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THREE-DIMENSIONAL INCOMPRESSIBLE BOUNDARY LAYERS ON BLUNT BODIE--ETC(U)
MAY 77 D L DWOYER, C H LEWIS, P R GOGINENI

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VPI & SU AERO-063

Three-Dimensional Incompressible Boundary Layers On Blunt Bodies Including Effects Of Turbulence, Surface Curvature And Heat And Mass Transfer

Part II: Computer Code User's Manual

by

D. L. Dwoyer, Clark H. Lewis and P. R. Gogineni

This research was sponsored by the Applied Physics Laboratory of the Johns Hopkins University under Subcontract Number 600325.

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Aerospace and Ocean Engineering Department
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

May 1977

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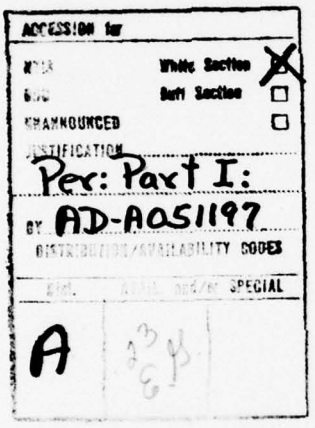
ABSTRACT

The computer code that was developed as a result of the analysis of Part I of this report, VPI-AERO-063, is herein described and documented. Included are programs input, expected output, description of mode of operation and other information useful in running the program.



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NOMENCLATURE

h_ξ	metric coefficient of the ξ coordinate
h_ω	metric coefficient of the ω coordinate
K_ξ	$(h_\xi h_\omega)^{-1} \partial h_\xi / \partial \omega$, curvature of the ξ coordinate line
K_ω	$(h_\xi h_\omega)^{-1} \partial h_\omega / \partial \xi$, curvature of the ω coordinate line
r	local body radius in stagnation point polar coordinates
s	surface distance along ξ coordinate
U_ξ	inviscid velocity component in ξ direction
U_ω	inviscid velocity component in ω direction
U_e	inviscid velocity component in ξ direction at the body surface
w	$w = W_e$ at stagnation point and on symmetry planes, $W = U_e$ elsewhere
W_e	inviscid velocity component in ω direction at the body surface
x	distance along stagnation point axis
α_1	W/U_e
α_2	W_e/U_e
α_3	W_e/W
β_1	$(h_\xi U_e)^{-1} \xi \partial U_e / \partial \xi$
β_2	$(h_\omega U_e)^{-1} \xi \partial U_e / \partial \omega$
β_3	$(h_\omega W_e)^{-1} \xi \partial W_e / \partial \omega$
β_4	$(h_\xi W_e)^{-1} \xi \partial W_e / \partial \xi$
ξ	orthogonal surface coordinate in longitudinal direction
σ	source density
ϕ	meridional angle in stagnation point coordinate system
ω	orthogonal surface coordinate in transverse direction

INTRODUCTION

A computer program has been developed for solving the three-dimensional boundary-layer flow on blunt bodies using a finite difference procedure. The program is capable of calculating laminar or turbulent flows and accounts for the effects of surface curvature. The equations solved, finite difference procedure used and results of test calculations with the code are presented in Ref. 1.

The boundary-layer program is not a stand alone program, but requires the generation of a data tape which describes the body geometry to be solved and the surface inviscid pressure distribution over the body. This report is divided into two sections, the first describes program TAPGEN which is capable of generating the required data tape for the boundary-layer code, and program ICBL3D which actually solves the boundary-layer equations for the body of interest.

All of the programs have been coded in FORTRAN IV and written for the IBM 370/158 computer with the JES2 operating system.

SECTION I

PROGRAM TAPGEN

In this section a brief description of the computer programs used to generate the inviscid data is presented to enable the user to execute the programs easily. The input data preparation and the outputs available have been described in detail. Finally the JCL required to execute the programs on IBM/370 Model 158 with JES2 operating system is listed.

The necessary computer programs are HESS, AOAT, BLOT, DERVAT and INVTAP. Program HESS generates the body geometry and inviscid velocity distribution for two onset flows: one in x-direction and the other in y-direction. These two flows are combined by program AOAT to give the inviscid velocity distribution at the given angle of attack. Programs HESS and AOAT may be replaced by program HESS3D for calculating the inviscid flow over bodies with non-axisymmetric shapes. Program BLOT reads this velocity distribution and computes the position of surface coordinates, metric coefficients and the inviscid velocities in surface coordinates. All this information is read by program DERVAT which computes the required derivatives. Program INVTAP fits appropriate Fourier series in ϕ; computes the Fourier coefficients and writes them on a tape as required by the boundary layer programs. These programs taken together represent program TAPGEN.

1. Body Geometry and Inviscid Velocities

The boundary-layer equations have been written in

an orthogonal curvilinear surface coordinate system with its origin fixed at the stagnation point. The boundary-layer computations need the body geometry, metric coefficients and the inviscid velocity distribution. These are computed separately and a brief description of these computations follows.

The surface of the body is defined in the cartesian coordinate system shown in Fig. 1 . These coordinates form the input to the computer program which computes the inviscid velocity distribution at the given angle of attack. This computer program is capable of handling axisymmetric bodies at angle of attack and three-dimensional bodies at zero-angle of attack.

The inviscid flow velocities obtained above have been transformed into a orthogonal curvilinear surface coordinate system in which boundary-layer computations were made. The position of the surface coordinate system and the metric coefficients have been determined as required by the boundary-layer program. The mathematical details of these computations can be found in Ref. 2 .

Since the position (x, r, ϕ) of the surface coordinates and the position of the inviscid velocity would not be the same in general, the inviscid velocities at the surface coordinates have been obtained by double interpolation technique in (x, ϕ). Then the results are written on a scratch tape unit for every ξ=constant. The quantities on tape are ϕ, h_ξ, h_ω, r, s, U_ξ, U_ω and x. Since the boundary-layer program needs the first

derivatives with respect to ξ, of h_ξ, h_ω, U_ξ, U_ω, x, r and the second derivative of r, they have been computed using the five-point Lagrangian formula and written on the same tape. These data are fitted with appropriate Fourier series in ϕ and the Fourier coefficients have been written on another tape. It is from this tape that the boundary-layer program reads and obtains the necessary information about the geometry and inviscid velocity distribution of the body.

Immediately following is a description of the input to the inviscid program package along with sample input/output and a description of the Job Control Language required.

Basically, the calculation of the inviscid data tape is broken up into three steps as illustrated in the flow chart in Fig. 2 . First the inviscid velocity distribution is generated with either of the potential flow programs of Refs. 3 or 4 . Next the surface coordinate system is generated by program BLOT. The inviscid velocity field is then interpolated onto the surface coordinate system, Fourier fitted and written on the boundary-layer code data tape in programs DERVAT and INVTAP. Program AOAT is used only with the axisymmetric HESS code and serves to combine the zero and ninety degree angle of attack solutions into the solution at the desired angle of attack.

2. Description of Input Data

Program HESS (Axisymmetric)

A. Card Column Parameter Locations

Card 1 - Header Card.

cc1-60	Header	Any alphanumeric run description.
cc63-68	Case	Case number.

Card 2 - Control Flag Card

cc1	NB	Number of bodies ($1 \leq NB \leq 9$).
cc2	NNU	Number of non-uniform flows ($0 \leq NNU \leq 5$).
cc3	IAXI	Axisymmetric flow flag.
cc4	ICRØSS	Crossflow flag.
cc5	IØFF	Off-body point input flag.
cc6	IØNLY	Basic-data-only flag.
cc7	IELPSE	Ellipse generator flag (see also Card 5).
cc8-10	(blank)	
cc11	IPRTRB	Perturbation velocities only.
cc12	IPØTNL*	Solve potential matrix.
cc14	IPTANV	Prescribed tangential velocity (for the last IPTANV bodies).
cc15	IVØRT	Strip-ring vorticity flag.
cc16	IØMITA	Omit axisymmetric uniform flow solution.
cc17	IOMITC	Omit crossflow uniform flow solution.
cc18	ISURFV	Surface vorticity (instead of sources) for the final ISURFV bodies.
cc19	IPRSCV	Prescribed values of the surface vortex strengths for the final ISURFV bodies will be input.
cc20	IALLV	All bodies are surface vorticity bodies.
cc21	IEXCRS*	Extra crossflow.
cc22	IGENBC	Generated boundary conditions.
cc23	IRNGW	Ring wing option.
cc28	IPNCH	Punched output.
cc29,30	IUNIT	Unit number for input coordinates (default = 05).

*Available if and only if NØNEWF = 1, ISIGF = 1 and IGEØMF = 1.

cc31	IVIJ	Matrix print flag.
cc32	ICØEF	Matrix-assembly coefficient print flag.
cc33	IPRINT	Very detailed matrix construction print flag.
cc34	IRAKF	Automatic rake generation flag (see also Cards 8 & 9)

Card 3 - Chord/Mach number card.

cc1-10	CHØRD	Reference chord length (default = 1.0).
cc11-20	XMACH	Mach number for Goethert correction (0.0 implies incompressible).
cc21-80	(blank)	

Card 4 - Body Control Card 1 of 2.

cc1	IGEØMF	0 = curved elements; 1 = flat elements.
cc2	ISIGF	0 = parabolic σ; 1 = linear σ; 2 = constant σ (on each element).
cc3	ICURVN	0 = internally calculated element curvatures; 1 = input curvature (see card 7).
cc4	NØNEWF	0 = use the newest formulas; 1 = use the old formulas (implies flat elements and constant σ).
cc5	IFØRMT	Input format flag (see Card Set 6).
cc6-10	NN	Number of defining endpoints for this body.
cc11-20	XMULT	x-multiplier value (default = 1.0).
cc21-30	YMULT	y-multiplier value (default = 1.0).
cc31-40	THETA	Coordinate rotation value (degrees, measured about -Z-axis.
cc41-50	ADDX	x-increment (to be applied to all the input coordinates for this body).
cc51-60	ADDY	y-increment (to be applied to all the input coordinates for this body).

Card 5 - Body Control Card 2 of 2

cc1-10	IBDN	"Body" number (sequential for bodies, zero for off-body points)
cc11-20	ISUBKS	Subcase flag
cc21-30	NLF	Non-lifting flag (for combination cases, only)
cc31-40	A	Semi-major axis for ellipse cases } If IELPSE ≠ 0
cc41-50	B	Semi-minor axis for ellipse cases } If IELPSE ≠ 0

Card (Set) 6 - Body Definition Cards

IF IFØRMT=0: X-coordinates (6F10.5), then Y-coordinates (6F10.5)

IF IFØRMT=1: X, Y coordinates (2F10.5) (i.e., one "point-set" per card).

IF IFØRMT=2: X, Y coordinates (F10.5,10X,F10.5) (i.e., one "point set" per card).

Card (Set) 7 - Input curvature values (needed only if ICURVN ≠ 0)

(6F10.5) CURV(I),I=1,NN-1 The curvature values for the NN-1 elements which constitute this body

Repeat Cards 4-7 a total of (NB+IØFF) times

Card 8 - Rake Number Card (needed only if IRAKF ≠ 0)

cc1-10	NRAKES	The number of "automatically" generated mass-flow rakes

Card 9 - Rake Definition Card (needed only if IRAKF ≠ 0)

cc1-10	X1 }	Coordinates of "start" of the rake
cc11-20	Y1 }	
cc21-30	X2 }	Coordinates of the "end" of the rake
cc31-40	Y2 }	
cc41-45	N	Number of intervals to be used in the rake (note, $4 \leq N < 200$, and N must be an even integer)

Repeat Card 9 a total of NRAKES times.

Card 10 - Non-Uniform Flow Control Card (needed only if NNU ≠ 0)

cc1-10	NUN	Flow identification number
cc11-20	MSF	0 = axisymmetric onset flow; 1 = cross-flow onset flow, 2 = both 0 and 1
cc21-30	TYPE	+1.0 = velocity will be input in x,y component form; 0 = velocities will be input in normal, tangential form; -1 = automatic generation of flow due to rotation about the Z-axis (for crossflow, only)
cc31-40	FG	Flow generator constant

Card (Set) 11 - Non-Uniform Flow Velocities (needed only if NNU ≠ 0)

(6F10.5)	VX(I) or VN(I), I = 1, total number of control points
(6F10.5)	VY(I) or VT(I), I = 1, total number of control points

Repeat Cards 10 and 11 a total of NNU times.

Card (Set) 12 - Specified Tangential Flow Velocities needed only if IPTANV ≠ 0

(6F10.5)	TG(I), I = 1, total number of control points on the last IPTANV bodies

B. Discussion of Parameters

In all cases, the integer values (indicated by the standard FØRTRAN IV naming convention) must be right adjusted within the specified input fields. For floating-point type input, the input decimal point will override the quoted FØRMAT specifications.

Card 1. Self-explanatory.

Card 2. Although most of these flags are unchanged from the original program, a brief description of each one will be given here for completeness.

NB The total number of separate "bodies" ($1 \leq NB \leq 8$).

NNU The total number of (user specified) input non-uniform flows ($0 \leq NNU \leq 5$).

IAXI Axisymmetric flow flag (0: no axisymmetric flow, 1: axisymmetric flow)

ICROSS Crossflow flag (0: no crossflow, 1: crossflow)

IOFF Off-body point input flag (0: no off-body points will be input, 1: off-body points will be input)

IONLY Basic-data-only flag (0: full execution, 1: basic data only)

IELPSE Ellipse generator flag (see also card 5)(0: standard body defining coordinates will be input, 1: coordinates for the ellipse whose properties are specified on card 5 are to be created automatically by the program).

IPRTRB Perturbation velocities only (0: standard total net velocities including the onset flow will be printed, 1: perturbation velocities only will be printed).

IPØTNL Solve the potential matrix (0: standard solution for the surface velocities, 1: solution for the surface velocity potential). Since the velocity potential problem for the higher order elements has not been coded in the present version, the solution for the

potential is available only for the case of flat elements and, in particular, through the usage of the "old" velocity formulas. These "old" formulas have been retained as a subsection of this new, higher order program and may be "reached" by setting the following quantities (on Card 4): IGEØMF = 1, ISIGF = 2, and NØNEWF = 1; in such a case, the solution for the potential is still available.

IPTANV Prescribed tangential velocity flag (0: standard zero normal velocity solution is to be obtained, 1: a user defined set of prescribed tangential velocities will be input on the last IPTANV bodies; obviously, IPTANV $\leq$ NB).

IVØRT Strip ring vorticity onset flows for each of the bodies (0: no strip ring vorticity, 1: automatic generation of the strip ring vorticity onset flows).

IØMITA Omit the uniform axisymmetric flow solution (0: calculate the standard uniform axisymmetric flow solution if IAXI $\neq$ 0, 1: omit this uniform axisymmetric flow solution even if IAXI $\neq$ 0).

IØMITC Omit the uniform crossflow solution (0: calculate the uniform crossflow solution if ICROSS $\neq$ 0, 1: omit the uniform crossflow solution even if ICRØSS $\neq$ 0).

ISURFV Surface vorticity for axisymmetric flow (in place of surface sources) flag (0: use the standard source

distribution on all elements, $\neq 0$: use vorticity instead of a source distribution as the singularity on the elements of the last ISURFV bodies). Note that if ISURFV $\neq 0$, then both IVØRT and IPTANV must be $\neq 0$, and then in particular, IPTANV must = ISURFV). If we assume that IPTANV = ISURFV = k, and that M is the total number of elements on the last k bodies, then the surface vorticity option causes the source induced velocity formulas to be used on the first N-M elements of each matrix row, and the vortex formulas to be used on the remaining M elements of each matrix row. The solution for the unknown strengths then proceeds as it would have if only IPTANV was nonzero.

IPRSCV Prescribed vorticity flag for axisymmetric flow (0: prescribed vorticity values will not be input, 1: prescribed vorticity values (W_i) for the last IPRSCV bodies will be input; note that if IPRSCV is $\neq 0$, then both IVØRT and IPTANV must $\neq 0$, and then, in particular, IPTANV must = IPRSCV). If IPRSCV is $\neq 0$, then the vortex strengths of the affected elements are taken to be $W_i/4\pi$.

IALLV Total vorticity flag for axisymmetric flow (0: all elements are assumed to be source type elements (unless ISURFV $\neq 0$), 1: all elements are assumed to be vortex type elements). Note that if IALLV is $\neq 0$, the use of IPTANV is optional, but not mandatory.

IEXCRS Extra crossflow flag (0: no "extra" crossflow, 1: generate an "extra" crossflow (i.e., having a potential which varies as the cosine of twice the circumferential angle)). Note that if IEXCRS ≠ 0, then NØNEWF = 1, ISIGF = 2, and IGEOMF must = 1, since the higher order formulas for this kind of velocity potential have not been included in this program.

IGENBC Generated boundary condition flag (0: do not generate any additional boundary conditions for the crossflow case; 1: generate the onset crossflow due to rotation about an axis normal to the axis of symmetry (see also the notes for Card 10)).

IRNGW Ring wing option (0: no ring wing option, 1: use the ring wing option (see MDC Report J0741/01, April 1970 for further details)).

IPNCH Punched card output flag (0: no punched card output, 1: punched card output).

Card 3. This card is usually left blank, which results in a default chord length of unity, and no Mach number corrections (i.e., incompressible results). If a non-zero value of the Mach number is input, the program uses the Goethert correction to account for compressibility.

Card 4. Usage of the IGEOMF and ISIGF flags permit the user to "turn-off" any or all of the higher order element

curvature and/or varying source density terms. The default values are curved elements with parabolically varying source density. If IGEØMF = 0, the program will automatically calculate the local element curvature values by the procedure described in Section II.A, unless ICURVN is non-zero, in which case the user must supply these curvature values (see Card 7). The value for the NØNEWF flag is ordinarily left blank (or zero), even if a flat element, constant source density solution is required. However, since certain of the original Douglas-Neumann Axisymmetric Potential Flow Program capabilities have not been made available in the higher order program (e.g., calculation of the potential (hence the added mass, etc.) the original formulas have been preserved within this version (see description of the IPØTNL and IEXCRS flags). The original capacilities can be obtained by setting IGEØMF = 1, ISIGF = 2, and NØNEWF = 1 for each of the input bodies, in which case the input instructions of Reference 5 apply.

The other parameters on Card 4 are self-explanatory, with the understanding that the order of coordinate transformations are as listed on the input.

Card 5. The "bodies" are normally loaded prior to any off-body points (although the latter require the usage

of body control Cards 1 and 2, also). For this reason, the value of IBDN should be sequentially increasing beginning with unity. A non-zero value for ISUBKS means that the body definition cards for this body (Card Set 6), (say this is the ith body input under this header card) will not be included, but that the program is to use the ith set of points that were input under the previous header card. Obviously, this capability is useful only with "stacked" input cases.

Card 6. The three input formats that are available are as shown. The value of IFØRMT determines which format is used. The default format is the "old" format: x-coordinates, followed by the y-coordinates.

Card 7. These values are to be input only if ICURVN $\neq$ 0.

Card 8. This card is needed only if IRAKF $\neq$ 0. Note that $1 \leq$ NRAKES ≤ 20.

Card 9. These are the rake definition cards, which define the "start" and "end" of each mass flow rake. The sign convention that is employed is as follows: a positive mass flux means that the flow is from left to right to an observer traversing the rake from point (X1, Y1) to point (X2, Y2). For example, for an inlet without a bullet, point 1 is typically at y = 0.0, and point 2 would have a y-coordinate located on the inlet wall. Note that the x-coordinates need not be the same, i.e., a tilted rake may be used,

if desired. Note also that one rake may "overlap" another if so desired, since they are each treated independently. It should be pointed out that a Simpson Rule integration is performed over the "N" intervals (and therefore N must be an even integer), with the program automatically generating N-1 "intermediate" points as "off-body points" for each input rake (program limit is 500 total off-body points). The velocity values at the first and last rake points are obtained by linear extrapolation of the two nearest values. In this way, the difficulty associated with calculating induced velocities at off-body points which lie very near to, or on, the surface is avoided. Typically, values of N between 10 and 20 appear to be satisfactory for most cases.

Card 10. Self-explanatory, except that FG, if entered is used in the following way to generate the rotation onset flow:

$$V_{x_i} = y_i$$

$$V_{y_i} = FG - x_i$$

$$V_N = V_{x_i} \sin \alpha_i - V_{y_i} \cos \alpha_i$$

$$V_T = V_{x_i} \cos \alpha_i + V_{y_i} \sin \alpha_i .$$

Card 11. Self-explanatory.

Program AOAT

Card 1. Format (3I3,F10.6)

cc1-3	IPRT = 1, writes the output of program HESS on Unit 6; = 0, does not write
cc4-6	N, Number of elements used in the program HESS
cc7-9	KPL, Number of meriodonial planes required
cc10-19	ALPD, Angle of attack in degrees

Program HESS (3-D)

Card 1.

cc	CONTENTS	NOTES
1→60	Title	Header information
61	IFLAG	= "0" for input body coordinates (this is the usual case) = "1" for generated ellipsoids = "2" for generated bodies with elliptical cross section
62	LIST	= "0" for full execution = "1" for basic data listing only
63	KX	= "F" or blank for no generated uniform x-flow = "T" for generated uniform x-flow (calculate x-flow matrices)
64	KY	= "F" or blank for no generated uniform y-flow = "T" for generated uniform y-flow (calculate y-flow matrices)

cc	CONTENTS	NOTES
65	KZ	= "F" or blank for no generated uniform z-flow = "T" for generated uniform z-flow (calculate z-flow matrices)
66	ISIG	= "0" for no input guesses for source densities = "1" for input guesses for source densities (rarely used)
67	IPRS	= "0" for no mid-iteration print = "1" for print of solution iterations
68	MPR	= "0" for no intermediate matrix print = "1" for V_{ij} print = "2" for A_{ij} print = "3" for V_{ij} and A_{ij} print (Never use for large case, or output is excessive)
69	METHØD	= "0" for automatic solution selection = "1" for direct matrix solution = "2" for modified Seidel iterative solution
70→71	NNØN	Number of input onset flows
72	NSYM	Number of symmetry planes
73	NØFF	= "0" for no off-body points = "1" for off-body points
74	KMACH	= "0" for no Mach number correction = "1" for input Mach number

cc	CONTENTS	NOTES
75-76	---	
77-80	KASE	Alpha-numeric case identification

Mach Number is input on a separate card only if KMACH = 1.

INPUT GENERATOR DATA

Card 2.

cc	CONTENTS	NOTES
1 →5	NLM1	Number of "latitudinal" element divisions
6→10	MMIN	Number of "longitudinal" element divisions
11→20	B	Y semi-axis of elliptical cross section
21→30	C	Z semi-axis of elliptical cross section

(If ellipsoid is generated, X semi-axis is unity)

NOTE: This card is input only when IFLAG ≠ 0

X-Z INPUT

This input consists of the coordinate pairs (X_1, Z_1, X_2, Z_2, . . . X_{NLM1+1}, Z_{NLM1+1}) that define the profile in the x-z plane of the body of elliptical cross-section to be generated by the program. These coordinates are read with an 8F10.0 format.

ON-BODY COORDINATES

General (non-elliptical) bodies are input by giving the

coordinates of a large number of points on the body. The three dimensional coordinates defining the body surface(s) are input 2 points-to-a-card. Each point has associated with it a quantity called its "status" that has the following meaning:

VALUE	MEANING
"0" or blank	This point is on the same n-line as the last point
1	This point starts a new n-line
2	This point starts a new section
3	This is the last point of the input

NOTE: These cards are only input if IFLAG=0

OFF-BODY POINT COORDINATES

The three-dimensional coordinates defining the off-body points are input with the identical format of the on-body coordinates. The only status flag used, however, is that of "3" for the last off-body point.

NOTE: These cards are input only if NØFF=1.

FLOW FLAGS

Each input onset flow is preceded by a card that describes the flow. All x-flows must precede all y-flows which precede all z-flows. (An "x-flow" is any flow that is solved using the matrix appropriate for a uniform onset flow parallel to the x-axis.)

cc	MEANING
1	= "1" if this is an x-flow = "2" if this is a y-flow = "3" if this is a z-flow
2	= "0" if this is a non-uniform onset flow, i.e., values of the onset flow velocities will be specified for each element = "1" if this is a uniform onset flow, the value of which is only specified once
3	= "0" if the onset flow velocity is expressed in component form = "1" if the onset flow is expressed in normal velocity values

NOTES: The onset flow velocities and sigma guesses are read with a "6F10.0" format.

This input is only required if NNØN = 0.

GENERAL PROCEDURES

All coordinates are input with the following format

2 (3F10.0, I1)

Except where noted elsewhere, zeroes or blanks may be interchanged on input.

Program BLOT

Card Name Col. 1-5	Fortran Name	Format	Column	Description
TITLE	TITLE	9A8	6-77	Problem Identification - this will appear as a heading in the output
LIMTS	JMAX	I5	6-10	Number of points across boundary layer
	KMAX	I5	11-15	Number of points around body (in phi-direction)
	LITER	I5	16-20	Number of iterations for initial profile
	IPRT	I5	21-25	Every how many steps printing will occur along the body
	KPRT	I5	26-30	Every how many steps printing will occur around the body
	PSIMAX	E10.0	31-40	Distance along body at which program will terminate
	UINF	E10.0	41-50	Freestream velocity - V_∞
DW	DW(K)	E10.0	6-15	$\Delta\omega$'s around the body, K = 1, KMAX - 1.
			16-25	
			.	
			.	
			.	
			etc.	
DN	DN(J)	E10.0	6-15	$\Delta\eta$'s across the boundary layer. J = 1, JMAX - 1.
			16-25	
SIZE	A	E10.0	6-15	a - length of axis of triaxial ellipsoid ($A>10^6$ gives paraboloids)

Card Name Col. 1-5	Fortran Name	Format	Column	Description
	RB	E10.0	16-25	R_b - radius of curvature of nose of body in the plane y'= 0
	RC	E10.0	26-35	R_c - radius of curvature of nose of body in the plane z' = 0
	EPS	E10.0	36-45	Convergence criterion used in calculating the body coordinates
	ALP	E10.0	46-55	α - angle of attack (deg)
	CAPTH	E10.0	56-65	Θ - indicates which finite-difference scheme is being used. = { 1 = Kruase scheme; 2 = Crank-Nicolson scheme
	CRI	E10.0	66-75	= { 1 Implicit scheme; 1/2 Crank-Nicolson scheme

Programs DERVAT and INVTAP

These programs obtain the necessary data sets internally and they do not need any external input.

3. Description of Program Output

Program HESS(Axisymmetric)

Unit 6

The main output of the program, which consists of calculated surface velocities and/or pressures has not been changed. Its format is that of Ref.2. The surface coordinates with which the calculated velocities are associated are the

transformed coordinates, i.e., the original input coordinates altered by any specified translations, multiplications, or rotations. Similarly, the format of the calculated velocities at the off-body points is similar to that of Ref.5. The only change is that output at rake points (q.v.) is included.

The initial output, which details the surface geometry, has been changed considerably. The header identifies what kind of solution has been computed: (1) curved or flat elements; (2) constant, linear, or parabolic source density element curvatures. The header also specifies whether "new" or "old" velocity formulas have been used, the latter of which apply only to the flat-element constant-source case. In the body of the output, the first two columns are the untransformed (input) coordinates, and the third and fourth columns are the transformed coordinates, which are the endpoints of the surface elements. The fifth and sixth columns are the coordinates of the control points of the elements. Element arc lengths are given in column 7 and a running total of arc length is displayed in column 8. Column 9 lists the differences between average slopes of successive elements, i.e., the differences in the slopes of the two straight lines, through the respective element endpoints. The actual slope discontinuity at an endpoint between two parabolic elements is normally much smaller than the difference between the average slopes of the two elements. Moreover, this discontinuity approaches zero if the body contour approaches a parabola. The final (tenth) column lists elements curvatures.

A new output is entitled Automatic Rake Calculation. For each rake the two input points that bound the rake and the input identification are output together with three calculated quantities. The first is the surface area of the cone frustum defined by the two input rake points. The third is the total flux of fluid that crosses this area per unit time. The second quantity, average velocity, is the ratio of the third and the first quantities. There is a rake output for all axisymmetric flows, both uniform and non-uniform, but there is no rake output for cross-flow, because its circumferential variation guarantees zero flux.

With regard to surface vorticity solutions, there are only two possibilities. Either there are no vorticity solutions or there is one solution for each body, which corresponds to a unit vorticity strength on that body and zero vorticity strength on all other bodies. The order of these solutions is the same as the order in which the bodies are input. Thus, in particular, an inlet with centerbody has two vorticity solutions - one with vorticity on the inlet and one with vorticity on the centerbody. The second of these is not meaningful and should be discarded. (It may, of course, occur first on the output.)

Units 1- 4, 7-15	These are scratch disks, which are used to write and read internally.
Unit 16	The coordinates x, y and the velocities T_1, T_1, T_2 are written in order one after the other for all axial stations.

Program AOAT

Unit 6 — For each axial station (x), the pressure coefficient (CP), the velocities UX, UY, UZ are written. These velocities are in body axes. Finally, the stagnation point location XO is printed.

Unit 10 — For each axial station, two records are written unformated. The first record contains X and KPL. The second record contains the meridonial plane angle, UX, UY, UZ and radius R for all planes.

Unit 22 — This is not used.

Unit 30 — Formated image of Unit 10.

Program BLOT

Unit 6 — Initially all input data is printed out. This includes several quantities which are computed strictly from the input. Next, initial profile calculations, including all iterations are printed. Finally, the solution at each desired location along and around the body is displayed. At each point where printing occurs, the following quantities appear:

X
Y
Z
} x,y,z coordinates

	R	r, radial distance to body surface
	S	s, distance along surface in ξ-direction
	ALPHA	$\bar{\alpha} = w_e/u_e$
	ALBET2	$\bar{\alpha}_2 = w_e/u_e$
	ALBET3	$\bar{\alpha}_3 = w_e/W$
	XIKA	parameter $\xi K_\xi/\bar{\alpha}$
	UE	u_e — inviscid edge velocities in ξ and ω directions
	WE	w_e — inviscid edge velocities in ξ and ω directions
	BETA1	β_1 — inviscid velocity gradient parameters
	BETA2	β_2 — inviscid velocity gradient parameters
	BETA3	β_3 — inviscid velocity gradient parameters
	BETA4	β_4 — inviscid velocity gradient parameters
	DFDN	Not calculated
	DGDN	Not calculated
	HPSI	h_ξ — Metric coefficients
	HOMEGA	h_ω — Metric coefficients
	KAPPAS	K_ξ — Curvatures of the coordinate lines
	KAPPAW	K_ω — Curvatures of the coordinate lines
	TOTAL SHEAR STRESS	Not calculated
	TOTAL SKIN FRICTION	Not calculated
	ANGLE	Not calculated
Unit 8		Formated image of Unit 25
Unit 11		The diagnostic printout from the double interpolation subroutine SLOALL. Useful for debugging only.

Unit 25	For each (PSI) the longitudinal surface coordinate, the metric coefficients (HPSI, HW), R, S, UPSI, UW are written for each meridonial plane, unformated.

Program DERVAT

Unit 6	The angle of attack in radians and the number of meridonial planes are written. Next the image of Unit 25 of program BLOT has been written.
Unit 26	The angle of attack in radians and KPL are written. Next, the station No. I, XS, HPSI, HW, R, S, UPSI, UW, X, and the derivatives of these D(UPSI), D(UW), D(R), the second derivative D2(R); D(HPSI), D(HW), D(X), are written in order for each meridonial plane. These are written unformated.
Unit 29	Formated image of part of Unit 26. The data written is I, XS, S, X, D(X), UPSI, D(UPSI), UW, and D(UW) for each plane.
Unit 30	Formated image of part of Unit 26. First the angle of attack in radians and KPL are written. Next I, XS, HPSI, D(HPSI), HW, D(HW), R, D(R) and D2(R) are written for each plane.

Program INVTAP

Unit 6	Errors and messages are written on this unit.
Unit 10	For each station the Fourier coefficients are written unformated. This is the data set required by ICBL3D.
Unit 30	Formated image of Unit 10. Also at each station the data written on Unit 26 of program DERVAT is rewritten.

JCL

The programs described above require large memory, which made it necessary to execute them one after the other in a multi-step job. Also the programs were compiled, linkedited and stored as members of a partition data set, named A30303. MARK1. SUBLIB. This has the advantages of avoiding handling large Fortran source decks and compiling everytime the job is executed. The input cards for each program have to be inserted after the //FT05F001 DD* card, except for the program BLOT for which they have to be after the //FT04F001 DD* card. Finally, the required inviscid data has been written on an on line disk (CHEKOV) as a partition data set named A505F3.INVTAP. The relevant JCL has been listed below.

```
1       Job Card
2       //JOBLIB DD DSN=A30303,MARK1,SUBLIB,DISP=(SHR,KEEP),
        //VOL=SER=USERPK,UNIT=SYSDA
3       //STEP1 EXEC PGM=HESS,TIME=1,REGION=520K
4       //FT06F001 DD DUMMY
```

```
5        //FT01F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

6        //FT02F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

7        //FT03F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

8        //FT04F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

9        //FT07F001 DD DUMMY

10       //FT08F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

11       //FT09F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

12       //FT10F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

13       //FT11F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

14       //FT12F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

15       //FT13F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

16       //FT15F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE
         =(TRK,(50,1))

17       //FT16F001 DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE
         =(TRK,(50,1)),DSN=&&T1

18       //FT05F001 DD *

19       //STEP2 EXEC PGM=AOAT,COND=(0,NE),TIME=(0.30),
         REGION=150K

20       //FT06F001 DD DUMMY

21       //FT16F001 DD UNIT=SYSDA,DISP=(OLD,DELETE),DSN=&&T1

22       //FT22F001 DD DUMMY

23       //FT30F001 DD DUMMY

24       //FT10F001 DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE=
         (TRK,(50,1)),DSN=&&T2
```

```
25        //FT05F001 DD *
26        //STEP3 EXEC PGM=BLOT,COND=(0,NE),TIME=5,REGION=350K
27        //FT06F001 DD SYSOUT=A
28        //FT08F001 DD SYSOUT=A
29        //FT11F001 DD DUMMY
30        //FT10F001 DD UNIT=SYSDA,DISP=(OLD,DELETE),DSN=&&T2
31        //FT25F001 DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE=
          (TRK,(50,1)),DSN=&&T3
32        //FT04F001 DD *
33        //STEP4 EXEC PGM=DERVAT,COND=(0,NE),TIME=1,REGION=650K
34        //FT06F001 DD SYSOUT=A
35        //FT25F001 DD UNIT=SYSDA,DISP=(OLD,DELETE),DSN=&&T3
36        //FT26F001 DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE=
          (TRK,(50,1)),DSN=&&T4
37        //FT29F001 DD SYSOUT=A
38        //FT30F001 DD SYSOUT=A
39        //STEP5 EXEC PGM=INVTAP,COND=(0,NE),TIME=1,REGION=650K
40        //FT06F001 DD SYSOUT=A
41        //FT25F001 DD UNIT=SYSDA,DISP=(OLD,DELETE),DSN=&&T4
42        //FT10F001 DD UNIT=SYSDA,DISP=(NEW,CATLG),SPACE=
          (TRK,(50,1)),
          // DSN=A505F3.INVTAP,VOL=SER=CHEKOV
43        //FT30F001 DD SYSOUT=A
```

JCL for use with Fortran source decks

In the JCL listed above the following changes have to be made:

1. Card 2 has to be removed.

2. In card 3 (PGM = HESS) has to be replaced by (FORTGCG)

   19 (= AOAT) has to be replaced by (FORTGCG)

   26 (= BLOT) has to be replaced by (FORTGCG)

   33 (= DERVAT) has to be replaced by (FORTGCG)

   39 (= INVTAP) has to be replaced by (FORTGCG)

3. After cards 3, 19, 26, 33, 39 insert the following card:

   //FORT.SYSIN DD* and then appropriate Fortran source deck.

Listings of Job Control Language, sample data decks, sample output and program listings for the TAPGEN package are found in Appendices I through V.

SECTION II

PROGRAM ICBL3D

In this section program ICBL3D is described. The general structure of the program is briefly described and then the input data and output of the program are described in detail. Finally, the Job Control Language required to execute the program on an IBM 370/158 computer with the JES2 operating system is listed.

A flow chart of the program appears in Fig. 3 where the function of the various subroutines are indicated. As can be seen, the code requires a small amount of card input, but its' primary mode of data input is from a data tape designated as logical unit 10. This data tape can be prepared using program TAPGEN described earlier in this report.

The program proceeds in a forward marching fashion from the body stagnation point downstream and from the windward to leeward symmetry planes. The number of solution planes around the body in the ω-direction is fixed by the user, while the step size in the ξ-direction is adjusted internally by the program as it proceeds downstream. The initial step size is set by the user and this step size is continually adjusted by the program based upon the number of iterations required to achieve a solution at a previous station. Further, at the user's option, the edge value of the transformed normal coordinate η can be automatically increased or decreased to meet a predetermined criteria for profile decay at the boundary-layer outer edge.

There is a special feature of the program for full three-dimensional solutions. If the program cannot obtain a converged solution at some point between the windward and leeward symmetry planes it will drop that point (and all subsequent points to the leeward plane) from the solution around the body at all subsequent streamwise stations. This feature allows the solution to proceed even after separation or other problems are encountered near the leeward plane of the body.

1. Program Input

As mentioned, input to the program is from two different sources: (1) cards or card image data and (2) data sets residing on tape or disk. The data sets residing on tape or disk are generated by program TAPGEN and basically consist of Fourier coefficients. The first record on the tape contains the angle of attack in radians and an integer variable giving the number of coefficients in each Fourier series. All the records on the file after the first are identical in format. They consist of the value of ξ followed by the Fourier coefficients for the series fits to r, U_e, W_e, h_ξ, h_ω, s, $\partial U_e/\partial\xi$, $\partial W_e/\partial\xi$, $\partial r/\partial\xi$, $\partial^2 r/\partial\xi^2$, $\partial h_\xi/\partial\xi$, $\partial h_\omega/\partial\xi$, x, $\partial x/\partial\xi$ in that order. The series are in terms of the angle ϕ and their range is from the windward to leeward planes of symmetry for constant ξ. All data on the tape are written with unformatted WRITE's. The data must appear on logical unit 10.

The card or card image data to the program will now be described.

2. Description of Input Data

CARD 1. LABEL (20A4)

LABEL is the title of the case and is a single subscripted array. LABEL is passed to the output routines and appears as the header to the program output.

CARD 2. IE (49X,I3)

IE is the number of points taken normal to the body. The program is dimensioned for a maximum of 101 points in the normal profile arrays. 101 is the recommended value; however, savings in execution time occur by decreasing IE. IE must be an odd number.

CARD 3. INJCT (49X,I3)

INJCT is the subscript of the XSTA array (see below) giving the surface location at which mass injection begins. A zero value of INJCT is set to NSOLVE.

CARD 4. KADETA (49X,I3)

KADETA is an indicator for the adjustment of the transformed normal coordinate. If KADETA = 0, the maximum value of η is held constant. If KADETA = 1 the maximum η is adjusted when the velocity profiles fail to decay properly at the outer edge as prescribed by the input variable ADTEST. The value of η_{max} as adjusted up or down for windward symmetry plane only runs. For full three dimensional runs η_{max} is only adjusted up, and can be adjusted at every point. A value of 1 is recommended.

CARD 5. KEND2 (49X,I3)

KEND2 specifies the number of circumferential planes to be used in the solution, and thereby also sets the circumferential step size. The program can accept a maximum value of KEND2 = 61. A total of sixty-one planes would lead to excessive computing time, however, and a value of KEND2 = 11 is recommended.

CARD 6. KONSET (49X,I3)

KONSET is the subscript of the XSTA array giving the location of the onset of transition. At X = XSTA(KONSET) the variable LAMTRB is reset to 2 and transition to turbulence begins. A zero value is reset to NSOLVE.

CARD 7. KPRT (49X,I3)

KPRT is a print control parameter which controls the printing of profiles in the ϕ direction. The program prints every KPRT'th profile around the body at a given value of ξ starting with the $\phi = 0^{o}$ profile.

CARD 8. KTRANS (49X,I3)

KTRANS is an indicator for the transition model. If KTRANS = 0 transition to turbulence will be instantaneous, if KTRANS = 1 a smooth transition to turbulence will take place over the distance XBAR (see below).

CARD 9. LAMTRB (49X,I3)

LAMTRB indicates whether the flow is laminar or turbulent. LAMTRB = 1 indicates the solution <u>begins</u> with laminar

flow. LAMTRB = 2 means fully turbulent flow. When KONSET $\neq$ 0, LAMTRB = 1.

CARD 10. LPRT (49X,I3)

LPRT is the print control parameter in the streamwise direction. The program prints solutions at every LPRT'th station in ξ.

CARD 11. NIT1 (49X,I3)

NIT1 is an iteration counter used to adjust the streamwise step size. If the total number of iterations required to obtain the solution at a point is less than or equal to NIT1 then the ξ step size is doubled.

CARD 12. NIT2 (49X,I3)

NIT2 is an iteration counter used to adjust the streamwise step size. If the total number of iterations required to obtain a solution at a point is greater than NIT1 and less than NIT2 the ξ step size is unchanged.

CARD 13. NIT3 (49X,I3)

NIT3 is an iteration counter affecting ξ step size and the convergence of the solution. If the total number of iterations required for a solution at a particular point is greater than NIT3 the program halves the ξ step size and cuts back the value of ξ by the new step size. A solution at the smaller value of ξ is then tried. If this procedure fails three consecutive times execution is terminated.

NOTE: The ξ step size is adjusted only at the windward symmetry plane.

CARD 14. NOINJ (49X,I3)

NOINJ is the subscript of the XSTA array giving the surface location at which injection ends. NOINJ = 0 is reset to NOINJ = NSOLVE.

CARD 15. SFC (49X,A3)

SFC is a literal variable coded as either YES or NO to indicate whether surface curvature effects are to be included in the calculations.

CARD 16. NSOLVE (49X,I3)

NSOLVE is the number of variables in the XSTA array, and is therefore the subscript of the last XSTA value which indicates the end of the body. It is also the default value for INJCT, NOINJ, and KONSET.

CARD 17. ADTEST (49X,E14.6)

ADTEST is used in conjunction with KADETA. When KADETA is 1 ADTEST provides the convergence criteria for checking the streamwise velocity profile. When $|F(IE) - F(IE-4)|$ or $|G(IE) - G(IE-4)|$ is less than ADTEST/10 the maximum value of η is decreased by 10%. When it is greater than ADTEST the maximum value of η is increased by 10%.

CARD 18. AKSTAR (49X,E14.6)

AKSTAR is a numerical constant in the Van Driest inner eddy viscosity law (k^* in Ref. 1). The recommended value is 0.435.

CARD 19. ALAMDA (49X,E14.6)

ALAMDA is a numerical constant in the outer eddy viscosity law used in the program (λ in Ref. 1). The recommended value is 0.09.

CARD 20. ASTAR (49X,E14.6)

ASTAR is a numerical constant used in the damping term of Van Driest's inner eddy viscosity law in the program (A* in Ref. 1). The recommended value is 26.0.

CARD 21. CWALL (49X,E14.6)

CWALL is the injection rate for mass transfer cases where the rate is a constant. CWALL = v_w/u_∞.

CARD 22. CONV (49X,E14.6)

CONV is the solution convergence criterion. The dependent variable arrays of streamwise and cross flow velocities are all checked for convergence at all points. When the largest percentage difference between the current and previous iterations is less than or equal to CONV the solution is taken to be converged.

CARD 23. DXMAX (49X,E14.6)

DXMAX is the maximum step size, to be taken in the streamwise direction.

CARD 24. DX1 (49X,E14.6)

DX1 is the initial streamwise step size. Since this value will be adjusted internally it is not critical that

the user choose an accurate value. Usually a value of 0.01 is a good initial DX.

CARD 25. EDYLAW (49X,A3)

EDYLAW specifies the inner eddy viscosity law to be used in turbulent cases. Two options are available to the user: (1) EDYLAW = VAN DRIEST and (2) EDYLAW = REICHARDT. The program picks up only the first 3 letters of each name. The user should note the comments on these two laws for mass transfer problems stated in Ref. 1. In general the REICHARDT law is recommended.

CARD 26. ETAFAC (49X,E14.6)

ETAFAC controls the normal grid spacing. A value of 1.0 gives an equally spaced grid for the transformed normal coordinate. A value greater than 1.0 gives a finer grid at the wall than at the outer edge. A value of 1.04 is recommended with IE = 101 and ETAINF = 6.0. A value of 1.09 is recommended with IE = 101 and ETAINF = 100.0.

CARD 27. ETAINF (49X,E14.6)

ETAINF is the maximum value of η. A value between 6.0 and 10.0 is recommended for laminar flow. A value between 10.0 and 100.0 is recommended for turbulent flow. This value can be adjusted internally by specifying KADETA = 1.

CARD 28. PR (49X,E14.6)

PR is the value of the laminar Prandtl number in the fluid.

CARD 29. RTW (49X,E14.6)

RTW is the ratio of the wall temperature to stagnation temperature. It is used to calculate wall temperature when wall temperature is held constant.

CARD 29. TFS (49X,E14.6)

TFS is the free-stream static temperature in degrees Rankine.

CARD 30. CP (49X,E14.6)

CP is the specific heat of the fluid in $ft^2/sec^{2o}R$.

CARD 31. AMUINF (49X,E14.6)

AMUINF is the coefficient of viscosity in slugs/ft-sec.

CARD 32. PSTAG (49X,E14.6)

PSTAG is the free-stream total pressure in lbf/ft^2.

CARD 33. PINF (49X,E14.6)

PINF is the free-stream static pressure in lbf/ft^2.

CARD 34. XBAR (49X,E14.6)

XBAR is the relative length of the transition regime in turbulent cases. It is the ratio of the transition end point location to the transition onset distance.

CARD 35. UFS (49X,E14.6)

UFS is the free-stream velocity in ft/sec.

CARD 36 to 36+NSOLVE XSTA(I), I = 1, NSOLVE (F12.6)

XSTA is an important input array. It is an array of surface distances

solutions calculated. The program will always obtain solutions at these points regardless of internal adjustments to the streamwise step size. Both the value 0.0 and the end point of the body must be included in the array as well as any distances describing the beginning or end of injection and transition.

CARD 36+NSOLVE+1 TO LAST CARD XTW(I), TWX(I), XCI(I), CIX(I)
(4E12.6)

TWX(I) is the wall temperature in degrees Rankine at XTW(I) which is a surface distance.

CIX(I) is the injection rate v_w/u_∞ at XCI(I) which is a surface distance.

These arrays are dimensioned for a maximum of 500 values each. If none of these cards appear in the input deck the program will automatically assume constant wall temperature and injection rate values based on RTW and CWALL. This input allows the wall temperature distribution and injection rate distribution to be read in versus their own surface distance tables. If both distributions are to be read in versus the same distance table, then either one of the two distance tables may be left blank. Another important feature is the fact that the distributions need not cover the same surface distance. For instance, the wall temperature distribution might be defined over the entire body while the injection rate distribution might only be defined over a short distance.

3. Description of Output Data

The output from program ICBL3D is in the form of printed output. The printed output is presented in two forms,

station data and profile data. This section will define the output by listing the variable name as it appears in the output along with the definition of the variable. The program also prints miscellaneous messages which are described at the end of this section.

Station Data

Line 1

XO	distance from the stagnation point along the body axis non-dimensionalized by the reference length (one foot)
R	radial distance from the stagnation point body axis to the body surface non-dimensionalized by the reference length
PHI	meridional angle about the stagnation point body axis measured from the windward symmetry plane in degrees

Line 2

XI	longitudinal surface coordinate ξ
DXI	$\Delta\xi$, streamwise step size
CWALL	local injection rate v_w/u_∞
NIT	number of iterations to obtain the solution

Line 3

HX	metric coefficient h_ξ evaluated at the body
HW	metric coefficient h_ω evaluated at the body

Line 4

TE	nondimensional edge static temperature, $T_\infty C_p/u_\infty^2 = T_e$

UE — nondimensional ξ component of velocity at the boundary-layer edge $u_e/u_\infty = U_e$

VE — nondimensional ω component of velocity at the boundary-layer edge $w_e/u_\infty = W_e$

Line 5

DUEDX — $\partial U_e/\partial \xi$

DVEDX — $\partial W_e/\partial \xi$

DUEDW — $\partial U_e/\partial \omega$

DVEDW — $\partial W_e/\partial \omega$

Line 6

LOCAL EDGE REYNOLDS NUMBER = $\rho_\infty u_e \xi/\mu_\infty$

Line 7

CFXINF — $C_{f_{\xi_\infty}} = 2\tau_{w_\xi}/\rho_\infty u_\infty^2$, streamwise skin friction coefficient

CFXEDG — $C_{f_{\xi_e}} = 2\tau_{w_\xi}/\rho_\infty u_e^2$, streamwise skin friction coefficient based on edge conditions

CFWINF — $C_{f_{\omega_\infty}} = 2\tau_{w_\omega}/\rho_\infty u_\infty^2$, transverse skin friction coefficient based on free-conditions

CFWEDG — $C_{f_{\omega_e}} = 2\tau_{w_\omega}/\rho_\infty u_e^2$, transverse skin friction coefficient based on edge conditions.

Line 8

QW — $q_w/\rho_\infty u_\infty^3$, wall heat transfer coefficient

CHIMAX — maximum vorticity Reynolds number $n^2/\nu \ \partial u/\partial n$

Line 9

LONGITUDINAL SKIN FRICTION τ_{ω_ξ} in lbf/ft^2

DELTA*(X) — δ^*_ξ, streamwise boundary-layer displacement thickness in feet.

THETA(X)	θ_ξ, streamwise boundary-layer momentum thickness in feet.
Line 10	
TRANSVERSE SKIN FRICTION	τ_{w_ω}, in lbf/ft^2
DELTA*(PHI)	δ^*_ω, transverse boundary-layer displacement thickness in feet.
THETA(PHI)	θ_ω, transverse boundary-layer momentum thickness in feet.
Line 11	
WALL HEAT TRANSFER RATE	q_ω in $Btu/ft^2/sec$
DELTA(FT)	δ, the boundary-layer thickness in feet.

Profile Data

One group of boundary layer profile data is printed by the program. Every other point is printed in the profile arrays. The following columns are identified:

ETA	η, the transformed normal coordinate.
Y	n, the physical normal distance nondimensionalized by the reference length.
F	$h_\xi u/h_{\xi,0}U_e$
FN	$\partial F/\partial\eta$
G	$h_\omega w/h_{\omega,0}W$ where $W = W_e$ at the stagnation point and symmetry planes and $W = U_e$ elsewhere.
GN	$\partial G/\partial\eta$
T	T/T_e
TN	$\partial(T/T_e)/\partial\eta$
V	transformed normal velocity profile.
EPLUS	ε^+ the eddy viscosity coefficient

Miscellaneous Messages

The program has a few internal messages which are written to indicate problems with the solution, or coordinate adjustments. A message is printed by subroutine ADDETA whenever η_∞ is adjusted up or down. The direction of adjustment is given along with X, the old η_∞ and the new η_∞.

A message is printed by subroutine CHANGX indicating the beginning of transition or mass transfer. Included in the messages are the values of X and the particular integer counter involved. A similar message is also printed by CHANGX when mass transfer ends.

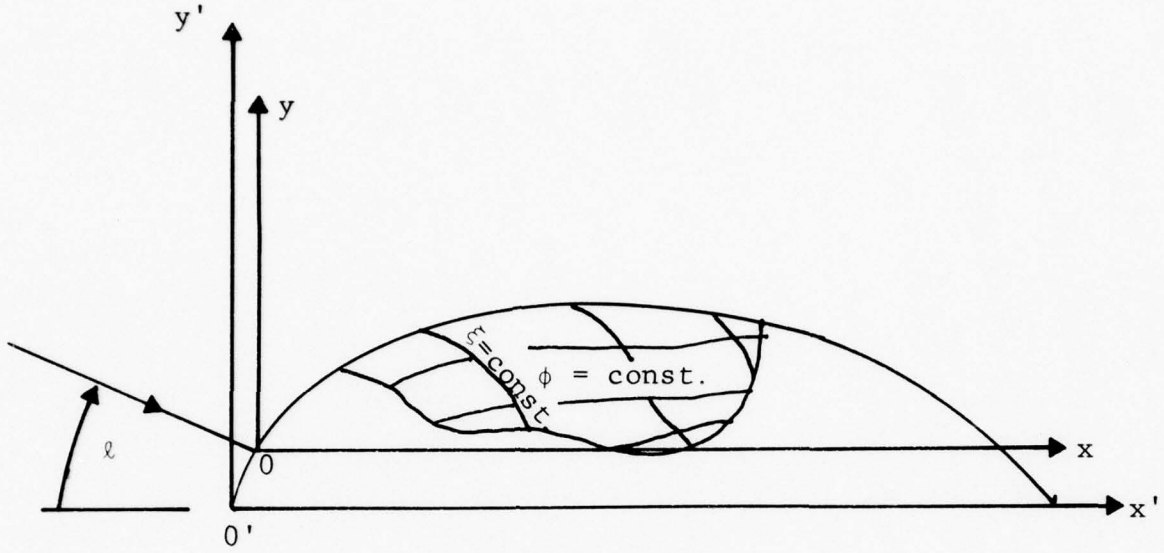
Whenever the program fails to obtain a converged solution within NIT3 iterations, a message is printed by subroutine CONTRL to that effect which includes the values of the transverse and streamwise solution counters and NIT. If this should occur three consecutive times, a message will be printed indicating that execution is terminating.

If a particular boundary-layer problem drops all of its circumferential solution planes due to convergence problems, a message will be printed by CONTRL indicating that execution is terminating.

A normal termination of the program is indicated by the message "THE END" printed out after the last station results.

3. Sample Input/Output

Listings of Job Control Language, sample input decks, sample outputs and format sheets for the input data cards and the program listings are found in Appendices VI through X.



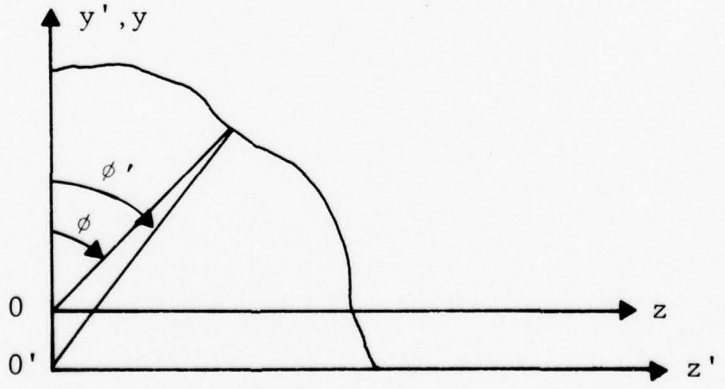


Figure 1. BODY COORDINATE SYSTEMS FOR INVISCID AND BOUNDARY-LAYER CALCULATIONS

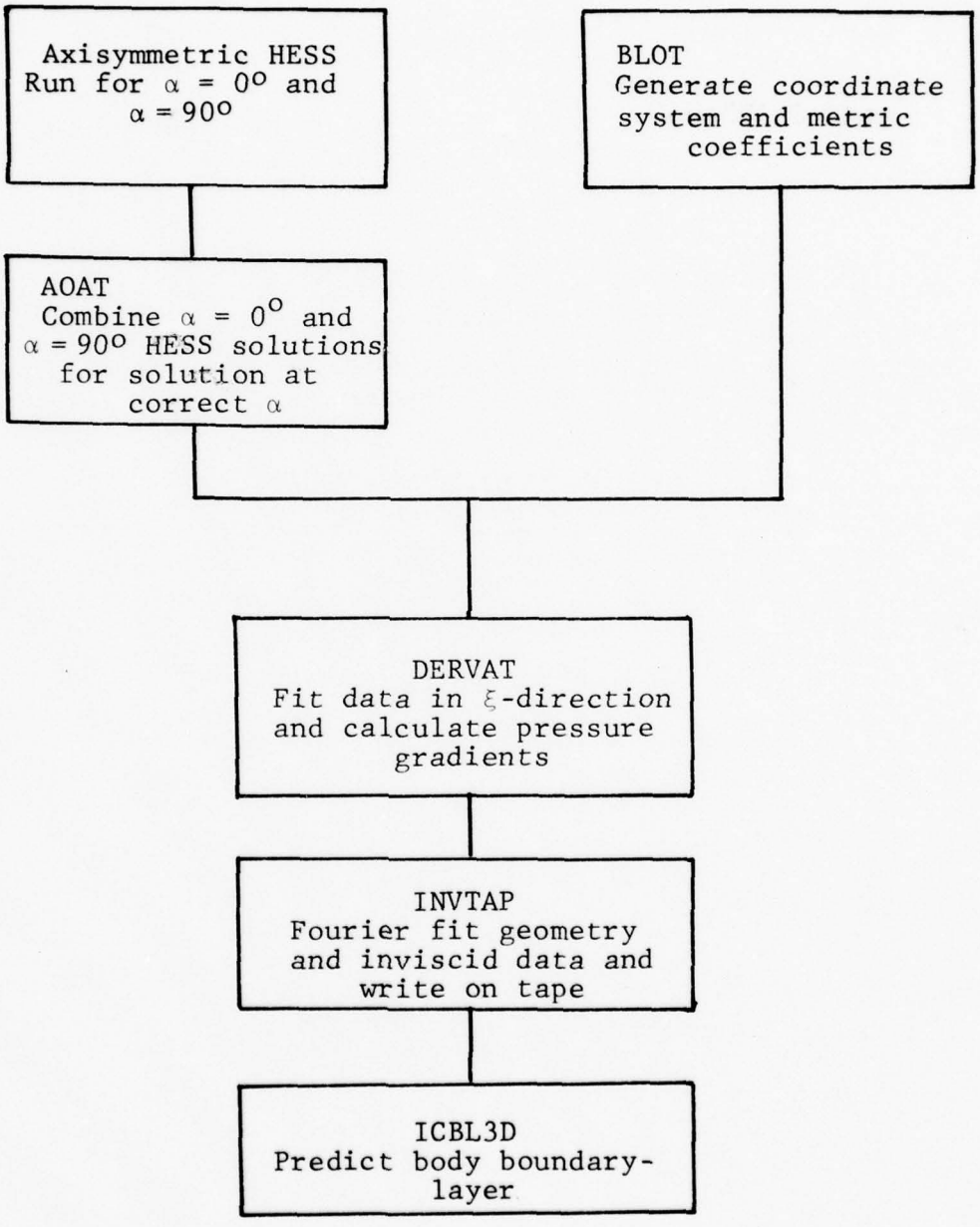


Figure 2a. BLOCK DIAGRAM FOR ICBL3D AXISYMMETRIC BODIES

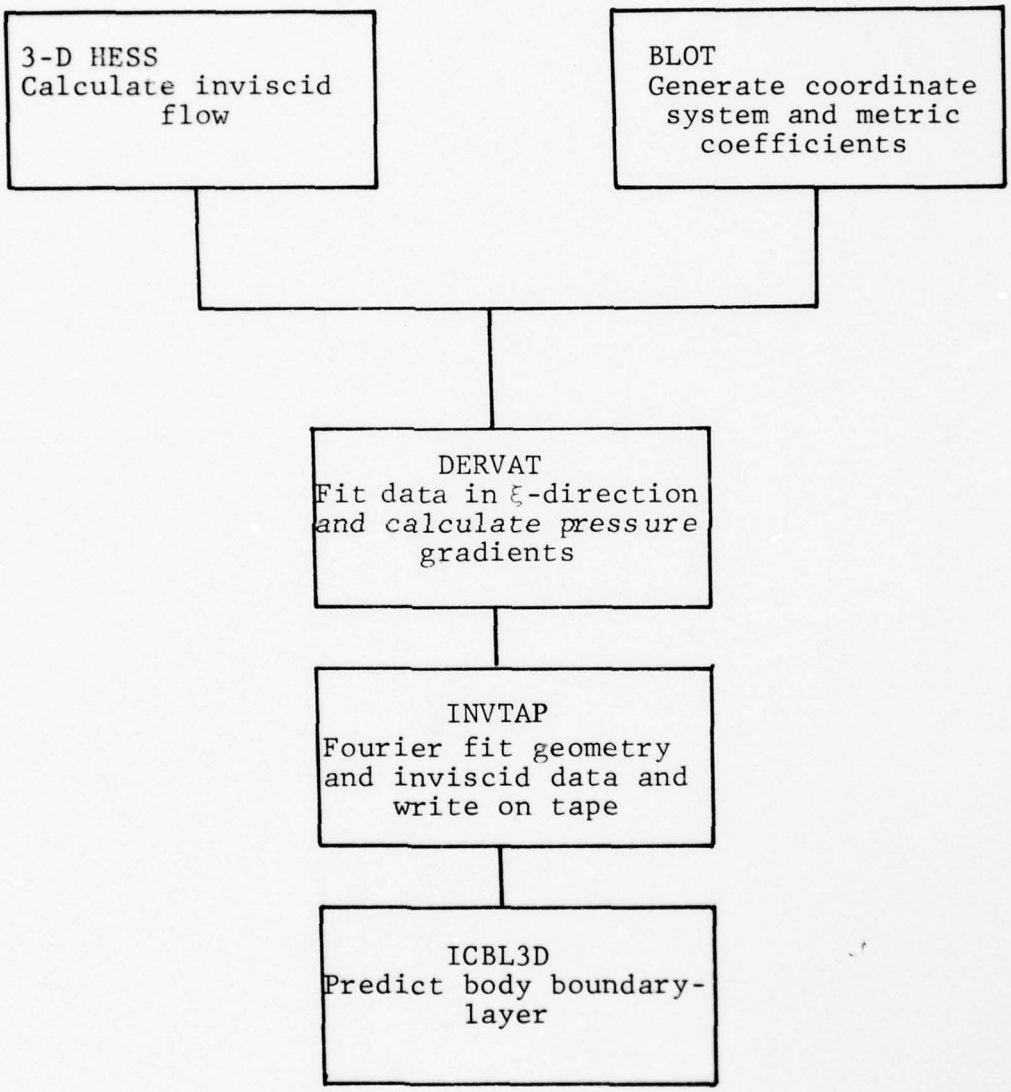


Figure 2b. BLOCK DIAGRAM FOR ICBL3D NONAXISYMMETRIC BODIES

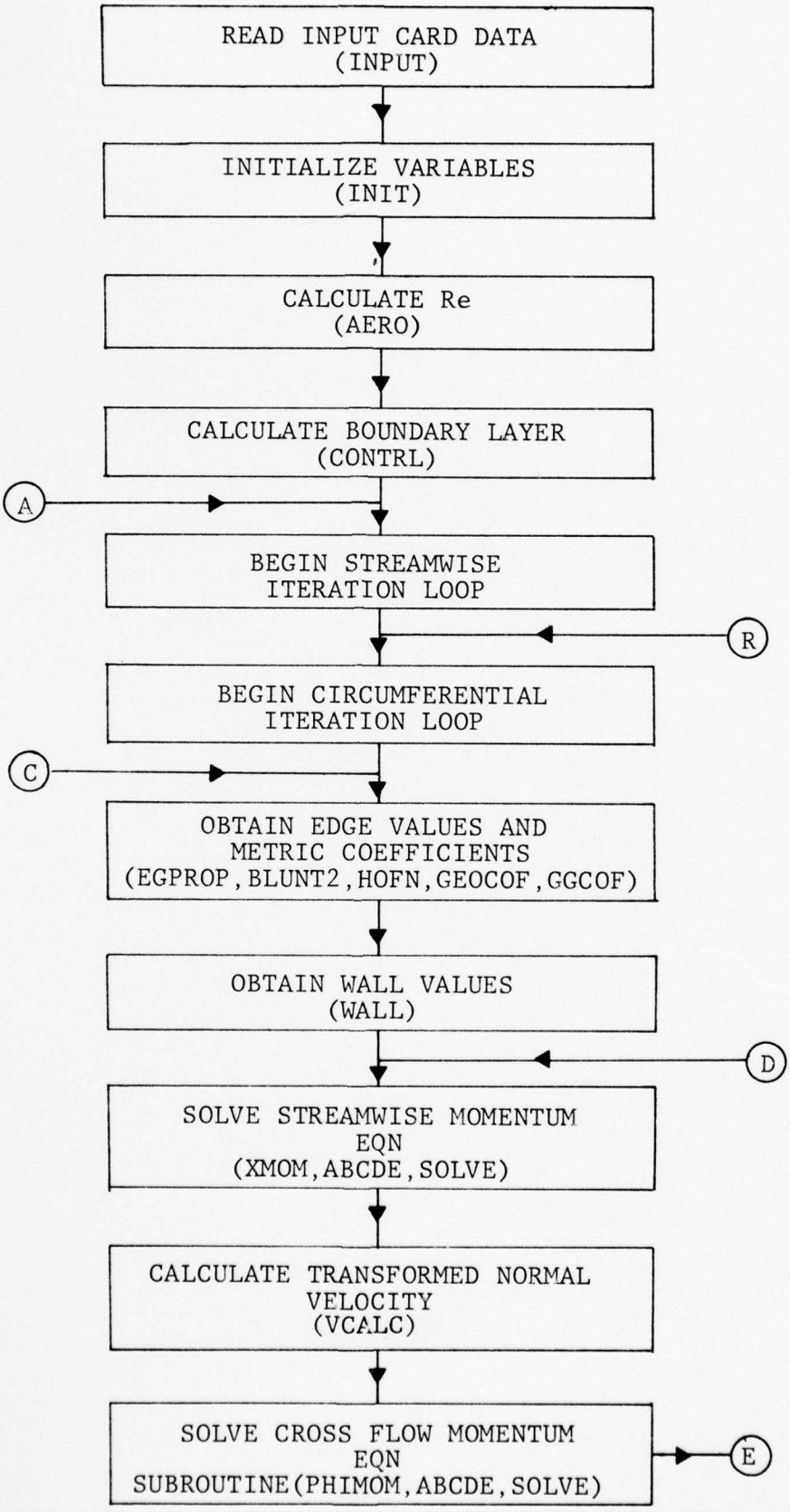


Figure 3. FLOW CHART OF PROGRAM ICBL3D

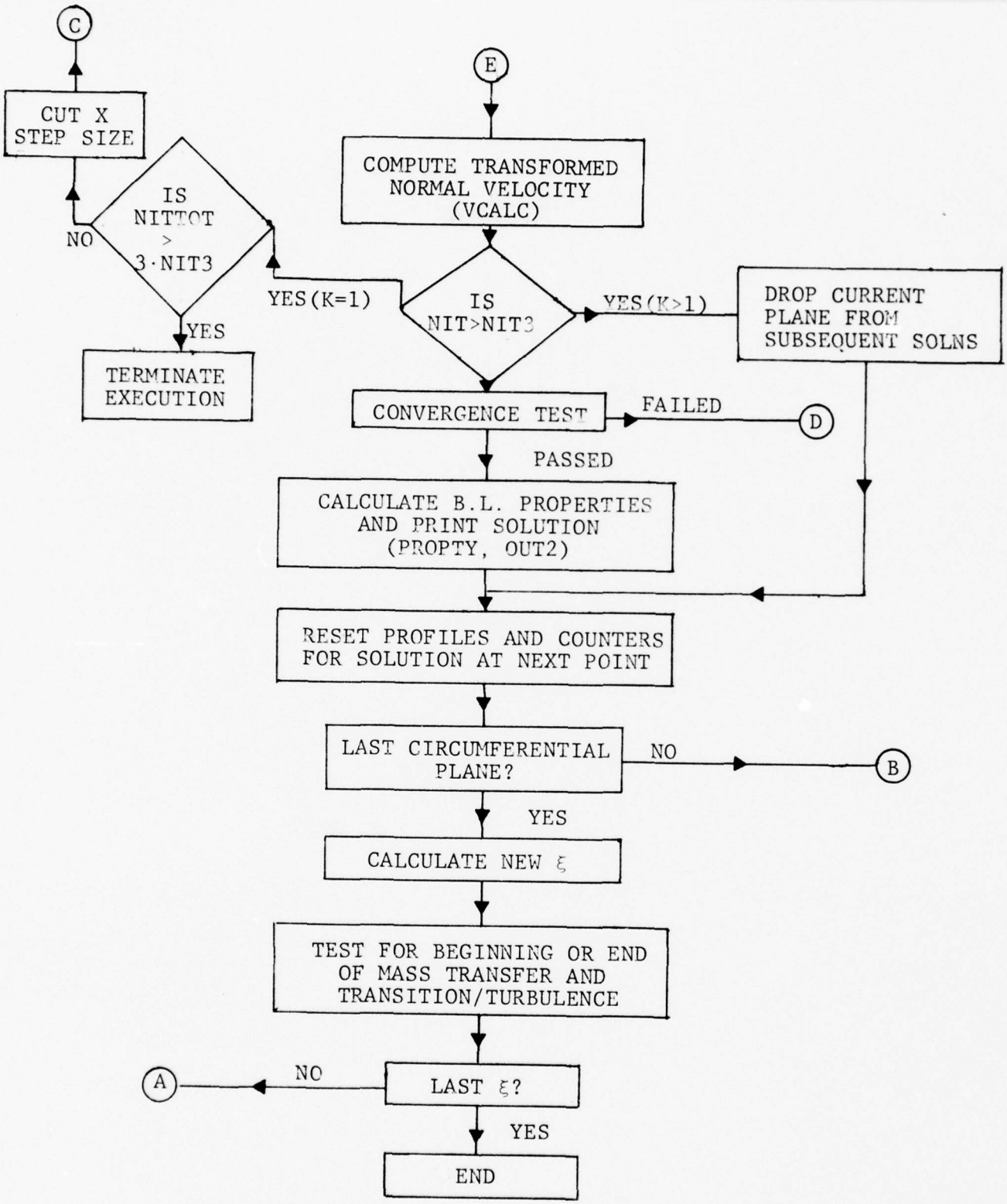


Figure 3 continued: FLOW CHART OF PROGRAM ICBL3D

( ) = Subroutine Names

REFERENCES

1. Dwoyer, D. L., Lewis, C. H. and Gogineni, P. R., "Three-Dimensional Incompressible Boundary Layers on Blunt Bodies Including Effects of Turbulence, Surface Curvature and Heat and Mass Transfer. Part I: Analysis and Results." VPI&SU Aero-063, May 1977.

