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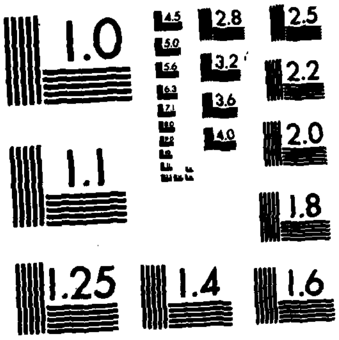

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CALCULATIONS OF FLOWFIELD ABOUT INDENTED NOSETIPS

BY DR. TSUYING HSIEH

RESEARCH AND TECHNOLOGY DEPARTMENT

23 AUGUST 1982

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The unsteady implicit numerical procedure for solving Euler or Navier-Stokes equations with thin-layer approximation (or thin-layer theory) for hypersonic flows over blunt noses developed by Kutler et al is examined and the numerical code (a research code) has been applied to compute the flowfield of hypersonic flows over a series of four severely indented nosetip shapes with small radius expansion corners and compression turn. For inviscid flows, the code can give satisfactory results for smooth nosetip shapes. For

severely indented nosetip shapes under investigation, routine calculation fails to give a solution and a special calculation procedure has been developed in order to obtain reasonable solutions. For viscous flows, extensive calculations have been performed for both smooth and indented nosetip shapes, however, comparisons of calculated results and measured data are not satisfactory. For smooth nosetip shapes, although the surface pressure and shock location agree well but the temperature field is poor. For indented nosetip shapes, difficulties to simulate flows with large separation bubble and sharp corner as well as turbulent flows are described.

Because of the poor results obtained for viscous flow calculations, a reanalysis of the complete calculation procedure for solving the full Navier-Stokes equations has been carried out. The original code was then modified by rewritting all the viscous subroutines according to the new analysis for thin-layer theory without turbulence model. The modified nosetip code has been applied to compute laminar flow over a hemisphere-cylinder and a sphere-cone. The new results do not show that temperature is a mesh dependent variable as reported by Kutler et al and the temperature field compare well with the available solution for full Navier-Stokes equations and boundary layer calculation.

Finally, a coupling of the nosetip code with an existing NSWC supersonic marching code for inviscid afterbody solution has been carried out. Results for surface pressure are presented for a very blunt nose cone and an indented nosetip cone and the agreement is good.

FOREWORD

A finite difference computer program has been developed at NSWC to calculate the inviscid and viscous flow fields for blunt or indented nosetips for reentry vehicles at hypersonic flight. This report describes the development of the computer program, illustration of numerical examples and the operating instructions.

This work was supported by the Reentry Aerodynamic Program of NSWC at White Oak and monitored by Drs. A. M. Morrison and W. C. Lyons.

The author would like to thank Dr. Paul Kutler of NASA Ames Research Center for providing a copy of the computer code and the instructions for its operation.

Ira M Blatstein
IRA M. BLATSTEIN
By direction

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ILLUSTRATIONS (Cont.)

TABLES

NOTATIONS

a	Speed of sound
a',a",b'	Parameters used in temporal differencing, Eq. (3.2) and (3.6)
A,B,K,L, M,N,P,Q	Jacobian Matrices, see Appendix A
b_n, C_n	Coefficients appeared in Eq. (1.17) and (A.1)
CN	Courant number, Eq. (4.5)
C_p	Pressure coefficient, $(p - p_\infty)/\frac{1}{2} \rho_\infty U_\infty$
$\bar{C}p$, $\bar{C}v$	Specific heat at constant pressure and volume respectively
e	Total energy per unit volume
E,F,H,R,S,T	Functions of U
ΔH_T, H_T	Error in total enthalpy and total enthalpy respectively
i,j	Grid index in ξ and η directions respectively
I	Identity matrix
J,K	Maximum grid point in ξ and η directions respectively
J	Jacobian of transformation from (x,y) to (ξ,η)
ℓ,m	Row and column of a matrix
L	Reference length
M	Mach number
n	Number in time integration
$\bar{n}$	Normal distance
p	Pressure
Pr	Prandtl number
q	Total velocity, or $(u^2 + v^2)^{\frac{1}{2}}$
qs	Shock velocity
$qs\eta$	Velocity along ξ = constant line
Rn	Radius of corners or turn used in defining body geometry,n=1 to 4
Re	Reynolds number
R_N, R_N,R_s	Nose Radius for the sphere portion
S	Arc length

St	Stanton number, $\frac{\mu/\mu_\infty}{Re_\infty Pr}\left(\frac{To}{T_\infty}-\frac{Tw}{T_\infty}\right)^{-1}\frac{\partial(T/T_\infty)}{\partial(\bar{n}/L)}$
t	Time
T	Temperature
u,v	Velocity components in cylindrical coordinates
$\tilde{u},\tilde{v}$	Contravariant velocity components, Eq. (4.1)
U	Vector of conservative variables
x,y,ϕ or X,Y,ϕ	Cylindrical coordinates in the physical plane
XP_n,YP_n	Control points for, n = 1 to 7 nosetip geometry
Ys	Thickness of shock layer along body normal direction
β	Clustering parameter, Eq. (5.1)
β'	Angle between shock normal and ξ = constant line, See Fig. 2
βn	Angles used in defining body geometry, n = 1 to 3
γ	Ratio of specific heat $\bar{C}p/\bar{C}_v$
$\Gamma,\phi,\psi,$ Γ',ϕ',ψ'	Matrices in block tridiagonal system, Eqs. (3.11) and (3.12)
δ	Angle between shock normal and x-axis, see Fig. 2
δ'	Distance of deformation from sphere to the indented nosetip shape along a ray
δ_o	Shock standoff distance at axis of symmetry
ε	Internal energy of a gas, Eq. (2.3b)
$\varepsilon_E,\varepsilon_I$	Explicit and Implicit dissipation coefficients respectively
θ	Angle between axis and ξ = constant line
κ	Coefficient of thermal conductivity of a gas
μ λ	First and second coefficients of viscosity
ξ η	Coordinates in the computational plane
ρ	Density
σ	Eigenvalue
τ	Time after transformation
τ_{xx}, τ_{yy}, τ_{xy}, $\tau_{\phi\phi}$	Viscous stress terms

Subscripts

∞	Free stream condition
1	Upstream of shock
2	Downstream of shock
w	Wall
s	Values at shock
b	Values at body
0	Stagnation condition

Superscript

*	Intermediate solution in time integration

INTRODUCTION

Because of ablation, the nosetip of a spherical body undergoes continuous change during re-entry. The shape of the nosetip has a great influence on the flowfield over the entire body, i.e., the nose region and thus the afterbody. In order to predict the flowfield about indented nosetip shapes that are likely to occur during the reentry, considerable effort has been expended in the numerical simulation of hypersonic flow over indented nosetips.[1-5]

Among the many numerical schemes intended for indented nosetip calculation, an attractive one seems to be due to Kulter et al,[1] who solve the unsteady Navier-Stokes equations with the thin-layer approximation for nosetip of arbitrary shapes at zero incidence using the implicit factored numerical algorithm of Warming and Beam.[6] The steady solution is obtained asymptotically in time and both viscous and inviscid flowfields can be computed using the same computer program.

The obvious reason for choosing implicit scheme is that it is more efficient for viscous flow calculation and one expects flow separation to play an important role in nosetip flowfield simulation. A research code was then obtained from Dr. Kutler of NASA Ames Research Center. First, the code was applied to compute inviscid flow over sphere (or sphere-cone), results compared well with experiments. When the similar calculations were performed for a series of four indented nosetip shapes reported in Ref. 7 and 8, surmountable difficulties were encountered during the course of computation because of the presence of small radius expandion corner and concave compression turn in these nosetips. It was later found that a special calculation procedure is required in order to obtain reasonable solutions. Example to demonstrate this special calculation procedure will be given and the code was modified accordingly to do the job. All inviscid results for indented nosetips are described in Section 5.

---

1. Kutler, P., Chakravartly, S. R., and Lombard, C. P., "Supersonic Flow Over Ablated Nosetips Using an Unsteady Implicit Numerical Procedure," AIAA Paper 78-213, Jan 16-18, 1978.
2. Taylor, T. D. and Masson, B. S., "Application of the Unsteady Numerical Method of Godunov to Computation of Supersonic Flows Past Bell-Shaped Bodies," J. of Computational Physics, Vol. 5, 1970, pp. 443-454.
3. Moretti, G. and Bleich, G., "Three Dimensional Flow Around Blunt Bodies," AIAA Journal, Vol. 5, No. 9, Sep 1967, pp. 1557-1562.
4. Widholf, G. F. and Victoria, K. J., "Numerical Solution of the Unsteady Navier-Stokes Equations for the Oscillatory Flow Over a Concave Body," Lecture Notes in Physics, No. 35, Proceedings of the Fourth International Conference on Numerical Methods in Fluid Dynamics, Ed. R. D. Richtaryer, Boulder, Colo., Jun 1974, pp. 431-444.
5. Reeves, B. L., Todisco, A., Lin, T. C., and Pallone, A., "Hypersonic Flow Over Indented Nosetips," AIAA Paper 77-91, Jan 24-26, 1977.
6. Beam, R. M., and Warming, R. F., "An Implicit Factored Scheme for the Compressible Navier-Stokes Equations," AIAA J., Vol. 16, No. 4, Apr 1978.
7. Ragsdale, W. C., and Morrison, A. M., "IAP 202 Heat Transfer and Pressure Tests in the NSWC/WOL Hypersonic Tunnel," 1980.
8. Yanta, W. J., "Indented Nose Flowfield Tests," WTR 1329, Naval Surface Weapons Center, White Oak, MD , Jul 1980.

Later, viscous laminar flow over a sphere-cone with isothermal wall was calculated and results for heat transfer rate compare reasonably well with measured data (within experimental error band) but are higher than that predicted by boundary layer calculation. Then, calculations were performed for laminar flow over two of the indented nosetip shapes under investigation using the same special calculation procedures as used for inviscid calculations. Solutions obtained were not satisfactory as compared to the measured data for surface pressure and separation region (also negative heat transfer rate were found in part of the body surface). For turbulent flow calculation with the algebraic turbulence model of Baldwin and Lomax,[9] it was found not possible to obtain a converged solution for these indented nosetip shapes. Finally, attempt was made to repeat the hemisphere-cylinder results given in Figs. 5 to 8 of Ref. 1 and was not able to duplicate the temperature field as shown in Fig. 7 of Ref. 1. With all the difficulties in the viscous flow calculations, which are described in detail in Section 6, it was decided that a reanalysis of the complete calculation procedure must be performed and all the viscous subroutines must be rewritten. The analysis is given in Sections 1 and 2. The boundary conditions given in Section 3 are the same as described in Ref. 1, but the initial condition has been modified.

The modified computer code has since been applied to compute laminar flows over a hemisphere-cylinder with adiabatic wall and a sphere-cone with isothermal wall. New results for the temperature field of the hemisphere-cylinder case are compared to the available solution given by Viviand and Ghazzi,[10] who solved the full Navier-Stokes equations and that given by Kutler et al.[1] The dubious statement that temperature is a mesh dependent variable as given in Ref. 1 does not appear in the present results. New results for the heat transfer rate in terms of Stanton number for the sphere-cone case are compared to the result obtained with original code, the experimental data and a boundary layer calculation. Surprisingly good agreement is shown for the heat transfer rate between the thin-layer and the boundary layer calculations as expected. All the new results are described in Section 7. The entire code has since been rewritten for the convenience of applying to indented nosetip shapes described in this report. Simple operational manual and the computer program are given in Appendix D. Due to the termination of support, no further calculation has been made for the indented nosetip shapes with the new code. Also no investigation of the behavior of turbulence models with the new code has been performed.

Since the nosetip flowfield calculation is to provide a starting solution for the afterbody calculation. Thus, a coupling of the nosetip code with an existing NSWC supersonic marching code for inviscid calculation has been carried out.[11] Examples are given for a very blunt cone at $M_\infty = 9.8$ and an indented nosetip cone at $M_\infty = 5$.

---

[9] Baldwin, B. S., and Lomax, A. M., "Thin-Layer Approximation and Algebraic Model for Separated Turbulent Flows," AIAA Paper 78-257, 1978.

[10] Viviand, H., and Ghazzi, W., "Numerical Solution of the Navier-Stokes Equations at High Reynolds Numbers with Application to the Bound Body Problem," Lecture notes in Physics, No. 59, Proceedings of the Fifth International Conference on Numerical Methods in Fluid Dynamics, 1976.

[11] Wardlaw, A. B. Jr., Solomon, J. M., and Baltakis, F. P., "Supersonic Inviscid Flowfield Computations of Missile Type Bodies," AIAA Journal, 19, 7, pp. 899-906, Jul 1981.

CHAPTER 1

GOVERNING EQUATIONS

The time-dependent compressible Navier-Stokes equations in the cylindrical coordinates (x,y,ϕ), Fig. 1, for axisymmetric flow can be written in dimensionless, conservation-law form for a perfect gas without external force as follows[12]:

$$\bar{U}_t + \bar{E}_x + \bar{F}_y + (\bar{F} + \bar{H})/y = \frac{1}{R_e}\left[\bar{R}_x + \bar{S}_y + (\bar{S} + \bar{T})/y\right] \qquad (1.1)$$

where

$$\bar{U} = \begin{bmatrix} \rho \\ \rho u \\ \rho v \\ e \end{bmatrix}, \quad \bar{E} = \begin{bmatrix} \rho u \\ p+\rho u^2 \\ \rho uv \\ (e+p)u \end{bmatrix}, \quad \bar{F} = \begin{bmatrix} \rho v \\ \rho uv \\ p+\rho v^2 \\ (e+p)v \end{bmatrix}, \quad \bar{H} = \begin{bmatrix} 0 \\ 0 \\ -p \\ 0 \end{bmatrix}$$

$$\bar{R} = \begin{bmatrix} 0 \\ \tau_{xy} \\ \tau_{xy} \\ \frac{\gamma}{Pr}\kappa\epsilon_x + u\,\tau_{xx} + v\,\tau_{xy} \end{bmatrix}, \quad \bar{S} = \begin{bmatrix} 0 \\ \tau_{xy} \\ \tau_{yy} \\ \frac{\gamma}{Pr}\kappa\epsilon_y + u\,\tau_{xy} + v\,\tau_{yy} \end{bmatrix}, \quad \bar{T} = \begin{bmatrix} 0 \\ 0 \\ -\tau_{\phi\phi} \\ 0 \end{bmatrix}.$$

and

$$R_e = \frac{\rho_\infty q_\infty L}{\mu_\infty}\,\frac{1}{\sqrt{\gamma}M_\infty} = R_{e_\infty}\left(\frac{1}{\sqrt{\gamma}M_\infty}\right)$$

$$P_r = \mu_\infty \bar{C}_p/\kappa_\infty$$

$$\tau_{xx} = (\lambda + 2\mu)\,u_x + \lambda\,v_y + \lambda\frac{v}{y}$$

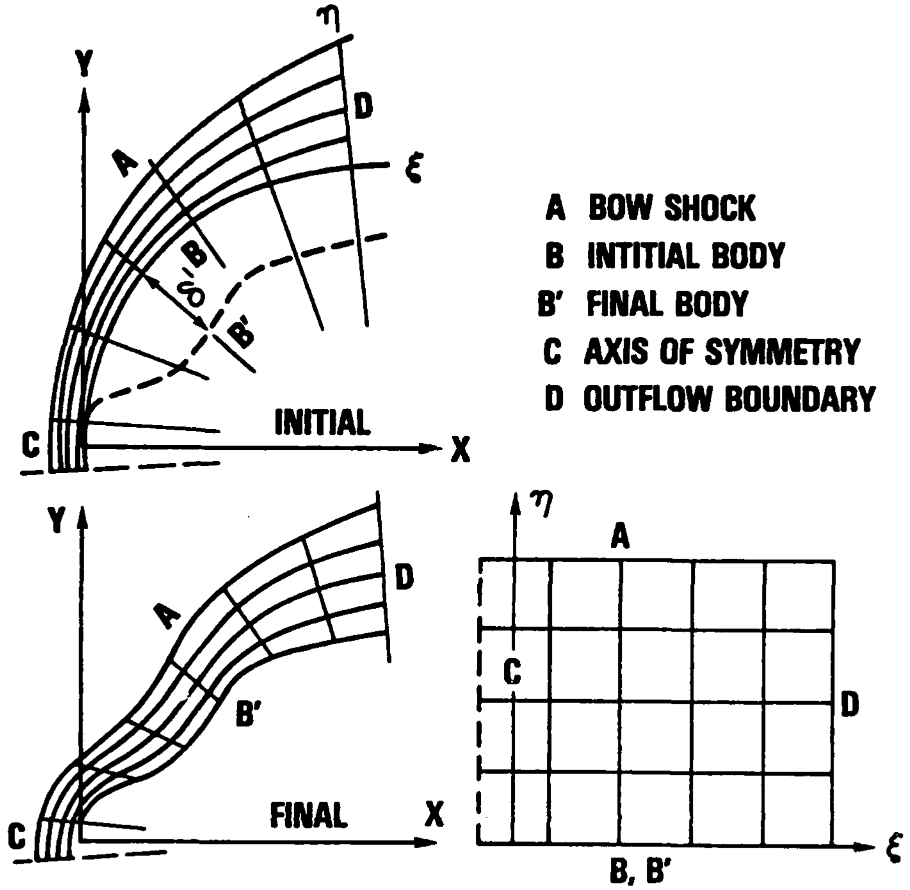
$$\tau_{xy} = (u_y + v_x)$$

$$\tau_{yy} = (\lambda + 2\mu)\,v_y + \lambda u_x + \lambda\frac{v}{y}$$

$$\tau_{\phi\phi} = (\lambda + 2\mu)\,\frac{v}{y} + \lambda(u_x + v_y)$$

---

[12] Peyret, R., and Viviand, H., "Computations of Viscous Compressible Flows Based on the Navier-Stokes Equations," AGARD-AG-212, Sep 1975.



a. PHYSICAL PLANE b. COMPUTATIONAL PLANE

FIGURE 1. COORDINATE SYSTEM

In Eq. (1.1), the reference quantities used to nondimensionalize the flow variables are: the length L, the velocity $a_\infty/\sqrt{\gamma}$, the density ρ_∞, the viscosity μ_∞ and the thermal conductivity κ_∞. The time is nondinemsionalized by $\sqrt{\gamma}\,L/a_\infty$, the total energy per unit volume e and pressure p by p_∞ (= $\rho_\infty a_\infty^2/\gamma$) and the viscous stress term τ_{xx} etc. by $\mu_\infty a_\infty/(L\sqrt{\gamma})$. For perfect gas, the equation of state gives

$$p = (\gamma - 1)\,[e - \tfrac{1}{2}\rho(u^2 + v^2)] \qquad (1.2)$$

and

$$e = \rho[\varepsilon + \tfrac{1}{2}\,(u^2 + v^2)] \qquad (1.3a)$$

$$\varepsilon = \bar{C}_v\,T \qquad (1.3b)$$

Equations (1.1) and (1.2) provide 5 equations for 5 unknowns, i.e. ρ, u, v, e, p (or T). It should be pointed out that the momentum equations and the energy are of parabolic type and the continuity equation carrys the hyperbolic character. Therefore, the system of the N. S. equations is of hybrid parabolic and hyperbolic type [12].

A mapping between the physical plane and the computational plane (Fig. 1) is accomplished by the following independent variable transformation:

$$\tau = t, \quad \xi = \xi\ (t,x,y), \quad \eta = \eta\ (t,x,y) \tag{1.4}$$

Applying Eq. (1.4) to Eq. (1.1), one obtains

$$U_\tau + E_\xi + F_\eta + H = \frac{1}{R_e}\,(R_\xi + S_\eta + T) \tag{1.5}$$

where

$$\begin{aligned}
U &= \bar{U}/J \\
E &= (\xi_t\,\bar{U} + \xi_x\,\bar{E} + \xi_y\,\bar{F})/J \\
F &= (\eta_t\,\bar{U} + \eta_x\,\bar{E} + \eta_y\,\bar{F})/J \\
H &= (\bar{F} + \bar{H})/(yJ) \\
R &= (\xi_x\,\bar{R} + \xi_y\,\bar{S})/J \\
S &= (\eta_x\,\bar{R} + \eta_y\,\bar{S})/J \\
T &= (\bar{S} + \bar{T})/(yJ)
\end{aligned}$$

with metrics of transformation given by

$$\left.\begin{aligned}
\xi_t &= (x_\eta\, y_\tau - y_\eta\, x_\tau)J\ , &\quad \eta_t &= (y_\xi\, x_\tau - x_\xi y_\tau)J \\
\xi_x &= y_\eta J &, \quad \eta_x &= -y_\xi J \\
\xi_y &= -x_\eta J &, \quad \eta_y &= x_\xi J \\
& J^{-1} = x_\xi\, y_\eta - y_\xi\, x_\eta\ .
\end{aligned}\right\} \tag{1.6}$$

In general, the metrices of Eq. (1.6) are not known analytically and must be determined numerically at each step of integration procedure.

The viscous vectors may be rewritten as follows:

$$R \text{ or } S = \frac{1}{J}\begin{bmatrix} 0 \\ (\ )_x\,\tau_{xx} + (\ )_y\,\tau_{xy} \\ (\ )_x\,\tau_{xy} + (\ )_y\,\tau_{yy} \\ (\ )_x\left(\frac{\gamma}{Pr}\,\kappa\epsilon_x + u\tau_{xx} + v\tau_{xy}\right) + (\ )_y\left(\frac{\gamma}{Pr}\kappa\epsilon_y + u\tau_{xy} + v\tau_{yy}\right) \end{bmatrix} \tag{1.7}$$

where ( ) = ξ for R and ( ) = η for S. And

$$T = \frac{1}{Jy}\begin{bmatrix} 0 \\ \tau_{xy} \\ \tau_{yy} - \tau_{\phi\phi} \\ \frac{\gamma}{Pr}\kappa\varepsilon_y\eta_y + u\,\tau_{xy} + v\,\tau_{yy} \end{bmatrix} \tag{1.8}$$

with

$$\tau_{xx} = \frac{4}{3}\mu\,(u_\eta\,\eta_x + u_\xi\,\xi_x) - \frac{2}{3}\mu\,(\eta_y\,v_\eta + \xi_y\,v_\xi) - \frac{2}{3}\mu\,\frac{v}{y}$$

$$\tau_{xy} = \mu(\xi_y\,u_\xi + \eta_y\,u_\eta + \xi_x\,v_\xi + \eta_x\,v_\eta)$$

$$\tau_{yy} = \frac{4}{3}\mu(\xi_y\,v_\xi + \eta_y\,v_\eta) - \frac{2}{3}\mu(\xi_x\,u_\xi + \eta_x\,u_\eta + \frac{v}{y})$$

$$\tau_{\phi\phi} = -\frac{2}{3}\mu(\xi_x\,u_\xi + \eta_x\,u_\eta + \xi_y\,v_\xi + \eta_y\,v_\eta) + \frac{4}{3}\mu\,\frac{v}{y}$$

In Eqs. (1.7) and (1.2), the Stokes hypothesis, i.e. $3\lambda + 2\mu = 0$ was used. Equations (1.7) and (1.8) may be rewritten by separating terms with flow variables differentiating with respect to ξ and η as follows:

$$R = R_1 + R_2 \tag{1.9}$$

$$S = S_1 + S_2 \tag{1.10}$$

$$T = T_1 + T_2 \tag{1.11}$$

where

$$R_1 = \frac{1}{J}\begin{bmatrix} 0 \\ b_2u_\xi + b_3v_\xi - c_6\xi_xv \\ b_3u_\xi + b_4v_\xi - c_6\xi_yv \\ b_5\varepsilon_\xi + (b_2u + b_3v)u_\xi + (b_3u + b_4v)v_\xi - c_6v(u\xi_x + v\xi y) \end{bmatrix} \tag{1.12}$$

$$R_2 \text{ or } S_2 = \frac{1}{J} \begin{bmatrix} 0 \\ b_8 u_{()} + b_9 \, v_{()} \\ b_{10} u_{()} + b_{11} v_{()} \\ b_7 \varepsilon_{()} + (b_8 u + b_{10} v) u_{()} + (b_9 \, u + b_{11} v) v_{()} \end{bmatrix} \tag{1.13}$$

where ( ) = η for R_2 and ( ) = ξ for S_2.

$$S_1 = \frac{1}{J} \begin{bmatrix} 0 \\ C_2 u_\eta + C_3 \, v_\eta - C_6 \eta_x v \\ C_3 u_\eta + C_4 \, v_\eta - C_6 \eta_y v \\ C_5 \varepsilon \eta + (C_2 u + C_3 v) \, u_\eta + (C_3 u + C_4 v) v_\eta - C_6 v \, (u \, \eta_x + v \eta_y) \end{bmatrix} \tag{1.14}$$

$$T_1 = \frac{1}{Jy} \begin{bmatrix} 0 \\ \mu(\eta_y \, u_\eta + \eta_x \, v_\eta) \\ 2\mu \eta_y \, v_\eta - 2 \, \mu \, \frac{v}{y} \\ C_7 \, \varepsilon_\eta + \mu \, [\eta_y (u u_\eta + \frac{4}{3} \, v v_\eta) + \eta_x (u v_\eta - \frac{2}{3} \, v u_\eta)] - \frac{2}{3} \, \mu \, \frac{v^2}{y} \end{bmatrix} \tag{1.15}$$

$$T_2 = \frac{1}{Jy} \begin{bmatrix} 0 \\ u(\xi_y u_\xi + \xi_x v_\xi) \\ 2\mu \xi_y v_\mu \\ b_6 \varepsilon_\xi + \mu \xi_y (u u_\xi + \frac{4}{3} \, v v_\xi) + \mu \xi_x \, (u v_\xi - \frac{2}{3} \, v u_\xi) \end{bmatrix} \tag{1.16}$$

where

$$\left.\begin{aligned}
&C_2 = \mu\,(\tfrac{4}{3}\,\eta_x^{\,2} + \eta_y^{\,2}) &&, \quad C_3 = \mu\,\tfrac{1}{3}\,\eta_x\,\eta_y)\\
&C_4 = \mu(\eta_x^{\,2} + \eta_y^{\,2}) &&, \quad C_5 = \frac{\gamma\kappa}{Pr}\,(\eta_x^{\,2} + \eta_y^{\,2})\\
&C_6 = \mu\,\frac{2}{3}\,\frac{1}{y} &&, \quad C_7 = \frac{\gamma\kappa}{Pr}\,\eta_y\,.\\
&b_2 = \mu\left(\frac{4}{3}\,\xi_x^{\,2} + \xi_y^{\,2}\right) &&, \quad b_3 = \frac{1}{3}\,\mu\xi_x\,\xi_y\\
&b_4 = \mu\left(\xi_x^{\,2} + \frac{4}{3}\,\xi_y^{\,2}\right) &&, \quad b_5 = \frac{\gamma k}{Pr}\,(\xi_x^{\,2} + \xi_y^{\,2})\\
&b_6 = \frac{\gamma k}{Pr}\,\xi_y &&, \quad b_7 = \frac{\gamma k}{Pr}\,(\xi_x\eta_x + \xi_y\eta_y)\\
&b_8 = \frac{4}{3}\,\xi_x\eta_x + \xi_y\eta_x &&, \quad b_9 = \xi_x\eta_y - \frac{2}{3}\,\xi_y\,\eta_x\\
&b_{10} = -\,\frac{2}{3}\,\xi_x\eta_y + \xi_y\eta_x &&, \quad b_{11} = \xi_x\eta_x + \frac{4}{3}\,\xi_y\eta y
\end{aligned}\right\}\tag{1.17}$$

Equations (1.5) are the governing equations to be solved with the boundary and initial conditions described in section 4. When thin layer approximation is made, i.e. $\frac{\partial}{\partial\xi}(\ ) << \frac{\partial}{\partial\eta}(\ )$ for all diffusion terms, then one sets $R_1 = R_2 = S_2 = T_2 = 0$.

CHAPTER 2

NUMERICAL ALGORITHM

The numerical algorithm described in this section is based on the work of Ref. 3. It is intended to solve the full Navier-Stokes equations, Eq. (1.5). However, the thin-layer approximation will be made at the end.

Rewritten Eq. (1.5) as follows:

$$U_\tau + E_\xi + F_\eta + H = \frac{1}{R_e}\Big[R_1(U,U_\xi)_\xi + R_2(U,U_\eta)_\xi + S_1(U,U_\eta)_\eta + S_2(U,U_\xi)_\eta + T_1(U,U_\eta) + T_2(U,U_\xi)\Big] \tag{2.1}$$

A single step temporal scheme for advancing the solution of Eq. (2.1) is

$$\Delta U^n = \frac{a'\Delta\tau}{1+b'}\frac{\partial}{\partial\tau}\Delta U^n + \frac{\Delta\tau}{1+b'}\frac{\partial}{\partial\tau}U^n + \frac{b'}{1+b'}\Delta U^{n-1} + 0\left[(a' - \frac{1}{2} - b')\,\Delta\tau^2 + \Delta\tau^3\right] \tag{2.2}$$

where $U^n = U(n\Delta t)$ and $\Delta U^n = U^{n+1} - U^n$. Substituting U_τ from Eq. (2.1) into Eq. (2.2) one obtains

$$\Delta U^n = \frac{a'\Delta\tau}{1+b'}\Bigg[\left(-\Delta E + \frac{\Delta R_1 + \Delta R_2}{R_e}\right)^n_\xi + \left(-\Delta F + \frac{\Delta S_1 + \Delta S_2}{R_e}\right)^n_\eta - \Delta H^n + \frac{\Delta T_1^n + \Delta T_2^n}{R_e}\Bigg]$$
$$+ \frac{\Delta\tau}{1+b'}\Bigg[\left(-E + \frac{R_1 + R_2}{R_e}\right)^n_\xi + \left(-F + \frac{S_1 + S_2}{R_e}\right)^n_\eta - H^n + \frac{T_1 + T_2}{R_e}\Bigg] + \frac{b'}{1+b'}\Delta U^{n-1} + 0\left[\left(a' - \frac{1}{2} - b'\right)\Delta\tau^2 + \Delta\tau^3\right] \tag{2.3}$$

where $E^{n+1} = E(U^{n+1})$, $\Delta E = E^{n+1} - E^n$. A local linearization can be achieved by the Taylor series expansion:

$$E^{n+1} = E^n + \left(\frac{\partial E}{\partial U}\right)^n \left(U^{n+1} - U^n\right) + 0\ (\Delta\tau^2)$$

or

$$\Delta E^n = A^n \Delta U^n + 0\ (\Delta\tau^2). \tag{2.4a}$$

where $A^n = (\frac{E}{U})^n$ is the Jacobian matrix. Similarly,

$$\Delta F^n = B^n\ \Delta U^n + 0\ (\Delta\tau^2) \tag{2.4b}$$

$$\Delta H^n = K^n\ \Delta U^n + 0\ (\Delta\tau^2) \tag{2.4c}$$

$$\begin{aligned}\Delta R_1^n &= \left(\frac{\partial R_1}{\partial U}\right)^n \Delta U^n + \left(\frac{\partial R_1}{\partial U_\xi}\right) \Delta U_\xi^n + 0\ (\Delta\tau^2)\\ &= \overline{L}^{\,n}\ \Delta U^n + P^n\ \Delta U_\xi^n + 0\ (\Delta\tau^2)\\ &= L^n\ \Delta U^n + (P\Delta U)_\xi^n + 0\ (\Delta\tau^2).\end{aligned} \tag{2.4d}$$

where

$$L^n = \left(\frac{\partial R_1}{\partial U} - P_\xi\right)^n, P^n = \left(\frac{\partial R_1}{\partial U_\xi}\right)^n .$$

$$\Delta S_1^n = M^n\ \Delta U^n + (Q\Delta U)_\eta^n + 0\ (\Delta\tau^2) \tag{2.4e}$$

where

$$M^n = \left(\frac{\partial S_1}{\partial U} - Q_\eta\right)^n, \quad Q^n = \left(\frac{\partial S_1}{\partial U_\eta}\right)^n .$$

$$\Delta T_1^n = N_1^n\ \Delta U^n + (W_1 \Delta U)_\eta^n + 0\ (\Delta\tau^2) \tag{2.4f}$$

where

$$N_1 = \left(\frac{\partial T_1}{\partial U} - W_{1\eta}\right)^n, W_1 = \left(\frac{\partial T_1}{\partial U_\eta}\right)^n .$$

$$\Delta T_2^n = N_2^n \, \Delta U^n + (W_2 \Delta U)_\xi^n + 0\,(\Delta\tau^2) \quad (2.4g)$$

where

$$N_2 = \left(\frac{\partial T_2}{\partial U} - W_{2\xi}\right)^n, W_2 = \left(\frac{\partial T_2}{\partial U_\xi}\right)^n .$$

The cross-derivative terms are treated explicitly

$$\Delta R_2^n = \Delta R_2^{n-1} + 0\,(\Delta\tau^2) \quad (2.5a)$$

$$\Delta S_2^n = \Delta S_2^{n-1} + 0\,(\Delta\tau^2) \quad (2.5b)$$

All the Jacobian matrices are given in Appendix A. In the analytical derivation of Jacobian matrices for viscous portion, it is assumed that transport coefficients are locally constant, i.e. $\mu_\xi = \kappa_\xi = \mu_\eta = \kappa_\eta = 0$.

By substituting Eqs. (2.4) and (2.5) into (2.3), one obtains the spatially factored form:

$$\left\{I + \frac{a'\Delta\tau}{1+b'}\left[\left(A - \frac{L}{R_e}\right)^n_\xi - \left(\frac{P}{R_e}\right)^n_{\xi\xi} - \frac{1}{R_e}\left(N_2 + W_{2\xi}\right)^n\right]\right\}$$

$$\times\left\{I + \frac{a'\Delta\tau}{1+b'}\left[\left(B - \frac{M}{R_e}\right)^n_\eta - \frac{1}{R_e}Q^n_{\eta\eta} + K^n - \frac{1}{R_e}\left(N_1 + W_{1\eta}\right)^n\right]\right\}\Delta U^n$$

$$= \frac{\Delta\tau}{1+b'}\left[\left(-E^n + \frac{R^n}{R_e}\right)_\xi + \left(-F^n + \frac{S^n}{R_e}\right)_\eta - H^n + \frac{T^n}{R_e}\right]$$

$$+ \frac{a''\Delta\tau}{1+b'}\left[\left(\Delta R_2\right)^{n-1}_\xi + \left(\Delta S_2\right)^{n-1}_\eta\right] + \frac{b'}{1+b'}\Delta U^{n-1}$$

$$+ O\left[\left(a' - \frac{1}{2} - b'\right)\Delta\tau^2,\ \left(a'' - a\right)\Delta\tau^2,\ \Delta\tau^3\right] \qquad (2.6)$$

where a" has been introduced in the coefficient of the cross-derivative terms for notation convenience.[3] For second-order-accurate schemes, a" should be set equal to a'. However, for the first-order-accurate scheme ($a' \neq \frac{1}{2} + b'$) it is consistant to set a" equal to zero. Now, Eq. (2.6) has the same temporal accuracy as Eq. (2.3) but is linear in ΔU^n. In practice, Eq. (2.6) is implemented by the sequence

$$\left\{I + \frac{a'\Delta\tau}{1+b'}\left[\left(A - \frac{L}{R_e}\right)^n_\xi - \frac{1}{R_e}P^n_{\xi\xi} - \frac{1}{R_e}\left(N_2 + W_{2\xi}\right)^n\right]\right\}\Delta U^{*n}$$

$$= \text{RHS of Eq. (2.6)} \qquad (2.7a)$$

$$\left\{I + \frac{a'\Delta\tau}{1+b'}\left[\left(B - \frac{M}{R_e}\right)^n_\eta - \frac{1}{R_e}Q^n_{\eta\eta} + K^n - \frac{1}{R_e}\left(N_1 + W_{1\eta}\right)^n\right]\right\}\Delta U^n = \Delta U^{*n} \qquad (2.7b)$$

From now on, it is assumed that the thin-layer approximation is applicable. Also the first-order-accurate Euler implicit scheme (a' = 1, a" = 0 and b' = 0) is chosen for the time integration. As described in Refs. 3 and 6, it is necessary to add the fourth-order explicit dissipation terms in order to damp high-frequency growth and thus serve to control nonlinear instability. Also the addition of the second-order implicit dissipation terms will extend the linear stability bound of the fourth order terms. Therefore, the final form of Eq. (2.7) for thin-layer approximation of the time-dependent compressible

Navier-Stokes equations using Euler implicit time differencing scheme may be written as follows:

$$\left[I + \Delta\tau A^n_\xi - \varepsilon_I \left(J^{-1}\nabla_\xi\Delta_\xi J\right)^n\right] \Delta U^{*n} = -\Delta\tau\left[E^n_\xi + F^n_\eta + H^n - \frac{1}{R_e}\left(S^n_{1\eta} + T_1\right)\right]$$

$$- \varepsilon_E\left[J^{-1}(\nabla_\eta\Delta_\eta)^2 JU\right]^n - \varepsilon_E\left[J^{-1}(\nabla_\xi\Delta_\xi)^2 JU\right]^n. \tag{2.8a}$$

$$\left[I + \Delta\tau\left(B - \frac{M}{R_e}\right)^n_\eta - \frac{1}{R_e} Q^n_{\eta\eta} + K^n - \frac{1}{R_e}\left(N_1 + W_{1\eta}\right)^n - \varepsilon_I\left(J^{-1}\nabla_\eta\Delta_\eta J\right)^n\right]\Delta U^n$$

$$= \Delta U^{*n} . \tag{2.8b}$$

The spatial derivatives appearing in Eqs. (2.8) or (2.7) are approximated by three-point second-order-accurate finite difference

$$(f_\xi)_{j,k} \approx \frac{1}{2\Delta\xi}\left(f_{j+1,k} - f_{j-1,k}\right) \tag{2.9a}$$

$$\nabla_\xi\Delta_\xi f_{j,k} = (f_{\xi\xi})_{j,k} \approx \frac{1}{\Delta\xi^2}\left(f_{j+1,k} - 2f_{j,k} + f_{j-1,k}\right) \tag{2.9b}$$

$$(\nabla_\xi\Delta_\xi)^2 f_{j,k} = \frac{1}{\Delta\xi^4}\left(f_{j+2,k} - 4f_{j+1,k} + 6f_{j,k} - 4f_{j-1,k} + f_{j-2,k}\right) \tag{2.9c}$$

With the finite difference approximation of Eq. (2.9), a block-tridiagonal system of the differenced equations is formed. It should be noted that Eq. (2.9c) is applied to the RHS of Eq. (2.8a) only, therefore will not affect the block tridiagonal system (use parabolic extrapolation for j = 2 and (J-1)). For the ξ - sweep, one obtains

$$\tilde{\phi}_{j-1}\, \Delta U^*_{j-1} + \Gamma_j\, \Delta U^*_j + \psi_{j+1}\, \Delta U^*_{j+1} = (RHS)_j,\ j = 2 \cdots J-1 \tag{2.10}$$

where the $(RHS)_j$ is a column matrix which are computed with known flow variables over the entire grid points and $\tilde{\phi}$,Γ and ψ are 4x4 (m x 1) matrix. As described in the next section, the boundary conditions at the axis of symmetry and the outflow plane are imposed implictly. This is done by modifying the coefficient in the matrix at $j = 2$ and $j = J - 1$, thus Eq. (2.10) will produce a bock tridiagonal system as follows:

$$\begin{bmatrix} \Gamma_2 & \psi_3 & & & \\ \tilde{\phi}_2 & \Gamma_3 & \psi_4 & & \\ & \ddots & \ddots & \ddots & \\ & & \tilde{\phi}_{J-3} & \Gamma_{J-2} & \psi_{J-1} \\ & & & (\tilde{\phi}_{J-2}-\psi_J) & \Gamma_{J-1} \end{bmatrix} \begin{bmatrix} \Delta U_2^* \\ \Delta U_3^* \\ \vdots \\ \Delta U_{J-2}^* \\ \Delta U_{J-1}^* \end{bmatrix} = \begin{bmatrix} (RHS)_2 \\ (RHS)_3 \\ \vdots \\ (RHS)_{J-2} \\ (RHS)_{J-1} \end{bmatrix} \qquad (2.11)$$

where, for Eq. (2.8),

$$\Gamma_2 = I + \frac{\Delta\tau}{2} A_2^n - \varepsilon_I \left(J_2^{-1} J_1 - 2\right) I \quad \text{for } m = 1, 2, 4$$

$$\Gamma_2 = I - \frac{\Delta\tau}{2} A_2^n + \varepsilon_I \left(J_2^{-1} J_1 + 2\right) I \quad \text{for } m = 3$$

$$\Gamma_j = (1 + 2\varepsilon_I)\, I, \; j = 3 \ldots\ldots J-2$$

$$\Gamma_{J-1} = I + \Delta\tau A_J^n - 2\varepsilon_I \left(J_{J-1}^{-1} J_J - 1\right)^n I$$

$$\tilde{\phi}_{j-1} = - \frac{\Delta\tau}{2} A_{j-1}^n - \varepsilon_I \left(J_j^{-1} J_{j-1}\right)^n I, \; j=3 \ldots\ldots J-2$$

$$\psi_{j+1} = \frac{\Delta\tau}{2} A_{j+1}^n - \varepsilon_I \left(J_j^{-1} J_{j+1}\right)^n I, \; j=2 \ldots\ldots J-2$$

Equation (3.11) applies to k from 2 to K-1. The solution of the block tridiagonal system is obtained by the non-pivoted LU decomposition method.

Once ΔU^* are obtained, it is ready to perform the η-sweep. As described in the next section, the boundary conditions at the shock and the body surface are imposed explicitly, thus the flow variables in these two boundaries ($k = 1$ and K) are updated first and treated as known. The block tridiagonal system is

$$\begin{bmatrix} \Gamma'_2 & \psi'_3 & & & & \\ \tilde{\phi}'_2 & \Gamma'_3 & \psi'_4 & & & \\ & \ddots & \ddots & \ddots & & \\ & & \tilde{\phi}'_{K-3} & \Gamma'_{K-2} & \psi'_{K-1} \\ & & & \tilde{\phi}'_{K-2} & \Gamma'_{K-1} \end{bmatrix} \begin{bmatrix} \Delta U^n_2 \\ \Delta U^n_3 \\ \vdots \\ \Delta U^n_{k-2} \\ \Delta U^n_{k-1} \end{bmatrix} = \begin{bmatrix} \Delta U^{**}_2 \\ \Delta U^{*}_3 \\ \vdots \\ \Delta U^{*}_{K-2} \\ \Delta U^{**}_{K-1} \end{bmatrix} \tag{2.12}$$

where

$$\Gamma'_k = (1 + 2\varepsilon_I)\, I + \Delta\tau\, K^n_k + \frac{\Delta\tau}{R_e}\left(Q^n_k - N^n_{1_k} \right), \quad k = 2 \cdots\cdots K-1$$

$$\tilde{\phi}'_{k-1} = -\frac{\Delta\tau}{2}\left[B^n_{k-1} - \frac{1}{R_e}\left(M^n_{k-1} - Q^n_{k-1} + W^n_{1_{k-1}}\right)\right] - \varepsilon_I \left(J^{-1}_k\, J_{k-1}\right)^n I, \quad k=2 \cdots\cdots K-1$$

$$\psi'_{k+1} = \frac{\Delta\tau}{2}\left[B^n_{k+1} - \frac{1}{R_e}\left(M^n_{k+1} + Q^n_{k+1} + W^n_{1_{k+1}}\right)\right] - \varepsilon_I \left(J^{-1}_k\, J_{k+1}\right)^n I, \quad k=2 \cdots\cdots K-1$$

$$\Delta U_2^{**} = \Delta U^*_2 + \tilde{\phi}'_1$$

$$\Delta U_{K-1}^{**} = \Delta U^*_{K-1} - \psi'_1$$

$$\tilde{\phi}_1 = \frac{\Delta\tau}{2} B^n_1 - \frac{\Delta\tau}{2R_e}\left(M^n_1 - Q^n_1 + W^n_{1_1}\right) - \varepsilon_I \left(J^{-1}_2\, J_1\right)^n I$$

$$\psi_1 = \frac{\Delta\tau}{2} B^n_K - \frac{\Delta\tau}{2R_e}\left(M^n_K - Q^n_K + W^n_{1_K}\right) - \varepsilon_I \left(J^{-1}_{K-1}\, J_K\right)^n I$$

Equation (2.12) applies to $j = 2$ to $J - 1$. The same block tridiagonal solver is used to solve (2.12). This completes one full integration per time step.

CHAPTER 3

BOUNDARY AND INITIAL CONDITIONS

As shown in Fig. 1, one would like to compute the flowfield enclosed by the four boundaries A,B,C and D, where A is the bow shock, B is the body surface, C is the axis of symmetry and D is the outflow boundary. In implementing the boundary conditions, one intuitively expects implicit boundary conditions to be more stable than explicit one. However, according to many authors[13,14,15] this has not been their experience. Since treating the boundary conditions explicitly is far more simpler to implement than to do it implicitly, the shock points and body points boundary conditions are imposed explicitly according to the method described by Kutler[4] and are briefly given in the following.

3.1 Shock Points

The flow in the vicinity of the bow shock is assumed to be inviscid and the Rankine-Hugoniot relations are satisfied or the shock is tracked. Since the final location of the shock must come from the solution, so it is allowed to move. A quasi steady propagation of the shock is assumed. The pressure behind the shock is first determined by integrating the energy equation in nonconservative form as follows:

$$p_\tau = -\tilde{u}p_\xi - \tilde{v}p_\eta - \rho a^2(u_\xi \xi_x + v_\xi \xi_y + u_\eta \eta_x + v_\eta \eta_y + \frac{v}{y}) \tag{3.1}$$

where

$$\tilde{u} = \xi_t + \xi_x u + \xi_y v \ ,$$

$$\tilde{v} = \eta_t + \eta_x u + \eta_y v \ .$$

Because explicit method is used, the time step $\Delta\tau_s$ for shock integration, Eq. (3.1) is restricted by the CFL condition (CN = 1), or

$$\Delta\tau_s = (0.9/\sigma_{max}) \tag{3.2}$$

where σ_{max} is the maximum of the eigenvalues of the matrices A and B of all the nodel points at shock wave, or

$$\begin{aligned} \sigma_{1,2} &= k_o + uk_1 + vk_2 \ , \\ \sigma_{3,4} &= k_o + uk_1 + vk_2 \pm a(k_1^2 + k_2^2)^{\frac{1}{2}} \end{aligned} \tag{3.3}$$

where for A: $k_o = \xi_t$, $k_1 = \xi_x$, $k_2 = \xi_y$; and for B: $k_o = \eta_t$, $k_1 = \eta_x$, $k_2 = \eta_y$; and the constant 0.9 is a safety factor which must be less than 1. It should be noted that $\Delta\tau_s$ is different from the $\Delta\tau$ used in the integration of the interior points, this means that the calculation cannot be time-accurate. However, this does not prevent one to obtain steady state solution.

Knowing the pressure, the shock velocity can be determined as follows (see Fig. 2):

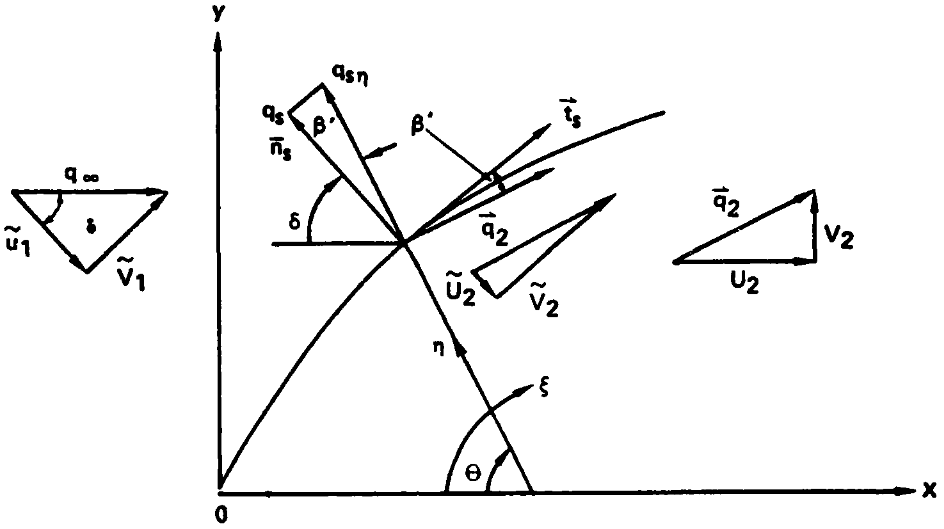


FIGURE 2. NOTATION FOR SHOCK POINT BOUNDARY CONDITION

$$q_s = a_\infty M_x - \tilde{u}_1 \tag{3.4}$$

where

$$M_x = \left\{\frac{1}{2\gamma}\left[\frac{p_2}{p_\infty}\cdot(\gamma + 1) + (\gamma - 1)\right]\right\}^{\frac{1}{2}}$$

$$\tilde{u}_1 = q_\infty \cos\delta$$

$$a_\infty = (\gamma p_\infty/\rho_\infty)^{\frac{1}{2}} \quad .$$

The shock angle δ is a function of the metrics

$$\delta = \tan^{-1}(-\eta_y/\eta_x)_{\text{shock}} \tag{3.5}$$

where η_y and η_x are defined in Eq. (1.6). From the Rankine-Hugoniot relations the density behind the shock can be determined by

$$\rho_2 = \rho_\infty \left(\frac{p_2}{p_\infty} + \frac{\gamma-1}{\gamma+1} \right) \Big/ \left(1 + \frac{\gamma-1}{\gamma+1} \cdot \frac{p_2}{p_\infty} \right) \tag{3.6}$$

The velocity components behind the shock in cylindrical coordinates are:

$$u_2 = q_\infty \sin^2\delta + \tilde{u}_2 \cos\delta \tag{3.7}$$

$$v_2 = q_\infty \sin\delta\cos\delta - \tilde{u}_2 \sin\delta \quad .$$

where

$$\tilde{u}_2 = 2(1 - M_x{}^2)\, a_\infty \Big/ \Big[(\gamma + 1)M_x\Big] + \tilde{u}_1 .$$

The value of e can be obtained from Eq. (2.3a) with known p_2, ρ_2, u_2, v_2.

Once the shock velocity q_s of Eq. (4.4) is known, the new shock position at time $\tau + \Delta\tau$ can be determined by propagating the shock along a ξ = constant line, or equivalently in the η direction with a velocity.

$$q_{s_\eta} = q_s / \cos\beta' \tag{3.8}$$

where $\beta' = \theta - \delta$ and $\theta = \tan^{-1}(\xi_x/\xi_y)$. This determines the new x and y values of the shock points and subsequently the new x and y values of the interior points.

3.2 Body Points

The tangency condition for inviscid flow at the body surface is imposed explicitly using Kentzer's[16] scheme through characteristic analysis (see Appendix B) to yield the following equation for the pressure time derivative on the body:

$$\begin{aligned} p_\tau = &- \frac{\rho C}{\sqrt{\eta_x{}^2 + \eta_y{}^2}} \left[(\eta_t)_\tau + u(\eta_x)_\tau + v(\eta_y)_\tau \right] + a\sqrt{\eta_x{}^2 + \eta_y{}^2}\, p_\eta - \tilde{u} P_\xi \\ &- \rho a^2 \left(\xi_x u_\xi + \xi_y v_\xi + \eta_x u_\eta + \eta_y v_\eta + \frac{v}{y} \right) \\ &+ \frac{a}{\sqrt{\eta_x{}^2 + \eta_y{}^2}} \left[\eta_x (\rho \tilde{u}\, u_\xi + \xi_x p_\xi) + \eta_y (\rho \tilde{u} v_\xi + \xi_y p_\xi) \right] \end{aligned} \tag{3.9}$$

where

$$\tilde{u} = \xi_t + u\xi_x + v\xi_y$$

$$\tilde{v} = \eta_t + u\eta_x + v\eta_y \equiv 0$$

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[16] Kentzer, C. P., "Discretization of Boundary Conditions on Moving Discontinuities," Lecture Notes in Physics, published by Springer-Verlag, No. 8, Sep 1970, pp. 108-113.

In the numerical code, the time derivative terms were neglected and the time step was modified by a safety factor of 0.2 for stability reason. The stagnation pressure was enforced at the stagnation region (J = 1 and 2) as follows:

$$\left.\begin{aligned} A &= (p_{4,1} - \frac{25}{9} p_{3,1} + \frac{16}{9} p_t)/6.25 \\ B &= 4(p_{3,1} - p_t - \frac{27}{8} A)/9 \\ p_{1,1} &= p_{x,1} = (p_t = \frac{A}{8} + \frac{B}{4}) \end{aligned}\right\} \quad (3.10)$$

where $p_{J,K}$ is the pressure at point (J,K) and p_t is the total stagnation pressure. It was found, Eq. 3.10 helps to speed up the convergence process.

Once the surface pressure is determined, the remaining variables on the body surface are determined by the following isentropic relations:

$$\left.\begin{aligned} \rho_b &= (p_b/S)^{1/\gamma} \\ q_b &= \left[\frac{2\gamma}{\gamma-1} \left(\frac{p_t}{\rho_t} - \frac{p_b}{\rho_b}\right)\right]^{\frac{1}{2}} \\ u_b &= q_b \cos \theta_b \\ v_b &= q_b \sin \theta_b \end{aligned}\right\} \quad (3.11)$$

where

$$S = \frac{p_1}{\rho_1 \gamma} = \left\{\frac{[2\gamma M_\infty^2 - (\gamma-1)]/(\gamma+1)}{(\gamma+1)M_\infty^2/[(\gamma-1)M_\infty^2+2]}\right\}^{\gamma} \cdot \frac{p_\infty}{\rho_\infty^\gamma} \quad (3.12)$$

is the stagnation entropy, p_t, ρ_t are the stagnation pressure and density,

$$p_t = \frac{[\frac{1}{2}(\gamma+1)M_\infty^2]^{\frac{\gamma}{\gamma-1}}}{\{[2\gamma M_\infty^2 - (\gamma-1)]/\gamma+1\}^{1/(\gamma-1)}} \; p_\infty$$

$$\frac{p_t}{\rho_t} = [1 + \tfrac{1}{2}(\gamma-1)M_\infty^2] \cdot \left(\frac{p_\infty}{\rho_\infty}\right) \quad (3.13)$$

and θ_b is given by

$$\theta_b = \tan^{-1}(-\eta_x/\eta_y)_{body} \quad (3.14)$$

with η_x and η_y defined by Eq. 1.6.

To simulate viscous flows, the no-slip boundary condition requires

$$\tilde{u} = \tilde{v} = 0 \tag{3.15}$$

when the body surface is not moving, Eq. (3.15) also implies u = v = 0. To determine the surface pressure, it is assumed that the normal pressure gradient over the first 3 grid points above the body surface is zero, or

$$p_n = \frac{1}{(\eta_x^2 + \eta_y^2)^{\frac{1}{2}}} \left[(\xi_x\eta_x + \xi_y\eta_y)p_\xi + (\eta_x^2 + \eta_y^2)p_\eta \right] = 0 \tag{3.16}$$

Similarly, for an adiabatic wall boundary condition, the temperature may be determined by

$$(\xi_x\eta_x + \xi_y\eta_y)T_\xi + (\eta_x^2 + \eta_y^2)T_\eta = 0 \tag{3.17}$$

The ξ and η derivatives in Eqs. (3.16) or (3.17) are differenced using a second-order central difference formula for the ξ-derivatives and a three-point one-sided formula for the η-derivatives. This results in a tridiagonal system of equations which can be solved to yield the pressure and temperature. For a constant temperature wall, the temperature along the wall is kept constant at its initialized value throughout the entire convergence process. Once pressure and temperature are known, the density is determined from the equation of state.

3.3 Plane of Symmetry

The axis of symmetry line is bypassed by choosing the first two ξ = constant lines to straddle the axis or stagnation streamline. The plane of symmetry boundary is then enforced by the reflection principle. The flow variables are either even or odd functions with respect to the plane of symmetry, or

$$\begin{aligned} \rho(1,k) &= \rho(2,k), \qquad & v(1,k) &= -v(2,k) \\ u(1,k) &= u(2,k), \qquad & e(1,k) &= e(2,k) \quad . \end{aligned} \tag{3.18}$$

The boundary condition at the plane of symmetry is imposed implicitly.

3.4 Outflow Points

Since velocity at majority of the grids in this plane is supersonic, a simple linear extrapolation of the conservative variables is used. For those points near the surface, the flow is subsonic there, thus some error is introduced. The supersonic outflow boundary condition is imposed implicitly, or

$$Q(J,k) = 2Q(J-1,k) - Q(J-2,k) \tag{3.19}$$

3.5 Initial Conditions

To start the calculation, an initial flowfield must be provided. In the numerical code, two starting methods are provided: (1) starting the calculation with a sphere at a given free stream Mach number or (2) reading in, point by point, the shock and body locations along rays (ξ = constant lines). For the indented nosetip shapes described in this report, the calculation always starts from a sphere and let the body gradually deformed to the desired shape by giving a set of values for δ along each ray (see Fig. 1). For sphere, a good guess for the shape and position of the shock is made based on known spherical blunt body solutions as follows:

$$\delta_o = 0.78 \{[(\gamma-1)M_\infty^2 + 2]/[(\gamma-1)M_\infty^2]\}$$

$$y_b = 2.376 - 0.1834M_\infty + 0.01036M_\infty^2, \quad 3 \leq M_\infty \leq 10$$

$$= 1.576 - 0.0018(M_\infty - 10), \quad M_\infty > 10$$

$$P_s = y_b/[2(1+\delta_o)]$$

$$y_s = 2P_s(x_s + \delta_o) \tag{3.20}$$

where δ_0 is the stand off distance at axis of symmetry, y_b and P_s are empirical constants as a function of Mach number and y_s and x_s are the shock position. As one can see a parabolic shock shape is assumed.

Once the shock and body locations are determined, the flow variables along the shock are obtained by assuming a zero shock velocity and applying the Rankine-Hugoniot relations. On the body, a Newtonian pressure distribution and isentropic relations are applied to provide the flow variables. The equations to implement the initial flow variable on shock and body are listed in the following:

On shock:

$$\begin{aligned}
p_s &= \{[2\gamma(M_\infty \sin \theta_s)^2 - (\gamma-1)]/(\gamma+1)\} p_\infty \\
\rho_s &= [(\gamma-1)(M_\infty \sin \theta_s)^2/[(\gamma-1)(M_\infty \sin \theta)^2 + 2]\} \rho_\infty \\
u_s &= \{1-2(M_\infty^2 \sin^2 \theta_s - 1)/[(\gamma+1)M_\infty^2]\} q_\infty \\
v_s &= \{2(M_\infty^2 \sin^2 \theta_s - 1)\cos \theta_s/[(\gamma+1)M_\infty^2 \sin \theta_s]\} q_\infty \ .
\end{aligned} \tag{3.21}$$

At stagnation region

$$S = \left\{ \frac{[2\gamma M_\infty^2 - (\gamma-1)]/(\gamma+1)}{(\gamma+1)M_\infty^2/[(\gamma-1)M_\infty^2+2]} \right\}^\gamma \frac{p_\infty}{\rho_\infty^\gamma}$$

$$t = \frac{1}{\{[2\gamma M_\infty^2-(\gamma-1)]/(\gamma+1)\}^{1/\gamma-1}} \cdot [\tfrac{1}{2}(\gamma+1)M_\infty^2]^{\frac{\gamma}{\gamma-1}} \; p_\infty \qquad (3.22)$$

$$t/\rho_t = [1+\tfrac{1}{2}(\gamma-1)M_\infty^2] \frac{p_\infty}{\rho_\infty} .$$

On body:

$$p_b = p_\infty[(\frac{p_t}{p_\infty} - 1)(1.0 - 1.02 \sin^2\theta + 0.12 \sin^4\theta) + 1.]$$

$$\rho_b = (p_b/S)^{\frac{1}{2}}$$

$$q_b = \left\{ \frac{2\gamma}{(\gamma-1)} \left| \frac{p_t}{\rho_t} - \frac{p_b}{\rho_b} \right| \right\}^{\frac{1}{2}} \qquad (3.23)$$

$$u_b = |\ q_b \cos\theta_b\ |$$

$$v_b = q_b \sin\theta_b \quad .$$

The flow variables at each nodal point within the shock layer are linearly interpolated. In order to maintain a constant total enthalpy for the initial flowfield at each nodal point, a modification of the interpolated valocity components is made

$$u_i = u_i' \, (\tilde{q}/q)$$

$$\qquad (3.24)$$

$$v_i = v_i' \, (\tilde{q}/q)$$

where

$$q = [\frac{2\gamma}{\gamma-1}/P_t/\rho_t - \frac{P}{\rho}/]$$

$$q = \sqrt{u_i'^2 + v_i'^2} \quad .$$

CHAPTER 4

INDENTED NOSETIP SHAPES AND COMPUTATIONAL MESH

4.1 Indented Nosetip Shapes

In this report, the series of indented nosetips as shown in Figure 3 are of primarily concerned. These shapes are composed of arcs and straight lines. Three portions can be identified: (I) expansion corner near the flat nose, (II) compression turn and (III) expansion shoulder. The detail description of the models is given in Table 1. It should be emphasized that these nosetips present serious computational difficulties because of the sharp corners and convex and concave curvatures. Experimental measurements of bow shock location and surface pressure for model 1 to 3 are reported in Ref. 7. Also velocity and density data have been obtained in Ref. 8 for model 4. Numerical calculations will be compared to these results.

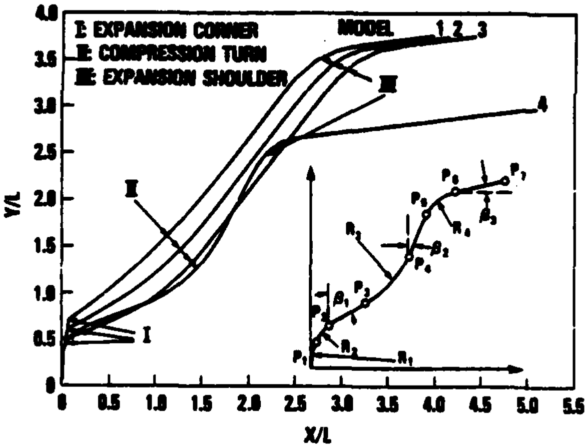

FIGURE 3. NOSETIP SHAPES

Table 1 Description of Nosetip Models

Model	Parameter	Subscript n 1	2	3	4	5	6	7
1	XP_n/L	0.053	0.077	0.579	1.508	2.474	3.140	5.906
	YP_n/L	0.676	0.715	1.108	2.037	3.274	3.651	3.990
	R_n/L	4.320	0.062	5.389	1.000			
	β_n,deg	52.00	38.00	7.000				
2	XP_n/L	0.038	0.069	0.572	1.475	2.712	3.378	6.144
	YP_n/L	0.569	0.615	0.906	1.692	3.274	3.651	3.990
	R_n/L	4.320	0.062	3.137	1.000			
	β_n,deg	60.00	38.00	7.000				
3	XP_n/L	0.025	0.064	0.564	1.454	2.929	3.595	7.631
	YP_n/L	0.463	0.514	0.717	1.388	3.274	3.651	3.990
	R_n/L	4.320	0.062	2.154	1.000			
	β_n,deg	68.00	38.00	7.000				
4	XP_n/L	0.	0.263	0.830	1.693	2.099	2.506	5.225
	YP_n/L	0.266	0.642	0.848	1.605	2.386	2.569	3.000
	R_n/L	∞	0.400	1.585	0.533			
	β_n,deg	70.00	27.50	7.000				

4.2 Computational Grids

As shown in Figure 1, the computational grids are formed with constant spacing rays. The first two rays (j=1 and 2) must straddle the axis of symmetry. Hence

$$\Delta\theta = \theta_{max}/(J-1.5) \tag{4.1a}$$

$$\theta = (j-1.5)*\Delta\theta$$

To deform a sphere to the indented nosetip shapes, the distance of deformation $\delta(\theta)$ must be calculated for each ray. Expressions for $\delta(\theta)$, $x(\theta)$, $y(\theta)$ are given in Appendix C.

The distribution of points along a ray between the shock (x_s, y_s) and the body (x_b, y_b) is given by

$$\bar{a}(k) = 1 + \beta[1-(\frac{\beta+1}{\beta-1})^{1-b}]/[H(\frac{\beta+1}{\beta-1})^{1-b}] \qquad (4.2a)$$

where

$$b = (k-1)/(K-1) \qquad (4.2b)$$

and β is a free parameter. A uniform distribution of grids is obtained as $\beta \rightarrow \infty$ and a strongly clustering of points near the body surface is obtained as $\beta \rightarrow 1$. Table 2 gives the first 6 values of $\bar{a}(k)$, $k=1,7$ for $\beta = 1.01$, 1.005 and 1.001.

TABLE 2. MESHES USED FOR HEMISPHERE-CYLINDER AND SPHERE-CONE CALCULATION

Mesh	β	Points / 0.1Ys	First 6 points					
			n_1/Ys	n_2/Ys	n_3/Ys	n_4/Ys	n_5/Ys	n_6/Ys
A	1.01	12	.0025	.0055	.0093	.014	.0199	.0271
B	1.005	17	.0011	.0024	.0039	.0058	.0081	.0109
C	1.001	20	.0003	.0006	.0011	.0017	.0024	.0033
D	1.005	17	.0011	.0024	.0039	.0058	.0081	.0109

The distribution of $\bar{a}(k)$ once initiated is kept unchanged throughout the calculation even though the grid points may vary at each time step as the shock or body location varies. For inviscid calculation, uniform distribution of point across the shock layer is always used with $\beta = 10^5$ in Eq. (4.2). The clustering of points near the surface must be used for viscous calculations.

4.3 Criterion for Convergence. The convergence of solution is judged by the convergence of shock speed. From experience for smooth nosetip, when the non-dimensional shock speed reaches 10^{-3} to 10^{-5}, all the flow variables remain essentially constant and the residue of the solution, which is given by the RMS of Eq. (2.7), is in the order of 10^{-5} to 10^{-7} over all the grid points. The shock speed does not converge monotonously, it will oscillate but decrease in the averaged magnitude. For all cases computed for smooth nosetips, a converged solution may be obtained in about 300 to 1000 time steps depending on the mesh selected. In general, the convergence rate slows down rapidly for a strongly clustered mesh such as Mesh C; see Table 3 for the hemisphere-cylinder case.

TABLE 3. CONVERGENCE RATE FOR HEMISPHERE-CYLINDER

Mesh	Number of Time Integrations	Shock Speed	Remark
A	300	$.51 \times 10^{-4}$	CN = 75 and final $\varepsilon_E = 0.02$ and $\varepsilon_I \equiv 3\ \varepsilon_E$ for all cases.
B	600	$.68 \times 10^{-4}$	Mesh C starts with $\varepsilon_E = 0.1$ for 400 steps.
C	1000	$.16 \times 10^{-2}$	

For indented nosetips, the convergence of shock speed becomes very slow when it reaches the order of 0.01 with long oscillation cycle in both inviscid and viscous calculations. Under such conditions, the flow variables near the body are essentially unchanged for over a few hundred time steps and calculations are then considered completed. The residue may go up to 10^{-3} in some grid points.

4.4 Time steps

The time step $\Delta\tau$ used for each time integration is determined from the input Courant number CN according to

$$\Delta\tau = \frac{CN}{\sigma_{max}} \tag{4.5}$$

where σ_{max} is given by Eq. (3.3) and is the maximum of the eigenvalues of the matrices A and B over all the interior points. For inviscid flow calculations, the allowable value of CN is 2 for both smooth and indented nosetip calculation. For viscous flow calculation, the allowable Courant number is problem dependent and also related to the dissipation coefficients used. For smooth nosetip laminar flow calculations $\varepsilon_E = 0.02$ and $\varepsilon_I \equiv 3\varepsilon_E$ are used and a CN of 75 has been achieved (can also run for CN = 150 if let $\varepsilon_E = 0.1$). In some situations, a larger value of ε_E is required at the beginning of the convergence process and may be reduced afterward as the flowfield gradually approaching the final solution. For indented nosetip laminar flow calculation, CN has been reduced to 50 or 25 in some part of the calculation. The CPU time required for the integration is about 0.000851 per time step per mesh point using CDC-7600 computer.

4.5 Dissipation Coefficients

Experiments about the effect of adding dissipation terms on the solution were conducted for the cases of sphere and hemisphere-cylinder for both inviscid and laminar flow calculations. For these smooth noses, no significant difference between the solutions with $\varepsilon_E = 0.02$ and 0.001 ($\varepsilon_I \equiv 3\varepsilon_E$) can be found. However, if let $\varepsilon_E = \varepsilon_I = 0$ the solution diverges. Thus, for smooth nosetip $\varepsilon_E = 0.02$ is used for all calculations. For indented nosetip calculations, it is necessary to have a larger value of ε_E in the order of 0.2 to 0.4 in order to have a solution. No assessment about the influence of the dissipation terms on the solution can be made at present time. How good the solution is can only be judged by comparison to experimental data for the indented nosetips. More discussion about the effect of dissipation are provided at the presentation of results.

CHAPTER 5

INVISCID FLOW CALCULATIONS

5.1 Code Verification

A copy of the research computer code described in Ref. 1 was obtained from NASA Ames Research Center, referred to as K-C-L code. The inviscid portion (mainly contributed by P. Kutler) of the code is first verified for the case of a sphere at $M_\infty = 5.96$. Grid points of 6 (normal direction) x 10 (streamwise direction), 12 x 19 and 12 x 32 have been used and results obtained for surface pressure agree well. The total number of time steps used in each calculation is 600 and the final shock speed (normalized by free stream sound speed) reached is in the order of 10^{-5} to 10^{-8} which is considered to be sufficiently small for the results to be judged as steady state. The maximum total enthalpy error in the flowfield varies from 0.7% for the 6 x 10 grid to 0.1% for the 12 x 32 grid; this relation is almost linearly proportional to the grid points used. Therefore, the code seems to behave consistently for sphere. Next, the effects of explicit dissipation terms used in the numerical scheme is examined. The value of ε_E is varied from 0.4 to 0.005 and the resulting surface pressure agree to the first two digits. When $\varepsilon_E = 0$ or ≥ 0.6, the calculation diverges. Thus, the effect of explicit dissipation on the calculated results for flow over sphere is small. As will be discussed later, they are not so small for the indented nosetip. In the above calculations, the maximum Courant number is 2.5. The results obtained with 12 x 32 grid are compared to the work of Inouye and Lomax[17] and the measured data of Baer[18] for the surface pressure as shown in Fig. 4a and to the measured data of Sedney and Kahl[19] for the density distribution as shown in Fig. 4b. The agreements are seen to be satisfactory except for $\rho/\rho_\infty = 5.2$ in Fig. 4b. It should be pointed out that the calculated result for $\rho/\rho_\infty = 5.2$ agrees well with the numerical results of Shubin et al[*] who solve the steady Euler equations in conservation law form with an entirely different numerical method.

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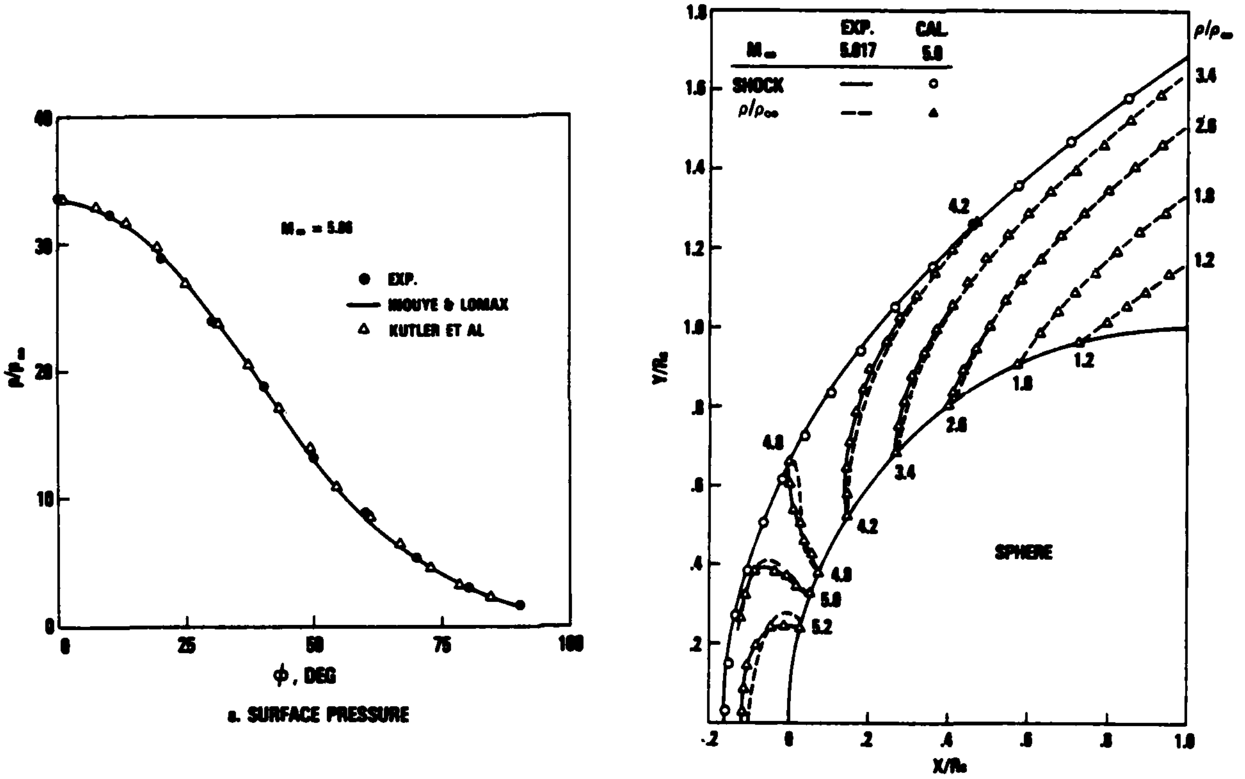
[17] Inonye, M., and Lomax, H., "Comparison of Experimental and Numerical Results for the Flow of a Perfect Gas About Blunt-Nosed Bodies," NASA TN D-1426, Sep 1962.

[18] Baer, A. L., "Pressure Distribution on a Hemphisphere Cylinder at Supersonic and Hypersonic Mach Numbers," AEDC TN 61-96, Arnold Engineering Development Center, 1961.

[19] Sedney, R., and Kahl, G. D., "Interferometric Study of the Blunt Body Problem," Ballistic Research Laboratory Report No. 1100, 1960.

[*] Shubin, et al., private communication.



a. SURFACE PRESSURE

b. DENSITY DISTRIBUTION

FIGURE 4. COMPARISON OF SURFACE PRESSURE AND DENSITY FIELD BETWEEN CALCULATION AND EXPERIMENT

5.2 Special Calculation Procedure for Indented Nosetips

Difficulties arise when apply the code to compute the flowfield around the indented nosetips given in Fig. 3. In order to represent the nosetip shape reasonably well, a sufficient number of grid points must be located in the areas where the body geometry changes rapidly. The code fails to carry out the computation with both the starting methods provided. These two starting methods are either to deform from a sphere or to specify the locations for the initial body and shock. Only with a coarse grid, for example 12 x 19, can a solution be obtained with the body not well represented, particularly near the nose tip. The solution obtained then suffers an error of the total enthalpy in the flowfield as high as 20 percent for a severely indented nosetip. Such solution is obviously unsatisfactory.

Experience indicate that the problem always occur at the shock boundary and results in a shock speed which continuously increases as the time progresses and finally leads to the breakdown of the computation. One of the reasons that the code behaves in this manner is perhaps that the shock boundary points are treated explicitly and in a quasi-steady manner (it is not time accurate); thus the starting flowfield must be sufficiently close to the final flowfield in order for the computation to carry through smoothly. A fundamental improvement of the algorithm is to incorporate an unsteady shock boundary condition and to make the entire calculation time accurate with implicit treatment of shock and body boundary conditions. This requires considerable modification of the code (in fact, a new code) and is not persuaded in this report. The alternative approach would be to proceed slowly by gradually approximating the body geometry and this has been successfully accomplished as described in the following paragraphs.

The optimal procedure for computing the flow about an indented nosetip is to obtain a solution with a coarse mesh. Additional grid points are then added in areas of rapid geometry variation and a new solution is obtained using the previous one as a starting guess.

The calculation made for Model 2 at $M_\infty = 6$ is used as an example to demonstrate the procedure. To begin with, a coarse mesh (typically 12 x 19) for sphere with equal angular increment rays (i.e. ξ = constant lines, the first two rays have to straddle the axis) is used and a calculation is performed with the body being guadually deforming in time along each ray to the desired nosetip shape. The surface pressure obtained is plotted versus the arch length as shown in Fig. 5 by the broken line. The intersection point of the ray and the body surface is numbered along the body as shown in the sketch in Fig. 5. This solution is poor because the expansion corner is apparently missed and the maximum error in total enthalpy is 11.87%. An obvious cause is an insufficient number of grid points in the stagnation region and around the expansion corner. New rays are added which contain the same number of uniformly distributed grid points between the body and and the shock. All of the original grid points are kept where they are. The flow variables at the new grid point are interpolated from the flowfield solution just obtained. Thus a new initial condition is obtained to continue the calculation.

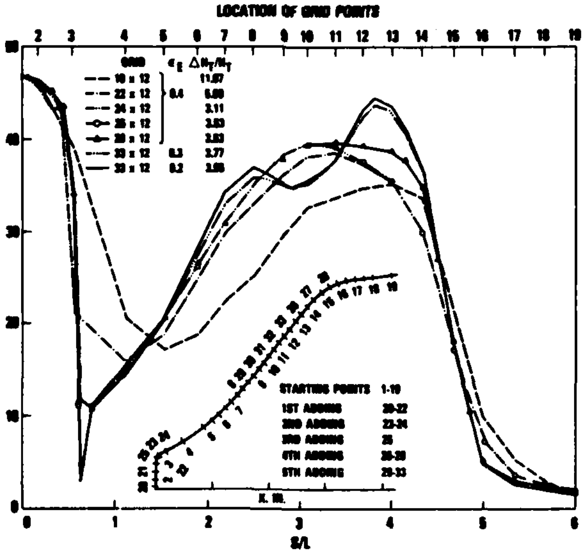


FIGURE 5. PROGRESS OF SURFACE PRESSURE AS A FUNCTION OF ADDING GRID POINTS

As shown in Fig. 5, significant change in surface pressure distribution is found after adding three more rays (denoted by #20, 21 and 22). The error in total enthalpy also reduces to 5.09%. The same procedure is repeated by adding ray #23 (the end point of the circular arc of the expansion corner) and #24. Now, the surface pressure looks like flow over a corner. In order to represent the corner better, the #25 ray is added in the middle of the circular arc. This addition is seen to catch the minimum surface pressure of the expansion corner. At this point, it is felt that the body geometry is well represented. A further attempt to add rays between #24 and #7 fails to obtain a solution. This part of the calculation is most difficult and time consumming. Each addition of grid points requires about 600-1200 time steps to guarantee that the solution will converge.

At first, it seems that the solution obtained with 12 x 35 mesh is sufficiently accurate as shown in Fig. 5. Surprisingly enough, when three more rays (#26, 27 and 28) are added at the expansion shoulder, the surface pressure there changes. Further addition of rays in the downstream of #28 does not have a large effect on surface pressure. Yet the addition of rays in front of #26, i.e. #29-33, are seen to catch the details of a process of recompression and expansion and recompression again. A further increasing the number of rays between #29 and #28 will change the surface pressure locally, but the general trend of the curve remain the same. The addition of rays between the compression turn and the expandion shoulder will not present any difficulty in obtaining a converged solution.

Next, the effects of explicit dissipation used in the code is examined. This is done by reducing the value of ${}^{\epsilon}E$. As shown in Fig. 5, the minimum value of ${}^{\epsilon}E$ required to obtain a converged solution is 0.2 (or ${}^{\epsilon}E/\Delta t \sim 25$) and the difference in surface pressure between ${}^{\epsilon}E = 0.2$ and 0.3 is small. Quantitative comparison of results with and without the explicit dissipation for the indented nosetips investigated in this paper is not possible because of the lack of a solution with ${}^{\epsilon}E = 0$. However, Wardlaw* has calculated a midly indented nosetip at $M_\infty = 5$ using MacCormicks's explicit method without explicit dissipation. The K-C-L code has been run on the same configuration with ${}^{\epsilon}E = 0.2$ and 0.005 (${}^{\epsilon}E/\Delta t \sim 1$). A comparison of calculated surface pressure indicate that the ${}^{\epsilon}E = 0.005$ run agrees better with Wardlaw's surface pressure calculation. There is a maximum of 8% discrepancy between the ${}^{\epsilon}E = 0.2$ and 0.005 solution in the location with large flow gradient.

The procedure used to carry out indented nosetip calculation can be summarized as follows: (1) Use a coarse mesh for a sphere to start the calculation and deform the sphere along each ray to the desired nosetip shape. (2) Add new rays (a few rays at a time) to the critical areas featuring rapid variation in geometry and obtain a new converged solution. (3) Reduce the value of the explicit dissipation coefficient to the minimum value producing a converged solution. This entire calculation sequence requires a net C P U time of about 15-25 minutes on a CDC 7600 computer.

5.3 Flowfield for Indented Nosetips

Following the calculation steps described in the previous section, the inviscid solutions for the series of nosetips given in Fig. 3 were obtained and results are present in the following paragraphs.

5.3.1 Comparison of Surface Pressure and Shock Location

The inviscid solution, flowfield pictures and the measured data for Model 1 to 4 are presented in Figs. 6 to 9 respectively. The degree of indentation increases with the model number. Model 1 is the least indented nosetip. As seen

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*Wardlaw, private communication.

from the flowfield picture (not shown), the flow remains attached over the expansion corner ($0.679 < S/L < 0.725$) and separation occurs near the compression turn ($1.36 < S/L < 2.5$). Good agreement of surface pressure (Fig. 6b) between numerical solution and measured data up to $S/L \sim 1.3$ is obtained. After the flow separation, a sudden increase in the measured surface pressure can be easily understood by the concept of displacement thickness which suddenly thicken the body at the point of separation. Since the separation bubble is small, the difference between the calculated and measured surface pressure is also small. The compression turn is covered by the separation bubble, hence the slight expansion and recompression before the expansion shoulder as predicted by the inviscid solution is not given by the measured data. It is difficult to identify from the flowfield picture where the flow reattaches, but it seems likely that the flow reattaches before the expansion shoulder ($4.3 < S/L < 5.0$) because of the good agreement obtained between calculated and measured surface pressure after $S/L = 4.0$. The comparison of experimental and computed shock locations is in good agreement as shown in Fig. 6a. The inviscid solution gives a thinner shock layer as expected. Also shown in Fig. 6a are the subsonic region and the sonic lines.

The results for Model 2 are given in Fig. 7. Experimental data indicate that the location of separation and the surface pressure are sensitive to the Reynolds number, which accounts for the wide spread in experimental measurements. The flow separates from the downstream of the expansion corner ($0.566 < S/L < 0.628$). The compression turn ($1.2 < S/L < 2.5$) is submerged in the separation bubble. The flow probably reattaches at $S/L \sim 4.0$ and the expansion shoulder is located at $4.4 < S/L < 5.2$. Because of a larger separation bubble in this case, the difference between calculated and measured shock location (Fig. 7a) and surface pressure (Fig. 7b) in the separation region is increased also. The subsonic region associated with the compression turn also increases in this case.

