
	IF (IE.EQ.0) AM=Z0	MAI	60
	IF (IE.EQ.0) Z0=ONE	MAI	61
	OM=ONE	MAI	62
	JX=0	MAI	63
2	JQ=0	MAI	64
	LV=0	MAI	65
3	CALL AXIAL	MAI	66
	IF (LV.LT.0) GO TO 1	MAI	67
	CALL PERFC	MAI	68
	IF (NOCON.NE.0) GO TO 24	MAI	69
	IF ((JQ.GT.0).OR.(JX.GT.0)) GO TO 3	MAI	70
	IF (JB.GT.0) CALL BOUND	MAI	71
	IF (XBL.EQ.1.D+3) GO TO 5	MAI	72
	IF (IT.LT.1) GO TO 4	MAI	73
	LA=L3	MAI	74
	DCA=DC5	MAI	75
	DCC=DC7	MAI	76
	KUP=IT	MAI	77
	KAP=KUP+1	MAI	78
	XEND=ZRO	MAI	79
C	READ (5,28,END=24) (SJ(K),K=1,KUP),XST	MAI	80
	CSK=ONE/DSQRT(ONE+DRX(KAT)**2)	MAI	81
	SNK=CSK*DRX(KAT)	MAI	82
	CALL SPLIND (SL,RCO,ZRO,SNK,KAT)	MAI	83
	GO TO 6	MAI	84
4	IF (LV.GT.0) GO TO 24	MAI	85
	IF (JX.LT.0) GO TO 1	MAI	86
	GO TO 2	MAI	87
5	CONTINUE	MAI	88
C	READ (5,28,END=24) XST,XLOW,XEND,XINC,BJ,XMID,XINC2,CN	MAI	89
	IF (XST.EQ.XBL) XST=S(1)	MAI	90
	NC=CN-ONE	MAI	91
	IF (JB.LE.0) CALL SPLIND (S,FS,WALTAN(1),WALTAN(KING),KING)	MAI	92
	IF (JB.GT.0) CALL SPLIND (S,RCO,DRX(1),DRX(KAT),KAT)	MAI	93
	IF (XEND.GT.ZRO) GO TO 6	MAI	94
	LB=L5	MAI	95
	DCB=DC4	MAI	96
6	SLONG=S(KING)-S(1)	MAI	97
	IPP=0	MAI	98
	WRITE (6,25) ITLE,SLONG	MAI	99
	WRITE (6,31) LA,L2,DCA,DC3,DCC,DCB,LB	MAI	100
	IF (JB.GT.0) GO TO 7	MAI	101
	WRITE (6,26) XST,FS(1),WALTAN(1),ZRO,SD(1)	MAI	102
	XMAX=SLONG*XST	MAI	103
	YMAX=FS(KING)	MAI	104
	TMAX=WALTAN(KING)	MAI	105
	GO TO 8	MAI	106
7	WRITE (6,26) XST,RCO(1),DRX(1),ZRO,DR2	MAI	107
	XMAX=S(KAT)-S(1)*XST	MAI	108
	YMAX=RCO(KAT)	MAI	109
	TMAX=DRX(KAT)	MAI	110
		MAI	111
		MAI	112

8	IF (IT.GT.0) GO TO 11	MAI 113
	JB=BJ	MAI 114
	IF (XEND.GT.ZRO) GO TO 10	MAI 115
	IF (JB.LT.0) GO TO 9	MAI 116
	KUP=KING-1	MAI 117
	KAP=KING-1	MAI 118
	GO TO 11	MAI 119
9	KUP=-JB	MAI 120
	KAP=KUP+1	MAI 121
C		MAI 122
	READ (5,28,END=24) (SJ(K),K=1,KUP)	MAI 123
	GO TO 11	MAI 124
10	IF (XINC.GT.ZRO) KUP=(XEND-XLOW)/XINC+1.0-2	MAI 125
	IF (XMID.NE.ZRO) JJ=(XMID-XLOW)/XINC+1.0-2	MAI 126
	IF (XMID.NE.ZRO) KUP=JJ+(XEND-XMID)/XINC2+1.0-2	MAI 127
	IF (JB.GT.10) KUP=JB	MAI 128
	IF (JB.GT.10) XINC=SLONG/BJ	MAI 129
	KAP=(XMAX-XLOW)/XINC+1	MAI 130
	IF (XMID.NE.ZRO) KAP=JJ+(XMAX-XMID)/XINC2+1	MAI 131
11	DO 19 K=1,KUP	MAI 132
	IF (XEND.EQ.ZRO) GO TO 12	MAI 133
	X=XLOW+K*XINC	MAI 134
	IF (K.GT.JJ) X=XMID+(K-JJ)*XINC2	MAI 135
	GO TO 13	MAI 136
12	IF (IT.LT.1.AND.JB.GE.0) X=S(K+1)	MAI 137
	IF (IT.GT.0.OR.JB.LT.0) X=SJ(K)	MAI 138
13	XX=X-XST+S(1)	MAI 139
	IF (K.LT.KAP) CALL XYZ (XX,YY,YYP,YPPP)	MAI 140
	IF (K.EQ.KAP) X=XMAX	MAI 141
	IF (K.GE.KAP) YY=YMAX	MAI 142
	IF (K.GE.KAP) YYP=TMAX	MAI 143
	IF (K.GE.KAP) YPPP=ZRO	MAI 144
	IF (IT.LT.1) GO TO 16	MAI 145
	IF (IPP.GT.0) GO TO 14	MAI 146
	YJ(K)=YY	MAI 147
	AJ(K)=DARSIN(YYP)	MAI 148
	WANG=CONV*AJ(K)	MAI 149
	CURV=YPPP/DCOS(AJ(K))	MAI 150
	WRITE (6,26) X,YY,YYP,WANG,CURV	MAI 151
	GO TO 18	MAI 152
14	YY=YY-S(1)*XST	MAI 153
	XJ(K)=YY	MAI 154
	WANG=CONV*DARCOS(YYP)	MAI 155
	WRITE (6,26) X,YY,YYP,WANG	MAI 156
	GO TO 18	MAI 157
16	WANG=CONV*DATAN(YYP)	MAI 158
	IF (XEND.EQ.ZRO.AND.JB.GE.0) DY=YYP-WALTAN(K+1)	MAI 159
	IF (JB.LE.0) GO TO 17	MAI 160
	FS(K+1)=YY	MAI 161
	WALTAN(K+1)=YYP	MAI 162
	SD(K+1)=YPPP	MAI 163
17	IF (XEND.GT.ZRO.OR.JB.LT.0) WRITE (6,26) X,YY,YYP,WANG,YPPP	MAI 164
	IF (XEND.EQ.ZRO.AND.JB.GE.0) WRITE (6,26) X,YY,YYP,WANG,YPPP,DY	MAI 165
18	IF (MOD(K,10).EQ.0) WRITE (6,29)	MAI 166
	IF (MOD(K,50).NE.0) GO TO 19	MAI 167
	WRITE (6,25) ITLE,SLONG	MAI 168

	WRITE (6,31) LA,L2,DCA,DC3,DCC,DCB,LB	MAI 169
19	CONTINUE	MAI 170
	IF (IT.GT.0.AND.IPP.EQ.1) CALL PLATE	MAI 171
	IF (IPP.GE.NC) GO TO 20	MAI 172
	IPP=IPP+1	MAI 173
	WRITE (6,25) ITLE,SLONG	MAI 174
	WRITE (6,31) LA,L2,DCA,DC3,DCC	MAI 175
	WRITE (6,26) XST,RCO(1),DRX(1),ZRO,DR2	MAI 176
	GO TO 11	MAI 177
20	IF ((IPP.GT.0).OR.(JX.LT.0)) GO TO 1	MAI 178
	IF (IT.EQ.0) GO TO 21	MAI 179
	IPP=1	MAI 180
	CALL SPLIND (SL,S,ONE,CSK,KAT)	MAI 181
	WRITE (6,29)	MAI 182
	WRITE (6,31) L3,L1,DC6,DC3	MAI 183
	WRITE (6,26) XST,XST,ONE,ZRO	MAI 184
	GO TO 11	MAI 185
21	IF (JB) 1,2,22	MAI 186
22	CALL SPLIND (S,WMN,DMDX(1),DMDX(KING),KING)	MAI 187
	DO 23 K=1,KUP	MAI 188
	X=XLOW+K*XINC	MAI 189
	IF (XEND.EQ.ZRO) X=S(K+1)	MAI 190
	XX=X-XST+S(1)	MAI 191
	IF (K.LT.KAP) CALL XYZ (XX,YY,YY,YYPP)	MAI 192
	IF (K.GE.KAP) YY=CMACH	MAI 193
	IF (K.GE.KAP) YYP=ZRO	MAI 194
	S(K+1)=X	MAI 195
	WMN(K+1)=YY	MAI 196
	TTR(K+1)=ONE/G8*YY**2	MAI 197
	SPR(K+1)=ONE/TTR(K+1)**(ONE+G1)	MAI 198
	DMDX(K+1)=YYP	MAI 199
23	DPX(K+1)=-GAM*YY*YYP*SPR(K+1)/TTR(K+1)	MAI 200
	S(1)=XST	MAI 201
	KAT=KUP+1	MAI 202
	KBL=KAT+4	MAI 203
	KO=1	MAI 204
	CALL BOUND	MAI 205
	IF (JB.EQ.7) STOP	MAI 206
	IF (JB.GT.10) GO TO 1	MAI 207
	WRITE (6,25) ITLE,SLONG	MAI 208
	WRITE (6,31) L1,L2,DC4	MAI 209
	WRITE (6,27) (S(K),RCO(K),DRX(K),K=1,KAT)	MAI 210
	GO TO 1	MAI 211
24	STOP	MAI 212
C		MAI 213
25	FORMAT (1H1,9X,3A4,' COORDINATES AND DERIVATIVES, LENGTH =',F12.7)	MAI 214
26	FORMAT (1H ,8X,2F15.6,1P4E20.8)	MAI 215
27	FORMAT (10(9X,0P2F15.6,1PE20.8/))	MAI 216
28	FORMAT (8E10.0)	MAI 217
29	FORMAT (1H)	MAI 218
30	FORMAT (3A4,13)	MAI 219
31	FORMAT (1H0,14X,A4,' (IN)',7X,A4,' (IN)',6X,A8,12X,A8,14X,A8,9X,A8,2	MAI 220
	1X,A4 /)	MAI 221
	END	MAI 222
	SUBROUTINE AXIAL	AXI 1
C		AXI 2

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C      TO OBTAIN THE AXIAL DISTRIBUTION OF VELOCITY AND/OR MACH NUMBER AXI 3
C
C      IMPLICIT REAL*8(A-H,O-Z) AXI 4
C      COMMON /FG/ GC,GD,GE,GF,GH,GI,HA,HB,HC,HE AXI 5
C      COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,GB,GT AXI 6
C      COMMON /CLINE/ AXIS(5,150),TAXI(5,150),WIP,X1,FRIP,ZONK,SEO,CSE AXI 7
C      COMMON /PROP/ AR,ZO,RO,VISC,VISM,SFOA,XRL,CONV AXI 8
C      COMMON /PARAM/ ETAD,RC,AMACH,BMACH,CMACH,EMACH,GMACH,FRC,SF,WWO,WWAXI 9
C      IOP,QM,WE,CBET,XE,ETA,EPSI,BPSI,XO,YO,RRR,SDO,XB,XC,AM,PP,SE,TYPE,XAAXI 10
C      COMMON /CONTR/ ITLE(3),IE,LR,IT,JB,JQ,JX,KAT,KBL,KING,KO,LV,NOCN,AXI 11
C      IIN,MC,MCP,IP,IO,ISE,JC,M,MP,MQ,N,NP,NF,NUT,NR,LC,MD,MF,MT,ND,NT AXI 12
C      DATA ZRO/0.0D+0/,ONE/1.0D+0/,TWO/2.0D+0/,SIX/6.0D+0/,HALF/5.0D-1/ AXI 13
C      DATA THR/3.0D+0/,FOUR/4.0D+0/,FIV/5.0D+0/,TEN/1.0D+1/,TLV/1.2D+1/ AXI 14
C      DATA SEV/7.0D+0/,EIT/8.0D+0/,FFTN/1.5D+1/,TRTY/3.0D+1/,SXTY/6.0D+1/ AXI 15
C      DATA M1/4HGMAC/,M2/4H2-D /,IAXIS/4HAXIS/,NS/4H SPE/,NC/4HCIAL/ AXI 16
C      DATA N3/4H 3RD/,N4/4H 4TH/,N5/4H 5TH/,N0/4H-DE6/ AXI 17
C      DIMENSION C(6), D(4), AX(150), AXN(150), AXMP(150) AXI 18
C
C      MPI=9.0D+1/CONV AXI 19
C      IF (JQ.EQ.0.AND.JX.EQ.0) CALL OREZ (AXIS,2*750) AXI 20
C      IF (JQ.GT.0) GO TO 50 AXI 21
C      IF (JX.EQ.0) GO TO 2 AXI 22
C
C      CARD USED TO OBTAIN INTERNAL STREAMLINES (JX > 0) AXI 23
C
C      READ (5,93,END=91) ETAD,QM,XJ AXI 24
C
C      JX=XJ AXI 25
C      IF (ETAD.EQ.SXTY) GO TO 1 AXI 26
C      ETA=ETAD/CONV AXI 27
C      IF (IE.EQ.0) SE=ETA AXI 28
C      IF (IE.EQ.1) SE=TWO*OSIN(HALF*ETA) AXI 29
C      CSE=DCOS(ETA) AXI 30
C      APSI=BPSI-ETA/QT AXI 31
C      AMACH=FMV(PSI) AXI 32
C      RA=((G6*G5*AMACH**2)**GA/AMACH)**QT AXI 33
C      GPSI=EPSI+ETA/QT AXI 34
C      GMACH=FMV(GPSI) AXI 35
C      RG=((G6*G5*GMACH**2)**GA/GMACH)**QT AXI 36
C      MP=ONE+THR*(RA-RG) AXI 37
C      GO TO 14 AXI 38
C      SE=QM*SEO AXI 39
C      GO TO 14 AXI 40
C
C      CONSTANTS USED IN TRANSONIC SOLUTION AXI 41
C
C      GC=(TWO*GAM/QT-THR)/SIX/(3+IE) AXI 42
C      GE=(THR*(8+IE)-FOUR*GAM/QT)/THR/(7+IE) AXI 43
C      GH=(FFTN+(2-6*IE)*GAM)/TLV/(5+IE) AXI 44
C      GJ=(GAM*(GAM+9.25D+0*IE-26.5D+0)+.75D+0*(6-IE))/TLV/(3-IE) AXI 45
C      GK=(GAM*(GAM+2.25D+0*IE-16.5D+0)+2.25D+0*(2+IE))/SIX AXI 46
C      GR=(FFTN-(1+9*IE)*GAM)/(15+IE)/18.0D+0 AXI 47
C      HB=(14.0D+0*GAM-75.0D+0*18*IE)/(270.0D+0*18*IE) AXI 48
C      IF (IE.EQ.0) GO TO 3 AXI 49
C      GD=(GM*(652.0D+0*GM+1319.0D+0)+1000.0D+0)/6912.0D+0 AXI 50
C      GF=(3612.0D+0*GM*(751.0D+0*GM+754.0D+0))/2880.0D+0 AXI 51
C      GI=(909.0D+0*GAM*(270.0D+0*GAM+412.0D+0))/10368.0D+0 AXI 52

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C      GS=(GAM*(GAM*2708.D+0+2079.D+0)+2115.D+0)/82944.D+0      AXI 59
C      HC=(GAM*(2364.D+0+GAM*3915.D+0)+14337.D+0)/82944.D+0      AXI 60
C      ME=(GAM*(64.D+0+GAM*117.D+0)-1026.D+0)/1152.D+0          AXI 61
C      GO TO 4                                                      AXI 62
C                                                                    AXI 63
C      AXISYM FLOW, IF=1, QT=0.5, GAM=1.4, GC=0.10833333, GD=0.236099537, AXI 64
C      GE=0.65833333, GF=1.40036111, GH=0.13055556, GI=0.2020177469, AXI 65
C      GJ=-0.76833333, GK=-1.87333333, GR=0.003472222, GS=0.1245814043, AXI 66
C      HB=-0.12986111, HC=0.1626331019, HE=-0.6395486111        AXI 67
C                                                                    AXI 68
C      3      GD=(GM*(32.D+0+GM*14.D+0)+221.D+0)/1080.D+0        AXI 69
C      GF=(4230.D+0+GM*(211.D+0+GM*334.D+0))/3780.D+0          AXI 70
C      GI=(738.D+0+GAM*(273.D+0+GAM*82.D+0))/7560.D+0          AXI 71
C      GS=(GAM*(GAM*782.D+0+3507.D+0)+7767.D+0)/272160.D+0      AXI 72
C      HC=(GAM*(274.D+0+GAM*861.D+0)+4464.D+0)/17010.D+0        AXI 73
C      ME=(GAM*(32.D+0+GAM*87.D+0)-561.D+0)/540.D+0            AXI 74
C                                                                    AXI 75
C      PLANAR FLOW, IE=0, QT=1.0, GAM=1.4, GC=-0.011111, GD=0.2041851852, AXI 76
C      GE=0.8761904762, GF=1.155513228, GH=0.29666667, GI=0.1269153439, AXI 77
C      GJ=-0.85111111, GK=-2.7733333, GR=0.05037037037, GS=0.05221017049, AXI 78
C      HB=-0.2051851852, HC=0.2231416814, HE=-0.6971851852     AXI 79
C                                                                    AXI 80
C      CARD USED TO ESTABLISH INVISCID PARAMETERS                  AXI 81
C                                                                    AXI 82
C      4      READ (5,93,END=91) ETAD,RC,FMACH,BMACH,CMC,SF,PP,XC  AXI 83
C                                                                    AXI 84
C      CARD USED TO CONTROL CALCULATIONS                           AXI 85
C                                                                    AXI 86
C      READ (5,92) MT,NT,IX,IN,IQ,MD,ND,NF,MP,MQ,JB,JX,JC,IT,LR,NX AXI 87
C                                                                    AXI 88
C      LC=XC                                                         AXI 89
C      IF (XC.GT.ONE) LC=XC+ONE                                     AXI 90
C      NR=SIX*MC                                                      AXI 91
C      MF=FMACH                                                         AXI 92
C      IF (IE.EQ.1) MC=M1                                              AXI 93
C      IF (IE.EQ.0) MC=M2                                              AXI 94
C      NOCON=0                                                         AXI 95
C      ETA=ETAD/CONV                                                  AXI 96
C      IF (IE.EQ.0) SE=ETA                                             AXI 97
C      IF (IE.EQ.1) SE=TWO*DSIN(HALF*ETA)                             AXI 98
C      IF (ETAU.EQ.SXTY) SE=ONE                                       AXI 99
C      SEQ=SE                                                         AXI 100
C      ISE=SE                                                         AXI 101
C      CSE=DCOS(ETA)                                                  AXI 102
C      RT=RC+ONE                                                      AXI 103
C      AM=ONE                                                         AXI 104
C      WI=ONE                                                         AXI 105
C      WIPP=ZRO                                                       AXI 106
C      MCP=CMC                                                         AXI 107
C      CMACH=DABS(CMC)                                                 AXI 108
C      CBET=DSQRT(CMACH*CMACH-ONE)                                    AXI 109
C      FRC=((66+G5*CMACH**2)**GA/CMACH)**QT                           AXI 110
C      TYE=FRC*SE                                                     AXI 111
C      IF (SF.LT.ZRO) SF=-SF/TYE                                       AXI 112
C      IF (ISE.EQ.0) GO TO 5                                           AXI 113
C                                                                    AXI 114

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C	NON-RADIAL FLOW AT INFLECTION POINT	AXI 115
	IQ=1	AXI 116
	AMACH=CMACH	AXI 117
	BMACH=CMACH	AXI 118
	EMACH=CMACH	AXI 119
	FMACH=CMACH	AXI 120
	GMACH=CMACH	AXI 121
	IF (IE.EQ.1) AH=GMACH	AXI 122
	WE=G2*EMACH/DSORT(EMACH**2*G9)	AXI 123
	DW=WE-WI	AXI 124
	XO=ZRO	AXI 125
	EOE=ZRO	AXI 126
	GO TO 15	AXI 127
C		AXI 128
C	RADIAL FLOW AT INFLECTION POINT	AXI 129
5	IF (IN.EQ.0) GO TO 6	AXI 130
	IF (LC.LT.0.AND.IN.LT.0) IN=-1	AXI 131
	IF (LC.EQ.0.OR.MCP.LT.0) IN=ISIGN(10,IN)	AXI 132
6	BBET=DSORT(BMACH*BMACH-ONE)	AXI 133
	BPSI=G2*DATAN(G4*BBET)-DATAN(BBET)	AXI 134
	IF (FMACH) 9,8,7	AXI 135
7	FBET=DSORT(FMACH*FMACH-ONE)	AXI 136
	FPSI=G2*DATAN(G4*FBET)-DATAN(FBET)	AXI 137
	GO TO 10	AXI 138
8	FMACH=BPSI/ETA	AXI 139
	IF (BPSI/ETA.GT.7.5D+0) FMACH=-7.5D+0	AXI 140
9	FPSI=FMACH*ETA	AXI 141
	FMACH=FMV(FPSI)	AXI 142
10	EPSI=FPSI-TWO*ETA/QT	AXI 143
	EMACH=FMV(EPSI)	AXI 144
	WE=G2*EMACH/DSORT(EMACH*EMACH*G9)	AXI 145
	DW=WE-WI	AXI 146
	CALL SORCE (WE,D)	AXI 147
	XE=D(1)	AXI 148
	WEP=D(2)	AXI 149
	WEPP=D(3)	AXI 150
	WRPPP=D(4)	AXI 151
	IF (NR.NE.0) GO TO 15	AXI 152
	IF (LR.NE.0.OR.IQ.LT.0) GO TO 11	AXI 153
	IF (IX.EQ.0) WRITE (6,106) ITLE,N3	AXI 154
	IF (IX.NE.0) WRITE (6,106) ITLE,N4	AXI 155
C		AXI 156
C	ITERATION TO DETERMINE RC IF NOT SPECIFIED (NR = 0)	AXI 157
11	EA=WRPPP	AXI 158
	EB=-FIV*WEPP-WIPP	AXI 159
	EC=TLV*WEP	AXI 160
	ED=-TLV*DW	AXI 161
	XIE=CUBIC(EA,EB,EC,ED)	AXI 162
	IF (XIE.LE.ZRO) GO TO 89	AXI 163
12	WIP=TWO*(WE-ONE)/XIE-WEP*(WEPP-WIPP)*XIE/SIX	AXI 164
13	NOCON=NOCON+1	AXI 165
	IF (NOCON.GT.100) GO TO 90	AXI 166
14	RT=TORIC(WIP,SE)	AXI 167
	RC=RT-ONE	AXI 168
15	TK=(ONE-G7*ONE+(GE*GF/RT)/RT)/RT**2/(15+IE)/THR)**QT	AXI 169
	YO=SE/TK	AXI 170

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      AA=DSQRT(QT*(GAM+ONE)*RT)
      IF (QM.NE.ONE) GO TO 19
      WMPP=(ONE-GAM/1.5D+0+GJ/RT)/(AA*Y0)**2
      IF (NR.NE.0.OR.ISE.EQ.1) GO TO 18
      IF (DABS(WMPP-WIPP).LT.1D-10) GO TO 18
      WIPP=WMPP
      IF (IX) 11,17,16
      EA=GK/(AA*Y0)**3
16    EB=THR*(WIPP+WEPP)
      EC=-TLV*WEP
      ED=TLV*DW
      XIE=CUBIC(EA,EB,EC,ED)
      IF (XIE.LE.ZRO) GO TO 89
      GO TO 12
17    H=(EIT*WIP+SEV*WEP)/(THR*WIPP-TWO*WEPP)
      HH=TRTY*DW/(THR*WIPP-TWO*WEPP)
      XIE=HH/(DSQRT(H*H+HH)+H)
      WIP=WEP-HALF*XIE*(WEPP+WIPP)
      GO TO 13
C
C    ITERATION FOR RC COMPLETED, REMAINDER OF TRANSONIC VALUES COMPUTED
18    WIP=(ONE-(GC-GD/RT)/RT)/Y0/AA
      WHP=WIP
      WIPP=WHPP
      AMP=G7*WIP
      AMPP=G7*(WHPP+THR*G8*WIP**2)
19    XOI=Y0*DSQRT(G7/TWO*(9-IE)/RT)*(ONE+(GM+GI/RT)/RT)
      IF (QM.NE.ONE) GO TO 21
      IF (ISE.EQ.1) XI=XOI
      XOI=XOI
      WO=ONE-(HALF/(3-IE)+(GR+GS/RT)/RT)/RT
      OM=WO/DSQRT(G7-G8*WO**2)
      WOPPP=GK/(AA*Y0)**3
      IF (LR.EQ.0) GO TO 21
C
C    CALL FOR THROAT CHARACTERISTIC VALUES
      CALL TRANS (RT,TK,WO,AM,AMP,AMPP,WI,AWP,AWPP,AWPPP,XI)
      IF (NX.LT.0.AND.NT.LT.0) GO TO 87
      IF (NX.LT.0) GO TO 4
      AMP=AMP/SE
      AMPP=AMPP/SE**2
      WAP=AWP/SE
      WAPP=AWPP/SE**2
      WOPPP=AWPPP/SE**3
      IF (ISE.EQ.1) GO TO 21
      DW=WE-WI
      XOI=XI*SE
      IF (NR.GT.0) GO TO 20
      X1=XE-XIE
      X0=XE-XIE-XOI
      C2=XIE*WIP
      C3=HALF*WIPP*XIE**2
      C4=WE-ONE-C2-C3
      IF (IX.NE.0) C4=FOUR*C4+TWO*C3+C2-XIE*WEP
      IF (IQ.LT.0) GO TO 20
      WRITE (6,110) ITLE,N4,LR

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AXI 171
AXI 172
AXI 173
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AXI 225
AXI 226

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	WRITE (6,96) XIE,C2,C3,C4,X1	AXI	227
20	WIP=WAP	AXI	228
	WIPP=WAPP	AXI	229
21	WWO=ONE*(ONE/(IE*3)-(HB-HC/RT)/RT)/RT	AXI	230
	WWOP=(ONE*(ONE-IE/EIT-HE/RT)/RT)/YO/AA	AXI	231
	RRC=ONE/RC	AXI	232
	SDO=RRC/YO	AXI	233
	ZONK=QM*1.0D-03	AXI	234
	NP=ZONK*(IABS(NF)-1)*1	AXI	235
	IF (SF.GT.ZRO) GO TO 22	AXI	236
	SF=ONE/YO	AXI	237
22	IF (IQ.LT.0) GO TO 31	AXI	238
	IP=0	AXI	239
	JQ=0	AXI	240
	M=ZONK*(MT-1)*1	AXI	241
	N=NT	AXI	242
	IF (QM.EQ.ONE) GO TO 23	AXI	243
	XO=X1-XOI	AXI	244
	RETURN	AXI	245
23	CALL OREZ (C,6)	AXI	246
	IF (ISE.EQ.0) GO TO 31	AXI	247
C		AXI	248
C	LENGTH OF AXIAL DISTRIBUTION FOR NON-RADIAL FLOW	AXI	249
	X1=XOI	AXI	250
	AEM=EMACH-AM	AXI	251
	C(1)=AM	AXI	252
	IF (LC) 25,24,27	AXI	253
24	AMSQ=AMP**2+AEM*AMPP*FOUR/THR	AXI	254
	IF (LR.EQ.0) WRITE (6,122) ITLE,N4,N0	AXI	255
	IF (LR.NE.0) WRITE (6,107) ITLE,N4,N0,LR	AXI	256
	IF (AMSQ.LT.ZRO) GO TO 28	AXI	257
	XIE=FOUR*AEM/(DSQRT(AMSQ)*AMP)	AXI	258
	XE=XIE*X1	AXI	259
	C(5)=THR*AEM-AMP*XIE	AXI	260
	GO TO 26	AXI	261
25	XIE=THR*AEM/AMP	AXI	262
	XE=XIE*X1	AXI	263
	IF (LR.EQ.0) WRITE (6,122) ITLE,N3,N0	AXI	264
	IF (LR.NE.0) WRITE (6,107) ITLE,N3,N0,LR	AXI	265
26	C(2)=AMP*XIE	AXI	266
	C(3)=SIX*AEM-THR*C(2)	AXI	267
	C(4)=THR*C(2)-EIT*AEM	AXI	268
	GO TO 46	AXI	269
27	IF (LC.EQ.1) GO TO 29	AXI	270
	XE=XC/TK	AXI	271
	XIE=FIV*AEM/(DSQRT(AMP**2+IN*AEM*AMPP/EIT)*AMP)	AXI	272
	IF (XE.GT.X1+XIE) XE=X1+XIE	AXI	273
	XIE=XE-X1	AXI	274
	C(2)=AMP*XIE	AXI	275
	C(3)=HALF*IN*AMPP*XIE**2/TEN	AXI	276
	C(4)=TEN*AEM-SIX*C(2)-THR*C(3)	AXI	277
	C(5)=FFIN*AEM+EIT*C(2)+THR*C(3)	AXI	278
	C(6)=SIX*AEM-THR*C(2)-C(3)	AXI	279
	IF (LR.EQ.0) WRITE (6,122) ITLE,N5,N0	AXI	280
	IF (LR.NE.0) WRITE (6,107) ITLE,N5,N0,LR	AXI	281
	GO TO 46	AXI	282

28	C(2)=TWO*AEM	AXI 283
	C(4)=-C(2)	AXI 284
	C(5)=AEM	AXI 285
	XIE=TWO*AEM/AMP	AXI 286
	XE=XIE*XI	AXI 287
	GO TO 46	AXI 288
29	DO 30 J=1,NT	AXI 289
	K=NT+1-J	AXI 290
	READ (9) AX(K),AXM(K),AXMP(K)	AXI 291
	IF (J.EQ.1) DX=XI-AX(K)	AXI 292
30	AXIS(1,K)=AX(K)+DX	AXI 293
	AXM(NT)=AM	AXI 294
	AXMP(NT)=AMP	AXI 295
	XE=AXIS(1,1)	AXI 296
	XIE=XE-XI	AXI 297
	IF (LR.EQ.0) WRITE (6,122) ITLE,NS,NC	AXI 298
	IF (LR.NE.0) WRITE (6,107) ITLE,NS,NC,LR	AXI 299
	GO TO 46	AXI 300
C		AXI 301
C	LENGTH OF UPSTREAM AXIAL DISTRIBUTION FOR RADIAL FLOW	AXI 302
31	IF (SFOA.EQ.ZRO) GO TO 32	AXI 303
	IF (LR.EQ.0) WRITE (6,106) ITLE,N5	AXI 304
	IF (LR.NE.0) WRITE (6,110) ITLE,N5,LR	AXI 305
	GO TO 44	AXI 306
32	IF (LR.EQ.0) GO TO 33	AXI 307
	IF (NR.EQ.0.AND.IX.EQ.0) GO TO 41	AXI 308
	IF (NR.EQ.0.AND.IX.NE.0) MF=0	AXI 309
	IF (MF.NE.0) GO TO 40	AXI 310
	IF (IQ.LT.0.OR.NR.EQ.0) GO TO 35	AXI 311
	IF (IX.EQ.0) WRITE (6,110) ITLE,N3,LR	AXI 312
	IF (IX.NE.0) WRITE (6,110) ITLE,N4,LR	AXI 313
	GO TO 35	AXI 314
33	IF (MF.EQ.0) GO TO 34	AXI 315
	IF (NR.EQ.0) GO TO 45	AXI 316
	IF (IQ.GE.0) WRITE (6,106) ITLE,N4	AXI 317
	GO TO 41	AXI 318
C		AXI 319
C	ITERATION FOR EMACH IF NOT SPECIFIED (MF = 0)	AXI 320
34	IF (IQ.LT.0) GO TO 35	AXI 321
	IF (IX.EQ.0) WRITE (6,106) ITLE,N3	AXI 322
	IF (IX.NE.0) WRITE (6,106) ITLE,N4	AXI 323
35	IF (NOCON.GT.100) GO TO 90	AXI 324
	IF (IX) 41,36,37	AXI 325
36	XIE=SIX*DW/(DSQRT((WIP+WEP+WEP)**2-SIX*DW*WEPP)+WIP+WEP+WEP)	AXI 326
	FXW=HALF*XIE*(WEPP+WIPP)/(WEP-WIP)	AXI 327
	IF (FXW.LE.ZRO) EW=WE+.1D+0	AXI 328
	IF (FXW.LE.ZRO) GO TO 39	AXI 329
	IF (FXW.LT.ONE) EW=W1+DW*(FOUR+FXW**2)/FIV	AXI 330
	IF (FXW.GT.ONE.OR.IE.EQ.0) EW=W1+DW*(9.D+0+FXW)/TEN	AXI 331
	GO TO 39	AXI 332
37	EA=WOPPP	AXI 333
	EB=FIV*WIPP+WEPP	AXI 334
	EC=TLV*WIP	AXI 335
	ED=-TLV*DW	AXI 336
	XIE=CUBIC(EA,EB,EC,ED)	AXI 337
	IF (XIE.GT.ZRO) GO TO 38	AXI 338

	EW=WE-.10*0	AXI	339
	IF (EW.GT.WI) GO TO 39	AXI	340
	WRITE (6,113)	AXI	341
	GO TO 4	AXI	342
38	EW=WI*HALF*XIE*(WIP+WEP*XIE*(WIPP-WEPP)/SIX)	AXI	343
39	WE=EW	AXI	344
	IF (WE.GT.G2) GO TO 79	AXI	345
	IF (DABS(EW-DW-WI).LT.1.0-9) GO TO 43	AXI	346
	DW=WE-WI	AXI	347
	CALL SORCE (WE,D)	AXI	348
	XE=D(1)	AXI	349
	WEP=D(2)	AXI	350
	WEPP=D(3)	AXI	351
	WRPPP=D(4)	AXI	352
	NOCON=NOCON+1	AXI	353
	GO TO 35	AXI	354
40	IF (IQ.LT.0) GO TO 41	AXI	355
	WRITE (6,110) ITLE,N4,LR	AXI	356
41	H=THR*(WEP+WIP)/(WIPP-WEPP)	AXI	357
	HH=TLV*DW/(WIPP-WEPP)	AXI	358
	XIE=HH/(DSQRT(H*H+HH)*H)	AXI	359
	IF (MF) 44,42,45	AXI	360
42	EW=WI*XIE*(WIP+THR*WEP-XIE*(WEPP-XIE*WRPPP/SIX))/FOUR	AXI	361
	GO TO 39	AXI	362
43	EMACH=WE/DSQRT(G7-G8*WE*WE)	AXI	363
C		AXI	364
C	ITERATION FOR EMACH COMPLETED	AXI	365
	EBET=DSURT(EMACH*EMACH-ONE)	AXI	366
	EPSI=G2*DATAN(G4*EBET)-DATAN(EBET)	AXI	367
	FPSI=EPSI*TWO*ETA/QT	AXI	368
	FMACH=FMV(FPSI)	AXI	369
44	IF (BMACH.GT.FMACH) GO TO 45	AXI	370
	BMACH=FMACH	AXI	371
	BPSI=FPSI	AXI	372
	MP=0	AXI	373
45	GPSI=FPSI-ETA/QT	AXI	374
	GMACH=FMV(GPSI)	AXI	375
	IF (IE.EQ.1) AH=GMACH	AXI	376
	RG=((G6+G5*GMACH**2)**GA/GMACH)**QT	AXI	377
	APSI=BPSI-ETA/QT	AXI	378
	AMACH=FMV(APSI)	AXI	379
	RA=((G6+G5*AMACH**2)**GA/AMACH)**QT	AXI	380
	XA=RA*CSE	AXI	381
	IF (SFOA.GT.ZRO) XIE=SFOA/SF*XE-XA-XOI	AXI	382
	IF (SFOA.LT.ZRO) XIE=XE-SFOA/SF-RG*CSE-XOI	AXI	383
	XI=XE-XIE	AXI	384
	XO=XI-XOI	AXI	385
	X1=XO-XOI	AXI	386
	IF (IQ.LT.0) GO TO 48	AXI	387
	XB=((G6+G5*BMACH**2)**GA/BMACH)**QT	AXI	388
	IF (LC.LT.2) XC=((G6+G5*CMACH**2)**GA/CMACH)**QT	AXI	389
	C(1)=WI	AXI	390
	C(2)=XIE*WIP	AXI	391
	C(3)=HALF*WIPP*XIE*XIE	AXI	392
	C(4)=TEN*DW-XIE*(FOUR*WEP-HALF*XIE*WEPP)-SIX*C(2)-THR*C(3)	AXI	393
	C(5)=XIE*(SEV*WEP-EIT*WIP-XIE*(WEPP-THR*WIPP/TWO))-FFTN*DW	AXI	394

	C(6)=SIX*DW-THR*XIE*(WEP+WIP)+HALF*XIE*XIE*(WEPP-WIPP)	AXI	395
	IF (MF.EQ.0.AND.IX.EQ.0) C(5)=ZRO	AXI	396
	IF (NR.EQ.0.AND.IX.EQ.0.AND.LR.EQ.0) C(5)=ZRO	AXI	397
	IF (SFOA.EQ.ZRO) C(6)=ZRO	AXI	398
	EOE=EPSI/ETA	AXI	399
	WIPPP=SIX*C(4)/XIE/XIE/XIE	AXI	400
	WEPPP=SIX*(C(4)+FOUR*C(5)+TEN*C(6))/XIE/XIE/XIE	AXI	401
46	WRITE (6,99) M,N,EOE,BMACH,CMACH,GAM,ETAD,RC,SF	AXI	402
	WRITE (6,102) SE,TK,WVO,WVOP,EMACH,FMACH,MC,AM	AXI	403
	IF (LR.NE.0) WRITE (6,123) WI,WAP,WAPP,AM,AMP,AMPP	AXI	404
	IF (ISE.EQ.1.AND.LR.EQ.0) WRITE (6,123) WI,WIP,WHPP,AM,AMP,AMPP	AXI	405
	IF (ISE.EQ.1) GO TO 47	AXI	406
	WRITE (6,101) WI,WIP,WIPP,WIPPP,WOPPP	AXI	407
	WRITE (6,98) WE,WEP,WEPP,WEPPP,WRPPP	AXI	408
47	WRITE (6,94) C(1),C(2),C(3),C(4),C(5),C(6)	AXI	409
	WRITE (6,95) XO1,XI,XO,YO,XIE,XE,NOCON	AXI	410
	IF (ISE.EQ.1) XC=XE	AXI	411
	IF (ISE.EQ.1) XA=XE+TYE*CBET	AXI	412
48	NOCON=0	AXI	413
	WIP=WHP	AXI	414
	IF (QM.NE.ONE) GO TO 49	AXI	415
	IF (PP.LT.ZRO) FRIP=ZRO	AXI	416
	IF (PP.EQ.ZRO) FRIP=XO*SF	AXI	417
	IF (PP.GT.ZRO) FRIP=PP-SF*XA	AXI	418
	IF (IQ.LT.0) GO TO 50	AXI	419
	XOIN=SF*XO+FRIP	AXI	420
	XIIN=SF*X1+FRIP	AXI	421
	XIIN=SF*X1+FRIP	AXI	422
	WRITE (6,125) OM,XOIN,XIIN,AM,XIIN	AXI	423
	IF (IQ.GT.0) GO TO 67	AXI	424
49	IF (N) 87,50,68	AXI	425
50	M=ZONK*(MD-1)+1	AXI	426
	JQ=1	AXI	427
	N=ND	AXI	428
	IP=IN	AXI	429
	IF (QM.NE.ONE) RETURN	AXI	430
	CALL OREZ (C,6)	AXI	431
	IF (IQ.LT.0) GO TO 51	AXI	432
	IF (MQ.GE.0.AND.N.GT.0) GO TO 51	AXI	433
	WRITE (6,104)	AXI	434
	GO TO 52	AXI	435
51	WRITE (6,105)	AXI	436
52	IF (IP) 53,67,58	AXI	437
C		AXI	438
C	LENGTH OF DOWNSTREAM VELOCITY DISTRIBUTION, RADIAL FLOW	AXI	439
53	WC=G2*CMACH/DSQRT(CMACH*CMACH+G9)	AXI	440
	WB=G2*BMACH/DSQRT(BMACH*BMACH+G9)	AXI	441
	WCB=WC-WB	AXI	442
	CALL SORCE (WB,D)	AXI	443
	XB=D(1)	AXI	444
	WBP=D(2)	AXI	445
	WSPP=D(3)	AXI	446
	WSPPP=D(4)	AXI	447
	C(1)=WB	AXI	448
	WCP=ZRO	AXI	449
	IF (LC) 54,55,56	AXI	450

54	XBC=THR*WCB/WBP	AXI 451
	WBPP=-TWO*WBP/XBC	AXI 452
	WRITE (6,109) ITLE,N3	AXI 453
	GO TO 57	AXI 454
55	WBPP=WSPP	AXI 455
	IF (MCP.LT.0) WRITE (6,109) ITLE,N3	AXI 456
	IF (MCP.LT.0) XBCN=THR*WCB/WBP	AXI 457
	IF (MCP.LT.0) XBCM=-TWO*WBP/WBPP	AXI 458
	IF (MCP.GT.0) WRITE (6,109) ITLE,N4	AXI 459
	IF (MCP.GT.0) XBCN=FOUR*WCB/WBP	AXI 460
	IF (MCP.GT.0) XBCM=-THR*WBP/WBPP	AXI 461
	ABCM=ONE-XBCN/XBCM	AXI 462
	IF (ABCM.LT.ZRO) GO TO 88	AXI 463
	XBC=XBCN/(DSQRT(ABCM)+ONE)	AXI 464
	GO TO 57	AXI 465
56	WBPP=-WSPP*IP/TEN	AXI 466
	IF (MCP.GT.0) XBCMN=CUBIC(WSPPP/THR,THR*WBPP,TLV*WBP,-TWO*TEN*WCB)	AXI 467
	IF (MCP.LT.0) XBCMN=CUBIC(WSPPP/SIX,WBPP,THR*WBP,-FOUR*WCB)	AXI 468
	XBCMX=FIV*WCB/(DSQRT(WBP**2-IP*WCB*WSPP/EIT)+WBP)	AXI 469
	IF (XC.GT.XB+XBCMX) XC=XB+XBCMX	AXI 470
	IF (XC.LT.XB+XBCMN) XC=XB+XBCMN	AXI 471
	XBC=XC-XB	AXI 472
	IF (MCP.LT.0) WRITE (6,109) ITLE,N4	AXI 473
	IF (MCP.GT.0) WRITE (6,109) ITLE,N5	AXI 474
57	C(2)=XBC*WBP	AXI 475
	C(3)=HALF*XBC*XBC*WBPP	AXI 476
	IF (MCP.LT.0) C(4)=FOUR*WCB-THR*C(2)-TWO*C(3)	AXI 477
	IF (MCP.LT.0) C(5)=-THR*WCB+TWO*C(2)+C(3)	AXI 478
	IF (MCP.GT.0) C(4)=TEN*WCB-SIX*C(2)-THR*C(3)	AXI 479
	IF (MCP.GT.0) C(5)=-FFTN*WCB+EIT*C(2)+THR*C(3)	AXI 480
	IF (MCP.GT.0) C(6)=SIX*WCB-THR*C(2)-C(3)	AXI 481
	IF (LC.LT.0) C(5)=ZRO	AXI 482
	IF (LC.LE.0) C(6)=ZRO	AXI 483
	XC=XB+XBC	AXI 484
	GO TO 63	AXI 485
C		AXI 486
58	LENGTH OF DOWNSTREAM MACH NO. DISTRIBUTION, RADIAL FLOW	AXI 487
	CALL CONIC (BMACH,D)	AXI 488
	XB=D(1)	AXI 489
	BMP=D(2)	AXI 490
	SMPP=D(3)	AXI 491
	SMPPP=D(4)	AXI 492
	CBM=CMACH-BMACH	AXI 493
	C(1)=BMACH	AXI 494
	BMPP=SMPP*IP/TEN	AXI 495
	IF (LC.NE.0) GO TO 59	AXI 496
	IF (MCP.LT.0) WRITE (6,108) ITLE,N3	AXI 497
	IF (MCP.LT.0) XBCN=THR*CBM/BMP	AXI 498
	IF (MCP.LT.0) XBCM=-TWO*BMPP/BMPP	AXI 499
	IF (MCP.GT.0) WRITE (6,108) ITLE,N4	AXI 500
	IF (MCP.GT.0) XBCN=FOUR*CBM/BMP	AXI 501
	IF (MCP.GT.0) XBCM=-THR*BMPP/BMPP	AXI 502
	ABCM=ONE-XBCN/XBCM	AXI 503
	IF (ABCM.LT.ZRO) GO TO 88	AXI 504
	XBC=XBCN/(DSQRT(ABCM)+ONE)	AXI 505
	XC=XB+XBC	AXI 506

