

N74-1114
CR 132351

OCTOBER 1972

ANALYSIS AND DESIGN OF THREE
DIMENSIONAL SUPERSONIC NOZZLES

ATL TR 166 - VOLUME II
NUMERICAL PROGRAM FOR ANALYSIS OF
NOZZLE-EXHAUST FLOW FIELDS

By

P. Kalben

PREPARED FOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HAMPTON, VIRGINIA

UNDER
CONTRACT NO. NAS1-10327

By

ADVANCED TECHNOLOGY LABORATORIES, INC.
Merrick and Stewart Avenues
Westbury, New York 11590

INDEX

		<u>Page</u>
I.	INTRODUCTION	1
II.	DESCRIPTION OF INPUT	10
	A. INITIAL INPUT DATA	10
	B. COWL INPUT DATA	17
	C. RESTARTING PROGRAM	20
III.	DESCRIPTION OF OUTPUT	22
	A. OUTPUT FORMAT	22
	B. IDENTIFICATION OF VARIABLES	23
IV.	SUBROUTINES AND FUNCTIONS	27
	A. SUBROUTINES	27
	B. FUNCTIONS	31
V.	MACHINE CONTROL CONSIDERATIONS	32
VI.	FLOW CHART	33
VII.	PROGRAM LISTING	38

LIST OF FIGURES

	<u>Page</u>
FIG. 1a. NUMERICAL GRID-CARTESIAN OR LINE SOURCE	2
FIG. 1b. NUMERICAL GRID-CYLINDRICAL	3
FIG. 2. INTERNAL SIDEWALL GRID	5
FIG. 3. EXTERNAL FLOW-REFERENCE PLANE J	7
FIG. 4. EXTERNAL FLOW-END MODULE	9

ABSTRACT

This manual describes the FORTRAN IV Program developed to analyze the flow field associated with scramjet exhaust systems. The instructions for preparing input and interpreting output are described. The program analyzes steady three dimensional supersonic flow by the reference plane characteristic technique. The governing equations and numerical techniques employed are presented in Volume I of this report.

I. INTRODUCTION

The FORTRAN IV program described herein analyzes inviscid three dimensional supersonic flow in scramjet exhaust systems by use of a reference plane characteristic procedure. The governing equations and numerical techniques employed are described in detail in Volume I of this report.

The numerical grid employed in Figures (1a) and (1b) follows streamline projections in each reference plane (R,Z) or (X,Z) or (X, θ). The grid is described by a matrix of points (I,J) where "I" denotes the streamline projection being traced in a reference plane and "J" denotes the reference plane considered. The number of streamline points (I) may not vary from reference plane to reference plane, and the addition or deletion of streamline points in accordance with step size considerations is provided for in subroutine "SPACE".

For internal flow calculations the program may use either Cartesian (X, Y, Z), line source (R, θ , Z) or cylindrical (X, θ , R) coordinates depending upon the internal geometry considered. For the external flow calculation the Cartesian system or cylindrical system is used and the switch-over is performed automatically in subroutine INTER. The marching direction is either R or X and the direction normal to the reference plane is either

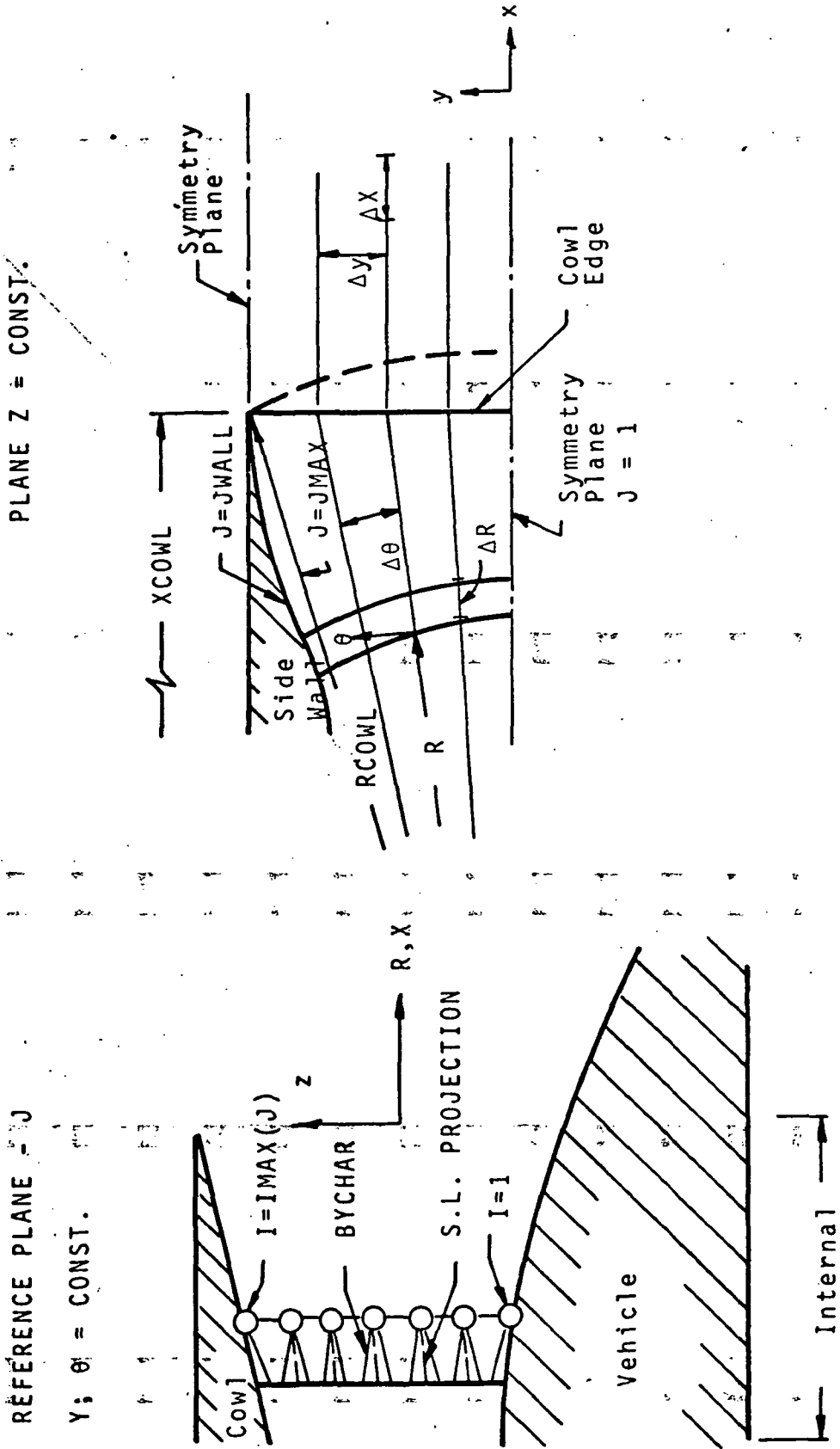


FIGURE 1a. NUMERICAL GRID-CARTESIAN OR LINE SOURCE

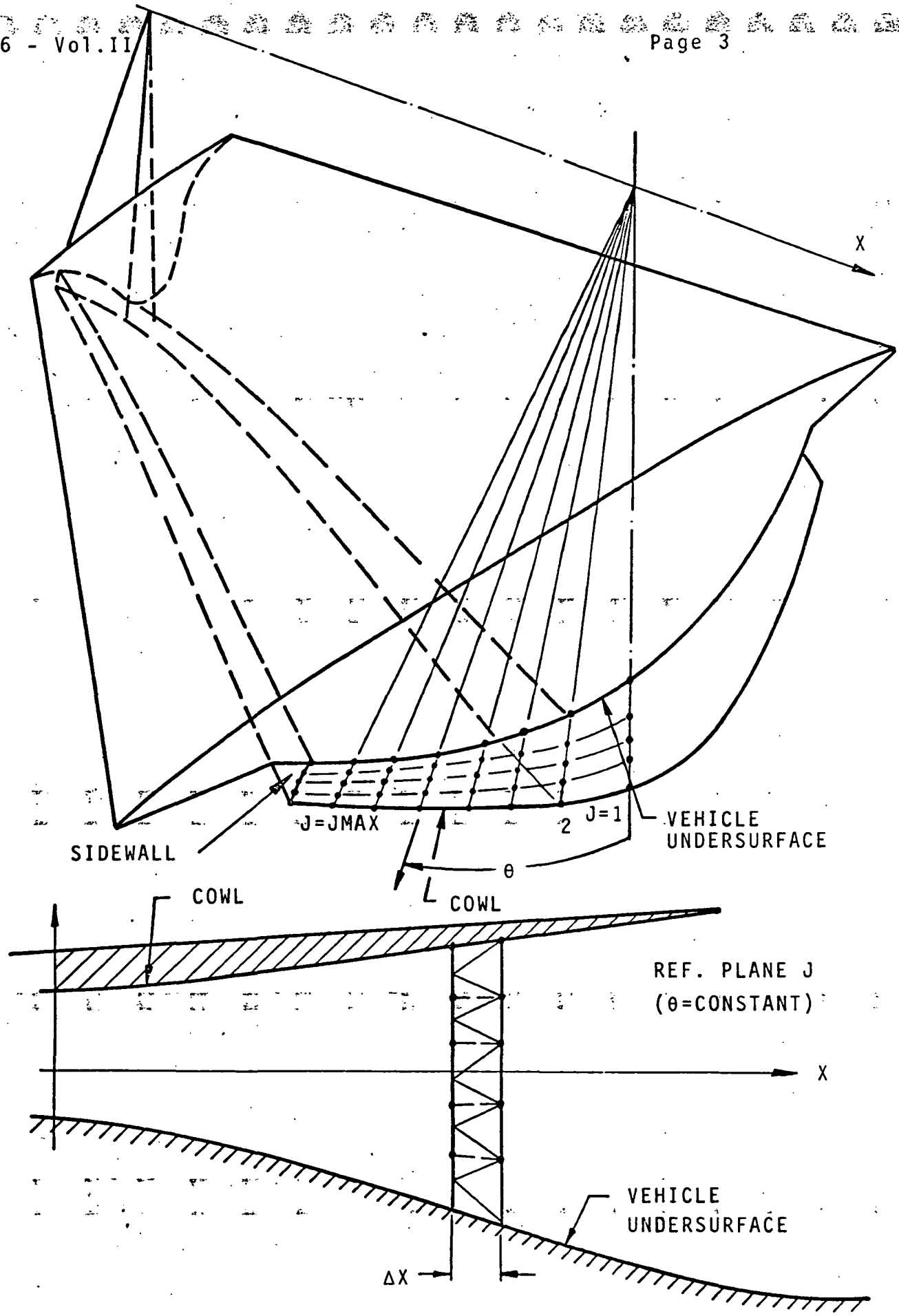


FIGURE 1b. NUMERICAL GRID-CYLINDRICAL

θ or y . Specifying $XJ = 0$ or 1 with $XJ1 = 0$ in the input determines whether a Cartesian or line source system is used.

For the cylindrical system $XJ1 = 1$ and $XJ = 0$.

For the program described herein, the following stipulations apply:

- (1) The internal flow is underexpanded.
- (2) The cowl and sidewalls end on a plane $X =$ constant. The sidewall edges at the cowl lip plane are assumed to be straight lines for external central module configuration (Figure 2).
- (3) The program is dimensioned such that ten (10) reference planes may be used with forty (40) streamline points in each reference plane (40, 10). This, of course, may be changed depending on storage availability and the number of grid points needed to complete a problem.
- (4) The flow deflection at the sidewall exit is assumed to be zero.

PLANE - R, X = CONST.

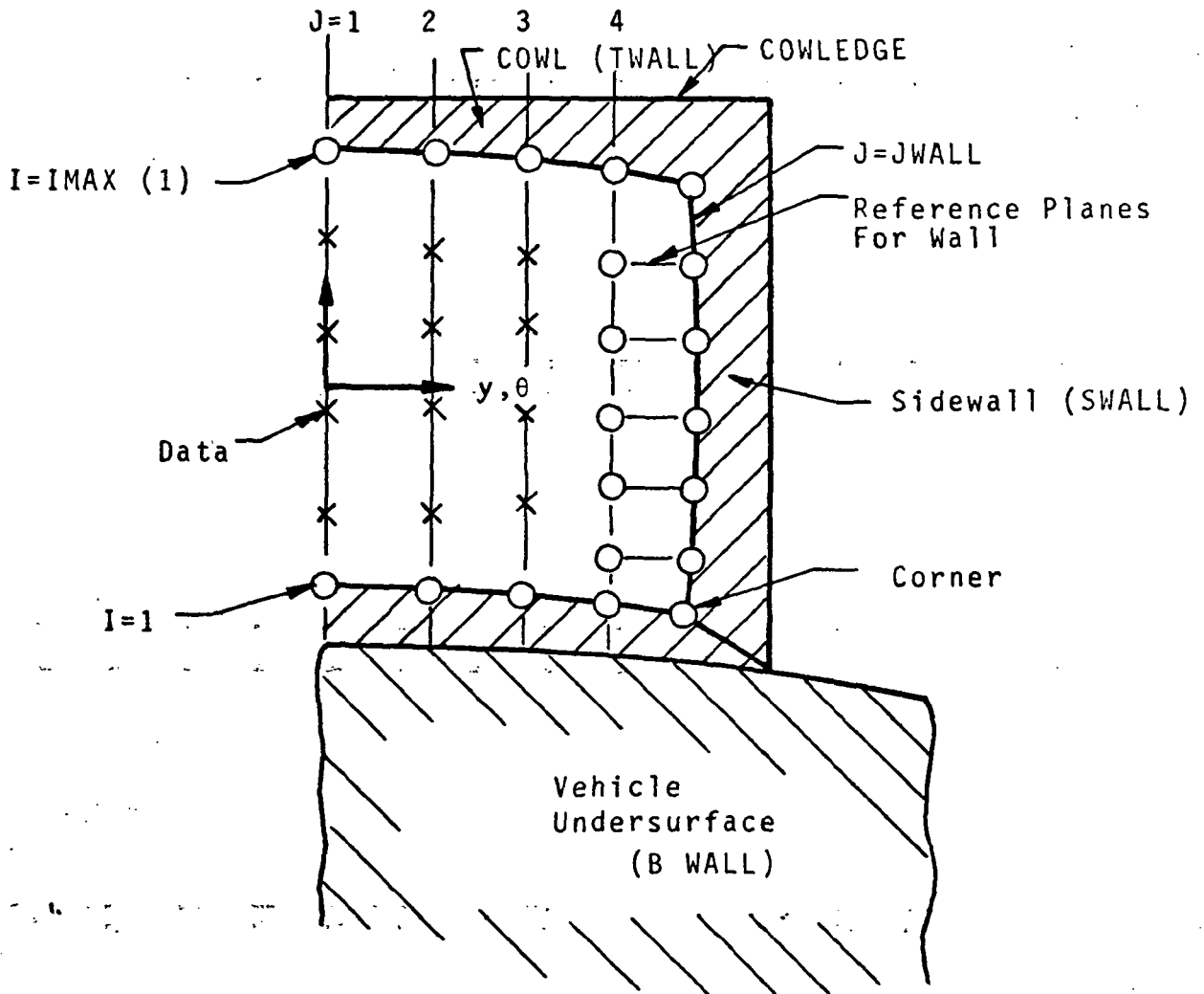


FIGURE 2. INTERNAL SIDEWALL GRID

- (5) For the cylindrical coordinate system only central module flows are possible.

In general, doubly curved upper, lower and sidewalls can be assumed, the only limitations being those given above. Subroutines TWALL, BWALL and SWALL describe the shape of these walls using parabolas defined in the Input Section.

Thermodynamic curve fits are contained in functions FT, FGAM and RHEQ, for temperature, equilibrium exponent and density. These are multi-variate fits obtained from data in Reference (1) and are described in Volume I.

The external flow calculation requires specifying the shape of an internal stream surface described by a two parameter parabola as in TWALL. Subroutine COWL computes the under-expansion interaction between the internal and external flows at the cowl edge station. This data, the internal flow data and external flow data provide the necessary initial data surface and boundary conditions to calculate the external flow interaction (Figure 3). The strength of the underexpansion shock is calculated in HSHOCK and the properties on the contact surface are calculated in CSURF. The crosswise shape of the discontinuities is calculated in ALSHOCK.