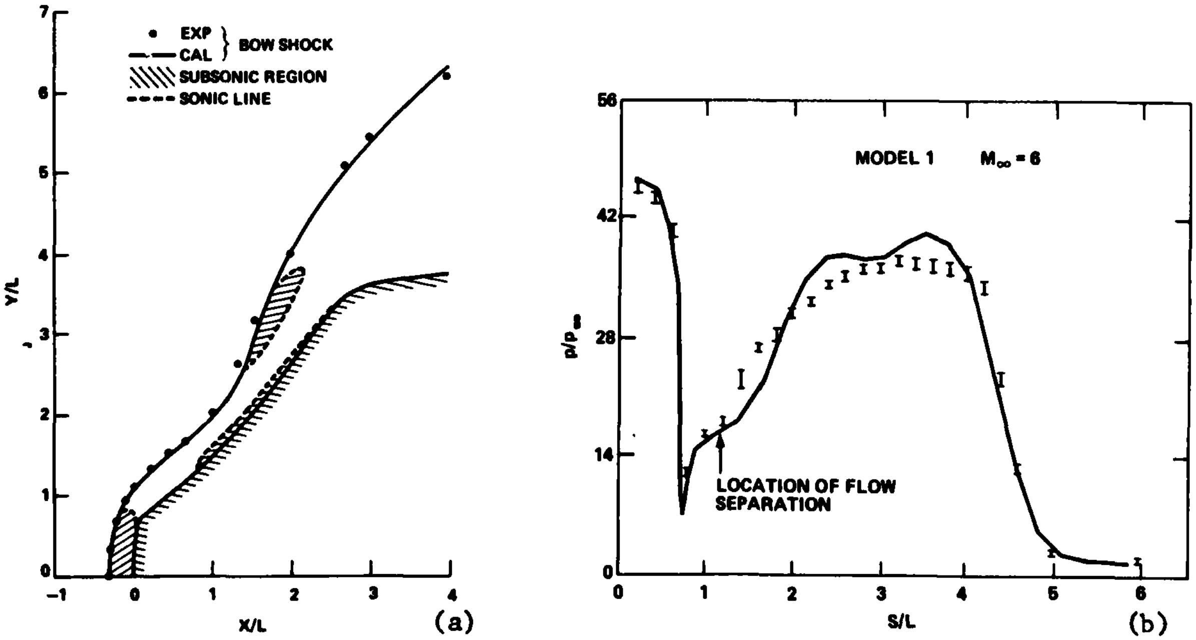


FIGURE 6. COMPARISON OF INVISCID SOLUTION WITH EXPERIMENTS FOR MODEL 1 AT $M_\infty = 6.0$

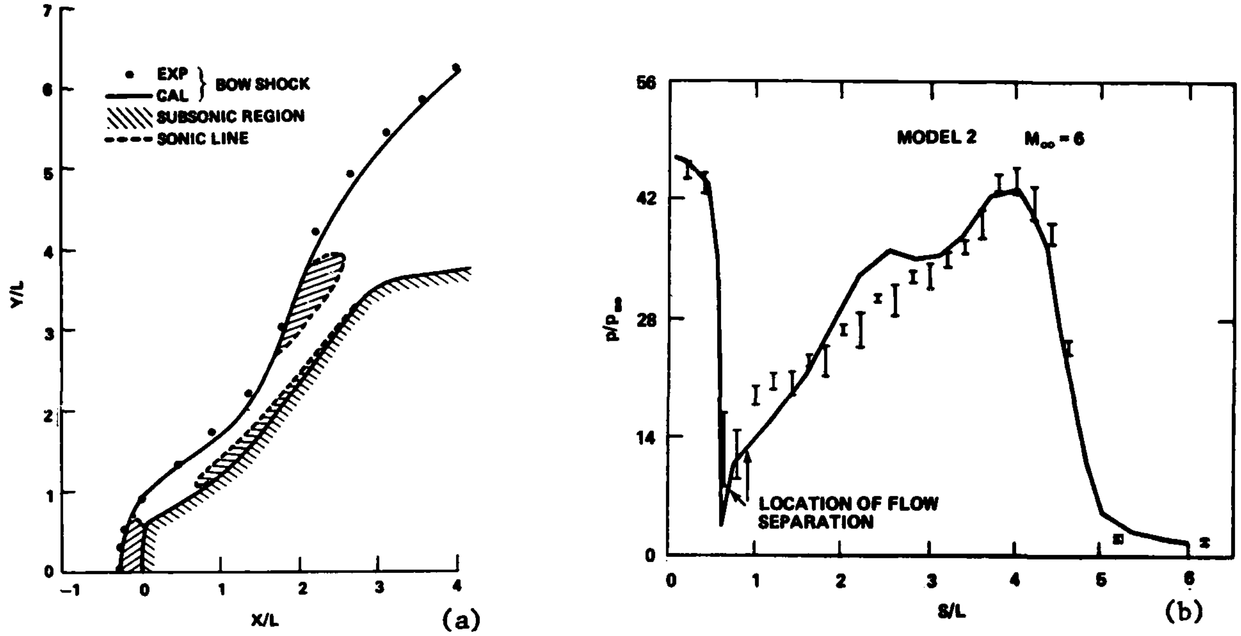


FIGURE 7. COMPARISON OF INVISCID SOLUTION WITH EXPERIMENTS FOR MODEL 2 AT $M_\infty = 6.0$

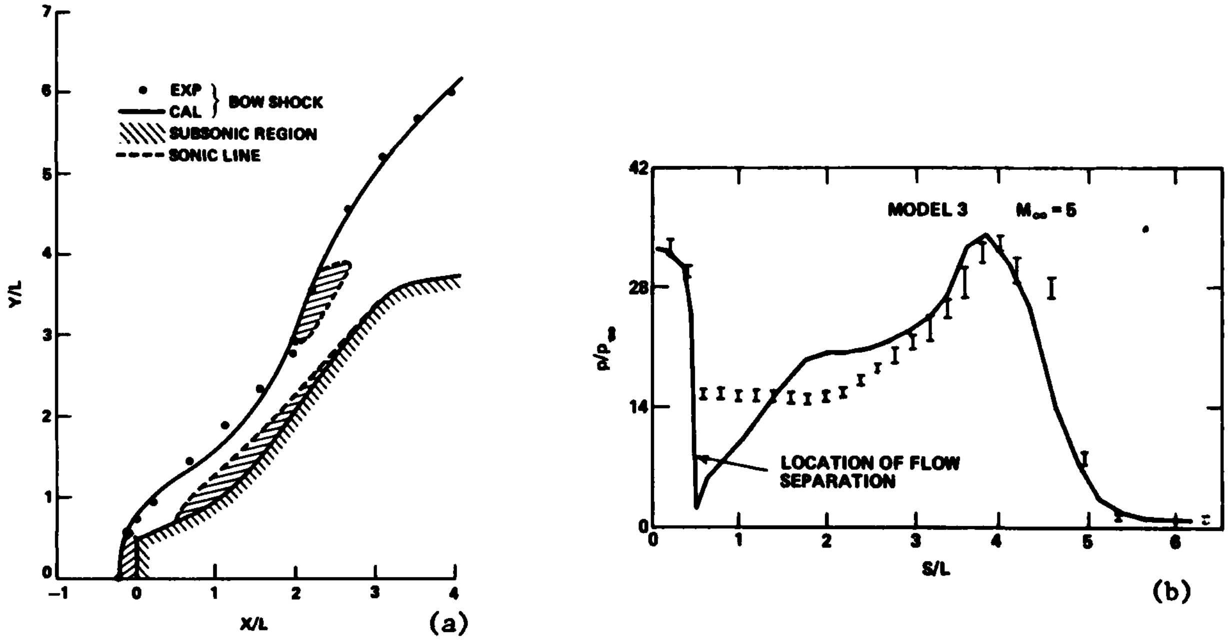


FIGURE 8. COMPARISON OF INVISCID SOLUTION WITH EXPERIMENTS FOR MODEL 3 AT $M_\infty = 5.0$

The results for Model 3 are given in Fig. 8. Experimental data indicate that the flow separation occurs either before or on the expansion corner ($0.465 < S/L < 0.53$) to form a large separation bubble. The compression turn ($1.1 < S/L < 2.16$) is fully submerged in the separation bubble. The flow reattaches near $S/L = 4.0$ before the expansion shoulder ($4.6 < S/L < 5.4$). The measured surface pressure is seen to be nearly constant in the forward portion of the separation bubble (i.e. $0.53 < S/L < 2.0$).

The most severely indented nosetip of this group is Model 4. As shown by the holograph of Fig. 9a, the flow is separated immediately at the beginning of the expansion corner ($0.266 < S/L < 0.75$) and the separation region extends all the way to the expansion shoulder ($3.42 < S/L < 3.95$). The compression turn is located at $1.35 < S/L < 2.52$, and is fully submerged. Therefore, good agreement between inviscid solution and measured data for surface pressure (Fig. 9c) can only be found in the portion of stagnation region and for $S/L \gtrsim 3.5$. The comparison of shock location (Fig. 9b) is also poor. A further analysis of this case using the concept of effective body will be described later.

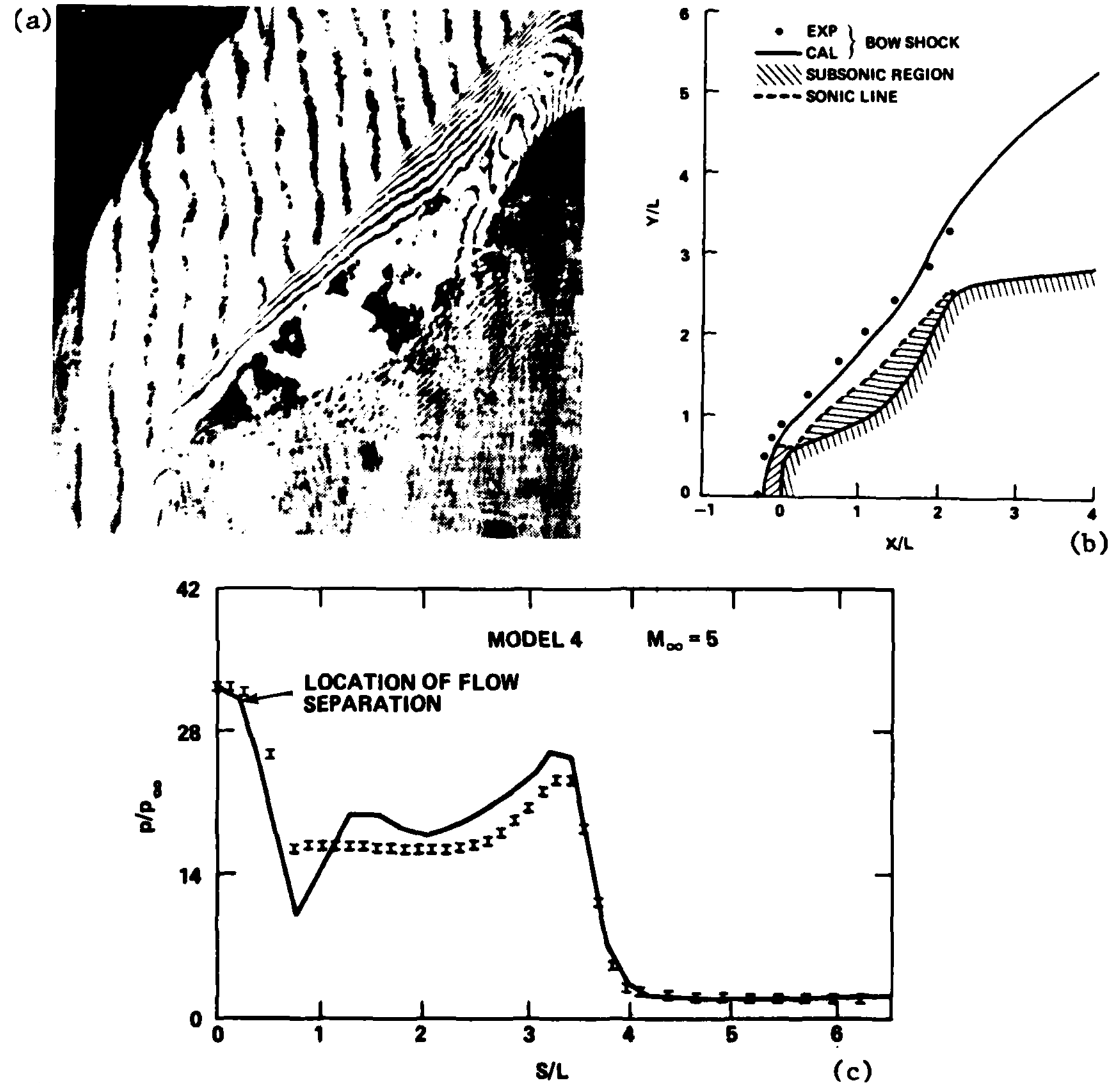


FIGURE 9. COMPARISON OF INVISCID SOLUTION WITH EXPERIMENTS FOR MODEL 4 AT $M_\infty = 5.0$

5.3.2 Contour of Pressure and Density and Velocity Vector

Plots of the inviscid solution for the pressure, velocity vector and density distribution in the shock layer for Model 1-4 are shown in Fig. 10. The range and number of constant pressure and density contour are given in Table 4. From the pressure and density contour plots, it is seen that there are no strong embedded shock or slip surfaces in the shock layer for all the models. On the velocity plots, it is interesting to see that in the compression turn area the velocity magnitude distribution toward the body surface first decreases and then increases to form a retarded velocity regime. As the degree of indentation increases, this retarded velocity region also increases. For Model 4, part of the flow in the core of the retarded velocity region reverse its direction to form two vortices. One would generally not expect inviscid flow solution to behave like this, but such solution should not be excluded either since all the boundary conditions are satisfied. Whether the explicit dissipation (like effective viscosity) is solely responsible for the resulting velocity field is not clear. Nevertheless, the appearance of the retarded velocity region does suggest that a flow separation is likely to occur.

TABLE 4. VALUES FOR PRESSURE AND DENSITY CONTOUR

Model No.	No. of Contours	p/p_∞		ρ/ρ_∞	
		From	To	From	To
1	10	2.51	48.06	.71	7.33
2	10	1.61	46.72	.51	7.46
3	10	1.74	32.61	.67	6.74
4	20	1.17	32.46	.62	6.34

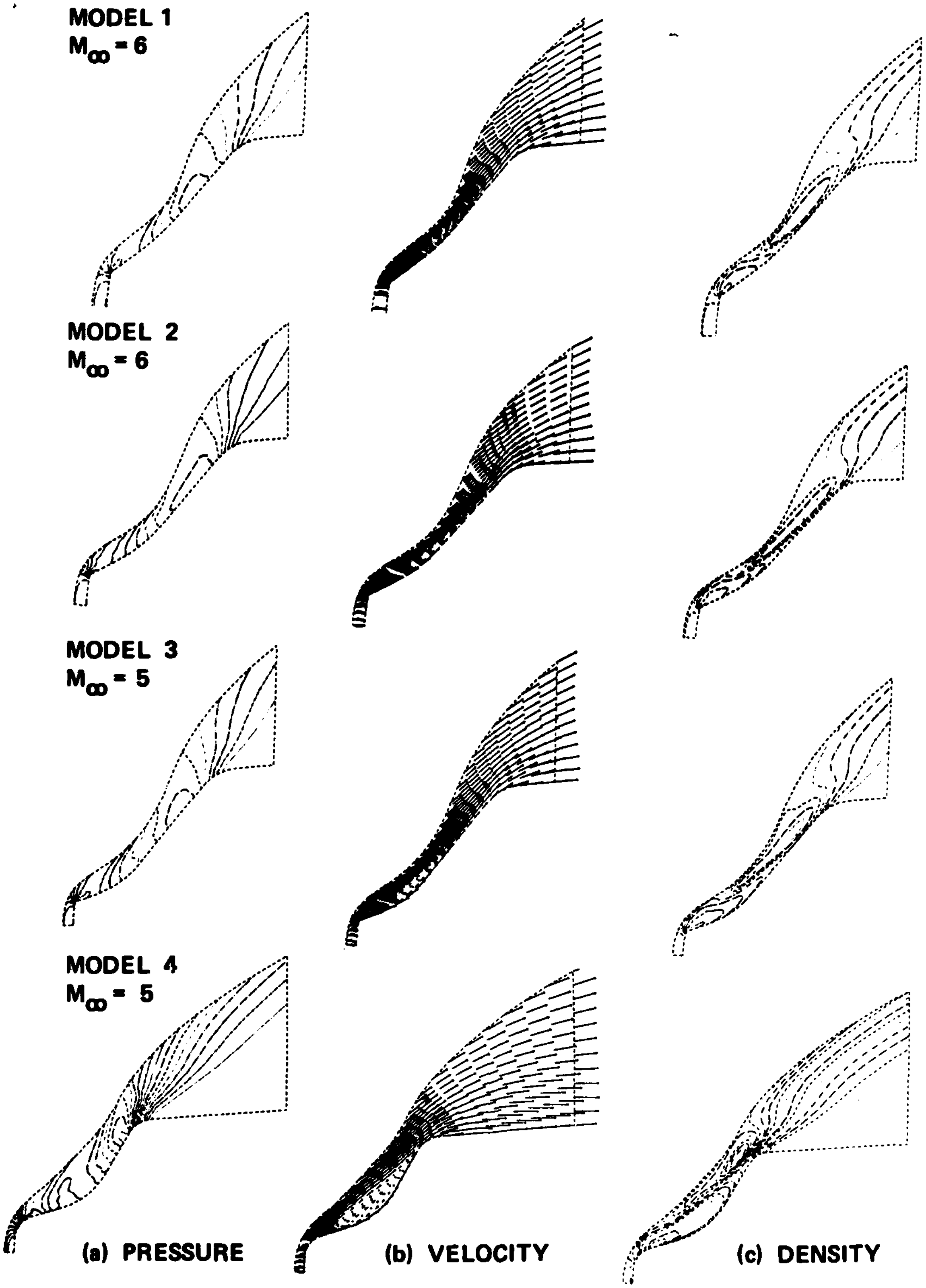
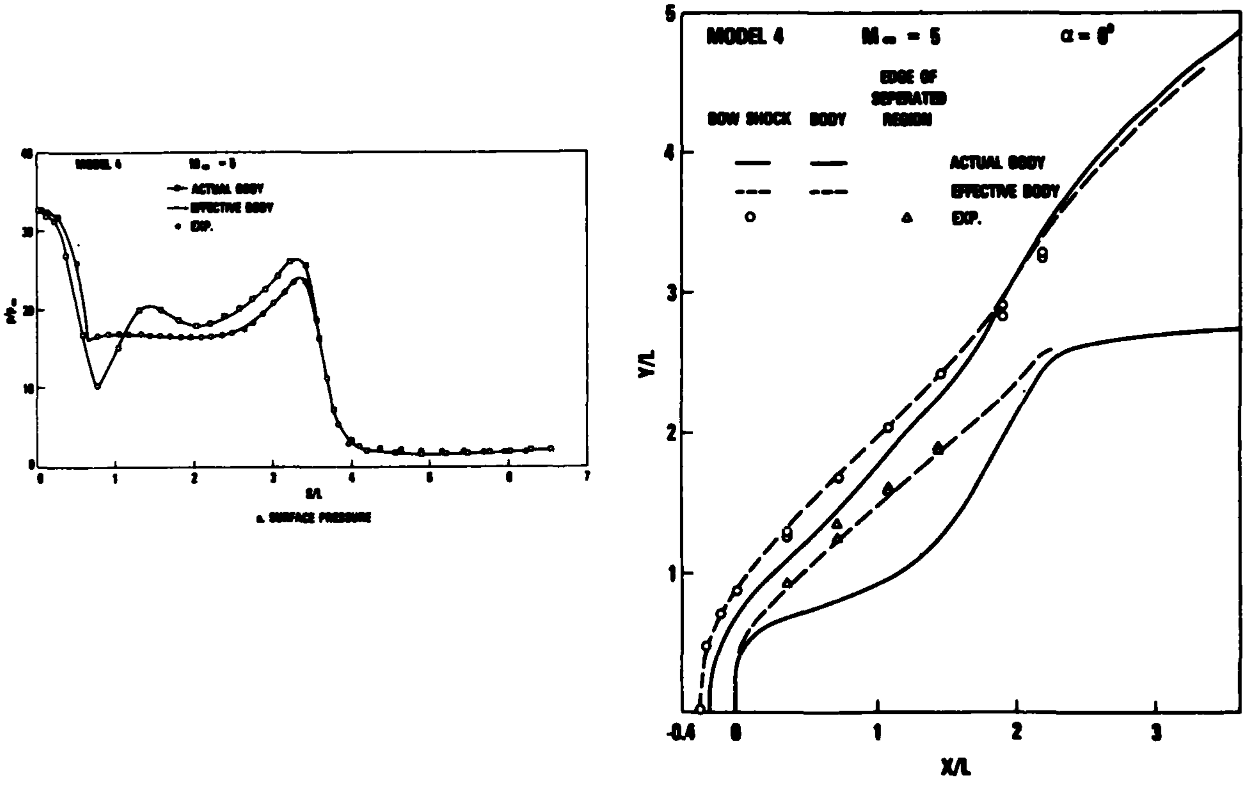


FIGURE 10. INVISCID FLOWFIELD

5.3.3 Effective Body Analysis

The concept of an effective body to replace the separated region or the displacement thickness of boundary layer is examined for Model 4. The effective body is defined as a new body for which the calculated inviscid surface pressure agrees with the measured data for the original body geometry. Because the separation bubble is so large for Model 4 that the new body will have the same order of coordinate perturbation in both x and y directions, therefore a further assumption that the pressure is constant along the normal direction of the original body (a boundary layer like assumption) within the viscous layer is made. The new body is then obtained by trial and error until the surface pressure matches with the experimental data as shown in Fig. 11a. In Fig. 11b, a comparison is made between the effective body shape and the edge of separated region obtained from the flowfield picture (Fig. 11a). Also included in the figure is the measured shock location and the computed ones using both the actual and effective body shapes. Good agreement is obtained between the effective body calculation and measurements. The implication of the effective body analysis is that the separated region may be considered as a solid portion of the body and inviscid solution for the effective body give a better flowfield than does the actual body.



a. SURFACE PRESSURE

b. BOW SHOCK AND SEPARATION REGION

FIGURE 11. COMPARISON OF EFFECTIVE BODY SOLUTION WITH EXPERIMENT

5.3.4 Mach Number Effects

In actual flight, the freestream Mach number is higher than what have been calculated. To see the Mach number effects on the surface pressure distribution, the $M_\infty = 14$ case is compared to that of $M_\infty = 5$ for Model 4 as shown in Fig. 12 and no significant change is shown. The procedure used to obtain $M_\infty = 14$ results is by continuously increasing the freestream Mach number (the sequence is $M_\infty = 6,8,10,12,14$) starting from the $M_\infty = 5$ solution obtained previously without changing the number of grid points.

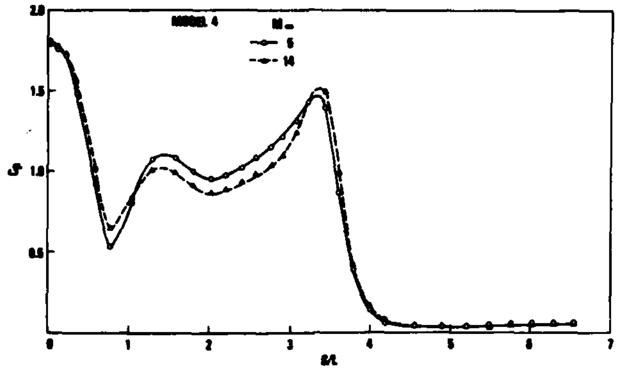


FIGURE 12. CALCULATED SURFACE PRESSURE COEFFICIENT AT DIFFERENT MACH NUMBER

5.4 Coupling with Afterbody Code

A coupling of the inviscid nosetip calculation with an existing NSWC afterbody code[11] has been accomplished. An initial plane flowfield data is stored in tape with the appropriate format to be accepted by the afterbody code. Two examples of this type calculation are given in Fig. 13 and 14. In Fig. 13, the surface pressure distribution for a blunted-nose-cone (LAM) at $M_\infty = 9.8$ is compared to the experimental data. The initial plane is located at x/RN = 1.3 and calculation covers a body length of 30. The agreement with the experimental data is satisfactory. In the same figure, a sphere-cone result is also plotted, this shows the influence of nose shape on the afterbody pressure distribution. In Fig. 14, the afterbody pressure distributions for model 4 at $M_\infty = 5$ are plotted for two different initial plane flowfields obtained previously; i.e. the real body and the effective body. The pressure and the axial velocity at the initial plane x = 4.32 in. are also shown in Fig. 14. As shown in Fig. 14, the influence of initial plane flowfield on the afterbody pressure distribution is limited to about 4 in. downstream. The agreement with experimental data is not as good as the previous example. The obvious reason is that the nosetip flowfield is not well calculated because of flow separation.

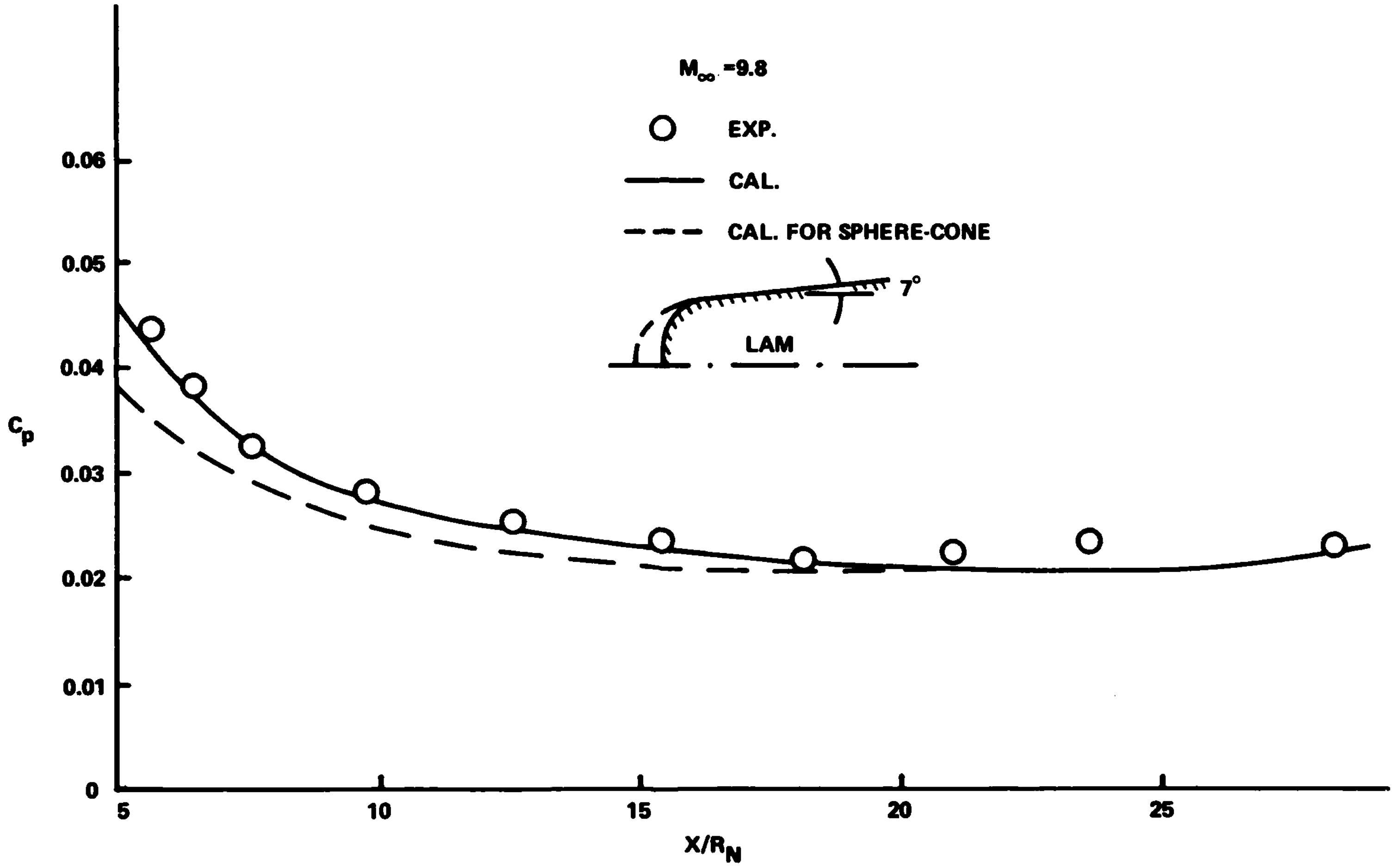


FIGURE 13. COMPARISON OF INVISCID SOLUTION AND EXPERIMENT FOR AFTERBODY SURFACE PRESSURE OF LAM NOSETIP CONE AT $M_\infty = 9.8$

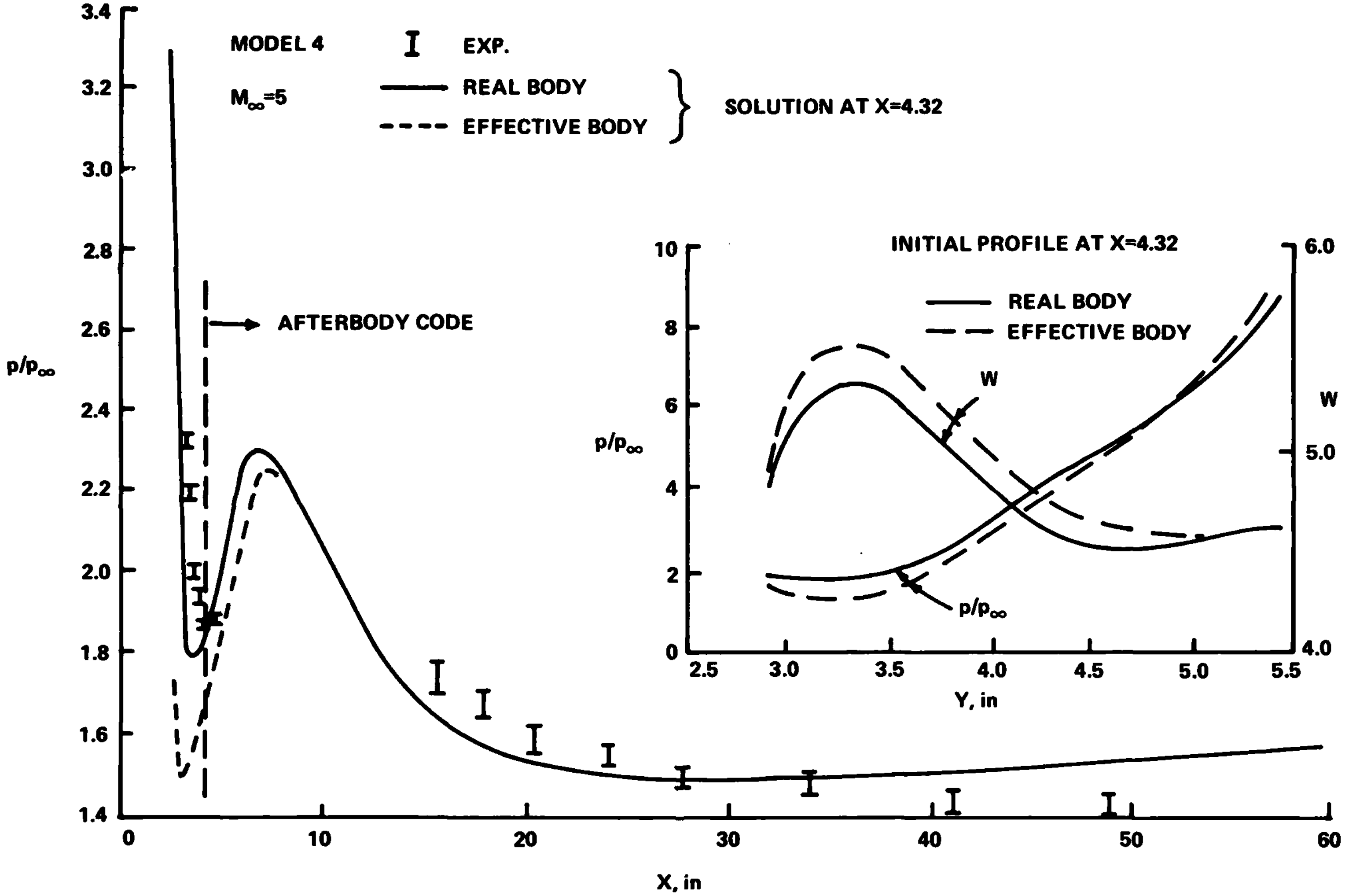


FIGURE 14. COMPARISON OF INVISCID SOLUTION AND EXPERIMENT FOR AFTERBODY SURFACE PRESSURE OF A CONE WITH MODEL 4 NOSETIP AT $M_\infty = 5$

CHAPTER 6

PROBLEMS IN VISCOUS FLOW CALCULATION USING KCL CODE

6.1 Sphere-cone

To verify the code for viscous flow calculation based on the thin-layer approximation of the Navier-Stokes equations (or thin layer theory), laminar flow over a sphere-cone at $M_\infty = 5.92$, $Re_\infty = 10^6$ and $Tw/T_\infty = 4.4$ was computed. The grid used was 32(J) x 28(K) with $\beta = 1.005$ (Eq. 4.2). The steady state solution was obtained in 400 time steps with a Courant number of 75 (the non-dimensional shock speed is in the order of 10^{-3}). As shown in Fig. 15 the calculated results for heat transfer in term of Stanton number over the surface is compared to the measured data reported in Ref. 7. Also plotted in Fig. 15 is the boundary layer calculation using Cebeci-Smith's boundary layer code[20] as given in Ref. 7.

It is seen that the K-C-L code gives higher ST value up to 30% than predicted by the boundary layer theory. It should be pointed out that for the hemisphere-cone case, the flow is fully attached and the surface pressure agrees well between the inviscid solution (obtained from an existing NSWC code[22] and was used in the boundary layer calculation) and the laminar solution given by the K-C-L code. Therefore, one would expect good agreement in heat transfer results. As described in Section 7, after a major modification of the K-C-L code by rewriting all the viscous subroutines according to the analysis presented in Sections 2 and 3, the new results indeed agree well with the boundary layer calculation.

An algebraic turbulence model developed by Baldwin and Lomax[9] was incorporated in the original code. To test out the turbulent solution, the final laminar solution with $\varepsilon_E = 0.1$ was used as the initial condition. It was found that the turbulent calculation would not converge if the implicit discipation terms are set to zero, i.e., $\varepsilon_I = 0$ (Note that although Ref. 1 mentioned about the imposing of implicit dissipation terms, but these terms were not appeared in the code received). Only after the implicit dissipation terms were added into the code with $\varepsilon_I = 3\varepsilon_E$, the shock speed converges well. For hemisphere-cone, a turbulent solution was obtained in 200 time steps with the non-dimensional shock speed in the order of 10^{-3}. As shown in Fig. 15, the Stanton number increases significantly for turbulent flow as compared to the laminar solution. No measured data is available for comparison. It should be pointed out that the values of surface pressure obtained from the laminar and turbulent solution agree to two digits.

A minor modification in the distribution of ε_E values has been added into the code. Instead of a uniform distribution of ε_E over all the grid points, it is linearly reduced from ε_E at the shock (k = K) to $0.1\varepsilon_E$ at the body (k = 1). This is done for viscous flow calculation only and will help to show the real viscous effects because: (i) the true viscous terms are important in the area near to the wall and (ii) the flow is essentially inviscid at the shock where more dissipation is needed to smooth out the oscillations of the flow variables there. When ε_E is linearly reduced, it is denoted by ε_E' to distinguish from the uniform one. For hemisphere-cone, the effects of ε_E' are seen to be insignificant on the heat transfer results as shown in Fig. 15.

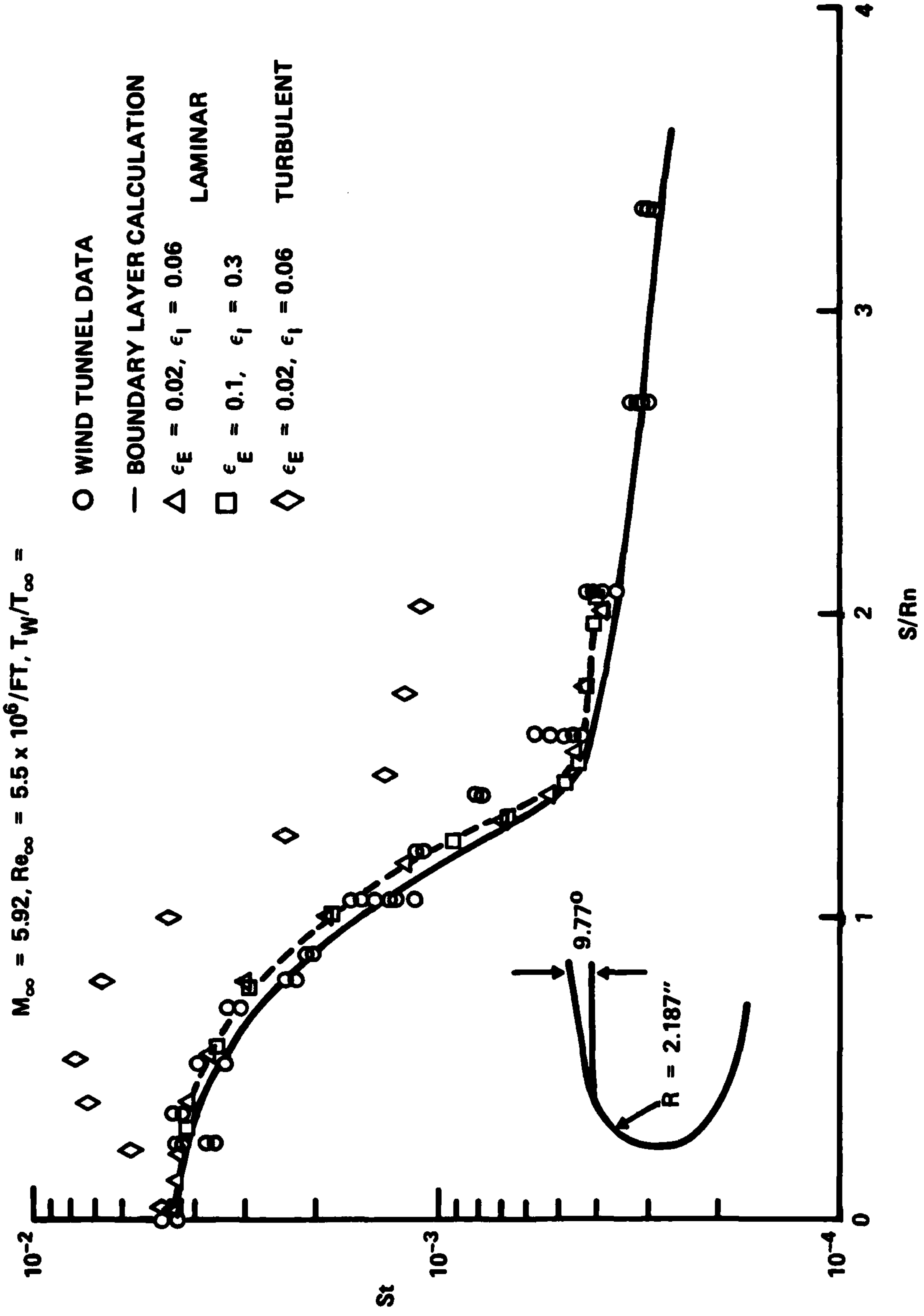


FIGURE 15. COMPARISON OF HEAT TRANSFER FOR A SPHERE-CONE AMONG K-C-L CODE SOLUTION, MEASURED DATA AND B.L. CALCULATION

6.2 Indented Nosetips

The calculation procedure used for inviscid flow over indented nosetips as described in section 5.0 was also applied to calculate viscous flow over indented nosetips. Model 1 and 4 were chosen for this investigation.

Laminar flow over Model 4 was first calculated. The calculation started with a grid of 24 x 32 (CN = 150, $\varepsilon_E = 0.4$, $\varepsilon_I = 0$) for 400 time steps to obtain a laminar solution over a sphere at $M_\infty = 5.0$, Re = 8 x 10^6/FT and $T_w/T_\infty = 5.4$. The sphere was then deformed to the shape of Model 4 in 1800 time steps. The grids were then increased to: (A) 58 x 32 and (B) 56 x 48 in another 1600 time steps each with the final values of CN = 50, $\varepsilon_E = 0.1$ for (A) and $\varepsilon_E' = 0.3$ for (B). The calculated surface pressure and shock locations from these two solutions are close as shown in Fig. 16. This provides a self verification of the results. Since grid (B) contains more points in the η direction, its solution is used for comparison with the measured data as shown in Fig. 17 and 18.

Unlike the hemisphere-cone, the turbulent calculations for Model 4 encountered serious difficulties. Large amplitude oscillation of pressure in the flowfield quickly interrupted the computation. The value of CN was gradually reduced and the value of ε_I was increased ($\varepsilon_E' = 0.3$ was maintained). At CN = 2 and $\varepsilon_I = 6$, it was possible to run for 200 time steps with the non-dimensional shock speed converging to a value of 0.04. The shock speed then starts to increase slowly but steadily. A further increase of ε_I up to 12 would not help to obtain a converged solution. Thus, the solution before the shock speed started to increase is shown in Fig. 17 and 18 for comparison.

Fig. 17 shows the comparison of shock location between calculations and experiments. The inviscid shock layer is thinner around the indented region as expected. The laminar and turbulent solutions for shock location are almost coincide and fall in between the inviscid solution and the measured data. The primary separation bubble indicated by the laminar solution is smaller than observed experimentally. The laminar separation point of the primary separation bubble is at the downstream end of the expansion corner, but the flow picture (Fig. 9a) shows that the flow separates immediately at the beginning of the expansion corner. In general, the effects of turbulence is to move the separation point toward downstream and the separation bubble will be smaller. This fact suggests that the discrepancy shown in Fig. 17 is not because of turbulence effects but from some other sources which are not correctly simulated in the numerical solution. Also the laminar solution indicates that there is a secondary separation bubble within the primary separation bubble as sketched in Fig. 17. The secondary separation bubble was not reported in Ref. 8.

In Fig. 18, the surface pressure distribution obtained from the inviscid, laminar and turbulent solution are compared to the measured data. It is noted that the viscous solutions compare better with the measured data than the inviscid curve. The region around the expansion corner S/L $\sim$ 0.26 - 0.7 where the inviscid and viscous solutions are seen to agree well (i.e., no flow separation) but are lower than the measured data. The dip in the pressure curve in the region S/L $\sim$ 2.5 (where the secondary separation bubble starts) is not shown by the measured data.

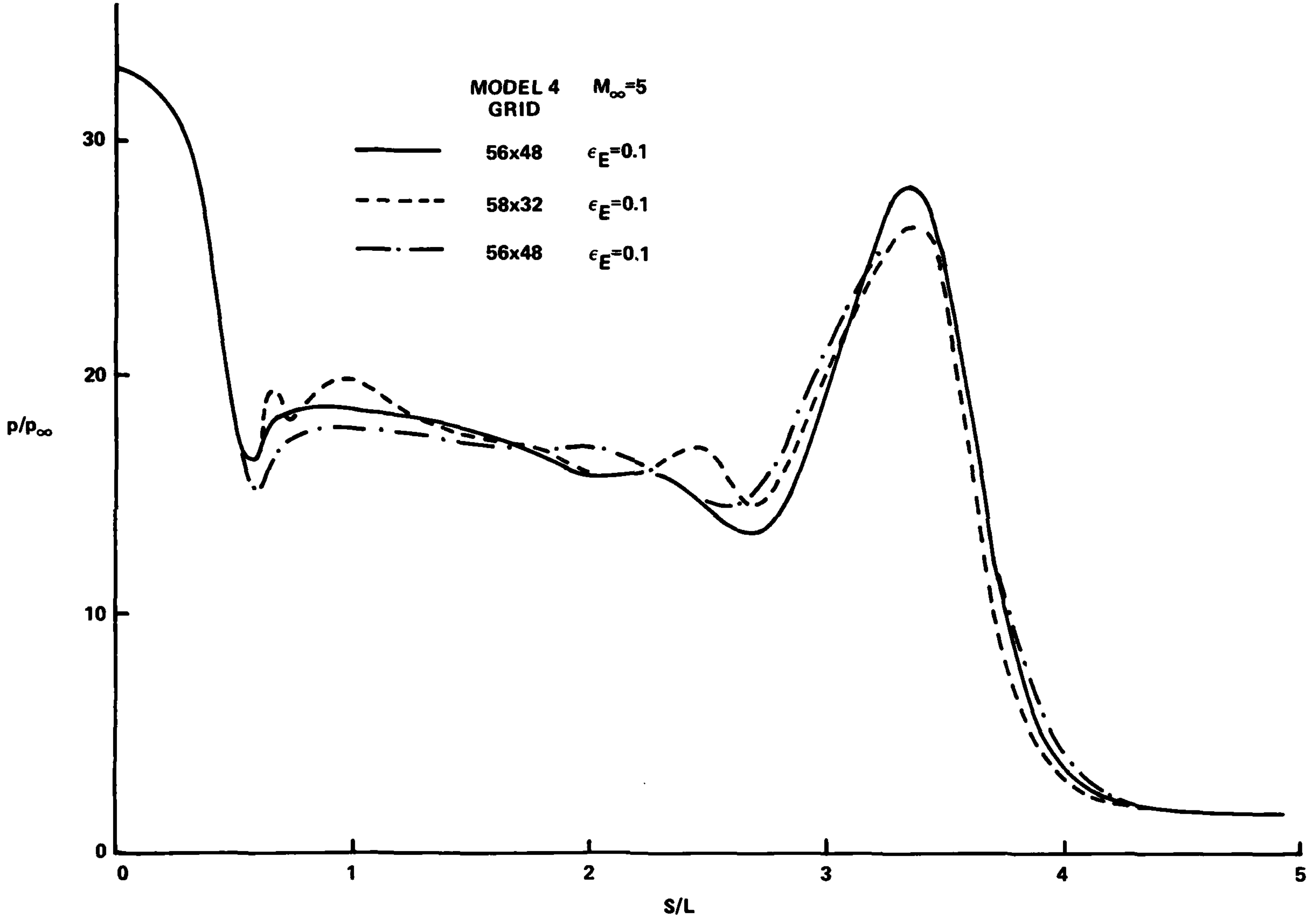


FIGURE 16. VISCOUS SOLUTIONS FOR MODEL 4 USING DIFFERENT GRID DISTRIBUTION

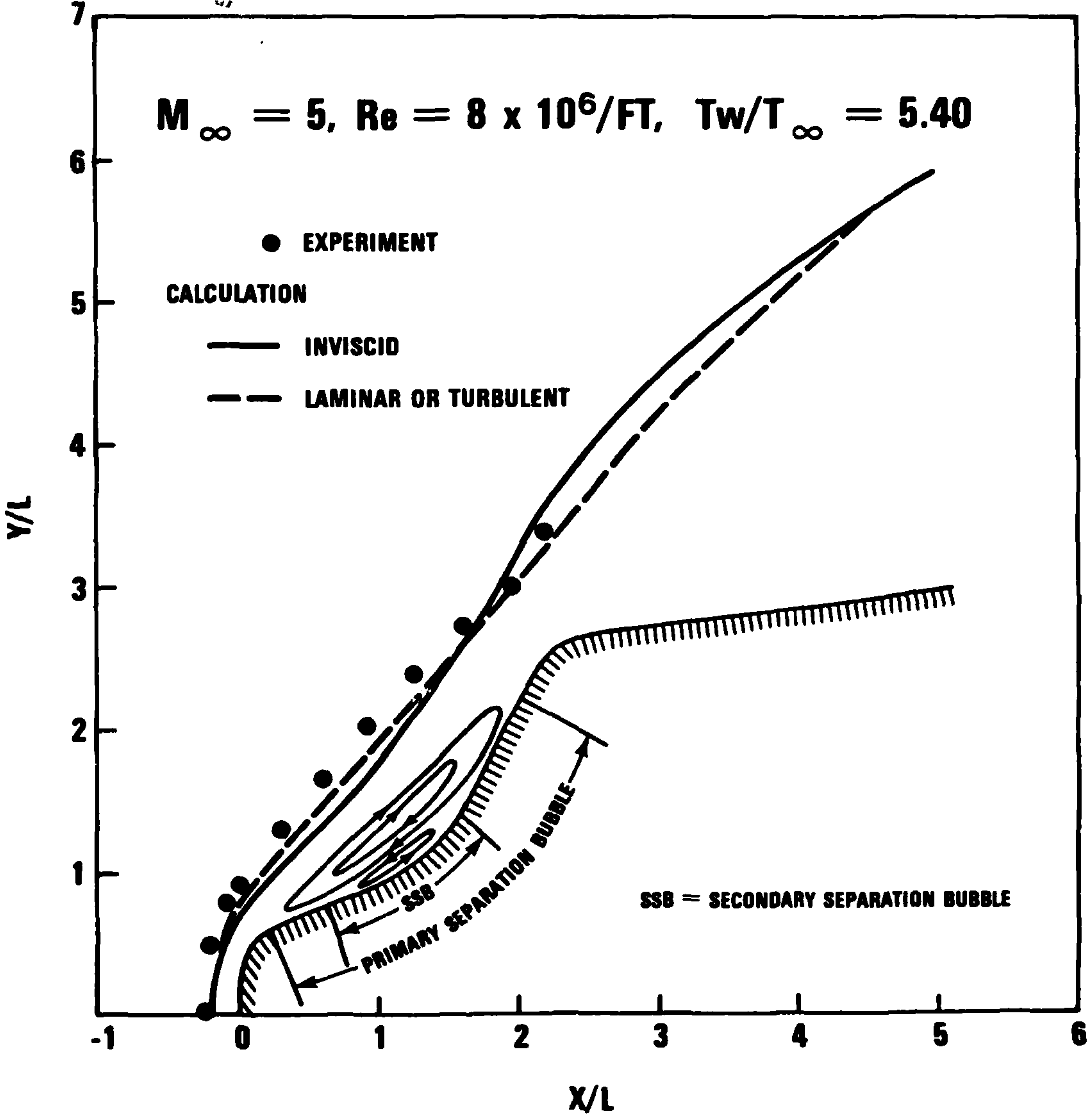


FIGURE 17. COMPARISON OF SHOCK LOCATION BETWEEN K-C-L CODE SOLUTION AND EXPERIMENT FOR MODEL 4

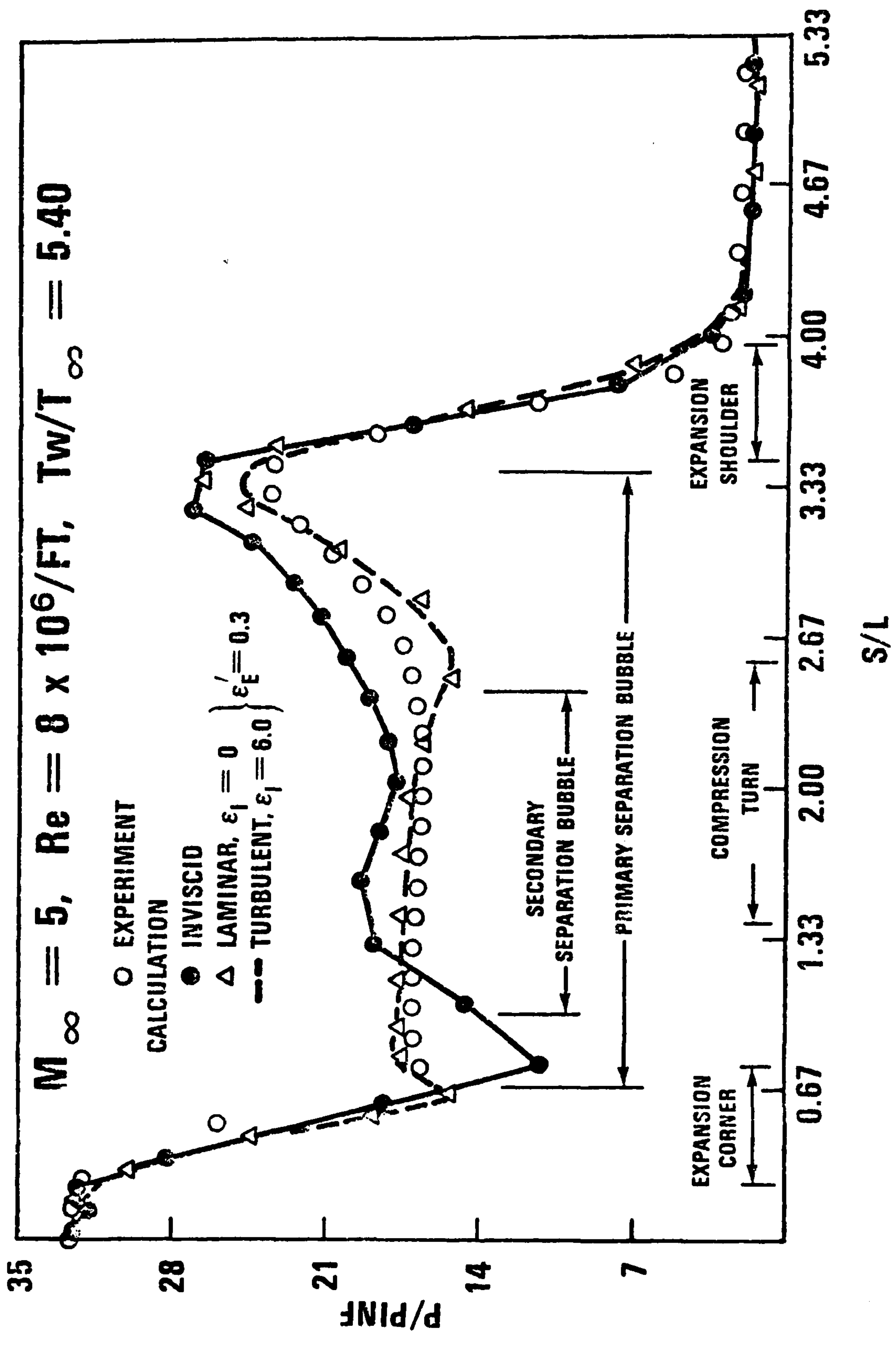


FIGURE 18. COMPARISON OF SURFACE PRESSURE BETWEEN K-C-L CODE SOLUTION AND EXPERIMENT FOR MODEL 4

The most troublesome result obtained from the K-C-L code for Model 4 is the heat transfer rate. For S/L > 0.68 (after flow separation) the heat transfer rate becomes negative which is not realistic.

For Model 1, there is a sharp expansion corner with a radius of 0.062 inch. Three grid points were used to cover the corner as was done for the inviscid calculation and a total grid points of 33 x 32 were used for the viscous calculation. Only laminar solution can be obtained. As shown in Fig. 19 and 20, while the inviscid solution agrees reasonably well with the measured data for both the shock location and the surface pressure, the laminar solution is very poor. The reason is that the flow separates immediately after the corner and form a large primary separation bubble as shown in Fig. 19. Within the primary separation bubble, there is also a secondary separation bubble around the location of compression turn. As a result of the primary separation bubble, the laminar shock layer becomes thicker near the separation bubble and thinner afterwards as compared to the measured data. The surface pressure obtained from the laminar solution looks entirely wrong as shown in Fig. 20.

It was not possible to obtain a turbulent solution for Model 1, not even one like that of Model 4. The obvious reason is that the laminar solution is too far off from the measured data, which is assumed to be close to the turbulent solution, therefore the starting flowfield is too poor to carry through the calculation.

With all the troubles in simulating the viscous flowfield, particularly the temperature field, an effort was made to repeat the results given in Fig. 5-8 of Ref. 1 for a hemisphere-cylinder with adiabatic wall at $M_\infty = 2.94$ $Re_\infty = 2.2 \times 10^5$ and To = 293°K. It was found not possible to duplicate the temperature results given in Fig. 7 of Ref. 1 with the K-C-L code, but the obtained surface pressure and shock shape do repeat well. Therefore, a reanalysis was carried out for the entire calculation procedure as shown in Sections 2 and 3 and also all the viscous subroutines were rewritten. As given in the next section, a significant improvement of the results of temperature field is obtained.

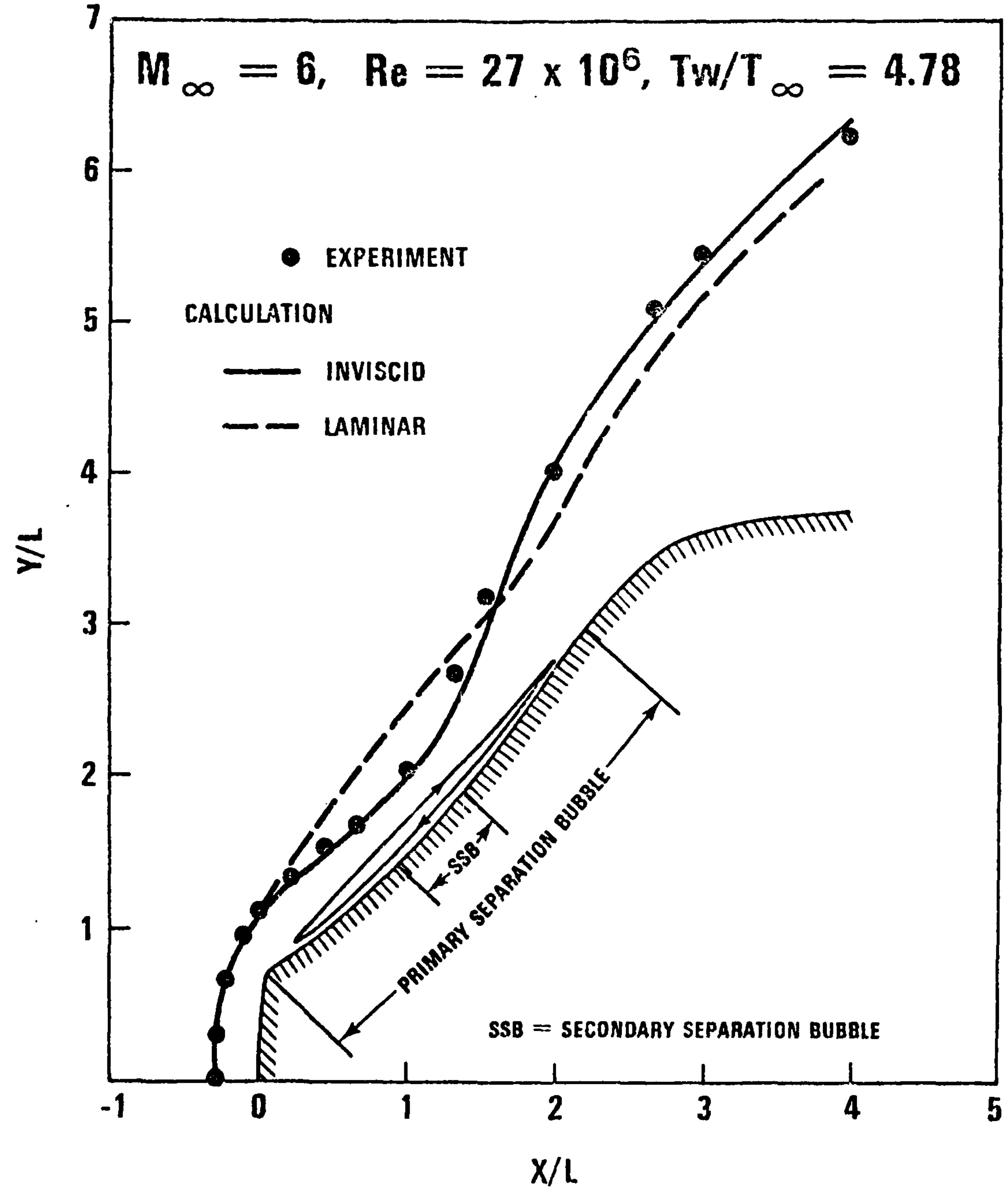


FIGURE 19. COMPARISON OF SHOCK LOCATION BETWEEN K-C-L CODE SOLUTION AND EXPERIMENT FOR MODEL 1

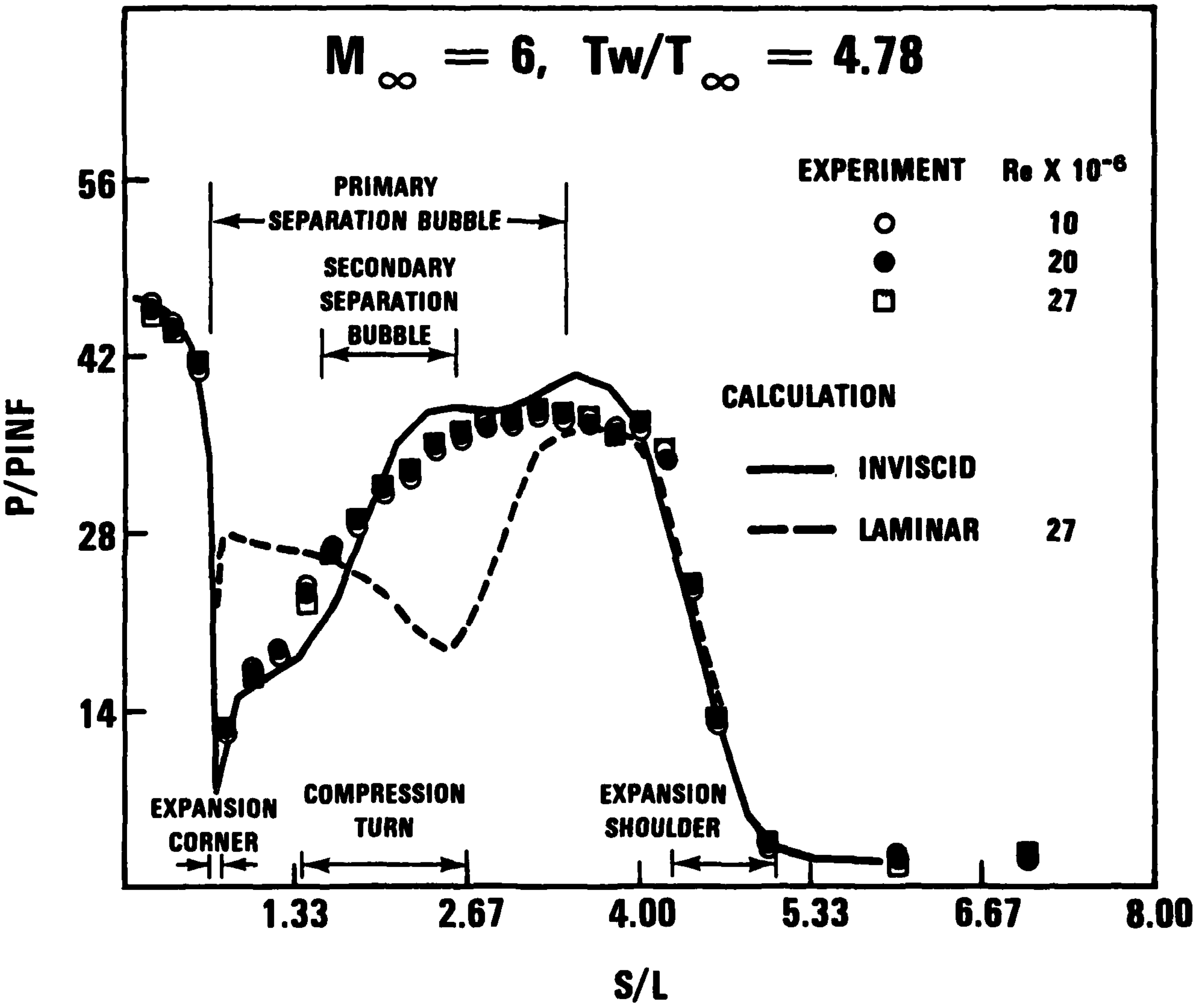


FIGURE 20. COMPARISON OF SURFACE PRESSURE BETWEEN K-C-L CODE SOLUTION AND EXPERIMENT FOR MODEL 1

CHAPTER 7

VISCOUS FLOW CALCULATIONS USING THE NEW CODE

A modification of the K-C-L code by rewritten all the viscous subroutines has been accomplished and calculations were performed for laminar flows over a hemisphere-cylinder and a sphere-cone using the meshes A, B, C and D given in Table 2 (section 4.2). Comparison of results is described in this section. Because of the termination of support, calculations for indented nosetips and incorporation of turbulent model have not been carried out.

7.1 Hemisphere - Cylinder

The results for hemisphere-cylinder with adiabatic wall at M_∞ of 2.94, Re_∞ of 2.2 x 10^6 and To of 293°K are given in Figs. 21 to 23. Figure 21 shows the temperature distribution T/T_∞ over the body surface. It is seen that the results obtained from Mesh B and C agree quite well but not that given by Mesh A which provides not enough points in the viscous layer. As shown in Table 2, the distribution of mesh point differs significantly between Mesh B and C and the solutions agree well (temperature is a more sensitive variable than other variables). Thus, it is necessary to provide sufficient grid points to resolve the viscous effects near the surface, such as that given by Mesh B or C. Also plot in Fig. 21 is the solution of Viviand and Ghazzi[10] who solved the full Navier-Stokes equation and slight differences are found in the area near the shoulder between his and the present solution. It was unable to produce the results of Kulter et al as given in Fig. 7 of Ref. 10 from the copy of computer code supplied by him. The result of T/T_∞ given by Kutler's code using Mesh B is shown in dotted line which is obviously wrong. Kutler et al also indicated that temperature is a mesh dependent variable, it seems not so as seen from the present results of Mesh B and C given in Fig. 21.

The temperature profile at three stations obtained from Mesh B and C are shown in Fig. 22, the agreement with the solution of Viviand and Ghazzi at slightly different station (given in parenthesis) is good. The shock shape and surface pressure are plotted in Fig. 23. It is interesting to note that these two quantities are not as sensitive as temperature and all solutions, including the one obtained using the K-C-L code, agree well.

7.2 Sphere-Cone

The results for sphere-cone with cone half angle of 9.75 deg and with isothermal wall of $Tw/T_\infty = 4.4$ at $M_\infty = 5.92$ and $Re_\infty = 10^6$ are shown in Fig. 24-26. In hemisphere-cylinder calculation, it is noted that Mesh B gives as accurate results as Mesh C but with much less computing time, thus the same value of $\beta = 1.005$ is chosen for sphere-cone calculation. In order to compare heat transfer with boundary layer calculation, it is important that the surface pressure used in the boundary layer calculation must be consistent with that obtained from the

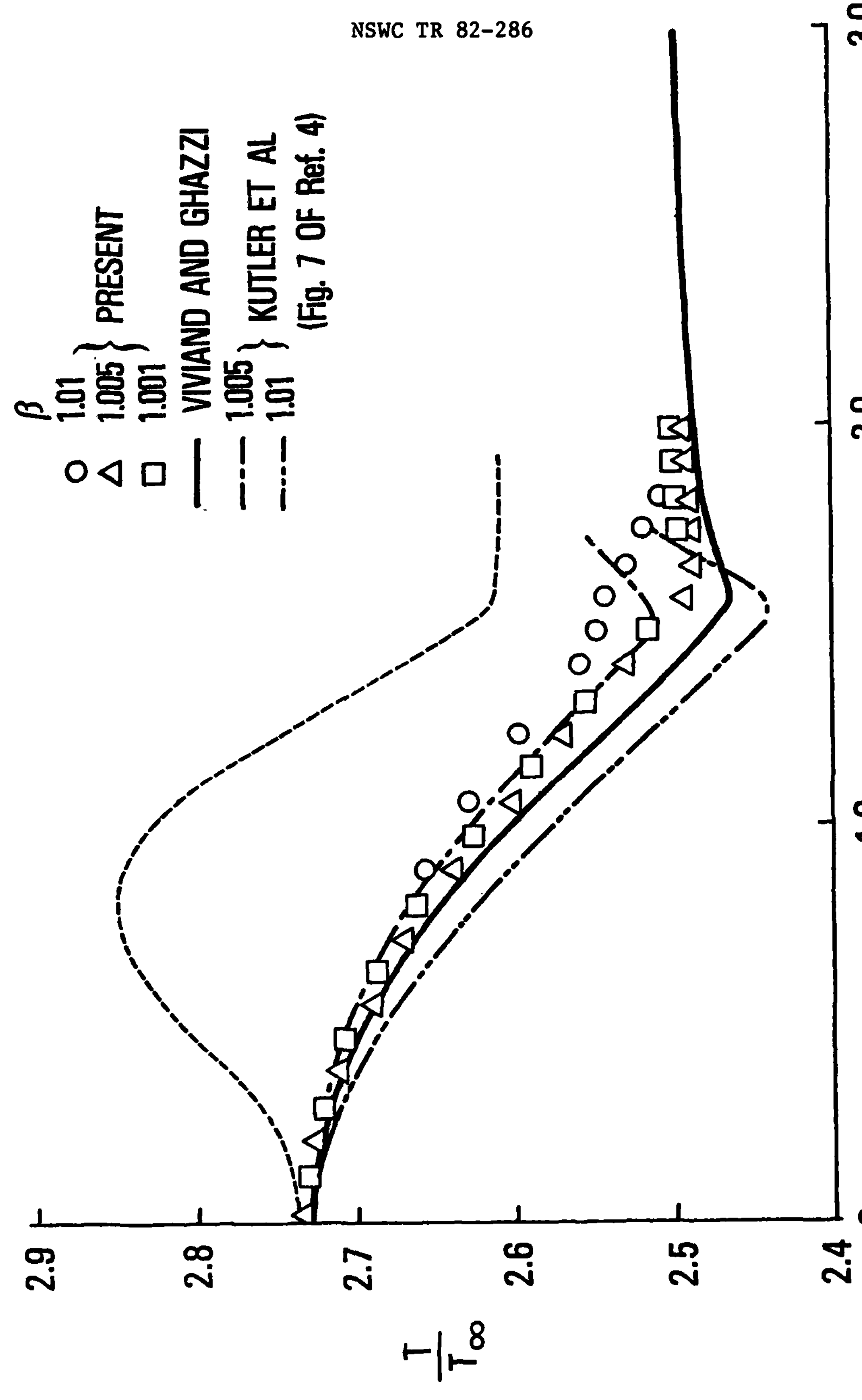


FIGURE 21. SURFACE TEMPERATURE DISTRIBUTION FOR HEMISPHERE-CYLINDER WITH ADIABATIC WALL AT $M_\infty = 2.94$, $Re_\infty = 2.2 \times 10^5$ AND $T_o = 293^oK$

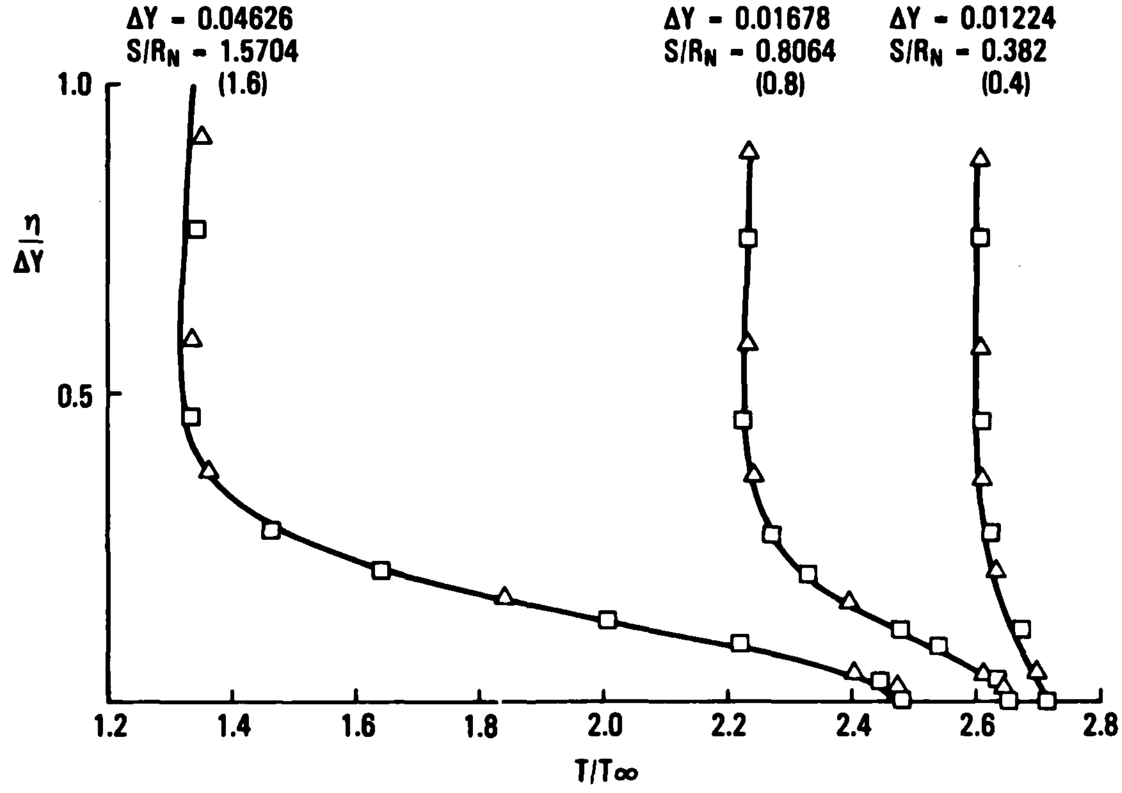


FIGURE 22. TEMPERATURE PROFILE NORMAL TO SURFACE AT DIFFERENT STATIONS FOR HEMISPHERE-CYLINDER WITH ADIABATIC WALL AT $M_\infty = 2.94$, $Re_\infty = 2.2 \times 10^5$ AND To = 293°K

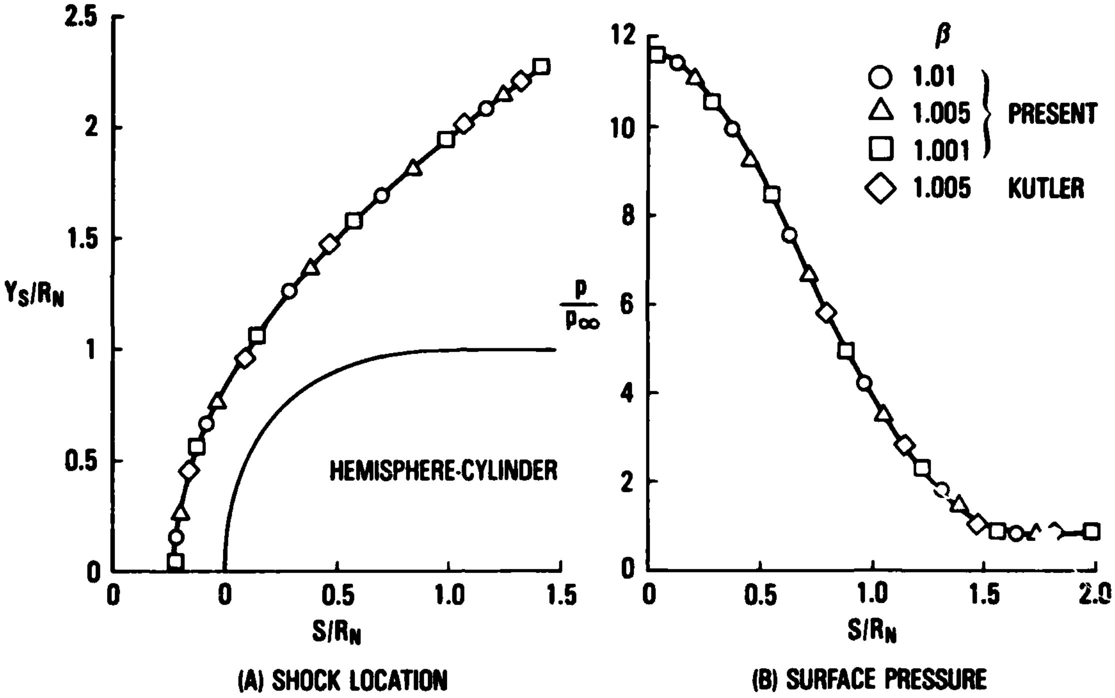


FIGURE 23. COMPARISON OF SHOCK LOCATION AND SURFACE PRESSURE FOR HEMISPHERE-CYLINDER WITH ADIABATIC WALL AT $M_\infty = 2.94$, $Re_\infty = 2.2 \times 10^5$ AND $T_o = 293^\circ K$

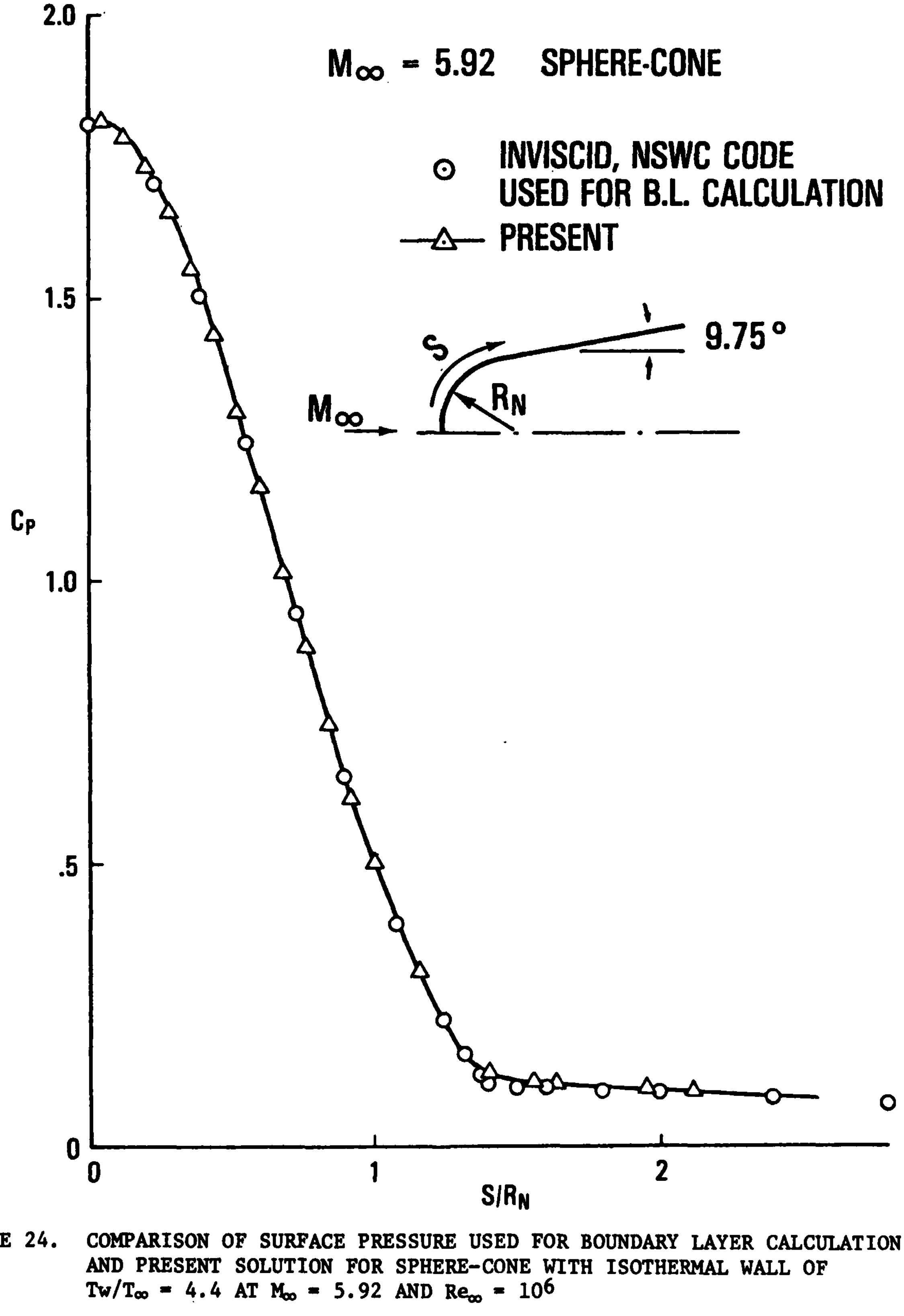


FIGURE 24. COMPARISON OF SURFACE PRESSURE USED FOR BOUNDARY LAYER CALCULATION AND PRESENT SOLUTION FOR SPHERE-CONE WITH ISOTHERMAL WALL OF $T_w/T_\infty = 4.4$ AT $M_\infty = 5.92$ AND $Re_\infty = 10^6$

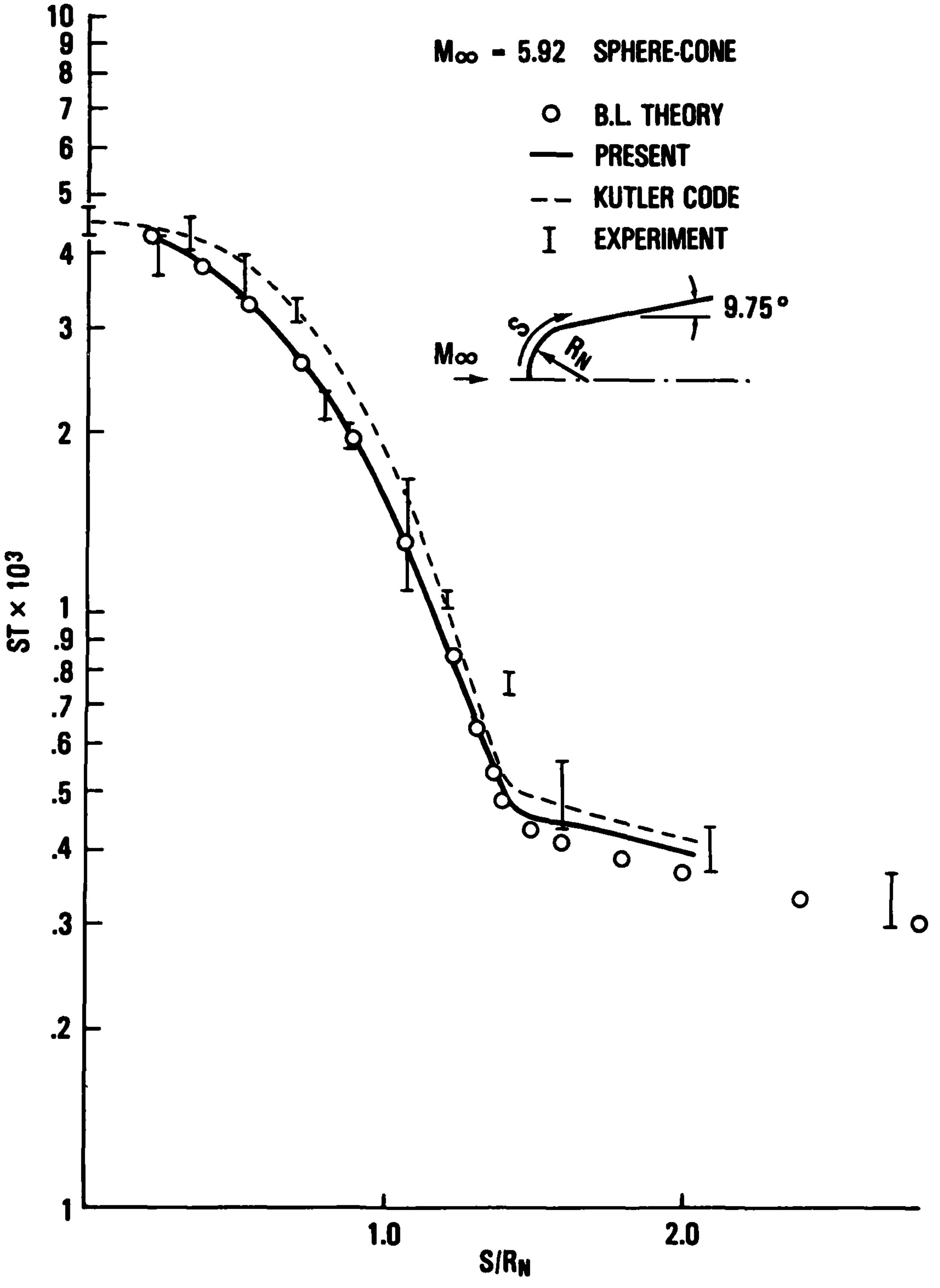


FIGURE 25. HEAT TRANSFER DISTRIBUTION IN TERMS OF STANTON NUMBER OF SPHERE-CONE WITH ISOTHERMAL WALL OF $T_w/T_\infty = 4.4$ AT $M_\infty = 5.92$ AND $Re_\infty = 10^6$

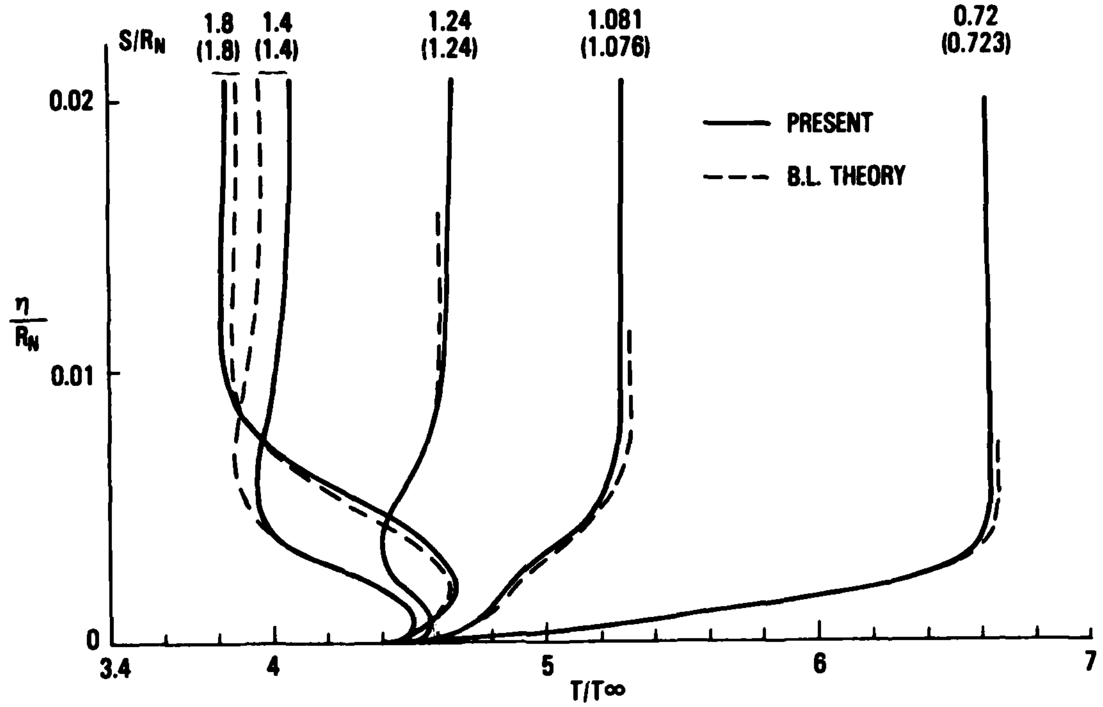


FIGURE 26. COMPARISON OF TEMPERATURE PROFILE NORMAL TO SURFACE BETWEEN PRESENT SOLUTION AND BOUNDARY LAYER CALCULATION FOR SPHERE-CONE WITH ISOTHERMAL WALL OF $T_w/T_\infty = 4.4$ AT $M_\infty = 5.92$ AND $Re_\infty = 10^6$

present solution. In Fig. 24 a comparison is made for the surface pressure between the present solution and the inviscid surface pressure solution (using a blunt body code developed at NSWC)[21] used in the boundary layer calculation. The agreement is excellent except at the shoulder where slight difference is shown. The Stanton number distribution is given in Fig. 25. It is seen that the agreement between present solution and the boundary layer calculation is surprisingly good up to the shoulder, from there on slight difference is shown. The solution obtained with K-C-L code gives overall higher values of ST. Because of wide spread in the experimental data, all calculations seem to fall within the experimental error band.

A comparison of temperature profile at several stations between present calculation and that of boundary layer calculation (Station given in parenthesis) is given in Fig. 26. The agreement is good. At station S/Rn = 1.4, i.e. the shoulder, again the difference is larger. The good agreement of present calculation with boundary layer calculation for the temperature field is a good check of the code since the surface pressure distributions in both cases agree well.

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[21] Courant, R., and Hilbert, D., "Methods of Mathematical Physics," Vol. 2, Interscience, New York, 1062, pp. 558-605.

CHAPTER 8

SUMMARIES AND RECOMMENDATIONS

1. Extensive applications of the K-C-L code, which solves the Euler or Navier-Stokes equations with thin-layer approximation, have been performed for inviscid and viscous flows over smooth (hemisphere-cylinder and sphere-cone) and indented (given in Section 4.1 or Fig. 3) nosetips at hypersonic speed. Comparisons of calculated results and measured data are made for surface pressure, shock location and heat transfer rate.

2. The inviscid portion of the K-C-L code works well for smooth nosetips. For indented nosetip calculations, a special calculation procedure has been developed in order to run the code and reasonable solutions for surface pressure are obtained as compared to the measured data when the separation bubble is small.

3. The calculated inviscid flowfields for the series of indented nosetips under investigation indicate that there is no strong embedded shock or slip surface within the shock layer for the cases investigated. The most serious aerodynamic problem for this series of nosetips is flow separation, which requires a solution to the Navier-Stokes equations.

4. Because of the poor results of the temperature field given by the K-C-L code, a reanalysis of the complete calculation procedure has been carried out as given in Sections 2 and 3 and all the viscous subroutines have been rewritten.

5. The modified code gives good results for the temperature field as demonstrated for the cases of laminar flow over hemisphere-cylinder and sphere-cone. It is believed that the modified code can provide reliable prediction of laminar flowfield for nosetips without flow separation.

6. In order to predict indented nosetip with large separation bubble, it is necessary to extend the present code to include: (i) a solution to the full Navier-Stokes equations with considerable more grids available to cover the separated region and (ii) a good trubulence model (to be searched and tested) since the flow is likely to be turbulent after separation.