	GO TO 62	AXI 507
59	IF (LC.NE.1) GO TO 61	AXI 508
	DO 60 K=1,ND	AXI 509
	READ (9) AX(K),AXM(K),AXMP(K)	AXI 510
	IF (K.EQ.1) DX=XB-AX(1)	AXI 511
60	AXIS(1,K)=AX(K)+DX	AXI 512
	IF (AXMP(2).EQ.ZRO) CALL SCOND (AX,AXM,AXMP,ND)	AXI 513
	AXM(1)=BMACH	AXI 514
	AXMP(1)=BMP	AXI 515
	XC=AXIS(1,ND)	AXI 516
	XBC=XC-XB	AXI 517
	WRITE (6,111) ITLE	AXI 518
	GO TO 63	AXI 519
61	IF (MCP.GT.0) XBCM=CUBIC(SMPPP/THR,THR*BMP,TLV*BMP,-TWO*TEN*CBM)	AXI 520
	IF (MCP.LT.0) XBCM=CUBIC(SMPPP/SIX,BMP,THR*BMP,-FOUR*CBM)	AXI 521
	XBCM=FIV*CBM/(DSQRT(BMP**2+IP*CBM*SMPP/EIT)+BMP)	AXI 522
	IF (XC.GT.XB+XBCM) XC=XB+XBCM	AXI 523
	IF (XC.LT.XB+XBCM) XC=XB+XBCM	AXI 524
	XBC=XC-XB	AXI 525
	IF (MCP.LT.0) WRITE (6,108) ITLE,N4	AXI 526
	IF (MCP.GT.0) WRITE (6,108) ITLE,N5	AXI 527
62	C(2)=XBC*BMP	AXI 528
	C(3)=HALF*XBC*XBC*BMPP	AXI 529
	IF (MCP.LT.0) C(4)=FOUR*CBM-THR*C(2)-TWO*C(3)	AXI 530
	IF (MCP.LT.0) C(5)=-THR*CBM-TWO*C(2)+C(3)	AXI 531
	IF (MCP.GT.0) C(4)=TEN*CBM-SIX*C(2)-THR*C(3)	AXI 532
	IF (MCP.GT.0) C(5)=-FFIN*CBM+EIT*C(2)+THR*C(3)	AXI 533
	IF (MCP.GT.0) C(6)=SIX*CBM-THR*C(2)-C(3)	AXI 534
	IF (LC.LE.0) C(6)=ZRO	AXI 535
63	CPP=ZRO	AXI 536
	CMP=ZRO	AXI 537
	IF (MCP.LT.0) CPP=(TWO*C(3)+SIX*C(4)+TLV*C(5))/XBC**2	AXI 538
	BPPP=SIX*C(4)/XBC/XBC/XBC	AXI 539
	CPPP=SIX*(C(4)+FOUR*C(5)+TEN*C(6))/XBC/XBC/XBC	AXI 540
	XD=XC+TYE*CBET	AXI 541
	WRITE (6,100) M,N,NP,GAM,ETAD,RC,SF	AXI 542
	IF (IP) 64,67,65	AXI 543
64	WRITE (6,116) WB,WBP,WBPP,BPPP,WSPP,WC,WCP,CPP,CPPP,WSPPP	AXI 544
	GO TO 66	AXI 545
65	WRITE (6,117) BMACH,BMP,BMPP,BPPP,SMPP,CMACH,CMP,CPP,CPPP,SMPPP	AXI 546
66	WRITE (6,94) C(1),C(2),C(3),C(4),C(5),C(6)	AXI 547
	WRITE (6,118) AMACH,XA,XB,XBC,XC,XD	AXI 548
	XAIN=SF*XA*FRIP	AXI 549
	YAIN=SF*XA*DTAN(ETA)	AXI 550
	XBIN=SF*XB*FRIP	AXI 551
	XCIN=SF*XC*FRIP	AXI 552
	XDIN=SF*XD*FRIP	AXI 553
	TYIN=SF*TYE	AXI 554
	WRITE (6,120) XAIN,YAIN,XBIN,XCIN,XDIN,TYIN	AXI 555
67	IF (N) 87,4,68	AXI 556
68	IF (NQ.LT.0) GO TO 69	AXI 557
C		AXI 558
C	CALCULATE AXIAL DISTRIBUTION	AXI 559
	WRITE (6,103) IAXIS	AXI 560
69	FN=N-1	AXI 561
	L=(N+40)/41	AXI 562

	IF (IP.NE.0) XIE=XBC	AXI	563
	IF (IP.NE.0) XI=XB	AXI	564
	Q=ZRO	AXI	565
	DO 84 K=1,N	AXI	566
	IF (ISE.EQ.1.AND.LC.EQ.1) GO TO 72	AXI	567
	IF (IP.NE.0) GO TO 70	AXI	568
	IF (NX.EQ.0) Q=((N-K)/FN)**2	AXI	569
	IF (NX.NE.0) Q=((N-K)/FN)**(NX*1.D-1)	AXI	570
	GO TO 71	AXI	571
70	IF (LC.EQ.1) GO TO 72	AXI	572
	Q=(K-1)/FN	AXI	573
71	AXIS(1,K)=XIE*Q+XI	AXI	574
72	RMACH=ONE	AXI	575
	IF (ISE.EQ.1) GO TO 75	AXI	576
	IF (AXIS(1,K).LT.ONE+1.D-9) GO TO 74	AXI	577
	AB=AXIS(1,K)**(RGA/QT)	AXI	578
	IF (AB.LT.TWO) SM=((ONE+DSQRT(AB*GM-GM))**GA)**2	AXI	579
	IF (AB.GE.TWO) SM=(AB/GS)**G7	AXI	580
73	CM=SM**G5	AXI	581
	FQ=SM*(G6+G5*SM-CM*AB)/(SM-ONE)/G5/G6	AXI	582
	SM=SM-FQ	AXI	583
	IF (DABS(FQ).GT.1.D-9) GO TO 73	AXI	584
	RMACH=DSQRT(SM)	AXI	585
74	IF (IP.LT.1) GO TO 78	AXI	586
75	IF (LC.EQ.1) GO TO 76	AXI	587
	XM=C(1)+Q*(C(2)+Q*(C(3)+Q*(C(4)+Q*(C(5)+Q*(C(6))))))	AXI	588
	IF (ISE.EQ.1.OR.K.EQ.1) GO TO 77	AXI	589
	IF (RMACH.LT.XM) WRITE (6,124) K, RMACH, XM	AXI	590
	GO TO 77	AXI	591
76	XM=AXM(K)	AXI	592
77	XMP=(C(2)+Q*(TWO*C(3)+Q*(THR*C(4)+Q*(FOUR*C(5)+Q*(FIV*C(6)))))/XIE	AXI	593
	IF (LC.EQ.1) XMP=AXMP(K)	AXI	594
	XMPP=TWO*(C(3)+Q*(THR*C(4)+Q*(SIX*C(5)+Q*(TEN*C(6))))/XIE/XIE	AXI	595
	XMPPP=SIX*(C(4)+Q*(FOUR*C(5)+TEN*Q*(C(6))))/XIE/XI=XIE	AXI	596
	GMM=XM*XM+G9	AXI	597
	GQ=DSQRT(GMM)	AXI	598
	W=G2*XM/GQ	AXI	599
	WM=G9*G2/GQ/GMM	AXI	600
	WP=WM*XMP	AXI	601
	WPP=WM*(XMPP-THR*XM*XMP*XMP/GMM)	AXI	602
	GMP=FIV*XM*XM*XMP*XMP/GMM-THR*XM*XMPP-XMP*XMP	AXI	603
	WPPP=WM*(XMPPP+THR*XMP*GMP/GMM)	AXI	604
	IF (MQ.LT.0) GO TO 83	AXI	605
	IF (MOD(K-1,L).NE.0) GO TO 83	AXI	606
	GO TO 82	AXI	607
78	W=C(1)+Q*(C(2)+Q*(C(3)+Q*(C(4)+Q*(C(5)+Q*(C(6))))))	AXI	608
	WP=(C(2)+Q*(TWO*C(3)+Q*(THR*C(4)+Q*(FOUR*C(5)+Q*(FIV*C(6)))))/XIE	AXI	609
	WPP=TWO*(C(3)+Q*(THR*C(4)+Q*(SIX*C(5)+Q*(TEN*C(6))))/XIE/XIE	AXI	610
	WPPP=SIX*(C(4)+Q*(FOUR*C(5)+TEN*Q*(C(6))))/XIE/XIE/XIE	AXI	611
	GWW=G7-W*W*G8	AXI	612
	IF (GWW.GT.ZRO) GO TO 80	AXI	613
79	WRITE (6,119)	AXI	614
	GO TO 4	AXI	615
80	GW=DSQRT(GWW)	AXI	616
	XM=W/GW	AXI	617
	IF (K.EQ.1.OR.K.EQ.N) GO TO 81	AXI	618

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      IF (IP.EQ.0.AND.RMACH.GT.XM) WRITE (6,124) K,RMACH,XM      AXI 619
      IF (IP.NE.0.AND.RMACH.LT.XM) WRITE (6,124) K,RMACH,XM      AXI 620
81     XMW=G7/GW/GWW      AXI 621
      XMP=XMW*WP      AXI 622
      XMPP=XMW*(WPP+THR*GB*W*WP*WP/GWW)      AXI 623
      GWP=FIV*W*W*WP*WP*G8/GWW+THR*W*WPP*WP*WP      AXI 624
      XMPPP=XMW*(WPPP+THR*WP*GB*GWP/GWW)      AXI 625
      IF (MQ.LT.0) GO TO 83      AXI 626
      IF (MOD(K-1,L).NE.0) GO TO 83      AXI 627
82     XINCH=SF*AXIS(1,K)*FRIP      AXI 628
      WRITE (6,97) K,AXIS(1,K),XINCH,XM,XMP,XMPP,XMPPP,W,WP,WPP,WPPP      AXI 629
      IF (MOD(K+L-1,10*L).EQ.0) WRITE (6,115)      AXI 630
83     AXIS(3,K)=XM      AXI 631
      AXIS(2,K)=ZRO      AXI 632
      AXIS(5,K)=IE*HALF*(XM-ONE/XM)*WP/W      AXI 633
      XBET=DSURT(XM**2-ONE)      AXI 634
84     AXIS(4,K)=G2*DATAN(G4*XBET)-DATAN(XBET)      AXI 635
      IF (IQ.EQ.0.AND.IP.EQ.0.AND.M.LE.0) GO TO 50      AXI 636
      IF (M) 87,4,85      AXI 637
85     IF (IP.NE.0) RETURN      AXI 638
      DO 86 K=1,N      AXI 639
      DO 86 J=1,5      AXI 640
86     TAXI(J,K)=AXIS(J,K)      AXI 641
      RETURN      AXI 642
87     LV=-1      AXI 643
      RETURN      AXI 644
88     WRITE (6,114)      AXI 645
      GO TO 4      AXI 646
89     WRITE (6,112)      AXI 647
      GO TO 4      AXI 648
90     WRITE (6,121) NOCON      AXI 649
      GO TO 4      AXI 650
91     STOP      AXI 651
C      AXI 652
92     FORMAT (16I5)      AXI 653
93     FORMAT (8E10.0)      AXI 654
94     FORMAT (1H0,9X,3HC1=F11.7,3X,3HC2=F12.8,3X,3HC3=1PE15.7,3X,3HC4=, AXI 655
      1E15.7,3X,3HC5=E15.7,3X,3HC6=E15.7)      AXI 656
95     FORMAT (1H0,9X,4HX0I=F12.8,3X,3HXI=F12.8,3X,3HXO=F12.8,3X,3HYO=F12AXI 657
      1.8,3X,4HXIE=F12.8,3X,3HXE=F12.8,I5,11H ITERATIONS/)      AXI 658
96     FORMAT (1H .4X,26HCURVE FROM MACH 1. XIE=F12.8,6H C2=F12.8,6HAXI 659
      1 C3=1PE15.7,6H C4=E15.7,6H X1=0PF12.8 /)      AXI 660
97     FORMAT (1H ,I3,2F10.5,F10.6,1P3E14.6,0PF10.6,1P3E14.6 )      AXI 661
98     FORMAT (1H0,9X,3HWE=F12.8,4X,4HWEPP=F12.8,4X,5HWEPP=,1PE15.7,4X,6HMAXI 662
      1EPPP=E15.7,4X,6HWRPPP=E15.7)      AXI 663
99     FORMAT (1H .4X,31HNO. OF POINTS ON 1ST CHAR. (M)=I3,5X,26HNO. OF PAXI 664
      10INTS ON AXIS (N)=I3,5X,9HEPSI/ETA=F8.5,4X,6HBMACH=F9.5,4X,6HGMACHAXI 665
      2=F9.5//5X,6HGAMMA=F7.4,5X,22HINFLECTION ANG. (ETA)=F8.4,2X,7HDEGREAXI 666
      3ES,5X,19HRAD. OF CURV. (RC)=F11.6,5X,18HSCALE FACTOR (SF)=F13.8) AXI 667
100    FORMAT (1H .4X,31HNO. OF POINTS ON 1ST CHAR. (M)=I3,5X,26HNO. OF PAXI 668
      10INTS ON AXIS (N)=I3,5X,33HNO. OF POINTS ON LAST CHAR. (NP)=I3//5XAXI 669
      2,6HGAMMA=F7.4,5X,22HINFLECTION ANG. (ETA)=F8.4,2X,7HDEGREES,5X,19HAXI 670
      3RAD. OF CURV. (RC)=F13.8,5X,18HSCALE FACTOR (SF)=F11.6) AXI 671
101    FORMAT (1H0,9X,3HWI=F12.8,4X,4HWIP=F12.8,4X,5HWIPP=,1PE15.7,4X,6HMAXI 672
      1IPPP=E15.7,4X,6HWOPPP=E15.7)      AXI 673
102    FORMAT (1H0,4X,3HY=F10.8,4X,6HRMASS=F10.8,4X,4HWWO=F10.7,4X,5HWWOAXI 674

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103 1P=F11.8,4X,6HEMACH=F8.5,4X,6HFMACH=F10.7,4X,A4,2HH=F9.5) AXI 675
    FORMAT (1H ,1X,A4/6H POINT,4X,1HX,7X,5MX(IN),3X,8MMACH NO.,4X,5HDMAXI 676
1/0X,8X,7HD2M/DX2,7X,7HD3M/DX3,7X,6HW=Q/A*,5X,5HDW/DX,8X,7HD2W/DX2,AXI 677
27X,7HD3W/DX3/) AXI 678
104 FORMAT (1H0,/) AXI 679
105 FORMAT (1H1) AXI 680
106 FORMAT (1H1,3A4,16H THROAT CONTOUR,,A4,49H-DEG AXIAL VELOCITY DISTAXI 681
1RIBUTION FROM SONIC POINT/) AXI 682
107 FORMAT (1H1,3A4,18H INVISCID CONTOUR,,A4,A4,68H AXIAL MACH NUMBER AXI 683
1DISTRIBUTION FROM THROAT CHARACTERISTIC WHICH HAS,I4,7H POINTS /) AXI 684
108 FORMAT (1H ,3A4,20H DOWNSTREAM CONTOUR,,A4,35H-DEG AXIAL MACH NUMBAXI 685
1ER DISTRIBUTION/) AXI 686
109 FORMAT (1H ,3A4,20H DOWNSTREAM CONTOUR,,A4,32H-DEG AXIAL VELOCITY AXI 687
1DISTRIBUTION/) AXI 688
110 FORMAT (1H1,3A4,16H THROAT CONTOUR,,A4,69H-DEG AXIAL VELOCITY DISTAXI 689
1RIBUTION FROM THROAT CHARACTERISTIC WHICH HAS,I4,7H POINTS /) AXI 690
111 FORMAT (1H ,3A4,19H DOWNSTREAM CONTOUR/) AXI 691
112 FORMAT (1H0,38HSOLUTION TO CUBIC EQUATION IS NEGATIVE) AXI 692
113 FORMAT (1H0,35HRC IS TOO LARGE TO ALLOW A SOLUTION) AXI 693
114 FORMAT (1H0,38HBMACH IS TOO SMALL TO ALLOW A SOLUTION) AXI 694
115 FORMAT (1H ) AXI 695
116 FORMAT (1H0,9X,3HWB=F12.8,4X,4HWBP=F12.8,4X,5HWBPP=,1PE15.7,4X,6HMAXI 696
1BPPP=E15.7,5X,5HWSPP=E15.7//10X,3HWC=0PF12.8,4X,4HWC=PF12.8,4X, AXI 697
25HWCPP=,1PE15.7,4X,6HWCPP=E15.7,4X,6HWSPPP=E15.7 ) AXI 698
117 FORMAT (1H0,9X,6HBMACH=F9.5,4X,4HBMP=F12.8,4X,5HBMP=,1PE15.7,4X, AXI 699
16HBMP=,E15.7,5X,5HSMPP=E15.7//10X,6HBMACH=0PF9.5,4X,4HMP=,F12.8,AXI 700
28,4X,5HSMPP=,1PE15.7,4X,6HSMPP=E15.7,4X,6HSMPP=,E15.7) AXI 701
118 FORMAT (1H0,9X,6HAMACH=F11.7,4X,3HXA=F11.7,4X,3HXB=F11.7,4X, AXI 702
14HXC=F11.7,4X,3HXC=F12.7,4X,3HXC=F12.7/) AXI 703
119 FORMAT (1H0,47HVELOCITY GREATER THAN THEORETICAL MAXIMUM VALUE) AXI 704
120 FORMAT (1H ,9X,7HXA(IN)=,F11.7,9H, YA(IN)=,F11.7,9H, XB(IN)=,F12.7,AXI 705
1,9H, XC(IN)=,F12.7,9H, XD(IN)=,F12.7,9H, YD(IN)=,F11.7 /) AXI 706
121 FORMAT (1H1,'NO CONVERGENCE IN',I4,' ITERATIONS' ) AXI 707
122 FORMAT (1H1,3A4,18H INVISCID CONTOUR,,A4,A4,48H AXIAL MACH NUMBER AXI 708
1DISTRIBUTION FROM SONIC POINT /) AXI 709
123 FORMAT (1H0,9X,3HWI=F12.8,4X,4HWIP=F12.8,4X,5HWIPP=1PE15.7,4X,3HMIAXI 710
1=0PF12.8,4X,4HWIP=F12.8,4X,5HWIPP=1PE15.7 ) AXI 711
124 FORMAT (1H ,13,8H RMACH=,2F12.8 ) AXI 712
125 FORMAT (1H ,9X,4HMACH,F11.8,3H AT,F11.7,17H IN., MACH 1 AT,F11.7,AXI 713
1,12H IN., MACH,F11.8,3H AT,F11.7,4H IN. /) AXI 714
END AXI 715
SUBROUTINE BOUND BOU 1
C BOU 2
C TO OBTAIN THE CORRECTION DUE TO THE TURBULENT BOUNDARY LAYER BOU 3
C BOU 4
IMPLICIT REAL*8(A-H,O-Z) BOU 5
COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,RGA,QT BOU 6
COMMON /CORR/ DLA(200),RCO(200),DAX(200),DRX(200),SL(200),DR2 BOU 7
COMMON /COORD/ S(200),FS(200),WALTAN(200),SU(200),WMN(200),TTR(200)BOU 8
1),DMDX(200),SPR(200),BTA(200),SREF(200),XBIN,XCIN,GMA,GMB,GMC,GMD BOU 9
COMMON /PROP/ AR,ZO,RO,VISC,VISM,SFOA,SBL,CONV BOU 10
COMMON /PARAM/ ETAD,RC,AMACH,BMACH,CMACH,EMACH,GMACH,FRC,SF,WWO,WWBOU 11
10P,QM,WE,CBET,XE,ETA,EPSI,8PSI,XO,YO,RRC,SDO,XB,XC,AM,PP,SE,TYE,XABOU 12
COMMON /HTTR/ HAIR,TAW,TWQ,TW,TWAT,QFUN,QFUNN,IP,IJ,IV,IW BOU 13
COMMON /CONTR/ ITLE(3),IE,LR,IT,JB,JQ,JX,KAT,KBL,KING,KO,LV,NOCON,BOU 14
1IN,MC,MCP BOU 15

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DIMENSION Z(16), D(16), SCV(200), SK(200), CDS(200), RW(200)      80U 16
DATA ZR0/0.00+0/ONE/1.0+0/TWO/2.0+0/SIX/6.0+0/HALF/5.0-1/      80U 17
DATA THR/3.0+0/FOUR/4.0+0/TEN/1.0+1/TLV/1.20+1/                80U 18
DATA CF1/3.8650-2/CF2/4.5610+0/CF3/5.460-1/FS1/3.178979710+0/  80U 19
DATA LY/4H Y/LS/4H S/DD/8HD2Y/DX2 /DK/8H CURV. /                80U 20
DATA Z(1)/.0529953250-1/Z(4)/.12229779580+0/Z(7)/.35919822460+0/80U 21
DATA Z(2)/.2771248850-1/Z(5)/.19106187780+0/Z(8)/.45249374510+0/80U 22
DATA Z(3)/.6718439880-1/Z(6)/.27099161120+0/                    80U 23
DATA D(1)/.1357622970-1/D(2)/.311267620-1/D(3)/.4757925580-1/ 80U 24
DATA D(4)/.6231448560-1/D(5)/.7479799440-1/D(6)/.8457825970-1/ 80U 25
DATA D(7)/.9130170750-1/D(8)/.9472530520-1/                    80U 26
DO 1 J=9.16                                                        80U 27
D(J)=D(17-J)                                                       80U 28
1 Z(J)=ONE-Z(17-J)                                                 80U 29
DO 2 J=1.KAT                                                        80U 30
2 SREF(J)=S(J)                                                      80U 31
SBIN=XBIN                                                           80U 32
SCIN=XCIN                                                           80U 33
TRPI=CONV/90.D+0                                                    80U 34
FCC=2.050+0.DLOG(.410+0)                                           80U 35
CHAIR=GAM*G1*AR/R0/R0/777.648850+0                                80U 36
IF (IT.EQ.0) XBL=SBL                                               80U 37
C READ (5,66.END=65) PPQ,TO,TWT,TWAT,QFUN,ALPH,INT,IR,LD,LV      80U 38
3                                                                    80U 39
C                                                                    80U 40
PPS=PPQ                                                             80U 41
RHO=144.D+0*PPS/Z0/AR/TO                                           80U 42
ID=IABS(LD)                                                         80U 43
KOR=KO                                                               80U 44
IF (IABS(IN).EQ.10) KOR=1                                           80U 45
IF (MCP.LT.0) KOR=KING                                             80U 46
ROY=ONE                                                             80U 47
IF (IE.EQ.0) HW=AH                                                  80U 48
IF ((ID.EQ.0).OR.(IE.EQ.1)) HW=ZRO                                80U 49
IF (HW.EQ.ZRO) YOM=ZRO                                              80U 50
IF (HW.EQ.ZRO) YOHA=ZRO                                             80U 51
ALF=DABS(ALPH)                                                       80U 52
ARC=FRC                                                             80U 53
IF (INT.LT.0) ARC=FRC**((IE+1)                                     80U 54
IPQ=0                                                                80U 55
IW=1                                                                80U 56
IF (LV.NE.0) IW=IABS(LV)                                           80U 57
DO 4 J=1.KAT                                                        80U 58
S(J)=SREF(J)                                                        80U 59
SL(J)=S(J)                                                          80U 60
RW(J)=FS(J)                                                         80U 61
RCO(J)=FS(J)                                                        80U 62
SCW=DSQRT(ONE+WALTAN(J)**2)                                         80U 63
SK(J)=SD(J)/SCW**3                                                  80U 64
IF (KAT.EQ.KING) GO TO 4                                             80U 65
IF (S(J).LT.SBL) KBL=J+2                                           80U 66
4 ORX(J)=WALTAN(J)                                                  80U 67
IF (KBL.GT.KAT) KBL=KAT+4                                           80U 68
DO 58 IV=1,IW                                                       80U 69
IF ((IV.GT.1).AND.(IV.LT.IW)) GO TO 15                             80U 70
IF (LD.GE.0) WRITE (6,80) ITLE,PPS,TO                             80U 71

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5	IF (ALPH.GT.ZRO) GO TO 6	80U	72
	ALPHA=ZRO	80U	73
	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,71)	80U	74
	GO TO 7	80U	75
6	ALPHA=ALPH	80U	76
	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,70)	80U	77
7	IF (IR.EQ.2) GO TO 13	80U	78
	IF (ALF.EQ.ONE) GO TO 8	80U	79
	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,75)	80U	80
	GO TO 9	80U	81
8	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,72)	80U	82
9	IF (IR) 10,11,12	80U	83
10	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,74)	80U	84
	GO TO 14	80U	85
11	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,73)	80U	86
	GO TO 14	80U	87
12	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,76)	80U	88
	GO TO 14	80U	89
13	IF (LD.GE.0.OR.PPQ.EQ.ZRO) WRITE (6,77)	80U	90
14	IF (PPQ.EQ.ZRO) GO TO 60	80U	91
15	CAP1=.550*0	80U	92
	IPP=0	80U	93
	IJ=1	80U	94
	DO 56 J=1,KAT	80U	95
	BET=TTR(J)-ONE	80U	96
	STR=ONE/TTR(J)	80U	97
	TE=TQ*STR	80U	98
	RAJ=WMN(J)*(G7*STR)**GA	80U	99
	IF (IHT.GE.0) RAJ=RAJ**GT	80U	100
	SCW=DSQRT(ONE+DRX(J)**2)	80U	101
	EMU=VISC*TE*DSQRT(TE)/(TE+VISM)	80U	102
	IF (TE.LT.VISM) EMU=HALF*VISC*TE/DSQRT(VISM)	80U	103
	IF (VISM.LE.ONE) EMU=VISC*TE**VISM	80U	104
	TAW=TE*(ONE+RO*BET)	80U	105
	RHOE=RHO*STR**G1	80U	106
	VE=WMN(J)*DSQRT(GAM*AR*TE)	80U	107
	REO=RHOE*VE/EMU/TLV	80U	108
	IF (HW.GT.ZRO) YOH=FS(J)/HW	80U	109
	IF (IE.EQ.0.AND.HW.GT.ZRO) ROY=(HW/FS(J)+ONE)*TRPI	80U	110
	K=J	80U	111
	IF (J.EQ.1) GO TO 19	80U	112
	IF (J.GT.KOR) K=J-KOR+1	80U	113
	IF (K-3) 16,17,18	80U	114
16	DS=S(J)-S(J-1)	80U	115
	SMD=HALF*DS	80U	116
	GO TO 19	80U	117
17	DT=S(J)-S(J-1)	80U	118
	DST=DS*DT	80U	119
	SMA=DST*(TWO-DT/DS)/SIX	80U	120
	SMC=DST*(TWO-DS/DT)/SIX	80U	121
	SMB=DST-SMA-SMC	80U	122
	HB=H	80U	123
	IF (IV.GT.1) GO TO 19	80U	124
	BMA=TWO/DS/DST	80U	125
	BMB=-TWO/DS/DT	80U	126
	BMC=TWO/DT/DST	80U	127

	GO TO 19	80U	128
18	DU=S(J)-S(J-1)	80U	129
	DT=S(J-1)-S(J-2)	80U	130
	DS=S(J-2)-S(J-3)	80U	131
	DST=DS+DT	80U	132
	DSTU=DST+DU	80U	133
	DTU=DT+DU	80U	134
	DUT=DU-DT	80U	135
	DTS=DS-DT	80U	136
	DTUS=DT+TWO*(DU-DS)	80U	137
	DTSU=DT+TWO*(DS-DU)	80U	138
	DSTTU=TWO*(DST+DTU)	80U	139
	HA=HB	80U	140
	HB=H	80U	141
	QMA=HALF*DS*(ONE-DS*(THR*(DTU+DU)/DST)/DSTU/SIX)	80U	142
	QMB=HALF*DS*(ONE+DS*(TWO*(DST+DT)/DTU)/DT/SIX)	80U	143
	QMC=-DS**3*(ONE*(DTU+DU)/DST)/DT/DTU/TLV	80U	144
	QMD=DS**3*(DST+DT)/DU/DTU/DSTU/TLV	80U	145
	SMA=HALF*DS*(DUT+DTU**3/DS-DS*DS*(DS+DSTTU))/DST/DSTU/TLV	80U	146
	SMB=HALF*DS*(DS*DS*(DSTTU-DS)/DT+DT*DT*DTUS/DS-DU**3*(DSTU+DST)/DSTU/DTU/TLV	80U	147
	SMC=HALF*DTU*(DT+DT*DTSU/DTU+DU*DU*(DSTTU-DU)/DT-DS**3*(DSTU+DTU)/DSTU/DTU/TLV	80U	148
	SMO=HALF*DU*(DTS+DST**3/DTU-DU*DU*(DU+DSTTU))/DTU/DSTU/TLV	80U	149
19	IF (TWT.NE.ZRO) GO TO 20	80U	150
	TW=TAW	80U	151
	GO TO 21	80U	152
20	TWO=(ARC*RAJ-ONE)*(TWT-TWAT)/(ARC-ONE)	80U	153
	IF (TWO.LT.ZRO) TWO=ZRO	80U	154
	TW=TWO+TWAT	80U	155
21	WMU=VISC*TW*DSQRT(TW)/(TW+VISM)	80U	156
	IF (VISM.LE.ONE) WMU=VISC*TW**VISM	80U	157
	DL=TW/TE	80U	158
	DM=ALPHA*(TAW-TW)/TE	80U	159
	DN=ONE-DL-DM	80U	160
	DA=ALF*(TAW-TW)	80U	161
	DB=DA+TW-TE	80U	162
	IF (DB) 22,23,24	80U	163
22	DG=DSQRT(-DB*TE)	80U	164
	DH=DSQRT(-DB*TW)	80U	165
	DI=(TWO*(DG+TE-TW)-DA)/(TWO*DH+DA)	80U	166
	DJ=DLOG(DI)	80U	167
	TP=-DB/DJ/DJ	80U	168
	GO TO 25	80U	169
23	TP=(DSQRT(TE)+DSQRT(TW))**2/FOUR	80U	170
	GO TO 25	80U	171
24	DC=DSQRT(DA*DA+FOUR*TW*DB)	80U	172
	DF=DARSIN((DB+TW-TE)/DC)	80U	173
	DE=DARSIN(DA/DC)	80U	174
	TP=DB/(DF+DE)/(DF+DE)	80U	175
25	IF (IR) 26,27,28	80U	176
26	FRD=TW*EMU/WMU/TP	80U	177
	GO TO 29	80U	178
27	FRD=EMU/WMU	80U	179
	GO TO 29	80U	180
28	FRD=TE*EMU/WMU/DSQRT(TP*TW)	80U	181
		80U	182
		80U	183

29	IF (IPP.GT.0) GO TO 31	80U 184
	RTHI=1.0-2*RE0*FS(1)	80U 185
	RTII=RTHI	80U 186
	RDLI=TEN*RTHI	80U 187
	IF (IR.EQ.1) GO TO 32	80U 188
30	RTHG=DLOG10(RTHI)	80U 189
	CFI=CF1/(RTHG*CF2)/(RTHG-CF3)	80U 190
31	IF (IR.NE.2) GO TO 33	80U 191
	SCFI=DSQRT(CFI)	80U 192
	TC=TW*17.2D+0*SCFI*DA-305.D+0*CFI*DB	80U 193
	CMU=VISC*TC*DSQRT(TC)/(TC+VISM)	80U 194
	IF (VISM.LE.ONE) CMU=VISC*TC**VISM	80U 195
	TP=TW*CM/WMU	80U 196
	FRD=EMU/CMU	80U 197
	GO TO 33	80U 198
32	RDLG=DLOG10(RDLI)	80U 199
	CFI=0.0444D+0/(RDLG+4.6221D+0)/(RDLG-1.4402D+0)	80U 200
33	CF=CFI*TE/TP	80U 201
	CFS=CF*SCW	80U 202
	RTIG=DLOG10(RTII)	80U 203
	XCF=.41D+0*DSQRT((RTIG+CF2)*(RTIG-CF3)/CF1)	80U 204
34	C3=TWO*CAPI*(FSI+1.5D+0*CAPI)	80U 205
	C2=ONE*CAPI	80U 206
	C1=C2-C3/XCF	80U 207
	FXCF=XCF*DLOG(C1/RTII)-FCC-TWO*CAPI	80U 208
	FPCP=(XCF-FSI-THR*CAPI)/XCF/C1-TWO	80U 209
	CAPI=CAPI-FXCF/FPCP	80U 210
	IF (DABS(FXCF).GT.1.D-8) GO TO 34	80U 211
	DOTI=XCF/C1	80U 212
	XN=HALF*(DOTI+DSQRT(DOTI*(DOTI-SIX)+ONE)-THR)	80U 213
	HI=ONE+TWO/XN	80U 214
	SUMA=ZRO	80U 215
	SUMB=ZRO	80U 216
	SUMC=ZRO	80U 217
	SUMD=ZRO	80U 218
	DO 35 L=1,16	80U 219
	UN=Z(L)**XN	80U 220
	TR=DL+Z(L)*(DM+Z(L)*DN)	80U 221
	ADD=D(L)*XN*UN/TR	80U 222
	BDD=ADD*Z(L)	80U 223
	CDD=ADD*UN	80U 224
	DOD=BDD*UN	80U 225
	SUMA=SUMA+ADD	80U 226
	SUMB=SUMB+BDD	80U 227
	SUMC=SUMC+CDD	80U 228
35	SUMD=SUMD+DOD	80U 229
	DOT=ONE/(SUMA-SUMB)	80U 230
	DSOD=ONE-SUMA	80U 231
	DSH=HALF-SUMC	80U 232
	THH=SUMC-SUMD	80U 233
	HU=DSOD*DOT	80U 234
	IF (IPP.GT.0) GO TO 36	80U 235
	H=HU	80U 236
	DOTR=DOT	80U 237
36	FMY=(H+TWO-G9*BET)*DMDX(J)*STR/WMN(J)*ID*DRX(J)/(RW(J)+HW)	80U 238
	IF (J.EQ.1) TH=CFS/FMY	80U 239

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IF (K.EQ.2) TH=(THA+SMD*(DTHA+CFS))/(ONE+SMD*FMY)      80U 240
IF (K.EQ.3) TH=(THA+SMA*DTHA+SMB*DTHB+SMC*CFS)/(ONE+SMC*FMY) 80U 241
IF (K.GT.3) TH=(THA+SMA*DTHA+SMB*DTHB+SMC*DTHC+SMD*CFS)/(ONE+SMD*FMY) 80U 242
IMY) 80U 243
DELST=H*TH 80U 244
ASEC=DELST*DSQRT(ID*DELST**2*(FS(J)*SCH*ROY)**2) 80U 245
DOR=ID*DOTR*TH/ASEC 80U 246
DSROD=DSOD-DOR*DSM 80U 247
IPP=1 80U 248
DOTR=ONE/(ONE/DOT-TMH*DOR) 80U 249
HR=DSROD*DOTR 80U 250
IF (DABS(H-HR).LT.5.D-7) GO TO 37 80U 251
H=HR 80U 252
GO TO 36 80U 253
37 DELTA=DOTR*TH 80U 254
THU=DELTA/DOT 80U 255
DSU=DELTA*DSOD 80U 256
RDEL=REO*DELTA 80U 257
RTII=RDEL/DOTI 80U 258
RDLX=FRD*RDEL 80U 259
RTHX=RDLX/DOT 80U 260
IF (RTHX.LT.100.D+0) GO TO 38 80U 261
IF (IR.EQ.1) GO TO 39 80U 262
IF (DABS(ONE-RTHX/RTHI).LT.1.D-6) GO TO 41 80U 263
RTHI=RTHX 80U 264
GO TO 30 80U 265
38 WRITE (6,88) RTHX,REO,FRD,TH,DELTA,DOT 80U 266
RETURN 80U 267
39 IF (DABS(ONE-RDLX/RDLI).LT.1.D-6) GO TO 40 80U 268
RDLI=RDLX 80U 269
GO TO 32 80U 270
40 RTHG=HALF*(DSQRT((CF2+CF3)**2+FOUR*CF1/CF1)-CF2+CF3) 80U 271
RTHX=TEN**RTHG 80U 272
41 IF (J.GT.1) GO TO 42 80U 273
DTH=ZRO 80U 274
HAIR=RHOE*VE*CF*CHAIR 80U 275
TAIR=HAIR 80U 276
IF (TWAT.EQ.TWT.OR.QFUN.EQ.ZRO) GO TO 46 80U 277
TWQ=(HAIR*TAW*QFUN*(TWAT-15.D+0))/(HAIR*QFUN) 80U 278
CALL HEAT 80U 279
IF (IPQ.GT.100) GO TO 65 80U 280
IF (DABS(TW-TWQ).LT.1.D-2.AND.DABS(QFUN-QFUNW).LT.1.D-5) GO TO 46 80U 281
TWT=TWAT*(TWQ-TWAT)*(ARC-ONE)/(ARC*RAJ-ONE) 80U 282
QFUN=QFUNW 80U 283
GO TO 20 80U 284
42 DTH=CFS-TH*FMY 80U 285
IF (DTH.LT.ZRO) DTH=ZRO 80U 286
IF (J.EQ.KOR) GO TO 46 80U 287
IF (K-3) 43,45,44 80U 288
43 DTHB=DTH 80U 289
GO TO 47 80U 290
44 THA=THA+QMA*DTHA+QMB*DTHB+QMC*DTHC+QMD*DTH 80U 291
DTHA=DTHB 80U 292
DTHB=DTHC 80U 293
IF (K.GT.5) GO TO 45 80U 294
SCU=DSQRT(ONE+DRX(J-2)**2) 80U 295

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	DELA=HA*THA	80U	296
	IF ((IE.EQ.1).OR.(ID.EQ.0)) YSEC=FS(J-2)*SCU	80U	297
	IF (IE.EQ.0.AND.HW.GT.ZRO) YSEC=SCU*(FS(J-2)+HW)*TRPI	80U	298
	IF (HW.GT.ZRO) YOHA=FS(J-2)/HW	80U	299
	ASCA=DELA*DSORT(ID*DELA**2*YSEC**2)	80U	300
	RW(J-2)=ASCA/SCU	80U	301
	DLA(J-2)=SCU*(ASCA-YSEC)*(ONE+YOHA)	80U	302
	RCQ(J-2)=FS(J-2)*DLA(J-2)	80U	303
45	DTHC=DTH	80U	304
	GO TO 47	80U	305
46	THA=TH	80U	306
	DTHA=DTH	80U	307
	IF ((IV.GT.1).AND.(IV.LT.IW)) GO TO 47	80U	308
	IF (J.EQ.1.AND.LD.GE.0) WRITE (6,82)	80U	309
47	CDS(J)=ASEC*SCW*FS(J)*HOY	80U	310
	DLA(J)=SCW*CDS(J)*(ONE+YOH)	80U	311
	RCQ(J)=FS(J)*DLA(J)	80U	312
	RW(J)=ASEC/SCW	80U	313
	IF (IV.LT.IW) GO TO 48	80U	314
	BTA(J)=-DMDX(J)*DSU/WMN(J)/TTR(J)/SCW/CFI	80U	315
	IF (J.EQ.1.OR.J.GT.KO.OR.IMT.EQ.0) GO TO 48	80U	316
	IF (MOD(J,IMT).NE.1) GO TO 48	80U	317
	IJ=J	80U	318
	HAIR=RHOE*VE*CF*CHAIR	80U	319
	CALL HEAT	80U	320
48	IF (LD.LT.0) GO TO 56	80U	321
	IF ((IV.GT.1).AND.(IV.LT.IW)) GO TO 56	80U	322
	CFIK=2000.0*0*CFI	80U	323
	CFK=2000.0*0*CF	80U	324
	CFSK=2000.0*0*CFS	80U	325
	DTHK=1000.0*0*DTH	80U	326
	CTH=TWO*TH/(ONE+DSORT(ONE-TWO*TH*ID/ASEC))	80U	327
	CH=CDS(J)/CTH	80U	328
	IEO=REO*HALF	80U	329
	ITHX=RTMX*HALF	80U	330
	WRITE (6,83) J,TW,TE,TAW,TP,IEO,ITHX,FRD,CFIK,CFK,CFSK,H,HI,FMY,DT	80U	331
	IMK,TH,DELTA,DELST	80U	332
	IF (J.LT.KBL-3) GO TO 54	80U	333
	IF (J-KBL*2) 49,50,51	80U	334
49	CTHA=CTH	80U	335
	XNA=XN	80U	336
	DLTA=DELTA	80U	337
	REOA=REO	80U	338
	GO TO 55	80U	339
50	CTHB=CTH	80U	340
	XNB=XN	80U	341
	DLTB=DELTA	80U	342
	REOB=REO	80U	343
	GO TO 55	80U	344
51	IF (J-KBL) 52,53,54	80U	345
52	CTHC=CTH	80U	346
	XNC=XN	80U	347
	DLTC=DELTA	80U	348
	REOC=REO	80U	349
	GO TO 55	80U	350
53	IF (IT.GT.0) GO TO 55	80U	351

	DLST=GMA*CDS(J-3)+GMB*CDS(J-2)+GMC*CDS(J-1)+GMD*CDS(J)	80U	352
	THBL=GMA*CTHA+GMB*CTHB+GMC*CTHC+GMD*CTH	80U	353
	MBL=DLST/THBL	80U	354
	DLTBL=GMA*DLTA+GMB*DLTB+GMC*DLTC+GMD*DELTA	80U	355
	REOBL=GMA*REOA+GMB*REOB+GMC*REOC+GMD*REO	80U	356
	REOFT=TLV*REOBL	80U	357
	RETH=THBL*REOBL	80U	358
	REDL=DLTBL*REOBL	80U	359
	RETHG=DLOG10(RETH)	80U	360
	REDLG=DLOG10(REDL)	80U	361
	XNBL=GMA*XNA+GMB*XNB+GMC*XNC+GMD*XN	80U	362
	GO TO 55	80U	363
54	IF ((J.GT.3).AND.(MOD(J,10).NE.0)) GO TO 56	80U	364
55	WRITE (6,86) S(J),DSU,THU,CTH,HU,H,CH,XN	80U	365
56	CONTINUE	80U	366
	RW(1)=RCO(1)	80U	367
	CALL SCONV(S,DLA,DAX,KAT)	80U	368
	DO 57 J=1,KAT	80U	369
57	DRX(J)=WALTAN(J)*DAX(J)	80U	370
	IF ((IT.GT.0).OR.(LD.LT.0)) GO TO 58	80U	371
	IF ((IV.GT.1).AND.(IV.LT.IW)) GO TO 58	80U	372
	IF (KBL.LE.KAT) WRITE (6,85) XBL,DLST,THBL,MBL,XNBL,DLTBL,REOFT,REOBL	80U	373
	1TH,RETHG,REDL,REDLG	80U	374
	IF (KBL.LE.KAT) GO TO 58	80U	375
	MBL=CDS(KAT)/CTH	80U	376
	REOFT=TLV*REO	80U	377
	RETH=CTH*REO	80U	378
	REDL=DELTA*REO	80U	379
	RETHG=DLOG10(RETH)	80U	380
	REDLG=DLOG10(REDL)	80U	381
	IF (KBL.GT.KAT) WRITE (6,85) S(KAT),CDS(KAT),CTH,MBL,XN,DELTA,REOFT,REOBL	80U	382
	1T,RETH,RETHG,REDL,REDLG	80U	383
58	CONTINUE	80U	384
	DD2=BMA*DLA(1)+BMB*DLA(2)+BMC*DLA(3)	80U	385
	DR2=SD(1)*DD2	80U	386
	OXS=DAX(1)/DR2	80U	387
	XST=S(1)-OXS	80U	388
	YST=RCO(1)-HALF*DAX(1)**2/DR2	80U	389
	SCW=DSQRT(ONE*DAX(1)**2)	80U	390
	DR2=DR2/SCW**3	80U	391
	RCV=ONE/DR2/YST	80U	392
	IF (IT.GT.0) XBIN=SBIN-XST	80U	393
	IF (IT.GT.0) XCIN=SCIN-XST	80U	394
	WRITE (6,78) ITLE,XBIN,XCIN,SF	80U	395
	PPQ=ZRO	80U	396
	WRITE (6,67) RC,ETAD,AMACH,BHACH,CMACH,EMACH,MC,AM	80U	397
	IF (TWT.NE.ZRO) GO TO 59	80U	398
	WRITE (6,81) PPS,TO	80U	399
	GO TO 5	80U	400
59	WRITE (6,79) PPS,TO,TWT,TWAT,TAIR	80U	401
	GO TO 5	80U	402
60	IF (IT.EQ.0) GO TO 63	80U	403
	DO 61 K=1,KAT	80U	404
	S(K)=SREF(K)-XST	80U	405
61	SCV(K)=DSQRT(ONE+DRX(K)**2)	80U	406
	SCV(1)=ONE	80U	407