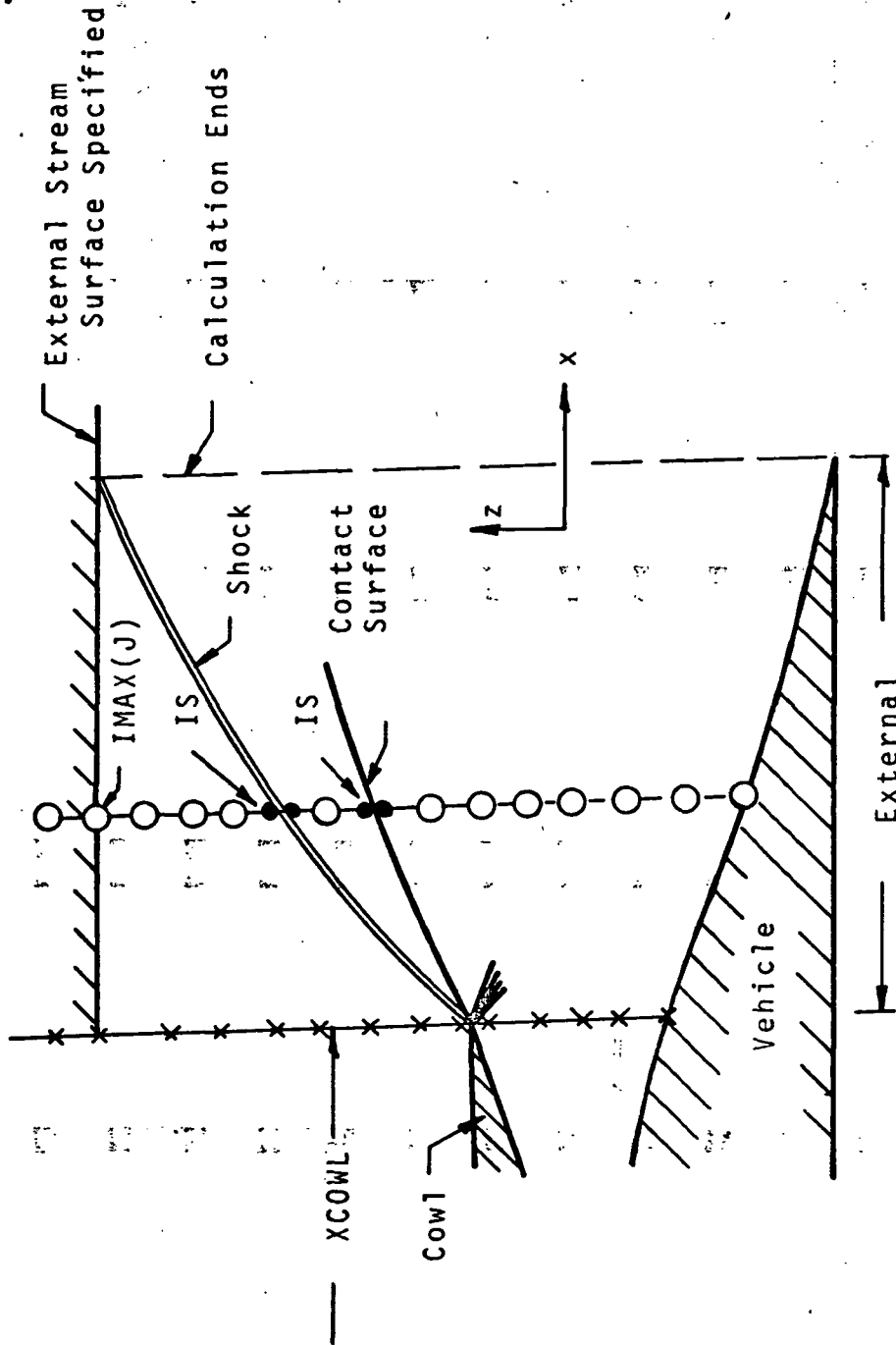


FIGURE 3. EXTERNAL FLOW-REFERENCE PLANE J

For end modules (Figure 4) WRAP calculates the property variations as a function of a local reference plane orientation in the wrap-around region of the flow.

The program computes derivatives for each flow field point on the initial value surface in DERIV while derivatives on the new data surface ($r + \Delta r$ or $x + \Delta x$) are computed in DERIVN. Integral correction factors for mass flow and total energy are computed in MOTHER. The flow field properties are corrected in UNOWAT based on these correction factors. The user chooses the frequency of application of these corrections by an input variable described in Section II, "Description of Input."

The main program executes the characteristic calculations and provides the control necessary to execute boundary calculations, compute thermodynamic data etc., and provides for other peripheral computations or instructions necessary to complete the overall calculation.

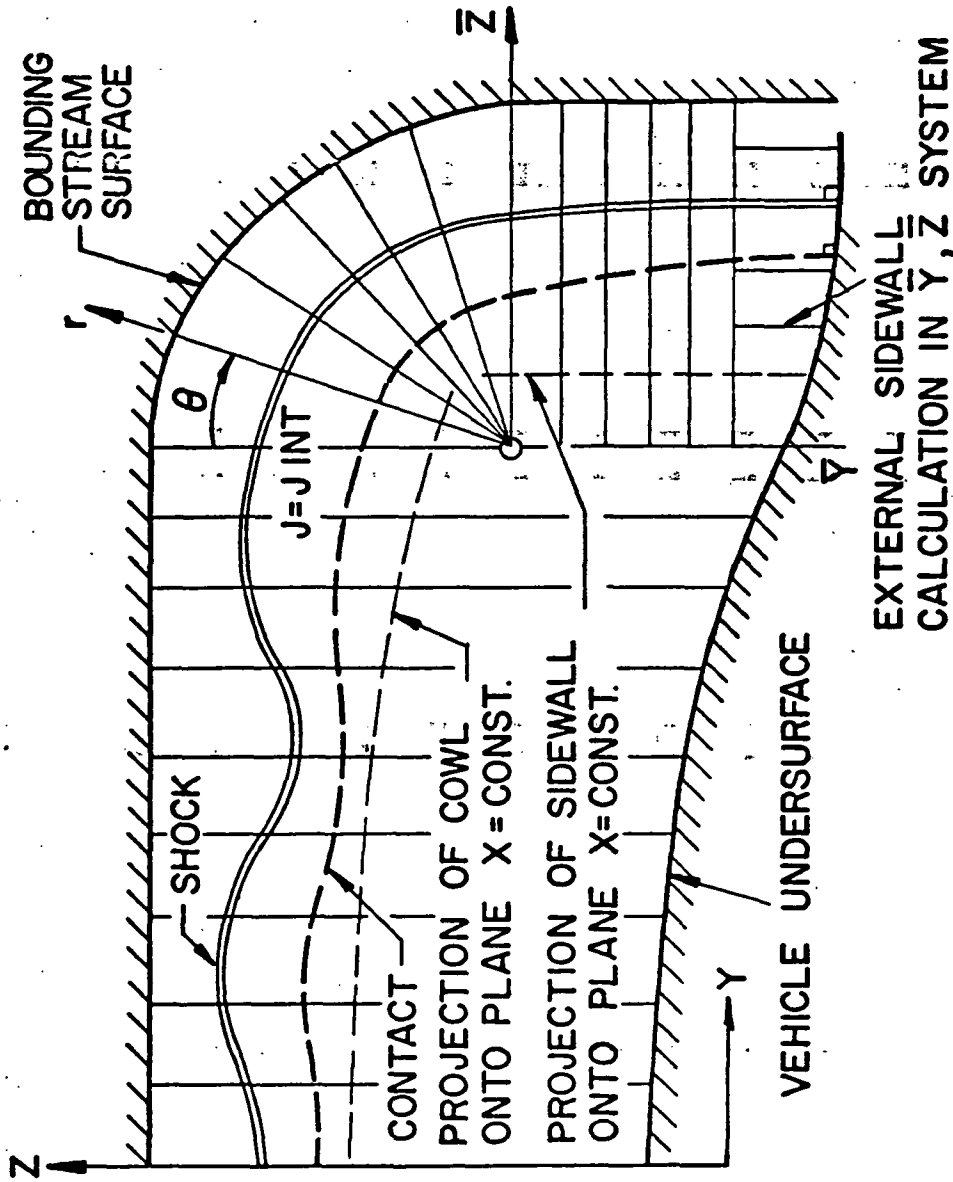


FIGURE 4. EXTERNAL FLOW-END MODULE

II. DESCRIPTION OF INPUT

A. Initial Input Data

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
1	I5	1-5	final marching step
	I5	6-10	print interval (in number of steps)
	I5	11-15	restart indicator (0-initial run; 1-restart)
	I5	16-20	indicator for second order accuracy in characteristic calculations (0-first order; 1-second order)
	I5	21-25	indicator for second order accuracy in crosswise derivatives (0-first order; 1-second order) NOTE: if this input equals 1, the characteristic calculations are also second order
	I5	26-30	mass flow and energy correction interval (in number of steps)
	I5	31-35	number of reference planes allowed for in dimension statement (now is 10)
	I5	36-40	intermediate punched output may be obtained at a maximum of three
	I5	41-45	stations (input station numbers desired, if any)
	I5	46-50	
	E10.0	51-60	stepsize factor (presently 2)
2	I5	1-5	JMAX number of reference planes excluding sidewall but including planes of symmetry - maximum is 9. NOTE: if run termination is in an external end module configuration, the maximum number of initial reference planes JMAX=9-NUMEXP; where NUMEXP is input #5 on card #2.

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
2	I5	6-10	internal symmetry indicator (0-one plane of symmetry; 1-two planes of symmetry)
	I5	11-15	external symmetry indicator (0-one plane of symmetry...)
	I5	16-20	external flow indicator (0-end module, 1-central module)
	I5	21-25	number of rotated reference planes for wraparound calculation (max is number of data points in z direction between vehicle undersurface and ZSAV, described on card 3) - external vehicle undersurface is a plane
	I5	26-30	sweepback indicator (0-no sweepback; 1-sweepback). If this equals one, the number of initial data points in each reference plane and sidewall must be the same.
	I5	31-35	IMAX(1) number of initial data points in first reference plane (J=1)
	I5	36-40	IMAX(2) number of initial data points in second reference plane (J=2)
	I5		IMAX(JMAX) number of initial data points in last reference plane (J=JMAX)

*Note: Number of data points on each reference plane are equal (i.e., IMAX(1) = IMAX(2) = ... = IMAX(JMAX))

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
3	E10.3	1-10	origin of (r,θ,z) coordinate system of initial station (ft)
	E10.3	11-20	XJ-(0-Cartesian; 1-cylindrical)
	E10.3	21-30	XJI-(0-Vehicle I; 1-Vehicle II)
	E10.3	31-40	X coordinate of cowl at end of sidewall (ft)
	E10.3	41-50	radial distance to intersection of cowl lip with sidewall or last reference plane if no sidewall (ft)
	E10.3	51-60	final X coordinate of run (ft)
	E10.3	61-70	ZSAV-Z direction point of JMAX internal reference plane which defines origin of sweep around coordinate system
	E10.3	71-80	static pressure at vehicle infinity conditions (lb_f/ft^2)

If input 6 on card 2 is zero, leave this card out of deck:

3a	E10.3	1-10	X coordinate of sweepback plane in first reference plane
	E10.3	11-20	X coordinate of sweepback plane in second reference plane
	:	:	:
	E10.3		X coordinate of sweepback plane in last reference plane or sidewall if it exists
3b	E10.3	1-10	initial lift
	E10.3	11-20	initial thrust

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
3b	E10.3	21-30	initial pitching moment
	E10.3	31-40	z moment axis
	E10.3	41-50	x moment axis
4a	E10.3	1-10	angular coordinates (XJ=1) (degrees) or y (XJ=0) coordinate (ft) or first reference plane
	E10.3	11-20	z coordinate of first data point (I=1) on first (J=1) reference plane (ft)
	E10.3	21-30	z coordinate of second data point (I=2) on first (J=1) reference plane (ft)
	.	.	.
	E10.3		z coordinate of last data point (I=IMAX(1)) on first (J=1) reference plane (ft)

(If there are more than 6 data points on a reference plane continue on the next data card in Column #1 with same format)

4b-4m Same as 4a for each of the reference planes.

5 Leave this card out of input deck if input 2 on card 2 equals 1:

I5	1-5	number of initial data points on sidewall
E10.0	6-15	z coordinate of first data point on sidewall (ft)

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
5	E10.0	16-25	z coordinate of second data point on sidewall (ft)
	E10.0		z coordinate of last data point on sidewall (ft)
6	I5	1-5	number of parabolas used to define lower wall (max is 3)
7a	E10.3	1-10	distance R defining starting location of first parabola (ft) (input equals input 1 on card 3)
	E10.3	11-20	coordinates for first parabola defining lower wall (for T=THETA or Y, and X = marching distance) $Z = A11X^2T^2 + A12X^2T + A13XT^2 + A14X^2 + A15T^2 + A16XT + A17X + A18T + A19$ inputs A11 - A17
	E10.3	71-80	
8a	E10.3	1-10	A18
	E10.3	11-20	A19
7b,8b 7c,8c			Give starting locations and coordinates of the second and third parabolas defining lower wall (if used).
9 10a-10c 11a-11c			Same as cards 6, 7a-7c and 8a-8c except coordinates for equation of upper wall.

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
12 13a-13c 14a-14c			Same format as cards 6, 7a-7c and 8a-8c except coordinates for equation of sidewall (these cards are only necessary if input 2 on card 2 is 0), where parabola is $T=A31X^2Z^2+A32X^2Z+A33XZ^2+A34X^2+A35Z^2+A36XZ+A37X+A38Z+A39$.

The following is the input format for properties at data points in the flow field. There is a set of 6 properties for each reference plane. They are read from 1 to the number of data points for that reference plane (IMAX(J)) (inputs 7,8,... on card 2). If there are more than 7 data points on a reference plane the remaining data points are continued on the next card with the same format.

15a	E10.3	1-10	pressure at first data point in first reference plane (lb_f/ft^2)
	E10.3	11-20	pressure at second data point in first reference plane (lb_f/ft^2)
	E10.3		pressure at last data point in first reference plane (lb_f/ft^2)

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
16a			Same as 15a except values of PHE* (degrees)
17a			Same as 15a except values of Q* (ft/sec)
18a			Same as 15a except values of SI* (degrees)
19a			Same as 15a except values of H static enthalpy (ft ² /sec ²)
20a			Same as 15a except values of ϕ fuel to air equivalence ratio

- 21 $\phi \geq 0$ - equilibrium hydrogen-air
- 21 $\phi = -1$ - methane
- 22 $\phi = -2$ - ethylene

*PHE is the angle associated with the direction cosine of the projection of the velocity vector in the reference plane and the marching direction R or X.

Q is the projection of the velocity vector in the reference plane.

SI is the angle associated with the direction cosine of the velocity vector and its projection in the reference plane.

<u>Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
15b-20b			are the same as 15a-20a except properties are in the second reference plane

15. 5-10 number of points in the axial direction

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
--------------------	---------------	----------------	--------------------

The following is the input format for properties at data points in the free stream. There is a set of the Z locations and 6 properties for each reference plane. They are read from 1 to the number of data points in the free stream (input 1, card 1). This is done the same as cards 15a-20a to 15n-20n in the initial Input Data Section except the Z locations are added. If an end module configuration is being computed the number of external reference planes is the original JMAX (input 1 on card 2) planes plus the number of external planes (input 5 on card 2). Subtract one if external vehicle undersurface is a wall rather than a plane of symmetry.

2a	E10.3	1-10	Z location of first data point in first reference plane (ft) (input equals Z coordinate of the cowl)
	E10.3	11-20	Z location of second data point in first reference plane (ft)
	.	.	.
	.	.	.
	.	.	.
	E10.3		Z location of last data point in first reference plane (ft)

For uniform external flow allow sufficient Z direction space between cowl lip and limiting external stream surface point for shock propagation.

<u>Card Number</u>	<u>Format</u>	<u>Columns</u>	<u>Description</u>
3a			Same as 2a except values of pressure (lb_f/ft^2).
4a			Same as 2a except values of PHE (degrees).
5a			Same as 2a except values of Q (ft/sec).
6a	E10.3	1-10	Angles in each reference plane. θ equals a constant associated with the direction cosines of the interactions of the cowl and the plane. θ equals a constant.
7a			Same as 2a except values of H static enthalpy (ft^2/sec^2).
8a	E10.3	11-20	Same as 2a except values of ϕ fuel to air equivalence ratio.
2b-8b			Same as 2a-8a except properties are in the second reference plane.
15		1-5	number of parabolas for equation of limiting external stream surface (maximum of 3)
2n-8n			Same as 2a-8a except properties are in the last reference plane.
17 & 18			Same as cards 10a-10c and 11a-11c of Initial Input Data Section except coordinates for equation of limiting external stream surface.
If input 3 on card 2 of Initial Input Section is one, cards 9-14 are omitted:			
19-21			Same as cards 12, 13a-13c and 14a-14c of Initial Input Data Section except coordinates for equation of limiting external stream surface (only 12a, 13a-13c and 14a-14c are used if input 3 is one).
9			Same as 2a except along vehicle undersurface.
10			Same as 3a except along vehicle undersurface.
11			Same as 7a except along vehicle undersurface.
12			Same as 8a except along vehicle undersurface.

sweepback if this option was used.