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APPENDIX A

JACOBIAN MATRICES FOR A, B, K, L, M, N, P, Q

The Jacobian matrices used in Eq. 2.7 are listed in the following:

$$A \text{ or } B = \left[\begin{array}{c:c:c:c}
k_o & k_1 & k_2 & 0 \\
\hline
k_1 c_1 - u(k_1 u + k_2 v) & k_o - k_1(\gamma-2)u + k_1 u + k_2 v & -k_1(\gamma-1)v + k_2 u & k_1(\gamma-1) \\
\hline
k_2 c_1 - v(k_1 u + k_2 v) & k_1 v - k_2(\gamma-1)u & k_o - (\gamma-2)k_2 v + k_1 u + k_2 v & k_2(\gamma-1) \\
\hline
(k_1 u + k_2 v)(2c_1 - \frac{\gamma e}{\rho}) & (\frac{\gamma e}{\rho} - c_1)k_1 - (\gamma-1)(k_1 u + k_2 v)u & (\frac{\gamma e}{\rho} - c_1)k_2 - (\gamma-1)(k_1 u + k_2 v)v & k_o + (k_1 u + k_2 v)
\end{array}\right] \qquad (A.1)$$

where $c_1 = (\gamma-1)(u^2+v^2)$ and k_o, k_1 and k_2 can be found in Eq. (4.3).

$$K = \frac{1}{y}\left[\begin{array}{c:c:c:c}
0 & 0 & 1 & 0 \\
\hline
-uv & v & u & 0 \\
\hline
-v^2 & 0 & 2v & 0 \\
\hline
v[c_1 - (e+p)/\rho] & -uv(\gamma-1) & \frac{1}{\rho}(e+p) - (\gamma-1)v^2 & \gamma v
\end{array}\right] \qquad (A.2)$$

$$L \text{ or } M = \frac{c_6}{J\rho}\begin{bmatrix} 0 & 0 & 0 & 0 \\ v(\ )_x & 0 & -(\ )_x & 0 \\ v(\ )_y & 0 & -(\ )_y & 0 \\ 2v\left[u(\ )_x+v(\ )_y\right] & -v(\ )_x & -\left[u(\ )_x+2v(\ )_y\right] & 0 \end{bmatrix} \qquad (A.3)$$

where ( ) = ξ for L and ( ) = η for M.

$$P \text{ or } Q = \frac{1}{J\rho}\begin{bmatrix} 0 & 0 & 0 & 0 \\ -(\ )_2u-(\ )_3v & (\ )_2 & (\ )_3 & 0 \\ -(\ )_3u-(\ )_4v & (\ )_3 & (\ )_4 & 0 \\ \begin{array}{l} -(\ )_5\left(\epsilon-\frac{u^2+v^2}{2}\right) \\ -(\ )_2u^2-2(\ )_3uv \\ -(\ )_4v^2 \end{array} & \begin{array}{c} -(\ )_5u+(\ )_2u \\ +(\ )_3v \\ \ \end{array} & \begin{array}{c} -(\ )_5v+(\ )_4v \\ +(\ )_3u \\ \ \end{array} & \begin{array}{c} (\ )_5 \\ \ \\ \ \end{array} \end{bmatrix} \qquad (A.4)$$

where ( ) = b for P and ( ) = c for Q.

$$N_1 = \frac{1}{J\rho y}\begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 3c_6v & 0 & -3c_6 & 0 \\ 2c_6v^2 & \frac{5}{3}d_2v_\eta & -\frac{5}{3}d_2u_\eta-2c_6v & 0 \end{bmatrix} \qquad (A.5)$$

$$N_2 = \frac{1}{\rho J y}\left[\begin{array}{c:c:c:c} 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 \\ \hline 0 & 0 & 0 & 0 \\ \hline 0 & \frac{5}{3}d_2 v_\xi & -\frac{5}{3}d_2 u_\xi & 0 \end{array}\right] \qquad (A.6)$$

where $d_2 = \mu\eta_x$ for N_1 and $d_2 = \mu\xi_x$ for N_2

$$W_1 \text{ or } W_2 = \frac{1}{Jy\rho}\left[\begin{array}{c:c:c:c} 0 & 0 & 0 & 0 \\ \hline -(d_1 u + d_2 v) & d_1 & d_2 & 0 \\ \hline -2d_1 v & 0 & 2d_1 & 0 \\ \hline -d_3(\varepsilon - \frac{u^2+v^2}{2} & -(c_7 - d_1)u & -(c_7 - \frac{4}{3}d_1)v & c_7 \\ -d_1(u^2 + \frac{4}{3}v^2) & -\frac{2}{3}d_2 v & +d_2 u & \\ -d_2\frac{uv}{3} & & & \end{array}\right] \qquad (A.7)$$

where for w_1: $d_1 = \mu\eta_y$, $d_2 = \mu\eta_x$, $d_3 = c_7$ and for w_2: $d_1 = \mu\xi_x$, $d_2 = \mu\xi_x$, $d_3 = b_6$.

APPENDIX B

DERIVATION OF EQ. (3.9)

To obtain Eq. (3.9) through characteristic analysis is briefly described in this appendix. The background of characteristic theory and characteristic compatibility conditions may be found in Ref. B-1 and their applications in fluid dynamic may be found in Ref. B-2.

Equation (1.1) for inviscid flow is

$$\bar{U}_t + \bar{E}_x + \bar{F}_y + \frac{\bar{F} + \bar{H}}{y} = 0 \tag{B.1}$$

It is preferred to change the dependent variable from $\bar{U}$ to $\bar{Q}$,

$$\bar{Q} = \begin{pmatrix} \rho \\ u \\ v \\ p \end{pmatrix} \tag{B.2}$$

The resulting equation is

$$\bar{Q}_t + B_o\bar{Q}_x + C_o\bar{Q}_y + D_o = 0 \tag{B.3}$$

where

$$B_o = \begin{pmatrix} u & \rho & 0 & 0 \\ 0 & u & 0 & 1/\rho \\ 0 & 0 & u & 0 \\ 0 & \gamma p & 0 & u \end{pmatrix}$$

$$C_o = \begin{pmatrix} v & 0 & \rho & 0 \\ 0 & v & 0 & 0 \\ 0 & 0 & v & 1/\rho \\ 0 & 0 & \gamma p & v \end{pmatrix}$$

$$D_o = \frac{v}{y}\begin{pmatrix} \rho \\ 0 \\ 0 \\ \gamma p \end{pmatrix}$$

The characteristic matrix for Eq. (3.3) is

$$A_o^* \ (\lambda_1, \lambda_2, \lambda_3) = \lambda_1 I + \lambda_2 B_o + \lambda_3 C_o$$

$$= \begin{pmatrix} \sigma_o & \lambda_2\rho & \lambda_3\rho & 0 \\ 0 & \sigma_o & 0 & \lambda_2/\rho \\ 0 & 0 & \sigma_o & {}_3/\rho \\ 0 & \lambda_2\gamma p & \lambda_3\gamma p & \sigma_o \end{pmatrix} \tag{B.4}$$

where $\sigma_o = \lambda_1 + u\lambda_2 + v\lambda_3$ (B.4a)

With the transformation of Eq. (1.4), Eq. (B.3) becomes

$$Q_\tau + B_1 Q_\xi + C_1 Q_\eta = -D_o \tag{B.5}$$

where

$$B_1 = \xi_t I + \xi_x B_o + \xi_y C_o$$

$$C_1 = \eta_t I + \eta_x B_o + \eta_y C_o$$

The characteristic matrix for Eq. (B.5) is

$$\begin{aligned} A_1^* \ (\bar\lambda_1, \bar\lambda_2, \bar\lambda_3) &= \bar\lambda_1 I + \bar\lambda_2 B_1 + \bar\lambda_3 C_1 \\ &= \bar\lambda_1 I + \bar\lambda_2 A_o^* \ (\xi_t, \xi_x, \xi_y) + \bar\lambda_3 A_o^* (\eta_t, \eta_x, \eta_y) \\ &= A_o^* (\bar\lambda_1 + \xi_t \bar\lambda_2 + \eta_t \bar\lambda_3, \xi_x \bar\lambda_2 + \eta_x \bar\lambda_3, \xi_y \bar\lambda_2 + \eta_y \bar\lambda_3) \\ &= A_o^* \ (\lambda_1, \lambda_2, \lambda_3). \end{aligned} \tag{B.6}$$

Hence

$$\begin{aligned} \lambda_1 &= \bar\lambda_1 + \xi_t \bar\lambda_2 + \eta_t \bar\lambda_3 \\ \lambda_2 &= \xi_x \bar\lambda_2 + \eta_x \bar\lambda_3 \\ \lambda_3 &= \xi_y \bar\lambda_2 + \eta_y \bar\lambda_3 \end{aligned} \tag{B.7}$$

The characteristic condition is

$$\det.\ A_0^* = \sigma_o^2\ [\sigma_o^2 - a^2(\lambda_2^2 + \lambda_3^2)] = 0 \qquad \text{(B.8)}$$

$$\sigma_o = 0 \qquad \text{(B.8a)}$$

$$\sigma_o = \pm\ a\sqrt{\lambda_2^2 + \lambda_3^2} \qquad \text{(B.8b)}$$

The characteristic curves $\phi(\tau,\ \xi,\ \eta)$ corresponding to the four distinct characteristic conditions of Eq. (B.8) have slopes:

$$\frac{d\xi}{d\tau}_{1,2} = \xi_t + u\xi_x + v\xi_y \qquad \text{(B.9a)}$$

$$\frac{d\eta}{d\tau}_{1,2} = \eta_t + u\eta_x + v\eta_y \qquad \text{(B.9b)}$$

for $\sigma_o = 0$ and

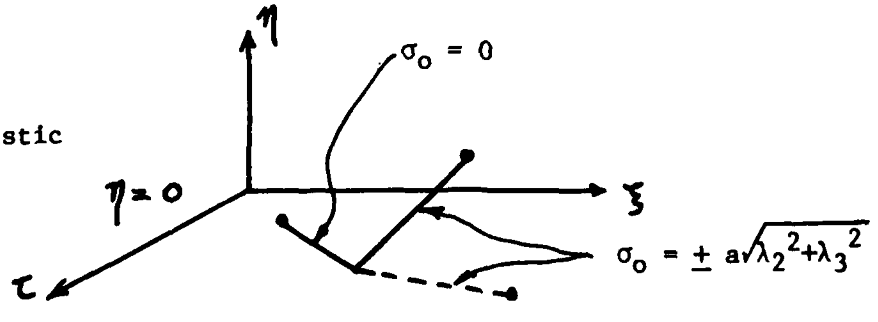
$$\left(\frac{d\xi}{d\tau}\right)_{3,4} = \xi_t + u\xi_x + v\xi_y - \frac{a^2}{\sigma_o}\ [(\xi_x^2 + \xi_y^2)\ \bar{\lambda}_2 + (\xi_x\eta_x + \xi_y\eta_y)\bar{\lambda}_3] \qquad \text{(B.10a)}$$

$$\left(\frac{d\eta}{d\tau}\right)_{3,4} = \eta_t + u\eta_x + v\eta_y - \frac{a^2}{\sigma_o}\ [(\eta_x\xi_x + \eta_y\xi_y)\bar{\lambda}_2 + (\eta_x^2 + \eta_y^2)\bar{\lambda}_3] \qquad \text{(B.10b)}$$

a

for $\sigma_o = \pm\ a\sqrt{\lambda_2^2 + \lambda_3^2}$. On the boundary $\eta = 0$, the physical boundary condition requires $\tilde{v} = \eta_t + u\eta_x + v\eta_y \equiv 0$, the slopes of $(d\eta/d\tau)_{1,2}$ are zero and that $\left(\frac{d\eta}{d\tau}\right)_{3,4} = \mp \frac{\quad}{a^2\sqrt{\lambda_2^2 + \lambda_3^2}}\ [\eta_x\xi_x + \eta_y\xi_y)\bar{\lambda}_2 + (\eta_x^2 + \eta_y^2)\bar{\lambda}_3]$. Hence, the admissible characteristic conditions are 1, 2 and 3 (see sketch)

Sketch of Bicharacteristic Directions



To obtain the compatability conditions corresponding to the three admissible characteristic conditions 1, 2 and 3, one finds the left null vector $\vec{\ell}_1$, $\vec{\ell}_2$ and $\vec{\ell}_3$ by requiring

$$\ell \cdot A_1^* = 0 \qquad \text{(B.11)}$$

Then,

$$\vec{\ell}_1 = (0,\ \lambda_3\eta_y,\ -\lambda_3\eta_x, 0) \qquad \text{(B.12a)}$$

$$\vec{\ell}_2 = (\ p,\ 0,\ 0,\ \rho) \qquad \text{(B.12b)}$$

$$\vec{\ell}_3 = (0,\ -\frac{\eta_x \gamma P}{a\sqrt{\eta_x^2 + \eta_y^2}}\ ,\ -\frac{\eta_y \gamma P}{a\sqrt{\eta_x^2 + \eta_y^2}}\ ,1 \qquad \text{(B.12c)}$$

where the case of $\lambda_2 = 0$ and $\lambda_3 \neq 0$ is considered. The compatability condition is then obtained by

$$\vec{\ell} \cdot A_1^* (1,0,0)\ Q_t + \vec{\ell} \cdot A_1^* (0,1,0)\ Q_x + \vec{\ell} \cdot A_1^*(0,0,1)\ Q_y + \vec{\ell} \cdot D_o = 0 \qquad \text{(B.13)}$$

It is noted that the compatibility conditions for ℓ_1 and ℓ_2 are the equations for a fluid particle or streamlines,

For ℓ_1:

$$\eta_y\ (u_t + uu_x + vu_y + \frac{p_x}{\rho}\ ) \mp \eta_x(v_t + uv_x + vv_y + \frac{p_y}{\rho} = 0 \qquad \text{(B.14)}$$

which is automatically satisfied when the momentum equations are satisfied, and

$$\rho_t + (\rho u)_x + (\rho v)_y - \frac{1}{a^2}(p_t + up_x + vp_y) = 0 \qquad \text{(B.15)}$$

which is the principle of constancy of particle entropy. Thus Eqs. (B.14) and (B.15) describe a particle path. The last compatibility condition is

$$\begin{aligned} p_\tau = &- \frac{\rho a}{\sqrt{\eta_x^2 + \eta_y^2}}\ (\eta_{t\tau} + u\eta_{x\tau} + v\eta_{y\tau}) \\ &+ a\sqrt{\eta_x^2 + \eta_y^2}\ p_\eta - \rho a^2(\xi_x u_\xi + \xi_y v_\xi + \eta_x u_\eta + \eta_y v_\eta) - \rho a^2 \frac{v}{y} \\ &- \tilde{u} p_\xi + \frac{a}{\sqrt{\eta_x^2 + \eta_y^2}}\ [\eta_x(\rho\tilde{u}u_\xi + \xi_x p_\xi) + \eta_y(\rho\tilde{u}v_\xi + \xi_y p_\xi)] \end{aligned} \qquad \text{(B.16)}$$

Therefore, the pressure on body surface can be integrated. Once the pressure is obtained the rest of the flow variables may be determined by the isentropic relations as described in section 3.

REFERENCES

B-1 Courant, R., and Hilbert, D., "Methods of Mathematical Physics," Vol. 2, Interscience, New York, 1962, pp. 558-605.

B-2 Kentzer, C. P., "Discretization of Boundary Conditions on Moving Discontinuities," Lecture Notes in Physics, published by Springer-Verlag, No. 8, Sep 1970, pp. 108-113.

APPENDIX C

CALCULATION OF δ FOR INDENTED NOSETIP SHAPES

For indented nosetip shapes given in Fig. 3, expressions for the body point $(x_b(\theta), y_b(\theta))$ and distance of deformation $\delta(\theta)$ are listed in the following.

Given: control points (XPn, YPn), n = 1 to 7

Rn: n = 1 to 4

βn: n = 1 to 3

The centers of circular arc for expansion corner, compression turn and expansion shoulder are:

$$X_{01} = R_1 \text{ (for flat nose } R_1 \rightarrow \infty)$$

$$X_{02} = XP_2 + R_2 * \cos \beta_1$$

$$X_{02} = YP_2 - R_2 * \sin \beta_1$$

$$X_{03} = XP_3 - R_3 * \cos \beta_1$$

$$Y_{03} = YP_3 + R_3 \sin \beta_1$$

$$X_{04} = XP_5 + R_4 \cos \beta_2$$

$$Y_{04} = YP_5 - R_4 \sin \beta_2$$

Let the center of the sphere-cone be located at $(X_{oo}, 0)$. The value of X_{oo} (radius for the sphere) must be greater than XP_6. Then the θn for each control point are given by:

$$\theta_1 = \tan^{-1}(YP_1/(X_{01} - XP_1))$$

$$\theta_2 = \tan^{-1}(YP_2/(X_{01} - XP_2))$$

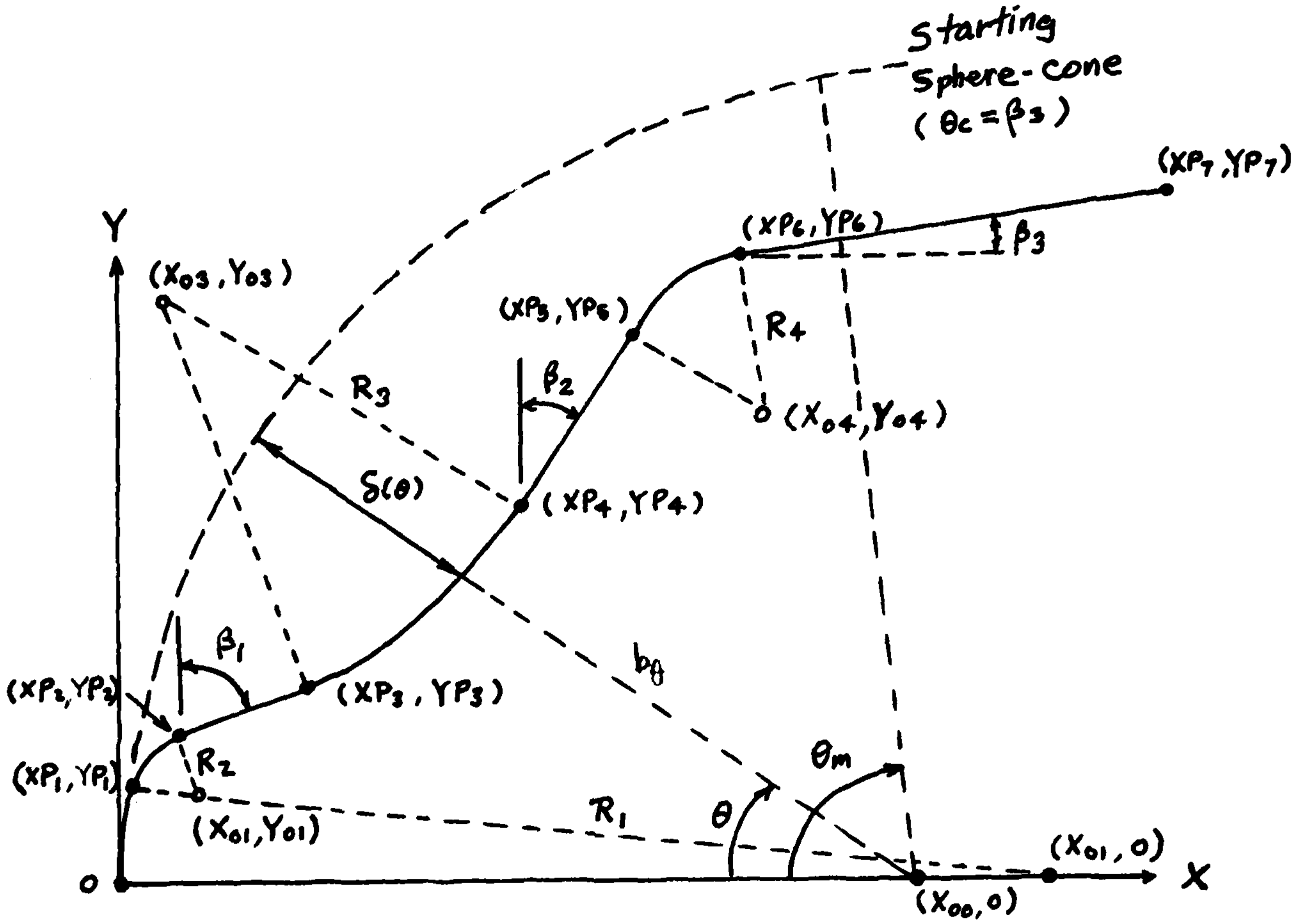
$$\theta_3 = \tan^{-1}(YP_3/(X_{01} - XP_3))$$

$$\theta_4 = \tan^{-1}(YP_4/(X_{01} - XP_4))$$

$$\theta_5 = \tan^{-1}(YP_5/(X_{01} - XP_5))$$

$$\theta_6 = \tan^{-1}(YP_6/(X_{01} - XP_6))$$

To find the X_b value for a given θ, the expressions are:



$$0 < \theta \leq \theta_1: \quad X_b = B - \sqrt{B^2 - C}$$

$$A = X_{oo} \tan\theta$$

$$B = X_{01}\cos^2\theta + X_{oo}\sin^2\theta$$

$$C = (X_{01} + A^2 - R_1{}^2)\cos^2\theta$$

$$\theta_1 < \theta \leq \theta_2: \quad X_b = B - \sqrt{B^2 - C}$$

$$A = X_{oo}\tan\theta - Y_{02}$$

$$B = (X_{02} + A\tan\theta)\cos^2\theta$$

$$C = (X_{02}{}^2 + A^2 - R_2{}^2)\cos^2\theta$$

$\theta_2 < \theta \leq \theta_3$: $X_b = (XP_2 + A \tan \beta_1)/(1 + \tan \theta \tan \beta_1)$

$A = X_{oo} \tan \theta - YP_2$

$\theta_3 < \theta \leq \theta_4$: $X_b = B + \sqrt{B^2 - C}$

$A = X_{oo} \tan \theta - Y_{03}$

$B = (X_{03} + A \tan \theta) \cos^2\theta$

$C = (X_{03}{}^2 + A^2 - R_3{}^2) \cos^2\theta$

$\theta_4 < \theta \leq \theta_5$: $X_B = (XP_4 + A \tan \beta 2)/(1 + \tan \theta \tan \beta_2)$

$A = X_{oo} \tan \theta - YP_4$

$\theta_5 < \theta \leq \theta_6$: $X_B = B - \sqrt{B^2-C}$

$A = X_{oo} \tan \theta - Y_{04}$

$B = (X_{04} + A \tan \theta) \cos^2\theta$

$C = (X_{04}{}^2 + A^2 - R_4{}^2) \cos^2\theta$

$\theta_6 < \theta < \theta_m$: $X_B = (XP_6 + A/\tan \beta_3)/(1 + \tan \theta/\tan \beta_3)$

$A = X_{oo} \tan \theta - YP_6$

The corresponding Y_b and δ are given by:

$$Y_b = (X_{oo} - x) \tan \theta$$

$$\delta = X_{oo} \left[1 - \left(1-\frac{X}{X_{oo}}\right)/\cos \theta\right]$$

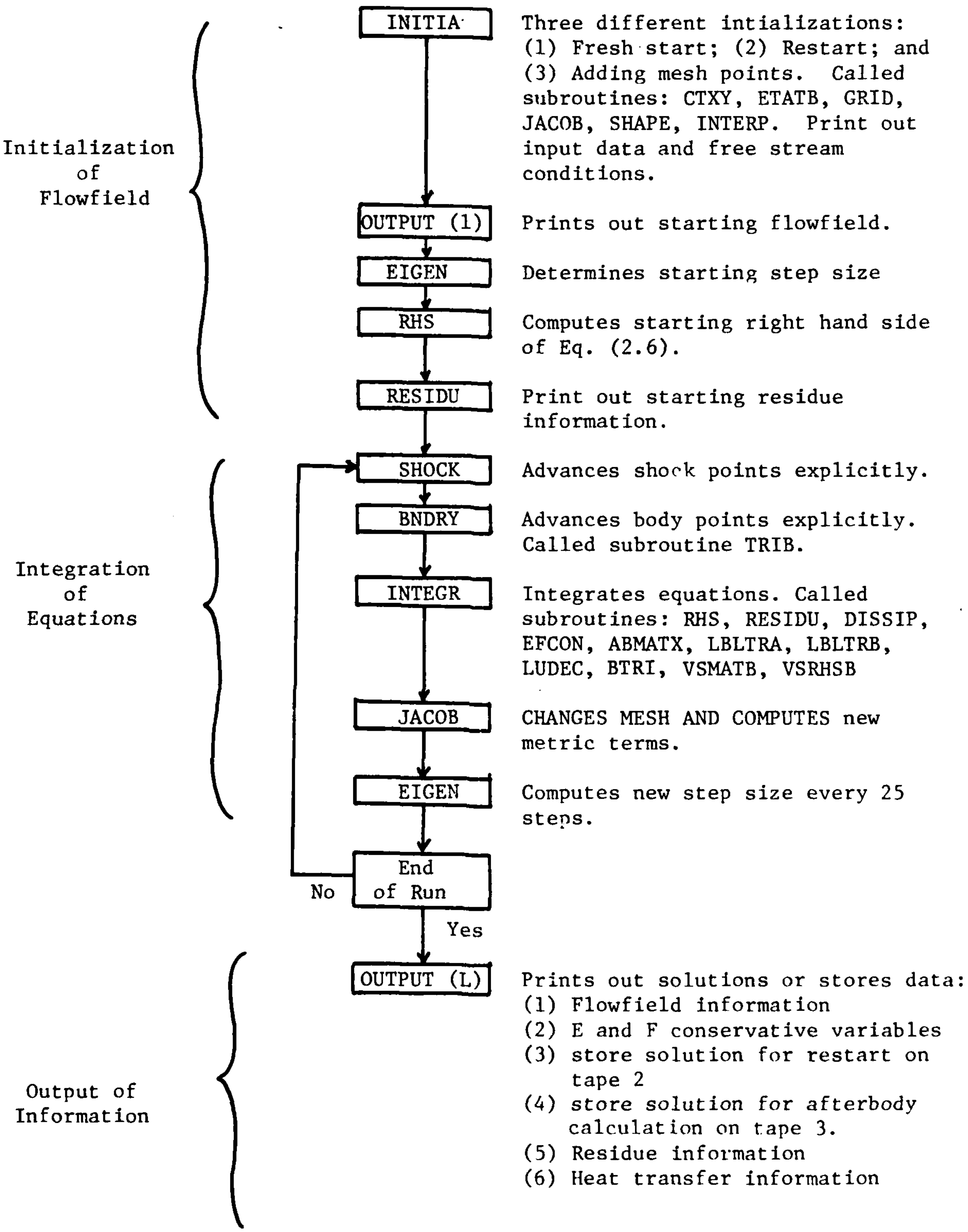
Therefore, a sphere-cone with nose radius equals to X_{oo} and cone half angle $\theta_C = \beta_3$ is used as the initialized shape and let it deformed to the desired indented nosetip shape.

APPENDIX D

PROGRAM DESCRIPTION AND OPERATING MANUAL

This computer program contains one main program called NOSETIP and twenty four subroutines. The main program NOSETIP serves as a flow chart as given in Fig. D1 which also describe the structure of the computer program. A brief description of the function of each subroutine is given in Table D2. A listing of important Fortran symbols is given in Table D3 and the complete listing of the program follows.

The operating manual is best described by the input data cards for different cases that the computer program can handle. This is given in Table D4. The corresponding examples, seven all together, and the output data are separately described immediately after Table D4.



Three different intializations: (1) Fresh start; (2) Restart; and (3) Adding mesh points. Called subroutines: CTXY, ETATB, GRID, JACOB, SHAPE, INTERP. Print out input data and free stream conditions.

Prints out starting flowfield.

Determines starting step size

Computes starting right hand side of Eq. (2.6).

Print out starting residue information.

Advances shock points explicitly.

Advances body points explicitly. Called subroutine TRIB.

Integrates equations. Called subroutines: RHS, RESIDU, DISSIP, EFCON, ABMATX, LBLTRA, LBLTRB, LUDEC, BTRI, VSMATB, VSRHSB

CHANGES MESH AND COMPUTES new metric terms.

Computes new step size every 25 steps.

Prints out solutions or stores data:
(1) Flowfield information
(2) E and F conservative variables
(3) store solution for restart on tape 2
(4) store solution for afterbody calculation on tape 3.
(5) Residue information
(6) Heat transfer information

FIGURE D1. FLOW CHART

Table D2. Brief Description of Subroutines

Subroutine Name	Function
ABMATX(J,K,I):	Computes coefficients for matrix A(I=1) and B(I=2) as given by Eq. (A.1) at nodal point (J,K)
BNDRY:	Advances explicitly the body boundary condition in time see body points in section 3.0.
BTRI(IL,IU):	Solves a block tridiagonal system of equations. IL and IU denote the starting and finishing indices.
CTXY(XAA, YAA, DED, BF, CT):	Obtains (x,y) δ and b_θ values corresponding to a given θ (=CT in radian) value for the nosetip shape described in Appendix C.
DISSIP:	Computes the explicit dissipation terms.
EFCON(J,K,I):	Computes the conservative flux terms given by E (with I=1) and F(with I=2) at nodal point (J,K).
EIGEN:	Computes step size for given CN by Eq. (4.5).
ETATB(ET,CF,KMAX):	Computes the mesh distribution in η direction according to Eq. (4.2a) with CF = β.
GRID:	Sets up a grid in the physical plane at the starting of a new computation.
INITIA:	Initializes the flowfield and prints out the freestream conditions and inputs.
INTEGR:	Integrates the system of equations in time. First sweep over ξ direction and then η direction.
INTERP:	Interpolates the flow variables when more grid points are needed at the beginning of a continuation run.
JACOB:	Computes the matrices given by Eq. (2.6).
LBLTRA(K):	Computes all the block matrices for all J arrays in ξ sweep, see Eq. (2.11).
LBLTRB(J):	Computes all the block matrices for all K arrays in η sweep, see Eq. (2.12).
LUDEC(A):	Computes L-U decomposition elements, for 2D problem A is (4 x 4) matrix.

OUTPUT(L):	Prints out results and other information identified by L (see operating manual).
RESIDU:	Computes residues at each nodal point.
RHS:	Computes the terms in the right hand side of Eq. (2.6) without the viscous part.
SHAPE:	Reads and writes the control parameters for the nosetip.
SHOCK:	Advances explicitly the shock boundary condition in time, see shock point in section 3.0.
TRIP:	Solves tridiagonal system of equations.
VSMATB(J):	Computes all the viscous terms in the block matrices for all k array in η sweep, see Eq. (2.12).
VSRHSB:	Computes all the viscous terms in the right hand side of Eq. (2.6)

Table D3. Listing of Important Fortran Symbols

Fortran Symbol	Description	Principal Defining Routine	Common Block
A(J,4,4)	Matrices for Φ_{j-1} or Φ'_{j-1} in Eq. (2.11) of (2.12).	LBLTRA LBLTRB	COM4
AB(4,4)	Elements for matrices A or B, Eq. (A.1)	ABMATX	COM3
B(J,4,4)	Matrices for Γ_j or Γ'_j in Eqs. (2.11) or (2.12)	LBLTRA LBLTRB	COM4
C(J,4,4)	Matrices for ψ_{j+1} or ψ'_{j+1} in Eqs. (2.11) of (2.12).	LBLTRA LBLTRB	COM4
C1	$\frac{1}{\rho}(\frac{\Delta t}{R_e})C_2/J$	VSMATB	VISC
C2	$\frac{1}{\rho}(\Delta t/R_e)C_3/J$	↓	↓
C3	$\frac{1}{\rho}(\Delta t/R_e)C_4/J$	↓	↓
C4	$\frac{1}{\rho}(\Delta t/R_e)C_5/J$	↓	↓
C5	$\frac{1}{\rho}(\Delta t/R_e)\cdot\frac{1}{3}\cdot\frac{1}{y^2}J$	↓	↓
C6	$\frac{1}{2}\cdot\frac{1}{\rho}(\Delta t/R_e)\frac{1}{y}\eta y$	↓	↓
C7	$\frac{1}{2}\ \frac{1}{\rho}(\Delta t/R_e)\frac{1}{y}\eta x$	↓	↓
CC	x stretching parameter in cone portion	GRID	COM1
CF	β in Eq. (4.2a)	ETATB	COM1
CINF	free stream sound speed	INITIA	COM1
CMUKAP	$(\mu/\mu_\infty) = (\frac{T}{T_\infty})^{1.5}(1 + \text{CVIS})/(\frac{T}{T_\infty} + \text{CVIS})$	VSMATB	VISK
CN	Courant number, Eq. (4.5)	INITIA	COM1
CS1	$\frac{1}{y}(\frac{\Delta t}{2R_e})\mu$	VSMATB	VISC
[illegible]	$\frac{1}{3}(\Delta t/R_e)\ (\frac{1}{\rho y2J})\ \eta_x\ V$	│	│

CS3	$\frac{1}{3}(\Delta t/R_e)(\frac{1}{\rho y2J})\eta_y\ V$	↓	↓
CS4	$\frac{1}{3}(\Delta t/R_e)(\frac{1}{\rho y2J})(\eta_x u + \eta_y\ V)$	↓	↓
CS5	$\frac{1}{3}(\Delta t/R_e)(1/\rho y2J)\eta_x$	↓	↓
CS6	$\frac{1}{3}(\Delta t/R_e)(1/\rho y2J)\eta_y$	↓	↓
CS7	$-\frac{\gamma}{P_r}(\frac{1}{2}\frac{\Delta t}{R_e J})\ \eta_y\ \frac{1}{\rho y}J$	↓	↓
CVIS	$110/T_\infty(^oK)$	INITIA	COM1
CVIS1	CVIS + 1.	INITIA	COM1
D(80,80)	J	JACOB	COM2
DT	ΔT	EIGEN	COM1
DETL(80)	Deformation $\delta(\theta)$ *FACTB	FACOB	COM1
DETT(80)	Deformation $\delta(\theta)$	GRID	COM1
EIINF	$\frac{p_\infty/\rho_\infty}{\gamma-1}$	INITIA	COM1
ENT	Entropy behind shock front, $(p_t/\rho_1)^\gamma$	INITIA	COM1
ET	$\bar{a}(k)$, Eq. (4.2a)	ETATB	COM1
ETING	Free stream internal energy of the gas	INITIA	COM1
FACTB	Fraction of deformation for current run	INITIA	COM1
FACTT	Fraction of total deformation	INITIA	COM1
GAM	γ	INITIA	COM1
GAMM1	$(\gamma-1)$	INITIA	COM1
GAMP1	$(\gamma+1)$	INITIA	COM1
GAM1I	$1/\gamma$	INITIA	COM1

H	$\Delta t/2$	EIGEN	COM1
HTINF	Free stream total enthalpy of the gas	INITIA	COM1
IAFBD	=1, store data for afterbody calculation =0, do nothing	INITIA	COM1
IGEM	=0 uniform points on sphere for sphere cone =1 read in XB, YB, XS, YS =2 read in PH(J) and DETT(J) for arbitrary body shape =3 uniform spacing for TH(J), calculate DETT(J) and determine XB, YB for indented nosetip. =4 read in TH(J), calculate DETT(J) and XB, YB for indented nosetip.	GRID	COM1
IPRT	=1 detailed printout from EIGEN =0 do nothing	INITIA	COM1
IR1	=1 read starting flowfield from tape 1 =0 do nothing	INITIA	COM1
IT	time step for current run	INITIA	COM1
ITER	total time steps for current run	INITIA	COM1
ITF	=1 printout heat transfer information =0 do nothing	INITIA	COM1
ITRAN	No. of stations at cone portion for θ to go to $\frac{\pi}{2}$	INITIA	COM1
ITS	accumulated time steps from fresh start	↓	↓
ITWA	= 1 Isothermal wall = 0 Adiabatic wall	↓	↓
IVIS	= 1 Viscous calculation = 0 Inviscid calculation	↓	↓
IW2	= 1 Write results on tape 2 = 0 do nothing.	↓	↓
J	Index for ξ direction	INITIA	COM1
JM	JMAX-1	INITIA	COM1

JMAX	Maximum J	INITIA	COM1
JNM	Value of J at junction of sphere and cone.	INITIA	COM1
JWRIT	Station with vertical flowfield data to be stored for afterbody calculation using SWINT.	OUTPUT	None
K	Index for η direction	INTIA	COM1
KM	KMAX-1	↓	↓
KMAX	Maximum K		
KRES	Interval for printout residues in K-plane		
LIP	Number of time steps to complete the body change in current run.		
OMEGA	Body radius; when IGEOM = 3 or 4, this value is recalculated by subroutine shape. = 0 for adding mesh points.		
PINF	Free stream pressure p_∞	INITIA	COM1
PRD	Prandtl number	↓	↓
PRT	Turbulent Prandtl number		
PT	P_t, total pressure, Eq. (2.22)		
PTORT	$P_t/\rho t$, Eq. (2.22)		
Q(80,80,4)	Vector U	INITIA	COM3
QINF	Free stream velocity of ∞	INITIA	COM1
REY	Reynolds number, $R_{e_\infty} (\frac{1}{\sqrt{\gamma} M_\infty})$	INITIA	COM1
REYIN	Read in $R_e = p_\infty q_\infty L/\mu_\infty$	INITIA	COM1
RINF	Free stream density, ρ_∞	INITIA	COM1
RR(80)	$1/\rho$	VSMATB	VISC
S(80,80,4)	Intermediate values of U vector	RHS	COM3
SINF	Free stream entropy S_∞	INITIA	COM3
SMU	Coefficient of explicit dissipation, ε_E	DISSIP	COM1
SMUIMP	Coefficient of implicit dissipation, ε_I	LBLTRA	COM1

TAU	Accumulated time, $\Sigma\, \Delta t$	INTEGR	COM1
TC(80)	$\frac{e}{p} + \frac{1}{2}(u^2 + v^2)$	VSRHSB	
TH(80)	θ array	INITIA	COM1
TM	Cone half angle in deg	INITIA	COM1
U	u	↓	↓
V	v	↓	↓
X(80,80)	x	JACOB	COM2
XB	Body mesh points	GRID	
XEX(80,80,I)	$I = 1,\ \xi_x,\ I = 2,\ \eta_x$	JACOB	COM2
XEY(80,80,I)	$I = 1,\ \xi_y,\ I = 2,\ \eta_y$	JACOB	COM2
XMACH	M_∞	INITIA	COM1
XS	Shock mesh points	GRID	
Y(80,80)	y	JACOB	COM2
YB	Body mesh point	GRID	
YS	Shock mesh point	GRID	

A LISTING OF COMPUTER PROGRAM

```
      PROGRAM NOSTIP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE1,TAPE2,
     1TAPE7,TAPE8)
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IW1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,RKD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),ITF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      COMMON/VISK/CMUKAP(40),TURMU(40,40)
C     INITIALIZE FLOWFIELD
      CALL INITIA
C     PRINT OUT STARTING SOLUTION
      CALL OUTPUT(1)
C     DETERMINE STEP SIZE
      CALL EIGEN
C     COMPUTE RESIDUE INFORMATION AT START OF EXECUTION
      CALL RHS
      CALL RESIDU
C     INTEGRATE EQUATIONS
      DO 1 I=ITS,ITER
      IT=IT+1
      CALL SHOCK
      CALL BNDRY
      CALL INTEGR
      CALL JACOB
      IF(MOD(I,25).EQ.0) CALL EIGEN
    1 CONTINUE
C     PRINT OUT SOLUTION
      CALL OUTPUT(1)
      IF(IVIS.EQ.0) GO TO 4
C     PRINT OUT HEAT TRANSFER INFORMATION.  ITF=0 WITHOUT HEAT TRANSFER
C     CAL., =1 FOR STANTON NO. ONLY, =2 TEMPERATURE FIELD ALSO
      IF(ITF.EQ.0) GO TO 4
      CALL OUTPUT(6)
    4 CONTINUE
C     STORE STARTING SOLUTION FOR AFTERBODY CALCULATION
C     IAFBD=1 FOR STORAGE OF STARTING DATA, =0 OTHERWISE
      IF(IAFBD.EQ.0) GO TO 3
      CALL OUTPUT(4)
    3 CONTINUE
C     STORE SOLUTION ON TAPE FOR RESTART
C     IW2=1 FOR STORAGE OF SOLUTION ON TAPE2 FOR RESTART, =0 OTHERWUSE
      IF(IW2.EQ.0) GO TO 2
      CALL OUTPUT(3)
    2 CONTINUE
C     OUTPUT DETAILED RESIDUE INFORMATION
C     PRINTOUT LOOP FOR K=1,KMAX,KRES AND FOR ALL J,KRES IS AN INPUT
      CALL RHS
      CALL RESIDU
      CALL OUTPUT(5)
      STOP
      END
```

```
      SUBROUTINE ABMATX(J,K,I)
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      COMMON/COM4/A(40,4,4),B(40,4,4),C(40,4,4),HD(40,4,4),
     1UD(40,4,4),AX(40),AY(40),BX(40),BY(40)
C...FORM JACOBIAN MATRICES AT A GIVEN J-K NODE POINT.  A MATRIX IF I=1,
C    B MATRIX IF I=2.
      XX=0.
      YY=XFX(J,K,I)
      ZZ=XFY(J,K,I)
      RI=1.0/Q(J,K,1)
      U=Q(J,K,2)*RI
      V=Q(J,K,3)*RI
      SS=GAMM1*0.5*(U*U+V*V)
      T=YY*U+ZZ*V
      W=GAM*Q(J,K,4)*RI
      AB(1,1)=XX
      AB(1,2)=YY
      AB(1,3)=ZZ
      AB(1,4)=0.0
      AB(2,1)=YY*SS-U*T
      AB(2,2)=XX-YY*(GAM-2.0)*U+T
      AB(2,3)=-YY*GAMM1*V+ZZ*U
      AB(2,4)=YY*GAMM1
      AB(3,1)=ZZ*SS-V*T
      AB(3,2)=YY*V-ZZ*GAMM1*U
      AB(3,3)=XX-ZZ*(GAM-2.0)*V+T
      AB(3,4)=ZZ*GAMM1
      AB(4,1)=T*(2.0*SS-W)
      AB(4,2)=(W-SS)*YY-GAMM1*T*U
      AB(4,3)=(W-SS)*ZZ-GAMM1*T*V
      AB(4,4)=XX+GAM*T
C...ADD SOURCE TERM IMPLICITLY
      IF(JCS.EQ.0.OR.I.EQ.1) RETURN
      YI=DT/Y(J,K)
      UD(K,1,1)=0.0
      UD(K,1,2)=0.0
      UD(K,1,3)=YI
      UD(K,1,4)=0.0
      UD(K,2,1)=-U*V*YI
      UD(K,2,2)=V*YI
      UD(K,2,3)=U*YI
      UD(K,2,4)=0.0
      UD(K,3,1)=-V*V*YI
      UD(K,3,2)=0.0
      UD(K,3,3)=2.0*V*YI
      UD(K,3,4)=0.0
      UD(K,4,1)=V*(2.0*SS-W)*YI
      UD(K,4,2)=-U*V*GAMM1*YI
      UD(K,4,3)=(W-SS-GAMM1*V*V)*YI
      UD(K,4,4)=V*GAM*YI
      RETURN
      END
```

```
          SUBROUTINE BNDRY
          COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
         1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORI,PINF,RINF,QINF,CINF,PT,ITS,
         2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITPAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
         3 TWA,ITWA,LIP,KRES,SMUIMP,HTINF,FTINF,SINF,ETINF,REYIN,SUM(40),
         4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTH,FACTT,REYNLD,PRTURB
          COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XEY(40,40,2),D(40,40)
          COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
          DIMENSION P(40,3),PXI(40),PETA(40),U(40,3),UXI(40),UETA(40),
         1V(40,3),VXI(40),VETA(40),R(40,3)
          DIMENSION T(40,3),BDIAG(40),DIAG(40),ADIAG(40),RIGHT(40)
          DIMENSION DUMMY(40),DCON(40),ECON(40)
C...      DATA C1,C2,C3/-3.0,4.0,-1.0/      THIS SET DATA USED FOR 3 POINT
C...                      ONE SIDED DERIVATIVE APPROXIMATION AT BODY BOUNDARY
C...      DATA C1,C2,C3/-2.0,2.0,-0.0/      THIS SET DATA USED FOR 2 POINT
C...                      ONE SIDED DERIVATIVE APPROXIMATION AT BODY BOUNDARY
          DATA C1,C2,C3/-3.0,4.0,-1.0/
C...USE REFLECTION TO SIMULATE PLANE OF SYMMETRY AT J=2
          DO 12 K=1,KMAX
          Q(1,K,1)=Q(2,K,1)
          Q(1,K,2)=Q(2,K,2)
          Q(1,K,4)=Q(2,K,4)
       12 Q(1,K,3)=-Q(2,K,3)
C...USE FIRST ORDER EXTRAPOLATION TO SIMULATE SUPERSONIC OUTFLOW
C...BOUNDARY CONDITION AT JMAX
          DO 1 N=1,4
          DO 1 K=1,KM
        1 Q(JMAX,K,N)=(2.0*Q(JM,K,N)-Q(JM-1,K,N))
          IF(IVIS.EQ.0)GOTO14
C...APPLY VISCOUS NOSLIP BOUNDARY CONDITION
C         ITWA=0 FOR ADIABATIC WALL $ ITWA=1 FOR ISOTHERMAL WALL
          DO 15 J=1,JMAX
          DCON(J)=XEX(J,1,1)*XEX(J,1,2)+XFY(J,1,1)*XEY(J,1,2)
          ECON(J)=XEX(J,1,2)**2+XEY(J,1,2)**2
          DO 15 K=1,3
          P(J,K)=(Q(J,K,4)-0.5*(Q(J,K,2)**2+Q(J,K,3)**2)/Q(J,K,1))
         > *D(J,K)*GAMM1
          T(J,K)=P(J,K)/D(J,K)/Q(J,K,1)
       15 CONTINUE
C...SET UP COEFFICIENT MATRIX FOR TRIDIAGONAL INVERSION
          DO 16 J=2,JM
          BDIAG(J)=-DCON(J)
          DIAG(J)=C1*ECON(J)
          ADIAG(J)=DCON(J)
       16 CONTINUE
          DIAG(2)=DIAG(2)-DCON(2)
C...COMPUTE WALL PRESSURE
          DO 17 J=2,JM
       17 RIGHT(J)=ECON(J)*(-C3*P(J,3)-C2*P(J,2))
          RIGHT(JM)=RIGHT(JM)-DCON(JM)*P(JMAX,1)
          CALL TRIB(BDIAG,DIAG,ADIAG,DUMMY,RIGHT,2,JM)
          DO 18 J=2,JM
       18 P(J,1)=RIGHT(J)
          P(1,1)=P(2,1)
C...COMPUTE WALL TEMPERATURE FOR ADIBATIC WALL
          IF(ITWA.EQ.1) GO TO 21
          DO 19 J=2,JM
       19 RIGHT(J)=ECON(J)*(-C3*T(J,3)-C2*T(J,2))
          RIGHT(JM)=RIGHT(JM)-DCON(JM)*T(JMAX,1)
          CALL TRIB(BDIAG,DIAG,ADIAG,DUMMY,RIGHT,2,JM)
          DO 20 J=2,JM
       20 T(J,1)=RIGHT(J)
          T(1,1)=T(2,1)
       21 CONTINUE
C...COMPUTE CONSERVATIVE VARIABLES
          DO 22 J=1,JMAX
```

```
      IF(ITWA.EQ.0) TWA=T(J,1)
      T1=TWA
      P1=P(J,1)
      R1=P1/T1
      DI=1.0/D(J,1)
      Q(J,1,1)=R1*DI
      Q(J,1,2)=0.0
      Q(J,1,3)=0.0
      Q(J,1,4)=P1/GAMM1*DI
   22 CONTINUE
      RETURN
   14 CONTINUE
C...APPLY INVISCID BOUNDARY CONDITION
C...SATISFY TANGENCY CONDITION USING CHARACTERISTIC EQUATION
      DO 3 K=1,3
      DO 3 J=1,JMAX
      Z=1.0/Q(J,K,1)
      R(J,K)=Q(J,K,1)*D(J,K)
      U(J,K)=Q(J,K,2)*Z
      V(J,K)=Q(J,K,3)*Z
      E2=Q(J,K,4)*D(J,K)
    3 P(J,K)=(E2-0.5*R(J,K)*(U(J,K)**2+V(J,K)**2))*GAMM1
C...COMPUTE P-XI, U-XI,V-XI, P-ETA,U-ETA, AND V-ETA DERIVATIVES
      DO 4 J=2,JM
      PXI(J)=(P(J+1,1)-P(J-1,1))*0.5
      UXI(J)=(U(J+1,1)-U(J-1,1))*0.5
    4 VXI(J)=(V(J+1,1)-V(J-1,1))*0.5
      PXI(1)=-PXI(2)
      UXI(1)=-UXI(2)
      VXI(1)=VXI(2)
      PXI(JMAX)=(3.0*P(JMAX,1)-4.0*P(JM,1)+P(JM-1,1))*0.5
      UXI(JMAX)=(3.0*U(JMAX,1)-4.0*U(JM,1)+U(JM-1,1))*0.5
      VXI(JMAX)=(3.0*V(JMAX,1)-4.0*V(JM,1)+V(JM-1,1))*0.5
      DO 5 J=1,JMAX
      PETA(J)=(-3.0*P(J,1)+4.0*P(J,2)-P(J,3))*0.5
      UETA(J)=(-3.0*U(J,1)+4.0*U(J,2)-U(J,3))*0.5
      VETA(J)=(-3.0*V(J,1)+4.0*V(J,2)-V(J,3))*0.5
    5 CONTINUE
      K=1
      IF(IT.EQ.ITER) WRITE(6,102)
  102 FORMAT(*0FROM SUB. BNDRY*)
      DO 2 J=1,JMAX
      CBB=SQRT(GAM*P(J,1)/R(J,1))
      Z=1.0/SQRT(XEX(J,1,2)**2+XEY(J,1,2)**2)
      UBAR=U(J,1)*XEX(J,1,1)+V(J,1)*XEY(J,1,1)
      VBAR=U(J,1)*XEX(J,1,2)+V(J,1)*XEY(J,1,2)
      EE=UBAR*PXI(J)+R(J,1)*CBB**2*(XEY(J,1,1)*UXI(J)+XEY(J,1,1)*VXI(J))
     > -CBB*Z*(XEX(J,1,2)*(XEX(J,1,1)*PXI(J)+R(J,1)*UBAR*UXI(J))+
     > XEY(J,1,2)*(XEY(J,1,1)*PXI(J)+R(J,1)*UBAR*VXI(J)))
     1 +(V(J,1)/Y(J,1))
      PTAU=CBB/Z*PETA(J)-R(J,1)*CBB**2*(XEX(J,1,2)*UETA(J)+XEY(J,1,2)*
     > VETA(J))-EE
      P1=P(J,1)+PTAU*DT*0.2
      IF(P1.LE.0.0) GO TO 9
   10 CONTINUE
      IF(J.GT.2) GO TO 11
      A=(P(4,1)-25.0*P(3,1)/9.0+16.0*PT/9.0)/6.25
      B=(P(3,1)-PT-27.0*A/8.0)*4.0/9.0
      P1=PT+A/8.0+B/4.0
   11 CONTINUE
      R1=(P1/ENT)**(1.0/GAM)
      Q1=SQRT(2.0*GAM/GAMM1*ABS(PTORT-P1/R1))
      IF(ABS(XEY(J,1,2))-0.000001) 6,6,7
    6 THETB=1.570796327
      GO TO 8
    7 THETB=ATAN(-XEX(J,1,2)/XEY(J,1,2))
    8 CONTINUE
      U1=Q1*COS(THETB)
      V1=Q1*SIN(THETB)
```

```
      THETBD=90.0-THETB*57.29578
      IF(IT.EQ.ITER)
     >WRITE(6,101) J,CBB,Z,PTAU,DT,XFX(J,1,1),XFY(J,1,1),XEX(J,1,2),
     > XEY(J,1,2),PXI(J),PETA(J),P(J,1),P1,UXI(J),UETA(J),R(J,1),R1,
     > VXI(J),VETA(J),U(J,1),U1,V(J,1),V1,THETBD,EF
  101 FORMAT(* J=*,I2,4X,8F13.5,/,9X,8F13.5,/,9X,8F13.5)
      DI=1.0/D(J,1)
      Q(J,1,1)=R1*DI
      Q(J,1,2)=R1*U1*DI
      Q(J,1,3)=R1*V1*DI
      Q(J,1,4)=(P1/GAMM1+0.5*R1*Q1**2)*DI
    2 CONTINUE
      RETURN
    9 WRITE(6,100) IT,J,P1
      P1=ABS(P1)
      GO TO 10
  100 FORMAT(* ITER=*,I4,3X,*J=*,I2,3X,*P1=*,E12.4)
      END



      SUBROUTINE BTRI(IL,IU)
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AJ(4,4),HVEC(40,4)
      COMMON/COM4/A(40,4,4),B(40,4,4),C(40,4,4),HD(40,4,4),
     1UD(40,4,4),AX(40),AY(40),BX(40),BY(40)
      COMMON/LUD/ L11,L21,L22,L31,L32,L33,L41,L42,L43,L44,V1,V2,V3,V4,
     1  U12,U13,U14,U23,U24,U34
      DIMENSION H(4,4),F(40,4)
      REAL       L11,L21,L22,L31,L32,L33,L41,L42,L43,L44
      EQUIVALENCE (EF(1,1),F(1,1))
C  INVERSION OF BLOCK TRIDIAGONAL... A,B,C ARE 4*4 BLOCKS
C  F IS FORCING FUNCTION AND SOLUTION IS OUTPUT IN F,  B IS OVERLOADED
C  BLOCK INVERSIONS USE NONPIVOTED LU DECOMPOSITION
C  IL AND IU ARE STARTING AND FINISHING INDICES
      IS = IL +1
      I = IL
      DO 11 N=1,4
      DO 11 M=1,4
   11 H(N,M)=B(I,N,M)
      CALL LUDEC(H)
      D1 = V1*F(I,1)
      D2 = V2*( F(I,2) - L21*D1)
      D3 = V3*( F(I,3) - L31*D1 - L32*D2)
      D4 = V4*( F(I,4) - L41*D1 - L42*D2 - L43*D3)
      F(I,4) = D4
      F(I,3) = D3 - U34*D4
      F(I,2) = D2 - U24*D4 - U23*F(I,3)
      F(I,1) = D1 - U14*D4 - U13*F(I,3) - U12*F(I,2)
      DO 12 M=1,4
      D1 = V1*C(I,1,M)
      D2 = V2*( C(I,2,M) - L21*D1)
      D3 = V3*( C(I,3,M) - L31*D1 - L32*D2)
      D4 = V4*( C(I,4,M) -L41*D1 - L42*D2 - L43*D3)
      B(I,4,M) = D4
      B(I,3,M) = D3 - U34*D4
      B(I,2,M) = D2 - U24*D4 - U23*B(I,3,M)
      B(I,1,M) = D1 - U14*D4 - U13*B(I,3,M) - U12*B(I,2,M)
C...FORWARD SWEEP
   12 CONTINUE
      DO 13 I=IS,IU
      IR = I -1
      DO 14 N=1,4
      F(I,N) = F(I,N) -A(I,N,1)*F(IR,1) -A(I,N,2)*F(IR,2)
     1      -A(I,N,3)*F(IR,3) - A(I,N,4)*F(IR,4)
      DO 14 M=1,4
      H(N,M) = B(I,N,M) -A(I,N,1)*B(IR,1,M) -A(I,N,2)*B(IR,2,M)
     1     -A(I,N,3)*B(IR,3,M) - A(I,N,4)*B(IR,4,M)
   14 CONTINUE
```

```
      CALL LUDEC(H)
      D1 = V1*F(I,1)
      D2 = V2*( F(I,2) - L21*D1)
      D3 = V3*( F(I,3) - L31*D1 - L32*D2)
      D4 = V4*( F(I,4) - L41*D1 - L42*D2 - L43*D3)
      F(I,4) = D4
      F(I,3) = D3 - U34*D4
      F(I,2) = D2 - U24*D4 - U23*F(I,3)
      F(I,1) = D1 - U14*D4 - U13*F(I,3) - U12*F(I,2)
      IF( I - IU)16,13,13
   16 CONTINUE
      DO 15 M=1,4
      D1 = V1*C(I,1,M)
      D2 = V2*( C(I,2,M) - L21*D1)
      D3 = V3*( C(I,3,M) - L31*D1 - L32*D2)
      D4 = V4*( C(I,4,M) -L41*D1 - L42*D2 - L43*D3)
      B(I,4,M) = D4
      B(I,3,M) = D3 - U34*D4
      B(I,2,M) = D2 - U24*D4 - U23*B(I,3,M)
      B(I,1,M) = D1 - U14*D4 - U13*B(I,3,M) - U12*B(I,2,M)
   15 CONTINUE
   13 CONTINUE
C...BACK SUBSTITUTION
      IT = IL + IU
      DO 21 II = IS,IU
      I = IT - II
      IP = I+1
      DO 22 N=1,4
      F(I,N) = F(I,N) - B(I ,N,1)*F(IP,1) - B(I ,N,2)*F(IP,2)
     1     -B(I ,N,3)*F(IP,3) - B(I ,N,4)*F(IP,4)
   22 CONTINUE
   21 CONTINUE
      RETURN
      END


      SUBROUTINE CTXY(XAA,YAA,DED,HF,CT)
      COMMON/BDTH/X01,X02,X03,X04,Y01,Y02,Y03,Y04,SL1,SL2,SL3,R1,R2,
     1R3,R4,CT1,CT2,CT3,CT4,CT5,CT6,X00,RBODY
      COMMON/XYPS/X1,X2,X3,X4,X5,X6,X7,Y1,Y2,Y3,Y4,Y5,Y6,Y7
C     THIS SUBROUTINE CALCULATES X,Y,HF AND DELTA FOR A GIVEN CT
      P2=2.*ATAN(1.)
      IF(CT.GT.CT1) GO TO 2
      A=X00*TAN(CT)
      Q=1.+TAN(CT)**2
      B=(X01+A*TAN(CT))/Q
      C=(X01**2+A**2-R1**2)/Q
      X=B-SQRT(B**2-C)
      IF(R1.GT.10.) X=0.
      GO TO 10
    2 IF(CT.GT.CT2) GO TO 3
      A=X00*TAN(CT)-Y02
      Q=1.+TAN(CT)**2
      B=(X02+A*TAN(CT))/Q
      C=(X02**2+A**2-R2**2)/Q
      X=B-SQRT(B**2-C)
      GO TO 10
    3 IF(CT.GT.CT3) GO TO 4
      A1=X00*TAN(CT)-Y2
      X=(X2+A1*TAN(SL1))/(1.+TAN(CT)*TAN(SL1))
      GO TO 10
    4 IF(CT.GT.CT4) GO TO 5
      A=X00*TAN(CT)-Y03
      Q=1.+TAN(CT)**2
      B=(X03+A*TAN(CT))/Q
      C=(X03**2+A**2-R3**2)/Q
      X=B+SQRT(B**2-C)
      GO TO 10
```

```
    5 IF(CT.GT.CT5) GO TO 6
      A1=X00*TAN(CT)-Y4
      X=(X4+A1*TAN(SL2))/(1.+TAN(CT)*TAN(SL2))
      GO TO 10
    6 IF(CT.EQ.P2) GO TO 11
      A=X00*TAN(CT)-Y04
      Q=1.+TAN(CT)**2
      B=(X04+A*TAN(CT))/Q
      C=(X04**2+A**2-R4**2)/Q
      X=B-SQRT(B**2-C)
   10 BF=(X00-X)/COS(CT)
      DED=X00-BF
      Y=(X00-X)*TAN(CT)
      GO TO 12
   11 X=X00
      Y=RBODY
      DED=X00-Y
      BF=Y
   12 CONTINUE
      XAA=X
      YAA=Y
      RETURN
      END



      SUBROUTINF DISSIP
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,ICS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,ETINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVFC(40,4)
C...SMOOTH IN THE X AND Y DIRECTIONS AND ADD SMOOTHING TERM TO S ARRAY
C...  DATA C1S,C2S,C3S,C4S/-2.0,5.0,-4.0,1.0/FOR LINFAR EXTRAP AT SHOCK
C...  DATA C1S,C2S,C3S,C4S/-1.0,3.0,-3.0,1.0/FOR PARAR EXTRAP AT SHOCK
C...  DATA C1B,C2B,C3B,C4B/-2.0,5.0,-4.0,1.0/FOR LINFAR EXTRAP AT BODY
C...  DATA C1B,C2B,C3B,C4B/-1.0,3.0,-3.0,1.0/FOR PARAB EXTRAP AT BODY
C...  DATA C1O,C2O,C3O,C4O/-2.0,5.0,-4.0,1.0/FOR LINFAR EXTRAP AT OUTFLO
C...  DATA C1O,C2O,C3O,C4O/-1.0,3.0,-3.0,1.0/FOR PAPAB EXTRAP AT OUTFLOW
      DATA C1S,C2S,C3S,C4S/-1.0,3.0,-3.0,1.0/
      DATA C1B,C2B,C3B,C4B/-1.0,3.0,-3.0,1.0/
      DATA C1O,C2O,C3O,C4O/-2.0,5.0,-4.0,1.0/
      KMM=KM-1
      JMM=JM-1
C...SMOOTHING IN XI DIRECTION
      DO 4 N=1,4
      DO 2 K=2,KM
C...USE LINEAR OR PARABOLIC EXTRAPOLATION FOR J=JM
C...SEE DATA STATEMENTS ABOVE
      S(JM,K,N)=S(JM,K,N)-SMU*0.125*(C1O*Q(JMAX,K,N)*D(JMAX,K)+
     > C2O*Q(JM,K,N)*D(JM,K)+C3O*Q(JMM,K,N)*D(JMM,K)+
     > C4O*Q(JM-2,K,N)*D(JM-2,K))/D(JM,K)
      DO 2 J=3,JMM
    2 S(J,K,N)=S(J,K,N)-SMU*0.125*(Q(J-2,K,N)*D(J-2,K)-4.0*Q(J-1,K,N)
     > *D(J-1,K)+6.0*Q(J,K,N)*D(J,K)-4.0*Q(J+1,K,N)*D(J+1,K)+Q(J+2,K,
     > *D(J+2,K))/D(J,K)
C...SMOOTHING IN ETA DIRECTION
      DO 1 J=2,JM
C...USE LINEAR OR PARABOLIC EXTRAPOLATION AT BODY AND SHOCK
C...SEE DATA STATEMENTS ABOVE
      S(J,2,N)=S(J,2,N)-SMU*0.125*(C1B*Q(J,1,N)*D(J,1)+
     > C2B*Q(J,2,N)*D(J,2)+C3B*Q(J,3,N)*D(J,3)+
     > C4B*Q(J,4,N)*D(J,4))/D(J,2)
      S(J,KM,N)=S(J,KM,N)-SMU*0.125*(C1S*Q(J,KMAX,N)*D(J,KMAX)+
     > C2S*Q(J,KM,N)*D(J,KM)+C3S*Q(J,KMM,N)*D(J,KMM)+
     > C4S*Q(J,KM-2,N)*D(J,KM-2))/D(J,KM)
```

```
      DO 1 K=3,KMM
    1 S(J,K,N)=S(J,K,N)-SMU*0.125*(Q(J,K-2,N)*D(J,K-2)-4.0*Q(J,K-1,N)
     > *D(J,K-1)+6.0*Q(J,K,N)*D(J,K)-4.0*Q(J,K+1,N)*D(J,K+1)+Q(J,K+2,N)
     > *D(J,K+2))/D(J,K)
    4 CONTINUE
C...COMPUTE SMOOTHING FOR J=2 BY USING SYMMETRY CONDITIONS
      DO 3 K=2,KM
      S(2,K,1)=S(2,K,1)-SMU*0.125*(-4.0*Q(1,K,1)*D(1,K)+6.0*Q(2,K,1)*
     > D(2,K)-3.0*Q(3,K,1)*D(3,K)+Q(4,K,1)*D(4,K))/D(2,K)
      S(2,K,2)=S(2,K,2)-SMU*0.125*(-4.0*Q(1,K,2)*D(1,K)+6.0*Q(2,K,2)*
     > D(2,K)-3.0*Q(3,K,2)*D(3,K)+Q(4,K,2)*D(4,K))/D(2,K)
      S(2,K,3)=S(2,K,3)-SMU*0.125*(-4.0*Q(1,K,3)*D(1,K)+6.0*Q(2,K,3)*
     > D(2,K)-5.0*Q(3,K,3)*D(3,K)+Q(4,K,3)*D(4,K))/D(2,K)
      S(2,K,4)=S(2,K,4)-SMU*0.125*(-4.0*Q(1,K,4)*D(1,K)+6.0*Q(2,K,4)*
     > D(2,K)-3.0*Q(3,K,4)*D(3,K)+Q(4,K,4)*D(4,K))/D(2,K)
    3 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE EFCON(J,K,I)
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      DATA HVEC/160*0.0/
C...FORM E CONSERVATIVE VARIABLES (I=1) OR F CONSERVATIVE VARIABLES
C...(I=2) AT A GIVEN NODE POINT
      W=Q(J,K,1)
      RI=1.0/W
      U=Q(J,K,2)*RI
      V=Q(J,K,3)*RI
      POJ=GAMM1*(Q(J,K,4)-W*0.5*(U*U+V*V))
      XX=0.
      YY=XFX(J,K,I)
      Z=XFY(J,K,I)
      CAPUV=XX+YY*U+Z*V
      G(1)=W*CAPUV
      G(2)=Q(J,K,2)*CAPUV+YY*POJ
      G(3)=Q(J,K,3)*CAPUV+Z*POJ
      G(4)=Q(J,K,4)*CAPUV+(CAPUV-XX)*POJ
C...SOURCE TERM IN ETA-MOM. EQN. FOR AXISYMMETRIC FLOW
      IF(JCS.EQ.0.OR.I.EQ.1)RETURN
      YI=DT/Y(J,K)
      HVEC(K,1)=Q(J,K,3)*YI
      HVEC(K,2)=Q(J,K,3)*YI*U
      HVEC(K,3)=Q(J,K,3)*YI*V
      HVEC(K,4)=(Q(J,K,4)+POJ)*V*YI
      RETURN
      END
```

```
      SUBROUTINE EIGEN
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
C...COMPUTE STEPSIZE GIVEN COURANT NUMBER
      IF(IPRT.GT.0) WRITE(6,100)
      SIGMAX=0.0
      SIGMIN=10.E+100
```

```
      DO 1 K=1,KMAX
      DO 1 J=1,JMAX
      RI=1.0/Q(J,K,1)
      U=Q(J,K,2)*RI
      V=Q(J,K,3)*RI
      XX=GAM*GAMM1*(Q(J,K,4)*RI-0.5*(U*U+V*V))
      IF(XX) 2,2,3
    2 WRITE(6,103) J,K,Q(J,K,4),RI,U,V,XX
      XX=-XX
    3 SPSND=SQRT(XX)
      XIX=XEX(J,K,1)
      XIY=XEY(J,K,1)
      ETAX=XEX(J,K,2)
      ETAY=XEY(J,K,2)
      XET=0.
      SIGA=ABS(XET+U*XIX+V*XIY)+SPSND*SQRT(XIX**2+XIY**2)
      SIGB=ABS(XET+U*ETAX+V*ETAY)+SPSND*SQRT(ETAX**2+ETAY**2)
      SIGAB=AMAX1(SIGA,SIGB)
      SIGABM=AMIN1(SIGA,SIGB)
      IF(SIGAB.GT.SIGMAX)GOTO4
      GOTO5
    4 SIGMAX=SIGAB
      JEIGMX=J
      KEIGMX=K
    5 CONTINUE
      IF(SIGABM.LT.SIGMIN)GOTO6
      GOTO7
    6 SIGMIN=SIGABM
      JEIGMN=J
      KEIGMN=K
    7 CONTINUE
      IF(IPRT.EQ.0) GO TO 1
      WRITE(6,101) J,K,SIGA,SIGB
    1 CONTINUE
      DT=CN/ABS(SIGMAX)
      WRITE(6,102)SIGMAX,JEIGMX,KEIGMX,SIGMIN,JEIGMN,KEIGMN,CN,DT
      H=0.5*DT
  100 FORMAT(*0*,3X,*J*,4X,*K*,7X,*SIGA*,8X,*SIGB*)
  101 FORMAT(2I5,2F12.6)
  102 FORMAT(*0*,*SIGMAX=*,E10.4,3X,*J=*,I5,3X,*K=*,I5,3X,*SIGMIN=*,
     > E10.4,3X,*J=*,I5,3X,*K=*,I5,3X,*CN=*,E10.4,3X,*DT=*,E10.4)
  103 FORMAT(*0NEGATIVE SQRT IN EIGEN AT J=*,I2,* K=*,I2,3X,*E/J=*,E10.4
     > ,3X,*J/R=*,E10.4,3X,*U=*,E10.4,3X,*V=*,E10.4,3X,*DISCRM=*,E10.4)
      RETURN
      END



      SUBROUTINE ETATH(ET,CF,KMAX)
      DIMENSION JJI(3),JJF(3),XXI(3),XXF(3),DDXI(3),DDXF(3),ET(40)
      DATA JJI(1),JJI(2),JJI(3),JJF(1),JJF(2),JJF(3)/1,18,43,17,42,48/
      DATA XXI(1),XXI(2),XXI(3)/0.,0.115,0.64/
      DATA XXF(1),XXF(2),XXF(3)/0.1,0.6,1./
      DATA DDXI(1),DDXI(2),DDXI(3)/0.001,0.015,0.05/
      DATA DDXF(1),DDXF(2),DDXF(3)/0.015,0.03,0.009/
      KM1 = KMAX-1
      RAT = (CF+1.)/(CF-1.)
      DETAC = 1./KM1
      ET(1) = 0.
      ET(KMAX) = 1.
      DO 1  K = 2,KM1
      ETAC = (K-1)*DETAC
      EX = 1.-ETAC
      ARG = RAT**EX
    1 ET(K) = 1. + CF*(1.-ARG)/(1.+ARG)
      RETURN
      END
```

AD-A125 329 CALCULATIONS OF FLOWFIELD ABOUT INDENTED NOSETIPS(U) 2/2
NAVAL SURFACE WEAPONS CENTER SILVER SPRING MD T HSIEH
23 AUG 82 NSWC/TR-82-286 SBI-AD-F500 125

UNCLASSIFIED F/G 12/1 NL

END

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3 83

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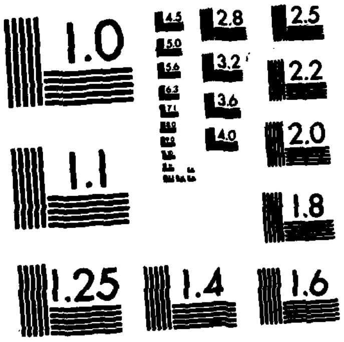

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      SUBROUTINE GRID
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMUIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVFC(40,4)
      COMMON/BDTH/X01,X02,X03,X04,Y01,Y02,Y03,Y04,SL1,SL2,SL3,R1,R2,
     1R3,R4,CT1,CT2,CT3,CT4,CT5,CT6,X00,RBODY
C     THIS SUBROUTINE DETERMINES X AND Y FOR GRID POINTS
      PI2=2.*ATAN(1.)
      PI=2.*PI2
      DTR=PI/180.
      TM=(90.-TM)*DTR
      JNM1=JNM-1
      TH(JNM)=TM
      JNM5=JNM+ITRAN
      DTH=(PI2-TM)/FLOAT(ITRAN)
      JNMP=JNM+1
      TMM=PI2-TM
C     FOR SPHERE PORTION
      DTHMIN=TM/(FLOAT(JNM1)-0.5)
      DTH1=0.5*DTHMIN
      DO 51 J=1,JNM1
   51 TH(J)=(J-1)*DTHMIN-DTH1
C     IGEOM=0 UNIFORM POINTS ON SPHERE FOR SPHERE-CONE
C     IGEOM=1 READ IN XB,YB,XS,YS
C     IGEOM=2 READ IN TH(J) AND DETT(J) FOR ARBITRARY BODY SHAPE
C     IGEOM=3 UNIFORM SPACING FOR TH(J), CAL. DETT(J) AND DETERMINE THE
C     XB AND YB FOR INDENTED NOSE
C     IGEOM=4 READ IN TH(J) ON NOSE AND CAL. DETT(J) AND FINAL XB AND YB
      IF(IGEOM.EQ.0) GO TO 41
      IF(IGEOM.EQ.1) GO TO 3
      IF(IGEOM-3) 42,43,43
   42 READ(5,102)(TH(J),J=1,JMAX)
      READ(5,102)(DETT(J),J=1,JMAX)
  102 FORMAT(8F10.5)
      WRITE(6,103)
  103 FORMAT(/,2X,*READ IN TH(J) AND DETT(J)*,/,20X,*J*,5X,*TH(J),DEGREE
     1*,5X,*DETT(J)*)
      DO 104 J=1,JMAX
      WRITE(6,105) J,TH(J),DETT(J)
  105 FORMAT(19X,I2,6X,F6.2,9X,F6.3)
      TH(J)=TH(J)*DTR
  104 CONTINUE
      GO TO 41
   43 CONTINUE
C     READ AND WRITE CONTROL POINTS FOR NOSETIP SHAPE
      CALL SHAPE
      IF(IGEOM.NE.4) GO TO 201
      READ(5,102)(TH(J),J=1,JMAX)
      WRITE(6,203)(TH(J),J=1,JMAX)
  203 FORMAT(2X,*READ IN TH(J) IN DEGREE FOR INDENTED NOSETIP*,/,20X,
     110F10.6)
      DO 202 J=1,JMAX
  202 TH(J)=TH(J)*DTR
  201 CONTINUE
      WRITE(6,304)
  304 FORMAT(*0*,*INDENTED NOSETIP SHAPE*,/,22X,*J*,11X,*THETA*,10X,
     1*RB*,13X,*XB*,13X,*YB*,11X,*DELTA*,/)
      DO 61 J=1,JNM
      CT=TH  (J)
      CALL CTXY(XAA,YAA,DED,BF,CT)
      DETT(J)=DED
      CTT=CT/DTR
      WRITE(6,303) J,CTT,BF,XAA,YAA,DED
  303 FORMAT(20X,I3,5F15.5)
   61 CONTINUE
```

```
   41 CONTINUE
C     BODY POINTS FOR SPHERE-CONE
      WRITE(6,306)
  306 FORMAT(*0*,*COORDINATES FOR UNIT SPHERE-CONE*,/)
      DO 58 J=1,JNM
      X(J,1)=1.-COS(TH(J))
      Y(J,1)=SIN(TH(J))
      RSH=0.
      IF(IGEOM.EQ.0) DETT(J)=0.
      WRITE(6,303) J,TH(J),RSH,X(J,1),Y(J,1)
   58 CONTINUE
      DTHMIN=TH(JNM)-TH(JNM1)
      DO 56 J=JNMP,JMAX
      TH(J)=TH(J-1)+DTH
      IF(J.GE.JNM5) TH(J)=PI2
      DETT(J)=DETT(JNM)/(COS(TH(J)-TH(JNM)))
      X(J,1)=DTHMIN*COS(TMM)+X(J-1,1)
      Y(J,1)=DTHMIN*SIN(TMM)+Y(J-1,1)
C     STREAMWISE COORDINATE STRETCHING ON CONE PORTION FOR J GT. JNM
      DTHMIN=CC *DTHMIN
      WRITE(6,307) J, TH(J),X(J,1),Y(J,1),DETT(J)
  307 FORMAT(20X,I3,F15.5,15X,3F15.5)
   56 CONTINUE
C     SHOCK LOCATION
      XM2=XMACH**2
      DLTO=(GAMM1*XM2+2.)/((GAM+1.) *XM2)*0.78
      IF(XMACH-2.5) 21,22,22
   21 WRITE(6,191)
  191 FORMAT(1H0,*NOT READY FOR MINF LESS THAN 2.5*)
      GO TO 81
   22 IF(XMACH-10.) 23,23,24
   23 YX1=2.376-0.1834*XMACH+0.01036*XM2
      GO TO 25
   24 YX1=1.576-0.0018*(XMACH-10.)
   25 PB=YX1**2*0.5/(1.+DLTO)
      DO 7 J=2,JMAX
      IF(TH(J).EQ.PI2) GO TO 71
      TCB=TAN(TH(J))
      CGC=X(J,1)+Y(J,1)/TCB+DLTO
      Y(J,KMAX)=-PB/TCB+SQRT((PB/TCB)**2+2.*PB*CGC)
      X(J,KMAX)=X(J,1)-(Y(J,KMAX)-Y(J,1))/TCH
      GO TO 7
   71 Y(J,KMAX)=SQRT(2.*PB*(X(J,1)+DLTO))
      X(J,KMAX)=X(J,1)
    7 CONTINUE
      X(1,KMAX)=X(2,KMAX)
      Y(1,KMAX)=-Y(2,KMAX)
      WRITE(6,701)
  701 FORMAT(/,*0STARTING BODY AND BOW SHOCK LOCATIONS*,/)
      WRITE(6,125)
  125 FORMAT(15X,*XB*,18X,*YB*,18X,*XS*,18X,*YS*,16X,*THETA*,14X,*J*)
      DO 9 J=1,JMAX
      X(J,1)=X(J,1)*OMEGA
      Y(J,1)=Y(J,1)*OMEGA
      X(J,KMAX)=X(J,KMAX)*OMEGA
      Y(J,KMAX)=Y(J,KMAX)*OMEGA
      WRITE(6,124) X(J,1),Y(J,1),X(J,KMAX),Y(J,KMAX),TH(J),J
  124 FORMAT(5F20.6,I5)
    9 CONTINUE
      IF(IGEOM.EQ.0) GO TO 64
      FACTA=0.
C     FACTA IS THE FRACTION OF DELTA ALREADY DEFORMED, FACTB IS THE FRAC
C     OF DELTA TO BE DEFORMED IN THIS RUN, FACTT=FACTA+FACTB
      READ(5,102) FACTB
      FACTT=FACTA+FACTB
      WRITE(6,305) FACTA,FACTB,FACTT
  305 FORMAT(*0*,4X,*FRACTION OF DELTA PREVIOUSLY DONE=*,F5.2,/,5X,
     1*FRACTION OF DELTA FOR THIS RUN=*,F5.2,/,5X,*TOTAL FRACTION OF
     2DELTA COMPLETED=*,F5.2,/)
      DO 63 J=1,JMAX
   63 DETL(J)=DETT(J)*FACTB
```

```
   64 CONTINUE
    3 CONTINUE
C     FILL ETA COORDINATE STRETCHING ARRAY
      CALL ETATB(ET,CF,KMAX)
C     DETERMINE X AND Y FOR GRID POINTS BETWEEN BODY AND SHOCK
      IF(IGEOM.EQ.1) WRITE(6,106)
  106 FORMAT(/,2X,*READ IN XB(J),YB(J),XS(J),YS(J)*,/,20X,*J*,5X,*XB(J)*
     1,5X,*YB(J)*,5X,*XS(J)*,5X,*YS(J)*)
      DO 5 J=1,JMAX
C     READ IN XB,YB,XS,YS
      IF(IGEOM.NE. 1) GO TO 4
      READ(5,102) XB,YB,XS,YS
      WRITE(6,108) J,XB,YB,XS,YS
  108 FORMAT(19X,I2,4F10.3)
      GO TO 6
    4 CONTINUE
      XS=X(J,KMAX)
      YS=Y(J,KMAX)
      XB=X(J,1)
      YB=Y(J,1)
    6 CONTINUE
      DXX=XS-XB
      DYY=YS-YB
      DO 5 K=1,KMAX
      ETA=ET(K)
      X(J,K)=XB+DXX*ETA
      Y(J,K)=YB+DYY*ETA
    5 CONTINUE
   81 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INITIA
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMUIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTE,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVFC(40,4)
      COMMON/COM4/A(40,4,4),B(40,4,4),C(40,4,4),BD(40,4,4),
     1UD(40,4,4),AX(40),AY(40),BX(40),BY(40)
      COMMON/VISK/CMUKAP(40),TURMU(40,40)
      DATA AX/40*0.0/,BX/40*1.0/,AY/40*0.0/,BY/40*1.0/
      DATA TURMU/1600*0.0/
C     THIS SUBROUTINE INITIALIZES THE FLOWFIELD
      PI=4.*ATAN(1.)
      READ(5,108) JMAX,KMAX,ITER,IPRT,IR1,IW2,IAFBD
  108 FORMAT(8I5)
C     JMAX=TOTAL PLINTS IN J-ARRAY, KMAX=TOTAL POINTS IN K-ARRAY
C     ITER=TOTAL INTEGRATION STEPS
C     IPRT=1 FOR DETAILED PRINTOUT IN FIGEN, =0 OTHERWISE
C     IR1=1 READ DATA FROM TAPE1, =0 OTHERWISE
C     IW2=1  WRITE DATA ON TAPE2 FOR RESTART, =0 OTHERWISE
C     IAFBD=1 STORE STARTING DATA FOR AFTERBODY CAL., =0 OTHERWISE
      READ(5,108) JNM,IGEOM,LIP,KRES,ITRAN,IVIS
C     JNM=JUNCTURE OF SPHERE AND CONE, LIP= NO. OF STEPS TO COMPLETE THE
C     DEFORMATION, KRES=PRINTOUT INTERVAL IN K ARRAY FOR RESIDUE INFORMA
C     ITRAN=NO. OF POINTS OVER WHICH THETA BECOMES PI/2, MUST BE LT.JMAX
C     IGEOM=0 UNIFORM SPACING ON NOSE, =1  READ IN XB,YB,XS,YS,
C        =2 CAL. DELTAS AND FINAL XB,YB,  =3 READ IN DELTAS
C     IVIS=0 INVISCID FLOW,  =1 LAMINAR FLOW
      JM=JMAX-1
      KM=KMAX-1
      READ(5,107) XMACH,GAM,TM,OMEGA,CN,CF,CC,SMU,SMUIMP
  107 FORMAT(7F10.0,2F5.0)
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```
C     XMACH=FREE STREAM MACH NUMBER
C     GAM= RATIO OF SPECIFIC HEATS,  TM=CONE(AFTERBODY) HALF-ANGLE
C     OMEGA= RADIUS OF SPHERE-CONE, = 0  FOR ADDING POINTS
C     CN=INPUT COURANT NO.
C     CF=STRETCHING PARAMETER(BETA)FOR GRID POINTS IN K
C     SMU=EXPLICIT DISS. COEF., SMUIMP=IMPLICIT DISS. COEF.
      WRITE(6,102)
  102 FORMAT(*1*,2X,*AXISYMMETRIC FLOW OVER NOSETIP*,//)
      WRITE(6,103) XMACH,GAM,TM,OMEGA,IR1,IW2,IPRT,IAFBD,IGEOM
  103 FORMAT(*0*,2X,*MACH NUMBER =*,F5.2,/,3X,*RATIO OF SPECIFIC HEAT =*
     1,F5.2,/,3X,*CONE(AFTERBODY) HALF-ANGLE =*,F7.3,2X,*DEGREES*,/,3X,
     2*OMEGA =*,F7.3,5X,*(OMEGA.GT.0,OMEGA IS THE RADIUS OF SPHERE-CONE$
     2 IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED*,/,21X,*IN SUP. SHAPE$
     3OMEGA=0,MORE RAYS TO BE ADDED)*,//,3X,*IR1 =*,I2,5X,*( 1 FOR READ
     4TAPE1$ 0     OTHERWISE)*,/,3X,*IW2 =*,I2,5X,*(1 FOR WRITE ON TAPE2
     5$ 0   OTHERWISE)*, /,3X,*IPRT =*,I2,5X,*( 1 FOR DETAILED WRITE OUT
     6 FROM EIGEN$ 0     OTHERWISE)*,/,3X,*IAFBD =*,I2,5X,*( 1 FOR
     7STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)*,
     8/,3X,*IGEOM =*,I2,5X,*( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ
     9 IN XB,YB,XS,YS $ 2 FOR READ IN TH(J) AND DETT(J) $*,/,17X,
     1 * 3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)$ 4 FOR REA
     2D IN TH(J) AND CAL. FINAL XB,YB)*)
      WRITE(6,207) LIP,IVIS,CF,CC,ITRAN,KRES,SMU,SMUIMP,CN
  207 FORMAT(*0*,     2X,*LIP =*,I4,5X,*( 0 FOR WITHOUT SHAPE CHANGE $
     3N FOR SHAPE CHANGE COMPLETED IN N STEPS)*,/,3X,*IVIS =*,I2,5X,*(
     40 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)*,//,3X,*CF(BETA)=*,F12.5
     5,5X,*( FOR UNIFORM SPACING SET TO 10000)*,/,3X,*CC =*,F5.2,5X,*(
     6STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)*,/,3X,*ITRAN =*,I2,
     75X,*(MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)*,/,3X,*KRES =*,
     8I2,5X,*(INTERVAL IN K FOR RESIDUE INFORMATION)*,/,3X,*EXPLICIT DIS
     9SI. COEF. =*,F5.3,/,3X,*IMPLICIT DISSI. COEF. =*,F5.3,/,3X,
     1*COURANT NO. =*,F8.2,//)
      WRITE(6,208) JMAX,KMAX,JNM,ITER
  208 FORMAT(*0*,2X,*JMAX=*,I5,/,3X,*KMAX=*,I5,/,3X,*JNM=*,I5,5X,
     1 *(JUNCTURE OF SPHERE AND CONE)*,/,3X,*ITER =*,I4,5X,*(TIME STEPS
     2FOR THIS RUN)*)
      GAMM1=GAM-1
      GAM1I=1.0/GAMM1
      ITF=0
      TAU=0.
      IT=0
      ITS=1
      FACTT=0.
      FACTA=0.
      FACTB=0.
      JCS=1
      PINF=1.
      RINF=1.
      CINF=SQRT(PINF*GAM/RINF)
      QINF=XMACH*CINF
      IF(IVIS.EQ.0) GO TO  9
C     READ CONSTANTS NEEDED FOR VISCOUS FLOW CAL.
      READ(5,104) REY,PRD,PRT,CVIS,TWA,ITWA,ITUR,ITF
  104 FORMAT(5F10.0,3I5)
C     REY=FREE STREAM REYNOLDS NO., PRD= FREE STREAM PRANDTL NO.
C     PRT= TURBULENT PRANDTL NO., CVIS=CONSTANT IN SOUTHERLAND"S LAW
C     FOR VISCOSITY, TWA= WALL TEMPERATURE
C     ITWA=1 ISOTHERMAL WALL, =0 ADIABATIC WALL
C     ITUR=1 TURBULENT FLOW, =0 LAMINAR FLOW
C     ITF=1 PRINTOUT STANTON NO. ONLY, =2 PRINTOUT T-FIELD ALSO,=0  NO H
      REYIN=REY
      REYNLD=REY/QINF
      PRTURB=PRD/PRT
      CVIS1=CVIS+1.
      WRITE(6,105) REY,PRD,PRT,CVIS,ITWA,ITUR,ITF
  105 FORMAT(*0*,2X,*RE =*,E15.6,/,3X,*PR =*,F6.3,/,3X,*PR(TURB.) =*,F
     18.3,/,3X,*CVIS = 110/TINF(KELVIN) =*,F8.3,5X,*( CONSTANT USED IN S
     2UTHERLAND"S LAW OF VISCOSITY )*,/,3X,*ITWA =*,I2,5X,*( 0 FOR ADIAB
     3ATIC WALL$ 1 FOR ISOTHERMAL WALL)*,/,3X,*ITUR =*,I2,5X,*( 0 FOR LA
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     4MINAR $ 1 FOR TURBULENT)*,/,3X,*TTF =*,I2,5X,*( 1 FOR PRINT OUT ST
     5 NO. ONLY $ 2 PRINT OUT T-FIELD ALSO)*,//)
      IF(ITWA.EQ.1) WRITE(6,106) TWA
  106 FORMAT(*0*,2X,*TW =*F8.3,//)
    9 CONTINUE
C     SET UP CONSTANTS AT FREE STREAM
      WRITE(6,109)
  109 FORMAT(*0*,*FREE STREAM CONDITIONS*)
      UINF=QINF
      VINF=0.
      HTINF=GAM/GAMM1*PINF/RINF+0.5*QINF**2
      ETINF=HTINF-PINF/RINF
      SINF=PINF/RINF**GAM
      EIINF=1./GAMM1*PINF/RINF
      WRITE(6,100) PINF,RINF,QINF,CINF,UINF,VINF,HTINF,ETINF,SINF,EIINF
  100 FORMAT(*0*,2X,*PINF(PRESSURE) =*,F8.4,/,3X,*RINF(DENSITY) =*,F8.4,
     2/,3X,*QINF(TOTAL VEL.) =*,F8.4,/,3X,*AINF(SOUND SPEED) =*,F8.4,/,
     33X,*UINF(U COMP.) =*,F8.4,/,3X,*VINF(V COMP.) =*,F8.4,/,
     4               3X,*HTINF(T. ENTHALPY) =*,F8.4,/,3X,*ETINF(T. SPEC. EN
     4ERGY) =*,F8.4,/,3X,*SINF(ENTROPY) =*,F8.4,/,3X,*EIINF(INTERNAL ENE
     6RGY) =*,F8.4,//)
      CALL ETATB(ET,CF,KMAX)
      WRITE(6,112)
      WRITE(6,111)(ET(K),K=1,KMAX)
  112 FORMAT(*0*,2X,*NORMALIZED DISTANCE FROM BODY TO SHOCK*)
  111 FORMAT(20X,10F10.6)
      X1=(2.0*GAM*XMACH**2-GAMM1)/(GAM+1.0)
      X2=(GAM+1.0)*XMACH**2/(GAMM1*XMACH**2+2.0)
      P1=X1*PINF
      R1=X2*RINF
      ENT=P1/R1**GAM
      PT=(1.0/X1)**(1.0/GAMM1)*(0.5*(GAM+1.)*XMACH**2)**(GAM/GAMM1)*PINF
      XX=1.0+0.5*GAMM1*XMACH**2
      PTORT=XX*PINF/RINF
      WRITE(6,117) PT
  117 FORMAT(/,2X,*STAGNATION PRESSURE PT=*,F10.4)
C     CHECK FOR FRESH START OR CONTINUATION
      IF(IR1.EQ.1) GO TO 22
      CALL GRID
      CALL JACOB
C...INITIALIZE Q VECTOR TO FREE STREAM VALUES
      DO 1 K=1,KMAX
      DO 1 J=1,JMAX
      DI=1.0/D(J,K)
      Q(J,K,1)=RINF*DI
      Q(J,K,2)=RINF*UINF*DI
      Q(J,K,3)=RINF*VINF*DI
      Q(J,K,4)=(PINF*GAM1I+RINF*QINF**2*0.5)*DI
C...SET S ARRAY TO 0 EVERYWHERE
      DO 1 N=1,4
    1 S(J,K,N)=0.0
C...INITIALIZE FLOW FIELD FOR BLUNT BODY PROBLEM
      GAMP1=GAM+1.0
      DO 2 J=2,JMAX
      IF(ABS(XEX(J,1,2))-0.000001) 6,6,7
    6 THET=0.5*PI
      GO TO 8
    7 THET=ATAN (XEY(J,1,2)/XEX(J,1,2))
    8 CONTINUE
      K=KMAX
      SANG=0.5*PI-ATAN(-XEY(J,K,2)/XEX(J,K,2))
      XX=XMACH**2*SIN(SANG)**2
      PS=(2.0*GAM*XX-GAMM1)/GAMP1*PINF
      RS=GAMP1*XX/(GAMM1*XX+2.0)*RINF
      US=(1.0-2.0*(XX-1.0)/GAMP1/XMACH**2)*QINF
      VS=2.0*(XX-1.0)*COS(SANG)/(GAMP1*XMACH**2*SIN(SANG))*QINF
      PB=PINF*((PT/PINF-1.0)*(1.0-1.02*SIN(THET)**2+0.12*SIN(THET)**4)+
     * 1.)
```