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SL(1)=ZRO                                80U 408
IM=(KAT-1)/2                             80U 409
DO 62 I=1,IM                             80U 410
J=2*I                                    80U 411
SS=S(J)-S(J-1)                          80U 412
IF (I.EQ.1) SS=S(2)                     80U 413
TT=S(J+1)-S(J)                          80U 414
ST=SS+TT                                80U 415
S1=(TWO-TT/SS)*ST/SIX                    80U 416
S3=(TWO-SS/TT)*ST/SIX                    80U 417
S2=ST-S1-S3                             80U 418
SA=(TWO+TT/ST)*SS/SIX                    80U 419
SB=(TWO+ST/TT)*SS/SIX                    80U 420
SC=SS-SA-SB                             80U 421
SL(J)=SL(J-1)+SA*SCV(J-1)+SB*SCV(J)+SC*SCV(J+1) 80U 422
62 SL(J+1)=SL(J-1)+S1*SCV(J-1)+S2*SCV(J)+S3*SCV(J+1) 80U 423
XST=ZRO                                80U 424
WRITE (6,68) LS,DK                      80U 425
WRITE (6,69) (K,S(K),SL(K),DLA(K),RCO(K),WALTAN(K),SK(K),DAX(K),DRBOU 426
IX(K),WMN(K),DMDX(K),SPR(K),BTA(K),K=1,KAT) 80U 427
IF (KBL.GT.KAT) GO TO 64                 80U 428
CALL TWIXT (SL,GMA,GMB,GMC,GMD,SBL,KAT,KBL) 80U 429
XBL=GMA*S(KBL-3)+GMB*S(KBL-2)+GMC*S(KBL-1)+GMD*S(KBL) 80U 430
DLAB=GMA*DLA(KBL-3)+GMB*DLA(KBL-2)+GMC*DLA(KBL-1)+GMD*DLA(KBL) 80U 431
RCOB=GMA*RCO(KBL-3)+GMB*RCO(KBL-2)+GMC*RCO(KBL-1)+GMD*RCO(KBL) 80U 432
WRITE (6,89) XBL,SBL,DLAB,RCOB,GMA,GMB,GMC,GMD 80U 433
GO TO 64                                80U 434
63 WRITE (6,68) LY,DD                    80U 435
WRITE (6,69) (K,S(K),FS(K),DLA(K),RCO(K),WALTAN(K),SD(K),DAX(K),DRBOU 436
IX(K),WMN(K),DMDX(K),SPR(K),BTA(K),K=1,KAT) 80U 437
IF (KBL.GT.KAT) GO TO 64                 80U 438
CALL TWIXT (S,GMA,GMB,GMC,GMD,XBL,KAT,KBL) 80U 439
DLAB=GMA*DLA(KBL-3)+GMB*DLA(KBL-2)+GMC*DLA(KBL-1)+GMD*DLA(KBL) 80U 440
RCOB=GMA*RCO(KBL-3)+GMB*RCO(KBL-2)+GMC*RCO(KBL-1)+GMD*RCO(KBL) 80U 441
YBL=RCOB-DLAB                           80U 442
WRITE (6,84) XBL,YBL,DLAB,RCOB,GMA,GMB,GMC,GMD 80U 443
64 WRITE (6,87) XST,YST,DD2,DR2,RCV      80U 444
S(1)=XST                                80U 445
RCO(1)=YST                              80U 446
DRX(1)=ZRO                              80U 447
IF (SBL.EQ.1.D+3) RETURN                 80U 448
IF (LY.GT.0) GO TO 3                     80U 449
65 CONTINUE                             80U 450
IF (J.EQ.1) WRITE (6,90) IPQ,QFUNW,TWT 80U 451
RETURN                                    80U 452
C                                         80U 453
66 FORMAT (6E10.0,4I5)                   80U 454
67 FORMAT (1H,4H RC=F11.6,3X,5HETAD=F8.4,4H DEG,3X,6HACH=F10.7,3XBOU 455
1,6HBMACH=F10.7,3X,6HBMACH=F10.7,3X,6HEMACH=F10.7,3X,A4,2HH=F11.7/180U 456
68 FORMAT (1H,7X,9HSTA(IN) ,A4,40H(IN) DELR(IN) R(IN) DY80U 457
1/DX ,A8,50H DA/DX OR/DX MACH NO. DM/DX PE/PO,780U 458
2X,4HRETA /)                             80U 459
69 FORMAT (10(I4,0P2F11.6,2F11.7,4F10.7,F11.7,F10.7,1P2E12.4/)) 80U 460
70 FORMAT (1H,5X,34HQUADRATIC TEMPERATURE DISTRIBUTION) 80U 461
71 FORMAT (1H,5X,34HPARABOLIC TEMPERATURE DISTRIBUTION) 80U 462
72 FORMAT (1H,44X,34HSPALDING-CHI REFERENCE TEMPERATURE) 80U 463

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73  FORMAT (1H+.83X.36HVAN DRIEST REFERENCE REYNOLDS NUMBER /)      80U 464
74  FORMAT (1H+.83X.35HCOLES LAW REFERENCE REYNOLDS NUMBER /)      80U 465
75  FORMAT (1H+.44X.34HMODIF. SPALDING-CHI REFERENCE TEMP)         80U 466
76  FORMAT (1H+.83X.40HREFERENCE REYNOLDS NUMBER BASED ON DELTA /)  80U 467
77  FORMAT (1H+.44X.29HMODIFIED COLES TRANSFORMATION /)            80U 468
78  FORMAT (1H1.3A4.39HNOZZLE CONTOUR. RADIAL FLOW ENDS AT STA.F12.7.280U 469
15H. TEST CONE BEGINS AT STA.F1.7.16H. SCALE FACTOR =F13.8/)      80U 470
79  FORMAT (1H .1X.15HSTAG. PRESSURE=FS.0.24H PSI. STAG. TEMPERATURE=.80U 471
1F5.0.21H DEG R. THROAT TEMP.=F5.0.19H DEG R. WALL TEMP.=F4.0.24H DB0U 472
2EG R. THROAT HT COEF.=F8.5//)                                     80U 473
80  FORMAT (1H1.3A4.49HBOUNDARY LAYER CALCULATIONS. STAGNATION PRESSUR80U 474
1E=FS.0.28HPSI. STAGNATION TEMPERATURE=.F5.0.27H DEG R. N BASED ON 80U 475
2RE.DELTA //)                                                     80U 476
81  FORMAT (1H .5X.15HSTAG. PRESSURE=FS.0.24H PSI STAG. TEMPERATURE=.80U 477
1F5.0.34H DEG R ADIABATIC WALL TEMPERATURE//)                     80U 478
82  FORMAT (1H .5X.38HTW TE TAW TP RE/IN RTHI. 80U 479
14X.3HFRU.5X.4HKCF1.4X.3HKCF.SX.4HKCFS.5X.1HH.6X.2HH1.5X.38HFMY 80U 480
2 KTHP THETA=1 DELTA DELTA=-1 /)                                  80U 481
83  FORMAT (1H .13.2F6.1.F7.1.F6.1.I9.17.4F8.5.F8.4.F7.4.2F8.5.F9.6 . 80U 482
1F7.4.F9.6 )                                                       80U 483
84  FORMAT (1H .3HSTA.2F11.6.2F11.7.7X.27HINTERPOLATION COEFFICIENTS,.80U 484
1 F12.8.1H. F11.8.1H. F11.8.1H. F12.8/)                          80U 485
85  FORMAT (1H0.5H X=F7.3.11H. DELTA*=F10.7.10H. THETA=F9.7.680U 486
1H. H=F10.6.6H. N=F10.7.10H. DELTA=F11.7.10H. RE/FT=F1180U 487
2.0//35X.9HRE.THETA=F9.0.8H. LOG=F8.5.1H.16X.9HRE.DELTA=F11.080U 488
3.8H. LOG=F8.5)                                                    80U 489
86  FORMAT (1H .3X.2HX=F7.3.8H. DSU=F8.5.8H. THU=F9.7.8H. CTH80U 490
1=F9.7.7H. HU=F10.6.6H. H=F10.6.7H. CM=F10.6.6H. N=F8.80U 491
25)                                                                  80U 492
87  FORMAT (1H .3HSTA.F11.6.9H. Y*=F11.7.14H. D2A/DX2=F12.9.80U 493
114H. D2R/DX2=F12.9.16H. VISCID RC=F14.8 )                       80U 494
88  FORMAT (1H .1RTHX=.1PE12.5.1. REO=.1E12.5.1. FR0=.1OPF8.5.1. TH=.80U 495
1.F8.5.1. DELTA=.1.F8.5.1. DOT=.1.F9.5 )                         80U 496
89  FORMAT (1H .3HSTA.2F11.6.2F11.7.7X.27HINTERPOLATION COEFFICIENTS,.80U 497
1F12.8.1H. F11.8.1H. F11.8.1H. F12.8 /)                          80U 498
90  FORMAT (1H0.1 ITERATION.14.1. QFUN =.1.F8.5.1. THROAT TEMP =80U 499
1.1.F6.1 / )                                                       80U 500
END                                                                    80U 501
SUBROUTINE CONIC (XM*8)
CON 1
C TO OBTAIN MACH NUMBER DERIVATIVES IN RADIAL FLOW
CON 2
IMPLICIT REAL*8(A-H,O-Z)
CON 3
COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,RGA,QT
CON 4
DATA ONE 1.0+0./,TWO/2.0+0./,THR/3.0+0./,FOUR/4.0+0/
CON 5
DIMENSION B(4)
CON 6
XMM=XM*XM
CON 7
XMM1=XMM-ONE
CON 8
XMM2=XMM1**2
CON 9
BMM=ONE+G8*XMM
CON 10
AREA=(G6+G5*XMM)**GA/XM
CON 11
B(1)=AREA**QT
CON 12
B(2)=XM*BMM/QT/XMM1/B(1)
CON 13
C2=TWO-(ONE+THR*G8)/QT
CON 14
C4=G8/QT-ONE
CON 15
CMM=XMM*(C2+XMM*C4)-ONE-ONE/QT
CON 16
B(3)=B(2)*CMM/XMM2/B(1)
CON 17
DMM=(FOUR*C4*XMM+TWO*C2)/CMM-FOUR/XMM1
CON 18

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	B(4)=B(3)*(B(3)/B(2)+X*B(2)*DMM-ONE/B(1))	CON	19
	RETURN	CON	20
	END	CON	21
	FUNCTION CUBIC (EA,EB,EC,ED)	CUB	1
	IMPLICIT REAL*8(A=H,O=Z)	CUB	2
C	TO OBTAIN POSITIVE REAL ROOT OF CUBIC EQUATION	CUB	3
	DATA ZRO/0.0D+0/,ONE/1.0+0/,TWO/2.0+0/,THR/3.0+0/	CUB	4
	E3=EB/THR	CUB	5
	Q1=EA*EC/THR-E3**2	CUB	6
	R1=EA*(E3*EC-EA*ED)/TWO-E3**3	CUB	7
	QR=Q1**3+R1**2	CUB	8
	RQ=DSQRT(DABS(QR))	CUB	9
	Q=DSQRT(DABS(Q1))	CUB	10
	B=DSIGN(ONE,R1)	CUB	11
	CBB=-ONE	CUB	12
	CBC=-ONE	CUB	13
	CBT1=ZRO	CUB	14
	CBT2=ZRO	CUB	15
	A=ZRO	CUB	16
	IF (QR.GT.ZRO) GO TO 1	CUB	17
	IF (QR.NE.ZRO) A=DARSIN(-RQ/Q1/Q)/THR	CUB	18
	CSA=DCOS(A)	CUB	19
	CSNA=DSQRT(THR)*DSIN(A)	CUB	20
	CBA=(TWO*B*Q*CSA-E3)/EA	CUB	21
	CBB=-(B*Q*(CSA+CSNA)+E3)/EA	CUB	22
	CBC=-(B*Q*(CSA-CSNA)+E3)/EA	CUB	23
	GO TO 2	CUB	24
1	IF (R1+RQ.NE.ZRO) CBT1=DSIGN(DEXP(DLOG(DABS(R1+RQ)))/THR),R1+RQ)	CUB	25
	IF (R1-RQ.NE.ZRO) CBT2=DSIGN(DEXP(DLOG(DABS(R1-RQ)))/THR),R1-RQ)	CUB	26
	CBA=(CBT1+CBT2-E3)/EA	CUB	27
2	IA=DSIGN(ONE,CBA)	CUB	28
	IB=DSIGN(ONE,CBB)	CUB	29
	IC=DSIGN(ONE,CBC)	CUB	30
	IF (IA+IB+IC-1) 11,3,7	CUB	31
3	IF (IA.EQ.1) GO TO 5	CUB	32
	IF (IB.EQ.1) GO TO 6	CUB	33
4	CUBIC=CBC	CUB	34
	RETURN	CUB	35
5	CUBIC=CBA	CUB	36
	RETURN	CUB	37
6	CUBIC=CBB	CUB	38
	RETURN	CUB	39
7	IF (IA+2*IB+3*IC-2) 8,9,10	CUB	40
8	IF (CBA.GT.CBB) GO TO 6	CUB	41
	GO TO 5	CUB	42
9	IF (CBA.GT.CBC) GO TO 4	CUB	43
	GO TO 5	CUB	44
10	IF (CBB.GT.CBC) GO TO 4	CUB	45
	GO TO 6	CUB	46
11	AA=A*9.D+1/DARSIN(ONE)	CUB	47
	WRITE (6,12) EA,EB,EC,ED,Q1,R1,QR,RQ,Q,AA,CBA,CBB,CBC	CUB	48
	CUBIC=-ONE	CUB	49
	RETURN	CUB	50
C		CUB	51
12	FORMAT (1H0,3HEA=E14.7,5H EB=E14.7,5H EC=E14.7,5H ED=E14.7,	CUB	52
	15H Q1=E14.7,5H R1=E14.7,5H QR=E14.7/5H RQ=E14.7,5H Q=E14.7,	CUB	53

	Z*, AA=*,E14.7,*,CBA=*,E14.7,*,CBB=*,E14.7,*,CBC=*,E14.7 /)	CUB	54
	END	CUB	55
	FUNCTION FMV (PMA)	FMV	1
	TO OBTAIN MACH NUMBER FROM PRANDTL MEYER ANGLE	FMV	2
C	IMPLICIT REAL*8(A-H,O-Z)	FMV	3
	COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,RGA,QT	FMV	4
	ONE=1.D+0	FMV	5
	THIRD=ONE/3.D+0	FMV	6
	VM=(DARSIN(ONE)*(PMA/(G2-ONE))*2)**THIRD	FMV	7
	Z=ONE+.895D+0*((G7*(G2-ONE))*2)**THIRD*DTAN(VM)	FMV	8
	DO 1 I=1,100	FMV	9
	ZBET=DSQRT(Z*Z-ONE)	FMV	10
	ANG=G2*DATAN(ZBET/G2)-DATAN(ZBET)	FMV	11
	REM=(ANG-PMA)*Z*(Z*Z+G9)/G9/ZBET	FMV	12
	IF (DABS(REM).LT.1.D-10) GO TO 2	FMV	13
1	Z=Z-REM	FMV	14
2	FMV=Z-REM	FMV	15
	RETURN	FMV	16
	END	FMV	17
	SUBROUTINE FVDGE (X,Y,DS,DY)	FV	1
C	IMPLICIT REAL*8(A-H,O-Z)	FVD	2
	DIMENSION X(5), Y(5)	FVD	3
	DATA H/0.5D+0/,TWO/2.0D+0/	FVD	4
C		FVD	5
	X1=X(1)	FVD	6
	X2=X(2)	FVD	7
	X3=X(3)	FVD	8
	X4=X(4)	FVD	9
	X5=X(5)	FVD	10
C		FVD	11
	Y1=Y(1)	FVD	12
	Y2=Y(2)	FVD	13
	Y3=Y(3)	FVD	14
	Y4=Y(4)	FVD	15
	Y5=Y(5)	FVD	16
C		FVD	17
	FIND DELTA=Y.	FVD	18
C	F1=(X3-X1)*(X3-X2)	FVD	19
	F1=TWO/F1	FVD	20
C		FVD	21
	F2=(X4-X3)*(X3-X2)	FVD	22
	F2=-TWO/F2	FVD	23
C		FVD	24
	F3=(X5-X3)*(X4-X3)	FVD	25
	F3=TWO/F3	FVD	26
C		FVD	27
	Z13=X1+X2+X2-X4-X4-X5	FVD	28
	A1=(X2+X3-X4-X5)/Z13	FVD	29
	A3=(X1+X2-X3-X4)/Z13	FVD	30
C		FVD	31
	YP21=(Y2-Y1)/(X2-X1)	FVD	32
	YP32=(Y3-Y2)/(X3-X2)	FVD	33
	YP43=(Y4-Y3)/(X4-X3)	FVD	34
	YP54=(Y5-Y4)/(X5-X4)	FVD	35
C		FVD	36
		FVD	37

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      X21=H*(X2+X1)
      X32=H*(X3+X2)
      X43=H*(X4+X3)
      X54=H*(X5+X4)
C
      YPP1=(YP32-YP21)/(X32-X21)
      YPP2=(YP43-YP32)/(X43-X32)
      YPP3=(YP54-YP43)/(X54-X43)
      DS=A1*YPP1+A3*YPP3-YPP2
      FX=F2-A1*F1-A3*F3
      DY=US/FX
C
      RETURN
      END
      SUBROUTINE HEAT
C
      DUMMY TO BE MODIFIED FOR SPECIAL CALCULATIONS OF HEAT TRANSFER
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /HTTR/ HAIR,TAW,TWQ,TWT,TWAT,QFUN,QFUNW,IPQ,IJ,IV,IW
      QFUNW=QFUN
      RETURN
      END
      SUBROUTINE NEO
C
      SMOOTH BY LINEAR SECOND DERIVATIVE
C
      IMPLICIT REAL*8(A-H,O-Z)
      COMMON /WORK/ E(400),Z(400),X(400),Y(400),YST(400),WTN(250),WALL(5NEO
1,200),WAX(200),WAY(200),WAN(200)
      COMMON /CONTR/ ITLE(3),IE,LR,IT,JB,JQ,JX,KAT,KBL,KING,KO,LV,NOCON,NEO
1IN,MC,MCP,IP,IQ,ISE,JC,H,MP,MQ,N,NP,NR,NUT,NF
      DATA ZERO/0.00*0/,ONE/1.0*0/,TWO/.0*0/
      DATA J0/4H UP/,J1/4HDOWN/
C
      CONV=90.D*0/DARSIN(ONE)
      TNI=DTAN(WALL(5,1))
C
      IF (JQ.EQ.0.OR.IQ.LT.0) READ (5,14,END=13) NOUP,NPCT,NODO
C
      IF (JQ.EQ.0.OR.IQ.LT.0) READ (5,14,END=13) NOUP,NPCT,NODO
      IF (JQ.GT.0) GO TO 2
      JN=J0
      LIM=NUT
      NOTM=NOUP
      DO 1 J=1,LIM
      X(J+1)=WAX(J)
      Y(J+1)=WAY(J)
1
      YST(J+1)=Y(J+1)
      X(1)=TWO*X(2)-X(3)
      Y(1)=Y(3)
      X(LIM+2)=TWO*X(LIM+1)-X(LIM)
      Y(LIM+2)=Y(LIM+1)+TNI*(X(LIM+2)-X(LIM+1))
      GO TO 4
2
      LIM=N+NP-1
      NOTM=NODO
      JN=J1
      DO 3 J=1,LIM
      X(J+1)=WALL(1,J)

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      FVD 38
      FVU 39
      FVD 40
      FVD 41
      FVD 42
      FVD 43
      FVD 44
      FVD 45
      FVD 46
      FVD 47
      FVU 48
      FVD 49
      FVD 50
      FVD 51
      HEA 1
      HEA 2
      HEA 3
      HEA 4
      HEA 5
      HEA 6
      HEA 7
      NEO 1
      NEO 2
      NEO 3
      NEO 4
      NEO 5
      NEO 6
      NEO 7
      NEO 8
      NEO 9
      NEO 10
      NEO 11
      NEO 12
      NEO 13
      NEO 14
      NEO 15
      NEO 16
      NEO 17
      NEO 18
      NEO 19
      NEO 20
      NEO 21
      NEO 22
      NEO 23
      NEO 24
      NEO 25
      NEO 26
      NEO 27
      NEO 28
      NEO 29
      NEO 30
      NEO 31
      NEO 32
      NEO 33
      NEO 34
      NEO 35

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	Y(J+1)=WALL(2,J)	NEO	36
3	YST(J+1)=Y(J+1)	NEO	37
	X(1)=TWO*X(2)-X(3)	NEO	38
	Y(1)=Y(2)-TNI*(X(2)-X(1))	NEO	39
	X(LIM+2)=TWO*X(LIM+1)-X(LIM)	NEO	40
	Y(LIM+2)=Y(LIM+1)	NEO	41
4	LUS=1+(LIM-3)/6	NEO	42
	IF (NOTH.EQ.0) RETURN	NEO	43
	YST(1)=Y(1)	NEO	44
	YST(LIM+2)=Y(LIM+2)	NEO	45
	SMP=1.D-2*NPCT	NEO	46
	WRITE (6,16) ITLE,JN,NOTH,SMP	NEO	47
C		NEO	48
	DO 8 M=1,NOTH	NEO	49
	CALL OREZ (E,800)	NEO	50
C		NEO	51
	DO 5 K=3,LIM	NEO	52
	CALL FVDGE (X(K-2),Y(K-2),E(K),Z(K))	NEO	53
5	CONTINUE	NEO	54
	E(1)=ZERO	NEO	55
	E(2)=ZERO	NEO	56
	E(LIM+1)=ZERO	NEO	57
	E(LIM+2)=ZERO	NEO	58
C	SEARCH ARRAY AND FIND MAX ERR	NEO	59
	DO 7 LU=1,LUS	NEO	60
	EMAX=ZERO	NEO	61
	DO 6 K=-,LIM	NEO	62
	TEST=DABS(E(K))	NEO	63
	IF (EMAX.GT.TEST) GO TO 6	NEO	64
	J=K	NEO	65
	EMAX=TEST	NEO	66
6	CONTINUE	NEO	67
C	APPLY CORRECTION	NEO	68
	E(J)=ZERO	NEO	69
	E(J+1)=ZERO	NEO	70
	E(J+2)=ZERO	NEO	71
	E(J-1)=ZERO	NEO	72
	E(J-2)=ZERO	NEO	73
	Y(J)=Y(J)+SMP*Z(J)	NEO	74
7	CONTINUE	NEO	75
8	CONTINUE	NEO	76
C		NEO	77
	ERR=ZERO	NEO	78
	DO 9 J=1,LIM	NEO	79
	K=J+1	NEO	80
	E(K)=Y(K)-YST(K)	NEO	81
	IF (ERR.LT.DABS(E(K))) MAX=J	NEO	82
	IF (ERR.LT.DABS(E(K))) ERR=DABS(E(K))	NEO	83
	WRITE (6,15) J,X(K),Y(K),YST(K),E(K),J	NEO	84
9	IF (MOD(J,10).EQ.0) WRITE (6,17)	NEO	85
	WRITE (6,19) ERR,MAX	NEO	86
C		NEO	87
	LM=LIM-1	NEO	88
	CALL SCUND (X,Y,WTN,LIM+2)	NEO	89
	IF (JG.EQ.1) GO TO 11	NEO	90
	DO 10 J=2,LM	NEO	91

	WAY(J)=Y(J+1)	NEO	92
10	WAN(J)=CONV*DATAN(WTN(J+1))	NEO	93
	RETURN	NEO	94
C		NEO	95
11	DO 12 J=2,LM	NEO	96
	WALL(2,J)=Y(J+1)	NEO	97
12	WALL(5,J)=DATAN(WTN(J+1))	NEO	98
	RETURN	NEO	99
C		NEO	100
13	WRITE (6,18)	NEO	101
	STOP	NEO	102
C		NEO	103
14	FORMAT (16I5)	NEO	104
15	FORMAT (1H,20X,15,2X,0P4F13.7,18)	NEO	105
16	FORMAT (1H1,3A4,2X,A4,24HSTREAM CONTOUR, SMOOTHED,15,19H TIMES WITNEO	NEO	106
	1H FACTOR=F4.2	NEO	107
	2//34X,1HX,11X,6HY-CALC,7X,4HY-IN,10X,4HDIFF /)	NEO	108
17	FORMAT (1H)	NEO	109
18	FORMAT (1H0,10X,34HCARD NOT AVAILABLE FOR NEGATIVE NF)	NEO	110
19	FORMAT (1H0,26X,21HMAX. ABSOLUTE ERROR =,1PG15.6,10H AT POINT,15)NEO	NEO	111
	END	NEO	112
	SUBROUTINE OFELD (A,B,C,NOCON)	OFE	1
C	TO OBTAIN POINTS IN CHARACTERISTIC NETWORK	OFE	2
	IMPLICIT REAL*8(A-H,O-Z)	OFE	3
	COMMON /CONTR/ ITLE(3),IE	OFE	4
	DATA ZRO/0.0D+0/,ONE/1.0+0/.,TWO/2.0+0/.,HALF/5.0-1/	OFE	5
	DIMENSION A(5), B(5), C(5)	OFE	6
	A1=DARSIN(ONE/A(3))	OFE	7
	A2=DARSIN(ONE/B(3))	OFE	8
	T1=A(5)	OFE	9
	T2=B(5)	OFE	10
	IF (IE.EQ.0) GO TO 8	OFE	11
	IF (A(2).EQ.ZRO) GO TO 5	OFE	12
	FSY1=DSIN(A(5))/A(2)/A(3)	OFE	13
	GO TO 6	OFE	14
5	T1=ZRO	OFE	15
	FSY1=A(5)	OFE	16
6	IF (B(2).EQ.ZRO) GO TO 7	OFE	17
	FSY2=DSIN(B(5))/B(2)/B(3)	OFE	18
	GO TO 8	OFE	19
7	T2=ZRO	OFE	20
	FSY2=B(5)	OFE	21
8	TN1=DTAN(T1-A1)	OFE	22
	IF (B(3).NE.ONE) TN2=DTAN(T2+A2)	OFE	23
	I=-1	OFE	24
	HDP5I=HALF*(A(4)-B(4))	OFE	25
	HT3=HALF*(T1+T2)+HDP5I	OFE	26
	T3=HT3-HALF*IE+HDP5I	OFE	27
	HPSI3=HALF*(A(4)+B(4)+T1-T2)	OFE	28
	PSI3=HPSI3+HALF*IE*(T1-T2)	OFE	29
	C(3)=FMV(PSI3)	OFE	30
	TOLD=T3	OFE	31
1	I=I+1	OFE	32
	FM3=C(3)	OFE	33
	A3=DARSIN(ONE/C(3))	OFE	34
	TNA=HALF*(TN1+DTAN(T3-A3))	OFE	35

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IF (R(3).NE.ONE) TNB=HALF*(DTAN(T3+A3)+TN2)
IF (R(3).EQ.ONE) TNB=TWO*DTAN(T3+A3)
DTN=TNB-TNA
X3=(R(1)*TNB-A(1)*TNA+A(2)-B(2))/DTN
Y3=(A(2)*TNB-B(2)*TNA+(B(1)-A(1))*TNA*TNB)/DTN
IF (IE.EQ.0.OR.DABS(Y3).LT.1.D-9) GO TO 4
FSY3=DSIN(T3)/Y3/FM3
P1=HALF*(FSY1+FSY3)*(X3-A(1))*DSQRT(ONE+TNA**2)
P2=HALF*(FSY2+FSY3)*(X3-B(1))*DSQRT(ONE+TNB**2)
T3=HT3+HALF*(P1+P2)
PSI3=HPSI3+HALF*(P1+P2)
C(3)=FMV(PSI3)
IF (DABS(T3-TOLD).GT.1.D-9) GO TO 2
IF (DABS(C(3)-FM3).LT.1.D-9) GO TO 4
2 IF (I.EQ.40) GO TO 3
TEMP=T3
T3=(T3+TOLD)*HALF
TOLD=TEMP
GO TO 1
3 NOCON=1
4 C(1)=X3
C(2)=Y3
C(4)=PSI3
C(5)=T3
RETURN
END
SUBROUTINE OREZ (A,NA)
IMPLICIT REAL*8(A-H,O-Z)
DIMENSION A(1)
DO 1 K=1,NA
1 A(K)=0.D+0
RETURN
END
SUBROUTINE PERFC
C
C TO OBTAIN THE INVISCID CONTOUR OF THE NOZZLE
C
IMPLICIT REAL*8(A-H,O-Z)
COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,GA,QT
COMMON /CLINE/ AXIS(5,150),TAXI(5,150),WIP,X1,FRIP,ZONK,SEO,CSE
COMMON /COORD/ S(200),FS(200),WALTAN(200),SD(200),WMN(200),TTR(200)
1),DMDX(200),SPR(200),DPX(200),SECO(200),XBIN,XCIN,GMA,GMB,GMC,GMD
COMMON /WORK/ A(5,150),B(5,150),FINAL(5,150),WALL(5,200),WAX(200),PER
1WAY(200),WAN(200)
COMMON /PROP/ AR,ZO,RO,VISC,VISM,SFOA,XBL,CONV
COMMON /PARAM/ ETAD,RC,AMACH,BMACH,CMACH,EMACH,GMACH,FRC,SF,WWO,WWPER
10P,QM,WE,CBET,XE,ETA,EPSI,BPSI,XO,YO,RRR,SDO,XB,XC,AM,PP,SE,TYE,XAPER
COMMON /TROAT/ FC(6,51)
COMMON /CONTR/ ITLE(3),IE,LR,IT,JB,JQ,JX,KAT,KBL,KING,KO,LV,NOCON,PER
1IN,MC,MCP,IP,IQ,ISE,JC,M,MP,MQ,N,NP,NF,NUT
DIMENSION CHAR(6,150),SU(150),WDX(200),WTAN(200),SCDF(200),YIPER
1(100)
DATA ZRO/0.0D+0/,ONE/1.0D+0/,TWO/2.0D+0/,SIX/6.0D+0/,HALF/5.D-1/
DATA IFR/4HFIRS/,IWL/4HWALL/,LST/4HLAST/,IBL/4H /,THR/3.D+0/
CALL OREZ (A,4*750*250)
CPSI=G2*DATAN(G4*CBET)=DATAN(CBET)
PER 23

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	IF (JQ.GT.0) GO TO 6	PER	24
	IF (LR.EQ.0) GO TO 4	PER	25
C	THROAT CHARACTERISTIC VALUES	PER	26
C	SUMAX=(SE/SEO)**(IE+1)	PER	27
	IF (QM.EQ.ONE) SUMAX=ONE	PER	28
	LQ=ZONK*(LR-1)+1	PER	29
	NL=N+LQ-1	PER	30
	DO 3 J=1,LQ	PER	31
	IF (QM.NE.ONE) GO TO 1	PER	32
	FC(1,J)=FC(1,J)*SE+XO	PER	33
	FC(2,J)=FC(2,J)*SE	PER	34
1	FINAL(1,J)=FC(1,J)	PER	35
	FINAL(2,J)=FC(2,J)	PER	36
	FINAL(3,J)=FC(3,J)	PER	37
	FINAL(4,J)=FC(4,J)	PER	38
	FINAL(5,J)=FC(5,J)	PER	39
	IF (MQ.LT.0) GO TO 3	PER	40
	IF (J.GT.1) GO TO 2	PER	41
	WRITE (6,93) ITLE	PER	42
	WRITE (6,99) IBL	PER	43
2	XMU=CONV*DARSIN(ONE/FINAL(3,J))	PER	44
	PSI=CONV*FINAL(4,J)	PER	45
	AN=CONV*FINAL(5,J)	PER	46
	XINCH=SF*FINAL(1,J)+FRIP	PER	47
	YINCH=SF*FINAL(2,J)	PER	48
	WRITE (6,103) J, (FINAL(K,J),K=1,3),XMU,PSI,AN,XINCH,YINCH	PER	49
	IF (MOD(J,10).EQ.0) WRITE (6,98)	PER	50
3	SU(J)=FC(6,J)/SUMAX	PER	51
4	IF (ISE.EQ.0) GO TO 8	PER	52
C		PER	53
C	INITIAL CHARACTERISTIC VALUES IF NON-RADIAL FLOW	PER	54
	DO 5 K=1,M	PER	55
	A(2,K)=(K-1)*TYE/(M-1)	PER	56
	A(1,K)=A(2,K)*CBET+XE	PER	57
	A(3,K)=CMACH	PER	58
	A(4,K)=CPSI	PER	59
5	A(5,K)=ZRO	PER	60
	GO TO 10	PER	61
C		PER	62
C	FINAL CHARACTERISTIC VALUES IF RADIAL FLOW	PER	63
6	NL=N+NP-1	PER	64
	FN=NP-1	PER	65
	DO 7 JJ=1,NP	PER	66
	IF (IE.EQ.0) F=(JJ-1)/FN	PER	67
	IF (IE.EQ.1) F=TWO*DSIN(HALF*ETA*(JJ-1)/FN)/SE	PER	68
	FINAL(2,JJ)=F*TYE	PER	69
	FINAL(1,JJ)=FINAL(2,JJ)*CBET+XC	PER	70
	FINAL(3,JJ)=CMACH	PER	71
	FINAL(4,JJ)=CPSI	PER	72
	FINAL(5,JJ)=ZRO	PER	73
7	SU(JJ)=F** (IE+1)	PER	74
C		PER	75
C	INITIAL CHARACTERISTIC VALUES IF RADIAL FLOW	PER	76
8	EM=ETA/(M-1)	PER	77
	DO 9 K=1,M	PER	78
		PER	79

	T=(K-1)*EM	PER 80
	IF (IP.EQ.0) XM=FMV(EPSI-T/QT)	PER 81
	IF (IP.NE.0) XM=FMV(BPSI-T/QT)	PER 82
	R=((G6+G5*XM**2)**GA/XM)**QT	PER 83
	XBET=DSQRT(XM**2-ONE)	PER 84
	A(1,K)=R*DCOS(T)	PER 85
	A(2,K)=R*DSIN(T)	PER 86
	A(3,K)=XM	PER 87
	A(4,K)=G2*DATAN(G4*XBET)-DATAN(XBET)	PER 88
9	A(5,K)=T	PER 89
	IF (IE.EQ.1.AND.IP.EQ.0) A(5,1)=TAXI(5,1)	PER 90
	IF (IE.EQ.1.AND.IP.NE.0) A(5,1)=AXIS(5,1)	PER 91
10	DO 11 J=1,5	PER 92
11	WALL(J,1)=A(J,M)	PER 93
	LINE=1	PER 94
	IF (MQ.LT.0) GO TO 14	PER 95
	IF (ISE.EQ.1) GO TO 12	PER 96
	IF (JQ.EQ.0) WRITE (6,91) ITLE	PER 97
	IF (JQ.EQ.1) WRITE (6,94) ITLE	PER 98
	GO TO 13	PER 99
12	WRITE (6,102) ITLE	PER 100
13	WRITE (6,106) LINE	PER 101
14	SU(1)=ZRO	PER 102
	IF (IE.EQ.0) BX=ONE/SE	PER 103
	NN=1	PER 104
	DO 15 K=1,M	PER 105
	DO 15 J=1,5	PER 106
15	B(J,K)=A(J,K)	PER 107
	LAST=M-1	PER 108
	GO TO 20	PER 109
16	LAST=M	PER 110
	LINE=2	PER 111
	IF (IP.NE.0) GO TO 38	PER 112
17	DO 18 J=1,5	PER 113
18	H(J,1)=TAXI(J,LINE)	PER 114
	DO 19 J=1,LAST	PER 115
	K=J	PER 116
	CALL OFELD (A(1,K),B(1,K)+B(1,K+1),NOCON)	PER 117
	IF (NOCON.NE.0) GO TO 83	PER 118
19	CONTINUE	PER 119
20	LASTP=LAST+1	PER 120
	IF (LINE.LT.(LASTP) LP=LINE	PER 121
	NK=1+LP/52	PER 122
	LA=CONV*DARSIN(ONE/B(3,NN))	PER 123
	IPRNT=0	PER 124
	ICHAR=0	PER 125
	IF (JC.EQ.0) GO TO 21	PER 126
	KC=IABS(JC)	PER 127
	IF (JC.GT.0.AND.JQ.NE.0) GO TO 21	PER 128
	IF (JC.LT.0.AND.JQ.EQ.0) GO TO 21	PER 129
	ICHAR=1	PER 130
	IF (KC.GT.100.AND.KC.LT.101+LINE) IPRNT=1	PER 131
	IF (NN.EQ.1.AND.MOD(LINE-1,KC).EQ.0) IPRNT=1	PER 132
	IF (NN.GT.1.AND.MOD(NN-1,KC).EQ.0) IPRNT=1	PER 133
21	DO 27 J=NN, LASTP	PER 134
	IF (IE.EQ.1) BX=TWO*B(2,J)/SE**2	PER 135

	XM=B(3,J)	PER 136
	XMUR=DARSIN(ONE/XM)	PER 137
	XMU=CONV*XMUR	PER 138
	PSI=B(4,J)*CONV	PER 139
	AN=B(5,J)*CONV	PER 140
	IF (B(2,J).EQ.ZRO) AN=ZRO	PER 141
	IF (IP.EQ.0.OR.LA.GT.45) GO TO 22	PER 142
	S(J)=B(1,NN)-B(1,J)	PER 143
C	MASS INTEGRATION WITH RESPECT TO X	PER 144
	DSX=ONE/DCOS(B(5,J)-XMUR)	PER 145
	IF (B(2,J).EQ.ZRO) DSX=XM/DSQRT(XM**2-ONE)	PER 146
	GO TO 23	PER 147
22	S(J)=B(2,J)-B(2,NN)	PER 148
C	MASS INTEGRATION WITH RESPECT TO Y	PER 149
	IF (IP.EQ.0) DSX=ONE/DSIN(XMUR+B(5,J))	PER 150
	IF (IP.NE.0) DSX=ONE/DSIN(XMUR-B(5,J))	PER 151
	IF (B(2,J).EQ.ZRO) DSX=XM	PER 152
23	IF (ICAR.EQ.0.OR.J.NE.LINE) GO TO 24	PER 153
	CHAR(1,J)=B(1,J)	PER 154
	CHAR(2,J)=B(2,J)	PER 155
	CHAR(3,J)=XM	PER 156
	CHAR(4,J)=XMU	PER 157
	CHAR(5,J)=PSI	PER 158
	CHAR(6,J)=AN	PER 159
24	FS(J)=DSX*BX/(G6+G5*XM**2)**GA	PER 160
	IF (MQ.GE.0.AND.LINE.EQ.1) GO TO 25	PER 161
	IF (IPRNT.EQ.0) GO TO 27	PER 162
	IF (J.GT.NN) GO TO 25	PER 163
	IF (IP.EQ.0) WRITE (6,104) ITLE	PER 164
	IF (IP.NE.0) WRITE (6,105) ITLE	PER 165
	WRITE (6,106) LINE	PER 166
25	IF ((NK.GT.1).AND.(MOD(J,NK).EQ.0)) GO TO 26	PER 167
	XINCH=SF*B(1,J)*FRIP	PER 168
	YINCH=SF*B(2,J)	PER 169
	WRITE (6,103) J,B(1,J),B(2,J),XM,XMU,PSI,AN,XINCH,YINCH	PER 170
26	IF (MOD(J,10*NK).EQ.0) WRITE (6,98)	PER 171
27	CONTINUE	PER 172
C		PER 173
C	INTEGRATION AND INTERPOLATION FOR MASS FLOW	PER 174
	SA=ZRO	PER 175
	SB=ZRO	PER 176
	SC=ZRO	PER 177
	SUM=SU(NN)	PER 178
	KAN=(LASTP-NN)/2	PER 179
	DO 28 J=1,KAN	PER 180
	K=NN+2-J	PER 181
	KT=K	PER 182
	AS=S(K-1)-S(K-2)	PER 183
	BS=S(K)-S(K-1)	PER 184
	CS=AS+BS	PER 185
	S1=(TWO-B5/AS)*CS/SIX	PER 186
	S3=(TWO-AS/B5)*CS/SIX	PER 187
	S2=CS-S1-S3	PER 188
	ADD=S1*FS(K-2)+S2*FS(K-1)+S3*FS(K)	PER 189
	SUM=ADD+SUM	PER 190
	IF (LINE.EQ.1) GO TO 28	PER 191

	DEL=ONE-SUM	PER 192
	IF (DEL) 30,29,28	PER 193
28	CONTINUE	PER 194
	IF (LINE.EQ.1) WRITE (6,96) SUM	PER 195
	IF (LINE.EQ.1) GO TO 16	PER 196
	BS=S(K+1)-S(K)	PER 197
	KT=K+1	PER 198
	DN=TWO*DEL/BS	PER 199
	SC=DN/(FS(K)+DSQRT(FS(K)**2+(FS(KT)-FS(K))*DN))	PER 200
	SB=ONE-SC	PER 201
	GO TO 34	PER 202
29	SC=ONE	PER 203
	GO TO 34	PER 204
30	S2=BS*(TWO+CS/AS)/SIX	PER 205
	S3=BS*(TWO+AS/CS)/SIX	PER 206
	S1=BS-S2-S3	PER 207
	BDD=S1*FS(K-2)+S2*FS(K-1)+S3*FS(K)	PER 208
	IF (BDD+DEL) 31,32,33	PER 209
31	DN=TWO*(ADD+DEL)/AS	PER 210
	SB=DN/(FS(K-2)+DSQRT(FS(K-2)**2+(FS(K-1)-FS(K-2))*DN))	PER 211
	SA=ONE-SB	PER 212
	GO TO 34	PER 213
32	SB=ONE	PER 214
	GO TO 34	PER 215
33	DN=TWO*DEL/BS	PER 216
	SC=ONE+DN/(FS(K)+DSQRT(FS(K)**2+(FS(K)-FS(K-1))*DN))	PER 217
	SB=ONE-SC	PER 218
34	DO 35 J=1,5	PER 219
35	WALL(J,LINE)=B(J,KT-2)*SA+B(J,KT-1)*SB+B(J,KT)*SC	PER 220
	IF (IPRNT.EQ.1) WRITE (6,107) (WALL(J,LINE),J=1,5)	PER 221
	LAST=KT	PER 222
	IF (N=LINE) 42,41,36	PER 223
36	LINE=LINE+1	PER 224
	DO 37 K=1,5	PER 225
	DO 37 L=1,150	PER 226
37	A(K,L)=B(K,L)	PER 227
	IF (IP.EQ.0) GO TO 17	PER 228
38	DO 39 J=1,5	PER 229
39	B(J,1)=AXIS(J,LINE)	PER 230
	DO 40 J=1, LAST	PER 231
	K=J	PER 232
	CALL OFELD (B(1,K),A(1,K),B(1,K+1),NOCON)	PER 233
	IF (NOCON.NE.0) GO TO 83	PER 234
40	CONTINUE	PER 235
	GO TO 20	PER 236
41	IF (IP.NE.0) GO TO 42	PER 237
	IF (LR.EQ.0.OR.IT.NE.0) GO TO 49	PER 238
42	IF (LINE.EQ.NL=1) GO TO 48	PER 239
	NN=NN+1	PER 240
	LINE=LINE+1	PER 241
	DO 43 K=1,5	PER 242
	DO 43 L=1,150	PER 243
43	A(K,L)=B(K,L)	PER 244
	DO 44 K=1,5	PER 245
	DO 44 L=1,150	PER 246
44	B(K,L)=FINAL(K,L)	PER 247