2. Blottner, F. G. and Ellis, M., "Three-Dimensional Incompressible Boundary Layer on Blunt Bodies." Sandia Laboratories Report No. SLA-73-0366, Albuquerque, New Mexico, April 1973.

3. Hess, J. L. and Martin, R. P., Jr., "Improved Solution for Potential Flow about Arbitrary Axisymmetric Bodies by the Use of a Higher-Order Surface Source Method. Part I. Theory and Results." NASA Contractor Report No. NASA CR 134694, NASA Lewis Research Center, Cleveland, Ohio, July 1974.

4. Hess, J. L. and Smith, A.M.O., "Calculation of Non-Lifting Potential Flow about Arbitrary Three-Dimensional Bodies." March 1962, McDonnell-Douglas Report No. ES 40622.

APPENDIX I

Job Control Language for Program TAPGEN

```
DATE  05/17/77


// JOB CARD
/*PRIORITY URGENT
/*JOBPARM LINES=10,CARDS=0
//STEP1 EXEC FORTGCG,TIME=4,REGION=520K,PARM.FORT='NOSOURCE'
//FORT.SYSIN DD *

          PROGRAM HESS    FORTRAN SOURCE DECK

//GO.FT05F001 DD *

         INPUT DATA DECK FOR  PROGRAM  HESS

//FT06F001 DD SYSOUT=A
//FT07F001 DD DUMMY
//FT01F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT02F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT03F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT04F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT08F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT09F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT10F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT11F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT12F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT13F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT15F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT16F001 DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE=(TRK,(50,1)),DSN=&&T1
/*
//STEP2 EXEC FORTGCG,COND=(0,NE),TIME=1,REGION=300K
//FORT.SYSIN DD *

         PROGRAM AOAT     FORTRAN SOURCE DECK

//GO.FT05F001 DD *

         INPUT DATA DECK FOR  PROGRAM  AOAT

 //FT06F001 DD DUMMY
//FT16F001 DD UNIT=SYSDA,DISP=(OLD,DELETE),DSN=&&T1
//FT22F001 DD DUMMY
//FT30F001 DD DUMMY
//FT10F001 DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE=(TRK,(50,1)),DSN=&&T2
/*
//STEP3 EXEC FORTGCG,COND=(0,NE),TIME=10,REGION=500K
//FORT.SYSIN DD *

         PROGRAM BLOT     FORTRAN SOURCE DECK

//GO.FT05F001 DD DUMMY

         INPUT DATA DECK FOR  PROGRAM  BLOT
```

```
DATE  05/17/77


//FT06F001 DD DUMMY
//FT08F001 DD DUMMY
//FT11F001 DD DUMMY
//FT12F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1))
//FT13F001 DD UNIT=SYSDA,DISP=(NEW,DELETE),SPACE=(TRK,(50,1)),
//            DCB=(RECFM=VS,LRECL=2884,BLKSIZE=2888)
//FT10F001 DD UNIT=SYSDA,DISP=(OLD,DELETE),DSN=&&T2
//FT25F001 DD UNIT=SYSDA,DISP=(NEW,CATLG,CATLG),SPACE=(TRK,(50,1)),
//            DSN=AF01F3.T.T4
//FT04F001 DD *
/*
//STEP4 EXEC FORTGCG,TIME=4,REGION=500K
//FORT.SYSIN DD *

         PROGRAM DERVAT   FORTRAN SOURCE DECK

//FT06F001 DD SYSOUT=A
//FT25F001 DD UNIT=SYSDA,DISP=(OLD,KEEP),DSN=AF01F3.T.T4
//FT26F001 DD UNIT=SYSDA,DISP=(NEW,PASS),SPACE=(TRK,(50,1)),DSN=&&T4
//FT29F001 DD SYSOUT=A
//FT30F001 DD SYSOUT=A
//STEP5 EXEC FORTGCG,COND=(0,NE),TIME=4,REGION=300K
//FORT.SYSIN DD *

          PROGRAM INVTAP    FORTRAN SOURCE DECK

//GO.FT05F001 DD DUMMY
//FT06F001 DD SYSOUT=A
//FT10F001 DD UNIT=SYSDA,DISP=(NEW,CATLG),SPACE=(TRK,(50),RLSE),
//            DSN=A505F3.INVTAP.EL412,VOL=SER=USERPK,
// DCB=(RECFM=VS,LRECL=117,BLKSIZE=121)
//FT25F001 DD UNIT=SYSDA,DISP=(OLD,DELETE),DSN=&&T4
//FT30F001 DD SYSOUT=A
/*
//
```

APPENDIX II

TAPGEN Sample Input

```
DATE  04/21/77

        INPUT DATA DECK FOR  PROGRAM  HESS
         ELLIPSOID (4:1)  AT    ALPHA= 10 DEG    120 ELEMENTS          2          1
1011001    00 00 0            1                                                    2
                                                                                   3
01001  121   1.0          1.0                                                      4
         1          0          1     1.0      0.25                                5
```

DATE 04/21/77

```
      INPUT DATA DECK FOR  PROGRAM  BLOT
TITLE CASE 7  ELLIPSOID(4:1) - 10 DEG  ANGLE OF ATTACK
LIMTS   31    26    01    10     1     0  6.00      100.0
DW       .02         .02         .02         .02         .02         .02         .02
DW       .02         .02         .02         .02         .02         .02         .02
DW       .02         .02         .02         .02         .02         .02         .02
DW       .02         .02         .02         .02         .02         .02         .02
DN       .3          .3          .3          .3          .3          .3          .3
DN       .3          .3          .3          .3          .3          .3          .3
DN       .3          .3          .3          .3          .3          .3          .3
DN       .3          .3          .3          .3          .3          .3          .3
DN       .3          .3          .3          .3          .3          .3          .3
DPSI     .01
SIZE    4.00        .25         .25        .0000001 +10.0       1.0         0.5
```

APPENDIX III

TAPGEN Sample Output

INVISCID EDGE CONDITIONS FOR BOUNDARY LAYER SOLUTION
TAKEN FROM THE INVISCID FLOW FIELD DATA

NUMBER OF PLANES IN THE INVISCID DATA = 26

ALPHA= 0.0

UNIFORM FLOW STARTING SOLUTION FOR THE INVISCID FLOW FIELD

WALL DATA AT STATION 1, XI = .0

K	HPSI	HW	P	S	UPSI	UW	X
1	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
2	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
3	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
4	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
5	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
6	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
7	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
8	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
9	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
10	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
11	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
12	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
13	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
14	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
15	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
16	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
17	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
18	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
19	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
20	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
21	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
22	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
23	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
24	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
25	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0
26	0.1000000D 01	0.0	0.0	0.0	0.0	0.0	0.0

K	D(UPSI)	D(UW)	D(R)	D2(R)	D(HPSI)	D(HW)	D(X)
1	0.4685020 01	0.0	0.1014470 01	-0.4809080 00	-0.6661340-15	0.6374090 01	-0.1390290-01
2	0.4747200 01	0.4625930-16	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
3	0.4775820 01	0.4810970-16	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
4	0.4783320 01	0.8861780-16	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
5	0.4785180 01	-0.1006600-14	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
6	0.4785630 01	0.4736950-15	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
7	0.4785750 01	-0.2960590-14	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
8	0.4785770 01	0.0	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
9	0.4785780 01	-0.1156630-14	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
10	0.4785780 01	-0.9473900-15	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
11	0.4785780 01	-0.3756250-15	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
12	0.4785780 01	-0.2498000-15	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
13	0.4785780 01	-0.1480300-15	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
14	0.4785780 01	-0.5551120-16	0.1014470 01	-0.4809080 00	0.4220810-07	0.6374090 01	-0.1390290-01
15	0.4785780 01	0.6661340-16	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
16	0.4785780 01	0.1315610-14	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
17	0.4785780 01	-0.1894780-14	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01

18	0.4785780 01	0.0	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
19	0.4785780 01	0.1421090-14	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
20	0.4785780 01	0.1421090-14	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
21	0.4785780 01	0.1539510-14	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
22	0.4785780 01	-0.6217250-15	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
23	0.4785780 01	0.2072420-15	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
24	0.4785780 01	-0.7401490-16	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
25	0.4785780 01	-0.2590520-16	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01
26	0.4785780 01	0.2258750-20	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	-0.1390290-01

FOURIER COEFFICIENTS

K	AXSRFS	ARADS	AHXS	AHWS	AUS	AVS
1	0.0	0.0	0.1000000 01	0.0	0.0	0.0
2	0.0	0.0	0.7105430-16	0.0	0.0	0.0
3	0.0	0.0	-0.5329070-16	0.0	0.0	0.0
4	0.0	0.0	0.1243450-15	0.0	0.0	0.0
5	0.0	0.0	-0.2664540-15	0.0	0.0	0.0
6	0.0	0.0	0.5817570-15	0.0	0.0	0.0
7	0.0	0.0	-0.7638330-15	0.0	0.0	0.0
8	0.0	0.0	0.6661340-17	0.0	0.0	0.0
9	0.0	0.0	-0.9414690-15	0.0	0.0	0.0
10	0.0	0.0	0.5329070-15	0.0	0.0	0.0
11	0.0	0.0	-0.1776360-15	0.0	0.0	0.0
12	0.0	0.0	0.7105430-15	0.0	0.0	0.0
13	0.0	0.0	-0.4085620-15	0.0	0.0	0.0
14	0.0	0.0	0.2797760-15	0.0	0.0	0.0
15	0.0	0.0	-0.3375080-15	0.0	0.0	0.0
16	0.0	0.0	0.8648640-15	0.0	0.0	0.0
17	0.0	0.0	-0.1776360-15	0.0	0.0	0.0
18	0.0	0.0	0.9325870-15	0.0	0.0	0.0
19	0.0	0.0	0.5706550-15	0.0	0.0	0.0
20	0.0	0.0	0.5440090-16	0.0	0.0	0.0
21	0.0	0.0	0.9547920-16	0.0	0.0	0.0
22	0.0	0.0	0.6339370-15	0.0	0.0	0.0
23	0.0	0.0	-0.2486900-15	0.0	0.0	0.0
24	0.0	0.0	0.3086420-15	0.0	0.0	0.0
25	0.0	0.0	0.8026910-15	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0

K	AUSX	AVSX	ARADSX	ARDSXX	AHXSX	AHWSX	AX	AX
1	0.4781690 01	-0.1992470-15	0.1014470 01	-0.4809080 00	0.4220820-07	0.6374090 01	0.0	-0.1390290-01
2	-0.8102400-02	-0.6839020-15	0.1065810-15	0.1694200-14	-0.1688330-08	-0.4352070-15	0.0	0.1447690-15
3	-0.7891670-02	0.3278400-16	-0.1776360-16	0.1701970-14	-0.1688320-08	0.5506710-15	0.0	0.5179510-16
4	-0.7562080-02	0.6608480-16	0.1587620-15	-0.4707350-15	-0.1688330-08	0.1838530-14	0.0	-0.1744520-16
5	-0.7141230-02	0.1066090-15	-0.3019810-15	0.5412340-14	-0.1688330-08	-0.2469140-14	0.0	0.4316280-17
6	-0.6659970-02	0.3981540-15	0.6550320-15	-0.5973000-15	-0.1688330-08	0.4467540-14	0.0	0.2246260-16
7	-0.6147830-02	-0.2324290-15	-0.7460700-15	0.1222360-14	-0.1688330-08	-0.5080380-14	0.0	0.4[illegible]10-16
8	-0.5629970-02	0.1722160-15	0.1554310-16	0.3475000-15	-0.1688320-08	-0.2753350-15	0.0	0.7771960-17
9	-0.5125730-02	0.1196220-15	-0.9769960-15	0.3953500-14	-0.1688330-08	-0.6941000-14	0.0	0.1452130-16
10	-0.4648590-02	-0.4003290-15	0.5739350-15	-0.1619920-14	-0.1688330-08	0.3561600-14	0.0	0.9352230-17
11	-0.4206880-02	0.2226580-15	-0.1776360-15	-0.9792170-15	-0.1688320-08	-0.1794120-14	0.0	0.2[illegible]520-16
12	-0.3804880-02	-0.2977940-16	0.6916690-15	0.4329970-16	-0.1688320-08	0.3899100-14	0.0	0.2619430-17
13	-0.3443940-02	-0.2386650-15	-0.3730350-15	0.1225600-14	-0.1688320-08	-0.3073100-14	0.0	0.4716450-17
14	-0.3123400-02	0.2934160-15	0.2809860-15	-0.1479810-14	-0.1688320-08	0.1914020-14	0.0	0.2272490-17
15	-0.2841400-02	0.2064960-15	-0.3019810-15	-0.2142730-14	-0.1688320-08	-0.2806640-14	0.0	0.5199630-16
16	-0.2595440-02	-0.6180070-16	0.8726350-15	0.1115770-14	-0.1688320-08	0.4911630-14	0.0	-0.1526960-17
17	-0.2382720-02	-0.1421170-15	-0.1421090-15	-0.5662140-16	-0.1688330-08	-0.1314500-14	0.0	-0.2775960-17
18	-0.2200460-02	-0.3674060-17	0.1176840-15	-0.8393290-15	-0.1688330-08	0.7016610-15	0.0	-0.7216450-17
19	-0.2046020-02	-0.4851700-15	0.6217250-15	-0.2391420-14	-0.1688330-08	0.3179680-14	0.0	-0.2612280-17
20	-0.1917020-02	-0.2349650-15	-0.3552710-16	0.3277380-14	-0.1688330-08	-0.1332270-15	0.0	0.4446690-17
21	-0.1811360-02	0.4419670-15	0.1421090-15	-0.7882590-15	-0.1688330-08	0.7283060-15	0.0	-0.1275550-16
22	-0.1727290-02	0.7912870-16	0.6229350-15	-0.1754150-15	-0.1688330-08	0.3845810-14	0.0	-0.2459220-16
23	-0.1663370-02	0.3761990-15	-0.1953990-15	-0.1844090-14	-0.1688320-08	-0.1509900-14	0.0	-0.1347780-17
24	-0.1618490-02	0.3696500-15	0.2453590-15	0.3823610-14	-0.1688320-08	0.1909580-14	0.0	-0.3[illegible]6390-17
25	-0.1591880-02	0.1481310-16	0.8726350-15	-0.3911450-14	-0.1688320-08	-0.1170000-14	0.0	[illegible]

26	-0.7915280-03	0.0	0.0	0.1021410-15	-0.3441610-09	-0.2230450-16	0.0	-0.4438500-17

WALL DATA AT STATION 2, XI = .10000 00

K	HPSI	HW	R	S	UPSI	UW	X
1	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.0	0.1900500-01
2	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.4440340-17	0.1900500-01
3	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.4440340-17	0.1900500-01
4	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.2220450-17	0.1900500-01
5	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.6661340-17	0.1900500-01
6	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.0	0.1900500-01
7	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.3552710-16	0.1900500-01
8	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.0	0.1900500-01
9	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.0	0.1900500-01
10	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.4661340-17	0.1900500-01
11	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.2220450-17	0.1900500-01
12	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.2220450-17	0.1900500-01
13	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.4440340-17	0.1900500-01
14	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.0	0.1900500-01
15	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.6661340-17	0.1900500-01
16	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.1110220-16	0.1900500-01
17	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.1110220-16	0.1900500-01
18	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.0	0.1900500-01
19	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.3552710-16	0.1900500-01
20	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.3552710-16	0.1900500-01
21	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.0	0.1900500-01
22	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	0.1332270-16	0.1900500-01
23	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.6661340-17	0.1900500-01
24	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.2220450-17	0.1900500-01
25	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.2220450-17	0.1900500-01
26	0.1000000 01	0.6130450 00	0.9756910-01	0.1000000 00	0.3933530 00	-0.6776260-22	0.1900500-01

K	D(UPSI)	D(UW)	D(R)	D2(R)	D(HPSI)	D(HW)	D(X)
1	0.3217430 01	0.0	0.9272550 00	-0.1152470 01	0.2470240-14	0.5826120 01	0.3669490 00
2	0.3175230 01	0.2035410-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
3	0.3156170 01	-0.8141640-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
4	0.3151170 01	-0.1850370-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
5	0.3149930 01	0.3108620-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
6	0.3149630 01	-0.1776360-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
7	0.3149550 01	0.1066800-14	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
8	0.3149530 01	0.0	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
9	0.3149530 01	0.5625130-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
10	0.3149530 01	0.4403880-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
11	0.3149530 01	0.2275960-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
12	0.3149530 01	0.8696750-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
13	0.3149530 01	0.2590520-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
14	0.3149530 01	0.3700740-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
15	0.3149530 01	0.2590520-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
16	0.3149530 01	-0.5347570-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
17	0.3149530 01	0.7734550-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
18	0.3149530 01	0.0	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
19	0.3149530 01	-0.2960590-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
20	0.3149530 01	-0.2960590-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
21	0.3149530 01	-0.7105430-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
22	0.3149530 01	0.4514910-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
23	0.3149530 01	-0.1221250-15	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
24	0.3149530 01	0.4070820-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
25	0.3149530 01	-0.2220450-16	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00
26	0.3149530 01	-0.3952820-21	0.9272550 00	-0.1152470 01	-0.4139650-07	0.5826120 01	0.3669490 00

FOURIER COEFFICIENTS

K	AXSRFS	ARADS	AHXS	AHWS	AUS	AVS

APPENDIX IV

Program TAPGEN Data FORMAT Sheets

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM HESS

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

PAGE OF

CARD ELECTRO NUMBER

C&M	STATEMENT NUMBER	CONT	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
			DATA DECK	
			CARD 1 - HEADER CARD	
			HEADER CASE	
			(15A4, I6)	
			HEADER ANY ALPHANUMERIC RUN DESCRIPTION	
			CASE CASE NUMBER	

Number of forms per pad may vary slightly

IBM FORTRAN Coding Form GX28-7327-6 U/M 050** Printed in U.S.A.

PROGRAM: HESS

PROGRAMMER: DATE: PUNCHING INSTRUCTIONS: GRAPHIC: PUNCH: PAGE OF CARD ELECTRO NUMBER

CARD 2 - CONTROL FLAG CARD

NB NNU IAXI ICRØSS IØFF IØNLY IELPSE IPRTRB IPØTNL* IPTANV IVØRT IØMITA IOMITC ISURFV IPRSCV IALLV IEXCRS* IGENBC IRNGW IPNCH IUNIT IVIJ ICØEF IPRINT IRAKF

(7I1,3X,2I1,1X,10I1,4X,I1,I2,4I1)

NB	NUMBER OF BODIES ($1 \leq NB \leq 9$)
NNU	NUMBER OF NONUNIFORM FLOWS ($0 \leq NNU \leq 5$)
IAXI	AXISYMMETRIC FLOW FLAG
ICRØSS	CROSSFLOW FLAG
IØFF	OFF BODY POINT INPUT FLAG
IØNLY	BASIC-DATA-ONLY FLAG
IELPSE	ELLIPSE GENERATOR FLAG (SEE ALSO CARD 5).
IPRTRB	PERTURBATION VELOCITIES ONLY
IPØTNL*	SOLVE POTENTIAL MATRIX
IPTANV	PRESCRIBED TANGENTIAL VELOCITY (FOR LAST IPTANV BODIES)
IVØRT	STRIP-RING VORTICITY FLAG
IØMITA	OMIT AXISYMMETRIC UNIFORM FLOW SOLUTION
IOMITC	OMIT CROSSFLOW UNIFORM FLOW SOLUTION
ISURFV	SURFACE VORTICITY (INSTEAD OF SOURCES) FOR FINAL ISURFV BODIES
IPRSCV	PRESCRIBED VALUES OF SURFACE VORTEX STRENGTHS FOR FINAL ISURFV
IALLV	ALL BODIES ARE SURFACE VORTICITY BODIES WILL BE INPUT.
IEXCRS*	EXTRA CROSSFLOW

*Available if and only if NØNEWF = 1, ISIGF = 2, IGEØMF = 1.

IBM

FORTRAN Coding Form

GX26-7327-6 U/M 050
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PROGRAM: HESS

PROGRAMMER:

PUNCHING INSTRUCTIONS: GRAPHIC / PUNCH

PAGE OF

CARD SEQUENCE NUMBER

STATEMENT NUMBER	C	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
CARD 2		IGEN BC GENERATED BOUNDARY CONDITIONS	
		IRNGW RING WING OPTION	
		IPNCH PUNCHED OUTPUT	
		IUNIT UNIT NUMBER FOR INPUT COORDINATES (default = 05)	
		IVIJ MATRIX PRINT FLAG	
		ICØEF MATRIX-ASSEMBLY COEFFICIENT PRINT FLAG	
		IPRINT VERY DETAILED MATRIX CONSTRUCTION PRINT FLAG	
		IRAKF AUTOMATIC RAKE GENERATION FLAG	

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM HESS

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

PAGE OF

CARD ELECTRO NUMBER*

FORTRAN STATEMENT

IDENTIFICATION SEQUENCE

```
CARD 3 - CHORD/MACH NUMBER CARD *

   CHORD     XMACH
   |_____|_____|

        2F10.6
        CHORD     REFERENCE CHORD LENGTH (DEFAULT = 1.0)
        XMACH     MACH NUMBER FOR GOETHERT CORRECTION (0.0 IMPLIES INCOMPRESSIBLE)


*THIS CARD USUALLY LEFT BLANK
```

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: HESS

PROGRAMMER | DATE | PUNCHING INSTRUCTIONS | GRAPHIC | PUNCH | PAGE OF | CARD ELECTRO NUMBER

FORTRAN STATEMENT

CARD 4 BODY CONTROL CARD 1 OF 2

IGEØMF
ISIGF
ICURVN
NONEWF
IFORMT

NN XMULT YMULT THETA ADDX ADDY

(5I1,1I5,5F10.4)

IGEØMF	0=CURVED ELEMENTS; 1=FLAT ELEMENTS
ISIGF	0=PARABOLIC σ; 1= LINEAR σ; 2= CONSTANT σ (ON EACH ELEMENT)
ICURVN	0=INTERNALLY CALCULATED ELEMENT CURVATURES
NØNEWF	0=USE NEWEST FORMULAE; 1=USE OLD FORMULAE (IMPLIES FLAT ELEMENTS AND CONSTANT σ)
IFØRMT	INPUT FORMAT FLAG
NN	NUMBER OF DEFINING ENDPOINTS FOR THIS BODY
XMULT	X-MULTIPLIER VALUE (DEFAULT = 1.0)
YMULT	Y-MULTIPLIER VALUE (DEFAULT = 1.0)
THETA	COORDINATE ROTATION VALUE (DEGREES, MEASURED ABOUT -Z-AXIS)
ADDX	X-INCREMENT (TO BE APPLIED TO ALL INPUT COORDINATES FOR THIS BODY)
ADDY	Y-INCREMENT (TO BE APPLIED TO ALL INPUT COORDINATES FOR THIS BODY)

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FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: HESS

PROGRAMMER: DATE: PUNCHING INSTRUCTIONS: GRAPHIC PUNCH: PAGE OF CARD ELECTRO NUMBER

FORTRAN STATEMENT

CARD 5 BODY CONTROL CARD 2 OF 2

IBDN	ISUBKS	NLF	A	B

(3110,2F10.3)

IBDN	"BODY" NUMBER (SEQUENTIAL FOR BODIES, ZERO FOR OFF BODY POINTS)
ISUBKS	SUBCASE FLAG
NLF	NON-LIFTING FLAG (FOR COMBINATION CASES, ONLY)
A	SEMI-MAJOR AXIS FOR ELLIPSE CASES } IF IELPSE≠0
B	SEMI-MINOR AXIS FOR ELLIPSE CASES }

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM AOAT

PROGRAMMER

DATE

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

PAGE OF

CARD ELECTRO NUMBER*

C | STATEMENT NUMBER | CONT | FORTRAN STATEMENT | IDENTIFICATION SEQUENCE

```
DATA SET

CARD 1

IPRT N KPL    ALPD

    (3I3,F10.6)

  IPRT  =1 WRITES THE OUTPUT OF PROGRAM HESS ON UNIT 6 ; =0, DOES NOT WRITE
  N       NUMBER OF ELEMENTS USED IN THE PROGRAM HESS
  KPL     NUMBER OF MERIDONIAL PLANES REQUIRED
  ALPD    ANGLE OF ATTACK IN DEGREES
```

*Number of items per pad may vary slightly

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

THREE-DIMENSIONAL, INCOMPRESSIBLE BOUNDARY LAYER ON BLUNT BODIES,
PART II: COMPUTER CODE - USER'S GUIDE, Molly A. Ellis, F. G. Blottner
RE: SLA-73-0704

PUNCHING INSTRUCTIONS — GRAPHIC / PUNCH — PAGE 1 OF 1 — CARD ELECTRO NUMBER

FORTRAN STATEMENT — IDENT (columns 73-80) / SEQUENCE

```
TITLE  PROBLEM IDENTIFICATION                                   (5X,9A8)
1 TITLE

LIMTS  JMAX KMAXLITER IPRT KPRT  PSIMAX      UINF               (5X,5I5,2E10.0)
2 LIMTS

DW     Δω's AROUND THE BODY                                     (5X,7E10.0)
3 DW(K)

DN     Δη's ACROSS THE BOUNDARY LAYER                           (5X,7E10.0)
4 DN(J)

DPSI   Δξ - STEPSIZE TO BE USED ALONG THE BODY                  (5X,E10.0)
5 DPSI

SIZE       A          RB          RC          EPS         ALP         CAPTH   CRI (5X,7E10.0)
6 SIZE
```

JMAX	No. of pts. across boundary layer
KMAX	No. of pts. around body (in phi-direction)
LITER	No. of iterations for initial profile
IPRT	Every how many steps printing will occur along the body
KPRT	Every how many steps printing will occur around the body
PSIMAX	Distance along body at which program will terminate
UINF	Freestream velocity - V_∞

A	a - length of axis of triaxial ellipsoid
RB	R_b - radius of curvature of nose; plane y'=0
RC	R_c - radius of curvature of nose; plane z'=0
EPS	Convergence criterion; body coordinates
ALP	α - angle of attack (deg)
CAPTH	Θ - indicates finite-difference scheme used
CRI	1 Implicit scheme, ½ Crank-Nicolson scheme

**Number of forms per pad may vary locally

APPENDIX V

TAPGEN Program Listings

1. Program BLOT Listing

DATE 04/20/77

```
C      PROGRAM BL3D (INPUT,OUTPUT,TAPE60=INPUT,TAPE61=OUTPUT)                  BL000010
C                                                                              BL000020
CCC       BL3D IS THE MAIN PROGRAM AND CALLS SEVERAL OTHER SUBROUTINES         BL000030
C                                                                              BL000040
       IMPLICIT REAL*8 (A-H,O-Z)                                               BL000050
       COMMON /C01/    A          ,  EPS        ,  JMAX       ,  JMAX1      , BL000060
      1              JMAX2      ,  KMAX       ,  KMAX1,JK   ,  PI         ,BL000070
      2              PSIMAX     ,  SO         ,  S1         ,  UINF       , BL000080
      3              WINF       ,  XO         ,  YO                       BL000090
       COMMON /C08/    IN         ,  IOUT                                     BL000100
       CALL ERRSET(207,256,10,0,0,209)                                         BL000110
       PI = 3.1415926536                                                       BL000120
       IN = 5                                                                  BL000130
       IOUT = 6                                                                BL000140
10     CONTINUE                                                                BL000150
       CALL INPUT                                                              BL000160
       CALL PRECAL                                                             BL000170
       CALL GEOM                                                               BL000180
       GO TO 10                                                                BL000190
       END                                                                     BL000200
```

```
       SUBROUTINE CALCUV (K,CS,SN,U,IMET,V)                                    BL000210
C                                                                              BL000220
CCC       CALCUV COMPUTES EITHER R OR X, DEPENDING UPON WHICH IS THE UNK       BL000230
CCC       ** ARGUMENTS **                                                      BL000240
CCC            K - SUBSCRIPT IN PHI-DIRECTION.                                 BL000250
CCC           CS - COS OF ANGLE UPON WHICH R OR X DEPENDS.                     BL000260
CCC           SN - SIN OF ANGLE UPON WHICH R OR X DEPENDS.                     BL000270
CCC            U - THE UNKNOWN - R OR X.                                       BL000280
CCC         IMET - = 2, IMPLIES SOLVING FOR X.                                 BL000290
CCC                = 1, IMPLIES SOLVING FOR R.                                 BL000300
CCC              V - THE KNOWN VARIABLE - X OR R.                              BL000310
C                                                                              BL000320
       IMPLICIT REAL*8 (A-H,O-Z)                                               BL000330
       COMMON/C030/    IA, JK2    ,  OTA        ,  PRX        ,  PRXOR      , BL000340
      1              XPOVA                                                   BL000350
       DIMENSION V(100)                                                        BL000360
       IF (IMET .NE. 1) GO TO 20                                               BL000370
10     CONTINUE                                                                BL000380
       XK = V(K)                                                               BL000390
       CALL CXPOVA (XK)                                                        BL000400
       U = RELLIP (CS,SN,K)                                                    BL000410
       GO TO 60                                                                BL000420
20     CONTINUE                                                                BL000430
       GO TO (30,40), IA                                                       BL000440
30     CONTINUE                                                                BL000450
       U = ELLSP(CS,SN,K)                                                      BL000460
```

```
      GO TO 50                                                          BL000470
40    CONTINUE                                                          BL000480
      U = ELLPD (CS,SN,K)                                               BL000490
50    CONTINUE                                                          BL000500
      CALL CXPOVA(U)                                                    BL000510
60    CONTINUE                                                          BL000520
      RETURN                                                            BL000530
      END                                                               BL000540


      SUBROUTINE COORD(V,U,UV,VOLD,UOLD,IMET,K,DS)                      BL000550
C                                                                       BL000560
CCC   SUBROUTINE COORD CALCULATES THE R AND X CYLINDRICAL COORDINATES   BL000570
CCC       OF A POINT ON THE SURFACE OF THE BODY.                        BL000580
CCC    ** ARGUMENTS **                                                  BL000590
CCC              V - R, IF IMET = 2.                                    BL000600
CCC                  X, IF IMET = 1.                                    BL000610
CCC              U - X, IF IMET = 2.                                    BL000620
CCC                  R, IF IMET = 1.                                    BL000630
CCC             UV - A PARTIAL DERIVATIVE - EITHER X W.R.T. R OR R      BL000640
CCC                  W.R.T. X.                                          BL000650
CCC           VOLD - EITHER R  OR  X FROM THE PREVIOUS STEP.           BL000660
CCC           UOLD - EITHER R  OR  X FROM THE PREVIOUS STEP.           BL000670
CCC           IMET - = 2, IMPLIES SOLVING EXPLICITLY FOR X, IMPLICITLY BL000680
CCC                       FOR R.                                       BL000690
CCC                  = 1, IMPLIES SOLVING EXPLICITLY FOR R, IMPLICITLY BL000700
CCC                       FOR X.                                       BL000710
CCC              K - SUBSCRIPT IN THE PHI-DIRECTION.                   BL000720
CCC             DS - INCREMENTAL DISTANCE ALONG SURFACE OF THE BODY.   BL000730
C                                                                       BL000740
      IMPLICIT REAL*8 (A-H,O-Z)                                         BL000750
      COMMON /C01/   A        ,  EPS       ,  JMAX      ,  JMAX1     , BL000760
     1             JMAX2     ,  KMAX      ,  KMAX1,JK  ,  PI        ,BL000770
     2             PSIMAX    ,  SO        ,  SI        ,  UINF      , BL000780
     3             WINF      ,  XO        ,  YO                     BL000790
      COMMON /C04/   ALP       ,  COSPH(100),  DPHI(100) ,  DPSI      , BL000800
     1             DW(100)   ,  PHI(100)  ,  PSI       ,  PSIO      , BL000810
     2             SINPH(100),  SINTHB                               BL000820
      COMMON /C05/   HPSI(100) ,  HW(100)   ,  HWO(100)                BL000830
      COMMON/C010/   LITER,JK1 ,  PI2       ,  SNTHB2                  BL000840
      COMMON/C023/   AO        ,  BO        ,  CO        ,  P         , BL000850
     1             RB        ,  RC                                   BL000860
      COMMON/C030/   IA, JK2   ,  OTA       ,  PRX       ,  PRXOR     , BL000870
     1             XPOVA                                             BL000880
      COMMON /EXT/ IBEXT                                              BL000890
      DIMENSION U(100), V(100), UV(100), UOLD(100), VOLD(100)         BL000900
      DIMENSION MET(2)                                                BL000910
      IF (K.NE.0) GO TO 60                                            BL000920
```

```
      DS = DPSI                                                          BL000930
      DV = DS / DSQRT(1.0D0+UV(1)*UV(1))                                 BL000940
      V(1) = VOLD(1) + DV                                                BL000950
10    CONTINUE                                                           BL000960
      CALL CALCUV (1,COSPH(1),SINPH(1),US,IMET,V)                        BL000970
      U(1) = US                                                          BL000980
      UV(1) = (U(1) - UOLD(1)) / DV                                      BL000990
      DV = DS / DSQRT(1.0D0 + UV(1)*UV(1))                               BL001000
      VORG = V(1)                                                        BL001010
      V(1) = VOLD(1) + DV                                                BL001020
      IF (V(1).EQ.VORG) GO TO 20                                         BL001030
      IF (DABS(V(1)-VORG).GT.DABS(V(1)*EPS)) GO TO 10                    BL001040
20    CONTINUE                                                           BL001050
      CALL CALCUV (1,COSPH(1),SINPH(1),US,IMET,V)                        BL001060
      U(1) = US                                                          BL001070
      GO TO (30,40), IMET                                                BL001080
30    CONTINUE                                                           BL001090
      IF(IBEXT.EQ.0) GO TO 31                                            BL001100
      CALL DPRX(COSPH(1),U(1),PRX)                                       BL001110
      GO TO 32                                                           BL001120
   31 PRX = RB*(1.0D0-XPOVA) / (U(1)*OTA+YO*COSPH(1))                    BL001130
   32 PRXOR = (YO+U(1)*COSPH(1)*(1.0D0-RB/RC))*SINPH(1)/(U(1)*OTA +      BL001140
     1   YO*COSPH(1) + RB*PRX*(1.0D0-XPOVA))                             BL001150
      GO TO 50                                                           BL001160
40    CONTINUE                                                           BL001170
      IF(IBEXT.EQ.0) GO TO 41                                            BL001180
      CALL DPRX(COSPH(1),V(1),PRX)                                       BL001190
      GO TO 42                                                           BL001200
   41 PRX = RB*(1.0D0-XPOVA)/(V(1)*OTA + YO*COSPH(1))                    BL001210
   42 PRXOR = (YO+V(1)*COSPH(1)*(1.0D0-RB/RC))*SINPH(1)/(V(1)*OTA        BL001220
     1   +YO*COSPH(1) + RB*PRX*(1.0D0-XPOVA))                            BL001230
50    CONTINUE                                                           BL001240
      HPSI(1) = 1.0D0                                                    BL001250
      DV = 0.0D0                                                         BL001260
      MET(1) = 0                                                         BL001270
      MET(2) = 0                                                         BL001280
      RETURN                                                             BL001290
C           GENERAL CASE, K (NOT)=0.                                     BL001300
60    CONTINUE                                                           BL001310
      V(K+1) = V(K) + DV                                                 BL001320
      MET(IMET) = MET(IMET) + 1                                          BL001330
      CSPH3 = DCOS(PHI(K+1) + 0.5D0*DPHI(K))                             BL001340
      CSPH4 = DCOS(PHI(K+1) - 0.5D0*DPHI(K))                             BL001350
      SINPH3 = DSIN(PHI(K+1) + 0.5D0*DPHI(K))                            BL001360
      SINPH4 = DSIN(PHI(K+1) - 0.5D0*DPHI(K))                            BL001370
      IF ((MET(1).NE.1).AND.(MET(2).NE.1)) GO TO 110                     BL001380
70    CONTINUE                                                           BL001390
      CSPH1 = DCOS(PHI(K) + 0.5D0*DPHI(K))                               BL001400
      CSPH2 = DCOS(PHI(K) - 0.5D0*DPHI(K))                               BL001410
      SINPH1 = DSIN(PHI(K) + 0.5D0*DPHI(K))                              BL001420
      SINPH2 = DSIN(PHI(K) - 0.5D0*DPHI(K))                              BL001430
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      CALL CALCUV(K,CSPH1,SINPH1,US,IMET,V)                                  BL001440
      U1 = US                                                                BL001450
      CALL CALCUV (K,CSPH2,SINPH2,US,IMET,V)                                 BL001460
      U2 = US                                                                BL001470
      GO TO (80,90), IMET                                                    BL001480
80    CONTINUE                                                               BL001490
      IF(IBEXT.EQ.0) GO TO 81                                                BL001500
      CALL DPRX(COSPH(K),U(K),PRX)                                           BL001510
      UV(K)=PRX                                                              BL001520
      GO TO 100                                                              BL001530
   81 UV(K) = RB * (1.0D0-XPOVA) / (U(K)*OTA+YO*COSPH(K))                    BL001540
      GO TO 100                                                              BL001550
90    CONTINUE                                                               BL001560
      IF(IBEXT.EQ.0) GO TO 91                                                BL001570
      CALL DPRX(COSPH(K),V(K),PRX)                                           BL001580
      UV(K)=PRX                                                              BL001590
      GO TO 100                                                              BL001600
   91 UV(K) = (V(K)*OTA+YO*COSPH(K)) / (RB*(1.0D0-XPOVA))                    BL001610
100   CONTINUE                                                               BL001620
      TERM1 = (U1 - U2) / DPHI(K)                                            BL001630
      GO TO 120                                                              BL001640
110   CONTINUE                                                               BL001650
      TERM1 = TERM2                                                          BL001660
120   CONTINUE                                                               BL001670
130   CONTINUE                                                               BL001680
      CALL CALCUV (K+1,CSPH3,SINPH3,US,IMET,V)                               BL001690
      U3 = US                                                                BL001700
      CALL CALCUV(K+1,CSPH4,SINPH4,US,IMET,V)                                BL001710
      U4 = US                                                                BL001720
      CALL CALCUV (K+1,COSPH(K+1),SINPH(K+1),US,IMET,V)                      BL001730
      U(K+1) = US                                                            BL001740
      GO TO (140,150), IMET                                                  BL001750
140   CONTINUE                                                               BL001760
      IF(IBEXT.EQ.0) GO TO 141                                               BL001770
      CALL DPRX(COSPH(K+1),U(K+1),PRX)                                       BL001780
      UV(K+1)=PRX                                                            BL001790
      GO TO 160                                                              BL001800
  141 UV(K+1) = RB*(1.-XPOVA)/(U(K+1)*OTA+YO*COSPH(K+1))                     BL001810
      GO TO 160                                                              BL001820
150   CONTINUE                                                               BL001830
      IF(IBEXT.EQ.0) GO TO 151                                               BL001840
      CALL DPRX(COSPH(K+1),V(K+1),PRX)                                       BL001850
      UV(K+1)=PRX                                                            BL001860
      GO TO 160                                                              BL001870
  151 UV(K+1) = (V(K+1)*OTA + YO*COSPH(K+1)) / (RB*(1.0D0-XPOVA))            BL001880
160   CONTINUE                                                               BL001890
      DUDV = 0.5D0*(UV(K) + UV(K+1))                                         BL001900
      TERM2 = (U3 - U4) / DPHI(K)                                            BL001910
      DUDPH = 0.5D0 * (TERM1 + TERM2)                                        BL001920
      DV = -PI2*DUDPH*DUDV    / (1.0D0+DUDV    *DUDV    )*DW(K)               BL001930
      VORG = V(K+1)                                                          BL001940
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      V(K+1) = V(K) + DV                                                    BL001950
      IF (V(K+1).EQ.VORG) GO TO 170                                         BL001960
      IF (DABS(V(K+1)-VORG).GT.DABS(V(K+1)*EPS)) GO TO 130                  BL001970
  170 CONTINUE                                                              BL001980
      HWO(K) = HW(K)                                                        BL001990
      IF (IMET.NE.1) GO TO 190                                              BL002000
  180 CONTINUE                                                              BL002010
      HW(K) = DSQRT((U(K+1)-U(K))**2 + (PI*(U(K+1)+U(K))*DW(K))**2          BL002020
     1     + (V(K+1) - V(K))**2) / DW(K)                                    BL002030
      PRX = UV(K+1)                                                         BL002040
      PRXOR=(YO+U(K+1)*COSPH(K+1)*(1.0D0-RB/RC))*SINPH(K+1)/(U(K+1)*OTA     BL002050
     1   +YO*COSPH(K+1)+RB*PRX*(1.0D0-XPOVA))                               BL002060
      GO TO 200                                                             BL002070
  190 CONTINUE                                                              BL002080
      HW(K) = DSQRT((U(K+1)-U(K))**2 + (PI*(V(K+1)+V(K))*DW(K))**2          BL002090
     1     + (V(K+1) - V(K))**2) / DW(K)                                    BL002100
      PRX = 1.0D0/UV(K+1)                                                   BL002110
     1   +YO*COSPH(K+1)+RB*PRX*(1.0D0-XPOVA)                                BL002120
  200 CONTINUE                                                              BL002130
      DELV = V(K+1) - VOLD(K+1)                                             BL002140
      UVH = (U(K+1) - UOLD(K+1)) / DELV                                     BL002150
      DS = DSQRT(1.0D0 + UVH*UVH) * DELV                                    BL002160
      HPSI(K+1) = DS/DPSI                                                   BL002170
      RETURN                                                                BL002180
      END                                                                   BL002190
```



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      SUBROUTINE CXPOVA (X)                                                 BL002200
C                                                                           BL002210
CCC       CXPOVA CALCULATES THE RELATION XPRIME/A.                          BL002220
CCC       **ARGUMENTS **                                                    BL002230
CCC            X - X-COORDINATE.                                            BL002240
C                                                                           BL002250
      IMPLICIT REAL*8 (A-H,O-Z)                                             BL002260
      COMMON /COI/   A        , EPS      , JMAX     , JMAX1    ,           BL002270
     1             JMAX2     , KMAX     , KMAX1,JK , PI       ,           BL002280
     2             PSIMAX    , SO       , S1       , UINF     ,           BL002290
     3             WINF      , XO       , YO                             BL002300
      COMMON/CO30/   IA, JK2  , OTA      , PRX      , PRXOR    ,           BL002310
     1             XPOVA                                                  BL002320
      GO TO (10,20), IA                                                     BL002330
   10 CONTINUE                                                              BL002340
      XPOVA = (X + XO) /A                                                   BL002350
      GO TO 30                                                              BL002360
   20 CONTINUE                                                              BL002370
      XPOVA = 0.0D0                                                         BL002380
   30 CONTINUE                                                              BL002390
      RETURN                                                                BL002400
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      END                                                                BL002410



      DOUBLE PRECISION FUNCTION ELLPD (COSP,SINP,K)                      BL002420
C                                                                        BL002430
CCC       ELLPD DEFINES X WHEN THE BODY GEOMETRY IS AN ELLIPTIC          BL002440
CCC     PARABOLOID.                                                      BL002450
CCC       ** ARGUMENTS **                                                BL002460
CCC            COSP - COS OF THE ANGLE.                                  BL002470
CCC            SINP - SIN OF THE ANGLE.                                  BL002480
CCC               K - SUBSCRIPT IN THE PHI-DIRECTION.                    BL002490
C                                                                        BL002500
      IMPLICIT REAL*8 (A-H,O-Z)                                          BL002510
      COMMON /CO1/   A        , EPS      , JMAX     , JMAX1    , BL002520
     1               JMAX2    , KMAX     , KMAX1,JK , PI       ,BL002530
     2               PSIMAX   , SO       , S1       , UINF     ,  BL002540
     3               WINF     , XO       , YO                     BL002550
      COMMON /CO2/   ALPHA(100), DN(50)   , DN2(50)  , R(100)   , BL002560
     1               RWRTX(100), S(100)   , W(100)   , X(100)     BL002570
      COMMON/CO23/   AO       , BO       , CO       , P        , BL002580
     1               RB       , RC                               BL002590
      COMMON/CO30/   IA, JK2  , OTA      , PRX      , PRXOR    , BL002600
     1               XPOVA                                       BL002610
      OTA = COSP*COSP + RB/RC*SINP*SINP                          BL002620
      RP2 = R(K)*R(K) + 2.0D0*YO * R(K)*COSP + YO*YO             BL002630
      D = RB*RP2/(R(K)*R(K)*OTA + 2.0D0*YO*R(K)*COSP+YO*YO)      BL002640
      ELLPD = 0.5D0*RP2/D - XO                                   BL002650
      RETURN                                                     BL002660
      END                                                        BL002670



      DOUBLE PRECISION FUNCTION ELLSP(COSP,SINP,K)                       BL002680
C                                                                        BL002690
CCC       THIS FUNCTION DEFINES X WHEN THE BODY GEOMERTY IS AN ELLIPSOID.BL002700
CCC        ** ARGUMENTS **                                               BL002710
CCC            COSP - COS OF THE ANGLE.                                  BL002720
CCC            SINP - SIN OF THE ANGLE.                                  BL002730
CCC               K - SUBSCRIPT IN THE PHI DIRECTION.                    BL002740
C                                                                        BL002750
      IMPLICIT REAL*8 (A-H,O-Z)                                          BL002760
      COMMON /CO1/   A        , EPS      , JMAX     , JMAX1    , BL002770
     1               JMAX2    , KMAX     , KMAX1,JK , PI       ,BL002780
     2               PSIMAX   , SO       , S1       , UINF     ,  BL002790
     3               WINF     , XO       , YO                     BL002800
      COMMON /CO2/   ALPHA(100), DN(50)   , DN2(50)  , R(100)   , BL002810
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     1              RWRTX(100),  S(100)     ,  W(100)     ,  X(100)        BL002820
      COMMON/C023/    AO        , BO         ,  CO         ,  P           , BL002830
     1              RB         , RC                                       BL002840
      COMMON/C030/    IA, JK2   ,  OTA       ,  PRX        ,  PRXOR       , BL002850
     1              XPOVA                                                 BL002860
      COMMON /EXT/ IBEXT                                                   BL002870
      DIMENSION ZSLO(2)                                                    BL002880
      OTA = COSP*COSP + RB/RC*SINP*SINP                                    BL002890
      IF(IBEXT.EQ.1) GO TO 10                                              BL002900
      RP2 = R(K)*R(K) + 2.0D0*YO * R(K)*COSP + YO*YO                       BL002910
      D = RB *RP2/(R(K)*R(K)*OTA + 2.0D0*YO*R(K)*COSP + YO*YO)             BL002920
      ELLSP = A - XO - DSQRT(A*A-A*RP2/D)                                  BL002930
      GO TO 20                                                             BL002940
   10 TANP=SINP/COSP                                                       BL002950
      PH1=DATAN(TANP)                                                      BL002960
      PP=PH1                                                               BL002970
      ZSLO(1)=R(K)                                                         BL002980
      CALL SLOALL(PP,ZSLO,1,13,2,0,0,3,0)                                  BL002990
      ELLSP=ZSLO(2)                                                        BL003000
   20 RETURN                                                               BL003010
      END                                                                  BL003020


      SUBROUTINE INPUT                                                     BL003030
C                                                                          BL003040
C        INPUT READS INPUT DATA AND INITIALIZES A FEW PARAMETERS.          BL003050
C                                                                          BL003060
      IMPLICIT REAL*8 (A-H,O-Z)                                            BL003070
      COMMON /C01/    A         ,  EPS        ,  JMAX       ,  JMAX1       , BL003080
     1              JMAX2      ,  KMAX       ,  KMAX1,JK   ,  PI          , BL003090
     2              PSIMAX     ,  SO         ,  S1         ,  UINF        , BL003100
     3              WINF       ,  XO         ,  YO                        BL003110
      COMMON /C02/    ALPHA(100),  DN(50)     ,  DN2(50)    ,  R(100)      , BL003120
     1              RWRTX(100),  S(100)     ,  W(100)     ,  X(100)      , BL003130
      COMMON /C04/    ALP       ,  COSPH(100),  DPHI(100) ,  DPSI        , BL003140
     1              DW(100)    ,  PHI(100)   ,  PSI        ,  PSIO        , BL003150
     2              SINPH(100),  SINTHB                                   BL003160
      COMMON /C08/    IN        ,  IOUT                                    BL003170
      COMMON/C010/    LITER,JK1 ,  PI2        ,  SNTHB2                    BL003180
      COMMON/C017/    IPRT      ,  KPRT                                    BL003190
      COMMON/C023/    AO        ,  BO         ,  CO         ,  P           , BL003200
     1              RB         , RC                                       BL003210
      COMMON/C025/    CAPTH     ,  CPTHM      ,  CPTHP      ,  CPTH2       BL003220
      COMMON/C041/    CRI       ,  KHALF                                   BL003230
      COMMON /EXT/ IBEXT                                                   BL003240
      DIMENSION TITLE(9)                                                   BL003250
      READ (4,9000,END=10) (TITLE(I),I=1,9)                                BL003260
      GO TO 20                                                             BL003270
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C     IF (EOF,60) 10,20                                                          BL003280
10    CONTINUE                                                                   BL003290
      WRITE(6,11) PSI,PSIMAX                                                     BL003300
   11 FORMAT(///10X,'PSI =',F10.4,5X,'GREATER THAN  PSIMAX=',F10.4,10X,          BL003310
     1'SO      THE END')                                                        BL003320
      STOP                                                                       BL003330
20    CONTINUE                                                                   BL003340
      WRITE(IOUT,9900) (TITLE(I),I=1,9)                                          BL003350
      READ (4,9010) JMAX, KMAX, LITER, IPRT, KPRT, IBEXT,  PSIMAX, UINF          BL003360
      KMAX1 = KMAX - 1                                                           BL003370
      JMAX1 = JMAX - 1                                                           BL003380
      READ (4,9020) (DW(K),K=1,KMAX1)                                            BL003390
      READ (4,9020) (DN(J),J=1,JMAX1)                                            BL003400
      READ (4,9020) DPSI                                                         BL003410
      READ (4,9020) A,RB,RC,EPS,ALP,CAPTH,CRI                                    BL003420
      KHALF = KMAX/2 + 1                                                         BL003430
      IF (MOD(KMAX,2) .NE. 0) KHALF = KHALF + 1                                  BL003440
C                                                                                BL003450
C                                                                                BL003460
C                                                                                BL003470
      RETURN                                                                     BL003480
C                                                                                BL003490
 9000 FORMAT (5X,9A8)                                                            BL003500
 9900 FORMAT (1H1,20X,9A8)                                                       BL003510
 9010 FORMAT (5X,6I5,3E10.0)                                                     BL003520
 9020 FORMAT (5X,7E10.0)                                                         BL003530
      END                                                                        BL003540
      SUBROUTINE PARVAL (K,IP)                                                   BL003550
C                                                                                BL003560
CCC     PARVAL - PARAMETER EVALUATION   - -  KEY PARAMETERS NEEDED FOR           BL003570
CCC    THE SOLUTION OF F,G, ADD V ARE CALCULATED IN THIS SUBROUTINE.             BL003580
CCC       ** ARGUMENTS **                                                        BL003590
CCC            K - SUBSCRIPT IN THE PHI-DIRECTION.                               BL003600
CCC           IP - SUBSCRIPT IN THE PSI-DIRECTION.                               BL003610
C                                                                                BL003620
      IMPLICIT REAL*8 (A-H,O-Z)                                                  BL003630
      REAL*8 KAPPAS, KAPPAW                                                      BL003640
      COMMON /C01/   A        ,  EPS       ,  JMAX      ,  JMAX1     ,        BL003650
     1              JMAX2     ,  KMAX      ,  KMAX1,JK  ,  PI        ,        BL003660
     2              PSIMAX    ,  SO        ,  S1        ,  UINF      ,        BL003670
     3              WINF      ,  XO        ,  YO                              BL003680
      COMMON /C02/   ALPHA(100),  DN(50)    ,  DN2(50)   ,  R(100)    ,        BL003690
     1              RWRTX(100),  S(100)     ,  W(100)    ,  X(100)            BL003700
      COMMON /C03/   F(50,100) ,  FO(50,100),  G(50,100) ,  GO(50,100),        BL003710
     1              UE(100)   ,  UEO(100)   ,  V(50,100) ,  WE(100)   ,        BL003720
     2              WEO(100)                                                   BL003730
      COMMON /C04/   ALP       ,  COSPH(100),  DPHI(100) ,  DPSI      ,        BL003740
     1              DW(100)   ,  PHI(100)   ,  PSI       ,  PSIO      ,        BL003750
     2              SINPH(100),  SINTHB                                        BL003760
      COMMON /C05/   HPSI(100) ,  HW(100)    ,  HWO(100)                        BL003770
      COMMON /C06/   ALBET2    ,  ALBET3     ,  ALP2      ,  BETA1     ,        BL003780
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     1              BETA2     ,  BETA3     ,  BETA4     ,  KAPPAS    ,   BL003790
     2              KAPPAW                                               BL003800
      COMMON /CO7/   ALPHO(50) ,  ALPH1(50) ,  ALPH2(50) ,  ALPH3(50) ,  BL003810
     1              ALPH4(50) ,  ALPH5(50) ,  ALPH6(50)                  BL003820
      COMMON /CO9/   TOL                                                  BL003830
      COMMON/CO10/   LITER,JK1 ,  PI2       ,  SNTHB2                     BL003840
      COMMON/CO11/   PIH                                                  BL003850
      COMMON/CO12/   H         ,  HH        ,  WE1                        BL003860
      COMMON/CO13/   COSAL     ,  SINAL                                   BL003870
      COMMON/CO14/   COSPH2    ,  DW2       ,  PRXS      ,  PRXORS    ,  BL003880
     1              R2        ,  SINPH2    ,  XPOVAS    ,  X2           BL003890
      COMMON/CO15/   ROLD(100) ,  SOLD(100) ,  THB(100)  ,  XOLD(100) ,  BL003900
     1              XWRTR(100)                                           BL003910
      COMMON/CO18/   CAPW(100)                                            BL003920
      COMMON/CO19/   PWOU(100) ,  PUOW                                    BL003930
      COMMON/CO20/   ALBAV     ,  ALPAV                                   BL003940
      COMMON/CO21/   ALB1(100) ,  ALB2      ,  ALB3      ,  BETA5     ,  BL003950
     1              BETA6                                                BL003960
      COMMON/CO23/   AO        ,  BO        ,  CO        ,  P         ,  BL003970
     1              RB        ,  RC                                      BL003980
      COMMON/CO24/   GPR       ,  PHIPR     ,  RP        ,  UPHP      ,  BL003990
     1              USP       ,  XP                                      BL004000
      COMMON/CO25/   CAPTH     ,  CPTHM     ,  CPTHP     ,  CPTH2        BL004010
      COMMON/CO26/   XIKA      ,  AL3T                                    BL004020
      COMMON/CO29/    WE1AV                                              BL004030
      COMMON/CO30/   IA, JK2   ,  OTA       ,  PRX       ,  PRXOR     ,  BL004040
     1              XPOVA                                                BL004050
      COMMON/CO31/   UXP       ,  UYP       ,  UZP                      BL004060
      COMMON/CO32/   CU        ,  CV        ,  CW                       BL004070
      COMMON/CO36/   ICAP                                                BL004080
      COMMON/CO38/   HPS       ,  FKWPSI                                 BL004090
      COMMON/CO40/   ALSTG                                               BL004100
      COMMON/CO42/   UE2       ,  WE2                                    BL004110
      COMMON/CO43/   DRDSI     ,  XTST                                   BL004120
      COMMON /CO50/ KDUM                                                 BL004130
      KDUM=K                                                             BL004140
      IF (IP .EQ. 1) GO TO 100                                           BL004150
      UEO(K+1) = UE(K+1)                                                 BL004160
      WEO(K+1) = WE(K+1)                                                 BL004170
      Y = R(K+1)*COSPH(K+1)                                              BL004180
      Z = R(K+1)*SINPH(K+1)                                              BL004190
      CALL UXYZ (Y,Z,XPOVAS)                                             BL004200
      UE(K+1) = (UXP + (UYP*COSPH(K+1)+UZP*SINPH(K+1))*PRXS)             BL004210
     1    /DSQRT(1.+PRXS*PRXS)                                           BL004220
C                                                                        BL004230
C        THE CALCULATION OF UE INVOLVES SETTING UE TO A RADICAL WHICH    BL004240
C     CAN ASSUME EITHER A (+) OR (-) SIGN.  A TEST IS MADE CONCERNING    BL004250
C     THE SIGNS OF TWO PARTIAL DERIVATIVES IN ORDER TO DETERMINE THE     BL004260
C     APPROPRIATE SIGN FOR UE.                                           BL004270
C        IT IS ASSUMED THAT FOR X GREATER THAN OR = XTST THE             BL004280
C     (+) SIGN SHOULD BE USED.                                           BL004290
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C                                                                       BL004300
      IF (X(K+1).GE.XTST) GO TO 10                                      BL004310
      IF ((PRXS*DRDSI) .LT. 0.) UE(K+1) = - UE(K+1)                     BL004320
10    CONTINUE                                                          BL004330
      WE(K+1) = ((UYP*COSPH(K+1)+UZP*SINPH(K+1)-UXP*PRXS)*PRXORS        BL004340
     1  + UZP*COSPH(K+1) - UYP*SINPH(K+1))/DSQRT(1.+(1.+PRXS*PRXS)      BL004350
     1    * PRXORS*PRXORS)                                             BL004360
      IF (K.EQ.KMAX1) GO TO 80                                          BL004370
      Y = R2*COSPH2                                                     BL004380
      Z = R2*SINPH2                                                     BL004390
      CALL UXYZ (Y,Z,XPOVA)                                             BL004400
      UE2 = (UXP + (UYP*COSPH2+UZP*SINPH2)*PRX)/DSQRT(1.+PRX*PRX)       BL004410
      IF (X2.GE.XTST) GO TO 20                                          BL004420
      DRDSIN = (R(K+2) - ROLD(K+2)) / DPSI                              BL004430
      IF ((PRX*DRDSIN) .LT. 0.) UE2 = -UE2                              BL004440
20    CONTINUE                                                          BL004450
      WE2 = ((UYP*COSPH2+UZP*SINPH2-UXP*PRX )*PRXOR  + UZP*COSPH2-UYP   BL004460
     1  *SINPH2)/DSQRT(1.+(1.+PRX *PRX )*PRXOR *PRXOR )                 BL004470
      IF (K.NE.0) GO TO 80                                              BL004480
30    CONTINUE                                                          BL004490
      CAPW(K+1) = WE(K+1)                                               BL004500
      H2 = (HPSI(K+2) - HPSI(K+1)) / (DW(K+1) * DW(K+1))                BL004510
      WE10 = WE1                                                        BL004520
      WE1 = WE2/(PI2*DW2)                                               BL004530
      WE1AV = .5 * (WE1 + WE10)                                         BL004540
      USUBE = .5 * (UEO(K+1) + UE(K+1))                                 BL004550
      RB1 = .5 * (ROLD(K+1) + R(K+1))                                   BL004560
      KAPPAW = (R(K+1) - ROLD(K+1)) / (RB1*DPSI)                        BL004570
      FKPSO = FXPS                                                      BL004580
      FKPS = KAPPAW * PSI                                               BL004590
      DWE1 = (WE1 - WE10) / DPSI                                        BL004600
      HPS = .5*(PSI + PSIO)                                             BL004610
      FKWPSI = KAPPAW * HPS                                             BL004620
      IF (WE1AV.LE..0000000001) GO TO 40                                BL004630
      BETA4 = (HPS*DWE1) / WE1AV                                        BL004640
      KAPPAS = H2 * USUBE / (PI2*PI*RB1*WE1AV)                          BL004650
      GO TO 50                                                          BL004660
40    CONTINUE                                                          BL004670
      BETA4 = 0.0                                                       BL004680
      KAPPAS = FKWPSI / HPS                                             BL004690
50    CONTINUE                                                          BL004700
      ALBET3 = HPS * WE1AV / (RB1*USUBE)                                BL004710
      IF (IP.EQ.2) GO TO 60                                             BL004720
      BETA1 = (UE(K+1) - UEO(K+1))/(DPSI*.5*(UE(K+1)/PSI+UEO(K+1)/PSIO))BL004730
      GO TO 70                                                          BL004740
60    CONTINUE                                                          BL004750
      BETA1 = (UE(K+1) - UEO(K+1)) / (DPSI*.5*(UE(K+1)/PSI + UO1))      BL004760
70    CONTINUE                                                          BL004770
      BETA6 = BETA4                                                     BL004780
      BETA2 = 0.0                                                       BL004790
      ALSTG = ALPHA(K+1)                                                BL004800
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      ALPHA(K+1) = 0.0                                                  BL004810
      ALB1(K+1) = ALPHA(K+1)                                            BL004820
      ALB2 = ALPHA(K+1)                                                 BL004830
      ALB3 = 1.0                                                        BL004840
      ALBET2 = 0.0                                                      BL004850
      XIKA = 0.0                                                        BL004860
      BETA3 = 0.0                                                       BL004870
      GO TO 90                                                          BL004880
80    CONTINUE                                                          BL004890
      CAPW(K+1) = UE(K+1)                                               BL004900
      CALL AVERG(K,IP)                                                  BL004910
      IF(ALB1(K+1) .LT. 1.0D-06) GO TO 90                               BL004920
      XIKA = HPS * KAPPAS / ALB1(K+1)                                   BL004930
90    CONTINUE                                                          BL004940
      ALP2 = ALPHA(K+1) * ALPHA(K+1)                                    BL004950
      GO TO 210                                                         BL004960
100   CONTINUE                                                          BL004970
      IF (K.NE.0) GO TO 110                                             BL004980
      CSP = COSPH(1)                                                    BL004990
      SNP = SINPH(1)                                                    BL005000
      GO TO 120                                                         BL005010
110   CONTINUE                                                          BL005020
      PHIAV = .5*(PHI(K) + PHI(K+1))                                    BL005030
      CSP = DCOS(PHIAV)                                                 BL005040
      SNP = DSIN(PHIAV)                                                 BL005050
120   CONTINUE                                                          BL005060
      COMDE = SO*CSP*CSP + S1*SNTHB2*SNP*SNP                            BL005070
      UE(K+1) = 0.0                                                     BL005080
      WE(K+1) = 0.0                                                     BL005090
      CAPW(K+1) = WE(K+1)                                               BL005100
      IF (K .EQ. 1) WE1 = WE(2) / (PI2*DW(2))                           BL005110
      ALPHA(K+1) = (S1-SO)*SINTHB*SNP*CSP/COMDE                         BL005120
      ALP2 = ALPHA(K+1) * ALPHA(K+1)                                    BL005130
      PWOU(K+1) = (S1-SO)*(CSP*CSP-SNTHB2*SNP*SNP)/COMDE                BL005140
      PUOW = 1.0                                                        BL005150
      FKPS = 1.0                                                        BL005160
      ALB3 = 1.0                                                        BL005170
      IF (DABS(SO-S1).GT..0000000001) GO TO 140                         BL005180
130   CONTINUE                                                          BL005190
      XIKA = 2.0                                                        BL005200
      BETA4 = 2.0                                                       BL005210
      GO TO 150                                                         BL005220
140   CONTINUE                                                          BL005230
      XIKA = 0.0                                                        BL005240
      BETA4 = 1.0                                                       BL005250
150   CONTINUE                                                          BL005260
      IF (K.EQ.0) GO TO 170                                             BL005270
160   CONTINUE                                                          BL005280
      HOLD = H                                                          BL005290
170   CONTINUE                                                          BL005300
      H = SINTHB / (CSP*CSP + SNTHB2*SNP*SNP)                           BL005310
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      IF (K.EQ.0) GO TO 190                                                 BL005320
180   CONTINUE                                                              BL005330
      ALBET3 = PWOU(K+1)                                                    BL005340
      GO TO 200                                                             BL005350
190   CONTINUE                                                              BL005360
      UO1 = H*SO/SINTHB                                                     BL005370
      WO2 = (S1-SO) * SINPH(2)*COSPH(2) *SINTHB/                            BL005380
     1  (COSPH(2)*COSPH(2)+SNTHB2*SINPH(2)*SINPH(2))                        BL005390
      ALBET3 = WO2/(PI2*H*UO1*DW(1))                                        BL005400
200   CONTINUE                                                              BL005410
      PIH = H * PI2                                                         BL005420
      ALPAV = ALPHA(K+1)                                                    BL005430
      COMDE = SO*COSPH(K+1)*COSPH(K+1)+S1*SNTHB2*SINPH(K+1)*SINPH(K+1)      BL005440
      ALPHA(K+1) = (S1-SO)*SINTHB*SINPH(K+1)*COSPH(K+1)/COMDE               BL005450
210   CONTINUE                                                              BL005460
      RETURN                                                                BL005470
      END                                                                   BL005480