Card

Number Format Columns Description

- Whenever a punch deck is received printed output at that station is in X direction along vehicle undersurface.
- 13 Same as 2a except velocity component in Cartesian direction along vehicle undersurface.
- deck with the exception that it may be desirable to change input variable Z direction along vehicle undersurface.
- 14 Same as 2a except velocity component in Cartesian direction along vehicle undersurface.
- (in number of sweeps) on punch card #1. If the cowl has been passed all points are considered. (y equals a constant) associated with the direction cosines of the interactions of the cowl lip and the plane X equals a constant
- 15 E10.3 1-10 angles in each reference plane (y equals a constant) associated with the direction cosines of the interactions of the cowl lip and the plane X equals a constant
- E10.3 11-20
- .
- E10.3
- 16 I5 1-5 number of parabolas for equation of limiting external stream surface (maximum of 3)
- 17 & 18 Same as cards 10a-10c and 11a-11c of Initial Input Data Section except coordinates for equation of limiting external stream surface.
- 19-21 Same as cards 12, 13a-13c and 14a-14c of Initial Input Data Section except coordinates for equations of external vehicle undersurface (only use these cards if external vehicle undersurface is not a wall of symmetry).

C. Restarting Program

The program may be restarted using the final punch deck or any intermediate punch deck at any point outside of the initial

sweepback if this option was used.

Whenever a punch deck is received printed output at that station is also given. This deck replaces the Initial Input Data deck with the exception that it may be desirable to change input variables #1 [final marching step] and #2 [print interval (in number of steps)] on punched card #1. If the cowl has been passed all inputs are completed. If the cowl has not been passed, the Cowl Input Data deck is appended and the data deck is complete.

the program then continues marching in the Cartesian system with the same point scheme as before with the addition of ALP, ALPHA, BETA, IS and flow variables in the external wraparound region at radii measured from the "ZSAV" point. The program prints a statement when an enclosed shock is encountered. This statement includes shock type (2 - downrunning shock; 7 - uprunning shock) IS, ALP, ALPHA, BETA in each preference plane. The program terminates when either the input value of final marching step or final PRINTS is reached.

III. DESCRIPTION OF OUTPUT Variables.

A. Output Format: The program prints a narrative describing the input data that has been read: steps taken

since initial input accepted

At every "KOUNT" which is a multiple of the print interval starting with KOUNT=0 the properties are printed at each grid point in the flow field. This includes sidewall output if applicable. Marching steps are taken in successive radii (line source system) or in the x direction (Cartesian and Cylindrical systems) until the intersection of the cowl edge and the last plane of symmetry or sidewall is reached. At this time the properties are interpolated onto the plane $X = X_{COWL}$ then the shock and contact surfaces, the Prandtl-Meyer fan and the free stream points are printed. The program then continues marching in the Cartesian system with the same print scheme as before with the addition of ALP, ALPHA, BETA, IS and flow variables in the external wraparound region at radii measured from the "ZSAV" point. The program prints a statement when an embedded shock is encountered. This statement includes its type (2 - downrunning shock; 7 - uprunning shock) IS, ALP, ALPHA, BETA in each reference plane. The program terminates when either the input values of final X coordinate or final "KOUNT" is reached.

radius (cylindrical system)

(degrees) or X coordinate

(Cartesian system) (ft)

(Cartesian and Cylindrical systems)

angular coordinate in degrees

(cylindrical system) or X coordinate

ordinate in ft. (Cartesian system)

of reference planes

Z coordinate (ft)

direction of velocity vector

reference plane (ft/sec)

angle associated with the direction

cosine of θ and the marching direction

tion R or X (degrees)

B. Identification of Variables.

(1) Reference plane output

KOUNT - number of marching steps taken since initial input accepted

R - radius (cylindrical system) (degrees) or X coordinate (Cartesian system) (ft)

J - reference plane number

THETA - angular coordinate in degrees (cylindrical system) or Y coordinate in ft. (Cartesian system)

(2) of reference planes

I - data point index within a reference plane

Z - Z coordinate (ft)

P - pressure (lb_f/ft^2)

Q - projection of velocity vector in reference plane (ft/sec)

PHE - angle associated with the direction cosine of Q and the marching direction R or X (degrees)

(1) Discontinuities

- SI - angle associated with the direction of intersection between discontinuity and plane X or R equals a constant
- ALPHA - angle associated with the direction cosine of Q and the velocity vector (degrees)
- M - Mach number
- ALPHA - angle associated with the direction cosine of Q and the normal to the reference plane and the tangent to the discontinuity
- H - static enthalpy (ft²/sec²)
- PHI - fuel to air equivalence ratio
- RHO - density (slugs/ft³)
- BETA - angle associated with the direction cosine of Q and the normal to the reference plane and the tangent to the discontinuity
- GAM - isentropic exponent
- T - temperature (°R)

(2) Sidewall output (extra variables printed)

- X - Cartesian X coordinate of data point
- Y - Cartesian Y coordinate of data point
- U - component of velocity vector in X direction
- V - component of velocity vector in Y direction
- W - component of velocity vector in Z direction

(3) Discontinuities

ALP - angle of intersection between discontinuity and plane X or R equals a constant

ALPHA - angle associated with the direction cosine between the normal to the reference plane and the tangent to the discontinuity

BETA - angle associated with the direction cosine between the intersection of discontinuity and marching direction

IS - matrix whose non-zero elements indicate the data points in each reference plane where a discontinuity exists

Column 1 - first uprunning shock wave

Column 2 - first downrunning shock wave

Column 3 - first contact discontinuity

Column 4 - second downrunning shock wave

IV. SUBROUTINES AND FUNCTIONS **Column 5 - second contact discontinuity**

A. Subroutines **Column 6 - third downrunning shock wave**

Name **Description** **Column 7 - second uprunning shock wave**

- 1. INTER interpolates interior flow properties onto plane X equals X coordinate of cowl
- 2. IBI single table linear interpolation and extrapolation of flow properties to be used for derivatives normal to reference planes
- 3. STEP computer marching step based on characteristic criteria
- 4. INDATA accepts initial input data and program re-start data
- 5. INDATA2 accepts interior interpolated data in plane X equal to X coordinate of cowl and free stream data at same X
- 6. CSURF computes properties upstream and downstream of all contact surfaces
- 7. HSHOCK computes properties downstream of all shock discontinuities in marching direction

IV. Subroutines AND FUNCTIONS

9. NOTHIA. Subroutines integral correction factors for
mass flow and total energy

<u>Name</u>	<u>Description</u>
9. COWL	compute shock surface strength, contact sur-
1. INTER	interpolates internal flow properties onto plane X equals X coordinate of cowl
2. TBL	single table linear interpolation and
10. A.SIDE	extrapolation of flow properties to be used for derivatives normal to reference planes in
3. STEP	computes marching step based on characteristic criteria
4. INDATA	accepts initial input data and program re- start data
12. FSHOCK	computes flow properties upstream of specified marching station
5. INDAT2	accepts interior interpolated data in plane X equal to X coordinate of cowl and free stream
13. WALL	computes flow properties at wall and stream- data at same X
6. CSURF	computes properties upstream and downstream of all contact surfaces
7. HSHOCK	computes properties downstream of all shock discontinuities in marching direction
14b. SWALL1	Notes direction of flow at sidewall for cylin- drical system

	<u>Name</u>	<u>Description</u>
15.	CORNER	computes flow properties in corners of flow.
8.	MOTHER	computes integral correction factors for mass flow and total energy
16.	BWALL	locates lower wall at new marching step and
9.	COWL	computes shock surface strength, contact surface strength and extent of Prandtl-Meyer expansion normal to cowl edge for under-expanded
17.	FWALL	computes direction cosines of upper wall internal flow
18.	UPPER	prints error statement and program line number
10.	ALSHOC	computes angles associated with the direction cosine of a tangent to each discontinuity in the crosswise direction for each reference plane
19.	ALSOUB	add or subtract direction cosine for each reference plane
20.	ADISC	computes properties across discontinuity at external equilibrium density
11.	RHEQ	computes equilibrium density
12.	FSHOCK	computes flow properties upstream of shock at new marching station calculations for end module calculation
13.	WALL	computes flow properties associated with side-
22.	PSOLV	is a four point least squares routine
		wall
23.	WSHR	compute line or transverse wave speeds
14a.	SWALL	locates sidewall at new marching step and computes direction cosines of sidewall for Cartesian coordinate system
24.	PNCH	portion of output used to restart the program
14b.	SWALL1	locates sidewall at new marching step and computes direction cosines of sidewall for cylindrical system

	<u>Name</u>	<u>Description</u>
15.	CORNER	computes flow properties in corners of flow field
16.	BWALL	locates lower wall at new marching step and computes direction cosines of lower wall
17.	TWALL	locates upper wall at new marching step and computes direction cosines of upper wall
18.	ERROR	prints error statement and program line number nearest iteration error
19.	ADDSUB	add or subtracts reference planes
20.	WDISC	computes properties across discontinuity at external vehicle undersurface
21.	PLANES	inserts a pseudo reference plane in flow to facilitate derivative calculations for end module calculation
22.	PSOLV	is a four point least squares routine
23.	WSHK	computes line of intersection between discontinuity and vehicle undersurface
24.	PNCH	gives intermediate and final printed and punched output used to restart the program

	<u>Name</u>	<u>Description</u>
25.	SPACE	adds or subtracts data points to facilitate maximum allowable marching step
26.	SWEEP	interpolates data points along throat sweep-back plane
27.	EMBED	locates embedded shocks
28.	WRAP	computes derivatives at all data points except discontinuities on two reference planes bounding 90° wraparound area
29.	SOLVE	solves the determinant of 3x3 matrix
30.	TBLDUM	single table linear interpolation used for derivatives on reference planes bounding wrap-around area
31.	ALWRAP	computes angles associated with the direction cosines of a tangent to each discontinuity in crosswise direction for planes bounding wrap-around region
32.	L TH M	computes lift, thrust and moment
33.	SETN	sets flow variables and crosswise derivatives at the new station equal to these quantities at old station prior to the new station being calculated

	<u>Name</u>	<u>Description</u>
34.	UNOWAT	corrects flow field properties based on correction factors computed in MOTHER
35.	DERIV	computes crosswise derivatives on initial value surface (old station)
36.	DERIVN	computes crosswise derivatives on new data surface (new station)

B. Functions

	<u>Name</u>	<u>Description</u>
1.	XLAM	computes bi-characteristic directions in each reference plane
2.	F	computes the terms associated with derivatives normal to reference plane used by bi-characteristic calculation
3.	FGAM	computes isentropic exponent and associated thermodynamic data at each point in flow field
4.	FT	computes temperature at any point in flow field
5.	FH	computes static enthalpy at any point in flow field

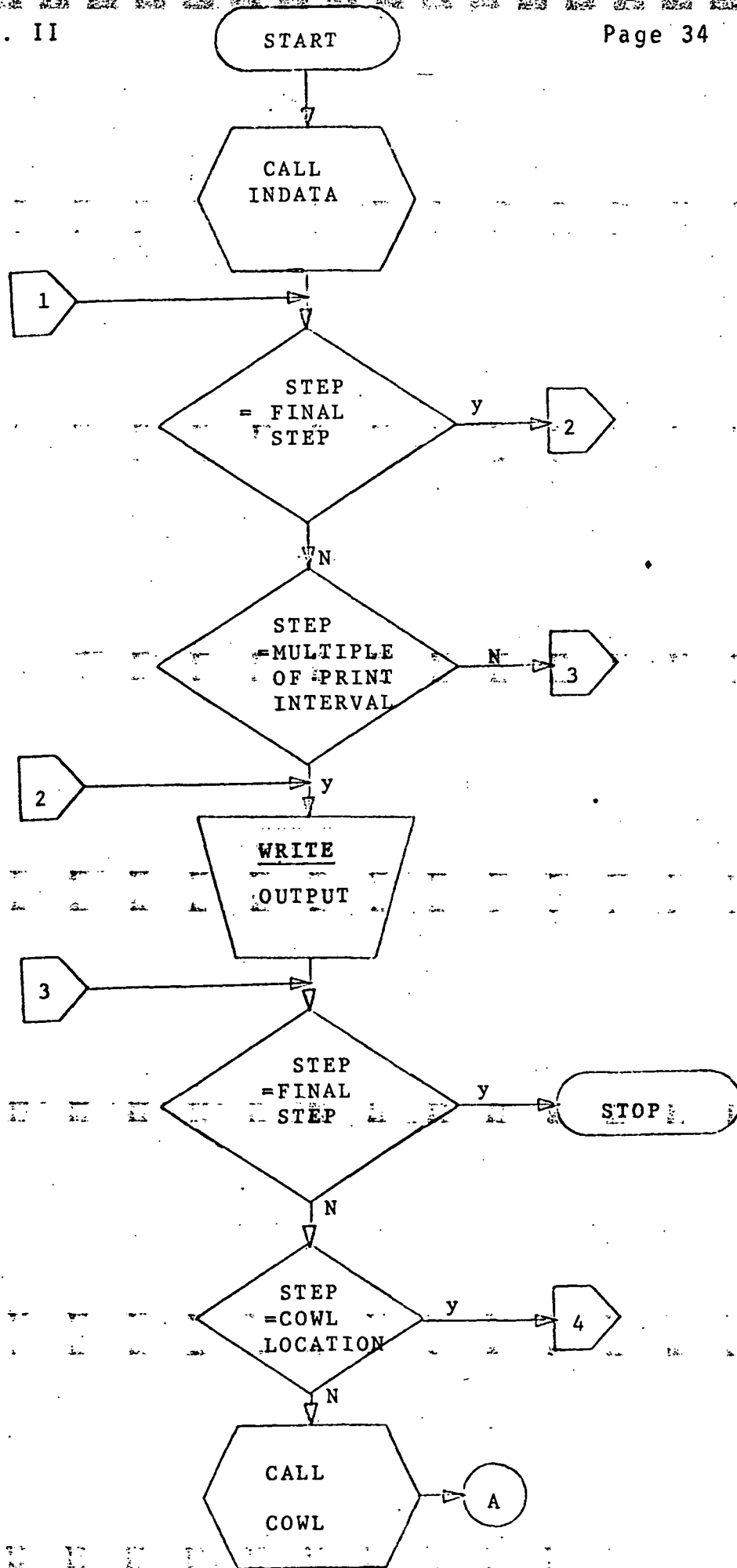
V. MACHINE CONTROL CONSIDERATIONS

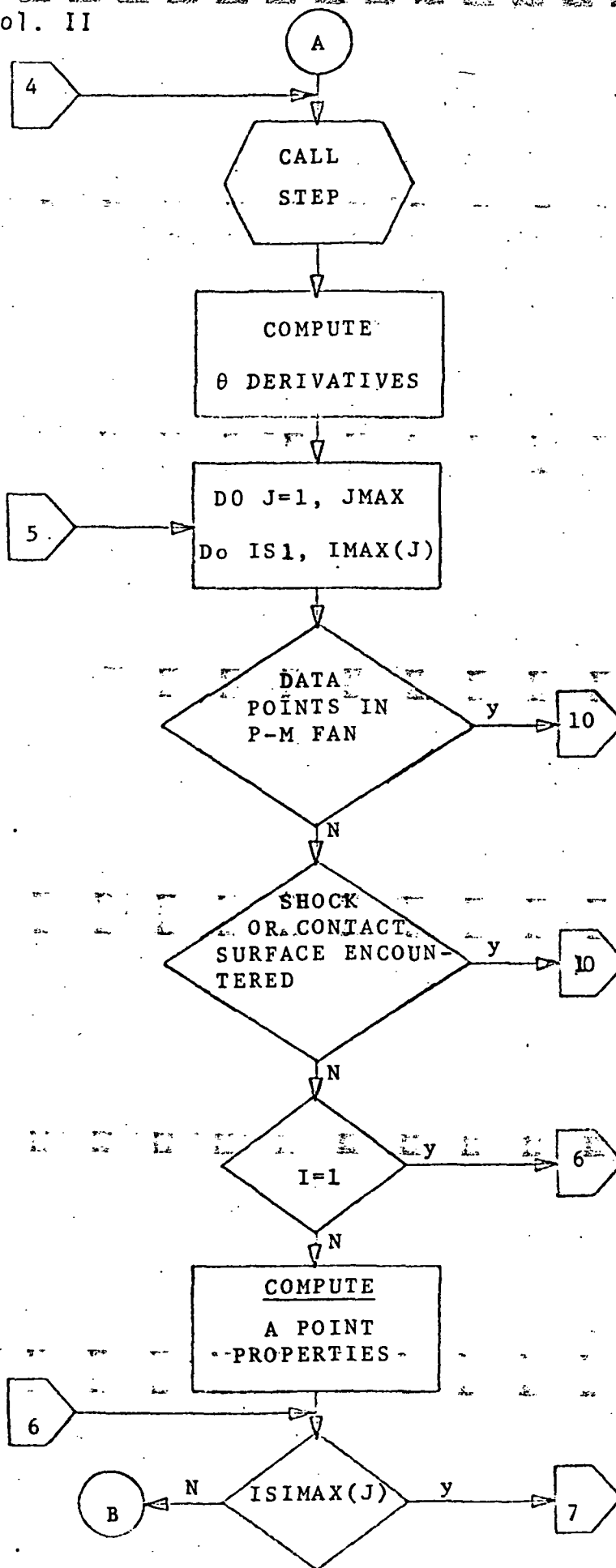
1. Computer program is written in FORTRAN IV for CDC 6600.