	IF ((LR.NE.0).AND.(JO.EQ.0)) GO TO 46	PER 248
	DO 45 J=NN, LAST	PER 249
	K=J	PER 250
	CALL OFELD (B(1,K)+A(1,K)+B(1,K+1), NOCON)	PER 251
	IF (NOCON.NE.0) GO TO 83	PER 252
45	CONTINUE	PER 253
	GO TO 20	PER 254
46	DO 47 J=NN, LAST	PER 255
	K=J	PER 256
	CALL OFELD (A(1,K)+B(1,K)+B(1,K+1), NOCON)	PER 257
	IF (NOCON.NE.0) GO TO 83	PER 258
47	CONTINUE	PER 259
	GO TO 20	PER 260
48	IF (IP.NE.0) GO TO 64	PER 261
C		PER 262
	INTEGRATION OF SLOPES	PER 263
49	IB=1	PER 264
	IF (IABS(JB).GT.1) IB=2	PER 265
	LT=0	PER 266
	IF (IT.NE.0) LT=IB	PER 267
	NUT=(LINE-1)/IB+2-LT	PER 268
	WALL(1, LINE+1)=X0	PER 269
	WALL(5, LINE+1)=ZRO	PER 270
	YI(NUT)=WALL(2, 1)	PER 271
	Y=YI(NUT)	PER 272
	LIN=2*((LINE-LT)/2)	PER 273
	DO 50 J=2, LIN+2	PER 274
	I=NUT-J	PER 275
	SS=WALL(1, J)-WALL(1, J-1)	PER 276
	TT=WALL(1, J+1)-WALL(1, J)	PER 277
	ST=SS+TT	PER 278
	S1=SS*(TWO+TT/ST)/SIX	PER 279
	S2=SS*(TWO+ST/TT)/SIX	PER 280
	S3=SS-S1-S2	PER 281
	T3=TT*(TWO+SS/ST)/SIX	PER 282
	T2=TT*(TWO+ST/SS)/SIX	PER 283
	T1=TT-T2-T3	PER 284
	Y=Y+S1*DTAN(WALL(5, J-1))+S2*DTAN(WALL(5, J))+S3*DTAN(WALL(5, J+1))	PER 285
	IF (IB.EQ.1) YI(I+1)=Y	PER 286
	Y=Y+T1*DTAN(WALL(5, J-1))+T2*DTAN(WALL(5, J))+T3*DTAN(WALL(5, J+1))	PER 287
	IF (IB.EQ.1) YI(I)=Y	PER 288
	IF (IB.EQ.2) YI(I+J/2)=Y	PER 289
50	CONTINUE	PER 290
	IF (LR.NE.0.AND.LINE.EQ.LIN) GO TO 51	PER 291
	X=WALL(1, LINE-LT)-X0	PER 292
	YI(1)=YI(2)-X*(DTAN(WALL(5, LINE-LT))+HALF*X*SDO)/THR	PER 293
51	DO 52 L=2, NUT	PER 294
	JJ=1+IB*(NUT-L)	PER 295
	WAX(L)=WALL(1, JJ)	PER 296
	WAY(L)=WALL(2, JJ)	PER 297
	WHN(L)=WALL(3, JJ)	PER 298
	WAN(L)=CONV*WALL(5, JJ)	PER 299
52	WALTAN(L)=DTAN(WALL(5, JJ))	PER 300
	WAX(1)=X0	PER 301
	WAY(1)=Y0	PER 302
	WAN(1)=ZRO	PER 303

	WMN(1)=WVO/DSQRT(G7-G8*WVO**2)	PER 304
	WALTAN(1)=ZRO	PER 305
	IF (NF.GE.0) GO TO 54	PER 306
C		PER 307
C	SMOOTH UPSTREAM CONTOUR IF DESIRED	PER 308
	CALL NEO	PER 309
	DO 53 J=1,NUT	PER 310
53	WALTAN(J)=DTAN(WAN(J)/CONV)	PER 311
54	CALL SCOND (WAX,WALTAN,SECD,NUT)	PER 312
	SECD(1)=S00	PER 313
	SECD(NUT)=ZRO	PER 314
	KO=NUT*MP	PER 315
	IF (MP.EQ.0) GO TO 56	PER 316
C		PER 317
C	RADIAL FLOW SECTION COORDINATES	PER 318
	SNE=DSIN(ETA)	PER 319
	TNE=DTAN(ETA)	PER 320
	DM=(AMACH-GMACH)/MP	PER 321
	DO 55 L=1,MP	PER 322
	LL=NUT*L	PER 323
	WMN(LL)=GMACH*L*DM	PER 324
	RL=((G5*WMN(LL)**2+G6)**GA/WMN(LL))**QT	PER 325
	WAX(LL)=RL*CSE	PER 326
	WAY(LL)=RL*SNE	PER 327
	WAN(LL)=ETAD	PER 328
	WALTAN(LL)=TNE	PER 329
55	SECD(LL)=ZRO	PER 330
56	IF (MQ.LT.0) GO TO 60	PER 331
	IF (JC.LE.0) GO TO 58	PER 332
	WRITE (6,105) ITLE	PER 333
	WRITE (6,99) LST	PER 334
	DO 57 K=1,LP,NK	PER 335
	I=(K-1)/NK+1	PER 336
	XINCH=SF*CHAR(1,K)*FRIP	PER 337
	YINCH=SF*CHAR(2,K)	PER 338
	WRITE (6,103) K,(CHAR(J,K),J=1,6),XINCH,YINCH	PER 339
57	IF (MOD(I,10).EQ.0) WRITE (6,98)	PER 340
58	IF (ISE.EQ.0) WRITE (6,91) ITLE	PER 341
	IF (ISE.EQ.1) WRITE (6,102) ITLE	PER 342
	WRITE (6,84) RC,ETAD,AMACH,BMACH,CMACH,EMACH,MC,AH	PER 343
	IF (NOCUN.NE.0) GO TO 59	PER 344
	WRITE (6,100) IWL	PER 345
	WRITE (6,85) (K,WAX(K),WAY(K),WMN(K),WAN(K),WALTAN(K),SECD(K),K=1,	PER 346
	INUT)	PER 347
	IF ((LR.EQ.0).AND.(N.LT.42)) GO TO 59	PER 348
	IF ((LR.NE.0).AND.(N+LR.LT.27)) GO TO 59	PER 349
	NOCUN=1	PER 350
	GO TO 58	PER 351
59	WRITE (6,87)	PER 352
	NOCUN=0	PER 353
C		PER 354
C	COMPARISON OF CONTOUR WITH PARABOLA AND HYPERBOLA	PER 355
60	DO 62 J=1,NUT	PER 356
	X5=(WAX(J)-X0)/Y0	PER 357
	X52=X5**2	PER 358
	X53=X5**3	PER 359

	YS=WAY(J)/Y0	PER 360
	YE=YI(J)/Y0	PER 361
	PS=ONE*HALF*XS2*RRC	PER 362
	DHP=ONE*XS2*RRC	PER 363
	HS=DSORT(DHP)	PER 364
	IF (J.GT.1) GO TO 61	PER 365
	IF (MQ.LT.0) GO TO 62	PER 366
	WRITE (6,88) J,XS,YS,YE,PS,HS	PER 367
	GO TO 62	PER 368
61	YPX=WALTAN(J)/XS	PER 369
	CY=(PS-YS)/XS3	PER 370
	CI=(PS-YE)/XS3	PER 371
	IF (J.EQ.2) ICY=1.D+6*(DABS(CY)-DABS(CI))	PER 372
	IF (MQ.LT.0) GO TO 63	PER 373
	CYP=(RRC-YPX)/XS/THR	PER 374
	WRITE (6,88) J,XS,YS,YE,PS,HS,CY,CI,CYP	PER 375
62	IF (MOD(J,10).EQ.0) WRITE (6,98)	PER 376
63	WRITE (6,97) ICY	PER 377
	IF (IQ.GT.0) GO TO 70	PER 378
	JQ=1	PER 379
	RETURN	PER 380
64	LINE=NL	PER 381
	DO 65 J=1,5	PER 382
65	WALL(J,NL)=FINAL(J,NP)	PER 383
C		PER 384
C	SMOOTH DOWNSTREAM CONTOUR IF DESIRED	PER 385
	IF (NF.LT.0) CALL NEO	PER 386
	DO 66 J=1,NL	PER 387
	WDX(J)=WALL(1,J)	PER 388
66	WTAN(J)=DTAN(WALL(5,J))	PER 389
	CALL SCOND (WDX,WTAN,SCDF,NL)	PER 390
	SCDF(1)=ZRO	PER 391
	SCDF(NL)=ZRO	PER 392
	IF (JC.GE.0) GO TO 68	PER 393
	WRITE (6,104) ITLE	PER 394
	WRITE (6,99) IFR	PER 395
	DO 67 K=1,LP,NK	PER 396
	I=(K-1)/NK+1	PER 397
	XINCH=SF*CHAR(1,K)*FRIP	PER 398
	YINCH=SF*CHAR(2,K)	PER 399
	WRITE (6,103) K,(CHAR(J,K),J=1,6),XINCH,YINCH	PER 400
67	IF (MOD(I,10).EQ.0) WRITE (6,98)	PER 401
68	IF (IQ.LT.0) KO=1	PER 402
	NAG=KO-1	PER 403
	KING=LINE+NAG	PER 404
	DO 69 L=1,LINE	PER 405
	WAX(NAG+L)=WALL(1,L)	PER 406
	WAY(NAG+L)=WALL(2,L)	PER 407
	WMN(NAG+L)=WALL(3,L)	PER 408
	WAN(NAG+L)=CONV*WALL(5,L)	PER 409
	WALTAN(NAG+L)=WTAN(L)	PER 410
69	SECD(NAG+L)=SCDF(L)	PER 411
	IF (MQ.LT.0) GO TO 71	PER 412
	WRITE (6,94) ITLE	PER 413
	WRITE (6,84) RC,ETAD,AMACH,BNACH,CNACH,EMACH,MC,AM	PER 414
	WRITE (6,100) IWL	PER 415

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        WRITE (6,85) (K,WAX(K),WAY(K),WMN(K),WAN(K),WALTAN(K),SECD(K),K=KOPER 416
1,KING) PER 417
        GO TO 71 PER 418
70 KING=KO PER 419
C PER 420
C APPLICATION OF SCALE FACTOR TO NON-DIMENSIONAL COORDINATES PER 421
71 DO 72 K=1,KING PER 422
    S(K)=SF*WAX(K)+FRIP PER 423
    FS(K)=SF*WAY(K) PER 424
    TTR(K)=ONE+GB*WMN(K)**2 PER 425
    SPR(K)=ONE/TTR(K)**(ONE+G1) PER 426
72 SD(K)=SECD(K)/SF PER 427
    IF (ISE.EQ.1) XBIN=ZRO PER 428
    IF (ISE.EQ.0) XBIN=XB*SF+FRIP PER 429
    XCIN=XC*SF+FRIP PER 430
    CALL SCND (S,WMN,DMDX,KING) PER 431
    DMDX(1)=G7*WWOP*WMN(1)**3/WWO**3/SF PER 432
    IF (MP.EQ.0.OR.IQ.LT.0) GO TO 74 PER 433
    DO 73 K=NUT,KO PER 434
73 DMDX(K)=WMN(K)*TTR(K)/(WMN(K)**2-ONE)/QT/SF/WAX(K) PER 435
    GO TO 75 PER 436
74 IF (ISE.EQ.0) DMDX(KO)=AMACH*TTR(KO)/(AMACH**2-ONE)/QT/SF/XA PER 437
75 IF (IQ.LT.1.OR.ISE.EQ.1) DMDX(KING)=ZRO PER 438
    DO 76 K=1,KING PER 439
76 DPX(K)=-GAM*WMN(K)*DMDX(K)*SPR(K)/TTR(K) PER 440
    JQ=0 PER 441
    KAT=KING PER 442
    IF (IABS(MQ).LT.2) GO TO 78 PER 443
C PER 444
C EXTENSION OF PARALLEL-FLOW CONTOUR PER 445
KIT=KING+1 PER 446
KAT=KING+IABS(MQ) PER 447
KUT=S(KING)+HALF PER 448
INC=S(KING)-S(KING-1) PER 449
IF (INC.LT.1) INC=1 PER 450
DO 77 K=KIT,KAT PER 451
S(K)=KUT+(K-KING)*INC PER 452
FS(K)=FS(KING) PER 453
WMN(K)=WMN(KING) PER 454
TTR(K)=TTR(KING) PER 455
SPR(K)=SPR(KING) PER 456
WAN(K)=ZRO PER 457
WALTAN(K)=ZRO PER 458
DMDX(K)=ZRO PER 459
DPX(K)=ZRO PER 460
77 SD(K)=ZRO PER 461
78 IF (XBL.EQ.ZRO) GO TO 79 PER 462
    IF (S(KING-1).LT.XBL) GO TO 79 PER 463
C PER 464
C INTERPOLATE FOR VALUES AT SPECIFIED STATION PER 465
CALL TWIXT (S,GMA,GMB,GMC,GMD,-BL,KING,XBL) PER 466
GO TO 80 PER 467
79 KBL=KAT+4 PER 468
80 IF (JB.GT.0) RETURN PER 469
    IF (ISE.EQ.0) GO TO 81 PER 470
    WRITE (6,102) ITLE PER 471

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WRITE (6,92) RC,SE,XCIN PER 472
GO TO 82 PER 473
81 IF (IQ.GT.0) WRITE (6,91) ITLE PER 474
IF (IQ.LE.0) WRITE (6,95) ITLE,XBIN,XCIN,SF PER 475
WRITE (6,84) RC,ETA0,AMACH,BMACH,CMACH,EMACH,MC,AM PER 476
82 WRITE (6,89) PER 477
WRITE (6,90) (K,S(K),FS(K),WALTAN(K),SD(K),WMN(K),DMDX(K),SPR(K),DPER 478
1PX(K),K=1,KING) PER 479
IF (KBL.GT.KAT) RETURN PER 480
J=KBL-1 PER 481
FSX=GMA*FS(J-2)+GMB*FS(J-1)+GMC*FS(J)+GMD*FS(J+1) PER 482
WMNX=GMA*WMN(J-2)+GMB*WMN(J-1)+GMC*WMN(J)+GMD*WMN(J+1) PER 483
DMXX=GMA*DMDX(J-2)+GMB*DMDX(J-1)+GMC*DMDX(J)+GMD*DMDX(J+1) PER 484
DYDX=GMA*WALTAN(J-2)+GMB*WALTAN(J-1)+GMC*WALTAN(J)+GMD*WALTAN(J+1) PER 485
SDX=GMA*SD(J-2)+GMB*SD(J-1)+GMC*SD(J)+GMD*SD(J+1) PER 486
SPRX=GMA*SPR(J-2)+GMB*SPR(J-1)+GMC*SPR(J)+GMD*SPR(J+1) PER 487
DPXX=GMA*DPX(J-2)+GMB*DPX(J-1)+GMC*DPX(J)+GMD*DPX(J+1) PER 488
WRITE (6,101) XBL,FSX,DYDX,SDX,WMNX,DMXX,SPRX,DPXX PER 489
RETURN PER 490
83 WRITE (6,86) IP,NN,LINE,J PER 491
RETURN PER 492
C PER 493
84 FORMAT (1H,4H RC=,F11.6,3X,SHETAD=F8.4,4H DEG,3X,6HAMACH=F10.7,3XPER 494
1,6HBMACH=F10.7,3X,6HCMACH=F10.7,3X,6HEMACH=F10.7,3X,A4,2HH=F11.7//)PER 495
85 FORMAT (10(8X,I3,2X,1P6E15.7//)) PER 496
86 FORMAT (1H0,9HOFELD,IP=,I3,5H, NN=,I3,7H, LINE=,I3,8H, POINT=,I3 )PER 497
87 FORMAT (1H,9X,'POINT X/YO',8X,'Y/YO',7X,'INT.Y/YO',7X,'PAR/YO'PER 498
1',7X,'MYP/YO C(Y)',11X,'C(YI)',10X,'C(YP)' /) PER 499
88 FORMAT (1H,9X,I3,5F13.7,1P3E15.6 ) PER 500
89 FORMAT (1H,9X,5HPOINT,7X,5HX(IN),9X,5HY(IN),9X,5HDY/DX,8X,7HD2Y/DPER 501
1X2,7X,8HMMACH NO.,7X,5HDM/DX,9X,5HPE/PO,11X,6HDP/DX//) PER 502
90 FORMAT (10(10X,I3,2X,0P6F14.7,1P2E16.5//)) PER 503
91 FORMAT (1H1,3A4,17H UPSTREAM CONTOUR//) PER 504
92 FORMAT (1H, ' RC=,F11.7,' , STREAMLINE RATIO=,F11.8,' , TESTPER 505
1 CONE BEGINS AT',F12.7,' IN,' / ) PER 506
93 FORMAT (1H1,3A4,22H THROAT CHARACTERISTIC ) PER 507
94 FORMAT (1H1,3A4,19H DOWNSTREAM CONTOUR/) PER 508
95 FORMAT (1H1,3A4,45H INVISCID NOZZLE CONTOUR, RADIAL FLOW ENDS ATF1PER 509
11.6,25H IN., TEST CONE BEGINS ATF11.6,19H IN., SCALE FACTOR=F9.4//)PER 510
96 FORMAT (1H0,8X,6HMASS =,F13.10) PER 511
97 FORMAT (1H0,9X,5HICY =,I13 / ) PER 512
98 FORMAT (1H ) PER 513
99 FORMAT (1H,8X,A4/8X,5HPOINT,8X,1HX,14X,1HY,10X,68HMMACH NO. NPER 514
1ACH ANG.(D) PSI (D) FLOW ANG.(D) X(IN),9X,5HY(IN))//)PER 515
100 FORMAT (1H,8X,A4/8X,5HPOINT,8X,1HX,14X,1HY,10X,37HMMACH NO. FPER 516
1LOW ANG.(D) WALTAN,9X,6HSECDIF//) PER 517
101 FORMAT (1H0,14X,6F14.7,1P2E16.5) PER 518
102 FORMAT (1H1,3A4,17H INVISCID CONTOUR//) PER 519
103 FORMAT (1H,110,2X,1P6E15.7,0P2F14.7) PER 520
104 FORMAT (1H1,3A4,33H INTERMEDIATE LEFT CHARACTERISTIC //) PER 521
105 FORMAT (1H1,3A4,34H INTERMEDIATE RIGHT CHARACTERISTIC //) PER 522
106 FORMAT (1H,8H CHARACTER,14/8X,5HPOINT,8X,1HX,14X,1HY,10X,68HMMACH NOPER 523
1, MACH ANG.(D) PSI (D) FLOW ANG.(D) X(IN),9X,5PER 524
2HY(IN) //) PER 525
107 FORMAT (1H0,12H CONTOUR,1P3E15.7 ) PER 526
END PER 527

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	SUBROUTINE PLATE	PLA	1
C	DUMMY TO BE MODIFIED FOR SPECIAL CALCULATIONS FOR FLEXIBLE PLATE	PLA	2
	IMPLICIT REAL*8(A-H,O-Z)	PLA	3
	COMMON /JACK/ SJ(30),XJ(30),YJ(30),AJ(30)	PLA	4
	RETURN	PLA	5
	END	PLA	6
	SUBROUTINE SCOND (A,B,C,KING)	SCO	1
C	TO OBTAIN PARABOLIC DERIVATIVE OF CURVE (UNEQUALLY SPACED POINTS)	SCO	2
	IMPLICIT REAL*8(A-H,O-Z)	SCO	3
	DIMENSION A(300), B(300), C(300)	SCO	4
	N=KING-1	SCO	5
	DO 1 K=2,N	SCO	6
	S=A(K)-A(K-1)	SCO	7
	T=A(K+1)-A(K)	SCO	8
1	C(K)=(B(K+1)-B(K))*S*(B(K)-B(K-1))*T)/(S*S*T+T*T)	SCO	9
	S0=A(2)-A(1)	SCO	10
	T0=A(3)-A(2)	SCO	11
	Q0=S0*T0	SCO	12
	C(1)=(-T0*(Q0+S0)*B(1)+Q0*Q0*B(2)-S0*S0*B(3))/Q0/S0/T0	SCO	13
	SF=A(KING-1)-A(KING-2)	SCO	14
	TF=A(KING)-A(KING-1)	SCO	15
	QF=SF*TF	SCO	16
	QST=QF*SF*TF	SCO	17
	C(KING)=(SF*(QF+TF)*B(KING)-QF*QF*B(KING-1)+TF*TF*B(KING-2))/QST	SCO	18
	RETURN	SCO	19
	END	SCO	20
	SUBROUTINE SORCE (W,B)	SOR	1
C	TO OBTAIN VELOCITY DERIVATIVES IN RADIAL FLOW	SOR	2
	IMPLICIT REAL*8(A-H,O-Z)	SOR	3
	COMMON /GG/ GAM,GH,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,RGA,GT	SOR	4
	DATA ONE/1.0+0/,TWO/2.0+0/,THR/3.0+0/,FOUR/4.0+0/	SOR	5
	DIMENSION B(4)	SOR	6
	WW=W*W	SOR	7
	AL=G7*G9	SOR	8
	AWW=AL*WW	SOR	9
	WW1=WW-ONE	SOR	10
	AREA=((AL-ONE)/AWW)**G1)/W	SOR	11
	B(1)=AREA*GT	SOR	12
	AXW=AL*WW1*B(1)	SOR	13
	B(2)=W*AWW/AXW/GT	SOR	14
	C2=THR/GT*AL*(TWO-ONE/GT)	SOR	15
	C4=AL*ONE/GT	SOR	16
	CWW=WW*(C2-WW*C4)-AL*(ONE-ONE/GT)	SOR	17
	B(3)=B(2)*CWW/AXW/WW1	SOR	18
	DWW=(TWO*C2-FOUR*C4*WW)/CWW-FOUR/WW1	SOR	19
	B(4)=B(3)*(B(3)/B(2)+W*B(2)*DWW-ONE/B(1))	SOR	20
	RETURN	SOR	21
	END	SOR	22
	SUBROUTINE SPLIND (X,Y,TNZ,TNL,L)	SPL	1
C	COMPUTE CUBIC COEFFICIENTS FOR A CURVE X=Y	SPL	2
	IMPLICIT REAL*8(A-H,O-Z)	SPL	3
	COMMON /COEF/ E(5,200),NE	SPL	4
	COMMON /WORK/ A(300),B(300),C(300),D(300),G(300),SB(300),XM(300),DSPL	SPL	5
	IX(300),OY(300)	SPL	6
	DIMENSION X(1), Y(1)	SPL	7
	DATA ZERO/0.00+0/,ONE/1.0+0/,THR/3.0+0/,SIX/6.0+0/	SPL	8

	CALL OREZ (E,5*200)	SPL	9
	CALL OREZ (A,9*300)	SPL	10
	DX(1)=ZERO	SPL	11
	DY(1)=ZERO	SPL	12
	N=L-1	SPL	13
	DO 1 K=2,L	SPL	14
	DX(K)=X(K)-X(K-1)	SPL	15
1	DY(K)=Y(K)-Y(K-1)	SPL	16
C		SPL	17
	B(1)=DX(2)/THR	SPL	18
	C(1)=DX(2)/SIX	SPL	19
	D(1)=DY(2)/DX(2)-TNZ	SPL	20
	A(L)=DX(L)/SIX	SPL	21
	B(L)=DX(L)/THR	SPL	22
	D(L)=TNL-DY(L)/DX(L)	SPL	23
	A(1)=ZERO	SPL	24
	DO 2 K=2,N	SPL	25
	A(K)=DX(K)/SIX	SPL	26
	B(K)=(DX(K)+DX(K+1))/THR	SPL	27
	D(K)=DY(K+1)/DX(K+1)-DY(K)/DX(K)	SPL	28
2	C(K)=DX(K+1)/SIX	SPL	29
	SW=ONE/B(1)	SPL	30
	SB(1)=SW*C(1)	SPL	31
	G(1)=SW*D(1)	SPL	32
	DO 3 K=2,L	SPL	33
	SW=ONE/(B(K)-A(K)*SB(K-1))	SPL	34
	SB(K)=SW*C(K)	SPL	35
3	G(K)=SW*(D(K)-A(K)*G(K-1))	SPL	36
	XM(L)=G(L)	SPL	37
	DO 4 K=1,N	SPL	38
	J=L-K	SPL	39
4	XM(J)=G(J)-SB(J)*XM(J+1)	SPL	40
	DO 5 K=2,L	SPL	41
	DXR=ONE/..X(K)	SPL	42
	Q=DXR/SIX	SPL	43
	P=-XM(K-1)*Q	SPL	44
	Q=Q*XM(K)	SPL	45
	R=DX(K)*XM(K-1)/SIX-DXR*Y(K-1)	SPL	46
	S=Y(K)*DXR-DX(K)*XM(K)/SIX	SPL	47
	XK=X(K)	SPL	48
	PX=XK*P	SPL	49
	PXX=PX*XK	SPL	50
	PXXX=PXK*XK	SPL	51
	XJ=X(K-1)	SPL	52
	QX=XJ*Q	SPL	53
	QXX=QX*XJ	SPL	54
	QXXX=QXX*XJ	SPL	55
	E(2,K)=P+Q	SPL	56
	E(3,K)=-THR*(PX+QX)	SPL	57
	E(4,K)=THR*(PXX+QXX)+R+S	SPL	58
	E(5,K)=-PXXX-QXXX-R*XK-S*XJ	SPL	59
5	CONTINUE	SPL	60
	DO 6 K=2,L	SPL	61
	E(1,K)=X(K)	SPL	62
6	CONTINUE	SPL	63
	E(1,1)=X(1)	SPL	64

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NE=L
RETURN
END
FUNCTION TORIC (WIP,SE)
C TO OBTAIN THROAT RADIUS OF CURVATURE FROM VELOCITY GRADIENT
IMPLICIT REAL*8(A-H,O-Z)
COMMON /GC/ GC,GD,GE,GF,GM,GI,MA,MB,MC,ME
COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,RGA,QT
DATA ONE/1.0+0/,THR/3.0+0/,FIV/5.0+0/
IE=ONE/QT-ONE
FW=WIP*SE*DSQRT(QT*(GAM+ONE))
TRR=FW*(ONE+(GC*(THR*GC**2-GD)*FW**2)*FW**2)
1 TR2=TRR**2
TK=(ONE-G7*(ONE+(GE+GF*TR2)*TR2)*TR2**2/(45.0+0.3*IE))*QT
FF=FW/TK-TRR*(ONE-TR2*(GC-GD*TR2))
FP=ONE-TR2*(THR*GC-FIV*GQ*TR2)
TRR=TRR+FF/FP
IF (DABS(FF).GT.1.0-11) GO TO 1
TORIC=ONE/TRR**2
RETURN
END
SUBROUTINE TRANS (RTO,TK,XO,AMN,AMP,AMPP,W,AWP,AWPP,CWOPPP,AXN)
C TO DETERMINE THROAT CHARACTERISTIC
IMPLICIT REAL*8(A-H,O-Z)
COMMON /GG/ GAM,GM,G1,G2,G3,G4,G5,G6,G7,G8,G9,GA,RGA,QT
COMMON /CONTR/ ITLE(3),IE,LR
COMMON /TROAT/ FC(6,51)
DATA ZRO/0.00+0/,ONE/1.0+0/,TWO/2.0+0/,SIX/6.0+0/,HALF/5.0-1/
DATA TRHV/1.50+0/,THR/3.0+0/,FOUR/4.0+0/,EIT/8.0+0/,TLV/1.20+1/
NN=IABS(LR)
JJ=240/(NN-1)
IF (MOD(JJ,2).NE.0) JJ=JJ+1
IF (JJ.LT.10) JJ=10
KK=JJ*NN-JJ
GB=IE/EIT
GK=(GAM*(GAM+2.250+0*IE-16.50+0)+2.250+0*(2+IE))/TLV
GU=ONE-GAM/TRHV
GV=(HALF*(5-3*IE)*GAM+IE)/(9-IE)
GZ=DSQRT(QT*(GAM+ONE))
U22=GB+GAM/THR/(3-IE)
U42=(GAM*(4-IE)*TRHV)/SIX/(3-IE)
IF (IE.EQ.0) GO TO 1
GT=(GAM*(GAM*92.0+0+180.0+0)-9.0+0)/1152.0+0
U23=(GAM*(304.0+0*GAM+255.0+0)-54.0+0)/1728.0+0
U43=(GAM*(388.0+0*GAM+777.0+0)+153.0+0)/2304.0+0
U63=(GAM*(556.0+0*GAM+1737.0+0)+3069.0+0)/10368.0+0
UP0=(GAM*(52.0+0*GAM+75.0+0)-9.0+0)/192.0+0
UP2=(GAM*(52.0+0*GAM+51.0+0)+327.0+0)/384.0+0
V02=(28.0+0*GAM-15.0+0)/288.0+0
V22=(20.0+0*GAM+27.0+0)/96.0+0
V42=(GAM/THR+ONE)/THR
V03=(GAM*(7100.0+0*GAM+2151.0+0)+2169.0+0)/82944.0+0
V23=(GAM*(3424.0+0*GAM+4071.0+0)-972.0+0)/13824.0+0
V43=(GAM*(3380.0+0*GAM+7551.0+0)+3771.0+0)/13824.0+0
V63=(GAM*(6836.0+0*GAM+23031.0+0)+30627.0+0)/82944.0+0
GO TO 2

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SPL 65
SPL 66
SPL 67
TOR 1
TOR 2
TOR 3
TOR 4
TOR 5
TOR 6
TOR 7
TOR 8
TOR 9
TOR 10
TOR 11
TOR 12
TOR 13
TOR 14
TOR 15
TOR 16
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TOR 18
TRA 1
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TRA 23
TRA 24
TRA 25
TRA 26
TRA 27
TRA 28
TRA 29
TRA 30
TRA 31
TRA 32
TRA 33
TRA 34
TRA 35

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1  GT=(GAM*(GAM*134.D+0+429.D+0)+123.D+0)/4320.D+0      TRA 36
   U23=(GAM*(854.D+0+GAM*807.D+0)+279.D+0)/12960.D+0      TRA 37
   U43=(GAM*(194.D+0+GAM*549.D+0)-63.D+0)/2592.D+0        TRA 38
   U63=(GAM*(362.D+0+GAM*1449.D+0)+3177.D+0)/12960.D+0    TRA 39
   UP0=(GAM*(26.D+0+GAM*51.D+0)-27.D+0)/144.D+0           TRA 40
   UP2=(GAM*(26.D+0+GAM*27.D+0)+237.D+0)/288.D+0           TRA 41
   V02=(34.D+0+GAM*75.D+0)/1080.D+0                         TRA 42
   V22=(10.D+0+GAM*15.D+0)/108.D+0                          TRA 43
   V42=(22.D+0+GAM*75.D+0)/360.D+0                          TRA 44
   V03=(GAM*(7570.D+0+GAM*3087.D+0)+23157.D+0)/544320.D+0 TRA 45
   V23=(GAM*(5026.D+0+GAM*7551.D+0)-4923.D+0)/77760.D+0   TRA 46
   V43=(GAM*(2254.D+0+GAM*6153.D+0)+2979.D+0)/25920.D+0   TRA 47
   V63=(GAM*(6574.D+0+GAM*26481.D+0)+40059.D+0)/181440.D+0 TRA 48
2  WWO=WO*(HALF*(U42-U22+(U63-U43+U23)/RTO)/RTO)/RTO      TRA 49
   WOP=(ONE-(GB-GT/RTO)/RTO)/DSQRT(RTO)                     TRA 50
   WOPP=(GU-GV/RTO)/RTO                                       TRA 51
   HOPPPP=GK/RTO/DSQRT(RTO)                                    TRA 52
   HVPPPP=(3*IE-(10-3*IE)*GAM)/FOUR/RTO/DSQRT(RTO)          TRA 53
   AMN=WWO/DSQRT(G7-G8*WWO**2)                                TRA 54
   BET=DSQRT(AMN**2-ONE)                                       TRA 55
   PS11=G2*DATAN(BET/G2)-DATAN(BET)                           TRA 56
   P1=ZRO                                                       TRA 57
   T1=ZRO                                                       TRA 58
   X1=ZRO                                                       TRA 59
   Y1=ONE                                                       TRA 60
   FSV1=ZRO                                                     TRA 61
   TN2=-ONE/BET                                                TRA 62
   FC(1,NN)=X1                                                  TRA 63
   FC(2,NN)=Y1                                                  TRA 64
   FC(3,NN)=AMN                                                 TRA 65
   FC(4,NN)=PS11                                                TRA 66
   FC(5,NN)=ZRO                                                 TRA 67
   FC(6,NN)=ZRO                                                 TRA 68
   BX=ONE                                                       TRA 69
   SUM=ZRO                                                       TRA 70
   FSA=(IE+1)*AMN/(G6+G5*AMN**2)**GA                          TRA 71
   DO 8 J=1,KK                                                  TRA 72
   Y=DFLOAT(KK-J)/KK                                           TRA 73
   IF (IE.EQ.1) BX=Y+Y                                          TRA 74
   YY=Y*Y                                                         TRA 75
   TN1=TN2                                                       TRA 76
   VO=((YY*(YY*(YY*(YY*V63-V43)+V23)-V03)/RTO+YY*(YY*V42-V22)+V02)/RTO+HTRA 77
   HALF=(YY-ONE)/(3-IE)/RTO                                     TRA 78
   VP=(ONE+((YY*(TWO*GAM+3*(4-IE))-TWO*GAM-TRHV*IE)/(3-IE)/THR*(YY*(STRA 79
   IIX=U63*YY-FOUR*U43)+TWO*U23)/RTO)/RTO)/DSQRT(RTO)        TRA 80
   VPP=TWO*(ONE+(TWO*UP2*YY-UP0)/RTO)/RTO                     TRA 81
C  ITERATE FOR X AND MACH NUMBER FROM CHARACTERISTIC EQUATIONS TRA 82
   DO 4 I=1,10                                                  TRA 83
   TNA=HALF*(TN1+TN2)                                           TRA 84
   X=X1+(Y-Y1)/TNA                                              TRA 85
   DXI=DSQRT((Y-Y1)**2+(X-X1)**2)                              TRA 86
   XOT=X/GZ                                                      TRA 87
   VY=GZ*(VO+XOT*(VP+XOT*(HALF*VPP+XOT*(HVPPPP/THR)))/DSQRT(RTO) TRA 88
   W=AMN/DSQRT(G6+G5*AMN**2)                                    TRA 89
   T=DARSIN(VY*Y/W)                                             TRA 90
   FSY=IE*VY/W/AMN                                             TRA 91

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	P1=HALF*(FSY1+FSY)*DXI	TRA	92
3	PSI=P1+PSI1+T1-T	TRA	93
	FMA=FMV(PSI)	TRA	94
	IF (DABS(AMN-FMA).LT.1.0-10) GO TO 5	TRA	95
	FMU=DARSIN(ONE/FMA)	TRA	96
	TN2=DTAN(T-FMU)	TRA	97
	AMN=FMA	TRA	98
4	CONTINUE	TRA	99
C	ITERATION COMPLETE	TRA	100
5	IF (MOD(J,2).EQ.0) GO TO 6	TRA	101
	AS=Y1-Y	TRA	102
	FSR=RX/USIN(FMU-T)/(G6+G5*FMA**2)**GA	TRA	103
	GO TO 7	TRA	104
6	BS=Y1-Y	TRA	105
	CS=AS+BS	TRA	106
	S1=(TWO-B5/AS)*CS/SIX	TRA	107
	S3=(TWO-AS/BS)*CS/SIX	TRA	108
	S2=CS-S1-S3	TRA	109
	FSC=RX/USIN(FMU-T)/(G6+G5*FMA**2)**GA	TRA	110
	ADD=S1*FSA+S2*FSB+S3*FSC	TRA	111
	SUM=ADD+SUM	TRA	112
	FSA=FSC	TRA	113
7	X1=X	TRA	114
	Y1=Y	TRA	115
	T1=T	TRA	116
	FSY1=FSY	TRA	117
	PSI1=PSI	TRA	118
	IF (MOD(J+JJ).NE.0) GO TO 8	TRA	119
	K=NN-J/JJ	TRA	120
	FC(1,K)=X	TRA	121
	FC(2,K)=Y	TRA	122
	FC(3,K)=FMA	TRA	123
	FC(4,K)=PSI	TRA	124
	FC(5,K)=T	TRA	125
	FC(6,K)=SUM	TRA	126
8	CONTINUE	TRA	126
	DO 9 J=1,NN	TRA	127
	FC(1,J)=FC(1,J)/TK	TRA	128
	FC(2,J)=FC(2,J)/TK	TRA	129
9	FC(6,J)=ONE-FC(6,J)/SUM	TRA	130
	AXN=FC(1,1)	TRA	131
	AWOP=WOP*TK/GZ	TRA	132
	AWOPP=WOPP*(TK/GZ)**2	TRA	133
	AWOPPP=TWO*HOPPP*(TK/GZ)**3	TRA	134
	CWOPPP=SIX*(W-WO-AXN*(AWOP+AXN*AWOPP/TWO))/AXN**3	TRA	135
	IF (CWOPPP.LT.AWOPPP) CWOPPP=AWOPPP	TRA	136
	AWP=AWOP+AXN*(AWOPP+AXN*CWOPPP/TWO)	TRA	137
	AWPP=AWOPP+AXN*CWOPPP	TRA	138
	AMP=AWP*G7*(AMN/W)**3	TRA	139
	AMPP=AMP*(AWPP/AWP+THR*G5*AMP*W*W/AMN)	TRA	140
	IF (LR.GT.0) RETURN	TRA	141
	LR=NN	TRA	142
	RC=RT0-ONE	TRA	143
	WRITE (6,12) ITLE,RC,AWOP,AWOPP,AWOPPP	TRA	144
	DO 10 J=1,NN	TRA	145
	Y=DFLOAT(J-1)/(NN-1)	TRA	146
		TRA	147

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YY=YY*Y                      TRA 148
Y4=YY**2                     TRA 149
Y6=YY**3                     TRA 150
DUY=(HALF*YY*(U42*Y4-U22*YY*(U63*Y6-U43*Y4+U23*YY)/RTO)/RTO) TRA 151
UY=WO+DUY                    TRA 152
VO=((YY*(YY*(YY*V63-V43)+V23)-V03)/RTO+YY*(YY*V42-V22)+V02)/RTO+HTRA 153
1ALF=(YY-ONE)/(3-IE))/RTO   TRA 154
VY=GZ*VO*Y/DSQRT(RTO)      TRA 155
WY=DSQRT(UY**2+VY**2)      TRA 156
YM=WY/DSQRT(G7-G8*WY**2)   TRA 157
WRITE (6,13) Y,UY,VY,WY,YM TRA 158
10 IF (MOD(J,10).EQ.0) WRIT (6,14) TRA 159
XX1=CUBIC(CWOPPP/SIX,AWOPP/TWO,AWOP,WO-ONE) TRA 160
XXI=CUBIC(AWOPPP/SIX,AWOPP/TWO,AWOP,WO-W) TRA 161
WRITE (6,15) XX1,XXI,W,CWOPPP,TK TRA 162
WRITE (6,16)                TRA 163
PX=AXN+1,D-1               TRA 164
DO 11 J=1,11               TRA 165
X=.1D+0*(J-1)              TRA 166
XW=WO*X*(AWOP*X*(AWOPP/TWO+X*CWOPPP/SIX)) TRA 167
XWP=AWOP*X*(AWOPP+X*CWOPPP/TWO) TRA 168
XWPP=AWOPP*X*CWOPPP        TRA 169
XM=XW/DSQRT(G7-G8*XW**2)   TRA 170
XMP=XWP*G7*(XM/XW)**3      TRA 171
XMPX=XMP*(XWPP/XWP+THR*G5*XMP*XW/XM) TRA 172
IF (X.LT.AXN.OR.X.GT.PX) GO TO 11 TRA 173
WRITE (6,18) AXN,W,AWP,AWPP,AMN,AMP,AMPP TRA 174
11 WRITE (6,17) X,XW,XWP,XWPP,XM,XMP,XMPX TRA 175
RETURN                      TRA 176
C                            TRA 177
12 FORMAT (1H1,8X,3A4,39H THROAT VELOCITY DISTRIBUTION, X=0, RC=,F10,TRA 178
16//10X,44HDERIVATIVES TAKEN WITH RESPECT TO x/Y*, WOP=,F11.8//10X,TRA 179
25HWOPP=,1PE15.7,5X,6HWOPPP=,E15.7//10X,4HY/YO,7X,4HU/A*,10X,4HV/A*TRA 180
3,11X,1HW,11X,8HMACH NO. /) TRA 181
13 FORMAT (1H ,F14.4,4F14.8 ) TRA 182
14 FORMAT (1H )             TRA 183
15 FORMAT (1H0,9X,18HFROM CUBIC, X/Y* =,F11.8,11H FOR W= 1.0 //22X,6HTRA 184
1X/Y* =,F11.8,7H FOR W=,F11.8 //10X,16HCORRECTED WOPPP=,1PE15.7 // TRA 185
210X,15HRMASS = Y*/YO *,0PF13.10 //) TRA 186
16 FORMAT (1H0,9X,32HAXIAL VELOCITY DISTRIBUTION, Y=0 //10X,4HX/Y*,9XTRA 187
1,1HW,17X,2HWP,16X,3HWPP,15X,1HM,17X,2HMP,16X,3HMPP //) TRA 188
17 FORMAT (1H ,F13.3,1PE18.7 ) TRA 189
18 FORMAT (1H ,F16.8,1PE15.7,5E18.7 ) TRA 190
END                          TRA 191
C                            TRA 191
SUBROUTINE TWIXT (S,GMA,GMB,GMC,GMD,XBL,KAT,KBL) TRA 191
C TO DETERMINE INTERPOLATION COEFFICIENTS TRA 192
IMPLICIT REAL*8 (A-H,O-Z) TRA 193
DIMENSION S(200)            TRA 194
DO 1 L=1,KAT                TRA 195
IF (S(KAT-L).LT.XBL) GO TO 2 TRA 196
CONTINUE                    TRA 197
1 J=KAT-L+1                 TRA 198
XBB=S(J)-XBL                TRA 199
KBL=J+1                     TRA 200
DU=S(J+1)-S(J)              TRA 201
DT=S(J)-S(J-1)              TRA 202

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SEV00469(09-01-1977) VKF07600 TUESDAY JUN 06,1978 11:35.34

1	M A C H 4										1
2	14	1716.563	1.	0.896	2.26968E-8	198.72		1000.			2
3	8.67	6.		3.		-12.25	60.				3
4	41	21	10	41	49	-61	1	10	-21	13	4
5	50	85	50								5
6	200.	1638.	900.	540.	.38				1	5	6
7	1000.	46.	172.	2.							7

1.....10.....20.....30.....40.....50.....60.....70.....80

*****END OF INPUT DATA *****

M A C H 4 THROAT VELOCITY DISTRIBUTION. X=0. RC= 6.000000

DERIVATIVES TAKEN WITH RESPECT TO X/Y*. WOP= 0.34136118

WOPP= 2.8328436D-03 WOPPP= -7.6881686D-02

Y/YO	U/A*	V/A*	W	MACH NO.
0.0	0.96385164	0.0	0.96385164	0.95708127
0.0500	0.96401577	-0.00071638	0.96401603	0.95727442
0.1000	0.96450872	-0.00142453	0.96450977	0.95785464
0.1500	0.96533218	-0.00211614	0.96533450	0.95882420
0.2000	0.96648905	-0.00278269	0.96649305	0.96018698
0.2500	0.96798341	-0.00341543	0.96798943	0.96194847
0.3000	0.96982065	-0.00400516	0.96982892	0.96411593
0.3500	0.97200756	-0.00454220	0.97201817	0.96669850
0.4000	0.97455242	-0.00501616	0.97456533	0.96970739
0.4500	0.97746515	-0.00541581	0.97748016	0.97315605
0.5000	0.98075749	-0.00572885	0.98077422	0.97706044
0.5500	0.98444311	-0.00594164	0.98446104	0.98143928
0.6000	0.98853789	-0.00603898	0.98855634	0.98631439
0.6500	0.99306008	-0.00600372	0.99307823	0.99171105
0.7000	0.99803057	-0.00581642	0.99804752	0.99765839
0.7500	1.00347313	-0.00545488	1.00348795	1.00418993
0.8000	1.00941470	-0.00489374	1.00942656	1.01134407
0.8500	1.01588572	-0.00410381	1.01589400	1.01916472
0.9000	1.02292039	-0.00305157	1.02292494	1.02770206
0.9500	1.03055708	-0.00169844	1.03055848	1.03701332
1.0000	1.03883866	-0.00000000	1.03883866	1.04716380

FROM CUBIC, X/Y* = 0.10589172 FOR W= 1.0

X/Y* = 0.30916451 FOR W= 1.06914514

CORRECTED WOPPP= -7.5023201D-02

RMASS = Y*/YO = 0.9997135747

AXIAL VELOCITY DISTRIBUTION, Y=0

X/Y*	W	WP	MPP	M	MP	MPP
0.0	9.6385164D-01	3.4136118D-01	2.8328436D-03	9.5708127D-01	4.0106175D-01	8.1394664D-02
0.100	9.9798942D-01	3.4126935D-01	-4.6694765D-03	9.9758876D-01	4.0903018D-01	7.7921558D-02
0.200	1.0320805D 00	3.4042728D-01	-1.2171797D-02	1.0388752D 00	4.1663426D-01	7.4093984D-02
0.300	1.0660499D 00	3.3883499D-01	-1.9674117D-02	1.0809022D 00	4.2383427D-01	6.9825012D-02
0.30913748	1.0691451D 00	3.3865208D-01	-2.0359640D-02	1.0847778D 00	4.2447041D-01	6.9409656D-02
0.400	1.0998225D 00	3.3649246D-01	-2.7176437D-02	1.1236269D 00	4.3058135D-01	6.5018363D-02
0.500	1.1333234D 00	3.3339970D-01	-3.4678757D-02	1.1670014D 00	4.3681650D-01	5.9567934D-02
0.600	1.1664774D 00	3.2955671D-01	-4.2181077D-02	1.2109708D 00	4.4246962D-01	5.3357501D-02
0.700	1.1992097D 00	3.2496349D-01	-4.9683397D-02	1.2554732D 00	4.4745846D-01	4.6260683D-02
0.800	1.2314451D 00	3.1962003D-01	-5.7185717D-02	1.3004372D 00	4.5168768D-01	3.8141263D-02
0.900	1.2631087D 00	3.1352634D-01	-6.4688038D-02	1.3457817D 00	4.5504780D-01	2.8854013D-02
1.000	1.2941254D 00	3.0668242D-01	-7.2190358D-02	1.3914137D 00	4.5741446D-01	1.8246177D-02

M A C H 4 THROAT CONTOUR, 3RD-DEG AXIAL VELOCITY DISTRIBUTION FROM THROAT CHARACTERISTIC WHICH HAS 21 POINTS

NO. OF POINTS ON 1ST CHAR. (M)= 41 NO. OF POINTS ON AXIS (N)= 21 EPSI/ETA= 1.91896 BMACH= 3.08215 CMACH= 4.00000

GAMMA= 1.4000 INFLECTION ANG. (ETA)= 8.6700 DEGREES RAD. OF CURV. (RC)= 6.000000 SCALE FACTOR (SF)= 24.75038624

Y*=0.15117572 RMASS=0.99971357 WWO= 1.0388387 WWO= 2.59666557 FMACH= 1.66015 FMACH= 3.0821543 GMACH= 2.28784

WI= 1.06914514 WIP= 2.24012223 WIPP= -8.90852940-01 MI= 1.08477784 MIP= 2.80779489 MIPP= 3.03707710 00

WI= 1.06914514 WIP= 2.24012223 WIPP= -8.90852940-01 WIPPP= -3.00096030 01 WOPPP= -2.17144820 01

WE= 1.46016505 WEP= 1.45785766 WEPP= -6.90974160 00 WEPPP= -3.00096030 01 WRPPP= 7.08852360 01

C1= 1.0691451 C2= 0.44929096 C3= -1.79179340-02 C4= -4.03530990-02 C5= 0.0 C6= 0.0

XOI= 0.04673408 XI= 0.94011759 XO= 0.89338351 YO= 0.15121903 XIE= 0.20056538 XE= 1.14068296 44 ITERATIONS

MACH 0.95708127 AT 46.0758555 IN., MACH 1 AT 46.4720875 IN., MACH 1.08477784 AT 47.2325420 IN.