      SUBROUTINE PRECAL                                                     BL005490
C                                                                           BL005500
CCC   SUBROUTINE PRECAL DOES ONE-TIME CALCULATIONS AND INITIALIZES          BL005510
CCC       VARIABLES.  ALSO THE INITIAL INPUT IS PRINTED OUT IN THIS         BL005520
CCC       SUBROUTINE.                                                       BL005530
C                                                                           BL005540
      IMPLICIT REAL*8 (A-H,O-Z)                                             BL005550
      COMMON /CO1/   A          , EPS        , JMAX       , JMAX1      ,   BL005560
     1               JMAX2      , KMAX       , KMAX1,JK   , PI         ,  BL005570
     2               PSIMAX     , SO         , S1         , UINF       ,   BL005580
     3               WINF       , XO         , YO                      ,   BL005590
      COMMON /CO2/   ALPHA(100), DN(50)     , DN2(50)    , R(100)     ,   BL005600
     1               RWRTX(100), S(100)     , W(100)     , X(100)     ,   BL005610
      COMMON /CO3/   F(50,100) , FO(50,100), G(50,100) , GO(50,100),     BL005620
     1               UE(100)    , UEO(100)   , V(50,100) , WE(100)    ,   BL005630
     2               WEO(100)                                             BL005640
      COMMON /CO4/   ALP        , COSPH(100), DPHI(100) , DPSI       ,   BL005650
     1               DW(100)    , PHI(100)   , PSI       , PSIO       ,   BL005660
     2               SINPH(100), SINTHB                                   BL005670
      COMMON /CO5/   HPSI(100) , HW(100)    , HWO(100)                    BL005680
      COMMON /CO6/   ALBET2     , ALBET3     , ALP2       , BETA1      ,   BL005690
     1               BETA2      , BETA3      , BETA4      , KAPPAS     ,   BL005700
     2               KAPPAW                                               BL005710
      COMMON /CO8/   IN         , IOUT                                     BL005720
      COMMON /CO9/   TOL                                                   BL005730
      COMMON/CO10/   LITER,JK1 , PI2        , SNTHB2                      BL005740
      COMMON/CO13/   COSAL      , SINAL                                    BL005750
      COMMON/CO15/   ROLD(100) , SOLD(100) , THB(100) , XOLD(100) ,      BL005760
     1               XWRTR(100)                                           BL005770
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      COMMON/C017/   IPRT       ,  KPRT                                          BL005780
      COMMON/C023/   AO         ,  BO         ,  CO         ,  P         ,      BL005790
     1           RB         ,  RC                                               BL005800
      COMMON/C025/   CAPTH      ,  CPTHM      ,  CPTHP      ,  CPTH2           BL005810
      COMMON/C030/   IA, JK2    ,  DTA        ,  PRX        ,  PRXOR     ,      BL005820
     1           XPOVA                                                         BL005830
      COMMON/C032/   CU         ,  CV         ,  CW                            BL005840
      COMMON/C034/   ICON       ,  JTST       ,  NIT                           BL005850
      COMMON/C036/   ICAP                                                     BL005860
      COMMON/C041/   CRI        ,  KHALF                                      BL005870
      COMMON/C043/   DRDSI      ,  XTST                                       BL005880
      COMMON /EXT/ IBEXT                                                      BL005890
      DIMENSION    DNSUM(50)                                                  BL005900
      TOL = .001                                                              BL005910
      DNSUM(1) = 0.0                                                          BL005920
      ALP = .0174533 * ALP                                                    BL005930
      PI2 = 2.*PI                                                             BL005940
      JMAX1 = JMAX - 1                                                        BL005950
      JMAX2 = JMAX - 2                                                        BL005960
      KMAX1 = KMAX - 1                                                        BL005970
      ICAP = CAPTH                                                            BL005980
      CPTHM = 1. - CAPTH                                                      BL005990
      CPTHP = 1. + CAPTH                                                      BL006000
      CPTH2 = 2. - CAPTH                                                      BL006010
      JTST = JMAX/2 + 1                                                       BL006020
C                                                                             BL006030
      XTST = .1                                                               BL006040
      RWRTX(1) = 0.0                                                          BL006050
      XOLD(1) = -DPSI                                                         BL006060
      ROLD(1) = 0.0                                                           BL006070
      S(1) = 0.0                                                              BL006080
      X(1) = -DPSI                                                            BL006090
      PSI = -DPSI                                                             BL006100
      PSIO = PSI                                                              BL006110
      XWRTR(1) = 0.0                                                          BL006120
      DO 10 J=1,JMAX1                                                         BL006130
      DN2(J) = DN(J) * DN(J)                                                  BL006140
10    CONTINUE                                                                BL006150
      F(1,1) = 0.0                                                            BL006160
      G(1,1) = 0.0                                                            BL006170
      FGINCR = 1./JMAX1                                                       BL006180
      F(JMAX,1) = 1.0                                                         BL006190
      G(JMAX,1) = 1.0                                                         BL006200
      DO 20 J=2,JMAX1                                                         BL006210
      F(J,1) = F(J-1,1) + FGINCR*F(JMAX,1)                                    BL006220
      G(J,1) = G(J-1,1) + FGINCR*G(JMAX,1)                                    BL006230
20    CONTINUE                                                                BL006240
      PHI(1) = 0.0                                                            BL006250
      DPHI(1) = PI2*DW(1)                                                     BL006260
      COSAL = DCOS(ALP)                                                       BL006270
      SINAL = DSIN(ALP)                                                       BL006280
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      DO 30 K=2,KMAX1                                                   BL006290
      DPHI(K) = PI2 * DW(K)                                             BL006300
      PHI(K) = PHI(K-1) + DPHI(K-1)                                     BL006310
30    CONTINUE                                                          BL006320
      PHI(KMAX) = PHI(KMAX1) + DPHI(KMAX1)                              BL006330
      DO 40 K=1,KMAX                                                    BL006340
      SINPH(K) = DSIN(PHI(K))                                           BL006350
      COSPH(K) = DCOS(PHI(K))                                           BL006360
      HW(K) = 0.0                                                       BL006370
      SOLD(K) = 0.0                                                     BL006380
      R(K) = 0.0                                                        BL006390
      FO(1,K) = 0.0                                                     BL006400
      GO(1,K) = 0.0                                                     BL006410
      FO(JMAX,K) = 1.0                                                  BL006420
      GO(JMAX,K) = 1.0                                                  BL006430
40    CONTINUE                                                          BL006440
C**       COEFFICIENTS FOR SEVERAL GEOMETRIES ARE DEFINED.              BL006450
      IF (A.LT.1.E+06)  GO TO 60                                        BL006460
50    CONTINUE                                                          BL006470
      IA = 2                                                            BL006480
      GO TO 70                                                          BL006490
60    CONTINUE                                                          BL006500
      IA = 1                                                            BL006510
70    CONTINUE                                                          BL006520
      IF (IA.EQ.2)  GO TO 110                                           BL006530
80    CONTINUE                                                          BL006540
      IF (A.NE.RB) GO TO 100                                            BL006550
C*****  SPHERE                                                          BL006560
90    CONTINUE                                                          BL006570
      AO = 2. / 3.                                                      BL006580
      BO = AO                                                           BL006590
      CO = BO                                                           BL006600
      GO TO 130                                                         BL006610
C*****  ELLIPSOID OF REVOLUTION                                         BL006620
100   CONTINUE                                                          BL006630
      E = DSQRT(1.-RB/A)                                                BL006640
      AO = 2.*(1.-E*E)/(E**3.)*(.5*DLOG((1.+E)/(1.-E)) - E)             BL006650
      BO = 1./(E*E) - (1.-E*E) / (2.*E**3.)*DLOG((1.+E)/(1.-E))         BL006660
      CO = BO                                                           BL006670
      GO TO 130                                                         BL006680
110   CONTINUE                                                          BL006690
      IF (RB.EQ.RC) GO TO 120                                           BL006700
C*****  ELLIPTIC PARABOLOID                                             BL006710
      Q = DSQRT(RC/RB)                                                  BL006720
      AO = 0.0                                                          BL006730
      BO = 2.*Q / (1. + Q)                                              BL006740
      CO = 2./(1. + Q)                                                  BL006750
      GO TO 130                                                         BL006760
C*****  PARABOLOID OF REVOLUTION                                        BL006770
120   CONTINUE                                                          BL006780
      AO = 0.0                                                          BL006790
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      BO = 1.0                                                          BL006800
      CO = BO                                                           BL006810
  130 CONTINUE                                                          BL006820
      P = (2.-AO) / (2.-BO) * DTAN(ALP)                                 BL006830
      CU    = UINF * COSAL                                              BL006840
      CV    = -UINF * SINAL                                             BL006850
      CW = 0.0                                                          BL006860
      S1 = 2.*UINF*COSAL*DSQRT(1.+RB*P*P/A) / (RC*(2.-AO))              BL006870
      SO = S1 *(RC/RB) * (1.+RB*P*P/A) / (1.+P*P)                       BL006880
      GO TO (140,150), IA                                               BL006890
  140 CONTINUE                                                          BL006900
      SQ = DSQRT(1. + RB*P*P/A)                                         BL006910
      XO = A * (1. - 1./SQ)                                             BL006920
      YO = RB*P/SQ                                                      BL006930
      GO TO 160                                                         BL006940
  150 CONTINUE                                                          BL006950
      XO = RB * .5*P*P                                                  BL006960
      YO = RB*P                                                         BL006970
  160 CONTINUE                                                          BL006980
      SINTHB = 1. / DSQRT(1.+P*P)                                       BL006990
      SNTHB2 = SINTHB*SINTHB                                            BL007000
      PIH = PI2 * SINTHB                                                BL007010
      ALPHA(1) = 0.0                                                    BL007020
      ALBET2 = 0.0                                                      BL007030
      ALBET3 = -(1.-S1/SO)                                              BL007040
      ALP1 = ALP/.0174533                                               BL007050
C                                                                       BL007060
C**       PRINT OUT INPUT                                               BL007070
C                                                                       BL007080
      WRITE (IOUT,9910) JMAX,PSIMAX,A,XO,KMAX,DPSI,SO,YO,LITER,         BL007090
     1     EPS,S1,CKA,IPRT,UINF,CAPTH,CKC,KPRT,ALP1,RB,E,IBEXT,RC,CRI   BL007100
      WRITE(IOUT,9920)                                                  BL007110
      DO 170 K=1,KMAX1                                                  BL007120
      WRITE (IOUT,9930) K, DW(K)                                        BL007130
  170 CONTINUE                                                          BL007140
      WRITE(IOUT,9940)                                                  BL007150
      DO 180 J=1,JMAX1                                                  BL007160
      DNSUM(J+1) = DNSUM(J) + DN(J)                                     BL007170
      WRITE(IOUT,9950) J, DN(J), DNSUM(J+1)                             BL007180
  180 CONTINUE                                                          BL007190
      IF(IBEXT.EQ.0) GO TO 190                                          BL007200
      CALL BODYG                                                        BL007210
  190 RETURN                                                            BL007220
C                                                                       BL007230
 9910 FORMAT (1H0,14X'JMAX = ',I5,9X'PSIMAX = ',E11.4,9X'A = ',E11.4,8X,BL007240
     1             'XO = ',E11.4/                                       BL007250
     2          15X'KMAX = ',I5,11X'DPSI = ',E11.4,8X'SO = ',E11.4,8X,  BL007260
     3             'YO = ',E11.4/                                       BL007270
     4       14X'LITER = ',I5,12X',EPS = ',E11.4,8X'S1 = ',E11.4,8X,    BL007280
     5             'KA = ',E11.4/                                       BL007290
     6          15X',IPRT = ',I5,11X'UINF = ',E11.4,5X'CAPTH = ',E11.4BL007300
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     7           ,8X,'KC = ',E11.4/                                                    BL007310
     8            15X'KPRT = ',I5,10X'ALPHA = ',E11.4,8X'RB = ',F11.4,9X              BL007320
     9                ,',E = ',E11.4/                                                  BL007330
     1            32X,'IBEXT = ',I5,19X,'RC = ',E11.4,7X'CRI = ',E11.4)               BL007340
 9920 FORMAT (1HO// 14X'DW')                                                          BL007350
 9930 FORMAT (2X,I3,4X,E11.4)                                                         BL007360
 9940 FORMAT (1HO//4X,'J',9X,'DN',9X,'ETA')                                           BL007370
 9950 FORMAT (2X,I3,4X,E11.4,4X,E11.4)                                                BL007380
      END                                                                             BL007390


      DOUBLE PRECISION FUNCTION RELLIP (COSP,SINP,K)                                  BL007400
C                                                                                     BL007410
CCC       RELATIONSHIP FOR DEFINING THE COORDINATE R.                                 BL007420
C                                                                                     BL007430
      IMPLICIT REAL*8 (A-H,O-Z)                                                       BL007440
      COMMON /C01/   A          ,  EPS        ,  JMAX       ,  JMAX1      ,         BL007450
     1              JMAX2      ,  KMAX       ,  KMAX1,JK   ,  PI         ,         BL007460
     2              PSIMAX     ,  SO         ,  S1         ,  UINF       ,         BL007470
     3              WINF       ,  XO         ,  YO                                 BL007480
      COMMON /C02/   ALPHA(100),  DN(50)     ,  DN2(50)    ,  R(100)     ,         BL007490
     1              RWRTX(100),  S(100)     ,  W(100)     ,  X(100)               BL007500
      COMMON/C023/   AO         ,  BO         ,  CO         ,  P          ,         BL007510
     1              RB         ,  RC                                               BL007520
      COMMON/C030/   IA, JK2    ,  OTA        ,  PRX        ,  PRXOR      ,         BL007530
     1              XPOVA                                                           BL007540
      COMMON /EXT/ IBEXT                                                           BL007550
      DIMENSION ZSLO(2)                                                            BL007560
      OTA = COSP*COSP + RB/RC*SINP*SINP                                            BL007570
      IF(IBEXT.EQ.1) GO TO 10                                                      BL007580
      RELLIP=(-YO*COSP+DSQRT((DABS(YO*COSP))**2.-OTA*(YO*YO-(X(K)+XO)              BL007590
     1   *RB*(2.-XPOVA))))/OTA                                                     BL007600
      GO TO 20                                                                     BL007610
   10 TANP=SINP/COSP                                                               BL007620
      PH1=DATAN(TANP)                                                              BL007630
      XX=X(K)                                                                      BL007640
      ZSLO(1)=PH1                                                                  BL007650
      CALL SLOALL(XX,ZSLO,1,12,2,0,0,3,0)                                          BL007660
      RELLIP=ZSLO(2)                                                               BL007670
   20 RETURN                                                                       BL007680
      END                                                                          BL007690


      SUBROUTINE UXYZ (Y,Z,XPOVA)                                                  BL007700
C                                                                                  BL007710
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CCC       UXYZ COMPUTES THE VELOCITY COMPONENTS IN THE RECTANGULAR       BL007720
CCC     COORDINATE DIRECTIONS.                                          BL007730
CCC        ** ARGUMENTS **                                              BL007740
CCC             Y - Y-COORDINATE.                                       BL007750
CCC             Z - Z-COORDINATE.                                       BL007760
CCC         XPOVA - XPRIME/A.                                           BL007770
C                                                                       BL007780
      IMPLICIT REAL*8 (A-H,O-Z)                                         BL007790
      COMMON /CO1/   A          ,  EPS        ,  JMAX       ,  JMAX1    ,BL007800
     1               JMAX2      ,  KMAX       ,  KMAX1,JK   ,  PI       ,BL007810
     2               PSIMAX     ,  SO         ,  S1         ,  UINF     ,BL007820
     3               WINF       ,  XO         ,  YO                     BL007830
      COMMON /CO2/   ALPHA(100),  DN(50)     ,  DN2(50)    ,  R(100)   ,BL007840
     1               RWRTX(100),  S(100)     ,  W(100)     ,  X(100)   ,BL007850
      COMMON/CO23/   AO         ,  BO         ,  CO         ,  P        ,BL007860
     1               RB         ,  RC                                   BL007870
      COMMON/CO31/   UXP        ,  UYP        ,  UZP                    BL007880
      COMMON/CO32/   CU         ,  CV         ,  CW                     BL007890
      COMMON /CO4/ ALP,COSPH(100),DPHI(100),DPSI,DW(100),PHI(100),PSI,  BL007900
     1               PSID,SINPH(100),SINTHB                             BL007910
      COMMON /CO50/ K                                                   BL007920
      COMMON /EXT/ IBEXT                                                BL007930
      DIMENSION ZSLO(9)                                                 BL007940
      IF(IBEXT.EQ.1) GO TO 10                                           BL007950
      UAO = 2.*CU/(2.-AO)                                               BL007960
      VAO = 2.*CV/(2.-BO)                                               BL007970
      WAO = 2.*CW/(2.-CO)                                               BL007980
      XPA1 = XPOVA - 1.                                                 BL007990
      YPORB = (Y + YO) / RB                                             BL008000
      ZPORC = Z/RC                                                      BL008010
      XP2 = XPA1*XPA1                                                   BL008020
      YP2 = YPORB*YPORB                                                 BL008030
      ZP2 = ZPORC*ZPORC                                                 BL008040
      A2P2 = XP2 + YP2 + ZP2                                            BL008050
      UXP = (UAO*(A2P2-XP2) - VAO*XPA1*YPORB - WAO*XPA1*ZPORC) / A2P2   BL008060
      UYP = (VAO*(A2P2-YP2) - UAO*XPA1*YPORB - WAO*YPORB*ZPORC) / A2P2  BL008070
      UZP = (WAO*(A2P2-ZP2) - UAO*XPA1*ZPORC - VAO*YPORB*ZPORC) / A2P2  BL008080
      GO TO 20                                                          BL008090
C                                                                       BL008100
   10 NERR=0                                                            BL008110
      IF(PSI.LT.0.1001D0 .AND. PSI.GT.0.0990D0) NERR=1                  BL008120
      IF(PSI.LT.0.2001D0 .AND. PSI.GT.0.1990D0) NERR=1                  BL008130
      IF(PSI.LT.0.3001D0 .AND. PSI.GT.0.2990D0) NERR=1                  BL008140
      PI=DARCOS(-1.0D0)                                                 BL008150
      RAD=PI/180.0D0                                                    BL008160
      RB2=Y*Y + Z*Z                                                     BL008170
      YO2=YO*YO                                                         BL008180
      RBP2=RB2 + 2.0D0*YO*Y + YO2                                       BL008190
      RBP=DSQRT(RBP2)                                                   BL008200
      YP=Y+YO                                                           BL008210
      YBRP=YP/RBP                                                       BL008220
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      PHIP=DARCOS(YBRP)                                                  BL008230
      PHID=PHIP/RAD                                                      BL008240
      IF(NERR.EQ.1) WRITE(8,11) XPOVA,PHID,PSI,PHI(K+1)                  BL008250
      ZSLO(1)=PHIP                                                       BL008260
      CALL SLOALL(XPOVA,ZSLO,1,10,4,0,0,4,NERR)                          BL008270
      UXP=ZSLO(2)*UINF                                                   BL008280
      UYP=ZSLO(3)*UINF                                                   BL008290
      UZP=ZSLO(4)*UINF                                                   BL008300
      IF(NERR.EQ.1) WRITE(8,12) UXP,UYP,UZP                              BL008310
   20 RETURN                                                             BL008320
   12 FORMAT(10X,3E15.6)                                                 BL008330
   11 FORMAT(/10X,4E15.6)                                                BL008340
      END                                                                BL008350
```

```
      SUBROUTINE GEOM                                                     1
C                                                                         2
CC       GEOM SETS UP THE PARAMETERS AND CALLS FOR SOLVING THE VARI       3
CC    EQUATIONS.  IN DOING THIS A STEP IS TAKEN ALONG THE BODY            4
CC    (THE PSI-DIRECTION) AND SOLUTIONS FOR ALL PHI AT THIS LOCATIO       5
CC    ARE FOUND.                                                          6
C                                                                         7
      IMPLICIT REAL*8 (A-H,O-Z)                                           8
       REAL*8 KAPPAS, KAPPAW                                              9
      COMMON /CO1/ A,EPS,JMAX,JMAX1,JMAX2,KMAX,KMAX1,JK,PI,PSIMAX,SO,S1,  10
     1UINF,WINF,XO,YO                                                     11
      COMMON /CO2/ ALPHA(100),DN(50),DN2(50),R(100),RWRTX(100),S(100),W(  12
     1100),X(100)                                                         13
      COMMON /CO3/ F(50,100),FO(50,100),G(50,100),GO(50,100),UE(100),UEO  14
     1(100),V(50,100),WE(100),WEO(100)                                    15
      COMMON /CO4/ ALP,COSPH(100),DPHI(100),DPSI,DW(100),PHI(100),PSI,PS  16
     1IO,SINPH(100),SINTHB                                                17
      COMMON /CO5/ HPSI(100),HW(100),HWO(100)                             18
      COMMON /CO6/ ALBET2,ALBET3,ALP2,BETA1,BETA2,BETA3,BETA4,KAPPAS,KAP  19
     1PAW                                                                 20
      COMMON /CO7/ ALPHO(50),ALPH1(50),ALPH2(50),ALPH3(50),ALPH4(50),ALP  21
     1H5(50),ALPH6(50)                                                    22
      COMMON /CO10/ LITER,JK1,PI2,SNTHB2                                  23
      COMMON /CO11/ PIH                                                   24
      COMMON /CO12/ H,HH,WE1                                              25
      COMMON /CO14/ COSPH2,DW2,PRXS,PRXORS,R2,SINPH2,XPOVAS,X2            26
      COMMON /CO15/ ROLD(100),SOLD(100),THB(100),XOLD(100),XWRTR(100)     27
      COMMON /CO16/ ANGAL,A3,B3,C3,DFDN1,DGDN1,GAMMA(50),TSS              28
      COMMON /CO17/ IPRT,KPRT                                             29
      COMMON /CO22/ ANGLE(50)                                             30
      COMMON /CO24/ GPR,PHIPR,RP,UPHP,USP,XP                              31
      COMMON /CO26/ XIKA,AL3T                                             32
      COMMON /CO27/ GOSAV(50),GSAV(50)                                    33
```

AD-A051 971 VIRGINIA POLYTECHNIC INST AND STATE UNIV BLACKSBURG --ETC F/G 20/4
THREE-DIMENSIONAL INCOMPRESSIBLE BOUNDARY LAYERS ON BLUNT BODIE--ETC(U)
MAY 77 D L DWOYER, C H LEWIS, P R GOGINENI

UNCLASSIFIED VPI/SU-AERO-063-PT-2 NL

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```
      COMMON /C030/ IA,JK2,OTA,PRX,PRXOR,XPOVA                          34
      COMMON /C034/ ICON,JTST,NIT                                       35
      COMMON /C035/ FTST,FTSTL,GTST,GTSTL,VTST,VTSTL                    36
      COMMON /C036/ ICAP                                                37
      COMMON /C037/ FNSAV(50),GNSAV(50)                                 38
      COMMON /C041/ CRI,KHALF                                           39
      COMMON /C043/ DRDSI,XTST                                          40
      ITER=0                                                            41
      PSIDIF=DPSI-PSIMAX                                                42
      W(1)=0.0D0                                                        43
      DS=0.0D0                                                          44
      IP=0                                                              45
      NPRT=0                                                            46
      NPRT=IPRT-1                                                       47
      S(1)=-DS                                                          48
   10 CONTINUE                                                          49
      NIT=1                                                             50
      K=0                                                               51
      ROLD(1)=R(1)                                                      52
      XOLD(1)=X(1)                                                      53
      SOLD(1)=S(1)                                                      54
      PSI=PSI+DPSI                                                      55
      S(1)=PSI                                                          56
      IF (PSI.GT.PSIMAX) GO TO 440                                      57
      IP=IP+1                                                           58
      NPRT=NPRT+1                                                       59
      IF (IP.EQ.1) GO TO 30                                             60
      IF (X(1).GE.XTST) GO TO 20                                        61
C                                                                       62
C     FIND COORDINATES IN THE PLANE OF SYMMETRY.                        63
C                                                                       64
      CALL COORD (R,X,XWRTR,ROLD,XOLD,2,K,DS)                           65
      GO TO 40                                                          66
   20 CONTINUE                                                          67
      CALL COORD (X,R,RWRTX,XOLD,ROLD,1,K,DS)                           68
      GO TO 40                                                          69
   30 CONTINUE                                                          70
      R(1)=0.0D0                                                        71
      X(1)=0.0D0                                                        72
      HPSI(1)=1.0D0                                                     73
   40 CONTINUE                                                          74
      IF (ITER.NE.0) GO TO 70                                           75
      CALL CALCV (1,0)                                                  76
      DO 50 J=1,JMAX                                                    77
      GAMMA(J)=0.0D0                                                    78
   50 CONTINUE                                                          79
      PRINT 450                                                         80
      DO 60 J=1,JMAX                                                    81
      PRINT 460, J,F(J,1),G(J,1),V(J,1),ANGLE(J),GAMMA(J)               82
   60 CONTINUE                                                          83
   70 CONTINUE                                                          84
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      IF (IP.NE.1) GO TO 80                                              85
      CALL PARVAL (0,IP)                                                 86
C                                                                        87
CC    FIND INITIAL PROFILE SOLUTION FOR F,G, AND V.                      88
C                                                                        89
80    CONTINUE                                                           90
      DO 90 J=1,JMAX                                                     91
      FNSAV(J)=F(J,1)                                                    92
      GNSAV(J)=G(J,1)                                                    93
90    CONTINUE                                                           94
      ITER=ITER+1                                                        95
      IF (IP.NE.1) GO TO 100                                             96
      ICON=0                                                             97
      CALL PSIMOM (IP,0)                                                 98
      CALL OMEMOM (IP,0)                                                 99
      ICON=1                                                            100
      CALL PSIMOM (IP,0)                                                101
      CALL OMEMOM (IP,0)                                                102
      IF (ITER.LE.LITER) PRINT 470, ITER                                103
      IF (ITER.EQ.LITER) PRINT 480                                      104
      CALL PRTPRO (1,0)                                                 105
100   CONTINUE                                                          106
      IF (ITER.LT.LITER) GO TO 80                                       107
      DS=0.0D0                                                          108
      DRDSI=(R(1)-ROLD(1))/DPSI                                         109
      DO 430 K=1,KMAX                                                   110
      OMEGA=PHI(K)/PI2                                                  111
      IF ((IP.NE.1).OR.(K.EQ.1)) GO TO 120                              112
      DO 110 J=1,JMAX                                                   113
      F(J,K)=F(J,K-1)                                                   114
      G(J,K)=G(J,K-1)                                                   115
      V(J,K)=V(J,K-1)                                                   116
110   CONTINUE                                                          117
120   CONTINUE                                                          118
      ICON=0                                                            119
      NIT=1                                                             120
      KS=K-1+ICAP                                                       121
      IF (KS.EQ.0) KS=KS+1                                              122
      KM1=K-1                                                           123
      MPRT=MPRT+1                                                       124
      IF (K.NE.KMAX) GO TO 230                                          125
C                                                                       126
CC    FIND F,G, AND V IN THE 180 DEGREE PLANE.                          127
C                                                                       128
130   CONTINUE                                                          129
      DO 140 J=1,JMAX                                                   130
      FNSAV(J)=F(J,KMAX)                                                131
      GNSAV(J)=G(J,KMAX)                                                132
C                                                                       133
CC    FIND AVERAGE F AND G VALUES.                                      134
C                                                                       135
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140   CONTINUE                                                          136
      IF (IP.EQ.1) GO TO 160                                            137
      IF (NIT.EQ.1) GO TO 180                                           138
      DO 150 J=1,JMAX                                                   139
      F(J,KMAX)=0.5D0*(F(J,KMAX)+FO(J,KS))                              140
      G(J,KMAX)=0.5D0*(G(J,KMAX)+GO(J,KS))                              141
150   CONTINUE                                                          142
      GO TO 180                                                         143
160   CONTINUE                                                          144
      DO 170 J=1,JMAX                                                   145
      F(J,KMAX)=0.5D0*(F(J,KMAX)+F(J,KMAX1))                            146
      G(J,KMAX)=0.5D0*(G(J,KMAX)+G(J,KMAX1))                            147
170   CONTINUE                                                          148
180   CONTINUE                                                          149
      IF (NIT.NE.1) GO TO 190                                           150
      CALL PARVAL (KMAX1,IP)                                            151
190   CONTINUE                                                          152
      IF (CRI.EQ.1.) GO TO 200                                          153
      IF (IP.NE.1) GO TO 200                                            154
      CALL SYMM (KMAX)                                                  155
      ICON=1                                                            156
      GO TO 210                                                         157
200   CONTINUE                                                          158
      CALL PSIMOM (IP,KMAX1)                                            159
      CALL OMEMOM (IP,KMAX1)                                            160
      FTST1=F(JTST,KMAX)                                                161
      GTST1=G(JTST,KMAX)                                                162
      VTST1=V(JTST,KMAX)                                                163
      IF (NIT.EQ.1) GO TO 220                                           164
      CALL CONV                                                         165
      ICON=1                                                            166
      IF (ICON.NE.1) GO TO 220                                          167
210   CONTINUE                                                          168
      CALL PSIMOM (IP,KMAX1)                                            169
      CALL OMEMOM (IP,KMAX1)                                            170
      ICON=0                                                            171
      GO TO 410                                                         172
220   CONTINUE                                                          173
      NIT=NIT+1                                                         174
      FTST=FTST1                                                        175
      GTST=GTST1                                                        176
      VTST=VTST1                                                        177
      GO TO 130                                                         178
C                                                                       179
C     FIND SOLUTION FOR PHI LESS THAN 180 DEGREES.                      180
C                                                                       181
230   CONTINUE                                                          182
      ROLD(K+1)=R(K+1)                                                  183
      XOLD(K+1)=X(K+1)                                                  184
      IF (IP.EQ.1) GO TO 250                                            185
C                                                                       186
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C     CALCULATE THE COORDINATES AT A STEP AHEAD OF LOCATION WHERE                187
C     F,G, AND V SOLUTIONS ARE DESIRED.                                          188
C                                                                                189
      XPOVAS=XPOVA                                                               190
      PRXS=PRX                                                                   191
      PRXORS=PRXOR                                                               192
      IF (X(K+1).GE.XTST) GO TO 240                                              193
      CALL COORD (R,X,XWRTR,ROLD,XOLD,2,K,DS)                                    194
      GO TO 260                                                                  195
240   CONTINUE                                                                   196
      CALL COORD (X,R,RWRTX,XOLD,ROLD,1,K,DS)                                    197
      GO TO 260                                                                  198
250   CONTINUE                                                                   199
      R(K+1)=0.0D0                                                               200
      X(K+1)=0.0D0                                                               201
      HPSI(K+1)=0.0D0                                                            202
260   CONTINUE                                                                   203
      S(K+1)=SOLD(K+1)+DS                                                        204
      IF ((IP.EQ.1).AND.(K.EQ.1)) GO TO 390                                      205
      R2=R(K+1)                                                                  206
      X2=X(K+1)                                                                  207
      DW2=DW(K+1)                                                                208
      COSPH2=COSPH(K+1)                                                          209
      SINPH2=SINPH(K+1)                                                          210
270   CONTINUE                                                                   211
      DO 280 J=1,JMAX                                                            212
      FNSAV(J)=F(J,K)                                                            213
      GNSAV(J)=G(J,K)                                                            214
      IF ((K.EQ.1).AND.(NIT.EQ.1)) GNSAV(J)=GSAV(J)                              215
280   CONTINUE                                                                   216
C                                                                                217
C     FIND AVERAGE F AND G VALUES.                                               218
C                                                                                219
      IF (IP.EQ.1) GO TO 320                                                     220
      IF (K.EQ.1) GO TO 290                                                      221
      IF (NIT.EQ.1) GO TO 340                                                    222
290   CONTINUE                                                                   223
      DO 310 J=1,JMAX                                                            224
      IF ((K.EQ.1).AND.(NIT.EQ.1)) GO TO 300                                     225
      F(J,K)=0.0D0                                                               226
      FO(J,KS)=0.0D0                                                             227
      G(J,K)=0.0D0                                                               228
      GO(J,KS)=0.0D0                                                             229
      F(J,K)=0.5D0*(F(J,K)+FO(J,KS))                                             230
      G(J,K)=0.5D0*(G(J,K)+GO(J,KS))                                             231
      GO TO 310                                                                  232
300   CONTINUE                                                                   233
      G(J,K)=GSAV(J)                                                             234
310   CONTINUE                                                                   235
      GO TO 340                                                                  236
320   CONTINUE                                                                   237
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      DO 330 J=1,JMAX                                                    238
      F(J,K)=0.5D0*(F(J,K)+F(J,K-1))                                     239
      G(J,K)=0.5D0*(G(J,K)+G(J,K-1))                                     240
330   CONTINUE                                                           241
340   CONTINUE                                                           242
      IF (NIT.NE.1) GO TO 350                                            243
      CALL PARVAL (KM1,IP)                                               244
350   CONTINUE                                                           245
      IF (CRI.EQ.1.0D0) GO TO 360                                        246
      IF ((IP.NE.1).OR.(OMEGA.LE.0.25D0)) GO TO 360                      247
      CALL SYMM (K)                                                      248
      ICON=1                                                             249
      GO TO 370                                                          250
360   CONTINUE                                                           251
      CALL PSIMOM (IP,KM1)                                               252
      CALL OMEMOM (IP,KM1)                                               253
      FTST1=F(JTST,K)                                                    254
      GTST1=G(JTST,K)                                                    255
      VTST1=V(JTST,K)                                                    256
      IF (NIT.EQ.1) GO TO 380                                            257
      CALL CONV                                                          258
      ICON=1                                                             259
      IF (ICON.NE.1) GO TO 380                                           260
370   CONTINUE                                                           261
      CALL PSIMOM (IP,KM1)                                               262
      CALL OMEMOM (IP,KM1)                                               263
      ICON=0                                                             264
      GO TO 390                                                          265
380   CONTINUE                                                           266
      FTST=FTST1                                                         267
      GTST=GTST1                                                         268
      VTST=VTST1                                                         269
      NIT=NIT+1                                                          270
      GO TO 270                                                          271
390   CONTINUE                                                           272
      IF (KM1.NE.0) GO TO 410                                            273
      PSIDIF=PSI+DPSI-PSIMAX                                             274
      IF ((NPRT.NE.IPRT).AND.(PSIDIF.LE.0.001D0)) GO TO 400              275
      MPRT=0                                                             276
      CALL PRTPRO (2,0)                                                  277
400   CONTINUE                                                           278
      GO TO 420                                                          279
410   CONTINUE                                                           280
      IF ((MPRT.NE.KPRT).AND.(K.NE.KMAX)) GO TO 420                      281
      MPRT=0                                                             282
      IF ((NPRT.NE.IPRT).AND.(PSIDIF.LE.0.001D0)) GO TO 420              283
      CALL PRTPRO (3,KM1)                                                284
420   CONTINUE                                                           285
      IF (K.EQ.KMAX) GO TO 430                                           286
      XOLD(K+1)=X(K+1)                                                   287
      DRDSI=(R(K+1)-ROLD(K+1))/DPSI                                      288
```

```
      ROLD(K+1)=R(K+1)                                                    289
      SOLD(K+1)=S(K+1)                                                    290
C                                                                         291
C                                                                         292
430   CONTINUE                                                            293
      IF (NPRT.EQ.IPRT) NPRT=0                                            294
      PSIO=PSI                                                            295
C                                                                         296
CC    GO BACK TO 5 AND TAKE ANOTHER STEP IN THE PSI-DIRECTION.            297
C                                                                         298
      GO TO 10                                                            299
440   CONTINUE                                                            300
      RETURN                                                              301
C                                                                         302
C                                                                         303
450   FORMAT (1HO,11HITERATION 0//8X,1HJ,5X,1HF,12X,1HG,12X,1HV,10X,5HAL  304
     1PHA,10X,5HGAMMA)                                                    305
460   FORMAT (6X,I3,5(E11.4,2X),4(E9.2,2X))                               306
470   FORMAT (1H1,10HITERATION ,I3)                                       307
480   FORMAT (30X,15HINITIAL PROFILE)                                     308
      END                                                                 309
```

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```
      SUBROUTINE PRTPRO (LOC,K)                                   BLOO   1
C                                                                 BLOO   2
CC        SUBROUTINE PRTPRO CONTROLS PRINTING AS THE SOLUTION PROCEBLOO   3
CC        ** ARGUMENTS **                                         BLOO   4
CC             LOC - INDICATES LOCATION ON BODY WHERE PRINTING IS TBLOO   5
CC                   OCCUR.                                       BLOO   6
CC                   = 1, INITIAL PROFILE.                        BLOO   7
CC                   = 3, NOT INITIAL PROFILE.                    BLOO   8
CC               K - SUBSCRIPT IN THE PHI-DIRECTION.              BLOO   9
C                                                                 BLOO  10
      IMPLICIT REAL*8 (A-H,O-Z)                                   BLOO  11
       REAL*8 KAPPAS, KAPPAW                                      BLOO  12
      COMMON /CO1/ A,EPS,JMAX,JMAX1,JMAX2,KMAX,KMAX1,JK,PI,PSIMAX,SO,S1,BLOO  13
     1UINF,WINF,XO,YO                                             BLOO  14
      COMMON /CO2/ ALPHA(100),DN(50),DN2(50),R(100),RWRTX(100),S(100),W(BLOO  15
     1100),X(100)                                                 BLOO  16
      COMMON /CO3/ F(50,100),FO(50,100),G(50,100),GO(50,100),UE(100),UEOBLOO  17
     1(100),V(50,100),WE(100),WEO(100)                            BLOO  18
      COMMON /CO4/ ALP,COSPH(100),DPHI(100),DPSI,DW(100),PHI(100),PSI,PSBLOO  19
     1IO,SINPH(100),SINTHB                                        BLOO  20
      COMMON /CO5/ HPSI(100),HW(100),HWO(100)                     BLOO  21
      COMMON /CO6/ ALBET2,ALBET3,ALP2,BETA1,BETA2,BETA3,BETA4,KAPPAS,KAPBLOO  22
     1PAW                                                         BLOO  23
      COMMON /CO7/ ALPHO(50),ALPH1(50),ALPH2(50),ALPH3(50),ALPH4(50),ALPBLOO  24
     1H5(50),ALPH6(50)                                            BLOO  25
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      COMMON /C016/ ANGAL,A3,B3,C3,DFDN1,DGDN1,GAMMA(50),TSS                BL00  26
      COMMON /C022/ ANGLE(50)                                               BL00  27
      COMMON /C024/ GPR,PHIPR,RP,UPHP,USP,XP                                BL00  28
      COMMON /C026/ XIKA,AL3T                                               BL00  29
      COMMON /C031/ UXP,UYP,UZP                                             BL00  30
      COMMON /C034/ ICON,JTST,NIT                                           BL00  31
      COMMON /C044/ TSF                                                     BL00  32
      Y=R(K+1)*COSPH(K+1)                                                   BL00  33
      Z=R(K+1)*SINPH(K+1)                                                   BL00  34
      UINF2=UINF*UINF                                                       BL00  35
      PRCOF=1.0D0-(UE(K+1)**2+WE(K+1)**2)/UINF2                             BL00  36
      GO TO (10,30,30), LOC                                                 BL00  37
C                                                                           BL00  38
CCC                                                                         BL00  39
CCC   ***************************INITIAL PROFILE                           BL00  40
10    CONTINUE                                                              BL00  41
      WRITE (6,100) PSI,PHI(1),X(1),ALPHA(1),DFDN1,Y,ALBET3,DGDN1,Z,UE(1BL00  42
     1),WE(1),HPSI(1),R(1),HW(1),S(1),TSS,PRCOF                             BL00  43
      DO 20 J=1,JMAX                                                        BL00  44
      WRITE (6,110) J,F(J,1),G(J,1),V(J,1),ANGLE(J),GAMMA(J)                BL00  45
20    CONTINUE                                                              BL00  46
      WRITE (8,90) ALP                                                      BL00  47
      WRITE (8,60)                                                          BL00  48
      WRITE (25) ALP                                                        BL00  49
      GO TO 50                                                              BL00  50
C                                                                           BL00  51
CCC                                                                         BL00  52
CCC   ***************************GENERAL CASE                              BL00  53
30    CONTINUE                                                              BL00  54
C     WRITE (6,8000) XP, RP, PHIPR, GPR, USP, UPHP                          BL00  55
C     WRITE (6,8001)                                                        BL00  56
C     8001  FORMAT (1H1)                                                    BL00  57
C      FOLLOWING CARDS ARE TO BE USED FOR BLOTTNERS PRESSURE PATCH          BL00  58
C     IF(PSI .GT. 0.491D0 .AND. PSI .LT. 0.505D0) GO TO 31                  BL00  59
C     IF(PSI .GT. 0.591D0 .AND. PSI .LT. 0.605D0) GO TO 31                  BL00  60
C     IF(PSI .GT. 0.691D0 .AND. PSI. LT. 0.705D0) GO TO 31                  BL00  61
C     IF(PSI .GT. 0.791D0 .AND. PSI .LT. 0.805D0) GO TO 31                  BL00  62
C     GO TO 50                                                              BL00  63
C     31 IF(PHI(K+1) .LT. 2.2D0) GO TO 50                                   BL00  64
      KK=K                                                                  BL00  65
      IF (KK.EQ.0) KK=1                                                     BL00  66
      WRITE (6,120) PSI,PHI(K+1),X(K+1),ALPHA(K+1),BETA1,DFDN1,Y,ALBET2,BL00  67
     1BETA2,DGDN1,Z,ALBET3,BETA3,HPSI(K+1),XIKA,BETA4,HW(KK),R(K+1),UE(KBL00  68
     2+1),KAPPAS,S(K+1),WE(K+1),NIT,KAPPAW,TSS,TSF,ANGAL,PRCOF              BL00  69
C                                                                           BL00  70
      UEND=UE(K+1)/UINF                                                     BL00  71
      WEND=WE(K+1)/UINF                                                     BL00  72
      UXPND=UXP/UINF                                                        BL00  73
      UYPND=UYP/UINF                                                        BL00  74
      UZPND=UZP/UINF                                                        BL00  75
      WRITE (25) PSI,HPSI(K+1),HW(KK),R(K+1),S(K+1),UEND,WEND,X(K+1)        BL00  76
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```
      IF (K.EQ.1) WRITE (8,70)                                          BLOO  77
      WRITE (8,80) PSI,HPSI(K+1),HW(KK),R(K+1),S(K+1),UEND,WEND,UXPND,UYBLOO  78
     1PND,UZPND                                                         BLOO  79
C                                                                       BLOO  80
      IPP=0                                                             BLOO  81
      IF (IPP.EQ.0) GO TO 50                                            BLOO  82
      DO 40 J=1,JMAX                                                    BLOO  83
      WRITE (6,110) J,F(J,K+1),G(J,K+1),V(J,K+1),ANGLE(J),GAMMA(J),ALPH2BLOO  84
     1(J),ALPH3(J),ALPH4(J),ALPH5(J)                                    BLOO  85
40    CONTINUE                                                          BLOO  86
50    CONTINUE                                                          BLOO  87
      RETURN                                                            BLOO  88
C     9    8X'J',5X'F',12X'G',12X'V',10X'ALPHA',10X'GAMMA',5X'ALPHA2',  BLOO  89
C     1    5X'ALPHA3',5X'ALPHA4',5X'ALPHA5')                            BLOO  90
C                                                                       BLOO  91
60    FORMAT (//1X,3HPSI,10X,4HHPSI,9X,2HHW,11X,1HR,12X,1HS,12X,9HUPSI/UBLOO  92
     1INF,4X,7HUW/UINF,6X,7HUX/UINF,6X,7HUY/UINF,6X,7HUZ/UINF/)         BLOO  93
70    FORMAT (1H1)                                                      BLOO  94
80    FORMAT (1X,10E13.6)                                               BLOO  95
90    FORMAT (/10X,11HALPHA(RAD)=,E15.6/)                               BLOO  96
100   FORMAT (1HO,48X,8HAT XI  = ,E11.4,9H,  PHI = ,E11.4//17X,4HX = ,E11BLOO  97
     1.4,17X,8HALPHA = ,E11.4,16X,7HDFDN = ,E11.4/17X,4HY = ,E11.4,15X,1BLOO  98
     2OHA-BETA3 = ,E11.4,16X,7HDGDN = ,E11.4/17X,4HZ = ,E11.4,20X,5HUE =BLOO  99
     3 ,E11.4/52X,5HWE = ,E11.4,16X,7HHPSI = ,E11.4/17X,4HR = ,E11.4,50XBLOO 100
     4,9HHOMEGA = ,E11.4/17X,4HS = ,E11.4//30X,25HTOTAL  SHEAR  STRESS  BLOO 101
     5=  ,E11.4,10X,21HPRESSURE COEFFICIENT=,E11.4//8X,1HJ,5X,1HF,12X,1HBLOO 102
     6G,12X,1HV,10X,5HALPHA,10X,5HGAMMA)                                BLOO 103
110   FORMAT (6X,I3,5(E11.4,2X),4(E9.2,2X))                             BLOO 104
120   FORMAT (1HO,48X,8HAT XI = ,E11.4,9H,  PHI = ,E11.4//17X,4HX = ,E11BLOO 105
     1.4,9X,8HALPHA = ,E11.4,7X,8HBETA1 = ,E11.4,9X,7HDFDN = ,E11.4/17X,BLOO 106
     25HY =  ,E11.4,7X,10HA-BETA2 = ,E11.4,7X,8HBETA2 = ,E11.4,9X,7HDGDNBLOO 107
     3 = ,E11.4/17X,4HZ = ,E11.4,7X,10HA-BETA3 = ,E11.4,7X,8HBETA3 = ,E1BLOO 108
     41.4,9X,7HHPSI = ,E11.4/42X,7HXIKA = ,E11.4,7X,8HBETA4 = ,E11.4,7X,BLOO 109
     59HHOMEGA = ,E11.4/17X,4HR = ,E11.4,12X,5HUE = ,E11.4,33X,9HKAPPAS BLOO 110
     6= ,E11.4/17X,4HS = ,E11.4,12X,5HWE = ,E11.4,9X,6HNIT = ,I2,16X,9HKBLOO 111
     7APPAW = ,E11.4//30X,25HTOTAL  SHEAR  STRESS  =  ,E11.4,3X,25HTOTALBLOO 112
     8  SKIN  FRICTION  = ,E11.4/45X,10HANGLE  =  ,E11.4,10X,21HPRESSUREBLOO 113
     9 COEFFICIENT=,E11.4//)                                            BLOO 114
      END                                                               BLOO 115
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```
      SUBROUTINE BODYG                                                  BLOO   1
C           BODYG   TRANSFORMS BODY AXES TO STAGNATION POINT AXIS       BLOO   2
C                                                                       BLOO   3
      IMPLICIT REAL*8(A-H,O-Z)                                          BLOO   4
      COMMON /COI/ A,EPS,JMAX,JMAX1,JMAX2,KMAX,KMAX1,JK,PI,PSIMAX,SO,SI,BLOO   5
     1UINF,WINF,XO,YO                                                   BLOO   6
      DIMENSION ANYVA(130,5,19), XP(130), P(19), R(19), ADR(130), DRDX(1BLOO   7
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```
     130)                                                                    BL00   8
      CALL ERRSET (207,256,10,0,0,209)                                       BL00   9
C                                                                            BL00  10
      PI=DARCOS(-1.D0)                                                       BL00  11
      DO 10 I=1,150                                                          BL00  12
      READ (10,END=20) XP(I),KPL                                             BL00  13
      READ (10) ((ANYVA(I,K,J),J=1,KPL),K=1,5)                               BL00  14
10    CONTINUE                                                               BL00  15
20    NS=I-1                                                                 BL00  16
      DO 60 I=1,NS                                                           BL00  17
      XP(I)=XP(I)-XO                                                         BL00  18
      DO 30 J=1,KPL                                                          BL00  19
      PHP=ANYVA(I,1,J)                                                       BL00  20
      RPR=ANYVA(I,5,J)                                                       BL00  21
      CPHP=DCOS(PHP)                                                         BL00  22
      SPHP=DSIN(PHP)                                                         BL00  23
      Y=RPR*CPHP-YO                                                          BL00  24
      Z=RPR*SPHP                                                             BL00  25
      ZBY=Z/Y                                                                BL00  26
      P(J)=DATAN(ZBY)                                                        BL00  27
      IF (P(J).LT.0.D0) P(J)=P(J)+PI                                         BL00  28
      R(J)=DSQRT(Y*Y+Z*Z)                                                    BL00  29
30    CONTINUE                                                               BL00  30
      DO 50 J=1,KPL                                                          BL00  31
      PP=ANYVA(I,1,J)                                                        BL00  32
      JJ=0                                                                   BL00  33
40    JJ=JJ+1                                                                BL00  34
      IF (P(JJ).LT.PP) GO TO 40                                              BL00  35
      IF (JJ.LT.3) JJ=3                                                      BL00  36
      IF (JJ.GT.(KPL-1)) JJ=(KPL-1)                                          BL00  37
      J2=JJ-2                                                                BL00  38
      J1=JJ-1                                                                BL00  39
      JP=JJ+1                                                                BL00  40
      CALL INTER4 (PP,P(J2),P(J1),P(JJ),P(JP),R(J2),R(J1),R(JJ),R(JP),RRBL00  41
     1)                                                                      BL00  42
      WRITE (8,120) P(J2),P(J1),P(JJ),P(JP),R(J2),R(J1),R(JJ),R(JP)          BL00  43
      WRITE (8,130) I,J,JJ,PP,RR                                             BL00  44
      ANYVA(I,2,J)=RR                                                        BL00  45
50    CONTINUE                                                               BL00  46
      WRITE (12) XP(I),KPL                                                   BL00  47
      WRITE (12) ((ANYVA(I,K,J),J=1,KPL),K=1,2)                              BL00  48
      WRITE (6,90) I,XP(I),KPL                                               BL00  49
      WRITE (6,100) (J,ANYVA(I,1,J),ANYVA(I,2,J),J=1,KPL)                    BL00  50
60    CONTINUE                                                               BL00  51
      WRITE (6,110)                                                          BL00  52
      DO 80 J=1,KPL                                                          BL00  53
      DO 70 I=1,NS                                                           BL00  54
70    ADR(I)=ANYVA(I,2,J)                                                    BL00  55
      CALL DERIV5 (XP,ADR,NS,0,0,DRDX)                                       BL00  56
      WRITE (13) ANYVA(I,1,J),NS                                             BL00  57
      WRITE (13) (ANYVA(I,2,J),I=1,NS),(XP(I),I=1,NS),(DRDX(I),I=1,NS)       BL00  58
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      WRITE (6,90) J,ANYVA(1,1,J),NS                                    BL00  59
      WRITE (6,100) (I,ANYVA(I,2,J),XP(I),DRDX(I),I=1,NS)               BL00  60
80    CONTINUE                                                          BL00  61
      REWIND 12                                                         BL00  62
      REWIND 13                                                         BL00  63
      RETURN                                                            BL00  64
C                                                                       BL00  65
90    FORMAT (//1X,I3,6X,E15.6,5X,I3)                                   BL00  66
100   FORMAT (/1X,4(I3,2X,2E13.6))                                      BL00  67
110   FORMAT (//20X,8HUNIT  13//)                                       BL00  68
120   FORMAT (5E13.6,2X,5E13.6)                                         BL00  69
130   FORMAT (3I6,5X,5E15.6)                                            BL00  70
      END                                                               BL00  71



      SUBROUTINE DERIV5 (X,Y,NP,JP,IP,DYDX)                             BL00   1
      IMPLICIT REAL *8(A-H,O-Z)                                         BL00   2
C                                                                       BL00   3
      DIMENSION X(130), Y(130), DYDX(130)                               BL00   4
C                                                                       BL00   5
      DO 10 J=1,NP                                                      BL00   6
      K=J                                                               BL00   7
      IF (IP.EQ.1) K=JP                                                 BL00   8
      IF (K.LT.3) K=3                                                   BL00   9
      IF (K.GT.(NP-2)) K=NP-2                                           BL00  10
      XX=X(J)                                                           BL00  11
      XX1=X(K-2)                                                        BL00  12
      XX2=X(K-1)                                                        BL00  13
      XX3=X(K)                                                          BL00  14
      XX4=X(K+1)                                                        BL00  15
      XX5=X(K+2)                                                        BL00  16
      YY1=Y(K-2)                                                        BL00  17
      YY2=Y(K-1)                                                        BL00  18
      YY3=Y(K)                                                          BL00  19
      YY4=Y(K+1)                                                        BL00  20
      YY5=Y(K+2)                                                        BL00  21
      CALL FD5 (XX,XX1,XX2,XX3,XX4,XX5,YY1,YY2,YY3,YY4,YY5,DER)         BL00  22
      DYDX(J)=DER                                                       BL00  23
      IF (IP.EQ.1) GO TO 20                                             BL00  24
10    CONTINUE                                                          BL00  25
20    RETURN                                                            BL00  26
      END                                                               BL00  27



      SUBROUTINE FD5 (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,FX)               BL00   1
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      IMPLICIT REAL*8(A-H,O-Z)                                          BLOO   2
      A1=(X-X4)*(X-X5)*(2.DO*X-X2-X3)+(X-X2)*(X-X3)*(2.DO*X-X4-X5)      BLOO   3
      A2=(X-X4)*(X-X5)*(2.DO*X-X1-X3)+(X-X1)*(X-X3)*(2.DO*X-X4-X5)      BLOO   4
      A3=(X-X4)*(X-X5)*(2.DO*X-X1-X2)+(X-X1)*(X-X2)*(2.DO*X-X4-X5)      BLOO   5
      A4=(X-X3)*(X-X5)*(2.DO*X-X1-X2)+(X-X1)*(X-X2)*(2.DO*X-X3-X5)      BLOO   6
      A5=(X-X3)*(X-X4)*(2.DO*X-X1-X2)+(X-X1)*(X-X2)*(2.DO*X-X3-X4)      BLOO   7
      D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)                                BLOO   8
      D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)                                BLOO   9
      D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)                                BLOO  10
      D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)                                BLOO  11
      D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)                                BLOO  12
      C1=A1/D1                                                          BLOO  13
      C2=A2/D2                                                          BLOO  14
      C3=A3/D3                                                          BLOO  15
      C4=A4/D4                                                          BLOO  16
      C5=A5/D5                                                          BLOO  17
      FX=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5                                  BLOO  18
      RETURN                                                            BLOO  19
      END                                                               BLOO  20


      SUBROUTINE INTER4 (X,X1,X2,X3,X4,F1,F2,F3,F4,F)                   BLOO   1
      IMPLICIT REAL*8(A-H,O-Z)                                          BLOO   2
      A1=(X-X2)*(X-X3)*(X-X4)                                           BLOO   3
      A2=(X-X1)*(X-X3)*(X-X4)                                           BLOO   4
      A3=(X-X1)*(X-X2)*(X-X4)                                           BLOO   5
      A4=(X-X1)*(X-X2)*(X-X3)                                           BLOO   6
      D1=(X1-X2)*(X1-X3)*(X1-X4)                                        BLOO   7
      D2=(X2-X1)*(X2-X3)*(X2-X4)                                        BLOO   8
      D3=(X3-X1)*(X3-X2)*(X3-X4)                                        BLOO   9
      D4=(X4-X1)*(X4-X2)*(X4-X3)                                        BLOO  10
      C1=A1/D1                                                          BLOO  11
      C2=A2/D2                                                          BLOO  12
      C3=A3/D3                                                          BLOO  13
      C4=A4/D4                                                          BLOO  14
      F=C1*F1+C2*F2+C3*F3+C4*F4                                         BLOO  15
      RETURN                                                            BLOO  16
      END                                                               BLOO  17


      SUBROUTINE SLOALL (XX,Z,I1,IT,NV,MX,MZ,NOR,NPRT)                  BLOO   1
      IMPLICIT REAL*8(A-H,O-Z)                                          BLOO   2
C                                                                       BLOO   3
C     LATEST REVISION DONE ON 11/23/1976  BY  P.R. GOGINENI             BLOO   4
C                                                                       BLOO   5
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C                                                                       BL00   6
C     EACH CALL TO THE SUBROUTINE SLOW RETURNS A VALUE OF THE ARRAYS    BL00   7
C     Z(JJ) CORRESPONDING TO XX,Z(II).  THE VALUES ARE OBTAINED         BL00   8
C     BY DOUBLE INTERPOLATION FROM THE DATA READ FROM A TAPE            BL00   9
C                                                                       BL00  10
C      DESCRIPTION OF ARGUMENTS                                         BL00  11
C                                                                       BL00  12
C     XX,Z(II)  ARE THE INPUT VALUES ; II   IDENTIFIES THE ARRAY FROM THBL00  13
C           Z ARRAYS (NV) WRITTEN ON THE DATA TAPE                      BL00  14
C                                                                       BL00  15
C     IT          UNIT NO.(DATA TAPE)  FROM WHICH DATA HAS TO BE READ   BL00  16
C                                                                       BL00  17
C     NV          NO. OF ARRAYS WRITTEN ON DATA TAPE AS SECOND RECORD   BL00  18
C     MX=0        XX- VALUES MONOTONICALLY INCREASING                   BL00  19
C     MX=1        XX-   :         :       DECREASING                    BL00  20
C     MZ          SAME AS ABOVE  BUT FOR Z-VALUES                       BL00  21
C     NOR         ORDER OF THE LEGENDRE POLYNOMIAL TO BE USED           BL00  22
C           FOR INTERPOLATION; EX. NOR=2 (2ND ORDER) USES 3 POINTS      BL00  23
C                                                                       BL00  24
C     NPRT=1      DIAGNOSTIC PRINTOUT                                   BL00  25
C      =0    NO     :       :                                          BL00  26
C                                                                       BL00  27
C     NDUMMY=0                                                          BL00  28
C                                                                       BL00  29
C     FOR EACH  XX ,  DATA ON UNIT  IT,  IS AS SHOWN BELOW              BL00  30
C                                                                       BL00  31
C     FIRST RECORD:     XX,JJ                                           BL00  32
C     SECOND  :       1  Z(1), Z(2), . . .., Z(NV)                      BL00  33
C                     2  Z(1), Z(2), . . .; Z(NV)                       BL00  34
C                     .   .    .    . . .;  .                          BL00  35
C                     .   .    .    . . .;  .                          BL00  36
C                     JJ  Z(1), Z(2), . . .; Z(NV)                      BL00  37
C                                                                       BL00  38
C                                                                       BL00  39
      COMMON /COMIJK/ IJKEDG,IJK                                        BL00  40
      COMMON /COMSLO/ X(5),Y(5,5,120),Y2(5,120),XX1,JJ                  BL00  41
      DIMENSION Z(5)                                                    BL00  42
C                                                                       BL00  43
CC                                                                      BL00  44
      IF (NOR.LE.3) GO TO 10                                            BL00  45
      MMI=NOR-1                                                         BL00  46
      MMI1=2                                                            BL00  47
      NCI=2                                                             BL00  48
      NCI1=4                                                            BL00  49
      GO TO 20                                                          BL00  50
10    MMI=NOR                                                           BL00  51
      MMI1=1                                                            BL00  52
      NCI=1                                                             BL00  53
      NCI1=3                                                            BL00  54
      IF (NOR.EQ.3) NCI=2                                               BL00  55
20    NOR1=NOR+1                                                        BL00  56
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      NOR2=NOR+2                                                        BL00  57
      IF (NOR.EQ.3) NOR2=2*NOR                                          BL00  58
      IF (IJK.NE.301) XX1=10.0**20                                      BL00  59
      IF (IJK.NE.301) GO TO 50                                          BL00  60
      IF (MX.EQ.0) GO TO 30                                             BL00  61
      IF (XX.GT.X(NCI)) GO TO 50                                        BL00  62
      IF (XX.GE.X(NCI1)) GO TO 110                                      BL00  63
      GO TO 40                                                          BL00  64
30    IF (XX.LT.X(NCI)) GO TO 50                                        BL00  65
      IF (XX.LE.X(NCI1)) GO TO 110                                      BL00  66
40    BACKSPACE IT                                                      BL00  67
      BACKSPACE IT                                                      BL00  68
      GO TO 60                                                          BL00  69
50    REWIND IT                                                         BL00  70
      IJK=301                                                           BL00  71
60    READ (IT) X1,JJ                                                   BL00  72
      READ (IT)                                                         BL00  73
      IF (MX.EQ.0) GO TO 70                                             BL00  74
      IF (X1.GT.XX) GO TO 60                                            BL00  75
      GO TO 80                                                          BL00  76
70    IF (X1.LT.XX) GO TO 60                                            BL00  77
80    DO 90 K=1,NOR2                                                    BL00  78
      BACKSPACE IT                                                      BL00  79
90    CONTINUE                                                          BL00  80
      DO 100 K=1,NOR1                                                   BL00  81
      READ (IT) X(K),JJ                                                 BL00  82
      READ (IT) ((Y(K,I,L),L=1,JJ),I=1,NV)                              BL00  83
100   CONTINUE                                                          BL00  84
110   CONTINUE                                                          BL00  85
      IF (XX.EQ.XX1) GO TO 140                                          BL00  86
      DO 130 I=1,NV                                                     BL00  87
      DO 120 L=1,JJ                                                     BL00  88
      IF (NPRT.EQ.1) WRITE (11,240) (X(K),Y(K,I,L),K=1,NOR1)            BL00  89
      IF (NOR.EQ.2) CALL INTER3 (XX,X(1),X(2),X(3),Y(1,I,L),Y(2,I,L),Y(3BL00  90
     1,I,L),Y2(I,L))                                                    BL00  91
      IF (NOR.EQ.3) CALL INTER4 (XX,X(1),X(2),X(3),X(4),Y(1,I,L),Y(2,I,LBL00  92
     1),Y(3,I,L),Y(4,I,L),Y2(I,L))                                      BL00  93
      IF (NOR.EQ.4) CALL INTER5 (XX,X(1),X(2),X(3),X(4),X(5),Y(1,I,L),Y(BL00  94
     12,I,L),Y(3,I,L),Y(4,I,L),Y(5,I,L),Y2(I,L))                        BL00  95
      IF (NPRT.EQ.1) WRITE (11,250) XX,Y2(I,L)                          BL00  96
120   CONTINUE                                                          BL00  97
130   CONTINUE                                                          BL00  98
140   CONTINUE                                                          BL00  99
      MM=0                                                              BL00 100
150   MM=MM+1                                                           BL00 101
      IF (MZ.EQ.0) GO TO 160                                            BL00 102
      IF (Z(I1).LT.Y2(I1,MM)) GO TO 150                                 BL00 103
      GO TO 170                                                         BL00 104
160   IF (Z(I1).GT.Y2(I1,MM)) GO TO 150                                 BL00 105
170   IF (Y2(1,MM).LT.0.0D0) GO TO 220                                  BL00 106
      IF (MM.LT.MMI) MM=MMI                                             BL00 107
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      IF (MM.GT.(JJ-MM11)) MM=JJ-MM11                                   BL00 108
      MM1=MM-1                                                          BL00 109
      MM2=MM-2                                                          BL00 110
      MP1=MM+1                                                          BL00 111
      MP2=MM+2                                                          BL00 112
      IF (NPRT.EQ.0) GO TO 180                                          BL00 113
      IF (NOR.EQ.2) WRITE (11,260) Z(I1),(Y2(I1,MR),MR=MM1,MP1)         BL00 114
      IF (NOR.EQ.3) WRITE (11,260) Z(I1),(Y2(I1,MR),MR=MM2,MP1)         BL00 115
      IF (NOR.EQ.4) WRITE (11,260) Z(I1),(Y2(I1,MR),MR=MM2,MP2)         BL00 116
180   DO 230 J1=1,NV                                                    BL00 117
      IF (J1.EQ.I1) GO TO 230                                           BL00 118
      IF (NOR.EQ.3) GO TO 190                                           BL00 119
      IF (NOR.EQ.4) GO TO 200                                           BL00 120
      IF (NPRT.EQ.1) WRITE (11,270) J1,(Y2(J1,MR),MR=MM1,MP1)           BL00 121
      CALL INTER3 (Z(I1),Y2(I1,MM1),Y2(I1,MM),Y2(I1,MP1),Y2(J1,MM1),Y2(JBL00 122
     11,MM),Y2(J1,MP1),Z(J1))                                           BL00 123
      GO TO 210                                                         BL00 124
190   IF (NPRT.EQ.1) WRITE (11,270) J1,(Y2(J1,MR),MR=MM2,MP1)           BL00 125
      CALL INTER4 (Z(I1),Y2(I1,MM2),Y2(I1,MM1),Y2(I1,MM),Y2(I1,MP1),Y2(JBL00 126
     11,MM2),Y2(J1,MM1),Y2(J1,MM),Y2(J1,MP1),Z(J1))                     BL00 127
      GO TO 210                                                         BL00 128
200   IF (NPRT.EQ.1) WRITE (11,270) J1,(Y2(J1,MR),MR=MM2,MP2)           BL00 129
      CALL INTER5 (Z(I1),Y2(I1,MM2),Y2(I1,MM1),Y2(I1,MM),Y2(I1,MP1),Y2(IBL00 130
     11,MP2),Y2(J1,MM2),Y2(J1,MM1),Y2(J1,MM),Y2(J1,MP1),Y2(J1,MP2),Z(J1)BL00 131
     2)                                                                 BL00 132
210   IF (NPRT.EQ.1) WRITE (11,280) Z(I1),Z(J1),J1                      BL00 133
      XX1=XX                                                            BL00 134
      GO TO 230                                                         BL00 135
220   CONTINUE                                                          BL00 136
      Z(J1)=Y2(J1,MM)-(Y2(J1,MM)-Y2(J1,MM1))/(Y2(I1,MM)-Y2(I1,MM1))*(Y2(BL00 137
     1I1,MM)-Z(I1))                                                     BL00 138
      XX1=XX                                                            BL00 139
230   CONTINUE                                                          BL00 140
      RETURN                                                            BL00 141
C                                                                       BL00 142
240   FORMAT (1X,5(2E13.6))                                             BL00 143
250   FORMAT (10X,E15.6,15X,E15.6)                                      BL00 144
260   FORMAT (10X,E15.6,5X,5E15.6)                                      BL00 145
270   FORMAT (10X,I3,5X,5E15.6)                                         BL00 146
280   FORMAT (10X,E15.6,5X,E15.6,2X,I3)                                 BL00 147
      END                                                               BL00 148