```
      RB=(PB/ENT)**(1.0/GAM)
      QB=SQRT(2.0*GAM/GAMM1*ABS(PTORT-PB/RB))
      YY=PI*0.5-THET
      UB=ABS(QB*COS(YY))
      VB=QB*SIN(YY)
      DO 2 K=1,KMAX
      YY=FT(K)
      PRESS=PB+YY*(PS-PB)
      RHO=RB+YY*(RS-RB)
      QVELN=SQRT(2.0*GAM/GAMM1*ABS(PTORT-PRESS/RHO))
      UVEL=UB+YY*(US-UB)
      VVEL=VB+YY*(VS-VB)
      QVELO=SQRT(UVEL**2+VVEL**2)
      RAT=QVELN/QVELO
      UVEL=UVEL*RAT
      VVEL=VVEL*RAT
      DI=1.0/D(J,K)
      Q(J,K,1)=RHO*DI
      Q(J,K,2)=RHO*UVEL*DI
      Q(J,K,3)=RHO*VVEL*DI
    2 Q(J,K,4)=(PRESS*GAM1I+RHO*(UVEL**2+VVEL**2)*0.5)*DI
C...REFLECT METRICS AND DEPENDENT VARIABLES ABOUT PLANE OF SYMMETRY
      DO 4 K=1,KMAX
      D(1,K)=D(2,K)
      XEX(1,K,1)=-XEX(2,K,1)
      XEY(1,K,1)=XEY(2,K,1)
      XEX(1,K,2)=XEX(2,K,2)
      XEY(1,K,2)=-XEY(2,K,2)
      DO 5 N=1,4
    5 Q(1,K,N)=Q(2,K,N)
    4 Q(1,K,3)=-Q(2,K,3)
      GO TO 24
   22 CONTINUE
      REWIND 1
      READ(1)  ((X(J,K),J=1,JMAX),K=1,KMAX),
     1          ((Y(J,K),J=1,JMAX),K=1,KMAX),
     1          ((D(J,K),J=1,JMAX),K=1,KMAX),
     1          (((XEX(J,K,N),J=1,JMAX),K=1,KMAX),N=1,2),
     1          (((XEY(J,K,N),J=1,JMAX),K=1,KMAX),N=1,2),
     1          (((Q(J,K,N),J=1,JMAX),K=1,KMAX),N=1,4),
     1   JMAX,KMAX,XMACH,GAM,IT,TAU,FACTA,(DETT(J),J=1,JMAX)
      XMACH=QINF/CINF
      ITS=IT+1
      ITER=ITER+IT
      WRITE(6,110)
  110 FORMAT(*0*,*STARTING SOLUTION WAS READ FROM TAPE*)
C     CHECK FOR OPTION OF ADDING POINTS
      IF(OMEGA.EQ.0) GO TO 23
C     CHECK IF FURTHER DEFORMATIOM IS NEEDED
      IF(LIP.EQ.0) GO TO 21
C     FACTA IS THE FRACTION OF DELTA ALREADY DEFORMED. FACTB IS THE FRAC
C     OF DELTA TO BE DEFORMED IN THIS RUN, FACTT=FACTA+FACTB
      READ(5,107) FACTB
      FACTT=FACTA+FACTB
      WRITE(6,305) FACTA,FACTB,FACTT
  305 FORMAT(*0*,4X,*FRACTION OF DELTA PREVIOUSLY DONE=*,F5.2,/,5X,
     1*FRACTION OF DELTA FOR THIS RUN-*,F5.2,/,5X,*TOTAL FRACTION OF
     2DELTA COMPLETED=*,F5.2,/)
      CALL JACOB
      DO 306 J=1,JMAX
  306 DETL(J)=DETT(J)*FACTB
   21 GO TO 24
C     OMEGA = 0  ADDING GRID POINTS
   23 CONTINUE
      CALL INTERP
   24 CONTINUE
      SUM(2)=SQRT(X(2,1)**2+Y(2,1)**2)
      DO 11 J=3,JMAX
   11 SUM(J)=SUM(J-1)+SQRT((X(J,1)-X(J-1,1))**2+(Y(J,1)-Y(J-1,1))**2)
```

```
      WRITE(6,113)
  113 FORMAT(*0*,*ARC LENGTH*)
      WRITE(6,114)(SUM(J),J=2,JMAX)
  114 FORMAT(20X,10F10.5)
      WRITE(6,401)
  401 FORMAT(/,*0STARTING FLOWFIELD INFORMATION*,/)
      RETURN
      END
```

```
      SUBROUTINE INTEGR
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMUIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
C...COMPUTE FORCING FUNCTION AND STORE TEMPORARILY IN S ARRAY
      CALL RHS
C...COMPUTE RESIDUE EVERY 25 STEPS TO CHECK FOR CONVERGENCE
      IF(MOD(IT,25).EQ.0)CALL RESIDU
C...ADD FOURTH ORDER DISSIPATION TO SMOOTH SOLUTION
      CALL DISSIP
C...SOLVE FOR Q-BAR-BAR
      DO 1 K=2,KM
C...FILL ELEMENTS OF I+H*DX A FOR BLOCK TRIDIAGONAL INVERSION AT EACH
C...K TH LEVEL
      CALL LBLTRA(K)
C...INVERT BLOCK TRIDIAGONAL MATRIX AT K TH LEVEL AND STORE SOLUTION IN
C...S ARRAY
      CALL BTRI(2,JM)
      DO 1 L=1,4
      DO 1 J=2,JM
    1 S(J,K,L)=EF(J,L)
C...SOLVE FOR Q-BAR
      DO 2 J=2,JM
C...FILL ELEMENTS OF I+H*DY B FOR BLOCK TRIDIAGONAL INVERSION AT EACH
C...J TH LEVEL
      CALL LBLTRB(J)
C...INVERT BLOCK TRIDIAGONAL MATRIX AT J TH LEVEL AND STORE SOLUTION IN
C...Q ARRAY
      CALL BTRI(2,KM)
      DO 2 L=1,4
      DO 2 K=2,KM
    2 Q(J,K,L)=EF(K,L)+Q(J,K,L)
      TAU=TAU+DT
      RETURN
      END
```

```
      SUBROUTINE INTERP
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMUIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      COMMON/BDTH/X01,X02,X03,X04,Y01,Y02,Y03,Y04,SL1,SL2,SL3,R1,R2,
     1R3,R4,CT1,CT2,CT3,CT4,CT5,CT6,X00,RBODY
      DIMENSION P(40),YA(20),XA(20),THAD(20)
      DIMENSION XZ(40),YZ(40),QZ(40,4),DZ(40),ETZ(40)
C     THIS SUBROUTINE INTERPOLATES FLOW VARIABLES FOR NEW GRID POINTS
      PI=ATAN(1.)*4.
      DTR=PI/180.
      P2=0.5*PI
```

```
      READ(5,100) JAA,JIX,KIM
  100 FORMAT (3I5)
      IF(JAA.EQ.0) GO TO 51
      WRITE(6,138)
  138 FORMAT(*0*,*INFORMATION FOR NOSETIP SHAPE*)
      WRITE(6,200) JAA,JIX
  200 FORMAT(*0*,*ADDING GRIDS IN J-ARRAY, NO. OF RAYS =*,I2,10X,*JIX =*
     1,I2)
C     READ INPUT VALUES OF JAA THETAS TO BE ADDED
      READ(5,101) (THAD(J),J=1,JAA)
  101 FORMAT(8F10.0)
C     READ AND WRITE CONTROL POINTS FOR NOSETIP SHAPE
      CALL SHAPE
      WRITE(6,205)
  205 FORMAT(//,*0NEW POINTS ON BODY:*)
      DO 9 N=1,JAA
      CT=THAD(N)
      CALL CTXY(XAA,YAA,DED,BF,CT)
      XA(N)=XAA
      YA(N)=YAA
      CT=CT/DTR
      WRITE(6,201) N,CT,XA(N),YA(N)
  201 FORMAT(5X,*RAY =*,I2,5X,*AT THB =*,F7.2,5X,*XA =*,F8.4,5X,*YA =*,F
     18.4)
    9 CONTINUE
      JS=2
      DO 495 J=2,JMAX
  495 TH(J)=-ATAN((Y(J,KMAX)-Y(J,1))/(X(J,KMAX)-X(J,1)))
      TH(1)=-TH(2)
      DO 11 I=1,JAA
      JMAX=JMAX+1
      JNM=JNM+1
      DO 12 J=JS,JMAX
      IF(TH (J).LT.THAD(I)) GO TO 12
      JBF=J-1
      JAF=J+1
      RATA=(TH(J)-THAD(I))/(TH(J)-TH(JBF))
      RATE=(TH(J)-THAD(I))/(TH(JAF)-TH(J))
      DO 3 JA=JAF,JMAX
      JI=JMAX-JA+JAF
      JL=JI-1
      DO 3 K=1,KMAX
      X(JI,K)=X(JL,K)
      Y(JI,K)=Y(JL,K)
      D(JI,K)=D(JL,K)
      TH(JI)=TH(JL)
      DO 4 N=1,4
    4 Q(JI,K,N)=Q(JL,K,N)
    3 CONTINUE
      TH(J)=THAD(I)
      TH(1)=-TH(2)
      DA=SQRT((X(J-1,KMAX)-X(J-1,1))**2+(Y(J-1,KMAX)-Y(J-1,1))**2)
      DB=SQRT((X(J+1,KMAX)-X(J+1,1))**2+(Y(J+1,KMAX)-Y(J+1,1))**2)
      DS=DB+RATA*(DA-DB)
      SX=DS*COS(TH(J))
      SY=DS*SIN(TH(J))
      DO 5 K=1,KMAX
      X(J,K)=XA(I)-SX*ET(K)
      Y(J,K)=YA(I)+SY*ET(K)
      JFF=JAF+1
      RJ=Q(J,K,1)*D(J,K)
      RJB=Q(JBF,K,1)*D(JBF,K)
      RJA=Q(JFF,K,1)*D(JFF,K)
      UJ=Q(J,K,2)/Q(J,K,1)
      UJB=Q(JBF,K,2)/Q(JBF,K,1)
      UJA=Q(JFF,K,2)/Q(JFF,K,1)
      VJ=Q(J,K,3)/Q(J,K,1)
      VJB=Q(JBF,K,3)/Q(JBF,K,1)
      VJA=Q(JFF,K,3)/Q(JFF,K,1)
      EJ=Q(J,K,4)*D(J,K)
```

```
      EJB=Q(JBF,K,4)*D(JBF,K)
      EJA=Q(JFF,K,4)*D(JFF,K)
      IF(I.GE.JIX) GO TO 15
      RJ=RJ-RATA*(RJ-RJB)
      UJ=UJ-RATA*(UJ-UJB)
      VJ=VJ-RATA*(VJ-VJB)
      EJ=EJ-RATA*(EJ-EJB)
      GO TO 16
   15 RJ=RJ-RATE*(RJA-RJ)
      UJ=UJ-RATE*(UJA-UJ)
      VJ=VJ-RATE*(VJA-VJ)
      EJ=EJ-RATE*(EJA-EJ)
   16 D(J,K)=D(J,K)-RATA*(D(J,K)-D(JBF,K))
      DI=1./D(J,K)
      Q(J,K,1)=RJ*DI
      Q(J,K,2)=UJ*Q(J,K,1)
      Q(J,K,3)=VJ*Q(J,K,1)
      Q(J,K,4)=EJ*DI
    5 CONTINUE
      JS=J
      GO TO 11
   12 CONTINUE
   11 CONTINUE
      JM=JMAX-1
      DO 17 K=1,KMAX
      DO 18 N=1,4
   18 Q(1,K,N)=Q(2,K,N)
      Q(1,K,3)=-Q(2,K,3)
      D(1,K)=D(2,K)
      X(1,K)=X(2,K)
   17 Y(1,K)=-Y(2,K)
      DO 301 J=1,JMAX
      DO 301 K=1,KMAX
      DO 301 N=1,4
  301 Q(J,K,N)=Q(J,K,N)*D(J,K)
      CALL JACOB
      DO 302 J=1,JMAX
      DO 302 K=1,KMAX
      DO 302 N=1,4
  302 Q(J,K,N)=Q(J,K,N)/D(J,K)
      K=1
      DO 8 J=1,JMAX
      Z=1./Q(J,K,1)
      R=Q(J,K,1)*D(J,K)
      U=Q(J,K,2)*Z
      V=Q(J,K,3)*Z
      E=Q(J,K,4)*D(J,K)
    8 P(J)=(E-0.5*R*(U**2+V**2))*GAMM1
      WRITE(6,136)
  136 FORMAT(*0*,*SURFACE PRESSURE DISTRIBUTION AFTER ADDING POINTS*)
      WRITE(6,122)(P(J),J=1,JMAX)
  122 FORMAT(20X,10F10.5)
      RETURN
   51 CONTINUE
C     ADD OR/AND REARRANGE GRID POINTS IN K-ARRAY WITH NEW VALUE CF1
      READ(5,101) CF1
      WRITE(6,202) KIM, CF1
  202 FORMAT(*0*,*NEW GRIDS IN K-ARRAY. NO. OF POINTS =*,I3,5X,*NEW STRE
     1TCHING COEF. =*,F10.4/,5X,*NORMALIZED DISTANCE FROM BODY TO SHOCK*
     2)
      CALL ETATB(ET,CF,KMAX)
      DO 54 I=1,KMAX
   54 ETZ(I)=ET(I)
      CALL ETATB(ET,CF1,KIM)
      WRITE(6,203) (ET(K),K=1,KIM)
      WRITE(6,204)
  204 FORMAT(5X,*THE OLD VALUES ARE*)
      WRITE(6,203) (ETZ(K),K=1,KMAX)
  203 FORMAT(10X,10F10.4)
      DO 52 J=1,JMAX
```

```
      DO 53 K=1,KMAX
      XZ(K)=X(J,K)
      YZ(K)=Y(J,K)
      DZ(K)=D(J,K)
      DO 53 N=1,4
   53 QZ(K,N)=Q(J,K,N)
      DO 55 K=2,KIM
      DO 56 M=2,KMAX
   56 IF(ETZ(M).GE.ET(K)) GO TO 57
   57 RATE=(ETZ(M)-ET(K))/(ETZ(M)-ETZ(M-1))
      X(J,K)=XZ(M)-RATE*(XZ(M)-XZ(M-1))
      Y(J,K)=YZ(M)-RATE*(YZ(M)-YZ(M-1))
      D(J,K)=DZ(M)-RATE*(DZ(M)-DZ(M-1))
      RM=QZ(M,1)*DZ(M)
      RM1=QZ(M-1,1)*DZ(M-1)
      UM=QZ(M,2)/QZ(M,1)
      UM1=QZ(M-1,2)/QZ(M-1,1)
      VM=QZ(M,3)/QZ(M,1)
      VM1=QZ(M-1,3)/QZ(M-1,1)
      EM=QZ(M,4)*DZ(M)
      EM1=QZ(M-1,4)*DZ(M-1)
      R=(RM-RATE*(RM-RM1))
      U=(UM-RATE*(UM-UM1))
      V=(VM-RATE*(VM-VM1))
      E=(EM-RATE*(EM-EM1))
      Q(J,K,1)=R/D(J,K)
      Q(J,K,2)=U*Q(J,K,1)
      Q(J,K,3)=V*Q(J,K,1)
      Q(J,K,4)=E/D(J,K)
      P1=(E-0.5*R*(U**2+V**2))*GAMM1
   55 CONTINUE
   52 CONTINUE
      KMAX=KIM
      KM=KMAX-1
      CALL JACOB
  121 FORMAT(12F10.5)
      RETURN
      END

      SUBROUTINE JACOB
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAJ,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IW1,IW2,IAFBD,IGEOM,TM,IVIS,ICAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,ETINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),B(4),AB(4,4),HVEC(40,4)
      DATA IFLAG/0/
      IF(LIP.EQ.0) GO TO 13
      IF(IFLAG.EQ.1) GO TO 11
      DO 26 J=1,JMAX
   26 DETL(J)=DETL(J)/(FLOAT(LIP))
      WRITE(6,101)
  101 FORMAT(*0BODY SHAPE CHANGE BEING INSTITUTED*)
   11 CONTINUE
      IF(IT-ITS.GE.LIP.OR.IT.LT.ITS) GO TO 13
      DO 14 J=1,JMAX
      IF(ABS(X(J,1)-X(J,KMAX)).LT.1.0E-6) GO TO 15
      SLP=(Y(J,1)-Y(J,KMAX))/(X(J,1)-X(J,KMAX))
      DD=SQRT(SLP**2+1.0)
      GO TO 15
   16 CC=0.
      DD=-1.0
      GO TO 17
   15 CC=1./DD
      DD=SLP/DD
   17 CONTINUE
      X([illegible]=X(J,[illegible]C*DETL(J)
      Y(J,[illegible]=[illegible](J,[illegible]+DD*DETL(J)
      DO 1[illegible]=2,KM
      ETA=ET(K)
      X(J,K)=(X(J,KMAX)-X(J,1))*ETA+X(J,1)
```

```
   14 Y(J,K)=(Y(J,KMAX)-Y(J,1))*ETA+Y(J,1)
   13 CONTINUE
      JMM=JM-1
      KMM=KM-1
C...COMPUTE X-XI AND Y-XI, DXI AND DETA = 1
      DO 1 K=1,KMAX
      DO 2 J=2,JM
      XEY(J,K,2)=(X(J+1,K)-X(J-1,K))*0.5
    2 XEX(J,K,2)=(Y(J+1,K)-Y(J-1,K))*0.5
      XEY(1,K,2)=(-3.0*X(1,K)+4.0*X(2,K)-X(3,K))*0.5
      XEY(JMAX,K,2)=(3.0*X(JMAX,K)-4.0*X(JM,K)+X(JMM,K))*0.5
      XEX(1,K,2)=(-3.0*Y(1,K)+4.0*Y(2,K)-Y(3,K))*0.5
    1 XEX(JMAX,K,2)=(3.0*Y(JMAX,K)-4.0*Y(JM,K)+Y(JMM,K))*0.5
C...COMPUTE X-ETA AND Y-ETA
      DO 3 J=1,JMAX
      DO 4 K=2,KM
      XEY(J,K,1)=(X(J,K+1)-X(J,K-1))*0.5
    4 XEX(J,K,1)=(Y(J,K+1)-Y(J,K-1))*0.5
      XEY(J,1,1)=(-3.0*X(J,1)+4.0*X(J,2)-X(J,3))*0.5
      XEY(J,KMAX,1)=(3.0*X(J,KMAX)-4.0*X(J,KM)+X(J,KMM))*0.5
      XEX(J,1,1)=(-3.0*Y(J,1)+4.0*Y(J,2)-Y(J,3))*0.5
    3 XEX(J,KMAX,1)=(3.0*Y(J,KMAX)-4.0*Y(J,KM)+Y(J,KMM))*0.5
C...COMPUTE XI-X, XI-Y, ETA-X, AND ETA-Y
      DO 5 K=1,KMAX
      DO 5 J=1,JMAX
      DI=1.0/(XEX(J,K,1)*XEY(J,K,2)-XEY(J,K,1)*XEX(J,K,2))
      DII=DI
      IF(IFLAG.EQ.0) GO TO 7
C...ADJUST CONSERVATIVE VARIABLES BASED ON NEW MESH
      DO 6 N=1,4
    6 Q(J,K,N)=Q(J,K,N)*D(J,K)/DII
    7 CONTINUE
C...THE GEOMETRIC JACOBIAN IS DEFINED HERE AND STORED IN THE D ARRAY
      D(J,K)=DII
      XEX(J,K,1)=XEX(J,K,1)*DI
      XEY(J,K,1)=-XEY(J,K,1)*DI
      XEX(J,K,2)=-XEX(J,K,2)*DI
    5 XEY(J,K,2)=XEY(J,K,2)*DI
C...REFLECT METRICS AND DEPENDENT VARIABLES ABOUT PLANE OF SYMMETRY
      IF(IFLAG.EQ.0) GO TO 8
      DO 9 K=1,KMAX
      D(1,K)=D(2,K)
      XEX(1,K,1)=-XEX(2,K,1)
      XEY(1,K,1)=XEY(2,K,1)
      XEX(1,K,2)=XEX(2,K,2)
      XEY(1,K,2)=-XEY(2,K,2)
      DO 10 N=1,4
   10 Q(1,K,N)=Q(2,K,N)
    9 Q(1,K,3)=-Q(2,K,3)
    8 CONTINUE
      IFLAG=1
      RETURN
      END
```

```
      SUBROUTINE LBLTRA(K)
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IW1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XEX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),FF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      COMMON/COM4/A(40,4,4),B(40,4,4),C(40,4,4),HD(40,4,4),
     1UD(40,4,4),AX(40),AY(40),BX(40),BY(40)
      DO 1 J=1,JMAX
C...LOAD BLOCK A MATRIX EVALUATED AT N TH LEVEL FOR ALL J INTO HD ARRAY
      CALL ABMATX(J,K,1)
      DO 1 M=1,4
```

```
      DO 1 L=1,4
    1 HD(J,L,M)=AB(L,M)
C...FILL OFF-DIAGONAL AND DIAGONAL ELEMENTS BASED ON A 2-ND ORDER
C...CENTRAL DIFFERENCE
      DO 2 J=2,JM
      SM1=SMUIMP*D(J-1,K)/D(J,K)
      SP1=SMUIMP*D(J+1,K)/D(J,K)
      DO 2 M=1,4
      DO 3 L=1,4
      A(J,L,M)=-HD(J-1,L,M)*H
      B(J,L,M)=0.0
    3 C(J,L,M)=HD(J+1,L,M)*H
C...SET B ON THE DIAGONAL REPRESENTING THE IDENTITY MATRIX TO ONE
      A(J,M,M)=A(J,M,M)-SM1
      B(J,M,M)=1.+2.*SMUIMP
      C(J,M,M)=C(J,M,M)-SP1
    2 CONTINUE
C...APPLY SYMMETRY B.C. IMPLICITLY
      DO 4 L=1,4
      B(2,L,1)=B(2,L,1)+A(2,L,1)
      B(2,L,2)=B(2,L,2)+A(2,L,2)
      B(2,L,3)=B(2,L,3)-A(2,L,3)
      B(2,L,4)=B(2,L,4)+A(2,L,4)
    4 CONTINUE
      SM1=SMUIMP*D(1,K)/D(2,K)
      B(2,1,1)=B(2,1,1)-SM1
      B(2,2,2)=B(2,2,2)-SM1
      B(2,3,3)=B(2,3,3)+SM1
      B(2,4,4)=B(2,4,4)-SM1
C...IMPOSE OUTFLOW B.C. USING LINEAR EXTRAPOLATION IMPLICITLY
      J=JM
      SP1=SMUIMP*D(J+1,K)/D(J,K)
      DO 6 M=1,4
      DO 5 L=1,4
      A(J,L,M)=A(J,L,M)-C(J,L,M)
    5 B(J,L,M)=B(J,L,M)+2.0*C(J,L,M)
      A(J,M,M)=A(J,M,M)+SP1
      B(J,M,M)=B(J,M,M)-2.*SP1
    6 CONTINUE
C...FILL FORCING FUNCTION FROM S ARRAY
      DO 7 J=2,JM
      DO 7 M=1,4
    7 EF(J,M)=S(J,K,M)
      RETURN
      END



      SUBROUTINE LBLTRB(J)
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTOKT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IW1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMUIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVFC(40,4)
      COMMON/COM4/A(40,4,4),B(40,4,4),C(40,4,4),HD(40,4,4),
     1UD(40,4,4),AX(40),AY(40),BX(40),BY(40)
      DO 1 K=1,KMAX
C...LOAD BLOCK B MATRIX EVALUATED AT N TH LEVEL FOR ALL K INTO HD ARRAY
      CALL ABMATX(J,K,2)
      DO 1 M=1,4
      DO 1 L=1,4
    1 HD(K,L,M)=AB(L,M)
C...FILL OFF-DIAGONAL AND DIAGONAL ELEMENTS BASED ON A 2-ND ORDER
C...CENTRAL DIFFERENCE
      DO 2 K=2,KM
      SM1=SMUIMP*D(J,K-1)/D(J,K)
      SP1=SMUIMP*D(J,K+1)/D(J,K)
```

```
      DO 2 M=1,4
      DO 3 L=1,4
      A(K,L,M)=-HD(K-1,L,M)*H
      B(K,L,M)=0.0
    3 C(K,L,M)=HD(K+1,L,M)*H
C...SET B ON THE DIAGONAL REPRESENTING THE IDENTITY MATRIX TO ONE
      A(K,M,M)=A(K,M,M)-SM1
      B(K,M,M)=1.+2.*SMUIMP
      C(K,M,M)=C(K,M,M)-SP1
    2 CONTINUE
C...ADD SOURCE TERM IMPLICITLY. UD REPRESENTS THE DH/DQ OF SOURCE TERM
      IF(JCS.EQ.0)GOTO5
      DO 4 K=2,KMAX
      DO 4 M=1,4
      DO 4 L=1,4
    4 B(K,L,M)=B(K,L,M)+UD(K,L,M)
    5 CONTINUE
C...ADD VISCOUS TERMS IMPLICITLY
      IF(IVIS.GT.0) CALL VSMATB(J)
C...APPLY BODY B.C. IMPLICITLY FOR NOSLIP VISCOUS FLOW
C...FILL FORCING FUNCTION FROM S ARRAY
      DO 7 K=2,KMAX
      DO 7 M=1,4
    7 EF(K,M)=S(J,K,M)
      RETURN
      END
```

```
      SUBROUTINE LUDEC(A)
      DIMENSION A(4,4)
      COMMON/LUD/ L11,L21,L22,L31,L32,L33,L41,L42,L43,L44,V1,V2,V3,V4,
     1  U12,U13,U14,U23,U24,U34
      REAL        L11,L21,L22,L31,L32,L33,L41,L42,L43,L44
C  SUBROUTINE COMPUTES L-U DECOMPOSITION ELEMENTS
      L11 = A(1,1)
       V1 = 1./L11
      U12 =  V1*A(1,2)
      U13 =  V1*A(1,3)
      U14 =  V1*A(1,4)
      L21 = A(2,1)
      L22 = A(2,2) - L21*U12
       V2 = 1./L22
      U23 = ( A(2,3) -L21*U13)* V2
      U24 = ( A(2,4) - L21*U14)* V2
      L31 = A(3,1)
      L32 = A(3,2) - L31*U12
      L33 = A(3,3) - L31*U13 -L32*U23
       V3 = 1./L33
      U34 = ( A(3,4) - L31*U14 - L32*U24)* V3
      L41 = A(4,1)
      L42 = A(4,2) - L41*U12
      L43 = A(4,3) - L41*U13 - L42*U23
      L44 = A(4,4) - L41*U14 -L42*U24 -L43*U34
       V4 = 1./L44
      RETURN
      END
```

```
      SUBROUTINE OUTPUT(L)
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMUIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),ITF,FACTB,FACTT,REYNLD,PPTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      DIMENSION RHO(40,40),SL(40),CON(8),CP(40),RCP2(40),DRAG(40),
     1LP(40),XSL(500),YSL(500)
      DIMENSION DCON(40),ECON(40),TP(40,3),P(40,3)
      DIMENSION RD(40,3),DRO(40,3),W(40,3)
      DIMENSION PHI(3),C(3),CZ(3),CPHI(3),UO(40,3),VO(40,3)
      DATA FLAG/1./
      GO TO (1,2,3,4,5,6),L
    1 CONTINUE
C     OUTPUT FLOWFIELD DATA
      IF(FLAG.EQ.0.) GO TO 118
      READ(5,119)(LP(I),I=1,KMAX)
      FLAG=0.
  118 CONTINUE
  119 FORMAT(80I1)
      SUM(2)=SQRT(X(2,1)**2+Y(2,1)**2)
      DO 11 J=3,JMAX
   11 SUM(J)=SUM(J-1)+SQRT((X(J,1)-X(J-1,1))**2+(Y(J,1)-Y(J-1,1))**2)
      RMS=0.0
      PERRMX=0.0
      KSL=1
      SUM(1)=-SUM(2)
      DO 10 K=1,KMAX
      IF(LP(K).EQ.0) GO TO 131
      WRITE(6,120) K
  120 FORMAT(*0*,*SECOND INDEX=*,I3,/)
      IF(K-1) 303,304,303
  303 CONTINUE
      WRITE(6,117)
  117 FORMAT(* 1ST*,4X,*P/PINF*,4X,*RO/RINF*,4X,*U/QINF*,5X,*V/QINF*,5X,
     #*S/SINF*,4X,*HT/HTINF*,5X,*MACH*,8X,*CP*,9X,*X*,10X,*Y*,7X,
     #*EI/EIINF*)
      GO TO 309
  304 WRITE(6,301)
  301 FORMAT(* 1ST*,4X,*P/PINF*,4X,*    S    *,4X,*U/QINF*,5X,*V/QINF*,5X,
     #*S/SINF*,4X,*HT/HTINF*,5X,*R/RI*,8X,*CP*,9X,*X*,10X,*Y*,7X,
     #*EI/EIINF*)
  309 CONTINUE
  131 CONTINUE
      DO 66 J=1,JMAX
      EN=Q(J,K,4)*D(J,K)
      RHO(J,K)=Q(J,K,1)*D(J,K)
      U=Q(J,K,2)/Q(J,K,1)
      V=Q(J,K,3)/Q(J,K,1)
      PA=GAMM1*(EN-RHO(J,K)*0.5*(U*U+V*V))
      CPP=(PA-1.)/(0.5*GAM*XMACH**2)
      ENTRO=PA/RHO(J,K)**GAM
      HT=GAM/GAMM1*PA/RHO(J,K)+0.5*(U*U+V*V)
      SS=SQRT(GAM*PA/RHO(J,K))
      U1=U/QINF
      V1=V/QINF
      HT1=HT/HTINF
      EIR=(PA/RHO(J,K))/(GAMM1*EIINF)
      PERR=ABS(HT-HTINF)*100.0/HTINF
      IF(PERR.GT.PERRMX) PERRMX=PERR
      RMS=RMS+PERR**2
      SL(J)=SQRT(U*U+V*V)/SS
      IF(LP(K).EQ.0) GO TO 66
      IF(K-1) 306,307,306
  306 CONTINUE
      WRITE(6,121) J,PA,RHO(J,K),U1,V1,ENTRO,HT1,SL(J),CPP,X(J,K),Y(J,K)
     1,EIR
```

```
      GO TO 308
  307 WRITE(6,121) J,PA,SUM(J),U1,V1,ENTRO,HT1,RHO(J,K),
     1 CPP,X(J,K),Y(J,K),EIR
  121 FORMAT(I3,11E11.4)
  308 CONTINUE
   66 CONTINUE
      DO 10 J=3,JMAX
      IF((SL(J).LE.1.0.AND.SL(J-1).GE.1.0).OR.(SL(J).GE.1.0.AND.SL(J-1).
     1 LE.1.0)) GO TO 12
      GO TO 10
   12 JSL=J
      JSLM=JSL-1
      COEF=(1.0-SL(JSLM))/(SL(JSL)-SL(JSLM))
      XSL(KSL)=X(JSLM,K)+COEF*(X(JSL,K)-X(JSLM,K))
      YSL(KSL)=Y(JSLM,K)+COEF*(Y(JSL,K)-Y(JSLM,K))
      KSL=KSL+1
   10 CONTINUE
      WRITE(6,111)
  111 FORMAT(*0*,* SONIC LINE LOCATION*,/)
      KSL=KSL-1
      DO 122 K=1,KSL
  122 WRITE(6,110) XSL(K),YSL(K)
  110 FORMAT(* XSL=*,E11.4,3X,*YSL=*,F11.4)
      RMS=SQRT(RMS/JMAX/KMAX)
      WRITE(6,107) PERRMX,RMS
  107 FORMAT(*0*,*    PERCENT ERROR IN HT=*,F12.4,3X,* RMS OF PERCENT ER
     2ROR IN HT=*,E12.4,/)
      TOGM2=2./GAM/XMACH**2
      DO 61 J=1,JMAX
      RQ=Q(J,1,1)*D(J,1)
      E=Q(J,1,4)*D(J,1)
      U=Q(J,1,2)/Q(J,1,1)
      V=Q(J,1,3)/Q(J,1,1)
      PA=GAMM1*(E-RQ*0.5*(U**2+V**2))
      CP(J)=TOGM2*(PA-1.)
      RCP2(J)=Y(J,1)**2
   61 CONTINUE
      SUM2=CP(2)*RCP2(2)
      IF(JMAX-1) 64,63,62
   62 DO 65 J=2,JMAX
      SUM1=SUM2
      SUM2=SUM2+0.5*(RCP2(J)-RCP2(J-1)) *(CP(J)+CP(J-1))
      RB=Y(JMAX,1)
   65 DRAG(J-1)=SUM1/RB**2
   63 DRAG(JMAX)=SUM2/RB**2
      WRITE(6,164) DRAG(JMAX)
  164 FORMAT(1X,*PRESSURE DRAG =*,5X,F13.10)
   64 CONTINUE
      RETURN
    2 CONTINUE
C    OUTPUT E AND F CONSERVATIVE VARIABLES
      WRITE(6,103)
  103 FORMAT(*0*,37X,*CONSERVATIVE VARIABLES*)
      DO 7 K=1,KMAX
      WRITE(6,104) K
  104 FORMAT(*0*,*K=*,I2,//,4X,*J*,6X,*E1*,10X,*E2*,10X,*E3*,10X,*E4*,
     2 10X,*F1*,10X,*F2*,10X,*F3*,10X,*F4*,/)
      DO 7 J=1,JMAX
      CALL EFCON(J,K,1)
      DO 8 N=1,4
    8 CON(N)=G(N)
      CALL EFCON(J,K,2)
      DO 9 N=1,4
      NN=N+4
    9 CON(NN)=G(N)
    7 WRITE(6,105) J,(CON(N),N=1,8)
  105 FORMAT(I5,8E12.4)
      RETURN
C     STORE DATA ON TAPE2 FOR RESTART
```

```
    3 CONTINUE
      WRITE(2)  ((X(J,K),J=1,JMAX),K=1,KMAX),
     1         ((Y(J,K),J=1,JMAX),K=1,KMAX),
     1         ((D(J,K),J=1,JMAX),K=1,KMAX),
     1         (((XEX(J,K,N),J=1,JMAX),K=1,KMAX),N=1,2),
     1         (((XEY(J,K,N),J=1,JMAX),K=1,KMAX),N=1,2),
     1         (((Q(J,K,N),J=1,JMAX),K=1,KMAX),N=1,4),
     1   JMAX,KMAX,XMACH,GAM,IT,TAU,FACTT,(DFTT(J),J=1,JMAX)
      WRITE(6,113)
  113 FORMAT(*0*,*SOLUTION HAS BEEN STORED ON DISK*)
      RETURN
C     STORE INITIAL DATA FOR AFTERBODY CAL. USING NSWC INVISCID 3D CODE
    4 CONTINUE
      READ(5,100) JWRIT
      WRITE(6,401) JWRIT
  401 FORMAT(*0*,*DATA AT J=*,I3,2X,* IS STORED FOR AFTERBODY CAL.*)
      J=JWRIT
      NC=KMAX
      MC=3
      ZZ=X(J,1)
      ATTACK=0.
      ACH=XMACH
      YAW=0.
      GAMMA=1.4
      PINF=1.
      DINF=1.
      PHI0=3.141592
      NGAS=0
      NTEST=0
      RRX=0.
      FN=0.
      FY=0.
      FA=0.
      MX=0
      MY=0
      MZ=0
      FNZ=0.
      FYZ=0.
      FAZ=0.
      MXZ=0
      MYZ=0
      MZZ=0
      DPH=2.*ATAN(1.)
      DO 35 M=1,MC
      J=JWRIT
      PHI(M)=DPH*(M-1)
      C(M)=Y(J,KMAX)
      CZ(M)=(Y(J+1,KMAX)-Y(J-1,KMAX))/(X(J+1,KMAX)-X(J-1,KMAX))
      CPHI(M)=0.
      DO 31 K=1,KMAX
      JA=J+1
      IF(X(JA,K).LT.ZZ) J=JA
      J1=J+1
      RD(K,M)=Y(J,K)
      DRO(K,M)=Q(J,K,1)*D (J,K)
      VQ(K,M)=0.
      EN=Q(J,K,4)*D (J,K)
      UA=Q(J,K,3)/Q(J,K,1)
      VA=Q(J,K,2)/Q(J,K,1)
      R1=Y(J1,K)
      D1=Q(J1,K,1)*D (J1,K)
      E1=Q(J1,K,4)*D (J1,K)
      U1=Q(J1,K,3)/Q(J1,K,1)
      V1=Q(J1,K,2)/Q(J1,K,1)
      RATIO=(ZZ-X(J,K))/(X(J1,K)-X(J,K))
      UA=UA+RATIO*(U1-UA)
      VA=VA+RATIO*(V1-VA)
      EN=EN+RATIO*(E1-EN)
      DRO(K,M)=DRO(K,M)+RATIO*(D1-DRO(K,M))
      RD(K,M)=RD(K,M)+RATIO*(R1-RD(K,M))
```

```
      UQ(K,M)=UA
      W(K,M)=VA
      P(K,M)=(GAM-1.)*(EN-DRO(K,M)*0.5*(UA*UA+VA*VA))
      IF(M.GT.1) GO TO 31
      WRITE(6,101) K,P(K,M),DRO(K,M),W(K,M),VO(K,M),UQ(K,M),RD(K,M)
  101 FORMAT(*0*,*K=*,I2,2X,*PRESS=*,F10.4,2X,*DENS=*,E10.4,2X,
     1*AX VEL=*,E10.4,2X,*CIRCUM VEL=*,E10.4,2X,*RAD VEL=*,E10.4,2X,
     2*RD=*,E10.4)
   31 CONTINUE
  100 FORMAT(I5)
      IF(X(JWRIT,KMAX).EQ.ZZ) GO TO 34
      C(M)=RD(KMAX,M)
      CZ(M)=(Y(J1,KMAX)-Y(J,KMAX))/(X(J1,KMAX)-X(J,KMAX))
   34 CONTINUE
      IF(M.GT.1) GO TO 35
      WRITE(6,302) M,PHI(M),C(M),CZ(M),CPHI(M)
  302 FORMAT(*0*,I5,4(2X,E10.4),//)
   35 CONTINUE
      K=1
      WRITE(7) NC,MC,ATTACK,YAW,ACH,GAMMA,PINF,DINF,PHIO,K,ZZ,
     1           NGAS, NTEST, RRX,
     2           FN, FY, FA, MX, MY, MZ, FNZ, FYZ, FAZ, MXZ, MYZ, MZZ,
     3           (PHI(M), C(M), CZ(M), CPHI(M), M = 1 , MC),
     4           ((RD(N,M),UQ(N,M),VQ(N,M),W(N,M),P(N,M),DRO(N,M),
     5           M = 1 , MC), N = 1 , NC)
      RETURN
C     OUTPUT DETAILED RESIDUE INFORMATION
    5 CONTINUE
      IF(KRES.EQ.0) GO TO 33
      WRITE(6,114)
      DO 32 K=2,KM,KRES
      WRITE(6,115)K
      WRITE(6,116)(J,S(J,K,1),S(J,K,2),S(J,K,3),S(J,K,4),J=2,JM)
   32 CONTINUE
   33 CONTINUE
  114 FORMAT(1H0,T45,*DETAILED RESIDUE INFORMATION*,/,T45,28(1H*))
  115 FORMAT(1H ,T60,*SECOND INDEX =*,I4)
  116 FORMAT(1H ,I4,4E15.7,2X,I4,4E15.7)
      RETURN
C     OUTPUT HEAT TRANSFER INFORMATION
    6 CONTINUE
      REY=REYIN
      CMUU=(TWA**1.5)*CVIS1/(TWA+CVIS)
      TSTAG=1.+0.5*GAMM1*XMACH**2
      CC=CMUU/(REY*PRD*(TSTAG-TWA))
      WRITE(6,221)
  221 FORMAT(*0*,*DISTRIBUTION OF STANTON NUMBER*)
      WRITE(6,220)
  220 FORMAT(*0*,2X,*J*,15X,*S*,18X,*ST*,18X,*T1*,18X,*T2*,18X,*T3*)
      DO 69 J=1,JMAX
      ECON(J)=SQRT(XEX(J,1,2)**2+XEY(J,1,2)**2)
      DCON(J)=(XEX(J,1,1)* XEX(J,1,2)+XEY(J,1,1)*XEY(J,1,2))/ECON(J)
      DO 69 K=1,3
      P(J,K)=(Q(J,K,4)-0.5*(Q(J,K,2)**2+Q(J,K,3)**2)/Q(J,K,1))
     1 *D(J,K)*GAMM1
      TP(J,K)=P(J,K)/D(J,K)/Q(J,K,1)
   69 CONTINUE
      DO 79 J=2,JM
      TNN=DCON(J)*0.5*(TP(J+1,1)-TP(J-1,1))+ECON(J)*(-3.*TP(J,1)+4.*TP(J
     1 ,2)-TP(J,3))*0.5
      ST=CC*TNN
      WRITE(6,218) J,SUM(J),ST,TP(J,1),TP(J,2),TP(J,3)
  218 FORMAT(I5,5E20.6)
   79 CONTINUE
      IF(ITF.EQ.1) RETURN
      DO 89 J=2,JM
      WRITE(6,501) J,SUM(J)
      WRITE(6,502)
      DO 89 K=1,KMAX
```

```
      PJK=(Q(J,K,4)-0.5*(Q(J,K,2)**2+Q(J,K,3)**2)/Q(J,K,1))
     1 *D(J,K)*GAMM1
      TJK=PJK/D(J,K)/Q(J,K,1)
      SJK=(X(J,K)-X(J,1))**2+(Y(J,K)-Y(J,1))**2
      SJK=SQRT(SJK)
      UJK=Q(J,K,2)/Q(J,K,1)
      VJK=Q(J,K,3)/Q(J,K,1)
      SUV=PJK*GAM/(Q(J,K,1)*D(J,K))
      UMACH=SQRT((UJK**2+VJK**2)/SUV)
      WRITE (6,503)K,SJK,TJK,PJK,UMACH,UJK,VJK
   89 CONTINUE
  501 FORMAT(5X,*J=*,I5,10X,*S/L=*,F8.4)
  502 FORMAT(8X,*K*,5X,*NORMAL DISTANCE*,10X,*TEMPERATURE*,10X,
     1 *PRESSURE*,10X,*MACH NO.*,10X,*U-VELOCITY*,10X,*V-VELOCITY*)
  503 FORMAT(5X,I3,5X,E15.5,5X,E15.5,5X,E15.5,5X,E15.5,5X,E15.5,5X,E15.5
     1 )
      RETURN
      END
```

```
      SUBROUTINE RESIDU
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,FTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITPAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),ITF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      RSDMAX=0.0
      RSDTOT=0.0
      Q1234=0.0
      DO 100 J=2,JM
      DO 100 K=2,KM
      RSDSQR=0.0
      DO 5 L=1,4
      QLMNT=S(J,K,L)**2
      RSDSQR=RSDSQR+QLMNT
      IF(QLMNT.LT.Q1234)GOTO5
      Q1234=QLMNT
      J1234=J
      K1234=K
      L1234=L
    5 CONTINUE
      IF(RSDSQR.LT.RSDMAX)GOTO10
      RSDMAX=RSDSQR
      JRESDU=J
      KRESDU=K
   10 CONTINUE
      RSDTOT=RSDTOT+RSDSQR
  100 CONTINUE
      RSDMAX=SQRT(RSDMAX)
      RSDTOT=SQRT(RSDTOT)
      Q1234=SQRT(Q1234)
      PERCNT=RSDMAX/RSDTOT*100.
      WRITE(6,200)JRESDU,KRESDU,RSDMAX,RSDTOT,PERCNT,J1234,K1234,L1234,
     1  Q1234
  200 FORMAT(* RESIDUE INFORMATION*,9X,2I5,3F10.5,*S(*,I3,*,*,I3,*,*,I2,
     # *)=*,F10.5)
      RETURN
      END
```

```
      SUBROUTINE RHS
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),ITF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),FF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
C...  DATA C1,C2,C3/1.0,-1.0,0.0/ FOR 2 POINT ONESIDED DIFFERENCING
C...  DATA C1,C2,C3/1.5,-2.0,+0.5/FOR 3 POINT ONESIDED DIFFERENCING
      DATA C1,C2,C3/1.0,-1.0,0.0/
C...THIS SUBROUTINE COMPUTES THE RIGHT HAND SIDE OF THE DELTA FORM
C...EQUATION
C...FORM E CONSERVATIVE VARIABLES AND DIFFERENCE, STORE IN THE S ARRAY
      DO 1 K=2,KM
      DO 2 J=1,JMAX
      CALL EFCON(J,K,1)
      DO 2 N=1,4
    2 EF(J,N)=G(N)
C...CENTRAL DIFFERENCE E CONSERVATIVE VARIABLE
      DO 1 N=1,4
      DO 1 J=2,JM
    1 S(J,K,N)=(EF(J+1,N)-EF(J-1,N))*H
C...FORM F CONSERVATIVE VARIABLES AND DIFFERENCE, ADD TO PREVIOUS S
C...ARRAY
      DO 15 J=2,JM
      DO 4 K=1,KMAX
      CALL EFCON(J,K,2)
      DO 4 N=1,4
    4 EF(K,N)=G(N)
C...CENTRAL DIFFERENCE F CONSERVATIVE VARIABLE
      DO 3 N=1,4
      DO 3 K=2,KM
      S(J,K,N)=-S(J,K,N)-(EF(K+1,N)-EF(K-1,N))*H-HVEC(K,N)
    3 CONTINUE
   15 CONTINUE
C...COMPUTE TURBULENT VISCOSITY COEFFICIENT IF NECESSARY
C     IF(IVIS.EQ.1.AND.ITURB.EQ.1) CALL MUTUR
C...ADD VISCOUS TERMS TO RIGHT HAND SIDE
      IF(IVIS.EQ.1) CALL VSRHSB
      RETURN
      END
```

```
      SUBROUTINE SHAPE
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),ITF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/BDTH/X01,X02,X03,X04,Y01,Y02,Y03,Y04,SL1,SL2,SL3,R1,R2,
     1R3,R4,CT1,CT2,CT3,CT4,CT5,CT6,X00,RBODY
      COMMON/XYPS/X1,X2,X3,X4,X5,X6,X7,Y1,Y2,Y3,Y4,Y5,Y6,Y7
C     THIS SUBROUTINE READS AND WRITES  CONTROL PARAMETERS FOR NOSETIP S
C
      READ(5,121) X1,X2,X3,X4,X5,X6,X7
  121 FORMAT(8F10.0)
C
  122 FORMAT(20X,10F10.5)
C
      READ(5,121) Y1,Y2,Y3,Y4,Y5,Y6,Y7
C
      WRITE(6,131)
  131 FORMAT(*0*, 5X,*X AND Y VALUES FOR THE CONTROL POINTS*)
      WRITE(6,122) X1,X2,X3,X4,X5,X6,X7
      WRITE(6,122) Y1,Y2,Y3,Y4,Y5,Y6,Y7
C
```

```
      READ(5,121) R1,R2,R3,R4
C
      WRITE(6,132)
  132 FORMAT(*0* ,5X,*RADIUS FOR CIRCULAR ARCS*)
      WRITE(6,122) R1,R2,R3,R4
C
      READ(5,121) SL1,SL2,SL3
C
      WRITE(6,133)
  133 FORMAT(*0*,5X,*ANGLES FOR STRAIGHT LINES*)
      WRITE(6,122) SL1,SL2,SL3
      DTR=3.14159265/180.
      YO1=0.
      XO1=R1
      SL1=DTR*SL1
      SL2=DTR*SL2
      SL3=DTR*SL3
      XO2=X2+R2*COS(SL1)
      YO2=Y2-R2*SIN(SL1)
      XO3=X3-R3*COS(SL1)
      YO3=Y3+R3*SIN(SL1)
      XO4=X5+R4*COS(SL2)
      YO4=Y5-R4*SIN (SL2)
      WRITE(6,134)
  134 FORMAT(*0*,5X,*CENTERS FOR THE CIRCULAR ARCS*)
      WRITE(6,122) XO1,YO1,XO2,YO2,XO3,YO3,XO4,YO4
      RCONE=Y6/COS(SL3)
      XOO=X6+RCONE*SIN(SL3)
      OMEGA=XOO
      WRITE(6,422) XOO
  422 FORMAT(*0*,*XOO=NEW OMEGA=*,F10.4)
      RBODY=XOO
      CT1   =ATAN(Y1/(XOO-X1))
      CT2   =ATAN(Y2/(XOO-X2))
      CT3   =ATAN(Y3/(XOO-X3))
      CT4   =ATAN(Y4/(XOO-X4))
      CT5   =ATAN(Y5/(XOO-X5))
      CT6   =ATAN(Y6/(XOO-X5))
      WRITE(6,135)
  135 FORMAT(*0*,*THETA VALUES FOR CONTROL POINTS*)
      WRITE(6,122) CT1,CT2,CT3,CT4,CT5,CT6
      RETURN
      END



      SUBROUTINE SHOCK
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,RPRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,FNT,RTORT,PINF,RINF,QINF,CINF,RT,ITS,
     2 IW1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVFC(40,4)
      DIMENSION P(40,3),PXI(40),PETA(40),U(40,3),UXI(40),UETA(40),
     # V(40,3),VXI(40),VETA(40),R(40,3),RTAU(40),DTS(40),XST(40),YST(40)
      DATA XST,YST/40*0.0,40*0.0/
C...COMPUTE THE FLOW VARIABLES ONE MESH INTERVAL BELOW SHOCK
      RMS=0.0
      OSEM=0.0
      JMM=JMAX-2
      KMM=KMAX-2
      DO 3 K=1,3
      DO 3 J=1,JMAX
      KK=KMAX-3+K
      Z=1.0/Q(J,KK,1)
      R(J,K)=Q(J,KK,1)*D(J,KK)
      U(J,K)=Q(J,KK,2)*Z
      V(J,K)=Q(J,KK,3)*Z
```

```
      E2=Q(J,KK,4)*D(J,KK)
    3 P(J,K)=(E2-0.5*R(J,K)*(U(J,K)**2+V(J,K)**2))*GAMM1
C...COMPUTE P-XI, U-XI, P-ETA, U-ETA, AND V-ETA DERIVATIVES
      DO 4 J=2,JM
      PXI(J)=(P(J+1,3)-P(J-1,3))*0.5
      UXI(J)=(U(J+1,3)-U(J-1,3))*0.5
    4 VXI(J)=(V(J+1,3)-V(J-1,3))*0.5
      PXI(1)=-PXI(2)
      UXI(1)=-UXI(2)
      VXI(1)=VXI(2)
      PXI(JMAX)=(3.0*P(JMAX,3)-4.0*P(JM,3)+P(JMM,3))*0.5
      UXI(JMAX)=(3.0*U(JMAX,3)-4.0*U(JM,3)+U(JMM,3))*0.5
      VXI(JMAX)=(3.0*V(JMAX,3)-4.0*V(JM,3)+V(JMM,3))*0.5
      DO 5 J=1,JMAX
      PETA(J)=(3.0*P(J,3)-4.0*P(J,2)+P(J,1))*0.5
      UETA(J)=(3.0*U(J,3)-4.0*U(J,2)+U(J,1))*0.5
      VETA(J)=(3.0*V(J,3)-4.0*V(J,2)+V(J,1))*0.5
    5 CONTINUE
      IF(IT.EQ.ITER) WRITE(6,100)
      DO 10 J=1,JMAX
      K=KMAX
      XET=0.
      UBAR=XET+U(J,3)*XEX(J,K,1)+V(J,3)*XEY(J,K,1)
      VBAR=XET+U(J,3)*XEX(J,K,2)+V(J,3)*XEY(J,K,2)
      RCS=GAM*P(J,3)
C...DETERMINE SHOCK TIME STEP
      SPSND=SQRT(GAM*P(J,3)/R(J,3))
      ETAT=-(XEX(J,K,2)*XST(J)+XEY(J,K,2)*YST(J))
      SIGA=ABS(UBAR)+SPSND*SQRT(XEX(J,K,1)**2+XFY(J,K,1)**2)
      SIGB=ABS(ETAT+VBAR)+SPSND*SQRT(XFX(J,K,2)**2+XFY(J,K,2)**2)
      SIGAB=AMAX1(SIGA,SIGB)
      DTS(J)=.90/SIGAB
      IF(IT.EQ.ITER) WRITE(6,105) J,SIGA,SIGB,DTS(J)
  105 FORMAT(* J=*,I2,3X,*SIGA=*,E13.5,3X,*SIGB=*,E13.5,3X,*DTS=*,E13.5)
      B=-RCS*(UXI(J)*XEX(J,K,1)+VXI(J)*XEY(J,K,1)+UETA(J)*XEX(J,K,2)
     1 +VETA(J)*XEY(J,K,2)+(V(J,3)/Y(J,K)))
C...DETERMINE PRESSURE AT SHOCK EXPLICITLY
   11 PETA(J)=P(J,3)+DTS(J)*(-UBAR*PXI(J)-VBAR*PETA(J)+B)
   10 CONTINUE
C...FILL BOUNDARY POINTS FOR PRESSURE
      PETA(1)=PETA(2)
      PETA(JMAX)=2.0*PETA(JM)-PETA(JM-1)
C...SMOOTH PRESSURES AT SHOCK USING FOURTH ORDER SMOOTHING
      SMUS=0.5
      DO 14 J=3,JMM
   14 PXI(J)=PETA(J)-SMUS*0.125*(PETA(J-2)-4.0*PETA(J-1)+6.0*PETA(J)-4.0
     > *PETA(J+1)+PETA(J+2))
      PXI(2)=PETA(2)-SMUS*0.125*(2.0*PETA(2)-3.0*PETA(3)+PETA(4))
      PXI(1)=PXI(2)
      PXI(JM)=PETA(JM)-SMUS*0.125*(PETA(JM-2)-4.0*PETA(JMM)+5.0*PETA(JM)
     > -2.0*PETA(JMAX))
      PXI(JMAX)=2.0*PXI(JM)-PXI(JMM)
      DO 1 J=1,JMAX
C...DETERMINE SHOCK ANGLE DELTA=ARCTAN(-ETAY/ETAX)
      DELTA=ATAN(-XEY(J,K,2)/XEX(J,K,2))
      SD=SIN(DELTA)
      CD=COS(DELTA)
      U1T=QINF*CD
      P2=PXI(J)
      IF(P2.LE.0.0) GO TO 6
      Z=GAM+1.0
      XMX=SQRT(0.5/GAM*(P2/PINF*Z+GAMM1))
      QS=CINF*XMX-U1T
      PB=P(J,3)
      RB=R(J,3)
      UB=U(J,3)
      VB=V(J,3)
      EB=PB/GAMM1+0.5*RB*(UB**2+VB**2)
      U2T=2.0*(1.0-XMX**2)*CINF/((GAM+1.0)*XMX)+U1T
```

```
      R2=RINF*(P2/PINF+GAMM1/Z)/(1.0+GAMM1/Z*P2/PINF)
      U2=QINF*SD**2+U2T*CD
      V2=QINF*SD*CD-U2T*SD
      E2=P2/GAMM1+0.5*R2*(U2**2+V2**2)
C...COMPUTE PTAU
      PTAU(J)=(P2-PB)/DTS(J)
C...COMPUTE CONSERVATIVE VARIABLES AT SHOCK
      K=KMAX
      DI=1.0/D(J,K)
      Q(J,K,1)=R2*DI
      Q(J,K,2)=R2*U2*DI
      Q(J,K,3)=R2*V2*DI
      Q(J,K,4)=E2*DI
C...DETERMINE ANGLE OF XI=CONST LINE WITH X-AXIS
      K=KMAX
      IF(ABS(XEY(J,K,1))-0.000001) 7,7,8
    7 THETA=1.57079633
      GO TO 9
    8 CONTINUE
      THETA=ATAN(XEX(J,K,1)/XEY(J,K,1))
    9 CONTINUE
C...COMPUTE SHOCK SPEED IN X AND Y DIRECTIONS
      BETA=THETA-DELTA
      QSE=QS/COS(BETA)
      IF(ABS(QSE) .GE. ABS(QSEM))JQS=J
      IF(ABS(QSE) .GE. ABS(QSEM))QSEM=QSE
      RMS=RMS+QSE**2
      XST(J)=-QSE*COS(THETA)
      YST(J)=QSE*SIN(THETA)
      THETA=THETA*57.29578
      DELTA=DELTA*57.29578
      BETA=BETA*57.29578
      IF(IT.EQ.ITER) WRITE(6,101) J,THETA,DELTA,BETA,XMX,U1T,U2T,QSE,
     > XST(J),YST(J),PB,P2,RB,R2,UB,U2,VB,V2,EB,E2
     > ,PTAU(J)
C...PROPAGATE SHOCK
      X(J,K)=X(J,K)+XST(J)*DT
      Y(J,K)=Y(J,K)+YST(J)*DT
C...ADJUST OTHER GRID POINTS
      XB=X(J,1)
      YB=Y(J,1)
      DXX=X(J,KMAX)-XB
      DYY=Y(J,KMAX)-YB
      DO 2 K=2,KM
      ETA=ET(K)
      X(J,K) = XB + DXX*ETA
      Y(J,K) = YB + DYY*ETA
    2 CONTINUE
    1 CONTINUE
      RMS=SQRT(RMS/JMAX)
      WRITE(6,102) RMS,JQS,QSEM
  100 FORMAT(*0*,*FROM SUB. SHOCK*)
  101 FORMAT(*0*,*J=*,I2,4X,*THETA=*,F10.4,1X,*DELTA=*,E10.4,1X,*BETA=*,
     > E10.4,/,9X,*MX=*,E10.4,4X,*U1T=*,E10.4,3X,*U2T=*,E10.4,2X,*QSE=*,
     # E10.4,2X,*XST=*,E10.4,2X,*YST=*,E10.4,/,9X,11F10.4)
  102 FORMAT(* RMS OF SHOCK SPEED=*,E12.4,3X,*J=*,I3,3X,*MAX SHK SPD=*,
     > E12.4)
      RETURN
    6 CONTINUE
      K=KMAX
      WRITE(6,103) J,P2,P(J,3),PTAU(J)
      WRITE(6,104) UBAR,VBAR,PXI(J),UXI(J),VXI(J),PETA(J),UETA(J),
     > VETA(J),RCS,XEX(J,K,1),XEX(J,K,2),XEY(J,K,1),XEY(J,K,2),V(J,3),
     > Y(J,K)
  104 FORMAT(5E15.5)
      CALL OUTPUT(1)
      CALL EXIT
  103 FORMAT(* NEGATIVE PRESS. AT SHOCK, J=*,I2,3X,*PN=*,E10.4,3X,
     > *PO=*,E10.4,3X,*PTAU=*,E10.4)
      END
```

```
      SUBROUTINE TRIB (A,B,C,X,F,NL,NU)
      DIMENSION A(2),B(2),C(2),X(2),F(2)
      X(NL) = C(NL)/B(NL)
      F (NL) = F(NL)/B(NL)
      NLP1 = NL + 1
      DO 1 J = NLP1, NU
      Z = 1. / (B(J) -A(J)*X(J-1))
      X(J) = C(J) *Z
    1 F(J) = (F(J)-A(J)*F(J-1))*Z
      NUPNL = NU + NL
      DO 2 J1 = NLP1, NU
      J = NUPNL - J1
    2 F(J)=F(J)-X(J)*F(J+1)
      RETURN
      END
```

```
      SUBROUTINE VSMATH(J)
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IW1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,REY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,E1INF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTH,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XEX(40,40,2),XEY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),A3(4,4),HVEC(40,4)
      COMMON/COM4/A(40,4,4),B(40,4,4),C(40,4,4),H3(40,4,4),
     1UD(40,4,4),AX(40),AY(40),BX(40),BY(40)
      COMMON/VISC/U(40),V(40),C1(40),C2(40),C3(40),C4(40),C5(40),C6(40),
     1C7(40),TC(40),CS1(40),CS2(40),CS3(40),CS4(40),CS5(40),CS6(40),
     2CS7(40),RR(40)
      COMMON/VISK/CMUKAP(40),TURMU(40,40)
      DATA PRTR,FRT,O3,T3/1.,1.333333333333,.333333333333,.666666666666/
C...SET UP CONSTANTS NEEDED FOR ADDING VISCOUS TERMS OF S AND
C...T MATRICES IMPLICITLY
      HRE=0.5*DT/REYNLD
      GPR=GAM/PRD
C
      DO 10 K=1,KMAX
C...ADD NON-AXISYMMETRIC VISCOUS TERMS OF S MATRIX IMPLICITLY
C    THESE TERMS ARE OF SECOND DERIVATIVE TYPE
      R1=1.0/Q(J,K,1)
      U(K)=Q(J,K,2)*R1
      V(K)=Q(J,K,3)*R1
      TT=(Q(J,K,4)*R1-0.5*(U(K)**2+V(K)**2))*GAMM1
      CMUKAP(K)=(TT**1.5)*CVIS1/(TT+CVIS)
      GMU=CMUKAP(K)+TURMU(J,K)
      GKAP=CMUKAP(K)+TURMU(J,K)*PRTURB
      GPRK=GPR*GKAP
      OY=1./Y(J,K)
      DJAC=HRE/D(J,K)
      GMUJAC=GMU*DJAC
      EY=XEY(J,K,2)
      EX=XEX(J,K,2)
      EYS=EY*EY
      EXS=EX*EX
      EXY=EX*EY
      C1(K)=GMUJAC*(FRT*EXS+EYS)
      C2(K)=GMUJAC*EXY*O3
      C3(K)=GMUJAC*(EXS+FRT*EYS)
      C4(K)=GPRK*DJAC*(EXS+EYS)
      RR(K)=R1
      TC(K)=Q(J,K,4)*R1-(U(K)**2+V(K)**2)
      CS1(K)=GMUJAC*OY
      C1(K)=C1(K)*RR(K)*2.
      C2(K)=C2(K)*RR(K)*2.
      C3(K)=C3(K)*RR(K)*2.
      C4(K)=C4(K)*RR(K)*2.
      C5(K)=T3*CS1(K)*RR(K)/Y(J,K)
```

```
      C6(K)=EY*DJAC*RR(K)/Y(J,K)
      C7(K)=EX*DJAC*RR(K)/Y(J,K)
      CS2(K)=C5(K)*V(K)*EX
      CS3(K)=C5(K)*V(K)*EY
      CS4(K)=C5(K)*(U(K)*EX+V(K)*EY)
      CS5(K)=C5(K)*EX
      CS6(K)=C5(K)*EY
      CS7(K)=-GPRK*DJAC*XEY(J,K,2)*RR(K)/Y(J,K)
   10 CONTINUE
C
      DO 20 K=2,KMAX
      KR=K-1
      HD(K,2,1)=-(C1(KR)*U(KR)+C2(KR)*V(KR))
      HD(K,2,2)=C1(KR)
      HD(K,2,3)=C2(KR)
      HD(K,2,4)=0.
      HD(K,3,1)=-(C2(KR)*U(KR)+C3(KR)*V(KR))
      HD(K,3,2)=C2(KR)
      HD(K,3,3)=C3(KR)
      HD(K,3,4)=0.
      HD(K,4,1)=-(C4(KR)*TC(KR)+C1(KR)*U(KR)**2+2.*C2(KR)*U(KR)*V(KR)+C3
     1(KR)*V(KR)**2)
      HD(K,4,2)=-(C4(KR)-C1(KR))*U(KR)+C2(KR)*V(KR)
      HD(K,4,3)=-(C4(KR)-C3(KR))*V(KR)+C2(KR)*U(KR)
      HD(K,4,4)=C4(KR)
      IF(K.EQ.KMAX) GO TO 20
      KP=K+1
      UD(K,2,1)=-(C1(KP)*U(KP)+C2(KP)*V(KP))
      UD(K,2,2)=C1(KP)
      UD(K,2,3)=C2(KP)
      UD(K,2,4)=0.
      UD(K,3,1)=-(C2(KP)*U(KP)+C3(KP)*V(KP))
      UD(K,3,2)=C2(KP)
      UD(K,3,3)=C3(KP)
      UD(K,3,4)=0.
      UD(K,4,1)=-(C4(KP)*TC(KP)+C1(KP)*U(KP)**2+2.*C2(KP)*U(KP)*V(KP)+C3
     1(KP)*V(KP)**2)
      UD(K,4,2)=-(C4(KP)-C1(KP))*U(KP)+C2(KP)*V(KP)
      UD(K,4,3)=-(C4(KP)-C3(KP))*V(KP)+C2(KP)*U(KP)
      UD(K,4,4)=C4(KP)
   20 CONTINUE
      DO 30 K=2,KM
      KR=K-1
      KP=K+1
      DO 31 N=2,4
      DO 31 M=1,4
      A(K,N,M)=A(K,N,M)-HD(K,N,M)
      B(K,N,M)=B(K,N,M)+    HD(KP,N,M)+UD(KR,N,M)
      C(K,N,M)=C(K,N,M)-UD(K,N,M)
   31 CONTINUE
   30 CONTINUE
C...ADD ADDITIONAL AXISYMMETRIC CONTRIBUTION TO S MATRIX IMPLICITLY
C...THESE TERMS ARE OF FIRST DERIVATIVE TYPE
      DO 40 K=1,KMAX
      HD(K,2,1)=CS2(K)
      HD(K,2,2)=0.
      HD(K,2,3)=-CS5(K)
      HD(K,3,1)=CS3(K)
      HD(K,3,2)=0.
      HD(K,3,3)=-CS6(K)
      HD(K,4,1)=CS4(K)*2.*V(K)
      HD(K,4,2)=-CS2(K)
      HD(K,4,3)=-CS4(K)-CS3(K)
   40 CONTINUE
      DO 41 K=2,KM
      DO 41 N=2,4
      DO 41 M=1,3
      A(K,N,M)=A(K,N,M)+HD(K-1,N,M)
      C(K,N,M)=C(K,N,M)-HD(K+1,N,M)
   41 CONTINUE
```

```
C...ADD THE TERMS OF AXISYMMETRIC MATRIX T IMPLICITLY
C...FIRST ADD TERMS OPERATING ON Q VECTOR
      DO 60 K=2,KM
      KP=K+1
      KR=K-1
      DV=V(KP)-V(KR)
      DU=U(KP)-U(KR)
      HD(K,2,1)=-(C6(KP)*U(KP)+C7(KP)*V(KP))
      UD(K,2,1)=-(C6(KR)*U(KR)+C7(KR)*V(KR))
      HD  (K,2,2)=C6(KP)
      UD  (K,2,2)=C6(KR)
      HD(K,2,3)=C7(KP)
      UD(K,2,3)=C7(KR)
      HD(K,2,4)=0.
      UD(K,2,4)=0.
      HD(K,3,1)=-2.*C6(KP)*V(KP)
      UD(K,3,1)=-2.*C6(KR)*V(KR)
      HD(K,3,2)=0.
      UD(K,3,2)=0.
      HD(K,3,3)=2.*C6(KP)
      UD(K,3,3)=2.*C6(KR)
      HD(K,3,4)=0.
      UD(K,3,4)=0.
      HD(K,4,1)=CS7(KP)*TC(KP)-C6(KP)*(U(KP)**2+FRT*V(KP)**2)-C7(KP)
     + *U(KP)*V(KP)/3.
      UD(K,4,1)=CS7(KR)*TC(KP)-C6(KR)*(U(KR)**2+FRT*V(KR)**2)-C7(KR)
     + *U(KR)*V(KR)/3.
      HD(K,4,2)=-(CS7(KP)-C6(KP))*U(KP)-T3*C7(KP)*V(KP)
      UD(K,4,2)=-(CS7(KR)-C6(KR))*U(KP)-T3*C7(KR)*V(KR)
      HD(K,4,3)=-(CS7(KP)-FRT*C6(KP))*V(KP)+C7(KP)*U(KP)
      UD(K,4,3)=-(CS7(KR)-FRT*C6(KR))*V(KR)+C7(KR)*U(KR)
      HD(K,4,4)=CS7(KP)
      UD(K,4,4)=CS7(KR)
      DO 61 N=2,4
      DO 61 M=1,4
      A(K,N,M)=A(K,N,M)+UD(K,N,M)
   61 C(K,N,M)=C(K,N,M)-HD(K,N,M)
      B(K,3,1)=B(K,3,1)+6.*C5(K)*V(K)
      B(K,3,3)=B(K,3,3)-6.*C5(K)
      B(K,4,1)=B(K,4,1)+4.*C5(K)*V(K)**2
      B(K,4,2)=B(K,4,2)+5.*C7(K)*DV/3.
      B(K,4,3)=B(K,4,3)-5.*C7(K)*DU/3.-4.*C5(K)*V(K)
   60 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE VSPHSH
      COMMON/COM1/JMAX,KMAX,JM,KM,XMACH,GAM,GAMM1,CN,DT,SMU,JCS,PRT,
     1 IPRT,H,OMEGA,IT,TAU,ITER,ENT,PTORT,PINF,RINF,QINF,CINF,PT,ITS,
     2 IR1,IW2,IAFBD,IGEOM,TM,IVIS,ITRAN,CF,CC,JNM,RFY,PRD,CVIS,CVIS1,
     3 TWA,ITWA,LIP,KRES,SMJIMP,HTINF,FTINF,SINF,EIINF,REYIN,SUM(40),
     4DETT(40),DETL(40),ET(40),TH(40),TTF,FACTB,FACTT,REYNLD,PRTURB
      COMMON/COM2/X(40,40),Y(40,40),XFX(40,40,2),XFY(40,40,2),D(40,40)
      COMMON/COM3/Q(40,40,4),EF(40,4),S(40,40,4),G(4),AB(4,4),HVEC(40,4)
      COMMON/COM4/A(40,4,4),B(40,4,4),C(40,4,4),HD(40,4,4),
     1UD(40,4,4),AX(40),AY(40),BX(40),BY(40)
      COMMON/VISC/U(40),V(40),C1(40),C2(40),C3(40),C4(40),C5(40),C6(40),
     1C7(40),TC(40),CS1(40),CS2(40),CS3(40),CS4(40),CS5(40),CS6(40),
     2CS7(40),RR(40)
      COMMON/VISK/CMUKAP(40),TURMU(40,40)
      DATA PRTR,FRT,O3,T3/1.,1.333333333333,.333333333333,.666666666666/
      DO 1 J=1,JMAX
      DO 1 K=1,KMAX
    1 TURMU(J,K)=0.
      HRE=0.5*DT/REYNLD
      GPR=GAM/PRD
      DO 30 J=2,JM
```

```
      DO 31 K=1,KMAX
      R1=1.0/Q(J,K,1)
      RR(K)=R1
      U(K)=Q(J,K,2)*R1
      V(K)=Q(J,K,3)*R1
      TT=(Q(J,K,4)*R1-0.5*(U(K)**2+V(K)**2))*GAMM1
      CMUKAP(K)=(TT**1.5)*CVIS1/(TT+CVIS)
      GMU=CMUKAP(K)+TURMU(J,K)
      GKAP=CMUKAP(K)+TURMU(J,K)*PRTURB
      GPRK=GPR*GKAP
      OY=1./Y(J,K)
      DJAC=HRE/D(J,K)
      GMUJAC=GMU*DJAC
      EY=XEY(J,K,2)
      EX=XEX(J,K,2)
      EYS=EY*EY
      EXS=EX*EX
      EXY=EX*EY
      C1(K)=GMUJAC*(FRT*EXS+EYS)
      C2(K)=GMUJAC*EXY*O3
      C3(K)=GMUJAC*(EXS+FRT*EYS)
      C4(K)=GPRK*DJAC*(EXS+EYS)
      TC(K)=Q(J,K,4)*R1-0.5*(U(K)**2+V(K)**2)
      CS1(K)=GMUJAC*OY
      CSS=-T3*CS1(K)*V(K)
      CS2(K)=CS1(K)*EX
      CS3(K)=CS1(K)*EY
      CS4(K)=-CSS*(U(K)*EX+V(K)*EY)
      CS7(K)=GPRK*DJAC*EY
   31 CONTINUE
      DO 41 K=2,KM
      C5(K)=(TC(K+1)-TC(K-1))*0.5
      C6(K)=( U(K+1)- U(K-1))*0.5
      C7(K)=( V(K+1)- V(K-1))*0.5
      CS5(K)=CS2(K)*(U(K)*C7(K)-T3*V(K)*C6(K))
      CS6(K)=CS3(K)*(U(K)*C6(K)+FRT*V(K)*C7(K))
   41 CONTINUE
      C5(1)=(-3.*TC(1)+4.*TC(2)-TC(3))*0.5
      C6(1)=(-3.* U(1)+4.* U(2)- U(3))*0.5
      C7(1)=(-3.* V(1)+4.* V(2)- V(3))*0.5
      C5(KMAX)=(3.*TC(KMAX)-4.*TC  (KM)+TC(KM-1))*0.5
      C6(KMAX)=(3.* U(KMAX)-4.* U  (KM)+ U(KM-1))*0.5
      C7(KMAX)=(3.* V(KMAX)-4.* V  (KM)+ V(KM-1))*0.5
      DO 32 K=2,KM
      KP=K+1
      KR=K-1
      C5KPKP=CS1(KP)*T3*Y(J,KP)
      C5KRKR=CS1(KR)*T3*Y(J,KR)
      SP2=C1(KP)*C6(KP)+C2(KP)*C7(KP)-C5KPKP*XEX(J,K,2)*V(KP)
      SR2=C1(KR)*C6(KR)+C2(KR)*C7(KR)-C5KRKR*XEX(J,K,2)*V(KR)
      EF(K,2)=SP2-SR2
      SP3=C2(KP)*C6(KP)+C3(KP)*C7(KP)-C5KPKP*XEY(J,K,2)*V(KP)
      SR3=C2(KR)*C6(KR)+C3(KR)*C7(KR)-C5KRKR*XEY(J,K,2)*V(KR)
      EF(K,3)=SP3-SR3
      SP4=C4(KP)*C5(KP)+(C1(KP)*U(KP)+C2(KP)*V(KP))*C6(KP)
     1     +(C2(KP)*U(KP)+C3(KP)*V(KP))*C7(KP)-CS4(KP)
      SR4=C4(KR)*C5(KR)+(C1(KR)*U(KR)+C2(KR)*V(KR))*C6(KR)
     1     +(C2(KR)*U(KR)+C3(KR)*V(KR))*C7(KR)-CS4(KR)
      EF(K,4)=SP4-SR4
      T2=(CS3(K)*C6(K)+CS2(K)*C7(K))*2.
      T3=(2.*(CS3(K)*C7(K)-CS1(K)*V(K)/Y(J,K)))*2.
      T4=(CS7(K)*C5(K)+(CS5(K)+CS6(K)-T3*V(K)**2/Y(J,K))*CS1(K))*2.
      EF(K,2)=EF(K,2)+T2
      EF(K,3)=EF(K,3)+T3
      EF(K,4)=EF(K,4)+T4
   32 CONTINUE
C
      DO 33 K=2,KM
      DO 33 N=2,4
   33 S(J,K,N)=S(J,K,N)+EF(K,N)
```

```
30 CONTINUE
   RETURN
   END
```

Table D4. Input Data Cards

Card No.	Format	Parameters
1	8I5	JMAX, KMAX, ITER, IPRT, IR1, IW2, IFABD
2	8I5	JNM, IGEOM, LIP, KRES, ITRAN, IVIS
3	7F10.0, 2F5.0	XMACH, GAM, TM, OMEGA, CN, CF, CC, SMU, SUMIMP

* * * * * Stop here for inviscid flow over sphere-cone and follow by last input card, Example 1 * * * * *

Card No.	Format	Parameters
4	5F10.0, 3I5	REY, PRD, PRT, CVIS, TWA, ITWA, ITUR, ITF

* * * * * Stop here for viscous (laminar) flow over sphere-cone and follow by last input card, Example 2 * * * * *

* * * * * Data cards 1-3 are always needed for any runs of inviscid calculation. Card 4 must be added for any runs of viscous calculation * * * * *

* * * * * The following data cards are needed for doing arbitrary nosetip shapes with cone afterbody. For simplicity, examples are given for inviscid flow only. For viscous flows the same additional data cards must be included. * * * * *

* * * * * If IGEOM = 1, read in XB, YB, XS, YS for arbitrary nosetips shape, Example 3 * * * * *

Card No.	Format	Parameters
$(4)_1$	8F10.5	XB, YB, XS, YS for each J
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
$(4 + \text{JMAX})_1$		

Followed by the last input card

* * * * * If IGEOM = 2, read in Th(J) and DETT(J) and LIP for the nosetip to deform from sphere-cone to the desired nosetip shape, Example 4 * * * * *

$(4)_2$	8F10.5	TH(J), J = 1,JMAX
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
$(4 + \mathrm{JMAX}/8)_2$		

$(5 + \mathrm{JMAX}/8)_2$	8F10.5	DETT(J), J = 1, JMAX
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
$(5 + (\mathrm{JMAX}/\delta)\mathrm{x}2)_2$		

Followed by the last input card

* * * * * If IGEOM = 3 or 4, read in control points for the nosetip shape. * * * * *

$(4)_{3,4}$	7F10.0	X1, X2, X3, X4, X5, X6, X7
$(5)_{3,4}$	7F10.0	Y1, Y2, Y3, Y4, Y5, Y6, Y7
$(6)_{3,4}$	7F10.0	R1, R2, R3, R4
$(8)_{3,4}$	7F10.0	SL1, SL2, SL3

* * * * * For IGEOM = 3 uniformly distributed TH(J) in the nosetip portion, then the last input card follows. Example 5. * * * * *

* * * * * If IGEOM = 4, read in TH(J) in the nosetip portion, then the last input card follows. Example 6. * * * * *

$(9)_4$	8F10.0	TH(J), J = 1, JMAX
.	.	.
.	.	.
.	.	.
.	.	.
$(9 + \frac{\mathrm{JMAX}}{8})_4$		

* * * * * Note: when only a fraction of the total deformation is done for this run, read in FACTB before the last input card. * * * * *

$(9)_3$ or $(10 + \frac{JMAX}{8})_4$	8F10.0	FACTB

* * * * * For adding points. OMEGA ≡ 0 and IR1 ≡ 1 after reading cards 1, 2 and 3 the 4th card is * * * * *

4	3I5	JAA, JIX, KIM

* * * * * When more rays are needed, JAA ≠ 0 and KIM ≡ 0. Read in the THs for each added ray. Example 7 * * * * *

5	8F10.0	THAD(J), J = 1, JAA

Followed by reading control points for nosetip shape:

6	7F10.0	X1, X2, ..., X7
7	7F10.0	Y1, Y2, ..., Y7
8	7F10.0	R1, ..., R4
9	7F10.0	SL1,....SL3

Followed by the last input card.

* * * * * When only increase or change points in the K - direction Then JAA ≡ 0 and KIM ≠ 0. Example 8 * * * * *

5'	F10.0	CF1

Followed by the last input card.

* * * * * Last input card controls the output of flow variables at each K line. LP(K) = 1 prints out the flow variables; LP(K) = 0 skip printing * * * * *

Last	80I1	LP(K), K = 1, KMAX

* * * * * When starting data is needed for afterbody calculation, let IAFBD = 1. A data card for JWRIT must be read in after the last card. Example 8. * * * * *

Final	I5	JWRIT

Example 1

Input Data Cards

```
   20   12  100    0    0    0    0
   19    0    0    1    1    0
3.         1.4      0.0       5.225     2.5       100000.   1.        .05  .15
100100100111
```

Printed Output

```
AXISYMMETRIC FLOW OVER NOSETIP


MACH NUMBER = 3.00
RATIO OF SPECIFIC HEAT = 1.40
CONE(AFTERBODY) HALF-ANGLE =  0.000  DEGREES
OMEGA =  5.225     (OMEGA.GT.0,OMEGA IS THE RADIUS OF SPHERE-CONESOMEGA=0,MORE RAYS TO BE ADDED)

IR1 = 0      ( 1 FOR READ TAPE1S 0     OTHERWISE)
IW2 = 0      (1 FOR WRITE ON TAPE2S 0   OTHERWISE)
IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGENS 0     OTHERWISE)
IAFBD = 0      ( 1 FOR      STORAGE OF STARTING DATA FOR AFTERBODY CAL.S 0     OTHERWISE)
IGEOM = 0      ( 0 FOR UNIFORM SPACING ON NOSE S 1 FOR RFAD IN XB,YB,XS,YS S 2 FOR READ IN TH(J) AND DETT(J) S
                3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)S 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

LIP = 0      ( 0 FOR WITHOUT SHAPE CHANGE S  N FOR SHAPF CHANGE COMPLETED IN N STEPS)
IVIS = 0      (  0 FOR INVISCID FLOW S 1 FOR LAMINAR FLOW)

CF(BETA)=100000.00000      ( FOR UNIFORM SPACING SET TO 10000)
CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
ITRAN = 1      (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
KRES = 1      (INTERVAL IN K FOR RESIDUE INFORMATION)
EXPLICIT DISSI. COEF. = .050
IMPLICIT DISSI. COEF. = .150
COURANT NO. =    2.50



JMAX=   20
KMAX=   12
JNM=   19      (JUNCTURE OF SPHERE AND CONE)
ITER = 100      (TIME STEPS FOR THIS RUN)

FREE STREAM CONDITIONS

PINF(PRESSURE) =  1.0000
RINF(DENSITY) =  1.0000
QINF(TOTAL VEL.) =  3.5496
AINF(SOUND SPEED) =  1.1832
UINF(U COMP.) =  3.5496
VINF(V COMP.) =  0.0000
HTINF(T. ENTHALPY) =  9.8000
ETINF(T. SPEC. ENERGY) =  8.8000
SINF(ENTROPY) =  1.0000
EIINF(INTERNAL ENERGY) =  2.5000
```

```
NORMALIZED DISTANCE FROM BODY TO SHOCK
                       0.000000   .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                        .909091  1.000000

ARC LENGTH
                         .23442    .70326   1.17209   1.64093   2.10977   2.57861   3.04744   3.51628   3.98512   4.45396
                        4.92279   5.39163   5.86047   6.32931   6.79814   7.26698   7.73582   8.20466   8.67365