AXIS POINT	X	X(IN)	MACH NO.	DM/DX	D2M/DX2	D3M/DX3	W=Q/A*	DW/DX	D2W/DX2	D3W/DX3
1	1.14068	52.19661	1.660154	2.5711980 00	-7.9414020 00	-9.7369330 01	1.460165	1.4578580 00	-6.9097400 00	-3.0009600 01
2	1.12775	51.87640	1.626258	2.6659540 00	-6.7191180 00	-9.1512930 01	1.440736	1.5447430 00	-6.5214820 00	-3.0009600 01
3	1.11501	51.56120	1.591793	2.7442630 00	-5.5920330 00	-8.5459530 01	1.420545	1.6253610 00	-6.1393080 00	-3.0009600 01
4	1.10249	51.25121	1.557012	2.8077560 00	-4.5596600 00	-7.9390400 01	1.399717	1.6998990 00	-5.7634540 00	-3.0009600 01
5	1.09018	50.94665	1.522140	2.8580040 00	-3.6193890 00	-7.3445950 01	1.378372	1.7685480 00	-5.3941770 00	-3.0009600 01
6	1.07810	50.64775	1.487383	2.8964980 00	-2.7670860 00	-6.7730520 01	1.356629	1.8315030 00	-5.0317640 00	-3.0009600 01
7	1.06627	50.35478	1.452920	2.9246350 00	-1.9975420 00	-6.2317620 01	1.334605	1.8889630 00	-4.6765310 00	-3.0009600 01
8	1.05468	50.06801	1.418917	2.9437120 00	-1.3051430 00	-5.7255390 01	1.312413	1.9411310 00	-4.3288350 00	-3.0009600 01
9	1.04336	49.78780	1.385519	2.9549200 00	-0.8369160-01	-5.2571540 01	1.290166	1.9882180 00	-3.9890770 00	-3.0009600 01
10	1.03232	49.51451	1.352861	2.9593530 00	-1.2716810-01	-4.8277930 01	1.267976	2.0304350 00	-3.6577160 00	-3.0009600 01
11	1.02157	49.24858	1.321067	2.9580090 00	3.7033290-01	-4.4374450 01	1.245956	2.0680030 00	-3.3352810 00	-3.0009600 01
12	1.01115	48.99052	1.290254	2.9518010 00	8.1440910-01	-4.0852340 01	1.224218	2.1011470 00	-3.0223880 00	-3.0009600 01
13	1.00106	48.74094	1.260536	2.9415660 00	1.2102470 00	-3.7696860 01	1.202882	2.1300990 00	-2.7197710 00	-3.0009600 01
14	0.99135	48.50056	1.232030	2.9280790 00	1.5625460 00	-3.4889580 01	1.182070	2.1550980 00	-2.4283160 00	-3.0009600 01
15	0.98205	48.27030	1.204861	2.9120690 00	1.8754490 00	-3.2410180 01	1.161919	2.1763910 00	-2.1491230 00	-3.0009600 01
16	0.97320	48.05131	1.179173	2.8942350 00	2.1524720 00	-3.0238110 01	1.142582	2.1942310 00	-1.8835990 00	-3.0009600 01
17	0.96487	47.84514	1.155142	2.8752780 00	2.3963970 00	-2.8354150 01	1.124242	2.2088800 00	-1.6336240 00	-3.0009600 01
18	0.95715	47.65400	1.133010	2.8559430 00	2.6090620 00	-2.6742500 01	1.107137	2.2206010 00	-1.4018690 00	-3.0009600 01
19	0.95017	47.48133	1.113151	2.8371010 00	2.7908670 00	-2.5394600 01	1.091613	2.2296510 00	-1.1925120 00	-3.0009600 01
20	0.94420	47.33358	1.096265	2.8199950 00	2.9392210 00	-2.4319980 01	1.078282	2.2362350 00	-1.0133650 00	-3.0009600 01
21	0.94012	47.23254	1.084778	2.8077950 00	3.0370770 00	-2.3625730 01	1.069145	2.2401220 00	-8.9085290-01	-3.0009600 01

M A C H 4 THROAT CHARACTERISTIC

POINT	X	Y	MACH NO.	MACH ANG.(D)	PSI (D)	FLOW ANG.(D)	X(IN)	Y(IN)
1	9.40117590-01	0.0	1.08477780 00	6.71977220 01	1.05290740 00	0.0	47.2325420	0.0
2	9.37018400-01	7.56095150-03	1.07632920 00	6.82924460 01	9.04249970-01	7.23832840-02	47.1558360	0.1871365
3	9.34072480-01	1.51219030-02	1.06880590 00	6.93291220 01	7.77562380-01	1.30305260-01	47.0829233	0.3742729
4	9.31270550-01	2.26828550-02	1.06216310 00	7.03007620 01	6.70511860-01	1.75513180-01	47.0135744	0.5614094
5	9.28602420-01	3.02438060-02	1.05635750 00	7.11999850 01	5.80930090-01	2.09619000-01	46.9475371	0.7485459
6	9.26056950-01	3.78047580-02	1.05134760 00	7.20192280 01	5.06816410-01	2.34097490-01	46.8845358	0.9356823
7	9.23622060-01	4.53657090-02	1.04709260 00	7.27510430 01	4.46343490-01	2.50282270-01	46.8242714	1.1228188
8	9.21284790-01	5.29266610-02	1.04355250 00	7.33884850 01	3.97864230-01	2.59360470-01	46.7664229	1.3099553
9	9.19031360-01	6.04876120-02	1.04068800 00	7.39255700 01	3.59918720-01	2.62367440-01	46.7106498	1.4970918
10	9.16847400-01	6.80485640-02	1.03846040 00	7.43577440 01	3.31239770-01	2.60182550-01	46.6565958	1.6842282
11	9.14718090-01	7.56095150-02	1.03683250 00	7.46823080 01	3.10755610-01	2.53527570-01	46.6038946	1.8713647
12	9.12628470-01	8.31704670-02	1.03576850 00	7.48987020 01	2.97588700-01	2.42968490-01	46.5521759	2.0585012
13	9.10563740-01	9.07314180-02	1.03523460 00	7.50085900 01	2.91050110-01	2.28921160-01	46.5010728	2.2456376
14	9.08509460-01	9.82923700-02	1.03520020 00	7.50157120 01	2.90629720-01	2.11660430-01	46.4502286	2.4327741
15	9.06451880-01	1.05853320-01	1.03563770 00	7.49255310 01	2.95983200-01	1.91332120-01	46.3993029	2.6199106
16	9.04378110-01	1.13414270-01	1.03652380 00	7.47447360 01	3.06917180-01	1.67966080-01	46.3479762	2.8070470
17	9.02276200-01	1.20975220-01	1.03783920 00	7.44807090 01	3.23374200-01	1.41489330-01	46.2959531	2.9941835
18	9.00135220-01	1.28536180-01	1.03956890 00	7.41410150 01	3.45418890-01	1.11737670-01	46.2429631	3.1813200
19	8.97945280-01	1.36097130-01	1.04170280 00	7.37329910 01	3.73226460-01	7.84650450-02	46.1887611	3.3684565
20	8.95697400-01	1.43658080-01	1.04423480 00	7.32634520 01	4.07074080-01	4.13501380-02	46.1331253	3.5555929
21	8.93383510-01	1.51219030-01	1.04716380 00	7.27385060 01	4.47335460-01	0.0	46.0758555	3.7427294

M A C H 4 UPSTREAM CONTOUR

CHARACT POINT	X	Y	MACH NO.	MACH ANG.(D)	PSI (D)	FLOW ANG.(D)	X(IN)	Y(IN)
1	1.14068300	0.0	1.66015380	0.0	1.66373790	0.0	52.1966126	0.0
2	1.14644740	0.0	1.67486670	0.0	1.70708790	2.16750000	52.3392858	0.1073432
3	1.15230460	0.0	1.68960100	0.0	1.75043790	4.33500000	52.4842521	0.2157864
4	1.15825520	0.0	1.70435940	0.0	1.79378790	6.50250000	52.6315327	0.3253588
5	1.16430030	0.0	1.71914460	0.0	1.83713790	8.67000000	52.7811500	0.4360905
6	1.17044070	0.0	1.73395940	0.0	1.88048790	1.08375000	52.9331274	0.5480115
7	1.17667740	0.0	1.74880620	0.0	1.92383790	1.30050000	53.0874894	0.6611526
8	1.18301160	0.0	1.76368760	0.0	1.96718790	1.51725000	53.2442616	0.7755450
9	1.18944410	0.0	1.77860580	0.0	2.01053790	1.73400000	53.4034705	0.8912204
10	1.19597630	0.0	1.79356330	0.0	2.05388790	1.95075000	53.5651437	1.0082109
11	1.20260920	0.0	1.80856230	0.0	2.09723790	2.16750000	53.7293100	1.1265493
12	1.20934400	0.0	1.82360500	0.0	2.14058790	2.38425000	53.8959990	1.2462689
13	1.21618190	0.0	1.83869360	0.0	2.18393790	2.60100000	54.0652414	1.3674036
14	1.22312440	0.0	1.85383020	0.0	2.22728790	2.81775000	54.2370690	1.4899879
15	1.23017260	0.0	1.86901700	0.0	2.27063790	3.03450000	54.4115145	1.6140569
16	1.23732790	0.0	1.88425600	0.0	2.31398790	3.25125000	54.5886119	1.7396465
17	1.24459180	0.0	1.89954920	0.0	2.35733790	3.46800000	54.7683961	1.8667931
18	1.25196570	0.0	1.91489860	0.0	2.40068790	3.68475000	54.9509029	1.9955339
19	1.25945110	0.0	1.93030620	0.0	2.44403790	3.90150000	55.1361696	2.1259069
20	1.26704950	0.0	1.94577390	0.0	2.48738790	4.11825000	55.3242341	2.2579507
21	1.27476260	0.0	1.96130370	0.0	2.53073790	4.33500000	55.5151358	2.3917048
22	1.28259200	0.0	1.97689750	0.0	2.57408790	4.55175000	55.7089151	2.5272095
23	1.29053920	0.0	1.99255730	0.0	2.61743790	4.76850000	55.9056134	2.6645060
24	1.29860620	0.0	2.00828480	0.0	2.66078790	4.98525000	56.1052734	2.8036361
25	1.30679460	0.0	2.02408200	0.0	2.70413790	5.20200000	56.3079389	2.9446429
26	1.31510620	0.0	2.03995080	0.0	2.74748790	5.41875000	56.5136549	3.0875702
27	1.32354290	0.0	2.05589300	0.0	2.79083790	5.63550000	56.7224677	3.2324626
28	1.33210670	0.0	2.07191040	0.0	2.83418790	5.85225000	56.9344247	3.3793660
29	1.34079950	0.0	2.08800510	0.0	2.87753790	6.06900000	57.1495747	3.5283271
30	1.34962330	0.0	2.10417880	0.0	2.92088790	6.28575000	57.3679677	3.6793939
31	1.35858030	0.0	2.12043340	0.0	2.96423790	6.50250000	57.5896549	3.8326151
32	1.36767240	0.0	2.13677080	0.0	2.79042860	3.00758790	57.8146890	3.9880408
33	1.37690200	0.0	2.15319280	0.0	2.76731190	3.05093790	58.0431242	4.1457223
34	1.38627120	0.0	2.16970130	0.0	2.74447420	3.09428790	58.2750157	4.3057118
35	1.39578230	0.0	2.18629830	0.0	2.72190930	3.13763790	58.5104205	4.4680630
36	1.40543780	0.0	2.20298550	0.0	2.69960740	3.18098790	58.7493969	4.6328309
37	1.41524000	0.0	2.21976500	0.0	2.67756480	3.22433790	58.9920046	4.8000714
38	1.42519140	0.0	2.23663870	0.0	2.65577420	3.26768790	59.2383050	4.9698423
39	1.43529450	0.0	2.25360830	0.0	2.63422940	3.31103790	59.4883611	5.1422024
40	1.44555190	0.0	2.27067600	0.0	2.61292440	3.35438790	59.7422374	5.3172121
41	1.45596640	0.0	2.28784370	0.0	2.59185360	3.39773790	60.0000000	5.4949332

MASS = 1.0000000381

M A C H 4 INTERMEDIATE LEFT CHARACTERISTIC

CHARACT 11 POINT	X	Y	MACH NO.	MACH ANG.(D)	PSI (D)	FLOW ANG.(D)	X(IN)	Y(IN)
1	1.02157240 00	0.0	1.32106730 00	4.91972530 01	6.75094380 00	0.0	49.2485811	0.0
2	1.02685110 00	6.05542980-03	1.33687760 00	4.84184340 01	7.19182130 00	2.22664950-01	49.3792293	0.1498742
3	1.03209250 00	1.19543960-02	1.35294410 00	4.76572580 01	7.64383540 00	4.55128270-01	49.5089554	0.2958759
4	1.03729000 00	1.76992200-02	1.36920590 00	4.69157710 01	8.10501140 00	6.96049490-01	49.6375964	0.4380625
5	1.04243890 00	2.32940230-02	1.38560290 00	4.61956340 01	8.57335050 00	9.44010040-01	49.7650329	0.5765361
6	1.04753590 00	2.87443510-02	1.40207560 00	4.54981900 01	9.04683190 00	1.19751120 00	49.8911859	0.7114338
7	1.05257940 00	3.40569760-02	1.41856440 00	4.48245400 01	9.52341000 00	1.45497110 00	50.0160153	0.8429233
8	1.05756950 00	3.92397980-02	1.43500950 00	4.41755790 01	1.00010200 01	1.71472770 00	50.1395211	0.9712002
9	1.06250770 00	4.43018400-02	1.45135100 00	4.35520440 01	1.04775810 01	1.97503820 00	50.2617444	1.0964877
10	1.06739760 00	4.92532930-02	1.46752840 00	4.29545370 01	1.09510030 01	2.23408170 00	50.3827712	1.2190380
11	1.07224460 00	5.41056060-02	1.48348050 00	4.23835570 01	1.14191910 01	2.48995760 00	50.5027359	1.3391346
12	1.07651890 00	5.83417510-02	1.49741200 00	4.18989470 01	1.18289980 01	2.71304310 00	50.6085268	1.4439809
13	1.08087220 00	6.26177810-02	1.51114320 00	4.14238530 01	1.22421330 01	2.93682560 00	50.7162740	1.5498143
14	1.08530570 00	6.69351900-02	1.52552170 00	4.09585960 01	1.26578880 01	3.16087680 00	50.8260034	1.6566718
15	1.08981990 00	7.12951860-02	1.53966760 00	4.05032250 01	1.30757690 01	3.38496050 00	50.9377333	1.7645834
16	1.09441570 00	7.56988660-02	1.55386170 00	4.00576400 01	1.34954080 01	3.60893970 00	51.0514789	1.8735762
17	1.09909340 00	8.01472820-02	1.56809940 00	3.96216500 01	1.39165220 01	3.83273490 00	51.1672544	1.9836762
18	1.10385370 00	8.46414740-02	1.58237410 00	3.91950110 01	1.43388880 01	4.05630070 00	51.2850733	2.0949092
19	1.10869710 00	8.91824840-02	1.59668640 00	3.87774520 01	1.47623300 01	4.27961370 00	51.4049497	2.2073009
20	1.11362420 00	9.37713650-02	1.61103400 00	3.83686860 01	1.51867020 01	4.50266360 00	51.5268977	2.3208775
21	1.11863560 00	9.84091880-02	1.62541630 00	3.79684170 01	1.56118860 01	4.72544900 00	51.6509323	2.4356654
22	1.12373200 00	1.03097040-01	1.63983320 00	3.75763530 01	1.60377820 01	4.94797370 00	51.7770691	2.5516916
23	1.12891390 00	1.07836040-01	1.65428500 00	3.71922050 01	1.64643070 01	5.17024500 00	51.9053245	2.6689836
24	1.13418220 00	1.12627310-01	1.66877250 00	3.68156910 01	1.68913910 01	5.39227220 00	52.0357158	2.7875693
25	1.13953750 00	1.17472010-01	1.68329640 00	3.64465370 01	1.73189740 01	5.61406560 00	52.1682609	2.9074775
26	1.14498050 00	1.22371320-01	1.69785790 00	3.60844790 01	1.77470030 01	5.83563610 00	52.3029789	3.0287375
27	1.15051220 00	1.27326450-01	1.71245810 00	3.57292630 01	1.81754340 01	6.05699480 00	52.4398896	3.1513789
28	1.15613330 00	1.32338640-01	1.72709840 00	3.53806470 01	1.86042280 01	6.27815240 00	52.5790137	3.2754324
29	1.16184470 00	1.37409130-01	1.74178010 00	3.50383980 01	1.90333510 01	6.49911950 00	52.7203729	3.4009291
30	1.16764730 00	1.42539220-01	1.75650490 00	3.47022910 01	1.94627740 01	6.71990630 00	52.8639897	3.5279008
31	1.17354200 00	1.47730220-01	1.77127410 00	3.43721150 01	1.98924690 01	6.94052240 00	53.0098876	3.6563799
32	1.17953000 00	1.52983460-01	1.78608930 00	3.40476660 01	2.03224140 01	7.16097710 00	53.1580910	3.7863997
33	1.18561210 00	1.58300310-01	1.80095220 00	3.37287500 01	2.07525880 01	7.38127900 00	53.3086250	3.9179939
34	1.19178940 00	1.63682180-01	1.81586430 00	3.34151820 01	2.11829720 01	7.60143630 00	53.4615161	4.0511971
35	1.19806300 00	1.69130480-01	1.83082740 00	3.31067840 01	2.16135490 01	7.82145680 00	53.6167912	4.1860447
36	1.20443410 00	1.74646680-01	1.84584290 00	3.28033880 01	2.20443050 01	8.04134760 00	53.7744785	4.3225728
37	1.21090390 00	1.80232270-01	1.86091270 00	3.25048310 01	2.24752270 01	8.26111560 00	53.9346070	4.4608182
38	1.21747340 00	1.85888750-01	1.87603830 00	3.22109610 01	2.29063010 01	8.48076710 00	54.0972066	4.6008185
39	1.22414410 00	1.91617700-01	1.89122150 00	3.19216290 01	2.33375180 01	8.70030820 00	54.2623083	4.7426121
40	1.23091720 00	1.97420700-01	1.90646400 00	3.16366950 01	2.37688860 01	8.91974450 00	54.4299439	4.8862385
CONTOUR	1.21737530 00	1.85804250-01	1.87581240 00					

M A C H 4 INTERMEDIATE LEFT CHARACTERISTIC

CHARACT POINT	X	Y	MACH NO.	MACH ANG.(D)	PSI (D)	FLOW ANG.(D)	X(IN)	Y(IN)
1	9.40117590-01	0.0	1.08477780 00	6.71977220 01	1.05290740 00	0.0	47.2325420	0.0
2	9.42122380-01	4.69464590-03	1.09050750 00	6.64919820 01	1.15730650 00	5.30091340-02	47.2821613	0.1161943
3	9.44938240-01	1.10496750-02	1.09887870 00	6.55079200 01	1.31469870 00	1.35602210-01	47.3518550	0.2734837
4	9.48084750-01	1.78473630-02	1.10864610 00	6.44223650 01	1.50515240 00	2.38991450-01	47.4297324	0.4417291
5	9.51418460-01	2.47331730-02	1.11943270 00	6.32921250 01	1.72334780 00	3.61096500-01	47.5122430	0.6121556
6	9.54866970-01	3.15480190-02	1.13102940 00	6.21471430 01	1.96639340 00	5.00745270-01	47.5975949	0.7808257
7	9.58387290-01	3.82144980-02	1.14329540 00	6.10053030 01	2.23221590 00	6.56988400-01	47.6847242	0.9458236
8	9.61951230-01	4.46950780-02	1.15612540 00	5.98779190 01	2.51906560 00	8.28913230-01	47.7729330	1.1062204
9	9.65538930-01	5.09732340-02	1.16943420 00	5.87723700 01	2.82531990 00	1.01557780 00	47.8617301	1.2616072
10	9.69135710-01	5.70440310-02	1.18314950 00	5.76935540 01	3.14939480 00	1.21598510 00	47.9507518	1.4118618
11	9.72730330-01	6.29091390-02	1.19720710 00	5.66447350 01	3.48970260 00	1.42907230 00	48.0397199	1.5570255
12	9.76314040-01	6.85741040-02	1.21154810 00	5.56280750 01	3.84463170 00	1.65370650 00	48.1284183	1.6972356
13	9.79880110-01	7.40468270-02	1.22611770 00	5.46449850 01	4.21253680 00	1.88868140 00	48.2166797	1.8326876
14	9.83423440-01	7.93367230-02	1.24086340 00	5.36963430 01	4.59173890 00	2.13271990 00	48.3043787	1.9636145
15	9.86940520-01	8.44542750-02	1.25573430 00	5.27826520 01	4.98052510 00	2.38447150 00	48.3914278	2.0902759
16	9.90429310-01	8.94108270-02	1.27068080 00	5.19041490 01	5.37715480 00	2.64251560 00	48.4777766	2.2129525
17	9.93889280-01	9.42185250-02	1.28565420 00	5.10608700 01	5.77986620 00	2.90536200 00	48.5634121	2.3319449
18	9.97321460-01	9.88903530-02	1.30060640 00	5.02527120 01	6.18688300 00	3.17145190 00	48.6483600	2.4475744
19	1.00072860 00	1.03440230-01	1.31548980 00	4.94794640 01	6.59642320 00	3.43915990 00	48.7326871	2.5601856
20	1.00411510 00	1.07883150-01	1.33025710 00	4.87408400 01	7.00670770 00	3.70679530 00	48.8165045	2.6701496
21	1.00748740 00	1.12235360-01	1.34486160 00	4.80365000 01	7.41596650 00	3.97260230 00	48.8999711	2.7778684
22	1.01047690 00	1.16038090-01	1.35765970 00	4.74393350 01	7.77720450 00	4.20572910 00	48.9739616	2.8719875
23	1.01353790 00	1.19882260-01	1.37058280 00	4.68452650 01	8.14421460 00	4.44086530 00	49.0497224	2.9671322
24	1.01667200 00	1.23770300-01	1.38361130 00	4.62816920 01	8.51629830 00	4.67740380 00	49.1272938	3.0633628
25	1.01988030 00	1.27703810-01	1.39673060 00	4.57217390 01	8.89284360 00	4.91490730 00	49.2066996	3.1607185
26	1.02316330 00	1.31683920-01	1.40992970 00	4.51743520 01	9.27353190 00	5.15304740 00	49.2879551	3.2592280
27	1.02652140 00	1.35711580-01	1.42319970 00	4.46393640 01	9.65781490 00	5.39157290 00	49.3710703	3.3589140
28	1.02995500 00	1.39787540-01	1.43653400 00	4.41165310 01	1.00453990 01	5.63028900 00	49.4560528	3.4597957
29	1.03346430 00	1.43912520-01	1.44992720 00	4.36055600 01	1.04359860 01	5.86904370 00	49.5429083	3.5618906
30	1.03704940 00	1.48087190-01	1.46337500 00	4.31061260 01	1.08293140 01	6.10771870 00	49.6316417	3.6652151
31	1.04071060 00	1.52312190-01	1.47687420 00	4.26178860 01	1.12251520 01	6.34622120 00	49.7222577	3.7697855
32	1.04444800 00	1.56588180-01	1.49042230 00	4.21404880 01	1.16232940 01	6.58447920 00	49.8147608	3.8756179
33	1.04826190 00	1.60915830-01	1.50401740 00	4.16735760 01	1.20235570 01	6.82243690 00	49.9091562	3.9827290
34	1.05215250 00	1.65295830-01	1.51765800 00	4.12167960 01	1.24257780 01	7.06005170 00	50.0054492	4.0911356
35	1.05612000 00	1.69728890-01	1.53134310 00	4.07698010 01	1.28298100 01	7.29729130 00	50.1036461	4.2008556
36	1.06016470 00	1.74215760-01	1.54507210 00	4.03322520 01	1.32355190 01	7.53413210 00	50.2037536	4.3119073
CONTOUR	1.04964940 00	1.62477880-01	1.50888200 00					

M A C H 4 INTERMEDIATE LEFT CHARACTERISTIC

CHARACT 31 POINT	X	Y	MACH NO.	MACH ANG. (D)	PSI (D)	FLOW ANG. (D)	X (IN)	Y (IN)
11	9.14718090-01	7.56095150-02	1.03683250 00	7.46823080 01	3.10755610-01	2.53527570-01	46.6038946	1.8713647
12	9.15711220-01	7.91859510-02	1.04192150 00	7.36918210 01	3.76114380-01	3.06001260-01	46.6284751	1.9598829
13	9.17162560-01	8.40518470-02	1.04938900 00	7.23517030 01	4.78689270-01	3.87991910-01	46.6643962	2.0803157
14	9.18853930-01	8.92881310-02	1.05813020 00	7.09200330 01	6.07873660-01	4.90781660-01	46.7062582	2.2099157
15	9.20714500-01	9.46217330-02	1.06781060 00	6.94711340 01	7.61227310-01	6.12346590-01	46.7523082	2.3419244
16	9.22702420-01	9.99262960-02	1.07824340 00	6.80383530 01	9.37357630-01	7.51554850-01	46.8015100	2.4732144
17	9.24788370-01	1.05137480-01	1.08930190 00	6.66381920 01	1.13510870 00	9.07491690-01	46.8531380	2.6021932
18	9.26950050-01	1.10221810-01	1.10089080 00	6.52790510 01	1.35335030 00	1.07927670 00	46.9066404	2.7280323
19	9.29169780-01	1.15162560-01	1.11293260 00	6.39651230 01	1.59090910 00	1.26599980 00	46.9615796	2.8503177
20	9.31433170-01	1.19952640-01	1.12536110 00	6.26983010 01	1.84654810 00	1.46669700 00	47.0175993	2.9688742
21	9.33728400-01	1.24590810-01	1.13811770 00	6.14791890 01	2.11896060 00	1.68034090 00	47.0744071	3.0836706
22	9.36045780-01	1.29079520-01	1.15114850 00	6.03076520 01	2.40677370 00	1.90583670 00	47.1317633	3.1947680
23	9.38377500-01	1.33423740-01	1.16440300 00	5.91831400 01	2.70855290 00	2.14202100 00	47.1894742	3.3022891
24	9.40717440-01	1.37630250-01	1.17783350 00	5.81048550 01	3.02281170 00	2.38766490 00	47.2473887	3.4064020
25	9.43061140-01	1.41707310-01	1.19139370 00	5.70718740 01	3.34801830 00	2.64147270 00	47.3053961	3.5073107
26	9.45405730-01	1.45664420-01	1.20503890 00	5.60832050 01	3.68260680 00	2.90208590 00	47.3634256	3.6052504
27	9.47749990-01	1.49951230-01	1.21872540 00	5.51378230 01	4.02498770 00	3.16808560 00	47.4214470	3.7004876
28	9.50094390-01	1.53262980-01	1.23241050 00	5.42346980 01	4.37355740 00	3.43799390 00	47.4794717	3.7933180
29	9.52441160-01	1.56929740-01	1.24605260 00	5.33728030 01	4.72670930 00	3.71027690 00	47.5375552	3.8840716
30	9.54794400-01	1.60527350-01	1.25961050 00	5.25511210 01	5.08284540 00	3.98334740 00	47.5957989	3.9731140
31	9.57160230-01	1.64072230-01	1.27304450 00	5.17686560 01	5.44038350 00	4.25556470 00	47.6543542	4.0608510
CONTOUR	9.49893690-01	1.52941900-01	1.23123900 00					

	X	Y-CALC	Y-IN	DIFF	
1	0.8933835	0.1512190	0.1512190	0.0	1
2	0.8981780	0.1512317	0.1512316	0.0000001	2
3	0.9031363	0.1512714	0.1512712	0.0000002	3
4	0.9082511	0.1513406	0.1513403	0.0000002	4
5	0.9135380	0.1514422	0.1514422	0.0000000	5
6	0.9189965	0.1515789	0.1515787	0.0000003	6
7	0.9246596	0.1517547	0.1517539	0.0000009	7
8	0.9305367	0.1519731	0.1519726	0.0000005	8
9	0.9366783	0.1522399	0.1522387	0.0000012	9
10	0.9431175	0.1525609	0.1525592	0.0000017	10
11	0.9498937	0.1529430	0.1529419	0.0000011	11
12	0.9570730	0.1533955	0.1533942	0.0000014	12
13	0.9647004	0.1539274	0.1539264	0.0000009	13
14	0.9728364	0.1545491	0.1545491	0.0	14
15	0.9815448	0.1552720	0.1552734	-0.0000014	15
16	0.9908919	0.1561084	0.1561105	-0.0000022	16
17	1.0009363	0.1570703	0.1570737	-0.0000035	17
18	1.0117627	0.1581731	0.1581767	-0.0000036	18
19	1.0234319	0.1594306	0.1594343	-0.0000037	19
20	1.0360337	0.1608591	0.1608628	-0.0000036	20
21	1.0496494	0.1624749	0.1624779	-0.0000030	21
22	1.0586537	0.1635797	0.1635826	-0.0000029	22
23	1.0715645	0.1652082	0.1652117	-0.0000036	23
24	1.0863627	0.1671320	0.1671360	-0.0000040	24
25	1.1024792	0.1692874	0.1692926	-0.0000052	25
26	1.1196438	0.1716423	0.1716478	-0.0000054	26
27	1.1376982	0.1741740	0.1741802	-0.0000061	27
28	1.1565561	0.1768682	0.1768733	-0.0000051	28
29	1.1761470	0.1797114	0.1797158	-0.0000044	29
30	1.1964348	0.1826928	0.1826961	-0.0000032	30
31	1.2173753	0.1858020	0.1858043	-0.0000022	31
32	1.2389456	0.1890300	0.1890304	-0.0000004	32
33	1.2611122	0.1923669	0.1923672	-0.0000004	33
34	1.2838486	0.1958053	0.1958053	0.0	34
35	1.3071231	0.1993364	0.1993364	0.0	35
36	1.3309005	0.2029516	0.2029521	-0.0000005	36
37	1.3551440	0.2066430	0.2066430	0.0	37
38	1.3798149	0.2104028	0.2104028	0.0	38
39	1.4048689	0.2142226	0.2142226	0.0	39
40	1.4302636	0.2180949	0.2180949	0.0	40
41	1.4559664	0.2220140	0.2220140	0.0	41

MAX. ABSOLUTE ERROR = 6.1268970-06 AT POINT 27

M A C H 4 INTERMEDIATE RIGHT CHARACTERISTIC

LAST POINT	X	Y	MACH NO.	MACH ANG.(D)	PSI (D)	FLOW ANG.(D)	X(IN)	Y(IN)
1	1.14068300 00	0.0	1.66015380 00	3.70386650 01	1.66373790 01	0.0	52.1966126	0.0
2	1.13413180 00	4.96135430-03	1.64318410 00	3.74865040 01	1.61367180 01	2.50226280-01	52.0344692	0.1227954
3	1.12751270 00	1.00117670-02	1.62585030 00	3.79564810 01	1.56247130 01	5.05245830-01	51.8706443	0.2477951
4	1.12082370 00	1.51571300-02	1.60823410 00	3.84477020 01	1.51039000 01	7.63015230-01	51.7050870	0.3751448
5	1.11406440 00	2.04022610-02	1.59041490 00	3.89591950 01	1.45767900 01	1.02155670 00	51.5377939	0.5049638
6	1.10723670 00	2.57509600-02	1.57247050 00	3.94898850 01	1.40458700 01	1.27898870 00	51.3688057	0.6373462
7	1.10034390 00	3.12060160-02	1.55447690 00	4.00385770 01	1.35136010 01	1.53351780 00	51.1982044	0.7723609
8	1.09339080 00	3.67691680-02	1.53650840 00	4.06039270 01	1.29824110 01	1.78344390 00	51.0261121	0.9100511
9	1.08638400 00	4.24409860-02	1.51863810 00	4.11844130 01	1.24547000 01	2.02715750 00	50.8526913	1.0504308
10	1.07933180 00	4.82206520-02	1.50093810 00	4.17782920 01	1.19328410 01	2.26313870 00	50.6781476	1.1934798
11	1.07224460 00	5.41056060-02	1.48348050 00	4.23835570 01	1.14191910 01	2.48995760 00	50.5027359	1.3391346
12	1.06513500 00	6.00909700-02	1.46633770 00	4.29978690 01	1.09161070 01	2.70626910 00	50.3267714	1.4872747
13	1.05801900 00	6.61686470-02	1.44958440 00	4.36184670 01	1.04259740 01	2.91080960 00	50.1506482	1.6376996
14	1.05091700 00	7.23258910-02	1.43329920 00	4.42420480 01	9.95124980 00	3.10239000 00	49.9748707	1.7900937
15	1.04385590 00	7.85429670-02	1.41756820 00	4.48645710 01	9.49454920 00	3.27988490 00	49.8001059	1.9439688
16	1.03687300 00	8.47891860-02	1.40249010 00	4.54809610 01	9.05878230 00	3.44221320 00	49.6272753	2.0985651
17	1.03002240 00	9.10157930-02	1.38818630 00	4.60845750 01	8.64741720 00	3.58830090 00	49.4577215	2.2526760
18	1.02338880 00	9.71421470-02	1.37482020 00	4.66661820 01	8.26501220 00	3.71699670 00	49.2935376	2.4043057
19	1.01711680 00	1.03025340-01	1.36264220 00	4.72116790 01	7.91845070 00	3.82685340 00	49.1383024	2.5499170
20	1.01149480 00	1.08375950-01	1.35212270 00	4.76954660 01	7.62063550 00	3.91535930 00	48.9991555	2.6823466
21	1.00748740 00	1.12235360-01	1.34486160 00	4.80365000 01	7.41596650 00	3.97260230 00	48.8999711	2.7778684
22	1.00128570 00	1.18284240-01	1.33402770 00	4.85565720 01	7.11205220 00	4.05148220 00	48.7464767	2.9275806
23	9.95385510-01	1.24126240-01	1.32419270 00	4.90408450 01	6.83776920 00	4.11540370 00	48.6004446	3.0721723
24	9.89773480-01	1.29762900-01	1.31528290 00	4.94900080 01	6.59070290 00	4.16599000 00	48.4615445	3.2116818
25	9.84435130-01	1.35197670-01	1.30722610 00	4.99050870 01	6.36851820 00	4.20474180 00	48.3294183	3.3461946
26	9.79354660-01	1.40436270-01	1.29995200 00	5.02874090 01	6.16897270 00	4.23302880 00	48.2036747	3.4758520
27	9.74514750-01	1.45486970-01	1.29339240 00	5.06385600 01	5.98992830 00	4.25208370 00	48.0838852	3.6008587
28	9.69896490-01	1.50360810-01	1.28748180 00	5.09603260 01	5.82936260 00	4.26299670 00	47.9695814	3.7214882
29	9.65479390-01	1.55071630-01	1.28215820 00	5.12540220 01	5.68538460 00	4.26671080 00	47.8602565	3.8380827

M A C H 4 UPSTREAM CONTOUR

RC= 6.000000 ETAD= 8.6700 DEG AMACH= 2.2878437 BMACH= 3.0821543 CMACH= 4.0000000 EMACH= 1.6601538 GMACH= 2.2878437

WALL POINT	X	Y	MACH NO.	FLOW ANG.(D)	WALTAN	SECDF
1	8.93383510-01	1.51219030-01	1.04716380 00	0.0	0.0	1.10215410 00
2	8.98178030-01	1.51231700-01	1.06260270 00	3.02459250-01	5.27895880-03	1.09963210 00
3	9.03136290-01	1.51271390-01	1.07862930 00	6.14416450-01	1.07240010-02	1.09683920 00
4	9.08251110-01	1.51340590-01	1.09523000 00	9.35389910-01	1.63270840-02	1.09269530 00
5	9.13538010-01	1.51442200-01	1.11249320 00	1.28539790 00	2.20889510-02	1.08558260 00
6	9.18996460-01	1.51578940-01	1.13035520 00	1.60332250 00	2.79905630-02	1.07515640 00
7	9.24659570-01	1.51754730-01	1.14895920 00	1.94981580 00	3.40438490-02	1.06072050 00
8	9.30536680-01	1.51973130-01	1.16823050 00	2.30364950 00	4.02279470-02	1.04264740 00
9	9.36678280-01	1.52239870-01	1.18835890 00	2.66633460 00	4.65699410-02	1.01916460 00
10	9.43117480-01	1.52560930-01	1.20935560 00	3.03621740 00	5.30416500-02	9.87911420-01
11	9.49893690-01	1.52943040-01	1.23123900 00	3.41157840 00	5.96137440-02	9.49521990-01
12	9.57073000-01	1.53395540-01	1.25411900 00	3.79177930 00	6.62758170-02	9.03059030-01
13	9.64700380-01	1.53927370-01	1.27794330 00	4.17302310 00	7.29620510-02	8.47222460-01
14	9.72836360-01	1.54549070-01	1.30267850 00	4.55114850 00	7.96000090-02	7.84099510-01
15	9.81544830-01	1.55271960-01	1.32834690 00	4.92285660 00	8.61321100-02	7.17491700-01
16	9.90891890-01	1.56108370-01	1.35503990 00	5.28547690 00	9.25115440-02	6.50534180-01
17	1.00093630 00	1.57070280-01	1.38292050 00	5.63687540 00	9.87006840-02	5.86440400-01
18	1.01176270 00	1.58173100-01	1.41208730 00	5.97724410 00	1.04702700-01	5.24740310-01
19	1.02343190 00	1.59430600-01	1.44272440 00	6.30294810 00	1.10453110-01	4.64101300-01
20	1.03603370 00	1.60859120-01	1.47494090 00	6.61172130 00	1.15911270-01	4.07886710-01
21	1.04964940 00	1.62474890-01	1.50888200 00	6.90453590 00	1.21093620-01	3.53098110-01
22	1.05865370 00	1.63579690-01	1.53088170 00	7.07475540 00	1.24109170-01	3.19092190-01
23	1.07156450 00	1.65208170-01	1.56186230 00	7.29060210 00	1.27936240-01	2.79735690-01
24	1.08636270 00	1.67131980-01	1.59660170 00	7.50789960 00	1.31792760-01	2.43425290-01
25	1.10247920 00	1.69287440-01	1.63358980 00	7.71176190 00	1.35414350-01	2.07807000-01
26	1.11964380 00	1.71642330-01	1.67206110 00	7.89498270 00	1.38672210-01	1.74143200-01
27	1.13769820 00	1.74174030-01	1.71161100 00	8.05494640 00	1.41518900-01	1.44306350-01
28	1.15655610 00	1.76868250-01	1.75191400 00	8.19296940 00	1.43976950-01	1.17715950-01
29	1.17614780 00	1.79711420-01	1.79283120 00	8.30795710 00	1.46026060-01	9.38496700-02
30	1.19643400 00	1.82692840-01	1.83415150 00	8.40208310 00	1.47704300-01	7.37369280-02
31	1.21737530 00	1.85802010-01	1.87581240 00	8.47775980 00	1.49054190-01	5.62904070-02
32	1.23894560 00	1.89030000-01	1.91764070 00	8.53562980 00	1.50086810-01	4.18915450-02
33	1.26111220 00	1.92366870-01	1.95959490 00	8.58002320 00	1.50879170-01	3.09451470-02
34	1.28384860 00	1.95805330-01	2.00154400 00	8.61316380 00	1.51470800-01	2.17786560-02
35	1.30712310 00	1.99336440-01	2.04340240 00	8.63589180 00	1.51876600-01	1.45122710-02
36	1.33090050 00	2.02951570-01	2.08509680 00	8.65123930 00	1.52150650-01	9.48145870-03
37	1.35514400 00	2.06642950-01	2.12650440 00	8.66128140 00	1.52329980-01	5.74761310-03
38	1.37981490 00	2.10402760-01	2.16755280 00	8.66690280 00	1.52430370-01	2.91359480-03
39	1.40486890 00	2.14222570-01	2.20817100 00	8.66934390 00	1.52473970-01	1.04252170-03
40	1.43026360 00	2.18094870-01	2.24828490 00	8.66982090 00	1.52482490-01	2.30580180-04
41	1.45596640 00	2.22014040-01	2.28784370 00	8.67000000 00	1.52485690-01	0.0