      SUBROUTINE INTER5 (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,F)             BL00   1
      IMPLICIT REAL*8(A-H,O-Z)                                          BL00   2
C                                                                       BL00   3
C     SUBROUTINE INTER5 IS CALLED BY SUBROUTINES BLUNT1, BLUNT2, EDGE,  BL00   4
C     INIT, MACH, SLOW, WALL, ZRO, AND INTRP5.                          BL00   5
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```
C                                                                       BL00   6
C       SUBROUTINE INTER5 INTERPOLATES FOR THE VALUE F CORRESPONDING TO  BL00   7
C       POINT X USING 5 POINT LAGRANGIAN INTERPOLATION FORMULA.          BL00   8
C                                                                       BL00   9
C       ASSUMES X1 .LE. X .LE. X5.                                      BL00  10
C                                                                       BL00  11
        A1=(X-X2)*(X-X3)*(X-X4)*(X-X5)                                  BL00  12
        A2=(X-X1)*(X-X3)*(X-X4)*(X-X5)                                  BL00  13
        A3=(X-X1)*(X-X2)*(X-X4)*(X-X5)                                  BL00  14
        A4=(X-X1)*(X-X2)*(X-X3)*(X-X5)                                  BL00  15
        A5=(X-X1)*(X-X2)*(X-X3)*(X-X4)                                  BL00  16
        D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)                              BL00  17
        D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)                              BL00  18
        D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)                              BL00  19
        D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)                              BL00  20
        D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)                              BL00  21
        C1=A1/D1                                                        BL00  22
        C2=A2/D2                                                        BL00  23
        C3=A3/D3                                                        BL00  24
        C4=A4/D4                                                        BL00  25
        C5=A5/D5                                                        BL00  26
        F=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5                                 BL00  27
        RETURN                                                          BL00  28
        END                                                             BL00  29
```



```
        SUBROUTINE INTER3 (X,X1,X2,X3,F1,F2,F3,F)                       BL00   1
        IMPLICIT REAL*8(A-H,O-Z)                                        BL00   2
C                                                                       BL00   3
C       SUBROUTINE INTER3 IS CALLED BY SUBROUTINE ADDETA.               BL00   4
C                                                                       BL00   5
C       SUBROUTINE INTER3 INTERPOLATES FOR THE VALUE F CORRESPONDING TO  BL00   6
C       POINT X USING 3 POINT LAGRANGIAN INTERPOLATION.                 BL00   7
C                                                                       BL00   8
C       ASSUMES X1 .LE. X .LE. X3.                                      BL00   9
C                                                                       BL00  10
        A1=(X-X2)*(X-X3)                                                BL00  11
        A2=(X-X1)*(X-X3)                                                BL00  12
        A3=(X-X1)*(X-X2)                                                BL00  13
        D1=(X1-X2)*(X1-X3)                                              BL00  14
        D2=(X2-X1)*(X2-X3)                                              BL00  15
        D3=(X3-X1)*(X3-X2)                                              BL00  16
        C1=A1/D1                                                        BL00  17
        C2=A2/D2                                                        BL00  18
        C3=A3/D3                                                        BL00  19
        F=C1*F1+C2*F2+C3*F3                                             BL00  20
        RETURN                                                          BL00  21
        END                                                             BL00  22
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```
      SUBROUTINE INTER4 (X,X1,X2,X3,X4,F1,F2,F3,F4,F)                    BL00   1
      IMPLICIT REAL*8(A-H,O-Z)                                           BL00   2
      A1=(X-X2)*(X-X3)*(X-X4)                                            BL00   3
      A2=(X-X1)*(X-X3)*(X-X4)                                            BL00   4
      A3=(X-X1)*(X-X2)*(X-X4)                                            BL00   5
      A4=(X-X1)*(X-X2)*(X-X3)                                            BL00   6
      D1=(X1-X2)*(X1-X3)*(X1-X4)                                         BL00   7
      D2=(X2-X1)*(X2-X3)*(X2-X4)                                         BL00   8
      D3=(X3-X1)*(X3-X2)*(X3-X4)                                         BL00   9
      D4=(X4-X1)*(X4-X2)*(X4-X3)                                         BL00  10
      C1=A1/D1                                                           BL00  11
      C2=A2/D2                                                           BL00  12
      C3=A3/D3                                                           BL00  13
      C4=A4/D4                                                           BL00  14
      F=C1*F1+C2*F2+C3*F3+C4*F4                                          BL00  15
      RETURN                                                             BL00  16
      END                                                                BL00  17
C
C      THESE SUBROUTINES ARE DUMMIED TO GET THE INVISCID PRESSURE        BL00   1
C      DISTRIBUTION FROM  BLOTTNERS PROGRAM                              BL00   2
C                                                                        BL00   3
      SUBROUTINE AVERG (K,IP)                                            BL00   4
      RETURN                                                             BL00   5
      END                                                                BL00   6
      SUBROUTINE CALCV (IP,K)                                            BL00   1
      RETURN                                                             BL00   2
      END                                                                BL00   3
      SUBROUTINE CONV                                                    BL00   1
      RETURN                                                             BL00   2
      END                                                                BL00   3
      SUBROUTINE OMEMOM (IP,K)                                           BL00   1
      RETURN                                                             BL00   2
      END                                                                BL00   3
      SUBROUTINE PSIMOM (IP,K)                                           BL00   1
      RETURN                                                             BL00   2
      END                                                                BL00   3
      SUBROUTINE SYMM (K)                                                BL00   1
      RETURN                                                             BL00   2
      END                                                                BL00   3
      SUBROUTINE TRIDAG (W,WO,K,IP,WN)                                   BL00   1
      RETURN                                                             BL00   2
      END                                                                BL00   3
```

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```
      SUBROUTINE DPRX (COSP,RR,PRX)                                    BL00   1
      IMPLICIT REAL*8(A-H,O-Z)                                         BL00   2
      DIMENSION ZSLO(3)                                                BL00   3
      PHI=DARCOS(COSP)                                                 BL00   4
      XX=PHI                                                           BL00   5
      ZSLO(1)=RR                                                       BL00   6
      CALL SLOALL (XX,ZSLO,1,13,3,0,0,3,0)                             BL00   7
      PRX=ZSLO(3)                                                      BL00   8
      RETURN                                                           BL00   9
      END                                                              BL00  10
```

2. Program DERVAT Listing

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C       PROGRAM MAIN                                                          1
        IMPLICIT REAL*8(A-H,O-Z)                                              2
        DIMENSION ANYVA(100,14,40), XS(100), ADUM(100), DADUM(100)            3
        CALL ERRSET (207,256,10,0,0,209)                                      4
C
C       THIS PROGRAM COMPUTES DERIVATIVES OF THE VELOCITY COMPONENTS, BODY
C       RADIUS AND SCALE FACTORS.  THE RAW DATA IS READ FROM UNIT 25. THE
C       X DERIVATIVES ARE COMPUTED USING A 5 POINT LAGRANGIAN POLYNOMIAL
C       IN SUBROUTINES DERIV5 AND FD5. THE ORIGINAL DATA ALONG WITH THE
C       REQUIRED DERIVATIVES ARE WRITTEN ON UNIT 26
C                                                                             5
        I=1                                                                   6
        J=0                                                                   7
        READ (25) ALPHA                                                       8
10      J=J+1                                                                 9
        READ (25) XS(J),(ANYVA(I,K,J),K=1,7)                                 10
        IF (J.EQ.1) GO TO 10                                                  11
        ANYVA(I,1,J)=ANYVA(I,1,1)                                             12
        XSD=XS(J)-XS(J-1)                                                     13
        IF (XSD.GT.0.1D-02) GO TO 20                                          14
        GO TO 10                                                              15
20      BACKSPACE 25                                                          16
        J=J-1                                                                 17
        KPL=J                                                                 18
        XS(I)=XS(J)                                                           19
        I=I+1                                                                 20
        WRITE (6,200) ALPHA,KPL                                               21
30      CONTINUE                                                              22
        DO 40 J=1,KPL                                                         23
40      READ (25,END=50) XS(I),(ANYVA(I,K,J),K=1,7)                           24
        I=I+1                                                                 25
        GO TO 30                                                              26
50      NS=I-1                                                                27
        WRITE (6,170)                                                         28
        DO 60 I=1,NS                                                          29
        WRITE (6,180) I,XS(I),(ANYVA(I,K,1),K=1,7)                            30
60      WRITE (6,190) ((ANYVA(I,K,J),K=1,7),J=2,KPL)                          31
        DO 100 J=1,KPL                                                        32
        DO 90 K=1,7                                                           33
        IF (K.EQ.1) K1=12                                                     34
        IF (K.EQ.2) K1=13                                                     35
        IF (K.EQ.3) K1=10                                                     36
        IF (K.EQ.4) GO TO 90                                                  37
        IF (K.EQ.5) K1=8                                                      38
        IF (K.EQ.6) K1=9                                                      39
        IF (K.EQ.7) K1=14                                                     40
        DO 70 I=1,NS                                                          41
70      ADUM(I)=ANYVA(I,K,J)                                                  42
        CALL DERIV5 (XS,ADUM,NS,0,0,DADUM)                                    43
        DO 80 I=1,NS                                                          44
80      ANYVA(I,K1,J)=DADUM(I)                                                45
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 90     CONTINUE                                                          46
100     CONTINUE                                                          47
        DO 130 J=1,KPL                                                    48
        DO 110 I=1,NS                                                     49
110     ADUM(I)=ANYVA(I,10,J)                                             50
        CALL DERIV5 (XS,ADUM,NS,0,0,DADUM)                                51
        DO 120 I=1,NS                                                     52
120     ANYVA(I,11,J)=DADUM(I)                                            53
130     CONTINUE                                                          54
        WRITE (26) ALPHA,KPL                                              55
        WRITE (30,200) ALPHA,KPL                                          56
        DO 140 I=1,NS                                                     57
        WRITE (26) I,XS(I),((ANYVA(I,K,J),K=1,14),J=1,KPL)                58
140     CONTINUE                                                          59
        WRITE (30,210)                                                    60
        WRITE (29,220)                                                    61
        DO 160 I=1,NS                                                     62
        WRITE (30,230) I,XS(I),ANYVA(I,1,1),ANYVA(I,12,1),ANYVA(I,2,1),ANY  63
       1VA(I,13,1),ANYVA(I,3,1),ANYVA(I,10,1),ANYVA(I,11,1)               64
        WRITE (29,230) I,XS(I),ANYVA(I,4,1),ANYVA(I,7,1),ANYVA(I,14,1),ANY  65
       1VA(I,5,1),ANYVA(I,8,1),ANYVA(I,6,1),ANYVA(I,9,1)                  66
        DO 150 J=2,KPL                                                    67
        WRITE (30,240) ANYVA(I,1,J),ANYVA(I,12,J),ANYVA(I,2,J),ANYVA(I,13,  68
       1J),ANYVA(I,3,J),ANYVA(I,10,J),ANYVA(I,11,J)                       69
        WRITE (29,240) ANYVA(I,4,J),ANYVA(I,7,J),ANYVA(I,14,J),ANYVA(I,5,J  70
       1),ANYVA(I,8,J),ANYVA(I,6,J),ANYVA(I,9,J)                          71
150     CONTINUE                                                          72
160     CONTINUE                                                          73
        STOP                                                              74
C                                                                         75
170     FORMAT (/5X,4HISTA,4X,2HXS,13X,4HHPSI,11X,2HHW,13X,1HR,14X,1HS,14X  76
       1,4HUPSI,11X,2HUW,13X,4HXBLT/)                                     77
180     FORMAT (5X,I3,2X,8E15.6)                                          78
190     FORMAT (25X,7E15.6)                                               79
200     FORMAT (/10X,11HALPHA(RAD)=,E15.6,5X,14HNO. OF PLANES=,I3/)       80
210     FORMAT (/5X,4HISTA,4X,2HXS,13X,4HHPSI,11X,7HD(HPSI),8X,2HHW,13X,5H  81
       1D(HW),10X,1HR,14X,4HD(R),11X,5HD2(R)/)                            82
220     FORMAT (/5X,4HISTA,4X,2HXS,13X,1HS,14X,1HX,14X,4HD(X),11X,4HUPSI,1  83
       11X,7HD(UPSI),8X,2HUW,13X,5HD(UW)/)                                84
230     FORMAT (5X,I3,2X,8E15.6)                                          85
240     FORMAT (25X,7E15.6)                                               86
        END                                                               87



        SUBROUTINE DERIV5 (X,Y,NP,JP,IP,DYDX)                    DERO   1
        IMPLICIT REAL *8(A-H,O-Z)                                DERO   2
C                                                                DERO   3
        DIMENSION X(50), Y(50), DYDX(50)                         DERO   4
```

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C
C       THIS SUBROUTINE SETS UP THE FITTING OF FIFTH ORDER LAGRANGIAN
C       POLYNOMIALS TO DATA IN ARRAYS X AND Y.  THE ACTUAL CALCULATIONS
C       ARE CARRIED OUT IN SUBROUTINE FD5.
C
      DO 10 J=1,NP                                                      DERO   5
      K=J                                                               DERO   6
      IF (IP.EQ.1) K=JP                                                 DERO   7
      IF (K.LT.3) K=3                                                   DERO   8
      IF (K.GT.(NP-2)) K=NP-2                                           DERO   9
      XX=X(J)                                                           DERO  10
      XX1=X(K-2)                                                        DERO  11
      XX2=X(K-1)                                                        DERO  12
      XX3=X(K)                                                          DERO  13
      XX4=X(K+1)                                                        DERO  14
      XX5=X(K+2)                                                        DERO  15
      YY1=Y(K-2)                                                        DERO  16
      YY2=Y(K-1)                                                        DERO  17
      YY3=Y(K)                                                          DERO  18
      YY4=Y(K+1)                                                        DERO  19
      YY5=Y(K+2)                                                        DERO  20
      CALL FD5 (XX,XX1,XX2,XX3,XX4,XX5,YY1,YY2,YY3,YY4,YY5,DER)         DERO  21
      DYDX(J)=DER                                                       DERO  22
      IF (IP.EQ.1) GO TO 20                                             DERO  23
10    CONTINUE                                                          DERO  24
20    RETURN                                                            DERO  25
      END                                                               DERO  26
                                                                        DERO  27


      SUBROUTINE FD5 (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,FX)               DERO   1
      IMPLICIT REAL*8(A-H,O-Z)                                          DERO   2
C
C       THIS SUBROUTINE FITS DATA AND CALCULATES ITS FIRST DERIVATIVE
C       USING A FIFTH ORDER POLYNOMIAL
C
      A1=(X-X4)*(X-X5)*(2.D0*X-X2-X3)+(X-X2)*(X-X3)*(2.D0*X-X4-X5)      DERO   3
      A2=(X-X4)*(X-X5)*(2.D0*X-X1-X3)+(X-X1)*(X-X3)*(2.D0*X-X4-X5)      DERO   4
      A3=(X-X4)*(X-X5)*(2.D0*X-X1-X2)+(X-X1)*(X-X2)*(2.D0*X-X4-X5)      DERO   5
      A4=(X-X3)*(X-X5)*(2.D0*X-X1-X2)+(X-X1)*(X-X2)*(2.D0*X-X3-X5)      DERO   6
      A5=(X-X3)*(X-X4)*(2.D0*X-X1-X2)+(X-X1)*(X-X2)*(2.D0*X-X3-X4)      DERO   7
      D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)                                DERO   8
      D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)                                DERO   9
      D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)                                DERO  10
      D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)                                DERO  11
      D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)                                DERO  12
      C1=A1/D1                                                          DERO  13
      C2=A2/D2                                                          DERO  14
      C3=A3/D3                                                          DERO  15
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```
      C4=A4/D4                                                    DERO  16
      C5=A5/D5                                                    DERO  17
      FX=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5                            DERO  18
      RETURN                                                      DERO  19
      END                                                         DERO  20
```

3. Program INVTAP Listing

```
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C       PROGRAM INVTAP CREATES THE INVISCID DATA TAPE AS REQUIRED                1
C       BY THE BOUNDARY LAYER PROGRAMME; CALLING  DISKIN                         2
       IMPLICIT REAL*8(A-H,O-Z)                                                  3
C                                                                                4
       WRITE (6,10)                                                              5
       CALL ERRSET (207,256,10,0,0,209)                                          6
C                                                                                7
       CALL DISKIN                                                               8
       STOP                                                                      9
C                                                                               10
10     FORMAT (/10X,60HGENERATING INVISCID DATA TAPE FOR BOUNDARY LAYER         11
     1   PROGRAM//)                                                            12
       END                                                                      13
       SUBROUTINE DISKIN                                                 MODO    1
       IMPLICIT REAL*8 (A-H,O-Z)                                         MODO    2
       REAL*8 NOSE                                                       MODO    3
       DIMENSION RADS(40), US(40), VS(40), XSURFS(40), HXS(40), HWS(40), MODO    4
      1USX(40), VSX(40), RADSX(40), RADSXX(40), HXSX(40), HWSX(40), X(40)MODO    5
      2, XX(40), ARADS(40), AUS(40), AVS(40), AHXS(40), AHWS(40), AXSRFS(MODO    6
      340), AUSX(40), AVSX(40), ARADSX(40), ARDSXX(40), AHXSX(40), AHWSX(MODO    7
      440), AX(40), AXX(40), FLOFLD(14,40)                               MODO    8
       DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                 MODO    9
       ICOUNT=0                                                          MODO   10
       WRITE (30,250)                                                    MODO   11
       WRITE (30,140)                                                    MODO   12
       WRITE (30,140)                                                    MODO   13
       READ (25) ALPHA,KL                                                MODO   14
                                                                         MODO   15
CCC    READ THE FIRST SET OF INVISCID AND BODY DATA                      MODO   16
CCC                                                                      MODO   17
       READ (25) ISTA,XS,((FLOFLD(J,K),J=1,14),K=1,KL)                   MODO   18
                                                                         MODO   19
CCC    XS = LONGITUDINAL SURFACE COORDINATE                              MODO   20
CCC    FLOFLD(1,K) = STREAMWISE SCALE FACTOR                             MODO   21
CCC    FLOFLD(2,K) = CROSS SCALE FACTOR                                  MODO   22
CCC    FLOFLD(3,K) = RADIUS                                              MODO   23
CCC    FLOFLD(4,K) = SURFACE DISTANCE FROM NOSE                          MODO   24
CCC    FLOFLD(5,K) = STREAMWISE VELOCITY COMPONENT                       MODO   25
CCC    FLOFLD(6,K) = CROSS FLOW VELOCITY COMPONENT                       MODO   26
CCC    FLOFLD(7,K) = AXIAL DISTANCE                                      MODO   27
CCC    FLOFLD(8,K) = XS DERIVATIVE OF STREAMWISE VELOCITY COMPONENT      MODO   28
CCC    FLOFLD(9,K) = XS DERIVATIVE OF CROSS FLOW VELOITY COMPONENT       MODO   29
CCC    FLOFLD(10,K) = XS DERIVATIVE OF BODY RADIUS                       MODO   30
CCC    FLOFLD(11,K) = 2ND X DERIVATIVE OF BODY RADIUS                    MODO   31
CCC    FLOFLD(12,K) = XS DERIVATIVE OF STREAMWISE SCALE FACTOR           MODO   32
CCC    FLOFLD(13,K) = XS DERIVATIVE OF CROSS SCALE FACTOR                MODO   33
CCC    FLOFLD(14,K) = XS DERIVATIVE OF AXIAL DISTANCE                    MODO   34
CCC    KL IS THE NUMBER OF PLANES                                        MODO   35
CCC    K=1 IS THE WINDWARD PLANE                                         MODO   36
CCC    K=KL IS THE LEEWARD PLANE                                         MODO   37
C                                                                        MODO   38
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      PI=DARCOS(-1.000)                                                    MODO  39
      WRITE (30,140)                                                       MODO  40
      WRITE (30,150) KL                                                    MODO  41
      WRITE (30,140)                                                       MODO  42
      ALPH=ALPHA*(180.000/PI)                                              MODO  43
      WRITE (30,160) ALPH                                                  MODO  44
      WRITE (30,140)                                                       MODO  45
C                                                                          MODO  46
C     UNIT 10 IS THE EDGE PROPERTY DATA SET                                MODO  47
C                                                                          MODO  48
      WRITE (10) ALPH,KL                                                   MODO  49
      WRITE (30,140)                                                       MODO  50
      WRITE (30,240)                                                       MODO  51
      WRITE (30,140)                                                       MODO  52
C                                                                          MODO  53
C                                                                          MODO  54
      WRITE (30,170) ISTA,XS                                               MODO  55
      WRITE (30,140)                                                       MODO  56
      WRITE (30,180)                                                       MODO  57
      DO 10 K=1,KL                                                         MODO  58
      WRITE (30,200) K,(FLOFLD(I,K),I=1,7)                                 MODO  59
10    CONTINUE                                                             MODO  60
      WRITE (30,190)                                                       MODO  61
      DO 20 K=1,KL                                                         MODO  62
20    WRITE (30,200) K,(FLOFLD(I,K),I=8,14)                                MODO  63
      WRITE (30,140)                                                       MODO  64
      GO TO 60                                                             MODO  65
30    CONTINUE                                                             MODO  66
C                                                                          MODO  67
C     FLOWFIELD DATA FROM THE INVISCID SOLUTION IS READ FROM UNIT 25       MODO  68
C                                                                          MODO  69
      READ (25,END=130) ISTA,XS,((FLOFLD(J,K),J=1,14),K=1,KL)              MODO  70
C                                                                          MODO  71
      FLOFLD(6,1)=0.000                                                    MODO  72
      WRITE (30,170) ISTA,XS                                               MODO  73
      WRITE (30,140)                                                       MODO  74
      WRITE (30,180)                                                       MODO  75
      DO 40 K=1,KL                                                         MODO  76
      WRITE (30,200) K,(FLOFLD(I,K),I=1,7)                                 MODO  77
40    CONTINUE                                                             MODO  78
      WRITE (30,190)                                                       MODO  79
      DO 50 K=1,KL                                                         MODO  80
50    WRITE (30,200) K,(FLOFLD(I,K),I=8,14)                                MODO  81
      WRITE (30,140)                                                       MODO  82
60    CONTINUE                                                             MODO  83
      DO 70 K=1,KL                                                         MODO  84
      HXS(K)=FLOFLD(1,K)                                                   MODO  85
      HWS(K)=FLOFLD(2,K)                                                   MODO  86
      RADS(K)=FLOFLD(3,K)                                                  MODO  87
      XSURFS(K)=FLOFLD(4,K)                                                MODO  88
      US(K)=FLOFLD(5,K)                                                    MODO  89
```

```
      VS(K)=FLOFLD(6,K)                                                 MODO  90
      X(K)=FLOFLD(7,K)                                                  MODO  91
      USX(K)=FLOFLD(8,K)                                                MODO  92
      VSX(K)=FLOFLD(9,K)                                                MODO  93
      RADSX(K)=FLOFLD(10,K)                                             MODO  94
      RADSXX(K)=FLOFLD(11,K)                                            MODO  95
      HXSX(K)=FLOFLD(12,K)                                              MODO  96
      HWSX(K)=FLOFLD(13,K)                                              MODO  97
      XX(K)=FLOFLD(14,K)                                                MODO  98
70    CONTINUE                                                          MODO  99
      VS(1)=0.DO                                                        MODO 100
      VS(KL)=0.DO                                                       MODO 101
      VSX(1)=0.DO                                                       MODO 102
      VSX(KL)=0.DO                                                      MODO 103
C                                                                       MODO 104
CC    EDGE PROPERTIES ARE CONVERTED TO FOURIER COEFFICIENTS             MODO 105
C                                                                       MODO 106
      IF (KL.EQ.1) GO TO 80                                             MODO 107
      CALL FORIER (RADS,ARADS,KL,1)                                     MODO 108
      CALL FORIER (US,AUS,KL,1)                                         MODO 109
      CALL FORIER (VS,AVS,KL,2)                                         MODO 110
      CALL FORIER (HXS,AHXS,KL,1)                                       MODO 111
      CALL FORIER (HWS,AHWS,KL,1)                                       MODO 112
      CALL FORIER (XSURFS,AXSRFS,KL,1)                                  MODO 113
      CALL FORIER (USX,AUSX,KL,1)                                       MODO 114
      CALL FORIER (VSX,AVSX,KL,2)                                       MODO 115
      CALL FORIER (RADSX,ARADSX,KL,1)                                   MODO 116
      CALL FORIER (RADSXX,ARDSXX,KL,1)                                  MODO 117
      CALL FORIER (HXSX,AHXSX,KL,1)                                     MODO 118
      CALL FORIER (HWSX,AHWSX,KL,1)                                     MODO 119
      CALL FORIER (X,AX,KL,1)                                           MODO 120
      CALL FORIER (XX,AXX,KL,1)                                         MODO 121
      GO TO 100                                                         MODO 122
80    CONTINUE                                                          MODO 123
      ARADS(1)=RADS(1)                                                  MODO 124
      AUS(1)=US(1)                                                      MODO 125
      AVS(1)=VS(1)                                                      MODO 126
      AHXS(1)=HXS(1)                                                    MODO 127
      AHWS(1)=HWS(1)                                                    MODO 128
      AXSRFS(1)=XSURFS(1)                                               MODO 129
      AUSX(1)=USX(1)                                                    MODO 130
      AVSX(1)=VSX(1)                                                    MODO 131
      ARADSX(1)=RADSX(1)                                                MODO 132
      ARDSXX(1)=RADSXX(1)                                               MODO 133
      AHXSX(1)=HXSX(1)                                                  MODO 134
      AHWSX(1)=HWSX(1)                                                  MODO 135
      AX(1)=X(1)                                                        MODO 136
      AXX(1)=XX(1)                                                      MODO 137
      DO 90 I=2,KL                                                      MODO 138
      ARADS(I)=0.0DO                                                    MODO 139
      AUS(I)=0.DO                                                       MODO 140
```

```
      AVS(I)=0.0D0                                                      MODO 141
      AHXS(I)=0.0D0                                                     MODO 142
      AHWS(I)=0.0D0                                                     MODO 143
      AXSRFS(I)=0.0D0                                                   MODO 144
      AUSX(I)=0.0D0                                                     MODO 145
      AVSX(I)=0.0D0                                                     MODO 146
      ARADSX(I)=0.0D0                                                   MODO 147
      ARDSXX(I)=0.0D0                                                   MODO 148
      AHXSX(I)=0.0D0                                                    MODO 149
      AHWSX(I)=0.0D0                                                    MODO 150
      AX(I)=0.0D0                                                       MODO 151
      AXX(I)=0.0D0                                                      MODO 152
   90 CONTINUE                                                          MODO 153
  100 CONTINUE                                                          MODO 154
      WRITE (30,210)                                                    MODO 155
      WRITE (30,140)                                                    MODO 156
      WRITE (10) XS,ARADS,AUS,AVS,AHXS,AHWS,AXSRFS,AUSX,AVSX,ARADSX,ARDSMODO 157
     1XX,AHXSX,AHWSX,AX,AXX                                             MODO 158
      WRITE (30,220)                                                    MODO 159
      DO 110 K=1,KL                                                     MODO 160
      WRITE (30,200) K,AXSRFS(K),ARADS(K),AHXS(K),AHWS(K),AUS(K),AVS(K) MODO 161
  110 CONTINUE                                                          MODO 162
      WRITE (30,230)                                                    MODO 163
      DO 120 K=1,KL                                                     MODO 164
      WRITE (30,200) K,AUSX(K),AVSX(K),ARADSX(K),ARDSXX(K),AHXSX(K),AHWSMODO 165
     1X(K),AX(K),AXX(K)                                                 MODO 166
  120 CONTINUE                                                          MODO 167
      WRITE (30,140)                                                    MODO 168
      GO TO 30                                                          MODO 169
C                                                                       MODO 170
C                                                                       MODO 171
  130 RETURN                                                            MODO 172
C                                                                       MODO 173
C                                                                       MODO 174
C                                                                       MODO 175
  140 FORMAT (1H )                                                      MODO 176
  150 FORMAT (10X,39HNUMBER OF PLANES IN THE INVISCID DATA =,I3)        MODO 177
  160 FORMAT (10X,6HALPHA=,F6.2)                                        MODO 178
  170 FORMAT (5X,20HWALL DATA AT STATION,1X,I3,7H; XI = ,E9.4)          MODO 179
  180 FORMAT (/5X,1HK,4X,4HHPSI,11X,2HHW,13X,1HR,14X,1HS,14X,4HUPSI,11X,MODO 180
     12HUW,13X,1HX/)                                                    MODO 181
  190 FORMAT (/5X,1HK,4X,7HD(UPSI),8X,5HD(UW),10X,4HD(R),11X,5HD2(R),10XMODO 182
     1,7HD(HPSI),8X,5HD(HW),10X,4HD(X)/)                                MODO 183
  200 FORMAT (4X,I2,8E15.6)                                             MODO 184
  210 FORMAT (30X,20HFOURIER COEFFICIENTS)                              MODO 185
  220 FORMAT (/5X,1HK,4X,6HAXSRFS,9X,5HARADS,10X,4HAHXS,11X,4HAHWS,11X,3MODO 186
     1HAUS,12X,3HAVS/)                                                  MODO 187
  230 FORMAT (/5X,1HK,4X,4HAUSX,11X,4HAVSX,11X,6HARADSX,9X,6HARDSXX,9X,5MODO 188
     1HAHXSX,10X,5HAHWSX,10X,2HAX,13X,3HAXX/)                           MODO 189
  240 FORMAT (10X,58HUNIFORM FLOW STARTING SOLUTION FOR THE INVISCID FLOMODO 190
     1W FIELD)                                                          MODO 191
```

```
DATE  05/13/77

250   FORMAT (40X,52HINVISCID EDGE CONDITIONS FOR BOUNDARY LAYER SOLUTIOMODD 192
     1N/47X,39HTAKEN FROM THE INVISCID FLOW FIELD DATA)                 MODD 193
      END                                                               MODD 194



      SUBROUTINE FORIER (AR,BR,KL,KK)                                   MODD   1
C
CCCCC SUBROUTINE FORIER FITS THE DATA IN ARRAY AR WITH EITHER A FOURIER
CCCCC SINE OR COSINE SERIES.
CCCCC                                                                   MODD   2
CCCCC BR IS THE OUTPUT ARRAY OF FOURIER COEFFICIENTS                    MODD   3
CCCCC KL IS THE NUMBER OF INPUT DATA POINTS                             MODD   4
CCCCC KK = 1 OUTPUTS COEFFICIENTS FOR A COSINE SERIES                   MODD   5
CCCCC KK = 2 OUTPUTS COEFFICIENTS FOR A SINE SERIES                     MODD   6
CCCCC                                                                   MODD   7
C     AR IS THE INPUT ARRAY OF FUNCTION VALUES                          MODD   8
      IMPLICIT REAL*8(A-H,O-Z)                                          MODD   9
      DIMENSION AR(40), BR(40)                                          MODD  10
      PI=DARCOS(-1.0D0)                                                 MODD  11
      G=DFLOAT(KL-1)                                                    MODD  12
      FAC=2.0D0/G                                                       MODD  13
      IF (KK.EQ.2) GO TO 30                                             MODD  14
      M=KL-1                                                            MODD  15
      DO 20 N=1,KL                                                      MODD  16
      F=DFLOAT(N-1)                                                     MODD  17
      A=0.0D0                                                           MODD  18
      DO 10 K=2,M                                                       MODD  19
      E=DFLOAT(K-1)                                                     MODD  20
      A=A+AR(K)*DCOS(F*PI*E/G)                                          MODD  21
10    CONTINUE                                                          MODD  22
      BR(N)=FAC*(((AR(1)+AR(KL)*DCOS(F*PI))/2.0D0)+A)                   MODD  23
20    CONTINUE                                                          MODD  24
      BR(1)=BR(1)/2.0D0                                                 MODD  25
      BR(KL)=BR(KL)/2.0D0                                               MODD  26
      RETURN                                                            MODD  27
30    CONTINUE                                                          MODD  28
      DO 50 N=1,M                                                       MODD  29
      F=DFLOAT(N)                                                       MODD  30
      B=0.0D0                                                           MODD  31
      DO 40 K=2,M                                                       MODD  32
      E=DFLOAT(K-1)                                                     MODD  33
      B=B+AR(K)*DSIN(F*PI*E/G)                                          MODD  34
40    CONTINUE                                                          MODD  35
      BR(N)=FAC*B                                                       MODD  36
50    CONTINUE                                                          MODD  37
      RETURN                                                            MODD  38
      END                                                               MODD  39
```

APPENDIX VI

Job Control Language for Program ICBL3D

```
DATE  05/17/77


// JOB CARD
/*PRIORITY URGENT
/*JOBPARM LINES=10
//STEP1 EXEC FORTGCG,TIME=1,REGION=520K,PARM.FORT='NOSOURCE'
//FORT.SYSIN DD *

                    ICBL3D SOURCE DECK

//GO.SYSIN DD *

                    ICBL3D DATA DECK

//GO.FT06F001 DD SYSOUT=A
//GO.FT07F001 DD DUMMY
//GO.FT08F001 DD DSN=$$FT08,DISP=(NEW,DELETE),
//               UNIT=SYSDA,SPACE=(6472,(61,10),,CONTIG),
//               DCB=(RECFM=F,BLKSIZE=6472,DSORG=DA)
//GO.FT10F001 DD DSN=A505F3.INVTAP.EL412,DISP=(OLD,KEEP)
/*
//
```

APPENDIX VII

ICBL3D Sample Input

FILE: FSTR43E DATA A VIRGINIA TECH CONVERSATIONAL MONITOR SYSTEM

4:1 ELLIPSOID AT 2 DEG - - WITHOUT CURVATURE EFFECTS

```
      IE                                                  61
    INJCT                                                  0
   KADETA                                                  1
    KEND2                                                 10
   KONSET                                                  0
     KPRT                                                  1
   KTRANS
   LAMTRB                                                  1
     LPRT                                                  1
     NIT1                                                  7
     NIT2                                                 10
     NIT3                                                 10
    NOINJ
      SFC                                                  2
   NSOLVE                                                  4
   ADTEST                                                          .001
   AKSTAR                                                          .75
   ALAMDA                                                          .05
    ASTAR                                                         20.
    CWALL
     CONV                                                          .001
    DXMAX                                                          .10
      DX1                                                          .01
   EDYLAW                                              REI
   ETAFAC                                                         1.00
   ETAINF                                                           9.
       PR                                                           1.
       RTW                                  9.9983378E-01
       TFS                                                        500.
        CP                                                       6006.
    AMUINF                                      7.650E-02
    PSTAG                                         2116.80
     PINF                                          1734.3
     XBAR                                                         1.
      UFS                                                       100.
        0.
     .0600
        .3
      1.5
```

APPENDIX VIII

ICBL3D Sample Output

THREE-DIMENSIONAL BOUNDARY LAYER PROGRAM
FOR
LAMINAR OR TURBULENT FLOW
WITH
SURFACE CURVATURE EFFECTS
DEVELOPED BY
AEROSPACE ENGINEERING DEPARTMENT
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
BLACKSBURG, VA. 24061

4:1 ELLIPSOID AT 2 DEG - - WITHOUT CURVATURE EFFECTS

FREE STREAM, STAGNATION, AND VEHICLE DATA:

PSTAG = 0.2116800 04 PSIA
TSTAG = 0.5008330 03 DEG.R
PINF = 0.1734300 04 PSIA
UINF = 0.1000000 03 FT/SEC
TINF = 0.5000000 03 DEG.R
RHOINF= 0.7650000-01 SLUGS/FT**3
AMUINF= 0.7650000-01 SLUGS/FT-SEC
TW/TO = 0.9998340 00
ALPHA = 0.2000000 01 DEG.
CP = 0.6006000 04 FT**2/(SEC**2-DEG.R)
REINF = 0.1000000 03
PR = 0.1000000 01
POINTS AT WHICH A SOLUTION IS TO BE OBTAINED:

I	XSTA(I)
1	0.0
2	0.060000
3	0.300000
4	1.500000

XO = 0.0 R = 0.0 PHI = 0.0 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 4
HX = 0.1000000 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.4280700 01 DVEDX= 0.0 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.7875010-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.2753870-01 THETA(X) = 0.1190060-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.3053990-01 THETA(PHI)= 0.1317640-01

WALL HEAT TRANSFER RATE =-0.774735D 00 BTU DELTA (FT) = 0.1024660 00

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.927864	0.0	0.618048	0.999834	0.000090	0.0	0.0
0.300000	0.1030-01	0.255876	0.776115	0.184767	0.610967	0.999861	0.000069	-0.3920-01	0.0
0.600000	0.2050-01	0.467015	0.630470	0.364616	0.530028	0.999887	0.000057	-0.1480 00	0.0
0.900000	0.3080-01	0.634652	0.489511	0.530279	0.516594	0.999912	0.000041	-0.3150 00	0.0
1.200000	0.4100-01	0.761642	0.361340	0.672608	0.427451	0.999935	0.000022	-0.5250 00	0.0
1.500000	0.5130-01	0.852861	0.251774	0.785901	0.327040	0.999955	0.000009	-0.7660 00	0.0
1.800000	0.6150-01	0.914439	0.164568	0.869161	0.230744	0.999971	0.000045	-0.1030 01	0.0
2.100000	0.7180-01	0.953344	0.103386	0.925534	0.149865	0.999982	0.000032	-0.1310 01	0.0
2.400000	0.8200-01	0.976232	0.056908	0.960645	0.089479	0.999990	0.000021	-0.1600 01	0.0
2.700000	0.9230-01	0.988725	0.029883	0.980735	0.049056	0.999995	0.000012	-0.1900 01	0.0
3.000000	0.1030 00	0.995032	0.014498	0.991285	0.024669	0.999997	0.000007	-0.2200 01	0.0
3.300000	0.1130 00	0.997971	0.006486	0.996364	0.011367	0.999999	0.000003	-0.2490 01	0.0
3.600000	0.1230 00	0.999233	0.002672	0.998604	0.004795	1.000000	0.000001	-0.2790 01	0.0
3.900000	0.1330 00	0.999731	0.001013	0.999507	0.001849	1.000000	0.000001	-0.3090 01	0.0
4.200000	0.1440 00	0.999913	0.000354	0.999840	0.000652	1.000000	0.000000	-0.3390 01	0.0
4.500000	0.1540 00	0.999973	0.000114	0.999953	0.000210	1.000000	0.000000	-0.3690 01	0.0
4.800000	0.1640 00	0.999992	0.000034	0.999987	0.000062	1.000000	0.000000	-0.3990 01	0.0
5.100000	0.1740 00	0.999998	0.000010	0.999997	0.000017	1.000000	0.000000	-0.4290 01	0.0
5.400000	0.1850 00	0.999999	0.000003	0.999999	0.000004	1.000000	0.000000	-0.4590 01	0.0
5.700000	0.1950 00	1.000000	0.000001	1.000000	0.000001	1.000000	0.000000	-0.4890 01	0.0
6.000000	0.2050 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.5190 01	0.0
6.300000	0.2150 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.5490 01	0.0
6.600000	0.2260 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.5790 01	0.0
6.900000	0.2360 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.6090 01	0.0
7.200000	0.2460 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.6390 01	0.0
7.500000	0.2560 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.6690 01	0.0
7.800000	0.2670 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.6990 01	0.0
8.100000	0.2770 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.7290 01	0.0
8.400000	0.2870 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.7590 01	0.0
8.700000	0.2970 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.7890 01	0.0
9.000000	0.3080 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.0	-0.8190 01	0.0
				*****	*****	*****			

XO = 0.0 R = 0.0 PHI = 20.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 3
HX = 0.1000000 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.4409190 01 DVEDX=-0.2688700-01 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.8114310-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.269183D-01 THETA(X) = 0.1161600-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.1929400-01 THETA(PHI)= 0.1007090-01
WALL HEAT TRANSFER RATE =-0.798278D 00 BTU DELTA (FT) = 0.1027720 00

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS

0.0	0.0	0.0	0.932627	0.0	1.269941	0.999834	0.000091	0.0	0.0
0.300000	0.101D-01	0.257247	0.782398	0.333017	0.962803	0.999861	0.000090	-0.427D-01	0.0
0.600000	0.202D-01	0.469529	0.633644	0.579691	0.690952	0.999888	0.000088	-0.157D 00	0.0
0.900000	0.303D-01	0.637891	0.491094	0.750952	0.463335	0.999914	0.000082	-0.329D 00	0.0
1.200000	0.404D-01	0.765140	0.361259	0.861671	0.288207	0.999937	0.000072	-0.547D 00	0.0
1.500000	0.505D-01	0.856078	0.250367	0.927792	0.164859	0.999956	0.000059	-0.797D 00	0.0
1.800000	0.606D-01	0.917098	0.162423	0.963928	0.085840	0.999972	0.000045	-0.107D 01	0.0
2.100000	0.707D-01	0.955319	0.098108	0.981800	0.043198	0.999983	0.000031	-0.136D 01	0.0
2.400000	0.808D-01	0.977558	0.054934	0.989698	0.019716	0.999991	0.000020	-0.165D 01	0.0
2.700000	0.909D-01	0.989531	0.028415	0.992785	0.008157	0.999995	0.000011	-0.196D 01	0.0
3.000000	0.101D 00	0.995477	0.013537	0.993872	0.002155	0.999998	0.000006	-0.226D 01	0.0
3.300000	0.111D 00	0.998193	0.005926	0.994281	0.000985	0.999999	0.000003	-0.257D 01	0.0
3.600000	0.121D 00	0.999331	0.002379	0.994532	0.000809	1.000000	0.000001	-0.287D 01	0.0
3.900000	0.131D 00	0.999769	0.000874	0.994782	0.000877	1.000000	0.000001	-0.318D 01	0.0
4.200000	0.141D 00	0.999923	0.000294	0.995058	0.000954	1.000000	0.000000	-0.349D 01	0.0
4.500000	0.152D 00	0.999972	0.000091	0.995352	0.000998	1.000000	0.000000	-0.379D 01	0.0
4.800000	0.162D 00	0.999987	0.000026	0.995655	0.001018	1.000000	0.000000	-0.410D 01	0.0
5.100000	0.172D 00	0.999991	0.000008	0.995962	0.001026	1.000000	0.000000	-0.441D 01	0.0
5.400000	0.182D 00	0.999992	0.000003	0.996271	0.001029	1.000000	0.000000	-0.471D 01	0.0
5.700000	0.192D 00	0.999993	0.000002	0.996580	0.001031	1.000000	0.000000	-0.502D 01	0.0
6.000000	0.202D 00	0.999994	0.000002	0.996889	0.001032	1.000000	0.000000	-0.533D 01	0.0
6.300000	0.212D 00	0.999994	0.000002	0.997199	0.001033	1.000000	0.000000	-0.563D 01	0.0
6.600000	0.222D 00	0.999995	0.000002	0.997509	0.001034	1.000000	0.000000	-0.594D 01	0.0
6.900000	0.232D 00	0.999995	0.000002	0.997820	0.001035	1.000000	0.000000	-0.625D 01	0.0
7.200000	0.242D 00	0.999996	0.000002	0.998130	0.001036	1.000000	0.000000	-0.655D 01	0.0
7.500000	0.253D 00	0.999997	0.000002	0.998441	0.001037	1.000000	0.000000	-0.686D 01	0.0
7.800000	0.263D 00	0.999997	0.000002	0.998753	0.001038	1.000000	0.000000	-0.717D 01	0.0
8.100000	0.273D 00	0.999998	0.000002	0.999064	0.001039	1.000000	0.0	-0.748D 01	0.0
8.400000	0.283D 00	0.999999	0.000002	0.999376	0.001040	1.000000	0.0	-0.778D 01	0.0
8.700000	0.293D 00	0.999999	0.000002	0.999688	0.001040	1.000000	0.000000	-0.809D 01	0.0
9.000000	0.303D 00	1.000000	0.000002	1.000000	0.001041	1.000000	0.000000	-0.840D 01	0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI = 40.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 2
HX = 0.1000000 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.4537960 01 DVEDX=-0.7482320-01 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.8222300-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.265519D-01 THETA(X) = 0.1145860-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.178395D-01 THETA(PHI)= 0.8888940-02
WALL HEAT TRANSFER RATE =-0.8089010 00 BTU DELTA (FT) = 0.911607D-01

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.931822	0.0	1.269805	0.999834	0.000091	0.0	0.0
0.300000	0.996D-02	0.257041	0.781866	0.335589	0.970157	0.999861	0.000090	-0.407D-01	0.0
0.600000	0.199D-01	0.469226	0.633538	0.584139	0.696195	0.999888	0.000088	-0.154D 00	0.0
0.900000	0.299D-01	0.637613	0.491320	0.756691	0.466760	0.999913	0.000082	-0.327D 00	0.0
1.200000	0.398D-01	0.764957	0.361610	0.868197	0.290107	0.999937	0.000072	-0.545D 00	0.0

1.500000	0.498D-01	0.855997	0.250666	0.934698	0.165590	0.999956	0.000059	-0.7970 00	0.0
1.800000	0.597D-01	0.917088	0.162584	0.970920	0.085774	0.999972	0.000045	-0.1070 01	0.0
2.100000	0.697D-01	0.955335	0.098135	0.988691	0.039655	0.999983	0.000031	-0.1360 01	0.0
2.400000	0.797D-01	0.977568	0.054880	0.996382	0.015921	0.999991	0.000020	-0.1660 01	0.0
2.700000	0.896D-01	0.989519	0.023335	0.999209	0.005245	0.999995	0.000011	-0.1960 01	0.0
3.000000	0.996D-01	0.995442	0.013470	1.000013	0.001191	0.999998	0.000006	-0.2270 01	0.0
3.300000	0.110D 00	0.998141	0.005883	1.000129	-0.000002	0.999999	0.000003	-0.2580 01	0.0
3.600000	0.119D 00	0.999271	0.002359	1.000082	-0.000191	1.000000	0.000001	-0.2890 01	0.0
3.900000	0.129D 00	0.999705	0.000871	1.000031	-0.000131	1.000000	0.000001	-0.3200 01	0.0
4.200000	0.139D 00	0.999859	0.000300	1.000013	-0.000059	1.000000	0.000000	-0.3500 01	0.0
4.500000	0.149D 00	0.999911	0.000101	0.999993	-0.000019	1.000000	0.000000	-0.3810 01	0.0
4.800000	0.159D 00	0.999929	0.000039	0.999990	-0.000002	1.000000	0.000000	-0.4120 01	0.0
5.100000	0.169D 00	0.999937	0.000021	0.999990	0.000003	1.000000	0.000000	-0.4430 01	0.0
5.400000	0.179D 00	0.999943	0.000017	0.999992	0.000004	1.000000	0.000000	-0.4740 01	0.0
5.700000	0.189D 00	0.999948	0.000016	0.999993	0.000004	1.000000	0.000000	-0.5050 01	0.0
6.000000	0.199D 00	0.999952	0.000016	0.999994	0.000004	1.000000	0.000000	-0.5360 01	0.0
6.300000	0.209D 00	0.999957	0.000016	0.999995	0.000003	1.000000	0.000000	-0.5660 01	0.0
6.600000	0.219D 00	0.999962	0.000016	0.999996	0.000003	1.000000	0.000000	-0.5970 01	0.0
6.900000	0.229D 00	0.999966	0.000016	0.999997	0.000003	1.000000	0.000000	-0.6280 01	0.0
7.200000	0.239D 00	0.999971	0.000016	0.999998	0.000002	1.000000	0.000000	-0.6590 01	0.0
7.500000	0.249D 00	0.999976	0.000016	0.999999	0.000002	1.000000	0.000000	-0.6900 01	0.0
7.800000	0.259D 00	0.999981	0.000016	0.999999	0.000001	1.000000	0.0	-0.7210 01	0.0
8.100000	0.269D 00	0.999986	0.000016	0.999999	0.000001	1.000000	0.0	-0.7520 01	0.0
8.400000	0.279D 00	0.999990	0.000016	1.000000	0.000001	1.000000	-0.000000	-0.7830 01	0.0
8.700000	0.289D 00	0.999995	0.000016	1.000000	0.000000	1.000000	0.000000	-0.8130 01	0.0
9.000000	0.299D 00	1.000000	0.000016	1.000000	0.000000	1.000000	0.000000	-0.8440 01	0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI = 60.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 2
HX = 0.1000000 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.4756840 01 DVEDX=-0.1660120 00 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.8504480-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.2583720-01 THETA(X) = 0.1116060-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.1724460-01 THETA(PHI)= 0.8585940-02
WALL HEAT TRANSFER RATE =-0.8366620 00 BTU DELTA (FT) = 0.9836370-01

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.934920	0.0	1.279138	0.999834	0.000092	0.0	0.0
0.300000	0.973D-02	0.257923	0.784612	0.337768	0.975409	0.999861	0.000091	-0.4180-01	0.0
0.600000	0.195D-01	0.470848	0.635624	0.587337	0.697945	0.999888	0.000089	-0.1590 00	0.0
0.900000	0.292D-01	0.639718	0.492387	0.759996	0.466004	0.999914	0.000082	-0.3370 00	0.0
1.200000	0.389D-01	0.767208	0.361523	0.871028	0.287996	0.999938	0.000072	-0.5610 00	0.0
1.500000	0.486D-01	0.858064	0.249608	0.936813	0.163144	0.999957	0.000059	-0.8200 00	0.0
1.800000	0.584D-01	0.918736	0.160968	0.972335	0.083669	0.999973	0.000044	-0.1130 01	0.0
2.100000	0.681D-01	0.956468	0.096422	0.989564	0.038173	0.999984	0.000030	-0.1420 01	0.0
2.400000	0.778D-01	0.978215	0.053414	0.996905	0.015039	0.999991	0.000019	-0.1700 01	0.0
2.700000	0.875D-01	0.989784	0.027273	0.999538	0.004791	0.999996	0.000011	-0.2020 01	0.0

3.000000	0.973D-01	0.995450	0.012807	1.000249	0.000981	0.999995	0.000005	-0.233D 01	0.0
3.300000	0.107D 00	0.998001	0.005530	1.000323	-0.000103	0.999999	0.000003	-0.264D 01	0.0
3.600000	0.117D 00	0.999059	0.002205	1.000252	-0.000255	1.000000	0.000001	-0.296D 01	0.0
3.900000	0.126D 00	0.999466	0.000828	1.000184	-0.000168	1.000000	0.000000	-0.327D 01	0.0
4.200000	0.136D 00	0.999617	0.000312	1.000139	-0.000115	1.000000	0.000000	-0.359D 01	0.0
4.500000	0.146D 00	0.999677	0.000137	1.000112	-0.000074	1.000000	0.000000	-0.391D 01	0.0
4.800000	0.156D 00	0.999708	0.000084	1.000093	-0.000055	1.000000	0.000000	-0.422D 01	0.0
5.100000	0.165D 00	0.999730	0.000070	1.000079	-0.000045	1.000000	0.000000	-0.454D 01	0.0
5.400000	0.175D 00	0.999751	0.000067	1.000066	-0.000039	1.000000	0.000000	-0.485D 01	0.0
5.700000	0.185D 00	0.999771	0.000067	1.000055	-0.000035	1.000000	0.000000	-0.517D 01	0.0
6.000000	0.195D 00	0.999791	0.000068	1.000045	-0.000031	1.000000	0.000000	-0.548D 01	0.0
6.300000	0.204D 00	0.999812	0.000068	1.000036	-0.000027	1.000000	0.000000	-0.580D 01	0.0
6.600000	0.214D 00	0.999832	0.000069	1.000029	-0.000024	1.000000	0.000000	-0.611D 01	0.0
6.900000	0.224D 00	0.999853	0.000069	1.000022	-0.000021	1.000000	0.000000	-0.643D 01	0.0
7.200000	0.233D 00	0.999874	0.000069	1.000016	-0.000018	1.000000	0.000000	-0.674D 01	0.0
7.500000	0.243D 00	0.999895	0.000070	1.000011	-0.000015	1.000000	0.000000	-0.706D 01	0.0
7.800000	0.253D 00	0.999916	0.000070	1.000007	-0.000012	1.000000	0.000000	-0.738D 01	0.0
8.100000	0.263D 00	0.999937	0.000070	1.000004	-0.000009	1.000000	-0.000000	-0.769D 01	0.0
8.400000	0.272D 00	0.999958	0.000070	1.000002	-0.000006	1.000000	0.0	-0.801D 01	0.0
8.700000	0.282D 00	0.999979	0.000070	1.000001	-0.000003	1.000000	0.000000	-0.832D 01	0.0
9.000000	0.292D 00	1.000000	0.000070	1.000000	-0.000001	1.000000	-0.000000	-0.864D 01	0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI = 80.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 2
HX = 0.1000000D 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.5052300 01 DVEDX=-0.2992700 00 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.882051D-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.2508830-01 THETA(X) = 0.1088550-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.1663390-01 THETA(PHI)= 0.8263430-02
WALL HEAT TRANSFER RATE =-0.867753D 00 BTU DELTA (FT) = 0.8572330-01

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.937403	0.0	1.282273	0.999834	0.000092	0.0	0.0
0.300000	0.944D-02	0.258568	0.786421	0.338540	0.977427	0.999861	0.000092	-0.424D-01	0.0
0.600000	0.189D-01	0.471928	0.636690	0.588551	0.698898	0.999889	0.000089	-0.162D 00	0.0
0.900000	0.283D-01	0.640996	0.492638	0.761352	0.466056	0.999915	0.000083	-0.343D 00	0.0
1.200000	0.378D-01	0.768442	0.361012	0.872297	0.287452	0.999938	0.000072	-0.571D 00	0.0
1.500000	0.472D-01	0.859051	0.248544	0.937870	0.162358	0.999958	0.000059	-0.834D 00	0.0
1.800000	0.566D-01	0.919355	0.159661	0.973154	0.082924	0.999973	0.000044	-0.112D 01	0.0
2.100000	0.661D-01	0.956694	0.095170	0.990184	0.037611	0.999984	0.000030	-0.142D 01	0.0
2.400000	0.755D-01	0.978098	0.052416	0.997387	0.014675	0.999991	0.000019	-0.173D 01	0.0
2.700000	0.849D-01	0.989416	0.026601	0.999937	0.004573	0.999996	0.000011	-0.205D 01	0.0
3.000000	0.944D-01	0.994928	0.012431	1.000596	0.000840	0.999998	0.000005	-0.237D 01	0.0
3.300000	0.104D 00	0.997402	0.005372	1.000633	-0.000213	0.999999	0.000003	-0.268D 01	0.0
3.600000	0.113D 00	0.998435	0.002185	1.000531	-0.000357	1.000000	0.000001	-0.300D 01	0.0
3.900000	0.123D 00	0.998850	0.000883	1.000433	-0.000287	1.000000	0.000000	-0.332D 01	0.0
4.200000	0.132D 00	0.999024	0.000404	1.000359	-0.000212	1.000000	0.000000	-0.364D 01	0.0

4.200000	0.142D 00	0.999115	0.000246	1.000303	-0.000165	1.000000	0.000000	-0.3960 01	0.0
4.800000	0.151D 00	0.999180	0.000200	1.000258	-0.000139	1.000000	0.000000	-0.4280 01	0.0
5.100000	0.160D 00	0.999238	0.000190	1.000219	-0.000122	1.000000	0.000000	-0.4600 01	0.0
5.400000	0.170D 00	0.999294	0.000189	1.000184	-0.000109	1.000000	0.000000	-0.4920 01	0.0
5.700000	0.179D 00	0.999351	0.000191	1.000153	-0.000098	1.000000	0.000000	-0.5240 01	0.0
6.000000	0.189D 00	0.999409	0.000192	1.000126	-0.000087	1.000000	0.000000	-0.5560 01	0.0
6.300000	0.198D 00	0.999467	0.000194	1.000101	-0.000077	1.000000	0.000000	-0.5880 01	0.0
6.600000	0.208D 00	0.999525	0.000195	1.000080	-0.000067	1.000000	0.000000	-0.6200 01	0.0
6.900000	0.217D 00	0.999584	0.000196	1.000061	-0.000058	1.000000	0.000000	-0.6520 01	0.0
7.200000	0.227D 00	0.999642	0.000197	1.000045	-0.000049	1.000000	0.000000	-0.6840 01	0.0
7.500000	0.236D 00	0.999702	0.000198	1.000032	-0.000041	1.000000	0.000000	-0.7160 01	0.0
7.800000	0.245D 00	0.999761	0.000198	1.000021	-0.000032	1.000000	0.000000	-0.7480 01	0.0
8.100000	0.255D 00	0.999820	0.000199	1.000012	-0.000025	1.000000	0.000000	-0.7800 01	0.0
8.400000	0.264D 00	0.999880	0.000199	1.000006	-0.000017	1.000000	0.000000	-0.8120 01	0.0
8.700000	0.274D 00	0.999940	0.000200	1.000002	-0.000010	1.000000	0.000000	-0.8440 01	0.0
9.000000	0.283D 00	1.000000	0.000200	1.000000	-0.000003	1.000000	0.0	-0.8760 01	0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI =180.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 2
HX = 0.1000000 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.5267390 01 DVEDX=-0.4019200 00 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.892456D-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.248026D-01 THETA(X) = 0.108330D-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.164713D-01 THETA(PHI)= 0.814739D-02
WALL HEAT TRANSFER RATE =-0.877989D 00 BTU DELTA (FT) = 0.850817D-01

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.935520	0.0	1.265914	0.999834	0.000092	0.0	0.0
0.300000	0.924D-02	0.257917	0.784030	0.334848	0.959015	0.999861	0.000091	-0.4100-01	0.0
0.600000	0.185D-01	0.470537	0.634314	0.583387	0.696979	0.999888	0.000089	-0.1570 00	0.0
0.900000	0.277D-01	0.638968	0.490899	0.756334	0.468353	0.999914	0.000082	-0.3330 00	0.0
1.200000	0.370D-01	0.766036	0.360271	0.868337	0.291678	0.999937	0.000072	-0.5560 00	0.0
1.500000	0.462D-01	0.856578	0.248791	0.935255	0.166745	0.999957	0.000059	-0.8120 00	0.0
1.800000	0.555D-01	0.917073	0.160592	0.971750	0.086453	0.999973	0.000044	-0.1090 01	0.0
2.100000	0.647D-01	0.954748	0.096378	0.989662	0.039954	0.999984	0.000031	-0.1390 01	0.0
2.400000	0.739D-01	0.976515	0.053566	0.997401	0.015964	0.999991	0.000019	-0.1690 01	0.0
2.700000	0.832D-01	0.988146	0.027513	1.000213	0.005127	0.999995	0.000011	-0.2000 01	0.0
3.000000	0.924D-01	0.993890	0.013072	1.000965	0.000976	0.999998	0.000006	-0.2310 01	0.0
3.300000	0.102D 00	0.996520	0.005792	1.001008	-0.000270	0.999999	0.000003	-0.2620 01	0.0
3.600000	0.111D 00	0.997655	0.002461	1.000876	-0.000482	1.000000	0.000001	-0.2940 01	0.0
3.900000	0.120D 00	0.998139	0.001079	1.000736	-0.000424	1.000000	0.000000	-0.3250 01	0.0
4.200000	0.129D 00	0.998365	0.000561	1.000622	-0.000340	1.000000	0.000000	-0.3560 01	0.0
4.500000	0.139D 00	0.998500	0.000387	1.000530	-0.000281	1.000000	0.000000	-0.3880 01	0.0
4.800000	0.148D 00	0.998606	0.000337	1.000452	-0.000243	1.000000	0.000000	-0.4190 01	0.0
5.100000	0.157D 00	0.998704	0.000325	1.000384	-0.000215	1.000000	0.000000	-0.4500 01	0.0
5.400000	0.166D 00	0.998801	0.000324	1.000323	-0.000192	1.000000	0.000000	-0.4820 01	0.0
5.700000	0.176D 00	0.998899	0.000326	1.000268	-0.000172	1.000000	0.000000	-0.5130 01	0.0

6.000000	0.1850 00	0.998997	0.000328	1.000220	-0.000152	1.000000	0.000000	-0.5440 01	0.0
6.300000	0.1940 00	0.999095	0.000329	1.000177	-0.000134	1.000000	0.000000	-0.5760 01	0.0
6.600000	0.2030 00	0.999194	0.000331	1.000139	-0.000117	1.000000	0.000000	-0.6070 01	0.0
6.900000	0.2130 00	0.999294	0.000333	1.000106	-0.000101	1.000000	0.000000	-0.6390 01	0.0
7.200000	0.2220 00	0.999394	0.000334	1.000078	-0.000086	1.000000	0.000000	-0.6700 01	0.0
7.500000	0.2310 00	0.999494	0.000335	1.000055	-0.000071	1.000000	0.000000	-0.7010 01	0.0
7.800000	0.2400 00	0.999595	0.000336	1.000036	-0.000056	1.000000	0.000000	-0.7330 01	0.0
8.100000	0.2500 00	0.999696	0.000337	1.000021	-0.000043	1.000000	0.000000	-0.7640 01	0.0
8.400000	0.2590 00	0.999797	0.000338	1.000010	-0.000030	1.000000	0.000000	-0.7950 01	0.0
8.700000	0.2680 00	0.999898	0.000338	1.000003	-0.000017	1.000000	0.0	-0.8270 01	0.0
9.000000	0.2770 00	1.000000	0.000339	1.000000	-0.000005	1.000000	0.0	-0.8580 01	0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI =120.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 2
HX = 0.1000000D 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.5138510 01 DVEDX=-0.338351D 00 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.854976D-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.254735D-01 THETA(X) = 0.111394D-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.172907D-01 THETA(PHI)= 0.853044D-02
WALL HEAT TRANSFER RATE =-0.841117D 00 BTU DELTA (FT) = 0.879576D-01