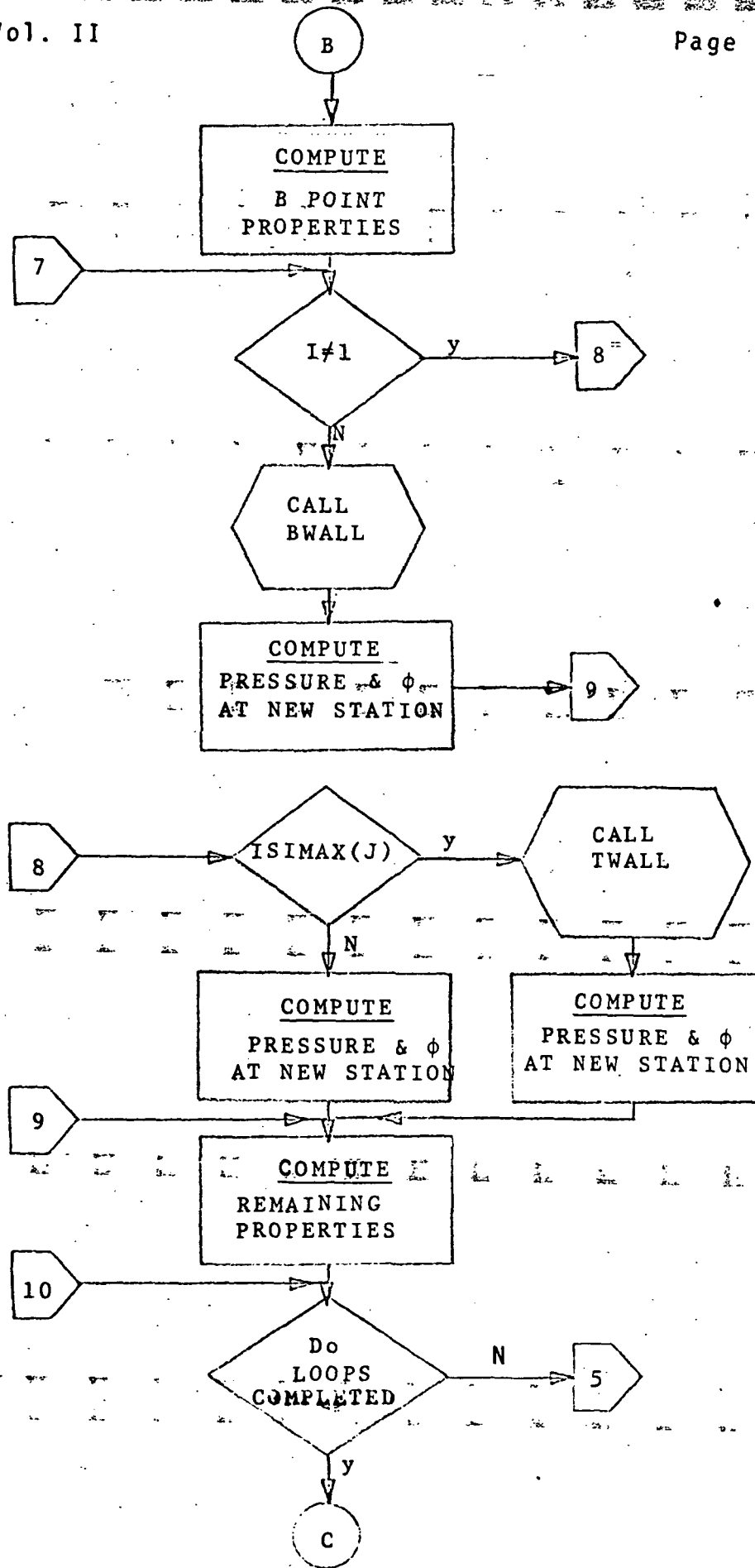
2. Time and core estimates.
 - (a) Field length
 - (1) compile - 60,000 octal
 - (2) execution - 177,000 octal
 - (b) CP time variable depending on mesh size and number of steps to be run.
 - (c) I/O: less than 100 octal seconds.
 - (d) Tape or disk storage necessary.
 - (1) tape 5 - card input
 - (2) tape 6 - printed output
 - (3) tape 7 - punched output
 - (4) tape 55 - used temporarily during run to store primary flow properties interpolated along cowl edge
 - (e) Printed output: variable depending on print interval and length of run.

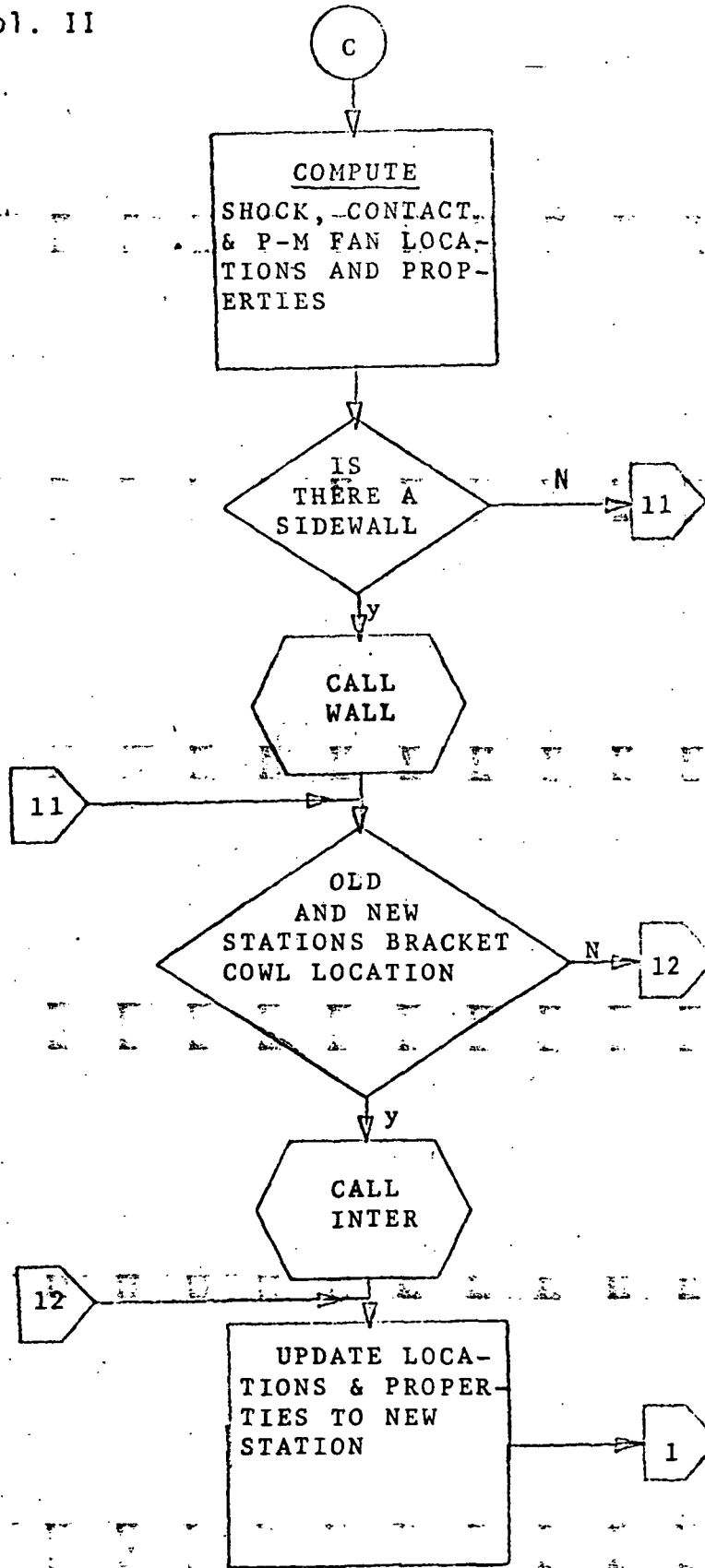
VI. FLOW CHART

The following is a flow chart of program CHAR3D.









VII. PROGRAM LISTING

The following is a listing of the program.

```

PROGRAM CHAR3D(INPUT,OUTPUT,      TAPE5=INPUT,TAPE6=OUTPUT,
1TAPE7,TAPE5)
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHF(40,10),
1 Q(40,10),SI(40,10),H(40,10),PDI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /F/ XPW(40)
COMMON /H/ ISIM
COMMON /I/ XJ
COMMON /SCLTM/ ZLIFTC,XTHRC,YMOMC,ZLIFTS,XTHRS,YMOMS
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /K/ RN,RELR
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON /M/ IS(7,10)
COMMON /N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1QQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /ALLR1/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /ALLR2/ PQN(40,10),HQN(40,10),QQN(40,10),SIGN(40,10),
1PHEQN(40,10),PHIQN(40,10),RHOQN(40,10),GAMQN(40,10)
COMMON /IVY/ IVY,KCORR,IAV
COMMON /FN/ FPN(40,10),FMN(40,10)
COMMON /AV/ AAV,BAV
COMMON /P/ KC1,KC2,KS1,KS2
COMMON /Q/ XCOWL
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,PCOWL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL
COMMON /U/ ERZZZ
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,JDUMMY(40),THWW(2),JD1,JD2
COMMON /Z/ ISTOP
COMMON /TB/ IMAXJ,IS1,IS2,ISL1,ISL2
COMMON /EX/ KTPIN(3)
COMMON /XF/ XFYN
COMMON /IQ/ NUMEXP,ZSAV
COMMON /THR/ PINF,ZLIFT,XTHR,YMOM,JJI,ZSHIFT,XSHIFT
COMMON /FWA/ ISOP
COMMON /SA/ XJIS
COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2
COMMON /ISW1/ YFR
COMMON /PL/ DE TH
COMMON /SPE/ KOUNTC
COMMON /WR/ IWRAP
COMMON /TEM/ T(40,10)
COMMON /JF/ JFINAL
COMMON /STREAM/ XMAST,XENT,FSX,FSZ
COMMON /PS/ ZR(40,2),PR(40,2),QR(40,2),WR(40,2),SIR(40,2),RHOR(40,2)
1,PHIR(40,2),PHER(40,2),THR(2),THWR(40)
COMMON /PSS/ GAMRR(40)
DIMENSION HE(10)
DATA HE/5H Y ,5H THETA,5H Z ,3H = .1HZ,1HR,1HY,3H THW,3H Y ,
13H Z /

```

```

DATA ICOWL/0/
ILOCAL=15
KOUNTC=10000
ICOWL=0
FRZZZ=1.E-04
ISTOP=0
ZLIFT=0.
XTHR=0.
YMOM=0.
ISL1=0
IFS=0
MM=0
KC1=0
KC2=0
JD1=100
JD2=100
JINT=100
AAV=1.
RAV=0.
101 FORMAT(7E10.3)
INT=0
CALL INDATA
IF(IAV.EQ.1) IVY=1
CALL SETN(0)
XJIS=XJ1
XXI=XCOWL
JJI=0
JW=JMAX+1
IF(ISIM.EQ.1) JW=JMAX
1 CONTINUE
IF(KOUNT.EQ.0 ) CALL MOTHER
IF(KOUNT.EQ.0)
1WRITE(6,1066) XMAST,XENT,FSX,FSZ
1066 FORMAT(///10X,*INITIAL MASS FLOW IS*,E13.5//10X,*INITIAL ENERGY IS
1*,E13.5//10X,*INITIAL STREAM THRUST IS */20X,*X DIRECTION - *,
1E13.5/20X,*Z DIRECTION - *,E13.5)
IF(X1.GE.XFIN) KOUNTF=KOUNT
IF(KOUNT.EQ.KOUNTS) GO TO 73
IF(KOUNT.EQ.KOUNTF) CALL PNCH
IF(KOUNT.EQ.KTPUN(1).OR.KOUNT.EQ.KTPUN(2).OR.KOUNT.EQ.KTPUN(3))
1CALL PNCH
IF(KOUNT.GE.KOUNTF) CALL EXIT
IF(((KOUNT/KOUNTF)*KOUNTF).NE.KOUNT) GO TO 3002
IF(ICOWL.EQ.1.AND.ICOWL=0) GO TO 3002
73 CONTINUE
IF(XJ.EQ.0.) GO TO 513
WRITE(6,70) KOUNT,X1
70 FORMAT(1H1,10X,*KOUNT = *,I4,1RX,*R = *,E13.5//)
GO TO 503
513 WRITE(6,504) KOUNT,X1
504 FORMAT(1H1,10X,*KOUNT = *,I4,1RX,*X = *,E13.5//)
503 CONTINUE
WRITE(6,610) ZSHIFT,XSHIFT,XTHR,ZLIFT,YMOM
610 FORMAT(10X,*Z MOMENT AXIS = *,E11.3,5X,*X MOMENT AXIS = *,E11.3/
1 10X,*THRUST = *,E11.3,5X,*LIFT = *,E11.3,5X
1.*PITCHING MOMENT = *,E11.3)

```

```

      IF (IS(3).NE.0.AND.KOUNT.NE.0.AND.ISIM.EQ.0) WRITE(6,621) XTHRC,ZLI
      IFTC,YMOMC
621  FORMAT(* CONTACT *      ,*THRUST = *,E11.3,5X,*LIFT = *,E11.3,5X
      1,*PITCHING MOMENT = *,E11.3)
      IF (IS(1).NE.0.AND.KOUNT.NE.0.AND.ISIM.EQ.0 ) WRITE(6,622) XTHRS,ZL
      IFTS,YMOMS
622  FORMAT(* SHOCK *      ,*THRUST = *,E11.3,5X,*LIFT = *,E11.3,5X
      1,*PITCHING MOMENT = *,E11.3)
      WRITE(6,623)
623  FORMAT(/)
      DO 71 J=1,JMAX
      IF(J.GT.JCALC) GO TO 71
      IF(J.GT.JINT ) GO TO 2260
      IF(XJ.NE.0..OR.XJ1.NE.0.) GO TO 505
      WRITE(6,506) J,HE(1),HE(4),TH(J),HE(5)
506  FORMAT(//10X,*J = *,I2,24X,A5,A3      ,E13.5,/4X,*I*,6X,A1 ,10X,
      1,*P*,10X,*Q*, 9X,*PHE*, 8X,*SI*,10X,*M*,10X,*H*, 9X,*PHI*
      1,8X,*RHO*,8X,*GAM*,9X,*T*)
      GO TO 510
505  IF(XJ1.EQ.0.) GO TO 507
      WRITE(6,506) J,HE(2),HE(4),TH(J),HE(6)
      GO TO 510
507  CONTINUE
      WRITE(6,506) J,HE(2),HE(4),TH(J),HE(5)
      GO TO 510
2260  Z15=ZSAV=TH(J)
      WRITE(6,506) J,HE(3),HE(4),Z15,HE(7)
510  CONTINUE
      IMAXJ=IMAX(J)
      IF(R.GT.(XCOWL-1.E-06).AND.ICOWLT.EQ.1) IMAXJ=IMAXJ+1
      DO 710 I=1,IMAXJ
      EM=G(I,J)/COS(SI(I,J))/A(I,J)
      Z15=Z(I,J)
      WRITE(6,79) I,Z15 ,P(I,J),Q(I,J),PHE(I,J),SI(I,J),EM,H(I,J),
      1PHI(I,J),RHO(I,J),GAM(I,J),T(I,J)
79  FORMAT(I5,11E11.3)
710  CONTINUE
71  CONTINUE
      IF(ISIM.EQ.1) GO TO 211
      J=JW
      IF(J.GT.JCALC) GO TO 211
      IF(J.LT.JINT.OR.ICOWLT.EQ.0) GO TO 2270
      WRITE(6,2300) JW,HE(10),HE(7)
2300  FORMAT(/// 40X,*SIDEWALL*/ 10X,*J = *,I2/11X,*X*,9X,A3
      1,9X ,*U*,10X,*W*,10X,*V*/
      14X,*I*,6X,A1 ,10X,
      1,*P*,10X,*Q*, 9X,*PHE*, 8X,*SI*,10X,*M*,10X,*H*, 9X,*PHI*
      1,8X,*RHO*,8X,*GAM*,9X,*T*)
      GO TO 6885
2270  CONTINUE
      IF(XJ1.EQ.1.) GO TO 6884
      WRITE(6,2300) JW,HE(9 ),HE(5)
      GO TO 6885
6884  WRITE(6,2300) JW,HE(8 ),HE(6)
6885  CONTINUE
      IMAXJ=IMAX(J)