M A C H 4 UPSTREAM CONTOUR

RC= 6.000000 ETAD= 8.6700 DEG AMACH= 2.2878437 BMACH= 3.0821543 CMACH= 4.0000000 EMACH= 1.6601538 GMACH= 2.2878437

POINT	X/Y0	Y/Y0	INT.Y/Y0	PAR/Y0	HYP/Y0	C(Y)	C(YI)	C(YP)
1	0.0	1.0000000	1.0000088	1.0000000	1.0000000			
2	0.0317058	1.0000838	1.0000929	1.0000838	1.0000838	-9.0270280-04	-2.8528070-01	1.7714580-03
3	0.0644944	1.0003463	1.0003562	1.0003466	1.0003466	1.3356690-03	-3.5499110-02	2.0086530-03
4	0.0983183	1.0008039	1.0008144	1.0008055	1.0008052	1.7558740-03	-9.3410500-03	2.0450230-03
5	0.1332802	1.0014758	1.0014864	1.0014803	1.0014792	1.8944620-03	-2.5754650-03	2.3347300-03
6	0.1693765	1.0023801	1.0023903	1.0023907	1.0023878	2.1837070-03	8.7066240-05	2.7752710-03
7	0.2068262	1.0035425	1.0035516	1.0035648	1.0035584	2.5140290-03	1.4830450-03	3.3288140-03
8	0.2456911	1.0049868	1.0049947	1.0050303	1.0050178	2.9363020-03	2.4013550-03	3.9790320-03
9	0.2863051	1.0067508	1.0067572	1.0068309	1.0068077	3.4143290-03	3.1406260-03	4.6665920-03
10	0.3288870	1.0088739	1.0088791	1.0090139	1.0089736	3.9358510-03	3.7885620-03	5.4633410-03
11	0.3736976	1.0114008	1.0114059	1.0116375	1.0115706	4.5363910-03	4.4381390-03	6.3711370-03
12	0.4211738	1.0143931	1.0143998	1.0147823	1.0146746	5.2087510-03	5.1187970-03	7.3658240-03
13	0.4716131	1.0179100	1.0179204	1.0185349	1.0183662	5.9572190-03	5.8581470-03	8.4527150-03
14	0.5254157	1.0220213	1.0220373	1.0230051	1.0227464	6.7826680-03	6.6726340-03	9.6225850-03
15	0.5830041	1.0268017	1.0268248	1.0283245	1.0279343	7.6845590-03	7.5681880-03	1.0822250-02
16	0.6448156	1.0323328	1.0323620	1.0346489	1.0340686	8.6387150-03	8.5300620-03	1.1991490-02
17	0.7112386	1.0386939	1.0387293	1.0421550	1.0413021	9.6200600-03	9.5216590-03	1.3072830-02
18	0.7828325	1.0459867	1.0460258	1.0510689	1.0498275	1.0593540-02	1.0512040-02	1.4016680-02
19	0.8600004	1.0543025	1.0543411	1.0616334	1.0598428	1.1525550-02	1.1464790-02	1.4818940-02
20	0.9433346	1.0637492	1.0637853	1.0741567	1.0715938	1.2397890-02	1.2354920-02	1.5474430-02
21	1.0333747	1.0744341	1.0744669	1.0889886	1.0853466	1.3189350-02	1.3159680-02	1.5961940-02
22	1.0929194	1.0817401	1.0817717	1.0995394	1.0950246	1.3634470-02	1.3610260-02	1.6197960-02
23	1.1782974	1.0925091	1.0925435	1.1156987	1.1096835	1.4175190-02	1.4154200-02	1.6433160-02
24	1.2761568	1.1052311	1.1052701	1.1357147	1.1275768	1.4667420-02	1.4648660-02	1.6558440-02
25	1.3827342	1.1194850	1.1195301	1.1593295	1.1483288	1.5071350-02	1.5054300-02	1.6659670-02
26	1.4962419	1.1350577	1.1351040	1.1865616	1.1718034	1.5375700-02	1.5361890-02	1.6482700-02
27	1.6156349	1.1517997	1.1518474	1.2175230	1.1979341	1.5584390-02	1.5573080-02	1.6314180-02
28	1.7403406	1.1696163	1.1696609	1.2523988	1.2267019	1.5704910-02	1.5696450-02	1.6076830-02
29	1.8698934	1.1884180	1.1884549	1.2913751	1.2580740	1.5747290-02	1.5741650-02	1.5789390-02
30	2.0040550	1.2081339	1.2081635	1.3346864	1.2920421	1.5723220-02	1.5719550-02	1.5462640-02
31	2.1425332	1.2286946	1.2287147	1.3825374	1.3285612	1.5642070-02	1.5640030-02	1.5106340-02
32	2.2851759	1.2500411	1.2500531	1.4351691	1.3676031	1.5513620-02	1.5512610-02	1.4730920-02
33	2.4317621	1.2721076	1.2721171	1.4927889	1.4091053	1.5346250-02	1.5345590-02	1.4340970-02
34	2.5821161	1.2948458	1.2948518	1.5556103	1.4530040	1.5146810-02	1.5146460-02	1.3942720-02
35	2.7360289	1.3181968	1.3182015	1.6238212	1.4992139	1.4921960-02	1.4921730-02	1.3542350-02
36	2.8932668	1.3421034	1.3421088	1.6975827	1.5476322	1.4677390-02	1.4677170-02	1.3143020-02
37	3.0535872	1.3665142	1.3665203	1.7770329	1.5981445	1.4417900-02	1.4417690-02	1.2747970-02
38	3.2167339	1.3913775	1.3913815	1.8622814	1.6506250	1.4147730-02	1.4147610-02	1.2360360-02
39	3.3824143	1.4166376	1.4166393	1.9533938	1.7049304	1.3870650-02	1.3870600-02	1.1982390-02
40	3.5503471	1.4422449	1.4422444	2.0504137	1.7609166	1.3589760-02	1.3589770-02	1.1615580-02
41	3.7203183	1.4681620	1.4681620	2.1533973	1.8184594	1.3307590-02	1.3307590-02	1.1260630-02

ICV = -284377

M A C H 4 DOWNSTREAM CONTOUR, 4TH-DEG AXIAL MACH NUMBER DISTRIBUTION

NO. OF POINTS ON 1ST CHAR. (M)= 41 NO. OF POINTS ON AXIS (N)= 49 NO. OF POINTS ON LAST CHAR. (NP)= 61

GAMMA= 1.4000 INFLECTION ANG. (ETA)= 8.6700 DEGREES RAD. OF CURV. (RC)= 6.00000000 SCALE FACTOR (SF)= 24.750386

BMACH= 3.08215 BMP= 0.98284937 BMPP= -4.35793230-01 BMPPP= -3.98632510-01 SMPP= -4.35793230-01

CMACH= 4.00000 CMP= 0.0 CMPP= 0.0 CMPPP= 7.88117500-01 SMPPP= 5.32835300-01

C1= 3.0821543 C2= 2.19941261 C3= -1.09116390 00 C4= -7.44527440-01 C5= 5.54124370-01 C6= 0.0

AMACH= 2.2878437 XA= 1.4559664 XR= 2.1398501 XRC= 2.2377922 XC= 4.3776423 XD= 6.2945435

XA(IN)= 60.0900000, YA(IN)= 5.4949332, XB(IN)= 76.9263852, XC(IN)= 132.3126057, XD(IN)= 179.7566517, YO(IN)= 12.2500000

AXIS POINT	X	X(IN)	MACH NO.	DM/OX	D2M/DX2	D3M/DX3	W=Q/A*	OW/DX	D2W/DX2	D3W/DX3
1	2.13985	76.92639	3.082154	9.8284940-01	-4.3579320-01	-3.9863250-01	1.982672	2.1801940-01	-2.3331610-01	1.9250830-01
3	2.23309	79.23414	3.171850	9.4055420-01	-4.7065700-01	-3.4918460-01	2.002012	1.9709000-01	-2.1574680-01	1.8392550-01
5	2.32633	81.54190	3.257457	8.9522330-01	-5.0091010-01	-2.9973670-01	2.019476	1.7775830-01	-1.9907840-01	1.7336500-01
7	2.41957	83.84966	3.338713	8.4728650-01	-5.2655270-01	-2.5028880-01	2.035208	1.5993300-01	-1.8344910-01	1.6177010-01
9	2.51282	86.15742	3.415394	7.9717360-01	-5.4758460-01	-2.0084080-01	2.049344	1.4351390-01	-1.6892130-01	1.4983750-01
11	2.60606	88.46518	3.487317	7.4531470-01	-5.6400600-01	-1.5139290-01	2.062011	1.2839760-01	-1.5550170-01	1.3806980-01
13	2.69930	90.77294	3.554341	6.9213960-01	-5.7581680-01	-1.0194500-01	2.073325	1.1448210-01	-1.4315750-01	1.2682020-01
15	2.79254	93.08070	3.616362	6.3807820-01	-5.8301700-01	-5.2497090-02	2.083394	1.0166960-01	-1.3182830-01	1.1633010-01
17	2.88578	95.38846	3.673317	5.8356030-01	-5.8560660-01	-3.0491730-03	2.092316	8.9869260-02	-1.2143530-01	1.0675920-01
19	2.97902	97.69622	3.725185	5.2901600-01	-5.8358560-01	4.6398740-02	2.100182	7.8997770-02	-1.1188780-01	9.8209360-02
21	3.07226	100.00398	3.771982	4.7487500-01	-5.7695400-01	9.5846660-02	2.107075	6.8980900-02	-1.0308730-01	9.0742350-02
23	3.16550	102.31174	3.813767	4.2156730-01	-5.6571190-01	1.4529460-01	2.113070	5.9753750-02	-9.4931120-02	8.4393700-02
25	3.25875	104.61950	3.850637	3.6952280-01	-5.4985910-01	1.9474250-01	2.118240	5.1261140-02	-8.7313980-02	7.9182270-02
27	3.35199	106.92725	3.882729	3.1917140-01	-5.2939580-01	2.4419040-01	2.122651	4.3457760-02	-8.0129370-02	7.5116890-02
29	3.44523	109.23501	3.910222	2.7094300-01	-5.0432180-01	2.9363830-01	2.126365	3.6308280-02	-7.3270270-02	7.2200290-02
31	3.53847	111.54277	3.933335	2.2526750-01	-4.7463730-01	3.4308620-01	2.129441	2.9787330-02	-6.6629610-02	7.0430840-02
33	3.63171	113.85053	3.952324	1.8257470-01	-4.4034220-01	3.9253420-01	2.131939	2.3879540-02	-6.0100670-02	6.9802270-02
35	3.72495	116.15829	3.967488	1.4329460-01	-4.0143650-01	4.4198210-01	2.133913	1.8579420-02	-5.3577630-02	7.0301520-02
37	3.81819	118.46605	3.979165	1.0785700-01	-3.5792020-01	4.9143000-01	2.135422	1.3891300-02	-4.6956320-02	7.1904850-02
39	3.91144	120.77381	3.987734	7.6691950-02	-3.0979330-01	5.4087790-01	2.136523	9.8290820-03	-4.0135520-02	7.4572240-02
41	4.00468	123.08157	3.993613	5.0229240-02	-2.5705580-01	5.9032580-01	2.137276	6.4159220-03	-3.3018760-02	7.8240130-02
43	4.09792	125.38933	3.997260	2.8898800-02	-1.9970770-01	6.3977370-01	2.137741	3.6836340-03	-2.5516940-02	8.2812640-02
45	4.19116	127.69709	3.999175	1.3130510-02	-1.3774910-01	6.8922170-01	2.137985	1.6718720-03	-1.7551760-02	8.8151680-02
47	4.28440	130.00485	3.999895	3.3542760-03	-7.1179840-02	7.3866960-01	2.138077	4.2691510-04	-9.0602230-03	9.0066180-02
49	4.37764	132.31261	4.000000	-4.1674440-15	-6.0303100-15	7.8811750-01	2.138090	-5.3037920-16	-7.6746100-16	1.0030160-01

M A C H 4 DOWNSTREAM CONTOUR

CHARACT	1									
POINT	X	Y	MACH NO.	MACH ANG.(D)	PSI (D)	FLOW ANG.(D)	X(IN)	Y(IN)		
1	2.13985010 00	0.0	3.08215430 00	1.89321590 01	5.13173790 01	0.0	76.9263852	0.0		
2	2.11646200 00	8.00661650-03	3.05906210 00	1.90805790 01	5.08838790 01	2.16750000-01	76.3475216	0.1981669		
3	2.09349230 00	1.58396700-02	3.03617440 00	1.92300470 01	5.04503790 01	4.33500000-01	75.7790116	0.3920379		
4	2.07093130 00	2.35040150-02	3.01348770 00	1.93805800 01	5.00168790 01	6.50250000-01	75.2206173	0.5817335		
5	2.04876960 00	3.10043580-02	2.99099830 00	1.95321980 01	4.95833790 01	8.67000000-01	74.6721080	0.7673698		
6	2.02699830 00	3.83452580-02	2.96870300 00	1.96849190 01	4.91498790 01	1.08375000 00	74.1332594	0.9490599		
7	2.00560850 00	4.55311350-02	2.94659820 00	1.98387640 01	4.87163790 01	1.30050000 00	73.6038537	1.1269132		
8	1.98459170 00	5.25662760-02	2.92468070 00	1.99937510 01	4.82828790 01	1.51725000 00	73.0836792	1.3010356		
9	1.96393950 00	5.94548360-02	2.90294730 00	2.01499030 01	4.78493790 01	1.73400000 00	72.5725301	1.4715302		
10	1.94364390 00	6.62008470-02	2.88139460 00	2.03072400 01	4.74158790 01	1.95075000 00	72.0702063	1.6384965		
11	1.92369700 00	7.28082170-02	2.86001960 00	2.04657840 01	4.69823790 01	2.16750000 00	71.5765135	1.8020315		
12	1.904409130 00	7.92807410-02	2.83881930 00	2.06255560 01	4.65488790 01	2.38425000 00	71.0912626	1.9622290		
13	1.88481910 00	8.56220990-02	2.81779050 00	2.07865800 01	4.61153790 01	2.60100000 00	70.6142697	2.1191800		
14	1.86587340 00	9.18358650-02	2.79693030 00	2.09488790 01	4.56818790 01	2.81775000 00	70.1453561	2.2729731		
15	1.84724710 00	9.79255070-02	2.77623580 00	2.11124760 01	4.52483790 01	3.03450000 00	69.6843478	2.4236941		
16	1.82893340 00	1.03894390-01	2.75570420 00	2.12773970 01	4.48148790 01	3.25125000 00	69.2310756	2.5714263		
17	1.81092550 00	1.09745790-01	2.73533250 00	2.14436670 01	4.43813790 01	3.46800000 00	68.7853750	2.7162507		
18	1.79321720 00	1.15482880-01	2.71511820 00	2.16113110 01	4.39478790 01	3.68475000 00	68.3470857	2.8582458		
19	1.77580190 00	1.21108740-01	2.69505840 00	2.17803560 01	4.35143790 01	3.90150000 00	67.9160519	2.9974880		
20	1.75867370 00	1.26626370-01	2.67515040 00	2.19508300 01	4.30808790 01	4.11825000 00	67.4921219	3.1340515		
21	1.74182650 00	1.32038680-01	2.65539170 00	2.21227600 01	4.26473790 01	4.33500000 00	67.0751479	3.2680083		
22	1.72525460 00	1.37348510-01	2.63577960 00	2.22961750 01	4.22138790 01	4.55175000 00	66.6649862	3.3994286		
23	1.70895220 00	1.42558600-01	2.61631170 00	2.24711050 01	4.17803790 01	4.76850000 00	66.2614968	3.5283805		
24	1.69291400 00	1.47671640-01	2.59698530 00	2.26475810 01	4.13468790 01	4.98525000 00	65.8645434	3.6549301		
25	1.67713440 00	1.52690220-01	2.57779810 00	2.28256330 01	4.09133790 01	5.20200000 00	65.47739932	3.7791418		
26	1.66160830 00	1.57616870-01	2.55874760 00	2.30052950 01	4.04798790 01	5.41875000 00	65.0897170	3.9010784		
27	1.64633070 00	1.62454060-01	2.53983140 00	2.31865990 01	4.00463790 01	5.63550000 00	64.7115887	4.0208006		
28	1.63129640 00	1.67204170-01	2.52104720 00	2.33695800 01	3.96128790 01	5.85225000 00	64.3394858	4.1383679		
29	1.61650080 00	1.71869550-01	2.50239260 00	2.35542720 01	3.91793790 01	6.06900000 00	63.9732887	4.2538379		
30	1.60193910 00	1.76452460-01	2.48386530 00	2.37407130 01	3.87458790 01	6.28575000 00	63.6128808	4.3672666		
31	1.58760670 00	1.80955110-01	2.46546320 00	2.39289390 01	3.83123790 01	6.50250000 00	63.2581489	4.4787089		
32	1.57349920 00	1.85379650-01	2.44718380 00	2.41189890 01	3.78788790 01	6.71925000 00	62.9089822	4.5882180		
33	1.55961220 00	1.89728170-01	2.42902520 00	2.43109030 01	3.74453790 01	6.93600000 00	62.5652729	4.6958456		
34	1.54594140 00	1.94002720-01	2.41098500 00	2.45047220 01	3.70118790 01	7.15275000 00	62.2269161	4.8016422		
35	1.53248280 00	1.98205280-01	2.39306110 00	2.47004890 01	3.65783790 01	7.36950000 00	61.8938093	4.9056572		
36	1.51923220 00	2.02337790-01	2.37525150 00	2.48982460 01	3.61448790 01	7.58625000 00	61.5658527	5.0079384		
37	1.50618580 00	2.06402130-01	2.35755390 00	2.50980400 01	3.57113790 01	7.80300000 00	61.2429489	5.1085325		
38	1.49333970 00	2.10400160-01	2.33996640 00	2.52999170 01	3.52778790 01	8.01975000 00	60.9250032	5.2074852		
39	1.48069020 00	2.14333660-01	2.32248690 00	2.55039250 01	3.48443790 01	8.23650000 00	60.6119228	5.3048408		
40	1.46823360 00	2.18204380-01	2.30511340 00	2.57101140 01	3.44108790 01	8.45325000 00	60.3036178	5.4006428		
41	1.45596640 00	2.22014040-01	2.28784370 00	2.59185360 01	3.39773790 01	8.67000000 00	60.0000000	5.4949332		

MASS = 0.9999999136

	X	Y-CALC	Y-IN	DIFF	
1	1.4559664	0.2220140	0.2220140	0.0	1
2	1.4783065	0.2254207	0.2254211	-0.0000004	2
3	1.5005471	0.2288121	0.2288122	-0.0000002	3
4	1.5227029	0.2321903	0.2321902	0.0000001	4
5	1.5447888	0.2355573	0.2355570	0.0000004	5
6	1.5668216	0.2389156	0.2389150	0.0000007	6
7	1.5888196	0.2422675	0.2422666	0.0000009	7
8	1.6108018	0.2456153	0.2456146	0.0000007	8
9	1.6327838	0.2489607	0.2489617	-0.0000010	9
10	1.6547950	0.2523073	0.2523073	-0.0000000	10
11	1.6768523	0.2556568	0.2556564	0.0000004	11
12	1.6989763	0.2590114	0.2590116	-0.0000002	12
13	1.7211884	0.2623733	0.2623733	-0.0000000	13
14	1.7435111	0.2657447	0.2657437	0.0000010	14
15	1.7659655	0.2691277	0.2691271	0.0000006	15
16	1.7885670	0.2725233	0.2725249	-0.0000016	16
17	1.8113487	0.2759349	0.2759349	0.0000000	17
18	1.8343264	0.2793635	0.2793639	-0.0000004	18
19	1.8575201	0.2828101	0.2828102	-0.0000001	19
20	1.8809524	0.2862765	0.2862751	0.0000014	20
21	1.9046426	0.2897636	0.2897639	-0.0000003	21
22	1.9286045	0.2932714	0.2932721	-0.0000007	22
23	1.9528712	0.2968028	0.2968031	-0.0000003	23
24	1.9774540	0.3003574	0.3003592	-0.0000018	24
25	2.0023732	0.3039357	0.3039348	0.0000009	25
26	2.0276463	0.3075379	0.3075385	-0.0000006	26
27	2.0532825	0.3111628	0.3111637	-0.0000009	27
28	2.0793143	0.3148122	0.3148121	0.0000001	28
29	2.1057480	0.3184841	0.3184853	-0.0000012	29
30	2.1326005	0.3221780	0.3221758	0.0000022	30
31	2.1598844	0.3258924	0.3258930	-0.0000006	31
32	2.1876038	0.3296247	0.3296246	0.0000002	32
33	2.2157874	0.3333758	0.3333762	-0.0000004	33
34	2.2444348	0.3371422	0.3371430	-0.0000008	34
35	2.2735572	0.3409220	0.3409208	0.0000012	35
36	2.3031506	0.3447114	0.3447171	-0.0000057	36
37	2.3332387	0.3485098	0.3485106	-0.0000008	37
38	2.3638162	0.3523172	0.3523172	-0.0000000	38
39	2.3948832	0.3561181	0.3561184	-0.0000003	39
40	2.4264414	0.3599210	0.3599209	0.0000000	40
41	2.4584751	0.3637164	0.3637192	-0.0000028	41
42	2.4910016	0.3675029	0.3675020	0.0000009	42
43	2.5240006	0.3712742	0.3712773	-0.0000030	43
44	2.5574640	0.3750262	0.3750226	0.0000036	44
45	2.5913777	0.3787536	0.3787554	-0.0000018	45
46	2.6257145	0.3824508	0.3824499	0.0000009	46
47	2.6604786	0.3861155	0.3861174	-0.0000018	47
48	2.6956345	0.3897415	0.3897411	0.0000005	48
49	2.7311606	0.3933244	0.3933235	0.0000010	49
50	2.7804383	0.3981596	0.3981670	-0.0000074	50
51	2.8303081	0.4028951	0.4028965	-0.0000014	51
52	2.8807504	0.4075249	0.4075214	0.0000035	52

53	2.9317139	0.4120413	0.4120429	-0.0000017	53
54	2.9831884	0.4164406	0.4164456	-0.0000050	54
55	3.0351722	0.4207206	0.4207173	0.0000033	55
56	3.0876232	0.4248761	0.4248761	0.0	56
57	3.1405382	0.4289056	0.4289149	-0.0000092	57
58	3.1939216	0.4328084	0.4328062	0.0000022	58
59	3.2477348	0.4365807	0.4365807	0.0000000	59
60	3.3019779	0.4402224	0.4402325	-0.0000102	60
61	3.3566594	0.4437334	0.4437302	0.0000032	61
62	3.4117403	0.4471112	0.4471113	-0.0000001	62
63	3.4672234	0.4503561	0.4503640	-0.0000079	63
64	3.5231177	0.4534684	0.4534660	0.0000029	64
65	3.5793863	0.4564483	0.4564488	-0.0000005	65
66	3.6360322	0.4592957	0.4593053	-0.0000097	66
67	3.6930612	0.4620126	0.4620117	0.0000008	67
68	3.7504417	0.4645990	0.4645983	0.0000007	68
69	3.8081853	0.4670572	0.4670598	-0.0000026	69
70	3.8662636	0.4693873	0.4693890	-0.0000017	70
71	3.9246796	0.4715916	0.4715896	0.0000020	71
72	3.9834323	0.4736721	0.4736688	0.0000033	72
73	4.0424953	0.4756301	0.4756315	-0.0000014	73
74	4.1018677	0.4774685	0.4774722	-0.0000037	74
75	4.1615486	0.4791899	0.4791889	0.0000010	75
76	4.2215140	0.4807971	0.4807957	0.0000014	76
77	4.2817672	0.4822935	0.4822915	0.0000020	77
78	4.3422861	0.4836819	0.4836815	0.0000003	78
79	4.4030717	0.4849655	0.4849659	-0.0000004	79
80	4.4641037	0.4861472	0.4861492	-0.0000020	80
81	4.5253768	0.4872307	0.4872314	-0.0000008	81
82	4.5868848	0.4882197	0.4882193	0.0000004	82
83	4.6486081	0.4891185	0.4891186	-0.0000001	83
84	4.7105436	0.4899314	0.4899311	0.0000003	84
85	4.7726727	0.4906627	0.4906628	-0.0000002	85
86	4.8349909	0.4913166	0.4913163	0.0000003	86
87	4.8974804	0.4918974	0.4918974	0.0	87
88	4.9601354	0.4924095	0.4924092	0.0000003	88
89	5.0229390	0.4928577	0.4928577	0.0	89
90	5.0858844	0.4932465	0.4932463	0.0000002	90
91	5.1489555	0.4935803	0.4935809	-0.0000006	91
92	5.2121447	0.4938637	0.4938637	0.0	92
93	5.2754384	0.4941018	0.4941011	0.0000006	93
94	5.3388238	0.4942989	0.4942984	0.0000005	94
95	5.4022929	0.4944599	0.4944593	0.0000006	95
96	5.4658324	0.4945892	0.4945890	0.0000002	96
97	5.5294342	0.4946909	0.4946906	0.0000003	97
98	5.5930872	0.4947690	0.4947681	0.0000009	98
99	5.6567813	0.4948275	0.4948264	0.0000010	99
100	5.7205095	0.4948696	0.4948687	0.0000009	100
101	5.7842631	0.4948988	0.4948979	0.0000010	101
102	5.8480345	0.4949182	0.4949172	0.0000010	102
103	5.9118183	0.4949301	0.4949293	0.0000008	103
104	5.9756089	0.4949369	0.4949362	0.0000007	104
105	6.0394017	0.4949403	0.4949397	0.0000007	105
106	6.1031937	0.4949417	0.4949412	0.0000005	106
107	6.1669822	0.4949420	0.4949417	0.0000004	107
108	6.2307657	0.4949419	0.4949418	0.0000001	108

109 6.2945435 0.4949418 0.4949418 0.0 109
MAX. ABSOLUTE ERROR = 1.015452D-05 AT POINT 60

M A C H * DOWNSTREAM CONTOUR

RC= 6.000000 ETAD= 8.6700 DEG AMACH= 2.2878437 BMACH= 3.0821543 CMACH= 4.0000000 EMACH= 1.6601538 GMACH= 2.2878437

WALL POINT	X	Y	MACH NO.	FLOW ANG.(D)	WALTAN	SECDIF
41	1.45596640 00	2.22014040-01	2.28784370 00	8.67000000 00	1.52485690-01	0.0
42	1.47830650 00	2.25420680-01	2.32140840 00	8.67012960 00	1.52488000-01	-1.23045200-04
43	1.50054710 00	2.28812060-01	2.35412350 00	8.66969540 00	1.52480250-01	-5.30408540-04
44	1.52270290 00	2.32190250-01	2.38604470 00	8.66881280 00	1.52464480-01	-9.48187020-04
45	1.54478840 00	2.35557340-01	2.41722560 00	8.66734830 00	1.52438330-01	-1.55133500-03
46	1.56682160 00	2.38915640-01	2.44771610 00	8.66498250 00	1.52396080-01	-2.39284830-03
47	1.58881960 00	2.42267480-01	2.47756250 00	8.66145050 00	1.52333000-01	-3.50869150-03
48	1.61080180 00	2.45615280-01	2.50680800 00	8.65634270 00	1.52241790-01	-4.97225660-03
49	1.63278380 00	2.48960660-01	2.53547180 00	8.64920930 00	1.52114400-01	-6.66159790-03
50	1.65479500 00	2.52307270-01	2.56359100 00	8.63992810 00	1.51948670-01	-8.46245440-03
51	1.67685230 00	2.55656790-01	2.59121850 00	8.62831940 00	1.51741390-01	-1.03770580-02
52	1.69897630 00	2.59011390-01	2.61838670 00	8.61424330 00	1.51490070-01	-1.23672490-02
53	1.72118840 00	2.62373260-01	2.64509500 00	8.59759780 00	1.51192900-01	-1.44339310-02
54	1.74351110 00	2.65744700-01	2.67137910 00	8.57822260 00	1.50847020-01	-1.65889750-02
55	1.76596550 00	2.69127690-01	2.69728640 00	8.55596860 00	1.50449800-01	-1.88643020-02
56	1.78856700 00	2.72523280-01	2.72281040 00	8.53058230 00	1.49996730-01	-2.12775550-02
57	1.81134870 00	2.75934950-01	2.74797250 00	8.50183320 00	1.49483710-01	-2.37701030-02
58	1.83432640 00	2.79363460-01	2.77282390 00	8.46959540 00	1.48908530-01	-2.62974250-02
59	1.85752010 00	2.82810130-01	2.79734720 00	8.43374300 00	1.48268970-01	-2.88056290-02
60	1.88045240 00	2.86276500-01	2.82156320 00	8.39426340 00	1.47564850-01	-3.12422490-02
61	1.90464260 00	2.89763570-01	2.84551950 00	8.35115360 00	1.46796140-01	-3.36181180-02
62	1.92860450 00	2.93271410-01	2.86916290 00	8.30437660 00	1.45962240-01	-3.59159160-02
63	1.95287120 00	2.96802850-01	2.89256680 00	8.25393850 00	1.45063290-01	-3.81304910-02
64	1.97745400 00	3.00357390-01	2.91572990 00	8.19981410 00	1.44098890-01	-4.02971140-02
65	2.00237320 00	3.03935710-01	2.93862090 00	8.14192880 00	1.43067770-01	-4.24356770-02
66	2.02764630 00	3.07537910-01	2.96130880 00	8.08018170 00	1.41968190-01	-4.45685990-02
67	2.05328250 00	3.11162800-01	2.98373270 00	8.01445080 00	1.40798040-01	-4.66810250-02
68	2.07931430 00	3.14812190-01	3.00595120 00	7.94462770 00	1.39555450-01	-4.87291550-02
69	2.10574800 00	3.18484120-01	3.02796030 00	7.87072020 00	1.38240630-01	-5.06592410-02
70	2.13260050 00	3.22177950-01	3.04972460 00	7.79281640 00	1.36855230-01	-5.24583210-02
71	2.15988440 00	3.25892360-01	3.07131070 00	7.71095350 00	1.35399980-01	-5.41254710-02
72	2.18760380 00	3.29624750-01	3.09263380 00	7.62527290 00	1.33877460-01	-5.56126120-02
73	2.21578740 00	3.33375790-01	3.11377550 00	7.53592490 00	1.32290420-01	-5.69652240-02
74	2.24443480 00	3.37142180-01	3.13449550 00	7.44293890 00	1.30639460-01	-5.82301480-02
75	2.27355720 00	3.40922010-01	3.15538820 00	7.34638540 00	1.28925900-01	-5.93567920-02
76	2.30315060 00	3.44711360-01	3.17588450 00	7.24448840 00	1.27153790-01	-6.03616650-02
77	2.33323870 00	3.48509850-01	3.19611710 00	7.14323460 00	1.25322950-01	-6.12757190-02
78	2.36381620 00	3.52313240-01	3.21616690 00	7.03676960 00	1.23436040-01	-6.20799660-02
79	2.39488320 00	3.56118050-01	3.23594850 00	6.92723920 00	1.21495700-01	-6.28181040-02
80	2.42644140 00	3.59920960-01	3.25551570 00	6.81462580 00	1.19501690-01	-6.35305580-02
81	2.45847510 00	3.63716440-01	3.27483130 00	6.69900170 00	1.17465340-01	-6.41973460-02
82	2.49100160 00	3.67502880-01	3.29389480 00	6.58037070 00	1.15356780-01	-6.47685390-02
83	2.52400060 00	3.71274250-01	3.31273860 00	6.45901780 00	1.13211110-01	-6.52089660-02
84	2.55746400 00	3.75026160-01	3.33127610 00	6.33518560 00	1.11022660-01	-6.54765170-02
85	2.59137770 00	3.78753640-01	3.34960370 00	6.20932380 00	1.08799420-01	-6.54975180-02
86	2.62571450 00	3.82450830-01	3.36760090 00	6.08205860 00	1.06552470-01	-6.53313770-02
87	2.66047860 00	3.86115540-01	3.38537410 00	5.95357330 00	1.04285060-01	-6.50780850-02
88	2.69563450 00	3.89741540-01	3.40284370 00	5.82415950 00	1.02002330-01	-6.47570580-02
89	2.73116060 00	3.93324420-01	3.42004500 00	5.69402950 00	9.97080270-02	-6.43892140-02
90	2.76043830 00	3.98159610-01	3.44320040 00	5.51470900 00	9.65481560-02	-6.38278660-02

91	2.83030810	00	4.02895060	-01	3.46575960	00	5.33480980	00	9.33800040	-02	-6.31854660	-02
92	2.88075040	00	4.07524940	-01	3.48781700	00	5.15471600	00	9.02102850	-02	-6.24211210	-02
93	2.93171390	00	4.12041250	-01	3.50916700	00	4.97508940	00	8.70505800	-02	-6.15287670	-02
94	2.98318840	00	4.16440610	-01	3.53038690	00	4.74633260	00	8.39078880	-02	-6.05507940	-02
95	3.03517220	00	4.20720630	-01	3.55087060	00	4.61870130	00	8.07866110	-02	-5.94947300	-02
96	3.08762320	00	4.24876100	-01	3.57087510	00	4.44267510	00	7.76950800	-02	-5.83768960	-02
97	3.14053820	00	4.28905610	-01	3.59040450	00	4.26842520	00	7.46362000	-02	-5.72439900	-02
98	3.19392160	00	4.32808380	-01	3.60938070	00	4.09599670	00	7.16106630	-02	-5.60914700	-02
99	3.24773480	00	4.36580740	-01	3.62790670	00	3.92570460	00	6.85238900	-02	-5.49081020	-02
100	3.30147790	00	4.40222350	-01	3.64598720	00	3.75767600	00	6.56780110	-02	-5.37283630	-02
101	3.35665940	00	4.43733410	-01	3.66351610	00	3.59186130	00	6.27720600	-02	-5.25589320	-02
102	3.41174030	00	4.47111210	-01	3.68062400	00	3.42846300	00	5.99094880	-02	-5.13695170	-02
103	3.46722340	00	4.50356100	-01	3.69728240	00	3.26763630	00	5.70929240	-02	-5.01431120	-02
104	3.52311770	00	4.53468920	-01	3.71341070	00	3.10954750	00	5.43251900	-02	-4.88693920	-02
105	3.57938630	00	4.56448340	-01	3.72911800	00	2.95453280	00	5.16120800	-02	-4.75425220	-02
106	3.63603220	00	4.59295660	-01	3.74439160	00	2.80281810	00	4.89574620	-02	-4.61882220	-02
107	3.69306120	00	4.62012580	-01	3.75912190	00	2.65445500	00	4.63621550	-02	-4.48505220	-02
108	3.75044170	00	4.64599030	-01	3.77342730	00	2.50947330	00	4.38266000	-02	-4.35496100	-02
109	3.80818530	00	4.67057160	-01	3.78731190	00	2.36777510	00	4.13490120	-02	-4.22726030	-02
110	3.86626360	00	4.69387330	-01	3.80069140	00	2.22945230	00	3.89309330	-02	-4.09793830	-02
111	3.92467960	00	4.71591590	-01	3.81359370	00	2.09469330	00	3.65755920	-02	-3.96603400	-02
112	3.98343230	00	4.73672060	-01	3.82606860	00	1.96358390	00	3.42844270	-02	-3.83286690	-02
113	4.04249530	00	4.75630130	-01	3.83810500	00	1.83629020	00	3.20602880	-02	-3.69714800	-02
114	4.10186770	00	4.77468460	-01	3.84966690	00	1.71298390	00	2.99061200	-02	-3.55746730	-02
115	4.16154860	00	4.79189900	-01	3.86073590	00	1.59386920	00	2.78254430	-02	-3.41468720	-02
116	4.22151400	00	4.80797090	-01	3.87136370	00	1.47910460	00	2.58209810	-02	-3.27361170	-02
117	4.28176720	00	4.82293500	-01	3.88155070	00	1.36855600	00	2.38903520	-02	-3.13834400	-02
118	4.34286610	00	4.83681870	-01	3.89129010	00	1.26208490	00	2.20311010	-02	-3.00840640	-02
119	4.40307170	00	4.84965480	-01	3.90058240	00	1.15958620	00	2.02413610	-02	-2.87918880	-02
120	4.46410370	00	4.86147200	-01	3.90941400	00	1.06122930	00	1.85240640	-02	-2.74615910	-02
121	4.52537680	00	4.87230670	-01	3.91776450	00	9.67232420	-01	1.68829940	-02	-2.60811440	-02
122	4.58688480	00	4.88219730	-01	3.92567280	00	8.77824190	-01	1.53221210	-02	-2.46607550	-02
123	4.64860810	00	4.89118500	-01	3.93313700	00	7.93170760	-01	1.38443260	-02	-2.32397590	-02
124	4.71054360	00	4.89931400	-01	3.94016010	00	7.13216540	-01	1.24486200	-02	-2.18561950	-02
125	4.77267270	00	4.90662670	-01	3.94674250	00	6.37848070	-01	1.11330090	-02	-2.05252180	-02
126	4.83499090	00	4.91316630	-01	3.95288890	00	5.66897940	-01	9.89455850	-03	-1.92179130	-02
127	4.89748040	00	4.91897390	-01	3.95860230	00	5.00448180	-01	8.73469070	-03	-1.78901230	-02
128	4.96013540	00	4.92409550	-01	3.96388950	00	4.38643900	-01	7.65592980	-03	-1.65634330	-02
129	5.02293900	00	4.92857730	-01	3.96875630	00	3.81404340	-01	6.65685980	-03	-1.52796470	-02
130	5.08588440	00	4.93246500	-01	3.97321160	00	3.28570940	-01	5.73470760	-03	-1.40268200	-02
131	5.14895550	00	4.93580290	-01	3.97726450	00	2.80140110	-01	4.88940620	-03	-1.27626460	-02
132	5.21214470	00	4.93863750	-01	3.98090200	00	2.36254540	-01	4.12344290	-03	-1.14929040	-02
133	5.27543840	00	4.94101760	-01	3.98415010	00	1.96860790	-01	3.43588240	-03	-1.02594090	-02
134	5.33882380	00	4.94298940	-01	3.98703200	00	1.61797200	-01	2.82390140	-03	-9.06612860	-03
135	5.40229290	00	4.94459940	-01	3.98956410	00	1.30972270	-01	2.28590120	-03	-7.92912290	-03
136	5.46583240	00	4.94589230	-01	3.99176390	00	1.04101280	-01	1.81691210	-03	-6.86602370	-03
137	5.52943420	00	4.94690910	-01	3.99364030	00	8.09594730	-02	1.41301030	-03	-5.85153270	-03
138	5.59308720	00	4.94769030	-01	3.99519340	00	6.14398040	-02	1.07232730	-03	-4.89658900	-03
139	5.65678130	00	4.94827460	-01	3.99647930	00	4.52339500	-02	7.89481520	-04	-4.02065400	-03
140	5.72050950	00	4.94869620	-01	3.99752190	00	3.20876320	-02	5.60034890	-04	-3.20399770	-03
141	5.78426310	00	4.94898850	-01	3.99832480	00	2.18325650	-02	3.81050160	-04	-2.46981630	-03
142	5.84803450	00	4.94918210	-01	3.99892550	00	1.40422610	-02	2.45083690	-04	-1.84098960	-03
143	5.91181830	00	4.94930110	-01	3.99936510	00	8.37834170	-03	1.46229650	-04	-1.29247310	-03
144	5.97560890	00	4.94936860	-01	3.99965820	00	4.59515570	-03	8.02005960	-05	-8.48933560	-04
145	6.03940170	00	4.94940340	-01	3.99983810	00	2.17269440	-03	3.79206710	-05	-5.24688660	-04

146	6.10319370 00	4.94941700-01	3.99994080 00	7.59634700-04	1.32581270-05	-2.84229700-04
147	6.16698220 00	4.94942030-01	3.99998450 00	9.49839700-05	1.65778300-06	-1.19883550-04
148	6.23076570 00	4.94941910-01	3.99999980 00	-1.16670880-04	-2.03629100-06	-1.29919210-05
149	6.29454350 00	4.94941770-01	4.00000000 00	0.0	0.0	0.0