STARTING FLOWFIELD INFORMATION

SECOND INDEX=  1

1ST    P/PINF       S        U/QINF      V/QINF      S/SINF     HT/HTINF      R/RI        CP          X           Y        EI/EIINF
  1  .1204E+02 -.2344E+00  .1298E-02 -.2891E-01  .1561E+01  .1000E+01  .4302E+01  .1752E+01  .5261E-02 -.2344E+00  .2798E+01
  2  .1204E+02  .2344E+00  .1298E-02  .2891E-01  .1561E+01  .1000E+01  .4302E+01  .1752E+01  .5261E-02  .2344E+00  .2798E+01
  3  .1186E+02  .7033E+00  .1164E-01  .8594E-01  .1561E+01  .1000E+01  .4256E+01  .1724E+01  .4729E-01  .7014E+00  .2786E+01
  4  .1151E+02  .1172E+01  .3210E-01  .1406E+00  .1561E+01  .1000E+01  .4165E+01  .1668E+01  .1310E+00  .1163E+01  .2763E+01
  5  .1100E+02  .1641E+01  .6223E-01  .1915E+00  .1561E+01  .1000E+01  .4032E+01  .1587E+01  .2557E+00  .1615E+01  .2727E+01
  6  .1035E+02  .2110E+01  .1014E+00  .2372E+00  .1561E+01  .1000E+01  .3862E+01  .1484E+01  .4205E+00  .2054E+01  .2680E+01
  7  .9594E+01  .2579E+01  .1487E+00  .2763E+00  .1561E+01  .1000E+01  .3658E+01  .1364E+01  .6239E+00  .2476E+01  .2623E+01
  8  .8759E+01  .3047E+01  .2031E+00  .3076E+00  .1561E+01  .1000E+01  .3428E+01  .1232E+01  .8644E+00  .2878E+01  .2555E+01
  9  .7876E+01  .3516E+01  .2633E+00  .3302E+00  .1561E+01  .1000E+01  .3177E+01  .1091E+01  .1140E+01  .3258E+01  .2479E+01
 10  .6976E+01  .3985E+01  .3280E+00  .3431E+00  .1561E+01  .1000E+01  .2913E+01  .9485E+00  .1448E+01  .3611E+01  .2395E+01
 11  .6090E+01  .4454E+01  .3956E+00  .3456E+00  .1561E+01  .1000E+01  .2644E+01  .8079E+00  .1787E+01  .3935E+01  .2303E+01
 12  .5245E+01  .4923E+01  .4643E+00  .3373E+00  .1561E+01  .1000E+01  .2376E+01  .6739E+00  .2154E+01  .4227E+01  .2207E+01
 13  .4468E+01  .5392E+01  .5322E+00  .3180E+00  .1561E+01  .1000E+01  .2119E+01  .5504E+00  .2545E+01  .4485E+01  .2108E+01
 14  .3777E+01  .5860E+01  .5970E+00  .2875E+00  .1561E+01  .1000E+01  .1880E+01  .4408E+00  .2958E+01  .4708E+01  .2010E+01
 15  .3192E+01  .6329E+01  .6564E+00  .2464E+00  .1561E+01  .1000E+01  .1667E+01  .3479E+00  .3389E+01  .4892E+01  .1915E+01
 16  .2723E+01  .6798E+01  .7075E+00  .1953E+00  .1561E+01  .1000E+01  .1488E+01  .2736E+00  .3835E+01  .5037E+01  .1830E+01
 17  .2383E+01  .7267E+01  .7473E+00  .1356E+00  .1561E+01  .1000E+01  .1352E+01  .2194E+00  .4292E+01  .5141E+01  .1762E+01
 18  .2176E+01  .7736E+01  .7727E+00  .6955E-01  .1561E+01  .1000E+01  .1267E+01  .1866E+00  .4757E+01  .5204E+01  .1716E+01
 19  .2110E+01  .8205E+01  .7810E+00  .1752E-01  .1561E+01  .1000E+01  .1240E+01  .1763E+00  .5225E+01  .5225E+01  .1702E+01
 20  .2110E+01  .8674E+01  .7810E+00  .1750E-01  .1561E+01  .1000E+01  .1240E+01  .1763E+00  .5694E+01  .5225E+01  .1702E+01

SECOND INDEX=  4

1ST    P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF     HT/HTINF     MACH        CP          X           Y        EI/EIINF
  1  .1157E+02  .4180E+01  .1244E+00 -.4863E-01  .1562E+01  .1000E+01  .2408E+00  .1678E+01 -.2830E+00 -.2474E+00  .2768E+01
  2  .1157E+02  .4180E+01  .1244E+00  .4863E-01  .1562E+01  .1000E+01  .2408E+00  .1678E+01 -.2830E+00  .2474E+00  .2768E+01
  3  .1141E+02  .4143E+01  .1113E+00  .1138E+00  .1560E+01  .1000E+01  .2878E+00  .1653E+01 -.2416E+00  .7405E+00  .2754E+01
  4  .1110E+02  .4069E+01  .1191E+00  .1612E+00  .1556E+01  .1000E+01  .3640E+00  .1603E+01 -.1592E+00  .1229E+01  .2728E+01
  5  .1065E+02  .3962E+01  .1419E+00  .2044E+00  .1550E+01  .1000E+01  .4553E+00  .1532E+01 -.3653E-01  .1710E+01  .2689E+01
  6  .1009E+02  .3825E+01  .1751E+00  .2439E+00  .1542E+01  .1000E+01  .5546E+00  .1443E+01  .1255E+00  .2180E+01  .2638E+01
  7  .9430E+01  .3660E+01  .2164E+00  .2781E+00  .1533E+01  .1000E+01  .6586E+00  .1338E+01  .3256E+00  .2636E+01  .2576E+01
  8  .8705E+01  .3474E+01  .2641E+00  .3059E+00  .1523E+01  .1000E+01  .7659E+00  .1223E+01  .5624E+00  .3078E+01  .2506E+01
  9  .7939E+01  .3270E+01  .3167E+00  .3265E+00  .1511E+01  .1000E+01  .8758E+00  .1101E+01  .8345E+00  .3501E+01  .2428E+01
 10  .7159E+01  .3056E+01  .3730E+00  .3389E+00  .1499E+01  .1000E+01  .9877E+00  .9776E+00  .1140E+01  .3905E+01  .2343E+01
 11  .6389E+01  .2835E+01  .4314E+00  .3429E+00  .1485E+01  .1000E+01  .1101E+01  .8554E+00  .1478E+01  .4289E+01  .2253E+01
 12  .5651E+01  .2615E+01  .4907E+00  .3380E+00  .1471E+01  .1000E+01  .1216E+01  .7383E+00  .1847E+01  .4650E+01  .2161E+01
 13  .4965E+01  .2401E+01  .5492E+00  .3242E+00  .1457E+01  .1000E+01  .1330E+01  .6293E+00  .2245E+01  .4988E+01  .2068E+01
 14  .4345E+01  .2199E+01  .6055E+00  .3016E+00  .1442E+01  .1000E+01  .1443E+01  .5310E+00  .2672E+01  .5302E+01  .1976E+01
 15  .3805E+01  .2014E+01  .6578E+00  .2705E+00  .1428E+01  .1000E+01  .1552E+01  .4453E+00  .3126E+01  .5593E+01  .1889E+01
 16  .3355E+01  .1854E+01  .7046E+00  .2317E+00  .1414E+01  .1000E+01  .1654E+01  .3738E+00  .3607E+01  .5861E+01  .1810E+01
 17  .3000E+01  .1724E+01  .7441E+00  .1862E+00  .1400E+01  .1000E+01  .1744E+01  .3175E+00  .4117E+01  .6106E+01  .1741E+01
 18  .2747E+01  .1629E+01  .7748E+00  .1352E+00  .1388E+01  .1000E+01  .1817E+01  .2773E+00  .4655E+01  .6330E+01  .1687E+01
 19  .2626E+01  .1584E+01  .7909E+00  .9463E-01  .1379E+01  .1000E+01  .1856E+01  .2581E+00  .5225E+01  .6535E+01  .1658E+01
 20  .2467E+01  .1525E+01  .8056E+00  .8731E-01  .1367E+01  .1000E+01  .1911E+01  .2329E+00  .5694E+01  .6635E+01  .1618E+01
```

```
SECOND INDEX=  7

1ST    P/PINF      RO/RINF      U/QINF      V/QINF       S/SINF     HT/HTINF      MACH         CP          X           Y         EI/EIINF
 1   .1110E+02   .4058E+01   .1860E+00 -.3565E-01   .1562E+01   .1000E+01   .3435E+00   .1603E+01 -.5712E+00 -.2603E+00   .2735E+01
 2   .1110E+02   .4058E+01   .1860E+00  .3565E-01   .1562E+01   .1000E+01   .3435E+00   .1603E+01 -.5712E+00  .2603E+00   .2735E+01
 3   .1096E+02   .4030E+01   .1853E+00  .9911E-01   .1558E+01   .1000E+01   .3823E+00   .1582E+01 -.5305E+00  .7796E+00   .2720E+01
 4   .1070E+02   .3974E+01   .1938E+00  .1513E+00   .1550E+01   .1000E+01   .4496E+00   .1539E+01 -.4495E+00  .1295E+01   .2691E+01
 5   .1031E+02   .3893E+01   .2134E+00  .1963E+00   .1538E+01   .1000E+01   .5345E+00   .1478E+01 -.3288E+00  .1805E+01   .2649E+01
 6   .9827E+01   .3788E+01   .2423E+00  .2355E+00   .1523E+01   .1000E+01   .6294E+00   .1401E+01 -.1695E+00  .2306E+01   .2594E+01
 7   .9266E+01   .3662E+01   .2784E+00  .2690E+00   .1505E+01   .1000E+01   .7301E+00   .1312E+01  .2730E-01  .2797E+01   .2530E+01
 8   .8650E+01   .3520E+01   .3200E+00  .2961E+00   .1486E+01   .1000E+01   .8343E+00   .1214E+01  .2605E+00  .3277E+01   .2458E+01
 9   .8002E+01   .3364E+01   .3655E+00  .3166E+00   .1465E+01   .1000E+01   .9405E+00   .1111E+01  .5290E+00  .3745E+01   .2379E+01
10   .7342E+01   .3198E+01   .4136E+00  .3301E+00   .1442E+01   .1000E+01   .1048E+01   .1007E+01  .8320E+00  .4200E+01   .2296E+01
11   .6689E+01   .3027E+01   .4633E+00  .3366E+00   .1419E+01   .1000E+01   .1156E+01   .9029E+00  .1169E+01  .4642E+01   .2210E+01
12   .6057E+01   .2854E+01   .5133E+00  .3359E+00   .1395E+01   .1000E+01   .1263E+01   .8027E+00  .1540E+01  .5072E+01   .2123E+01
13   .5462E+01   .2683E+01   .5627E+00  .3283E+00   .1372E+01   .1000E+01   .1370E+01   .7082E+00  .1945E+01  .5490E+01   .2036E+01
14   .4913E+01   .2517E+01   .6105E+00  .3140E+00   .1349E+01   .1000E+01   .1474E+01   .6211E+00  .2385E+01  .5897E+01   .1952E+01
15   .4419E+01   .2362E+01   .6557E+00  .2934E+00   .1327E+01   .1000E+01   .1575E+01   .5427E+00  .2863E+01  .6295E+01   .1871E+01
16   .3986E+01   .2220E+01   .6975E+00  .2671E+00   .1305E+01   .1000E+01   .1672E+01   .4740E+00  .3380E+01  .6685E+01   .1796E+01
17   .3618E+01   .2095E+01   .7350E+00  .2358E+00   .1285E+01   .1000E+01   .1762E+01   .4156E+00  .3942E+01  .7071E+01   .1727E+01
18   .3319E+01   .1990E+01   .7675E+00  .2004E+00   .1266E+01   .1000E+01   .1843E+01   .3680E+00  .4554E+01  .7456E+01   .1668E+01
19   .3142E+01   .1928E+01   .7877E+00  .1719E+00   .1254E+01   .1000E+01   .1895E+01   .3400E+00  .5225E+01  .7844E+01   .1630E+01
20   .2824E+01   .1810E+01   .8148E+00  .1570E+00   .1231E+01   .1000E+01   .1993E+01   .2895E+00  .5694E+01  .8045E+01   .1561E+01

SECOND INDEX= 10

1ST    P/PINF      RO/RINF      U/QINF      V/QINF       S/SINF     HT/HTINF      MACH         CP          X           Y         EI/EIINF
 1   .1063E+02   .3937E+01   .2327E+00 -.2897E-01   .1561E+01   .1000E+01   .4281E+00   .1529E+01 -.8595E+00 -.2733E+00   .2701E+01
 2   .1063E+02   .3937E+01   .2327E+00  .2897E-01   .1561E+01   .1000E+01   .4281E+00   .1529E+01 -.8595E+00  .2733E+00   .2701E+01
 3   .1052E+02   .3917E+01   .2385E+00  .8470E-01   .1555E+01   .1000E+01   .4635E+00   .1510E+01 -.8194E+00  .8188E+00   .2685E+01
 4   .1029E+02   .3879E+01   .2517E+00  .1355E+00   .1543E+01   .1000E+01   .5266E+00   .1475E+01 -.7397E+00  .1361E+01   .2653E+01
 5   .9967E+01   .3823E+01   .2726E+00  .1809E+00   .1525E+01   .1000E+01   .6078E+00   .1423E+01 -.6211E+00  .1900E+01   .2607E+01
 6   .9565E+01   .3751E+01   .3002E+00  .2205E+00   .1503E+01   .1000E+01   .6997E+00   .1360E+01 -.4645E+00  .2432E+01   .2550E+01
 7   .9102E+01   .3664E+01   .3332E+00  .2541E+00   .1478E+01   .1000E+01   .7975E+00   .1286E+01 -.2710E+00  .2958E+01   .2484E+01
 8   .8596E+01   .3565E+01   .3699E+00  .2816E+00   .1450E+01   .1000E+01   .8983E+00   .1206E+01 -.4145E-01  .3476E+01   .2411E+01
 9   .8066E+01   .3457E+01   .4093E+00  .3030E+00   .1421E+01   .1000E+01   .1000E+01   .1122E+01  .2235E+00  .3989E+01   .2333E+01
10   .7526E+01   .3341E+01   .4502E+00  .3183E+00   .1391E+01   .1000E+01   .1102E+01   .1036E+01  .5238E+00  .4495E+01   .2253E+01
11   .6988E+01   .3218E+01   .4917E+00  .3279E+00   .1360E+01   .1000E+01   .1203E+01   .9505E+00  .8599E+00  .4996E+01   .2171E+01
12   .6463E+01   .3092E+01   .5331E+00  .3320E+00   .1331E+01   .1000E+01   .1303E+01   .8672E+00  .1233E+01  .5495E+01   .2090E+01
13   .5959E+01   .2964E+01   .5738E+00  .3310E+00   .1302E+01   .1000E+01   .1402E+01   .7871E+00  .1645E+01  .5992E+01   .2010E+01
14   .5481E+01   .2836E+01   .6133E+00  .3253E+00   .1274E+01   .1000E+01   .1498E+01   .7113E+00  .2099E+01  .6492E+01   .1932E+01
15   .5033E+01   .2709E+01   .6513E+00  .3152E+00   .1247E+01   .1000E+01   .1593E+01   .6401E+00  .2599E+01  .6996E+01   .1858E+01
16   .4618E+01   .2585E+01   .6874E+00  .3012E+00   .1221E+01   .1000E+01   .1685E+01   .5742E+00  .3153E+01  .7509E+01   .1786E+01
17   .4236E+01   .2466E+01   .7215E+00  .2838E+00   .1198E+01   .1000E+01   .1774E+01   .5137E+00  .3767E+01  .8036E+01   .1718E+01
18   .3890E+01   .2352E+01   .7531E+00  .2633E+00   .1175E+01   .1000E+01   .1861E+01   .4588E+00  .4453E+01  .8582E+01   .1654E+01
19   .3658E+01   .2271E+01   .7747E+00  .2464E+00   .1160E+01   .1000E+01   .1922E+01   .4218E+00  .5225E+01  .9154E+01   .1610E+01
20   .3181E+01   .2094E+01   .8132E+00  .2241E+00   .1130E+01   .1000E+01   .2054E+01   .3462E+00  .5694E+01  .9455E+01   .1519E+01

SECOND INDEX= 11

1ST    P/PINF      RO/RINF      U/QINF      V/QINF       S/SINF     HT/HTINF      MACH         CP          X           Y         EI/EIINF
 1   .1048E+02   .3896E+01   .2468E+00 -.2739E-01   .1561E+01   .1000E+01   .4542E+00   .1504E+01 -.9556E+00 -.2776E+00   .2689E+01
 2   .1048E+02   .3896E+01   .2468E+00  .2739E-01   .1561E+01   .1000E+01   .4542E+00   .1504E+01 -.9556E+00  .2776E+00   .2689E+01
 3   .1037E+02   .3880E+01   .2539E+00  .8073E-01   .1554E+01   .1000E+01   .4889E+00   .1487E+01 -.9157E+00  .8318E+00   .2672E+01
 4   .1015E+02   .3847E+01   .2684E+00  .1304E+00   .1540E+01   .1000E+01   .5510E+00   .1453E+01 -.8364E+00  .1383E+01   .2640E+01
 5   .9853E+01   .3799E+01   .2900E+00  .1754E+00   .1520E+01   .1000E+01   .6313E+00   .1405E+01 -.7185E+00  .1931E+01   .2593E+01
 6   .9478E+01   .3738E+01   .3176E+00  .2149E+00   .1496E+01   .1000E+01   .7224E+00   .1346E+01 -.5628E+00  .2474E+01   .2535E+01
 7   .9047E+01   .3665E+01   .3498E+00  .2485E+00   .1468E+01   .1000E+01   .8193E+00   .1277E+01 -.3704E+00  .3011E+01   .2469E+01
 8   .8578E+01   .3581E+01   .3853E+00  .2761E+00   .1438E+01   .1000E+01   .9188E+00   .1203E+01 -.1421E+00  .3543E+01   .2396E+01
 9   .8087E+01   .3488E+01   .4229E+00  .2979E+00   .1407E+01   .1000E+01   .1019E+01   .1125E+01  .1217E+00  .4070E+01   .2318E+01
10   .7587E+01   .3388E+01   .4615E+00  .3139E+00   .1374E+01   .1000E+01   .1119E+01   .1045E+01  .4211E+00  .4593E+01   .2239E+01
11   .7088E+01   .3282E+01   .5005E+00  .3246E+00   .1342E+01   .1000E+01   .1218E+01   .9663E+00  .7568E+00  .5114E+01   .2160E+01
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12  .6599E+01  .3172E+01  .5391E+00  .3304E+00  .1311E+01  .1000E+01  .1315E+01  .8887E+00  .1130E+01  .5636E+01  .2000E+01
13  .6125E+01  .3058E+01  .5770E+00  .3317E+00  .1281E+01  .1000E+01  .1411E+01  .8135E+00  .1545E+01  .6160E+01  .2003E+01
14  .5670E+01  .2942E+01  .6139E+00  .3288E+00  .1251E+01  .1000E+01  .1505E+01  .7413E+00  .2003E+01  .6690E+01  .1927E+01
15  .5237E+01  .2825E+01  .6495E+00  .3223E+00  .1224E+01  .1000E+01  .1598E+01  .6726E+00  .2512E+01  .7230E+01  .1854E+01
16  .4820E+01  .2707E+01  .6836E+00  .3123E+00  .1197E+01  .1000E+01  .1688E+01  .6076E+00  .3077E+01  .7784E+01  .1783E+01
17  .4442E+01  .2589E+01  .7161E+00  .2993E+00  .1173E+01  .1000E+01  .1778E+01  .5464E+00  .3708E+01  .8358E+01  .1716E+01
18  .4081E+01  .2472E+01  .7470E+00  .2836E+00  .1149E+01  .1000E+01  .1866E+01  .4890E+00  .4419E+01  .8957E+01  .1651E+01
19  .3830E+01  .2386E+01  .7686E+00  .2703E+00  .1134E+01  .1000E+01  .1929E+01  .4491E+00  .5225E+01  .9590E+01  .1605E+01
20  .3300E+01  .2189E+01  .8111E+00  .2456E+00  .1102E+01  .1000E+01  .2071E+01  .3650E+00  .5694E+01  .9925E+01  .1507E+01

SECOND INDEX= 12

1ST    P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF    HT/HTINF      MACH         CP          X           Y        EI/EIINF
 1  .1032E+02  .3855E+01  .2603E+00 -.2602E-01  .1560E+01  .1000E+01  .4797E+00  .1479E+01 -.1052E+01 -.2819E+00  .2677E+01
 2  .1032E+02  .3855E+01  .2603E+00  .2602E-01  .1560E+01  .1000E+01  .4797E+00  .1479E+01 -.1052E+01  .2819E+00  .2677E+01
 3  .1022E+02  .3842E+01  .2684E+00  .7713E-01  .1552E+01  .1000E+01  .5138E+00  .1463E+01 -.1012E+01  .8449E+00  .2660E+01
 4  .1002E+02  .3815E+01  .2841E+00  .1256E+00  .1537E+01  .1000E+01  .5751E+00  .1432E+01 -.9332E+00  .1406E+01  .2626E+01
 5  .9739E+01  .3776E+01  .3064E+00  .1699E+00  .1516E+01  .1000E+01  .6546E+00  .1387E+01 -.8159E+00  .1963E+01  .2579E+01
 6  .9390E+01  .3726E+01  .3341E+00  .2092E+00  .1489E+01  .1000E+01  .7449E+00  .1332E+01 -.6612E+00  .2516E+01  .2520E+01
 7  .8992E+01  .3665E+01  .3657E+00  .2427E+00  .1459E+01  .1000E+01  .8407E+00  .1269E+01 -.4699E+00  .3065E+01  .2453E+01
 8  .8560E+01  .3596E+01  .4000E+00  .2705E+00  .1427E+01  .1000E+01  .9389E+00  .1200E+01 -.2427E+00  .3609E+01  .2380E+01
 9  .8108E+01  .3519E+01  .4359E+00  .2926E+00  .1393E+01  .1000E+01  .1030E+01  .1128E+01  .1990E-01  .4151E+01  .2304E+01
10  .7648E+01  .3435E+01  .4724E+00  .3093E+00  .1359E+01  .1000E+01  .1135E+01  .1055E+01  .3184E+00  .4691E+01  .2226E+01
11  .7188E+01  .3346E+01  .5089E+00  .3212E+00  .1325E+01  .1000E+01  .1232E+01  .9822E+00  .6538E+00  .5232E+01  .2148E+01
12  .6734E+01  .3251E+01  .5449E+00  .3287E+00  .1292E+01  .1000E+01  .1327E+01  .9102E+00  .1028E+01  .5776E+01  .2071E+01
13  .6290E+01  .3152E+01  .5801E+00  .3322E+00  .1261E+01  .1000E+01  .1420E+01  .8398E+00  .1445E+01  .6327E+01  .1996E+01
14  .5859E+01  .3049E+01  .6143E+00  .3323E+00  .1231E+01  .1000E+01  .1511E+01  .7713E+00  .1908E+01  .6888E+01  .1922E+01
15  .5442E+01  .2941E+01  .6475E+00  .3292E+00  .1202E+01  .1000E+01  .1602E+01  .7051E+00  .2424E+01  .7464E+01  .1850E+01
16  .5038E+01  .2829E+01  .6795E+00  .3233E+00  .1175E+01  .1000E+01  .1692E+01  .6410E+00  .3001E+01  .8059E+01  .1781E+01
17  .4648E+01  .2713E+01  .7104E+00  .3146E+00  .1149E+01  .1000E+01  .1781E+01  .5791E+00  .3650E+01  .8679E+01  .1713E+01
18  .4271E+01  .2592E+01  .7404E+00  .3034E+00  .1126E+01  .1000E+01  .1870E+01  .5193E+00  .4385E+01  .9333E+01  .1648E+01
19  .4001E+01  .2501E+01  .7618E+00  .2936E+00  .1109E+01  .1000E+01  .1936E+01  .4764E+00  .5225E+01  .1003E+02  .1600E+01
20  .3419E+01  .2284E+01  .8080E+00  .2666E+00  .1076E+01  .1000E+01  .2086E+01  .3839E+00  .5694E+01  .1039E+02  .1497E+01

 SONIC LINE LOCATION

XSL=  .1677E+01   YSL=  .3830E+01
XSL=  .1509E+01   YSL=  .3875E+01
XSL=  .1342E+01   YSL=  .3914E+01
XSL=  .1177E+01   YSL=  .3947E+01
XSL=  .1014E+01   YSL=  .3971E+01
XSL=  .8552E+00   YSL=  .3987E+01
XSL=  .6969E+00   YSL=  .3997E+01
XSL=  .5390E+00   YSL=  .4001E+01
XSL=  .3811E+00   YSL=  .3998E+01
XSL=  .2231E+00   YSL=  .3988E+01
XSL=  .7155E-01   YSL=  .3969E+01
XSL= -.8010E-01   YSL=  .3945E+01

    PERCENT ERROR IN HT=   .3480E-11    RMS OF PERCENT ERROR IN HT=   .1930E-11

PRESSURE DRAG =        .9307125919

SIGMAX= .2970E+02   J=    1   K=   12   SIGMIN=  .3262E+01   J=   20   K=    4   CN= .2500E+01   DT= .8419E-01
RESIDUE INFORMATION              18    11     .10981     .38968  28.18091S( 18, 11, 4)=    .10430
RMS OF SHOCK SPEED=   .2349E-01   J= 20   MAX SHK SPD=   .7505E-01
RMS OF SHOCK SPEED=   .2825E-01   J= 20   MAX SHK SPD=   .9094E-01
RMS OF SHOCK SPEED=   .3371E-01   J= 20   MAX SHK SPD=   .7945E-01
RMS OF SHOCK SPEED=   .4005E-01   J=  2   MAX SHK SPD=  -.9075E-01
RMS OF SHOCK SPEED=   .4782E-01   J=  2   MAX SHK SPD=  -.1159E+00
RMS OF SHOCK SPEED=   .5331E-01   J=  2   MAX SHK SPD=  -.1330E+00
RMS OF SHOCK SPEED=   .5493E-01   J=  2   MAX SHK SPD=  -.1395E+00
RMS OF SHOCK SPEED=   .5190E-01   J=  2   MAX SHK SPD=  -.1331E+00
RMS OF SHOCK SPEED=   .4389E-01   J=  2   MAX SHK SPD=  -.1123E+00
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RMS OF SHOCK SPEED=   .3134E-01   J=  2   MAX SHK SPD=  -.7621E-01
RMS OF SHOCK SPEED=   .1776E-01   J= 18   MAX SHK SPD=  -.3788E-01
RMS OF SHOCK SPEED=   .1999E-01   J= 18   MAX SHK SPD=  -.3697E-01
RMS OF SHOCK SPEED=   .3687E-01   J=  2   MAX SHK SPD=   .9024E-01
RMS OF SHOCK SPEED=   .5225E-01   J=  2   MAX SHK SPD=   .1356E+00
RMS OF SHOCK SPEED=   .6204E-01   J=  2   MAX SHK SPD=   .1626E+00
RMS OF SHOCK SPEED=   .6696E-01   J=  2   MAX SHK SPD=   .1746E+00
RMS OF SHOCK SPEED=   .6925E-01   J=  2   MAX SHK SPD=   .1784E+00
RMS OF SHOCK SPEED=   .7031E-01   J=  2   MAX SHK SPD=   .1783E+00
RMS OF SHOCK SPEED=   .7038E-01   J=  2   MAX SHK SPD=   .1747E+00
RMS OF SHOCK SPEED=   .6926E-01   J=  2   MAX SHK SPD=   .1670E+00
RMS OF SHOCK SPEED=   .6686E-01   J=  2   MAX SHK SPD=   .1552E+00
RMS OF SHOCK SPEED=   .6333E-01   J=  2   MAX SHK SPD=   .1400E+00
RMS OF SHOCK SPEED=   .5895E-01   J=  2   MAX SHK SPD=   .1222E+00
RMS OF SHOCK SPEED=   .5403E-01   J=  2   MAX SHK SPD=   .1030E+00
RMS OF SHOCK SPEED=   .4887E-01   J=  4   MAX SHK SPD=   .8494E-01
RESIDUE INFORMATION             18   11    .05005    .16870  29.66996S( 18, 11, 4)=    .04692

SIGMAX= .2714E+02   J=    1   K=   12   SIGMIN=  .2838E+01   J=   20   K=    1   CN= .2500E+01   DT= .9211E-01
RMS OF SHOCK SPEED=   .4377E-01   J=  5   MAX SHK SPD=   .7971E-01
RMS OF SHOCK SPEED=   .3868E-01   J=  5   MAX SHK SPD=   .7406E-01
RMS OF SHOCK SPEED=   .3427E-01   J=  5   MAX SHK SPD=   .6675E-01
RMS OF SHOCK SPEED=   .3097E-01   J=  6   MAX SHK SPD=   .6038E-01
RMS OF SHOCK SPEED=   .2899E-01   J=  6   MAX SHK SPD=   .5454E-01
RMS OF SHOCK SPEED=   .2820E-01   J=  7   MAX SHK SPD=   .4956E-01
RMS OF SHOCK SPEED=   .2826E-01   J=  8   MAX SHK SPD=   .4567E-01
RMS OF SHOCK SPEED=   .2869E-01   J=  2   MAX SHK SPD=  -.5022E-01
RMS OF SHOCK SPEED=   .2908E-01   J=  2   MAX SHK SPD=  -.5656E-01
RMS OF SHOCK SPEED=   .2911E-01   J=  2   MAX SHK SPD=  -.5990E-01
RMS OF SHOCK SPEED=   .2859E-01   J=  2   MAX SHK SPD=  -.6022E-01
RMS OF SHOCK SPEED=   .2744E-01   J=  2   MAX SHK SPD=  -.5761E-01
RMS OF SHOCK SPEED=   .2570E-01   J=  2   MAX SHK SPD=  -.5229E-01
RMS OF SHOCK SPEED=   .2352E-01   J=  2   MAX SHK SPD=  -.4462E-01
RMS OF SHOCK SPEED=   .2114E-01   J= 11   MAX SHK SPD=   .4048E-01
RMS OF SHOCK SPEED=   .1891E-01   J= 11   MAX SHK SPD=   .3996E-01
RMS OF SHOCK SPEED=   .1723E-01   J= 11   MAX SHK SPD=   .3832E-01
RMS OF SHOCK SPEED=   .1643E-01   J= 11   MAX SHK SPD=   .3551E-01
RMS OF SHOCK SPEED=   .1660E-01   J= 11   MAX SHK SPD=   .3158E-01
RMS OF SHOCK SPEED=   .1750E-01   J= 14   MAX SHK SPD=   .2908E-01
RMS OF SHOCK SPEED=   .1875E-01   J= 14   MAX SHK SPD=   .2898E-01
RMS OF SHOCK SPEED=   .2000E-01   J=  2   MAX SHK SPD=   .3595E-01
RMS OF SHOCK SPEED=   .2099E-01   J=  2   MAX SHK SPD=   .4107E-01
RMS OF SHOCK SPEED=   .2159E-01   J=  2   MAX SHK SPD=   .4424E-01
RMS OF SHOCK SPEED=   .2172E-01   J=  2   MAX SHK SPD=   .4550E-01
RESIDUE INFORMATION             19   11    .04650    .15586  29.83513S( 19, 11, 4)=    .04348

SIGMAX= .2777E+02   J=    1   K=   12   SIGMIN=  .2779E+01   J=   20   K=    1   CN= .2500E+01   DT= .9004E-01
RMS OF SHOCK SPEED=   .2139E-01   J=  2   MAX SHK SPD=   .4497E-01
RMS OF SHOCK SPEED=   .2064E-01   J=  2   MAX SHK SPD=   .4284E-01
RMS OF SHOCK SPEED=   .1956E-01   J=  2   MAX SHK SPD=   .3937E-01
RMS OF SHOCK SPEED=   .1824E-01   J=  2   MAX SHK SPD=   .3477E-01
RMS OF SHOCK SPEED=   .1678E-01   J=  2   MAX SHK SPD=   .2921E-01
RMS OF SHOCK SPEED=   .1531E-01   J= 11   MAX SHK SPD=  -.2485E-01
RMS OF SHOCK SPEED=   .1399E-01   J= 11   MAX SHK SPD=  -.2387E-01
RMS OF SHOCK SPEED=   .1300E-01   J= 17   MAX SHK SPD=   .2221E-01
RMS OF SHOCK SPEED=   .1249E-01   J=  7   MAX SHK SPD=   .2417E-01
RMS OF SHOCK SPEED=   .1254E-01   J=  7   MAX SHK SPD=   .2547E-01
RMS OF SHOCK SPEED=   .1310E-01   J=  7   MAX SHK SPD=   .2580E-01
RMS OF SHOCK SPEED=   .1401E-01   J=  7   MAX SHK SPD=   .2520E-01
RMS OF SHOCK SPEED=   .1506E-01   J=  2   MAX SHK SPD=  -.2444E-01
RMS OF SHOCK SPEED=   .1607E-01   J=  2   MAX SHK SPD=  -.2916E-01
RMS OF SHOCK SPEED=   .1690E-01   J=  2   MAX SHK SPD=  -.3279E-01
RMS OF SHOCK SPEED=   .1742E-01   J=  2   MAX SHK SPD=  -.3522E-01
RMS OF SHOCK SPEED=   .1759E-01   J=  2   MAX SHK SPD=  -.3640E-01
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RMS OF SHOCK SPEED=   .1737E-01   J=  2   MAX SHK SPD=  -.3629E-01
RMS OF SHOCK SPEED=   .1676E-01   J=  2   MAX SHK SPD=  -.3492E-01
RMS OF SHOCK SPEED=   .1578E-01   J=  2   MAX SHK SPD=  -.3235E-01
RMS OF SHOCK SPEED=   .1448E-01   J=  2   MAX SHK SPD=  -.2867E-01
RMS OF SHOCK SPEED=   .1295E-01   J=  2   MAX SHK SPD=  -.2405E-01
RMS OF SHOCK SPEED=   .1133E-01   J=  2   MAX SHK SPD=  -.1865E-01
RMS OF SHOCK SPEED=   .9779E-02   J= 20   MAX SHK SPD=   .1442E-01
RMS OF SHOCK SPEED=   .8569E-02   J= 13   MAX SHK SPD=   .1461E-01
RESIDUE INFORMATION            19    11    .04783    .15710  30.44767S( 19, 11, 4)=    .04473

SIGMAX= .2839E+02   J=    1   K=   12   SIGMIN=  .2763E+01   J=   20   K=    1   CN= .2500E+01   DT= .8805E-01
RMS OF SHOCK SPEED=   .7976E-02   J= 13   MAX SHK SPD=   .1492E-01
RMS OF SHOCK SPEED=   .8133E-02   J= 13   MAX SHK SPD=   .1460E-01
RMS OF SHOCK SPEED=   .8904E-02   J= 14   MAX SHK SPD=   .1498E-01
RMS OF SHOCK SPEED=   .1001E-01   J=  3   MAX SHK SPD=   .1775E-01
RMS OF SHOCK SPEED=   .1119E-01   J=  3   MAX SHK SPD=   .2181E-01
RMS OF SHOCK SPEED=   .1228E-01   J=  3   MAX SHK SPD=   .2513E-01
RMS OF SHOCK SPEED=   .1317E-01   J=  2   MAX SHK SPD=   .2780E-01
RMS OF SHOCK SPEED=   .1379E-01   J=  2   MAX SHK SPD=   .2966E-01
RMS OF SHOCK SPEED=   .1413E-01   J=  2   MAX SHK SPD=   .3063E-01
RMS OF SHOCK SPEED=   .1418E-01   J=  2   MAX SHK SPD=   .3074E-01
RMS OF SHOCK SPEED=   .1395E-01   J=  2   MAX SHK SPD=   .3003E-01
RMS OF SHOCK SPEED=   .1344E-01   J=  2   MAX SHK SPD=   .2856E-01
RMS OF SHOCK SPEED=   .1269E-01   J=  2   MAX SHK SPD=   .2639E-01
RMS OF SHOCK SPEED=   .1174E-01   J=  2   MAX SHK SPD=   .2359E-01
RMS OF SHOCK SPEED=   .1064E-01   J=  2   MAX SHK SPD=   .2025E-01
RMS OF SHOCK SPEED=   .9457E-02   J= 17   MAX SHK SPD=   .1847E-01
RMS OF SHOCK SPEED=   .8287E-02   J= 17   MAX SHK SPD=   .1838E-01
RMS OF SHOCK SPEED=   .7261E-02   J= 17   MAX SHK SPD=   .1762E-01
RMS OF SHOCK SPEED=   .6540E-02   J= 17   MAX SHK SPD=   .1622E-01
RMS OF SHOCK SPEED=   .6273E-02   J= 17   MAX SHK SPD=   .1424E-01
RMS OF SHOCK SPEED=   .6491E-02   J= 18   MAX SHK SPD=   .1417E-01
RMS OF SHOCK SPEED=   .7077E-02   J= 18   MAX SHK SPD=   .1426E-01
RMS OF SHOCK SPEED=   .7847E-02   J= 18   MAX SHK SPD=   .1386E-01
RMS OF SHOCK SPEED=   .8640E-02   J=  2   MAX SHK SPD=  -.1563E-01
RMS OF SHOCK SPEED=   .9347E-02   J=  2   MAX SHK SPD=  -.1812E-01
FROM SUB. SHOCK
J= 1    SIGA=    .36117E+01   SIGB=    .27574E+02   DTS=    .32640E-01
J= 2    SIGA=    .36117E+01   SIGB=    .27574E+02   DTS=    .32640E-01
J= 3    SIGA=    .40847E+01   SIGB=    .27211E+02   DTS=    .33075E-01
J= 4    SIGA=    .44857E+01   SIGB=    .26735E+02   DTS=    .33664E-01
J= 5    SIGA=    .48877E+01   SIGB=    .25670E+02   DTS=    .35060E-01
J= 6    SIGA=    .52105E+01   SIGB=    .24674E+02   DTS=    .36475E-01
J= 7    SIGA=    .55116E+01   SIGB=    .23105E+02   DTS=    .38953E-01
J= 8    SIGA=    .57502E+01   SIGB=    .21710E+02   DTS=    .41456E-01
J= 9    SIGA=    .59463E+01   SIGB=    .19951E+02   DTS=    .45110E-01
J=10    SIGA=    .60666E+01   SIGB=    .18398E+02   DTS=    .48919E-01
J=11    SIGA=    .61450E+01   SIGB=    .16646E+02   DTS=    .54068E-01
J=12    SIGA=    .61459E+01   SIGB=    .15140E+02   DTS=    .59445E-01
J=13    SIGA=    .60902E+01   SIGB=    .13598E+02   DTS=    .66186E-01
J=14    SIGA=    .59774E+01   SIGB=    .12219E+02   DTS=    .73654E-01
J=15    SIGA=    .58180E+01   SIGB=    .10891E+02   DTS=    .82634E-01
J=16    SIGA=    .55846E+01   SIGB=    .97861E+01   DTS=    .91967E-01
J=17    SIGA=    .53416E+01   SIGB=    .86617E+01   DTS=    .10391E+00
J=18    SIGA=    .49956E+01   SIGB=    .78351E+01   DTS=    .11487E+00
J=19    SIGA=    .63154E+01   SIGB=    .72597E+01   DTS=    .12397E+00
J=20    SIGA=    .14534E+02   SIGB=    .67462E+01   DTS=    .61926E-01
RESIDUE INFORMATION            19    11    .04735    .15383  30.78263S( 19, 11, 4)=    .04429

SIGMAX= .2778E+02   J=    1   K=   12   SIGMIN=  .2765E+01   J=   20   K=    1   CN= .2500E+01   DT= .9000E-01
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST   P/PINF        S         U/QINF      V/QINF      S/SINF    HT/HTINF     R/RI        CP          X           Y        EI/EIINF
  1  .1202E+02 -.2344E+00  .1644E-02 -.3660E-01  .1561E+01  .1000E+01  .4298E+01  .1750E+01  .5261E-02 -.2344E+00  .2798E+01
  2  .1202E+02  .2344E+00  .1644E-02  .3660E-01  .1561E+01  .1000E+01  .4298E+01  .1750E+01  .5261E-02  .2344E+00  .2798E+01
  3  .1180E+02  .7033E+00  .1318E-01  .9728E-01  .1561E+01  .1000E+01  .4241E+01  .1715E+01  .4729E-01  .7014E+00  .2783E+01
  4  .1148E+02  .1172E+01  .3283E-01  .1439E+00  .1561E+01  .1000E+01  .4158E+01  .1664E+01  .1310E+00  .1163E+01  .2761E+01
  5  .1085E+02  .1641E+01  .6664E-01  .2051E+00  .1561E+01  .1000E+01  .3993E+01  .1563E+01  .2557E+00  .1615E+01  .2716E+01
  6  .1024E+02  .2110E+01  .1046E+00  .2448E+00  .1561E+01  .1000E+01  .3833E+01  .1467E+01  .4205E+00  .2054E+01  .2672E+01
  7  .9249E+01  .2579E+01  .1597E+00  .2968E+00  .1561E+01  .1000E+01  .3563E+01  .1309E+01  .6239E+00  .2476E+01  .2595E+01
  8  .8521E+01  .3047E+01  .2112E+00  .3200E+00  .1561E+01  .1000E+01  .3361E+01  .1194E+01  .8644E+00  .2878E+01  .2535E+01
  9  .7342E+01  .3516E+01  .2828E+00  .3546E+00  .1561E+01  .1000E+01  .3022E+01  .1007E+01  .1140E+01  .3258E+01  .2430E+01
 10  .6634E+01  .3985E+01  .3415E+00  .3572E+00  .1561E+01  .1000E+01  .2811E+01  .8943E+00  .1448E+01  .3611E+01  .2360E+01
 11  .5361E+01  .4454E+01  .4271E+00  .3732E+00  .1561E+01  .1000E+01  .2414E+01  .6922E+00  .1787E+01  .3935E+01  .2221E+01
 12  .4877E+01  .4923E+01  .4818E+00  .3500E+00  .1561E+01  .1000E+01  .2256E+01  .6154E+00  .2154E+01  .4227E+01  .2162E+01
 13  .3461E+01  .5392E+01  .5865E+00  .3504E+00  .1561E+01  .1000E+01  .1766E+01  .3906E+00  .2545E+01  .4485E+01  .1960E+01
 14  .3593E+01  .5860E+01  .6077E+00  .2927E+00  .1561E+01  .1000E+01  .1814E+01  .4116E+00  .2958E+01  .4708E+01  .1981E+01
 15  .2059E+01  .6329E+01  .7353E+00  .2760E+00  .1561E+01  .1000E+01  .1219E+01  .1681E+00  .3389E+01  .4892E+01  .1690E+01
 16  .1954E+01  .6798E+01  .7656E+00  .2113E+00  .1561E+01  .1000E+01  .1174E+01  .1515E+00  .3835E+01  .5037E+01  .1665E+01
 17  .1455E+01  .7267E+01  .8264E+00  .1500E+00  .1561E+01  .1000E+01  .9510E+00  .7227E-01  .4292E+01  .5141E+01  .1530E+01
 18  .1162E+01  .7736E+01  .8674E+00  .7807E-01  .1561E+01  .1000E+01  .8096E+00  .2565E-01  .4757E+01  .5204E+01  .1435E+01
 19  .8873E+00  .8205E+01  .9039E+00  .2028E-01  .1561E+01  .1000E+01  .6679E+00 -.1789E-01  .5225E+01  .5225E+01  .1328E+01
 20  .6943E+00  .8674E+01  .9311E+00 -.2087E-01  .1561E+01  .1000E+01  .5605E+00 -.4853E-01  .5694E+01  .5225E+01  .1239E+01

SECOND INDEX=  4

1ST   P/PINF     RO/RINF      U/QINF      V/QINF      S/SINF    HT/HTINF     MACH        CP          X           Y        EI/EIINF
  1  .1177E+02  .4208E+01  .7670E-01 -.2984E-01  .1575E+01  .1004E+01  .1476E+00  .1710E+01 -.3040E+00 -.2483E+00  .2798E+01
  2  .1177E+02  .4208E+01  .7670E-01  .2984E-01  .1575E+01  .1004E+01  .1476E+00  .1710E+01 -.3040E+00  .2483E+00  .2798E+01
  3  .1159E+02  .4174E+01  .8493E-01  .8440E-01  .1568E+01  .1001E+01  .2156E+00  .1681E+01 -.2628E+00  .7434E+00  .2776E+01
  4  .1132E+02  .4113E+01  .1042E+00  .1347E+00  .1563E+01  .1002E+01  .3080E+00  .1638E+01 -.1788E+00  .1233E+01  .2752E+01
  5  .1079E+02  .3994E+01  .1364E+00  .1894E+00  .1552E+01  .9995E+00  .4260E+00  .1553E+01 -.5768E-01  .1716E+01  .2701E+01
  6  .1021E+02  .3847E+01  .1684E+00  .2302E+00  .1548E+01  .9999E+00  .5252E+00  .1461E+01  .1073E+00  .2187E+01  .2653E+01
  7  .9442E+01  .3650E+01  .2150E+00  .2675E+00  .1541E+01  .9995E+00  .6402E+00  .1340E+01  .3060E+00  .2647E+01  .2587E+01
  8  .8701E+01  .3489E+01  .2748E+00  .3111E+00  .1513E+01  .1002E+01  .7885E+00  .1222E+01  .5463E+00  .3088E+01  .2494E+01
  9  .7816E+01  .3189E+01  .3029E+00  .3037E+00  .1541E+01  .9937E+00  .8219E+00  .1082E+01  .8181E+00  .3514E+01  .2451E+01
 10  .7078E+01  .3065E+01  .3956E+00  .3526E+00  .1476E+01  .1005E+01  .1046E+01  .9647E+00  .1128E+01  .3917E+01  .2310E+01
 11  .6141E+01  .2706E+01  .4147E+00  .3269E+00  .1524E+01  .9896E+00  .1052E+01  .8160E+00  .1466E+01  .4302E+01  .2269E+01
 12  .5587E+01  .2618E+01  .5093E+00  .3512E+00  .1452E+01  .1008E+01  .1270E+01  .7281E+00  .1839E+01  .4660E+01  .2134E+01
 13  .4561E+01  .2210E+01  .5344E+00  .3265E+00  .1503E+01  .9894E+00  .1308E+01  .5653E+00  .2238E+01  .4999E+01  .2064E+01
 14  .4300E+01  .2192E+01  .6150E+00  .3161E+00  .1433E+01  .1008E+01  .1481E+01  .5238E+00  .2667E+01  .5312E+01  .1962E+01
 15  .3403E+01  .1809E+01  .6334E+00  .3142E+00  .1485E+01  .9934E+00  .1546E+01  .3814E+00  .3122E+01  .5603E+01  .1882E+01
 16  .3298E+01  .1832E+01  .7065E+00  .2546E+00  .1413E+01  .1005E+01  .1679E+01  .3648E+00  .3606E+01  .5867E+01  .1800E+01
 17  .2476E+01  .1452E+01  .7323E+00  .2645E+00  .1469E+01  .9989E+00  .1789E+01  .2344E+00  .4115E+01  .6115E+01  .1706E+01
 18  .2308E+01  .1427E+01  .7833E+00  .2171E+00  .1402E+01  .1002E+01  .1918E+01  .2076E+00  .4655E+01  .6331E+01  .1617E+01
 19  .1897E+01  .1206E+01  .8036E+00  .1952E+00  .1460E+01  .1002E+01  .1978E+01  .1424E+00  .5225E+01  .6543E+01  .1573E+01
 20  .1839E+01  .1217E+01  .8293E+00  .1672E+00  .1397E+01  .9998E+00  .2064E+01  .1332E+00  .5694E+01  .6654E+01  .1511E+01

SECOND INDEX=  7

1ST   P/PINF     RO/RINF      U/QINF      V/QINF      S/SINF    HT/HTINF     MACH        CP          X           Y        EI/EIINF
  1  .1145E+02  .4145E+01  .1485E+00 -.2680E-01  .1565E+01  .1001E+01  .2723E+00  .1659E+01 -.6133E+00 -.2622E+00  .2763E+01
  2  .1145E+02  .4145E+01  .1485E+00  .2680E-01  .1565E+01  .1001E+01  .2723E+00  .1659E+01 -.6133E+00  .2622E+00  .2763E+01
  3  .1128E+02  .4105E+01  .1567E+00  .8236E-01  .1561E+01  .1001E+01  .3205E+00  .1631E+01 -.5730E+00  .7854E+00  .2747E+01
  4  .1106E+02  .4063E+01  .1733E+00  .1327E+00  .1554E+01  .1003E+01  .3968E+00  .1597E+01 -.4887E+00  .1304E+01  .2723E+01
  5  .1061E+02  .3968E+01  .2016E+00  .1791E+00  .1540E+01  .1002E+01  .4948E+00  .1525E+01 -.3711E+00  .1818E+01  .2673E+01
  6  .1014E+02  .3869E+01  .2331E+00  .2211E+00  .1525E+01  .1002E+01  .5955E+00  .1450E+01 -.2059E+00  .2321E+01  .2621E+01
  7  .9472E+01  .3715E+01  .2747E+00  .2571E+00  .1508E+01  .1002E+01  .7069E+00  .1345E+01 -.1183E-01  .2818E+01  .2550E+01
  8  .8847E+01  .3572E+01  .3171E+00  .2867E+00  .1488E+01  .1002E+01  .8149E+00  .1246E+01  .2282E+00  .3298E+01  .2477E+01
  9  .8118E+01  .3395E+01  .3667E+00  .3081E+00  .1466E+01  .1001E+01  .9293E+00  .1130E+01  .4963E+00  .3771E+01  .2391E+01
 10  .7430E+01  .3211E+01  .4102E+00  .3210E+00  .1451E+01  .1001E+01  .1027E+01  .1021E+01  .8073E+00  .4224E+01  .2314E+01
```

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 11  .6719E+01  .3019E+01  .4607E+00  .3276E+00  .1430E+01  .1000E+01  .1137E+01  .9079E+00  .1145E+01  .4669E+01  .2226E+01
 12  .6104E+01  .2885E+01  .5178E+00  .3392E+00  .1385E+01  .1002E+01  .1277E+01  .8101E+00  .1524E+01  .5094E+01  .2116E+01
 13  .5439E+01  .2610E+01  .5387E+00  .3196E+00  .1420E+01  .9964E+00  .1302E+01  .7046E+00  .1931E+01  .5514E+01  .2084E+01
 14  .4864E+01  .2534E+01  .6228E+00  .3284E+00  .1323E+01  .1004E+01  .1525E+01  .6133E+00  .2376E+01  .5915E+01  .1919E+01
 15  .4362E+01  .2259E+01  .6157E+00  .3055E+00  .1394E+01  .9934E+00  .1484E+01  .5337E+00  .2855E+01  .6314E+01  .1931E+01
 16  .4026E+01  .2267E+01  .6981E+00  .2984E+00  .1280E+01  .1005E+01  .1709E+01  .4803E+00  .3377E+01  .6697E+01  .1776E+01
 17  .3328E+01  .1894E+01  .6969E+00  .2949E+00  .1361E+01  .9956E+00  .1713E+01  .3695E+00  .3939E+01  .7088E+01  .1757E+01
 18  .3350E+01  .2021E+01  .7579E+00  .2543E+00  .1251E+01  .1003E+01  .1863E+01  .3730E+00  .4554E+01  .7457E+01  .1658E+01
 19  .2700E+01  .1663E+01  .7718E+00  .2468E+00  .1324E+01  .1002E+01  .1908E+01  .2698E+00  .5225E+01  .7862E+01  .1623E+01
 20  .2846E+01  .1819E+01  .7944E+00  .2348E+00  .1231E+01  .9998E+00  .1987E+01  .2931E+00  .5694E+01  .8083E+01  .1564E+01

SECOND INDEX= 10

1ST    P/PINF     RO/RINF     U/QINF     V/QINF     S/SINF    HT/HTINF     MACH        CP          X          Y       EI/EIINF
  1  .1076E+02  .3979E+01  .2176E+00 -.2577E-01  .1556E+01  .9966E+00  .3997E+00  .1549E+01 -.9225E+00 -.2761E+00  .2704E+01
  2  .1076E+02  .3979E+01  .2176E+00  .2577E-01  .1556E+01  .9966E+00  .3997E+00  .1549E+01 -.9225E+00  .2761E+00  .2704E+01
  3  .1064E+02  .3958E+01  .2259E+00  .8104E-01  .1550E+01  .9967E+00  .4392E+00  .1530E+01 -.8831E+00  .8274E+00  .2687E+01
  4  .1047E+02  .3932E+01  .2405E+00  .1287E+00  .1540E+01  .9986E+00  .5016E+00  .1503E+01 -.7985E+00  .1375E+01  .2662E+01
  5  .1013E+02  .3869E+01  .2648E+00  .1753E+00  .1524E+01  .9999E+00  .5888E+00  .1449E+01 -.6845E+00  .1920E+01  .2618E+01
  6  .9737E+01  .3798E+01  .2936E+00  .2142E+00  .1503E+01  .1001E+01  .6808E+00  .1387E+01 -.5191E+00  .2455E+01  .2564E+01
  7  .9229E+01  .3699E+01  .3294E+00  .2488E+00  .1479E+01  .1001E+01  .7840E+00  .1306E+01 -.3297E+00  .2989E+01  .2495E+01
  8  .8715E+01  .3598E+01  .3674E+00  .2778E+00  .1451E+01  .1001E+01  .8879E+00  .1225E+01 -.8988E-01  .3508E+01  .2422E+01
  9  .8137E+01  .3476E+01  .4093E+00  .2996E+00  .1422E+01  .1001E+01  .9946E+00  .1133E+01  .1744E+00  .4028E+01  .2341E+01
 10  .7581E+01  .3354E+01  .4502E+00  .3152E+00  .1393E+01  .1001E+01  .1097E+01  .1045E+01  .4867E+00  .4530E+01  .2260E+01
 11  .6981E+01  .3212E+01  .4934E+00  .3246E+00  .1363E+01  .1001E+01  .1202E+01  .9494E+00  .8244E+00  .5037E+01  .2174E+01
 12  .6464E+01  .3093E+01  .5348E+00  .3306E+00  .1330E+01  .1000E+01  .1305E+01  .8673E+00  .1209E+01  .5527E+01  .2090E+01
 13  .5967E+01  .2975E+01  .5744E+00  .3330E+00  .1297E+01  .9998E+00  .1406E+01  .7884E+00  .1624E+01  .6028E+01  .2006E+01
 14  .5425E+01  .2809E+01  .6124E+00  .3272E+00  .1278E+01  .9997E+00  .1499E+01  .7024E+00  .2085E+01  .6519E+01  .1931E+01
 15  .4994E+01  .2681E+01  .6444E+00  .3198E+00  .1256E+01  .9980E+00  .1581E+01  .6340E+00  .2588E+01  .7025E+01  .1863E+01
 16  .4580E+01  .2599E+01  .6912E+00  .3182E+00  .1202E+01  .1002E+01  .1720E+01  .5682E+00  .3148E+01  .7527E+01  .1762E+01
 17  .4188E+01  .2382E+01  .6957E+00  .2991E+00  .1242E+01  .9965E+00  .1713E+01  .5060E+00  .3762E+01  .8062E+01  .1758E+01
 18  .4015E+01  .2475E+01  .7576E+00  .2921E+00  .1129E+01  .1003E+01  .1913E+01  .4786E+00  .4452E+01  .8584E+01  .1622E+01
 19  .3158E+01  .1973E+01  .7659E+00  .2881E+00  .1220E+01  .1002E+01  .1940E+01  .3426E+00  .5225E+01  .9180E+01  .1601E+01
 20  .3599E+01  .2314E+01  .7830E+00  .2799E+00  .1112E+01  .1000E+01  .2000E+01  .4126E+00  .5694E+01  .9512E+01  .1555E+01

SECOND INDEX= 11

1ST    P/PINF     RO/RINF     U/QINF     V/QINF     S/SINF    HT/HTINF     MACH        CP          X          Y       EI/EIINF
  1  .1059E+02  .3940E+01  .2394E+00 -.2556E-01  .1552E+01  .9969E+00  .4407E+00  .1522E+01 -.1026E+01 -.2807E+00  .2687E+01
  2  .1059E+02  .3940E+01  .2394E+00  .2556E-01  .1552E+01  .9969E+00  .4407E+00  .1522E+01 -.1026E+01  .2807E+00  .2687E+01
  3  .1042E+02  .3907E+01  .2501E+00  .7998E-01  .1545E+01  .9963E+00  .4824E+00  .1494E+01 -.9865E+00  .8414E+00  .2666E+01
  4  .1032E+02  .3901E+01  .2613E+00  .1274E+00  .1534E+01  .9989E+00  .5362E+00  .1479E+01 -.9018E+00  .1398E+01  .2645E+01
  5  .9974E+01  .3837E+01  .2861E+00  .1729E+00  .1518E+01  .1000E+01  .6220E+00  .1424E+01 -.7890E+00  .1954E+01  .2599E+01
  6  .9665E+01  .3793E+01  .3115E+00  .2125E+00  .1495E+01  .1001E+01  .7087E+00  .1375E+01 -.6235E+00  .2500E+01  .2548E+01
  7  .9140E+01  .3692E+01  .3482E+00  .2465E+00  .1468E+01  .1001E+01  .8136E+00  .1292E+01 -.4356E+00  .3046E+01  .2475E+01
  8  .8701E+01  .3619E+01  .3830E+00  .2760E+00  .1437E+01  .1002E+01  .9133E+00  .1222E+01 -.1959E+00  .3578E+01  .2404E+01
  9  .8141E+01  .3506E+01  .4244E+00  .2977E+00  .1406E+01  .1002E+01  .1021E+01  .1133E+01  .6715E-01  .4113E+01  .2322E+01
 10  .7637E+01  .3406E+01  .4626E+00  .3145E+00  .1373E+01  .1002E+01  .1121E+01  .1053E+01  .3799E+00  .4637E+01  .2242E+01
 11  .7082E+01  .3287E+01  .5051E+00  .3248E+00  .1339E+01  .1001E+01  .1227E+01  .9653E+00  .7175E+00  .5159E+01  .2155E+01
 12  .6560E+01  .3169E+01  .5449E+00  .3314E+00  .1305E+01  .1001E+01  .1330E+01  .8826E+00  .1104E+01  .5671E+01  .2070E+01
 13  .6112E+01  .3059E+01  .5790E+00  .3321E+00  .1277E+01  .9999E+00  .1417E+01  .8114E+00  .1521E+01  .6199E+01  .1998E+01
 14  .5617E+01  .2924E+01  .6162E+00  .3293E+00  .1251E+01  .9999E+00  .1512E+01  .7329E+00  .1988E+01  .6721E+01  .1921E+01
 15  .5169E+01  .2808E+01  .6527E+00  .3247E+00  .1218E+01  .9991E+00  .1612E+01  .6618E+00  .2499E+01  .7262E+01  .1841E+01
 16  .4780E+01  .2697E+01  .6852E+00  .3195E+00  .1192E+01  .1000E+01  .1704E+01  .6000E+00  .3071E+01  .7803E+01  .1772E+01
 17  .4388E+01  .2546E+01  .7082E+00  .3049E+00  .1186E+01  .9977E+00  .1762E+01  .5377E+00  .3703E+01  .8386E+01  .1723E+01
 18  .4248E+01  .2600E+01  .7486E+00  .3075E+00  .1114E+01  .1004E+01  .1898E+01  .5155E+00  .4419E+01  .8959E+01  .1633E+01
 19  .3347E+01  .2079E+01  .7617E+00  .2904E+00  .1201E+01  .1002E+01  .1927E+01  .3726E+00  .5225E+01  .9619E+01  .1610E+01
 20  .3989E+01  .2572E+01  .7912E+00  .2533E+00  .1063E+01  .9976E+00  .2001E+01  .4745E+00  .5694E+01  .9989E+01  .1551E+01

SECOND INDEX= 12

1ST    P/PINF     RO/RINF     U/QINF     V/QINF     S/SINF    HT/HTINF     MACH        CP          X          Y       EI/EIINF
  1  .1021E+02  .3841E+01  .2650E+00 -.2510E-01  .1552E+01  .9952E+00  .4896E+00  .1463E+01 -.1129E+01 -.2853E+00  .2659E+01
  2  .1021E+02  .3841E+01  .2650E+00  .2510E-01  .1552E+01  .9952E+00  .4896E+00  .1463E+01 -.1129E+01  .2853E+00  .2659E+01
```

```
  3  .1011E+02  .3827E+01  .2735E+00  .7945E-01  .1544E+01  .9955E+00  .5258E+00  .1446E+01 -.1090E+01  .8554E+00  .2641E+01
  4  .9959E+01  .3807E+01  .2867E+00  .1246E+00  .1533E+01  .9972E+00  .5799E+00  .1422E+01 -.1005E+01  .1422E+01  .2616E+01
  5  .9720E+01  .3774E+01  .3077E+00  .1716E+00  .1514E+01  .9998E+00  .6586E+00  .1384E+01 -.8934E+00  .1988E+01  .2576E+01
  6  .9388E+01  .3726E+01  .3345E+00  .2102E+00  .1489E+01  .1000E+01  .7466E+00  .1331E+01 -.7279E+00  .2544E+01  .2520E+01
  7  .8985E+01  .3664E+01  .3668E+00  .2446E+00  .1459E+01  .1001E+01  .8446E+00  .1267E+01 -.5416E+00  .3103E+01  .2452E+01
  8  .8540E+01  .3593E+01  .4025E+00  .2737E+00  .1425E+01  .1001E+01  .9472E+00  .1197E+01 -.3019E+00  .3648E+01  .2377E+01
  9  .8074E+01  .3513E+01  .4399E+00  .2965E+00  .1390E+01  .1002E+01  .1050E+01  .1123E+01 -.4013E-01  .4199E+01  .2298E+01
 10  .7590E+01  .3425E+01  .4783E+00  .3133E+00  .1355E+01  .1002E+01  .1152E+01  .1046E+01  .2730E+00  .4735E+01  .2216E+01
 11  .7091E+01  .3326E+01  .5173E+00  .3241E+00  .1318E+01  .1001E+01  .1254E+01  .9669E+00  .6105E+00  .5282E+01  .2132E+01
 12  .6622E+01  .3227E+01  .5543E+00  .3307E+00  .1284E+01  .1001E+01  .1352E+01  .8925E+00  .9995E+00  .5816E+01  .2052E+01
 13  .6193E+01  .3129E+01  .5876E+00  .3322E+00  .1254E+01  .9997E+00  .1440E+01  .8242E+00  .1419E+01  .6370E+01  .1979E+01
 14  .5748E+01  .3021E+01  .6228E+00  .3314E+00  .1223E+01  .9995E+00  .1534E+01  .7537E+00  .1891E+01  .6922E+01  .1903E+01
 15  .5327E+01  .2910E+01  .6562E+00  .3274E+00  .1194E+01  .9995E+00  .1626E+01  .6868E+00  .2411E+01  .7499E+01  .1831E+01
 16  .4943E+01  .2802E+01  .6857E+00  .3201E+00  .1168E+01  .9983E+00  .1709E+01  .6259E+00  .2995E+01  .8080E+01  .1764E+01
 17  .4537E+01  .2678E+01  .7192E+00  .3116E+00  .1142E+01  .9999E+00  .1807E+01  .5615E+00  .3644E+01  .8711E+01  .1694E+01
 18  .4287E+01  .2598E+01  .7402E+00  .3049E+00  .1127E+01  .1001E+01  .1870E+01  .5217E+00  .4385E+01  .9335E+01  .1650E+01
 19  .4351E+01  .2619E+01  .7350E+00  .3068E+00  .1131E+01  .1001E+01  .1854E+01  .5319E+00  .5225E+01  .1006E+02  .1662E+01
 20  .4415E+01  .2640E+01  .7297E+00  .3087E+00  .1135E+01  .1001E+01  .1838E+01  .5421E+00  .5694E+01  .1047E+02  .1673E+01

  SONIC LINE LOCATION

 XSL=  .1516E+01   YSL=  .3675E+01
 XSL=  .1286E+01   YSL=  .3646E+01
 XSL=  .1179E+01   YSL=  .3746E+01
 XSL=  .1064E+01   YSL=  .3834E+01
 XSL=  .9445E+00   YSL=  .3916E+01
 XSL=  .8359E+00   YSL=  .4012E+01
 XSL=  .7205E+00   YSL=  .4098E+01
 XSL=  .5503E+00   YSL=  .4100E+01
 XSL=  .3716E+00   YSL=  .4082E+01
 XSL=  .1908E+00   YSL=  .4054E+01
 XSL=  .1664E-01   YSL=  .4011E+01
 XSL= -.1674E+00   YSL=  .3931E+01

     PERCENT ERROR IN HT=   .1324E+01    RMS OF PERCENT ERROR IN HT=   .3948E+00

 PRESSURE DRAG =          .8546879051
 RESIDUE INFORMATION                19   11    .04865    .15740  30.90596S( 19, 11, 4)=    .04551

                                           DETAILED RESIDUE INFORMATION
                                           ****************************
                                                              SECOND INDEX =   2
    2  -.1234497E-05  -.4762270E-04   .3699180E-03   .5935800E-03    3   .1361900E-03  -.1923232E-03  -.9268552E-03   .1045244E-02
    4   .1652419E-03   .3346888E-03   .9454524E-03   .1985838E-02    5  -.1642547E-03  -.7249442E-03  -.1929728E-02  -.2356908E-02
    6   .1596502E-03   .1038045E-02   .2250582E-02   .2798213E-02    7  -.2673683E-03  -.1440047E-02  -.2458023E-02  -.4393197E-02
    8   .2331303E-03   .1425571E-02   .2071071E-02   .3711258E-02    9  -.4527265E-03  -.2049476E-02  -.2345613E-02  -.6617608E-02
   10   .4268425E-03   .1872908E-02   .1906486E-02   .5626115E-02   11  -.7158587E-03  -.2564880E-02  -.2010713E-02  -.8730900E-02
   12   .9364277E-03   .2709878E-02   .1825290E-02   .9584619E-02   13  -.1442710E-02  -.3620524E-02  -.1712474E-02  -.1355376E-01
   14   .1797514E-02   .4092118E-02   .1256262E-02   .1522522E-01   15  -.1659512E-02  -.3849834E-02  -.4397821E-03  -.1365536E-01
   16   .1124331E-02   .3009741E-02  -.1816178E-04   .9464057E-02   17  -.6513465E-03  -.1846638E-02   .1930989E-03  -.5177840E-02
   18   .4897946E-03   .1801460E-02  -.1873269E-04   .4537971E-02   19  -.3911724E-03  -.1224665E-02   .1187036E-04  -.3139393E-02
                                                              SECOND INDEX =   3
    2  -.5322636E-04   .8628165E-04   .3199595E-03   .8520315E-03    3   .8988872E-04   .7791144E-04   .1296106E-03   .1622312E-02
    4   .1333908E-03  -.6505522E-04  -.4774009E-03   .1851515E-02    5  -.5968436E-04   .1565073E-04  -.4004011E-03  -.3080519E-03
    6   .1695231E-03   .5664074E-03   .7900539E-03   .2149755E-02    7  -.1773391E-03  -.9624025E-03  -.1474066E-02  -.2207814E-02
    8   .2738940E-03   .1384573E-02   .1579059E-02   .3602990E-02    9  -.2950967E-03  -.1723033E-02  -.2109321E-02  -.4544506E-02
   10   .42316689E-03  .1782719E-02   .1599629E-02   .5066598E-02   11  -.4423131E-03  -.2017655E-02  -.1875249E-02  -.6170181E-02
   12   .7606461E-03   .2211661E-02   .1531740E-02   .7577791E-02   13  -.8591362E-03  -.2513035E-02  -.1566045E-02  -.8925036E-02
   14   .1255906E-02   .3185981E-02   .9301835E-03   .1092146E-01   15  -.1254839E-02  -.3428795E-02  -.2504491E-03  -.1099134E-01
   16   .1442342E-02   .4124235E-02  -.1921697E-03   .1221668E-01   17  -.8852918E-03  -.2636405E-02   .2171034E-03  -.7240298E-02
   18   .8766730E-03   .3056910E-02   .2143633E-03   .8102342E-02   19  -.5863280E-03  -.1715688E-02  -.7950528E-04  -.4413317E-02
                                                              SECOND INDEX =   4
    2  -.1774911E-03  -.1054393E-04   .1321054E-03  -.6409005E-04    3  -.8459390E-04  -.1498319E-03   .1990658E-03   .7693525E-03
    4  -.1021962E-03  -.2253500E-03  -.1494673E-03   .7440290E-03    5  -.2227967E-03   .5900681E-04  -.1400266E-03  -.8075910E-03
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  6  -.1642458E-03  -.2871582E-03  -.3338056E-03  -.5580842E-03     7  -.2689988E-03  -.3344178E-03  -.2648682E-03  -.1478596E-02
  8   .7096559E-05   .6777974E-03   .9360495E-03   .1453763E-02     9  -.5276401E-03  -.1896965E-02  -.1798122E-02  -.5184329E-02
 10   .2694406E-03   .1690701E-02   .1535813E-02   .4034428E-02    11  -.7189417E-03  -.2858802E-02  -.2123522E-02  -.8249047E-02
 12   .7039394E-03   .2576936E-02   .1607487E-02   .7518953E-02    13  -.1090323E-02  -.3692323E-02  -.1716339E-02  -.1146856E-01
 14   .1227500E-02   .3821470E-02   .8862756E-03   .1111838E-01    15  -.1358254E-02  -.4553563E-02  -.4924421E-03  -.1307076E-01
 16   .1611811E-02   .4953540E-02  -.9375306E-04   .1367589E-01    17  -.1480847E-02  -.4551766E-02   .1650592E-03  -.1289927E-01
 18   .1337119E-02   .4434538E-02   .4762352E-03   .1181714E-01    19  -.1005048E-02  -.2990268E-02  -.2452098E-03  -.8048290E-02
                                                       SECOND INDEX =    5
  2   .2244644E-03   .3324721E-03   .1197519E-03   .1319203E-02     3   .1204787E-03   .1005700E-03   .1835267E-03   .1110445E-02
  4   .1191017E-03   .3548274E-04   .4553196E-03   .1848349E-02     5  -.7691552E-04   .9027765E-04  -.7700565E-04  -.1288314E-03
  6   .4265975E-04   .1065407E-03   .1048003E-03   .9424411E-03     7  -.3271816E-04   .2943593E-03   .2291723E-03   .2851758E-03
  8   .2123321E-04   .2001576E-03   .3969748E-03   .1034434E-02     9  -.2367450E-03  -.7040359E-03  -.7066706E-03  -.1720352E-02
 10   .2846028E-03   .1560895E-02   .1421642E-02   .3909218E-02    11  -.5157242E-03  -.2205059E-02  -.1824405E-02  -.5423488E-02
 12   .6445724E-03   .2743381E-02   .1895386E-02   .7273416E-02    13  -.7443154E-03  -.3222765E-02  -.1856605E-02  -.8314319E-02
 14   .1010046E-02   .4066632E-02   .1297731E-02   .1019785E-01    15  -.1178280E-02  -.4814067E-02  -.8779063E-03  -.1233259E-01
 16   .1851496E-02   .6123484E-02   .3367355E-03   .1605953E-01    17  -.1704009E-02  -.5603722E-02  -.1103457E-03  -.1573803E-01
 18   .2148620E-02   .6812096E-02   .7883073E-03   .1829797E-01    19  -.1302510E-02  -.3940598E-02  -.5605486E-03  -.1092697E-01
                                                       SECOND INDEX =    6
  2   .1990341E-03   .2346650E-03  -.1308366E-03   .2841446E-03     3   .2126857E-03   .1017752E-03   .7115622E-04   .7730378E-03
  4   .1422261E-03   .7753811E-05   .2993933E-03   .7471939E-03     5  -.3611871E-04   .2046111E-03   .3793865E-03  -.6043179E-03
  6   .3268121E-04   .1440339E-03   .2632297E-03   .3279609E-04     7  -.4678232E-04   .1334341E-03   .1651382E-03  -.5951971E-03
  8  -.5376679E-04  -.4038776E-04   .2334312E-03  -.2199635E-03     9  -.1525257E-03  -.5342039E-04   .1100222E-03  -.9548955E-03
 10   .8701814E-04   .6323424E-03   .6860441E-03   .1567352E-02    11  -.5269026E-03  -.1831918E-02  -.1176023E-02  -.4932553E-02
 12   .5495391E-03   .2580669E-02   .1663770E-02   .6411155E-02    13  -.8710275E-03  -.3700749E-02  -.1774725E-02  -.9122210E-02
 14   .8834426E-03   .4274155E-02   .1507198E-02   .9746906E-02    15  -.1167745E-02  -.5316569E-02  -.1371669E-02  -.1257992E-01
 16   .1877668E-02   .6823684E-02   .9010383E-03   .1705005E-01    17  -.2039832E-02  -.7016406E-02  -.5659334E-03  -.1926272E-01
 18   .2753960E-02   .8717592E-02   .1329659E-02   .2331773E-01    19  -.1828950E-02  -.5541267E-02  -.9608286E-03  -.1561956E-01
                                                       SECOND INDEX =    7
  2   .3107400E-03   .3751031E-03  -.5162805E-04   .1360536E-02     3   .2895811E-03   .3490770E-03   .5403457E-04   .1089546E-02
  4   .3330938E-03   .2132048E-03   .3409153E-03   .1895728E-02     5   .7811121E-04   .3101822E-03   .3627713E-03   .6680409E-04
  6   .1729541E-03   .2017270E-03   .2024241E-03   .1020837E-02     7   .3940786E-04   .2888928E-03   .9125791E-04   .4835273E-04
  8   .7273741E-04   .1261124E-03   .3091561E-03   .6718586E-03     9  -.2894116E-04   .1931939E-03   .1029427E-03   .1152459E-03
 10  -.3227717E-04  -.1605101E-03   .7421927E-04   .1237297E-03    11  -.1462903E-03  -.3972839E-03  -.3507245E-03  -.9752265E-03
 12   .3037814E-03   .1465589E-02   .1085558E-02   .3805355E-02    13  -.5392654E-03  -.2827055E-02  -.1513913E-02  -.5870005E-02
 14   .7777502E-03   .4161882E-02   .1687335E-02   .9124422E-02    15  -.1127835E-02  -.5539986E-02  -.1867533E-02  -.1231015E-01
 16   .1910320E-02   .7397775E-02   .1605200E-02   .1801675E-01    17  -.2224164E-02  -.8152081E-02  -.1210695E-02  -.2141493E-01
 18   .3373286E-02   .1079091E-01   .2[illegible]32604E-02   .2897365E-01    19  -.2349689E-02  -.7112247E-02  -.1555001E-02  -.1993538E-01
                                                       SECOND INDEX =    8
  2   .1377906E-03   .2712131E-03  -.1477236E-03  -.2187011E-03     3   .2694806E-03   .3420647E-03  -.7566126E-05   .7508621E-03
  4   .2178925E-03   .2010050E-03   .2470071E-04   .6533093E-03     5  -.2964386E-04   .1878157E-03   .1799337E-03  -.8390180E-03
  6  -.6406023E-05   .9607733E-04   .2341327E-04  -.3304092E-03     7  -.5877004E-04   .4879662E-04  -.1128985E-03  -.7640479E-03
  8  -.7257169E-04  -.1123408E-03  -.2810781E-04  -.5694349E-03     9  -.1805947E-03  -.2311592E-03  -.1507596E-03  -.1255202E-02
 10  -.9827758E-04  -.1823019E-03   .2728633E-04  -.2615646E-03    11  -.1762443E-03  -.1172896E-03  -.9601828E-05  -.9019331E-03
 12  -.8807818E-05   .1256502E-03   .1214341E-03   .6355338E-03    13  -.3634334E-03  -.1753059E-02  -.7093568E-03  -.3576973E-02
 14   .4869861E-03   .3051272E-02   .1269324E-02   .6202621E-02    15  -.1009156E-02  -.5224286E-02  -.2029861E-02  -.1122300E-01
 16   .1757061E-02   .7391241E-02   .1996905E-02   .1705323E-01    17  -.2361182E-02  -.9214641E-02  -.2062460E-02  -.2343128E-01
 18   .3828274E-02   .1244170E-01   .2849169E-02   .3310474E-01    19  -.2961206E-02  -.8952893E-02  -.2401913E-02  -.2522905E-01
                                                       SECOND INDEX =    9
  2   .2648893E-03   .3356458E-03   .1863352E-04   .9012158E-03     3   .2872007E-03   .5193308E-03  -.6218906E-05   .9005392E-03
  4   .3942211E-03   .2240601E-03  -.1180326E-03   .2020588E-02     5   .3847281E-04   .2232673E-03   .1139371E-04  -.3673327E-03
  6   .1353893E-03   .7144456E-04   .2875424E-04   .7424776E-03     7  -.1647474E-04   .1285999E-03  -.2434054E-03  -.5080679E-03
  8   .4995836E-04  -.4782005E-04   .5965505E-06   .1708802E-03     9  -.5397525E-04   .1008935E-03  -.1792345E-04  -.2320676E-03
```

Example 2

Input Data Cards

```
      28    32    15     0     0     1     0
      19     0     0     4     5     1
 5.92       1.4       9.7       1.0       75.       1.005     1.        0.1  0.
 1006020.  0.723      0.9       1.7       4.4           1     0     1
 1110001000100010001000100010001l
```

Printed Output

```
AXISYMMETRIC FLOW OVER NOSETIP



MACH NUMBER = 5.92
RATIO OF SPECIFIC HEAT = 1.40
CONE(AFTERBODY) HALF-ANGLE =  9.700  DEGREES
OMEGA =  1.000      (OMEGA.GT.0.OMEGA IS THE RADIUS OF SPHERE-CONES IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED
                     IN SUB. SHAPES OMEGA=0.MORE RAYS TO BE ADDED)

IR1 = 0      ( 1 FOR READ TAPE1$ 0     OTHERWISE)
IW2 = 1      (1 FOR WRITE ON TAPE2$ 0   OTHERWISE)
IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGEN$ 0     OTHERWISE)
IAFBD = 0      ( 1 FOR      STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)
IGEOM = 0      ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB.YB.XS.YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                3 FOR CAL. DELTAS AND FINAL XB.YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB.YB)

LIP =   0      ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
IVIS = 1      (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

CF(BETA)=      1.00500      ( FOR UNIFORM SPACING SET TO 10000)
CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
ITRAN = 5      (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
KRES = 4      (INTERVAL IN K FOR RESIDUE INFORMATION)
EXPLICIT DISSI. COEF. = .100
IMPLICIT DISSI. COEF. =0.000
COURANT NO. =   75.00



JMAX=   28
KMAX=   32
JNM=   19      (JUNCTURE OF SPHERE AND CONE)
ITER =  15      (TIME STEPS FOR THIS RUN)

RE =     .100602E+07
PR =     .723
PR(TURB.) =     .900
CVIS = 110/TINF(KELVIN) =    1.700      ( CONSTANT USED IN SUTHERLAND"S LAW OF VISCOSITY )
ITWA = 1      ( 0 FOR ADIABATIC WALLS 1 FOR ISOTHERMAL WALL)
ITUR = 0      ( 0 FOR LAMINAR $ 1 FOR TURBULENT)
ITF = 1      ( 1 FOR PRINT OUT ST NO. ONLY $ 2 PRINT OUT T-FIELD ALSO)


TW =   4.400
```

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FREE STREAM CONDITIONS

  PINF(PRESSURE) =  1.0000
  RINF(DENSITY) =  1.0000
  QINF(TOTAL VEL.) =  7.0046
  AINF(SOUND SPEED) =  1.1832
  UINF(U COMP.) =  7.0046
  VINF(V COMP.) =  0.0000
  HTINF(T. ENTHALPY) = 28.0325
  ETINF(T. SPEC. ENERGY) = 27.0325
  SINF(ENTROPY) =  1.0000
  EIINF(INTERNAL ENERGY) =  2.5000

 NORMALIZED DISTANCE FROM BODY TO SHOCK
                    0.000000   .001063   .002352   .003913   .005804   .008094   .010865   .014217   .018269   .023163
                     .029068   .036187   .044755   .055051   .067399   .082173   .099798   .120755   .145570   .174815
                     .209086   .248983   .295072   .347845   .407659   .474677   .548806   .629639   .716426   .808066
                     .903141  1.000000

STAGNATION PRESSURE PT=   45.5875

ARC LENGTH
                       .04004    .12010    .20017    .28023    .36030    .44036    .52043    .60049    .68055    .76062
                       .84068    .92075   1.00081   1.08088   1.16094   1.24100   1.32107   1.40113   1.48122   1.56130
                      1.64139   1.72148   1.80156   1.88165   1.96173   2.04182   2.12190


STARTING FLOWFIELD INFORMATION


SECOND INDEX=  1

IST   P/PINF       S         U/QINF      V/QINF      S/SINF     HT/HTINF      R/RI         CP          X           Y        EI/EIINF
 1  .4551E+02 -.4004E-01  .9148E-03 -.2283E-01  .3995E+01  .1000E+01  .5685E+01  .1815E+01  .8016E-03 -.4003E-01  .8006E+01
 2  .4551E+02  .4004E-01  .9148E-03  .2283E-01  .3995E+01  .1000E+01  .5685E+01  .1815E+01  .8016E-03  .4003E-01  .8006E+01
 3  .4494E+02  .1201E+00  .8210E-02  .6802E-01  .3995E+01  .1000E+01  .5634E+01  .1791E+01  .7207E-02  .1198E+00  .7976E+01
 4  .4380E+02  .2002E+00  .2268E-01  .1118E+00  .3995E+01  .1000E+01  .5531E+01  .1745E+01  .1998E-01  .1989E+00  .7918E+01
 5  .4214E+02  .2802E+00  .4409E-01  .1532E+00  .3995E+01  .1000E+01  .5381E+01  .1677E+01  .3903E-01  .2766E+00  .7831E+01
 6  .4001E+02  .3603E+00  .7208E-01  .1913E+00  .3995E+01  .1000E+01  .5186E+01  .1590E+01  .6424E-01  .3526E+00  .7716E+01
 7  .3750E+02  .4404E+00  .1062E+00  .2253E+00  .3995E+01  .1000E+01  .4950E+01  .1488E+01  .9545E-01  .4264E+00  .7574E+01
 8  .3466E+02  .5204E+00  .1459E+00  .2544E+00  .3995E+01  .1000E+01  .4680E+01  .1372E+01  .1325E+00  .4974E+00  .7406E+01
 9  .3161E+02  .6005E+00  .1904E+00  .2780E+00  .3995E+01  .1000E+01  .4382E+01  .1248E+01  .1750E+00  .5652E+00  .7213E+01
10  .2841E+02  .6806E+00  .2391E+00  .2953E+00  .3995E+01  .1000E+01  .4061E+01  .1117E+01  .2229E+00  .6294E+00  .6997E+01
11  .2517E+02  .7606E+00  .2912E+00  .3058E+00  .3995E+01  .1000E+01  .3724E+01  .9854E+00  .2757E+00  .6895E+00  .6759E+01
12  .2198E+02  .8407E+00  .3455E+00  .3092E+00  .3995E+01  .1000E+01  .3380E+01  .8552E+00  .3332E+00  .7452E+00  .6507E+01
13  .1891E+02  .9207E+00  .4013E+00  .3050E+00  .3995E+01  .1000E+01  .3036E+01  .7299E+00  .3950E+00  .7962E+00  .6229E+01
14  .1603E+02  .1001E+01  .4573E+00  .2930E+00  .3995E+01  .1000E+01  .2698E+01  .6127E+00  .4606E+00  .8420E+00  .5942E+01
15  .1341E+02  .1081E+01  .5124E+00  .2731E+00  .3995E+01  .1000E+01  .2375E+01  .5060E+00  .5297E+00  .8825E+00  .5647E+01
16  .1111E+02  .1161E+01  .5650E+00  .2453E+00  .3995E+01  .1000E+01  .2075E+01  .4120E+00  .6018E+00  .9173E+00  .5350E+01
17  .9158E+01  .1241E+01  .6134E+00  .2098E+00  .3995E+01  .1000E+01  .1809E+01  .3325E+00  .6765E+00  .9462E+00  .5063E+01
18  .7597E+01  .1321E+01  .6557E+00  .1670E+00  .3995E+01  .1000E+01  .1583E+01  .2689E+00  .7532E+00  .9691E+00  .4800E+01
19  .6697E+01  .1401E+01  .6819E+00  .1307E+00  .3995E+01  .1000E+01  .1446E+01  .2322E+00  .8315E+00  .9857E+00  .4630E+01
20  .6450E+01  .1481E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .9105E+00  .9992E+00  .4581E+01
21  .6450E+01  .1561E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .9894E+00  .1013E+01  .4581E+01
22  .6450E+01  .1641E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .1069E+01  .1026E+01  .4581E+01
23  .6450E+01  .1721E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .1147E+01  .1040E+01  .4581E+01
24  .6450E+01  .1802E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .1226E+01  .1053E+01  .4581E+01
25  .6450E+01  .1882E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .1305E+01  .1067E+01  .4581E+01
26  .6450E+01  .1962E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .1384E+01  .1080E+01  .4581E+01
27  .6450E+01  .2042E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .1463E+01  .1094E+01  .4581E+01
28  .6450E+01  .2122E+01  .6894E+00  .1178E+00  .3995E+01  .1000E+01  .1408E+01  .2222E+00  .1542E+01  .1107E+01  .4581E+01
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```
SECOND INDEX= 32