```

```

IF(R.GT.(XCOWL-1.E-06).AND.ICOWL.EQ.1) IMAXJ=IMAXJ+1
DO 301 I=1,IMAXJ
FM=SQRT (UW(I)**2+VW(I)**2+WW(I)**2)/A(I,J)
THWX=THW(I)*XJ
XW(I)=R*COS(THWX)
YW(I)=R*SIN(THWX)+(1.-XJ)*THW(I)
Z15=YW(I)
IF(J.GT.JINT.AND.ICOWL.EQ.1) Z15=ZSAV-THW(I)
WRITE(6,302) XW(I),Z15 ,UW(I),WW(I),VW(I)
302 FORMAT(5X,5E11.3)
Z15=Z(I,J)
301 WRITE(6,79) I,Z15 ,P(I,J),Q(I,J),PHE(I,J),SI(I,J),EM,H(I,J),
1PHI(I,J),RHO(I,J),GAM(I,J),T(I,J)
211 CONTINUE
DO 3000 M=1,7
IF(IS(M,1).NE.0) GO TO 3001
3000 CONTINUE
GO TO 3002
3001 CONTINUE
WRITE(6,4005)
DO 4006 J=1,JW
IF(J.GT.JCALC) GO TO 4006
WRITE(6,79) J,(ALP(M,J),M=1,7)
4006 CONTINUE
4005 FORMAT(//10X,*ALP*/4X,*J*)
WRITE(6,4000)
DO 3003 J=1,JW
IF(J.GT.JCALC) GO TO 3003
WRITE(6,79) J,(ALPHA(M,J),M=1,7)
3003 CONTINUE
WRITE(6,4001)
DO 3008 J=1,JW
IF(J.GT.JCALC) GO TO 3008
WRITE(6,79) J,(BETA (M,J),M=1,7)
3008 CONTINUE
WRITE(6,4002)
DO 3009 J=1,JW
IF(J.GT.JCALC) GO TO 3009
WRITE(6,4004) J,(IS(M,J),M=1,7)
3009 CONTINUE
4000 FORMAT(//10X,*ALPHA*/4X,*J*)
4001 FORMAT(//10X,*BETA */4X,*J*)
4002 FORMAT(//10X,*IS */4X,*J*)
4004 FORMAT(I5,7(I4,7X))
3002 CONTINUE
IF(ICOWL.EQ.1) CALL COWL(MM,IFS,OPT)
IF(ICOWL.NE.1) GO TO 5023
ICOWL=1
IF(IWRAP.EQ.1)GO TO 5622
IMAXJ=IMAX(JINT)
DO 5621 L=1,IMAXJ
IF(Z(L,JINT).LT.ZSAV) GO TO 5621
IF(Z(L+1,JINT)-Z(L,JINT).LT.1.E-06) GO TO 5622
DO 5623 J=1,JINT
DO 5624 I=L,IMAXJ
Z (I,J)=Z (I+1,J)

```

```

P      (I,J)=P      (I+1,J)
Q      (I,J)=Q      (I+1,J)
H      (I,J)=H      (I+1,J)
A      (I,J)=A      (I+1,J)
SI     (I,J)=SI     (I+1,J)
PHI    (I,J)=PHI    (I+1,J)
PHE    (I,J)=PHE    (I+1,J)
RHO    (I,J)=RHO    (I+1,J)
GAM    (I,J)=GAM    (I+1,J)
XPLAM (I,J)=XPLAM (I+1,J)
XMLAM (I,J)=XMLAM (I+1,J)
5624 CONTINUE
      IMAX(J)=IMAX(J)-1
      IF(L.LT.IS(3,J)) IS(3,J)=IS(3,J)-1
      IF(L.LT.IS(1,J)) IS(1,J)=IS(1,J)-1
5623 CONTINUE
5621 CONTINUE
5622 CONTINUE
      CALL SETN(1)
      KOUNTC=KOUNT
      WRITE(6,5020) KOUNT
5020 FORMAT(1H1,10X,*COWL AND FREE STREAM DATA AT KOUNT = *,I5//)
      DO 3939 J=1,JW
      ISS=IMAX(J)-MM+1-IFS
      JMAXX=IMAX(J)+1
      IF(XJ1.EQ.0.) GO TO 509
      WRITE(6,511) J
511 FORMAT(/10X,*J = *,I2 /4X,*I*,6X,*R*,10X,
1*P*,10X,*Q*, 9X,*PHE*, 8X,*SI*,10X,*M*,10X,*H*, 9X,*PHI*
1.8X,*RHO*,8X,*GAM*,9X,*T*)
      GO TO 512
509 CONTINUE
      WRITE(6,5021) J
5021 FORMAT(/10X,*J = *,I2 /4X,*I*,6X,*Z*,10X,
1*P*,10X,*Q*, 9X,*PHE*, 8X,*SI*,10X,*M*,10X,*H*, 9X,*PHI*
1.8X,*RHO*,8X,*GAM*,9X,*T*)
512 CONTINUE
      DO 5022 I=1 ,JMAXX
      EM=Q(I,J)/COS(SI(I,J))/A(I,J)
      T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
      WRITE(6,79) I,Z(I,J),P(I,J),Q(I,J),PHE(I,J),SI(I,J),EM,H(I,J),
1PHI(I,J),RHO(I,J),GAM(I,J),T(I,J)
5022 CONTINUE
3939 CONTINUE
      DO 5000 M=1,7
      IF(IS(M,1).NE.0) GO TO 5001
5000 CONTINUE
      GO TO 5002
5001 CONTINUE
      WRITE(6,4000)
      DO 5003 J=1,JW
      DO 5004 M=1,7
      ALPHA(M,J)=ALPHAN(M,J)
5004 BETA(M,J)=BETAN(M,J)
      WRITE(6,79) J,(ALPHA(M,J),M=1,7)
5003 CONTINUE

```

```

WRITE(6,4001)
DO 5008 J=1,JW
WRITE(6,79) J,(BETA (M,J),M=1,7)
5008 CONTINUE
WRITE(6,4002)
DO 5009 J=1,JW
WRITE(6,4004) J,(IS(M,J),M=1,7)
5009 CONTINUE
5002 CONTINUE
5023 CONTINUE
74 CONTINUE
IF(KOUNT.GE.KOUNTC+20) CALL SPACE
IF(KOUNT.EQ.KOUNTC+20.AND.ICOWL.T.EQ.1.AND.IWRAP.EQ.0) CALL WRAP(0)
IF(KOUNT.EQ.KOUNTC+20) CALL MOTHER
KOUNT=KOUNT+1
IF(ICOWL.EQ.1.AND.IWRAP.EQ.0) CALL PLANES(0)
CALL STEP(IFS,MM, DFLX,X2,KOUNT)
IF(ISTOP.EQ.1) KOUNT=KOUNT-1
IF(ISTOP.EQ.1) WRITE(6,1000)
1000 FORMAT(* I INDEX GREATER THAN MAXIMUM DIMENSION, CONTACT AT LOWER
1WALL*/* OR SHOCK DOES NOT HAVE 2 FREE STREAM POINTS*)
IF(ISTOP.EQ.1) CALL PNCH
IF(KOUNT.NE.1.OR.ISWEEP.EQ.0) GO TO 1313
CALL SWEEP(1)
GO TO 620
1313 CONTINUE
CALL DERIV(MM)
620 IF(((KOUNT-1)/KOUNTP)*KOUNTP.NE.(KOUNT-1)) GO TO 7744
IF(ICOWL.EQ.1) GO TO 7744
IF(ICOWL.T.EQ.1.AND.IWRAP.EQ.0) CALL WRAP(1)
7744 CONTINUE
CALL SETN(1)
KS=0
961 CONTINUE
7678 CONTINUE
DO 707 J=1,JMAX
IF(J.GT.JCALC) GO TO 707
IF(J.GT.JINT) XJ1=0.
IIT=IMAX(J)-IFS+2
IITT=IIT-MM-2
DELR=DELX
IMAXJ=IMAX(J)
IF(R.GE.(XCOWL-1.E-06).AND.INT.EQ.2) IMAXJ=IMAXJ+1
DO 8 I=1,IMAXJ
CALL F(RHO(I,J),Q(I,J),R,Z(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J),
1 SI(I,J),A(I,J),SIG(I,J),PQ(I,J),PHEQ(I,J),FP(I),FM(I))
8 CONTINUE
IMAXJ=IMAX(J)
DO 7 I=1,IMAXJ
IF(I.NE.1.OR.J.LT.(JINT+1)) GO TO 735
IF(J.GT.(JINT+1)) GO TO 7
IMP=IDUMMY+1
ZDUMMY(1)=ZN(1,JINT)
DO 736 I10=1,IMP
7 R(I10,1)=Z (I10,JFINAL)
P R(I10,1)=P (I10,JFINAL)

```



```

Q R(I10,1)=Q (I10,JFINAL)
H R(I10,1)=H (I10,JFINAL)
SI R(I10,1)=SI (I10,JFINAL)
PHIR(I10,1)=PHI(I10,JFINAL)
PHER(I10,1)=PHE(I10,JFINAL)
RHOR(I10,1)=RHO(I10,JFINAL)
GAMRR(I10)=GAM(I10,JFINAL)
Z (I10,JFINAL)=Z N(I10,JINT)
P (I10,JFINAL)=P N(I10,JINT)
Q (I10,JFINAL)=Q N(I10,JINT)
H (I10,JFINAL)=H N(I10,JINT)
SI (I10,JFINAL)=SINN(I10,JINT)
PHI(I10,JFINAL)=PHIN(I10,JINT)
PHE(I10,JFINAL)=PHEN(I10,JINT)
GAM(I10,JFINAL)=GAMN(I10,JINT)
736 RHO(I10,JFINAL)=RHON(I10,JINT)
THSVR=TH(JFINAL)
TH(JFINAL)=0.
DO 737 I9=1,NUMEXP
J9=JW-I9+1
CALL TBL(ZDUMMY(I9),PN(1,J9),SINN(1,J9),HN(I,J9),PHIN(1,J9),
IQN(1,J9),PHEN(1,J9),RHON(1,J9),GAMN(1,J9),THX,JFINAL,IMP,I9)
U1=QN(1,J9)*COS(PHEN(1,J9))
V1=QN(1,J9)*TAN(SINN(1,J9))
W1=QN(1,J9)*SIN(PHEN(1,J9))
VT=-W1
WT=V1
IF(I9.NE.1) GO TO 8697
UWN(1)=U1
VWN(1)=VT
WWN(1)=WT
XWN(1)=RN
THWN(I)=ZSAV-ZN(1,JINT)
YWN(1)=THWN(1)
8697 CONTINUE
QN(1,J9)=SQRT(U1*U1+WT*WT)
PHEN(1,J9)=ATAN(WT/U1)
SINN(1,J9)=ATAN(VT/QN(1,J9))
737 ZN(1,J9)=0.
TH(JFINAL)=THSVR
DO 1743 I10=1,IMP
Z (I10,JFINAL)=Z R(I10,1)
P (I10,JFINAL)=P R(I10,1)
Q (I10,JFINAL)=Q R(I10,1)
H (I10,JFINAL)=H R(I10,1)
SI (I10,JFINAL)=SI R(I10,1)
PHI(I10,JFINAL)=PHIR(I10,1)
PHE(I10,JFINAL)=PHER(I10,1)
RHO(I10,JFINAL)=RHOR(I10,1)
1743 GAM(I10,JFINAL)=GAMRR(I10)
GO TO 7
735 CONTINUE
IF(ICOWL.EQ.1.AND.I.GT.IITT.AND.I.LT.IIT) GO TO 7
IF(ICOWL.EQ.1.AND.IS(1,J).EQ.IMAX(J)-1.AND.I.EQ.IMAX(J)) GO TO 7
DO 89 M=1,7
IF(IS(M,1).EQ.0) GO TO 89

```

```

      ITEST=IS(M,J)-1
      IF((M/2)*2.EQ.M) ITEST=IS(M,J)
      IF(I.GE.ITEST.AND.I.LE.(ITEST+1)) GO TO 7
89  CONTINUE
      PT=PN(I,J)
      PHET=PHEN(I,J)
      SIT=SYNN(I,J)
      KALL=1
      ALL=1.
      BALL=0.
      IF(BAV.EQ.0.) GO TO 1482
      ALL=.5
      BALL=.5
1482 CONTINUE
      DUM=DELR*(TAN(PHE(I,J))*ALL+BALL*TAN(PHEN(I,J)))
      ZN(I,J)=Z(I,J)+DUM
      IF(I.EQ.1) GO TO 13
      ZA=.5*(Z(I-1,J)+Z(I,J))
      IT=1
10  RATA=(ZA-Z(I-1,J))/(Z(I,J)-Z(I-1,J))
      IT=IT+1
      ALAM=XPLAM(I-1,J)+RATA*(XPLAM(I,J)-XPLAM(I-1,J))
      DUMP=ALL*ALAM+BALL*XPLAMN(I,J)
      ZAT=ZN(I,J)-DUMP*DELR
      ER=ABS((ZAT-ZA)/(Z(I,J)-Z(I-1,J)))
      IF(ER.LT.ERZZZ) GO TO 9
      ZA=ZAT
      IF(IT.LT.20) GO TO 10
      WRITE(6,200)
200  FORMAT(* ERROR IN A POINT ITERATION*)
      CALL PNCH
      9  IF(I.EQ.IMAX(J)) GO TO 11
13  ZB=.5*(Z(I,J)+Z(I+1,J))
      IT=1
12  RATB=(ZB-Z(I,J))/(Z(I+1,J)-Z(I,J))
      IT=IT+1
      BLAM=XMLAM(I,J)+RATB*(XMLAM(I+1,J)-XMLAM(I,J))
      DUMP=ALL*BLAM+BALL*XMLAMN(I,J)
      ZBT=ZN(I,J)-DUMP*DELR
      ER=ABS((ZBT-ZB)/(Z(I+1,J)-Z(I,J)))
      IF(ER.LT.ERZZZ) GO TO 11
      ZB=ZBT
      IF(IT.LT.20) GO TO 12
      WRITE(6,201)
201  FORMAT(* ERROR IN B POINT ITERATION*)
      CALL PNCH
11  CONTINUE
      RQZ=QN(I,J)*QN(I,J)*RHON(I,J)
      IF(I.EQ.1) GO TO 14
      II=I-1
      FP A=FP (II) +RATA*(FP (I) -FP (II) )
      RHOA=RHON(II,J)+RATA*(RHON(I,J)-RHON(II,J))
      Q A=Q (II,J)+RATA*(Q (I,J)-Q (II,J))
      A A=A (II,J)+RATA*(A (I,J)-A (II,J))
      PHEA=PHE(II,J)+RATA*(PHE(I,J)-PHE(II,J))
      P A=P (II,J)+RATA*(P (I,J)-P (II,J))

```

```

QA2=QA*QA
A1=FPA/(RHOA*QA2
A1=AAV*A1+BAV*FPN(I,J)/RQ2
AC=BALL*SQRT((QN(I,J)/AN(I,J))**2-1.)/RQ2
A2=SQRT((QA/AA)**2-1.)/(RHOA*QA2)*ALL+AC
14 IF(I.EQ.IMAX(J) ) GO TO 15
II=I+1
FP=FFM(I)+RATB*(FM(II)-FM(I))
RHOB=RHO(I,J)+RATB*(RHO(II,J)-RHO(I,J))
QB=Q(I,J)+RATB*(Q(II,J)-Q(I,J))
A=AA(I,J)+RATB*(AA(II,J)-AA(I,J))
P=PA(I,J)+RATB*(P(II,J)-P(I,J))
PHEB=PHE(I,J)+RATB*(PHE(II,J)-PHE(I,J))
QB2=QB*QB
B1=FPB/(RHOB*QB2
B1=AAV*B1+BAV*FMN(I,J)/RQ2
AC=BALL*SQRT((QN(I,J)/AN(I,J))**2-1.)/RQ2
B2=SQRT((QB/AB)**2-1.)/(RHOB*QB2)*ALL+AC
15 IF(I.NE.1) GO TO 16
IT=1
VOU=TAN(SI(1,J))/COS(PHE(1,J))
115 CALL BWALL(RN,TH(J),ZN(1,J),FRB,FTB)
PHEN(I,J)=ATAN(VOU*FTB+FRB)
PN(I,J)=PB+(PHEN(I,J)-PHEB-B1)*DEL R/B2
GO TO 17
16 IF(I.EQ.IMAX(J) ) GO TO 18
PN(I,J)=(A2*PA+B2*PB+(A1-B1)*DFLR+PHEA-PHEB)/(A2+B2)
PHEN(I,J)=PHEA-A2*(PN(I,J)-PA)+A1*DEL R
GO TO 17
18 CONTINUE
IT=1
VOU=TAN(SI(IMAXJ,J))/COS(PHE(IMAXJ,J))
118 CALL TWALL(RN,TH(J),ZN(IMAXJ,J),FRT,FTT)
PHEN(I,J)=ATAN(VOU*FTT+FRT)
PN(I,J)=PA+(PHEA-PHEN(I,J)+A1)*DEL R/A2
17 CONTINUE
SPHE=SIN(PHE(I,J))
TSI=TAN(SI(I,J))
CSI=COS(SI(I,J))
CPHE=COS(PHE(I,J))
VD=Q(I,J)*TSI
T1=DEL R/CPHE
IF(XJ1.EQ.1.) T1=T1/Z(I,J)
IF(XJ.EQ.1.) T1=T1/R
T2=PQ(I,J)/RHO(I,J)/Q(I,J)
T3=TSI*QQ(I,J)
T4=Q(I,J)*SIQ(I,J)/CSI**2
T5=Q(I,J)*CPHE*XJ
1+Q(I,J)*SPHE*XJ1
VC=VD-T1*(T2+TSI*(T3+T4+T5))*AAV
SPHEN=SIN(PHEN(I,J))
TSIN=TAN(SINN(I,J))
CSIN=COS(SINN(I,J))
CPHEN=COS(PHEN(I,J))
TT1=DFLR/CPHEN
IF(XJ1.GT.0.) TT1=TT1/ZN(I,J)