PARABOLIC TEMPERATURE DISTRIBUTION

MODIF. SPALDING-CHI REFERENCE TEMP

VAN DRIEST REFERENCE REYNOLDS NUMBER

TW	TE	TAW	TP	RE/IN	RTHI	FRO	KCFI	KCF	KCFS	M	MI	FMV	KTHP	THETA-1	DELTA	DELTA*-1
1 866.01343.4	1607.41011.2	1349924	19679	1.33396	2.32911	3.09435	3.09435	0.5083	1.3172	0.14257	0.0	0.010452	0.0909	0.005516		
X= 46.076, DSU= 0.00555, THU=0.0109284, CTH=0.0108678, MU= 0.507469, H= 0.508254, CH= 0.507892, N= 6.30583																
2 865.71336.2	1606.61008.9	1352630	19660	1.32983	2.32948	3.08522	3.08526	0.5155	1.3171	0.14015	0.02158	0.010853	0.0910	0.005595		
X= 46.195, DSU= 0.00563, THU=0.0109299, CTH=0.0108691, MU= 0.514745, H= 0.515535, CH= 0.515172, N= 6.30774																
3 865.31328.8	1605.81006.5	1354981	19640	1.32561	2.32987	3.07587	3.07605	0.5231	1.3170	0.13668	0.05401	0.010858	0.0912	0.005679		
X= 46.317, DSU= 0.00571, THU=0.0109345, CTH=0.0108735, MU= 0.522260, H= 0.523055, CH= 0.522693, N= 6.30970																
4 864.71321.1	1605.01004.0	1356933	19621	1.32129	2.33025	3.06627	3.06668	0.5308	1.3169	0.13330	0.08485	0.010867	0.0915	0.005768		
5 864.11313.0	1604.21001.2	1358454	19601	1.31686	2.33064	3.05641	3.05716	0.5388	1.3168	0.12971	0.11731	0.010880	0.0918	0.005862		
6 863.31304.6	1603.3 998.3	1359497	19582	1.31234	2.33101	3.04631	3.04750	0.5471	1.3167	0.12594	0.15122	0.010898	0.0921	0.005962		
7 862.41295.9	1602.4 995.1	1360023	19563	1.30770	2.33138	3.03590	3.03765	0.5556	1.3165	0.12188	0.18770	0.010922	0.0925	0.006069		
8 861.41286.8	1601.5 991.8	1359983	19546	1.30297	2.33172	3.02520	3.02764	0.5645	1.3164	0.11755	0.22645	0.010952	0.0929	0.006182		
9 860.21277.3	1600.5 988.2	1359327	19531	1.29810	2.33202	3.01411	3.01737	0.5736	1.3163	0.11302	0.26663	0.010989	0.0934	0.006304		
10 858.81267.3	1599.4 984.4	1357994	19519	1.29309	2.33226	3.00261	3.00683	0.5831	1.3162	0.10805	0.31100	0.011035	0.0940	0.006435		
X= 47.307, DSU= 0.00647, THU=0.0111153, CTH=0.0110514, MU= 0.582300, H= 0.583139, CH= 0.582784, N= 6.32598																
11 857.21256.9	1598.4 980.3	1355928	19511	1.28795	2.33241	2.99066	2.99597	0.5930	1.3160	0.10277	0.35807	0.011091	0.0947	0.006577		
12 855.51246.0	1597.2 975.9	1353056	19509	1.28265	2.33244	2.97817	2.98470	0.6033	1.3158	0.09716	0.40807	0.011159	0.0956	0.006732		
13 853.51234.7	1596.1 971.2	1349327	19517	1.27722	2.33230	2.96513	2.97301	0.6139	1.3157	0.09122	0.46109	0.011242	0.0965	0.006901		
14 851.31222.9	1594.8 966.2	1344694	19535	1.27167	2.33193	2.95149	2.96082	0.6249	1.3155	0.08517	0.51455	0.011340	0.0976	0.007086		
15 848.91210.7	1593.6 961.0	1339108	19568	1.26598	2.33130	2.93722	2.94810	0.6363	1.3153	0.07931	0.56541	0.011456	0.0989	0.007289		
16 846.31198.0	1592.2 955.4	1332502	19614	1.26016	2.33040	2.92228	2.93476	0.6480	1.3150	0.07382	0.61157	0.011593	0.1004	0.007512		
17 843.41184.8	1590.9 949.5	1324785	19672	1.25417	2.32924	2.90663	2.92075	0.6602	1.3147	0.06863	0.65396	0.011750	0.1020	0.007758		
18 840.21171.0	1589.4 943.1	1315877	19744	1.24799	2.32784	2.89063	2.90603	0.6730	1.3144	0.06370	0.69299	0.011431	0.1039	0.008029		
19 836.71156.5	1587.9 936.4	1305663	19828	1.24159	2.32621	2.87304	2.89052	0.6863	1.3141	0.05900	0.72927	0.012136	0.1061	0.008329		
20 832.91141.4	1586.4 929.2	1294046	19924	1.23495	2.32437	2.85505	2.87417	0.7003	1.3138	0.05442	0.76395	0.012369	0.1085	0.008663		
X= 49.607, DSU= 0.00872, THU=0.0124676, CTH=0.0123883, MU= 0.699364, H= 0.700334, CH= 0.700009, N= 6.33731																
21 828.71125.5	1584.7 921.6	1280919	20032	1.22805	2.32231	2.83622	2.85694	0.7151	1.3134	0.04998	0.79715	0.012632	0.1112	0.009033		
22 825.91115.3	1583.6 916.6	1271961	20104	1.22362	2.32093	2.82410	2.84577	0.7246	1.3132	0.04726	0.81738	0.012812	0.1131	0.009284		
23 821.91100.9	1582.1 909.4	1258800	20208	1.21745	2.31896	2.80715	2.83003	0.7380	1.3129	0.04362	0.84455	0.013078	0.1158	0.009652		
24 817.21084.9	1580.5 901.4	1243347	20328	1.21060	2.31670	2.78832	2.81244	0.7531	1.3125	0.03980	0.87319	0.013392	0.1191	0.010086		
25 812.21068.0	1578.7 892.8	1226175	20458	1.20339	2.31428	2.76849	2.79376	0.7692	1.3121	0.03600	0.90202	0.013747	0.1227	0.010574		
26 806.81050.6	1576.9 883.8	1207626	20595	1.19597	2.31175	2.74811	2.77441	0.7859	1.3117	0.03230	0.93056	0.014136	0.1267	0.011110		
27 801.11032.8	1575.1 874.4	1187927	20736	1.18842	2.30916	2.72742	2.75460	0.8032	1.3112	0.02875	0.95868	0.014558	0.1311	0.011693		
28 795.31015.0	1573.2 865.0	1167300	20880	1.18078	2.30654	2.70659	2.73450	0.8208	1.3108	0.02539	0.98611	0.015012	0.1358	0.012322		
29 789.3 997.0	1571.3 855.3	1145891	21025	1.17309	2.30392	2.68573	2.71421	0.8388	1.3104	0.02221	1.01299	0.015497	0.1408	0.012999		
30 783.2 979.2	1569.5 845.6	1123888	21171	1.16538	2.30131	2.66491	2.69382	0.8571	1.3099	0.01922	1.03912	0.016012	0.1461	0.013724		
X= 53.576, DSU= 0.01383, THU=0.0161641, CTH=0.0160401, MU= 0.855869, H= 0.857100, CH= 0.856885, N= 6.45346																
31 776.9 961.4	1567.6 835.8	1101410	21316	1.15765	2.29873	2.64420	2.67341	0.8756	1.3095	0.01644	1.06450	0.016557	0.1518	0.014498		
32 770.7 943.8	1565.8 826.0	1078631	21461	1.14993	2.29619	2.62365	2.65303	0.8944	1.3090	0.01386	1.08898	0.017132	0.1578	0.015323		
33 764.3 926.5	1564.0 816.3	1055651	21603	1.14222	2.29371	2.60329	2.63275	0.9133	1.3086	0.01149	1.11260	0.017736	0.1641	0.016199		
34 758.0 909.4	1562.2 806.6	1032618	21743	1.13453	2.29129	2.58317	2.61263	0.9324	1.3082	0.00933	1.13494	0.018369	0.1707	0.017127		
35 751.7 892.6	1560.5 797.1	1009643	21880	1.12689	2.28894	2.56332	2.59272	0.9516	1.3077	0.00736	1.15630	0.019029	0.1777	0.018108		
36 745.4 876.2	1558.8 787.6	986827	22013	1.11929	2.28668	2.54378	2.57306	0.9709	1.3073	0.00559	1.17632	0.019715	0.1849	0.019142		
37 739.3 860.1	1557.1 778.3	964289	22142	1.11175	2.28450	2.52458	2.55370	0.9903	1.3069	0.00402	1.19480	0.020427	0.1925	0.020228		
38 733.2 844.5	1555.5 769.2	942112	22267	1.10429	2.28241	2.50575	2.53470	1.0097	1.3065	0.00261	1.21204	0.021161	0.2003	0.021366		
39 727.2 829.3	1553.9 760.3	920368	22386	1.09691	2.28043	2.48732	2.51607	1.0290	1.3061	0.00137	1.22795	0.021918	0.2084	0.022554		
40 721.3 814.5	1552.4 751.6	899125	22499	1.08962	2.27855	2.46930	2.49785	1.0484	1.3057	0.00029	1.24242	0.022695	0.2167	0.023792		
X= 59.364, DSU= 0.02404, THU=0.0229654, CTH=0.0227417, MU= 1.046707, H= 1.048362, CH= 1.048468, N= 6.54185																
41 715.6 800.3	1550.9 743.2	878429	22607	1.08243	2.27678	2.45172	2.48006	1.0676	1.3053	0.00065	1.25527	0.023489	0.2253	0.025078		
42 710.7 788.3	1549.6 736.1	861085	22695	1.07633	2.27535	2.43694	2.46511	1.0841	1.3050	0.00137	1.26571	0.024186	0.2329	0.026221		
43 706.1 776.9	1548.4 729.2	844383	22777	1.07039	2.27402	2.42266	2.45066	1.1004	1.3047	0.00201	1.27533	0.024485	0.2405	0.027383		
44 701.6 765.9	1547.3 722.6	828292	22853	1.06458	2.27278	2.40884	2.43668	1.1164	1.3044	0.00257	1.28408	0.024587	0.2481	0.028565		
45 697.2 755.3	1546.2 716.3	812778	22924	1.05890	2.27163	2.39546	2.42313	1.1321	1.3041	0.00306	1.29201	0.024691	0.2558	0.029765		

46 693.0 745.1 1545.1 710.1	797810 22991 1.05335 2.27056 2.38248 2.40999	1.1477 1.3039-0.00349 1.29915 0.026998 0.2636 0.030985
47 688.9 735.3 1544.1 704.2	783356 23052 1.04791 2.26957 2.36987 2.39721	1.1630 1.3036-0.00386 1.30554 0.027707 0.2715 0.032224
48 685.0 725.8 1543.1 698.4	769389 23110 1.04257 2.26865 2.35761 2.38477	1.1782 1.3034-0.00417 1.31098 0.028419 0.2793 0.033484
49 681.1 716.6 1542.2 692.8	755892 23163 1.03734 2.26780 2.34567 2.37265	1.1932 1.3031-0.00443 1.31532 0.029133 0.2873 0.034763
50 677.4 707.7 1541.3 687.4	742838 23213 1.03220 2.26701 2.33603 2.36083	1.2081 1.3029-0.00465 1.31911 0.029851 0.2953 0.036062
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51 673.8 699.1 1540.4 682.2	730196 23260 1.02715 2.26627 2.32668 2.34927	1.2228 1.3026-0.00484 1.32262 0.030572 0.3034 0.037383
52 670.2 690.8 1539.5 677.0	717942 23303 1.02217 2.26559 2.31158 2.33795	1.2374 1.3024-0.00499 1.32500 0.031297 0.3115 0.038726
53 666.8 682.7 1538.6 672.1	706070 23344 1.01728 2.26494 2.30073 2.32687	1.2518 1.3022-0.00509 1.32634 0.032026 0.3198 0.040090
54 663.5 674.8 1537.8 667.2	694556 23383 1.01246 2.26434 2.29010 2.31601	1.2662 1.3019-0.00518 1.32755 0.032759 0.3281 0.041478
55 660.2 667.2 1537.0 662.5	683372 23419 1.00771 2.26377 2.27968 2.30534	1.2804 1.3017-0.00524 1.32816 0.033497 0.3364 0.042890
56 657.0 659.8 1536.3 657.9	672514 23453 1.00302 2.26324 2.26947 2.29485	1.2945 1.3015-0.00526 1.32754 0.034240 0.3449 0.044325
57 653.9 652.5 1535.5 653.5	661967 23485 0.99840 2.26273 2.25943 2.28454	1.3086 1.3013-0.00528 1.32684 0.034988 0.3535 0.045786
58 650.9 645.5 1534.8 649.1	651702 23516 0.99383 2.26225 2.24957 2.27437	1.3226 1.3011-0.00527 1.32572 0.035742 0.3621 0.047273
59 648.0 638.6 1534.1 644.8	641721 23546 0.98932 2.26178 2.23987 2.26435	1.3365 1.3009-0.00524 1.32351 0.036503 0.3709 0.048766
60 645.1 631.9 1533.4 640.7	632009 23575 0.98486 2.26133 2.23032 2.25447	1.3503 1.3007-0.00521 1.32158 0.037270 0.3797 0.050327
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61 642.3 625.3 1532.7 636.6	622542 23602 0.98045 2.26091 2.22090 2.24471	1.3641 1.3005-0.00516 1.31874 0.038044 0.3887 0.051896
62 639.5 618.9 1532.0 632.6	613335 23630 0.97609 2.26048 2.21163 2.23507	1.3778 1.3003-0.00509 1.31524 0.038825 0.3978 0.053494
63 636.8 612.7 1531.4 628.7	604355 23657 0.97178 2.26007 2.20248 2.22553	1.3915 1.3001-0.00504 1.31233 0.039614 0.4070 0.055122
64 634.2 606.6 1530.7 624.9	595596 23683 0.96751 2.25966 2.19344 2.21610	1.4051 1.2999-0.00495 1.30815 0.040411 0.4163 0.056782
65 631.6 600.6 1530.1 621.2	587066 23710 0.96328 2.25924 2.18452 2.20676	1.4187 1.2997-0.00487 1.30408 0.041217 0.4257 0.058472
66 629.1 594.8 1529.5 617.5	578734 23736 0.95910 2.25884 2.17570 2.19751	1.4322 1.2995-0.00478 1.29985 0.042031 0.4353 0.060196
67 626.6 589.1 1528.9 614.0	570618 23763 0.95496 2.25842 2.16698 2.18836	1.4456 1.2993-0.00468 1.29492 0.042855 0.4450 0.061952
68 624.2 583.5 1528.3 610.4	562693 23791 0.95086 2.25800 2.15836 2.17927	1.4591 1.2992-0.00460 1.29073 0.043687 0.4549 0.063743
69 621.8 578.0 1527.8 607.0	554955 23819 0.94679 2.25757 2.14982 2.17027	1.4724 1.2990-0.00450 1.28556 0.044530 0.4649 0.065568
70 619.5 572.7 1527.2 603.6	547413 23848 0.94277 2.25712 2.14138 2.16134	1.4858 1.2988-0.00441 1.28082 0.045383 0.4750 0.067429
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71 617.2 567.5 1526.7 600.3	540039 23877 0.93879 2.25667 2.13301 2.15247	1.4991 1.2986-0.00431 1.27577 0.046246 0.4853 0.069326
72 615.0 562.3 1526.1 597.1	532858 23909 0.93485 2.25619 2.12473 2.14368	1.5123 1.2984-0.00421 1.27038 0.047120 0.4958 0.071259
73 612.8 557.3 1525.6 594.0	525840 23941 0.93095 2.25569 2.11652 2.13496	1.5255 1.2982-0.00413 1.26585 0.048004 0.5064 0.073229
74 610.7 552.4 1525.1 590.9	518992 23975 0.92708 2.25517 2.10839 2.12631	1.5386 1.2980-0.00404 1.26048 0.048900 0.5172 0.075238
75 608.6 547.6 1524.6 587.8	512313 24011 0.92326 2.25463 2.10034 2.11772	1.5517 1.2978-0.00396 1.25595 0.049807 0.5281 0.077284
76 606.5 542.9 1524.1 584.8	505790 24048 0.91948 2.25406 2.09235 2.10920	1.5647 1.2976-0.00387 1.25072 0.050725 0.5392 0.079369
77 604.5 538.3 1523.6 581.9	499439 24088 0.91575 2.25346 2.08445 2.10075	1.5776 1.2975-0.00378 1.24583 0.051654 0.5505 0.081492
78 602.5 533.8 1523.2 579.1	493232 24129 0.91205 2.25284 2.07661 2.09237	1.5905 1.2973-0.00371 1.24140 0.052596 0.5620 0.083654
79 600.6 529.4 1522.7 576.3	487191 24173 0.90840 2.25217 2.06884 2.08405	1.6033 1.2971-0.00363 1.23653 0.053548 0.5736 0.085854
80 598.7 525.1 1522.3 573.5	481295 24219 0.90479 2.25148 2.06115 2.07581	1.6160 1.2969-0.00357 1.23268 0.054512 0.5854 0.088094
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81 596.9 520.8 1521.8 570.9	475553 24268 0.90124 2.25075 2.05353 2.06764	1.6287 1.2967-0.00350 1.22828 0.055488 0.5973 0.090371
82 595.1 516.7 1521.4 568.2	469961 24319 0.89772 2.24998 2.04598 2.05955	1.6412 1.2965-0.00346 1.22503 0.056475 0.6094 0.092687
83 593.4 512.7 1521.0 565.7	464506 24373 0.89426 2.24918 2.03850 2.05152	1.6536 1.2963-0.00340 1.22126 0.057475 0.6217 0.095042
84 591.6 508.8 1520.6 563.2	459209 24430 0.89084 2.24832 2.03110 2.04357	1.6659 1.2961-0.00336 1.21826 0.058485 0.6342 0.097433
85 590.0 504.9 1520.2 560.7	454038 24490 0.88747 2.24744 2.02376 2.03571	1.6782 1.2959-0.00332 1.21551 0.059506 0.6469 0.099862
86 588.3 501.2 1519.8 558.4	449025 24553 0.88417 2.24651 2.01652 2.02793	1.6903 1.2957-0.00328 1.21279 0.060538 0.6597 0.102325
87 586.7 497.5 1519.4 556.0	444136 24618 0.88090 2.24554 2.00934 2.02024	1.7022 1.2955-0.00327 1.21128 0.061581 0.6726 0.104825
88 585.2 494.0 1519.0 553.8	439389 24687 0.87769 2.24453 2.00225 2.01263	1.7141 1.2953-0.00324 1.20941 0.062634 0.6857 0.107359
89 583.7 490.5 1518.7 551.5	434772 24759 0.87454 2.24348 1.99523 2.00512	1.7258 1.2951-0.00324 1.20910 0.063697 0.6990 0.109927
90 581.7 485.9 1518.2 548.6	428644 24862 0.87029 2.24198 1.98574 1.99497	1.7416 1.2948-0.00323 1.20786 0.065171 0.7175 0.113504
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91 579.7 481.4 1517.7 545.7	422769 24971 0.86616 2.24039 1.97641 1.98501	1.7572 1.2945-0.00322 1.20701 0.066661 0.7362 0.117135
92 577.8 477.1 1517.3 543.0	417115 25085 0.86213 2.23874 1.96723 1.97522	1.7724 1.2943-0.00324 1.20823 0.068169 0.7552 0.120825
93 576.0 473.0 1516.8 540.3	411676 25205 0.85819 2.23703 1.95820 1.96561	1.7875 1.2940-0.00325 1.20918 0.069693 0.7745 0.124574
94 574.3 469.0 1516.4 537.8	406449 25331 0.85436 2.23524 1.94932 1.95617	1.8022 1.2937-0.00325 1.20934 0.071234 0.7940 0.128377
95 572.6 465.1 1516.0 535.3	401431 25462 0.85062 2.23338 1.94060 1.94692	1.8166 1.2934-0.00326 1.21048 0.072791 0.8138 0.132232
96 571.0 461.4 1515.6 532.9	396599 25599 0.84698 2.23146 1.93201 1.93784	1.8308 1.2931-0.00328 1.21284 0.074363 0.8338 0.136143
97 569.4 457.8 1515.3 530.6	391948 25740 0.84343 2.22948 1.92357 1.92892	1.8447 1.2928-0.00328 1.21333 0.075953 0.8541 0.140108
98 567.9 454.3 1514.9 528.3	387490 25889 0.83998 2.22742 1.91528 1.92018	1.8582 1.2925-0.00328 1.21414 0.077556 0.8747 0.144118
99 566.4 450.9 1514.5 526.2	383196 26042 0.83632 2.22531 1.90712 1.91161	1.8716 1.2923-0.00330 1.21708 0.079175 0.8955 0.148180
100 565.0 447.7 1514.2 524.1	379059 26200 0.83334 2.22315 1.89910 1.90319	1.8846 1.2920-0.00329 1.21745 0.080810 0.9166 0.152294
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101 563.7 444.6 1513.9 522.1 375099 26365 0.83017 2.22091 1.89123 1.89495 1.8973 1.2917-0.00328 1.21809 0.082458 0.9379 0.156447
 102 562.4 441.6 1513.6 520.2 371282 26535 0.82707 2.21862 1.88348 1.88686 1.9098 1.2914-0.00330 1.22079 0.084120 0.9594 0.160649
 103 561.1 438.7 1513.3 518.3 367609 26710 0.82407 2.21628 1.87587 1.87892 1.9219 1.2911-0.00328 1.22064 0.085797 0.9812 0.164896
 104 559.9 435.9 1513.0 516.5 364094 26892 0.82116 2.21388 1.86840 1.87115 1.9338 1.2908-0.00326 1.22077 0.087485 1.0032 0.169176
 105 558.7 433.2 1512.7 514.7 360710 27078 0.81833 2.21143 1.86106 1.86353 1.9453 1.2905-0.00328 1.22282 0.089186 1.0254 0.173498
 106 557.6 430.6 1512.4 513.1 357455 27270 0.81558 2.20893 1.85384 1.85606 1.9566 1.2902-0.00323 1.22155 0.090901 1.0478 0.177859
 107 556.5 428.1 1512.2 511.5 354349 27469 0.81293 2.20637 1.84678 1.84876 1.9676 1.2899-0.00319 1.22003 0.092624 1.0704 0.182242
 108 555.5 425.7 1511.9 509.9 351364 27672 0.81037 2.20377 1.83984 1.84161 1.9782 1.2896-0.00318 1.22095 0.094356 1.0932 0.186656
 109 554.5 423.4 1511.7 508.4 348496 27881 0.80788 2.20113 1.83303 1.83460 1.9886 1.2893-0.00315 1.21958 0.096101 1.1162 0.191103
 110 553.5 421.2 1511.5 507.0 345759 28096 0.80548 2.19843 1.82636 1.82774 1.9986 1.2891-0.00309 1.21643 0.097852 1.1393 0.195565
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 112 551.7 417.0 1511.0 504.3 340639 28543 0.80095 2.19291 1.81343 1.81449 2.0176 1.2885-0.00302 1.21311 0.101374 1.1860 0.204537
 113 550.8 415.1 1510.8 503.0 338242 28774 0.79880 2.19009 1.80715 1.80808 2.0267 1.2882-0.00297 1.21005 0.103146 1.2096 0.209048
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 118 547.2 406.6 1509.9 497.6 327896 30016 0.78934 2.17544 1.77783 1.77826 2.0671 1.2867-0.00264 1.18475 0.112033 1.3284 0.231578
 119 546.5 405.2 1509.8 496.6 326128 30281 0.78769 2.17242 1.77236 1.77272 2.0741 1.2865-0.00256 1.17779 0.113810 1.3522 0.236057
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 128 542.3 395.4 1508.8 490.3 314390 32890 0.77650 2.14427 1.72936 1.72941 2.1223 1.2840-0.00168 1.08219 0.129446 1.5637 0.274726
 129 542.0 394.7 1508.7 489.8 313509 33203 0.77564 2.14108 1.72526 1.72530 2.1260 1.2837-0.00157 1.06830 0.131117 1.5864 0.278755
 130 541.7 394.0 1508.6 489.4 312705 33520 0.77486 2.13789 1.72129 1.72132 2.1294 1.2835-0.00146 1.05392 0.132770 1.6089 0.282715
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 138 540.3 390.7 1508.3 487.2 308778 36168 0.77100 2.11262 1.69415 1.69415 2.1453 1.2815-0.00055 0.92663 0.145203 1.7782 0.311506
 139 540.2 390.5 1508.3 487.1 308550 36509 0.77077 2.10953 1.69127 1.69127 2.1461 1.2813-0.00046 0.91257 0.146653 1.7979 0.314737
 140 540.2 390.4 1508.2 487.0 308365 36852 0.77059 2.10646 1.68849 1.68849 2.1468 1.2810-0.00037 0.89858 0.148081 1.8174 0.317897
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 142 540.1 390.2 1508.2 486.9 308117 37541 0.77034 2.10040 1.68321 1.68321 2.1475 1.2806-0.00021 0.87366 0.150876 1.8555 0.324007
 143 540.0 390.1 1508.2 486.8 308039 37886 0.77026 2.09742 1.68068 1.68068 2.1477 1.2804-0.00015 0.86345 0.152247 1.8742 0.326975
 144 540.0 390.1 1508.2 486.8 307987 38233 0.77021 2.09446 1.67822 1.67822 2.1477 1.2802-0.00010 0.85344 0.153603 1.8926 0.329894
 145 540.0 390.0 1508.2 486.8 307956 38579 0.77018 2.09153 1.67582 1.67582 2.1477 1.2800-0.00006 0.84721 0.154946 1.9110 0.332770
 146 540.0 390.0 1508.2 486.8 307937 38925 0.77016 2.08864 1.67347 1.67347 2.1475 1.2797-0.00003 0.84168 0.156279 1.9291 0.335617
 147 540.0 390.0 1508.2 486.8 307930 39272 0.77016 2.08578 1.67116 1.67116 2.1474 1.2795-0.00001 0.83757 0.157604 1.9473 0.338439
 148 540.0 390.0 1508.2 486.8 307927 39618 0.77015 2.08295 1.66889 1.66889 2.1472 1.2793-0.00000 0.83502 0.158924 1.9653 0.341246
 149 540.0 390.0 1508.2 486.8 307927 39965 0.77015 2.08015 1.66664 1.66664 2.1470 1.2791 0.0 0.83332 0.160241 1.9833 0.344044

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RE,THETA= 49660., LOG= 4.69601.

RE,DELTA= 610725., LOG= 5.78585

M A C H 4 BOUNDARY LAYER CALCULATIONS, STAGNATION PRESSURE= 200.PSI, STAGNATION TEMPERATURE=1638. DEG R, N BASED ON RE.DELTA

PARABOLIC TEMPERATURE DISTRIBUTION

MODIF. SPALDING-CHI REFERENCE TEMP

VAN DRIEST REFERENCE REYNOLDS NUMBER

TW	TE	TAW	TP	RE/IN	RTMI	FRD	KCFI	KCF	KCFS	H	HI	FMY	KTHP	THETA-1	DELTA	DELTA*-1
1 866.01343.4	1607.41011.2	1349924	19656	1.33392	2.32956	3.09486	3.09486	0.5083	1.3172	0.14276	0.0	0.010840	0.0908	0.005510		
x= 46.076, DSU= 0.00554, THU=0.0109159, CTH=0.0108554, MU= 0.507560, H= 0.508344, CH= 0.507981, N= 6.30523																
2 865.71336.2	1606.61009.0	1352630	19637	1.32979	2.32993	3.08573	3.08579	0.5156	1.3171	0.14033	0.02154	0.010841	0.0909	0.005590		
x= 46.195, DSU= 0.00562, THU=0.0109173, CTH=0.0108567, MU= 0.514836, H= 0.515625, CH= 0.515263, N= 6.30714																
3 865.31328.8	1605.81006.6	1354981	19617	1.32556	2.33033	3.07638	3.07658	0.5231	1.3170	0.13687	0.05391	0.010845	0.0911	0.005674		
x= 46.317, DSU= 0.00571, THU=0.0109220, CTH=0.0108611, MU= 0.522351, H= 0.523146, CH= 0.522784, N= 6.30910																
4 864.81321.1	1605.01004.0	1356933	19598	1.32124	2.33070	3.06678	3.06723	0.5309	1.3169	0.13349	0.08469	0.010854	0.0914	0.005762		
5 864.11313.0	1604.21001.2	1358454	19578	1.31682	2.33109	3.05692	3.05771	0.5389	1.3168	0.12991	0.11708	0.010867	0.0917	0.005857		
6 863.41304.6	1603.3 998.3	1359497	19559	1.31230	2.33147	3.04682	3.04808	0.5472	1.3167	0.12614	0.15092	0.010886	0.0920	0.005956		
7 862.51295.9	1602.4 995.2	1360023	19540	1.30766	2.33184	3.03640	3.03824	0.5557	1.3166	0.12208	0.18732	0.010909	0.0924	0.006063		
8 861.41286.8	1601.5 991.8	1359983	19523	1.30293	2.33217	3.02570	3.02825	0.5645	1.3165	0.11775	0.22601	0.010939	0.0928	0.006176		
9 860.21277.3	1600.5 988.2	1359327	19508	1.29806	2.33248	3.01461	3.01799	0.5737	1.3163	0.11323	0.26611	0.010977	0.0933	0.006298		
10 858.81267.3	1599.4 984.4	1357994	19495	1.29305	2.33272	3.00311	3.00747	0.5832	1.3162	0.10826	0.31039	0.011023	0.0939	0.006429		
x= 47.307, DSU= 0.00647, THU=0.0111024, CTH=0.0110385, MU= 0.582394, H= 0.583232, CH= 0.582877, N= 6.32537																
11 857.31256.9	1598.4 980.3	1355928	19487	1.28791	2.33288	2.99116	2.99663	0.5931	1.3160	0.10299	0.35738	0.011079	0.0946	0.006571		
12 855.51246.0	1597.2 975.9	1353056	19486	1.28261	2.33291	2.97867	2.98539	0.6034	1.3159	0.09738	0.40729	0.011147	0.0954	0.006725		
13 853.61234.7	1596.1 971.2	1349327	19493	1.27718	2.33277	2.96563	2.97372	0.6140	1.3157	0.09143	0.46022	0.011228	0.0964	0.006894		
14 851.41222.9	1594.8 966.3	1344694	19512	1.27163	2.33240	2.95200	2.96156	0.6250	1.3155	0.08539	0.51360	0.011327	0.0975	0.007079		
15 849.01210.7	1593.6 961.0	1339108	19544	1.26594	2.33177	2.93773	2.94885	0.6363	1.3153	0.07953	0.56438	0.011443	0.0988	0.007282		
16 846.31198.0	1592.2 955.4	1332502	19589	1.26012	2.33087	2.92279	2.93554	0.6481	1.3150	0.07404	0.61046	0.011579	0.1002	0.007504		
17 843.41184.8	1590.9 949.5	1324786	19648	1.25413	2.32972	2.90714	2.92156	0.6603	1.3148	0.06885	0.65277	0.011736	0.1019	0.007750		
18 840.21171.0	1589.4 943.2	1315877	19720	1.24795	2.32832	2.89074	2.90686	0.6731	1.3145	0.06392	0.69172	0.011916	0.1038	0.008021		
19 836.71156.5	1587.9 936.4	1305663	19803	1.24155	2.32670	2.87356	2.89138	0.6864	1.3142	0.05922	0.72791	0.012121	0.1059	0.008320		
20 832.91141.4	1586.4 929.3	1294046	19899	1.23491	2.32485	2.85557	2.87506	0.7004	1.3138	0.05464	0.76251	0.012354	0.1084	0.008653		
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21 828.71125.5	1584.7 921.6	1280919	20006	1.22280	2.32280	2.83675	2.85786	0.7152	1.3135	0.05020	0.79561	0.012617	0.1111	0.009023		
22 825.91115.3	1583.6 916.6	1271961	20078	1.22359	2.32143	2.82463	2.84670	0.7247	1.3132	0.04748	0.81578	0.012796	0.1129	0.009274		
23 821.91100.9	1582.1 909.5	1258800	20182	1.21741	2.31946	2.80768	2.83099	0.7381	1.3129	0.04384	0.84285	0.013061	0.1157	0.009641		
24 817.31084.9	1580.5 901.4	1243347	20301	1.21057	2.31721	2.78886	2.81342	0.7532	1.3125	0.04002	0.87139	0.013375	0.1189	0.010074		
25 812.21068.0	1578.7 892.8	1226175	20430	1.20336	2.31479	2.76903	2.79478	0.7693	1.3121	0.03622	0.90010	0.013729	0.1226	0.010561		
26 806.81050.6	1576.9 883.8	1207626	20566	1.19594	2.31227	2.74866	2.77545	0.7860	1.3117	0.03253	0.92851	0.014117	0.1266	0.011096		
27 801.21032.8	1575.1 874.5	1187927	20707	1.18838	2.30969	2.72798	2.75568	0.8033	1.3113	0.02898	0.95648	0.014538	0.1309	0.011678		
28 795.31015.0	1573.2 865.0	1167300	20850	1.18075	2.30708	2.70716	2.73561	0.8209	1.3108	0.02562	0.98376	0.014991	0.1356	0.012307		
29 789.3 997.0	1571.3 855.3	1145891	20994	1.17306	2.30447	2.68630	2.71536	0.8389	1.3104	0.02244	1.01047	0.015475	0.1406	0.012982		
30 783.2 979.2	1569.5 845.6	1123888	21139	1.16535	2.30187	2.66550	2.69500	0.8572	1.3099	0.01946	1.03642	0.015989	0.1459	0.013706		
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31 777.0 961.4	1567.6 835.8	1101410	21283	1.15762	2.29931	2.64480	2.67462	0.8757	1.3095	0.01668	1.06161	0.016532	0.1515	0.014478		
32 770.7 943.8	1565.8 826.1	1078631	21427	1.14990	2.29679	2.62426	2.65428	0.8945	1.3091	0.01410	1.08590	0.017106	0.1575	0.015301		
33 764.4 926.5	1564.0 816.3	1055651	21568	1.14219	2.29432	2.60392	2.63404	0.9134	1.3086	0.01173	1.10930	0.017708	0.1638	0.016175		
34 758.0 909.4	1562.2 806.6	1032618	21707	1.13450	2.29192	2.58382	2.61395	0.9325	1.3082	0.00957	1.13143	0.018339	0.1704	0.017101		
35 751.7 892.6	1560.5 797.1	1009643	21842	1.12686	2.28959	2.56399	2.59407	0.9517	1.3078	0.00761	1.15256	0.018997	0.1774	0.018079		
36 745.5 876.2	1558.8 787.6	986827	21974	1.11926	2.28735	2.54447	2.57445	0.9710	1.3074	0.00584	1.17236	0.019681	0.1846	0.019110		
37 739.3 860.1	1557.1 778.3	964289	22101	1.11172	2.28519	2.52529	2.55513	0.9904	1.3070	0.00426	1.19060	0.020390	0.1921	0.020194		
38 733.2 844.5	1555.5 769.2	942112	22224	1.10426	2.28313	2.50648	2.53616	1.0098	1.3066	0.00286	1.20760	0.021122	0.1999	0.021328		
39 727.2 829.3	1553.9 760.3	920368	22341	1.09688	2.28117	2.48807	2.51757	1.0291	1.3062	0.00162	1.22328	0.021876	0.2080	0.022513		
40 721.3 814.5	1552.4 751.6	899125	22453	1.08959	2.27931	2.47008	2.49938	1.0485	1.3058	0.00054	1.23751	0.022649	0.2163	0.023747		
x= 59.364, DSU= 0.02399, THU=0.0229189, CTH=0.0226962, MU= 1.046817, H= 1.048468, CH= 1.048574, N= 6.54074																
41 715.6 800.3	1550.9 743.2	878429	22559	1.08241	2.27757	2.45252	2.48164	1.0677	1.3054	0.00040	1.25011	0.023441	0.2248	0.025028		
42 710.8 788.3	1549.6 736.1	861085	22645	1.07631	2.27616	2.43776	2.46672	1.0842	1.3051	0.00112	1.26035	0.024135	0.2323	0.026168		
43 706.1 776.9	1548.4 729.2	844383	22726	1.07036	2.27485	2.42350	2.45230	1.1005	1.3048	0.00176	1.26977	0.024831	0.2399	0.027326		
44 701.6 765.9	1547.3 722.7	828292	22801	1.06456	2.27363	2.40970	2.43835	1.1165	1.3045	0.00232	1.27831	0.025530	0.2475	0.028503		
45 697.2 755.3	1546.2 716.3	812778	22870	1.05888	2.27250	2.39634	2.42484	1.1322	1.3042	0.00281	1.28605	0.026231	0.2552	0.029699		

46 693.0 745.1 1545.1 710.1 797810 22935 1.05333 2.27146 2.38338 2.41172 1.1478 1.3039-0.00324 1.29300 0.026934 0.2630 0.030915
 47 688.9 735.3 1544.1 704.2 783356 22995 1.04789 2.27049 2.37079 2.39897 1.1632 1.3037-0.00361 1.29919 0.027640 0.2707 0.032149
 48 685.0 725.8 1543.1 698.4 769389 23051 1.04255 2.26960 2.35854 2.38656 1.1783 1.3034-0.00392 1.30445 0.028348 0.2786 0.033403
 49 681.1 716.6 1542.2 692.8 755892 23103 1.03732 2.26877 2.34663 2.37447 1.1933 1.3032-0.00418 1.30861 0.029059 0.2865 0.034677
 50 677.4 707.7 1541.3 687.4 742838 23151 1.03218 2.26800 2.33501 2.36268 1.2082 1.3029-0.00440 1.31223 0.029773 0.2945 0.035971
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 51 673.8 699.1 1540.4 682.2 730196 23196 1.02713 2.26728 2.32368 2.35114 1.2229 1.3027-0.00459 1.31557 0.030490 0.3025 0.037286
 52 670.3 690.8 1539.5 677.1 717942 23238 1.02216 2.26662 2.31260 2.33985 1.2375 1.3025-0.00474 1.31780 0.031211 0.3106 0.038623
 53 666.8 682.7 1538.6 672.1 706070 23277 1.01726 2.26600 2.30176 2.32880 1.2519 1.3022-0.00484 1.31899 0.031936 0.3188 0.039982
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 57 654.0 652.5 1535.5 653.5 661967 23412 0.99838 2.26388 2.26055 2.28655 1.3087 1.3014-0.00504 1.31895 0.034881 0.3523 0.045650
 58 650.9 645.5 1534.8 649.1 651702 23441 0.99381 2.26342 2.25070 2.27641 1.3227 1.3012-0.00504 1.31771 0.035631 0.3609 0.047129
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 60 645.1 631.9 1533.4 640.7 632009 23496 0.98485 2.26255 2.23149 2.25654 1.3505 1.3008-0.00498 1.31336 0.037149 0.3784 0.050168
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 67 626.6 589.1 1528.9 614.0 570618 23674 0.95495 2.25980 2.16828 2.19052 1.4458 1.2994-0.00447 1.28608 0.042697 0.4433 0.061730
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 78 602.6 533.8 1523.2 579.1 493232 24022 0.91204 2.25447 2.07809 2.09460 1.5907 1.2974-0.00352 1.23164 0.052367 0.5593 0.083298
 79 600.6 529.4 1522.7 576.3 487191 24064 0.90839 2.25382 2.07034 2.08629 1.6034 1.2972-0.00344 1.22667 0.053312 0.5708 0.085483
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 83 593.4 512.7 1521.0 565.7 464506 24256 0.89425 2.25092 2.04006 2.05376 1.6538 1.2964-0.00322 1.21089 0.057206 0.6186 0.094606
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 89 583.7 490.5 1518.7 551.5 434772 24630 0.87453 2.24538 1.99690 2.00739 1.7259 1.2952-0.00306 1.19762 0.063373 0.6952 0.109377
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 92 577.8 477.1 1517.3 543.0 417115 24946 0.86212 2.24076 1.96899 1.97751 1.7726 1.2944-0.00305 1.19572 0.067800 0.7508 0.120182
 93 576.0 473.0 1516.8 540.3 411676 25062 0.85819 2.23908 1.95998 1.96791 1.7876 1.2941-0.00306 1.19627 0.069309 0.7699 0.123897
 94 574.3 469.0 1516.4 537.8 406449 25184 0.85435 2.23733 1.95114 1.95849 1.8023 1.2938-0.00306 1.19604 0.070833 0.7892 0.127665
 95 572.6 465.1 1516.0 535.3 401431 25311 0.85062 2.23551 1.94244 1.94925 1.8168 1.2935-0.00307 1.19677 0.072372 0.8087 0.131483
 96 571.0 461.4 1515.6 532.9 396599 25444 0.84697 2.23363 1.93389 1.94018 1.8309 1.2933-0.00309 1.19866 0.073927 0.8285 0.135355
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 99 566.4 450.9 1514.5 526.2 383196 25874 0.83661 2.22762 1.90910 1.91399 1.8717 1.2924-0.00311 1.20151 0.078679 0.8895 0.147266
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102	562.4	441.6	1513.6	520.2	371282	26352	0.82707	2.22108	1.88556	1.88930	1.9099	1.2916-0.00310	1.20374	0.083558	0.9525	0.159591
103	561.1	438.7	1513.3	518.3	367609	26522	0.82406	2.21879	1.87798	1.88138	1.9221	1.2913-0.00308	1.20309	0.085211	0.9740	0.163786
104	559.9	435.9	1513.0	516.5	364094	26698	0.82116	2.21644	1.87055	1.87363	1.9340	1.2910-0.00306	1.20272	0.086875	0.9956	0.168013
105	558.7	433.2	1512.7	514.7	360710	26879	0.81833	2.21404	1.86325	1.86604	1.9455	1.2907-0.00306	1.20422	0.088550	1.0175	0.172278
106	557.6	430.6	1512.4	513.1	357455	27065	0.81558	2.21160	1.85608	1.85859	1.9568	1.2904-0.00303	1.20246	0.090238	1.0396	0.176581
107	556.5	428.1	1512.2	511.5	354349	27258	0.81293	2.20909	1.84905	1.85131	1.9678	1.2901-0.00299	1.20046	0.091934	1.0618	0.180904
108	555.5	425.7	1511.9	509.9	351364	27455	0.81036	2.20655	1.84216	1.84418	1.9784	1.2898-0.00298	1.20083	0.093639	1.0842	0.185255
109	554.5	423.4	1511.7	508.4	348496	27657	0.80788	2.20396	1.83538	1.83720	1.9888	1.2895-0.00294	1.19895	0.095354	1.1068	0.189638
110	553.5	421.2	1511.5	507.0	345759	27865	0.80548	2.20132	1.82876	1.83037	1.9988	1.2893-0.00289	1.19534	0.097075	1.1295	0.194033
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111	552.6	419.1	1511.2	505.6	343144	28079	0.80317	2.19864	1.82227	1.82370	2.0085	1.2890-0.00284	1.19294	0.098881	1.1524	0.198440
112	551.7	417.0	1511.0	504.3	340639	28298	0.80094	2.19592	1.81591	1.81718	2.0179	1.2887-0.00281	1.19101	0.100535	1.1754	0.202865
113	550.8	415.1	1510.8	503.0	338242	28522	0.79880	2.19316	1.80968	1.81079	2.0269	1.2884-0.00276	1.18749	0.102273	1.1985	0.207303
114	550.0	413.2	1510.6	501.8	335959	28752	0.79674	2.19036	1.80358	1.80456	2.0357	1.2881-0.00269	1.18197	0.104015	1.2216	0.211741
115	549.3	411.4	1510.4	500.7	333792	28988	0.79477	2.18752	1.79763	1.79849	2.0441	1.2878-0.00262	1.17665	0.105756	1.2449	0.216174
116	548.5	409.8	1510.3	499.6	331726	29228	0.79287	2.18465	1.79181	1.79256	2.0521	1.2875-0.00256	1.17197	0.107499	1.2681	0.220603
117	547.8	408.1	1510.1	498.5	329761	29474	0.79106	2.18174	1.78613	1.78677	2.0599	1.2873-0.00250	1.16648	0.109243	1.2915	0.225028
118	547.2	406.6	1509.9	497.6	327896	29725	0.78934	2.17881	1.78057	1.78113	2.0673	1.2870-0.00243	1.16019	0.110986	1.3148	0.229440
119	546.5	405.2	1509.8	496.6	326128	29981	0.78769	2.17584	1.77515	1.77563	2.0744	1.2867-0.00235	1.15291	0.112726	1.3382	0.233835
120	546.0	403.8	1509.6	495.7	324458	30243	0.78612	2.17285	1.76987	1.77028	2.0811	1.2864-0.00226	1.14407	0.114461	1.3615	0.238205
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121	545.4	402.5	1509.5	494.9	322890	30510	0.78464	2.16983	1.76473	1.76507	2.0875	1.2861-0.00217	1.13490	0.116189	1.3848	0.242542
122	544.9	401.3	1509.4	494.1	321412	30781	0.78325	2.16679	1.75972	1.76002	2.0935	1.2859-0.00209	1.12591	0.117910	1.4080	0.246845
123	544.4	400.1	1509.3	493.3	320026	31058	0.78193	2.16373	1.75485	1.75510	2.0992	1.2856-0.00199	1.11610	0.119622	1.4311	0.251112
124	543.9	399.0	1509.1	492.6	318728	31339	0.78069	2.16065	1.75012	1.75032	2.1046	1.2853-0.00190	1.10550	0.121325	1.4542	0.255337
125	543.5	398.0	1509.0	492.0	317517	31625	0.77952	2.15756	1.74552	1.74569	2.1096	1.2851-0.00180	1.09417	0.123017	1.4770	0.259513
126	543.1	397.1	1508.9	491.4	316392	31915	0.77844	2.15445	1.74106	1.74119	2.1143	1.2848-0.00170	1.08218	0.124695	1.4998	0.263637
127	542.7	396.2	1508.9	490.8	315350	32210	0.77743	2.15133	1.73673	1.73684	2.1186	1.2845-0.00159	1.06955	0.126359	1.5223	0.267704
128	542.3	395.4	1508.8	490.3	314390	32509	0.77650	2.14820	1.73253	1.73262	2.1226	1.2843-0.00148	1.05632	0.128008	1.5447	0.271709
129	542.0	394.7	1508.7	489.8	313509	32813	0.77564	2.14506	1.72847	1.72855	2.1263	1.2840-0.00138	1.04256	0.129639	1.5668	0.275648
130	541.7	394.0	1508.6	489.4	312705	33120	0.77486	2.14193	1.72454	1.72460	2.1296	1.2838-0.00127	1.02835	0.131252	1.5887	0.279518
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131	541.5	393.4	1508.6	489.0	311977	33430	0.77415	2.13879	1.72074	1.72079	2.1327	1.2835-0.00115	1.01305	0.132846	1.6104	0.283315
132	541.2	392.9	1508.5	488.6	311324	33745	0.77351	2.13565	1.71708	1.71712	2.1354	1.2833-0.00103	0.99711	0.134418	1.6318	0.287031
133	541.0	392.4	1508.5	488.3	310743	34063	0.77294	2.13251	1.71354	1.71357	2.1378	1.2830-0.00092	0.98159	0.135967	1.6528	0.290666
134	540.8	391.9	1508.4	488.0	310229	34383	0.77243	2.12938	1.71013	1.71015	2.1399	1.2828-0.00081	0.96624	0.137495	1.6736	0.294222
135	540.7	391.6	1508.4	487.8	309778	34707	0.77199	2.12626	1.70684	1.70686	2.1417	1.2825-0.00070	0.95091	0.139001	1.6941	0.297698
136	540.5	391.2	1508.3	487.6	309386	35033	0.77160	2.12316	1.70366	1.70368	2.1433	1.2823-0.00060	0.93543	0.140484	1.7143	0.301094
137	540.4	390.9	1508.3	487.4	309053	35361	0.77127	2.12007	1.70060	1.70061	2.1446	1.2820-0.00049	0.91930	0.141944	1.7341	0.304408
138	540.3	390.7	1508.3	487.2	308778	35692	0.77100	2.11699	1.69766	1.69766	2.1456	1.2818-0.00038	0.90400	0.143380	1.7536	0.307637
139	540.2	390.5	1508.3	487.1	308550	36024	0.77077	2.11393	1.69480	1.69481	2.1464	1.2816-0.00030	0.88935	0.144794	1.7729	0.310792
140	540.2	390.4	1508.2	487.0	308365	36357	0.77059	2.11090	1.69205	1.69205	2.1471	1.2814-0.00021	0.87678	0.146188	1.7918	0.313877
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141	540.1	390.2	1508.2	486.9	308223	36692	0.77045	2.10789	1.68938	1.68939	2.1475	1.2811-0.00013	0.86376	0.147561	1.8105	0.316891
142	540.1	390.2	1508.2	486.9	308117	37028	0.77034	2.10490	1.68681	1.68681	2.1478	1.2809-0.00006	0.85261	0.148915	1.8289	0.319841
143	540.0	390.1	1508.2	486.8	308039	37365	0.77026	2.10194	1.68430	1.68430	2.1480	1.2807-0.00000	0.84269	0.150253	1.8471	0.322739
144	540.0	390.1	1508.2	486.8	307987	37702	0.77021	2.09901	1.68186	1.68186	2.1480	1.2805-0.00005	0.83382	0.151577	1.8651	0.325588
145	540.0	390.0	1508.2	486.8	307956	38040	0.77018	2.09610	1.67948	1.67948	2.1480	1.2803-0.00008	0.82686	0.152887	1.8829	0.328396
146	540.0	390.0	1508.2	486.8	307937	38377	0.77016	2.09323	1.67715	1.67715	2.1479	1.2801-0.00011	0.82141	0.154189	1.9007	0.331174
147	540.0	390.0	1508.2	486.8	307930	38715	0.77016	2.09039	1.67486	1.67486	2.1477	1.2799-0.00013	0.81732	0.155482	1.9183	0.333928
148	540.0	390.0	1508.2	486.8	307927	39053	0.77015	2.08759	1.67261	1.67261	2.1475	1.2797-0.00014	0.81471	0.156770	1.9359	0.336667
149	540.0	390.0	1508.2	486.8	307927	39390	0.77015	2.08481	1.67038	1.67038	2.1473	1.2795-0.00014	0.81292	0.158055	1.9534	0.339397

X=179.757, DELTA= 0.3440982, THETA=0.1590590, H= 2.163337, N= 7.1564820, DELTA= 1.9534113, RE/FT= 3695124.