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.926719	0.0	1.227126	0.999834	0.000089	0.0	0.0
0.300000	0.936D-02	0.255369	0.775962	0.325890	0.947782	0.999860	0.000088	-0.3740-01	0.0
0.600000	0.187D-01	0.465778	0.627951	0.570424	0.690524	0.999887	0.000086	-0.1430 00	0.0
0.900000	0.281D-01	0.632690	0.487359	0.743155	0.472120	0.999912	0.000081	-0.3050 00	0.0
1.200000	0.374D-01	0.759189	0.360023	0.857260	0.300750	0.999935	0.000071	-0.5090 00	0.0
1.500000	0.468D-01	0.850117	0.251395	0.927205	0.176989	0.999954	0.000059	-0.7460 00	0.0
1.800000	0.561D-01	0.911703	0.164932	0.966621	0.095218	0.999970	0.000045	-0.1010 01	0.0
2.100000	0.655D-01	0.950791	0.101161	0.986793	0.046156	0.999982	0.000032	-0.1280 01	0.0
2.400000	0.749D-01	0.973938	0.057789	0.996001	0.019680	0.999990	0.000021	-0.1560 01	0.0
2.700000	0.842D-01	0.986687	0.030678	0.999625	0.007010	0.999994	0.000013	-0.1850 01	0.0
3.000000	0.936D-01	0.993210	0.015137	1.000752	0.001764	0.999997	0.000007	-0.2140 01	0.0
3.300000	0.103D 00	0.996318	0.006979	1.000934	-0.000019	0.999999	0.000003	-0.2440 01	0.0
3.600000	0.112D 00	0.997710	0.003061	1.000838	-0.000438	1.000000	0.000002	-0.2730 01	0.0
3.900000	0.122D 00	0.998315	0.001342	1.000701	-0.000433	1.000000	0.000001	-0.3020 01	0.0
4.200000	0.131D 00	0.998590	0.000653	1.000583	-0.000350	1.000000	0.000000	-0.3320 01	0.0
4.500000	0.140D 00	0.998738	0.000400	1.000489	-0.000281	1.000000	0.000000	-0.3610 01	0.0
4.800000	0.150D 00	0.998842	0.000315	1.000412	-0.000235	1.000000	0.000000	-0.3900 01	0.0
5.100000	0.159D 00	0.998931	0.000288	1.000347	-0.000203	1.000000	0.000000	-0.4200 01	0.0
5.400000	0.168D 00	0.999016	0.000280	1.000290	-0.000178	1.000000	0.000000	-0.4490 01	0.0
5.700000	0.178D 00	0.999099	0.000277	1.000240	-0.000157	1.000000	0.000000	-0.4790 01	0.0
6.000000	0.187D 00	0.999182	0.000276	1.000196	-0.000139	1.000000	0.000000	-0.5080 01	0.0
6.300000	0.197D 00	0.999265	0.000275	1.000157	-0.000121	1.000000	0.000000	-0.5370 01	0.0
6.600000	0.206D 00	0.999347	0.000274	1.000123	-0.000105	1.000000	0.000000	-0.5670 01	0.0
6.900000	0.215D 00	0.999429	0.000273	1.000094	-0.000090	1.000000	0.000000	-0.5960 01	0.0
7.200000	0.225D 00	0.999511	0.000273	1.000069	-0.000076	1.000000	0.000000	-0.6260 01	0.0

7.500000	0.234D 00	0.999593	0.000272	1.000048	-0.000062	1.000000	0.000000	-0.655D 01	0.0
7.800000	0.243D 00	0.999675	0.000272	1.000031	-0.000050	1.000000	0.000000	-0.684D 01	0.0
8.100000	0.253D 00	0.999756	0.000271	1.000016	-0.000037	1.000000	0.0	-0.714D 01	0.0
8.400000	0.262D 00	0.999838	0.000271	1.000009	-0.000026	1.000000	0.0	-0.743D 01	0.0
8.700000	0.271D 00	0.999919	0.000271	1.000003	-0.000015	1.000000	0.000000	-0.773D 01	0.0
9.000000	0.281D 00	1.000000	0.000270	1.000000	-0.000004	1.000000	0.0	-0.802D 01	0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI =140.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 2
HX = 0.1000000 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.4457320 01 DVEDX=-0.8096710-01 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.769736D-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.276252D-01 THETA(X) = 0.120177D-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.192198D-01 THETA(PHI)= 0.950648D-02
WALL HEAT TRANSFER RATE =-0.7572590 00 BTU DELTA (FT) = 0.961279D-01

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.916828	0.0	1.197140	0.999834	0.000085	0.0	0.0
0.300000	0.100D-01	0.252595	0.767450	0.318785	0.930242	0.999860	0.000085	-0.344D-01	0.0
0.600000	0.201D-01	0.460735	0.621592	0.559778	0.683885	0.999885	0.000083	-0.131D 00	0.0
0.900000	0.301D-01	0.626173	0.484070	0.731856	0.473609	0.999909	0.000079	-0.278D 00	0.0
1.200000	0.402D-01	0.752200	0.360150	0.847252	0.307018	0.999932	0.000070	-0.466D 00	0.0
1.500000	0.502D-01	0.843698	0.254454	0.919428	0.184899	0.999951	0.000059	-0.683D 00	0.0
1.800000	0.603D-01	0.906463	0.169797	0.961186	0.102497	0.999967	0.000047	-0.923D 00	0.0
2.100000	0.703D-01	0.947131	0.106518	0.983299	0.051660	0.999979	0.000034	-0.118D 01	0.0
2.400000	0.804D-01	0.971832	0.062580	0.993858	0.023233	0.999988	0.000023	-0.144D 01	0.0
2.700000	0.904D-01	0.985859	0.034333	0.998294	0.009007	0.999993	0.000014	-0.171D 01	0.0
3.000000	0.100D 00	0.993290	0.017555	0.999851	0.002767	0.999997	0.000008	-0.198D 01	0.0
3.300000	0.111D 00	0.996957	0.008363	1.000241	0.000466	0.999998	0.000004	-0.225D 01	0.0
3.600000	0.121D 00	0.998644	0.003720	1.000250	-0.000168	0.999999	0.000002	-0.253D 01	0.0
3.900000	0.131D 00	0.999371	0.001559	1.000180	-0.000232	1.000000	0.000001	-0.280D 01	0.0
4.200000	0.141D 00	0.999669	0.000630	1.000119	-0.000163	1.000000	0.000000	-0.308D 01	0.0
4.500000	0.151D 00	0.999790	0.000261	1.000081	-0.000098	1.000000	0.000000	-0.335D 01	0.0
4.800000	0.161D 00	0.999842	0.000123	1.000058	-0.000059	1.000000	0.000000	-0.363D 01	0.0
5.100000	0.171D 00	0.999869	0.000073	1.000044	-0.000038	1.000000	0.000000	-0.390D 01	0.0
5.400000	0.181D 00	0.999888	0.000054	1.000035	-0.000028	1.000000	0.000000	-0.418D 01	0.0
5.700000	0.191D 00	0.999902	0.000045	1.000027	-0.000022	1.000000	0.000000	-0.445D 01	0.0
6.000000	0.201D 00	0.999915	0.000040	1.000022	-0.000018	1.000000	0.000000	-0.473D 01	0.0
6.300000	0.211D 00	0.999926	0.000036	1.000017	-0.000015	1.000000	0.000000	-0.500D 01	0.0
6.600000	0.221D 00	0.999937	0.000033	1.000013	-0.000012	1.000000	0.000000	-0.528D 01	0.0
6.900000	0.231D 00	0.999946	0.000031	1.000010	-0.000010	1.000000	0.000000	-0.555D 01	0.0
7.200000	0.241D 00	0.999955	0.000029	1.000007	-0.000008	1.000000	0.000000	-0.583D 01	0.0
7.500000	0.251D 00	0.999963	0.000027	1.000005	-0.000006	1.000000	0.000000	-0.610D 01	0.0
7.800000	0.261D 00	0.999971	0.000026	1.000003	-0.000005	1.000000	0.000000	-0.637D 01	0.0
8.100000	0.271D 00	0.999979	0.000025	1.000002	-0.000004	1.000000	0.000000	-0.665D 01	0.0
8.400000	0.281D 00	0.999986	0.000024	1.000001	-0.000002	1.000000	0.000000	-0.692D 01	0.0
8.700000	0.291D 00	0.999993	0.000023	1.000000	-0.000001	1.000000	0.000000	-0.720D 01	0.0

9.000000 0.341D 00 1.000000 0.000022 1.000000 -0.000000 1.000000 -0.000000 -0.747D 01 0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI =180.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NTT = 3
HX = 0.1000000D 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.3490468 01 DVEDX= 0.1100158 00 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.7203830-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.3033810-01 THETA(X) = 0.1311830-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.2035000-01 THETA(PHI)= 0.1012310-01
WALL HEAT TRANSFER RATE =-0.7087060 00 BTU DELTA (FT) = 0.1041060 00

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.931703	0.0	1.267378	0.999834	0.000091	0.0	0.0
0.300000	0.1140-01	0.256978	0.781579	0.335252	0.968981	0.999861	0.000090	-0.4070-01	0.0
0.600000	0.2270-01	0.469061	0.633171	0.583416	0.696045	0.999888	0.000088	-0.1550 00	0.0
0.900000	0.3410-01	0.637338	0.490981	0.756035	0.467256	0.999913	0.000082	-0.3280 00	0.0
1.200000	0.4540-01	0.764595	0.361378	0.867742	0.290865	0.999937	0.000072	-0.5460 00	0.0
1.500000	0.5680-01	0.855585	0.250572	0.934475	0.166322	0.999956	0.000059	-0.7990 00	0.0
1.800000	0.6810-01	0.916667	0.162609	0.970893	0.086326	0.999972	0.000045	-0.1070 01	0.0
2.100000	0.7950-01	0.954935	0.098233	0.988796	0.039991	0.999983	0.000031	-0.1360 01	0.0
2.400000	0.9080-01	0.977203	0.055007	0.996559	0.015076	0.999991	0.000020	-0.1660 01	0.0
2.700000	0.1020 00	0.989192	0.028457	0.999411	0.005278	0.999995	0.000011	-0.1970 01	0.0
3.000000	0.1140 00	0.995149	0.013573	1.000213	0.001158	0.999998	0.000006	-0.2280 01	0.0
3.300000	0.1250 00	0.997876	0.005966	1.000314	-0.000064	0.999999	0.000003	-0.2580 01	0.0
3.600000	0.1360 00	0.999028	0.002426	1.000247	-0.000260	1.000000	0.000001	-0.2890 01	0.0
3.900000	0.1480 00	0.999481	0.000927	1.000175	-0.000198	1.000000	0.000001	-0.3200 01	0.0
4.200000	0.1590 00	0.999651	0.000350	1.000129	-0.000120	1.000000	0.000000	-0.3510 01	0.0
4.500000	0.1700 00	0.999717	0.000148	1.000101	-0.000074	1.000000	0.000000	-0.3820 01	0.0
4.800000	0.1820 00	0.999749	0.000084	1.000082	-0.000052	1.000000	0.000000	-0.4130 01	0.0
5.100000	0.1930 00	0.999771	0.000065	1.000069	-0.000041	1.000000	0.000000	-0.4440 01	0.0
5.400000	0.2040 00	0.999789	0.000060	1.000057	-0.000035	1.000000	0.000001	-0.4750 01	0.0
5.700000	0.2160 00	0.999807	0.000059	1.000048	-0.000031	1.000000	0.000000	-0.5060 01	0.0
6.000000	0.2270 00	0.999825	0.000059	1.000039	-0.000027	1.000000	0.000000	-0.5370 01	0.0
6.300000	0.2380 00	0.999842	0.000058	1.000031	-0.000024	1.000000	0.000000	-0.5680 01	0.0
6.600000	0.2500 00	0.999860	0.000058	1.000025	-0.000021	1.000000	0.000000	-0.5990 01	0.0
6.900000	0.2610 00	0.999877	0.000058	1.000019	-0.000018	1.000000	0.000000	-0.6300 01	0.0
7.200000	0.2730 00	0.999895	0.000058	1.000014	-0.000015	1.000000	0.000000	-0.6610 01	0.0
7.500000	0.2840 00	0.999912	0.000058	1.000010	-0.000012	1.000000	0.000000	-0.6920 01	0.0
7.800000	0.2950 00	0.999930	0.000058	1.000006	-0.000010	1.000000	0.000000	-0.7230 01	0.0
8.100000	0.3070 00	0.999947	0.000059	1.000004	-0.000008	1.000000	0.0	-0.7540 01	0.0
8.400000	0.3180 00	0.999965	0.000059	1.000002	-0.000005	1.000000	0.0	-0.7850 01	0.0
8.700000	0.3290 00	0.999982	0.000059	1.000001	-0.000003	1.000000	0.000000	-0.8160 01	0.0
9.000000	0.3410 00	1.000000	0.000059	1.000000	-0.000001	1.000000	0.000000	-0.8470 01	0.0

***** ***** *****

XO = 0.0 R = 0.0 PHI =180.00 DEG.
XI = 0.0 DXI = 0.0 CWALL= 0.0 NIT = 3
HX = 0.1000000 01 HW = 0.0

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.0 VE = 0.0
DUEDX= 0.3038120 01 DVEDX= 0.2614780-15 DUEDW= 0.0 DVEDW= 0.0

LOCAL EDGE REYNOLDS NUMBER =0.0

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.0 CFXEDG= 0.0 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.6646620-02 CHIMAX= 0.0

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.0 PSF DELTA*(X) = 0.3254310-01 THETA(X) = 0.1407100-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.3637600-01 THETA(PHI)= 0.1563910-01
WALL HEAT TRANSFER RATE =-0.653d88D 00 BTU DELTA (FT) = 0.1261040 00

ETA	Y	F	FN	G	GN	T	TN	V	FPLUS
0.0	0.0	0.0	0.926670	0.0	0.606461	0.999834	0.000089	0.0	0.0
0.300000	0.1210-01	0.255522	0.776962	0.161423	0.603551	0.999860	0.000089	-0.3880-01	0.0
0.600000	0.2420-01	0.466335	0.623497	0.360132	0.576361	0.999887	0.000086	-0.1470 00	0.0
0.900000	0.3630-01	0.633728	0.488902	0.525181	0.515961	0.999912	0.000081	-0.3110 00	0.0
1.200000	0.4830-01	0.760645	0.361206	0.667679	0.428987	0.999935	0.000071	-0.5180 00	0.0
1.500000	0.6040-01	0.851855	0.252092	0.781656	0.329837	0.999955	0.000059	-0.7570 00	0.0
1.800000	0.7250-01	0.913581	0.165190	0.865848	0.233970	0.999970	0.000045	-0.1020 01	0.0
2.100000	0.8460-01	0.952695	0.101112	0.923177	0.152881	0.999982	0.000032	-0.1300 01	0.0
2.400000	0.9670-01	0.975797	0.057569	0.959113	0.091938	0.999990	0.000021	-0.1580 01	0.0
2.700000	0.1090 00	0.988466	0.030383	0.979826	0.050780	0.999995	0.000012	-0.1870 01	0.0
3.000000	0.1210 00	0.994896	0.014822	0.990794	0.025760	0.999997	0.000007	-0.2170 01	0.0
3.300000	0.1330 00	0.997910	0.006667	0.996122	0.011985	0.999999	0.000003	-0.2460 01	0.0
3.600000	0.1450 00	0.999210	0.002759	0.998496	0.005109	1.000000	0.000002	-0.2760 01	0.0
3.900000	0.1570 00	0.999725	0.001048	0.999464	0.001993	1.000000	0.000001	-0.3050 01	0.0
4.200000	0.1690 00	0.999913	0.000364	0.999825	0.000710	1.000000	0.000000	-0.3350 01	0.0
4.500000	0.1810 00	0.999975	0.000115	0.999948	0.000231	1.000000	0.000000	-0.3640 01	0.0
4.800000	0.1930 00	0.999994	0.000033	0.999986	0.000068	1.000000	0.000000	-0.3940 01	0.0
5.100000	0.2050 00	0.999999	0.000008	0.999997	0.000018	1.000000	0.000000	-0.4230 01	0.0
5.400000	0.2180 00	1.000000	0.000002	0.999999	0.000004	1.000000	0.000000	-0.4530 01	0.0
5.700000	0.2300 00	1.000000	0.000000	1.000000	0.000001	1.000000	0.000000	-0.4820 01	0.0
6.000000	0.2420 00	1.000000	-0.000000	1.000000	0.000000	1.000000	0.000000	-0.5120 01	0.0
6.300000	0.2540 00	1.000000	-0.000000	1.000000	0.000000	1.000000	0.000000	-0.5420 01	0.0
6.600000	0.2660 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.5710 01	0.0
6.900000	0.2780 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.6010 01	0.0
7.200000	0.2900 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.6300 01	0.0
7.500000	0.3020 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.6600 01	0.0
7.800000	0.3140 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.6890 01	0.0
8.100000	0.3260 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.7190 01	0.0
8.400000	0.3380 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.7490 01	0.0
8.700000	0.3510 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.7780 01	0.0
9.000000	0.3630 00	1.000000	-0.000000	1.000000	-0.000000	1.000000	0.000000	-0.8080 01	0.0
			*****		*****		*****		

XO = 0.313260D-02 R = 0.1972310-01 PHI = 0.0 DEG.
XI = 0.2000000-01 DXI = 0.2000000-01 CWALL= 0.0 NIT = 3
HX = 0.1000000 01 HW = 0.1239320 00

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.8238820-01 VE = 0.0
DUEDX= 0.4119060 01 DVEDX= 0.0 DUEDW= 0.0 DVEDW= 0.4132960-02

LOCAL EDGE REYNOLDS NUMBER =0.1647760 00

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.4390240-01 CFXEDG= 0.1855480 01 CFWINF= 0.0 CFWEDG= 0.0
QW =-0.8500930-02 CHIMAX= 0.1625710-02

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.1679270 02 PSF DELTA*(X) = 0.2804630-01 THETA(X) = 0.1211560-01
TRANSVERSE SKIN FRICTION = 0.0 PSF DELTA*(PHI)= 0.2933620-01 THETA(PHI)= 0.1331460-01
WALL HEAT TRANSFER RATE =-0.8363130 00 BTU DELTA (FT) = 0.1042720 00

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.928241	0.0	0.733358	0.999834	0.000099	0.0	0.0
0.300000	0.105D-01	0.255990	0.776492	0.214103	0.673383	0.999863	0.000093	-0.3940-01	0.0
0.600000	0.209D-01	0.467237	0.630803	0.403582	0.587899	0.999890	0.000088	-0.1490 00	0.0
0.900000	0.314D-01	0.634961	0.489744	0.566229	0.494544	0.999915	0.000080	-0.3160 00	0.0
1.200000	0.418D-01	0.762041	0.361434	0.699889	0.395859	0.999938	0.000070	-0.5270 00	0.0
1.500000	0.523D-01	0.853227	0.251726	0.803822	0.298308	0.999957	0.000057	-0.7710 00	0.0
1.800000	0.627D-01	0.914771	0.164409	0.879564	0.209848	0.999972	0.000044	-0.1040 01	0.0
2.100000	0.732D-01	0.953617	0.100166	0.930914	0.136934	0.999983	0.000031	-0.1320 01	0.0
2.400000	0.836D-01	0.976437	0.056681	0.963129	0.082507	0.999990	0.000020	-0.1610 01	0.0
2.700000	0.941D-01	0.988865	0.029686	0.981756	0.045752	0.999995	0.000012	-0.1910 01	0.0
3.000000	0.105D 00	0.995120	0.014349	0.991656	0.023293	0.999998	0.000006	-0.2210 01	0.0
3.300000	0.115D 00	0.998022	0.006386	0.996482	0.010866	0.999999	0.000003	-0.2510 01	0.0
3.600000	0.125D 00	0.999260	0.002611	0.998636	0.004638	1.000000	0.000001	-0.2810 01	0.0
3.900000	0.136D 00	0.999745	0.000979	0.999514	0.001808	1.000000	0.000001	-0.3110 01	0.0
4.200000	0.146D 00	0.999919	0.000336	0.999842	0.000643	1.000000	0.000000	-0.3410 01	0.0
4.500000	0.157D 00	0.999977	0.000106	0.999953	0.000238	1.000000	0.000000	-0.3710 01	0.0
4.800000	0.167D 00	0.999994	0.000030	0.999987	0.000061	1.000000	0.000000	-0.4010 01	0.0
5.100000	0.178D 00	0.999998	0.000008	0.999997	0.000016	1.000000	0.000000	-0.4310 01	0.0
5.400000	0.188D 00	1.000000	0.000002	0.999999	0.000004	1.000000	0.000000	-0.4610 01	0.0
5.700000	0.199D 00	1.000000	0.000000	1.000000	0.000001	1.000000	0.000000	-0.4920 01	0.0
6.000000	0.209D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.5220 01	0.0
6.300000	0.219D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.5520 01	0.0
6.600000	0.230D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.5820 01	0.0
6.900000	0.240D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.6120 01	0.0
7.200000	0.251D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.6420 01	0.0
7.500000	0.261D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.6720 01	0.0
7.800000	0.272D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.7020 01	0.0
8.100000	0.282D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.7330 01	0.0
8.400000	0.293D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.0	-0.7630 01	0.0
8.700000	0.303D 00	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000	-0.7930 01	0.0
9.000000	0.314D 00	1.000000	0.000000	1.000000	0.000000	1.000000	-0.000000	-0.8230 01	0.0
			*****		*****		*****		

XO = 0.306541D-02 R = 0.1974030-01 PHI = 20.00 DEG.
XI = 0.2000000-01 DXI = 0.2000000-01 CWALL= 0.0 NIT = 3
HX = 0.1000230 01 HW = 0.1240170 00

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.8311930-01 VE = 0.2099460-03
DUEDX= 0.4190050 01 DVEDX=-0.1783960-02 DUEDW= 0.1621370-01 DVEDW= 0.2947920-02

LOCAL EDGE REYNOLDS NUMBER =0.166239D 00

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.446643D-01 CFXEDG= 0.186383D 01 CFWINF= 0.167951D-03 CFWEDG= 0.167951D-03
QW =-0.857481D-02 CHIMAX= 0.162664D-02

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.170341D 02 PSF DELTA*(X) = 0.278221D-01 THETA(X) = 0.120203D-01
TRANSVERSE SKIN FRICTION = 0.642411D-01 PSF DELTA*(PHI)= 0.169828D-01 THETA(PHI)= 0.855463D-02
WALL HEAT TRANSFER RATE =-0.843581D 00 BTU DELTA (FT) = 0.103529D 00

ETA	Y	F	FN	G	GN	T	TN	V	FPLUS
0.0	0.0	0.0	0.931917	0.0	0.003504	0.999834	0.000099	0.0	0.0
0.300000	0.104D-01	0.256903	0.760902	0.000913	0.002591	0.999863	0.000094	-0.400D-01	0.0
0.600000	0.208D-01	0.468687	0.632004	0.001563	0.001781	0.999890	0.000085	-0.150D 00	0.0
0.900000	0.312D-01	0.636609	0.483925	0.001994	0.001134	0.999915	0.000080	-0.318D 00	0.0
1.200000	0.416D-01	0.763621	0.360879	0.002257	0.000665	0.999938	0.000070	-0.530D 00	0.0
1.500000	0.520D-01	0.854567	0.259763	0.002434	0.000354	0.999957	0.000057	-0.774D 00	0.0
1.800000	0.624D-01	0.915794	0.183329	0.002479	0.000168	0.999972	0.000043	-0.104D 01	0.0
2.100000	0.728D-01	0.954326	0.099192	0.002512	0.000069	0.999983	0.000030	-0.132D 01	0.0
2.400000	0.832D-01	0.976884	0.033926	0.002524	0.000022	0.999991	0.000020	-0.161D 01	0.0
2.700000	0.937D-01	0.989122	0.029170	0.002527	0.000004	0.999995	0.000011	-0.191D 01	0.0
3.000000	0.104D 00	0.995255	0.014035	0.002527	-0.000001	0.999998	0.000006	-0.221D 01	0.0
3.300000	0.114D 00	0.998086	0.006214	0.002527	-0.000002	0.999999	0.000003	-0.251D 01	0.0
3.600000	0.125D 00	0.999288	0.002527	0.002526	-0.000001	1.000000	0.000001	-0.281D 01	0.0
3.900000	0.135D 00	0.999755	0.000942	0.002526	-0.000001	1.000000	0.000001	-0.311D 01	0.0
4.200000	0.146D 00	0.999922	0.000321	0.002526	-0.000000	1.000000	0.000000	-0.341D 01	0.0
4.500000	0.156D 00	0.999977	0.000100	0.002526	-0.000000	1.000000	0.000000	-0.371D 01	0.0
4.800000	0.166D 00	0.999993	0.000029	0.002526	-0.000000	1.000000	0.000000	-0.401D 01	0.0
5.100000	0.177D 00	0.999998	0.000008	0.002526	-0.000000	1.000000	-0.000000	-0.432D 01	0.0
5.400000	0.187D 00	0.999999	0.000002	0.002526	-0.000000	1.000000	-0.000000	-0.462D 01	0.0
5.700000	0.198D 00	0.999999	0.000001	0.002526	-0.000000	1.000000	-0.000000	-0.492D 01	0.0
6.000000	0.208D 00	0.999999	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.522D 01	0.0
6.300000	0.219D 00	0.999999	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.552D 01	0.0
6.600000	0.229D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.582D 01	0.0
6.900000	0.239D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.612D 01	0.0
7.200000	0.250D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.642D 01	0.0
7.500000	0.260D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.672D 01	0.0
7.800000	0.271D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.703D 01	0.0
8.100000	0.281D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.733D 01	0.0
8.400000	0.291D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.763D 01	0.0
8.700000	0.302D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.793D 01	0.0
9.000000	0.312D 00	1.000000	0.000000	0.002526	-0.000000	1.000000	-0.000000	-0.823D 01	0.0
			*****		*****		*****		

XO = 0.287100D-02 R = 0.197886D-01 PHI = 40.00 DEG.
XI = 0.200000D-01 DXI = 0.200000D-01 CWALL= 0.0 NIT = 2
HX = 0.100090D 01 HW = 0.124345D 00

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.300300D 03 UE = 0.841120D-01 VE = 0.275812D-03
DUEDX= 0.426873D 01 DVEDX=-0.158899D-01 DUEDW= 0.228429D-01 DVEDW=-0.107620D-02

LOCAL EDGE REYNOLDS NUMBER =0.168224D 00

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.4554980-01 CFXEDG= 0.1857240 01 CFWINF= 0.2099880-03 CFWEDG= 0.2099880-03
QW =-0.8672120-02 CHIMAX= 0.1633740-02

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.1742280 02 PSF DELTA*(X) = 0.2763040-01 THETA(X) = 0.1194230-01
TRANSVERSE SKIN FRICTION = 0.8032040-01 PSF DELTA*(PHI)= 0.1823190-01 THETA(PHI)= 0.9200520-02
WALL HEAT TRANSFER RATE =-0.8531540 00 BTU DELTA (FT) = 0.1029050 00

ETA	Y	F	FN	G	GN	T	TN	V	FPLUS
0.0	0.0	0.0	0.933618	0.0	0.004304	0.999834	0.000100	0.0	0.0
0.300000	0.1030-01	0.257284	0.781770	0.001129	0.003232	0.999863	0.000094	-0.3970-01	0.0
0.600000	0.2070-01	0.469224	0.632231	0.001948	0.002272	0.999890	0.000083	-0.1500 00	0.0
0.900000	0.3100-01	0.637145	0.489751	0.002506	0.001494	0.999916	0.000080	-0.3170 00	0.0
1.200000	0.4140-01	0.764370	0.363518	0.002860	0.000916	0.999938	0.000072	-0.5290 00	0.0
1.500000	0.5170-01	0.854897	0.259364	0.003069	0.000520	0.999957	0.000057	-0.7730 00	0.0
1.800000	0.6210-01	0.916012	0.162967	0.003183	0.000271	0.999972	0.000043	-0.1040 01	0.0
2.100000	0.7240-01	0.954454	0.098938	0.003239	0.000128	0.999983	0.000030	-0.1320 01	0.0
2.400000	0.8280-01	0.976949	0.055758	0.003265	0.000054	0.999991	0.000020	-0.1610 01	0.0
2.700000	0.9310-01	0.989148	0.029072	0.003275	0.000020	0.999995	0.000011	-0.1910 01	0.0
3.000000	0.1030 00	0.995259	0.013984	0.003276	0.000006	0.999998	0.000006	-0.2210 01	0.0
3.300000	0.1140 00	0.998080	0.006191	0.003279	0.000001	0.999999	0.000003	-0.2510 01	0.0
3.600000	0.1240 00	0.999277	0.002519	0.003279	0.000000	1.000000	0.000001	-0.2810 01	0.0
3.900000	0.1340 00	0.999744	0.000941	0.003279	-0.000000	1.000000	0.000000	-0.3110 01	0.0
4.200000	0.1450 00	0.999912	0.000324	0.003279	-0.000000	1.000000	0.000000	-0.3410 01	0.0
4.500000	0.1550 00	0.999967	0.000104	0.003279	-0.000000	1.000000	0.000000	-0.3710 01	0.0
4.800000	0.1660 00	0.999985	0.000033	0.003279	-0.000000	1.000000	-0.000000	-0.4010 01	0.0
5.100000	0.1760 00	0.999990	0.000012	0.003279	-0.000000	1.000000	-0.000000	-0.4310 01	0.0
5.400000	0.1860 00	0.999993	0.000006	0.003279	-0.000000	1.000000	-0.000000	-0.4610 01	0.0
5.700000	0.1970 00	0.999994	0.000004	0.003279	-0.000000	1.000000	-0.000000	-0.4920 01	0.0
6.000000	0.2070 00	0.999995	0.000003	0.003279	-0.000000	1.000000	-0.000000	-0.5220 01	0.0
6.300000	0.2170 00	0.999996	0.000003	0.003279	-0.000000	1.000000	-0.000000	-0.5520 01	0.0
6.600000	0.2280 00	0.999997	0.000003	0.003279	-0.000000	1.000000	-0.000000	-0.5820 01	0.0
6.900000	0.2380 00	0.999998	0.000002	0.003279	-0.000000	1.000000	-0.000000	-0.6120 01	0.0
7.200000	0.2480 00	0.999998	0.000002	0.003279	-0.000000	1.000000	-0.000000	-0.6420 01	0.0
7.500000	0.2590 00	0.999999	0.000002	0.003279	-0.000000	1.000000	-0.000000	-0.6720 01	0.0
7.800000	0.2690 00	0.999999	0.000001	0.003279	-0.000000	1.000000	-0.000000	-0.7020 01	0.0
8.100000	0.2790 00	0.999999	0.000001	0.003279	-0.000000	1.000000	-0.000000	-0.7320 01	0.0
8.400000	0.2900 00	1.000000	0.000001	0.003279	-0.000000	1.000000	-0.000000	-0.7620 01	0.0
8.700000	0.3000 00	1.000000	0.000000	0.003279	-0.000000	1.000000	-0.000000	-0.7930 01	0.0
9.000000	0.3100 00	1.000000	0.000000	0.003279	-0.000000	1.000000	-0.000000	-0.8230 01	0.0
			*****		*****		*****		

XO = 0.2570560-02 R = 0.1985960-01 PHI = 60.00 DEG.
XI = 0.2000000-01 DXI = 0.2000000-01 CWALL= 0.0 NIT = 4
HX = 0.1001950 01 HW = 0.1248440 00

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.3003000 03 UE = 0.8574730-01 VE = 0.4219880-04
DUEDX= 0.4400170 01 DVEDX=-0.5528260-01 DUEDW= 0.3524760-01 DVEDW=-0.7545450-02

LOCAL EDGE REYNOLDS NUMBER =0.1714950 00

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.4703820-01 CFXEDG= 0.1873350 01 CFWINF=-0.1505740-04 CFWEDG=-0.1505740-04
QW =-0.8842100-02 CHIMAX= 0.1644560-02

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.179921D 02 PSF DELTA*(X) = 0.273096D-01 THETA(X) = 0.118116D-01
TRANSVERSE SKIN FRICTION =-0.575945D-02 PSF DELTA*(PHI)= 0.522601D-01 THETA(PHI)= 0.976522D-02
WALL HEAT TRANSFER RATE =-0.869377D 00 BTU DELTA (FT) = 0.101900D 00

ETA	Y	F	FN	G	GN	T	TN	V	EPLUS
0.0	0.0	0.0	0.936677	0.0	-0.000300	0.999834	0.000101	0.0	0.0
0.300000	0.102D-01	0.257993	0.753473	-0.000047	-0.000323	0.999863	0.000095	-0.391D-01	0.0
0.600000	0.205D-01	0.470269	0.632851	-0.000019	0.000190	0.999891	0.000089	-0.146D 00	0.0
0.900000	0.307D-01	0.638251	0.489619	0.000059	0.000304	0.999916	0.000081	-0.315D 00	0.0
1.200000	0.410D-01	0.765059	0.359944	0.000160	0.000340	0.999939	0.000070	-0.528D 00	0.0
1.500000	0.512D-01	0.855678	0.249607	0.000258	0.000307	0.999958	0.000057	-0.772D 00	0.0
1.800000	0.615D-01	0.916562	0.162241	0.000341	0.000241	0.999973	0.000043	-0.104D 01	0.0
2.100000	0.717D-01	0.954795	0.098317	0.000403	0.000168	0.999984	0.000030	-0.132D 01	0.0
2.400000	0.820D-01	0.977130	0.055309	0.000443	0.000106	0.999991	0.000019	-0.161D 01	0.0
2.700000	0.922D-01	0.989219	0.028786	0.000468	0.000060	0.999996	0.000011	-0.191D 01	0.0
3.000000	0.102D 00	0.995265	0.013825	0.000481	0.000031	0.999998	0.000006	-0.220D 01	0.0
3.300000	0.113D 00	0.998053	0.006118	0.000487	0.000015	0.999999	0.000003	-0.250D 01	0.0
3.600000	0.123D 00	0.999237	0.002494	0.000490	0.000006	1.000000	0.000001	-0.280D 01	0.0
3.900000	0.133D 00	0.999701	0.000941	0.000491	0.000002	1.000000	0.000000	-0.311D 01	0.0
4.200000	0.143D 00	0.999870	0.000335	0.000492	0.000001	1.000000	0.000000	-0.341D 01	0.0
4.500000	0.154D 00	0.999929	0.000119	0.000492	0.000000	1.000000	-0.000000	-0.371D 01	0.0
4.800000	0.164D 00	0.999951	0.000048	0.000492	0.000000	1.000000	-0.000000	-0.401D 01	0.0
5.100000	0.174D 00	0.999962	0.000026	0.000492	0.000000	1.000000	-0.000000	-0.431D 01	0.0
5.400000	0.184D 00	0.999968	0.000019	0.000492	0.000000	1.000000	-0.000000	-0.461D 01	0.0
5.700000	0.195D 00	0.999973	0.000016	0.000492	0.000000	1.000000	-0.000000	-0.491D 01	0.0
6.000000	0.205D 00	0.999978	0.000015	0.000492	0.000000	1.000000	-0.000000	-0.521D 01	0.0
6.300000	0.215D 00	0.999982	0.000013	0.000492	0.000000	1.000000	-0.000000	-0.551D 01	0.0
6.600000	0.225D 00	0.999986	0.000012	0.000492	0.000000	1.000000	-0.000000	-0.581D 01	0.0
6.900000	0.236D 00	0.999989	0.000010	0.000492	0.000000	1.000000	-0.000000	-0.611D 01	0.0
7.200000	0.246D 00	0.999992	0.000009	0.000492	0.000000	1.000000	-0.000000	-0.641D 01	0.0
7.500000	0.256D 00	0.999994	0.000007	0.000492	0.000000	1.000000	-0.000000	-0.671D 01	0.0
7.800000	0.266D 00	0.999996	0.000006	0.000492	0.000000	1.000000	-0.000000	-0.701D 01	0.0
8.100000	0.277D 00	0.999998	0.000004	0.000492	0.000000	1.000000	-0.000000	-0.731D 01	0.0
8.400000	0.287D 00	0.999999	0.000003	0.000492	0.000000	1.000000	-0.000000	-0.761D 01	0.0
8.700000	0.297D 00	1.000000	0.000002	0.000492	0.000000	1.000000	-0.000000	-0.792D 01	0.0
9.000000	0.307D 00	1.000000	0.000001	0.000492	0.000000	1.000000	0.000000	-0.822D 01	0.0
			*****		*****		*****		

XO = 0.219793D-02 R = 0.199412D-01 PHI = 80.00 DEG.
XI = 0.200000D-01 DXI = 0.200000D-01 CWALL= 0.0 NIT = 3
HX = 0.100326D 01 HW = 0.125405D 00

NONDIMENSIONAL EDGE PROPERTIES

TE = 0.300300D 03 UE = 0.878899D-01 VE =-0.529943D-03
DUEDX= 0.457560D 01 DVEDX=-0.120707D 00 DUEDW= 0.386691D-01 DVEDW=-0.120687D-01

LOCAL EDGE REYNOLDS NUMBER =0.175780D 00

NONDIMENSIONAL BOUNDARY LAYER PARAMETERS

CFXINF= 0.490110D-01 CFXEDG= 0.188098D 01 CFWINF=-0.550906D-03 CFWEDG=-0.550906D-03
QW =-0.901737D-02 CHIMAX= 0.165825D-02

DIMENSIONAL BOUNDARY LAYER PARAMETERS

LONGITUDINAL SKIN FRICTION= 0.187467D 02 PSF DELTA*(X) = 0.269223D-01 THETA(X) = 0.116607D-01
TRANSVERSE SKIN FRICTION =-0.213722D 00 PSF DELTA*(PHI)= 0.103988D-01 THETA(PHI)= 0.431052D-02
WALL HEAT TRANSFER RATE =-0.887120D 00 BTU DELTA (FT) = 0.100831D 00

APPENDIX IX

Program ICBL3D Data FORMAT Sheets

IBM

FORTRAN Coding Form

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PROGRAM ICBL3D

PUNCHING INSTRUCTIONS

GRAPHIC

PUNCH

PAGE OF

PROGRAMMER DATE

CARD ELECTRO NUMBER

FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
DATA DECK	
CARD 1	
LABEL	
(20A4)	
LABEL TITLE OF CASE. APPEARS AS THE HEADER TO PROGRAM OUTPUT	
CARD 2	
IE	
(49X,I3)	
IE NUMBER OF POINTS NORMAL TO BODY. RECOMMENDED VALUE 101.	
CARD 3	
INJCT	
(49X,I3)	
INJCT SUBSCRIPT OF XSTA ARRAY, GIVES LOCATION FOR MASS INJECTION	

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FORTRAN Coding Form

GX28-7327-6 U/M 050** Printed in U.S.A.

PROGRAM ICBL3D | GRAPHIC | PAGE OF

PROGRAMMER | DATE | PUNCHING INSTRUCTIONS | PUNCH | CARD ELECTRO NUMBER*

STATEMENT NUMBER	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
CARD 4		
	KADETA	
	(49X,I3)	
	KADETA INDICATOR FOR THE ADJUSTMENT OF THE TRANSFORMED NORMAL COORDINATE	
CARD 5		
	KEND2	
	(49X,I3)	
	KEND2 NUMBER OF CIRCUMFERENTIAL PLANES	
CARD 6		
	KONSET	
	(49X,I3)	
	KONSET SUBSCRIPT OF XSTA ARRAY, LOCATES ONSET OF TRANSITION	

**Number of forms per pad may vary slightly

IBM

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PROGRAM ICBL3D

PROGRAMMER DATE

PUNCHING INSTRUCTIONS GRAPHIC PUNCH

PAGE OF

CARD ELECTRO NUMBER*

FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
CARD 7	
KPRT	
(49 X, I3)	
KPRT PARAMETER WHICH CONTROLS PRINTING OF PROFILES IN Φ DIRECTION	
CARD 8	
KTRANS	
(49X, I3)	
KTRANS INDICATOR FOR TRANSITION MODEL	
CARD 9	
LAMTRB	
(49X, I3)	
LAMTRB INDICATES WHETHER FLOW IS LAMINAR OR TURBULENT	

*Number of forms per pad may vary slightly

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PROGRAM ICBL3D

PROGRAMMER

DATE

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PAGE OF

CARD ELECTRO NUMBER

FORTRAN STATEMENT

IDENTIFICATION SEQUENCE

```
CARD 10
                                                    LPRT
                                                    [ ]
                                                  (49X,I3)
      LPRT     PRINT CONTROL PARAMETER IN THE STREAMWISE DIRECTION
CARD 11
                                                    NIT1
                                                    [ ]
                                                  (49X,I3)
      NIT1     ITERATION COUNTER USED TO ADJUST STREAMWISE STEP SIZE
CARD 12
                                                    NIT2
                                                    [ ]
                                                  (49X,I3)
      NIT2     ITERATION COUNTER USED TO ADJUST STREAMWISE STEP SIZE
```

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PROGRAM ICBL3D

DATE

PUNCHING INSTRUCTIONS

GRAPHIC PUNCH

PAGE OF

CARD ELECTRO NUMBER

C	STATEMENT NUMBER	Continue	FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
			CARD 13	
			NIT3	
			(49X,I3)	
			NIT3 ITERATION COUNTER USED TO ADJUST STREAMWISE STEP SIZE	
			CARD 14	
			NOINJ	
			(49X,I3)	
			NOINJ SUBSCRIPT OF XSTA ARRAY, LOCATES END OF INJECTION	
			CARD 15	
			SFC	
			(49X,A3)	
			SFC LITERAL VARIABLE INDICATES IF SURFACE CURVATURE EFFECTS INCLUDED	

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FORTRAN Coding Form

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PROGRAM ICBL3D | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE OF

PROGRAMMER | DATE | PUNCH | CARD ELECTRO NUMBER

FORTRAN STATEMENT

CARD 16

NSOLVE

(49X,I3)

NSOLVE NUMBER OF VARIABLES IN THE XSTA ARRAY

CARD 17

ADTEST

(49X,E14.6)

ADTEST PROVIDES CONVERGENCE CRITERIA FOR STREAMWISE VELOCITY PROFILE

CARD 18

AKSTAR

(49X,E14.6)

AKSTAR VAN DRIEST INNER EDDY VISCOSITY LAW CONSTANT (REC. VALUE .435)

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FORTRAN Coding Form

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PROGRAM ICBL3D

PROGRAMMER DATE FUNCTIONING INSTRUCTIONS GRAPHIC PUNCH PAGE OF CARD ELECTRO NUMBER*

FORTRAN STATEMENT

IDENTIFICATION SEQUENCE

CARD 19

ALAMDA

(49X,E14.6)

ALAMDA CONSTANT IN OUTER VISCOSITY LAW (REC. VALUE 0.09)

CARD 20

ASTAR

(49X,E14.6)

ASTAR CONSTANT IN DAMPING TERM VAN DRIEST'S INNER VISCOSITY LAW (REC.VALUE 26.0)

CARD 21

CWALL

(49X,E14.6)

CWALL CONSTANT RATE FOR MASS TRANSFER CASES

*Number of forms per pad may vary slightly

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PROGRAM ICBL3D

CARD 22

CONV

(49X,E14.6)

CONV CONVERGENCE CRITERION

CARD 23

DXMAX

(49X,E14.6)

DMAX MAXIMUM STEP SIZE

CARD 24

DX

(49X,E14.6)

DX1 INITIAL STREAMWISE STEP SIZE

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PROGRAM ICBL3D PUNCHING INSTRUCTIONS GRAPHIC PUNCH PAGE OF

PROGRAMMER DATE CARD ELECTRIC NUMBER

FORTRAN STATEMENT	IDENTIFICATION SEQUENCE
CARD 25	
EDYLAW [ ] (49X, A3)	
EDYLAW INNER EDDY VISCOSITY LAW TO BE USED IN TURBULENT CASES	
CARD 26	
ETAFAC [ ] (49X, E14.6)	
ETAFAC CONTROLS NORMAL GRID SPACING	
CARD 27	
ETAINF [ ] (49X, E14.6)	
ETAINF MAXIMUM VALUE OF η.	

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PROGRAM ICBL3D PUNCHING INSTRUCTIONS GRAPHIC PUNCH PAGE OF

PROGRAMMER DATE CARD ELECTRO NUMBER

| FORTRAN STATEMENT | | |

IBM

FORTRAN Coding Form

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PROGRAM ICBL3D

PROGRAMMER

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CARD ELECTRO NUMBER

FORTRAN STATEMENT

IDENTIFICATION SEQUENCE

CARD 3 1

AMUINF

(49X,E14.6)

AMUINF COEFFICIENT OF VISCOSITY

CARD 3 2

PSTAG

(49X,E14.6)

PSTAG FREESTREAM TOTAL PRESSURE

CARD 3 3

PINF

(49X,E14.6)

PINF FREESTREAM STATIC PRESSURE

PROGRAM ICBL3D DATE PUNCHING INSTRUCTIONS GRAPHIC PUNCH PAGE OF CARD ELECTRO NUMBER*

FORTRAN STATEMENT | IDENTIFICATION SEQUENCE

CARD 34

XBAR

(49X, E14.6)

XBAR RELATIVE LENGTH OF THE TRANSITION REGIME IN TURBULENT CASES

CARD 35

UFS

(49X, E14.6)

UFS FREE-STREAM VELOCITY

CARD 36 TO CARD 36+NSOLVE

XSTA(I) I=1, NSOLVE

(F12.6)

XSTA(I) ARRAY OF SURFACE DISTANCES WHERE SOLUTIONS DESIRED

*Number of punches per card may vary slightly

IBM

FORTRAN Coding Form

GX28-7327-6 U/M 050**
Printed in U.S.A.

PROGRAM: ICBL3D

PROGRAMMER | DATE | PUNCHING INSTRUCTIONS | GRAPHIC | PUNCH | PAGE OF | CARD ELECTRO NUMBER*

STATEMENT NUMBER | CONT | FORTRAN STATEMENT | IDENTIFICATION SEQUENCE

```
CARD 36+NSOLVE+1 TO LAST CARD
     XTW(I)        TWX(I)        XC1(I)        CIX(I)
                    (4E12.6)
     XTW(I)    ARRAY OF SURFACE DISTANCES CORRESPONDING TO WALL TEMPERATURES
     TWX(I)    WALL TEMPERATURE AT XTW(I)
     XC1(I)    ARRAY OF SURFACE DISTANCES CORRESPONDING TO INJECTION RATES
     CIX(I)    INJECTION RATE AT XC1(I)
```

*Number of forms per pad may vary slightly

APPENDIX X

Program ICBL3D Listing

DATE 05/12/77

```
C     PROGRAM MAIN                                                              10
      IMPLICIT REAL*8(A-H,O-Z)                                                  20
      REAL*8 NOSE                                                               30
      COMMON /ASSVAR/ IFL,KBL                                                   40
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                                   50
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,        60
     1101,3),TN(2,101,3),Y(101),YOL(101)                                        70
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101        80
     1),CRI                                                                     90
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR                    100
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,ALST,X,XX,WX                               110
      COMMON /INJECT/ INJCT,NOINJ,MASTRN                                        120
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KK,LL,NBLNT1,IND,KPRT,LPRT,KPR,      130
     1LPR                                                                       140
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)           150
      COMMON /STAG/ PSTAG,TSTAG,PNC,WSTAG                                       160
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,TWALL,TWALL,XTW(500),TWX(500),X        170
     1CI(500),CIX(500),TCONW,KCI,KTW                                            180
      COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                                  190
      COMMON /TRANSN/ KTRANS,KONSET,XIE,CHI2(101),CHIMAX,XBAR                   200
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUS        210
     1(101),LAMTRB                                                              220
      COMMON /WSOLVE/ DW                                                        230
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                          240
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE                       250
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA            260
      CALL ERRSET (208,256,0,0,0,207)                                           270
      DEFINE FILE 8(61,6472,L,IFL)                                              280
      CALL INPUT                                                                290
      CALL INIT                                                                 300
      CALL AERO                                                                 310
      CALL OUTI                                                                 320
      CALL CONTRL                                                               330
      END                                                                       340
*
      SUBROUTINE ABCDE (W)                                              ABCD   10
      IMPLICIT REAL*8(A-H,O-Z)                                          ABCD   20
      REAL*8 NOSE                                                       ABCD   30
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101ABCD   40
     1),CRI                                                             ABCD   50
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KK,LL,NBLNT1,IND,KPRT,LPRT,KPABCD   60
     1R,LPR                                                             ABCD   70
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)   ABCD   80
      COMMON /WSOLVE/ DW,WCOORD                                         ABCD   90
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                  ABCD  100
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA    ABCD  110
      DIMENSION W(2,101,3)                                              ABCD  120
```

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C                                                                       ABCD 130
C     SUBROUTINE ABCDE CALCULATES THE COEFFICIENTS OF THE GOVERNING     ABCD 140
C     EQUATIONS IN FINITE-DIFFERENCE FORM                               ABCD 150
C                                                                       ABCD 160
      I=1                                                               ABCD 170
      K=2                                                               ABCD 180
C                                                                       ABCD 190
C                                                                       ABCD 200
      IF (KK.EQ.1.AND.LL.EQ.1) GO TO 60                                 ABCD 210
      IF (KK.EQ.1) GO TO 40                                             ABCD 220
      IF (LL.EQ.1) GO TO 20                                             ABCD 230
C                                                                       ABCD 240
C     COEFFICIENTS FOR THE GENERAL CASE                                 ABCD 250
C                                                                       ABCD 260
      DO 10 J=2,IM                                                      ABCD 270
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))                 ABCD 280
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2            ABCD 290
      A(J)=CRI*(2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1)         ABCD 300
      CC(J)=CRI*(2.0D0*A0(J)/DETA2+A1(J)/DETA1)                         ABCD 310
      BB(J)=CRI*(-2.0D0*(1.0D0+ETAFAC)*A0(J)/DETA2-(1.0D0-ETAFAC**2)*A1(ABCD 320
     1J)/DETA1+A2(J))                                                   ABCD 330
      B(J)=BB(J)+A4(J)/DX1+A5(J)/2.0D0/DW                               ABCD 340
      DD(J)=-(1.0D0-CRI)/CRI*(A(J)*W(I,J-1,K)+BB(J)*W(I,J,K)+CC(J)*W(I,JABCD 350
     1+1,K))                                                            ABCD 360
      D(J)=DD(J)-A3(J)+A4(J)*W(I,J,K)/DX1+A5(J)*(W(I+1,J,K-1)-W(I,J,K+1)ABCD 370
     1+W(I,J,K))/2.0D0/DW                                               ABCD 380
10    CONTINUE                                                          ABCD 390
      RETURN                                                            ABCD 400
20    CONTINUE                                                          ABCD 410
C                                                                       ABCD 420
C     COEFFICIENTS FOR THE STAGNATION LINE                              ABCD 430
C                                                                       ABCD 440
      I=2                                                               ABCD 450
      K=1                                                               ABCD 460
      DO 30 J=2,IM                                                      ABCD 470
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))                 ABCD 480
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2            ABCD 490
      A(J)=CRI*(2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1)         ABCD 500
      CC(J)=CRI*(2.0D0*A0(J)/DETA2+A1(J)/DETA1)                         ABCD 510
      BB(J)=CRI*(-2.0D0*(1.0D0+ETAFAC)*A0(J)/DETA2-(1.0D0-ETAFAC**2)*A1(ABCD 520
     1J)/DETA1+A2(J))                                                   ABCD 530
      B(J)=BB(J)+A5(J)/DW                                               ABCD 540
      D(J)=-A3(J)+A5(J)*W(I,J,K)/DW-(1.0D0-CRI)/CRI*(A(J)*W(I,J-1,K)+BB(ABCD 550
     1J)*W(I,J,K)+CC(J)*W(I,J+1,K))                                     ABCD 560
30    CONTINUE                                                          ABCD 570
      RETURN                                                            ABCD 580
40    CONTINUE                                                          ABCD 590
C                                                                       ABCD 600
C     COEFFICIENTS FOR THE WINDWARD STREAMLINE                          ABCD 610
C                                                                       ABCD 620
      I=1                                                               ABCD 630
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      K=2                                                                ABCD 640
      DO 50 J=2,IM                                                       ABCD 650
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))                  ABCD 660
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2             ABCD 670
      A(J)=CRI*(2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1)          ABCD 680
      CC(J)=CRI*(2.0D0*A0(J)/DETA2+A1(J)/DETA1)                          ABCD 690
      BB(J)=CRI*(-2.0D0*(1.0D0+ETAFAC)*A0(J)/DETA2-(1.0D0-ETAFAC**2)*A1(ABCD 700
     1J)/DETA1+A2(J))                                                    ABCD 710
      B(J)=BB(J)+A4(J)/DXI                                               ABCD 720
      D(J)=-(1.0D0-CRI)/CRI*(A(J)*W(I,J-1,K)+BB(J)*W(I,J,K)+CC(J)*W(I,J+ABCD 730
     11,K))+A4(J)*W(I,J,K)/DXI-A3(J)                                     ABCD 740
50    CONTINUE                                                           ABCD 750
      RETURN                                                             ABCD 760
60    CONTINUE                                                           ABCD 770
C                                                                        ABCD 780
C     O.D.E. COEFFICIENTS FOR THE STAGNATION POINT                       ABCD 790
C                                                                        ABCD 800
      DO 70 J=2,IM                                                       ABCD 810
      DETA1=ETA(J+1)-ETA(J)+ETAFAC**2*(ETA(J)-ETA(J-1))                  ABCD 820
      DETA2=(ETA(J+1)-ETA(J))**2+ETAFAC*(ETA(J)-ETA(J-1))**2             ABCD 830
      A(J)=2.0D0*ETAFAC*A0(J)/DETA2-ETAFAC**2*A1(J)/DETA1                ABCD 840
      CC(J)=2.0D0*A0(J)/DETA2+A1(J)/DETA1                                ABCD 850
      B(J)=-2.0D0*(1.0D0+ETAFAC)*A0(J)/DETA2-(1.0D0-ETAFAC**2)*A1(J)/DETABCD 860
     1A1+A2(J)                                                           ABCD 870
      D(J)=-A3(J)                                                        ABCD 880
70    CONTINUE                                                           ABCD 890
      RETURN                                                             ABCD 900
      END                                                                ABCD 910


      SUBROUTINE ADDETA (TST,ASYM,ETAOLD)                                ADDE  10
      IMPLICIT REAL*8(A-H,O-Z)                                           ADDE  20
      REAL*8 NOSE                                                        ADDE  30
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,ADDE  40
     1101,3),TN(2,101,3),Y(101),YOL(101)                                 ADDE  50
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                        ADDE  60
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,ADDE  70
     1LPR                                                                ADDE  80
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),ADDE  90
     1TWN(101),XIW,XW,RW                                                 ADDE 100
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE                ADDE 110
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA0(101),DETA0(101),ADTEST,KADETA   ADDE 120
      DIMENSION ETA2(101), DETA2(101), GW2(101), VW2(101), FW2(101), GW2ADDE 130
     1(101), TW2(101), F2A(101), F2B(101), F2C(101), G2A(101), G2B(101),ADDE 140
     2 G2C(101), T2A(101), T2B(101), T2C(101)                            ADDE 150
      DIMENSION F2D(101), T2D(101), G2D(101), ETA(101)                   ADDE 160
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                  ADDE 170
C                                                                        ADDE 180
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DATE  05/12/77

C                                                                              ADDE 190
      IE2=(IE-1)/2                                                             ADDE 200
      IF (TST.EQ.0.0D0) GO TO 20                                               ADDE 210
      IF (TST.EQ.2.0D0) GO TO 10                                               ADDE 220
      ETAIN2=1.1D0*ETAINF                                                      ADDE 230
      WRITE (6,280) X,ETAINF,ETAIN2,TST                                        ADDE 240
      GO TO 20                                                                 ADDE 250
10    ETAIN2=.9D0*ETAINF                                                       ADDE 260
      WRITE (6,290) X,ETAINF,ETAIN2,TST                                        ADDE 270
      GO TO 20                                                                 ADDE 280
      ETAIN2=ETAINF                                                            ADDE 290
      WRITE (6,300) X,ETAOLD,ETAIN2,TST                                        ADDE 300
      GO TO 40                                                                 ADDE 310
20    CONTINUE                                                                 ADDE 320
      IF (ETAFAC.EQ.1.0D0) DETA1=ETAIN2/DFLOAT(IM)                             ADDE 330
      IF (ETAFAC.NE.1.0D0) DETA1=ETAIN2*(ETAFAC-1.0D0)/(ETAFAC**IM-1.0D0)ADDE 340
     1)                                                                        ADDE 350
      DETA2(1)=0.0D0                                                           ADDE 360
      DETA2(2)=DETA1                                                           ADDE 370
      ETA(1)=0.0D0                                                             ADDE 380
      ETA2(1)=0.0D0                                                            ADDE 390
      ETA2(2)=DETA2(2)                                                         ADDE 400
      DO 30 N=2,IM                                                             ADDE 410
      DETA2(N+1)=DETA2(N)*ETAFAC                                               ADDE 420
      ETA2(N+1)=ETA2(N)+DETA2(N+1)                                             ADDE 430
      ETA(N)=ETAO(N)                                                           ADDE 440
30    CONTINUE                                                                 ADDE 450
      ETA2(IE)=ETAIN2                                                          ADDE 460
      ETA(IE)=ETAINF                                                           ADDE 470
      GO TO 60                                                                 ADDE 480
40    CONTINUE                                                                 ADDE 490
      IF (ETAFAC.EQ.1.0D0) DETA1=ETAOLD/DFLOAT(IM)                             ADDE 500
      IF (ETAFAC.NE.1.0D0) DETA1=ETAOLD*(ETAFAC-1.0D0)/(ETAFAC**IM-1.0D0)ADDE 510
     1)                                                                        ADDE 520
      DETA2(1)=0.0D0                                                           ADDE 530
      DETA2(2)=DETA1                                                           ADDE 540
      ETA2(1)=0.0D0                                                            ADDE 550
      ETA(1)=0.0D0                                                             ADDE 560
      ETA(2)=DETA2(2)                                                          ADDE 570
      DO 50 N=2,IM                                                             ADDE 580
      DETA2(N+1)=DETA2(N)*ETAFAC                                               ADDE 590
      ETA(N+1)=ETA(N)+DETA2(N+1)                                               ADDE 600
      ETA2(N)=ETAO(N)                                                          ADDE 610
50    CONTINUE                                                                 ADDE 620
      ETA(IE)=ETAOLD                                                           ADDE 630
      ETA2(IE)=ETAINF                                                          ADDE 640
60    DO 160 N=1,IE                                                            ADDE 650
      IF (ETA2(N).GE.ETAOLD) GO TO 150                                         ADDE 660
      J=0                                                                      ADDE 670
70    J=J+1                                                                    ADDE 680
      IF (ETA2(N).GT.ETA(J)) GO TO 70                                          ADDE 690
```