```

```

IF(XJ.GT.0.) TT1=TT1/RN
T22=PCON(I,J)/RHON(I,J)/QN(I,J)
T33=TSIN*QQN(I,J)
T44=QN(I,J)*SIN(I,J)/CSIN
T55=QN(I,J)*(CPHEN*XJ+SPHEN*XJ)
DVC=TT1*(T22+TSIN*(T33+T44+T55))*BAV
VC=VC-DVC
T11=DELTA*TAN(SIT)/COS(PHET)
IF(XJ1.GT.0.) T11=T11/ZN(I,J)
IF(XJ.GT.0.) T11=T11/RN
T1=T1*TSI
T1=T1*ALL+T11*BALL
RHOZ=RHO(I,J)-RHOQ(I,J)*T1
PZ=P(I,J)-PQ(I,J)*T1
GAMZ=GAM(I,J)-GAMQ(I,J)*T1
PHON(I,J)=RHOZ*(PN(I,J)/PZ)**(T1/GAMZ)
T2=QQ(I,J)/CSI +Q(I,J)*TSI /CSI *SIQ(I,J)
VVZ=Q(I,J)/CSI -T2*T1
VVZ2=VVZ*VVZ
VVC=SQRT(VVZ2 +2.*GAMZ/(GAMZ-1.)*(PZ/RHOZ-PN(I,J)/RHON(I,J)))
VVC2=VVC*VVC
QN(I,J)=SQRT(VVC2 -VC*VC)
SINN(I,J)=ATAN(VC/QN(I,J))
HN(I,J)=H(I,J)+.5*(VVZ2 -VVC2 )-HQ(I,J)*T1
PHIN(I,J)=PHI(I,J)-PHIQ(I,J)*T1
TN(I,J)=FT(PN(I,J),PHIN(I,J),HN(I,J))
GAMN(I,J)=FGAM(TN(I,J),PN(I,J),PHIN(I,J))
AN(I,J)=SQRT(GAMN(I,J)*PN(I,J)/RHON(I,J))
CALL XLAM(QN(I,J),AN(I,J),PHEN(I,J),XPLAMN(I,J),XMLAMN(I,J))
IF(I.NE.1.AND.I.NE.IMAXJ) GO TO 1642
IT=IT+1
VOUT=TAN(SINN(I,J))/COS(PHEN(I,J))
ERR=(VOU-VOUT)
IF(ABS(ERR).LT.1.E-10) GO TO 1642
IF(IT.GT.2) GO TO 21
ER1=ERR
VOU1=VOU
VOU=VOUT
GO TO 171
21 VOUN=VOU1-ER1*(VOU-VOU1)/(ERR-ER1)
ER1=ERR
VOU1=VOU
VOU=VOUN
171 IF(IT.GT.10) CALL ERROR(171)
IF(I.EQ.1) GO TO 115
GO TO 118
1642 CONTINUE
EC=ABS(1.-PT/PN(I,J))
IF(EC.LT.1.E-04.OR.IVY.EQ.0) GO TO 7
SIT=SINN(I,J)
PHET=PHEN(I,J)
PT=PN(I,J)
KALL=KALL+1
IF(KALL.GT.ILOCAL) GO TO 1493
ALL=.5
BALL=.5

```

```

GO TO 1482
1493 WRITE(6,1393)
1393 FORMAT(* AVERAGING PROCESS DOES NOT CONVERGE IN CHAR3D*)
STOP
7 CONTINUE
707 CONTINUE
7070 CONTINUE
XJ1=XJ1S
IF(ICOWL.EQ.1) GO TO 430
DO 97 M=1,7
IF(IS(M,1).EQ.0) GO TO 97
JWW=JW
IF(KS.EQ.1) JWW=JMAX
DO 96 J=1,JWW
IF(J.GT.JINT) XJ1=0.
I=IS(M,J)
IF((M/2)*2.EQ.M) I=I+1
IF(BAV.EQ.0.) RETAN(M,J)=BETA(M,J)
ZN(I,J)=.5*(TAN(BETA(M,J))+TAN(BETAN(M,J)))*DELR+Z(I,J)
ZN(I-1,J)=ZN(I,J)
96 CONTINUE
XJ1=XJ1S
97 CONTINUE
430 CONTINUE
IF(JW.GT.JCALC) GO TO 7500
IF(ICOWL.EQ.1) GO TO 1875
DO 431 M=1,3
IF(IS(M,1).EQ.0) GO TO 431
SHC=0.
IF(BAV.GT.0.) SHC=1.
CALL ALSHOC(M)
JWW=JW
IF(KS.EQ.1) JWW=JMAX
IF(M.NE.KC1.AND.M.NE.KC2) CALL FSHOCK(M,1,JWW)
IF(M.NE.KC1.AND.M.NE.KC2) CALL HSHOCK(M,1,JWW,0)
IF(M.EQ.KC1.OR.M.EQ.KC2) CALL CSURF(M,JWW)
IF(ISIM.EQ.1) GO TO 431
IF(KS.EQ.0) CALL WSHK(M,1.)
431 CONTINUE
1875 CONTINUE
IF(ISIM.EQ.1) GO TO 2241
ISOP=0
IF(ICOWL.EQ.1.AND.IIT.EQ.IMAX(JMAX)) ISOP=1
CALL WALL(RN,ICOWL,IIT,IITT)
IF(ICOWL.EQ.1) GO TO 4483
IF(ICOWLT.EQ.0) GO TO 8892
DO 5631 J=1,JW
IMAXJQ=IMAX(J)
IMAXJP=IMAXJQ+J
Z N(IMAXJP,J)=ZN(IMAXJQ,J)
P N(IMAXJP,J)=P N(IMAXJQ,J)
Q N(IMAXJP,J)=Q N(IMAXJQ,J)
H N(IMAXJP,J)=H N(IMAXJQ,J)
SINN(IMAXJP,J)=SINN(IMAXJQ,J)
PHEN(IMAXJP,J)=PHEN(IMAXJQ,J)
PHIN(IMAXJP,J)=PHIN(IMAXJQ,J)

```

```

RHON(IMAXJP,J)=RHON(IMAXJQ,J)
IF(J.NE.JMAX+1) GO TO 5631
U WN(IMAXJP)=U WN(IMAXJQ)
V WN(IMAXJP)=V WN(IMAXJQ)
W WN(IMAXJP)=W WN(IMAXJQ)
X WN(IMAXJP)=X WN(IMAXJQ)
Y WN(IMAXJP)=Y WN(IMAXJQ)
THWN(IMAXJP)=THWN(IMAXJQ)
5631 CONTINUE
IF(KS.GT.0) GO TO 2241
DO 2346 M=1,3
IF(IS(M,1).EQ.0) GO TO 2346
CALL WDISC(M)
2346 CONTINUE
2241 CONTINUE
IF(ICOWL.EQ.0) GO TO 8892
4483 DO 788 J=1,JW
IF(J.GT.JINT) XJ1=0.
ISAVE=0
IIT=IMAX(J)-IFS+1
IITT=IIT-MM
IMAXJQ=IMAX(J)+1
DO 8890 I=IITT,IMAXJQ
IF(I.EQ.ISAVE) GO TO 8891
DO 8893 M=1,7
IF(IS(M,J).EQ.0) GO TO 8893
ITEST=IS(M,J)-1
IF((M/2)*2.EQ.M) ITEST=IS(M,J)
IF(I.NE.ITEST) GO TO 8893
ZN(I,J)=Z(I,J)+TAN(BETA(M,J))* (RN-R)
ZN(I+1,J)=ZN(I,J)
ISAVE=ITEST+1
GO TO 8891
8893 CONTINUE
ZLAM=EXPLAM(I,J)
IF(OPT.LT.0.) ZLAM=XMLAM(I,J)
IF(I.EQ.IIT.AND.ISOP.NE.0) ZLAM=PHE(IIT,JW)
ZN(I,J)=Z(I,J)+ZLAM*(RN-R)
8891 P N(I,J)=P (I,J)
Q N(I,J)=Q (I,J)
H N(I,J)=H (I,J)
RHON(I,J)=RHO(I,J)
PHIN(I,J)=PHI(I,J)
PHEN(I,J)=PHE(I,J)
SINN(I,J)=SI (I,J)
IF(J.NE.JMAX+1) GO TO 8890
ZN(I,J)=ZN(I,JMAX)
U WN(I)=U W(I)
W WN(I)=W W(I)
X WN(I)=RN
IF(XJ1.EQ.1.) GO TO 8696
CALL SWALL(RN,ZN(I,J),XWN(I),YWN(I),FX,FZ)
THWN(I)=YWN(I)
IF(XJ.EQ.1.) THWN(I)=ATAN(YWN(I)/XWN(I))
8696 IF(XJ1.EQ.1.) CALL SWALL1(THWN(I),RN,ZN(I,J),FX,FZ)
VWN(I)=(UWN(I)*FX+WVN(I)*FZ)

```

```

      IF(XJ1.GT.0.) VWN(I)=VWN(I)*ZN(2,J)
8890 CONTINUE
      788 CONTINUE
      XJ1=XJ1S
8892 CONTINUE
      KS=KS+1
      DO 9999 J=1,JW
      IMAXJ1=IMAX(J)
      DO 9999 I=1,IMAXJ1
      TN(I,J)=FT(PN(I,J),PHIN(I,J),HN(I,J))
      GAMN(I,J)=FGAM(TN(I,J),PN(I,J),PHIN(I,J))
      AN(I,J)=SQRT(GAMN(I,J)*PN(I,J)/RHON(I,J))
9999 CALL XLAM(QN(I,J),AN(I,J),PHEN(I,J),XPLAMN(I,J),XMLAMN(I,J))
      IF(IAV.EQ.0.OR.BAV.GT.0.) GO TO 8898
      AAV=.5
      BAV=.5
      IF(ICOWL.EQ.1.AND.IWRAP.EQ.0) CALL PLANES(I)
      CALL DERIVN(MM)
      DO 9998 J=1,JW
      IMAXJ=IMAX(J)
      DO 9998 I=1,IMAXJ
      CALL F(RHON(I,J),QN(I,J),RN,ZN(I,J),PHEN(I,J),XPLAMN(I,J),XMLAMN(
      I,I,J),SINN(I,J),AN(I,J),SIGN(I,J),PQN(I,J),PHEQN(I,J),PPN(I,J),
      IFMN(I,J))
9998 CONTINUE
      IF(KS.EQ.1) GO TO 961
8898 CONTINUE
      ICOWL=0
      AAV=1.
      BAV=0.
      DO 1645 M=1,3
      IF(M.EQ.2) GO TO 1645
      IF(IS(M,1).EQ.0) GO TO 1645
      CALL ALSHOC(M)
1645 CONTINUE
      212 CONTINUE
      IF(RN.LT.XXI) GO TO 7500
      IF(INT.EQ.2) GO TO 7500
      INT=1
      J=JJI+1
7501 THJJ=TH(J)*XJ
      XCN=RN*COS(THJJ)
      XC=R*COS(THJJ)
      IF(XCN.GE.(XXI-5.E-04).AND.XC.LT.(XXI-5.E-04)) CALL INTER
      IF(XCN.LT.(XXI-5.E-04)) GO TO 7500
      JJI=J
      J=J+1
      IF(J.GT.JW) GO TO 7500
      IF(ISIM.EQ.0.AND.J.EQ.JW) TH(J)=THWN(IMAXJ)
      GO TO 7501
7500 CONTINUE
      CALL L TH M
      IF(ISWEEP.EQ.0) CALL EMBED
      DO 1941 J=1,JW
      IF(J.GT.JCALC) GO TO 1941
      IMAXJ1=IMAX(J)+1

```

```

IF(ICOWLT.EQ.0) IMAXJ1=IMAX(J)
DO 20 I=1,IMAXJ1
Z(I,J)=ZN(I,J)
P(I,J)=PN(I,J)
PHE(I,J)=PHEN(I,J)
Q(I,J)=QN(I,J)
SI(I,J)=SINN(I,J)
H(I,J)=HN(I,J)
PHI(I,J)=PHIN(I,J)
RHO(I,J)=RHON(I,J)
T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))
A(I,J)=SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))
20 CONTINUE
DO 3004 M=1,7
ALPHA(M,J)=ALPHAN(M,J)
ALP(M,J)=ALPN(M,J)
3004 BETA(M,J)=BETAN(M,J)
1941 CONTINUE
IF(JW.GT.JCALC) GO TO 214
IF(ISIM.EQ.1) GO TO 214
IMAXJ=IMAX(JW)+1
IF(ICOWLT.EQ.0) IMAXJ=IMAX(J)
DO 401 I=1,IMAXJ
U W(I)=U WN(I)
V W(I)=V WN(I)
W W(I)=W WN(I)
THW(I)=THWN(I)
R=RN
THWX=THW(I)*XJ
XW(I)=R*COS(THWX)
401 YW(I)=R*SIN(THWX)+(1.-XJ)*THW(I)
TH(JW)=THW(1)
214 XI=X2
IFR=0
IF(JW.GT.JCALC) CALL SWEPT(2)
R=RN
IF(JW.GT.JCALC) GO TO 8759
IF( ISIM.EQ.0) CALL ADDSUR
8759 IF((KOUNT/KCORR)*KCORR.NE.KOUNT) GO TO 1
IF(ICOWLT.EQ.1.AND.IWRAP.EQ.0) CALL WRAP(0)
CALL MOTHER
GO TO 1
END

```


SUBROUTINE SPACE

```
COMMON /A/ XI,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PLI(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMA(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)
COMMON /H/ ISIM
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1 XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /M/ IS(7,10)
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /IQ/ NUMEXP,ZSAV
COMMON /WR/ IWRAP
COMMON /SPE/ KOUNTC
COMMON /TEM/ T(40,10)
COMMON /PL/ DE TH
DIMENSION LADR(100),LDROR(100)
DIMENSION LDROP(100),LADD(100)
DATA I942/0/
IF(I942.EQ.0.AND.IWRAP.EQ.0)DETH=TH(JINT)-TH(JINT-1)
I942=1
ICON=IS(3,1)-1
IS3=IS(3,1)
DZT=(Z(IS3,1)-Z(1,1))/FLOAT(IS3-2)
IJL=1
IJU=JMAX
1300 KSA=1
MSA=1
KSAS=1
MSAS=1
IREDO=0
DO 400 I=1,100
LDROP(I)=0
LDROR(I)=0
400 LADR(I)=0
402 LADD(I)=0
CONTINUE
DO 2 L=IJL,IJU
J=L
JS=J
ICON=IS(3,J)-1
IH=1
IL=2
IU=ICON
IF(LDROP(1).EQ.0.AND.IREDO.EQ.1.AND.LDROR(1).EQ.0) GO TO 7
KP=0
4 CONTINUE
KP=KP+1
4121 CONTINUE
DO 3 K=IL,IU
KP=KP+1
IT=K
DZ=Z(K,J)-Z(K-1,J)
IF(IREDO.EQ.0) GO TO 2600
DO 440 KR=1,KSAS
IF(J.GT.JINT.AND.KP.EQ.LDROR(KR)) GO TO 441
```

```

IF(J.LE.JINT.AND.KP.EQ.LDROP(KP)) GO TO 441
440 CONTINUE
GO TO 3
2600 CONTINUE
IF(DZ/DZT.GE..333) GO TO 3
IF(IT.NE.IU) GO TO 1500
IT=IT-1
IF(KOUNT.LT.KOUNTC+40) GO TO 3
1500 CONTINUE
LDROP(KSA)=IT
IF(J.GT.JINT) LDROP(KSA)=IT+IS(3,JINT)-IS(3,J)
IF(J.GT.JINT.AND.IU.EQ.IS(3,J)-1.AND.KOUNT.GT.KOUNTC+21) LDROP(KSA)
I=0
IF(J.GT.JINT) LDROR(KSA)=IT
KSA=KSA+1
GO TO 3
442 IT=IT-1
441 CONTINUE
IM=IMAX(J)
IOV=0
IF(J.EQ.JINT.AND.Z(IT,J).LT.ZSAV) IDUMMY=IDUMMY-1
32 DO 21 I=IT,IM
Z(I,J)=Z(I+1,J)
P(I,J)=P(I+1,J)
Q(I,J)=Q(I+1,J)
H(I,J)=H(I+1,J)
SI(I,J)=SI(I+1,J)
PHE(I,J)=PHE(I+1,J)
PHI(I,J)=PHI(I+1,J)
RHO(I,J)=RHO(I+1,J)
GAM(I,J)=GAM(I+1,J)
T(I,J)=T(I+1,J)
A(I,J)=A(I+1,J)
XPLAM(I,J)=XPLAM(I+1,J)
XMLAM(I,J)=XMLAM(I+1,J)
IF(IOV.EQ.0) GO TO 21
U W(I)=U W(I+1)
V W(I)=V W(I+1)
W W(I)=W W(I+1)
X W(I)=X W(I+1)
Y W(I)=Y W(I+1)
THW(I)=THW(I+1)
21 CONTINUE
IF(ISIM.EQ.1.OR.L.NE.JMAX) GO TO 30
IF(IOV.EQ.1) GO TO 31
IOV=1
J=J+1
GO TO 32
31 J=JS
30 CONTINUE
IMAX(J)=IMAX(J)-1
IF(IT.LT.IS(3,J)) IS(3,J)=IS(3,J)-1
IF(IT.LT.IS(1,J)) IS(1,J)=IS(1,J)-1
IF(K.GE.IU) GO TO 3
IL=IT
IU=IU-1