RE.THETA= 48979., LOG= 4.69001,

RE.DELTA= 601508., LOG= 5.77924

M A C H 4 NOZZLE CONTOUR, RADIAL FLOW ENDS AT STA 76.9263852, TEST CONE BEGINS AT STA 132.3126057, SCALE FACTOR = 24.75038624
 RC= 6.000000 ETAD= 8.6700 DEG AMACH= 2.2878437 RMACH= 3.0821543 CMACH= 4.0000000 EMACH= 1.6601538 GMACH= 2.2878437
 STAG. PRESSURE= 200. PSI, STAG. TEMPERATURE=1638. DEG R, THROAT TEMP.= 866. DEG R, WALL TEMP.=540. DEG R, THROAT HT COEF.= 0.17482

	PARABOLIC TEMPERATURE DISTRIBUTION			MODIF. SPALUING-CHI REFERENCE TEMP				VAN DRIEST REFERENCE REYNOLDS NUMBER				
	STA(IN)	Y(IN)	DELTA(IN)	R(IN)	OY/OX	OZY/OX2	OA/OX	DR/OX	MACH NO.	DM/OX	PE/PO	BETA
1	46.075855	3.742729	0.0055143	3.7482437	0.0	0.0445308	0.0006641	0.0006641	1.0471638	0.1289481	4.99570-01	-4.80380-01
2	46.194522	3.743043	0.0055941	3.7486371	0.0052790	0.0444289	0.0006795	0.0059585	1.0626027	0.1303456	4.90340-01	-4.82790-01
3	46.317241	3.744025	0.0056784	3.7497038	0.0107240	0.0443160	0.0006964	0.0114204	1.0786293	0.1308606	4.80850-01	-4.81870-01
4	46.443834	3.745738	0.0057677	3.7515058	0.0163271	0.0441486	0.0007156	0.0170426	1.0952300	0.1315243	4.71130-01	-4.81520-01
5	46.574687	3.748253	0.0058627	3.7541157	0.0220890	0.0438612	0.0007355	0.0228245	1.1124932	0.1320693	4.61130-01	-4.80710-01
6	46.709786	3.751637	0.0059634	3.7576009	0.0279906	0.0434400	0.0007567	0.0287473	1.1303552	0.1324678	4.50910-01	-4.79400-01
7	46.849950	3.755988	0.0060711	3.7620592	0.0340438	0.0428567	0.0007789	0.0348227	1.1489592	0.1326094	4.40410-01	-4.77200-01
8	46.995411	3.761334	0.0061860	3.7675796	0.0402279	0.0421265	0.0008019	0.0410298	1.1682305	0.1324519	4.29690-01	-4.74010-01
9	47.147418	3.767996	0.0063098	3.7743055	0.0465699	0.0411777	0.0008264	0.0473963	1.1883589	0.1320898	4.18670-01	-4.70180-01
10	47.306791	3.775942	0.0064435	3.7823854	0.0530416	0.0399150	0.0008511	0.0538927	1.2093556	0.1311293	4.07360-01	-4.64390-01
11	47.474504	3.785399	0.0065884	3.7919877	0.0596137	0.0383639	0.0008766	0.0604903	1.2312390	0.1296467	3.95800-01	-4.56980-01
12	47.652195	3.796599	0.0067465	3.8033455	0.0662758	0.0364867	0.0009022	0.0671780	1.2541190	0.1275207	3.83940-01	-4.47600-01
13	47.840976	3.809752	0.0069193	3.8166811	0.0729621	0.0342307	0.0009269	0.0738890	1.2779433	0.1245724	3.71860-01	-4.35720-01
14	48.042344	3.825149	0.0071085	3.8322578	0.0796000	0.0316403	0.0009509	0.0805509	1.3026785	0.1210265	3.59600-01	-4.22220-01
15	48.257882	3.843041	0.0073161	3.8503570	0.0861321	0.0289891	0.0009744	0.0871065	1.3283469	0.1173018	3.47190-01	-4.08590-01
16	48.489226	3.863742	0.0075443	3.8712867	0.0925115	0.0262838	0.0009986	0.0935101	1.3550399	0.1138238	3.34620-01	-3.96310-01
17	48.737829	3.887550	0.0077958	3.8953458	0.0987007	0.0236942	0.0010235	0.0997242	1.3829205	0.1105609	3.21870-01	-3.85220-01
18	49.005786	3.914845	0.0080735	3.9229188	0.1047027	0.0212013	0.0010497	0.1057524	1.4120873	0.1075151	3.08930-01	-3.75300-01
19	49.294604	3.945969	0.0083808	3.9543497	0.1104531	0.0187513	0.0010777	0.1115309	1.4427244	0.1047381	2.95780-01	-3.66700-01
20	49.606502	3.981325	0.0087215	3.9900470	0.1159113	0.0164800	0.0011075	0.1170188	1.4749409	0.1020542	2.82440-01	-3.58810-01
21	49.943497	4.021316	0.0091002	4.0304164	0.1210936	0.0142664	0.0011397	0.1222334	1.5088820	0.0995120	2.68920-01	-3.51800-01
22	50.166357	4.048660	0.0093566	4.0580171	0.1241092	0.0128924	0.0011610	0.1252702	1.5308817	0.0979907	2.60440-01	-3.47830-01
23	50.485904	4.088966	0.0097325	4.0986985	0.1279362	0.0113023	0.0011917	0.1291280	1.5618623	0.0959719	2.48890-01	-3.42830-01
24	50.852165	4.136581	0.0101754	4.1467564	0.1317928	0.0098352	0.0012271	0.1330199	1.5966017	0.0938333	2.36460-01	-3.37860-01
25	51.251055	4.189929	0.0106726	4.2006021	0.1354143	0.0083961	0.0012656	0.1366800	1.6335898	0.0916764	2.23810-01	-3.33180-01
26	51.675884	4.248214	0.0112190	4.2594329	0.1386722	0.0070360	0.0013068	0.1399790	1.6720611	0.0895581	2.11290-01	-3.28910-01
27	52.122740	4.310875	0.0118127	4.3226873	0.1415189	0.0058305	0.0013501	0.1428690	1.7116110	0.0874521	1.99070-01	-3.24930-01
28	52.589479	4.377557	0.0124533	4.3900108	0.1439769	0.0047561	0.0013955	0.1453724	1.7519140	0.0853867	1.87280-01	-3.21290-01
29	53.074361	4.447927	0.0131415	4.4610685	0.1460261	0.0037918	0.0014426	0.1474687	1.7928312	0.0833563	1.75960-01	-3.17930-01
30	53.576491	4.521718	0.0138780	4.5355964	0.1477043	0.0029792	0.0014914	0.1491957	1.8341515	0.0813511	1.65170-01	-3.14790-01
31	54.094777	4.598672	0.0146642	4.6133357	0.1490542	0.0022743	0.0015416	0.1505958	1.8758124	0.0793805	1.54910-01	-3.11860-01
32	54.628651	4.678566	0.0155008	4.6940663	0.1500868	0.0016926	0.0015929	0.1516797	1.9176407	0.0774225	1.45220-01	-3.09040-01
33	55.177283	4.761154	0.0163893	4.7775437	0.1508792	0.0012503	0.0016456	0.1525247	1.9595949	0.0755200	1.36080-01	-3.06460-01
34	55.740017	4.846257	0.0173303	4.8635878	0.1514708	0.0008799	0.0016987	0.1531694	2.0015440	0.0736156	1.27500-01	-3.03870-01
35	56.316071	4.933654	0.0183244	4.9519784	0.1518766	0.0005863	0.0017525	0.1536291	2.0434024	0.0717661	1.19450-01	-3.01460-01
36	56.904570	5.023130	0.0193719	5.0425017	0.1521507	0.0003831	0.0018065	0.1539571	2.0850968	0.0699376	1.11930-01	-2.99070-01
37	57.504606	5.114493	0.0204721	5.1349650	0.1523300	0.0002322	0.0018601	0.1541901	2.1265044	0.0681244	1.04920-01	-2.96650-01
38	58.115220	5.207549	0.0216244	5.2291739	0.1524304	0.0001177	0.0019137	0.1543441	2.1675528	0.0663705	9.83930-02	-2.94350-01
39	58.735317	5.302091	0.0228279	5.3249191	0.1524740	0.0000421	0.0019671	0.1544410	2.2081710	0.0646682	9.23330-02	-2.92140-01
40	59.363844	5.397932	0.0240810	5.4220133	0.1524825	0.0000093	0.0020197	0.1545022	2.2482849	0.0630080	8.67140-02	-2.89940-01
41	60.000000	5.494933	0.0253825	5.5203158	0.1524857	0.0	0.0020715	0.1545572	2.2878437	0.0613810	8.15080-02	-2.87710-01
42	60.552926	5.579249	0.0265402	5.6057892	0.1524880	0.0000050	0.0021158	0.1546038	2.3214084	0.0600664	7.73390-02	-2.86020-01
43	61.103390	5.663187	0.0277170	5.6909039	0.1524802	0.0000214	0.0021595	0.1546398	2.3541235	0.0588206	7.34820-02	-2.84460-01
44	61.651753	5.746798	0.0289130	5.7757114	0.1524645	0.0000383	0.0022022	0.1546666	2.3860447	0.0576257	6.99060-02	-2.82950-01

45	62.198387	5.830135	0.0301283	5.8602635	0.1524383-0.0000627	0.0022437	0.1546820	2.4172256	0.0564765	6.65850-02	-2.81470-01
46	62.743709	5.913254	0.0313630	5.9446174	0.1523961-0.0000967	0.0022841	0.1546802	2.4477161	0.0553653	6.34970-02	-2.80000-01
47	63.288168	5.996214	0.0326174	6.0288310	0.1523330-0.0001418	0.0023232	0.1546562	2.4775625	0.0542857	6.06080-02	-2.78520-01
48	63.832236	6.079073	0.0338918	6.1129649	0.1522418-0.0002009	0.0023606	0.1546024	2.5068080	0.0532190	5.79110-02	-2.76930-01
49	64.376299	6.161873	0.0351860	6.1970586	0.1521144-0.0002692	0.0023959	0.1545103	2.5354718	0.0525103	5.53880-02	-2.75170-01
50	64.921084	6.244702	0.0365006	6.2812030	0.1519487-0.0003419	0.0024301	0.1543788	2.5635910	0.0511115	5.30230-02	-2.73410-01
51	65.467010	6.327604	0.0378366	6.3654410	0.1517414-0.0004193	0.0024636	0.1542049	2.5912185	0.0501117	5.08010-02	-2.71700-01
52	66.014590	6.410632	0.0391946	6.4498266	0.1514901-0.0004997	0.0024948	0.1539849	2.6183867	0.0490995	4.87100-02	-2.69780-01
53	66.564347	6.493840	0.0405743	6.5344139	0.1511929-0.0005832	0.0025239	0.1537168	2.6450950	0.0480789	4.67410-02	-2.67670-01
54	67.116843	6.577284	0.0419766	6.6192606	0.1508470-0.0006703	0.0025522	0.1533993	2.6713791	0.0470964	4.48850-02	-2.65620-01
55	67.672596	6.661014	0.0434029	6.7044173	0.1504498-0.0007622	0.0025792	0.1530290	2.6972864	0.0461238	4.31300-02	-2.63500-01
56	68.231992	6.745056	0.0448529	6.7899094	0.1499967-0.0008597	0.0026035	0.1526003	2.7228104	0.0451284	4.14710-02	-2.61110-01
57	68.795850	6.829497	0.0463275	6.8758240	0.1494837-0.0009604	0.0026270	0.1521107	2.7479725	0.0441636	3.99000-02	-2.58770-01
58	69.364555	6.914354	0.0478283	6.9621818	0.1489085-0.0010625	0.0026493	0.1515578	2.7728239	0.0432111	3.84110-02	-2.56370-01
59	69.938609	6.999660	0.0493551	7.0490151	0.1482690-0.0011638	0.0026692	0.1509382	2.7973472	0.0422396	3.69980-02	-2.53730-01
60	70.518568	7.085454	0.0509087	7.1363625	0.1475648-0.0012623	0.0026888	0.1502536	2.8215632	0.0413084	3.56560-02	-2.51220-01
61	71.104909	7.171760	0.0524911	7.2242513	0.1467961-0.0013583	0.0027064	0.1495025	2.8455195	0.0403647	3.43790-02	-2.48500-01
62	71.697974	7.258581	0.0541007	7.3126815	0.1459622-0.0014511	0.0027222	0.1486844	2.8691629	0.0394195	3.31660-02	-2.45660-01
63	72.298584	7.345985	0.0557407	7.4017258	0.1450633-0.0015406	0.0027382	0.1478015	2.8925668	0.0385213	3.20100-02	-2.43000-01
64	72.907018	7.433961	0.0574114	7.4913728	0.1440989-0.0016281	0.0027518	0.1468507	2.9157299	0.0375957	3.09070-02	-2.40050-01
65	73.523780	7.522526	0.0591122	7.5816383	0.1430678-0.0017145	0.0027645	0.1458323	2.9386209	0.0366957	2.98570-02	-2.37150-01
66	74.149298	7.611682	0.0608458	7.6725280	0.1419682-0.0018007	0.0027764	0.1447446	2.9613088	0.0358090	2.88530-02	-2.34220-01
67	74.783805	7.701399	0.0626106	7.7640100	0.1407980-0.0018861	0.0027866	0.1435846	2.9837327	0.0349161	2.78970-02	-2.31140-01
68	75.428101	7.791723	0.0644094	7.8561328	0.1395555-0.0019688	0.0027970	0.1423525	3.0059512	0.0340659	2.69820-02	-2.28240-01
69	76.082345	7.882605	0.0662428	7.9488479	0.1382406-0.0020468	0.0028056	0.1410463	3.0279603	0.0331975	2.61070-02	-2.25110-01
70	76.746956	7.974029	0.0681098	8.0421385	0.1368552-0.0021195	0.0028139	0.1396691	3.0497246	0.0323598	2.52720-02	-2.22080-01
71	77.422242	8.065962	0.0700133	8.1359750	0.1354000-0.0021869	0.0028212	0.1382212	3.0713107	0.0315266	2.44710-02	-2.18980-01
72	78.108309	8.154340	0.0719505	8.2302903	0.1338775-0.0022469	0.0028274	0.1367049	3.0926338	0.0306975	2.37070-02	-2.15800-01
73	78.805862	8.251179	0.0739254	8.3251049	0.1322904-0.0023016	0.0028343	0.1351247	3.1137755	0.0299100	2.29740-02	-2.12810-01
74	79.514896	8.344399	0.0759373	8.4203364	0.1306395-0.0023527	0.0028397	0.1334791	3.1346955	0.0291099	2.22730-02	-2.09630-01
75	80.235689	8.437951	0.0779857	8.5159371	0.1289259-0.0023982	0.0028453	0.1317712	3.1553882	0.0283486	2.16020-02	-2.06640-01
76	80.968136	8.531739	0.0800723	8.6118115	0.1271538-0.0024388	0.0028497	0.1300035	3.1758845	0.0275796	2.09590-02	-2.03680-01
77	81.712829	8.625753	0.0821951	8.7079484	0.1253229-0.0024757	0.0028538	0.1281767	3.1961171	0.0268336	2.03440-02	-2.00390-01
78	82.469634	8.719889	0.0843573	8.8042461	0.1234360-0.0025082	0.0028583	0.1262943	3.2161669	0.0261126	1.97530-02	-1.97390-01
79	83.238552	8.814059	0.0865560	8.9006154	0.1214957-0.0025381	0.0028617	0.1243574	3.2359485	0.0253917	1.91890-02	-1.94300-01
80	84.019630	8.908183	0.0887931	8.9969758	0.1195017-0.0025669	0.0028661	0.1223678	3.2555157	0.0247095	1.86470-02	-1.91400-01
81	84.812477	9.002122	0.0910671	9.0931894	0.1174553-0.0025938	0.0028697	0.1203250	3.2748313	0.0240239	1.81290-02	-1.88380-01
82	85.617520	9.095838	0.0933785	9.1892167	0.1153568-0.0026169	0.0028743	0.1182310	3.2938948	0.0233783	1.76330-02	-1.85590-01
83	86.434259	9.189181	0.0957286	9.2849096	0.1132111-0.0026347	0.0028781	0.1160892	3.3127386	0.0227294	1.71560-02	-1.82670-01
84	87.262491	9.282042	0.0981129	9.3801551	0.1110227-0.0026455	0.0028826	0.1139052	3.3312761	0.0221102	1.67010-02	-1.79890-01
85	88.101869	9.374299	0.1005357	9.4748345	0.1087994-0.0026463	0.0028875	0.1116869	3.3496037	0.0215079	1.62640-02	-1.77170-01
86	88.951717	9.465806	0.1029906	9.5687962	0.1065525-0.0026396	0.0028924	0.1094449	3.3676009	0.0209182	1.58470-02	-1.74450-01
87	89.812142	9.556509	0.1054826	9.6619914	0.1042851-0.0026294	0.0028991	0.1071842	3.3853741	0.0203684	1.54460-02	-1.71980-01
88	90.682263	9.646254	0.1080077	9.7542614	0.1020023-0.0026164	0.0029058	0.1049081	3.4028437	0.0198214	1.50630-02	-1.69450-01
89	91.561549	9.734931	0.1105661	9.8454975	0.0997080-0.0026015	0.0029145	0.1026225	3.4200450	0.0193209	1.46960-02	-1.67220-01
90	92.781191	9.854604	0.1141289	9.9687331	0.0965482-0.0025789	0.0029252	0.0994733	3.4432004	0.0186333	1.42160-02	-1.64030-01
91	94.015488	9.971808	0.1177444	10.0895528	0.0933800-0.0025529	0.0029361	0.0963161	3.4657596	0.0179740	1.37660-02	-1.60930-01
92	95.263954	10.086400	0.1214187	10.2078184	0.0902103-0.0025220	0.0029509	0.0931612	3.4878170	0.0173776	1.33400-02	-1.58250-01
93	96.525320	10.198180	0.1251509	10.3233311	0.0870506-0.0024860	0.0029651	0.0900157	3.5093670	0.0167933	1.29380-02	-1.55530-01
94	97.799333	10.307066	0.1289366	10.4360026	0.0839079-0.0024465	0.0029770	0.0868849	3.5303869	0.0162112	1.25580-02	-1.52690-01
95	99.085954	10.412998	0.1327740	10.5457720	0.0807866-0.0024038	0.0029904	0.0837770	3.5508706	0.0156662	1.22000-02	-1.50060-01
96	100.384135	10.515847	0.1366663	10.6525138	0.0776951-0.0023586	0.0030057	0.0807008	3.5708751	0.0151618	1.18600-02	-1.47690-01
97	101.693801	10.615580	0.1406126	10.7561922	0.0746362-0.0023129	0.0030171	0.0776533	3.5904045	0.0146382	1.15390-02	-1.44990-01
98	103.015063	10.712175	0.1446040	10.8567787	0.0716107-0.0022663	0.0030281	0.0746388	3.6093807	0.0141368	1.12360-02	-1.42390-01
99	104.346959	10.805542	0.1486469	10.9541888	0.0686239-0.0022185	0.0030428	0.0716667	3.6279067	0.0136893	1.09480-02	-1.40190-01
100	105.689498	10.895673	0.1527419	11.0484151	0.0656780-0.0021708	0.0030524	0.0687304	3.6459872	0.0132107	1.06750-02	-1.37550-01

101	107.042885	10.982573	0.1568759	11.1394492	0.0627721-0.0021236	0.0030610	0.0658331	3.6635161	0.0127512	1.04180-02	-1.34980-01
102	108.406158	11.066175	0.1610578	11.2272328	0.0599095-0.0020755	0.0030732	0.0629826	3.6806240	0.0123407	1.01730-02	-1.32810-01
103	109.779387	11.146487	0.1652857	11.3117732	0.0570929-0.0020260	0.0030795	0.0601724	3.6972824	0.0118955	9.94030-03	-1.30140-01
104	111.162793	11.223531	0.1695469	11.3930778	0.0543252-0.0019745	0.0030848	0.0574100	3.7134107	0.0114691	9.72070-03	-1.27540-01
105	112.555461	11.297273	0.1738494	11.4711222	0.0516121-0.0019209	0.0030932	0.0547053	3.7291180	0.0110870	9.51200-03	-1.25310-01
106	113.957469	11.367745	0.1781915	11.5459365	0.0489575-0.0018662	0.0030945	0.0520520	3.7443916	0.0106658	9.31370-03	-1.22530-01
107	115.368960	11.434990	0.1825558	11.6175455	0.0463622-0.0018121	0.0030935	0.0494556	3.7591219	0.0102550	9.12670-03	-1.19720-01
108	116.789148	11.499005	0.1869513	11.6859567	0.0438266-0.0017596	0.0030969	0.0469235	3.7734273	0.0098946	8.94900-03	-1.17380-01
109	118.218325	11.559845	0.1913802	11.7512254	0.0413490-0.0017080	0.0030953	0.0444443	3.7873119	0.0095120	8.78020-03	-1.14660-01
110	119.655785	11.617518	0.1958242	11.8133419	0.0389309-0.0016557	0.0030877	0.0420186	3.8006914	0.0091164	8.62080-03	-1.11660-01
111	121.101604	11.672074	0.2002828	11.8723568	0.0365756-0.0016024	0.0030820	0.0396576	3.8135937	0.0087518	8.47010-03	-1.08900-01
112	122.555756	11.723567	0.2047620	11.9283285	0.0342844-0.0015486	0.0030772	0.0373616	3.8260686	0.0084067	8.32710-03	-1.06260-01
113	124.017588	11.772029	0.2092558	11.9812853	0.0320603-0.0014938	0.0030673	0.0351276	3.8381050	0.0080513	8.19160-03	-1.03370-01
114	125.487078	11.817529	0.2137532	12.0312820	0.0299061-0.0014373	0.0030514	0.0329575	3.8496669	0.0076813	8.06380-03	-1.00150-01
115	126.964204	11.860135	0.2182468	12.0783820	0.0278254-0.0013797	0.0030347	0.0308601	3.8607359	0.0073276	7.94340-03	-9.70240-02
116	128.448371	11.899914	0.2227397	12.1226533	0.0258210-0.0013227	0.0030191	0.0288401	3.8713637	0.0069963	7.82970-03	-9.40610-02
117	129.939660	11.936950	0.2272299	12.1641803	0.0238904-0.0012680	0.0030011	0.0268914	3.8815507	0.0066670	7.72230-03	-9.10010-02
118	131.437526	11.971313	0.2317102	12.2030234	0.0220311-0.0012155	0.0029797	0.0250108	3.8912901	0.0063397	7.62120-03	-8.78440-02
119	132.941993	12.003083	0.2361758	12.2392588	0.0202414-0.0011633	0.0029545	0.0231958	3.9005824	0.0060118	7.52610-03	-8.45500-02
120	134.452558	12.032331	0.2406179	12.2729487	0.0185241-0.0011095	0.0029244	0.0214485	3.9094140	0.0056768	7.43690-03	-8.10240-02
121	135.969093	12.059147	0.2450280	12.3041751	0.0168830-0.0010538	0.0028923	0.0197753	3.9177645	0.0053509	7.35370-03	-7.74950-02
122	137.491440	12.083627	0.2494072	12.3330347	0.0153221-0.0009964	0.0028601	0.0181822	3.9256728	0.0050407	7.27570-03	-7.40660-02
123	139.019115	12.105872	0.2537512	12.3596230	0.0138443-0.0009390	0.0028253	0.0166697	3.9331370	0.0047340	7.20300-03	-7.05100-02
124	140.552042	12.125941	0.2580543	12.3840457	0.0124486-0.0008831	0.0027876	0.0152362	3.9401601	0.0044313	7.13530-03	-6.69900-02
125	142.089762	12.144091	0.2623106	12.4064013	0.0111330-0.0008293	0.0027472	0.0138802	3.9467425	0.0041330	7.07250-03	-6.33600-02
126	143.632160	12.160276	0.2665156	12.4267920	0.0098946-0.0007765	0.0027043	0.0125988	3.9528889	0.0038397	7.01440-03	-5.96820-02
127	145.178800	12.174650	0.2706641	12.4453143	0.0087347-0.0007228	0.0026591	0.0113938	3.9586023	0.0035520	6.96090-03	-5.59670-02
128	146.729536	12.187326	0.2747517	12.4620781	0.0076559-0.0006692	0.0026118	0.0102677	3.9638895	0.0032704	6.91170-03	-5.22270-02
129	148.283950	12.198419	0.2787739	12.4771932	0.0066569-0.0006173	0.0025626	0.0092195	3.9687563	0.0029955	6.86680-03	-4.88470-02
130	149.841872	12.208041	0.2827273	12.4907688	0.0057347-0.0005667	0.0025116	0.0082463	3.9732116	0.0027282	6.82600-03	-4.47310-02
131	151.402906	12.216303	0.2866074	12.5029103	0.0048894-0.0005157	0.0024575	0.0073469	3.9772645	0.0024612	6.78910-03	-4.08760-02
132	152.966864	12.223318	0.2904067	12.5137252	0.0041234-0.0004644	0.0024013	0.0065248	3.9809020	0.0021997	6.75670-03	-3.70010-02
133	154.533406	12.229209	0.2941247	12.5233341	0.0034359-0.0004145	0.0023462	0.0057821	3.9841501	0.0019553	6.72690-03	-3.33020-02
134	156.102220	12.234090	0.2977629	12.5318526	0.0028239-0.0003663	0.0022921	0.0051160	3.9870320	0.0017245	6.70110-03	-2.97340-02
135	157.673105	12.238074	0.3013211	12.5393955	0.0022859-0.0003204	0.0022382	0.0045241	3.9895641	0.0015054	6.67840-03	-2.62710-02
136	159.245731	12.241275	0.3047986	12.5460732	0.0018169-0.0002774	0.0021839	0.0040008	3.9917639	0.0012955	6.65890-03	-2.28780-02
137	160.819901	12.243791	0.3081933	12.5519845	0.0014130-0.0002364	0.0021285	0.0035415	3.9936403	0.0010889	6.64220-03	-1.94560-02
138	162.395337	12.245725	0.3115025	12.5572270	0.0010723-0.0001978	0.0020758	0.0031481	3.9951934	0.0009008	6.62840-03	-1.62800-02
139	163.971791	12.247171	0.3147358	12.5619065	0.0007895-0.0001624	0.0020281	0.0028176	3.9964793	0.0007384	6.61710-03	-1.34960-02
140	165.549089	12.248214	0.3178987	12.5661128	0.0005600-0.0001295	0.0019822	0.0025422	3.9975219	0.0005849	6.60790-03	-1.08110-02
141	167.127015	12.248938	0.3209899	12.5699276	0.0003811-0.0000998	0.0019384	0.0023195	3.9983248	0.0004447	6.60080-03	-0.830960-03
142	168.705380	12.249417	0.3240170	12.5734338	0.0002451-0.0000744	0.0019006	0.0021457	3.9989255	0.0003295	6.59550-03	-0.622320-03
143	170.284056	12.249711	0.3269903	12.5767017	0.0001462-0.0000522	0.0018677	0.0020140	3.9993651	0.0002321	6.59170-03	-0.442940-03
144	171.862898	12.249878	0.3299144	12.5797929	0.0000802-0.0000343	0.0018390	0.0019192	3.9996582	0.0001498	6.58910-03	-0.288910-03
145	173.441792	12.249965	0.3327975	12.5827620	0.0000379-0.0000212	0.0018164	0.0018544	3.9998381	0.0000895	6.58750-03	-0.174420-03
146	175.020669	12.249998	0.3356503	12.5856485	0.0000133-0.0000115	0.0017994	0.0018127	3.9999408	0.0000464	6.58660-03	-0.130000-04
147	176.599460	12.250006	0.3384795	12.5884859	0.0000017-0.0000048	0.0017872	0.0017889	3.9999845	0.0000181	6.58620-03	-0.360110-04
148	178.178127	12.250003	0.3412934	12.5912968	0.0000020-0.0000005	0.0017798	0.0017778	3.9999980	0.0000049	6.58610-03	-0.984020-05
149	179.756652	12.250000	0.3440987	12.5940987	0.0 0.0	0.0017746	0.0017746	4.0000000	0.0	6.58610-03	0.0
STA	46.060986.	Y**	3.7482388.	D2A/DX2*	0.000130108.	D2R/DX2=	0.044660860.	VISCID RC=	5.97373108		

M A C H 4 COORDINATES AND DERIVATIVES. LENGTH = 133.6956656

X(IN)	Y(IN)	DY/DX	ANGLE	D2Y/DX2
46.000000	3.748239	0.0	0.0	4.466085900-02
48.000000	3.828872	7.928752760-02	4.533356900 00	3.233121120-02
50.000000	4.037350	1.231080500-01	7.018258590 00	1.386269750-02
52.000000	4.305187	1.422101290-01	8.093769320 00	6.177612540-03
54.000000	4.599067	1.504338720-01	8.555076090 00	2.444559730-03
56.000000	4.903448	1.534265540-01	8.722675330 00	7.895883750-04
58.000000	5.211391	1.543314570-01	8.773323200 00	2.044309060-04
60.000000	5.520316	1.545560260-01	8.785890300 00	1.179390930-04
62.000000	5.829576	1.546802720-01	8.792842860 00	2.740835130-05
64.000000	6.138901	1.545848900-01	8.787505500 00	-1.556272140-04
66.000000	6.447580	1.539992030-01	8.754728380 00	-4.406297800-04
68.000000	6.754483	1.527948470-01	8.687310280 00	-7.755900790-04
70.000000	7.058280	1.508777080-01	8.579941610 00	-1.145012590-03
72.000000	7.357525	1.482560530-01	8.433018670 00	-1.468822230-03
74.000000	7.650897	1.450194950-01	8.251481230 00	-1.764610790-03
76.000000	7.937226	1.412222640-01	8.038283180 00	-2.033388590-03
78.000000	8.215470	1.369524660-01	7.798284970 00	-2.228155560-03
80.000000	8.484813	1.323377850-01	7.538591680 00	-2.375525270-03
82.000000	8.744656	1.274704390-01	7.264341800 00	-2.482244430-03
84.000000	8.994573	1.224221840-01	6.979544820 00	-2.561567750-03
86.000000	9.234248	1.172335770-01	6.686468370 00	-2.622812320-03
88.000000	9.463443	1.119561990-01	6.388016790 00	-2.650252110-03
90.000000	9.682080	1.066895860-01	6.089826580 00	-2.623063850-03
92.000000	9.890242	1.014846590-01	5.794803160 00	-2.586320390-03
94.000000	10.088061	9.634882880-02	5.503393690 00	-2.542686850-03
96.000000	10.275706	9.131295110-02	5.217377890 00	-2.491214870-03
98.000000	10.453387	8.638684330-02	4.937343920 00	-2.433364030-03
100.000000	10.621344	8.159527320-02	4.664730830 00	-2.358694910-03
102.000000	10.779858	7.693788390-02	4.399548740 00	-2.297913470-03
104.000000	10.929194	7.242434540-02	4.142376780 00	-2.217338260-03
106.000000	11.069648	6.804791130-02	3.892856880 00	-2.158093120-03
108.000000	11.201485	6.381499830-02	3.651378870 00	-2.079367280-03
110.000000	11.324996	5.971422390-02	3.417315050 00	-2.020254400-03
112.000000	11.440445	5.576349840-02	3.191707570 00	-1.934949230-03
114.000000	11.548148	5.195996530-02	2.974411830 00	-1.871074660-03
116.000000	11.648387	4.830811190-02	2.765700850 00	-1.783716790-03
118.000000	11.741483	4.480880220-02	2.565639050 00	-1.722059550-03
120.000000	11.827702	4.143527470-02	2.372706230 00	-1.648198760-03
122.000000	11.907330	3.821807570-02	2.188669250 00	-1.572348910-03
124.000000	11.980667	3.514180090-02	2.012648650 00	-1.503872240-03
126.000000	12.047989	3.220385630-02	1.844507590 00	-1.430333420-03
128.000000	12.109594	2.942782410-02	1.685603660 00	-1.348942340-03
130.000000	12.165800	2.680149790-02	1.535245190 00	-1.278463020-03
132.000000	12.216891	2.431172790-02	1.392685060 00	-1.212328450-03
134.000000	12.263132	2.195079550-02	1.257486000 00	-1.147515930-03
136.000000	12.304785	1.972754010-02	1.130158190 00	-1.074282300-03
138.000000	12.342143	1.765517960-02	1.011462190 00	-9.990153030-04
140.000000	12.375503	1.572884230-02	9.011219710-01	-9.272061620-04
142.000000	12.405153	1.394414440-02	7.988888480-01	-8.583803270-04
144.000000	12.431367	1.229129490-02	7.042038580-01	-7.936860460-04
146.000000	12.454409	1.077353810-02	6.172543810-01	-7.242758240-04

M A G H * COORDINATES AND DERIVATIVES, LENGTH = 133.6956656

X(IN)	Y(IN)	DY/DX	ANGLE	OZY/OX2
148.000000	12.474553	9.39216534D-03	5.38115612D-01	-6.58091366D-04
150.000000	12.492063	8.13953236D-03	4.66350553D-01	-5.95039869D-04
152.000000	12.507192	7.00930971D-03	4.01597287D-01	-5.32529461D-04
154.000000	12.520192	6.01328645D-03	3.44531782D-01	-4.65704477D-04
156.000000	12.531329	5.14437478D-03	2.94748363D-01	-4.03224707D-04
158.000000	12.540852	4.39881668D-03	2.52032005D-01	-3.43757846D-04
160.000000	12.548996	3.76222227D-03	2.15558441D-01	-2.93142352D-04
162.000000	12.555969	3.22901915D-03	1.85008526D-01	-2.37784049D-04
164.000000	12.561986	2.80338138D-03	1.60621501D-01	-1.90196057D-04
166.000000	12.567239	2.46407018D-03	1.41180536D-01	-1.48366223D-04
168.000000	12.571900	2.21052027D-03	1.26653276D-01	-1.07725817D-04
170.000000	12.576128	2.02839844D-03	1.16218510D-01	-7.52059936D-05
172.000000	12.580055	1.90785138D-03	1.09311699D-01	-4.62866371D-05

NOMENCLATURE

A	Area
A_C	Exit area, inviscid contour
A^*	Sonic area
a^*	Sonic speed
C	Factor in logarithmic skin friction law, Eq. (77)
$C_{1,2,3,4,5,6}$	Coefficients, Eq. (35)
C_D	Ratio of actual mass flow to that if R were infinite
C_f	Skin friction coefficient, compressible
C_{f_i}	Skin friction coefficient, incompressible
C_p	Specific heat at constant pressure
$D_{1,2,3,4,5,6}$	Coefficients, Eq. (37)
F_c	Ratio, C_{f_i}/C_f
F_n	Multiplying factors, Eq. (97)
F_{R_δ}	Ratio, $R_{\theta_i}/R_{\theta_c}$
G_n	Multiplying factors, Eqs. (94) and (96)

H	Ratio, δ^*/θ
h_a	Heat-transfer coefficient
K	Streamline curvature
ln	Natural logarithm (base e)
log	Common logarithm (Base 10)
M	Mach number
m	Exponent in Eq. (90)
N	Velocity profile exponent
n	Distance normal to streamline
$P_{1,2}$	Factors in axisymmetric characteristics equations
P_n	Coefficient of θ at nth point on contour
Pr	Prandtl number
Q	Factor related to heat transfer, Eq. (91)
Q_n	Coefficient in momentum equation
q	Velocity along streamline or, in boundary-layer equations, velocity within boundary layer
q_e	Velocity at edge of boundary layer

R	Ratio of throat radius of curvature to throat radius (half height, $\sigma = 0$)
R_g	Gas constant, $\text{ft}^2/\text{sec}^2 R$
R_δ	Reynolds number based on δ , compressible
R_{δ_i}	Incompressible Reynolds number
R_{θ_c}	Reynolds number based on θ_c , compressible
R_{θ_i}	Incompressible Reynolds number
r	Distance from source
r_1	Distance from source where $M = 1$, used to non-dimensionalize distances for inviscid calculations
r_w	Radius of viscid contour
S	$R + 1$
s, t, u	Cubic integration increments, Appendix B
T	Temperature within boundary layer
T_{aw}	Adiabatic wall temperature
T_c	Reference temperature, Eq. (87)
T_e	Free-stream temperature at edge of inviscid contour

T_w	Wall temperature
T_{wD}	Wall temperature at nozzle exit
T_{wT}	Wall temperature at nozzle throat
u	Axial component of velocity, normalized by a^*
v	Normal component of velocity, normalized by a^*
W	Velocity along streamline, normalized by a^*
X	Ratio in Eq. (36) or (38)
x	Axial distance, normalized by y_0 in transonic equations, normalized by r_1 in inviscid calculations, not normalized in boundary-layer calculations
y	Normal distance, normalized same as x
y_0	Throat half height, used to normalize x and y in transonic calculations
y^*	Theoretical throat height if R is infinite
z	Function of x in transonic equations, or distance normal to contour in boundary-layer calculations

α	Mean angle of right-running characteristic, or factor in temperature distribution in boundary layer
β	Mean angle of left-running characteristic
Δ	Prefix to indicate increment in value
γ	Specific heat ratio
δ	Boundary-layer thickness
δ^*	Displacement thickness in boundary layer
δ_a^*	Displacement thickness when boundary layer is large relative to r_w
δ_i^*	Incompressible displacement thickness in boundary layer
ζ	Distance along left-running characteristic
η	Inflection angle, radians
θ	Momentum thickness in boundary layer
θ_a	Momentum thickness when boundary layer is large relative to r_w
θ_c	Compressible θ for flat plate
θ_i	Incompressible value of θ
θ_k	Kinematic momentum thickness

θ_n	Value of θ at nth point on contour
κ	Constant in logarithmic skin-friction law
λ	$\left[\frac{1+\sigma}{(\gamma+1)S} \right]^{\frac{1}{2}}$
μ	Mach angle, $\sin^{-1}(1/M)$
μ_c	Viscosity at value of T_c
μ_e	Viscosity at value of T_e
μ_w	Viscosity at value of T_w
ξ	Distance along right-running characteristic
Π	Wake variable in logarithmic skin-friction law
ρ	Density within boundary layer
ρ_e	Density at edge of boundary layer
σ	Zero for planar flow, 1 for axisymmetric flow
ϕ	Flow angle
ϕ_w	Flow angle of viscid contour
ψ	Prandtl-Meyer angle

SUBSCRIPTS

1	Values at point 1 on right-running characteristic
2	Values at point 2 on left-running characteristic
3	Values at intersection of characteristics
A,B,C,D,E, F,G,I,J,T	Variables evaluated at points on Figs. 1 through 4
a,b,c	With u and v, values corresponding to first-, second-, and third-order approximations, respectively

OTHER NOTATION

d/dx

OUTPUT NOMENCLATURE

BETA	Pressure gradient parameter
	$\frac{2\delta^* dP_E/dx}{\gamma M^2 P_E C_{f_i}}$
C(Y)	Coefficient of third-degree term if throat contour is a cubic
C(YI)	Coefficient of third-degree term if integrated throat contour is a cubic

C(YP)	Coefficient of third-degree term determined from slope of contour
D2A/DX2	Second derivative of boundary-layer correction evaluated at the throat
D2R/DX2	Second derivative of corrected contour evaluated at the throat
DA/DX	Slope of boundary-layer correction
DEL(R(IN)	Boundary-layer correction to inviscid contour
DELTA*	δ_a^* from Eq. (66)
DELTA* - 1	δ^* from Eq. (63)
FMY	Bracketed term in Eq. (61)
HYP/YO	Value of hyperbola with same throat curvature ratio
ICY	$10^6 [C(YI) - C(Y)]$ for Point 2
INT.Y/YO	Value of Y/YO obtained by integrating contour slopes starting at inflection point
KCF	$1000 C_f$
KCFI	$1000 C_{f_i}$
KCFS	$KCF \sec \phi_w$

KTHP	$1000 \, d\theta/dx$
MASS	Result of mass integration along characteristic EG or AB (measure of accuracy of numerical integration)
PAR/YO	Value of parabola with same throat curvature ratio
PE/PO	Ratio of static to stagnation pressure
R(IN)	Ordinate of viscoid contour
RMASS	$C_D^{1/(1+\sigma)}$
RTHI	Incompressible Reynolds number based on momentum thickness
SMPP	Second derivative of Mach number in source flow evaluated for BMACH
SMPPP	Third derivative of Mach number in source flow evaluated for BMACH
THETA - 1	θ from Eq. (62) used in Eq. (61)
WE	Velocity ratio at Point E (Fig. 3)
WI	Velocity ratio at Point I (Fig. 3)
WO	Velocity ratio on axis at throat
WOPPP	Third derivative of throat velocity distribution

WRPPP Third derivative of velocity ratio in source
 flow evaluated at WE

WWO Velocity ratio on wall at throat