```
      IF (J.LT.2) J=2                                                   ADDE 700
      IF (J.GT.(IE-1)) J=IE-1                                           ADDE 710
      IF (TST.GT.2.0D0) GO TO 90                                        ADDE 720
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),VW(J-1),VW(J),VW(J+1ADDE 730
     1),VW2(N))                                                         ADDE 740
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),FW(J-1),FW(J),FW(J+1ADDE 750
     1),FW2(N))                                                         ADDE 760
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),TW(J-1),TW(J),TW(J+1ADDE 770
     1),TW2(N))                                                         ADDE 780
      IF (GW(IE2).EQ.0.0D0) GO TO 80                                    ADDE 790
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),GW(J-1),GW(J),GW(J+1ADDE 800
     1),GW2(N))                                                         ADDE 810
80    CONTINUE                                                          ADDE 820
90    IF (TST.EQ.3.0D0) GO TO 110                                       ADDE 830
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(1,J-1,3),F(1,J,3),ADDE 840
     1F(1,J+1,3),F2C(N))                                                ADDE 850
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(1,J-1,3),T(1,J,3),ADDE 860
     1T(1,J+1,3),T2C(N))                                                ADDE 870
      IF (G(1,IE2,3).EQ.0.0D0) GO TO 100                                ADDE 880
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(1,J-1,3),G(1,J,3),ADDE 890
     1G(1,J+1,3),G2C(N))                                                ADDE 900
100   CONTINUE                                                          ADDE 910
110   IF (TST.GT.2.D0) GO TO 140                                        ADDE 920
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(2,J-1,2),F(2,J,2),ADDE 930
     1F(2,J+1,2),F2D(N))                                                ADDE 940
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(2,J-1,2),T(2,J,2),ADDE 950
     1T(2,J+1,2),T2D(N))                                                ADDE 960
      IF (G(2,IE2,2).EQ.0.0D0) GO TO 120                                ADDE 970
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(2,J-1,2),G(2,J,2),ADDE 980
     1G(2,J+1,2),G2D(N))                                                ADDE 990
      IF (TST.EQ.5.D0) GO TO 160                                        ADDE1000
120   CONTINUE                                                          ADDE1010
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(2,J-1,1),F(2,J,1),ADDE1020
     1F(2,J+1,1),F2A(N))                                                ADDE1030
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(2,J-1,1),T(2,J,1),ADDE1040
     1T(2,J+1,1),T2A(N))                                                ADDE1050
      IF (G(2,IE2,1).EQ.0.0D0) GO TO 130                                ADDE1060
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(2,J-1,1),G(2,J,1),ADDE1070
     1G(2,J+1,1),G2A(N))                                                ADDE1080
130   CONTINUE                                                          ADDE1090
140   IF (TST.EQ.4.0D0) GO TO 160                                       ADDE1100
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),F(1,J-1,2),F(1,J,2),ADDE1110
     1F(1,J+1,2),F2B(N))                                                ADDE1120
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),T(1,J-1,2),T(1,J,2),ADDE1130
     1T(1,J+1,2),T2B(N))                                                ADDE1140
      IF (G(1,IE2,2).EQ.0.0D0) GO TO 160                                ADDE1150
      CALL INTER3 (ETA2(N),ETA(J-1),ETA(J),ETA(J+1),G(1,J-1,2),G(1,J,2),ADDE1160
     1G(1,J+1,2),G2B(N))                                                ADDE1170
      GO TO 160                                                         ADDE1180
150   CONTINUE                                                          ADDE1190
      VW2(N)=VW(IE)                                                     ADDE1200
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      FW2(N)=1.0D0                                                      ADDE1210
      GW2(N)=GW(IE)                                                     ADDE1220
      TW2(N)=1.0D0                                                      ADDE1230
      F2A(N)=1.0D0                                                      ADDE1240
      F2B(N)=1.0D0                                                      ADDE1250
      F2C(N)=1.0D0                                                      ADDE1260
      F2D(N)=1.0D0                                                      ADDE1270
      G2A(N)=G(2,IE,1)                                                  ADDE1280
      G2C(N)=G(1,IE,3)                                                  ADDE1290
      G2B(N)=G(1,IE,2)                                                  ADDE1300
      G2D(N)=G(2,IE,2)                                                  ADDE1310
      T2B(N)=1.0D0                                                      ADDE1320
      T2C(N)=1.0D0                                                      ADDE1330
      T2A(N)=1.0D0                                                      ADDE1340
      T2D(N)=1.0D0                                                      ADDE1350
160   CONTINUE                                                          ADDE1360
      IF (TST.NE.2.0D0) GO TO 170                                       ADDE1370
      FW2(IE)=1.0D0                                                     ADDE1380
      GW2(IE)=GW(IE)                                                    ADDE1390
      TW2(IE)=1.0D0                                                     ADDE1400
      F2A(IE)=1.0D0                                                     ADDE1410
      F2B(IE)=1.0D0                                                     ADDE1420
      F2C(IE)=1.0D0                                                     ADDE1430
      F2D(IE)=1.0D0                                                     ADDE1440
      G2A(IE)=G(2,IE,1)                                                 ADDE1450
      G2B(IE)=G(1,IE,2)                                                 ADDE1460
      G2C(IE)=G(1,IE,3)                                                 ADDE1470
      G2D(IE)=G(2,IE,2)                                                 ADDE1480
      T2A(IE)=1.0D0                                                     ADDE1490
      T2B(IE)=1.0D0                                                     ADDE1500
      T2C(IE)=1.0D0                                                     ADDE1510
      T2D(IE)=1.0D0                                                     ADDE1520
170   CONTINUE                                                          ADDE1530
      ETAINF=ETAIN2                                                     ADDE1540
      DO 220 J=1,IE                                                     ADDE1550
      IF (TST.GT.2.0D0) GO TO 180                                       ADDE1560
      ETA0(J)=ETA2(J)                                                   ADDE1570
      DETA0(J)=DETA2(J)                                                 ADDE1580
      VW(J)=VW2(J)                                                      ADDE1590
      FW(J)=FW2(J)                                                      ADDE1600
      TW(J)=TW2(J)                                                      ADDE1610
      IF (GW(IE2).EQ.0.0D0) GO TO 180                                   ADDE1620
      GW(J)=GW2(J)                                                      ADDE1630
180   IF (TST.EQ.4.0D0) GO TO 190                                       ADDE1640
      F(1,J,2)=F2B(J)                                                   ADDE1650
      T(1,J,2)=T2B(J)                                                   ADDE1660
      IF (G(1,IE2,2).EQ.0.0D0) GO TO 190                                ADDE1670
      G(1,J,2)=G2B(J)                                                   ADDE1680
190   CONTINUE                                                          ADDE1690
      IF (TST.GT.2.0D0) GO TO 200                                       ADDE1700
      F(2,J,1)=F2A(J)                                                   ADDE1710
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      T(2,J,1)=T2A(J)                                                   ADDE1720
      IF (G(2,IE2,1).EQ.0.0D0) GO TO 200                                ADDE1730
      G(2,J,1)=G2A(J)                                                   ADDE1740
  200 IF (TST.EQ.3.0D0) GO TO 210                                       ADDE1750
      F(1,J,3)=F2C(J)                                                   ADDE1760
      T(1,J,3)=T2C(J)                                                   ADDE1770
      IF (G(1,IE2,3).EQ.0.0D0) GO TO 210                                ADDE1780
      G(1,J,3)=G2C(J)                                                   ADDE1790
  210 IF (TST.GT.2.0D0) GO TO 220                                       ADDE1800
      F(2,J,2)=F2D(J)                                                   ADDE1810
      T(2,J,2)=T2D(J)                                                   ADDE1820
      IF (G(2,IE2,2).EQ.0.0D0) GO TO 220                                ADDE1830
      G(2,J,2)=G2D(J)                                                   ADDE1840
  220 CONTINUE                                                          ADDE1850
      IF (TST.GT.2.0D0) GO TO 230                                       ADDE1860
      CALL DERIV (FW,ETA2,IE,1,FWN)                                     ADDE1870
      CALL DERIV (TW,ETA2,IE,1,TWN)                                     ADDE1880
      IF (GW(IE2).NE.0.0D0) CALL DERIV (GW,ETA2,IE,1,GWN)               ADDE1890
  230 IF (TST.EQ.4.0D0) GO TO 240                                       ADDE1900
      CALL DERIV3 (F,1,2,ETA2,IE,1,FN)                                  ADDE1910
      CALL DERIV3 (T,1,2,ETA2,IE,1,TN)                                  ADDE1920
      IF (G(1,IE2,2).NE.0.0D0) CALL DERIV3 (G,1,2,ETA2,IE,1,GN)         ADDE1930
  240 IF (TST.GT.2.0D0) GO TO 250                                       ADDE1940
      CALL DERIV3 (F,2,1,ETA2,IE,1,FN)                                  ADDE1950
      CALL DERIV3 (T,2,1,ETA2,IE,1,TN)                                  ADDE1960
      IF (G(2,IE2,1).NE.0.0D0) CALL DERIV3 (G,2,1,ETA2,IE,1,GN)         ADDE1970
  250 IF (TST.EQ.3.0D0) GO TO 260                                       ADDE1980
      CALL DERIV3 (F,1,3,ETA2,IE,1,FN)                                  ADDE1990
      CALL DERIV3 (T,1,3,ETA2,IE,1,TN)                                  ADDE2000
      IF (G(1,IE2,3).NE.0.0D0) CALL DERIV3 (G,1,3,ETA2,IE,1,GN)         ADDE2010
  260 IF (TST.GT.2.0D0) GO TO 270                                       ADDE2020
      CALL DERIV3 (F,2,2,ETA2,IE,1,FN)                                  ADDE2030
      CALL DERIV3 (T,2,2,ETA2,IE,1,TN)                                  ADDE2040
      IF (G(2,IE2,2).NE.0.0D0) CALL DERIV3 (G,2,2,ETA2,IE,1,GN)         ADDE2050
  270 CONTINUE                                                          ADDE2060
      RETURN                                                            ADDE2070
C                                                                       ADDE2080
C                                                                       ADDE2090
C                                                                       ADDE2100
  280  FORMAT (10X,22HETAINF INCREASED AT X=,F10.5,13H  OLD ETAINF=,F10.5ADDE2110
     1,13H  NEW ETAINF=,F10.5,5X,6HTST = ,F4.1/)                        ADDE2120
  290  FORMAT (10X,22HETAINF DECREASED AT X=,F10.5,13H  OLD ETAINF=,F10.5ADDE2130
     1,13H  NEW ETAINF=,F10.5,5X,6HTST = ,F4.1/)                        ADDE2140
  300  FORMAT (10X,24HETAOLD INCREASED AT X = ,F10.5,2X,13HOLD ETAINF = ,ADDE2150
     1F10.5,2X,13HNEW ETAINF = ,F10.5,2X,6HTST = ,F4.1/)                ADDE2160
      END                                                               ADDE2170
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      SUBROUTINE AERO                                                   AERO  10
      IMPLICIT REAL*8 (A-H,O-Z)                                         AERO  20
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR            AERO  30
      COMMON /REF/ PREF,TREF,AMUREF                                     AERO  40
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG                              AERO  50
      DATA ROIN/4HRHOI/,PIN/4HPINF/                                     AERO  60
C                                                                       AERO  70
CCCCCC RHOINF IS IN SLUGS                                               AERO  80
C      PINF IS IN PSIA                                                  AERO  90
C      PSTAG IS IN PSIA                                                 AERO 100
C      PREF IS IN PSIA                                                  AERO 110
C      CP IN FT**2/SEC**2/DEG.R                                         AERO 120
C      R IN FT**2/SEC**2/DEG.R                                          AERO 130
C      UFS IN FT/SEC                                                    AERO 140
C      TWALL,TREF,TSTAG IN DEG.R                                        AERO 150
C      AMUREF IS IN (LB-SEC)/FT**2                                      AERO 160
C                                                                       AERO 170
      AMUREF=AMUINF                                                     AERO 180
      RHOINF=2.D0*(PSTAG-PINF)/UFS**2                                   AERO 190
      REINF=RHOINF*UFS/AMUINF                                           AERO 200
      TSTAG=TFS+.5D0/CP*UFS**2                                          AERO 210
      RETURN                                                            AERO 220
      END                                                               AERO 230
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      SUBROUTINE BLUNT2 (ISNT)                                          BLUN  10
      IMPLICIT REAL*8 (A-H,O-Z)                                         BLUN  20
      REAL*8 NOSE                                                       BLUN  30
      COMMON /EDGE/ UEDG,TEDG,VEDG,DUEGDX,DUEGDW,D2UEDW,DVEGDX,DVEGDW,REBLUN  40
     1DG,DRDGDX,ZBOD,XEDG                                               BLUN  50
      COMMON /HRWALL/ RO,HXO,HWO,DRODX,DRODW,D2RDXX,D2RDWW,D2RDXW,D3RXXXBLUN  60
     1,D3RWXX,D3RWWX,D3RWWW,DRWWXX,DRWWWX,DHXODX,DHXODW,DHXDWW,DHWODX,DHBLUN  70
     2WODW,XO,DXODX,DXODW,D2XODX,D2XODW,D2XDWX,D3XXWW                   BLUN  80
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR            BLUN  90
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                       BLUN 100
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,BLUN 110
     1LPR                                                               BLUN 120
      COMMON /OLD/ VOLD(61),CVOLD(61),ROLD(61)                          BLUN 130
      COMMON /STGEDG/ DVEGXW,DVEWXW,DVE2XW,DVEGXX,DVEWXX,DVE2XX,DVGXXW,DBLUN 140
     1VWXXW,DV2XXW,DHWOXW,DHXOXW                                        BLUN 150
      COMMON /OLDEDG/ R3,UE3,DVE3DW                                     BLUN 160
      COMMON /WSOLVE/ DW,W                                              BLUN 170
      COMMON /TVCURV/ TVC                                               BLUN 180
      DIMENSION A(40,2), B(40,2), C(40,2), D(40,2), E(40,2), F(40,2), G(BLUN 190
     140,2), AX(40,2), BX(40,2), CX(40,2), AXX(40,2), DX(40,2), EX(40,2)BLUN 200
     2, USUM(2), RADSUM(2), VSUM(2), VNSUM(2), UNSUM(2), RANSUM(2), HXSUBLUN 210
     3M(2), HWSUM(2), XSFSUM(2), HXNSUM(2), HWNSUM(2), UXSUM(2), VXSUM(2BLUN 220
     4), RXSUM(2), RXXSUM(2), RXNSUM(2), RXNNSM(2), RXXNSM(2), RXXNNS(2)BLUN 230
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     5, HXXSUM(2), HWXSUM(2), HXNNSM(2), RNNNSM(2), RNNSUM(2), XOSUM(2),BLUN 240
     6 XONSUM(2), XONNSM(2), XOXSUM(2), XOXNSM(2), GX(40,2), RXNNNS(2), BLUN 250
     7XXS(2), UNNSUM(2), VXNSUM(2), HWXNSM(2), HXXNSM(2)                BLUN 260
      DIMENSION ARADS(40), AUS(40), AVS(40), AVXS(40), AHXS(40), AHWS(40BLUN 270
     1), AXSRFS(40), AUX(40), AVX(40), ARX(40), ARXX(40), AHXXS(40), AHWBLUN 280
     2XS(40), AXO(40), AXOX(40)                                         BLUN 290
      DATA YES/3HYES/                                                   BLUN 300
C                                                                       BLUN 310
C                                                                       BLUN 320
      PI=DARCOS(-1.DO)                                                  BLUN 330
      IF (K.NE.1) GO TO 50                                              BLUN 340
      IF (L.EQ.1) IRD=0                                                 BLUN 350
      M=2                                                               BLUN 360
C     ******************************************                        BLUN 370
C     XS = BODY FIXED SURFACE DISTANCE                                  BLUN 380
C     ******************************************                        BLUN 390
C                                                                       BLUN 400
C     AXIAL DISTANCE AND FOURIER COEFFICIENTS ARE READ FROM UNIT 10     BLUN 410
C                                                                       BLUN 420
10    CONTINUE                                                          BLUN 430
      IRD=IRD+1                                                         BLUN 440
      READ (10) XS,ARADS,AUS,AVS,AHXS,AHWS,AXSRFS,AUX,AVX,ARX,ARXX,AHXXSBLUN 450
     1,AHWXS,AXO,AXOX                                                   BLUN 460
      IF (X.GT.XS.OR.IRD.LE.1) GO TO 20                                 BLUN 470
      BACKSPACE 10                                                      BLUN 480
      BACKSPACE 10                                                      BLUN 490
      IRD=IRD-2                                                         BLUN 500
      GO TO 10                                                          BLUN 510
20    CONTINUE                                                          BLUN 520
      IRD=IRD+1                                                         BLUN 530
      READ (10) XS,ARADS,AUS,AVS,AHXS,AHWS,AXSRFS,AUX,AVX,ARX,ARXX,AHXXSBLUN 540
     1,AHWXS,AXO,AXOX                                                   BLUN 550
      IF (X.GT.XS) GO TO 20                                             BLUN 560
      DO 30 J=1,KLX                                                     BLUN 570
      A(J,2)=ARADS(J)                                                   BLUN 580
      B(J,2)=AUS(J)                                                     BLUN 590
      C(J,2)=AVS(J)                                                     BLUN 600
      D(J,2)=AHXS(J)                                                    BLUN 610
      E(J,2)=AHWS(J)                                                    BLUN 620
      F(J,2)=AXSRFS(J)                                                  BLUN 630
      G(J,2)=AXO(J)                                                     BLUN 640
      BX(J,2)=AUX(J)                                                    BLUN 650
      CX(J,2)=AVX(J)                                                    BLUN 660
      AX(J,2)=ARX(J)                                                    BLUN 670
      AXX(J,2)=ARXX(J)                                                  BLUN 680
      DX(J,2)=AHXXS(J)                                                  BLUN 690
      EX(J,2)=AHWXS(J)                                                  BLUN 700
      GX(J,2)=AXOX(J)                                                   BLUN 710
30    CONTINUE                                                          BLUN 720
      XXS(2)=XS                                                         BLUN 730
      BACKSPACE 10                                                      BLUN 740
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      BACKSPACE 10                                                          BLUN 750
      IRD=IRD-1                                                             BLUN 760
      READ (IRD) XS,ARADS,AUS,AVS,AHXS,AHWS,AXSRFS,AUX,AVX,ARX,ARXX,AHXXSBLUN 770
     1,AHWXS,AXO,AXOX                                                       BLUN 780
      DO 40 J=1,KLX                                                         BLUN 790
      A(J,1)=ARADS(J)                                                       BLUN 800
      B(J,1)=AUS(J)                                                         BLUN 810
      C(J,1)=AVS(J)                                                         BLUN 820
      D(J,1)=AHXS(J)                                                        BLUN 830
      E(J,1)=AHWS(J)                                                        BLUN 840
      F(J,1)=AXSRFS(J)                                                      BLUN 850
      G(J,1)=AXO(J)                                                         BLUN 860
      BX(J,1)=AUX(J)                                                        BLUN 870
      CX(J,1)=AVX(J)                                                        BLUN 880
      AX(J,1)=ARX(J)                                                        BLUN 890
      AXX(J,1)=ARXX(J)                                                      BLUN 900
      DX(J,1)=AHXXS(J)                                                      BLUN 910
      EX(J,1)=AHWXS(J)                                                      BLUN 920
      GX(J,1)=AXOX(J)                                                       BLUN 930
   40 CONTINUE                                                              BLUN 940
      XXS(1)=XS                                                             BLUN 950
   50 CONTINUE                                                              BLUN 960
      MM=M-1                                                                BLUN 970
      PHI=2.DO*PI*W                                                         BLUN 980
      KKL=KLX-1                                                             BLUN 990
C                                                                           BLUN1000
C     FOURIER SERIES ARE USED TO COMPUTE THE EDGE PROPERTIES                BLUN1010
C                                                                           BLUN1020
      DO 80 I=1,M                                                           BLUN1030
      USUM(I)=0.0DO                                                         BLUN1040
      RADSUM(I)=0.0DO                                                       BLUN1050
      VSUM(I)=0.0DO                                                         BLUN1060
      HXSUM(I)=0.DO                                                         BLUN1070
      HWSUM(I)=0.DO                                                         BLUN1080
      XOSUM(I)=0.DO                                                         BLUN1090
      XSFSUM(I)=0.DO                                                        BLUN1100
      UXSUM(I)=0.DO                                                         BLUN1110
      VXSUM(I)=0.DO                                                         BLUN1120
      VXNSUM(I)=0.DO                                                        BLUN1130
      RXSUM(I)=0.DO                                                         BLUN1140
      XOXSUM(I)=0.DO                                                        BLUN1150
      RXXSUM(I)=0.DO                                                        BLUN1160
      UNSUM(I)=0.0DO                                                        BLUN1170
      UNNSUM(I)=0.DO                                                        BLUN1180
      RANSUM(I)=0.0DO                                                       BLUN1190
      RNNSUM(I)=0.DO                                                        BLUN1200
      VNSUM(I)=0.0DO                                                        BLUN1210
      HXNSUM(I)=0.DO                                                        BLUN1220
      HWNSUM(I)=0.DO                                                        BLUN1230
      RXNSUM(I)=0.DO                                                        BLUN1240
      RXNNSM(I)=0.DO                                                        BLUN1250
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      RXNNNS(I)=0.DO                                                    BLUN1260
      RXXNSM(I)=0.DO                                                    BLUN1270
      RXXNNS(I)=0.DO                                                    BLUN1280
      HXXSUM(I)=0.DO                                                    BLUN1290
      HWXSUM(I)=0.DO                                                    BLUN1300
      HWXNSM(I)=0.DO                                                    BLUN1310
      HXXNSM(I)=0.DO                                                    BLUN1320
      HXNNSM(I)=0.DO                                                    BLUN1330
      RNNNSM(I)=0.DO                                                    BLUN1340
      XONSUM(I)=0.DO                                                    BLUN1350
      XONNSM(I)=0.DO                                                    BLUN1360
      XOXNSM(I)=0.DO                                                    BLUN1370
      DO 60 J=1,KLX                                                     BLUN1380
      Z=DFLOAT(J)-1.0DO                                                 BLUN1390
      SZP=DSIN(Z*PHI)                                                   BLUN1400
      CZP=DCOS(Z*PHI)                                                   BLUN1410
      RADSUM(I)=RADSUM(I)+A(J,I)*CZP                                    BLUN1420
      XOSUM(I)=XOSUM(I)+G(J,I)*CZP                                      BLUN1430
      USUM(I)=USUM(I)+B(J,I)*CZP                                        BLUN1440
      HXSUM(I)=HXSUM(I)+D(J,I)*CZP                                      BLUN1450
      HWSUM(I)=HWSUM(I)+E(J,I)*CZP                                      BLUN1460
      XSFSUM(I)=XSFSUM(I)+F(J,I)*CZP                                    BLUN1470
      RANSUM(I)=RANSUM(I)-A(J,I)*Z*SZP                                  BLUN1480
      UNSUM(I)=UNSUM(I)-B(J,I)*Z*SZP                                    BLUN1490
      HXNSUM(I)=HXNSUM(I)-D(J,I)*Z*SZP                                  BLUN1500
      HWNSUM(I)=HWNSUM(I)-E(J,I)*Z*SZP                                  BLUN1510
      XONSUM(I)=XONSUM(I)-G(J,I)*Z*SZP                                  BLUN1520
      RNNSUM(I)=RNNSUM(I)-A(J,I)*Z**2*CZP                               BLUN1530
      XONNSM(I)=XONNSM(I)-G(J,I)*Z**2*CZP                               BLUN1540
      RXSUM(I)=RXSUM(I)+AX(J,I)*CZP                                     BLUN1550
      UXSUM(I)=UXSUM(I)+BX(J,I)*CZP                                     BLUN1560
      XOXSUM(I)=XOXSUM(I)+GX(J,I)*CZP                                   BLUN1570
      RXNSUM(I)=RXNSUM(I)-AX(J,I)*Z*SZP                                 BLUN1580
      XOXNSM(I)=XOXNSM(I)-GX(J,I)*Z*SZP                                 BLUN1590
      RXNNSM(I)=RXNNSM(I)-AX(J,I)*Z**2*CZP                              BLUN1600
      RXNNNS(I)=RXNNNS(I)+AX(J,I)*Z**3*SZP                              BLUN1610
      RXXNSM(I)=RXXNSM(I)-AXX(J,I)*Z*SZP                                BLUN1620
      RXXNNS(I)=RXXNNS(I)-AXX(J,I)*Z**2*CZP                             BLUN1630
      HXXSUM(I)=HXXSUM(I)+DX(J,I)*CZP                                   BLUN1640
      HWXSUM(I)=HWXSUM(I)+EX(J,I)*CZP                                   BLUN1650
      IF (L.EQ.1) HWXNSM(I)=HWXNSM(I)-EX(J,I)*Z*SZP                     BLUN1660
      IF (L.EQ.1) HXXNSM(I)=HXXNSM(I)-DX(J,I)*Z*SZP                     BLUN1670
      HXNNSM(I)=HXNNSM(I)-D(J,I)*Z**2*CZP                               BLUN1680
      RXXSUM(I)=RXXSUM(I)+AXX(J,I)*CZP                                  BLUN1690
      RNNNSM(I)=RNNNSM(I)+A(J,I)*Z**3*SZP                               BLUN1700
      UNNSUM(I)=UNNSUM(I)-B(J,I)*Z**2*CZP                               BLUN1710
60    CONTINUE                                                          BLUN1720
      DO 70 J=1,KKL                                                     BLUN1730
      H=DFLOAT(J)                                                       BLUN1740
      CHP=DCOS(H*PHI)                                                   BLUN1750
      SHP=DSIN(H*PHI)                                                   BLUN1760
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      VSUM(I)=VSUM(I)+C(J,I)*SHP                                        BLUN1770
      VNSUM(I)=VNSUM(I)+C(J,I)*H*CHP                                    BLUN1780
      VXSUM(I)=VXSUM(I)+CX(J,I)*SHP                                     BLUN1790
      VXNSUM(I)=VXNSUM(I)+CX(J,I)*H*CHP                                 BLUN1800
70    CONTINUE                                                          BLUN1810
80    CONTINUE                                                          BLUN1820
      IF (K.GT.1) GO TO 90                                              BLUN1830
      VSUM(MM)=0.0D0                                                    BLUN1840
      VSUM(M)=0.0D0                                                     BLUN1850
      RANSUM(MM)=0.D0                                                   BLUN1860
      RANSUM(M)=0.D0                                                    BLUN1870
      VXSUM(MM)=0.D0                                                    BLUN1880
      VXSUM(M)=0.D0                                                     BLUN1890
90    CONTINUE                                                          BLUN1900
      IF (MM.EQ.M) GO TO 100                                            BLUN1910
C                                                                       BLUN1920
CC    INTERPOLATION FOR EDGE PROPERTY VALUES AT X                       BLUN1930
C                                                                       BLUN1940
      FAC=(X-XXS(MM))/(XXS(M)-XXS(MM))                                  BLUN1950
      GO TO 110                                                         BLUN1960
100   FAC=0.0D0                                                         BLUN1970
110   CONTINUE                                                          BLUN1980
      REDG=RADSUM(MM)+FAC*(RADSUM(M)-RADSUM(MM))                        BLUN1990
      RO=REDG                                                           BLUN2000
      XO=XOSUM(MM)+FAC*(XOSUM(M)-XOSUM(MM))                             BLUN2010
      XEDG=XO                                                           BLUN2020
      TEDG=TFS/UFS**2*CP                                                BLUN2030
      UEDG=USUM(MM)+FAC*(USUM(M)-USUM(MM))                              BLUN2040
      VEDG=VSUM(MM)+FAC*(VSUM(M)-VSUM(MM))                              BLUN2050
      HXO=HXSUM(MM)+FAC*(HXSUM(M)-HXSUM(MM))                            BLUN2060
      HWO=HWSUM(MM)+FAC*(HWSUM(M)-HWSUM(MM))                            BLUN2070
      XBAR=XSFSUM(MM)+FAC*(XSFSUM(M)-XSFSUM(MM))                        BLUN2080
      DUEGDW=(UNSUM(MM)+FAC*(UNSUM(M)-UNSUM(MM)))*2.D0*PI               BLUN2090
      D2UEDW=(UNNSUM(MM)+FAC*(UNNSUM(M)-UNNSUM(MM)))*4.D0*PI**2         BLUN2100
      DVEGDW=(VNSUM(MM)+FAC*(VNSUM(M)-VNSUM(MM)))*2.D0*PI               BLUN2110
      DRODW=(RANSUM(MM)+FAC*(RANSUM(M)-RANSUM(MM)))*2.D0*PI             BLUN2120
      DXODW=(XONSUM(MM)+FAC*(XONSUM(M)-XONSUM(MM)))*2.D0*PI             BLUN2130
      DHXODW=(HXNSUM(MM)+FAC*(HXNSUM(M)-HXNSUM(MM)))*2.D0*PI            BLUN2140
      DHWODW=(HWNSUM(MM)+FAC*(HWNSUM(M)-HWNSUM(MM)))*2.D0*PI            BLUN2150
      D2RDWW=(RNNSUM(MM)+FAC*(RNNSUM(M)-RNNSUM(MM)))*4.D0*PI**2         BLUN2160
      D2XODW=(XONNSM(MM)+FAC*(XONSUM(M)-XONSUM(MM)))*4.D0*PI**2         BLUN2170
      D3RWWW=(RNNNSM(MM)+FAC*(RNNNSM(M)-RNNNSM(MM)))*8.D0*PI**3         BLUN2180
      DHXDWW=(HXNNSM(MM)+FAC*(HXNNSM(M)-HXNNSM(MM)))*4.D0*PI**2         BLUN2190
      IF (L.EQ.1) DHWOXW=HWXNSM(MM)                                     BLUN2200
      IF (L.EQ.1) DHXOXW=HXXNSM(MM)                                     BLUN2210
      DUEGDX=UXSUM(MM)+FAC*(UXSUM(M)-UXSUM(MM))                         BLUN2220
      DVEGDX=VXSUM(MM)+FAC*(VXSUM(M)-VXSUM(MM))                         BLUN2230
      DVEGXW=(VXNSUM(MM)+FAC*(VXNSUM(M)-VXNSUM(MM)))*2.D0*PI            BLUN2240
      DRODX=RXSUM(MM)+FAC*(RXSUM(M)-RXSUM(MM))                          BLUN2250
      DXODX=XOXSUM(MM)+FAC*(XOXSUM(M)-XOXSUM(MM))                       BLUN2260
      DHXODX=HXXSUM(MM)+FAC*(HXXSUM(M)-HXXSUM(MM))                      BLUN2270
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      DHWODX=HWXSUM(MM)+FAC*(HWXSUM(M)-HWXSUM(MM))                          BLUN2280
      D2RDXW=(RXNSUM(MM)+FAC*(RXNSUM(M)-RXNSUM(MM)))*2.D0*PI                BLUN2290
      D2XDWX=(XOXNSM(MM)+FAC*(XOXNSM(M)-XOXNSM(MM)))*2.D0*PI                BLUN2300
      D3RWWX=(RXNNSM(MM)+FAC*(RXNNSM(M)-RXNNSM(MM)))*4.D0*PI**2             BLUN2310
      D2RDXX=RXXSUM(MM)+FAC*(RXXSUM(M)-RXXSUM(MM))                          BLUN2320
      D3RWXX=(RXXNSM(MM)+FAC*(RXXNSM(M)-RXXNSM(MM)))*2.D0*PI                BLUN2330
      DRWWWX=(RXNNNS(MM)+FAC*(RXNNNS(M)-RXNNNS(MM)))*8.D0*PI**3             BLUN2340
      DRWWXX=(RXXNNS(MM)+FAC*(RXXNNS(M)-RXXNNS(MM)))*4.D0*PI**2             BLUN2350
      IF (ISNT.EQ.2) GO TO 130                                              BLUN2360
C                                                                           BLUN2370
C     CALCULATE THE X DERIVATIVES                                           BLUN2380
C                                                                           BLUN2390
      D3RXXX=(RXXSUM(M)-RXXSUM(MM))/(XXS(M)-XXS(MM))                        BLUN2400
      D2XODX=(XOXSUM(M)-XOXSUM(MM))/(XXS(M)-XXS(MM))                        BLUN2410
      D3XXWW=(XONNSM(M)-XONNSM(MM))/(XXS(M)-XXS(MM))                        BLUN2420
      IF (L.NE.1) GO TO 120                                                 BLUN2430
      DVEGXX=(VXSUM(M)-VXSUM(MM))/(XXS(M)-XXS(MM))                          BLUN2440
      DVGXXW=(VXNSUM(M)-VXNSUM(MM))/(XXS(M)-XXS(MM))                        BLUN2450
120   CONTINUE                                                              BLUN2460
      CALL HOFN                                                             BLUN2470
130   CONTINUE                                                              BLUN2480
      IWT=0                                                                 BLUN2490
      IF (IWT.EQ.0) GO TO 140                                               BLUN2500
      WRITE (6,150) UEDG,DUEGDX,DUEGDW,VEDG,DVEGDX,DVEGDW                   BLUN2510
      WRITE (6,160) REDG,DRODX,D2RDXX,DRODW,D2RDWW                          BLUN2520
      WRITE (6,170) D2RDXW,D3RWWX,D3RWXX,DRWWXX,DRWWWX                      BLUN2530
      WRITE (6,180) HXO,HWO,DHXODX,DHWODX,DHXODW,DHWODW                     BLUN2540
      WRITE (6,190) XO,DXODX,DXODW                                          BLUN2550
140   CONTINUE                                                              BLUN2560
      RETURN                                                                BLUN2570
C                                                                           BLUN2580
150   FORMAT (1HO,7HUEDG = ,E13.6,10H DUEGDX = ,E13.6,10H DUEGDW = ,E13.BLUN2590
     16,7H VEG = ,E13.6,10H DVEGDX = ,E13.6,10H DVEGDW = ,E13.6)            BLUN2600
160   FORMAT (1HO,7HREDG = ,E13.6,9H DRODX = ,E13.6,10H D2RDXX = ,E13.6,BLUN2610
     110H  DRODW = ,E13.6,10H D2RDWW = ,E13.6)                              BLUN2620
170   FORMAT (1HO,9HD2RDXW = ,E13.6,10H D3RWWX = ,E13.6,10H D3RWXX = ,E1BLUN2630
     13.6,10H DRWWXX = ,E13.6,10H DRWWWX = ,E13.6)                          BLUN2640
180   FORMAT (1HO,6HHXO = ,E13.6,7H HWO = ,E13.6,10H DHXODX = ,E13.6,10HBLUN2650
     1 DHWODX = ,E13.6,10H DHXODW = ,E13.6,10H DHWODW = ,E13.6)             BLUN2660
190   FORMAT (1HO,5HXO = ,E13.6,9H DXODX = ,E13.6,9H DXODW = ,E13.6)        BLUN2670
      END                                                                   BLUN2680



      SUBROUTINE CHANGX                                                     CHAN  10
      IMPLICIT REAL*8(A-H,O-Z)                                              CHAN  20
      REAL*8 NOSE                                                           CHAN  30
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                               CHAN  40
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,CHAN  50
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     1(101,3),TN(2,101,3),Y(101),YOL(101)                                CHAN  60
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                        CHAN  70
      COMMON /INJECT/ INJCT,NOINJ,MASTRN                                 CHAN  80
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,CHAN  90
     1LPR                                                               CHAN 100
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),CHAN 110
     1TWN(101),XIW,XW,RW                                                CHAN 120
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR            CHAN 130
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSCHAN 140
     1(101),LAMTRB                                                      CHAN 150
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE                CHAN 160
      COMMON /SPECP/ LPRTP                                               CHAN 170
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                  CHAN 180
C                                                                        CHAN 190
CC                                                                       CHAN 200
      LPRTP=0                                                            CHAN 210
      IF (NIT.GE.0) GO TO 30                                             CHAN 220
C                                                                        CHAN 230
CCC   CUT BACK X AND DX AND SET DXOLD=DX                                 CHAN 240
CC                                                                       CHAN 250
      DX=DX/2.0D0                                                        CHAN 260
      X=X-DX                                                             CHAN 270
      DXOLD=DX                                                           CHAN 280
C                                                                        CHAN 290
CCC   RESET COUNTERS FOR TRANSITION                                      CHAN 300
CC                                                                       CHAN 310
      IF (X.GE.XSTA(KONSET)) GO TO 90                                    CHAN 320
      IF (KONSET.EQ.NSOLVE) GO TO 10                                     CHAN 330
      LAMTRB=1                                                           CHAN 340
      XIF=0.0D0                                                          CHAN 350
10    CONTINUE                                                           CHAN 360
CC                                                                       CHAN 370
CCC   RESET COUNTER FOR INJECTION                                        CHAN 380
CC                                                                       CHAN 390
      IF (INJCT.EQ.NSOLVE) GO TO 20                                      CHAN 400
      IF (X.GT.XSTA(INJCT)) GO TO 20                                     CHAN 410
      MASTRN=0                                                           CHAN 420
20    IF (X.GE.XSTA(NOINJ)) MASTRN=0                                     CHAN 430
      RETURN                                                             CHAN 440
30    CONTINUE                                                           CHAN 450
CC                                                                       CHAN 460
CCC   ADJUST DX USING NIT                                                CHAN 470
C                                                                        CHAN 480
      IF (NIT.GT.NIT1) GO TO 40                                          CHAN 490
      DX=2.0D0*DX                                                        CHAN 500
      IF (DX.GT.DXMAX) DX=DXMAX                                          CHAN 510
      GO TO 50                                                           CHAN 520
40    IF (NIT.LT.NIT2) GO TO 50                                          CHAN 530
      DX=0.5D0*DX                                                        CHAN 540
50    CONTINUE                                                           CHAN 550
      IF (X.EQ.XSTA(INJCT)) DX=DX/10.0D0                                 CHAN 560
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      IF (X.EQ.XSTA(KONSET)) DX=DX/10.0D0                                CHAN 570
      DXOLD=DX                                                           CHAN 580
C                                                                        CHAN 590
CC    SET DX TO GIVE A SOLUTION AT XSTA(IXSOLV(II))                      CHAN 600
C                                                                        CHAN 610
      DO 60 I=1,NSOLVE                                                   CHAN 620
      J=I                                                                CHAN 630
      IF (XSTA(I).GT.X.AND.XSTA(I).LE.(X+1.25D0*DX)) GO TO 70            CHAN 640
60    CONTINUE                                                           CHAN 650
      X=X+DX                                                             CHAN 660
      GO TO 80                                                           CHAN 670
70    DX=XSTA(J)-X                                                       CHAN 680
      X=X+DX                                                             CHAN 690
      LPRTP=1                                                            CHAN 700
80    CONTINUE                                                           CHAN 710
C                                                                        CHAN 720
C     BEGIN THE TRANSITION REGIME IF X=XSTA(KONSET)                      CHAN 730
C     CALCULATE THE TRANSITION INTERMITTANCY FACTOR FOR                  CHAN 740
CC    X.GE.XSTA(KONSET)                                                  CHAN 750
C                                                                        CHAN 760
      IF (KONSET.EQ.NSOLVE) GO TO 100                                    CHAN 770
      IF (X.LT.XSTA(KONSET)) GO TO 100                                   CHAN 780
      IF (X.GT.XSTA(KONSET)) GO TO 90                                    CHAN 790
      LAMTRB=2                                                           CHAN 800
      WRITE (6,130) X,LAMTRB                                             CHAN 810
90    CONTINUE                                                           CHAN 820
      IF (KTRANS.EQ.0) XIF=1.0D0                                         CHAN 830
      IF (KTRANS.EQ.1) XIF=1.0D0-DEXP(-0.412D0*2.917D0**2*((X-XSTA(KONSECHAN 840
     1T))/(XSTA(KONSET)*(XBAR-1.0D0)))**2)                               CHAN 850
      IF (NIT.LT.0) GO TO 10                                             CHAN 860
C                                                                        CHAN 870
CC    BEGIN MASS TRANSFER IF X=XSTA(INJCT)                               CHAN 880
C                                                                        CHAN 890
100   IF (INJCT.EQ.NSOLVE) GO TO 110                                     CHAN 900
      IF (X.LE.XSTA(INJCT)) GO TO 110                                    CHAN 910
      IF (MASTRN.EQ.1) GO TO 110                                         CHAN 920
      MASTRN=1                                                           CHAN 930
      WRITE (6,140) X,MASTRN                                             CHAN 940
C                                                                        CHAN 950
CC    END MASS TRANSFER IF X=XSTA(NOINJ)                                 CHAN 960
C                                                                        CHAN 970
110   IF (NOINJ.EQ.NSOLVE) GO TO 120                                     CHAN 980
      IF (X.NE.XSTA(NOINJ)) GO TO 120                                    CHAN 990
      MASTRN=0                                                           CHAN1000
      WRITE (6,150) X,MASTRN                                             CHAN1010
120   RETURN                                                             CHAN1020
CC                                                                       CHAN1030
C                                                                        CHAN1040
C                                                                        CHAN1050
130   FORMAT (1H0,10X,27HBEGIN TRANSITION REGIME, X=,E12.6,9H  LAMTRB=,I CHAN1060
     12/)                                                                CHAN1070
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140   FORMAT (1HQ,10X,23HBEGIN MASS TRANSFER, X=,E12.6,9H  MASTRN=,I2/)  CHAN1080
150   FORMAT (1HQ,10X,21HEND MASS TRANSFER, X=,E12.6,9H  MASTRN=,I2/)    CHAN1090
      END                                                                CHAN1100



      SUBROUTINE CONTRL                                                  CONT  10
      IMPLICIT REAL*8(A-H,O-Z)                                           CONT  20
      REAL*8 NOSE                                                        CONT  30
      COMMON /ASSVAR/ IFL,KBL                                            CONT  40
      COMMON /CONICL/ PE(61),TE(61),UE(61),VE(61),DUEDW(61),DVEDW(61),DPCONT  50
     1EDW2(61)                                                           CONT  60
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                            CONT  70
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,CONT  80
     1101,3),TN(2,101,3),Y(101),YOC(101)                                 CONT  90
      COMMON /EDGE/ UEDG,TEDG,VEDG,DUEGDX,DUEGDW,D2UEDW,DVEGDX,DVEGDW,RECONT 100
     1DG,Z800,XEDG                                                       CONT 110
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW   CONT 120
      COMMON /EDG2/ TE2,UE2,VE2,DUE2DX,DVE2DX,DUE2DW,D2UE2W,DVE2DW,RE2,XCONT 130
     12                                                                  CONT 140
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101CONT 150
     1),CRI                                                              CONT 160
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR             CONT 170
      COMMON /GASPRP/ PRANDT(101)                                        CONT 180
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                        CONT 190
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB                CONT 200
      COMMON /INJECT/ INJCT,NOINJ,MASTRN                                 CONT 210
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,CONT 220
     1LPR                                                                CONT 230
      COMMON /OLD/ VOLD(61),CVOLD(61),ROLD(61)                           CONT 240
      COMMON /OLDEDG/ R3,UE3,DVE3DW                                      CONT 250
      COMMON /OUTPUT/ CFWEDG,CFWINF,CFXEDG,CFXINF,DEL,QW,QWINF,QWOQWD,S,CONT 260
     1TAUETA,TAUX,DELSTX,DELPHI,THETAX,THEPHI,REX2                       CONT 270
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)    CONT 280
      COMMON /PDEREF/ UREF                                               CONT 290
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),CONT 300
     1TWN(101),XIW,XW,RW                                                 CONT 310
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG                               CONT 320
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XCONT 330
     1CI(500),CIX(500),TCONW,KCI,KTW                                     CONT 340
      COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                           CONT 350
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSCONT 360
     1(101),LAMTRB                                                       CONT 370
      COMMON /WSOLVE/ DW,W                                               CONT 380
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                   CONT 390
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE                CONT 400
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA     CONT 410
      COMMON /SPECP/ LPRTP                                               CONT 420
      COMMON /RAD/ RXS(2,101,3)                                          CONT 430
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      DIMENSION FOLD(101), GOLD(101), TOLD(101), TS(101,2)                  CONT 440
      DIMENSION GNN(2,101,2)                                                CONT 450
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                     CONT 460
      NITTOT=0                                                              CONT 470
      ASYM=1.000                                                            CONT 480
      ETA2SV=0.000                                                          CONT 490
C                                                                           CONT 500
CC    BEGIN THE LOOP FOR STEPPING DOWNSTREAM                                CONT 510
C                                                                           CONT 520
10    CONTINUE                                                              CONT 530
      L=L+1                                                                 CONT 540
      IFL=1                                                                 CONT 550
      FIND(8*IFL)                                                           CONT 560
      W=0.000                                                               CONT 570
      IF (KEND.EQ.1.OR.ALPHA.LT.1.D-08) GO TO 20                            CONT 580
      DW=WLST/DFLOAT(KEND2-1)                                               CONT 590
20    CONTINUE                                                              CONT 600
      KPR=KPRT                                                              CONT 610
      IF (L.EQ.1) KLAST=KEND                                                CONT 620
C                                                                           CONT 630
CC    BEGIN THE DO-LOOP FOR STEPPING AROUND THE BODY                        CONT 640
C                                                                           CONT 650
      DO 400 K=1,KEND                                                       CONT 660
      CALL TIMEON                                                           CONT 670
      LC=3                                                                  CONT 680
      IF (L.EQ.1) LC=1                                                      CONT 690
      IF (K.EQ.1.AND.L.GT.1) LC=2                                           CONT 700
      IF (K.EQ.KEND2.AND.L.GT.1) LC=2                                       CONT 710
      LADETA=0                                                              CONT 720
      WX=W/WLST*180.000                                                     CONT 730
      IF (KLAST.GT.0) GO TO 30                                              CONT 740
      WRITE (6,440)                                                         CONT 750
      RETURN                                                                CONT 760
30    IF (K.GT.KLAST) GO TO 370                                             CONT 770
40    CONTINUE                                                              CONT 780
C                                                                           CONT 790
C     OBTAIN EDGE,AND WALL INVISCID VALUES AND SET                          CONT 800
C     MIDPOINT VALUES TO VALUES OBTAINED FOR THIS PLANE AT                  CONT 810
CC    THE LAST STREAMWISE STATION                                           CONT 820
C                                                                           CONT 830
      CALL EGPROP (LC)                                                      CONT 840
      CALL WALL                                                             CONT 850
      DO 50 J=1,IE                                                          CONT 860
      FW(J)=F(1,J,2)                                                        CONT 870
      GW(J)=G(1,J,2)                                                        CONT 880
      GVEL=GW(J)                                                            CONT 890
      IF (K.EQ.1) GVEL=0.000                                                CONT 900
      TW(J)=T(1,J,2)                                                        CONT 910
      FWN(J)=FN(1,J,2)                                                      CONT 920
      GWN(J)=GN(1,J,2)                                                      CONT 930
      TWN(J)=TN(1,J,2)                                                      CONT 940
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50    CONTINUE                                                          CONT 950
      IF (L.EQ.1) CALL VCALC (LC)                                       CONT 960
C                                                                       CONT 970
C     SAVE THE PROFILES FROM THE LAST ITERATION                         CONT 980
C                                                                       CONT 990
60    DO 70 J=1,IE                                                      CONT1000
      FOLD(J)=F(2,J,2)                                                  CONT1010
      GOLD(J)=G(2,J,2)                                                  CONT1020
      TOLD(J)=T(2,J,2)                                                  CONT1030
70    CONTINUE                                                          CONT1040
C                                                                       CONT1050
C     SOLVE THE STREAMWISE MOMENTUM CONSERVATION EQUATION               CONT1060
C                                                                       CONT1070
      IF (LAMTRB.EQ.2) CALL EDYVIS                                      CONT1080
      CALL XMOM (LC)                                                    CONT1090
      CALL ABCDE (F)                                                    CONT1100
      CALL SOLVE (F,FN,0.0D0,0.0D0,1.0D0)                               CONT1110
      IF (L.GT.1) GO TO 90                                              CONT1120
      DO 80 J=1,IE                                                      CONT1130
      F(1,J,3)=F(2,J,2)*2.0D0-F(2,J,1)                                  CONT1140
      FN(1,J,3)=FN(2,J,2)*2.0D0-FN(2,J,1)                               CONT1150
      F(1,J,2)=F(2,J,2)                                                 CONT1160
      FN(1,J,2)=FN(2,J,2)                                               CONT1170
80    CONTINUE                                                          CONT1180
90    CONTINUE                                                          CONT1190
      IF (K.GT.1) GO TO 110                                             CONT1200
      DO 100 J=1,IE                                                     CONT1210
      F(2,J,1)=F(2,J,2)                                                 CONT1220
      F(1,J,3)=F(1,J,2)                                                 CONT1230
      FN(2,J,1)=FN(2,J,2)                                               CONT1240
      FN(1,J,3)=FN(1,J,2)                                               CONT1250
100   CONTINUE                                                          CONT1260
110   CONTINUE                                                          CONT1270
      DO 120 J=1,IE                                                     CONT1280
      IF (K.EQ.KLAST) F(1,J,3)=F(2,J,2)-F(2,J,1)+F(1,J,2)               CONT1290
      IF (K.EQ.KLAST) FN(1,J,3)=FN(2,J,2)-FN(2,J,1)+FN(1,J,2)           CONT1300
      FW(J)=F(2,J,2)*CRI+F(1,J,2)*(1.0D0-CRI)                           CONT1310
      FWN(J)=FN(2,J,2)*CRI+FN(1,J,2)*(1.0D0-CRI)                        CONT1320
      IF (L.EQ.1) FW(J)=F(2,J,1)*(1.0D0-CRI)+F(2,J,2)*CRI               CONT1330
      IF (L.EQ.1) FWN(J)=FN(2,J,1)*(1.0D0-CRI)+FN(2,J,2)*CRI            CONT1340
120   CONTINUE                                                          CONT1350
      IF (ALPHA.LT.1.D-08) GO TO 180                                    CONT1360
C                                                                       CONT1370
C     SOLVE THE CROSSFLOW MOMENTUM CONSERVATION EQUATION                CONT1380
C                                                                       CONT1390
      CALL VCALC (LC)                                                   CONT1400
      IF (LAMTRB.EQ.2) CALL EDYVIS                                      CONT1410
      CALL PHIMOM (LC)                                                  CONT1420
      CALL ABCDE (G)                                                    CONT1430
      CALL SOLVE (G,GN,0.0D0,0.0D0,AL3)                                 CONT1440
      IF (L.GT.1) GO TO 140                                             CONT1450
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      DO 130 J=1,IE                                                    CONT1460
      G(1,J,3)=G(2,J,2)*2.0D0-G(2,J,1)                                 CONT1470
      GN(1,J,3)=GN(2,J,2)*2.0D0-GN(2,J,1)                              CONT1480
      G(1,J,2)=G(2,J,2)                                                CONT1490
      GN(1,J,2)=GN(2,J,2)                                              CONT1500
  130 CONTINUE                                                         CONT1510
  140 CONTINUE                                                         CONT1520
      IF (K.GT.1) GO TO 160                                            CONT1530
      DO 150 J=1,IE                                                    CONT1540
      G(2,J,1)=G(2,J,2)                                                CONT1550
      G(1,J,3)=G(1,J,2)                                                CONT1560
      GN(2,J,1)=GN(2,J,2)                                              CONT1570
      GN(1,J,3)=GN(1,J,2)                                              CONT1580
  150 CONTINUE                                                         CONT1590
  160 CONTINUE                                                         CONT1600
      DO 170 J=1,IE                                                    CONT1610
      IF (K.EQ.KLAST) G(1,J,3)=G(2,J,2)-G(2,J,1)+G(1,J,2)              CONT1620
      IF (K.EQ.KLAST) GN(1,J,3)=GN(2,J,2)-GN(2,J,1)+GN(1,J,2)          CONT1630
      GW(J)=G(2,J,2)*CRI+(1.0D0-CRI)*G(1,J,2)                          CONT1640
      GWN(J)=GN(2,J,2)*CRI+(1.0D0-CRI)*GN(1,J,2)                       CONT1650
      IF (L.EQ.1) GW(J)=G(2,J,1)*(1.0D0-CRI)+G(2,J,2)*CRI              CONT1660
      IF (L.EQ.1) GWN(J)=GN(2,J,1)*(1.0D0-CRI)+GN(2,J,2)*CRI           CONT1670
  170 CONTINUE                                                         CONT1680
  180 CONTINUE                                                         CONT1690
      CALL VCALC (LC)                                                  CONT1700
      NIT=NIT+1                                                        CONT1710
C                                                                      CONT1720
CCC   THE SOLUTION IS CHECKED FOR CONVERGENCE                          CONT1730
C                                                                      CONT1740
      IF (NIT.LE.NIT3) GO TO 200                                       CONT1750
      WRITE (6,420) K,L,NIT                                            CONT1760
      IF (K.GT.1) GO TO 190                                            CONT1770
      NITTOT=NIT+NITTOT                                                CONT1780
      IF (NITTOT.GT.(3*NIT3)) WRITE (6,430) K,L,NITTOT                 CONT1790
      IF (NITTOT.GT.(3*NIT3)) STOP                                     CONT1800
      NIT=-1                                                           CONT1810
      CALL CHANGX                                                      CONT1820
      NIT=0                                                            CONT1830
      GO TO 40                                                         CONT1840
  190 CONTINUE                                                         CONT1850
      KLAST=K-1                                                        CONT1860
      GO TO 370                                                        CONT1870
  200 CONTINUE                                                         CONT1880
C                                                                      CONT1890
CCC   CONVERGENCE TEST ON ALL POINTS OF THE F AND G ARRAYS             CONT1900
C                                                                      CONT1910
      DIF=0.0D0                                                        CONT1920
      DO 210 J=2,IE                                                    CONT1930
      DIFF=DABS(F(2,J,2)-FOLD(J))/DABS(FOLD(J))                        CONT1940
      IF (DIFF.GT.DIF) DIF=DIFF                                        CONT1950
      IF (GOLD(J).EQ.0.0D0) GO TO 210                                  CONT1960
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      DIFF=DABS(G(2,J,2)-GOLD(J))/DABS(GOLD(J))                          CONT1970
      IF (DIFF.GT.DIF) DIF=DIFF                                          CONT1980
210   CONTINUE                                                           CONT1990
      IF (DIF.GT.CONV) GO TO 60                                          CONT2000
      IF (NIT.EQ.1) GO TO 60                                             CONT2010
C                                                                        CONT2020
C     SOLVE THE ENERGY CONSERVATION EQUATION                             CONT2030
C                                                                        CONT2040
      IF (LAMTRB.EQ.2) CALL EDYVIS                                       CONT2050
      TB=TWALL                                                           CONT2060
      CALL ENERGY (LC)                                                   CONT2070
      CALL ABCOE (T)                                                     CONT2080
      CALL SOLVE (T,TN,0.0D0,TB,1.0D0)                                   CONT2090
      IF (L.GT.1) GO TO 230                                              CONT2100
      DO 220 J=1,IE                                                      CONT2110
      T(1,J,3)=T(2,J,2)*2.0D0-T(2,J,1)                                   CONT2120
      TN(1,J,3)=TN(2,J,2)*2.0D0-TN(2,J,1)                                CONT2130
      T(1,J,2)=T(2,J,2)                                                  CONT2140
      TN(1,J,2)=TN(2,J,2)                                                CONT2150
220   CONTINUE                                                           CONT2160
230   CONTINUE                                                           CONT2170
      IF (K.GT.1) GO TO 250                                              CONT2180
      DO 240 J=1,IE                                                      CONT2190
      T(2,J,1)=T(2,J,2)                                                  CONT2200
      T(1,J,3)=T(1,J,2)                                                  CONT2210
      TN(2,J,1)=TN(2,J,2)                                                CONT2220
      TN(1,J,3)=TN(1,J,2)                                                CONT2230
240   CONTINUE                                                           CONT2240
250   CONTINUE                                                           CONT2250
      DO 260 J=1,IE                                                      CONT2260
      IF (K.EQ.KLAST) T(1,J,3)=T(2,J,2)-T(2,J,1)+T(1,J,2)                CONT2270
      IF (K.EQ.KLAST) TN(1,J,3)=TN(2,J,2)-TN(2,J,1)+TN(1,J,2)            CONT2280
      TW(J)=T(2,J,2)*CRI+T(1,J,2)*(1.0D0-CRI)                            CONT2290
      TWN(J)=TN(2,J,2)*CRI+TN(1,J,2)*(1.0D0-CRI)                         CONT2300
      IF (L.EQ.1) TW(J)=T(2,J,1)*(1.0D0-CRI)+T(2,J,2)*CRI                CONT2310
      IF (L.EQ.1) TWN(J)=TN(2,J,1)*(1.0D0-CRI)+TN(2,J,2)*CRI             CONT2320
260   CONTINUE                                                           CONT2330
      DO 270 J=1,IE                                                      CONT2340
      GVEL=GW(J)                                                         CONT2350
      IF (K.EQ.1) GVEL=0.0D0                                             CONT2360
270   CONTINUE                                                           CONT2370
C                                                                        CONT2380
C     TEST THE ASYMPTOTIC NATURE OF THE SOLUTION AND ADJUST ETAINF       CONT2390
C     IF NECESSARY                                                       CONT2400
      IF (L.EQ.1) GO TO 300                                              CONT2410
      IF (KADETA.EQ.0) GO TO 300                                         CONT2420
      ASYM=DABS(F(2,IE,2)-F(2,IE-4,2))                                   CONT2430
      IF (ASYM.LT.ADTEST) GO TO 280                                      CONT2440
      TST=1.0D0                                                          CONT2450
      ETAOLD=ETAINF                                                      CONT2460
      GO TO 290                                                          CONT2470
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280   IF (KEND2.GT.1) GO TO 300                                          CONT2480
      IF (ASYM.GT.ADTEST/10.000) GO TO 300                               CONT2490
      TST=2.000                                                          CONT2500
      ETAOLD=ETAINF                                                      CONT2510
290   CONTINUE                                                           CONT2520
      IF (LADETA.NE.0) GO TO 300                                         CONT2530
      LADETA=1                                                           CONT2540
      CALL ADDETA (TST,ASYM,ETAOLD)                                      CONT2550
      GO TO 60                                                           CONT2560
300   CONTINUE                                                           CONT2570
      IF (K.EQ.1.OR.K.EQ.(KEND-1)/2) NITHAF=NIT                          CONT2580
      WRITE (8'IFL) (T(2,J,2),F(2,J,2),G(2,J,2),TN(2,J,2),FN(2,J,2),GN(2CONT2590
     1,J,2),RXS(2,J,2),J=1,IE),ETAINF                                    CONT2600
C                                                                        CONT2610
CC    CALCULATE AND WRITE OUT THE RESULTS OF THE CURRENT SOLUTION        CONT2620
C                                                                        CONT2630
      CALL PROPTY                                                        CONT2640
      CALL OUT2                                                          CONT2650
      W=W+DW                                                             CONT2660
C                                                                        CONT2670
CCC   THE PROGRAM IS SET TO FIND THE SOLUTION AT THE NEXT                CONT2680
      COORDINATE POINT                                                   CONT2690
C                                                                        CONT2700
      DO 320 J=1,IE                                                      CONT2710
      IF (K.EQ.1.AND.KEND.GT.1) G(2,J,2)=0.000                           CONT2720
      IF (K.EQ.1.AND.KEND.GT.1) GN(2,J,2)=0.000                          CONT2730
      F(2,J,1)=F(2,J,2)                                                  CONT2740
      FN(2,J,1)=FN(2,J,2)                                                CONT2750
      F(1,J,2)=F(1,J,3)                                                  CONT2760
      FN(1,J,2)=FN(1,J,3)                                                CONT2770
      T(2,J,1)=T(2,J,2)                                                  CONT2780
      TN(2,J,1)=TN(2,J,2)                                                CONT2790
      T(1,J,2)=T(1,J,3)                                                  CONT2800
      TN(1,J,2)=TN(1,J,3)                                                CONT2810
      G(2,J,1)=G(2,J,2)                                                  CONT2820
      GN(2,J,1)=GN(2,J,2)                                                CONT2830
      G(1,J,2)=G(1,J,3)                                                  CONT2840
      GN(1,J,2)=GN(1,J,3)                                                CONT2850
      RXS(2,J,1)=RXS(2,J,2)                                              CONT2860
      RXS(1,J,2)=RXS(1,J,3)                                              CONT2870
      IF (L.NE.1) GO TO 310                                              CONT2880
      F(1,J,2)=F(2,J,2)                                                  CONT2890
      FN(1,J,2)=FN(2,J,2)                                                CONT2900
      T(1,J,2)=T(2,J,2)                                                  CONT2910
      TN(1,J,2)=TN(2,J,2)                                                CONT2920
      G(1,J,2)=G(2,J,2)                                                  CONT2930
      GN(1,J,2)=GN(2,J,2)                                                CONT2940
      F(1,J,3)=F(2,J,2)                                                  CONT2950
      FN(1,J,3)=FN(2,J,2)                                                CONT2960
      T(1,J,3)=T(2,J,2)                                                  CONT2970
      TN(1,J,3)=TN(2,J,2)                                                CONT2980
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      G(1,J,3)=G(2,J,2)                                                 CONT2990
      GN(1,J,3)=GN(2,J,2)                                               CONT3000
      RXS(1,J,2)=RXS(2,J,2)                                             CONT3010
310   CONTINUE                                                          CONT3020
320   CONTINUE                                                          CONT3030
      IF (L.EQ.1) GO TO 370                                             CONT3040
      IF (K.GE.KLAST-1) GO TO 370                                       CONT3050
      READ (8'IFL) ((T(1,J,2),F(1,J,2),G(1,J,2),TN(1,J,2),FN(1,J,2),GN(1,CONT3060
     1J,2),RXS(1,J,2),J=1,IE),ETAOLD                                    CONT3070
      TST=3.D0                                                          CONT3080
      IF (ETAOLD.LT.ETAINF) CALL ADDETA (TST,ASYM,ETAOLD)               CONT3090
      READ (8'IFL) ((T(1,J,3),F(1,J,3),G(1,J,3),TN(1,J,3),FN(1,J,3),GN(1,CONT3100
     1J,3),RXS(1,J,3),J=1,IE),ETAOLD                                    CONT3110
      TST=4.D0                                                          CONT3120
      IF (ETAOLD.LT.ETAINF) CALL ADDETA (TST,ASYM,ETAOLD)               CONT3130
      IF (L.GT.2) GO TO 340                                             CONT3140
      DO 330 KK=2,3                                                     CONT3150
      DO 330 LL=1,IE                                                    CONT3160
      G(1,LL,KK)=0.D0                                                   CONT3170
      GN(1,LL,KK)=0.D0                                                  CONT3180
330   CONTINUE                                                          CONT3190
340   CONTINUE                                                          CONT3200
      IF (K.NE.(KEND2-2)) GO TO 360                                     CONT3210
      DO 350 KK=1,IE                                                    CONT3220
      G(1,KK,3)=0.D0                                                    CONT3230
      GN(1,KK,3)=0.D0                                                   CONT3240
350   CONTINUE                                                          CONT3250
360   CONTINUE                                                          CONT3260
      IFL=IFL-2                                                         CONT3270
      FIND(8'IFL)                                                       CONT3280
370   CONTINUE                                                          CONT3290
      IF (K.NE.KEND) GO TO 390                                          CONT3300
      READ (8'1) ((T(1,J,2),F(1,J,2),G(1,J,2),TN(1,J,2),FN(1,J,2),GN(1,J,CONT3310
     12),RXS(1,J,2),J=1,IE),ETAOLD                                      CONT3320
      TST=3.D0                                                          CONT3330
      IF (ETAOLD.LT.ETAINF) CALL ADDETA (TST,ASYM,ETAOLD)               CONT3340
      DO 380 J=1,IE                                                     CONT3350
      T(2,J,1)=T(1,J,2)                                                 CONT3360
      TN(2,J,1)=TN(1,J,2)                                               CONT3370
      T(1,J,3)=T(1,J,2)                                                 CONT3380
      TN(1,J,3)=TN(1,J,2)                                               CONT3390
      F(2,J,1)=F(1,J,2)                                                 CONT3400
      FN(2,J,1)=FN(1,J,2)                                               CONT3410
      F(1,J,3)=F(1,J,2)                                                 CONT3420
      FN(1,J,3)=FN(1,J,2)                                               CONT3430
      G(2,J,1)=G(1,J,2)                                                 CONT3440
      GN(2,J,1)=GN(1,J,2)                                               CONT3450
      G(1,J,3)=G(1,J,2)                                                 CONT3460
      GN(1,J,3)=GN(1,J,2)                                               CONT3470
      RXS(2,J,1)=RXS(1,J,2)                                             CONT3480
      RXS(1,J,3)=RXS(1,J,2)                                             CONT3490
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  380   CONTINUE                                                          CONT3500
  390   CONTINUE                                                          CONT3510
        NIT=0                                                             CONT3520
        NITTOT=0                                                          CONT3530
        VOLD(K)=VE2                                                       CONT3540
        CVOLD(K)=VE2                                                      CONT3550
        ROLD(K)=RE2                                                       CONT3560
  400   CONTINUE                                                          CONT3570
        NIT=NITHAF                                                        CONT3580
        DX=DXOLD                                                          CONT3590
        CALL CHANGX                                                       CONT3600
        NIT=0                                                             CONT3610
        IF (X.GT.XSTA(NSOLVE)) GO TO 410                                  CONT3620
        IF (L.NE.1.AND.L.EQ.LPR.OR.LPRT.EQ.1) LPR=LPR+LPRT                CONT3630
        IF (LPRTP.EQ.1.AND.L.GE.LSAVE) LPR=L+1                            CONT3640
        GO TO 10                                                          CONT3650
  410   CONTINUE                                                          CONT3660
        WRITE (6,450)                                                     CONT3670
        RETURN                                                            CONT3680
C                                                                         CONT3690
CCC                                                                       CONT3700
C                                                                         CONT3710
  420   FORMAT (10X,40HFAILED TO GET A CONVERGED SOLUTION AT K=,I3,5X,2HL=CONT3720
     1,I3,5X,4HNIT=,I3)                                                   CONT3730
  430   FORMAT (10X,57HEXECUTION TERMINATING******NITTOT.GT.3*NIT3******  CONT3740
     1    K= ,I2,3HL= ,I3,8HNITTOT= ,I3/)                                 CONT3750
  440   FORMAT (10X,40HEXECUTION TERMINATING******KLAST=0******/)         CONT3760
  450   FORMAT (10X,7HTHE END)                                            CONT3770
        END                                                               CONT3780