```

```

GO TO 4121
3 CONTINUE
GO TO (6,5,7),IH
6 IF (IS(3,J)+2.EQ.IS(1,J)) GO TO 530
IL=IS(3,J)+1
IU=IS(1,J)-1
IH=2
IF (J.NE.JMAX.OR.ISIMEX.EQ.1) GO TO 4
DZ1Q=Z(IL,J+1)-Z(IL-1,J+1)
DZ2Q=Z(IL+1,J+1)-Z(IL-1,J+1)
IF (DZ1Q/DZ2Q.GE..2) GO TO 4
LDROP(KSA)=IL
IF (J.GT.JINT) LDROP(KSA)=IL+IS(3,JINT)-IS(3,J)
IF (J.GT.JINT) LDROR(KSA)=IL
KSA=KSA+1
GO TO 4
530 KP=KP+2
5 IL=IS(1,J)+1
IU=IMAX(J)
IH=3
GO TO 4
7 IL=2
IF (LADD(1).EQ.0.AND.MSAS.EQ.1.AND.IREDO.EQ.1) GO TO 2
IU=IS(3,J)-1
KP=0
IH=1
8 CONTINUE
KP=KP+1
8484 CONTINUE
DO 9 K=IL,IU
KP=KP+1
IT=K
DZ=Z(K,J)-Z(K-1,J)
IF (IREDO.EQ.0) GO TO 601
DO 444 KR=1,MSAS
IF (IMAX(J).GE.37) GO TO 9
IF (J.GT.JINT.AND.KP.EQ.LADR(KR)) GO TO 445
IF (J.LE.JINT.AND.KP.EQ.LADD(KR).AND.(IU.NE.IS(3,J)-1.OR.IWRAP.EQ.
11)) GO TO 445
444 CONTINUE
GO TO 9
601 CONTINUE
IF (DZ/DZT.LT.1.5) GO TO 9
1501 CONTINUE
IF (J.NE.JMAX.OR.ISIMEX.EQ.1) GO TO 5021
ZQQ=Z(K-1,J)+.5*(Z(K,J)-Z(K-1,J))
DZ1Q=ZQQ-Z(K-1,J+1)
DZ2Q=Z(K,J+1)-Z(K-1,J+1)
IF (DZ1Q/DZ2Q.LT..4 ) GO TO 9
5021 CONTINUE
LADD(MSA)=IT
IF (J.GT.JINT) LADD(MSA)=IT+IS(3,JINT)-IS(3,J)
IF (J.GT.JINT) LADR(MSA)=IT
MSA=MSA+1
GO TO 9
445 CONTINUE

```

```

IMAXX=IMAX(J)+1
IOV=0
33 DO 18 I=IT,IMAXX
I1=IMAXX+1+IT-I
I2=I1-1
Z(I1,J)=Z(I2,J)
P(I1,J)=P(I2,J)
Q(I1,J)=Q(I2,J)
H(I1,J)=H(I2,J)
PHI(I1,J)=PHI(I2,J)
PHE(I1,J)=PHE(I2,J)
RHO(I1,J)=RHO(I2,J)
SI(I1,J)=SI(I2,J)
GAM(I1,J)=GAM(I2,J)
T(I1,J)=T(I2,J)
A(I1,J)=A(I2,J)
XPLAM(I1,J)=XPLAM(I2,J)
XMLAM(I1,J)=XMLAM(I2,J)
IF(IOV.EQ.0) GO TO 18
UW(I1)=UW(I2)
VW(I1)=VW(I2)
WW(I1)=WW(I2)
XW(I1)=XW(I2)
YW(I1)=YW(I2)
THW(I1)=THW(I2)
18 CONTINUE
IF(ISIM.EQ.1.OR.L.NE.JMAX) GO TO 34
IF(IOV.EQ.1) GO TO 35
IOV=1
J=J+1
GO TO 33
35 J=JS
34 CONTINUE
IMAX(J)=IMAX(J)+1
IP=IT+1
IM=IT-1
IOV=0
RAT=.5
Z(IT,J)=.5*(Z(IP,J)+Z(IM,J))
38 P(IT,J)=P(IM,J)+RAT*(P(IP,J)-P(IM,J))
Q(IT,J)=Q(IM,J)+RAT*(Q(IP,J)-Q(IM,J))
H(IT,J)=H(IM,J)+RAT*(H(IP,J)-H(IM,J))
SI(IT,J)=SI(IM,J)+RAT*(SI(IP,J)-SI(IM,J))
PHE(IT,J)=PHE(IM,J)+RAT*(PHE(IP,J)-PHE(IM,J))
PHI(IT,J)=PHI(IM,J)+RAT*(PHI(IP,J)-PHI(IM,J))
RHO(IT,J)=RHO(IM,J)+RAT*(RHO(IP,J)-RHO(IM,J))
I=IT
T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))
A(I,J)=SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))
IF(ISIM.EQ.1.OR.L.NE.JMAX) GO TO 36
IF(IOV.EQ.1) GO TO 37
IOV=1
J=J+1
Z(IT,J)=Z(IT,J-1)

```

```

RAT=(Z(IT,J)-Z(IM,J))/(Z(IP,J)-Z(IM,J))
GO TO 3A
37 J=JS
U W(IT)=U W(IM)+RAT*(U W(IP)-U W(IM))
W W(IT)=W W(IM)+RAT*(W W(IP)-W W(IM))
XW(IT)=R
CALL SWALL(R,Z(IT,J),XW(IT),YW(IT),FX,FZ)
THW(IT)=YW(IT)
VW(IT)=UW(IT)*FX+WW(IT)*FZ
36 CONTINUE
IF(IT.LT.IS(1,J)) IS(1,J)=IS(1,J)+1
IF(IT.LT.IS(3,J)) IS(3,J)=IS(3,J)+1
IL=IT+2
IU=IU+1
IF(IL.GT.IU) GO TO 10
GO TO 8484
9 CONTINUE
10 CONTINUE
IF(IH.EQ.2) GO TO 2
IH=2
IL=IS(3,J)+1
IU=IS(1,J)-1
GO TO 8
2 CONTINUE
IF(IRED0.EQ.1) GO TO 600
IF(KSA.EQ.1.AND.MSA.EQ.1)GO TO 600
KSAS=KSA-1
IF(KSAS.EQ.0) KSAS=1
MSAS=MSA-1
IF(MSAS.EQ.0) MSAS=1
DO 500 K=1,KSAS
DO 500 M=1,MSAS
500 IF(LDROP(K).EQ.LADD(M)) LADD(M)=0
DO 321 J=IJL,IJU
IF(J.LE.JINT) GO TO 321
IF(Z(2,J).GT.2.*DETH) GO TO 321
DO 322 M=1,MSAS
322 IF(LADD(M).EQ.2) LADD(M)=0
GO TO 320
321 CONTINUE
320 CONTINUE
IRED0=1
IF(MSAS.GE.JMAX) GO TO 3000
DO 3001 M=1,MSAS
3001 LADD(M)=0
GO TO 3005
3000 DO 3002 M=1,MSAS
IF(LADD(M).EQ.0) GO TO 3005
IN=0
DO 3004 MM=1,MSAS
3004 IF(LADD(MM).EQ.LADD(M)) IN=IN+1
IF(IN.LT.JMAX) LADD(M)=0
3002 CONTINUE
3005 IF(IWRAP.EQ.1) GO TO 402
DO 3006 M=1,MSAS
IN=0

```

```
DO 3007 MM=1,MSAS
3007 IF(LADR(MM).EQ.LADR(M)) IN=IN+1
      IF(IN.LT.JMAX-JINT) LADR(M)=0
      IF(LADR(M).LT.IS(3,JINT+1)) GO TO 3006
      IN=0
      DO 2931 MM=1,MSAS
2931 IF(LADR(MM).EQ.LADR(M)+IS(3,JINT)-IS(3,JINT+1)) IN=IN+1
      IF(IN.LT.JINT) LADR(M)=0
3006 CONTINUE
      GO TO 402
600 IF(IJU.EQ.JMAX) GO TO 1301
      IJL=JINT+1
      IJU=JMAX
      GO TO 1300
1301 CONTINUE
      IF(ISIM.EQ.1) RETURN
      IMAX(JMAX+1)=IMAX(JMAX)
      IS(3,JMAX+1)=IS(3,JMAX)
      IS(1,JMAX+1)=IS(1,JMAX)
      RETURN
      END
```

```

SUBROUTINE DERIV(MM)
COMMON /IQ/ NUMEXP,ZSAV
COMMON /WR/ IWRAP
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHF(40,10),
1 Q(40,10),SI(40,10),H(40,10),PUI(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /H/ ISIM
COMMON /I/ XJ
COMMON/M/ IS(7,10)
COMMON/N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1 IQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /Q/ XCOWL
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /W/ ISIMEX,IDUMMY,JINT,JDUMMY(40),THWW(2),JD1,JD2
COMMON /TB/ IMAXJ,IS1,IS2,ISL1,ISL2
COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2
COMMON /ISW1/ IFR
COMMON /JF/ JFINAL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
COMMON /PL/ DE TH
COMMON /V/ XJ1
COMMON/PS/ZR(40,2),PR(40,2),QR(40,2),HR(40,2),SIR(40,2),RHOR(40,2)
1,PHIR(40,2),PHER(40,2),THR(2),THWR(40)
COMMON/PSS/GAMRR(40)
DO 10 J=1,JMAX
JSHOC=0
IF(J.GT.JCALC) GO TO 10
IF(J.EQ.JCALC.AND.IFR.EQ.1) GO TO 10
JM=J-1
JP=J+1
IF(J.EQ.JCALC) JP=J
IF(J.EQ.1) JM=JP
IF(ISIM.EQ.1.AND.J.EQ.JMAX) JP=JM
IMAX J =IMAX(J)
DO 20 I=1,IMAX J
THJ1=THW(I)
IF(JP.NE.JW) THJ1=TH(JP)
IF(ISIM.EQ.1.AND.JP.EQ.JMAX) THJ1=TH(JMAX)
IF(J.EQ.JINT.AND.I.LE.IDUMMY) GO TO 20
DZ=Z(I,J)-Z(I,JM)
DTH=TH(J)-TH(JM)
DUMZ=1.
IF(XJ1.GT.0.) DUMZ=.5*(Z(I,J)+Z(I,JM))
DUMR=1.
IF(XJ.GT.0.) DUMR=R
DS1=SQRT(DZ*DZ+(DTH*DUMZ*DUMR)**2)
IF(J.EQ.JINT.AND.I.GT.IDUMMY) GO TO 901
DZ=Z(I,JP)-Z(I,J)
DTH=THJ1-TH(J)
DUMZ=1.
IF(XJ1.GT.0.) DUMZ=.5*(Z(I,J)+Z(I,JP))
DS2=SQRT(DZ*DZ+(DTH*DUMZ*DUMR)**2)
IF(J.EQ.JINT+1) GO TO 900
D1=DS1/DS2
D2=DS2/DS1

```

```

D3=D1-D2
GO TO 902
901 D1=0.
    JP=J
    D2=1.
    D3=-1.
    IF(I.LT.IS(3,J)-1) GO TO 909
    JSHOC=1
    JP=J+1
    IA=IS(1,JP)+I-IS(1,J)
    RAV=(Z(I,J)-ZSAV+Z(IA,JP))/2.
    DS2=RAV*3.142/2.
    D1=DS1/DS2
    D2=DS2/DS1
    D3=D1-D2
909 CONTINUE
GO TO 902
900 D1=1.
    D2=0.
    D3=1.
    IF(I.LT.IS(3,J)-1) GO TO 910
    JSHOC=2
    IB=IS(1,JM)+I-IS(1,J)
    RAV=(Z(I,J)+Z(IB,JM)-ZSAV)/2.
    DS1=RAV*3.142/2.
    D1=DS1/DS2
    D2=DS2/DS1
    D3=D1-D2
910 CONTINUE
902 CONTINUE
M=I
N=I
IF(JSHOC.EQ.1) M=IA
IF(JSHOC.EQ.2) N=IB
DTHS=D1*TH(I)-D3*TH(J)-D2*TH(JM)
IF(J.EQ.1) DTHS=TH(2)
IF(ISJM.EQ.1.AND.J.EQ.JMAX) DTHS=TH(JMAX)-TH(JMAX-1)
IF(JSHOC.EQ.1) DTHS=(Z(I,J)-ZSAV)*3.142/2.*D1+(TH(J)-TH(JM))*D2
IF(JSHOC.EQ.2) DTHS=(TH(JP)-TH(J))*D1+Z(I,J)*3.142/2.*D2
DZ S=D1*Z (M,JP)-D3*Z (I,J)-D2*Z (N,JM)
IF(JSHOC.EQ.1) DZS=(Z(I,J)-Z(I,JM))*D2+(Z(M,JP)-Z(I,J)+ZSAV)*D1
IF(JSHOC.EQ.2) DZS=(Z(I,J)-Z(IR,JM)+ZSAV)*D2+(Z(I,JP)-Z(I,J))*D1
DP S=D1*P (M,JP)-D3*P (I,J)-D2*P (N,JM)
DH S=D1*H (M,JP)-D3*H (I,J)-D2*H (N,JM)
DQ S=D1*Q (M,JP)-D3*Q (I,J)-D2*Q (N,JM)
DPHES=D1*PHE(M,JP)-D3*PHE(I,J)-D2*PHE(N,JM)
DPHIS=D1*PHI(M,JP)-D3*PHI(I,J)-D2*PHI(N,JM)
DRHOS=D1*RHO(M,JP)-D3*RHO(I,J)-D2*RHO(N,JM)
DGAMS=D1*GAM(M,JP)-D3*GAM(I,J)-D2*GAM(N,JM)
DSI S=D1*SI (M,JP)-D3*SI (I,J)-D2*SI (N,JM)
IF(J.EQ.1) DSI S=SI(I,2)
IF(ISIM.EQ.1.AND.J.EQ.JMAX) DSI S=-SI(I,JMAX-1)
40 IF(I.EQ.1) GO TO 50
IF(I.EQ.IMAXJ) GO TO 50
IF(ICOWL.NE.1) GO TO 400
IF(I.LT.IS(1,J)-MM.OR.I.GT.IS(1,J)) GO TO 400

```


DP Z=0.
DH Z=0.
DQ Z=0.
DSI Z=0.
DPHEZ=0.
DPHIZ=0.
DRHOZ=0.
DGAMZ=0.
GO TO 60

400 CONTINUE

IF(I.EQ.IS(1,J).OR.I.EQ.IS(1,J)-1) GO TO 50
IF(I.EQ.IS(3,J).OR.I.EQ.IS(3,J)-1) GO TO 50

IP=I+1

IM=I-1

DZ1=Z(IP ,J)-Z(I ,J)

DZ2=Z(I ,J)-Z(IM ,J)

D1=DZ1/DZ2

D2=DZ2/DZ1

D3=D1-D2

D1PD2=D1+D2

DP Z=(D1*P(IP ,J)-D3*P(I ,J)-D2*P(IM ,J))/D1PD2

DH Z=(D1*H(IP ,J)-D3*H(I ,J)-D2*H(IM ,J))/D1PD2

DQ Z=(D1*Q(IP ,J)-D3*Q(I ,J)-D2*Q(IM ,J))/D1PD2

DPHEZ=(D1*PHE(IP ,J)-D3*PHE(I ,J)-D2*PHE(IM ,J))/D1PD2

DPHIZ=(D1*PHI(IP ,J)-D3*PHI(I ,J)-D2*PHI(IM ,J))/D1PD2

DRHOZ=(D1*RHO(IP ,J)-D3*RHO(I ,J)-D2*RHO(IM ,J))/D1PD2

DGAMZ=(D1*GAM(IP ,J)-D3*GAM(I ,J)-D2*GAM(IM ,J))/D1PD2

DSI Z=(D1*SI(IP ,J)-D3*SI(I ,J)-D2*SI(IM ,J))/D1PD2

GO TO 60

50 CONTINUE

L=-1

IF(I.EQ.IMAXJ) GO TO 100

DO 421 M=1,7

IF((M/2)*2.NE.M.AND.I.EQ.IS(M ,J)-1) GO TO 100

IF((M/2)*2.EQ.M.AND.I.EQ.IS(M ,J)) GO TO 100

421 CONTINUE

L=1

100 IL=I+L

I2L=I+2*L

DZ=Z(I ,J)-Z(IL ,J)

DZL=Z(IL ,J)-Z(I2L ,J)

IF(ABS(DZL).GT.1.E-10) GO TO 5000

DEL=0.