1ST   P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF     HT/HTINF     MACH        CP          X           Y         FI/FIINF
 1  .4066E+02  .5250E+01  .1917E+00 -.3114E-01  .3990E+01  .1000E+01  .4131E+00  .1617E+01 -.1477E+00 -.4598E-01  .7745E+01
 2  .4066E+02  .5250E+01  .1917E+00  .3114E-01  .3990E+01  .1000E+01  .4131E+00  .1617E+01 -.1477E+00  .4598E-01  .7745E+01
 3  .4018E+02  .5242E+01  .2014E+00  .9214E-01  .3951E+01  .1000E+01  .4736E+00  .1597E+01 -.1406E+00  .1377E+00  .7665E+01
 4  .3927E+02  .5227E+01  .2200E+00  .1495E+00  .3877E+01  .1000E+01  .5744E+00  .1560E+01 -.1266E+00  .2286E+00  .7514E+01
 5  .3800E+02  .5205E+01  .2459E+00  .2013E+00  .3775E+01  .1000E+01  .6962E+00  .1508E+01 -.1060E+00  .3184E+00  .7302E+01
 6  .3646E+02  .5176E+01  .2773E+00  .2465E+00  .3650E+01  .1000E+01  .8274E+00  .1445E+01 -.7907E-01  .4066E+00  .7045E+01
 7  .3475E+02  .5141E+01  .3122E+00  .2845E+00  .3511E+01  .1000E+01  .9619E+00  .1376E+01 -.4634E-01  .4932E+00  .6758E+01
 8  .3294E+02  .5101E+01  .3491E+00  .3157E+00  .3365E+01  .1000E+01  .1097E+01  .1302E+01 -.8181E-02  .5780E+00  .6457E+01
 9  .3110E+02  .5057E+01  .3866E+00  .3403E+00  .3216E+01  .1000E+01  .1230E+01  .1227E+01  .3506E-01  .6611E+00  .6150E+01
10  .2928E+02  .5008E+01  .4237E+00  .3593E+00  .3069E+01  .1000E+01  .1360E+01  .1153E+01  .8312E-01  .7425E+00  .5846E+01
11  .2751E+02  .4956E+01  .4597E+00  .3733E+00  .2927E+01  .1000E+01  .1488E+01  .1081E+01  .1358E+00  .8227E+00  .5551E+01
12  .2581E+02  .4900E+01  .4943E+00  .3831E+00  .2790E+01  .1000E+01  .1613E+01  .1011E+01  .1931E+00  .9018E+00  .5268E+01
13  .2420E+02  .4841E+01  .5272E+00  .3894E+00  .2660E+01  .1000E+01  .1736E+01  .9455E+00  .2551E+00  .9802E+00  .4998E+01
14  .2266E+02  .4779E+01  .5585E+00  .3927E+00  .2537E+01  .1000E+01  .1856E+01  .8830E+00  .3221E+00  .1058E+01  .4742E+01
15  .2121E+02  .4714E+01  .5881E+00  .3935E+00  .2420E+01  .1000E+01  .1975E+01  .8238E+00  .3943E+00  .1137E+01  .4499E+01
16  .1983E+02  .4645E+01  .6162E+00  .3923E+00  .2310E+01  .1000E+01  .2093E+01  .7676E+00  .4723E+00  .1216E+01  .4269E+01
17  .1853E+02  .4573E+01  .6428E+00  .3892E+00  .2206E+01  .1000E+01  .2210E+01  .7144E+00  .5569E+00  .1296E+01  .4051E+01
18  .1728E+02  .4497E+01  .6681E+00  .3846E+00  .2107E+01  .1000E+01  .2328E+01  .6638E+00  .6491E+00  .1378E+01  .3844E+01
19  .1622E+02  .4425E+01  .6898E+00  .3793E+00  .2022E+01  .1000E+01  .2434E+01  .6205E+00  .7500E+00  .1462E+01  .3666E+01
20  .1522E+02  .4351E+01  .7102E+00  .3731E+00  .1943E+01  .1000E+01  .2539E+01  .5796E+00  .8379E+00  .1532E+01  .3498E+01
21  .1438E+02  .4282E+01  .7274E+00  .3669E+00  .1876E+01  .1000E+01  .2632E+01  .5453E+00  .9294E+00  .1602E+01  .3357E+01
22  .1359E+02  .4214E+01  .7433E+00  .3604E+00  .1815E+01  .1000E+01  .2723E+01  .5133E+00  .1025E+01  .1671E+01  .3226E+01
23  .1286E+02  .4145E+01  .7582E+00  .3535E+00  .1758E+01  .1000E+01  .2811E+01  .4836E+00  .1124E+01  .1740E+01  .3104E+01
24  .1227E+02  .4084E+01  .7703E+00  .3474E+00  .1711E+01  .1000E+01  .2886E+01  .4593E+00  .1225E+01  .1809E+01  .3004E+01
25  .1171E+02  .4024E+01  .7816E+00  .3412E+00  .1668E+01  .1000E+01  .2959E+01  .4367E+00  .1305E+01  .1860E+01  .2911E+01
26  .1127E+02  .3974E+01  .7906E+00  .3359E+00  .1634E+01  .1000E+01  .3019E+01  .4188E+00  .1384E+01  .1910E+01  .2837E+01
27  .1086E+02  .3925E+01  .7990E+00  .3307E+00  .1602E+01  .1000E+01  .3077E+01  .4021E+00  .1463E+01  .1958E+01  .2768E+01
28  .1047E+02  .3875E+01  .8070E+00  .3255E+00  .1572E+01  .1000E+01  .3134E+01  .3860E+00  .1542E+01  .2006E+01  .2702E+01
```

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```
    PERCENT ERROR IN HT=   .4867E-11    RMS OF PERCENT ERROR IN HT=   .2764E-11

PRESSURE DRAG =        .8276035476

SIGMAX= .2370E+05   J=    1   K=    1   SIGMIN=  .3670E+02   J=   28   K=   30   CN= .7500E+02   DT= .3164E-02
RESIDUE INFORMATION              19    31     .00721     .03822  18.866485( 19, 31, 4)=     .00705
RMS OF SHOCK SPEED=    .6279E-01    J= 19    MAX SHK SPD=  -.1334E+00
RMS OF SHOCK SPEED=    .7221E-01    J= 20    MAX SHK SPD=  -.1388E+00
RMS OF SHOCK SPEED=    .7138E-01    J= 21    MAX SHK SPD=  -.1252E+00
RMS OF SHOCK SPEED=    .7050E-01    J=  2    MAX SHK SPD=  -.1264E+00
RMS OF SHOCK SPEED=    .7248E-01    J=  2    MAX SHK SPD=  -.1584E+00
RMS OF SHOCK SPEED=    .7783E-01    J=  2    MAX SHK SPD=  -.1910E+00
RMS OF SHOCK SPEED=    .8475E-01    J=  2    MAX SHK SPD=  -.2218E+00
RMS OF SHOCK SPEED=    .9231E-01    J=  2    MAX SHK SPD=  -.2497E+00
RMS OF SHOCK SPEED=    .9971E-01    J=  2    MAX SHK SPD=  -.2743E+00
RMS OF SHOCK SPEED=    .1064E+00    J=  2    MAX SHK SPD=  -.2950E+00
RMS OF SHOCK SPEED=    .1121E+00    J=  2    MAX SHK SPD=  -.3113E+00
RMS OF SHOCK SPEED=    .1164E+00    J=  2    MAX SHK SPD=  -.3226E+00
RMS OF SHOCK SPEED=    .1191E+00    J=  2    MAX SHK SPD=  -.3278E+00
RMS OF SHOCK SPEED=    .1201E+00    J=  2    MAX SHK SPD=  -.3261E+00
RMS OF SHOCK SPEED=    .1192E+00    J=  2    MAX SHK SPD=  -.3168E+00
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST   P/PINF       S          U/QINF      V/QINF      S/SINF     HT/HTINF     R/RI        CP          X           Y         FI/FIINF
 1  .4475E+02 -.4004E-01 0.             0.          .1740E+01  .5494E+00  .1017E+02  .1783E+01  .8016E-03 -.4003E-01  .4400E+01
 2  .4475E+02  .4004E-01 0.             0.          .1740E+01  .5494E+00  .1017E+02  .1783E+01  .8016E-03  .4003E-01  .4400E+01
 3  .4430E+02  .1201E+00 0.             0.          .1747E+01  .5494E+00  .1007E+02  .1765E+01  .7207E-02  .1198E+00  .4400E+01
 4  .4322E+02  .2002E+00 0.             0.          .1764E+01  .5494E+00  .9822E+01  .1721E+01  .1998E-01  .1989E+00  .4400E+01
 5  .4158E+02  .2802E+00 0.             0.          .1792E+01  .5494E+00  .9450E+01  .1654E+01  .3903E-01  .2766E+00  .4400E+01
 6  .3941E+02  .3603E+00 0.             0.          .1831E+01  .5494E+00  .8956E+01  .1566E+01  .6424E-01  .3526E+00  .4400E+01
 7  .3675E+02  .4404E+00 0.             0.          .1883E+01  .5494E+00  .8351E+01  .1457E+01  .9545E-01  .4264E+00  .4400E+01
 8  .3370E+02  .5204E+00 0.             0.          .1949E+01  .5494E+00  .7659E+01  .1333E+01  .1325E+00  .4974E+00  .4400E+01
 9  .3038E+02  .6005E+00 0.             0.          .2031E+01  .5494E+00  .6905E+01  .1198E+01  .1750E+00  .5652E+00  .4400E+01
10  .2692E+02  .6806E+00 0.             0.          .2132E+01  .5494E+00  .6119E+01  .1057E+01  .2229E+00  .6294E+00  .4400E+01
11  .2344E+02  .7606E+00 0.             0.          .2253E+01  .5494E+00  .5328E+01  .9148E+00  .2757E+00  .6895E+00  .4400E+01
12  .2006E+02  .8407E+00 0.             0.          .2398E+01  .5494E+00  .4560E+01  .7771E+00  .3332E+00  .7452E+00  .4400E+01
13  .1690E+02  .9207E+00 0.             0.          .2568E+01  .5494E+00  .3842E+01  .6482E+00  .3950E+00  .7962E+00  .4400E+01
14  .1405E+02  .1001E+01 0.             0.          .2766E+01  .5494E+00  .3192E+01  .5318E+00  .4606E+00  .8420E+00  .4400E+01
15  .1155E+02  .1081E+01 0.             0.          .2991E+01  .5494E+00  .2624E+01  .4299E+00  .5297E+00  .8825E+00  .4400E+01
16  .9415E+01  .1161E+01 0.             0.          .3246E+01  .5494E+00  .2140E+01  .3430E+00  .6018E+00  .9173E+00  .4400E+01
17  .7626E+01  .1241E+01 0.             0.          .3531E+01  .5494E+00  .1733E+01  .2701E+00  .6765E+00  .9462E+00  .4400E+01
18  .6172E+01  .1321E+01 0.             0.          .3843E+01  .5494E+00  .1403E+01  .2108E+00  .7532E+00  .9691E+00  .4400E+01
19  .5393E+01  .1401E+01 0.             0.          .4056E+01  .5494E+00  .1226E+01  .1791E+00  .8315E+00  .9857E+00  .4400E+01
20  .5417E+01  .1481E+01 0.             0.          .4049E+01  .5494E+00  .1231E+01  .1800E+00  .9105E+00  .9942E+00  .4400E+01
21  .5782E+01  .1561E+01 0.             0.          .3945E+01  .5494E+00  .1314E+01  .1949E+00  .9894E+00  .1013E+01  .4400E+01
22  .6035E+01  .1641E+01 0.             0.          .3878E+01  .5494E+00  .1371E+01  .2052E+00  .1069E+01  .1026E+01  .4400E+01
23  .6140E+01  .1721E+01 0.             0.          [illegible] .5494E+00 [illegible] [illegible] .1147E+01  .1040E+01  .4400E+01
24  .6157E+01  .1802E+01 0.             0.          .3847E+01  .5494E+00  .1394E+01  .2102E+00  .1226E+01  .1053E+01  .4400E+01
25  .6138E+01  .1882E+01 0.             0.          .3851E+01  .5494E+00  .1395E+01  .2094E+00  .1305E+01  .1067E+01  .4400E+01
26  .6112E+01  .1962E+01 0.             0.          .3858E+01  .5494E+00  .1389E+01  .2084E+00  .1384E+01  .1080E+01  .4400E+01
27  .6085E+01  .2042E+01 0.             0.          .3865E+01  .5494E+00  .1383E+01  .2073E+00  .1463E+01  .1094E+01  .4400E+01
28  .6097E+01  .2122E+01 0.             0.          .3862E+01  .5494E+00  .1386E+01  .2078E+00  .1542E+01  .1107E+01  .4400E+01
```

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```
SECOND INDEX= 15

1ST   P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF     HT/HTINF     MACH        CP          X           Y         FI/FIINF
 1  .4482E+02  .5619E+01  .1680E-01 -.3204E-01  .3999E+01  .9972E+00  .7582E-01  .1786E+01 -.8485E-02 -.4040E-01  .7977E+01
 2  .4482E+02  .5619E+01  .1680E-01  .3204E-01  .3999E+01  .9972E+00  .7582E-01  .1786E+01 -.8485E-02  .4040E-01  .7977E+01
 3  .4438E+02  .5587E+01  .2349E-01  .8529E-01  .3991E+01  .9986E+00  .1858E+00  .1768E+01 -.2164E-02  .1210E+00  .7943E+01
 4  .4329E+02  .5494E+01  .3777E-01  .1287E+00  .3986E+01  .9996E+00  .2829E+00  .1724E+01  .1051E-01  .2008E+00  .7880E+01
 5  .4166E+02  .5351E+01  .5963E-01  .1687E+00  .3981E+01  .1000E+01  .3795E+00  .1658E+01  .2951E-01  .2794E+00  .7786E+01
 6  .3952E+02  .5161E+01  .8847E-01  .2062E+00  .3972E+01  .1000E+01  .4799E+00  .1570E+01  .5471E-01  .3562E+00  .7657E+01
 7  .3689E+02  .4923E+01  .1235E+00  .2399E+00  .3961E+01  .9994E+00  .5836E+00  .1463E+01  .8592E-01  .4309E+00  .7494E+01
 8  .3390E+02  .4645E+01  .1640E+00  .2689E+00  .3949E+01  .9980E+00  .6902E+00  .1341E+01  .1229E+00  .5028E+00  .7298E+01
 9  .3064E+02  .4332E+01  .2092E+00  .2921E+00  .3935E+01  .9961E+00  .7997E+00  .1208E+01  .1655E+00  .5717E+00  .7073E+01
10  .2724E+02  .3994E+01  .2581E+00  .3089E+00  .3920E+01  .9935E+00  .9123E+00  .1070E+01  .2134E+00  .6370E+00  .6822E+01
11  .2383E+02  .3640E+01  .3096E+00  .3189E+00  .3905E+01  .9903E+00  .1029E+01  .9307E+00  .2662E+00  .6985E+00  .6547E+01
12  .2052E+02  .3281E+01  .3625E+00  .3217E+00  .3889E+01  .9865E+00  .1147E+01  .7957E+00  .3237E+00  .7558E+00  .6255E+01
13  .1742E+02  .2928E+01  .4157E+00  .3175E+00  .3872E+01  .9824E+00  .1270E+01  .6694E+00  .3855E+00  .8086E+00  .5950E+01
14  .1462E+02  .2592E+01  .4683E+00  .3064E+00  .3854E+01  .9784E+00  .1395E+01  .5552E+00  .4513E+00  .8566E+00  .5641E+01
15  .1217E+02  .2281E+01  .5193E+00  .2888E+00  .3835E+01  .9750E+00  .1523E+01  .4552E+00  .5206E+00  .8995E+00  .5334E+01
16  .1008E+02  .2002E+01  .5679E+00  .2651E+00  .3814E+01  .9724E+00  .1654E+01  .3701E+00  .5931E+00  .9373E+00  .5035E+01
17  .8325E+01  .1754E+01  .6142E+00  .2361E+00  .3790E+01  .9715E+00  .1788E+01  .2986E+00  .6685E+00  .9696E+00  .4746E+01
18  .6864E+01  .1534E+01  .6559E+00  .2006E+00  .3772E+01  .9705E+00  .1919E+01  .2390E+00  .7462E+00  .9964E+00  .4475E+01
19  .5897E+01  .1381E+01  .6860E+00  .1627E+00  .3751E+01  .9680E+00  .2020E+01  .1996E+00  .8261E+00  .1018E+01  .4269E+01
```

```
20  .5594E+01  .1343E+01  .7011E+00  .1370E+00  .3702E+01  .9666E+00  .2072E+01  .1873E+00  .9056E+00  .1035E+01  .4165E+01
21  .5760E+01  .1389E+01  .7069E+00  .1273E+00  .3636E+01  .9693E+00  .2088E+01  .1940E+00  .9854E+00  .1052E+01  .4147E+01
22  .5982E+01  .1441E+01  .7104E+00  .1253E+00  .3586E+01  .9736E+00  .2096E+01  .2031E+00  .1065E+01  .1069E+01  .4151E+01
23  .6090E+01  .1468E+01  .7137E+00  .1255E+00  .3556E+01  .9773E+00  .2107E+01  .2075E+00  .1146E+01  .1087E+01  .4147E+01
24  .6112E+01  .1476E+01  .7162E+00  .1262E+00  .3543E+01  .9798E+00  .2116E+01  .2084E+00  .1226E+01  .1104E+01  .4141E+01
25  .6099E+01  .1474E+01  .7176E+00  .1268E+00  .3542E+01  .9812E+00  .2121E+01  .2079E+00  .1305E+01  .1120E+01  .4137E+01
26  .6080E+01  .1471E+01  .7186E+00  .1274E+00  .3541E+01  .9821E+00  .2125E+01  .2071E+00  .1384E+01  .1136E+01  .4133E+01
27  .6062E+01  .1468E+01  .7192E+00  .1281E+00  .3542E+01  .9826E+00  .2128E+01  .2063E+00  .1463E+01  .1152E+01  .4129E+01
28  .6090E+01  .1473E+01  .7196E+00  .1288E+00  .3542E+01  .9840E+00  .2128E+01  .2075E+00  .1542E+01  .1168E+01  .4135E+01
```

*** skip print out ***

```
SECOND INDEX= 32

1ST   P/PINF     RO/RINF     U/QINF     V/QINF     S/SINF     HT/HTINF      MACH        CP         X          Y        FI/FIINF
 1  .3707E+02  .5187E+01  .2300E+00 -.2265E-01  .3699E+01  .9390E+00  .5117E+00  .1470E+01 -.1370E+00 -.4555E-01  .7147E+01
 2  .3707E+02  .5187E+01  .2300E+00  .2265E-01  .3699E+01  .9390E+00  .5117E+00  .1470E+01 -.1370E+00  .4555E-01  .7147E+01
 3  .3748E+02  .5195E+01  .2286E+00  .7220E-01  .3732E+01  .9510E+00  .5283E+00  .1487E+01 -.1319E+00  .1366E+00  .7214E+01
 4  .3770E+02  .5199E+01  .2334E+00  .1280E+00  .3750E+01  .9673E+00  .5853E+00  .1496E+01 -.1204E+00  .2274E+00  .7251E+01
 5  .3736E+02  .5193E+01  .2487E+00  .1840E+00  .3722E+01  .9820E+00  .6827E+00  .1482E+01 -.1022E+00  .3173E+00  .7194E+01
 6  .3650E+02  .5177E+01  .2728E+00  .2345E+00  .3653E+01  .9937E+00  .8021E+00  .1447E+01 -.7717E-01  .4059E+00  .7052E+01
 7  .3526E+02  .5152E+01  .3032E+00  .2781E+00  .3553E+01  .1003E+01  .9309E+00  .1397E+01 -.4586E-01  .4930E+00  .6845E+01
 8  .3374E+02  .5119E+01  .3381E+00  .3142E+00  .3429E+01  .1009E+01  .1064E+01  .1334E+01 -.8671E-02  .5783E+00  .6590E+01
 9  .3199E+02  .5079E+01  .3758E+00  .3430E+00  .3288E+01  .1013E+01  .1200E+01  .1263E+01  .3405E-01  .6618E+00  .6299E+01
10  .3010E+02  .5031E+01  .4149E+00  .3647E+00  .3136E+01  .1014E+01  .1337E+01  .1186E+01  .8700E-01  .7435E+00  .5984E+01
11  .2815E+02  .4975E+01  .4541E+00  .3796E+00  .2978E+01  .1013E+01  .1473E+01  .1107E+01  .1349E+00  .8236E+00  .5657E+01
12  .2619E+02  .4913E+01  .4923E+00  .3887E+00  .2820E+01  .1010E+01  .1608E+01  .1027E+01  .1926E+00  .9024E+00  .5331E+01
13  .2429E+02  .4845E+01  .5286E+00  .3931E+00  .2667E+01  .1006E+01  .1742E+01  .9494E+00  .2551E+00  .9803E+00  .5014E+01
14  .2250E+02  .4772E+01  .5627E+00  .3938E+00  .2523E+01  .1001E+01  .1873E+01  .8762E+00  .3224E+00  .1058E+01  .4714E+01
15  .2083E+02  .4695E+01  .5944E+00  .3918E+00  .2389E+01  .9973E+00  .2001E+01  .8081E+00  .3949E+00  .1135E+01  .4435E+01
16  .1929E+02  .4616E+01  .6239E+00  .3880E+00  .2267E+01  .9942E+00  .2128E+01  .7456E+00  .4732E+00  .1214E+01  .4179E+01
17  .1786E+02  .4533E+01  .6515E+00  .3827E+00  .2153E+01  .9917E+00  .2253E+01  .6875E+00  .5579E+00  .1293E+01  .3941E+01
18  .1655E+02  .4448E+01  .6776E+00  .3766E+00  .2049E+01  .9906E+00  .2379E+01  .6341E+00  .6499E+00  .1374E+01  .3722E+01
19  .1546E+02  .4369E+01  .6991E+00  .3696E+00  .1962E+01  .9890E+00  .2489E+01  .5892E+00  .7508E+00  .1458E+01  .3538E+01
20  .1458E+02  .4299E+01  .7167E+00  .3635E+00  .1892E+01  .9886E+00  .2584E+01  .5535E+00  .8384E+00  .1528E+01  .3391E+01
21  .1385E+02  .4237E+01  .7323E+00  .3583E+00  .1835E+01  .9898E+00  .2669E+01  .5238E+00  .9298E+00  .1598E+01  .3269E+01
22  .1320E+02  .4177E+01  .7463E+00  .3533E+00  .1784E+01  .9913E+00  .2750E+01  .4973E+00  .1025E+01  .1667E+01  .3160E+01
23  .1262E+02  .4120E+01  .7598E+00  .3487E+00  .1738E+01  .9940E+00  .2828E+01  .4736E+00  .1124E+01  .1737E+01  .3063E+01
24  .1214E+02  .4070E+01  .7706E+00  .3443E+00  .1701E+01  .9957E+00  .2894E+01  .4539E+00  .1226E+01  .1806E+01  .2982E+01
25  .1174E+02  .4028E+01  .7795E+00  .3406E+00  .1670E+01  .9974E+00  .2949E+01  .4380E+00  .1305E+01  .1858E+01  .2916E+01
26  .1138E+02  .3986E+01  .7879E+00  .3370E+00  .1642E+01  .9992E+00  .3002E+01  .4232E+00  .1384E+01  .1908E+01  .2855E+01
27  .1103E+02  .3945E+01  .7960E+00  .3331E+00  .1615E+01  .1001E+01  .3055E+01  .4088E+00  .1463E+01  .1957E+01  .2796E+01
28  .1068E+02  .3901E+01  .8039E+00  .3290E+00  .1588E+01  .1002E+01  .3108E+01  .3944E+00  .1542E+01  .2005E+01  .2737E+01

 SONIC LINE LOCATION

XSL=  .1022E+01   YSL=  .1020E+01
XSL=  .5125E+00   YSL=  .[illegible]777E+00

XSL=  .3697E+00   YSL=  .7770E+00
XSL=  .3039E+00   YSL=  .7191E+00
XSL=  .2845E+00   YSL=  .7010E+00
XSL=  .2771E+00   YSL=  .6947E+00
XSL=  .2745E+00   YSL=  .6933E+00
XSL=  .2721E+00   YSL=  .6922E+00
XSL=  .2697E+00   YSL=  .6912E+00
XSL=  .2665E+00   YSL=  .6896E+00
XSL=  .2630E+00   YSL=  .6880E+00
XSL=  .2584E+00   YSL=  .6858E+00
XSL=  .2534E+00   YSL=  .6836E+00
XSL=  .2471E+00   YSL=  .6806E+00
```

```
XSL=  .2400E+00   YSL=  .6774E+00
XSL=  .2315E+00   YSL=  .6735E+00
XSL=  .2219E+00   YSL=  .6692E+00
XSL=  .2106E+00   YSL=  .6641E+00
XSL=  .1979E+00   YSL=  .6586E+00
XSL=  .1837E+00   YSL=  .6519E+00
XSL=  .1685E+00   YSL=  .6444E+00
XSL=  .1516E+00   YSL=  .6363E+00
XSL=  .1332E+00   YSL=  .6279E+00
XSL=  .1134E+00   YSL=  .6190E+00
XSL=  .9271E-01   YSL=  .6093E+00
XSL=  .7116E-01   YSL=  .5985E+00
XSL=  .4799E-01   YSL=  .5861E+00
XSL=  .2310E-01   YSL=  .5716E+00
XSL= -.1827E-02   YSL=  .5550E+00
XSL= -.2662E-01   YSL=  .5371E+00

    PERCENT ERROR IN HT=   .4506E+02    RMS OF PERCENT ERROR IN HT=   .1195E+02

PRESSURE DRAG =        .7777554492

DISTRIBUTION OF STANTON NUMBER

 J          S                ST               T1               T2               T3
  2     .400402E-01      .785286E-02      .440000E+01      .509134E+01      .584219E+01
  3     .120104E+00      .749785E-02      .440000E+01      .505938E+01      .575451E+01
  4     .200169E+00      .718295E-02      .440000E+01      .504433E+01      .571979E+01
  5     .280233E+00      .696888E-02      .440000E+01      .504120E+01      .571365E+01
  6     .360297E+00      .671940E-02      .440000E+01      .503395E+01      .569515E+01
  7     .440362E+00      .639240E-02      .440000E+01      .501911E+01      .565622E+01
  8     .520426E+00      .599464E-02      .440000E+01      .499841E+01      .560110E+01
  9     .600490E+00      .555478E-02      .440000E+01      .497341E+01      .553383E+01
 10     .680554E+00      .506426E-02      .440000E+01      .494439E+01      .545576E+01
 11     .760619E+00      .453251E-02      .440000E+01      .491102E+01      .536732E+01
 12     .840683E+00      .397103E-02      .440000E+01      .487340E+01      .527050E+01
 13     .920747E+00      .340431E-02      .440000E+01      .483298E+01      .517010E+01
 14     .100081E+01      .286633E-02      .440000E+01      .479253E+01      .507282E+01
 15     .108088E+01      .239081E-02      .440000E+01      .475554E+01      .498522E+01
 16     .116094E+01      .194457E-02      .440000E+01      .472437E+01      .491017E+01
 17     .124100E+01      .166807E-02      .440000E+01      .469816E+01      .484554E+01
 18     .132107E+01      .135140E-02      .440000E+01      .466966E+01      .478787E+01
 19     .140113E+01      .118673E-02      .440000E+01      .467054E+01      .478741E+01
 20     .148122E+01      .142098E-02      .440000E+01      .475435E+01      .489165E+01
 21     .156130E+01      .191002E-02      .440000E+01      .489592E+01      .501476E+01
 22     .164139E+01      .232609E-02      .440000E+01      .501869E+01      .505814E+01
 23     .172148E+01      .259594E-02      .440000E+01      .511018E+01      .504812E+01
 24     .180156E+01      .273353E-02      .440000E+01      .517621E+01      .502613E+01
 25     .188165E+01      .280606E-02      .440000E+01      .522114E+01      .501030E+01
 26     .196173E+01      .283797E-02      .440000E+01      .525719E+01      .499779E+01
 27     .204182E+01      .285091E-02      .440000E+01      .528805E+01      .498628E+01

SOLUTION HAS BEEN STORED ON DISK
RESIDUE INFORMATION            23   28    .00457    .02721  17.161925( 23, 28, 4)=    .00456
```

*** Skip print out ***

Example 3

Input Data Cards

```
   20   12   15    0    0    0    0
   16    1    0    2    3    0
 6.0       1.4       7.0       4.32      2.0       10000.    1.        0.2  0.4
 .00423    -.19108   -.28      -.20
 .00423    .19108    -.28      .20
 .03890    .57196    -.21      .60
 .48157    .85320    .05       .96
 .84869    1.08579   .37       1.26
 1.11897   1.30636   .55       1.54
 1.33598   1.52503   .91       1.79
 1.52069   1.75048   1.16      2.02
 1.69911   1.97894   1.37      2.28
 1.88064   2.21119   1.55      2.57
 2.06915   2.45247   1.73      2.82
 2.26910   2.70940   1.88      3.39
 2.48603   2.98606   2.08      3.90
 2.72761   3.29347   2.34      4.46
 3.02707   3.53943   2.70      4.99
 3.37802   3.65087   3.15      5.48
 3.6       3.67813   3.47      5.78
 3.8       3.70268   3.78      6.04
 4.0       3.72724   4.12      6.28
 4.2       3.75180   4.47      6.49
 100100100011
```

Printed Output

```
AXISYMMETRIC FLOW OVER NOSETIP


MACH NUMBER = 6.00
RATIO OF SPECIFIC HEAT = 1.40
CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
OMEGA =  4.320     (OMEGA.GT.0.OMEGA IS THE RADIUS OF SPHERE-CONF$OMEGA=0,MORE RAYS TO BE ADDED)

IR1 = 0      ( 1 FOR READ TAPE1$ 0     OTHERWISE)
IW2 = 0      (1 FOR WRITE ON TAPE2$ 0   OTHERWISE)
IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGENS 0     OTHERWISE)
IAFBD = 0      ( 1 FOR       STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)
IGFOM = 1      ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB,YB,XS,YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

LIP = 0      ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
IVIS = 0      (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

CF(BETA)= 10000.00000      ( FOR UNIFORM SPACING SET TO 10000)
CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
ITRAN = 3     (MUST BE LT.JMAX-JNM FOR THETA TO 30 TO PI/2)
KRES = 2     (INTERVAL IN K FOR RESIDUE INFORMATION)
EXPLICIT DISSI. COEF. = .200
IMPLICIT DISSI. COEF. = .400
COURANT NO. =    2.00
```

```
 JMAX=   20
 KMAX=   12
 JNM=   14      (JUNCTURE OF SPHERE AND CONE)
 ITER =  15      (TIME STEPS FOR THIS RUN)

FREE STREAM CONDITIONS

 PINF(PRESSURE) =  1.0000
 RINF(DENSITY) =  1.0000
 QINF(TOTAL VEL.) =  7.0993
 AINF(SOUND SPEED) =  1.1832
 UINF(U COMP.) =  7.0993
 VINF(V COMP.) =  0.0000
 HTINF(T. ENTHALPY) = 28.7000
 ETINF(T. SPEC. ENERGY) = 27.7000
 SINF(ENTROPY) =  1.0000
 EIINF(INTERNAL ENERGY) =  2.5000


 NORMALIZED DISTANCE FROM BODY TO SHOCK
                    0.000000   .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                     .909091  1.000000

READ IN XB(J),YB(J),XS(J),YS(J)
                   J     XB(J)     YB(J)     XS(J)     YS(J)
                   1      .004     -.191     -.280     -.200
                   2      .004      .191     -.280      .200
                   3      .039      .572     -.210      .600
                   4      .482      .853      .050      .960
                   5      .849     1.096      .370     1.260
                   6     1.119     1.306      .650     1.540
                   7     1.336     1.525      .910     1.790
                   8     1.521     1.750     1.160     2.020
                   9     1.699     1.979     1.370     2.280
                  10     1.881     2.211     1.550     2.570
                  11     2.069     2.452     1.730     2.820
                  12     2.269     2.708     1.880     3.390
                  13     2.486     2.986     2.080     3.900
                  14     2.728     3.293     2.340     4.460
                  15     3.027     3.539     2.700     4.990
                  16     3.378     3.651     3.150     5.480
                  17     3.600     3.678     3.470     5.780
                  18     3.800     3.703     3.780     6.040
                  19     4.000     3.727     4.120     6.280
                  20     4.200     3.752     4.470     6.490

ARC LENGTH
                     .19108    .57344   1.09794   1.53254   1.88140   2.18947   2.48093   2.77072   3.06558   3.37177
                    3.69655   4.04890   4.43988   4.82740   5.19562   5.41926   5.62077   5.82227   6.02377

STARTING FLOWFIELD INFORMATION

SECOND INDEX=  1

1ST    P/PINF        S         U/QINF      V/QINF      S/SINF      HT/HTINF      R/RI         CP          X           Y         EI/EIINF
 1  .4672E+02 -.1911E+00  .1175E-02 -.2585E-01  .4085E+01  .1000E+01  .5701E+01  .1814E+01  .4230E-02 -.1911E+00  .8195E+01
 2  .4672E+02  .1911E+00  .1175E-02  .2585E-01  .4085E+01  .1000E+01  .5701E+01  .1814E+01  .4230E-02  .1911E+00  .8195E+01
 3  .3148E+02  .5734E+00  .2044E+00  .2835E+00  .4085E+01  .1000E+01  .4300E+01  .1209E+01  .3890E-01  .5719E+00  .7321E+01
 4  .1630E+02  .1098E+01  .4597E+00  .2918E+00  .4085E+01  .1000E+01  .2687E+01  .6070E+00  .4816E+00  .8532E+00  .6065E+01
 5  .1820E+02  .1533E+01  .4231E+00  .3008E+00  .4085E+01  .1000E+01  .2907E+01  .6825E+00  .8487E+00  .1086E+01  .6260E+01
 6  .2271E+02  .1881E+01  .3426E+00  .3088E+00  .4085E+01  .1000E+01  .3405E+01  .8613E+00  .1119E+01  .1306E+01  .6669E+01
```

```
  7  .2690E+02  .2189E+01  .2739E+00  .3028E+00  .4085E+01  .1000E+01  .3843E+01  .1028E+01  .1336E+01  .1525E+01  .6999E+01
  8  .2941E+02  .2481E+01  .2351E+00  .2939E+00  .4085E+01  .1000E+01  .4096E+01  .1127E+01  .1521E+01  .1750E+01  .7180E+01
  9  .2989E+02  .2771E+01  .2279E+00  .2917E+00  .4085E+01  .1000E+01  .4144E+01  .1146E+01  .1699E+01  .1979E+01  .7214E+01
 10  .2989E+02  .3066E+01  .2279E+00  .2917E+00  .4085E+01  .1000E+01  .4144E+01  .1147E+01  .1881E+01  .2211E+01  .7214E+01
 11  .2989E+02  .3372E+01  .2279E+00  .2917E+00  .4085E+01  .1000E+01  .4144E+01  .1147E+01  .2069E+01  .2452E+01  .7214E+01
 12  .2989E+02  .3697E+01  .2279E+00  .2917E+00  .4085E+01  .1000E+01  .4144E+01  .1147E+01  .2269E+01  .2708E+01  .7214E+01
 13  .2983E+02  .4049E+01  .2288E+00  .2920E+00  .4085E+01  .1000E+01  .4138E+01  .1144E+01  .2486E+01  .2986E+01  .7209E+01
 14  .2529E+02  .4440E+01  .2997E+00  .3065E+00  .4085E+01  .1000E+01  .3677E+01  .9639E+00  .2728E+01  .3293E+01  .6877E+01
 15  .1417E+02  .4827E+01  .5031E+00  .2764E+00  .4085E+01  .1000E+01  .2431E+01  .5224E+00  .3027E+01  .3539E+01  .5827E+01
 16  .7577E+01  .5196E+01  .6606E+00  .1599E+00  .4085E+01  .1000E+01  .1555E+01  .2610E+00  .3378E+01  .3651E+01  .4874E+01
 17  .6113E+01  .5419E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .3600E+01  .3678E+01  .4584E+01
 18  .6113E+01  .5621E+01  .7034E+00  .8636E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .3800E+01  .3703E+01  .4584E+01
 19  .6114E+01  .5822E+01  .7034E+00  .8638E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4000E+01  .3727E+01  .4584E+01
 20  .6114E+01  .6024E+01  .7034E+00  .8638E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4200E+01  .3752E+01  .4584E+01

SECOND INDEX= 12
```

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```
1ST    P/PINF     RO/RINF     U/QINF     V/QINF      S/SINF    HT/HTINF      MACH        CP          X          Y        EI/EIINF
  1  .4151E+02  .5263E+01  .1961E+00 -.7034E-01  .4059E+01  .1000E+01  .4452E+00  .1608E+01 -.2900E+00 -.2000E+00  .7887E+01
  2  .4151E+02  .5263E+01  .1961E+00  .7034E-01  .4059E+01  .1000E+01  .4452E+00  .1608E+01 -.2800E+00  .2000E+00  .7887E+01
  3  .3517E+02  .5150E+01  .3220E+00  .2944E+00  .3545E+01  .1000E+01  .1002E+01  .1356E+01 -.2100E+00  .6000E+00  .6929E+01
  4  .2353E+02  .4815E+01  .5529E+00  .3929E+00  .2606E+01  .1000E+01  . 841E+01  .8941E+00  .5000E-01  .9600E+00  .4887E+01
  5  .2012E+02  .4660E+01  .6206E+00  .3925E+00  .2333E+01  .1000E+01  .2120E+01  .7588E+00  .3700E+00  .1260E+01  .4318E+01
  6  .2044E+02  .4676E+01  .6143E+00  .3930E+00  .2359E+01  .1000E+01  .2093E+01  .7715E+00  .6500E+00  .1540E+01  .4371E+01
  7  .1956E+02  .4631E+01  .6317E+00  .3913E+00  .2288E+01  .1000E+01  .2169E+01  .7366E+00  .9100E+00  .1790E+01  .4224E+01
  8  .2216E+02  .4757E+01  .5802E+00  .3941E+00  .2496E+01  .1000E+01  .1950E+01  .8396E+00  .1160E+01  .2020E+01  .4658E+01
  9  .2778E+02  .4964E+01  .4686E+00  .3768E+00  .2948E+01  .1000E+01  .1525E+01  .1063E+01  .1370E+01  .2280E+01  .5597E+01
 10  .2891E+02  .4997E+01  .4462E+00  .3692E+00  .3040E+01  .1000E+01  .1445E+01  .1108E+01  .1550E+01  .2570E+01  .5785E+01
 11  .3598E+02  .5166E+01  .3040E+00  .2793E+00  .3511E+01  .1000E+01  .9419E+00  .1388E+01  .1730E+01  .2820E+01  .6964E+01
 12  .3784E+02  .5202E+01  .2690E+00  .2369E+00  .3762E+01  .1000E+01  .7974E+00  .1462E+01  .1880E+01  .3390E+01  .7275E+01
 13  .3528E+02  .5152E+01  .3198E+00  .2924E+00  .3554E+01  .1000E+01  .9936E+00  .1360E+01  .2080E+01  .3900E+01  .6948E+01
 14  .3157E+02  .5068E+01  .3935E+00  .3450E+00  .3254E+01  .1000E+01  .1258E+01  .1213E+01  .2340E+01  .4460E+01  .6228E+01
 15  .2559E+02  .4892E+01  .5121E+00  .3875E+00  .2772E+01  .1000E+01  .1685E+01  .9758E+00  .2700E+01  .4990E+01  .5231E+01
 16  .2137E+02  .4721E+01  .5958E+00  .3940E+00  .2433E+01  .1000E+01  .2014E+01  .8084E+00  .3150E+01  .5480E+01  .4527E+01
 17  .1837E+02  .4564E+01  .6553E+00  .3878E+00  .2193E+01  .1000E+01  .2277E+01  .6893E+00  .3470E+01  .5780E+01  .4025E+01
 18  .1545E+02  .4368E+01  .7134E+00  .3726E+00  .1961E+01  .1000E+01  .2568E+01  .5733E+00  .3780E+01  .6040E+01  .3536E+01
 19  .1237E+02  .4094E+01  .7745E+00  .3458E+00  .1719E+01  .1000E+01  .2928E+01  .4511E+00  .4120E+01  .6280E+01  .3020E+01
 20  .9568E+01  .3752E+01  .8300E+00  .3095E+00  .1503E+01  .1000E+01  .3328E+01  .3400E+00  .4470E+01  .6490E+01  .2558E+01

 SONIC LINE LOCATION

XSL=  .2195E+00   YSL=  .6867E+00
XSL=  .1226E+01   YSL=  .1414E+01
XSL=  .2741E+01   YSL=  .3304E+01
XSL=  .1576E+00   YSL=  .6701E+00
XSL=  .1413E+01   YSL=  .1686E+01
XSL=  .2670E+01   YSL=  .3369E+01
XSL=  .1051E+00   YSL=  .6574E+00
XSL=  .1604E+01   YSL=  .1988E+01
XSL=  .2593E+01   YSL=  .3414E+01
XSL=  .5885E-01   YSL=  .6472E+00
XSL=  .1823E+01   YSL=  .2351E+01
XSL=  .2524E+01   YSL=  .3462E+01
XSL=  .1713E-01   YSL=  .6387E+00
XSL=  .1837E+01   YSL=  .2443E+01
XSL=  .2460E+01   YSL=  .3514E+01
XSL= -.2124E-01   YSL=  .6314E+00
XSL=  .1834E+01   YSL=  .2512E+01
XSL=  .2400E+01   YSL=  .3569E+01
XSL= -.5700E-01   YSL=  .6249E+00
XSL=  .1821E+01   YSL=  .2569E+01
XSL=  .2344E+01   YSL=  .3624E+01
XSL= -.9068E-01   YSL=  .6190E+00
```

```
XSL=  .1804E+01   YSL=  .2619E+01
XSL=  .2289E+01   YSL=  .3681E+01
XSL= -.1226E+00   YSL=  .6136E+00
XSL=  .1783E+01   YSL=  .2666E+01
XSL=  .2236E+01   YSL=  .3738E+01
XSL= -.1531E+00   YSL=  .6086E+00
XSL=  .1769E+01   YSL=  .2709E+01
XSL=  .2185E+01   YSL=  .3797E+01
XSL= -.1824E+00   YSL=  .6038E+00
XSL=  .1735E+01   YSL=  .2751E+01
XSL=  .2135E+01   YSL=  .3855E+01
XSL= -.2102E+00   YSL=  .5988E+00
XSL=  .1709E+01   YSL=  .2791E+01
XSL=  .2086E+01   YSL=  .3914E+01

    PERCENT ERROR IN HT=   .3565E-11    RMS OF PERCENT ERROR IN HT=   .2275E-11

PRESSURE DRAG =        .9521687632

SIGMAX= .2001E+03   J=    3   K=   12   SIGMIN=  .9352E+01   J=    1   K=    1   CN= .2000E+01   DT= .9996E-02
RESIDUE INFORMATION              16   11    .16467    .67926  24.242355( 16, 11, 4)=    .16069
RMS OF SHOCK SPEED=    .1041E+00    J= 10    MAX SHK SPD=   .2027E+00
RMS OF SHOCK SPEED=    .1147E+00    J= 20    MAX SHK SPD=  -.2415E+00
RMS OF SHOCK SPEED=    .1218E+00    J= 20    MAX SHK SPD=  -.2674E+00
RMS OF SHOCK SPEED=    .1380E+00    J= 20    MAX SHK SPD=  -.3052E+00
RMS OF SHOCK SPEED=    .1573E+00    J= 20    MAX SHK SPD=  -.3409E+00
RMS OF SHOCK SPEED=    .1749E+00    J= 20    MAX SHK SPD=  -.3659E+00
RMS OF SHOCK SPEED=    .1892E+00    J= 20    MAX SHK SPD=  -.3804E+00
RMS OF SHOCK SPEED=    .2004E+00    J= 20    MAX SHK SPD=  -.3871E+00
RMS OF SHOCK SPEED=    .2087E+00    J=  3    MAX SHK SPD=  -.3950E+00
RMS OF SHOCK SPEED=    .2146E+00    J=  3    MAX SHK SPD=  -.4051E+00
RMS OF SHOCK SPEED=    .2191E+00    J=  3    MAX SHK SPD=  -.4098E+00
RMS OF SHOCK SPEED=    .2231E+00    J=  3    MAX SHK SPD=  -.4116E+00
RMS OF SHOCK SPEED=    .2278E+00    J=  3    MAX SHK SPD=  -.4133E+00
RMS OF SHOCK SPEED=    .2338E+00    J=  3    MAX SHK SPD=  -.4171E+00
RMS OF SHOCK SPEED=    .2413E+00    J=  3    MAX SHK SPD=  -.4235E+00
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST    P/PINF        S          U/QINF       V/QINF       S/SINF      HT/HTINF      R/RI         CP           X            Y         EI/EIINF
 1   .4399E+02 -.1911E+00   .6443E-02 -.1418E+00   .4085E+01   .1000E+01   .5460E+01   .1706E+01   .4230E-02 -.1911E+00   .8055E+01
 2   .4399E+02  .1911E+00   .6443E-02  .1418E+00   .4085E+01   .1000E+01   .5460E+01   .1706E+01   .4230E-02  .1911E+00   .8055E+01
 3   .2837E+02  .5734E+00   .2279E+00  .3161E+00   .4085E+01   .1000E+01   .3992E+01   .1086E+01   .3890E-01  .5719E+00   .7106E+01
 4   .1214E+02  .1098E+01   .5097E+00  .3235E+00   .4085E+01   .1000E+01   .2177E+01   .4421E+00   .4816E+00  .8532E+00   .5576E+01
 5   .1461E+02  .1433E+01   .4627E+00  .3289E+00   .4085E+01   .1000E+01   .2485E+01   .5402E+00   .8487E+00  .1086E+01   .5880E+01
 6   .2223E+02  .1881E+01   .3470E+00  .3128E+00   .4085E+01   .1000E+01   .3354E+01   .8426E+00   .1119E+01  .1306E+01   .6529E+01
 7   .2987E+02  .2189E+01   .2485E+00  .2747E+00   .4085E+01   .1000E+01   .4142E+01   .1146E+01   .1336E+01  .1525E+01   .7212E+01
 8   .3600E+02  .2481E+01   .1793E+00  .2241E+00   .4085E+01   .1000E+01   .4732E+01   .1389E+01   .1521E+01  .1750E+01   .7607E+01
 9   .3955E+02  .2771E+01   .1425E+00  .1823E+00   .4085E+01   .1000E+01   .5062E+01   .1530E+01   .1699E+01  .1979E+01   .7915E+01
10   .4136E+02  .3066E+01   .1225E+00  .1568E+00   .4085E+01   .1000E+01   .5226E+01   .1602E+01   .1881E+01  .2211E+01   .7915E+01
11   .4392E+02  .3372E+01   .8828E-01  .1130E+00   .4085E+01   .1000E+01   .5455E+01   .1703E+01   .2069E+01  .2452E+01   .8052E+01
12   .3848E+02  .3697E+01   .1533E+00  .1962E+00   .4085E+01   .1000E+01   .4964E+01   .1487E+01   .2269E+01  .2708E+01   .7754E+01
13   .3304E+02  .4049E+01   .2027E+00  .2586E+00   .4085E+01   .1000E+01   .4451E+01   .1271E+01   .2486E+01  .2986E+01   .7423E+01
14   .2429E+02  .4440E+01   .3085E+00  .3155E+00   .4085E+01   .1000E+01   .3573E+01   .9242E+00   .2728E+01  .3293E+01   .6798E+01
15   .1300E+02  .4827E+01   .5179E+00  .2846E+00   .4085E+01   .1000E+01   .2286E+01   .4761E+00   .3027E+01  .3539E+01   .5686E+01
16   .6910E+01  .5196E+01   .6731E+00  .1629E+00   .4085E+01   .1000E+01   .1456E+01   .2345E+00   .3378E+01  .3651E+01   .4747E+01
17   .5445E+01  .5419E+01   .7178E+00  .8813E-01   .4085E+01   .1000E+01   .1228E+01   .1764E+00   .3600E+01  .3678E+01   .4434E+01
18   .5844E+01  .5621E+01   .7091E+00  .8706E-01   .4085E+01   .1000E+01   .1292E+01   .1922E+00   .3800E+01  .3703E+01   .4525E+01
19   .5927E+01  .5822E+01   .7073E+00  .8686E-01   .4085E+01   .1000E+01   .1305E+01   .1955E+00   .4000E+01  .3727E+01   .4543E+01
20   .6051E+01  .6024E+01   .7047E+00  .8654E-01   .4085E+01   .1000E+01   .1324E+01   .2005E+00   .4200E+01  .3752E+01   .4570E+01
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```
SECOND INDEX=  7

1ST   P/PINF    RO/RINF    U/QINF     V/QINF     S/SINF    HT/HTINF     MACH       CP         X          Y        EI/EIINF
 1  .4217E+02  .5556E+01  .1393E+00 -.8443E-01  .3923E+01  .9490E+00  .3548E+00  .1634E+01 -.1278E+00 -.1952E+00  .7591E+01
 2  .4217E+02  .5556E+01  .1393E+00  .8443E-01  .3923E+01  .9490E+00  .3548E+00  .1634E+01 -.1278E+00  .1952E+00  .7591E+01
 3  .3207E+02  .4613E+01  .2600E+00  .2511E+00  .3772E+01  .9625E+00  .8225E+00  .1233E+01 -.7028E-01  .5842E+00  .6952E+01
 4  .1865E+02  .3329E+01  .4587E+00  .3143E+00  .3463E+01  .9547E+00  .1410E+01  .7004E+00  .2485E+00  .9109E+00  .5602E+01
 5  .1383E+02  .3130E+01  .5915E+00  .3368E+00  .2799E+01  .9457E+00  .1943E+01  .5091E+00  .5886E+00  .1180E+01  .4418E+01
 6  .1591E+02  .3710E+01  .5942E+00  .3580E+00  .2539E+01  .9477E+00  .2015E+01  .5918E+00  .8780E+00  .1426E+01  .4289E+01
 7  .2144E+02  .4627E+01  .5487E+00  .3909E+00  .2511E+01  .9637E+00  .1878E+01  .8113E+00  .1115E+01  .1663E+01  .4635E+01
 8  .2841E+02  .5554E+01  .4905E+00  .4170E+00  .2576E+01  .9877E+00  .1708E+01  .1088E+01  .1324E+01  .1898E+01  .5115E+01
 9  .3403E+02  .6160E+01  .4431E+00  .4245E+00  .2670E+01  .1004E+01  .1566E+01  .1311E+01  .1536E+01  .2128E+01  .5525E+01
10  .3698E+02  .6179E+01  .4028E+00  .4057E+00  .2989E+01  .1017E+01  .1402E+01  .1428E+01  .1697E+01  .2410E+01  .5986E+01
11  .3913E+02  .5747E+01  .3565E+00  .3593E+00  .3210E+01  .1025E+01  .1186E+01  .1513E+01  .1888E+01  .2649E+01  .6558E+01
12  .3702E+02  .5321E+01  .3159E+00  .3018E+00  .3564E+01  .1016E+01  .9938E+00  .1429E+01  .2063E+01  .3070E+01  .6957E+01
13  .3267E+02  .4720E+01  .3156E+00  .2868E+00  .3721E+01  .1004E+01  .9725E+00  .1257E+01  .2268E+01  .3477E+01  .6923E+01
14  .2666E+02  .4096E+01  .3647E+00  .3087E+00  .3703E+01  .9943E+00  .1124E+01  .1018E+01  .2521E+01  .3915E+01  .6509E+01
15  .1968E+02  .3408E+01  .4621E+00  .3309E+00  .3538E+01  .9891E+00  .1419E+01  .7415E+00  .2850E+01  .4324E+01  .5777E+01
16  .1432E+02  .2867E+01  .5671E+00  .3250E+00  .3276E+01  .9841E+00  .1755E+01  .5285E+00  .3254E+01  .4644E+01  .4993E+01
17  .1144E+02  .2578E+01  .6408E+00  .3023E+00  .3037E+01  .9817E+00  .2018E+01  .4142E+00  .3529E+01  .4820E+01  .4436E+01
18  .1001E+02  .2469E+01  .6908E+00  .2808E+00  .2924E+01  .9826E+00  .2222E+01  .3575E+00  .3789E+01  .4977E+01  .4054E+01
19  .8936E+01  .2345E+01  .7193E+00  .2680E+00  .2709E+01  .9820E+00  .2359E+01  .3149E+00  .4066E+01  .5132E+01  .3910E+01
20  .8261E+01  .2318E+01  .7472E+00  .2553E+00  .2547E+01  .9821E+00  .2509E+01  .2881E+00  .4350E+01  .5272E+01  .3564E+01
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*** skip print out ***

```
SECOND INDEX= 12

1ST   P/PINF    RO/RINF    U/QINF     V/QINF     S/SINF    HT/HTINF     MACH       CP         X          Y        EI/EIINF
 1  .3730E+02  .5192E+01  .2409E+00 -.7262E-01  .3718E+01  .9318E+00  .5631E+00  .1441E+01 -.2378E+00 -.1987E+00  .7185E+01
 2  .3730E+02  .5192E+01  .2409E+00  .7262E-01  .3718E+01  .9318E+00  .5631E+00  .1441E+01 -.2378E+00  .1987E+00  .7185E+01
 3  .3199E+02  .5079E+01  .3447E+00  .2535E+00  .3288E+01  .9298E+00  .1023E+01  .1230E+01 -.1613E+00  .5945E+00  .6298E+01
 4  .2395E+02  .4431E+01  .5327E+00  .3777E+00  .2640E+01  .9799E+00  .1760E+01  .9107E+00  .5432E-01  .9589E+00  .4957E+01
 5  .1881E+02  .4594E+01  .6453E+00  .3881E+00  .2228E+01  .9978E+00  .2232E+01  .7068E+00  .3718E+00  .1259E+01  .4099E+01
 6  .1747E+02  .4509E+01  .6551E+00  .3679E+00  .2121E+01  .9682E+00  .2290E+01  .6535E+00  .6772E+00  .1526E+01  .3874E+01
 7  .1794E+02  .4538E+01  .6346E+00  .3586E+00  .2159E+01  .9497E+00  .2199E+01  .6723E+00  .9301E+00  .1777E+01  .3954E+01
 8  .2041E+02  .4675E+01  .6092E+00  .3873E+00  .2356E+01  .9900E+00  .2073E+01  .7701E+00  .1159E+01  .2020E+01  .4366E+01
 9  .2469E+02  .4760E+01  .4981E+00  .3485E+00  .2700E+01  .9441E+00  .1618E+01  .9402E+00  .1400E+01  .2252E+01  .5081E+01
10  .3000E+02  .5028E+01  .4200E+00  .3530E+00  .3128E+01  .9920E+00  .1348E+01  .1151E+01  .1545E+01  .2576E+01  .5967E+01
11  .3477E+02  .5142E+01  .3259E+00  .2920E+00  .3513E+01  .9928E+00  .1010E+01  .1340E+01  .1737E+01  .2812E+01  .6763E+01
12  .3615E+02  .5170E+01  .2865E+00  .2312E+00  .3624E+01  .9717E+00  .8354E+00  .1395E+01  .1891E+01  .3371E+01  .6992E+01
13  .3376E+02  .5120E+01  .3359E+00  .2863E+00  .3431E+01  .9752E+00  .1031E+01  .1300E+01  .2086E+01  .3886E+01  .6594E+01
14  .2955E+02  .5015E+01  .4138E+00  .3315E+00  .3091E+01  .9653E+00  .1311E+01  .1133E+01  .2349E+01  .4434E+01  .5892E+01
15  .2491E+02  .4868E+01  .5148E+00  .3761E+00  .2717E+01  .9809E+00  .1691E+01  .9488E+00  .2703E+01  .4978E+01  .5117E+01
16  .2112E+02  .4709E+01  .5973E+00  .3901E+00  .2413E+01  .9937E+00  .2021E+01  .7983E+00  .3151E+01  .5472E+01  .4484E+01
17  .1855E+02  .4574E+01  .6511E+00  .3877E+00  .2207E+01  .9987E+00  .2258E+01  .6963E+00  .3470E+01  .5772E+01  .4055E+01
18  .1655E+02  .4448E+01  .6916E+00  .3795E+00  .2048E+01  .1000E+01  .2454E+01  .6169E+00  .3780E+01  .6038E+01  .3720E+01
19  .1477E+02  .4315E+01  .7331E+00  .3724E+00  .1908E+01  .1011E+01  .2666E+01  .5466E+00  .4121E+01  .6302E+01  .3424E+01
20  .1300E+02  .4158E+01  .7769E+00  .3620E+00  .1768E+01  .1026E+01  .2908E+01  .4763E+00  .4475E+01  .6539E+01  .3127E+01

 SONIC LINE LOCATION

XSL=  .1217E+00   YSL=  .6245E+00
XSL=  .1193E+01   YSL=  .1381E+01
XSL=  .2715E+01   YSL=  .3277E+01
XSL=  .2303E+00   YSL=  .7174E+00
```

```
XSL=  .1365E+01   YSL=  .1628E+01
XSL=  .2607E+01   YSL=  .3280E+01
XSL=  .2150E+00   YSL=  .7329E+00
XSL=  .2050E+01   YSL=  .2585E+01
XSL=  .2502E+01   YSL=  .3276E+01
XSL=  .1608E+00   YSL=  .7190E+00
XSL=  .2111E+01   YSL=  .2789E+01
XSL=  .2440E+01   YSL=  .3326E+01
XSL=  .1132E+00   YSL=  .7074E+00
XSL=  .2115E+01   YSL=  .2917E+01
XSL=  .2389E+01   YSL=  .3390E+01
XSL=  .6905E-01   YSL=  .6960E+00
XSL=  .2094E+01   YSL=  .3003E+01
XSL=  .2347E+01   YSL=  .3465E+01
XSL=  .2610E-01   YSL=  .6830E+00
XSL=  .2057E+01   YSL=  .3056E+01
XSL=  .2314E+01   YSL=  .3557E+01
XSL= -.1775E-01   YSL=  .6655E+00
XSL=  .2010E+01   YSL=  .3081E+01
XSL=  .2287E+01   YSL=  .3659E+01
XSL= -.6026E-01   YSL=  .6455E+00
XSL=  .1954E+01   YSL=  .3076E+01
XSL=  .2257E+01   YSL=  .3757E+01
XSL= -.1011E+00   YSL=  .6227E+00
XSL=  .1889E+01   YSL=  .3032E+01
XSL=  .2215E+01   YSL=  .3832E+01
XSL= -.1353E+00   YSL=  .6042E+00
XSL=  .1811E+01   YSL=  .2928E+01
XSL=  .2153E+01   YSL=  .3865E+01
XSL= -.1651E+00   YSL=  .5747E+00
XSL=  .1746E+01   YSL=  .2843E+01
XSL=  .2055E+01   YSL=  .3804E+01

    PERCENT ERROR IN HT=   .9072E+01    RMS OF PERCENT ERROR IN HT=   .3443E+01

PRESSURE DRAG =        1.1049488482
RESIDUE INFORMATION              12    2    .11388    .38235  29.783035( 12,  2, 4)=    .11292

                                          DETAILED RESIDUE INFORMATION
                                          ****************************
                                                   SECOND INDEX =   2
   2   .9499926E-03   .1224694E-02   .1724462E-02   .2792506E-01     3   .3873946E-03   .6387404E-03   .3750741E-02   .1421841E-01
   4  -.1171515E-02  -.2078316E-02  -.6010437E-02  -.2965561E-01     5  -.4858556E-03  -.1935759E-02  -.1382760E-02  -.1614592E-01
   6  -.3045429E-03  -.1708334E-02  -.9077751E-03  -.1404600E-01     7  -.8272398E-04  -.1670814E-02  -.3844987E-03  -.7864402E-02
   8   .1170249E-03  -.1893447E-02   .5699959E-03  -.1139636E-02     9   .5168031E-03  -.1026656E-02   .2330817E-02   .1157579E-01
  10   .9906820E-03  -.2335853E-03   .4141872E-02   .2638901E-01    11   .2476724E-02   .3206732E-02   .9478948E-02   .7591777E-01
  12   .3511253E-02   .1121862E-01   .8911015E-02   .1129168E+00    13   .3309789E-02   .1243941E-01   .7813052E-02   .1081334E+00
  14   .1604775E-02   .8786447E-02   .4491993E-02   .5599538E-01    15  -.1106738E-02  -.1133215E-02  -.2939732E-02  -.2560270E-01
  16  -.1571091E-02  -.8271565E-02  -.1479264E-02  -.4241483E-01    17  -.1395951E-02  -.8805287E-02   .1098986E-02  -.3918114E-01
  18  -.1189862E-02  -.7078790E-02   .9759803E-03  -.3347839E-01    19  -.1125882E-02  -.6643149E-02   .9110194E-03  -.3173713E-01
```

*** skip print out ***

Example 4

Input Data Cards

```
   20   12   10    0    0    0    0
   16    2    5    2    3    0
6.        1.4       7.        3.8263    2.        10000.    1.        0.2  0.4
-2.86     2.86      8.59      14.31     20.03     25.76     31.48     37.2
42.93     48.66     54.38     60.10     65.83     71.55     77.28     83.
85.33     87.66     90.00     90.
-0.00055  -0.00055  -0.00402  0.37447   0.65690   0.82027   0.90612   0.93147
0.92100   0.88096   0.80931   0.70214   0.55324   0.35439   0.19774   0.148
0.14812   0.14849   0.14911   0.14911
0.1
100100100011
```

Printed Output

```
AXISYMMETRIC FLOW OVER NOSETIP



MACH NUMBER = 6.00
RATIO OF SPECIFIC HEAT = 1.40
CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
OMEGA =  3.826      (OMEGA.GT.0,OMEGA IS THE RADIUS OF SPHERE-CONES IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED
                     IN SUB. SHAPES OMEGA=0,MORE RAYS TO BE ADDED)

IR1 = 0      ( 1 FOR READ TAPE1$ 0     OTHERWISE)
IW2 = 0      (1 FOR WRITE ON TAPE2$ 0   OTHERWISE)
IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGEN$ 0     OTHERWISE)
IAFBD = 0      ( 1 FOR      STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)
IGEOM = 2      ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB,YB,XS,YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

LIP = 5      ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
IVIS = 0      (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

CF(BETA)= 10000.00000      ( FOR UNIFORM SPACING SET TO 10000)
CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
ITRAN = 3      (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
KRES = 2      (INTERVAL IN K FOR RESIDUE INFORMATION)
EXPLICIT DISSI. COEF. = .200
IMPLICIT DISSI. COEF. = .400
COURANT NO. =    2.00



JMAX=   20
KMAX=   12
JNM=   16     (JUNCTURE OF SPHERE AND CONE)
ITER =  10     (TIME STEPS FOR THIS RUN)

FREE STREAM CONDITIONS

 PINF(PRESSURE) =  1.0000
 RINF(DENSITY) =  1.0000
```

```
QINF(TOTAL VEL.) =  7.0993
AINF(SOUND SPEED) =  1.1832
UINF(U COMP.) =  7.0993
VINF(V COMP.) =  0.0000
HTINF(T. ENTHALPY) = 28.7000
ETINF(T. SPEC. ENERGY) = 27.7000
SINF(ENTROPY) =  1.0000
EIINF(INTERNAL ENERGY) =  2.5000


NORMALIZED DISTANCE FROM BODY TO SHOCK
                    0.000000   .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                     .909091  1.000000

READ IN TH(J) AND DETT(J)
                   J     TH(J),DEGREE      DETT(J)
                   1        -2.86          -.001
                   2         2.86          -.001
                   3         8.59          -.004
                   4        14.31           .374
                   5        20.03           .657
                   6        25.76           .820
                   7        31.48           .906
                   8        37.20           .931
                   9        42.93           .921
                  10        48.66           .881
                  11        54.38           .809
                  12        60.10           .702
                  13        65.83           .553
                  14        71.55           .354
                  15        77.28           .198
                  16        83.00           .148
                  17        85.33           .148
                  18        87.66           .148
                  19        90.00           .149
                  20        90.00           .149

BODY SHAPE CHANGE BEING INSTITUTED

ARC LENGTH
                     .19092    .57341    .95525   1.33708   1.71958   2.10141   2.48324   2.86574   3.24824   3.63007
                    4.01190   4.39440   4.77623   5.15873   5.54056   5.92283   6.30510   6.68736   7.06963

STARTING FLOWFIELD INFORMATION

SECOND INDEX=  1

1ST   P/PINF        S          U/QINF      V/QINF      S/SINF     HT/HTINF      R/RI         CP          X           Y         EI/EIINF
 1  .4670E+02 -.1909E+00  .1424E-02 -.2846E-01  .4085E+01  .1000E+01  .5699E+01  .1813E+01  .4766E-02 -.1909E+00  .8194E+01
 2  .4670E+02  .1909E+00  .1424E-02  .2846E-01  .4085E+01  .1000E+01  .5699E+01  .1813E+01  .4766E-02  .1909E+00  .8194E+01
 3  .4578E+02  .5734E+00  .1273E-01  .8435E-01  .4085E+01  .1000E+01  .5618E+01  .1777E+01  .4292E-01  .5715E+00  .8148E+01
 4  .4398E+02  .9552E+00  .3508E-01  .1375E+00  .4085E+01  .1000E+01  .5460E+01  .1706E+01  .1187E+00  .9457E+00  .8055E+01
 5  .4141E+02  .1337E+01  .6788E-01  .1862E+00  .4085E+01  .1000E+01  .5230E+01  .1603E+01  .2314E+00  .1311E+01  .7917E+01
 6  .3819E+02  .1720E+01  .1103E+00  .2285E+00  .4085E+01  .1000E+01  .4936E+01  .1476E+01  .3802E+00  .1663E+01  .7736E+01
 7  .3448E+02  .2101E+01  .1612E+00  .2633E+00  .4085E+01  .1000E+01  .4589E+01  .1329E+01  .5631E+00  .1998E+01  .7514E+01
 8  .3046E+02  .2483E+01  .2193E+00  .2889E+00  .4085E+01  .1000E+01  .4200E+01  .1169E+01  .7785E+00  .2313E+01  .7253E+01
 9  .2632E+02  .2866E+01  .2831E+00  .3044E+00  .4085E+01  .1000E+01  .3784E+01  .1005E+01  .1025E+01  .2606E+01  .6956E+01
10  .2222E+02  .3248E+01  .3508E+00  .3087E+00  .4085E+01  .1000E+01  .3353E+01  .8422E+00  .1299E+01  .2873E+01  .6628E+01
11  .1834E+02  .3630E+01  .4205E+00  .3013E+00  .4085E+01  .1000E+01  .2923E+01  .6879E+00  .1598E+01  .3110E+01  .6273E+01
12  .1480E+02  .4012E+01  .4899E+00  .2817E+00  .4085E+01  .1000E+01  .2508E+01  .5475E+00  .1919E+01  .3317E+01  .5901E+01
```

```
13  .1173E+02  .4394E+01  .5564E+00  .2498E+00  .4085E+01  .1000E+01  .2124E+01  .4258E+00  .2260E+01  .3491E+01  .5522E+01
14  .9214E+01  .4776E+01  .6170E+00  .2058E+00  .4085E+01  .1000E+01  .1788E+01  .3260E+00  .2615E+01  .3630E+01  .5154E+01
15  .7328E+01  .5159E+01  .6676E+00  .1508E+00  .4085E+01  .1000E+01  .1518E+01  .2511E+00  .2984E+01  .3732E+01  .4827E+01
16  .6352E+01  .5541E+01  .6962E+00  .1032E+00  .4085E+01  .1000E+01  .1371E+01  .2124E+00  .3360E+01  .3798E+01  .4634E+01
17  .6113E+01  .5923E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .3739E+01  .3844E+01  .4584E+01
18  .6113E+01  .6305E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4119E+01  .3891E+01  .4584E+01
19  .6113E+01  .6687E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4498E+01  .3938E+01  .4584E+01
20  .6113E+01  .7070E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4878E+01  .3984E+01  .4584E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST   P/PINF     RO/RINF    U/QINF     V/QINF     S/SINF     HT/HTINF    MACH        CP          X          Y        EI/EIINF
 1  .4174E+02  .5267E+01  .1918E+00 -.3901E-01  .4077E+01  .1000E+01  .4171E+00  .1616E+01 -.5612E+00 -.2192E+00  .7924E+01
 2  .4174E+02  .5267E+01  .1918E+00  .3901E-01  .4077E+01  .1000E+01  .4171E+00  .1616E+01 -.5612E+00  .2192E+00  .7924E+01
 3  .4098E+02  .5255E+01  .2068E+00  .1144E+00  .4016E+01  .1000E+01  .5078E+00  .1586E+01 -.5189E+00  .6564E+00  .7798E+01
 4  .3956E+02  .5232E+01  .2349E+00  .1830E+00  .3901E+01  .1000E+01  .6497E+00  .1530E+01 -.4360E+00  .1087E+01  .7562E+01
 5  .3766E+02  .5198E+01  .2727E+00  .2417E+00  .3747E+01  .1000E+01  .8123E+00  .1455E+01 -.3149E+00  .1510E+01  .7244E+01
 6  .3545E+02  .5156E+01  .3164E+00  .2894E+00  .3568E+01  .1000E+01  .9811E+00  .1367E+01 -.1583E+00  .1923E+01  .6876E+01
 7  .3311E+02  .5105E+01  .3630E+00  .3262E+00  .3378E+01  .1000E+01  .1150E+01  .1274E+01  .3004E-01  .2325E+01  .6485E+01
 8  .3075E+02  .5048E+01  .4098E+00  .3534E+00  .3188E+01  .1000E+01  .1316E+01  .1180E+01  .2480E+00  .2716E+01  .6092E+01
 9  .2846E+02  .4984E+01  .4553E+00  .3724E+00  .3003E+01  .1000E+01  .1477E+01  .1089E+01  .4942E+00  .3100E+01  .5709E+01
10  .2627E+02  .4916E+01  .4985E+00  .3847E+00  .2827E+01  .1000E+01  .1634E+01  .1003E+01  .7678E+00  .3477E+01  .5345E+01
11  .2422E+02  .4842E+01  .5392E+00  .3915E+00  .2662E+01  .1000E+01  .1788E+01  .9216E+00  .1069E+01  .3849E+01  .5003E+01
12  .2231E+02  .4764E+01  .5773E+00  .3941E+00  .2508E+01  .1000E+01  .1938E+01  .8455E+00  .1400E+01  .4220E+01  .4683E+01
13  .2052E+02  .4680E+01  .6128E+00  .3931E+00  .2365E+01  .1000E+01  .2086E+01  .7745E+00  .1764E+01  .4595E+01  .4384E+01
14  .1884E+02  .4591E+01  .6460E+00  .3893E+00  .2231E+01  .1000E+01  .2234E+01  .7079E+00  .2166E+01  .4975E+01  .4104E+01
15  .1727E+02  .4496E+01  .6772E+00  .3831E+00  .2105E+01  .1000E+01  .2382E+01  .6456E+00  .2615E+01  .5368E+01  .3841E+01
16  .1595E+02  .4406E+01  .7033E+00  .3759E+00  .2001E+01  .1000E+01  .2515E+01  .5933E+00  .3117E+01  .5776E+01  .3621E+01
17  .1473E+02  .4312E+01  .7276E+00  .3675E+00  .1904E+01  .1000E+01  .2646E+01  .5448E+00  .3554E+01  .6110E+01  .3416E+01
18  .1373E+02  .4226E+01  .7475E+00  .3592E+00  .1825E+01  .1000E+01  .2761E+01  .5051E+00  .4015E+01  .6442E+01  .3248E+01
19  .1292E+02  .4150E+01  .7635E+00  .3515E+00  .1762E+01  .1000E+01  .2858E+01  .4730E+00  .4498E+01  .6773E+01  .3113E+01
20  .1191E+02  .4046E+01  .7835E+00  .3407E+00  .1683E+01  .1000E+01  .2988E+01  .4330E+00  .4878E+01  .7022E+01  .2944E+01

 SONIC LINE LOCATION
 XSL=  .1129E+01   YSL=  .2707E+01
 XSL=  .9595E+00   YSL=  .2630E+01
 XSL=  .8122E+00   YSL=  .2550E+01
 XSL=  .6761E+00   YSL=  .2478E+01
 XSL=  .5519E+00   YSL=  .2406E+01
 XSL=  .4380E+00   YSL=  .2336E+01
 XSL=  .3292E+00   YSL=  .2270E+01
 XSL=  .2244E+00   YSL=  .2207E+01
 XSL=  .1302E+00   YSL=  .2143E+01
 XSL=  .3882E-01   YSL=  .2082E+01
 XSL= -.5022E-01   YSL=  .2024E+01
 XSL= -.1373E+00   YSL=  .1968E+01

     PERCENT ERROR IN HT=   .3961E-11    RMS OF PERCENT ERROR IN HT=   .2224E-11

 PRESSURE DRAG =       .9051161900

 SIGMAX= .9079E+02   J=    1   K=   12   SIGMIN=  .8385E+01   J=    1   K=   12   CN= .2000E+01   DT= .2203E-01
 RESIDUE INFORMATION            16   11    .26433   1.20542  21.92810S( 16, 11, 4)=    .25832
 RMS OF SHOCK SPEED=   .7166E-01   J= 16   MAX SHK SPD=  -.1417E+00
 RMS OF SHOCK SPEED=   .7187E-01   J= 17   MAX SHK SPD=  -.1443E+00
 RMS OF SHOCK SPEED=   .7845E-01   J=  2   MAX SHK SPD=  -.1483E+00
 RMS OF SHOCK SPEED=   .9441E-01   J=  2   MAX SHK SPD=  -.2172E+00
 RMS OF SHOCK SPEED=   .1117E+00   J=  2   MAX SHK SPD=  -.2774E+00
 RMS OF SHOCK SPEED=   .1258E+00   J=  2   MAX SHK SPD=  -.3201E+00
 RMS OF SHOCK SPEED=   .1342E+00   J=  2   MAX SHK SPD=  -.3422E+00
 RMS OF SHOCK SPEED=   .1360E+00   J=  2   MAX SHK SPD=  -.3428E+00
 RMS OF SHOCK SPEED=   .1313E+00   J=  2   MAX SHK SPD=  -.3225E+00
```

```
RMS OF SHOCK SPEED=   .1214E+00   J=  2   MAX SHK SPD=  -.2846E+00
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST    P/PINF        S          U/QINF      V/QINF      S/SINF     HT/HTINF      R/RI         CP          X           Y        EI/EIINF
  1  .4625E+02 -.1909E+00  .3105E-02 -.6261E-01  .4085E+01  .1000E+01  .5660E+01  .1796E+01  .4711E-02 -.1909E+00  .8172E+01
  2  .4625E+02  .1909E+00  .3105E-02  .6261E-01  .4085E+01  .1000E+01  .5660E+01  .1796E+01  .4711E-02  .1909E+00  .8172E+01
  3  .4386E+02  .5734E+00  .2867E-01  .1422E+00  .4085E+01  .1000E+01  .5449E+01  .1701E+01  .4252E-01  .5716E+00  .8048E+01
  4  .4092E+02  .9552E+00  .6842E-01  .1956E+00  .4085E+01  .1000E+01  .5186E+01  .1584E+01  .1550E+00  .9365E+00  .7891E+01
  5  .3797E+02  .1337E+01  .1022E+00  .2359E+00  .4085E+01  .1000E+01  .4916E+01  .1467E+01  .2932E+00  .1288E+01  .7724E+01
  6  .3493E+02  .1720E+01  .1403E+00  .2678E+00  .4085E+01  .1000E+01  .4632E+01  .1347E+01  .4541E+00  .1627E+01  .7542E+01
  7  .3155E+02  .2101E+01  .1863E+00  .2944E+00  .4085E+01  .1000E+01  .4307E+01  .1212E+01  .6404E+00  .1951E+01  .7326E+01
  8  .2787E+02  .2483E+01  .2401E+00  .3150E+00  .4085E+01  .1000E+01  .3941E+01  .1066E+01  .8527E+00  .2257E+01  .7070E+01
  9  .2399E+02  .2866E+01  .3009E+00  .3278E+00  .4085E+01  .1000E+01  .3542E+01  .9125E+00  .1092E+01  .2543E+01  .6775E+01
 10  .2023E+02  .3248E+01  .3650E+00  .3309E+00  .4085E+01  .1000E+01  .3136E+01  .7632E+00  .1357E+01  .2807E+01  .6452E+01
 11  .1679E+02  .3630E+01  .4296E+00  .3236E+00  .4085E+01  .1000E+01  .2744E+01  .6264E+00  .1645E+01  .3045E+01  .6117E+01
 12  .1376E+02  .4012E+01  .4926E+00  .3059E+00  .4085E+01  .1000E+01  .2381E+01  .5062E+00  .1954E+01  .3256E+01  .5779E+01
 13  .1114E+02  .4394E+01  .5525E+00  .2792E+00  .4085E+01  .1000E+01  .2047E+01  .4023E+00  .2282E+01  .3440E+01  .5441E+01
 14  .8685E+01  .4776E+01  .6153E+00  .2377E+00  .4085E+01  .1000E+01  .1714E+01  .3049E+00  .2627E+01  .3596E+01  .5067E+01
 15  .6607E+01  .5159E+01  .6770E+00  .1723E+00  .4085E+01  .1000E+01  .1410E+01  .2225E+00  .2988E+01  .3713E+01  .4687E+01
 16  .5655E+01  .5541E+01  .7101E+00  .1099E+00  .4085E+01  .1000E+01  .1262E+01  .1847E+00  .3362E+01  .3783E+01  .4483E+01
 17  .5691E+01  .5923E+01  .7124E+00  .8747E-01  .4085E+01  .1000E+01  .1267E+01  .1861E+00  .3741E+01  .3830E+01  .4491E+01
 18  .5911E+01  .6305E+01  .7077E+00  .8689E-01  .4085E+01  .1000E+01  .1302E+01  .1949E+00  .4119E+01  .3876E+01  .4540E+01
 19  .5870E+01  .6687E+01  .7086E+00  .8700E-01  .4085E+01  .1000E+01  .1296E+01  .1932E+00  .4498E+01  .3923E+01  .4531E+01
 20  .5949E+01  .7070E+01  .7069E+00  .8679E-01  .4085E+01  .1000E+01  .1308E+01  .1964E+00  .4878E+01  .3969E+01  .4548E+01
```

*** skip print out ***

```
SECOND INDEX=  7

1ST    P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF     HT/HTINF     MACH         CP          X           Y        EI/EIINF
  1  .4460E+02  .5640E+01  .1235E+00 -.3458E-01  .3959E+01  .9789E+00  .2736E+00  .1730E+01 -.2750E+00 -.2049E+00  .7908E+01
  2  .4460E+02  .5640E+01  .1235E+00  .3458E-01  .3959E+01  .9789E+00  .2736E+00  .1730E+01 -.2750E+00  .2049E+00  .7908E+01
  3  .4401E+02  .5561E+01  .1271E+00  .1028E+00  .3984E+01  .9886E+00  .3487E+00  .1707E+01 -.2424E+00  .6146E+00  .7914E+01
  4  .4210E+02  .5407E+01  .1471E+00  .1679E+00  .3964E+01  .9932E+00  .4800E+00  .1631E+01 -.1542E+00  .1015E+01  .7786E+01
  5  .3957E+02  .5230E+01  .1803E+00  .2247E+00  .3903E+01  .9954E+00  .6284E+00  .1530E+01 -.3125E-01  .1406E+01  .7565E+01
  6  .3686E+02  .5052E+01  .2215E+00  .2719E+00  .3817E+01  .9978E+00  .7791E+00  .1423E+01  .1229E+00  .1787E+01  .7296E+01
  7  .3397E+02  .4858E+01  .2686E+00  .3096E+00  .3716E+01  .1000E+01  .9299E+00  .1308E+01  .3074E+00  .2155E+01  .6993E+01
  8  .3088E+02  .4636E+01  .3199E+00  .3378E+00  .3606E+01  .1002E+01  .1082E+01  .1186E+01  .5212E+00  .2509E+01  .6661E+01
  9  .2766E+02  .4386E+01  .3738E+00  .3567E+00  .3491E+01  .1004E+01  .1235E+01  .1058E+01  .7641E+00  .2849E+01  .6307E+01
 10  .2443E+02  .4113E+01  .4286E+00  .3669E+00  .3373E+01  .1004E+01  .1389E+01  .9297E+00  .1034E+01  .3173E+01  .5939E+01
 11  .2130E+02  .3828E+01  .4826E+00  .3692E+00  .3253E+01  .1003E+01  .1546E+01  .8057E+00  .1331E+01  .3483E+01  .5565E+01
 12  .1839E+02  .3543E+01  .5346E+00  .3650E+00  .3129E+01  .1001E+01  .1705E+01  .6900E+00  .1653E+01  .3780E+01  .5190E+01
 13  .1575E+02  .3267E+01  .5836E+00  .3555E+00  .3003E+01  .9981E+00  .1867E+01  .5854E+00  .2001E+01  .4067E+01  .4822E+01
 14  .1342E+02  .3005E+01  .6294E+00  .3417E+00  .2876E+01  .9950E+00  .2033E+01  .4929E+00  .2378E+01  .4343E+01  .4466E+01
 15  .1139E+02  .2762E+01  .6722E+00  .3212E+00  .2748E+01  .9905E+00  .2201E+01  .4124E+00  .2786E+01  .4608E+01  .4125E+01
 16  .9824E+01  .2562E+01  .7074E+00  .2955E+00  .2631E+01  .9836E+00  .2349E+01  .3502E+00  .3230E+01  .4860E+01  .3834E+01
 17  .8804E+01  .2447E+01  .7339E+00  .2718E+00  .2515E+01  .9765E+00  .2476E+01  .3097E+00  .3640E+01  .5062E+01  .3597E+01
 18  .8300E+01  .2423E+01  .7577E+00  .2564E+00  .2404E+01  .9795E+00  .2593E+01  .2897E+00  .4063E+01  .5264E+01  .3425E+01
 19  .7407E+01  .2241E+01  .7692E+00  .2493E+00  .2393E+01  .9772E+00  .2669E+01  .2542E+00  .4498E+01  .5467E+01  .3305E+01
 20  .7495E+01  .2356E+01  .7824E+00  .2413E+00  .2258E+01  .9765E+00  .2754E+01  .2577E+00  .4878E+01  .5628E+01  .3181E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST    P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF    HT/HTINF      MACH         CP          X           Y        EI/EIINF
 1  .3849E+02  .5213E+01  .2251E+00 -.2639E-01  .3814E+01  .9454E+00  .5006E+00  .1488E+01 -.5081E+00 -.2165E+00  .7382E+01
 2  .3849E+02  .5213E+01  .2251E+00  .2639E-01  .3814E+01  .9454E+00  .5006E+00  .1488E+01 -.5081E+00  .2165E+00  .7382E+01
 3  .3866E+02  .5216E+01  .2279E+00  .8858E-01  .3828E+01  .9563E+00  .5389E+00  .1494E+01 -.4799E+00  .6505E+00  .7412E+01
 4  .3826E+02  .5209E+01  .2440E+00  .1605E+00  .3795E+01  .9706E+00  .6466E+00  .1479E+01 -.4118E+00  .1081E+01  .7345E+01
 5  .3712E+02  .5188E+01  .2738E+00  .2263E+00  .3703E+01  .9834E+00  .7968E+00  .1433E+01 -.3016E+00  .1505E+01  .7155E+01
 6  .3550E+02  .5157E+01  .3120E+00  .2801E+00  .3572E+01  .9940E+00  .9588E+00  .1369E+01 -.1531E+00  .1920E+01  .6885E+01
 7  .3354E+02  .5115E+01  .3557E+00  .3228E+00  .3413E+01  .1002E+01  .1126E+01  .1291E+01  .2979E-01  .2325E+01  .6557E+01
 8  .3133E+02  .5062E+01  .4025E+00  .3548E+00  .3235E+01  .1007E+01  .1294E+01  .1204E+01  .2449E+00  .2718E+01  .6189E+01
 9  .2898E+02  .4999E+01  .4501E+00  .3766E+00  .3045E+01  .1009E+01  .1463E+01  .1110E+01  .4908E+00  .3103E+01  .5797E+01
10  .2660E+02  .4926E+01  .4967E+00  .3893E+00  .2853E+01  .1008E+01  .1629E+01  .1016E+01  .7656E+00  .3479E+01  .5400E+01
11  .2429E+02  .4844E+01  .5407E+00  .3947E+00  .2667E+01  .1005E+01  .1794E+01  .9242E+00  .1069E+01  .3849E+01  .5014E+01
12  .2212E+02  .4755E+01  .5814E+00  .3946E+00  .2493E+01  .1001E+01  .1955E+01  .8381E+00  .1401E+01  .4217E+01  .4652E+01
13  .2013E+02  .4661E+01  .6189E+00  .3911E+00  .2334E+01  .9974E+00  .2114E+01  .7592E+00  .1767E+01  .4588E+01  .4319E+01
14  .1830E+02  .4560E+01  .6535E+00  .3847E+00  .2188E+01  .9944E+00  .2271E+01  .6867E+00  .2170E+01  .4965E+01  .4014E+01
15  .1668E+02  .4457E+01  .6850E+00  .3769E+00  .2058E+01  .9931E+00  .2425E+01  .6221E+00  .2618E+01  .5354E+01  .3742E+01
16  .1535E+02  .4361E+01  .7109E+00  .3686E+00  .1953E+01  .9924E+00  .2561E+01  .5695E+00  .3119E+01  .5758E+01  .3520E+01
17  .1426E+02  .4272E+01  .7331E+00  .3608E+00  .1867E+01  .9931E+00  .2684E+01  .5260E+00  .3556E+01  .6090E+01  .3337E+01
18  .1337E+02  .4193E+01  .7506E+00  .3532E+00  .1797E+01  .9931E+00  .2787E+01  .4910E+00  .4016E+01  .6421E+01  .3189E+01
19  .1277E+02  .4135E+01  .7623E+00  .3471E+00  .1750E+01  .9926E+00  .2860E+01  .4669E+00  .4498E+01  .6755E+01  .3087E+01
20  .1216E+02  .4073E+01  .7744E+00  .3408E+00  .1703E+01  .9927E+00  .2938E+01  .4428E+00  .4878E+01  .7011E+01  .2986E+01

 SONIC LINE LOCATION

XSL=  .1045E+01   YSL=  .2488E+01
XSL=  .1004E+01   YSL=  .2554E+01
XSL=  .8791E+00   YSL=  .2514E+01
XSL=  .7440E+00   YSL=  .2457E+01
XSL=  .6218E+00   YSL=  .2409E+01
XSL=  .5119E+00   YSL=  .2362E+01
XSL=  .4062E+00   YSL=  .2318E+01
XSL=  .3018E+00   YSL=  .2273E+01
XSL=  .1962E+00   YSL=  .2222E+01
XSL=  .9532E-01   YSL=  .2160E+01
XSL= -.8122E-02   YSL=  .2088E+01
XSL= -.1079E+00   YSL=  .2020E+01

    PERCENT ERROR IN HT=   .5768E+01    RMS OF PERCENT ERROR IN HT=   .1656E+01

PRESSURE DRAG =         .8142961970
RESIDUE INFORMATION               19    11    .14433    .61033  23.64809S( 19, 11, 4)=    .14044

                                                  DETAILED RESIDUE INFORMATION
                                                  ****************************
                                                                  SECOND INDEX =   2
   2   .1754163E-02   .4123846E-02   .4893006E-03   .5151202E-01     3   .1352048E-02   .4556844E-02   .1089006E-02   .3972800E-01
   4  -.2513760E-04   .3036689E-02   .3160084E-03   .1025318E-02     5  -.3915119E-03   .1981658E-02  -.8641751E-03  -.9703477E-02
   6  -.5977352E-03   .9154068E-03  -.1655799E-02  -.1605267E-01     7  -.7281106E-03  -.1110003E-04  -.2089456E-02  -.2003217E-01
   8  -.7921913E-03  -.7429054E-03  -.2267244E-02  -.2182686E-01     9  -.8829069E-03  -.1440622E-02  -.2532536E-02  -.2421488E-01
  10  -.9994139E-03  -.2486329E-02  -.2693506E-02  -.2749060E-01    11  -.1151136E-02  -.4056134E-02  -.2539234E-02  -.3210705E-01
  12  -.1320014E-02  -.6070643E-02  -.1908891E-02  -.3778557E-01    13  -.1301202E-02  -.7255727E-02  -.3545616E-03  -.3799678E-01
  14  -.1378067E-02  -.7874088E-02   .8395896E-03  -.3883300E-01    15  -.2295355E-02  -.1229371E-01   .6122968E-03  -.6178820E-01
  16  -.3412196E-02  -.1850612E-01   .8772470E-03  -.9159028E-01    17  -.3787263E-02  -.2130095E-01   .1211688E-02  -.1055204E+00
  18  -.2584375E-02  -.1442841E-01   .7684652E-03  -.7343892E-01    19  -.2630743E-02  -.1500541E-01   .1006767E-02  -.7456108E-01
```

*** skip print out ***

Example 5

Input Data Cards

```
     20    12  400    0    0    1    0
     16     3  200    2    3    0
  6.0       1.4      7.0       4.32       2.0        10000.     1.
  0.038     0.069    0.572     1.475      2.712      3.378      6.144      0.2  0.4
  0.569     0.615    0.906     1.692      3.274      3.651      3.99
  4.32      0.062    3.137     1.
  60.       38.      7.
  1.0
  111111111111
```

Printed Output

```
  AXISYMMETRIC FLOW OV R NOSETIP


  MACH NUMBER = 6.00
  RATIO OF SPECIFIC HE T = 1.40
  CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
  OMEGA =  1.000      (OMEGA.GT.0.OMEGA IS THE RADIUS OF SPHERE-CONE*OMEGA=0.MORE RAYS TO BE ADDED)

  IR1 = 0      ( 1 FOR READ TAPE1S 0      OTHERWISE)
  IW2 = 0      (1 FOR WRITE ON TAPE2S 0   OTHERWISE)
  IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGENS 0      OTHERWISE)
  IAFBD = 0      ( 1 FOR       STORAGE OF STARTING DATA FOR AFTERBODY CAL.S 0      OTHERWISE)
  IGFOM = 3      ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB,YB,XS,YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                   3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

  LIP = 200   ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
  IVIS = 0      (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

  CF(BETA)= 10000.00000      ( FOR UNIFORM SPACING SET TO 10000)
  CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
  ITRAN = 3      (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
  KRES = 2      (INTERVAL IN K FOR RESIDUE INFORMATION)
  EXPLICIT DISSI. COEF. = .200
  IMPLICIT DISSI. COEF. = .400
  COURANT NO. =    2.00



  JMAX=   20
  KMAX=   12
  JNM=   16      (JUNCTURE OF SPHERE AND CONE)
  ITER =  400    (TIME STEPS FOR THIS RUN)