        SUBROUTINE DERIV (F,X,IMAX,IMIN,FP)                               DERI  10
        IMPLICIT REAL*8 (A-H,O-Z)                                         DERI  20
        DIMENSION F(101), X(101), FP(101)                                 DERI  30
C                                                                         DERI  40
CCC     SUBROUTINE DERIV3 CALCULATES THE FIRST DERIVATIVES OF F WITH      DERI  50
CCC     RESPECT TO X AND RETURNS THE ARRAY FP.                            DERI  60
C                                                                         DERI  70
        DO 10 J=IMIN,IMAX                                                 DERI  80
        K=J                                                               DERI  90
        IF (K.LT.(IMIN+1)) K=IMIN+1                                       DERI 100
        IF (K.GT.(IMAX-1)) K=IMAX-1                                       DERI 110
        CALL FD3 (X(J),X(K-1),X(K),X(K+1),F(K-1),F(K),F(K+1),FP(J))       DERI 120
  10    CONTINUE                                                          DERI 130
        RETURN                                                            DERI 140
        END                                                               DERI 150
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      SUBROUTINE DERIV3 (FX,II,KK,X,IMAX,IMIN,FPX)                          DER3  10
      IMPLICIT REAL*8 (A-H,O-Z)                                             DER3  20
      REAL*8 NOSE                                                           DER3  30
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KDUM,L,NBLNT1,IND,KPRT,LPRT,KDER3  40
     1PR,LPR                                                                DER3  50
      DIMENSION X(101), FX(2,101,3), FP(101), F(101), FPX(2,101,3)          DER3  60
C                                                                           DER3  70
CC    SUBROUTINE DERIV3 CALCULATES THE FIRST DERIVATIVES OF F WITH          DER3  80
CC    RESPECT TO X AND RETURNS THE ARRAY FP.                                DER3  90
C                                                                           DER3 100
      DO 10 J=1,IE                                                          DER3 110
      F(J)=FX(II,J,KK)                                                      DER3 120
10    CONTINUE                                                              DER3 130
      DO 20 J=IMIN,IMAX                                                     DER3 140
      K=J                                                                   DER3 150
      IF (K.LT.(IMIN+1)) K=IMIN+1                                           DER3 160
      IF (K.GT.(IMAX-1)) K=IMAX-1                                           DER3 170
      CALL FD3 (X(J),X(K-1),X(K),X(K+1),F(K-1),F(K),F(K+1),FP(J))           DER3 180
20    CONTINUE                                                              DER3 190
      DO 30 J=1,IE                                                          DER3 200
      FPX(II,J,KK)=FP(J)                                                    DER3 210
30    CONTINUE                                                              DER3 220
      RETURN                                                                DER3 230
      END                                                                   DER3 240
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      SUBROUTINE EDGCOF (LC)                                                EDGC  10
      IMPLICIT REAL*8(A-H,O-Z)                                              EDGC  20
      REAL*8 NOSE                                                           EDGC  30
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW      EDGC  40
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR                EDGC  50
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                           EDGC  60
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB                   EDGC  70
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,EDGC  80
     1LPR                                                                   EDGC  90
      COMMON /PDEREF/ UREF                                                  EDGC 100
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),EDGC 110
     1TWN(101),XIW,XW,RW                                                    EDGC 120
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG                                  EDGC 130
      COMMON /STGEDG/ DVEGXW,DVEWXW,DVE2XW,DVEGXX,DVEWXX,DVE2XX,DVGXXW,DEDGC 140
     1VWXXW,DV2XXW,DHWOXW,DHXOXW                                            EDGC 150
      COMMON /NCOORD/ XN(101),ETAX,ETAW                                     EDGC 160
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                      EDGC 170
      COMMON /HETA/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)EDGC 180
     1,HXNN(101),HWX(101),HWW(101),HWN(101),HWNN(101)                       EDGC 190
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      COMMON /PHI/ DAL3DX,DAL3DW,AL86                                    EDGC 200
      COMMON /WSOLVE/ DW,W                                               EDGC 210
      DIMENSION AL3OLD(61)                                               EDGC 220
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/                                  EDGC 230
C                                                                        EDGC 240
C     SUBROUTINE IECOEF CALCULATE GROUPS OF EDGE QUANTITIES USED IN      EDGC 250
C     THE COEFFICIENTS OF THE GOVERNING PARTIAL DIFFERENTIAL EQUATIONS   EDGC 260
C                                                                        EDGC 270
      PI=DARCOS(-1.DD)                                                   EDGC 280
      IF (LC.EQ.1) GO TO 10                                              EDGC 290
      B1=XI*DUEWDX/HX(1)/UEW                                             EDGC 300
      B2=XI*DUEWDW/HW(1)/UEW                                             EDGC 310
      XLAMB=UEW**2/TEW                                                   EDGC 320
      ETAX=DUEWDX/DSQRT(2.DD*UEW*XI)-DSQRT(UEW/2.DD/XI**3)               EDGC 330
      ETAW=DUEWDW/DSQRT(2.DD*UEW*XI)                                     EDGC 340
      IF (LC.EQ.2) GO TO 30                                              EDGC 350
      B3=XI*DVEWDX/HX(1)/VEW                                             EDGC 360
      B4=XI*DVEWDW/HW(1)/VEW                                             EDGC 370
      B5=B1                                                              EDGC 380
      B6=B2                                                              EDGC 390
      AL1=VEW/UEW                                                        EDGC 400
      AL2=1.DD                                                           EDGC 410
      AL3S=AL3                                                           EDGC 420
      IF (K.EQ.2) AL3S=0.DD                                              EDGC 430
      AL3=AL1                                                            EDGC 440
      DAL3DX=(AL3-AL3OLD(K))/DXI                                         EDGC 450
      DAL3DW=(AL3-AL3S+AL3OLD(K+1)-AL3OLD(K))/2.DD/DW                    EDGC 460
      AL3OLD(K)=AL3                                                      EDGC 470
      GO TO 40                                                           EDGC 480
   10 CONTINUE                                                           EDGC 490
      AL1=DABS(DVEWDX)/DUEWDX                                            EDGC 500
      B1=1.DD                                                            EDGC 510
      B2=2.DD*AL1                                                        EDGC 520
      B3=1.DD                                                            EDGC 530
      IF (DABS(DVEWDX).LT.1.D-05) B3=2.DD                                EDGC 540
      B4=0.DD                                                            EDGC 550
      IF (K.EQ.1) GO TO 20                                               EDGC 560
      IF (DABS(DVEWDX).GE.1.D-05) B4=DVEWXW/HWX(1)/DVEWDX                EDGC 570
      IF (DABS(DVEWDX).LE.1.D-05) B4=DVWXXW/HWX(1)/DVEWXX                EDGC 580
   20 CONTINUE                                                           EDGC 590
      B5=B3                                                              EDGC 600
      B6=B4                                                              EDGC 610
      AL2=AL1                                                            EDGC 620
      AL3=1.DD                                                           EDGC 630
      AL3OLD(K)=0.DD                                                     EDGC 640
      XLAMB=0.DD                                                         EDGC 650
      GO TO 40                                                           EDGC 660
   30 CONTINUE                                                           EDGC 670
      B3=XI*DVEWXW/DVEWDW                                                EDGC 680
      B4=0.DD                                                            EDGC 690
      B5=B3                                                              EDGC 700
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      B6=B4                                                                 EDGC 710
      ALB6=X1*DVEWDW/HW(1)/UEW                                              EDGC 720
      AL1=0.D0                                                              EDGC 730
      AL2=0.D0                                                              EDGC 740
      AL3=1.D0                                                              EDGC 750
40    CONTINUE                                                              EDGC 760
      IWT=0                                                                 EDGC 770
      IF (IWT.EQ.0) GO TO 50                                                EDGC 780
      WRITE (6,60) B1,B2,B3,B4,B5,B6                                        EDGC 790
      WRITE (6,70) AL1,AL2,AL3,XLAMB,DAL3DX                                 EDGC 800
50    CONTINUE                                                              EDGC 810
      RETURN                                                                EDGC 820
C                                                                           EDGC 830
60    FORMAT (1HO,7HB1-6 = ,6E13.6)                                         EDGC 840
70    FORMAT (1HO,8HAL1-3 = ,3E13.6,9H XLAMB = ,E13.6,10H DAL3DX = ,F13.EDGC 850
     16)                                                                    EDGC 860
      END                                                                   EDGC 870
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      SUBROUTINE EDYVIS                                                     EDYV  10
      IMPLICIT REAL*8(A-H,O-Z)                                              EDYV  20
      REAL*8 KLEB                                                           EDYV  30
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,EDYV  40
     1101,3),TN(2,101,3),Y(101),YOL(101)                                    EDYV  50
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW      EDYV  60
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR                EDYV  70
      COMMON /GASPRP/ PRANDT(101)                                           EDYV  80
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,EDYV  90
     1LPR                                                                   EDYV 100
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),EDYV 110
     1TWN(101),XIW,XW,RW                                                    EDYV 120
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XEDYV 130
     1CI(500),CIX(500),TCONW,KCI,KTW                                        EDYV 140
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSEDYV 150
     1(101),LAMTRB                                                          EDYV 160
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB                   EDYV 170
      COMMON /HETA/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)EDYV 180
     1,HXNN(101),HWX(101),HWW(101),HWN(101),HWNN(101)                       EDYV 190
      COMMON /GECOEF/ HXOHXO(101),HWOHWO(101),BHV(101),BHM(101),BHT(101)EDYV 200
     1,XKX(101),XKW(101),BMX(101),BMW(101),XLX(101),XLW(101),BAFF(101),BEDYV 210
     2AGF(101),BAFG(101),BAGG(101),XKXOAL(101)                              EDYV 220
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                      EDYV 230
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA        EDYV 240
      DIMENSION TAU(101), DAMP(101), EPSIN(101), EPSOUT(101), SCALAR(101EDYV 250
     1), VELCTY(101), YPLUS(101)                                            EDYV 260
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/                                     EDYV 270
      DATA REI,VAN/3HREI,3HVAN/                                             EDYV 280
      DATA CONST/5HCONST/                                                   EDYV 290
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C                                                                       EDYV 300
      IF (XI.EQ.0.0D0) RETURN                                           EDYV 310
C                                                                       EDYV 320
C     CALCULATE THE PHYSICAL NORMAL DISTANCE PROFILE                    EDYV 330
C                                                                       EDYV 340
      EPSVD=DSQRT(1.D0/REINF)                                           EDYV 350
      RETHET=0.0D0                                                      EDYV 360
      Y(1)=0.0D0                                                        EDYV 370
      YTRANS=DSQRT(XI/2.D0/UEW)                                         EDYV 380
      DO 10 J=2,IE                                                      EDYV 390
      Y(J)=Y(J-1)+YTRANS*DETA(J)*EPSVD                                  EDYV 400
      RETHET=RETHET+(FW(J)*(1.0D0-FW(J))+FW(J-1)*(1.0D0-FW(J-1)))*(Y(J)-EDYV 410
     1Y(J-1))/2.0D0                                                     EDYV 420
10    CONTINUE                                                          EDYV 430
C                                                                       EDYV 440
C     CALCULATE THE CONSTANT YSUBL                                      EDYV 450
C                                                                       EDYV 460
      DO 20 N=1,IE                                                      EDYV 470
      VELCTY(N)=DSQRT((FW(N)*UEW/HXOHXO(N))**2+(AL1*GW(N)*UEW/HWOHWO(N))EDYV 480
     1**2)/DSQRT((UEW/HXOHXO(N))**2+(VEW/HWOHWO(N))**2)                 EDYV 490
      NN=N-1                                                            EDYV 500
      IF (VELCTY(N).GE.0.99D0) GO TO 30                                 EDYV 510
20    CONTINUE                                                          EDYV 520
30    YSUBL=Y(NN)+(Y(NN+1)-Y(NN))*(0.99D0-VELCTY(NN))/(VELCTY(NN+1)-VELCEDYV 530
     1TY(NN))                                                           EDYV 540
C                                                                       EDYV 550
C     CALCULATE THE TOTAL SHEAR FOR USE IN THE VAN DRIEST DAMPING TERM  EDYV 560
C     CALCULATE THE SCALAR VELOCITY FUNCTION USED IN THE EDDY VISCOSITY EDYV 570
C                                                                       EDYV 580
      DO 40 N=1,IE                                                      EDYV 590
      DUDY=UFS*DSQRT(2.D0*UEW**3/XI)*HX(1)*(FWN(N)/HX(N)-FW(N)*HXN(N)/HXEDYV 600
     1(N)**2)/EPSVD                                                     EDYV 610
      IF (K.EQ.1) DWDY=0.0D0                                            EDYV 620
      IF (K.GT.1) DWDY=UFS*DSQRT(2.D0*UEW**3/XI)*HW(1)*(GWN(N)/HW(N)-GW(EDYV 630
     1N)*HWN(N)/HW(N)**2)/EPSVD                                         EDYV 640
      TAU(N)=AMUINF*DSQRT(DUDY**2+DWDY**2)                              EDYV 650
      SCALAR(N)=DSQRT(DUDY**2+DWDY**2)                                  EDYV 660
40    CONTINUE                                                          EDYV 670
      IF (EDYLAW.EQ.REI) GO TO 70                                       EDYV 680
C                                                                       EDYV 690
C     CALCULATE THE VAN DRIEST DAMPING TERM FOR THE INNER LAW           EDYV 700
C                                                                       EDYV 710
      DO 50 N=1,IE                                                      EDYV 720
      VWPLUS=CWALL*UFS/DSQRT(TAU(1)/RHOINF)                             EDYV 730
      ASTAR=26.0D0*DEXP(-5.9D0*VWPLUS)                                  EDYV 740
      DAMP(N)=(1.0D0-DEXP(-Y(N)*DSQRT(TAU(N)*RHOINF)/AMUINF/ASTAR))**2  EDYV 750
50    CONTINUE                                                          EDYV 760
C                                                                       EDYV 770
C     CALCULATE THE INNER EDDY VISCOSITY, VAN DRIEST EQ.                EDYV 780
C                                                                       EDYV 790
      DO 60 N=1,IE                                                      EDYV 800
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      EPSIN(N)=RHOINF*AKSTAR**2*Y(N)**2*DAMP(N)*SCALAR(N)/AMUINF          EDYV 810
60    CONTINUE                                                            EDYV 820
      GO TO 110                                                           EDYV 830
C                                                                         EDYV 840
CC    CALCULATE THE INNER EDDY VISCOSITY, REICHARDT EQ.                   EDYV 850
C                                                                         EDYV 860
70    CONTINUE                                                            EDYV 870
      UPLLST=1.0D0                                                        EDYV 880
      UPLUS=0.0D0                                                         EDYV 890
      UPL=0.0D0                                                           EDYV 900
      EPSIN(1)=0.0D0                                                      EDYV 910
      YPLUS(1)=0.0D0                                                      EDYV 920
      DO 90 N=2,IE                                                        EDYV 930
      VOPLUS=CWALL*UFS/DSQRT(TAU(1)/RHOINF)                               EDYV 940
      YPLUSA=3.65D0/(VOPLUS+0.344D0)                                      EDYV 950
      YPLUS(N)=Y(N)*DSQRT(TAU(1)*RHOINF)/AMUINF                           EDYV 960
      EPSIN(N)=AMUINF*0.4D0*(YPLUS(N)-YPLUSA*DTANH(YPLUS(N)/YPLUSA))      EDYV 970
      IF (VOPLUS.EQ.0.0D0) GO TO 90                                       EDYV 980
80    CONTINUE                                                            EDYV 990
      FACTR=DSQRT(1.0D0+VOPLUS*UPLUS)                                     EDYV1000
      EPSITR=EPSIN(N)*FACTR                                               EDYV1010
      UPL2=UPLUS                                                          EDYV1020
      UPLUS=UPL+((1.0D0+UPLUS*VOPLUS)/(1.0D0+EPSITR)+UPLLST)*(YPLUS(N)-YEDYV1030
     1PLUS(N-1))/2.0D0                                                    EDYV1040
      IF (UPL2.EQ.0.0D0) GO TO 80                                         EDYV1050
      IF (DABS((UPLUS-UPL2)/UPL2).GT.0.01D0) GO TO 80                     EDYV1060
      EPSIN(N)=EPSIN(N)*DSQRT(1.0D0+UPLUS*VOPLUS)                         EDYV1070
      UPLLST=(1.0D0+UPLUS*VOPLUS)/(1.0D0+EPSIN(N))                        EDYV1080
      UPL=UPLUS                                                           EDYV1090
90    CONTINUE                                                            EDYV1100
      DO 100 N=2,IE                                                       EDYV1110
100   EPSIN(N)=EPSIN(N)/AMUINF                                            EDYV1120
110   CONTINUE                                                            EDYV1130
C                                                                         EDYV1140
CC    CALCULATE THE OUTER EDDY VISCOSITY                                  EDYV1150
CC    KLEB IS THE KLEBANOFF INTERMITTANCY FACTOR                          EDYV1160
C                                                                         EDYV1170
      DO 120 N=1,IE                                                       EDYV1180
      KLEB=1.0D0/(1.0D0+5.5D0*(Y(N)/YSUBL)**6)                            EDYV1190
      EPSOUT(N)=RHOINF*ALAMDA**2*YSUBL**2*SCALAR(N)*KLEB/AMUINF           EDYV1200
120   CONTINUE                                                            EDYV1210
C                                                                         EDYV1220
      OUT=0.0D0                                                           EDYV1230
      DO 150 N=1,IE                                                       EDYV1240
      IF (OUT.EQ.1.0D0) GO TO 130                                         EDYV1250
      IF (EPSIN(N).GE.EPSOUT(N)) GO TO 130                                EDYV1260
      EPLUS(N)=EPSIN(N)                                                   EDYV1270
      GO TO 140                                                           EDYV1280
130   OUT=1.0D0                                                           EDYV1290
      EPLUS(N)=EPSOUT(N)                                                  EDYV1300
140   CONTINUE                                                            EDYV1310
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150   CONTINUE                                                          EDYV1320
      DO 160 J=2,IE                                                     EDYV1330
160   Y(J)=Y(J)/EPSVD                                                   EDYV1340
      RETURN                                                            EDYV1350
C                                                                       EDYV1360
      END                                                               EDYV1370



      SUBROUTINE EGPROP (LC)                                            EGPR  10
      IMPLICIT REAL*8(A-H,O-Z)                                          EGPR  20
      REAL*8 NOSE                                                       EGPR  30
      COMMON /CONICL/ PE(61),TE(61),UE(61),VE(61),DUEDW(61),DVEDW(61),DPEGPR  40
     1EDWZ(61)                                                          EGPR  50
      COMMON /EDGE/ UEDG,TEDG,VEDG,DUEGDX,DUEGDW,D2UEDW,DVEGDX,DVEGDW,REEGPR  60
     1DG,DRDGDX,ZBDD,XEDG                                               EGPR  70
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW  EGPR  80
      COMMON /EDG2/ TE2,UE2,VE2,DUE2DX,DVE2DX,DUE2DW,D2UE2W,DVE2DW,RE2,XEGPR  90
     12                                                                 EGPR 100
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101EGPR 110
     1J,CRI                                                             EGPR 120
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                       EGPR 130
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,EGPR 140
     1LPR                                                               EGPR 150
      COMMON /OLD/ VOLD(61),CVOLD(61),ROLD(61)                          EGPR 160
      COMMON /OLDEDG/ R3,UE3,DVE3DW                                     EGPR 170
      COMMON /PDEREF/ UREF                                              EGPR 180
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),PWN(101),PW(101),EGPR 190
     1TWN(101),XIW,DXDXIW,XW,RW                                         EGPR 200
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG                              EGPR 210
      COMMON /STGEDG/ DVEGXW,DVEWXW,DVE2XW,DVEGXX,DVEWXX,DVE2XX,DVGXXW,DEGPR 220
     1VWXXW,DV2XXW,DHWOXW,DHXOXW                                        EGPR 230
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                  EGPR 240
      COMMON /OUTSP/ DUDX,DVDX,DRDX                                     EGPR 250
      COMMON /XSOLVE/ XSTA(1100),DXMAX,DX,DXOLD,DX1,NSOLVE              EGPR 260
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                 EGPR 270
C                                                                       EGPR 280
CC    BODY EDGE QUANTITIES ARE OBTAINED                                 EGPR 290
C                                                                       EGPR 300
      IF (L.EQ.1.OR.K.GT.1) GO TO 10                                    EGPR 310
C                                                                       EGPR 320
CC    THE VALUE OF XI IS CALCULATED                                     EGPR 330
C                                                                       EGPR 340
      DXI=DX                                                            EGPR 350
      XI=XIOLD+DXI                                                      EGPR 360
      XXI=XIOLD+DX                                                      EGPR 370
      XIOLD=XI                                                          EGPR 380
10    CONTINUE                                                          EGPR 390
      X1=X                                                              EGPR 400
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      XX=X                                                              EGPR  410
      ISNT=1                                                            EGPR  420
      CALL BLUNT2 (ISNT)                                                EGPR  430
      TE2=TEDG                                                          EGPR  440
      RE2=REDG                                                          EGPR  450
      X2=XEDG                                                           EGPR  460
      UE2=UEDG                                                          EGPR  470
      VE2=VEDG                                                          EGPR  480
      DUE2DX=DUEGDX                                                     EGPR  490
      DVE2DX=DVEGDX                                                     EGPR  500
      DUE2DW=DUEGDW                                                     EGPR  510
      D2UE2W=D2UEDW                                                     EGPR  520
      DVE2DW=DVEGDW                                                     EGPR  530
      DVE2XW=DVEGXW                                                     EGPR  540
      IF (LC.NE.1) GO TO 20                                             EGPR  550
      DVE2XX=DVEGXX                                                     EGPR  560
      DV2XXW=DVGXXW                                                     EGPR  570
20    CONTINUE                                                          EGPR  580
      UE0=UE2                                                           EGPR  590
      IF (CRI.LT.1.000) GO TO 30                                        EGPR  600
      TEW=TE2                                                           EGPR  610
      REW=RE2                                                           EGPR  620
      UEW=UE2                                                           EGPR  630
      VEW=VE2                                                           EGPR  640
      DUEWDX=DUE2DX                                                     EGPR  650
      DVEWDX=DVE2DX                                                     EGPR  660
      DUEWDW=DUE2DW                                                     EGPR  670
      D2UEWW=D2UE2W                                                     EGPR  680
      DVEWDW=DVE2DW                                                     EGPR  690
      DVEWXW=DVE2XW                                                     EGPR  700
      IF (LC.NE.1) GO TO 30                                             EGPR  710
      DVEWXX=DVE2XX                                                     EGPR  720
      DVWXXW=DV2XXW                                                     EGPR  730
30    CONTINUE                                                          EGPR  740
      R2=RE2                                                            EGPR  750
      Z2=ZBOD                                                           EGPR  760
      IF (L.EQ.1) GO TO 40                                              EGPR  770
      ISNT=2                                                            EGPR  780
      X=X-DX/2.000                                                      EGPR  790
      XX=X                                                              EGPR  800
      CALL BLUNT2 (ISNT)                                                EGPR  810
      UE0=UEDG                                                          EGPR  820
      RO=REDG                                                           EGPR  830
      IF (CRI.EQ.1.000) GO TO 40                                        EGPR  840
      TEW=TEDG                                                          EGPR  850
      REW=REDG                                                          EGPR  860
      UEW=UEDG                                                          EGPR  870
      VEW=VEDG                                                          EGPR  880
      DUEWDX=DUEGDX                                                     EGPR  890
      DVEWDX=DVEGDX                                                     EGPR  900
      DUEWDW=DUEGDW                                                     EGPR  910
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      D2UEWW=D2UEDW                                                    EGPR 920
      DVEWDW=DVEGDW                                                    EGPR 930
      DVEWXW=DVEGXW                                                    EGPR 940
      IF (LC.NE.1) GO TO 40                                            EGPR 950
      DVEWXX=DVEGXX                                                    EGPR 960
      DVWXXW=DVGXXW                                                    EGPR 970
40    CONTINUE                                                         EGPR 980
      ZO=ZBOD                                                          EGPR 990
      ZBOD=Z2                                                          EGPR1000
      X=X1                                                             EGPR1010
C                                                                      EGPR1020
CCC   PROPERTIES AT THE BOUNDARY LAYER EDGE ARE CALCULATED             EGPR1030
C                                                                      EGPR1040
      IF (NOSE.EQ.BLUNT.AND.L.EQ.1) PNC=DSQRT(2.0D0*DUE2DX)            EGPR1050
      DUDX=DUE2DX                                                      EGPR1060
      DVDX=DVE2DX                                                      EGPR1070
      DRDX=DRE2DX                                                      EGPR1080
      IF (L.EQ.1) GO TO 50                                             EGPR1090
      XW=X-DX*(1.0D0-CRI)                                              EGPR1100
      RW=RE2                                                           EGPR1110
      IF (CRI.LT.1.0D0) RW=REW                                         EGPR1120
      XIW=XI                                                           EGPR1130
      IF (CRI.EQ.1.0D0) GO TO 50                                       EGPR1140
      XIW=XXI                                                          EGPR1150
50    CALL EDGCOF (LC)                                                 EGPR1160
      CALL GEOCOF                                                      EGPR1170
      RETURN                                                           EGPR1180
      END                                                              EGPR1190


      SUBROUTINE ENERGY (LC)                                           ENER  10
      IMPLICIT REAL*8(A-H,O-Z)                                         ENER  20
      REAL*8 NOSE                                                      ENER  30
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR           ENER  40
      COMMON /GASPRP/ PRANDT(101)                                      ENER  50
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                      ENER  60
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB              ENER  70
      COMMON /GECOEF/ HXOHXO(101),HWOHWO(101),BHV(101),BHM(101),BHT(101)ENER  80
     1,XKX(101),XKW(101),BMX(010),BMW(101),XLX(101),XLW(101),BAFF(101),BENER  90
     2AGF(101),BAFG(101),BAGG(101),XKXOAL(101)                         ENER 100
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,ENER 110
     1LPR                                                              ENER 120
      COMMON /PDECOF/ A0(101),AL(101),A2(101),A3(101),A4(101),A5(101)  ENER 130
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),ENER 140
     1TWN(101),XIW,XW,RW                                               ENER 150
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR          ENER 160
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSENER 170
     1(101),LAMTRB                                                     ENER 180
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      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                  ENER 190
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA    ENER 200
      COMMON /NCOORD/ XN(101),ETAX,ETAW                                 ENER 210
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW  ENER 220
      COMMON /HETA/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)ENER 230
     1,HXNN(101),HWX(010),HWW(101),HWN(101),HWNN(010)                   ENER 240
      COMMON /INTGRL/ XIFNX(101),XIFNW(101),XIFNXX(010),XIFNWW(101)     ENER 250
      COMMON /STGEDG/ DVEGXW,DVEWXW,DVE2XW,DVEGXX,DVEWXX,DVE2XX,DVGXXW,DENER 260
     1VWXXW,DV2XXW,DHWOXW,DHXOXW                                        ENER 270
      DIMENSION ROMU1(101), ROMU1N(101)                                 ENER 280
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/                                 ENER 290
C                                                                       ENER 300
CC    SUBROUTINE ENERGY SETS UP THE COEFFICIENTS OF THE PARTIAL         ENER 310
CC    DIFFERENTIAL ENERGY EQUATION                                      ENER 320
C                                                                       ENER 330
      DO 10 J=1,IE                                                      ENER 340
      ROMU1(J)=1.DO/PR*(1.0DO+XIF*EPLUS(J)*PR/PRANDT(J))                ENER 350
10    CONTINUE                                                          ENER 360
      CALL DERIV (ROMU1,ETA,IE,1,ROMU1N)                                ENER 370
      DO 40 J=1,IE                                                      ENER 380
      A0(J)=ROMU1(J)                                                    ENER 390
      A1(J)=-ROMU1N(J)*BHT(J)-VW(J)                                     ENER 400
      A2(J)=0.0DO                                                       ENER 410
      A3(J)=((HX(1)*FWN(J))**2+4.DO*(HX(1)*HXN(J)/HX(J)**2)**2)*XLAMB   ENER 420
      IF (LC.EQ.1) GO TO 20                                             ENER 430
      IF (LC.EQ.2) GO TO 30                                             ENER 440
      A3(J)=A3(J)+((HW(1)*AL2*GW(J))**2+4.DO*(HW(1)*HWN(J)*AL2/HW(J)**2)ENER 450
     1**2)*XLAMB                                                        ENER 460
      A4(J)=-HX(1)*XI*FW(J)/HX(J)**2                                    ENER 470
      A5(J)=-HW(1)*XI*AL2*GW(J)/HW(J)**2                                ENER 480
      GO TO 40                                                          ENER 490
20    CONTINUE                                                          ENER 500
      A4(J)=0.DO                                                        ENER 510
      A5(J)=-AL1*GW(J)/2.DO/HWX(1)                                      ENER 520
      GO TO 40                                                          ENER 530
30    CONTINUE                                                          ENER 540
      A4(J)=-XI*HX(1)*FW(J)/2.DO/HX(J)**2                               ENER 550
      A5(J)=0.DO                                                        ENER 560
40    CONTINUE                                                          ENER 570
      RETURN                                                            ENER 580
      END                                                               ENER 590



      SUBROUTINE FD3 (X,X1,X2,X3,F1,F2,F3,FX)                           FD30  10
      IMPLICIT REAL*8 (A-H,O-Z)                                         FD30  20
C                                                                       FD30  30
CC    SUBROUTINE FD3 CALCULATES THE FIRST DERIVATIVE-FX-CORRESPONDING   FD30  40
C     TO POINT X USING 3 POINT LAGRANGIAN DIFFERENTIATION FORMULA.      FD30  50
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C
CC      ASSUMES X1 .LE. X .LE. X3.                                      FD30  60
C                                                                       FD30  70
                                                                        FD30  80
        A1=2.0*X-X2-X3                                                  FD30  90
        A2=2.0*X-X1-X3                                                  FD30 100
        A3=2.0*X-X1-X2                                                  FD30 110
        D1=(X1-X2)*(X1-X3)                                              FD30 120
        D2=(X2-X1)*(X2-X3)                                              FD30 130
        D3=(X3-X1)*(X3-X2)                                              FD30 140
        C1=A1/D1                                                        FD30 150
        C2=A2/D2                                                        FD30 160
        C3=A3/D3                                                        FD30 170
        FX=C1*F1+C2*F2+C3*F3                                            FD30 180
        RETURN                                                          FD30 190
        END                                                             FD30 200



        SUBROUTINE FD5 (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,FX)             FD50  10
        IMPLICIT REAL*8 (A-H,O-Z)                                       FD50  20
                                                                        FD50  30
CCCCCC  SUBROUTINE FD5 CALCULATES THE FIRST DERIVATIVE-FX-CORRESPONDING FD50  40
        TO POINT X USING 5 POINT LAGRANGIAN DIFFERENTIATION FORMULA     FD50  50
                                                                        FD50  60
        ASSUMES X1 .LE. X .LE. X5.                                      FD50  70
                                                                        FD50  80
        A1=(X-X4)*(X-X5)*(2.0*X-X2-X3)+(X-X2)*(X-X3)*(2.0*X-X4-X5)      FD50  90
        A2=(X-X4)*(X-X5)*(2.0*X-X1-X3)+(X-X1)*(X-X3)*(2.0*X-X4-X5)      FD50 100
        A3=(X-X4)*(X-X5)*(2.0*X-X1-X2)+(X-X1)*(X-X2)*(2.0*X-X4-X5)      FD50 110
        A4=(X-X3)*(X-X5)*(2.0*X-X1-X2)+(X-X1)*(X-X2)*(2.0*X-X3-X5)      FD50 120
        A5=(X-X3)*(X-X4)*(2.0*X-X1-X2)+(X-X1)*(X-X2)*(2.0*X-X3-X4)      FD50 130
        D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)                              FD50 140
        D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)                              FD50 150
        D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)                              FD50 160
        D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)                              FD50 170
        D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)                              FD50 180
        C1=A1/D1                                                        FD50 190
        C2=A2/D2                                                        FD50 200
        C3=A3/D3                                                        FD50 210
        C4=A4/D4                                                        FD50 220
        C5=A5/D5                                                        FD50 230
        FX=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5                                FD50 240
        RETURN                                                          FD50 250
        END                                                             FD50 260
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      SUBROUTINE GEOCOF                                                 GEOC  10
      IMPLICIT REAL*8(A-H,O-Z)                                          GEOC  20
C                                                                       GEOC  30
CCCC   THIS SUBROUTINE CALCULATES THE GEOMETRIC COEFFICIENTS OF THE     GEOC  40
CCCC  GOVERNING EQUATIONS                                               GEOC  50
C                                                                       GEOC  60
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,GEOC  70
     1LPR                                                               GEOC  80
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                  GEOC  90
      COMMON /EDGW/ UEw,VEw,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW  GEOC 100
      COMMON /NCOORD/ XN(101),ETAX,ETAW                                 GEOC 110
      COMMON /HETA/ HX(101),Hw(101),HXX(101),HXW(101),HXWW(101),HXN(101)GEOC 120
     1,HXNN(101),HWX(101),Hww(101),HWN(101),HWNN(101)                   GEOC 130
      COMMON /GECOEF/ HXOHXO(101),HWOHWO(101),BHV(101),BHM(101),BHT(101)GEOC 140
     1,XKX(101),XKW(101),BMX(101),BMW(101),XLX(101),XLW(101),BAFF(101),BGEOC 150
     2AGF(101),BAFG(101),BAGG(101),XKXOAL(101)                          GEOC 160
      COMMON /STGEDG/ DVEGXW,DVEWXW,DVE2Xw,DVEGXX,DVEWXX,DVE2XX,DVGXXW,DGEOC 170
     1VWXXW,DV2XXW,DHWOXW,DHXOXW                                        GEOC 180
      COMMON /WSOLVE/ Dw,W                                              GEOC 190
      COMMON /STGSPC/ HXXOLD(101)                                       GEOC 200
      COMMON /TVCURV/ TVC                                               GEOC 210
      COMMON /EDGE/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB                 GEOC 220
      DATA YES/3HYES/                                                   GEOC 230
      PI=DARCOS(-1.DO)                                                  GEOC 240
      IF (TVC.NE.YES) GO TO 80                                          GEOC 250
C                                                                       GEOC 260
CCCC  CALCULATE COEFFICIENTS WITH TVC                                   GEOC 270
C                                                                       GEOC 280
CCCC  CALCULATE COEFFICIENTS AT STAGNATION POINT                        GEOC 290
C                                                                       GEOC 300
      IF (L.NE.1) GO TO 40                                              GEOC 310
      DO 30 I=1,IE                                                      GEOC 320
      HXOHXO(I)=HX(I)/HX(1)                                             GEOC 330
      HWOHWO(I)=1.DO                                                    GEOC 340
      BHV(I)=HXN(I)/HX(I)                                               GEOC 350
      BHM(I)=BHV(I)                                                     GEOC 360
      BHT(I)=BHM(I)                                                     GEOC 370
      XKX(I)=HXW(I)/(HX(I)*HwX(I))                                      GEOC 380
      XKW(I)=1.DO/HX(I)                                                 GEOC 390
      BMX(I)=HXNN(I)/HX(I)-(HXN(I)/HX(I))**2                            GEOC 400
      BMW(I)=0.DO                                                       GEOC 410
      XLX(I)=0.DO                                                       GEOC 420
      XLW(I)=0.DO                                                       GEOC 430
      IF (DABS(DVEWDX).LT.1.D-05) GO TO 10                              GEOC 440
      XKXOAL(I)=HXW(I)/HX(I)/HWX(I)/AL1                                 GEOC 450
      GO TO 20                                                          GEOC 460
   10 CONTINUE                                                          GEOC 470
      XKXOAL(I)=3.DO                                                    GEOC 480
   20 CONTINUE                                                          GEOC 490
      BAFF(I)=0.DO                                                      GEOC 500
      BAGF(I)=0.DO                                                      GEOC 510
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AD-A051 971 VIRGINIA POLYTECHNIC INST AND STATE UNIV BLACKSBURG --ETC F/G 20/4
THREE-DIMENSIONAL INCOMPRESSIBLE BOUNDARY LAYERS ON BLUNT BODIE--ETC(U).
MAY 77 D L DWOYER, C H LEWIS, P R GOGINENI

UNCLASSIFIED VPI/SU-AERO-063-PT-2 NL

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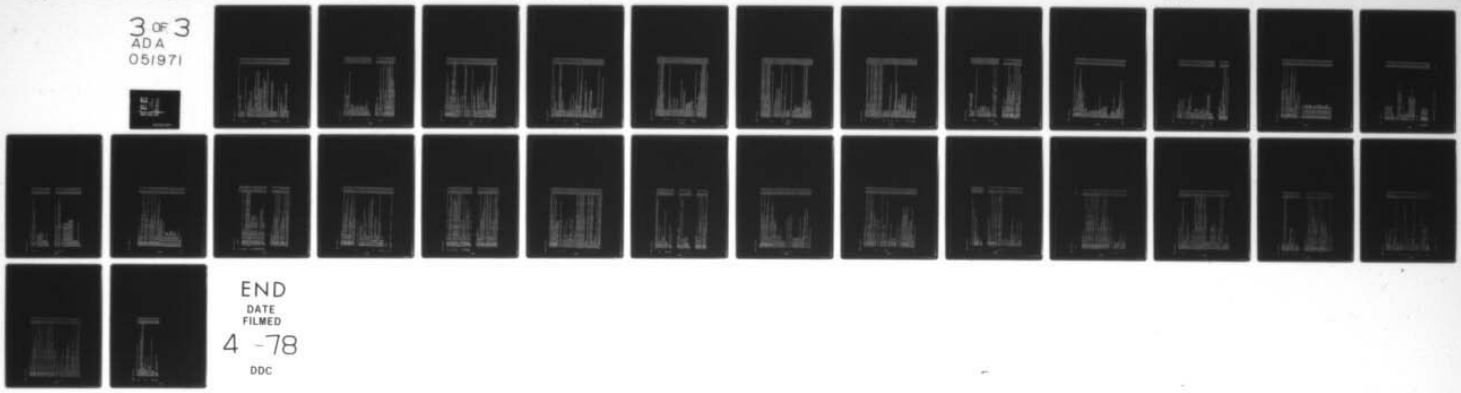

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      BAFG(I)=((DUEWDX/HXOHXO(I))**2*HXN(I)+DSQRT(DUEWDX**3/2.DO))/HXOHX)GEOC 520
     1(I)**3)/DSQRT(2.DO*DUEWDX**3)                                      GEOC 530
      BAGG(I)=DVEWDX/2.DO/DUEWDX**2                                      GEOC 540
   30 CONTINUE                                                           GEOC 550
      RETURN                                                             GEOC 560
   40 CONTINUE                                                           GEOC 570
C                                                                        GEOC 580
C     CALCULATE GEOMETRIC COEFFICIENTS FOR A GENERAL POINT               GEOC 590
C                                                                        GEOC 600
      DO 70 I=1,IE                                                       GEOC 610
      HXOHXO(I)=HX(I)/HX(1)                                              GEOC 620
      HWOHWO(I)=HW(I)/HW(1)                                              GEOC 630
      BHV(I)=HWN(I)/HW(I)+HXN(I)/HX(I)                                   GEOC 640
      BHM(I)=HXN(I)/HX(I)-HWN(I)/HW(I)                                   GEOC 650
      BHT(I)=BHV(I)                                                      GEOC 660
      XKX(I)=0.DO                                                        GEOC 670
      IF (K.NE.1) XKX(I)=XI*HXW(I)/HX(I)/HW(I)                           GEOC 680
      IF (K.EQ.1) XKXOAL(I)=XI*HXWW(I)*UEW/HX(I)/HW(I)/DVEWDW            GEOC 690
      XKW(I)=XI*HWX(I)/HX(I)/HW(I)                                       GEOC 700
      BMX(I)=(HWN(I)*HXN(I)/HW(I)-HXN(I)**2/HX(I)+HXNN(I))/HX(I)         GEOC 710
      BMW(I)=(HWN(I)*HXN(I)/HX(I)-HWN(I)**2/HW(I)+HWNN(I))/HW(I)         GEOC 720
      XLX(I)=XI*HXX(I)/HXOHXO(I)/HX(I)**2                                GEOC 730
      XLW(I)=XI*HWW(I)/HWOHWO(I)/HW(I)**2                                GEOC 740
      BAFFC=UEW**2*HXN(I)/HXOHXO(I)**2/HX(I)                             GEOC 750
      BAGFC=0.DO                                                         GEOC 760
      IF (K.NE.1) BAGFC=UEW**2*HWN(I)/HWOHWO(I)**2/HW(I)                 GEOC 770
      BAFF(I)=XI*BAFFC/2.DO/HX(1)/UEW**2*ETAX*XN(I)                      GEOC 780
      BAGF(I)=XI*BAGFC/2.DO/HX(I)/UEW**2*ETAX*XN(I)                      GEOC 790
      IF (K.NE.1) GO TO 50                                               GEOC 800
      BAFG(I)=BAFFC*DSQRT(XI/2.DO/UEW**3)/HW(1)*D2UEWW/DVEWDW*XN(I)      GEOC 810
      BAGG(I)=0.DO                                                       GEOC 820
      GO TO 60                                                           GEOC 830
   50 CONTINUE                                                           GEOC 840
      BAFG(I)=XI*BAFFC/2.DO/HW(1)/UEW**2*ETAW*XN(I)                      GEOC 850
      BAGG(I)=XI*BAGFC/2.DO/HW(1)/UEW**2*ETAW*XN(I)                      GEOC 860
   60 CONTINUE                                                           GEOC 870
   70 CONTINUE                                                           GEOC 880
      RETURN                                                             GEOC 890
   80 CONTINUE                                                           GEOC 900
C                                                                        GEOC 910
C     CALCULATE COEFFICIENTS WITHOUT TVC                                 GEOC 920
C                                                                        GEOC 930
      IF (L.NE.1) GO TO 90                                               GEOC 940
      XKX(1)=HXW(1)/(HX(1)*HWX(1))                                       GEOC 950
      XKW(1)=1.DO/HX(1)                                                  GEOC 960
      XLX(1)=0.DO                                                        GEOC 970
      XLW(1)=0.DO                                                        GEOC 980
      IF (DABS(DVEWDX).GT.1.D-05) XKXOAL(1)=0.DO                         GEOC 990
      IF (DABS(DVEWDX).LE.1.D-05) XKXOAL(1)=3.DO                         GEOC1000
      GO TO 100                                                          GEOC1010
   90 CONTINUE                                                           GEOC1020
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      XKX(1)=0.D0                                                       GEOC1030
      IF (K.NE.1) XKX(1)=XI*HXW(1)/HX(1)/HW(1)                          GEOC1040
      XKW(1)=XI*HWX(1)/HX(1)/HW(1)                                      GEOC1050
      XLX(1)=XI*HXX(1)/HX(1)**2                                         GEOC1060
      XLW(1)=XI*HWW(1)/HW(1)**2                                         GEOC1070
      IF (K.EQ.1) XKXOAL(1)=XI*HXWW(1)*UEW/HX(1)/HW(1)/DVEWDW           GEOC1080
100   CONTINUE                                                          GEOC1090
      DO 110 I=1,IE                                                     GEOC1100
      HXOHXO(I)=1.D0                                                    GEOC1110
      HWOHWO(I)=1.D0                                                    GEOC1120
      BHV(I)=0.D0                                                       GEOC1130
      BHM(I)=0.D0                                                       GEOC1140
      BHT(I)=0.D0                                                       GEOC1150
      XKX(I)=XKX(1)                                                     GEOC1160
      XKW(I)=XKW(1)                                                     GEOC1170
      BMX(I)=0.D0                                                       GEOC1180
      BMW(I)=0.D0                                                       GEOC1190
      XLX(I)=XLX(1)                                                     GEOC1200
      XLW(I)=XLW(1)                                                     GEOC1210
      BAFF(I)=0.D0                                                      GEOC1220
      BAGF(I)=0.D0                                                      GEOC1230
      BAFG(I)=0.D0                                                      GEOC1240
      BAGG(I)=0.D0                                                      GEOC1250
      XKXOAL(I)=XKXOAL(1)                                               GEOC1260
110   CONTINUE                                                          GEOC1270
      RETURN                                                            GEOC1280
      END                                                               GEOC1290
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      SUBROUTINE HOFN                                                   HOFN  10
      IMPLICIT REAL*8(A-H,O-Z)                                          HOFN  20
      REAL*8 NOSE                                                       HOFN  30
C                                                                       HOFN  40
CCC   THIS SUBROUTINE CALCULATES THE NORMAL VARIATION OF THE METRIC     HOFN  50
      COEFFICIENTS AND THEIR DERIVATIVES                                HOFN  60
C                                                                       HOFN  70
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,HOFN  80
     1LPR                                                               HOFN  90
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                  HOFN 100
      COMMON /EDGE/ UEDG,TEDG,VEDG,DUEGDX,DUEGDW,D2UEGW,DVEGDX,DVEGDW,REHOFN 110
     1DG,DRGDX,ZBOD,XEDG                                                HOFN 120
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA    HOFN 130
      COMMON /HRWALL/ RO,HXO,HWO,DRODX,DRODW,D2RDXX,D2RDWW,D2RDXW,D3RXXXHOFN 140
     1,D3RWXX,D3RWWX,D3RWWW,DRWWXX,DRWWWX,DHXODX,DHXODW,DHXDWW,DHWODX,DHHOFN 150
     2WODW,XO,DXODX,DXODW,D2XODX,D2XODW,D2XDWX,D3XXWW                   HOFN 160
      COMMON /HETA/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)HOFN 170
     1,HXNN(101),HWX(101),HWW(101),HWN(101),HWNN(101)                   HOFN 180
      COMMON /NCOORD/ XN(101),ETAX,ETAW                                 HOFN 190
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      COMMON /WSOLVE/ DW,W                                                    HOFN 200
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR                  HOFN 210
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                             HOFN 220
      COMMON /TVCURV/ TVC                                                     HOFN 230
      COMMON /STGSPC/ HXXOLD(101)                                             HOFN 240
      COMMON /RAD/ RXS(2,101,3)                                               HOFN 250
      DIMENSION TXXS(61), TWS(61), TWXS(61), HTXS(101)                        HOFN 260
      DIMENSION RT(101), RTW(101), RTWW(101), RTX(101), RTXX(101), RTWX(HOFN 270
     1101), PHT(101), PHTW(101), PHTWW(101), PHTX(101), PHTXX(101), PHTWHOFN 280
     2X(101), XT(101), XTW(101), XTWW(101), XTX(101), XTXX(101), XTWX(10HOFN 290
     31), RTWWX(101), XTXWW(101)                                              HOFN 300
      DATA YES/3HYES/                                                         HOFN 310
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                       HOFN 320
      EPSVD=1.D0/DSQRT(REINF)                                                 HOFN 330
      PI=DARCOS(-1.D0)                                                        HOFN 340
      IF (TVC.NE.YES) GO TO 310                                               HOFN 350
C                                                                             HOFN 360
CC    CALCULATE NORMAL COORDINATE                                             HOFN 370
C                                                                             HOFN 380
      IF (L.EQ.1.AND.NOSE.EQ.BLUNT) YTRANS=1.D0/DSQRT(2.D0*DUEGDX)*EPSVDHOFN 390
      IF (L.NE.1.OR.NOSE.EQ.SHARP) YTRANS=DSQRT(XI/(2.D0*UEDG))*EPSVD         HOFN 400
      XN(1)=0.D0                                                              HOFN 410
      DO 10 I=2,IE                                                            HOFN 420
      XN(I)=YTRANS*ETA(I)                                                     HOFN 430
   10 CONTINUE                                                                HOFN 440
C                                                                             HOFN 450
CC    CALCULATE BODY SLOPES AND DERIVATIVES IN X AND PHI DIRECTIONS           HOFN 460
C                                                                             HOFN 470
      IF (L.EQ.1.AND.K.GT.1) GO TO 20                                         HOFN 480
      TX=DATAN(DABS(DRODX/DXODX))                                             HOFN 490
   20 CONTINUE                                                                HOFN 500
      TW=0.D0                                                                 HOFN 510
      IF (L.GT.1) TW=DATAN(DRODW/2.D0/PI/RO)                                  HOFN 520
      AX=1.D0/(1.D0+(DRODX/DXODX)**2)                                         HOFN 530
      IF (L.EQ.1) GO TO 30                                                    HOFN 540
      AW=1.D0/(1.D0+.25D0*(DRODW/PI/RO)**2)                                   HOFN 550
   30 CONTINUE                                                                HOFN 560
      TXX=(-D2XODX*DRODX/DXODX**2+D2RDXX/DXODX)*AX                            HOFN 570
      IF (L.EQ.1) TXXS(K)=TXX                                                 HOFN 580
      TXXX=0.D0                                                               HOFN 590
      IF (L.EQ.1) GO TO 40                                                    HOFN 600
      TXXX=(TXX-TXXS(K))/DXI                                                  HOFN 610
      TXXS(K)=TXX                                                             HOFN 620
   40 CONTINUE                                                                HOFN 630
      TXW=(-D2XDWX*DRODX/DXODX**2+D2RDXW/DXODX)*AX                            HOFN 640
      TXWW=-TXW*(-2.D0*D2XDWX*DRODX**2/DXODX**3+2.D0*DRODX*D2RDXW/DXODX*HOFN 650
     1*2)*AX+(2.D0*D2XDWX**2*DRODX/DXODX**3-2.D0*D2XDWX*D2RDXW/DXODX**2+HOFN 660
     2D3RWWX/DXODX)*AX                                                        HOFN 670
      IF (L.EQ.1) GO TO 70                                                    HOFN 680
      TWW=(D2RDWW/RO-(DRODW/RO)**2)*AW/2.D0/PI                                HOFN 690
      TWWW=-TWW*(DRODW*D2RDWW/2.D0*PI**2/RO**2-(DRODW/RO)**3/2.D0/PI**2)HOFN 700
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     1*AW*(D3RWWW/RO-2.DO*D2RDWW*DRODW/RO**2+2.DO*DRODW**2*D2RDWW/RO**3)HOFN 710
     2*AW/2.DO/PI                                                      HOFN 720
      TWX=(D2RDXW/RO-DRODW*DRODX/RO**2)*AW/2.DO/PI                     HOFN 730
      IF (L.EQ.1) GO TO 50                                             HOFN 740
      TWX=(TW-TWS(K))/DXI                                              HOFN 750
      TWS(K)=TW                                                        HOFN 760
50    CONTINUE                                                         HOFN 770
      TWXX=-TWX*(DRODW*D2RDXW/2.DO*PI**2/RO**2-DRODW**2*DRODX/RO**3/2.DOHOFN 780
     1/PI**2)*AW+(D3RWXX/RO-2.DO*D2RDXW*DRODX/RO**2-DRODW*D2RDXW/RO**2+DHOFN 790
     2RODW*DRODX**2*2.DO/RO**3)*AW/2.DO/PI                             HOFN 800
      IF (L.EQ.1) GO TO 60                                             HOFN 810
      TWXX=(TWX-TWXS(K))/DXI                                           HOFN 820
      TWXS(K)=TWX                                                      HOFN 830
60    CONTINUE                                                         HOFN 840
      GO TO 80                                                         HOFN 850
70    CONTINUE                                                         HOFN 860
      TWW=0.DO                                                         HOFN 870
      TWWW=0.DO                                                        HOFN 880
      TWX=D3RWXX/DRODX/2.DO/PI                                         HOFN 890
      TWS(K)=TW                                                        HOFN 900
      TWXS(K)=TWX                                                      HOFN 910
      TWXX=-D3RWXX*D2RDXX/DRODX**2/PI                                  HOFN 920
80    CONTINUE                                                         HOFN 930
      IF (K.GT.1) GO TO 100                                            HOFN 940
      TXWX=D3RWXX*AX/DXODX                                             HOFN 950
      TXWWX=-2.DO*DRODX*D3RWWX/DXODX**2*AX**2+(-D2XODX*D3RWWX/DXODX**2+DHOFN 960
     1RWWXX/DXODX)*AX                                                  HOFN 970
      IF (L.EQ.1) GO TO 90                                             HOFN 980
      TWWX=(D3RWWX/RO-D2RDWW*DRODX/RO**2)/2.DO/PI                      HOFN 990
      TWWWX=((D2RDWW/RO)**3/2.DO/PI**2+DRWWWX/RO-D3RWWX*DRODX/RO**2)/2.DHOFN1000
     10/PI                                                             HOFN1010
      GO TO 100                                                        HOFN1020
90    CONTINUE                                                         HOFN1030
      TWWX=(DRWWXX/DRODX-D3RWXX*D2RDXX/DRODX)/2.DO/PI                  HOFN1040
      TWWWX=-DRWWXX*D2RDXX/DRODX**2/PI                                 HOFN1050
100   CONTINUE                                                         HOFN1060
      IWT=0                                                            HOFN1070
      IF (IWT.EQ.0) GO TO 110                                          HOFN1080
      WRITE (6,330) TX,TW,TXX,TXW,TWX,TWW                              HOFN1090
      WRITE (6,330) TXXX,TXWW,TWXX,TWWW                                HOFN1100
110   CONTINUE                                                         HOFN1110
      STX=DSIN(TX)                                                     HOFN1120
      CTX=DCOS(TX)                                                     HOFN1130
      STW=DSIN(TW)                                                     HOFN1140
      CTW=DCOS(TW)                                                     HOFN1150
C                                                                      HOFN1160
C     CALCULATE RADIUS AND DERIVATIVES OF RADIUS FOR PROFILE POINTS    HOFN1170
C                                                                      HOFN1180
      IINC=5                                                           HOFN1190
      DO 210 I=2,IE                                                    HOFN1200
      R=DSQRT(RO**2+(XN(I)*CTX)**2+2.DO*RO*XN(I)*CTX*CTW)              HOFN1210
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      RT(I)=R-RO                                                        HOFN1220
      IF (L.EQ.1) GO TO 120                                             HOFN1230
      RW=(RO*DRODW-XN(I)**2*CTX*STX*TXW+DRODW*XN(I)*CTX*CTW-RO*XN(I)*(ST HOFN1240
     1X*CTW*TXW+CTX*STW*TWW))/R                                         HOFN1250
      RWW=(-RW**2+DRODW**2+RO*D2RDWW+XN(I)**2*((STX*TXW)**2-(CTX*TXW)**2HOFN1260
     1+CTX*STX*TXWW)+D2RDWW*XN(I)*CTX*CTW-DRODW*XN(I)*(STX*CTW*TXW+CTX*SHOFN1270
     2TW*TWW)-RO*XN(I)*(CTX*CTW*TXW**2-2.DO*STX*STW*TXW*TWW+CTX*STW*TWW*HOFN1280
     3*2+STX*CTW*TXWW+CTX*STW*TWWW))/R                                  HOFN1290
      GO TO 130                                                         HOFN1300
  120 CONTINUE                                                          HOFN1310
      RW=0.DO                                                           HOFN1320
      RWW=0.DO                                                          HOFN1330
  130 CONTINUE                                                          HOFN1340
      RX=(RO*DRODX-XN(I)**2*CTX*STX*TXX+DRODX*XN(I)*CTX*CTW-RO*XN(I)*(ST HOFN1350
     1X*CTW*TXX+CTX*STW*TWX))/R                                         HOFN1360
      RXS(2,I,2)=RX                                                     HOFN1370
      RXX=0.DO                                                          HOFN1380
      IF (L.EQ.1) GO TO 140                                             HOFN1390
      RXX=(RX-RXS(1,I,2))/DXI                                           HOFN1400
  140 CONTINUE                                                          HOFN1410
      IF (K.EQ.1) GO TO 150                                             HOFN1420
      RWX=(RX-RXS(2,I,1))/DW                                            HOFN1430
      GO TO 160                                                         HOFN1440
  150 CONTINUE                                                          HOFN1450
      RWX=0.DO                                                          HOFN1460
      RWWX=D3RWWX-XN(I)*CTX*TXX*TXWW-XN(I)*STX*TXWWX                    HOFN1470
  160 CONTINUE                                                          HOFN1480
      IF (IINC.NE.5000) GO TO 170                                       HOFN1490
      WRITE (6,340) R,RX,RW,RXX,RWX,RWW                                 HOFN1500
  170 CONTINUE                                                          HOFN1510
      RTW(I)=RW-DRODW                                                   HOFN1520
      RTWW(I)=RWW-D2RDWW                                                HOFN1530
      RTX(I)=RX-DRODX                                                   HOFN1540
      RTXX(I)=RXX-D2RDXX                                                HOFN1550
      RTWX(I)=RWX-D2RDXW                                                HOFN1560
      IF (K.NE.1) GO TO 180                                             HOFN1570
      RTWWX(I)=RWWX-D3RWWX                                              HOFN1580
  180 CONTINUE                                                          HOFN1590
C                                                                       HOFN1600
C     CALCULATE MERIDIONAL ANGLE AND DERIVATIVES FOR PROFILE POINTS     HOFN1610
C                                                                       HOFN1620
      XNHAT=XN(I)*CTX                                                   HOFN1630
      PHT(I)=DARSIN(XNHAT*STW/R)                                        HOFN1640
      D=DSQRT(1.DO-(XNHAT*STW/R)**2)                                    HOFN1650
      PHTW(I)=XNHAT*(CTW*TWW-STW*RW/R)/R/D-XN(I)*STX*STW*TXW/R/D        HOFN1660
      PHTWW(I)=-PHTW(I)*XN(I)**2*(CTX**2*STW*CTW*TWW-STX*CTX*STW**2*TXW-HOFN1670
     1TX**2*STW**2*RW/R)/R**2/D**2+XN(I)*(-STX*CTW*TWW*TXW-CTX*STW*TWW**HOFN1680
     22+CTX*CTW*TWWW-CTX*CTW*TWW*RW/R-CTX*STW*TXW**2-STX*CTW*TXW*TWW-STXHOFN1690
     3*STW*TXWW+2.DO*STX*STW*RW*TXW/R-CTX*CTW*TWW*RW*R+2.DO*CTX*STW*RW**HOFN1700
     42/R**2-CTX*STW*RWW/R)/R/D                                         HOFN1710
      PHTX(I)=XNHAT*(CTW*TWX-STW*RX/R)/R/D-XN(I)*STX*STW*TXX/R/D        HOFN1720
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      PHTXX(I)=-PHTX(I)*XN(I)**2*(CTX**2*STW*CTW*TWX-STX*CTX*STW**2*TXX-HOFN1730
     1CTX**2*STW**2*RX/R)/R**2/D**2+XN(I)*(-STX*CTW*TWX*TXX-CTX*STW*TWX*HOFN1740
     2*2+CTX*CTW*TWXX-CTX*CTW*TWX*RX/R-CTX*STW*TXX**2-STX*CTW*TXX*TWX-STHOFN1750
     3X*STW*TXXX+2.D0*STX*STW*TXX*RX/R-CTX*CTW*TWX*RX/R+2.D0*CTX*STW*RW*HOFN1760
     4*2/R**2-CTX*STW*RWW/R)/R/D                                        HOFN1770
      PHTWX(I)=-PHTW(I)*XN(I)**2*(CTX**2*STW*CTW*TWX-STX*CTX*STW**2*TXX-HOFN1780
     1CTX**2*STW**2*RX/R)/R**2/D**2+XN(I)*(-STX*CTW*TWX*TXX-CTX*STW*TWX*HOFN1790
     2TWW+CTX*CTW*TWWX-CTX*CTW*TWX*RX/R-CTX*STW*TXX*TXW-STX*CTW*TXX*TWX-HOFN1800
     3STX*STW*TXWX+2.D0*STX*STW*TXX*RX/R-CTX*CTW*TWX*RX/R+CTX*STW*RX*RW/HOFN1810
     4R**2-CTX*STW*RWX/R)/R/D                                           HOFN1820
C                                                                       HOFN1830
CC    CALCULATE AXIAL DISTANCE AND DERIVATIVES FOR PROFILE POINTS       HOFN1840
C                                                                       HOFN1850
      XT(I)=-XN(I)*STX                                                  HOFN1860
      XTW(I)=-XN(I)*CTX*TXW                                             HOFN1870
      XTWW(I)=XN(I)*(STX*TXW**2+CTX*TXWW)                               HOFN1880
      XTX(I)=-XN(I)*CTX*TXX                                             HOFN1890
      XTXX(I)=XN(I)*(STX*TXX**2+CTX*TXXX)                               HOFN1900
      XTWX(I)=-XN(I)*(STX*TXX*TXW+CTX*TXWX)                             HOFN1910
      IF (K.NE.1) GO TO 190                                             HOFN1920
      XTXWW(I)=-XN(I)*(CTX*TXX*TXW**2+2.D0*STX*TXW*TXXW+STX*TXWW-CTX*TXWHOFN1930
     1WX)                                                               HOFN1940
  190 CONTINUE                                                          HOFN1950
      IF (IINC.NE.5000) GO TO 200                                       HOFN1960
      WRITE (6,340) PHT(I),PHTX(I),PHTW(I),XT(I),XTX(I),XTW(I)          HOFN1970
      IINC=0                                                            HOFN1980
  200 CONTINUE                                                          HOFN1990
      IINC=IINC+1                                                       HOFN2000
  210 CONTINUE                                                          HOFN2010
C                                                                       HOFN2020
CC    CALCULATE METRIC COEFFICIENTS AND DERIVATIVES FOR PROFILE POINTS  HOFN2030
C                                                                       HOFN2040
      HX(1)=HXO                                                         HOFN2050
      HW(1)=HWO                                                         HOFN2060
      HXXOLD(1)=HXX(1)                                                  HOFN2070
      HXX(1)=DHXODX                                                     HOFN2080
      HXW(1)=DHXODW                                                     HOFN2090
      HWX(1)=DHWODX                                                     HOFN2100
      HWW(1)=DHWODW                                                     HOFN2110
      HXWW(1)=DHXDWW                                                    HOFN2120
      IINC=5                                                            HOFN2130
      DO 300 I=2,IE                                                     HOFN2140
      HTX=RTX(I)*(2.D0*DRODX+RTX(I))+((RO+RT(I))*PHTX(I))**2+2.D0*XTX(I)HOFN2150
     1*(2.D0*OXODX+XTX(I))                                              HOFN2160
      HTXW=RTWX(I)*DRODX+RTX(I)*(D2RDXW+RTWX(I))+(RO+RT(I))*(DRODW+RTW(IHOFN2170
     1))*PHTX(I)**2+(RO+RT(I))**2*PHTX(I)*PHTWX(I)+XTWX(I)*DXODX+XTX(I)*HOFN2180
     2(D2XDWX+XTWX(I))                                                  HOFN2190
      IF (K.EQ.1) HTXS(I)=HTX                                           HOFN2200
      IF (K.EQ.1) GO TO 220                                             HOFN2210
      HTXW=(HTX-HTXS(I))/DW                                             HOFN2220
      HTXS(I)=HTX                                                       HOFN2230
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  220   CONTINUE                                                          HOFN2240
        HTXX=RTXX(I)*DRODX+RTX(I)*(D2RDXX+RTXX(I))+(RO+RT(I))*(DRODX+RTX(IHOFN2250
       1))*PHTX(I)**2+(RO+RT(I))**2*PHTX(I)*PHTXX(I)+XTXX(I)*DXODX+XTX(I)*HOFN2260
       2(D2XODX+XTXX(I))                                                 HOFN2270
        IF (L.EQ.1) GO TO 230                                            HOFN2280
        HTW=4.DO*PI**2*(RT(I)**2+2.DO*RT(I)*RO)+RTW(I)**2+2.DO*DRODW*RTW(IHOFN2290
       1)+4.DO*PI*(RT(I)+RO)**2*PHTW(I)+(RO+RT(I))**2*PHTW(I)**2+XTW(I)*(2HOFN2300
       2.DO*DXODW+XTW(I))                                                HOFN2310
        HTWW=4.DO*PI**2*(RT(I)*RTW(I)+RT(I)*DRODW+RTW(I)*RO)+RTW(I)*RTW(IHOFN2320
       1)+D2RDWW*RTW(I)+4.DO*PI*(RO+RT(I))*(DRODW+RTW(I))*PHTW(I)+DRODW*RTHOFN2330
       2WW(I)+2.DO*PI*(RT(I)+RO)**2*PHTWW(I)+(RO+RT(I))*(DRODW+RTW(I))*PHTHOFN2340
       3W(I)**2+(RO+RT(I))**2*PHTW(I)*PHTWW(I)+DXODW*XTWW(I)+XTW(I)*(D2XODHOFN2350
       4W+XTWW(I))                                                       HOFN2360
        HTWX=4.DO*PI**2*(RT(I)*(RTX(I)+DRODX)+RO*RTX(I))+RTW(I)*RTWX(I)+D2HOFN2370
       1RDXW*RTW(I)+DRODW*RTWX(I)+4.DO*PI*(RO+RT(I))*(DRODW+RTW(I))*PHTW(IHOFN2380
       2)+2.DO*PI*(RT(I)+RO)**2*PHTW(I)+(RO+RT(I))*(DRODX+RT(I))*PHTW(I)**HOFN2390
       32+(RO+RT(I))**2*PHTW(I)*PHTWX(I)+DXODW*XTWX(I)+XTW(I)*(D2XODWX+XTWXHOFN2400
       4(I))                                                             HOFN2410
        GO TO 240                                                        HOFN2420
  230   CONTINUE                                                          HOFN2430
        HTW=0.DO                                                         HOFN2440
        HTWW=0.DO                                                        HOFN2450
        HTWX=0.DO                                                        HOFN2460
  240   CONTINUE                                                          HOFN2470
        IF (IINC.NE.5000) GO TO 250                                      HOFN2480
        WRITE (6,340) HTX,HTW,HTXX,HTXW,HTWX,HTWW                        HOFN2490
        IINC=0                                                           HOFN2500
  250   CONTINUE                                                          HOFN2510
        IINC=IINC+1                                                      HOFN2520
        IF (K.NE.1) GO TO 260                                            HOFN2530
        HTXWW=RTWWX(I)*DRODX+RTX(I)*D3RWWX+RTX(I)*RTWWX(I)+XTX(I)*(XTXWW(IHOFN2540
       1)+D3XXWW)+DXODX*XTXWW(I)+(RO+RT(I))*PHTWX(I)                     HOFN2550
  260   CONTINUE                                                          HOFN2560
        HX(I)=DSQRT(HXO**2+HTX)                                          HOFN2570
        HW(I)=DSQRT(HWO**2+HTW)                                          HOFN2580
        HXXOLD(I)=HXX(I)                                                 HOFN2590
        HXX(I)=(HXO*DHXODX+HTXX)/HX(I)                                   HOFN2600
        HXW(I)=(HXO*DHXODW+HTXW)/HX(I)                                   HOFN2610
        IF (L.EQ.1) GO TO 270                                            HOFN2620
        HWX(I)=(HWO*DHWODX+HTWX)/HW(I)                                   HOFN2630
        HWW(I)=(HWO*DHWODW+HTWW)/HW(I)                                   HOFN2640
        GO TO 280                                                        HOFN2650
  270   CONTINUE                                                          HOFN2660
        HWX(I)=HWX(1)                                                    HOFN2670
        HWW(I)=0.DO                                                      HOFN2680
  280   CONTINUE                                                          HOFN2690
        IF (K.NE.1) GO TO 290                                            HOFN2700
        HXWW(I)=(HXO*DHXDWW+HTXWW)/HX(I)                                 HOFN2710
  290   CONTINUE                                                          HOFN2720
  300   CONTINUE                                                          HOFN2730
        CALL DERIV (HX,ETA,IE,1,HXN)                                     HOFN2740
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      CALL DERIV (HXN,ETA,IE,1,HXNN)                                    HOFN2750
      CALL DERIV (HW,ETA,IE,1,HWN)                                      HOFN2760
      CALL DERIV (HWN,ETA,IE,1,HWNN)                                    HOFN2770
      RETURN                                                            HOFN2780
310   CONTINUE                                                          HOFN2790
C                                                                       HOFN2800
C     CALCULATE METRIC COEFFICIENTS FOR PROFILE POINTS WHEN TVC = NO     HOFN2810
C                                                                       HOFN2820
      DO 320 I=1,IE                                                     HOFN2830
      HX(I)=HX0                                                         HOFN2840
      HW(I)=HW0                                                         HOFN2850
      HXX(I)=DHX0DX                                                     HOFN2860
      HXW(I)=DHX0DW                                                     HOFN2870
      HWX(I)=DHW0DX                                                     HOFN2880
      HWW(I)=DHW0DW                                                     HOFN2890
      HXWW(I)=DHXDWW                                                    HOFN2900
      HXN(I)=0.D0                                                       HOFN2910
      HXNN(I)=0.D0                                                      HOFN2920
      HWN(I)=0.D0                                                       HOFN2930
      HWNN(I)=0.D0                                                      HOFN2940
320   CONTINUE                                                          HOFN2950
      RETURN                                                            HOFN2960
C                                                                       HOFN2970
330   FORMAT (1H0,5HTX = ,E13.6,6H TW = ,E13.6,7H TXX = ,E13.6,6HTXW = ,HOFN2980
     1E13.6,7H TWX = ,E13.6,7H TWW = ,E13.6)                            HOFN2990
340   FORMAT (1H0,4HR = ,E13.6,6H RX = ,E13.6,6H RW = ,E13.6,7H RXX = ,EHOFN3000
     113.6,7H RWX = ,E13.6,7H RWW = ,E13.6)                             HOFN3010
      END                                                               HOFN3020


      SUBROUTINE INIT                                                   INIT  10
      IMPLICIT REAL*8 (A-H,O-Z)                                         INIT  20
      REAL*8 NOSE                                                       INIT  30
      COMMON /ASSVAR/ IFL,KBL                                           INIT  40
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                           INIT  50
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,INIT  60
     1101,3),TN(2,101,3),Y(101),YOL(101)                                INIT  70
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR            INIT  80
      COMMON /GASPRP/ PRANDT(101)                                       INIT  90
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                       INIT 100
      COMMON /INJECT/ INJCT,NOINJ,MASTRN                                INIT 110
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,INIT 120
     1LPR                                                               INIT 130
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),INIT 140
     1TWN(101),XIW,XW,RW                                                INIT 150
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XINIT 160
     1CI(500),CIX(500),TCONW,KCI,KTW                                    INIT 170
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR           INIT 180
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      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSINIT 190
     1(101),LAMTRB                                                    INIT 200
      COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                        INIT 210
      COMMON /WSOLVE/ DW,W                                            INIT 220
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                INIT 230
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE             INIT 240
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA  INIT 250
      COMMON /OLD/ VOLD(61),CVOLD(61),ROLD(61)                        INIT 260
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                               INIT 270
      READ (10) ALPHA,KLX                                             INIT 280
      ALPHA=ALPHA*DARCOS(-1.0D0)/180.0D0                              INIT 290
      WLST=0.500                                                      INIT 300
      ZWOLD=1.0D0                                                     INIT 310
      SINLST=0.0D0                                                    INIT 320
      X=0.0D0                                                         INIT 330
      DX=DX1                                                          INIT 340
      XX=0.0D0                                                        INIT 350
      XI=0.0D0                                                        INIT 360
      DXI=0.0D0                                                       INIT 370
      XXI=0.0D0                                                       INIT 380
      XIW=0.0D0                                                       INIT 390
      RW=0.0D0                                                        INIT 400
      XW=0.0D0                                                        INIT 410
      XIOLD=0.0D0                                                     INIT 420
      DXOLD=DX                                                        INIT 430
      XIF=0.0D0                                                       INIT 440
      IF (LAMTRB.EQ.2) XIF=1.0D0                                      INIT 450
      CWIND=CWALL                                                     INIT 460
      VWALL=0.0D0                                                     INIT 470
      DO 10 N=1,IE                                                    INIT 480
      PRANDT(N)=0.9D0                                                 INIT 490
      EPLUS(N)=0.0D0                                                  INIT 500
      CHI2(N)=0.0D0                                                   INIT 510
   10 EVSCTY(N)=0.0D0                                                 INIT 520
      IND=1                                                           INIT 530
      KBL=1                                                           INIT 540
      L=0                                                             INIT 550
      NIT=0                                                           INIT 560
      LPR=LPRT                                                        INIT 570
      KEND=KEND2                                                      INIT 580
      IF (ALPHA.LT.1.0-08) KEND=1                                     INIT 590
      IM=IE-1                                                         INIT 600
      DW=1.0D0                                                        INIT 610
      DETA(1)=0.0D0                                                   INIT 620
      ETA(1)=0.0D0                                                    INIT 630
      ETA(IE)=ETAINF                                                  INIT 640
      IF (ETAFAC.EQ.1.0D0) GO TO 20                                   INIT 650
      DETA(2)=ETAINF*(ETAFAC-1.0D0)/(ETAFAC**IM-1.0D0)                INIT 660
      GO TO 30                                                        INIT 670
   20 DETA(2)=ETAINF/DFLOAT(IM)                                       INIT 680
   30 ETA(2)=DETA(2)                                                  INIT 690
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      DO 40 I=3,IM                                                      INIT  700
      DETA(I)=ETAFAC*DETA(I-1)                                          INIT  710
      ETA(I)=ETA(I-1)+DETA(I)                                           INIT  720
40    CONTINUE                                                          INIT  730
      DETA(IE)=DETA(IM)*ETAFAC                                          INIT  740
C                                                                       INIT  750
C     CALCULATE INITIAL PROFILES                                        INIT  760
C                                                                       INIT  770
      DO 70 I=1,2                                                       INIT  780
      DO 60 N=1,3                                                       INIT  790
      DO 50 J=1,IE                                                      INIT  800
      F(I,J,N)=1.000-DEXP(-ETA(J))                                      INIT  810
      G(I,J,N)=.075D0*F(I,J,N)                                          INIT  820
      T(I,J,N)=RTW+(1.0D0-RTW)*F(I,J,N)                                 INIT  830
50    CONTINUE                                                          INIT  840
60    CONTINUE                                                          INIT  850
70    CONTINUE                                                          INIT  860
      DO 80 I=1,61                                                      INIT  870
      VOLD(I)=0.D0                                                      INIT  880
      CVOLD(I)=0.D0                                                     INIT  890
      ROLD(I)=0.D0                                                      INIT  900
80    CONTINUE                                                          INIT  910
      DO 90 J=1,IE                                                      INIT  920
      Y(J)=0.000                                                        INIT  930
      YOL(J)=0.000                                                      INIT  940
      GW(J)=G(2,J,1)                                                    INIT  950
      FW(J)=F(1,J,2)                                                    INIT  960
90    CONTINUE                                                          INIT  970
      DO 110 I=1,2                                                      INIT  980
      DO 100 N=1,3                                                      INIT  990
      CALL DERIV3 (F,I,N,ETA,IE,1,FN)                                   INIT1000
      CALL DERIV3 (G,I,N,ETA,IE,1,GN)                                   INIT1010
      CALL DERIV3 (T,I,N,ETA,IE,1,TN)                                   INIT1020
100   CONTINUE                                                          INIT1030
110   CONTINUE                                                          INIT1040
      RETURN                                                            INIT1050
      END                                                               INIT1060
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      SUBROUTINE INPUT                                                  INPU  10
      IMPLICIT REAL*8 (A-H,O-Z)                                         INPU  20
      REAL*8 NOSE                                                       INPU  30
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                           INPU  40
      COMMON /EDGE/ UEDG,TEDG,VEDG,DUEGDX,DUEGDW,D2UEDW,DVEGDX,DVEGDW,RE INPU  50
     1DG,DRDGDX,ZBOD,XEDG                                               INPU  60
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101INPU  70
     1),CRI                                                             INPU  80
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR            INPU  90
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      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                                INPU 100
      COMMON /INJECT/ INJCT,NOINJ,MASTRN                                         INPU 110
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,INPU 120
     1LPR                                                                       INPU 130
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG                                       INPU 140
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XINPU 150
     1CI(500),CIX(500),TCONW,KCI,KTW                                            INPU 160
      COMMON /TITLE/ LABEL(20)                                                   INPU 170
      COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                                   INPU 180
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR                    INPU 190
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSINPU 200
     1(101),LAMTRB                                                              INPU 210
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE                        INPU 220
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA             INPU 230
      COMMON /TVCURV/ SFC                                                        INPU 240
      DATA YES,NO/3HYES,3H NO/                                                   INPU 250
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                          INPU 260
C                                                                                INPU 270
C     THE INPUT QUANTITIES ARE READ IN                                           INPU 280
C                                                                                INPU 290
      J=5                                                                        INPU 300
      READ (J,70) LABEL                                                          INPU 310
      READ (J,50) IE                                                             INPU 320
      READ (J,50) INJCT                                                          INPU 330
      READ (J,50) KADETA                                                         INPU 340
      READ (J,50) KEND2                                                          INPU 350
      READ (J,50) KONSET                                                         INPU 360
      READ (J,50) KPRT                                                           INPU 370
      READ (J,50) KTRANS                                                         INPU 380
      READ (J,50) LAMTRB                                                         INPU 390
      READ (J,50) LPRT                                                           INPU 400
      READ (J,50) NITI                                                           INPU 410
      READ (J,50) NIT2                                                           INPU 420
      READ (J,50) NIT3                                                           INPU 430
      READ (J,50) NOINJ                                                          INPU 440
      READ (J,100) SFC                                                           INPU 450
      READ (J,50) NSOLVE                                                         INPU 460
      READ (J,60) ADTEST                                                         INPU 470
      READ (J,60) AKSTAR                                                         INPU 480
      READ (J,60) ALAMDA                                                         INPU 490
      READ (J,60) ASTAR                                                          INPU 500
      READ (J,60) CWALL                                                          INPU 510
      READ (J,60) CONV                                                           INPU 520
      READ (J,60) DXMAX                                                          INPU 530
      READ (J,60) DXI                                                            INPU 540
      READ (J,80) EDYLAW                                                         INPU 550
      READ (J,60) ETAFAC                                                         INPU 560
      READ (J,60) ETAINF                                                         INPU 570
      READ (J,60) PR                                                             INPU 580
      READ (J,60) RTW                                                            INPU 590
      READ (J,60) TFS                                                            INPU 600
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      READ (J,60) CP                                                    INPU 610
      READ (J,60) AMUINF                                                INPU 620
      READ (J,60) PSTAG                                                 INPU 630
      READ (J,60) PINF                                                  INPU 640
      READ (J,60) XBAR                                                  INPU 650
      READ (J,60) UFS                                                   INPU 660
      DO 10 I=1,NSOLVE                                                  INPU 670
      READ (J,40) XSTA(I)                                               INPU 680
10    CONTINUE                                                          INPU 690
      KTW=0                                                             INPU 700
      KCI=0                                                             INPU 710
      I=0                                                               INPU 720
20    I=I+1                                                             INPU 730
      READ (J,90,END=30) XTW(I),TWX(I),XCI(I),CIX(I)                    INPU 740
      IF (XTW(I).EQ.0.0D0) XTW(I)=XCI(I)                                INPU 750
      IF (XCI(I).EQ.0.0D0) XCI(I)=XTW(I)                                INPU 760
      IF (CIX(I).EQ.0.0D0.AND.KCI.EQ.0) KCI=I-1                         INPU 770
      GO TO 20                                                          INPU 780
30    KTW=I-1                                                           INPU 790
      IF (KCI.EQ.0) KCI=I-1                                             INPU 800
      MASTRN=0                                                          INPU 810
      NOSE=BLUNT                                                        INPU 820
      RNOSE=1.D0                                                        INPU 830
      CRI=1.D0                                                          INPU 840
      IF (KONSET.EQ.0) KONSET=NSOLVE                                    INPU 850
      IF (LAMTRB.EQ.2) KONSET=NSOLVE                                    INPU 860
      IF (INJCT.EQ.0) INJCT=NSOLVE                                      INPU 870
      IF (NOSE.EQ.SHARP.AND.INJCT.EQ.1) INJCT=2                         INPU 880
      IF (INJCT.EQ.1) MASTRN=1                                          INPU 890
      IF (MASTRN.EQ.1) INJCT=NSOLVE                                     INPU 900
      IF (NOINJ.EQ.0) NOINJ=NSOLVE                                      INPU 910
C                                                                       INPU 920
      RETURN                                                            INPU 930
C                                                                       INPU 940
C                                                                       INPU 950
C                                                                       INPU 960
40    FORMAT (F12.6)                                                    INPU 970
50    FORMAT (49X,I3)                                                   INPU 980
60    FORMAT (49X,E14.6)                                                INPU 990
70    FORMAT (20A4)                                                     INPU1000
80    FORMAT (49X,A3)                                                   INPU1010
90    FORMAT (4E12.6)                                                   INPU1020
100   FORMAT (49X,A3)                                                   INPU1030
      END                                                               INPU1040
                                                                        INPU1050


      SUBROUTINE INTER3 (X,X1,X2,X3,F1,F2,F3,F)                         INT3  10
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```
      IMPLICIT REAL*8(A-H,O-Z)                                          INT3  20
C                                                                       INT3  30
C     SUBROUTINE INTER3 INTERPOLATES FOR THE VALUE F CORRESPONDING TO   INT3  40
C     POINT X USING 3 POINT LAGRANGIAN INTERPOLATION.                   INT3  50
C                                                                       INT3  60
C     ASSUMES X1 .LE. X .LE. X3.                                        INT3  70
C                                                                       INT3  80
      A1=(X-X2)*(X-X3)                                                  INT3  90
      A2=(X-X1)*(X-X3)                                                  INT3 100
      A3=(X-X1)*(X-X2)                                                  INT3 110
      D1=(X1-X2)*(X1-X3)                                                INT3 120
      D2=(X2-X1)*(X2-X3)                                                INT3 130
      D3=(X3-X1)*(X3-X2)                                                INT3 140
      C1=A1/D1                                                          INT3 150
      C2=A2/D2                                                          INT3 160
      C3=A3/D3                                                          INT3 170
      F=C1*F1+C2*F2+C3*F3                                               INT3 180
      RETURN                                                            INT3 190
      END                                                               INT3 200
```

```
      SUBROUTINE INTER5 (X,X1,X2,X3,X4,X5,F1,F2,F3,F4,F5,F)             INT5  10
      IMPLICIT REAL*8 (A-H,O-Z)                                         INT5  20
C                                                                       INT5  30
C     SUBROUTINE INTER5 INTERPOLATES FOR THE VALUE F CORRESPONDING TO   INT5  40
C     POINT X USING 5 POINT LAGRANGIAN INTERPOLATION FORMULA.           INT5  50
C                                                                       INT5  60
C     ASSUMES X1 .LE. X .LE. X5.                                        INT5  70
C                                                                       INT5  80
      A1=(X-X2)*(X-X3)*(X-X4)*(X-X5)                                    INT5  90
      A2=(X-X1)*(X-X3)*(X-X4)*(X-X5)                                    INT5 100
      A3=(X-X1)*(X-X2)*(X-X4)*(X-X5)                                    INT5 110
      A4=(X-X1)*(X-X2)*(X-X3)*(X-X5)                                    INT5 120
      A5=(X-X1)*(X-X2)*(X-X3)*(X-X4)                                    INT5 130
      D1=(X1-X2)*(X1-X3)*(X1-X4)*(X1-X5)                                INT5 140
      D2=(X2-X1)*(X2-X3)*(X2-X4)*(X2-X5)                                INT5 150
      D3=(X3-X1)*(X3-X2)*(X3-X4)*(X3-X5)                                INT5 160
      D4=(X4-X1)*(X4-X2)*(X4-X3)*(X4-X5)                                INT5 170
      D5=(X5-X1)*(X5-X2)*(X5-X3)*(X5-X4)                                INT5 180
      C1=A1/D1                                                          INT5 190
      C2=A2/D2                                                          INT5 200
      C3=A3/D3                                                          INT5 210
      C4=A4/D4                                                          INT5 220
      C5=A5/D5                                                          INT5 230
      F=C1*F1+C2*F2+C3*F3+C4*F4+C5*F5                                   INT5 240
      RETURN                                                            INT5 250
      END                                                               INT5 260
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```
      SUBROUTINE OUT1                                                   OUT1   10
      IMPLICIT REAL*8 (A-H,O-Z)                                         OUT1   20
      REAL*8 NOSE                                                       OUT1   30
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                           OUT1   40
      COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101OUT1   50
     1),CRI                                                             OUT1   60
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR            OUT1   70
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                       OUT1   80
      COMMON /INJECT/ INJCT,NOINJ,MASTRN                                OUT1   90
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,OUT1  100
     1LPR                                                               OUT1  110
      COMMON /REF/ PREF,TREF,AMUREF                                     OUT1  120
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG                              OUT1  130
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XOUT1  140
     1CI(500),CIX(500),TCONW,KCI,KTW                                    OUT1  150
      COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                          OUT1  160
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSOUT1  170
     1(101),LAMTRB                                                      OUT1  180
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                  OUT1  190
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXL,NSOLVE               OUT1  200
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA    OUT1  210
      COMMON /TITLE/ LABEL(20)                                          OUT1  220
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                 OUT1  230
      ATTAK=ALPHA*180.0D0/DARCOS(-1.0D0)                                OUT1  240
      WRITE (6,50)                                                      OUT1  250
      WRITE (6,140) (LABEL(I),I=1,20)                                   OUT1  260
      WRITE (6,40)                                                      OUT1  270
      WRITE (6,60) PSTAG                                                OUT1  280
      WRITE (6,70) TSTAG                                                OUT1  290
      WRITE (6,80) PINF                                                 OUT1  300
      WRITE (6,100) UFS                                                 OUT1  310
      WRITE (6,90) TFS                                                  OUT1  320
      WRITE (6,150) RHOINF                                              OUT1  330
      WRITE (6,160) AMUINF                                              OUT1  340
      WRITE (6,110) RTW                                                 OUT1  350
      WRITE (6,120) ATTAK                                               OUT1  360
      WRITE (6,170) CP                                                  OUT1  370
      WRITE (6,180) REINF                                               OUT1  380
      WRITE (6,190) PR                                                  OUT1  390
      WRITE (6,20)                                                      OUT1  400
      DO 10 I=1,NSOLVE                                                  OUT1  410
      WRITE (6,30) I,XSTA(I)                                            OUT1  420
   10 CONTINUE                                                          OUT1  430
      WRITE (6,130)                                                     OUT1  440
C                                                                       OUT1  450
C                                                                       OUT1  460
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      RETURN                                                                OUT1  470
C                                                                           OUT1  480
C                                                                           OUT1  490
C                                                                           OUT1  500
20    FORMAT (26X,45HPOINTS AT WHICH A SOLUTION IS TO BE OBTAINED://28X,OUT1  510
     11HI,6X,7HXSTA(I)/)                                                    OUT1  520
30    FORMAT (26X,I3,5X,F9.6)                                               OUT1  530
40    FORMAT (//26X,42HFREE STREAM, STAGNATION, AND VEHICLE DATA://)        OUT1  540
50    FORMAT (46X,40HTHREE-DIMENSIONAL BOUNDARY LAYER PROGRAM/65X,3HFOR/OUT1  550
     154X,25HLAMINAR OR TURBULENT FLOW/64X,4HWITH/53X,25HSURFACE CURVATUOUT1  560
     2RE EFFECTS/60X,12HDEVELOPED BY/50X,32HAEROSPACE ENGINEERING DEPARTCUT1  570
     3MENT/40X,51HVIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY/56OUT1  580
     4X,21HBLACKSBURG, VA. 24061///)                                        OUT1  590
60    FORMAT (26X,7HPSTAG =,E13.6,5H PSIA)                                  OUT1  600
70    FORMAT (26X,7HTSTAG =,E13.6,6H DEG.R)                                 OUT1  610
80    FORMAT (26X,7HPINF  =,E13.6,5H PSIA)                                  OUT1  620
90    FORMAT (26X,7HTINF  =,E13.6,6H DEG.R)                                 OUT1  630
100   FORMAT (26X,7HUINF  =,E13.6,7H FT/SEC)                                OUT1  640
110   FORMAT (26X,7HTW/TO =,E13.6)                                          OUT1  650
120   FORMAT (26X,7HALPHA =,E13.6,5H DEG.)                                  OUT1  660
130   FORMAT (1HO)                                                          OUT1  670
140   FORMAT (26X,20A4)                                                     OUT1  680
150   FORMAT (26X,7HRHOINF=,E13.6,12H SLUGS/FT**3)                          OUT1  690
160   FORMAT (26X,7HAMUINF=,E13.6,13H SLUGS/FT-SEC)                         OUT1  700
170   FORMAT (26X,7HCP    =,E13.6,21H FT**2/(SEC**2-DEG.R))                 OUT1  710
180   FORMAT (26X,7HREINF =,E13.6)                                          OUT1  720
190   FORMAT (26X,7HPR    =,E13.6)                                          OUT1  730
      END                                                                   OUT1  740


      SUBROUTINE OUT2                                                       OUT2   10
      IMPLICIT REAL*8 (A-H,O-Z)                                             OUT2   20
      REAL*8 NOSE                                                           OUT2   30
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                               OUT2   40
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,OUT2   50
     1101,3),TN(2,101,3),Y(101),YOL(0101)                                   OUT2   60
      COMMON /EDGE/ UEDG,TEDG,VEDG,DUEGDX,DUEGDW,D2UEGW,DVEGDX,DVEGDW,REOUT2   70
     1DG,DRDGDX,ZBOD,XEDG                                                   OUT2   80
      COMMON /EDG2/ TE2,UE2,VE2,DUE2DX,DVE2DX,DUE2DW,D2UE2W,DVE2DW,RE2,XOUT2   90
     12                                                                     OUT2  100
      COMMON /GASPRP/ PRANDT(101)                                           OUT2  110
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                           OUT2  120
      COMMON /INJECT/ INJCT,NOINJ,MASTRN                                    OUT2  130
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,OUT2  140
     1LPR                                                                   OUT2  150
      COMMON /OUTPUT/ CFWEDG,CFWINF,CFXEDG,CFXINF,DEL,QW,QWINF,QWOQWO,S,OUT2  160
     1TAUETA,TAUX,DELSTX,DELPHI,THETAX,THEPHI,REX2                          OUT2  170
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),OUT2  180
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     1TWN(101),XIW,XW,RW                                                        OUT2 190
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XQUT2 200
     1CI(500),CIX(500),TCONW,KCI,KTW                                            OUT2 210
      COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                                  OUT2 220
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR                   OUT2 230
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSOUT2 240
     1(101),LAMTRB                                                              OUT2 250
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                          OUT2 260
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE                       OUT2 270
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA            OUT2 280
      COMMON /OUTSP/ DUDX,DVDX,DRDX                                             OUT2 290
      COMMON /HETA/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)OUT2 300
     1,HXNN(101),HWX(101),HWW(101),HWN(101),HWNN(101)                           OUT2 310
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                         OUT2 320
C                                                                               OUT2 330
C                                                                               OUT2 340
      IF (L.NE.1.AND.L.NE.LPR) GO TO 40                                         OUT2 350
C                                                                               OUT2 360
      WRITE (6,50) X2,RE2,WX                                                    OUT2 370
      WRITE (6,60) XI,DXI,CWALL,NIT                                             OUT2 380
      WRITE (6,200) HX(1),HW(1)                                                 OUT2 390
      WRITE (6,70)                                                              OUT2 400
      WRITE (6,80) TE2,UE2,VE2,DUDX,DVDX,DUE2DW,DVE2DW                          OUT2 410
      WRITE (6,180) REX2                                                        OUT2 420
      IF (L.EQ.1.AND.NOSE.EQ.SHARP) GO TO 10                                    OUT2 430
      WRITE (6,190)                                                             OUT2 440
      WRITE (6,90)                                                              OUT2 450
      WRITE (6,100) CFXINF,CFXEDG,CFWINF,CFWEDG,QWINF,CHIMAX                    OUT2 460
      WRITE (6,110)                                                             OUT2 470
      WRITE (6,120) TAUX,DELSTX,THETAX,TAUETA,DELPHI,THEPHI,QW,DEL              OUT2 480
      IF (X.GE.XSTA(KONSET).AND.KONSET.NE.NSOLVE) WRITE (6,170) XIF             OUT2 490
      WRITE (6,160)                                                             OUT2 500
10    CONTINUE                                                                  OUT2 510
      IF (K.NE.1.AND.K.NE.KPR) GO TO 30                                         OUT2 520
      IF (K.NE.1.OR.KPRT.EQ.1) KPR=KPR+KPRT                                     OUT2 530
      WRITE (6,140)                                                             OUT2 540
      DO 20 N=1,IE,2                                                            OUT2 550
      WRITE (6,150) ETA(N),Y(N),F(2,N,2),FN(2,N,2),G(2,N,2),GN(2,N,2),TI(OUT2 560
     12,N,2),TN(2,N,2),VW(N),EPLUS(N)                                           OUT2 570
20    CONTINUE                                                                  OUT2 580
30    CONTINUE                                                                  OUT2 590
      WRITE (6,130)                                                             OUT2 600
40    CONTINUE                                                                  OUT2 610
C                                                                               OUT2 620
C                                                                               OUT2 630
      RETURN                                                                    OUT2 640
C                                                                               OUT2 650
CC                                                                              OUT2 660
C                                                                               OUT2 670
50    FORMAT (10X,6HX0    =,E13.6,4X,6HR     =,E13.6,4X,6HPHI   =,F6.2,5H DOUT2 680
     1EG.)                                                                      OUT2 690
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60    FORMAT (10X,6HXI    =,E13.6,4X,6HDXI   =,E13.6,4X,6HCWALL=,E13.6,5X,OUT2  700
     16HNIT   =,I3)                                                      OUT2  710
70    FORMAT (10X,30HNONDIMENSIONAL EDGE PROPERTIES/)                     OUT2  720
80    FORMAT (10X,6HTE    =,E13.6,5X,6HUE    =,E13.6,5X,6HVE    =,E13.6/10XOUT2  730
     1,6HDUEDX=,E13.6,5X,6HDVEDX=,E13.6,5X,6HDUEDW=,E13.6,5X,6HDVEDW=,E1OUT2  740
     23.6/)                                                              OUT2  750
90    FORMAT (10X,40HNONDIMENSIONAL BOUNDARY LAYER PARAMETERS/)           OUT2  760
100   FORMAT (10X,7HCFXINF=,E13.6,5X,7HCFXEDG=,E13.6,5X,7HCFWINF=,E13.6,OUT2  770
     15X,7HCFWEDG=,E13.6/10X,7HQW     =,E13.6,5X,7HCHIMAX=,E13.6//)      OUT2  780
110   FORMAT (10X,37HDIMENSIONAL BOUNDARY LAYER PARAMETERS/)              OUT2  790
120   FORMAT (10X,27HLONGITUDINAL SKIN FRICTION=,E13.6,4H PSF,5X,12HDELTOUT2  800
     1A*(X)  =,E13.6,5X,11HTHETA(X)  =,E13.6/10X,27HTRANSVERSE SKIN FRICOUT2  810
     2TION  =,E13.6,4H PSF,5X,12HDELTA*(PHI)=,E13.6,5X,11HTHETA(PHI)=,E1OUT2  820
     33.6/10X,27HWALL HEAT TRANSFER RATE   =,E13.6,4H BTU,5X,12HDELTA (EOUT2  830
     4T) =,E13.6)                                                        OUT2  840
130   FORMAT (1HO,48X,3(5H*****,10X)//)                                   OUT2  850
140   FORMAT (7X,3HETA,11X,1HY,10X,1HF,10X,2HFN,9X,1HG,10X,2HGN,9X,1HT,1OUT2  860
     10X,2HTN,9X,1HV,8X,5HEPLUS/)                                        OUT2  870
150   FORMAT (1X,F12.6,3X,E9.3,1X,6(F10.6,1X),E10.3,1X,E10.3)             OUT2  880
160   FORMAT (1HO)                                                        OUT2  890
170   FORMAT (1HO,9X,34HTRANSITION INTERMITTENCY FACTOR = ,E12.6)         OUT2  900
180   FORMAT (10X,28HLOCAL EDGE REYNOLDS NUMBER =,E12.6/)                 OUT2  910
190   FORMAT (1H )                                                        OUT2  920
200   FORMAT (10X,6HHX    =,E13.6,4X,6HHW    =,E13.6//)                  OUT2  930
      END                                                                 OUT2  940


      SUBROUTINE PHIMOM (LC)                                              PHIM   10
      IMPLICIT REAL*8(A-H,O-Z)                                            PHIM   20
      REAL*8 NOSE                                                         PHIM   30
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,PHIM   40
     1101,3),TN(2,101,3),Y(101),YOL(101)                                  PHIM   50
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                         PHIM   60
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB                 PHIM   70
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNTI,IND,KPRT,LPRT,KPR,PHIM   80
     1LPR                                                                 PHIM   90
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)     PHIM  100
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),PHIM  110
     1TWN(101),XIW,XW,RW                                                  PHIM  120
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR             PHIM  130
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSPHIM  140
     1(101),LAMTRB                                                        PHIM  150
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                    PHIM  160
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA      PHIM  170
      COMMON /NCOORD/ XN(101),ETAX,ETAW                                   PHIM  180
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW    PHIM  190
      COMMON /HETA/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)PHIM  200
     1,HXNN(101),HWX(101),HWW(101),HWN(101),HWNN(101)                     PHIM  210
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      COMMON /GECOEF/ HXOHXO(101),HWOHWO(101),BHV(101),BHM(101),BHT(101)PHIM  220
     1,XKX(101),XKW(101),BMX(101),BMW(101),XLX(101),XLW(101),BAFF(101),BPHIM  230
     2AGF(101),BAFG(101),BAGG(101),XKXOAL(101)                          PHIM  240
      COMMON /STGEOG/ DVEGXW,DVEWXW,DVE2XW,DVEGXX,DVEWXX,DVE2XX,DVGXXW,DPHIM  250
     1VWXXW,DV2XXW,DHWOXW,DHXOXW                                        PHIM  260
      COMMON /INTGRL/ XIFNX(101),XIFNW(101),XIFNXX(101),XIFNWW(101)     PHIM  270
      COMMON /PHI/ DAL3DX,DAL3DW,ALB6                                   PHIM  280
      DIMENSION ROMU1(101), ROMU1N(101)                                 PHIM  290
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/                                 PHIM  300
C                                                                       PHIM  310
CC    SUBROUTINE PHIMOM SETS UP THE COEFFICIENTS OF THE PARTIAL         PHIM  320
CC    DIFFERENTIAL PHI MOMENTUM EQUATION                                PHIM  330
C                                                                       PHIM  340
      DO 10 J=1,IE                                                      PHIM  350
      ROMU1(J)=1.0D0+XIF*EPLUS(J)                                       PHIM  360
   10 CONTINUE                                                          PHIM  370
      CALL DERIV (ROMU1,ETA,IE,1,ROMU1N)                                PHIM  380
      CALL PRESSI (2)                                                   PHIM  390
      DO 40 J=1,IE                                                      PHIM  400
      A0(J)=ROMU1(J)                                                    PHIM  410
      A1(J)= ROMU1N(J)-BHM(J)*ROMU1(J)-VW(J)                            PHIM  420
      A2(J)=-BMW(J)*ROMU1(J)                                            PHIM  430
      A4(J)=-HX(1)*XI*FW(J)/2.D0/HX(J)**2                               PHIM  440
      A5(J)=0.D0                                                        PHIM  450
      IF (LC.EQ.1) GO TO 30                                             PHIM  460
      IF (LC.EQ.2) GO TO 20                                             PHIM  470
      A2S=-AL2**2*B6/HWOHWO(J)**2/2.D0+AL2*(XLW(J)-XLW(1))/2.D0+BAGG(J) PHIM  480
      A2(J)=A2(J)+2.D0*A2S*GW(J)+ROMU1N(J)*HWN(J)/HW(J)-.5D0*B5*FW(J)/HXPHIM  490
     1OHXO(J)**2-.5D0*XKW(1)*FW(J)/HXOHXO(J)**2                         PHIM  500
      A3(J)=B5/2.D0*AL3/HXOHXO(J)**2+AL1*AL3*B6/2.D0/HWOHWO(J)**2-XKX(J)PHIM  510
     1*HWOHWO(J)*(1.D0-FW(J)**2)/2.D0/HXOHXO(J)**2/AL2+XKW(1)/2.D0*AL3/HPHIM  520
     2XOHXO(J)**2-AL2*AL3**2*(XLW(J)-XLW(1))/2.D0-BAFG(J)*(1.D0-FW(J)**2PHIM  530
     3)-BAGG(J)*AL3**2-XI*XIFNW(J)/2.D0/HW(1)/UEW**2+.5D0*XI*DAL3DX/HXOHPHIM  540
     4XO(J)**2/HX(1)+AL1*XI*.5D0*DAL3DW/HW(1)/HWOHWO(J)**2-A2S*GW(J)**2 PHIM  550
      A5(J)=-HW(1)*XI*AL2*GW(J)/2.D0/HW(J)**2                           PHIM  560
      GO TO 40                                                          PHIM  570
   20 CONTINUE                                                          PHIM  580
      A2(J)=A2(J)-XKW(1)*FW(J)/2.D0/HXOHXO(J)**2-B5*FW(J)/2.D0/HXOHXO(J)PHIM  590
     1**2+BAGG(J)*GW(J)+ROMU1N(J)*HWN(J)/HW(J)-AL86/HWOHWO(J)**2*GW(J)/2PHIM  600
     2.D0                                                               PHIM  610
      A3(J)=B5/2.D0/HXOHXO(J)**2+XKW(1)/HXOHXO(J)**2/2.D0-XKXOAL(J)*(1.DPHIM  620
     1O-FW(J)**2)*HWOHWO(J)/2.D0/HXOHXO(J)**2-BAFG(J)*(1.D0-FW(J)**2)-BAPHIM  630
     2GG(J)*AL3**2-XI*XIFNW(J)/HW(1)/UEW/DVEWDW+.5D0*ALB6/HWOHWO(J)**2  PHIM  640
      GO TO 40                                                          PHIM  650
   30 CONTINUE                                                          PHIM  660
      A2S=-.5D0*AL1*B6                                                  PHIM  670
      A2(J)=-.5D0*FW(J)*B5/HXOHXO(J)**2-.5D0*FW(J)/HXOHXO(J)**2+2.D0*A2SPHIM  680
     1*GW(J)                                                            PHIM  690
      A3(J)=AL1*B6/2.D0-XKXOAL(J)*(1.D0-FW(J)**2)/2.D0/HXOHXO(J)**2+(BAGPHIM  700
     1F(J)*BAGG(J))/DUEWDX**1.5D0-3.D0*XIFNW(J)/DSQRT(2.D0*DUEWDX)-DSQRTPHIM  710
     2(2.D0*DUEWDX)*XIFNXX(J)/HWX(1)*DVEWDX-(DVEWXW*2.D0/HWX(1)/DUEWDX-APHIM  720
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     3L1**2)*XIFNW(J)/DSQRT(2.DO*DUEWDX)-AL1*XIFNWW(J)/DSQRT(2.DO*DUEWDXPHIM  730
     4)*HWX(1)+.5DO*B5/HXOHXO(J)**2+.5DO/HXOHXO(J)**2-A2S*GW(J)**2      PHIM  740
      A4(J)=0.DO                                                        PHIM  750
      A5(J)=-AL1*GW(J)/2.DO/HWX(1)                                      PHIM  760
40    CONTINUE                                                          PHIM  770
      IRITE=0                                                           PHIM  780
      IF (IRITE.EQ.0) GO TO 60                                          PHIM  790
      WRITE (6,70)                                                      PHIM  800
      DO 50 I=1,IE,5                                                    PHIM  810
      WRITE (6,80) A0(I),A1(I),A2(I),A3(I),A4(I),A5(I)                  PHIM  820
50    CONTINUE                                                          PHIM  830
60    CONTINUE                                                          PHIM  840
      RETURN                                                            PHIM  850
C                                                                       PHIM  860
70    FORMAT (1H0,15HIN PHIMOM A0-A1)                                   PHIM  870
80    FORMAT (1H0,6E13.6)                                               PHIM  880
      END                                                               PHIM  890


      SUBROUTINE PRESSI (IDIREC)                                        PRES   10
      IMPLICIT REAL*8(A-H,O-Z)                                          PRES   20
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,PRES   30
     1LPR                                                               PRES   40
      COMMON /INTGRL/ XIFNX(101),XIFNW(101),XIFNXX(101),XIFNWW(101)     PRES   50
      DO 10 I=1,IE                                                      PRES   60
      XIFNX(I)=0.DO                                                     PRES   70
      XIFNW(I)=0.DO                                                     PRES   80
      XIFNXX(I)=0.DO                                                    PRES   90
      XIFNWW(I)=0.DO                                                    PRES  100
10    CONTINUE                                                          PRES  110
      RETURN                                                            PRES  120
      END                                                               PRES  130


      SUBROUTINE PROPTY                                                 PROP   10
      IMPLICIT REAL*8 (A-H,O-Z)                                         PROP   20
      REAL*8 NOSE                                                       PROP   30
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,PROP   40
     1101,3),TN(2,101,3),Y(101),YDL(101)                                PROP   50
      COMMON /EDG2/ TE2,UE2,VE2,DUE2DX,DVE2DX,DUE2DW,D2UE2W,DVE2DW,RE2,XPROP   60
     12                                                                 PROP   70
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR            PROP   80
      COMMON /GASPRP/ PRANDT(101)                                       PROP   90
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                       PROP  100
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,PROP  110
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      1LPR                                                                      PROP 120
       COMMON /OUTPUT/ CFWEDG,CFWINF,CFXEDG,CFXINF,DEL,QW,QWINF,QWOQWO,S,PROP 130
      1TAUETA,TAUX,DELSTX,DELPHI,THETAX,THEPHI,REX2                             PROP 140
       COMMON /STAG/ PSTAG,TSTAG,PNC,GWSTAG                                     PROP 150
       COMMON /SURFAS/ GWALL,GWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XPROP 160
      1CI(500),CIX(500),TCONW,KCI,KTW                                           PROP 170
       COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                                 PROP 180
       COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR                  PROP 190
       COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCTY(101),EDYLAW,EPLUSPROP 200
      1(101),LAMTRB                                                             PROP 210
       COMMON /XICORD/ XI,XXI,DXI,XIOLD                                         PROP 220
       COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DX1,NSOLVE                      PROP 230
       COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA           PROP 240
       DIMENSION U(101), T2(101), Z2(101), F2(101), G2(101)                     PROP 250
       DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                        PROP 260
       IF (NOSE.EQ.SHARP) S=X/XSTA(NSOLVE)                                      PROP 270
       IF (NOSE.EQ.BLUNT) S=X/RNOSE                                             PROP 280
       DO 10 J=1,IE                                                             PROP 290
       F2(J)=F(2,J,2)                                                           PROP 300
       G2(J)=G(2,J,2)                                                           PROP 310
       IF (K.EQ.1) G2(J)=0.0D0                                                  PROP 320
       T2(J)=T(2,J,2)                                                           PROP 330
   10  CONTINUE                                                                 PROP 340
       LPR1=LPR                                                                 PROP 350
       LPR=-10                                                                  PROP 360
       LPR=LPR1                                                                 PROP 370
                                                                                PROP 380
C      THE OUTPUT QUANTITIES ARE CALCULATED                                     PROP 390
                                                                                PROP 400
       IF (L.EQ.1.AND.NOSE.EQ.SHARP) GO TO 50                                   PROP 410
                                                                                PROP 420
C      CALCULATE PHYSICAL NORMAL DISTANCE PROFILE                               PROP 430
                                                                                PROP 440
       DELSTX=0.0D0                                                             PROP 450
       DELPHI=0.0D0                                                             PROP 460
       THETAX=0.0D0                                                             PROP 470
       THEPHI=0.0D0                                                             PROP 480
       CHIMAX=0.0D0                                                             PROP 490
       CHI2(1)=0.0D0                                                            PROP 500
       G2IE=G(2,IE,2)                                                           PROP 510
       IF (DABS(G2IE).LT.1.0-10) G2IE=1.0D0                                     PROP 520
       Y(1)=0.000                                                               PROP 530
       YOL(1)=0.000                                                             PROP 540
       EPSVD=1.D0/DSQRT(REINF)                                                  PROP 550
       IF (XI.EQ.0.0D0) YTRANS=1.0D0/PNC*EPSVD                                  PROP 560
       IF (XI.GT.0.0D0) YTRANS=DSQRT(XI/(2.D0*UE2))*EPSVD                       PROP 570
                                                                                PROP 580
C      CALCULATE DISPLACEMENT AND MOMENTUM THICKNESSES                          PROP 590
                                                                                PROP 600
       DO 20 J=2,IE                                                             PROP 610
       Y(J)=Y(J-1)+YTRANS*DETA(J)                                               PROP 620
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      YOL(J)=Y(J)/XSTA(NSOLVE)                                                  PROP 630
      DELSTX=DELSTX+YTRANS*((1.0D0-F(2,J,2))+(1.0D0-F(2,J-1,2)))*DETA(J)        PROP 640
     1/2.D0                                                                     PROP 650
      THETAX=THETAX+YTRANS*(F(2,J,2)*(1.0D0-F(2,J,2))+F(2,J-1,2)*(1.0D0-        PROP 660
     1F(2,J-1,2)))*DETA(J)/2.0D0                                                PROP 670
      THEPHI=THEPHI+YTRANS*(G(2,J,2)/G2IE*(1.0D0-G(2,J,2)/G2IE)+G(2,J-1,        PROP 680
     12)/G2IE*(1.0D0-G(2,J-1,2)/G2IE))*DETA(J)/2.0D0                            PROP 690
      DELPHI=DELPHI+YTRANS*((1.0D0-G(2,J,2)/G2IE)+(1.0D0-G(2,J,2)/G2IE))        PROP 700
     1*DETA(J)/2.D0                                                             PROP 710
      CHI2(J)=Y(J)**2*FN(2,J,2)*UE2*(1.0D0/YTRANS)                              PROP 720
      IF (CHI2(J).GT.CHIMAX) CHIMAX=CHI2(J)                                     PROP 730
20    CONTINUE                                                                  PROP 740
      IF (G(2,IE,2).EQ.0.0D0) DELPHI=0.D0                                       PROP 750
C                                                                               PROP 760
C     CALCULATE BOUNDARY LAYER THICKNESS                                        PROP 770
C                                                                               PROP 780
      DO 30 N=1,IE                                                              PROP 790
      U(N)=DSQRT((F(2,N,2)**2+G(2,N,2)**2)/(F(2,IE,2)**2+G(2,IE,2)**2))         PROP 800
      IF (K.EQ.1) U(N)=F(2,N,2)                                                 PROP 810
      IF (U(N).GE.0.995D0) NN=N-1                                               PROP 820
      IF (U(N).GE.0.995D0) GO TO 40                                             PROP 830
30    CONTINUE                                                                  PROP 840
40    DEL=Y(NN)+(Y(NN+1)-Y(NN))*(0.995D0-U(NN))/(U(NN+1)-U(NN))                 PROP 850
C                                                                               PROP 860
50    CONTINUE                                                                  PROP 870
      REX2=REINF*UE2*X                                                          PROP 880
      IF (EPSVD.LT.1.D-25) EPSVD=0.D0                                           PROP 890
      CFXINF=0.D0                                                               PROP 900
      CFWINF=0.D0                                                               PROP 910
      CFXEDG=0.D0                                                               PROP 920
      CFWEDG=0.D0                                                               PROP 930
      QWINF=0.D0                                                                PROP 940
      IF (X.EQ.0.0D0) GO TO 60                                                  PROP 950
C                                                                               PROP 960
C     CALCULATE SURFACE PARAMETERS                                              PROP 970
C                                                                               PROP 980
      DWDETA=GN(2,1,2)                                                          PROP 990
      IF (K.EQ.1.OR.K.EQ.KEND) DWDETA=0.0D0                                     PROP1000
      CFXINF=2.0D0*EPSVD*UE2**1.5*FN(2,1,2)*DSQRT(2.D0/XI)                      PROP1010
      CFWINF=2.0D0*EPSVD*UE2**1.5*DWDETA*DSQRT(2.D0/XI)                         PROP1020
      CFXEDG=2.0D0*EPSVD*FN(2,1,2)*DSQRT(2.D0/XI)                               PROP1030
      CFWEDG=2.0D0*EPSVD*UE2**1.5*DWDETA*DSQRT(2.D0/XI)                         PROP1040
      QWINF=EPSVD*TE2*UE2**.5*DSQRT(2.D0/XI)*TN(2,1,2)/PR                       PROP1050
      QWINF=QWINF*(-1.0D0)                                                      PROP1060
      TAUX=CFXINF*RHOINF*UFS**2/2.0D0                                           PROP1070
      TAUETA=CFWINF*RHOINF*UFS**2/2.0D0                                         PROP1080
      QW=QWINF*RHOINF*UFS**3*1.286D-03/PR                                       PROP1090
      IF (L.EQ.2.AND.NOSE.EQ.SHARP.AND.K.EQ.1) QWSTAG=QW                        PROP1100
      QWOQWO=QW/QWSTAG                                                          PROP1110
      GO TO 70                                                                  PROP1120
60    IF (NOSE.EQ.SHARP) GO TO 70                                               PROP1130
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C                                                                       PROP1140
CC      CALCULATE HEAT TRANSFER FOR A BLUNT CONE STAGNATION POINT       PROP1150
C                                                                       PROP1160
        QWINF=EPSVD*TE2*DSQRT(2.00*DUE2DX)*TN(2,1,2)/PR                 PROP1170
        QWINF=QWINF*(-1.0D0)                                            PROP1180
        QW=QWINF*RHOINF*UFS**3*1.286D-03/PR                             PROP1190
        QWSTAG=QW                                                       PROP1200
        QWOQW0=1.0D0                                                    PROP1210
C                                                                       PROP1220
70      CONTINUE                                                        PROP1230
        RETURN                                                          PROP1240
        END                                                             PROP1250


        SUBROUTINE SOLVE (W,WN,EE1,FF1,EDGBC)                           SOLV  10
        IMPLICIT REAL*8(A-H,O-Z)                                        SOLV  20
        REAL*8 NOSE                                                     SOLV  30
        COMMON /FINDIF/ A(101),BB(101),B(101),CC(101),DD(101),D(101),E(101SOLV  40
       1),CRI                                                           SOLV  50
        COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,KDUM,L,NBLNT1,IND,KPRT,LPRT,KSOLV  60
       1PR,LPR                                                          SOLV  70
        COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA  SOLV  80
        DIMENSION EE(101), FF(101), W(2,101,3), WN(2,101,3)             SOLV  90
C                                                                       SOLV 100
CCCCCCC SUBROUTINE SOLVE CALCULATES THE SOLUTION OF A GENERAL PARABOLIC SOLV 110
        PARTIAL DIFFERENTIAL EQUATION WHEN THE THE P.D.E. IS REPRESENTED SOLV 120
        BY A SYSTEM OF IMPLICIT, THREE-POINT FINITE-DIFFERENCE EQUATIONS.SOLV 130
        THE THOMAS ALGORITHM AS SOLVED BY RICHTMEYER IS USED TO SOLVE THE SOLV 140
        SYSTEM.                                                         SOLV 150
C                                                                       SOLV 160
        EE(1)=EE1                                                       SOLV 170
        FF(1)=FF1                                                       SOLV 180
        DO 10 J=2,IM                                                    SOLV 190
        AP=A(J)                                                         SOLV 200
        BP=B(J)                                                         SOLV 210
        CP=CC(J)                                                        SOLV 220
        DP=D(J)                                                         SOLV 230
        EE(J)=-CP/(BP+AP*EE(J-1))                                       SOLV 240
        FF(J)=(DP-AP*FF(J-1))/(BP+AP*EE(J-1))                           SOLV 250
10      CONTINUE                                                        SOLV 260
        W(2,IE,2)=EDGBC                                                 SOLV 270
        K=IM                                                            SOLV 280
        DO 20 J=2,IE                                                    SOLV 290
        W(2,K,2)=EE(K)*W(2,K+1,2)+FF(K)                                 SOLV 300
        K=K-1                                                           SOLV 310
20      CONTINUE                                                        SOLV 320
        CALL DERIV3 (W,2,2,ETA,IE,1,WN)                                 SOLV 330
        RETURN                                                          SOLV 340
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      END                                                                SOLV 350



      SUBROUTINE VCALC (LC)                                              VCAL  10
      IMPLICIT REAL*8(A-H,O-Z)                                           VCAL  20
      REAL*8 NOSE                                                        VCAL  30
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,VCAL  40
     1101,3),TN(2,101,3),V(101),VOL(101)                                 VCAL  50
      COMMON /METR/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)VCAL  60
     1,HXNN(101),HWX(101),HWW(101),HWN(101),HWNN(101)                    VCAL  70
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB                VCAL  80
      COMMON /OECOEF/ HXOHXO(101),HWOHWO(101),BHV(101),BHM(101),BHT(101)VCAL  90
     1,XKX(101),XKW(101),BMX(101),BMW(101),XLX(101),XLW(101),BAFF(101),BVCAL 100
     2AGF(101),BAFG(101),BAGG(101),XKXOAL(101)                           VCAL 110
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,VCAL 120
     1LPR                                                                VCAL 130
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),VCAL 140
     1TWN(101),XIW,XW,RW                                                 VCAL 150
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XVCAL 160
     1C(500),CIX(500),ICONW,KC1,KTW                                      VCAL 170
      COMMON /WSOLVE/ DW,WCOORD                                          VCAL 180
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                   VCAL 190
      COMMON /XSOLVE/ XSTA(100),DXMAX,DX,DXOLD,DXI,NSOLVE                VCAL 200
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA     VCAL 210
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                        VCAL 220
      COMMON /STGEOG/ DVEGXW,DVEWXW,DVE2XW,DVEGXX,DVEWXX,DVE2XX,DVGXXW,DVCAL 230
     1VWXXW,DV2XXW,DHWOXW,DHXOXW                                         VCAL 240
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW   VCAL 250
      COMMON /CONVRG/ CONV,NIT1,NIT2,NIT3,NIT                            VCAL 260
      DIMENSION V(101)                                                   VCAL 270
      DATA SHARP,BLUNT/SHSHARP,SHBLUNT/                                  VCAL 280
                                                                         VCAL 290
C     THIS SUBROUTINE CALCULATES THE VALUE OF V                          VCAL 300
                                                                         VCAL 310
      DO 10 J=1,IE                                                       VCAL 320
      V(J)=0.D0                                                          VCAL 330
10    CONTINUE                                                           VCAL 340
      IIT=0                                                              VCAL 350
20    CONTINUE                                                           VCAL 360
      VW(1)=VWALL                                                        VCAL 370
      DO 80 J=2,IE                                                       VCAL 380
      IF (IIT.GT.0) GO TO 70                                             VCAL 390
      IF (K.GT.1) GO TO 30                                               VCAL 400
      DGDW1=GW(J)                                                        VCAL 410
      DGDW2=GW(J-1)                                                      VCAL 420
      GO TO 50                                                           VCAL 430
30    IF (LC.GT.1) GO TO 40                                              VCAL 440
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      DGDW1=(G(2,J,2)-G(2,J,1))/DW                                              VCAL 450
      DGDW2=(G(2,J-1,2)-G(2,J-1,1))/DW                                          VCAL 460
      GO TO 50                                                                  VCAL 470
40    DGDW1=(G(2,J,2)-G(2,J,1)+G(1,J,3)-G(1,J,2))/2.0D0/DW                      VCAL 480
      DGDW2=(G(2,J-1,2)-G(2,J-1,1)+G(1,J-1,3)-G(1,J-1,2))/2.0D0/DW              VCAL 490
50    DFDXI1=0.0D0                                                              VCAL 500
      DFDXI2=0.0D0                                                              VCAL 510
      IF (LC.EQ.1) GO TO 60                                                     VCAL 520
      DFDXI1=(F(2,J,2)-F(1,J,2))/DXI                                            VCAL 530
      DFDXI2=(F(2,J-1,2)-F(1,J-1,2))/DXI                                        VCAL 540
      IF (LC.EQ.1) GO TO 60                                                     VCAL 550
      W=UEW                                                                     VCAL 560
      IF (LC.EQ.2) W=0.D0                                                       VCAL 570
      DWDW=DUEWDW                                                               VCAL 580
      IF (LC.EQ.2) DWDW=DVEWDW                                                  VCAL 590
      A=DSQRT(XI/2.D0/UEW)                                                      VCAL 600
      A11=A*UEW*HWX(J)/HXOHXO(J)/HX(J)/HW(J)+A*UEW*HXX(1)/HX(J)**2-A*UEWVCAL 610
     1*HXX(J)/HXOHXO(J)/HX(J)**2+A*DUEWDX/2.D0/HXOHXO(J)/HX(J)+UEW/HXOHXVCAL 620
     2O(J)/HX(J)/2.D0/DSQRT(2.D0*UEW*XI)                                        VCAL 630
      A12=A*UEW*HWX(J-1)/HXOHXO(J-1)/HX(J-1)/HW(J-1)+A*UEW*HXX(1)/HX(J-1VCAL 640
     1)**2-A*UEW*HXX(J-1)/HXOHXO(J-1)/HX(J-1)**2+A*DUEWDX/2.D0/HXOHXO(J-VCAL 650
     21)/HX(J-1)+UEW/HXOHXO(J-1)/HX(J-1)/2.D0/DSQRT(2.D0*UEW*XI)            VCAL 660
      A21=A*W*HXW(J)/HWOHWO(J)/HW(J)/HX(J)+A*W*HWW(1)/HW(J)**2-A*W*HWW(JVCAL 670
     1)/HWOHWO(J)/HW(J)**2-W*DSQRT(XI/2.D0/UEW**3)/2.D0/HWOHWO(J)*DUEWDWVCAL 680
     2/HW(J)+A*DWDW/HWOHWO(J)/HW(J)                                             VCAL 690
      A22=A*W*HXW(J-1)/HWOHWO(J-1)/HW(J-1)/HX(J-1)+A*W*HWW(1)/HW(J-1)**2VCAL 700
     1-A*W*HWW(J-1)/HWOHWO(J-1)/HW(J-1)**2-W*DSQRT(XI/2.D0/UEW**3)*DUEWDVCAL 710
     2W/2.D0/HWOHWO(J-1)/HW(J-1)+A*DWDW/HWOHWO(J-1)/HW(J-1)                     VCAL 720
      A11=-A*A11                                                                VCAL 730
      A12=-A*A12                                                                VCAL 740
      A21=-A*A21                                                                VCAL 750
      A22=-A*A22                                                                VCAL 760
      A31=-XI/2.D0/HX(J)/HXOHXO(J)                                              VCAL 770
      A32=-XI/2.D0/HX(J-1)/HXOHXO(J-1)                                          VCAL 780
      A41=-XI*AL2/2.D0/HW(J)/HWOHWO(J)                                          VCAL 790
      A42=-XI*AL2/2.D0/HW(J-1)/HWOHWO(J-1)                                      VCAL 800
      A51=A*BHV(J)/HX(J)/HW(J)                                                  VCAL 810
      A52=A*BHV(J-1)/HX(J-1)/HW(J-1)                                            VCAL 820
      GO TO 70                                                                  VCAL 830
60    CONTINUE                                                                  VCAL 840
      A11=-1.D0/HXOHXO(J)/HX(J)                                                 VCAL 850
      A12=-1.D0/HXOHXO(J-1)/HX(J-1)                                             VCAL 860
      A21=-AL1*B4/2.D0+AL1**2/2.D0-AL1*(HXW(J)/HX(J)+DHWOXW/HWX(1))/HWX(VCAL 870
     11)                                                                        VCAL 880
      A22=-AL1*B4/2.D0+AL1**2/2.D0-AL1*(HWX(J-1)/HX(J-1)+DHWOXW/HWX(1))/VCAL 890
     1HWX(1)                                                                    VCAL 900
      A31=0.D0                                                                  VCAL 910
      A32=0.D0                                                                  VCAL 920
      A41=-AL1/2.D0/HWX(1)                                                      VCAL 930
      A42=A41                                                                   VCAL 940
      A51=BHV(J)                                                                VCAL 950
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      A52=BHV(J-1)                                                      VCAL 960
70    CONTINUE                                                          VCAL 970
      VW(J)=VW(J-1)+(A31*DFDXI1+A32*DFDXI2+A41*DGDW1+A42*DGDW2+A51*VW(J)VCAL 980
     1+A52*VW(J-1)+A11*FW(J)+A12*FW(J-1)+A21*GW(J)+A22*GW(J-1))*DETA(J)/VCAL 990
     22.D0                                                              VCAL1000
80    CONTINUE                                                          VCAL1010
      DIFV=0.D0                                                         VCAL1020
      DO 90 J=2,IE                                                      VCAL1030
      DIFVP=DABS((VW(J)-V(J))/VW(J))                                    VCAL1040
      IF (DIFVP.GT.DIFV) DIFV=DIFVP                                     VCAL1050
      V(J)=VW(J)                                                        VCAL1060
90    CONTINUE                                                          VCAL1070
      IF (DIFV.LE.CONV) GO TO 100                                       VCAL1080
      IIT=1                                                             VCAL1090
      GO TO 20                                                          VCAL1100
100   CONTINUE                                                          VCAL1110
      RETURN                                                            VCAL1120
      END                                                               VCAL1130
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      SUBROUTINE WALL                                                   WALL  10
      IMPLICIT REAL*8(A-H,O-Z)                                          WALL  20
      REAL*8 NOSE                                                       WALL  30
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,WALL  40
     1101,3),TN(2,101,3),Y(101),YDL(101)                                WALL  50
      COMMON /EDGE/ UEDG,TEDG,VEDG,DUEGDX,DUEGDW,D2UEDW,DVEGDX,DVEGDW,REWALL  60
     1DG,DRDGDX,ZBOD,XEDG                                               WALL  70
      COMMON /EDGW/ UEW,VEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW  WALL  80
      COMMON /FRSTRM/ RHOINF,PINF,TFS,UFS,AMUINF,CP,REINF,PR            WALL  90
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                       WALL 100
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB               WALL 110
      COMMON /INJECT/ INJCT,NDINJ,MASTRN                                WALL 120
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,WALL 130
     1LPR                                                               WALL 140
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),WALL 150
     1TWN(101),XIM,XW,RW                                                WALL 160
      COMMON /STAG/ PSTAG,TSTAG,PNC,QWSTAG                              WALL 170
      COMMON /SURFAS/ CWALL,CWIND,PEWIND,VWALL,TWALL,XTW(500),TWX(500),XWALL 180
     1CI(500),CIX(500),TCONW,KCI,KTH                                    WALL 190
      COMMON /TMPRTR/ TEMP(101),TP(101),RTW,TB                          WALL 200
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                  WALL 210
      DATA BLUNT,SHARP/5HBLUNT,5HSHARP/                                 WALL 220
      DATA ABL,TRA/3HABL,3HTRA/                                         WALL 230
      PI=DARCOS(-1.0D0)                                                 WALL 240
C                                                                       WALL 250
C     INTERPOLATE FOR VALUES OF CWALL AT THE WINDWARD STREAMLINE        WALL 260
C                                                                       WALL 270
      EPSVD=1.D0/DSQRT(REINF)                                           WALL 280
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      IF (MASTRN.EQ.0) GO TO 30                                          WALL 290
      IF (K.GT.1) GO TO 20                                               WALL 300
      PEWIND=PEW                                                         WALL 310
      IF (KCI.EQ.0) GO TO 20                                             WALL 320
      IF (XW.GT.XCI(KCI)) GO TO 30                                       WALL 330
      J=0                                                                WALL 340
10    J=J+1                                                              WALL 350
      IF (XW.GT.XCI(J)) GO TO 10                                         WALL 360
      IF (J.LT.2) J=2                                                    WALL 370
      IF (J.GT.KCI-1) J=KCI-1                                            WALL 380
      CALL INTER3 (XW,XCI(J-1),XCI(J),XCI(J+1),CIX(J-1),CIX(J),CIX(J+1),WALL 390
     1CWIND)                                                             WALL 400
      CWALL=CWIND                                                        WALL 410
      GO TO 40                                                           WALL 420
20    CONTINUE                                                           WALL 430
      IF (WX.LT.90.0D0) GO TO 40                                         WALL 440
30    CWALL=0.0D0                                                        WALL 450
40    CONTINUE                                                           WALL 460
C                                                                        WALL 470
C     INTERPOLATE FOR VALUES OF TWALL AT THE WINDWARD STREAMLINE         WALL 480
C                                                                        WALL 490
      IF (K.GT.1) GO TO 70                                               WALL 500
      IF (KTW.EQ.0) GO TO 60                                             WALL 510
      J=0                                                                WALL 520
50    J=J+1                                                              WALL 530
      IF (XW.GT.XTW(J)) GO TO 50                                         WALL 540
      IF (J.LT.2) J=2                                                    WALL 550
      IF (J.GT.KTW-1) J=KTW-1                                            WALL 560
      CALL INTER3 (XW,XTW(J-1),XTW(J),XTW(J+1),TWX(J-1),TWX(J),TWX(J+1),WALL 570
     1TWALL)                                                             WALL 580
      GO TO 70                                                           WALL 590
60    TWALL=RTW                                                          WALL 600
70    CONTINUE                                                           WALL 610
C                                                                        WALL 620
C     CALCULATE THE VALUE OF BIG V AT THE WALL                           WALL 630
C                                                                        WALL 640
      VWALL=0.D0                                                         WALL 650
      IF (NOSE.EQ.SHARP.AND.XIW.EQ.0.0D0) GO TO 90                       WALL 660
      IF (XIW.EQ.0.0D0) GO TO 80                                         WALL 670
      VWALL=DSQRT(XI/2.D0/UEW)*CWALL                                     WALL 680
      GO TO 90                                                           WALL 690
80    VWALL=DSQRT(.5D0/DUEWDX)*CWALL                                     WALL 700
90    CONTINUE                                                           WALL 710
      RETURN                                                             WALL 720
      END                                                                WALL 730


      SUBROUTINE XMOM (LC)                                               XMOM  10
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      IMPLICIT REAL*8(A-H,O-Z)                                                  XMOM  20
      REAL*8 NOSE                                                               XMOM  30
      COMMON /DEPVAR/ F(2,101,3),FN(2,101,3),G(2,101,3),GN(2,101,3),T(2,XMOM  40
     1101,3),TN(2,101,3),Y(101),YOL(101)                                        XMOM  50
      COMMON /GEOM/ ALPHA,NOSE,RNOSE,WLST,X,XX,WX                               XMOM  60
      COMMON /IECOEF/ B1,B2,B3,B4,B5,B6,AL1,AL2,AL3,XLAMB                       XMOM  70
      COMMON /INTEGR/ IE,IM,KEND,KEND2,KLX,K,L,NBLNT1,IND,KPRT,LPRT,KPR,XMOM  80
     1LPR                                                                       XMOM  90
      COMMON /PDECOF/ A0(101),A1(101),A2(101),A3(101),A4(101),A5(101)           XMOM 100
      COMMON /SOLPNT/ VW(101),GW(101),TW(101),GWN(101),FWN(101),FW(101),XMOM 110
     1TWN(101),XIW,XW,RW                                                        XMOM 120
      COMMON /TRANSN/ KTRANS,KONSET,XIF,CHI2(101),CHIMAX,XBAR                   XMOM 130
      COMMON /TRBLNT/ ASTAR,AKSTAR,ALAMDA,YSUBL,EVSCFY(101),EDYLAW,EPLUSXMOM 140
     1(101),LAMTRB                                                              XMOM 150
      COMMON /XICORD/ XI,XXI,DXI,XIOLD                                          XMOM 160
      COMMON /ZCOORD/ ETAINF,ETAFAC,ETA(101),DETA(101),ADTEST,KADETA            XMOM 170
      COMMON /NCOORD/ XN(101),ETAX,ETAW                                         XMOM 180
      COMMON /INTGRL/ XIFNX(101),XIFNW(101),XIFNXX(101),XIFNWW(101)             XMOM 190
      COMMON /EDGW/ UEW,UEW,TEW,DUEWDX,DUEWDW,D2UEWW,DVEWDX,DVEWDW,REW          XMOM 200
      COMMON /GECOEF/ HXOHXO(101),HWOHWO(101),BHV(101),BHM(101),BHT(101)XMOM 210
     1,XKX(101),XKW(101),BMX(101),BMW(101),XLX(101),XLW(101),BAFF(101),BXMOM 220
     2AGF(101),BAFG(101),BAGG(101),XKXOAL(101)                                  XMOM 230
      COMMON /HETA/ HX(101),HW(101),HXX(101),HXW(101),HXWW(101),HXN(101)XMOM 240
     1,HXNN(101),HWX(101),HWW(101),HWN(101),HWNN(101)                           XMOM 250
      DIMENSION ROMU1(101), ROMU1N(101)                                         XMOM 260
      DATA SHARP,BLUNT/5HSHARP,5HBLUNT/                                         XMOM 270
C                                                                               XMOM 280
C     SUBROUTINE SETS UP THE COEFFICIENTS OF THE PARTIAL DIFFERENTIAL           XMOM 290
C     X MOMENTUM EQUATION                                                       XMOM 300
C                                                                               XMOM 310
      DO 10 J=1,IE                                                              XMOM 320
      ROMU1(J)=1.0D0+XIF*EPLUS(J)                                               XMOM 330
   10 CONTINUE                                                                  XMOM 340
      CALL DERIV (ROMU1,ETA,IE,1,ROMU1N)                                        XMOM 350
      CALL PRESSI (1)                                                           XMOM 360
      DO 30 J=1,IE                                                              XMOM 370
      A0(J)=ROMU1(J)                                                            XMOM 380
      A1(J)= ROMU1N(J)-BHM(J)*ROMU1(J)-VW(J)                                    XMOM 390
      A2(J)=-BMX(J)*ROMU1(J)+ROMU1N(J)*HXN(J)/HX(J)                             XMOM 400
      A4(J)=-XI*HX(1)*FW(J)/2.D0/HX(J)**2                                       XMOM 410
      A5(J)=0.D0                                                                XMOM 420
      IF (LC.EQ.1) GO TO 20                                                     XMOM 430
      A2S=(XLX(1)-XLX(J))/2.D0-BAFF(J)+.5D0*B1/HXOHXO(J)**2                     XMOM 440
      A2(J)=A2(J)-2.D0*A2S*FW(J)                                                XMOM 450
      A3(J)=.5D0*B1/HXOHXO(J)**2+(XLX(1)-XLX(J))/2.D0-BAFF(J)+XI/2.D0/HXXMOM 460
     1(1)/UEW**2*XIFNX(J)+A2S*FW(J)**2                                          XMOM 470
      IF (LC.EQ.2) GO TO 30                                                     XMOM 480
      A2(J)=A2(J)-AL2*GW(J)/2.D0/HWOHWO(J)**2*(B2+XKX(1))                       XMOM 490
      A3(J)=A3(J)+AL1*B2/HWOHWO(J)**2/2.D0-XKW(J)*AL2**2*HXOHXO(J)*(AL3*XMOM 500
     1*2-GW(J)**2)/2.D0/HWOHWO(J)**2+XKX(1)*AL1/2.D0/HWOHWO(J)**2-BAGF(JXMOM 510
     2)*(AL3**2-GW(J)**2)                                                       XMOM 520
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      A5(J)=-XI*GW(J)*AL2/2.D0/HW(J)/HWOHWO(J)                                  XMOM 530
      GO TO 30                                                                  XMOM 540
20    CONTINUE                                                                  XMOM 550
      A2(J)=A2(J)-.5D0*FW(J)/HXOHXO(J)**2-ALI**2*GW(J)                          XMOM 560
      A3(J)=.5D0/HXOHXO(J)**2*AL2**2*HXOHXO(J)*(1.D0-GW(J)**2)/2.D0/HX(JXMOM 570
     1)+ALI**2/2.D0+DSQRT(2.D0)*(XIFNXX(J)+DVEWDX*XIFNWW(J)/DSQRT(DUEWDXXMOM 580
     2))/DUEWDX**2                                                              XMOM 590
      A4(J)=0.D0                                                                XMOM 600
      A5(J)=-ALI*GW(J)/HWX(1)                                                   XMOM 610
30    CONTINUE                                                                  XMOM 620
      IRITE=0                                                                   XMOM 630
      IF (IRITE.EQ.0) GO TO 50                                                  XMOM 640
      WRITE (6,60)                                                              XMOM 650
      DO 40 I=1,IE,5                                                            XMOM 660
      WRITE (6,70) A0(I),A1(I),A2(I),A3(I),A4(I),A5(I)                          XMOM 670
40    CONTINUE                                                                  XMOM 680
50    CONTINUE                                                                  XMOM 690
      RETURN                                                                    XMOM 700
C                                                                               XMOM 710
60    FORMAT (3H0,12HIN XMOM A0-5)                                              XMOM 720
70    FORMAT (1H0,6E13.6)                                                       XMOM 730
      END                                                                       XMOM 740
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