FREE STREAM CONDITIONS

  PINF(PRESSURE) =  1.0000
  RINF(DENSITY) =  1.0000
  QINF(TOTAL VEL.) =  7.0993
  AINF(SOUND SPEED) =  1.1832
  UINF(U COMP.) =  7.0993
  VINF(V COMP.) =  0.0000
  HTINF(T. ENTHALPY) = 28.7000
  ETINF(T. SPEC. ENERGY) = 27.7000
  SINF(ENTROPY) =  1.0000
  EIINF(INTERNAL ENERGY) =  2.5000
```

```
NORMALIZED DISTANCE FROM BODY TO SHOCK
                 0.000000   .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                  .909091  1.000000

  X AND Y VALUES FOR THE CONTROL POINTS
                  .03800    .06900    .57200   1.47500   2.71200   3.37800   6.14400
                  .56900    .61500    .90600   1.69200   3.27400   3.65100   3.99000

  RADIUS FOR CIRCULAR ARCS
                 4.32000    .06200   3.13700   1.00000

  ANGLES FOR STRAIGHT LINES
                4[illegible].00000  38.00000   7.00000

      CENTERS FOR THE CIRCULAR ARCS
                     4.32000   0.00000    .10000    .56131   -.99650   3.62272   3.50001   2.65834

  XOO=NEW OMEGA=    3.82 3

  THETA VALUES FOR CONTROL POINTS
                      .14909    .16224    .27153    .62376   1.24275   1.44862

  INDENTED NOSETIP SHAPE
                    J          THETA          RB           XB            YB           DELTA

                    1        -2.86207      3.82693       .00423       -.19108       -.00055
                    2         2.86207      3.82693       .00423        .19108       -.00055
                    3         8.58621      3.83031       .03890        .57196       -.00402
                    4        14.31034      3.45192       .48157        .85320        .37447
                    5        20.03448      3.16939       .84869       1.08579        .65690
                    6        25.75862      3.00601      1.11897       1.30636        .82027
                    7        31.48276      2.92016      1.33598       1.52503        .90612
                    8        37.20690      2.89492      1.52069       1.75048        .93147
                    9        42.93103      2.90529      1.69911       1.97884        .92100
                   10        48.65517      2.94532      1.88064       2.21119        .88096
                   11        54.37931      3.01698      2.06915       2.45247        .80931
                   12        60.10345      3.12414      2.26910       2.70840        .70214
                   13        65.82759      3.27305      2.48603       2.98606        .55324
                   14        71.55172      3.47190      2.72761       3.29347        .35439
                   15        77.27586      3.62854      3.02707       3.53943        .19774
                   16        83.00000      3.67829      3.37802       3.65087        .14800

 STARTING BODY AND BOW SHOCK LOCATIONS

              XB                YB                XS                YS               THETA
           .004773         -.191053          -.561191          -.219348          -.049953    1
           .004773          .191053          -.561191           .219348           .049953    2
           .042884          .571254          -.518980           .656090           .149858    3
           .118725          .945758          -.435993          1.087261           .249763    4
           .231542         1.310831          -.314762          1.510041           .349668    5
           .380207         1.662831          -.158369          1.922709           .449573    6
           .543239         1.998247           .030139          2.324711           .549478    7
           .778913         2.313736           .248234          2.716569           .649383    8
          1.024779         2.606151           .494245          3.099689           .749288    9
          1.298643         2.872575           .767569          3.476176           .849193   10
          1.597794         3.110352          1.068802          3.848677           .949098   11
          1.917127         3.317710          1.399848          4.220293          1.049003   12
          2.259496         3.490788          1.764070          4.594555          1.148908   13
          2.615464         3.629652          2.166514          4.975460          1.248813   14
          2.973519         3.732320          2.614273          5.367581          1.348718   15
          3.359979         3.797766          3.117053          5.776246          1.448623   16
          3.739395         3.844352          3.554485          6.109599          1.489348   17
          4.118811         3.890939          4.014870          6.441839          1.530072   18
          4.498227         3.937525          4.498227          6.773142          1.570796   19
          4.877643         3.984112          4.877643          7.022261          1.570796   20
```

```
FRACTION OF DELTA PREVIOUSLY DONE= 0.00
FRACTION OF DELTA FOR THIS RUN= 1.00
TOTAL FRACTION OF    DELTA COMPLETED= 1.00


BODY SHAPE CHANGE BEING INSTITUTED

ARC LENGTH
                      .19105    .57316    .95527   1.33737   1.71948   2.10159   2.48369   2.86580   3.24790   3.63001
                     4.01212   4.39422   4.77633   5.15844   5.54054   5.92281   6.30507   6.68734   7.06960


STARTING FLOWFIELD INFORMATION


SECOND INDEX=  1

1ST   P/PINF        S        U/QINF     V/QINF     S/SINF    HT/HTINF     R/RI       CP         X          Y        EI/EIINF
  1  .4670E+02 -.1911E+00  .1421E-02 -.2843E-01  .4085E+01  .1000E+01  .5699E+01  .1813E+01  .4773E-02 -.1911E+00  .8194E+01
  2  .4670E+02  .1911E+00  .1421E-02  .2843E-01  .4085E+01  .1000E+01  .5699E+01  .1813E+01  .4773E-02  .1911E+00  .8194E+01
  3  .4578E+02  .5732E+00  .1274E-01  .8436E-01  .4085E+01  .1000E+01  .5618E+01  .1777E+01  .4288E-01  .5713E+00  .8148E+01
  4  .4398E+02  .9553E+00  .3508E-01  .1375E+00  .4085E+01  .1000E+01  .5460E+01  .1706E+01  .1187E+00  .9458E+00  .8055E+01
  5  .4141E+02  .1337E+01  .6788E-01  .1861E+00  .4085E+01  .1000E+01  .5230E+01  .1603E+01  .2315E+00  .1311E+01  .7917E+01
  6  .3819E+02  .1719E+01  .1103E+00  .2286E+00  .4085E+01  .1000E+01  .4936E+01  .1476E+01  .3802E+00  .1663E+01  .7736E+01
  7  .3448E+02  .2102E+01  .1612E+00  .2633E+00  .4085E+01  .1000E+01  .4589E+01  .1329E+01  .5632E+00  .1998E+01  .7514E+01
  8  .3046E+02  .2484E+01  .2193E+00  .2889E+00  .4085E+01  .1000E+01  .4200E+01  .1169E+01  .7788E+00  .2314E+01  .7253E+01
  9  .2632E+02  .2866E+01  .2831E+00  .3044E+00  .4085E+01  .1000E+01  .3784E+01  .1005E+01  .1025E+01  .2606E+01  .6956E+01
 10  .2222E+02  .3248E+01  .3508E+00  .3087E+00  .4085E+01  .1000E+01  .3353E+01  .8422E+00  .1299E+01  .2873E+01  .6628E+01
 11  .1834E+02  .3630E+01  .4205E+00  .3013E+00  .4085E+01  .1000E+01  .2923E+01  .6879E+00  .1598E+01  .3110E+01  .6273E+01
 12  .1480E+02  .4012E+01  .4899E+00  .2817E+00  .4085E+01  .1000E+01  .2508E+01  .5476E+00  .1919E+01  .3317E+01  .5901E+01
 13  .1173E+02  .4394E+01  .5565E+00  .2498E+00  .4085E+01  .1000E+01  .2124E+01  .4257E+00  .2259E+01  .3491E+01  .5521E+01
 14  .9215E+01  .4776E+01  .6170E+00  .2058E+00  .4085E+01  .1000E+01  .1788E+01  .3260E+00  .2615E+01  .3630E+01  .5154E+01
 15  .7329E+01  .5158E+01  .6676E+00  .1507E+00  .4085E+01  .1000E+01  .1519E+01  .2511E+00  .2984E+01  .3732E+01  .4927E+01
 16  .6352E+01  .5541E+01  .6961E+00  .1032E+00  .4085E+01  .1000E+01  .1371E+01  .2124E+00  .3360E+01  .3798E+01  .4634E+01
 17  .6113E+01  .5923E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .3739E+01  .3844E+01  .4584E+01
 18  .6113E+01  .6305E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01   2029E+00  .4119E+01  .3891E+01  .4584E+01
 19  .6113E+01  .6687E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4498E+01  .3938E+01  .4584E+01
 20  .6113E+01  .7070E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4878E+01  .3984E+01  .4584E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST   P/PINF    RO/RINF     U/QINF     V/QINF     S/SINF    HT/HTINF     MACH       CP         X          Y        EI/EIINF
  1  .4174E+02  .5267E+01  .1917E+00 -.3897E-01  .4077E+01  .1000E+01  .4171E+00  .1617E+01 -.5612E+00 -.2193E+00  .7924E+01
  2  .4174E+02  .5267E+01  .1917E+00  .3897E-01  .4077E+01  .1000E+01  .4171E+00  .1617E+01 -.5612E+00  .2193E+00  .7924E+01
  3  .4099E+02  .5255E+01  .2068E+00  .1144E+00  .4016E+01  .1000E+01  .5078E+00  .1586E+01 -.5190E+00  .6561E+00  .7798E+01
  4  .3956E+02  .5232E+01  .2349E+00  .1830E+00  .3901E+01  .1000E+01  .6497E+00  .1530E+01 -.4360E+00  .1087E+01  .7562E+01
  5  .3766E+02  .5198E+01  .2727E+00  .2417E+00  .3747E+01  .1000E+01  .8123E+00  .1455E+01 -.3148E+00  .1510E+01  .7244E+01
  6  .3545E+02  .5156E+01  .3165E+00  .2894E+00  .3568E+01  .1000E+01  .9812E+00  .1367E+01 -.1584E+00  .1923E+01  .6876E+01
  7  .3311E+02  .5105E+01  .3630E+00  .3263E+00  .3378E+01  .1000E+01  .1150E+01  .1274E+01  .3014E-01  .2325E+01  .6485E+01
  8  .3075E+02  .5046E+01  .4098E+00  .3535E+00  .3188E+01  .1000E+01  .1316E+01  .1180E+01  .2482E+00  .2717E+01  .6091E+01
  9  [illegible] [illegible] [illegible] [illegible] .3053E+01  .1000E+01  .1477E+01  .1089E+01  .4442E+00  .3100E+01  .5709E+01
 10  .2627E+02  .4916E+01  .4985E+00  .3847E+00  .2927E+01  .1000E+01  .1634E+01  .1003E+01  .7676E+00  .3476E+01  .5345E+01
 11  .2422E+02  .4842E+01  .5392E+00  .3915E+00  .2662E+01  .1000E+01  .1788E+01  .9216E+00  .1069E+01  .3849E+01  .5003E+01
 12  .2231E+02  .4764E+01  .5773E+00  .3941E+00  .2508E+01  .1000E+01  .1938E+01  .8455E+00  .1400E+01  .4220E+01  .4683E+01
 13  .2052E+02  .4680E+01  .6128E+00  .3931E+00  .2365E+01  .1000E+01  .2086E+01  .7744E+00  .1764E+01  .4595E+01  .4384E+01
 14  .1884E+02  .4591E+01  .6460E+00  .3893E+00  .2231E+01  .1000E+01  .2234E+01  .7080E+00  .2167E+01  .4975E+01  .4104E+01
 15  .1727E+02  .4496E+01  .6772E+00  .3831E+00  .2105E+01  .1000E+01  .2382E+01  .6456E+00  .2614E+01  .5368E+01  .3841E+01
 16  .1595E+02  .4406E+01  .7033E+00  .3759E+00  .2001E+01  .1000E+01  .2515E+01  .5934E+00  .3117E+01  .5776E+01  .3621E+01
 17  .1473E+02  .4312E+01  .7276E+00  .3675E+00  .1904E+01  .1000E+01  .2646E+01  .5448E+00  .3554E+01  .5110E+01  .3416E+01
 18  .1373E+02  .4226E+01  .7475E+00  .3592E+00  .1925E+01  .1000E+01  .2761E+01  .5051E+00  .4015E+01  .6442E+01  .3248E+01
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19  .1292E+02  .4150E+01  .7635E+00  .3515E+00  .1762E+01  .1000E+01  .2858E+01  .4730E+00  .4498E+01  .6773E+01  .3113E+01
20  .1191E+02  .4046E+01  .7835E+00  .3407E+00  .1683E+01  .1000E+01  .2988E+01  .4330E+00  .4878E+01  .7022E+01  .2944E+01

 SONIC LINE LOCATION

XSL=  .1128E+01   YSL=  .2707E+01
XSL=  .9595E+00   YSL=  .2630E+01
XSL=  .8123E+00   YSL=  .2550E+01
XSL=  .6762E+00   YSL=  .2478E+01
XSL=  .5520E+00   YSL=  .2407E+01
XSL=  .4381E+00   YSL=  .2336E+01
XSL=  .3292E+00   YSL=  .2270E+01
XSL=  .2244E+00   YSL=  .2207E+01
XSL=  .1302E+00   YSL=  .2143E+01
XSL=  .3875E-01   YSL=  .2082E+01
XSL= -.5032E-01   YSL=  .2024E+01
XSL= -.1374E+00   YSL=  .1967E+01

    PERCENT ERROR IN HT=   .4357E-11    RMS OF PERCENT ERROR IN HT=   .2270E-11

PRESSURE DRAG =        .9051172390

SIGMAX= .9079E+02   J=    1   K=   12   SIGMIN=  .8386E+01   J=    1   K=   12   CN= .2000E+01   DT= .2203E-01
RESIDUE INFORMATION            16   11     .26440    1.20535  21.93540S( 16, 11, 4)=    .25839
RMS OF SHOCK SPEED=    .7165E-01    J= 16    MAX SHK SPD=  -.1418E+00
RMS OF SHOCK SPEED=    .7174E-01    J= 17    MAX SHK SPD=  -.1442E+00
RMS OF SHOCK SPEED=    .7820E-01    J=  2    MAX SHK SPD=  -.1483E+00
RMS OF SHOCK SPEED=    .9397E-01    J=  2    MAX SHK SPD=  -.2171E+00
RMS OF SHOCK SPEED=    .1110E+00    J=  2    MAX SHK SPD=  -.2769E+00
RMS OF SHOCK SPEED=    .1246E+00    J=  2    MAX SHK SPD=  -.3191E+00
RMS OF SHOCK SPEED=    .1325E+00    J=  2    MAX SHK SPD=  -.3401E+00
RMS OF SHOCK SPEED=    .1337E+00    J=  2    MAX SHK SPD=  -.3389E+00
RMS OF SHOCK SPEED=    .1285E+00    J=  2    MAX SHK SPD=  -.3161E+00
RMS OF SHOCK SPEED=    .1183E+00    J=  2    MAX SHK SPD=  -.2748E+00
RMS OF SHOCK SPEED=    .1061E+00    J=  2    MAX SHK SPD=  -.2210E+00
RMS OF SHOCK SPEED=    .9551E-01    J=  2    MAX SHK SPD=  -.1632E+00
RMS OF SHOCK SPEED=    .8935E-01    J=  9    MAX SHK SPD=   .1203E+00
RMS OF SHOCK SPEED=    .8771E-01    J=  9    MAX SHK SPD=   .1267E+00
RMS OF SHOCK SPEED=    .8869E-01    J= 10    MAX SHK SPD=   .1325E+00
RMS OF SHOCK SPEED=    .9041E-01    J= 10    MAX SHK SPD=   .1371E+00
RMS OF SHOCK SPEED=    .9200E-01    J= 20    MAX SHK SPD=  -.1427E+00
RMS OF SHOCK SPEED=    .9338E-01    J= 20    MAX SHK SPD=  -.1499E+00
RMS OF SHOCK SPEED=    .9489E-01    J= 20    MAX SHK SPD=  -.1566E+00
RMS OF SHOCK SPEED=    .9684E-01    J= 20    MAX SHK SPD=  -.1628E+00
RMS OF SHOCK SPEED=    .9918E-01    J= 20    MAX SHK SPD=  -.1683E+00
RMS OF SHOCK SPEED=    .1015E+00    J= 20    MAX SHK SPD=  -.1733E+00
RMS OF SHOCK SPEED=    .1032E+00    J= 20    MAX SHK SPD=  -.1776E+00
RMS OF SHOCK SPEED=    .1040E+00    J= 20    MAX SHK SPD=  -.1813E+00
RMS OF SHOCK SPEED=    .1040E+00    J= 20    MAX SHK SPD=  -.1842E+00
```

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```
RMS OF SHOCK SPEED=    .2435E+00    J=  7    MAX SHK SPD=   .6309E+00
RMS OF SHOCK SPEED=    .2453E+00    J=  8    MAX SHK SPD=   .6683E+00
RMS OF SHOCK SPEED=    .2469E+00    J=  8    MAX SHK SPD=   .7055E+00
RESIDUE INFORMATION            19   11     .06725     .15689   42.32468S( 19, 11, 4)=    .06545

SIGMAX= .3480E+03   J=    3   K=   12   SIGMIN=  .8842E+01   J=   20   K=    1   CN= .2000E+01   DT= .5747E-02
```

Finished Flowfield Information

```
SECOND INDEX=  1

IST      P/PINF           S      U/QINF      V/QINF      S/SINF    HT/HTINF        R/RI          CP           X           Y    EI/EIINF
  1   .4513E+02  -.1911E+00   .4944E-02  -.1088E+00   .4085E+01   .1000E+01   .5562E+01   .1751E+01   .4228E-02  -.1911E+00   .8115E+01
  2   .4513E+02   .1911E+00   .4944E-02   .1088E+00   .4085E+01   .1000E+01   .5562E+01   .1751E+01   .4228E-02   .1911E+00   .8115E+01
  3   .3360E+02   .5734E+00   .1877E+00   .2603E+00   .4085E+01   .1000E+01   .4505E+01   .1294E+01   .3890E-01   .5719E+00   .7459E+01
  4   .1552E+02   .1098E+01   .4686E+00   .2974E+00   .4085E+01   .1000E+01   .2595E+01   .5763E+00   .4816E+00   .8532E+00   .5982E+01
  5   .1651E+02   .1533E+01   .4414E+00   .3138E+00   .4085E+01   .1000E+01   .2712E+01   .6155E+00   .8487E+00   .1086E+01   .6088E+01
  6   .2271E+02   .1881E+01   .3426E+00   .3088E+00   .4085E+01   .1000E+01   .3405E+01   .8614E+00   .1119E+01   .1306E+01   .6669E+01
  7   .2769E+02   .2189E+01   .2672E+00   .2954E+00   .4085E+01   .1000E+01   .3924E+01   .1059E+01   .1336E+01   .1525E+01   .7058E+01
  8   .3175E+02   .2481E+01   .2161E+00   .2700E+00   .4085E+01   .1000E+01   .4326E+01   .1220E+01   .1521E+01   .1750E+01   .7339E+01
  9   .3705E+02   .2771E+01   .1671E+00   .2138E+00   .4085E+01   .1000E+01   .4831E+01   .1431E+01   .1699E+01   .1979E+01   .7670E+01
 10   .4041E+02   .3066E+01   .1333E+00   .1706E+00   .4085E+01   .1000E+01   .5140E+01   .1564E+01   .1881E+01   .2211E+01   .7863E+01
 11   .4053E+02   .3372E+01   .1320E+00   .1689E+00   .4085E+01   .1000E+01   .5150E+01   .1569E+01   .2069E+01   .2452E+01   .7869E+01
 12   .3777E+02   .3697E+01   .1603E+00   .2051E+00   .4085E+01   .1000E+01   .4898E+01   .1459E+01   .2269E+01   .2708E+01   .7712E+01
 13   .3413E+02   .4049E+01   .1934E+00   .2468E+00   .4085E+01   .1000E+01   .4555E+01   .1315E+01   .2486E+01   .2986E+01   .7492E+01
 14   .2454E+02   .4440E+01   .3062E+00   .3132E+00   .4085E+01   .1000E+01   .3600E+01   .9343E+00   .2728E+01   .3293E+01   .6819E+01
 15   .1124E+02   .4827E+01   .5411E+00   .2973E+00   .4085E+01   .1000E+01   .2061E+01   .4065E+00   .3027E+01   .3539E+01   .5455E+01
 16   .4576E+01   .5196E+01   .7266E+00   .1578E+00   .4085E+01   .1000E+01   .1084E+01   .1419E+00   .3378E+01   .3651E+01   .4219E+01
 17   .2690E+01   .5572E+01   .7912E+00   .9714E-01   .4085E+01   .1000E+01   .7420E+00   .6707E-01   .3751E+01   .3697E+01   .3625E+01
 18   .2396E+01   .5948E+01   .8013E+00   .9839E-01   .4085E+01   .1000E+01   .6831E+00   .5539E-01   .4125E+01   .3743E+01   .3507E+01
 19   .2378E+01   .6324E+01   .8019E+00   .9846E-01   .4085E+01   .1000E+01   .6795E+00   .5469E-01   .4498E+01   .3788E+01   .3500E+01
 20   .2402E+01   .6706E+01   .8011E+00   .9836E-01   .4085E+01   .1000E+01   .6843E+00   .5563E-01   .4878E+01   .3835E+01   .3510E+01
```

*** skip print out ***

```
SECOND INDEX= 12

IST      P/PINF     RO/RINF      U/QINF      V/QINF      S/SINF    HT/HTINF        MACH          CP           X           Y    EI/EIINF
  1   .4137E+02   .5261E+01   .1989E+00  -.8338E-01   .4048E+01   .9998E+00   .4614E+00   .1602E+01  -.1857E+00  -.2006E+00   .7864E+01
  2   .4137E+02   .5261E+01   .1989E+00   .8338E-01   .4048E+01   .9998E+00   .4614E+00   .1602E+01  -.1857E+00   .2006E+00   .7864E+01
  3   .3708E+02   .5187E+01   .2833E+00   .2533E+00   .3700E+01   .9984E+00   .8529E+00   .1432E+01  -.1031E+00   .5933E+00   .7147E+01
  4   .2907E+02   .5002E+01   .4475E+00   .3747E+00   .3053E+01   .1008E+01   .1453E+01   .1114E+01   .8071E-01   .9555E+00   .5812E+01
  5   .2153E+02   .4729E+01   .5855E+00   .3866E+00   .2446E+01   .9875E+00   .1973E+01   .8148E+00   .3540E+00   .1266E+01   .4553E+01
  6   .1740E+02   .4504E+01   .6525E+00   .3639E+00   .2116E+01   .9613E+00   .2281E+01   .6508E+00   .6306E+00   .1542E+01   .3863E+01
  7   .1792E+02   .4537E+01   .6977E+00   .4128E+00   .2157E+01   .1059E+01   .2447E+01   .6715E+00   .9000E+00   .1792E+01   .3950E+01
  8   .2242E+02   .4769E+01   .6334E+00   .4490E+00   .2517E+01   .1103E+01   .2148E+01   .8501E+00   .1219E+01   .1980E+01   .4702E+01
  9   .2832E+02   .4980E+01   .4641E+00   .3821E+00   .2942E+01   .1011E+01   .1512E+01   .1084E+01   .1434E+01   .2225E+01   .5686E+01
 10   .3340E+02   .5112E+01   .3575E+00   .3229E+00   .3402E+01   .1001E+01   .1131E+01   .1286E+01   .1609E+01   .2520E+01   .6534E+01
 11   .3575E+02   .5162E+01   .3066E+00   .2741E+00   .3592E+01   .9932E+00   .9376E+00   .1379E+01   .1764E+01   .2879E+01   .6926E+01
 12   .3500E+02   .5146E+01   .3167E+00   .2769E+00   .3532E+01   .9848E+00   .9677E+00   .1349E+01   .1922E+01   .3312E+01   .6802E+01
 13   .3250E+02   .5091E+01   .3669E+00   .3185E+00   .3330E+01   .9858E+00   .1154E+01   .1250E+01   .2129E+01   .3781E+01   .6384E+01
 14   .2941E+02   .5012E+01   .4361E+00   .3650E+00   .3080E+01   .9996E+00   .1408E+01   .1127E+01   .2403E+01   .4267E+01   .5868E+01
 15   .2615E+02   .4911E+01   .5128E+00   .4000E+00   .2817E+01   .1021E+01   .1691E+01   .9979E+00   .2754E+01   .4749E+01   .5324E+01
 16   .2293E+02   .4790E+01   .5825E+00   .4123E+00   .2558E+01   .1031E+01   .1957E+01   .8701E+00   .3185E+01   .5222E+01   .4786E+01
 17   .2012E+02   .4660E+01   .6400E+00   .4104E+00   .2333E+01   .1034E+01   .2195E+01   .7589E+00   .3596E+01   .5602E+01   .4318E+01
 18   .1796E+02   .4539E+01   .6780E+00   .3983E+00   .2160E+01   .1025E+01   .2372E+01   .6730E+00   .4034E+01   .5967E+01   .3957E+01
 19   .1623E+02   .4425E+01   .7055E+00   .3835E+00   .2022E+01   .1013E+01   .2516E+01   .6042E+00   .4498E+01   .6330E+01   .3667E+01
 20   .1449E+02   .4292E+01   .7349E+00   .3674E+00   .1885E+01   .1004E+01   .2683E+01   .5354E+00   .4878E+01   .6613E+01   .3376E+01

 SONIC LINE LOCATION

XSL=   .2378E+00   YSL=   .6982E+00
XSL=   .1209E+01   YSL=   .1397E+01
XSL=   .2723E+01   YSL=   .3287E+01
XSL=   .3449E+00   YSL=   .7935E+00
XSL=   .8956E+00   YSL=   .1174E+01
XSL=   .2193E+01   YSL=   .2701E+01
XSL=   .3572E+00   YSL=   .8332E+00
```

```
XSL=  .8130E+00   YSL=  .1165E+01
XSL=  .1915E+01   YSL=  .2387E+01
XSL=  .3118E+00   YSL=  .8318E+00
XSL=  .8250E+00   YSL=  .1231E+01
XSL=  .1684E+01   YSL=  .2125E+01
XSL=  .2773E+00   YSL=  .8382E+00
XSL=  .9385E+00   YSL=  .1390E+01
XSL=  .1457E+01   YSL=  .1890E+01
XSL=  .2431E+00   YSL=  .8447E+00
XSL=  .2002E+00   YSL=  .8412E+00
XSL=  .1438E+00   YSL=  .8193E+00
XSL=  .8537E-01   YSL=  .7876E+00
XSL=  .1974E+01   YSL=  .3050E+01
XSL=  .2202E+01   YSL=  .3515E+01
XSL=  .3078E-01   YSL=  .7520E+00
XSL=  .1844E+01   YSL=  .2862E+01
XSL=  .2097E+01   YSL=  .3435E+01
XSL= -.1602E-01   YSL=  .7182E+00
XSL=  .1765E+01   YSL=  .2781E+01
XSL=  .2024E+01   YSL=  .3408E+01
XSL= -.5799E-01   YSL=  .6821E+00
XSL=  .1714E+01   YSL=  .2763E+01
XSL=  .1958E+01   YSL=  .3393E+01

    PERCENT ERROR IN HT=   .1027E+02    RMS OF PERCENT ERROR IN HT=   .3522E+01

PRESSURE DRAG =       1.0286611681

SOLUTION HAS BEEN STORED ON DISK
RESIDUE INFORMATION            19   11    .06768    .15939  42.46351S( 19, 11, 4)=    .06588
```

*** skip print out ***

It is noticed that at the end of this run, the shock speed was not converged, therefore this case was continued for additional 800 time steps without shape changing. The input data cards and the printed output are described in the following:

Input data cards

```
    20    12   800     0     1     1     0
    16     3     0     2     3     0
 6.         1.4       7.          3.8263    2.          10000.    1.         0.4   0.0
 100010001001
```

Printed output

```
AXISYMMETRIC FLOW OVER NOSETIP


MACH NUMBER = 6.00
RATIO OF SPECIFIC HEAT = 1.40
CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
OMEGA =  3.826      (OMEGA.GT.0.OMEGA IS THE RADIUS OF SPHERE-CONES IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED
                     IN SUB. SHAPES OMEGA=0.MORE RAYS TO BE ADDED)

IR1 = 1      ( 1 FOR READ TAPE1$ 0     OTHERWISE)
IW2 = 1      (1 FOR WRITE ON TAPE2$ 0   OTHERWISE)
IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGENS 0     OTHERWISE)
IAFBD = 0      ( 1 FOR      STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)
IGEOM = 3      ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB,YB,XS,YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

LIP = 0      ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
IVIS = 0      (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

CF(BETA)= 10000.00000      ( FOR UNIFORM SPACING SET TO 10000)
CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
ITRAN = 3      (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
KRES = 2      (INTERVAL IN K FOR RESIDUE INFORMATION)
EXPLICIT DISSI. COEF. = .400
IMPLICIT DISSI. COEF. =0.000
COURANT NO. =    2.00



JMAX=   20
KMAX=   12
JNM=   16      (JUNCTURE OF SPHERE AND CONE)
ITER = 800      (TIME STEPS FOR THIS RUN)

FREE STREAM CONDITIONS

  PINF(PRESSURE) =  1.0000
  RINF(DENSITY) =  1.0000
  QINF(TOTAL VEL.) =  7.0993
  AINF(SOUND SPEED) =  1.1832
  UINF(U COMP.) =  7.0993
  VINF(V COMP.) =  0.0000
  HTINF(T. ENTHALPY) = 28.7000
  ETINF(T. SPEC. ENERGY) = 27.7000
  SINF(ENTROPY) =  1.0000
  EIINF(INTERNAL ENERGY) =  2.5000



  NORMALIZED DISTANCE FROM BODY TO SHOCK
                        0.000000   .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                         .909091  1.000000

STARTING SOLUTION WAS READ FROM TAPE

ARC LENGTH
                          .19106    .57343   1.09794   1.53253   1.88139   2.18947   2.48092   2.77072   3.06558   3.37177
                         3.69655   4.04889   4.43988   4.82740   5.19561   5.57184   5.94806   6.32423   6.70650


STARTING FLOWFIELD INFORMATION
```

```
SECOND INDEX=  1

IST   P/PINF        S          U/UINF      V/UINF      S/SINF     HT/HTINF      R/RI         CP          X           Y        EI/EIINF
 1  .4513E+02 -.1911E+00  .4944E-02 -.1088E+00  .4085E+01  .1000E+01  .5562E+01  .1751E+01  .4228E-02 -.1911E+00  .8115E+01
 2  .4513E+02  .1911E+00  .4944E-02  .1088E+00  .4085E+01  .1000E+01  .5562E+01  .1751E+01  .4228E-02  .1911E+00  .8115E+01
 3  .3360E+02  .5734E+00  .1877E+00  .2603E+00  .4085E+01  .1000E+01  .4505E+01  .1294E+01  .3890E-01  .5719E+00  .7459E+01
 4  .1552E+02  .1098E+01  .4686E+00  .2974E+00  .4085E+01  .1000E+01  .2595E+01  .5763E+00  .4816E+00  .8532E+00  .5982E+01
 5  .1651E+02  .1533E+01  .4414E+00  .3138E+00  .4085E+01  .1000E+01  .2712E+01  .6155E+00  .8487E+00  .1086E+01  .6088E+01
 6  .2271E+02  .1881E+01  .3426E+00  .3068E+00  .4085E+01  .1000E+01  .3405E+01  .8614E+00  .1119E+01  .1306E+01  .6669E+01
 7  .2769E+02  .2189E+01  .2672E+00  .2954E+00  .4085E+01  .1000E+01  .3924E+01  .1059E+01  .1336E+01  .1525E+01  .7058E+01
 8  .3175E+02  .2481E+01  .2161E+00  .2700E+00  .4085E+01  .1000E+01  .4326E+01  .1220E+01  .1521E+01  .1750E+01  .7339E+01
 9  .3705E+02  .2771E+01  .1671E+00  .2138E+00  .4085E+01  .1000E+01  .4831E+01  .1431E+01  .1699E+01  .1979E+01  .7670E+01
10  .4041E+02  .3066E+01  .1333E+00  .1706E+00  .4085E+01  .1000E+01  .5140E+01  .1564E+01  .1881E+01  .2211E+01  .7863E+01
11  .4053E+02  .3372E+01  .1320E+00  .1689E+00  .4085E+01  .1000E+01  .5150E+01  .1569E+01  .2069E+01  .2452E+01  .7869E+01
12  .3777E+02  .3697E+01  .1603E+00  .2051E+00  .4085E+01  .1000E+01  .4898E+01  .1459E+01  .2269E+01  .2708E+01  .7712E+01
13  .3413E+02  .4049E+01  .1934E+00  .2468E+00  .4085E+01  .1000E+01  .4555E+01  .1315E+01  .2486E+01  .2986E+01  .7492E+01
14  .2454E+02  .4440E+01  .3062E+00  .3132E+00  .4085E+01  .1000E+01  .3600E+01  .934 E+00  .2728E+01  .3293E+01  .6819E+01
15  .1124E+02  .4827E+01  .5411E+00  .2973E+00  .4085E+01  .1000E+01  .2061E+01  .4065E+00  .3027E+01  .3539E+01  .5455E+01
16  .4576E+01  .5196E+01  .7266E+00  .1578E+00  .4085E+01  .1000E+01  .1084E+01  .1419E+00  .3378E+01  .3651E+01  .4219E+01
17  .2690E+01  .5572E+01  .7912E+00  .9714E-01  .4085E+01  .1000E+01  .7420E+00  .6707E-01  .3751E+01  .3697E+01  .3625E+01
18  .2396E+01  .5948E+01  .8013E+00  .9839E-01  .4085E+01  .1000E+01  .6831E+00  .5539E-01  .4125E+01  .3743E+01  .3507E+01
19  .2378E+01  .6324E+01  .8019E+00  .9846E-01  .4085E+01  .1000E+01  .6795E+00  .5469E-01  .4498E+01  .3788E+01  .3500E+01
20  .2402E+01  .6706E+01  .8011E+00  .9836E-01  .4085E+01  .1000E+01  .6843E+00  .5563E-01  .4878E+01  .3835E+01  .3510E+01
```

*** skip print out ***

```
SECOND INDEX= 12

IST   P/PINF     RO/RINF      U/UINF      V/UINF      S/SINF     HT/HTINF      MACH         CP          X           Y        EI/EIINF
 1  .4137E+02  .5261E+01  .1969E+00 -.8338E-01  .4048E+01  .9998E+00  .4614E+00  .1602E+01 -.1857E+00 -.2006E+00  .7864E+01
 2  .4137E+02  .5261E+01  .1989E+00  .8338E-01  .4048E+01  .9998E+00  .4614E+00  .1602E+01 -.1857E+00  .2006E+00  .7864E+01
 3  .3708E+02  .5187E+01  .2833E+00  .2533E+00  .3700E+01  .9984E+00  .8529E+00  .1432E+01 -.1031E+00  .5933E+00  .7147E+01
 4  .2907E+02  .5002E+01  .4475E+00  .3747E+00  .3053E+01  .1008E+01  .1453E+01  .1114E+01  .8071E-01  .9555E+00  .5812E+01
 5  .2153E+02  .4729E+01  .5855E+00  .3866E+00  .2446E+01  .9875E+00  .1973E+01  .8148E+00  .3540E+00  .1266E+01  .4553E+01
 6  .1740E+02  .4504E+01  .6525E+00  .3639E+00  .2116E+01  .9613E+00  .2281E+01  .6508E+00  .6306E+00  .1542E+01  .3863E+01
 7  .1792E+02  .4537E+01  .6977E+00  .4128E+00  .2157E+01  .1059E+01  .2447E+01  .6715E+00  .9000E+00  .1792E+01  .3950E+01
 8  .2242E+02  .4769E+01  .6334E+00  .4490E+00  .2517E+01  .1103E+01  .2148E+01  .8501E+00  .1219E+01  .1980E+01  .4702E+01
 9  .2832E+02  .4980E+01  .4641E+00  .3621E+00  .2992E+01  .1011E+01  .1512E+01  .1084E+01  .1434E+01  .2225E+01  .5686E+01
10  .3340E+02  .5112E+01  .3575E+00  .3229E+00  .3402E+01  .1001E+01  .1131E+01  .1286E+01  .1609E+01  .2520E+01  .6534E+01
11  .3575E+02  .5162E+01  .3066E+00  .2741E+00  .3592E+01  .9932E+00  .9376E+00  .1379E+01  .1764E+01  .2879E+01  .6926E+01
12  .3500E+02  .5146E+01  .3167E+00  .2769E+00  .3532E+01  .9848E+00  .9677E+00  .1349E+01  .1922E+01  .3312E+01  .6802E+01
13  .3250E+02  .5091E+01  .3669E+00  .3185E+00  .3330E+01  .9858E+00  .1154E+01  .1250E+01  .2129E+01  .3781E+01  .6384E+01
14  .2941E+02  .5012E+01  .4361E+00  .3650E+00  .3080E+01  .9996E+00  .1408E+01  .1127E+01  .2403E+01  .4267E+01  .5868E+01
15  .2615E+02  .4911E+01  .5128E+00  .4000E+00  .2817E+01  .1021E+01  .1691E+01  .9979E+00  .2754E+01  .4749E+01  .5324E+01
16  .2293E+02  .4790E+01  .5825E+00  .4123E+00  .2558E+01  .1031E+01  .1957E+01  .8701E+00  .3185E+01  .5222E+01  .4786E+01
17  .2012E+02  .4660E+01  .6400E+00  .4104E+00  .2333E+01  .1034E+01  .2195E+01  .7589E+00  .3596E+01  .5602E+01  .4318E+01
18  .1796E+02  .4539E+01  .6780E+00  .3983E+00  .2160E+01  .1025E+01  .2372E+01  .6730E+00  .4034E+01  .5967E+01  .3957E+01
19  .1623E+02  .4425E+01  .7055E+00  .3835E+00  .2022E+01  .1013E+01  .2516E+01  .6042E+00  .4498E+01  .6330E+01  .3667E+01
20  .1449E+02  .4292E+01  .7349E+00  .3674E+00  .1885E+01  .1004E+01  .2683E+01  .5354E+00  .4878E+01  .6613E+01  .3376E+01
```

*** skip print out ***

```
PRESSURE DRAG =      1.0286611681

SIGMAX= .3480E+03   J=    3   K=   12   SIGMIN= .8842E+01   J=   20   K=    1   CN= .2000E+01   DT= .5747E-02
RESIDUE INFORMATION            19   11    .06768    .15939  42.4635151( 19, 11, 4)=    .06588
RMS OF SHOCK SPEED=   .2494E+00    J=  8   MAX SHK SPD=   .7657E+00
RMS OF SHOCK SPEED=   .2431E+00    J=  8   MAX SHK SPD=   .7602E+00
RMS OF SHOCK SPEED=   .2496E+00    J=  8   MAX SHK SPD=   .7986E+00
RMS OF SHOCK SPEED=   .2485E+00    J=  8   MAX SHK SPD=   .8032E+00
RMS OF SHOCK SPEED=   .2465E+00    J=  8   MAX SHK SPD=   .7997E+00
RMS OF SHOCK SPEED=   .2443E+00    J=  8   MAX SHK SPD=   .7909E+00
RMS OF SHOCK SPEED=   .2420E+00    J=  8   MAX SHK SPD=   .7771E+00
RMS OF SHOCK SPEED=   .2396E+00    J=  8   MAX SHK SPD=   .7587E+00
RMS OF SHOCK SPEED=   .2372E+00    J=  8   MAX SHK SPD=   .7361E+00
RMS OF SHOCK SPEED=   .2348E+00    J=  8   MAX SHK SPD=   .7097E+00
RMS OF SHOCK SPEED=   .2322E+00    J=  8   MAX SHK SPD=   .6798E+00
RMS OF SHOCK SPEED=   .2295E+00    J=  8   MAX SHK SPD=   .6466E+00
```

*** skip print out ***

```
RMS OF SHOCK SPEED=   .7230E-02    J=  9   MAX SHK SPD=   .1848E-01
RMS OF SHOCK SPEED=   .7184E-02    J=  7   MAX SHK SPD=  -.1870E-01
RMS OF SHOCK SPEED=   .7139E-02    J=  7   MAX SHK SPD=  -.1990E-01
RMS OF SHOCK SPEED=   .7094E-02    J=  7   MAX SHK SPD=  -.2096E-01
RMS OF SHOCK SPEED=   .7052E-02    J=  7   MAX SHK SPD=  -.2187E-01
RMS OF SHOCK SPEED=   .7013E-02    J=  7   MAX SHK SPD=  -.2262E-01
RMS OF SHOCK SPEED=   .6979E-02    J=  7   MAX SHK SPD=  -.2321E-01
RMS OF SHOCK SPEED=   .6951E-02    J=  7   MAX SHK SPD=  -.2365E-01
RMS OF SHOCK SPEED=   .6929E-02    J=  7   MAX SHK SPD=  -.2392E-01
RMS OF SHOCK SPEED=   .6914E-02    J=  7   MAX SHK SPD=  -.2402E-01
RMS OF SHOCK SPEED=   .6907E-02    J=  7   MAX SHK SPD=  -.2396E-01
RMS OF SHOCK SPEED=   .6907E-02    J=  7   MAX SHK SPD=  -.2374E-01
RMS OF SHOCK SPEED=   .6914E-02    J=  7   MAX SHK SPD=  -.2336E-01
RMS OF SHOCK SPEED=   .6929E-02    J=  7   MAX SHK SPD=  -.2283E-01
RMS OF SHOCK SPEED=   .6950E-02    J=  7   MAX SHK SPD=  -.2215E-01
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST    P/PINF       S         U/UINF      V/UINF       S/SINF      HT/HTI       R/RI         CP          X           Y        EI/EIINF
 1  .4567E+02 -.1911E+00  .4063E-02 -.8939E-01  .4085E+01  .1000E+01  .5609E+01  .1773E+01  .4228E-02 -.1911E+00  .8142E+01
 2  .4567E+02  .1911E+00  .4063E-02  .8939E-01  .4085E+01  .1000E+01  .5609E+01  .1773E+01  .4228E-02  .1911E+00  .8142E+01
 3  .3649E+02  .5734E+00  .1636E+00  .2269E+00  .4085E+01  .1000E+01  .4779E+01  .1408E+01  .3890E-01  .5719E+00  .7637E+01
 4  .1801E+02  .1098E+01  .4403E+00  .2795E+00  .4085E+01  .1000E+01  .2886E+01  .6751E+00  .4816E+00  .8532E+00  .6242E+01
 5  .1714E+02  .1533E+01  .4345E+00  .3089E+00  .4085E+01  .1000E+01  .2785E+01  .6403E+00  .8487E+00  .1086E+01  .6153E+01
 6  .2194E+02  .1881E+01  .3498E+00  .3153E+00  .4085E+01  .1000E+01  .3322E+01  .8309E+00  .1119E+01  .1306E+01  .6603E+01
 7  .2656E+02  .2189E+01  .2766E+00  .3061E+00  .4085E+01  .1000E+01  .3808E+01  .1014E+01  .1336E+01  .1525E+01  .6974E+01
 8  .2956E+02  .2481E+01  .2339E+00  .2924E+00  .4085E+01  .1000E+01  .4111E+01  .1133E+01  .1521E+01  .1750E+01  .7190E+01
 9  .3172E+02  .2771E+01  .2132E+00  .2729E+00  .4085E+01  .1000E+01  .4323E+01  .1219E+01  .1699E+01  .1979E+01  .7337E+01
10  .3378E+02  .3066E+01  .1960E+00  .2509E+00  .4085E+01  .1009E+01  .4522E+01  .1301E+01  .1881E+01  .2211E+01  .7470E+01
11  .3527E+02  .3372E+01  .1832E+00  .2344E+00' .4085E+01  .1000E+01  .4664E+01  .1360E+01  .2069E+01  .2452E+01  .7563E+01
12  .3584E+02  .3697E+01  .1781E+00  .2280E+00  .4085E+01  .1000E+01  .4717E+01  .1383E+01  .2269E+01  .2708E+01  .7597E+01
13  .3513E+02  .4049E+01  .1847E+00  .2357E+00  .4085E+01  .1000E+01  .4651E+01  .1355E+01  .2486E+01  .2986E+01  .7554E+01
14  .2698E+02  .4440E+01  .2847E+00  .2912E+00  .4085E+01  .1000E+01  .3852E+01  .1031E+01  .2728E+01  .3293E+01  .7006E+01
15  .1309E+02  .4827E+01  .5167E+00  .2839E+00  .4085E+01  .1000E+01  .2297E+01  .4797E+00  .3027E+01  .3539E+01  .5697E+01
16  .5470E+01  .5196E+01  .7062E+00  .1533E+00  .4085E+01  .1000E+01  .1232E+01  .1774E+00  .3378E+01  .3651E+01  .4440E+01
17  .3053E+01  .5572E+01  .7795E+00  .9571E-01  .4085E+01  .1000E+01  .8122E+00  .8147E-01  .3751E+01  .3697E+01  .3759E+01
18  .2379E+01  .5948E+01  .8019E+00  .9646E-01  .4085E+01  .1000E+01  .6796E+00  .5471E-01  .4125E+01  .3743E+01  .3500E+01
19  .2154E+01  .6324E+01  .8102E+00  .9948E-01  .4085E+01  .1000E+01  .6330E+00  .4578E-01  .4498E+01  .3788E+01  .3402E+01
20  .2024E+01  .6706E+01  .8153E+00  .1001E+00  .4085E+01  .1000E+01  .6056E+00  .4064E-01  .4878E+01  .3835E+01  .3342E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST    P/PINF     RO/RINF     U/UINF     V/UINF     S/SINF    HT/HTINF      MACH         CP          X          Y       EI/EIINF
  1  .4141E+02  .5262E+01  .1982E+00 -.8136E-01  .4051E+01  .1000E+01  .4583E+00  .1604E+01 -.1978E+00 -.2012E+00  .7870E+01
  2  .4141E+02  .5262E+01  .1982E+00  .8136E-01  .4051E+01  .1000E+01  .4583E+00  .1604E+01 -.1978E+00  .2012E+00  .7870E+01
  3  .3780E+02  .5201E+01  .2698E+00  .2379E+00  .3758E+01  .9999E+00  .8006E+00  .1460E+01 -.1169E+00  .5954E+00  .7267E+01
  4  .3124E+02  .5060E+01  .4000E+00  .3486E+00  .3228E+01  .1000E+01  .1281E+01  .1200E+01  .5047E-01  .9632E+00  .6174E+01
  5  .2486E+02  .4866E+01  .5269E+00  .3903E+00  .2714E+01  .1001E+01  .1740E+01  .9470E+00  .2870E+00  .1291E+01  .5110E+01
  6  .2053E+02  .4680E+01  .6128E+00  .3933E+00  .2365E+01  .1000E+01  .2086E+01  .7748E+00  .5572E+00  .1577E+01  .4385E+01
  7  .1866E+02  .4581E+01  .6480E+00  .3874E+00  .2216E+01  .9973E+00  .2244E+01  .7009E+00  .8362E+00  .1831E+01  .4074E+01
  8  .1970E+02  .4638E+01  .6274E+00  .3902E+00  .2299E+01  .9974E+00  .2151E+01  .7422E+00  .1100E+01  .2070E+01  .4248E+01
  9  .2313E+02  .4799E+01  .5610E+00  .3936E+00  .2574E+01  .1000E+01  .1873E+01  .8782E+00  .1340E+01  .2313E+01  .4820E+01
 10  .2744E+02  .4953E+01  .4760E+00  .3797E+00  .2921E+01  .1001E+01  .1552E+01  .1049E+01  .1556E+01  .2580E+01  .5540E+01
 11  .3087E+02  .5051E+01  .4078E+00  .3530E+00  .319[illegible]E+01  .1001E+01  .1309E+01  .1185E+01  .1757E+01  .2888E+01  .6112E+01
 12  .3228E+02  .5086E+01  .3794E+00  .3369E+00  .3312E+01  .1000E+01  .1208E+01  .1241E+01  .1957E+01  .3251E+01  .6348E+01
 13  .3163E+02  .5070E+01  .3922E+00  .3443E+00  .3259E+01  .1000E+01  .1254E+01  .1216E+01  .2180E+01  .3667E+01  .6239E+01
 14  .2954E+02  .5015E+01  .4338E+00  .3643E+00  .3090E+01  .1000E+01  .1400E+01  .1132E+01  .2451E+01  .4123E+01  .5890E+01
 15. .2669E+02  .4929E+01  .4903E+00  .3828E+00  .2861E+01  .1000E+01  .1604E+01  .1019E+01  .2786E+01  .4608E+01  .5415E+01
 16  .2371E+02  .4822E+01  .5498E+00  .3927E+00  .2620E+01  .1000E+01  .1828E+01  .9010E+00  .3198E+01  .5118E+01  .4917E+01
 17  .2110E+02  .4709E+01  .6012E+00  .3938E+00  .2412E+01  .1000E+01  .2037E+01  .7978E+00  .3601E+01  .5543E+01  .4482E+01
 18  .1897E+02  .4599E+01  .6434E+00  .3897E+00  .2241E+01  .1000E+01  .2222E+01  .7132E+00  .4034E+01  .5965E+01  .4126E+01
 19  .1702E+02  .4480E+01  .6821E+00  .3820E+00  .2086E+01  .1000E+01  .2406E+01  .6359E+00  .4498E+01  .6364E+01  .3800E+01
 20  .1508E+02  .4339E+01  .7208E+00  .3701E+00  .1931E+01  .1000E+01  .2608E+01  .5585E+00  .4878E+01  .6667E+01  .3474E+01

 SONIC LINE LOCATION

XSL=  .3083E+00   YSL=  .7431E+00
XSL=  .1252E+01   YSL=  .1441E+01
XSL=  .2769E+01   YSL=  .3327E+01
XSL=  .2449E+01   YSL=  .3035E+01
XSL=  .2194E+01   YSL=  .2782E+01
XSL=  .1946E+01   YSL=  .2519E+01
XSL=  .6259E+00   YSL=  .1145E+01
XSL=  .6818E+00   YSL=  .1194E+01
XSL=  .1632E+01   YSL=  .2180E+01
XSL=  .4427E+00   YSL=  .1044E+01
XSL=  .3329E+00   YSL=  .9963E+00
XSL=  .2407E+00   YSL=  .9577E+00
XSL=  .1523E+00   YSL=  .9103E+00
XSL=  .7236E-01   YSL=  .8517E+00
XSL=  .6425E-02   YSL=  .7975E+00
XSL= -.4749E-01   YSL=  .7479E+00

    PERCENT ERROR IN HT=   .1033E+02    RMS OF PERCENT ERROR IN HT=   .2847E+01

PRESSURE DRAG =        .9946295301

SOLUTION HAS BEEN STORED ON DISK
RESIDUE INFORMATION              19    11     .11682     .22049  52.982125( 19, 11, 4)=     .11387
```

*** skip print out ***

Example 6

Input Data Cards

```
    20   12   10    0    0    0    0
    16    4    5    2    3    0
  6.        1.4       7.        3.8263    2.        10000.    1.        0.2  0.4
  0.038     0.069     0.572     1.475     2.712     3.378     6.144
  0.569     0.615     0.906     1.692     3.274     3.651     3.99
  4.32      0.062     3.137     1.
  60.       38.       7.
  -2.86     2.86      8.59      14.31     20.03     25.76     31.48     37.2
  42.93     48.66     54.38     60.10     65.83     71.55     77.28     83.
  85.33     87.66     90.00     90.
  0.1
  100100100011
```

Printed Output

```
AXISYMMETRIC FLOW OVER NOSETIP



MACH NUMBER = 6.00
RATIO OF SPECIFIC HEAT = 1.40
CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
OMEGA =  3.826     (OMEGA.GT.0,OMEGA IS THE RADIUS OF SPHERE-CONES IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED
                    IN SUB. SHAPES OMEGA=0,MORE RAYS TO BE ADDED)

IR1 = 0      ( 1 FOR READ TAPE1$ 0     OTHERWISE)
IW2 = 0      (1 FOR WRITE ON TAPE2$ 0   OTHERWISE)
IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGEN$ 0     OTHERWISE)
IAFBD = 0      ( 1 FOR      STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)
IGEOM = 4      ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB,YB,XS,YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

LIP = 5      ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
IVIS = 0      (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

CF(BETA)= 10000.00000      ( FOR UNIFORM SPACING SET TO 10000)
CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
ITRAN = 3      (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
KRES = 2      (INTERVAL IN K FOR RESIDUE INFORMATION)
EXPLICIT DISSI. COEF. = .200
IMPLICIT DISSI. COEF. = .400
COURANT NO. =    2.00



JMAX=   20
KMAX=   12
JNM=   16      (JUNCTURE OF SPHERE AND CONE)
ITER =  10      (TIME STEPS FOR THIS RUN)
FREE STREAM CONDITIONS

PINF(PRESSURE) =  1.0000
RINF(DENSITY) =  1.0000
```

```
QINF(TOTAL VEL.) =  7.0993
AINF(SOUND SPEED) =  1.1832
UINF(U COMP.) =  7.0993
VINF(V COMP.) =  0.0000
HTINF(T. ENTHALPY) = 28.7000
ETINF(T. SPEC. ENERGY) = 27.7000
SINF(ENTROPY) =  1.0000
EIINF(INTERNAL ENERGY) =  2.5000


NORMALIZED DISTANCE FROM BODY TO SHOCK
                    0.000000   .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                     .909091  1.000000

   X AND Y VALUES FOR THE CONTROL POINTS
                     .03800    .06900    .57200   1.47500   2.71200   3.37800   6.14400
                     .56900    .61500    .90600   1.69200   3.27400   3.65100   3.99000

   RADIUS FOR CIRCULAR ARCS
                    4.32000    .06200   3.13700   1.00000

   ANGLES FOR STRAIGHT LINES
                   60.00000  38.00000   7.00000

   CENTERS FOR THE CIRCULAR ARCS
                    4.32000   0.00000    .10000    .56131   -.99650   3.62272   3.50001   2.65834

XOO=NEW OMEGA=    3.8263

THETA VALUES FOR CONTROL POINTS
                     .14909    .16224    .27153    .62376   1.24275   1.44862
 READ IN TH(J) IN DEGREE FOR INDENTED NOSETIP
                  -2.860000  2.860000  8.590000 14.310000 20.030000 25.760000 31.480000 37.200000 42.930000 48.660000
 READ IN TH(J) IN DEGREE FOR INDENTED NOSETIP
                  54.380000 60.100000 65.830000 71.550000 77.280000 83.000000 85.330000 87.660000 90.000000 90.000000

INDENTED NOSETIP SHAPE
                     J          THETA            RB              XB              YB             DELTA

                     1        -2.86000         3.82683          .00422        -.19094          -.00054
                     2         2.86000         3.82683          .00422         .19094          -.00054
                     3         8.59000         3.83031          .03895         .57211          -.00402
                     4        14.31000         3.45184          .48155         .85318           .37445
                     5        20.03000         3.16955          .84845        1.08561           .65673
                     6        25.76000         3.00599         1.11903        1.30641           .82030
                     7        31.48000         2.92019         1.33588        1.52492           .90610
                     8        37.20000         2.89482         1.52048        1.75021           .93147
                     9        42.93000         2.90529         1.69908        1.97880           .92100
                    10        48.66000         2.94537         1.88079        2.21139           .88092
                    11        54.38000         3.01699         2.06917        2.45250           .80930
                    12        60.10000         3.12407         2.26898        2.70824           .70222
                    13        65.83000         3.27312         2.48612        2.98618           .55317
                    14        71.55000         3.47183         2.72753        3.29338           .35446
                    15        77.28000         3.62862         3.02731        3.53956           .19767
                    16        83.00000         3.67829         3.37802        3.65087           .14800
```

*** skip print out ***

```
    FRACTION OF DELTA PREVIOUSLY DONE= 0.00
    FRACTION OF DELTA FOR THIS RUN=  .10
    TOTAL FRACTION OF    DELTA COMPLETED=  .10


BODY SHAPE CHANGE BEING INSTITUTED

ARC LENGTH
                    .19092     .57341     .95524    1.33707    1.71957    2.10140    2.48323    2.86573    3.24823    3.63006
                   4.01189    4.39438    4.77621    5.15871    5.54054    5.92281    6.30507    6.68734    7.06960

STARTING FLOWFIELD INFORMATION


SECOND INDEX=  1

1ST    P/PINF        S         U/QINF      V/QINF      S/SINF     HT/HTINF     R/RI        CP          X           Y        EI/EIINF
  1  .4670E+02 -.1909E+00  .1424E-02 -.2846E-01  .4085E+01  .1000E+01  .5699E+01  .1813E+01  .4766E-02 -.1909E+00  .8194E+01
  2  .4670E+02  .1909E+00  .1424E-02  .2846E-01  .4085E+01  .1000E+01  .5699E+01  .1813E+01  .4766E-02  .1909E+00  .8194E+01
  3  .4578E+02  .5734E+00  .1273E-01  .8435E-01  .4085E+01  .1000E+01  .5618E+01  .1777E+01  .4292E-01  .5715E+00  .8148E+01
  4  .4398E+02  .9552E+00  .3508E-01  .1375E+00  .4085E+01  .1000E+01  .5460E+01  .1706E+01  .1187E+00  .9457E+00  .8055E+01
  5  .4141E+02  .1337E+01  .6788E-01  .1862E+00  .4085E+01  .1000E+01  .5230E+01  .1603E+01  .2314E+00  .1311E+01  .7917E+01
  6  .3819E+02  .1720E+01  .1103E+00  .2285E+00  .4085E+01  .1000E+01  .4936E+01  .1476E+01  .3802E+00  .1663E+01  .7736E+01
  7  .3448E+02  .2101E+01  .1612E+00  .2633E+00  .4085E+01  .1000E+01  .4589E+01  .1329E+01  .5631E+00  .1998E+01  .7514E+01
  8  .3046E+02  .2483E+01  .2193E+00  .2889E+00  .4085E+01  .1000E+01  .4200E+01  .1169E+01  .7785E+00  .2313E+01  .7253E+01
  9  .2632E+02  .2866E+01  .2631E+00  .3044E+00  .4085E+01  .1000E+01  .3784E+01  .1005E+01  .1025E+01  .2606E+01  .6956E+01
 10  .2222E+02  .3248E+01  .3608E+00  .3087E+00  .4085E+01  .1000E+01  .3353E+01  .8422E+00  .1299E+01  .2873E+01  .6628E+01
 11  .1834E+02  .3630E+01  .4205E+00  .3013E+00  .4085E+01  .1000E+01  .2923E+01  .6879E+00  .1598E+01  .3110E+01  .6273E+01
 12  .1480E+02  .4012E+01  .4899E+00  .2817E+00  .4085E+01  .1000E+01  .2508E+01  .5475E+00  .1919E+01  .3317E+01  .5901E+01
 13  .1173E+02  .4394E+01  .5564E+00  .2498E+00  .4085E+01  .1000E+01  .2124E+01  .4258E+00  .2260E+01  .3491E+01  .5522E+01
 14  .9214E+01  .4776E+01  .6170E+00  .2058E+00  .4085E+01  .1000E+01  .1788E+01  .3260E+00  .2615E+01  .3630E+01  .5154E+01
 15  .7328E+01  .5159E+01  .6676E+00  .1508E+00  .4085E+01  .1000E+01  .1518E+01  .2511E+00  .2984E+01  .3732E+01  .4827E+01
 16  .6352E+01  .5541E+01  .6962E+00  .1032E+00  .4085E+01  .1000E+01  .1371E+01  .2124E+00  .3360E+01  .3798E+01  .4634E+01
 17  .6113E+01  .5923E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .3739E+01  .3844E+01  .4584E+01
 18  .6113E+01  .6305E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4119E+01  .3891E+01  .4584E+01
 19  .6113E+01  .6687E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4498E+01  .3938E+01  .4584E+01
 20  .6113E+01  .7070E+01  .7034E+00  .8637E-01  .4085E+01  .1000E+01  .1334E+01  .2029E+00  .4878E+01  .3984E+01  .4584E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST    P/PINF     RO/RINF      U/QINF      V/QINF      S/SINF     HT/HTINF     MACH        CP          X           Y        EI/EIINF
  1  .4174E+02  .5267E+01  .1918E+00 -.3901E-01  .4077E+01  .1000E+01  .4171E+00  .1616E+01 -.5612E+00 -.2192E+00  .7924E+01
  2  .4174E+02  .5267E+01  .1918E+00  .3901E-01  .4077E+01  .1000E+01  .4171E+00  .1616E+01 -.5612E+00  .2192E+00  .7924E+01
  3  .4098E+02  .5255E+01  .2068E+00  .1144E+00  .4016E+01  .1000E+01  .5078E+00  .1586E+01 -.5189E+00  .6564E+00  .7798E+01
  4  .3956E+02  .5232E+01  .2349E+00  .1830E+00  .3901E+01  .1000E+01  .6497E+00  .1530E+01 -.4360E+00  .1087E+01  .7562E+01
  5  .3766E+02  .5198E+01  .2727E+00  .2417E+00  .3747E+01  .1000E+01  .8123E+00  .1455E+01 -.3149E+00  .1510E+01  .7244E+01
  6  .3545E+02  .5156E+01  .3164E+00  .2894E+00  .3568E+01  .1000E+01  .9811E+00  .1367E+01 -.1583E+00  .1923E+01  .6876E+01
  7  .3311E+02  .5105E+01  .3630E+00  .3262E+00  .3378E+01  .1000E+01  .1150E+01  .1274E+01  .3004E-01  .2325E+01  .6485E+01
  8  .3075E+02  .5048E+01  .4098E+00  .3534E+00  .3188E+01  .1000E+01  .1316E+01  .1180E+01  .2480E+00  .2716E+01  .6092E+01
  9  .2846E+02  .4984E+01  .4553E+00  .3724E+00  .3003E+01  .1000E+01  .1477E+01  .1089E+01  .4942E+00  .3100E+01  .5709E+01
 10  .2627E+02  .4916E+01  .4985E+00  .3847E+00  .2827E+01  .1000E+01  .1634E+01  .1003E+01  .7678E+00  .3476E+01  .5345E+01
 11  .2422E+02  .4842E+01  .5392E+00  .3915E+00  .2662E+01  .1000E+01  .1788E+01  .9216E+00  .1069E+01  .3849E+01  .5003E+01
 12  .2231E+02  .4764E+01  .5773E+00  .3941E+00  .2508E+01  .1000E+01  .1938E+01  .8455E+00  .1400E+01  .4220E+01  .4683E+01
 13  .2052E+02  .4680E+01  .6128E+00  .3931E+00  .2365E+01  .1000E+01  .2086E+01  .7745E+00  .1764E+01  .4595E+01  .4384E+01
 14  .1884E+02  .4591E+01  .6460E+00  .3893E+00  .2231E+01  .1000E+01  .2234E+01  .7079E+00  .2166E+01  .4975E+01  .4104E+01
 15  .1727E+02  .4496E+01  .6772E+00  .3831E+00  .2105E+01  .1000E+01  .2382E+01  .6456E+00  .2615E+01  .5368E+01  .3841E+01
 16  .1595E+02  .4406E+01  .7033E+00  .3759E+00  .2001E+01  .1000E+01  .2515E+01  .5933E+00  .3117E+01  .5776E+01  .3621E+01
 17  .1473E+02  .4312E+01  .7276E+00  .3675E+00  .1904E+01  .1000E+01  .2646E+01  .5448E+00  .3554E+01  .6110E+01  .3416E+01
 18  .1373E+02  .4226E+01  .7475E+00  .3592E+00  .1825E+01  .1000E+01  .2761E+01  .5051E+00  .4015E+01  .6442E+01  .3248E+01
 19  .1292E+02  .4150E+01  .7635E+00  .3515E+00  .1762E+01  .1000E+01  .2858E+01  .4730E+00  .4498E+01  .6773E+01  .3113E+01
 20  .1191E+02  .4046E+01  .7835E+00  .3407E+00  .1683E+01  .1000E+01  .2988E+01  .4330E+00  .4878E+01  .7022E+01  .2944E+01
```

```
SONIC LINE LOCATION

XSL=  .1129E+01   YSL=  .2707E+01
XSL=  .9595E+00   YSL=  .2630E+01
XSL=  .8122E+00   YSL=  .2550E+01
XSL=  .6760E+00   YSL=  .2478E+01
XSL=  .5519E+00   YSL=  .2406E+01
XSL=  .4380E+00   YSL=  .2336E+01
XSL=  .3292E+00   YSL=  .2270E+01
XSL=  .2244E+00   YSL=  .2207E+01
XSL=  .1302E+00   YSL=  .2143E+01
XSL=  .3882E-01   YSL=  .2082E+01
XSL= -.5022E-01   YSL=  .2024E+01
XSL= -.1373E+00   YSL=  .1968E+01

    PERCENT ERROR IN HT=   .4357E-11    RMS OF PERCENT ERROR IN HT=   .2275E-11

PRESSURE DRAG =        .9051161900

SIGMAX= .9079E+02   J=   1   K=   12   SIGMIN=  .8385E+01   J=   1   K=   12   CN= .2000E+01   DT= .2203E-01
RESIDUE INFORMATION            16   11    .26432   1.20541  21.92810S( 16, 11, 4)=    .25832
RMS OF SHOCK SPEED=   .7166E-01   J= 16   MAX SHK SPD=  -.1417E+00
RMS OF SHOCK SPEED=   .7187E-01   J= 17   MAX SHK SPD=  -.1443E+00
RMS OF SHOCK SPEED=   .7645E-01   J=  2   MAX SHK SPD=  -.1483E+00
RMS OF SHOCK SPEED=   .9441E-01   J=  2   MAX SHK SPD=  -.2172E+00
RMS OF SHOCK SPEED=   .1117E+00   J=  2   MAX SHK SPD=  -.2774E+00
RMS OF SHOCK SPEED=   .1258E+00   J=  2   MAX SHK SPD=  -.3201E+00
RMS OF SHOCK SPEED=   .1342E+00   J=  2   MAX SHK SPD=  -.3422E+00
RMS OF SHOCK SPEED=   .1360E+00   J=  2   MAX SHK SPD=  -.3428E+00
RMS OF SHOCK SPEED=   .1313E+00   J=  2   MAX SHK SPD=  -.3225E+00
RMS OF SHOCK SPEED=   .1214E+00   J=  2   MAX SHK SPD=  -.2846E+00
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST   P/PINF        S          U/QINF      V/QINF      S/SINF     HT/HTINF     R/RI        CP          X           Y         EI/EIINF
 1  .4625E+02 -.1909E+00  .3105E-02 -.6260E-01  .4085E+01  .1000E+01  .5660E+01  .1796E+01  .4711E-02 -.1909E+00  .8172E+01
 2  .4625E+02  .1909E+00  .3105E-02  .6260E-01  .4085E+01  .1000E+01  .5660E+01  .1796E+01  .4711E-02  .1909E+00  .8172E+01
 3  .4386E+02  .5734E+00  .2867E-01  .1422E+00  .4085E+01  .1000E+01  .5449E+01  .1701E+01  .4252E-01  .5716E+00  .8048E+01
 4  .4092E+02  .9552E+00  .6841E-01  .1956E+00  .4085E+01  .1000E+01  .5186E+01  .1584E+01  .1550E+00  .9365E+00  .7891E+01
 5  .3797E+02  .1337E+01  .1022E+00  .2360E+00  .4085E+01  .1000E+01  .4916E+01  .1467E+01  .2931E+00  .1288E+01  .7724E+01
 6  .3493E+02  .1720E+01  .1403E+00  .2678E+00  .4085E+01  .1000E+01  .4632E+01  .1346E+01  .4541E+00  .1627E+01  .7542E+01
 7  .3155E+02  .2101E+01  .1863E+00  .2944E+00  .4085E+01  .1000E+01  .4307E+01  .1212E+01  .6404E+00  .1951E+01  .7326E+01
 8  .2787E+02  .2483E+01  .2401E+00  .3150E+00  .4085E+01  .1000E+01  .3941E+01  .1066E+01  .8527E+00  .2257E+01  .7070E+01
 9  .2399E+02  .2866E+01  .3009E+00  .3278E+00  .4085E+01  .1000E+01  .3542E+01  .9125E+00  .1092E+01  .2543E+01  .6775E+01
10  .2023E+02  .3248E+01  .3650E+00  .3309E+00  .4085E+01  .1000E+01  .3136E+01  .7632E+00  .1357E+01  .2807E+01  .6452E+01
11  .1679E+02  .3630E+01  .4296E+00  .3236E+00  .4085E+01  .1000E+01  .2744E+01  .6264E+00  .1645E+01  .3045E+01  .6117E+01
12  .1376E+02  .4012E+01  .4926E+00  .3059E+00  .4085E+01  .1000E+01  .2381E+01  .5063E+00  .1954E+01  .3256E+01  .5779E+01
13  .1114E+02  .4394E+01  .5525E+00  .2792E+00  .4085E+01  .1000E+01  .2047E+01  .4023E+00  .2282E+01  .3440E+01  .5441E+01
14  .8685E+01  .4776E+01  .6153E+00  .2377E+00  .4085E+01  .1000E+01  .1714E+01  .3050E+00  .2627E+01  .3596E+01  .5067E+01
15  .6607E+01  .5159E+01  .6770E+00  .1723E+00  .4085E+01  .1000E+01  .1410E+01  .2225E+00  .2988E+01  .3713E+01  .4687E+01
16  .5655E+01  .5541E+01  .7101E+00  .1099E+00  .4085E+01  .1000E+01  .1262E+01  .1847E+00  .3362E+01  .3783E+01  .4483E+01
17  .5691E+01  .5923E+01  .7124E+00  .8747E-01  .4085E+01  .1000E+01  .1267E+01  .1861E+00  .3741E+01  .3830E+01  .4491E+01
18  .5911E+01  .6305E+01  .7077E+00  .8689E-01  .4085E+01  .1000E+01  .1302E+01  .1949E+00  .4119E+01  .3876E+01  .4540E+01
19  .5870E+01  .6687E+01  .7086E+00  .8700E-01  .4085E+01  .1000E+01  .1296E+01  .1932E+00  .4498E+01  .3923E+01  .4531E+01
20  .5949E+01  .7070E+01  .7069E+00  .8679E-01  .4085E+01  .1000E+01  .1308E+01  .1964E+00  .4878E+01  .3969E+01  .4548E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST    P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF     HT/HTINF      MACH        CP          X           Y         EI/EIINF
 1  .3849E+02  .5213E+01  .2251E+00 -.2639E-01  .3814E+01  .9454E+00  .5006E+00  .1488E+01 -.5081E+00 -.2165E+00  .7382E+01
 2  .3849E+02  .5213E+01  .2251E+00  .2639E-01  .3814E+01  .9454E+00  .5006E+00  .1488E+01 -.5081E+00  .2165E+00  .7382E+01
 3  .3866E+02  .5216E+01  .2279E+00  .8858E-01  .3828E+01  .9563E+00  .5389E+00  .1494E+01 -.4799E+00  .6505E+00  .7412E+01
 4  .3826E+02  .5209E+01  .2440E+00  .1605E+00  .3795E+01  .9706E+00  .6466E+00  .1479E+01 -.4118E+00  .1081E+01  .7345E+01
 5  .3712E+02  .5188E+01  .2738E+00  .2263E+00  .3703E+01  .9834E+00  .7968E+00  .1433E+01 -.3016E+00  .1505E+01  .7155E+01
 6  .3550E+02  .5157E+01  .3120E+00  .2801E+00  .3572E+01  .9940E+00  .9588E+00  .1369E+01 -.1531E+00  .1920E+01  .6885E+01
 7  .3354E+02  .5115E+01  .3557E+00  .3228E+00  .3413E+01  .1002E+01  .1126E+01  .1291E+01  .2979E-01  .2325E+01  .6557E+01
 8  .3133E+02  .5062E+01  .4025E+00  .3548E+00  .3235E+01  .1007E+01  .1294E+01  .1204E+01  .2449E+00  .2718E+01  .6189E+01
 9  .2898E+02  .4999E+01  .4501E+00  .3766E+00  .3045E+01  .1009E+01  .1463E+01  .1110E+01  .4908E+00  .3103E+01  .5797E+01
10  .2660E+02  .4926E+01  .4967E+00  .3893E+00  .2853E+01  .1008E+01  .1629E+01  .1016E+01  .7656E+00  .3479E+01  .5400E+01
11  .2429E+02  .4844E+01  .5407E+00  .3947E+00  .2667E+01  .1005E+01  .1794E+01  .9242E+00  .1069E+01  .3849E+01  .5014E+01
12  .2212E+02  .4755E+01  .5814E+00  .3946E+00  .2493E+01  .1001E+01  .1955E+01  .8381E+00  .1401E+01  .4217E+01  .4652E+01
13  .2013E+02  .4661E+01  .6189E+00  .3911E+00  .2334E+01  .9974E+00  .2114E+01  .7592E+00  .1767E+01  .4588E+01  .4319E+01
14  .1830E+02  .4560E+01  .6535E+00  .3847E+00  .2188E+01  .9944E+00  .2271E+01  .6867E+00  .2170E+01  .4965E+01  .4014E+01
15  .1668E+02  .4457E+01  .6850E+00  .3769E+00  .2058E+01  .9931E+00  .2425E+01  .6221E+00  .2618E+01  .5354E+01  .3742E+01
16  .1535E+02  .4361E+01  .7109E+00  .3686E+00  .1953E+01  .9924E+00  .2561E+01  .5695E+00  .3119E+01  .5758E+01  .3520E+01
17  .1426E+02  .4272E+01  .7331E+00  .3608E+00  .1867E+01  .9931E+00  .2684E+01  .5260E+00  .3556E+01  .6090E+01  .3337E+01
18  .1337E+02  .4193E+01  .7506E+00  .3532E+00  .1797E+01  .9931E+00  .2787E+01  .4910E+00  .4016E+01  .6421E+01  .3189E+01
19  .1277E+02  .4135E+01  .7623E+00  .3471E+00  .1750E+01  .9926E+00  .2860E+01  .4669E+00  .4498E+01  .6755E+01  .3087E+01
20  .1216E+02  .4073E+01  .7744E+00  .3408E+00  .1703E+01  .9927E+00  .2938E+01  .4428E+00  .4878E+01  .7011E+01  .2986E+01

 SONIC LINE LOCATION

XSL=  .1045E+01   YSL=  .2488E+01
XSL=  .1004E+01   YSL=  .2554E+01
XSL=  .8791E+00   YSL=  .2514E+01
XSL=  .7440E+00   YSL=  .2457E+01
XSL=  .6218E+00   YSL=  .2409E+01
XSL=  .5119E+00   YSL=  .2362E+01
XSL=  .4061E+00   YSL=  .2318E+01
XSL=  .3017E+00   YSL=  .2273E+01
XSL=  .1962E+00   YSL=  .2222E+01
XSL=  .9532E-01   YSL=  .2160E+01
XSL= -.8122E-02   YSL=  .2088E+01
XSL= -.1079E+00   YSL=  .2020E+01

   PERCENT ERROR IN HT=   .5768E+01    RMS OF PERCENT ERROR IN HT=   .1656E+01

PRESSURE DRAG =        .8142959540
RESIDUE INFORMATION              19    11    .14433    .61033  23.648085( 19, 11, 4)=    .14044

                                                  DETAILED RESIDUE INFORMATION
                                                  ****************************
                                                            SECOND INDEX =   2
  2   .1754144E-02   .4123894E-02   .4892347E-03   .5151147E-01     3   .1351950E-02   .4556762E-02   .1088632E-02   .3972491E-01
  4  -.2487260E-04   .3035760E-02   .3168139E-03   .1032911E-02     5  -.3914614E-03   .1982311E-02  -.8637616E-03  -.9701139E-02
  6  -.5980167E-03   .9161802E-03  -.1656923E-02  -.1606058E-01     7  -.7278385E-03  -.1144006E-04  -.2088648E-02  -.2002488E-01
  8  -.7923055E-03  -.7429449E-03  -.2267774E-02  -.2183038E-01     9  -.8827863E-03  -.1440850E-02  -.2531996E-02  -.2421212E-01
 10  -.9991730E-03  -.2485498E-02  -.2692505E-02  -.2748265E-01    11  -.1151674E-02  -.4057022E-02  -.2541553E-02  -.3212162E-01
 12  -.1319783E-02  -.6070299E-02  -.1907998E-02  -.3778002E-01    13  -.1301113E-02  -.7255415E-02  -.3543037E-03  -.3799441E-01
 14  -.1378161E-02  -.7874631E-02   .8393749E-03  -.3883615E-01    15  -.2294998E-02  -.1229200E-01   .6131432E-03  -.6177820E-01
 16  -.3412369E-02  -.1850684E-01   .8767233E-03  -.9159454E-01    17  -.3787254E-02  -.2130089E-01   .1211705E-02  -.1055201E+00
 18  -.2584372E-02  -.1442840E-01   .7684420E-03  -.7343886E-01    19  -.2630736E-02  -.1500538E-01   .1006744E-02  -.7456091E-01
```

*** skip print out ***

Example 7

Input Data Cards

```
   20    12    10    0    1    0    0
   16     3     0    2    3    0
 6.          1.4      7.        0.        2.        10000.    1.         0.4   0.0
   3     4     0
0.01568   0.0837    0.1178
0.038     0.069     0.572     1.475     2.712     3.378     6.144
0.569     0.615     0.906     1.692     3.274     3.651     3.99
4.32      0.062     3.137     1.
60.       38.       7.
111111111111
```

Printed Output

```
 AXISYMMETRIC FLOW OVER NOSETIP


 MACH NUMBER = 6.00
 RATIO OF SPECIFIC HEAT = 1.40
 CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
 OMEGA =  0.000       (OMEGA.GT,0,OMEGA IS THE RADIUS OF SPHERE-CONES IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED
                      IN SUB. SHAPES OMEGA=0,MORE RAYS TO BE ADDED)

 IR1 = 1       ( 1 FOR READ TAPE1S 0     OTHERWISE)
 IW2 = 0       (1 FOR WRITE ON TAPE2S 0   OTHERWISE)
 IPRT = 0       ( 1 FOR DETAILED WRITE OUT FROM EIGENS 0     OTHERWISE)
 IAFBD = 0       ( 1 FOR       STORAGE OF STARTING DATA FOR AFTERBODY CAL.S 0     OTHERWISE)
 IGEOM = 3       ( 0 FOR UNIFORM SPACING ON NOSE S 1 FOR READ IN XB,YB,XS,YS S 2 FOR READ IN TH(J) AND DETT(J) S
                  3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)S 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

 LIP =   0       ( 0 FOR WITHOUT SHAPE CHANGE S  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
 IVIS = 0      (  0 FOR INVISCID FLOW S 1 FOR LAMINAR FLOW)

 CF(BETA)= 10000.00000      ( FOR UNIFORM SPACING SET TO 10000)
 CC = 1.00       (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
 ITRAN = 3       (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
 KRES = 2      (INTERVAL IN K FOR RESIDUE INFORMATION)
 EXPLICIT DISSI. COEF. = .400
 IMPLICIT DISSI. COEF. =0.000
 COURANT NO. =     2.00



 JMAX=   20
 KMAX=   12
 JNM=   16       (JUNCTURE OF SPHERE AND CONE)
 ITER =  10       (TIME STEPS FOR THIS RUN)

FREE STREAM CONDITIONS

 PINF(PRESSURE) =  1.0000
 RINF(DENSITY) =  1.0000
 QINF(TOTAL VEL.) =  7.0993
 AINF(SOUND SPEED) =  1.1832
 UINF(U COMP.) =  7.0993
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```
  VINF(V COMP.) =  0.0000
  HTINF(T. ENTHALPY) = 28.7000
  ETINF(T. SPEC. ENERGY) = 27.7000
  SINF(ENTROPY) =  1.0000
  EIINF(INTERNAL ENERGY) =  2.5000


  NORMALIZED DISTANCE FROM BODY TO SHOCK
                    0.000000   .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                     .909091  1.000000

 STAGNATION PRESSURE PT=   46.8152

 STARTING SOLUTION WAS READ FROM TAPE

 INFORMATION FOR NOSETIP SHAPE

 ADDING GRIDS IN J-ARRAY, NO. OF RAYS = 3          JIX = 4

      X AND Y VALUES FOR THE CONTROL POINTS
                      .03800    .06900    .57200   1.47500   2.71200   3.37800   6.14400
                      .56900    .61500    .90600   1.69200   3.27400   3.65100   3.99000

      RADIUS FOR CIRCULAR ARCS
                     4.32000    .06200   3.13700   1.00000

      ANGLES FOR STRAIGHT LINES
                    60.00000  38.00000   7.00000

      CENTERS FOR THE CIRCULAR ARCS
                     4.32000   0.00000    .10000    .56131   -.99650   3.62272   3.50001   2.65834

 XOO=NEW OMEGA=    3.8263

 THETA VALUES FOR CONTROL POINTS
                      .14909    .16224    .27153    .62376   1.24275   1.44862


 NEW POINTS ON BODY:
     RAY = 1     AT THB =    .90     XA =   .0004     YA =   .0600
     RAY = 2     AT THB =   4.80     XA =   .0119     YA =   .3200
     RAY = 3     AT THB =   6.75     XA =   .0235     YA =   .4501

 SURFACE PRESSURE DISTRIBUTION AFTER ADDING POINTS
                    45.67281  45.67281  45.13152  41.68005  37.68762  33.59906  15.52257  16.51121  22.70782  27.69290
                    31.75177  37.05012  40.41206  40.52891  37.77051  34.12792  24.54442  11.24408   4.57554   2.69017
                     2.39591   2.37828   2.40186

 ARC LENGTH
                      .06000    .19114    .32030    .45085    .57363   1.09814   1.53273   1.88159   2.18967   2.48112
                     2.77092   3.06577   3.37196   3.69674   4.04909   4.44007   4.82760   5.19581   5.57204   5.94826
                     6.32443   6.70670

 STARTING FLOWFIELD INFORMATION

 SECOND INDEX=  1

 1ST   P/PINF        S        U/QINF     V/QINF      S/SINF     HT/HTINF     R/RI         CP          X          Y        EI/EIINF
  1  .4567E+02 -.6000E-01  .4946E-02 -.3414E-01  .4141E+01  .1004E+01  .5555E+01  .1773E+01  .4166E-03 -.5999E-01  .8222E+01
  2  .4567E+02  .6000E-01  .4944E-02  .3414E-01  .4141E+01  .1004E+01  .5555E+01  .1773E+01  .4166E-03  .5999E-01  .8222E+01
  3  .4513E+02  .1911E+00  .4944E-02  .1088E+00  .4085E+01  .1000E+01  .5562E+01  .1751E+01  .4228E-02  .1911E+00  .8115E+01
```

```
  4  .4168E+02  .3203E+00  .6667E-01  .1600E+00  .4140E+01  .1003E+01  .5205E+01  .1614E+01  .1187E-01  .3200E+00  .8008E+01
  5  .3769E+02  .4509E+00  .1290E+00  .2117E+00  .4139E+01  .1003E+01  .4844E+01  .1456E+01  .2351E-01  .4501E+00  .7780E+01
  6  .3360E+02  .5736E+00  .1877E+00  .2603E+00  .4085E+01  .1000E+01  .4505E+01  .1294E+01  .3890E-01  .5719E+00  .7459E+01
  7  .1552E+02  .1098E+01  .4686E+00  .2974E+00  .4085E+01  .1000E+01  .2595E+01  .5763E+00  .4816E+00  .8532E+00  .5982E+01
  8  .1651E+02  .1533E+01  .4414E+00  .3138E+00  .4085E+01  .1000E+01  .2712E+01  .6155E+00  .8487E+00  .1086E+01  .6088E+01
  9  .2271E+02  .1882E+01  .3426E+00  .3088E+00  .4085E+01  .1000E+01  .3405E+01  .8614E+00  .1119E+01  .1306E+01  .6669E+01
 10  .2769E+02  .2190E+01  .2672E+00  .2954E+00  .4085E+01  .1000E+01  .3924E+01  .1059E+01  .1336E+01  .1525E+01  .7058E+01
 11  .3175E+02  .2481E+01  .2161E+00  .2700E+00  .4085E+01  .1000E+01  .4326E+01  .1220E+01  .1521E+01  .1750E+01  .7339E+01
 12  .3705E+02  .2771E+01  .1671E+00  .2138E+00  .4085E+01  .1000E+01  .4831E+01  .1431E+01  .1699E+01  .1979E+01  .7670E+01
 13  .4041E+02  .3066E+01  .1333E+00  .1706E+00  .4085E+01  .1000E+01  .5140E+01  .1564E+01  .1881E+01  .2211E+01  .7863E+01
 14  .4053E+02  .3372E+01  .1320E+00  .1689E+00  .4085E+01  .1000E+01  .5150E+01  .1569E+01  .2069E+01  .2452E+01  .7869E+01
 15  .3777E+02  .3697E+01  .1603E+00  .2051E+00  .4085E+01  .1000E+01  .4898E+01  .1459E+01  .2269E+01  .2708E+01  .7712E+01
 16  .3413E+02  .4049E+01  .1934E+00  .2468E+00  .4085E+01  .1000E+01  .4555E+01  .1315E+01  .2486E+01  .2986E+01  .7492E+01
 17  .2454E+02  .4440E+01  .3062E+00  .3132E+00  .4085E+01  .1000E+01  .3600E+01  .9343E+00  .2728E+01  .3293E+01  .6819E+01
 18  .1124E+02  .4828E+01  .5411E+00  .2973E+00  .4085E+01  .1000E+01  .2061E+01  .4065E+00  .3027E+01  .3539E+01  .5455E+01
 19  .4576E+01  .5196E+01  .7266E+00  .1578E+00  .4085E+01  .1000E+01  .1084E+01  .1419E+00  .3378E+01  .3651E+01  .4219E+01
 20  .2690E+01  .5572E+01  .7912E+00  .9714E-01  .4085E+01  .1000E+01  .7420E+00  .6707E-01  .3751E+01  .3697E+01  .3625E+01
 21  .2396E+01  .5948E+01  .8013E+00  .9839E-01  .4085E+01  .1000E+01  .6831E+00  .5539E-01  .4125E+01  .3743E+01  .3507E+01
 22  .2378E+01  .6324E+01  .8019E+00  .9846E-01  .4085E+01  .1000E+01  .6795E+00  .5469E-01  .4498E+01  .3788E+01  .3500E+01
 23  .2402E+01  .6707E+01  .8011E+00  .9836E-01  .4085E+01  .1000E+01  .6843E+00  .5563E-01  .4878E+01  .3835E+01  .3510E+01
```

*** skip print out ***

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SECOND INDEX= 12

1ST   P/PINF     RO/RINF    U/QINF     V/QINF     S/SINF    HT/HTINF     MACH       CP         X          Y        EI/EIINF
  1  .4141E+02  .5224E+01  .1989E+00 -.2617E-01  .4092E+01  .1002E+01  .4274E+00  .1603E+01 -.1898E+00 -.6298E-01  .7927E+01
  2  .4141E+02  .5224E+01  .1989E+00  .2617E-01  .4092E+01  .1002E+01  .4274E+00  .1603E+01 -.1898E+00  .6298E-01  .7927E+01
  3  .4137E+02  .5261E+01  .1989E+00  .8338E-01  .4048E+01  .9998E+00  .4614E+00  .1602E+01 -.1857E+00  .2006E+00  .7864E+01
  4  .4033E+02  .5236E+01  .2274E+00  .1408E+00  .3972E+01  .1002E+01  .5782E+00  .1561E+01 -.1469E+00  .3333E+00  .7702E+01
  5  .3885E+02  .5211E+01  .2562E+00  .1988E+00  .3852E+01  .1002E+01  .7125E+00  .1502E+01 -.1271E+00  .4679E+00  .7455E+01
  6  .3708E+02  .5187E+01  .2833E+00  .2533E+00  .3700E+01  .9984E+00  .8529E+00  .1432E+01 -.1031E+00  .5933E+00  .7147E+01
  7  .2907E+02  .5002E+01  .4475E+00  .3747E+00  .3053E+01  .1008E+01  .1453E+01  .1114E+01  .8071E-01  .9555E+00  .5812E+01
  8  .2153E+02  .4729E+01  .5855E+00  .3866E+00  .2446E+01  .9875E+00  .1973E+01  .8148E+00  .3540E+00  .1266E+01  .4553E+01
  9  .1740E+02  .4504E+01  .6525E+00  .3639E+00  .2116E+01  .9613E+00  .2281E+01  .6508E+00  .6306E+00  .1542E+01  .3863E+01
 10  .1792E+02  .4537E+01  .6977E+00  .4128E+00  .2157E+01  .1059E+01  .2447E+01  .6715E+00  .9000E+00  .1792E+01  .3950E+01
 11  .2242E+02  .4769E+01  .6334E+00  .4490E+00  .2517E+01  .1103E+01  .2148E+01  .8501E+00  .1219E+01  .1980E+01  .4702E+01
 12  .2832E+02  .4980E+01  .4641E+00  .3821E+00  .2992E+01  .1011E+01  .1512E+01  .1084E+01  .1434E+01  .2225E+01  .5686E+01
 13  .3340E+02  .5112E+01  .3575E+00  .3229E+00  .3402E+01  .1001E+01  .1131E+01  .1286E+01  .1609E+01  .2520E+01  .6534E+01
 14  .3575E+02  .5162E+01  .3066E+00  .2741E+00  .3592E+01  .9932E+00  .9376E+00  .1379E+01  .1764E+01  .2879E+01  .6926E+01
 15  .3500E+02  .5146E+01  .3167E+00  .2769E+00  .3532E+01  .9848E+00  .9677E+00  .1349E+01  .1922E+01  .3312E+01  .6802E+01
 16  .3250E+02  .5091E+01  .3669E+00  .3185E+00  .3330E+01  .9858E+00  .1154E+01  .1250E+01  .2129E+01  .3781E+01  .6384E+01
 17  .2941E+02  .5012E+01  .4361E+00  .3650E+00  .3080E+01  .9996E+00  .1408E+01  .1127E+01  .2403E+01  .4267E+01  .5868E+01
 18  .2615E+02  .4911E+01  .5128E+00  .4000E+00  .2817E+01  .1021E+01  .1691E+01  .9979E+00  .2754E+01  .4749E+01  .5324E+01
 19  .2293E+02  .4790E+01  .5825E+00  .4123E+00  .2558E+01  .1031E+01  .1957E+01  .8701E+00  .3185E+01  .5222E+01  .4786E+01
 20  .2012E+02  .4660E+01  .6400E+00  .4104E+00  .2333E+01  .1034E+01  .2195E+01  .7589E+00  .3596E+01  .5602E+01  .4318E+01
 21  .1796E+02  .4539E+01  .6780E+00  .3983E+00  .2160E+01  .1025E+01  .2372E+01  .6730E+00  .4034E+01  .5967E+01  .3957E+01
 22  .1623E+02  .4425E+01  .7055E+00  .3835E+00  .2022E+01  .1013E+01  .2516E+01  .6042E+00  .4498E+01  .6330E+01  .3667E+01
 23  .1449E+02  .4292E+01  .7349E+00  .3674E+00  .1885E+01  .1004E+01  .2683E+01  .5354E+00  .4878E+01  .6613E+01  .3376E+01

 SONIC LINE LOCATION

XSL=  .2378E+00   YSL=  .6982E+00
XSL=  .1209E+01   YSL=  .1397E+01
XSL=  .2723E+01   YSL=  .3287E+01
XSL=  .3449E+00   YSL=  .7935E+00
XSL=  .8956E+00   YSL=  .1179E+01
XSL=  .2193E+01   YSL=  .2701E+01
XSL=  .3572E+00   YSL=  .8332E+00
XSL=  .8130E+00   YSL=  .1165E+01
XSL=  .1915E+01   YSL=  .2387E+01
XSL=  .3118E+00   YSL=  .8318E+00
```

```
XSL=  .8250E+00    YSL=  .1231E+01
XSL=  .1684E+01    YSL=  .2125E+01
XSL=  .2773E+00    YSL=  .8382E+00
XSL=  .9385E+00    YSL=  .1390E+01
XSL=  .1457E+01    YSL=  .1890E+01
XSL=  .2431E+00    YSL=  .8447E+00
XSL=  .2002E+00    YSL=  .8412E+00
XSL=  .1438E+00    YSL=  .8193E+00
XSL=  .8537E-01    YSL=  .7876E+00
XSL=  .1974E+01    YSL=  .3050E+01
XSL=  .2202E+01    YSL=  .3515E+01
XSL=  .3078E-01    YSL=  .7520E+00
XSL=  .1844E+01    YSL=  .2862E+01
XSL=  .2097E+01    YSL=  .3435E+01
XSL= -.1602E-01    YSL=  .7182E+00
XSL=  .1765E+01    YSL=  .2781E+01
XSL=  .2024E+01    YSL=  .3408E+01
XSL= -.5799E-01    YSL=  .6821E+00
XSL=  .1714E+01    YSL=  .2763E+01
XSL=  .1958E+01    YSL=  .3393E+01

    PERCENT ERROR IN HT-   .1027E-02   RMS OF PERCENT ERROR IN HT-   [illegible]

PRESSURE DRAG =       1.0282449282

SIGMAX= .3742E+03   J=    6   K=    1   SIGMIN=  .8842E+01   J=   23   K=    1   CN= .2000E+01   DT= .5344E-02
RESIDUE INFORMATION          22    11     .06294     .14775  42.601665( 22, 11, 4)=    .06126
RMS OF SHOCK SPEED=    .2354E+00    J= 11    MAX SHK SPD=   .7657E+00
RMS OF SHOCK SPEED=    .2358E+00    J= 11    MAX SHK SPD=   .7838E+00
RMS OF SHOCK SPEED=    .2361E+00    J= 11    MAX SHK SPD=   .7979E+00
RMS OF SHOCK SPEED=    .2354E+00    J= 11    MAX SHK SPD=   .8056E+00
RMS OF SHOCK SPEED=    .2341E+00    J= 11    MAX SHK SPD=   .8066E+00
RMS OF SHOCK SPEED=    .2323E+00    J= 11    MAX SHK SPD=   .8017E+00
RMS OF SHOCK SPEED=    .2302E+00    J= 11    MAX SHK SPD=   .7918E+00
RMS OF SHOCK SPEED=    .2278E+00    J= 11    MAX SHK SPD=   .7776E+00
RMS OF SHOCK SPEED=    .2255E+00    J= 11    MAX SHK SPD=   .7598E+00
```

Finished Flowfield Information

```
SECOMO INDEX=  1

1ST   P/PINF       S          U/QINF      V/QINF       S/SINF     HT/HTINF      R/RI        CP          X           Y         EI/EIINF
  1  .4726E+02 -.6000E-01  .8466E-03 -.5577E-01  .4085E+01  .1005E+01  .5748E+01  .1836E+01  .4166E-03 -.5999E-01  .8222E+01
  2  .4726E+02  .6000E-01  .8466E-03  .5577E-01  .4085E+01  .1005E+01  .5748E+01  .1836E+01  .4166E-03  .5999E-01  .8222E+01
  3  .4950E+02  .1911E+00  .5952E-02  .1351E+00  .4085E+01  .1032E+01  .5941E+01  .1925E+01  .4228E-02  .1911E+00  .8332E+01
  4  .5104E+02  .3203E+00  .1252E-01  .1682E+00  .4085E+01  .1050E+01  .6072E+01  .1986E+01  .1187E-01  .3200E+00  .8405E+01
  5  .5235E+02  .4509E+00  .2052E-01  .1911E+00  .4085E+01  .1065E+01  .6184E+01  .2038E+01  .2351E-01  .4501E+00  .8466E+01
  6  .2625E+02  .5736E+00  .3127E+00  .2752E+00  .4085E+01  .1000E+01  .3776E+01  .1002E+01  .3890E-01  .5719E+00  .6950E+01
  7  .1711E+02  .1098E+01  .4504E+00  .2859E+00  .4085E+01  .1000E+01  .2782E+01  .6394E+00  .4816E+00  .8532E+00  .6151E+01
  8  .1774E+02  .1533E+01  .4280E+00  .3043E+00  .4085E+01  .1000E+01  .2855E+01  .6644E+00  .8487E+00  .1086E+01  .6215E+01
  9  .2342E+02  .1882E+01  .3359E+00  .3028E+00  .4085E+01  .1000E+01  .3481E+01  .8896E+00  .1119E+01  .1306E+01  .6728E+01
 10  .2763E+02  .2190E+01  .2677E+00  .2960E+00  .4085E+01  .1000E+01  .3917E+01  .1057E+01  .1336E+01  .1525E+01  .7053E+01
 11  .3067E+02  .2481E+01  .2249E+00  .2811E+00  .4085E+01  .1000E+01  .4221E+01  .1178E+01  .1521E+01  .1750E+01  .7267E+01
 12  .3468E+02  .2771E+01  .1883E+00  .2410E+00  .4085E+01  .1000E+01  .4608E+01  .1337E+01  .1699E+01  .1979E+01  .7527E+01
 13  .3860E+02  .3066E+01  .1521E+00  .1947E+00  .4085E+01  .1000E+01  .4974E+01  .1492E+01  .1881E+01  .2211E+01  .7760E+01
 14  .3963E+02  .3372E+01  .1417E+00  .1814E+00  .4085E+01  .1000E+01  .5068E+01  .1533E+01  .2069E+01  .2452E+01  .7819E+01
 15  .3777E+02  .3697E+01  .1603E+00  .2051E+00  .4085E+01  .1000E+01  .4897E+01  .1459E+01  .2269E+01  .2708E+01  .7712E+01
 16  .3454E+02  .4049E+01  .1899E+00  .2424E+00  .4085E+01  .1000E+01  .4594E+01  .1331E+01  .2486E+01  .2986E+01  .7517E+01
 17  .2472E+02  .4440E+01  .3047E+00  .3116E+00  .4085E+01  .1000E+01  .3618E+01  .9413E+00  .2728E+01  .3293E+01  .6832E+01
 18  .1126E+02  .4828E+01  .5409E+00  .2972E+00  .4085E+01  .1000E+01  .2063E+01  .4072E+00  .3027E+01  .3539E+01  .5458E+01
 19  .4570E+01  .5196E+01  .7267E+00  .1578E+00  .4085E+01  .1000E+01  .1083E+01  .1417E+00  .3378E+01  .3651E+01  .4218E+01
 20  .2643E+01  .5572E+01  .7927E+00  .9734E-01  .4085E+01  .1000E+01  .7326E+00  .6518E-01  .3751E+01  .3697E+01  .3607E+01
 21  .2339E+01  .5948E+01  .8033E+00  .9864E-01  .4085E+01  .1000E+01  .6715E+00  .5314E-01  .4125E+01  .3743E+01  .3483E+01
 22  .2338E+01  .6324E+01  .8034E+00  .9864E-01  .4085E+01  .1000E+01  .6712E+00  .5308E-01  .4498E+01  .3788E+01  .3483E+01
 23  .2373E+01  .6707E+01  .8021E+00  .9849E-01  .4085E+01  .1000E+01  .6784E+00  .5448E-01  .4878E+01  .3835E+01  .3498E+01
```

```
SECOND INDEX=  7

1ST    P/PINF      RO/RINF      U/QINF       V/QINF      S/SINF      HT/HTINF      MACH         CP          X            Y          EI/EIINF
  1  .4693E+02  .5722E+01  .9278E-01 -.2619E-01  .4081E+01  .1008E+01  .2020E+00  .1822E+01 -.1009E+00 -.6158E-01  .8201E+01
  2  .4693E+02  .5722E+01  .9278E-01  .2619E-01  .4081E+01  .1008E+01  .2020E+00  .1822E+01 -.1009E+00  .6158E-01  .8201E+01
  3  .4879E+02  .5909E+01  .8597E-01  .8407E-01  .4056E+01  .1019E+01  .2511E+00  .1896E+01 -.9864E-01  .1962E+00  .8255E+01
  4  .5081E+02  .6140E+01  .8698E-01  .1499E+00  .4005E+01  .1036E+01  .3614E+00  .1977E+01 -.7692E-01  .3275E+00  .8276E+01
  5  .4807E+02  .5938E+01  .1265E+00  .2197E+00  .3970E+01  .1044E+01  .5346E+00  .1868E+01 -.5587E-01  .4594E+00  .8095E+01
  6  .3685E+02  .4873E+01  .2327E+00  .2711E+00  .4013E+01  .1034E+01  .7796E+00  .1423E+01 -.3886E-01  .5836E+00  .7561E+01
  7  .2396E+02  .3583E+01  .3591E+00  .2772E+00  .4013E+01  .9961E+00  .1053E+01  .9110E+00  .2620E+00  .9092E+00  .6686E+01
  8  .1784E+02  .3099E+01  .4666E+00  .3033E+00  .3663E+01  .9741E+00  .1392E+01  .6683E+00  .5786E+00  .1184E+01  .5758E+01
  9  .1850E+02  .3504E+01  .4992E+00  .3525E+00  .3197E+01  .9717E+00  .1596E+01  .6943E+00  .8628E+00  .1430E+01  .5279E+01
 10  .2330E+02  .4458E+01  .4772E+00  .3911E+00  .2874E+01  .9716E+00  .1619E+01  .8847E+00  .1093E+01  .1674E+01  .5226E+01
 11  .2948E+02  .5676E+01  .4589E+00  .4214E+00  .2593E+01  .9743E+00  .1640E+01  .1130E+01  .1338E+01  .1889E+01  .5194E+01
 12  .3524E+02  .6835E+01  .4522E+00  .4469E+00  .2390E+01  .9836E+00  .1680E+01  .1359E+01  .1550E+01  .2118E+01  .5156E+01
 13  .3804E+02  .7103E+01  .4273E+00  .4472E+00  .2445E+01  .9891E+00  .1604E+01  .1470E+01  .1732E+01  .2380E+01  .5356E+01
 14  .3784E+02  .6529E+01  .3846E+00  .4182E+00  .2736E+01  .9902E+00  .1416E+01  .1462E+01  .1903E+01  .2684E+01  .5795E+01
 15  .3602E+02  .5744E+01  .3467E+00  .3754E+00  .3116E+01  .9940E+00  .1224E+01  .1390E+01  .2081E+01  .3035E+01  .6271E+01
 16  .3308E+02  .5049E+01  .3378E+00  .3420E+00  .3428E+01  .1002E+01  .1127E+01  .1273E+01  .2243E+01  .3416E+01  .6551E+01
 17  .2900E+02  .4465E+01  .3675E+00  .3318E+00  .3570E+01  .1007E+01  .1166E+01  .1111E+01  .2551E+01  .3823E+01  .6495E+01
 18  .2406E+02  .3943E+01  .4275E+00  .3362E+00  .3524E+01  .1004E+01  .1321E+01  .9149E+00  .2877E+01  .4202E+01  .6100E+01
 19  .1892E+02  .3429E+01  .4990E+00  .3365E+00  .3370E+01  .9909E+00  .1537E+01  .7111E+00  .3272E+01  .4515E+01  .5517E+01
 20  .1439E+02  .2911E+01  .5655E+00  .3237E+00  .3223E+01  .9755E+00  .1759E+01  .5312E+00  .3666E+01  .4745E+01  .4942E+01
 21  .1097E+02  .2451E+01  .6207E+00  .2994E+00  .3128E+01  .9629E+00  .1954E+01  .3956E+00  .4075E+01  .4964E+01  .4476E+01
 22  .8759E+01  .2160E+01  .6704E+00  .2672E+00  .2979E+01  .9518E+00  .2150E+01  .3079E+00  .4498E+01  .5180E+01  .4055E+01
 23  .7360E+01  .2099E+01  .7254E+00  .2312E+00  .2607E+01  .9366E+00  .2439E+01  .2524E+00  .4878E+01  .5352E+01  .3507E+01
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*** skip print out ***

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SECOND INDEX= 12

1ST    P/PINF      RO/RINF      U/QINF       V/QINF      S/SINF      HT/HTINF      MACH         CP          X            Y          EI/EIINF
  1  .4094E+02  .5254E+01  .1989E+00 -.4210E-02  .4013E+01  .9850E+00  .4277E+00  .1585E+01 -.1853E+00 -.6291E-01  .7792E+01
  2  .4094E+02  .5254E+01  .1989E+00  .4210E-02  .4013E+01  .9850E+00  .4277E+00  .1585E+01 -.1853E+00  .6291E-01  .7792E+01
  3  .4127E+02  .5260E+01  .2026E+00  .1057E+00  .4039E+01  .1003E+01  .4894E+00  .1598E+01 -.1844E+00  .2005E+00  .7846E+01
  4  .4205E+02  .5272E+01  .2089E+00  .1850E+00  .4103E+01  .1041E+01  .5929E+00  .1629E+01 -.1509E+00  .3337E+00  .7977E+01
  5  .4078E+02  .5252E+01  .2130E+00  .1400E+00  .3999E+01  .1004E+01  .5489E+00  .1578E+01 -.1220E+00  .4673E+00  .7764E+01
  6  .3591E+02  .5165E+01  .3088E+00  .2842E+00  .3605E+01  .1002E+01  .9550E+00  .1385E+01 -.1037E+00  .5934E+00  .6952E+01
  7  .2860E+02  .4988E+01  .4529E+00  .3721E+00  .3014E+01  .1001E+01  .1469E+01  .1095E+01  .7897E-01  .9559E+00  .5733E+01
  8  .2182E+02  .4742E+01  .5930E+00  .4003E+00  .2469E+01  .1011E+01  .2001E+01  .8260E+00  .3536E+00  .1266E+01  .4601E+01
  9  .1776E+02  .4527E+01  .6413E+00  .3610E+00  .2144E+01  .9539E+00  .2229E+01  .6650E+00  .6494E+00  .1533E+01  .3923E+01
 10  .1780E+02  .4529E+01  .6663E+00  .3851E+00  .2147E+01  .9992E+00  .2329E+01  .6665E+00  .8897E+00  .1798E+01  .3929E+01
 11  .2216E+02  .4757E+01  .6384E+00  .4481E+00  .2496E+01  .1102E+01  .2168E+01  .8395E+00  .1185E+01  .2005E+01  .4658E+01
 12  .2823E+02  .4978E+01  .4893E+00  .4135E+00  .2985E+01  .1052E+01  .1614E+01  .1081E+01  .1426E+01  .2233E+01  .5672E+01
 13  .3330E+02  .5109E+01  .3636E+00  .3325E+00  .3394E+01  .1008E+01  .1158E+01  .1282E+01  .1608E+01  .2521E+01  .6518E+01
 14  .3576E+02  .5162E+01  .3082E+00  .2783E+00  .3593E+01  .9962E+00  .9467E+00  .1379E+01  .1764E+01  .2878E+01  .6928E+01
 15  .3509E+02  .5148E+01  .3166E+00  .2794E+00  .3539E+01  .9879E+00  .9705E+00  .1353E+01  .1925E+01  .3307E+01  .6817E+01
 16  .3241E+02  .5089E+01  .3671E+00  .3165E+00  .3322E+01  .9830E+00  .1152E+01  .1247E+01  .2132E+01  .3775E+01  .6369E+01
 17  .2911E+02  .5003E+01  .4361E+00  .3581E+00  .3055E+01  .9891E+00  .1404E+01  .1115E+01  .2404E+01  .4265E+01  .5818E+01
 18  .2579E+02  .4899E+01  .5128E+00  .3926E+00  .2788E+01  .1008E+01  .1689E+01  .9838E+00  .2753E+01  .4754E+01  .5265E+01
 19  .2270E+02  .4781E+01  .5823E+00  .4075E+00  .2540E+01  .1023E+01  .1957E+01  .8613E+00  .3184E+01  .5235E+01  .4749E+01
 20  .2009E+02  .4659E+01  .6408E+00  .4098E+00  .2331E+01  .1033E+01  .2196E+01  .7576E+00  .3595E+01  .5619E+01  .4313E+01
 21  .1798E+02  .4541E+01  .6803E+00  .4007E+00  .2162E+01  .1030E+01  .2380E+01  .6740E+00  .4034E+01  .5982E+01  .3961E+01
 22  .1609E+02  .4415E+01  .7106E+00  .3844E+00  .2011E+01  .1017E+01  .2540E+01  .5986E+00  .4498E+01  .6339E+01  .3643E+01
 23  .1419E+02  .4266E+01  .7419E+00  .3657E+00  .1861E+01  .1006E+01  .2721E+01  .5233E+00  .4878E+01  .6616E+01  .3325E+01

 SONIC LINE LOCATION

XSL=  .1059E+00   YSL=  .6144E+00
XSL=  .1188E+01   YSL=  .1376E+01
XSL=  .2727E+01   YSL=  .3293E+01
```

```
XSL=  .3282E+00   YSL=  .7821E+00
XSL=  .8544E+00   YSL=  .1144E+01
XSL=  .2196E+01   YSL=  .2705E+01
XSL=  .3560E+00   YSL=  .8326E+00
XSL=  .7257E+00   YSL=  .1095E+01
XSL=  .1935E+01   YSL=  .2417E+01
XSL=  .3144E+00   YSL=  .8344E+00
XSL=  .7572E+00   YSL=  .1172E+01
XSL=  .1723E+01   YSL=  .2182E+01
XSL=  .2710E+00   YSL=  .8332E+00
XSL=  .8983E+00   YSL=  .1346E+01
XSL=  .1473E+01   YSL=  .1927E+01
XSL=  .2394E+00   YSL=  .8419E+00
XSL=  .2039E+00   YSL=  .8464E+00
XSL=  .1534E+00   YSL=  .8321E+00
XSL=  .9082E-01   YSL=  .7964E+00
XSL=  .2003E+01   YSL=  .3109E+01
XSL=  .2181E+01   YSL=  .3466E+01
XSL=  .2511E-01   YSL=  .7451E+00
XSL=  .1911E+01   YSL=  .3017E+01
XSL=  .2097E+01   YSL=  .3425E+01
XSL= -.3253E-01   YSL=  .6916E+00
XSL=  .1787E+01   YSL=  .2828E+01
XSL=  .2021E+01   YSL=  .3394E+01
XSL= -.8768E-01   YSL=  .6251E+00
XSL=  .1725E+01   YSL=  .2788E+01
XSL=  .1958E+01   YSL=  .3383E+01

   PERCENT ERROR IN HT=   .1335E+02    RMS OF PERCENT ERROR IN HT=   .3732E+01

PRESSURE DRAG =       1.0211281614
RESIDUE INFORMATION             22   11    .09863    .19812  49.782515( 22, 11, 4)=    .09603

                                          DETAILED RESIDUE INFORMATION
                                          ****************************
                                                    SECOND INDEX =   2
  2   .4283383E-04   .2583975E-03  -.1040915E-03   .1181511E-02    3  -.6617146E-04  -.1235662E-04  -.3556576E-03  -.2248817E-02
  4  -.1681763E-03   .1378115E-03  -.5943068E-03  -.5911385E-02    5   .3486947E-03  -.7099843E-03   .1314477E-02   .1128320E-01
  6  -.6305010E-03   .6027928E-03  -.1825853E-02  -.1686735E-01    7  -.8810737E-04  -.8370177E-06  -.5104091E-03  -.1530243E-02
  8   .3935656E-03   .7974840E-03   .1018069E-02   .1005600E-01    9   .3722815E-03   .3478348E-03   .7421823E-03   .9787239E-02
 10   .5146296E-04  -.1615716E-03   .1819152E-03   .1951249E-02   11  -.1658404E-03  -.4725812E-03  -.4647857E-03  -.3892859E-02
 12  -.2327465E-03  -.8976966E-03  -.1126651E-02  -.6648064E-02   13  -.2470445E-03  -.1013694E-02  -.1195537E-02  -.7621720E-02
 14  -.4190975E-03  -.1263542E-02  -.1441756E-02  -.1271133E-01   15  -.4916252E-03  -.1711442E-02  -.1468894E-02  -.1536707E-01
 16   .5527055E-03  -.4930919E-04   .3340261E-02   .1439560E-01   17   .8293849E-03   .3584257E-02   .3653234E-02   .2458764E-01
 18  -.1035297E-02  -.6910382E-03  -.5442634E-02  -.2543041E-01   19  -.1533676E-02  -.6222756E-02  -.5503364E-02  -.3838309E-01
 20  -.4832790E-03  -.3347455E-02  -.4203179E-03  -.1058689E-01   21   .1206258E-03  -.4127027E-04   .1299122E-02   .3580221E-02
 22   .2705954E-03   .1101844E-02   .1573901E-02   .6498939E-02
```

*** skip print out ***

Example 8

Input Data Cards

```
   20   12   10    0    1    0    0
   16    3    0    2    3    0
 6.          1.4        7.         0.         2.         10000.    1.        0.4  0.0
    0    0   20
 10000.
 1000010000010000l001
```

Printed Output

```
 AXISYMMETRIC FLOW OVER NOSETIP


 MACH NUMBER = 6.00
 RATIO OF SPECIFIC HEAT = 1.40
 CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
 OMEGA =  0.000     (OMEGA.GT.0.OMEGA IS THE RADIUS OF SPHERE-CONES IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED
                    IN SUB. SHAPES OMEGA=0.MORE RAYS TO BE ADDED)

 IR1 = 1      ( 1 FOR READ TAPE1$ 0     OTHERWISE)
 IW2 = 0      (1 FOR WRITE ON TAPE2$ 0   OTHERWISE)
 IPRT = 0      ( 1 FOR DETAILED WRITE OUT FROM EIGENS 0     OTHERWISE)
 IAFBD = 0      ( 1 FOR       STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)
 IGEOM = 3      ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB,YB,XS,YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                 3 FOR CAL. DELTAS AND FINAL XB,YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB,YB)

 LIP = 0      ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
 IVIS = 0      (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

 CF(BETA)= 10000.00000      ( FOR UNIFORM SPACING SET TO 10000)
 CC = 1.00      (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
 ITRAN = 3      (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
 KRES = 2      (INTERVAL IN K FOR RESIDUE INFORMATION)
 EXPLICIT DISSI. COEF. = .400
 IMPLICIT DISSI. COEF. =0.000
 COURANT NO. =    2.00



 JMAX=   20
 KMAX=   12
 JNM=   16     (JUNCTURE OF SPHERE AND CONE)
 ITER =  10      (TIME STEPS FOR THIS RUN)

FREE STREAM CONDITIONS

 PINF(PRESSURE) =  1.0000
 RINF(DENSITY) =  1.0000
 QINF(TOTAL VEL.) =  7.0993
 AINF(SOUND SPEED) =  1.1832
 UINF(U COMP.) =  7.0993
 VINF(V COMP.) =  0.0000
 HTINF(T. ENTHALPY) = 28.7000
```

```
ETINF(T. SPEC. ENERGY) = 27.7000
SINF(ENTHOPY) =  1.0000
EIINF(INTERNAL EN-RGY) =  2.5000


NORMALIZED DISTANCE FROM BODY TO SHOCK
                                0.000000  .090909   .181818   .272727   .363636   .454545   .545455   .636364   .727273   .818182
                                 .909091  1.000000

STARTING SOLUTION WAS READ FROM TAPE

NEW GRIDS IN K-ARRAY, NO. OF POINTS = 20     NEW STRETCHING COEF. =10000.0000
    NORMALIZED DI<TANCE FROM BODY TO SHOCK
             0.0000     .0526      .1053      .1579      .2105      .2632      .3158      .3684      .4211      .4737
              .5263     .5789      .6316      .6842      .7368      .7895      .8421      .8947      .9474     1.0000
    THE OLD VALUES ARE
             0.0000     .0909      .1818      .2727      .3636      .4545      .5455      .6364      .7273      .8182
              .9091    1.0000

ARC LENGTH
                                  .19113    .57348   1.09799   1.53258   1.88144   2.18952   2.48097   2.77077   3.06562   3.37181
                                 3.69659   4.04894   4.43992   4.82745   5.19566   5.57189   5.94811   6.32428   6.70655

STARTING FLOWFIELD INFORMATION


SECOND INDEX=  1

1ST    P/PINF        S         U/QINF      V/QINF      S/SINF     HT/HTINF     R/RI        CP          X           Y         EI/EIINF
 1  .4513E+02 -.1911E+00  .4944E-02 -.1088E+00  .4085E+01  .1000E+01  .5562E+01  .1751E+01  .4228E-02 -.1911E+00  .8115E+01
 2  .4513E+02  .1911E+00  .4944E-02  .1088E+00  .4085E+01  .1000E+01  .5562E+01  .1751E+01  .4228E-02  .1911E+00  .8115E+01
 3  .3360E+02  .5734E+00  .1877E+00  .2603E+00  .4085E+01  .1000E+01  .4505E+01  .1294E+01  .3890E-01  .5719E+00  .7459E+01
 4  .1552E+02  .1098E+01  .4686E+00  .2974E+00  .4085E+01  .1000E+01  .2595E+01  .5763E+00  .4816E+00  .8532E+00  .5982E+01
 5  .1651E+02  .1533E+01  .4414E+00  .3138E+00  .4085E+01  .1000E+01  .2712E+01  .6155E+00  .8487E+00  .1086E+01  .6088E+01
 6  .2271E+02  .1881E+01  .3426E+00  .3088E+00  .4085E+01  .1000E+01  .3405E+01  .8614E+00  .1119E+01  .1306E+01  .6669E+01
 7  .2769E+02  .2189E+01  .2672E+00  .2954E+00  .4085E+01  .1000E+01  .3924E+01  .1059E+01  .1336E+01  .1525E+01  .7058E+01
 8  .3175E+02  .2481E+01  .2161E+00  .2700E+00  .4085E+01  .1000E+01  .4326E+01  .1220E+01  .1521E+01  .1750E+01  .7339E+01
 9  .3705E+02  .2771E+01  .1671E+00  .2138E+00  .4085E+01  .1000E+01  .4831E+01  .1431E+01  .1699E+01  .1979E+01  .7670E+01
10  .4041E+02  .3066E+01  .1333E+00  .1706E+00  .4085E+01  .1000E+01  .5140E+01  .1564E+01  .1881E+01  .2211E+01  .7863E+01
11  .4053E+02  .3372E+01  .1320E+00  .1689E+00  .4085E+01  .1000E+01  .5150E+01  .1569E+01  .2069E+01  .2452E+01  .7869E+01
12  .3777E+02  .3697E+01  .1603E+00  .2051E+00  .4085E+01  .1000E+01  .4898E+01  .1459E+01  .2269E+01  .2708E+01  .7712E+01
13  .3413E+02  .4049E+01  .1934E+00  .2468E+00  .4085E+01  .1000E+01  .4555E+01  .1315E+01  .2486E+01  .2986E+01  .7492E+01
14  .2454E+02  .4440E+01  .3062E+00  .3132E+00  .4085E+01  .1000E+01  .3600E+01  .9343E+00  .2728E+01  .3293E+01  .6819E+01
15  .1124E+02  .4827E+01  .5411E+00  .2973E+00  .4085E+01  .1000E+01  .2061E+01  .4065E+00  .3027E+01  .3539E+01  .5455E+01
16  .4576E+01  .5196E+01  .7266E+00  .1578E+00  .4085E+01  .1000E+01  .1084E+01  .1419E+00  .3378E+01  .3651E+01  .4219E+01
17  .2690E+01  .5572E+01  .7912E+00  .9714E-01  .4085E+01  .1000E+01  .7420E+00  .6707E-01  .3751E+01  .3697E+01  .3625E+01
18  .2396E+01  .5948E+01  .8013E+00  .9839E-01  .4085E+01  .1000E+01  .6831E+00  .5539E-01  .4125E+01  .3743E+01  .3507E+01
19  .2378E+01  .6324E+01  .8019E+00  .9846E-01  .4085E+01  .1000E+01  .6795E+00  .5469E-01  .4498E+01  .3788E+01  .3500E+01
20  .2402E+01  .6706E+01  .8011E+00  .9836E-01  .4085E+01  .1000E+01  .6843E+00  .5563E-01  .4878E+01  .3835E+01  .3510E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST    P/PINF     RO/RINF      U/QINF      V/QINF      S/SINF     HT/HTINF     MACH        CP          X           Y         EI/EIINF
 1  .4429E+02  .5505E+01  .1277E+00 -.9374E-01  .4066E+01  .1003E+01  .3351E+00  .1718E+01 -.1058E+00 -.1966E+00  .8044E+01
 2  .4429E+02  .5505E+01  .1277E+00  .9374E-01  .4066E+01  .1003E+01  .3351E+00  .1718E+01 -.1058E+00  .1966E+00  .8044E+01
 3  .3689E+02  .4919E+01  .2237E+00  .2453E+00  .3965E+01  .1011E+01  .7273E+00  .1424E+01 -.4329E-01  .5843E+00  .7499E+01
 4  .2372E+02  .3612E+01  .3629E+00  .2895E+00  .3928E+01  .9900E+00  .1087E+01  .9015E+00  .2495E+00  .9124E+00  .6566E+01
 5  .1674E+02  .3018E+01  .4931E+00  .3130E+00  .3567E+01  .9761E+00  .1488E+01  .6247E+00  .5623E+00  .1190E+01  .5548E+01
 6  .1753E+02  .3430E+01  .5252E+00  .3486E+00  .3121E+01  .9720E+00  .1673E+01  .6559E+00  .8362E+00  .1443E+01  .5110E+01
 7  .2326E+02  .4504E+01  .4905E+00  .3887E+00  .2829E+01  .9737E+00  .1652E+01  .8833E+00  .1084E+01  .1680E+01  .5164E+01
```

```
 8  .3041E+02  .6075E+01  .4842E+00  .4347E+00  .2433E+01  .9822E+00  .1745E+01  .1167E+01  .1346E+01  .1883E+01  .5006E+01
 9  .3576E+02  .7256E+01  .4723E+00  .4673E+00  .2231E+01  .9887E+00  .1796E+01  .1379E+01  .1546E+01  .2121E+01  .4928E+01
10  .3769E+02  .7117E+01  .4286E+00  .4553E+00  .2416E+01  .9892E+00  .1630E+01  .1456E+01  .1723E+01  .2390E+01  .5296E+01
11  .3744E+02  .6293E+01  .3710E+00  .4043E+00  .2851E+01  .9900E+00  .1350E+01  .1446E+01  .1892E+01  .2699E+01  .5950E+01
12  .3586E+02  .5519E+01  .3306E+00  .3490E+00  .3281E+01  .9954E+00  .1132E+01  .1384E+01  .2068E+01  .3058E+01  .6498E+01
13  .3303E+02  .4923E+01  .3284E+00  .3231E+00  .3546E+01  .1004E+01  .1067E+01  .1271E+01  .2279E+01  .3446E+01  .6709E+01
14  .2897E+02  .4430E+01  .3649E+00  .3282E+00  .3606E+01  .1009E+01  .1151E+01  .1110E+01  .2539E+01  .3857E+01  .6540E+01
15  .2407E+02  .3970E+01  .4278E+00  .3408E+00  .3492E+01  .1002E+01  .1333E+01  .9153E+00  .2869E+01  .4240E+01  .6062E+01
16  .1903E+02  .3486E+01  .4994E+00  .3402E+00  .3313E+01  .9864E+00  .1552E+01  .7154E+00  .3266E+01  .4561E+01  .5459E+01
17  .1465E+02  .2984E+01  .5658E+00  .3240E+00  .3171E+01  .9720E+00  .1765E+01  .5416E+00  .3661E+01  .4800E+01  .4910E+01
18  .1134E+02  .2527E+01  .6191E+00  .3006E+00  .3097E+01  .9631E+00  .1949E+01  .4102E+00  .4072E+01  .5030E+01  .4487E+01
19  .9164E+01  .2209E+01  .6620E+00  .2743E+00  .3020E+01  .9567E+00  .2111E+01  .3240E+00  .4498E+01  .5260E+01  .4147E+01
20  .7928E+01  .2146E+01  .7109E+00  .2444E+00  .2723E+01  .9468E+00  .2346E+01  .2749E+00  .4878E+01  .5444E+01  .3695E+01
```

*** skip print out ***

```
SECOND INDEX= 20

1ST    P/PINF     RO/RINF     U/QINF     V/QINF      S/SINF     HT/HTINF     MACH        CP          X           Y        EI/EIINF
 1  .4137E+02  .5261E+01  .1989E+00 -.8338E-01  .4048E+01  .9998E+00  .4614E+00  .1602E+01 -.1857E+00 -.2006E+00  .7864E+01
 2  .4137E+02  .5261E+01  .1989E+00  .8338E-01  .4048E+01  .9998E+00  .4614E+00  .1602E+01 -.1857E+00  .2006E+00  .7864E+01
 3  .3708E+02  .5187E+01  .2833E+00  .2533E+00  .3700E+01  .9984E+00  .8529E+00  .1432E+01 -.1031E+00  .5933E+00  .7147E+01
 4  .2907E+02  .5002E+01  .4475E+00  .3747E+00  .3053E+01  .1008E+01  .1453E+01  .1114E+01  .8071E-01  .9555E+00  .5812E+01
 5  .2153E+02  .4729E+01  .5855E+00  .3866E+00  .2446E+01  .9875E+00  .1973E+01  .8148E+00  .3540E+00  .1266E+01  .4553E+01
 6  .1740E+02  .4504E+01  .6525E+00  .3639E+00  .2116E+01  .9613E+00  .2281E+01  .6508E+00  .6306E+00  .1542E+01  .3863E+01
 7  .1792E+02  .4537E+01  .6977E+00  .4128E+00  .2157E+01  .1059E+01  .2447E+01  .6715E+00  .9000E+00  .1792E+01  .3950E+01
 8  .2242E+02  .4769E+01  .6334E+00  .4490E+00  .2517E+01  .1103E+01  .2148E+01  .8501E+00  .1219E+01  .1980E+01  .4702E+01
 9  .2832E+02  .4980E+01  .4641E+00  .3821E+00  .2992E+01  .1011E+01  .1512E+01  .1084E+01  .1434E+01  .2225E+01  .5686E+01
10  .3340E+02  .5112E+01  .3575E+00  .3229E+00  .3402E+01  .1001E+01  .1131E+01  .1286E+01  .1609E+01  .2520E+01  .6534E+01
11  .3575E+02  .5162E+01  .3066E+00  .2741E+00  .3592E+01  .9932E+00  .9376E+00  .1379E+01  .1764E+01  .2879E+01  .6926E+01
12  .3500E+02  .5146E+01  .3167E+00  .2769E+00  .3532E+01  .9848E+00  .9677E+00  .1349E+01  .1922E+01  .3312E+01  .6802E+01
13  .3250E+02  .5091E+01  .3669E+00  .3185E+00  .3330E+01  .9858E+00  .1154E+01  .1250E+01  .2129E+01  .3781E+01  .6384E+01
14  .2941E+02  .5012E+01  .4361E+00  .3650E+00  .3080E+01  .9996E+00  .1408E+01  .1127E+01  .2403E+01  .4267E+01  .5868E+01
15  .2615E+02  .4911E+01  .5128E+00  .4000E+00  .2817E+01  .1021E+01  .1691E+01  .9979E+00  .2754E+01  .4749E+01  .5324E+01
16  .2293E+02  .4790E+01  .5825E+00  .4123E+00  .2558E+01  .1031E+01  .1957E+01  .8701E+00  .3185E+01  .5222E+01  .4786E+01
17  .2012E+02  .4660E+01  .6400E+00  .4104E+00  .2333E+01  .1034E+01  .2195E+01  .7589E+00  .3596E+01  .5602E+01  .4318E+01
18  .1796E+02  .4539E+01  .6780E+00  .3983E+00  .2160E+01  .1025E+01  .2372E+01  .6730E+00  .4034E+01  .5967E+01  .3957E+01
19  .1623E+02  .4425E+01  .7055E+00  .3835E+00  .2022E+01  .1013E+01  .2516E+01  .6042E+00  .4498E+01  .6330E+01  .3667E+01
20  .1449E+02  .4292E+01  .7349E+00  .3674E+00  .1885E+01  .1004E+01  .2683E+01  .5354E+00  .4878E+01  .6613E+01  .3376E+01

 SONIC LINE LOCATION

XSL=  .2378E+00   YSL=  .6982E+00
XSL=  .1209E+01   YSL=  .1397E+01
XSL=  .2723E+01   YSL=  .3287E+01
XSL=  .2884E+00   YSL=  .7440E+00
XSL=  .9907E+00   YSL=  .1234E+01
XSL=  .2468E+01   YSL=  .3029E+01
XSL=  .3467E+00   YSL=  .7993E+00
XSL=  .8817E+00   YSL=  .1176E+01
XSL=  .2147E+01   YSL=  .2652E+01
XSL=  .3537E+00   YSL=  .8221E+00
XSL=  .8337E+00   YSL=  .1168E+01
XSL=  .1978E+01   YSL=  .2459E+01
XSL=  .3428E+00   YSL=  .8329E+00
XSL=  .8153E+00   YSL=  .1184E+01
XSL=  .1841E+01   YSL=  .2302E+01
XSL=  .3165E+00   YSL=  .8320E+00
XSL=  .8230E+00   YSL=  .1224E+01
XSL=  .1708E+01   YSL=  .2152E+01
XSL=  .2955E+00   YSL=  .8349E+00
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XSL=  .8606E+00   YSL=  .1290E+01
XSL=  .1580E+01   YSL=  .2013E+01
XSL=  .2755E+00   YSL=  .8386E+00
XSL=  .9502E+00   YSL=  .1404E+01
XSL=  .1447E+01   YSL=  .1881E+01
XSL=  .2558E+00   YSL=  .8424E+00
XSL=  .1150E+01   YSL=  .1635E+01
XSL=  .1155E+01   YSL=  .1640E+01
XSL=  .2340E+00   YSL=  .8440F+00
XSL=  .2091E+00   YSL=  .8420F+00
XSL=  .1787E+00   YSL=  .8330E+00
XSL=  .1466E+00   YSL=  .8204E+00
XSL=  .1118E+00   YSL=  .8021E+00
XSL=  .7911E-01   YSL=  .7836E+00
XSL=  .1965E+01   YSL=  .3043E+01
XSL=  .2181E+01   YSL=  .3488E+01
XSL=  .4688E-01   YSL=  .7627E+00
XSL=  .1901E+01   YSL=  .2961E+01
XSL=  .2118E+01   YSL=  .3437E+01
XSL=  .1750E-01   YSL=  .7426E+00
XSL=  .1810E+01   YSL=  .2807E+01
XSL=  .2074E+01   YSL=  .3421E+01
XSL= -.9260E-02   YSL=  .7232E+00
XSL=  .1775E+01   YSL=  .2788E+01
XSL=  .2033E+01   YSL=  .3409E+01
XSL= -.3487E-01   YSL=  .7023E+00
XSL=  .1744E+01   YSL=  .2775E+01
XSL=  .1994E+01   YSL=  .3399E+01
XSL= -.5799E-01   YSL=  .6821E+00
XSL=  .1714E+01   YSL=  .2763E+01
XSL=  .1958E+01   YSL=  .3393E+01

    PERCENT ERROR IN HT=   .1027E+02    RMS OF PERCENT ERROR IN HT=   .3450E+01

PRESSURE DRAG =       1.0286611681

SIGMAX= .6011E+03   J=    3   K=   20   SIGMIN=  .9987E+01   J=    1   K=   20   CN= .2000E+01   DT= .3327E-02
RESIDUE INFORMATION                 2    2     .03186     .08404  37.91412S(  2,  2, 4)=     .03165
RMS OF SHOCK SPEED=   .2470E+00   J=  8   MAX SHK SPD=   .7632E+00
RMS OF SHOCK SPEED=   .2466E+00   J=  8   MAX SHK SPD=   .7688E+00
RMS OF SHOCK SPEED=   .2479E+00   J=  8   MAX SHK SPD=   .7815E+00
RMS OF SHOCK SPEED=   .2493E+00   J=  8   MAX SHK SPD=   .7938E+00
RMS OF SHOCK SPEED=   .2505E+00   J=  8   MAX SHK SPD=   .8042E+00
RMS OF SHOCK SPEED=   .2513E+00   J=  8   MAX SHK SPD=   .8121E+00
RMS OF SHOCK SPEED=   .2519E+00   J=  8   MAX SHK SPD=   .8174E+00
RMS OF SHOCK SPEED=   .2523E+00   J=  8   MAX SHK SPD=   .8203E+00
RMS OF SHOCK SPEED=   .2524E+00   J=  8   MAX SHK SPD=   .8209E+00
RMS OF SHOCK SPEED=   .2524E+00   J=  8   MAX SHK SPD=   .8195E+00
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST    P/PINF         S          U/QINF       V/QINF       S/SINF      HT/HTINF       R/RI          CP           X            Y          EI/EIINF
 1   .4560E+02 -.1911E+00   .4200E-02 -.9241E-01   .4085E+01   .1000E+01   .5603E+01   .1770E+01   .4228E-02 -.1911E+00   .8138E+01
 2   .4560E+02  .1911E+00   .4200E-02  .9241E-01   .4085E+01   .1000E+01   .5603E+01   .1770E+01   .4228E-02  .1911E+00   .8138E+01
 3   .3608E+02  .5734E+00   .1671E+00  .2318E+00   .4085E+01   .1000E+01   .4740E+01   .1392E+01   .3890E-01  .5719E+00   .7612E+01
 4   .1696E+02  .1098E+01   .4625E+00  .2935E+00   .4085E+01   .1000E+01   .2658E+01   .5974E+00   .4816E+00  .8532E+00   .6040E+01
 5   .1630E+02  .1533E+01   .4437E+00  .3154E+00   .4085E+01   .1000E+01   .2687E+01   .6072E+00   .8487E+00  .1086E+01   .6066E+01
 6   .2268E+02  .1881E+01   .3428E+00  .3090E+00   .4085E+01   .1000E+01   .3402E+01   .8604E+00   .1119E+01  .1306E+01   .6666E+01
 7   .2773E+02  .2189E+01   .2669E+00  .2950E+00   .4085E+01   .1000E+01   .3928E+01   .1061E+01   .1336E+01  .1525E+01   .7061E+01
 8   .3149E+02  .2481E+01   .2182E+00  .2727E+00   .4085E+01   .1000E+01   .4301E+01   .1210E+01   .1521E+01  .1750E+01   .7322E+01
 9   .3542E+02  .2771E+01   .1818E+00  .2327E+00   .4085E+01   .1000E+01   .4678E+01   .1366E+01   .1699E+01  .1979E+01   .7572E+01
10   .3890E+02  .3066E+01   .1492E+00  .1909E+00   .4085E+01   .1000E+01   .5002E+01   .1504E+01   .1881E+01  .2211E+01   .7777E+01
11   .3989E+02  .3372E+01   .1390E+00  .1779E+00   .4085E+01   .1000E+01   .5092E+01   .1543E+01   .2069E+01  .2452E+01   .7833E+01
```

```
12  .3814E+02  .3697E+01  .1567E+00  .2005E+00  .4085E+01  .1000E+01  .4932E+01  .1474E+01  .2269E+01  .2708E+01  .7734E+01
13  .3480E+02  .4049E+01  .1877E+00  .2395E+00  .4085E+01  .1000E+01  .4619E+01  .1341E+01  .2486E+01  .2986E+01  .7534E+01
14  .2506E+02  .4440E+01  .3017E+00  .3086E+00  .4085E+01  .1000E+01  .3653E+01  .9546E+00  .2728E+01  .3293E+01  .6859E+01
15  .1142E+02  .4827E+01  .5386E+00  .2960E+00  .4085E+01  .1000E+01  .2085E+01  .4137E+00  .3027E+01  .3539E+01  .5480E+01
16  .4534E+01  .5196E+01  .7276E+00  .1580E+00  .4085E+01  .1000E+01  .1077E+01  .1402E+00  .3378E+01  .3651E+01  .4209E+01
17  .2624E+01  .5572E+01  .7934E+00  .9742E-01  .4085E+01  .1000E+01  .7289E+00  .6443E-01  .3751E+01  .3697E+01  .3599E+01
18  .2355E+01  .5946E+01  .8028E+00  .9857E-01  .4085E+01  .1000E+01  .6748E+00  .5378E-01  .4125E+01  .3743E+01  .3490E+01
19  .2357E+01  .6324E+01  .8027E+00  .9856E-01  .4085E+01  .1000E+01  .6752E+00  .5385E-01  .4498E+01  .3788E+01  .3491E+01
20  .2394E+01  .6706E+01  .8014E+00  .9839E-01  .4085E+01  .1000E+01  .6828E+00  .5533E-01  .4878E+01  .3835E+01  .3507E+01
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SECOND INDEX= 12

1ST    P/PINF    RO/RINF     U/QINF     V/QINF     S/SINF   HT/HTINF      MACH         CP          X          Y     EI/EIINF
 1  .4339E+02  .5390E+01  .1501E+00 -.7543E-01  .4103E+01  .1006E+01  .3552E+00  .1682E+01 -.1047E+00 -.1965E+00  .8050E+01
 2  .4339E+02  .5390E+01  .1501E+00  .7543E-01  .4103E+01  .1006E+01  .3552E+00  .1682E+01 -.1047E+00  .1965E+00  .8050E+01
 3  .3643E+02  .4776E+01  .2169E+00  .2052E+00  .4082E+01  .1009E+01  .6485E+00  .1406E+01 -.4190E-01  .5841E+00  .7629E+01
 4  .2585E+02  .3794E+01  .3329E+00  .2829E+00  .3997E+01  .9985E+00  .1004E+01  .9862E+00  .2486E+00  .9126E+00  .6814E+01
 5  .1878E+02  .3283E+01  .4642E+00  .3316E+00  .3555E+01  .9833E+00  .1431E+01  .7055E+00  .5623E+00  .1190E+01  .5720E+01
 6  .1801E+02  .3598E+01  .5247E+00  .3702E+00  .2999E+01  .9725E+00  .1722E+01  .6749E+00  .8421E+00  .1440E+01  .5005E+01
 7  .2265E+02  .4597E+01  .5090E+00  .4060E+00  .2677E+01  .9732E+00  .1760E+01  .8593E+00  .1078E+01  .1683E+01  .4928E+01
 8  .2952E+02  .5909E+01  .4825E+00  .4355E+00  .2455E+01  .9802E+00  .1745E+01  .1132E+01  .1334E+01  .1893E+01  .4996E+01
 9  .3547E+02  .6924E+01  .4594E+00  .4503E+00  .2362E+01  .9880E+00  .1705E+01  .1368E+01  .1543E+01  .2124E+01  .5122E+01
10  .3805E+02  .6972E+01  .4219E+00  .4379E+00  .2510E+01  .9902E+00  .1562E+01  .1470E+01  .1723E+01  .2390E+01  .5457E+01
11  .3772E+02  .6330E+01  .3733E+00  .4006E+00  .2849E+01  .9900E+00  .1346E+01  .1457E+01  .1893E+01  .2699E+01  .5959E+01
12  .3586E+02  .5575E+01  .3350E+00  .3552E+00  .3235E+01  .9938E+00  .1155E+01  .1383E+01  .2069E+01  .3056E+01  .6433E+01
13  .3295E+02  .4933E+01  .3287E+00  .3245E+00  .3528E+01  .1002E+01  .1072E+01  .1268E+01  .2280E+01  .3444E+01  .6680E+01
14  .2896E+02  .4389E+01  .3606E+00  .3185E+00  .3652E+01  .1008E+01  .1124E+01  .1110E+01  .2540E+01  .3857E+01  .6598E+01
15  .2414E+02  .3892E+01  .4202E+00  .3269E+00  .3601E+01  .1005E+01  .1283E+01  .9183E+00  .2868E+01  .4242E+01  .6202E+01
16  .1916E+02  .3406E+01  .4904E+00  .3322E+00  .3445E+01  .9940E+00  .1499E+01  .7206E+00  .3266E+01  .4565E+01  .5625E+01
17  .1475E+02  .2924E+01  .5565E+00  .3247E+00  .3285E+01  .9798E+00  .1721E+01  .5457E+00  .3661E+01  .4806E+01  .5045E+01
18  .1142E+02  .2506E+01  .6132E+00  .3043E+00  .3156E+01  .9672E+00  .1924E+01  .4136E+00  .4072E+01  .5036E+01  .4557E+01
19  .9330E+01  .2278E+01  .6660E+00  .2749E+00  .2947E+01  .9554E+00  .2136E+01  .3306E+00  .4498E+01  .5263E+01  .4097E+01
20  .8113E+01  .2289E+01  .7210E+00  .2436E+00  .2545E+01  .9407E+00  .2426E+01  .2823E+00  .4878E+01  .5444E+01  .3544E+01
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SECOND INDEX= 20

1ST    P/PINF    RO/RINF     U/QINF     V/QINF     S/SINF   HT/HTINF      MACH         CP          X          Y     EI/EIINF
 1  .4015E+02  .5242E+01  .2115E+00 -.8264E-01  .3948E+01  .9794E+00  .4923E+00  .1553E+01 -.1838E+00 -.2005E+00  .7660E+01
 2  .4015E+02  .5242E+01  .2115E+00  .8264E-01  .3948E+01  .9794E+00  .4923E+00  .1553E+01 -.1838E+00  .2005E+00  .7660E+01
 3  .3605E+02  .5168E+01  .2929E+00  .2467E+00  .3616E+01  .9795E+00  .8700E+00  .1391E+01 -.1007E+00  .5929E+00  .6976E+01
 4  .2897E+02  .4999E+01  .4480E+00  .3733E+00  .3045E+01  .1005E+01  .1453E+01  .1110E+01  .7924E-01  .9558E+00  .5795E+01
 5  .2214E+02  .4756E+01  .5854E+00  .3993E+00  .2495E+01  .1009E+01  .1971E+01  .8390E+00  .3540E+00  .1266E+01  .4656E+01
 6  .1816E+02  .4551E+01  .6371E+00  .3660E+00  .2176E+01  .9605E+00  .2207E+01  .6808E+00  .6407E+00  .1537E+01  .3989E+01
 7  .1838E+02  .4564E+01  .6721E+00  .4021E+00  .2194E+01  .1030E+01  .2342E+01  .6895E+00  .8898E+00  .1798E+01  .4026E+01
 8  .2252E+02  .4773E+01  .6380E+00  .4544E+00  .2525E+01  .1114E+01  .2164E+01  .8540E+00  .1197E+01  .1996E+01  .4719E+01
 9  .2823E+02  .4978E+01  .4815E+00  .4037E+00  .2985E+01  .1038E+01  .1583E+01  .1081E+01  .1430E+01  .2229E+01  .5672E+01
10  .3312E+02  .5105E+01  .3632E+00  .3270E+00  .3379E+01  .1001E+01  .1151E+01  .1275E+01  .1609E+01  .2520E+01  .6487E+01
11  .3554E+02  .5157E+01  .3097E+00  .2756E+00  .3575E+01  .9913E+00  .9475E+00  .1371E+01  .1765E+01  .2878E+01  .6891E+01
12  .3500E+02  .5146E+01  .3172E+00  .2778E+00  .3531E+01  .9854E+00  .9701E+00  .1349E+01  .1924E+01  .3309E+01  .6800E+01
13  .3246E+02  .5090E+01  .3666E+00  .3169E+00  .3326E+01  .9840E+00  .1151E+01  .1249E+01  .2131E+01  .3778E+01  .6378E+01
14  .2922E+02  .5006E+01  .4359E+00  .3604E+00  .3065E+01  .9927E+00  .1404E+01  .1120E+01  .2403E+01  .4266E+01  .5637E+01
15  .2594E+02  .4904E+01  .5125E+00  .3953E+00  .2800E+01  .1013E+01  .1688E+01  .9898E+00  .2753E+01  .4753E+01  .5290E+01
16  .2290E+02  .4789E+01  .5812E+00  .4104E+00  .2556E+01  .1028E+01  .1952E+01  .8692E+00  .3184E+01  .5231E+01  .4782E+01
17  .2032E+02  .4670E+01  .6381E+00  .4125E+00  .2349E+01  .1037E+01  .2186E+01  .7665E+00  .3595E+01  .5613E+01  .4350E+01
18  .1812E+02  .4549E+01  .6784E+00  .4020E+00  .2173E+01  .1032E+01  .2371E+01  .6794E+00  .4034E+01  .5976E+01  .3983E+01
19  .1600E+02  .4409E+01  .7106E+00  .3826E+00  .2005E+01  .1015E+01  .2542E+01  .5953E+00  .4498E+01  .6335E+01  .3629E+01
20  .1388E+02  .4240E+01  .7444E+00  .3605E+00  .1838E+01  .1000E+01  .2742E+01  .5113E+00  .4878E+01  .6613E+01  .3275E+01
```

```
SONIC LINE LOCATION

XSL=  .2730E+00   YSL=  .7206E+00
XSL=  .1209E+01   YSL=  .1397E+01
XSL=  .2733E+01   YSL=  .3298E+01
XSL=  .5127E+00   YSL=  .8928E+00
XSL=  .9872E+00   YSL=  .1231E+01
XSL=  .2423E+01   YSL=  .2969E+01
XSL=  .6729E+00   YSL=  .1021E+01
XSL=  .8441E+00   YSL=  .1144E+01
XSL=  .2167E+01   YSL=  .2679E+01
XSL=  .7537E+00   YSL=  .1103E+01
XSL=  .7746E+00   YSL=  .1118E+01
XSL=  .2003E+01   YSL=  .2493E+01
XSL=  .7200E+00   YSL=  .1106E+01
XSL=  .7499E+00   YSL=  .1128E+01
XSL=  .1866E+01   YSL=  .2339E+01
XSL=  .5965E+00   YSL=  .1043E+01
XSL=  .7560E+00   YSL=  .1165E+01
XSL=  .1731E+01   YSL=  .2186E+01
XSL=  .4910E+00   YSL=  .9895E+00
XSL=  .8018E+00   YSL=  .1237E+01
XSL=  .1591E+01   YSL=  .2031E+01
XSL=  .4198E+00   YSL=  .9588E+00
XSL=  .9552E+00   YSL=  .1404E+01
XSL=  .1423E+01   YSL=  .1865E+01
XSL=  .3685E+00   YSL=  .9419E+00
XSL=  .3258E+00   YSL=  .9308E+00
XSL=  .2857E+00   YSL=  .9209E+00
XSL=  .2453E+00   YSL=  .9088E+00
XSL=  .2012E+00   YSL=  .8865E+00
XSL=  .1562E+00   YSL=  .8592E+00
XSL=  .1125E+00   YSL=  .8293E+00
XSL=  .2009E+01   YSL=  .3138E+01
XSL=  .2061E+01   YSL=  .3243E+01
XSL=  .7163E-01   YSL=  .7985E+00
XSL=  .1962E+01   YSL=  .3181E+01
XSL=  .2079E+01   YSL=  .3350E+01
XSL=  .3369E-01   YSL=  .7672E+00
XSL=  .1913E+01   YSL=  .3055E+01
XSL=  .2049E+01   YSL=  .3363E+01
XSL= -.1369E-02   YSL=  .7351E+00
XSL=  .1843E+01   YSL=  .2949E+01
XSL=  .2018E+01   YSL=  .3369E+01
XSL= -.3283E-01   YSL=  .7038E+00
XSL=  .1767E+01   YSL=  .2826E+01
XSL=  .1987E+01   YSL=  .3376E+01
XSL= -.6057E-01   YSL=  .6738E+00
XSL=  .1724E+01   YSL=  .2786E+01
XSL=  .1958E+01   YSL=  .3386E+01

    PERCENT ERROR IN HT=   .1141E+02    RMS OF PERCENT ERROR IN HT=   .3680E+01

PRESSURE DRAG =        1.0281362170
RESIDUE INFORMATION            19    19    .05103    .12475  40.905085( 19, 19, 4)=    .04969
```

*** skip print out ***

Example 9

Input Data Cards

```
   20   12   10    0    1    0    1
   16    3    0    2    3    0
 6.        1.4       7.        3.8263    2.        10000.    1.        0.4   0.0
100010001001
   19
```

Printed Output

```
    AXISYMMETRIC FLOW OVER NOSETIP


    MACH NUMBER = 6.00
    RATIO OF SPECIFIC HEAT = 1.40
    CONE(AFTERBODY) HALF-ANGLE =  7.000  DEGREES
    OMEGA =  3.826     (OMEGA.GT.0.OMEGA IS THE RADIUS OF SPHERE-CONES IF IGEOM=3OR4 OMEGA VALUE IS RECALCULATED
                        IN SUB. SHAPES OMEGA=0.MORE RAYS TO BE ADDED)

    IR1 = 1      ( 1 FOR READ TAPE1$ 0     OTHERWISE)
    IW2 = 0     (1 FOR WRITE ON TAPE2$ 0   OTHERWISE)
    IPRT = 0     ( 1 FOR DETAILED WRITE OUT FROM EIGEN$ 0     OTHERWISE)
    IAFBD = 1     ( 1 FOR      STORAGE OF STARTING DATA FOR AFTERBODY CAL.$ 0     OTHERWISE)
    IGEOM = 3     ( 0 FOR UNIFORM SPACING ON NOSE $ 1 FOR READ IN XB.YB.XS.YS $ 2 FOR READ IN TH(J) AND DETT(J) $
                   3 FOR CAL. DELTAS AND FINAL XB.YB WITH UNIFORM TH(J)$ 4 FOR READ IN TH(J) AND CAL. FINAL XB.YB)

    LIP =   0     ( 0 FOR WITHOUT SHAPE CHANGE $  N FOR SHAPE CHANGE COMPLETED IN N STEPS)
    IVIS = 0     (  0 FOR INVISCID FLOW $ 1 FOR LAMINAR FLOW)

    CF(BETA)= 10000.00000     ( FOR UNIFORM SPACING SET TO 10000)
    CC = 1.00     (  STRETCHING FOR POINTS BT. JNM+ITRAN AND JMAX)
    ITRAN = 3     (MUST BE LT.JMAX-JNM FOR THETA TO GO TO PI/2)
    KRES = 2     (INTERVAL IN K FOR RESIDUE INFORMATION)
    EXPLICIT DISSI. COEF. = .400
    IMPLICIT DISSI. COEF. =0.000
    COURANT NO. =    2.00


    JMAX=   20
    KMAX=   12
    JNM=    16      (JUNCTURE OF SPHERE AND CONE)
    ITER =  10      (TIME STEPS FOR THIS RUN)
  FREE STREAM CONDITIONS

    PINF(PRESSURE) =  1.0000
    RINF(DENSITY) =  1.0000
    QINF(TOTAL VEL.) =  7.0993
    AINF(SOUND SPEED) =  1.1832
    UINF(U COMP.) =  7.0993
    VINF(V COMP.) =  0.0000
```

```
HTINF(T. ENTHALPY) = 28.7000
ETINF(T. SPEC. ENERGY) = 27.7000
SINF(ENTROPY) =  1.0000
EIINF(INTERNAL ENERGY) =  2.5000



NORMALIZED DISTANCE FROM BODY TO SHOCK
                        0.000000   .090909    .181818    .272727    .363636    .454545    .545455    .636364    .727273    .818182
                         .909091  1.000000

STAGNATION PRESSURE PT=   46.8152

STARTING SOLUTION WAS READ FROM TAPE

ARC LENGTH
                          .19113    .57348   1.09799   1.53258   1.88144   2.18952   2.48097   2.77077   3.06562   3.37181
                         3.69659   4.04894   4.43992   4.82745   5.19566   5.57189   5.94811   6.32428   6.70655

STARTING FLOWFIELD INFORMATION


SECOND INDEX=  1

1ST    P/PINF         S        U/QINF       V/QINF       S/SINF     HT/HTINF       R/RI          CP           X            Y          EI/EIINF
 1   .4497E+02 -.1911E+00   .4944E-02  -.1088E+00   .4091E+01   .1000E+01   .5542E+01   .1745E+01   .4228E-02  -.1911E+00   .8115E+01
 2   .4513E+02  .1911E+00   .4944E-02   .1088E+00   .4085E+01   .1000E+01   .5562E+01   .1751E+01   .4228E-02   .1911E+00   .8115E+01
 3   .3360E+02  .5735E+00   .1877E+00   .2603E+00   .4085E+01   .1000E+01   .4505E+01   .1294E+01   .3890E-01   .5719E+00   .7459E+01
 4   .1552E+02  .1098E+01   .4686E+00   .2974E+00   .4085E+01   .1000E+01   .2595E+01   .5763E+00   .4816E+00   .8532E+00   .5982E+01
 5   .1651E+02  .1533E+01   .4414E+00   .3138E+00   .4085E+01   .1000E+01   .2712E+01   .6155E+00   .8487E+00   .1086E+01   .6084E+01
 6   .2271E+02  .1881E+01   .3426E+00   .3088E+00   .4085E+01   .1000E+01   .3405E+01   .8614E+00   .1119E+01   .1306E+01   .6669E+01
 7   .2769E+02  .2190E+01   .2672E+00   .2954E+00   .4085E+01   .1000E+01   .3924E+01   .1059E+01   .1336E+01   .1525E+01   .7058E+01
 8   .3175E+02  .2481E+01   .2161E+00   .2700E+00   .4085E+01   .1000E+01   .4326E+01   .1220E+01   .1521E+01   .1750E+01   .7339E+01
 9   .3705E+02  .2771E+01   .1671E+00   .2138E+00   .4085E+01   .1000E+01   .4831E+01   .1431E+01   .1699E+01   .1979E+01   .7670E+01
10   .4041E+02  .3066E+01   .1333E+00   .1706E+00   .4085E+01   .1000E+01   .5140E+01   .1564E+01   .1881E+01   .2211E+01   .7863E+01
11   .4053E+02  .3372E+01   .1320E+00   .1689E+00   .4085E+01   .1000E+01   .5150E+01   .1569E+01   .2069E+01   .2452E+01   .7869E+01
12   .3777E+02  .3697E+01   .1603E+00   .2051E+00   .4085E+01   .1000E+01   .4898E+01   .1459E+01   .2269E+01   .2708E+01   .7712E+01
13   .3413E+02  .4049E+01   .1934E+00   .2468E+00   .4085E+01   .1000E+01   .4555E+01   .1315E+01   .2486E+01   .2986E+01   .7492E+01
14   .2454E+02  .4440E+01   .3062E+00   .3132E+00   .4085E+01   .1000E+01   .3600E+01   .9343E+00   .2728E+01   .3293E+01   .6819E+01
15   .1124E+02  .4827E+01   .5411E+00   .2973E+00   .4085E+01   .1000E+01   .2061E+01   .4065E+00   .3027E+01   .3539E+01   .5455E+01
16   .4576E+01  .5196E+01   .7266E+00   .1578E+00   .4085E+01   .1000E+01   .1084E+01   .1419E+00   .3378E+01   .3651E+01   .4219E+01
17   .2690E+01  .5572E+01   .7912E+00   .9714E-01   .4085E+01   .1000E+01   .7420E+00   .6707E-01   .3751E+01   .3657E+01   .3625E+01
18   .2396E+01  .5948E+01   .8013E+00   .9839E-01   .4085E+01   .1000E+01   .6831E+00   .5539E-01   .4125E+01   .3743E+01   .3507E+01
19   .2378E+01  .6324E+01   .8019E+00   .9846E-01   .4085E+01   .1000E+01   .6795E+00   .5469E-01   .4498E+01   .3788E+01   .3500E+01
20   .2402E+01  .6707E+01   .8011E+00   .9836E-01   .4085E+01   .1000E+01   .6843E+00   .5563E-01   .4878E+01   .3835E+01   .3510E+01
```

*** skip print out ***

```
SECOND INDEX= 12

1ST    P/PINF      RO/RINF      U/QINF       V/QINF       S/SINF     HT/HTINF       MACH          CP           X            Y          EI/EIINF
 1   .4051E+02   .5152E+01   .1989E+00  -.8338E-01   .4082E+01   .9998E+00   .4614E+00   .1568E+01  -.1857E+00  -.2006E+00   .7864E+01
 2   .4137E+02   .5261E+01   .1989E+00   .8338E-01   .4048E+01   .9998E+00   .4614E+00   .1602E+01  -.1857E+00   .2006E+00   .7864E+01
 3   .3708E+02   .5187E+01   .2833E+00   .2533E+00   .3700E+01   .9984E+00   .8529E+00   .1432E+01  -.1031E+00   .5433E+00   .7147E+01
 4   .2907E+02   .5002E+01   .4475E+00   .3747E+00   .3053E+01   .1008E+01   .1453E+01   .1114E+01   .8071E-01   .9555E+00   .5812E+01
 5   .2153E+02   .4729E+01   .5855E+00   .3866E+00   .2446E+01   .9875E+00   .1973E+01   .8148E+00   .3540E+00   .1266E+01   .4553E+01
 6   .1740E+02   .4504E+01   .6525E+00   .3639E+00   .2116E+01   .9613E+00   .2281E+01   .6508E+00   .6306E+00   .1542E+01   .3863E+01
 7   .1792E+02   .4537E+01   .6977E+00   .4128E+00   .2157E+01   .1059E+01   .2447E+01   .6715E+00   .9000E+00   .1792E+01   .3950E+01
 8   .2242E+02   .4764E+01   .6334E+00   .4490E+00   .2517E+01   .1103E+01   .2148E+01   .8501E+00   .1219E+01   .1980E+01   .4702E+01
 9   .2832E+02   .4980E+01   .4641E+00   .3821E+00   .2992E+01   .1011E+01   .1512E+01   .1084E+01   .1434E+01   .2225E+01   .5686E+01
10   .3340E+02   .5112E+01   .3575E+00   .3229E+00   .3402E+01   .1001E+01   .1131E+01   .1286E+01   .1609E+01   .2520E+01   .6534E+01
11   .3575E+02   .5162E+01   .3066E+00   .2741E+00   .3592E+01   .9432E+00   .9376E+00   .1379E+01   .1764E+01   .2874E+01   .6926E+01
12   .3500E+02   .5146E+01   .3167E+00   .2769E+00   .3532E+01   .9848E+00   .9677E+00   .1349E+01   .1922E+01   .3312E+01   .6802E+01
```

```
13  .3250E+02  .5091E+01  .3669E+00  .3185E+00  .3330E+01  .9858E+00  .1154E+01  .1250E+01  .2129E+01  .3781E+01  .6384E+01
14  .2941E+02  .5012E+01  .4361E+00  .3650E+00  .3080E+01  .9996E+00  .1408E+01  .1127E+01  .2403E+01  .4267E+01  .5868E+01
15  .2615E+02  .4911E+01  .5128E+00  .4000E+00  .2817E+01  .1021E+01  .1691E+01  .9979E+00  .2754E+01  .4749E+01  .5324E+01
16  .2293E+02  .4790E+01  .5825E+00  .4123E+00  .2558E+01  .1031E+01  .1957E+01  .8701E+00  .3185E+01  .5222E+01  .4786E+01
17  .2012E+02  .4660E+01  .6400E+00  .4104E+00  .2333E+01  .1034E+01  .2195E+01  .7589E+00  .3596E+01  .5602E+01  .4318E+01
18  .1796E+02  .4539E+01  .6780E+00  .3983E+00  .2160E+01  .1025E+01  .2372E+01  .6730E+00  .4034E+01  .5967E+01  .3957E+01
19  .1623E+02  .4425E+01  .7055E+00  .3835E+00  .2022E+01  .1013E+01  .2516E+01  .6042E+00  .4498E+01  .6330E+01  .3667E+01
20  .1449E+02  .4292E+01  .7349E+00  .3674E+00  .1885E+01  .1004E+01  .2683E+01  .5354E+00  .4878E+01  .6613E+01  .3376E+01

 SONIC LINE LOCATION

XSL=  .2378E+00   YSL=  .6982E+00
XSL=  .1209E+01   YSL=  .1397E+01
XSL=  .2723E+01   YSL=  .3287E+01
XSL=  .3449E+00   YSL=  .7935E+00
XSL=  .8956E+00   YSL=  .1179E+01
XSL=  .2193E+01   YSL=  .2701E+01
XSL=  .3572E+00   YSL=  .8332E+00
XSL=  .8130E+00   YSL=  .1165E+01
XSL=  .1915E+01   YSL=  .2387E+01
XSL=  .3118E+00   YSL=  .8318E+00
XSL=  .8250E+00   YSL=  .1231E+01
XSL=  .1684E+01   YSL=  .2125E+01
XSL=  .2773E+00   YSL=  .8382E+00
XSL=  .9385E+00   YSL=  .1390E+01
XSL=  .1457E+01   YSL=  .1890E+01
XSL=  .2431E+00   YSL=  .8447E+00
XSL=  .2002E+00   YSL=  .8412E+00
XSL=  .1438E+00   YSL=  .8193E+00
XSL=  .8537E-01   YSL=  .7876E+00
XSL=  .1974E+01   YSL=  .3050E+01
XSL=  .2202E+01   YSL=  .3515E+01
XSL=  .3078E-01   YSL=  .7520E+00
XSL=  .1844E+01   YSL=  .2862E+01
XSL=  .2097E+01   YSL=  .3435E+01
XSL= -.1602E-01   YSL=  .7182E+00
XSL=  .1765E+01   YSL=  .2781E+01
XSL=  .2024E+01   YSL=  .3408E+01
XSL= -.5799E+01   YSL=  .6821E+00
XSL=  .1714E+01   YSL=  .2763E+01
XSL=  .1958E+01   YSL=  .3393E+01

    PERCENT ERROR IN HT=   .1027E+02    RMS OF PERCENT ERROR IN HT=   .3522E+01

PRESSURE DRAG =       1.0286611681

SIGMAX= .3480E+03   J=    3   K=   12   SIGMIN=  .8842E+01   J=   20   K=    1   CN= .2000E+01   DT= .5747E-02
RESIDUE INFORMATION            19   11     .06768    .15939  42.46475S( 19, 11, 4)=    .06588
RMS OF SHOCK SPEED=    .2494E+00    J=  8    MAX SHK SPD=   .7657E+00
RMS OF SHOCK SPEED=    .2499E+00    J=  8    MAX SHK SPD=   .7860E+00
RMS OF SHOCK SPEED=    .2501E+00    J=  8    MAX SHK SPD=   .8006E+00
RMS OF SHOCK SPEED=    .2493E+00    J=  8    MAX SHK SPD=   .8069E+00
RMS OF SHOCK SPEED=    .2479E+00    J=  8    MAX SHK SPD=   .8059E+00
RMS OF SHOCK SPEED=    .2460E+00    J=  8    MAX SHK SPD=   .7985E+00
RMS OF SHOCK SPEED=    .2439E+00    J=  8    MAX SHK SPD=   .7852E+00
RMS OF SHOCK SPEED=    .2416E+00    J=  8    MAX SHK SPD=   .7669E+00
RMS OF SHOCK SPEED=    .2392E+00    J=  8    MAX SHK SPD=   .7440E+00
RMS OF SHOCK SPEED=    .2367E+00    J=  8    MAX SHK SPD=   .7170E+00
```

Finished Flowfield Information

```
SECOND INDEX=  1

1ST   P/PINF        S        U/QINF      V/QINF      S/SINF     HT/HTINF     R/RI        CP          X           Y         EI/EIINF
 1  .4548E+02 -.1911E+00  .4401E-02 -.9683E-01  .4085E+01  .1000E+01  .5592E+01  .1765E+01  .4228E-02 -.1911E+00  .8132E+01
 2  .4548E+02  .1911E+00  .4401E-02  .9683E-01  .4085E+01  .1000E+01  .5592E+01  .1765E+01  .4228E-02  .1911E+00  .8132E+01
 3  .3542E+02  .5735E+00  .1727E+00  .2396E+00  .4085E+01  .1000E+01  .4678E+01  .1366E+01  .3890E-01  .5719E+00  .7572E+01
 4  .1589E+02  .1098E+01  .4643E+00  .2947E+00  .4085E+01  .1000E+01  .2639E+01  .5910E+00  .4816E+00  .8532E+00  .6022E+01
 5  .1682E+02  .1533E+01  .4380E+00  .3114E+00  .4085E+01  .1000E+01  .2748E+01  .6277E+00  .8487E+00  .1086E+01  .6120E+01
 6  .2339E+02  .1881E+01  .3362E+00  .3030E+00  .4085E+01  .1000E+01  .3478E+01  .8884E+00  .1119E+01  .1306E+01  .6725E+01
 7  .2775E+02  .2190E+01  .2667E+00  .2948E+00  .4085E+01  .1000E+01  .3930E+01  .1062E+01  .1336E+01  .1525E+01  .7062E+01
 8  .3064E+02  .2481E+01  .2252E+00  .2814E+00  .4085E+01  .1000E+01  .4218E+01  .1176E+01  .1521E+01  .1750E+01  .7265E+01
 9  .3452E+02  .2771E+01  .1897E+00  .2428E+00  .4085E+01  .1000E+01  .4593E+01  .1330E+01  .1699E+01  .1979E+01  .7517E+01
10  .3846E+02  .3066E+01  .1535E+00  .1965E+00  .4085E+01  .1000E+01  .4962E+01  .1487E+01  .1881E+01  .2211E+01  .7752E+01
11  .3953E+02  .3372E+01  .1427E+00  .1826E+00  .4085E+01  .1000E+01  .5060E+01  .1529E+01  .2069E+01  .2452E+01  .7813E+01
12  .3772E+02  .3697E+01  .1607E+00  .2057E+00  .4085E+01  .1000E+01  .4893E+01  .1457E+01  .2269E+01  .2708E+01  .7709E+01
13  .3454E+02  .4049E+01  .1899E+00  .2423E+00  .4085E+01  .1000E+01  .4594E+01  .1331E+01  .2486E+01  .2986E+01  .7517E+01
14  .2474E+02  .4440E+01  .3045E+00  .3115E+00  .4085E+01  .1000E+01  .3620E+01  .9420E+00  .2728E+01  .3293E+01  .6834E+01
15  .1126E+02  .4827E+01  .5408E+00  .2972E+00  .4085E+01  .1000E+01  .2064E+01  .4073E+00  .3027E+01  .3539E+01  .5458E+01
16  .4567E+01  .5196E+01  .7268E+00  .1578E+00  .4085E+01  .1000E+01  .1083E+01  .1415E+00  .3378E+01  .3651E+01  .4217E+01
17  .2639E+01  .5572E+01  .7929E+00  .9735E-01  .4085E+01  .1000E+01  .7319E+00  .6504E-01  .3751E+01  .3697E+01  .3606E+01
18  .2335E+01  .5948E+01  .8035E+00  .9865E-01  .4085E+01  .1000E+01  .6707E+00  .5299E-01  .4125E+01  .3743E+01  .3482E+01
19  .2334E+01  .6324E+01  .8035E+00  .9866E-01  .4085E+01  .1000E+01  .6705E+00  .5295E-01  .4498E+01  .3788E+01  .3481E+01
20  .2370E+01  .6707E+01  .8022E+00  .9850E-01  .4085E+01  .1000E+01  .6778E+00  .5437E-01  .4878E+01  .3835E+01  .3497E+01
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SECOND INDEX= 12

1ST   P/PINF     RO/RINF     U/QINF      V/QINF      S/SINF     HT/HTINF     MACH        CP          X           Y         EI/EIINF
 1  .4037E+02  .5245E+01  .2091E+00 -.8274E-01  .3967E+01  .9831E+00  .4864E+00  .1562E+01 -.1828E+00 -.2004E+00  .7697E+01
 2  .4037E+02  .5245E+01  .2091E+00  .8274E-01  .3967E+01  .9831E+00  .4864E+00  .1562E+01 -.1828E+00  .2004E+00  .7697E+01
 3  .3637E+02  .5174E+01  .2890E+00  .2463E+00  .3643E+01  .9839E+00  .8593E+00  .1404E+01 -.9978E-01  .5928E+00  .7030E+01
 4  .2859E+02  .4999E+01  .4476E+00  .3728E+00  .3045E+01  .1005E+01  .1452E+01  .1110E+01  .7830E-01  .9561E+00  .5797E+01
 5  .2189E+02  .4745E+01  .5933E+00  .4022E+00  .2475E+01  .1014E+01  .2002E+01  .8290E+00  .3535E+00  .1266E+01  .4613E+01
 6  .1767E+02  .4521E+01  .6423E+00  .3601E+00  .2137E+01  .9528E+00  .2235E+01  .6615E+00  .6512E+00  .1532E+01  .3908E+01
 7  .1766E+02  .4521E+01  .6654E+00  .3814E+00  .2136E+01  .9429E+00  .2328E+01  .6611E+00  .8901E+00  .1798E+01  .3906E+01
 8  .2208E+02  .4754E+01  .6381E+00  .4464E+00  .2490E+01  .1099E+01  .2168E+01  .8365E+00  .1183E+01  .2007E+01  .4645E+01
 9  .2824E+02  .4978E+01  .4907E+00  .4154E+00  .2986E+01  .1055E+01  .1619E+01  .1081E+01  .1425E+01  .2234E+01  .5674E+01
10  .3334E+02  .5110E+01  .3638E+00  .3338E+00  .3397E+01  .1010E+01  .1160E+01  .1283E+01  .1609E+01  .2521E+01  .6524E+01
11  .3578E+02  .5162E+01  .3082E+00  .2789E+00  .3595E+01  .9969E+00  .9472E+00  .1380E+01  .1764E+01  .2878E+01  .6931E+01
12  .3510E+02  .5148E+01  .3167E+00  .2797E+00  .3540E+01  .9881E+00  .9708E+00  .1353E+01  .1925E+01  .3307E+01  .6818E+01
13  .3242E+02  .5089E+01  .3670E+00  .3164E+00  .3323E+01  .9830E+00  .1152E+01  .1247E+01  .2132E+01  .3775E+01  .6370E+01
14  .2911E+02  .5003E+01  .4359E+00  .3578E+00  .3056E+01  .9688E+00  .1403E+01  .1115E+01  .2404E+01  .4265E+01  .5818E+01
15  .2579E+02  .4899E+01  .5126E+00  .3923E+00  .2788E+01  .1008E+01  .1688E+01  .9837E+00  .2753E+01  .4755E+01  .5264E+01
16  .2269E+02  .4780E+01  .5823E+00  .4072E+00  .2539E+01  .1022E+01  .1957E+01  .8607E+00  .3183E+01  .5235E+01  .4747E+01
17  .2007E+02  .4657E+01  .6402E+00  .4095E+00  .2329E+01  .1033E+01  .2197E+01  .7566E+00  .3594E+01  .5620E+01  .4309E+01
18  .1796E+02  .4539E+01  .6806E+00  .4005E+00  .2160E+01  .1030E+01  .2382E+01  .6730E+00  .4034E+01  .5983E+01  .3957E+01
19  .1609E+02  .4415E+01  .7107E+00  .3845E+00  .2011E+01  .1018E+01  .2540E+01  .5987E+00  .4498E+01  .6340E+01  .3643E+01
20  .1421E+02  .4268E+01  .7418E+00  .3662E+00  .1863E+01  .1007E+01  .2720E+01  .5243E+00  .4878E+01  .6617E+01  .3330E+01

 SONIC LINE LOCATION

XSL=  .2638E+00   YSL=  .7148E+00
XSL=  .1187E+01   YSL=  .1375E+01
XSL=  .2728E+01   YSL=  .3294E+01
XSL=  .4812E+00   YSL=  .8868E+00
XSL=  .8750E+00   YSL=  .1161E+01
XSL=  .2196E+01   YSL=  .2705E+01
XSL=  .6840E+00   YSL=  .1066E+01
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XSL=  .7725E+00   YSL=  .1130E+01
XSL=  .1936E+01   YSL=  .2418E+01
XSL=  .5059E+00   YSL=  .9809E+00
XSL=  .7773E+00   YSL=  .1188E+01
XSL=  .1725E+01   YSL=  .2185E+01
XSL=  .3765E+00   YSL=  .9231E+00
XSL=  .9456E+00   YSL=  .1386E+01
XSL=  .1477E+01   YSL=  .1934E+01
XSL=  .3094E+00   YSL=  .9091E+00
XSL=  .2513E+00   YSL=  .8980E+00
XSL=  .1838E+00   YSL=  .8687E+00
XSL=  .1113E+00   YSL=  .8232E+00
XSL=  .2002E+01   YSL=  .3105E+01
XSL=  .2186E+01   YSL=  .3474E+01
XSL=  .4362E-01   YSL=  .7710E+00
XSL=  .1910E+01   YSL=  .3014E+01
XSL=  .2097E+01   YSL=  .3425E+01
XSL= -.1244E-01   YSL=  .7224E+00
XSL=  .1787E+01   YSL=  .2828E+01
XSL=  .2022E+01   YSL=  .3394E+01
XSL= -.5749E-01   YSL=  .6791E+00
XSL=  .1726E+01   YSL=  .2789E+01
XSL=  .1958E+01   YSL=  .3382E+01
    PERCENT ERROR IN HT=   .9980E+01    RMS OF PERCENT ERROR IN HT=   .3555E+01

PRESSURE DRAG =      1.0177018777

DATA AT J= 19   IS STORED FOR AFTERBODY CAL.

K= 1  PRESS= .2334E+01  DENS= .6705E+00  AX VEL= .5704E+01  CIRCUM VEL=0.          RAD VEL= .7004E+00  RD= .3788E+01

K= 2  PRESS= .1974E+01  DENS= .8173E+00  AX VEL= .6020E+01  CIRCUM VEL=0.          RAD VEL= .5981E+00  RD= .4020E+01

K= 3  PRESS= .2726E+01  DENS= .1063E+01  AX VEL= .5835E+01  CIRCUM VEL=0.          RAD VEL= .8472E+00  RD= .4252E+01

K= 4  PRESS= .4170E+01  DENS= .1378E+01  AX VEL= .5507E+01  CIRCUM VEL=0.          RAD VEL= .1202E+01  RD= .4484E+01

K= 5  PRESS= .5806E+01  DENS= .1694E+01  AX VEL= .5200E+01  CIRCUM VEL=0.          RAD VEL= .1513E+01  RD= .4716E+01

K= 6  PRESS= .7356E+01  DENS= .1954E+01  AX VEL= .4944E+01  CIRCUM VEL=0.          RAD VEL= .1741E+01  RD= .4948E+01

K= 7  PRESS= .8754E+01  DENS= .2155E+01  AX VEL= .4756E+01  CIRCUM VEL=0.          RAD VEL= .1898E+01  RD= .5180E+01

K= 8  PRESS= .1006E+02  DENS= .2347E+01  AX VEL= .4660E+01  CIRCUM VEL=0.          RAD VEL= .2021E+01  RD= .5412E+01

K= 9  PRESS= .1142E+02  DENS= .2616E+01  AX VEL= .4670E+01  CIRCUM VEL=0.          RAD VEL= .2156E+01  RD= .5644E+01

K=10  PRESS= .1294E+02  DENS= .3048E+01  AX VEL= .4766E+01  CIRCUM VEL=0.          RAD VEL= .2333E+01  RD= .5876E+01

K=11  PRESS= .1460E+02  DENS= .3672E+01  AX VEL= .4902E+01  CIRCUM VEL=0.          RAD VEL= .2537E+01  RD= .6108E+01

K=12  PRESS= .1609E+02  DENS= .4415E+01  AX VEL= .5046E+01  CIRCUM VEL=0.          RAD VEL= .2730E+01  RD= .6340E+01

    1  0.           .6340E+01   .7297E+00  0.

RESIDUE INFORMATION           19   11    .10278    .21289  48.27775S( 19, 11, 4)=    .10007
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