GO TO 5001

5000 DEL=DZ/DZL

5001 DELLE=DEL*DEL

DELQ=1.+DEL

DELL=DELQ*DELQ

DELE=(1.+2.*DEL)

DP Z=(ELLE*P(I2L ,J)-DELL*P(IL ,J)+DELE*P(I ,J))/DZ/DELQ

DH Z=(ELLE*H(I2L ,J)-DELL*H(IL ,J)+DELE*H(I ,J))/DZ/DELQ

DQ Z=(ELLE*Q(I2L ,J)-DELL*Q(IL ,J)+DELE*Q(I ,J))/DZ/DELQ

DPHEZ=(ELLE*PHE(I2L ,J)-DELL*PHE(IL ,J)+DELE*PHE(I ,J))/DZ/DELQ

DPHIZ=(ELLE*PHI(I2L ,J)-DELL*PHI(IL ,J)+DELE*PHI(I ,J))/DZ/DELQ

DRHOZ=(ELLE*RHO(I2L ,J)-DELL*RHO(IL ,J)+DELE*RHO(I ,J))/DZ/DELQ

DGAMZ=(ELLE*GAM(I2L ,J)-DELL*GAM(IL ,J)+DELE*GAM(I ,J))/DZ/DELQ

DSI Z=(DELLE*SI (I2L ,J)-DELL*SI (IL ,J)+DELE*SI (I,J))/DZ/DELO

60 CONTINUE

P Q(I,J)=(DP S-DP Z *DZS)/DTHS
H Q(I,J)=(DH S-DH Z *DZS)/DTHS
Q Q(I,J)=(DQ S-DQ Z *DZS)/DTHS
SI Q(I,J)=(DSI S-DSI Z *DZS)/DTHS
PHEQ(I,J)=(DPHES-DPHEZ *DZS)/DTHS
PHIQ(I,J)=(DPHIS-DPHIZ *DZS)/DTHS
RHOQ(I,J)=(DRHOS-DRHOZ *DZS)/DTHS
GAMQ(I,J)=(DGAMS-DGAMZ *DZS)/DTHS

20 CONTINUE

10 CONTINUE

IF(IWRAP.EQ.1)GO TO 955
IF(ICOWL.EQ.1.OR.ICOWLT.EQ.0) GO TO 955

J2=JINT

J3=JINT+1

J4=JINT+2

IDU=IDUMMY+1

A1=ZSAV-Z(IDU,J2)

A2=TH(J4)-TH(J3)

A1A2=A1/A2

A2A1=A2/A1

A1PA2=A1.A2

A12=A1A2-A2A1

UT=Q(IDU,J2)*COS(PHE(IDU,J2))

VT=Q(IDU,J2)*SIN(PHE(IDU,J2))

WT=Q(IDU,J2)*TAN(SI(IDU,J2))

QT=SQRT(UT*UT+WT*WT)

PHET=ATAN(WT/UT)

SIT=ATAN(VT/QT)

P Q(I,J3)=(P (I,J4)*A1A2-P (I,J3)*A12-P (IDU,J2)*A2A1)/A1PA2

H Q(I,J3)=(H (I,J4)*A1A2-H (I,J3)*A12-H (IDU,J2)*A2A1)/A1PA2

Q Q(I,J3)=(Q (I,J4)*A1A2-Q (I,J3)*A12-Q T *A2A1)/A1PA2

SI Q(I,J3)=(SI (I,J4)*A1A2-SI (I,J3)*A12-SI T *A2A1)/A1PA2

PHEQ(I,J3)=(PHE(I,J4)*A1A2-PHE(I,J3)*A12-PHET *A2A1)/A1PA2

PHIQ(I,J3)=(PHI(I,J4)*A1A2-PHI(I,J3)*A12-PHI(IDU,J2)*A2A1)/A1PA2

RHOQ(I,J3)=(RHO(I,J4)*A1A2-RHO(I,J3)*A12-RHO(IDU,J2)*A2A1)/A1PA2

GAMQ(I,J3)=(GAM(I,J4)*A1A2-GAM(I,J3)*A12-GAM(IDU,J2)*A2A1)/A1PA2

IMAXJ2=IMAX(J2-1)

DO 7979 I=1,IMAXJ2

Z R(I,1)=Z (I,J2-1)

P R(I,1)=P (I,J2-1)

Q R(I,1)=Q (I,J2-1)

H R(I,1)=H (I,J2-1)

SI R(I,1)=SI (I,J2-1)

PHIR(I,1)=PHI (I,J2-1)

PHER(I,1)=PHE (I,J2-1)

RHOR(I,1)=RHO (I,J2-1)

7979 CONTINUE

DO 7878 I=1,IDUMMY

DO 3535 IJ=1,IMAXJ2

GAMRR(IJ)=THWR(IJ)

3535 THWR(IJ)=GAM (IJ,J2-1)

CALL TBLDUM(Z (I,J2),P1,SI1,H1,PHI1,Q1,PHE1,RHO1,GAM1, 1,IMAX(IJ2),2)

DO 3536 IJ=1,IMAXJ2

```

3536 THWR(I,J)=GAMRR(I,J)
      CALL TBLDUM(Z(I,J2),P2,SI2,H2,PHI2,Q2,PHE2,RHO2,GAM2, 2,IMAX(
1J2),2)
      D1=TH(J2)-TH(J2-1)
      D2=THR(2) -TH(J2)
      D1D2=D1/D2
      D2D1=D2/D1
      D12=D1D2-D2D1
      D1PD2=D1+D2
      P Q(I,J2)=(D1D2*P 2-D12*P (I,J2)-D2D1*P 1)/D1PD2
      H Q(I,J2)=(D1D2*H 2-D12*H (I,J2)-D2D1*H 1)/D1PD2
      Q Q(I,J2)=(D1D2*Q 2-D12*Q (I,J2)-D2D1*Q 1)/D1PD2
      SI Q(I,J2)=(D1D2*SI 2-D12*SI (I,J2)-D2D1*SI 1)/D1PD2
      PHI Q(I,J2)=(D1D2*PHI2-D12*PHI(I,J2)-D2D1*PHI1)/D1PD2
      PHE Q(I,J2)=(D1D2*PHE2-D12*PHE(I,J2)-D2D1*PHE1)/D1PD2
      RHO Q(I,J2)=(D1D2*RHO2-D12*RHO(I,J2)-D2D1*RHO1)/D1PD2
      GAM Q(I,J2)=(D1D2*GAM2-D12*GAM(I,J2)-D2D1*GAM1)/D1PD2
7878 CONTINUE
955 CONTINUE
      RETURN
      END

```

```

SUBROUTINE CSURF(K,JMW)
COMMON /FN/ FPN(40,10),FMN(40,10)
COMMON /ALLR2/ PQN(40,10),HQN(40,10),QQN(40,10),SIGN(40,10),
1PHEQN(40,10),PHIGN(40,10),RHOQN(40,10),GAMQN(40,10)
COMMON /AV/ AAV,BAV
COMMON /ALLR1/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /IVY/ IVY,KCORR,IAV
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /H/ ISIM
COMMON /I/ XJ
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /K/ RN,DELR
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON/M/ IS(7,10)
COMMON/N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1QQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /U/ ERZZZ
COMMON /V/ XJ1
COMMON /W/ ISIMEX, IDUMMY, JINT, DUMMY(40), THWW(2), JD1, JD2
COMMON /SA/ XJ1S
DIMENSION PIS(2),PHEIS(2),RHOZS(2),PZS(2),GAMZS(2),QDS(2),QDS(2),
1SIDS(2),SIDQS(2),TIS(2),VCS(2),HDS(2),HDQS(2),PHIZS(2)
1 DO 10 J=1,JMW
  IF(J.GT.JINT) XJ1=0.
  I=IS(K,J)
  KIL=1
  A93=1.
  B93=0.
  IF(BAV.GT.0.) A93=.5
  IF(BAV.GT.0.) B93=.5
  IF(BAV.EQ.0.) BETAN(K,J)=BETA(K,J)
  BT=BETAN(K,J)
  IF(J.NE.JMAX+1) GO TO 893
  XT=R
  CALL SWALL(R,Z(I,JMW),XT,YT,GX1,GZ1)
  GG=ATAN(GX1)
  ZDOT=Z(I,JMW)+TAN(BETA(K,JMW))*DELR/COS(GG)/COS(GG)
  XT=RN
  CALL SWALL(RN,ZDOT,XT,YDU,GX,GZ)
  XA=GX*SIN(BETA(K,JMW))
  RATC=(TH(JMW)-YDU)/(TH(JMAX)-YDU)
  I1=IS(K,J)-2
  I2=IS(K,J)+1
  DO 892 II=I1,I2
    P Q(II,J)=P Q(II,JMAX)
    H Q(II,J)=H Q(II,JMAX)
    Q Q(II,J)=Q Q(II,JMAX)
    SI Q(II,J)=SI Q(II,JMAX)
    PHEQ(II,J)=PHEQ(II,JMAX)
    PHIQ(II,J)=PHIQ(II,JMAX)

```

```

RHOQ(I,I,J)=RHOQ(I,I,JMAX)
GAMQ(I,I,J)=GAMQ(I,I,JMAX)
892 CONTINUE
893 CONTINUE
2525 ZA=Z(I-1,J)
C ZA=(Z(I-2,J)+Z(I-1,J))/2.
25 IT=1
5 RAT=(ZA-Z(I-2,J))/(Z(I-1,J)-Z(I-2,J))
ALAM=XPLAM(I-2,J)+RAT*(XPLAM(I-1,J)-XPLAM(I-2,J))
DUMP=A93*ALAM+B93*XPLAMN(I-1,J)
ZAT=ZN(I-1,J)-DUMP*DELR
ER=ABS((ZAT-ZA)/(Z(I-1,J)-Z(I-2,J)))
IF(ER.LT.ERZZZ)GO TO 6
IT=IT+1
ZA=ZAT
IF(IT.LE.10)GO TO 5
WRITE(6,200)
200 FORMAT(* ERROR IN A POINT ITERATION IN CSURF*)
CALL PNCH
6 M=I-1
BLAM=XMLAM(I-2,J)+RAT*(XMLAM(I-1,J)-XMLAM(I-2,J))
ZI=ZA
PA=P(I-2,J)+RAT*(P(I-1,J)-P(I-2,J))
PI=PA
QA=Q(I-2,J)+RAT*(Q(I-1,J)-Q(I-2,J))
QI=QA
HA=H(I-2,J)+RAT*(H(I-1,J)-H(I-2,J))
HI=HA
RHA=RHO(I-2,J)+RAT*(RHO(I-1,J)-RHO(I-2,J))
RHI=RHA
SIA=SI(I-2,J)+RAT*(SI(I-1,J)-SI(I-2,J))
SII=SIA
PHIA=PHI(I-2,J)+RAT*(PHI(I-1,J)-PHI(I-2,J))
PHII=PHIA
PHEA=PHE(I-2,J)+RAT*(PHE(I-1,J)-PHE(I-2,J))
RQ2=QN(M,J)*QN(M,J)*RHON(M,J)
PHEI=PHEA
TA=FT(PA,PHIA,HA)
GAMA=FGAM(TA,PA,PHIA)
AA=SQRT(GAMA*PA/RHA)
PQI=PQ(I-2,J)+RAT*(PQ(I-1,J)-PQ(I-2,J))
QQI=QQ(I-2,J)+RAT*(QQ(I-1,J)-QQ(I-2,J))
HQI=HQ(I-2,J)+RAT*(HQ(I-1,J)-HQ(I-2,J))
RHQI=RHOQ(I-2,J)+RAT*(RHOQ(I-1,J)-RHOQ(I-2,J))
PHEQI=PHEQ(I-2,J)+RAT*(PHEQ(I-1,J)-PHEQ(I-2,J))
PHIQI=PHIQ(I-2,J)+RAT*(PHIQ(I-1,J)-PHIQ(I-2,J))
SIQI=SIQ(I-2,J)+RAT*(SIQ(I-1,J)-SIQ(I-2,J))
CALL F(RHA,QA,P,ZA,PHEA,ALAM,BI,AM,SIA,AA,SIQI,PQI,PHEQI,FPA,FMA)
A1=FPA/RHA/QA/QA
A1=AAV*A1+BAV*FPN(M,J)/RQ2
A2=SQRT((QA/AA)**2-1.)/RHA/QA/QA
A2=A93*A2+B93*SQRT((QN(I-1,J)/AN(I-1,J))**2-1.)/RQ2
IT=1
ZB=Z(I,J)
C ZB=(Z(I+1,J)+Z(I,J))/2.
8 RAT=(ZB-Z(I,J))/(Z(I+1,J)-Z(I,J))

```

```

PLAM=XMLAM(I,J)+RAT*(XMLAM(I+1,J)-XMLAM(I,J))
DUMPE=A93*BLAM+B93*XMLAMN(I,J)
ZAT=ZN(I,J)-DUMP*DELR
ER=ABS((ZB-ZAT)/(Z(I+1,J)-Z(I,J)))
IF(ER.LT.ERZZZ)GO TO 9
IT=IT+1
7B=ZAT
IF(IT.LE.10)GO TO 8
WRITE(6,201)
201 FORMAT(* ERROR IN B POINT ITERATION IN CSURF*)
CALL PNCH
9 PB=P(I,J)+RAT*(P(I+1,J)-P(I,J))
RQ2=QN(I,J)*QN(I,J)*RHON(I,J)
ALAM=XPLAM(I,J)+RAT*(XPLAM(I+1,J)-XPLAM(I,J))
QB=Q(I,J)+RAT*(Q(I+1,J)-Q(I,J))
HB=H(I,J)+RAT*(H(I+1,J)-H(I,J))
RHB=RHO(I,J)+RAT*(RHO(I+1,J)-RHO(I,J))
SIB=SI(I,J)+RAT*(SI(I+1,J)-SI(I,J))
PHIB=PHI(I,J)+RAT*(PHI(I+1,J)-PHI(I,J))
PHEB=PHE(I,J)+RAT*(PHE(I+1,J)-PHE(I,J))
TB=FT(PB,PHIB,HB)
GAMB=FAM(TB,PB,PHIB)
AB=SQRT(GAMB*PB/RHB)
PQB=PQ(I,J)+RAT*(PQ(I+1,J)-PQ(I,J))
QQB=QQ(I,J)+RAT*(QQ(I+1,J)-QQ(I,J))
HQB=HQ(I,J)+RAT*(HQ(I+1,J)-HQ(I,J))
RHQB=RHOQ(I,J)+RAT*(RHOQ(I+1,J)-RHOQ(I,J))
SIQB=SIQ(I,J)+RAT*(SIQ(I+1,J)-SIQ(I,J))
PHEQB=PHEQ(I,J)+RAT*(PHEQ(I+1,J)-PHEQ(I,J))
PHIQB=PHIQ(I,J)+RAT*(PHIQ(I+1,J)-PHIQ(I,J))
CALL F(RHB,QB,R,7B,PHEB,ALAM,BLAM,SIB,AB,SIQB,PQB,PHEQB,FPB,FMB)
B1=FMB/RHB/QB/QB
R1=AAV*B1+BAV*FMN(I,J)/RQ2
R2=SQRT((QB/AB)**2-1.)/RHB/QB/QB
AC=B93*SQRT((QN(I,J)/AN(I,J))**2-1.)/RQ2
R2=A93*R2+AC
13 ZD=Z(M,J)
C 13 ZD=(ZI+Z(M,J))/2.
IT=1
18 RAT=(ZD-Z(M,J))/(ZI-Z(M,J))
DLAM=TAN(PHE(M,J))+RAT*(TAN(PHEI)-TAN(PHE(M,J)))
DUMP=A93*DLAM+B93*TAN(PHEN(M,J))
ZAT=ZN(M,J)-DUMP*DELR
ER=ABS((ZAT-ZD)/(ZI-Z(M,J)))
IF(ER.LT.ERZZZ)GO TO 19
IT=IT+1
IF(IT.GT.10)CALL ERROR(18)
ZD=ZAT
GO TO 18
19 CONTINUE
PD=P(M,J)+RAT*(PI-P(M,J))
QD=Q(M,J)+RAT*(QI-Q(M,J))
HD=H(M,J)+RAT*(HI-H(M,J))
RHD=RHO(M,J)+RAT*(RHI-RHO(M,J))
SID=SI(M,J)+RAT*(SII-SI(M,J))
PHID=PHI(M,J)+RAT*(PHII-PHI(M,J))

```

```

PHED=PHE(M,J)+RAT*(PHEI-PHE(M,I))
TD=FT(PD,PHID,HD)
GAMD=FGAM(TD,PD,PHID)
AD=SQRT(GAMD*PD/RHD)
PDQ=PQ(M,J)+RAT*(PQI-PQ(M,J))
HDQ=HQ(M,J)+RAT*(HQI-HQ(M,J))
QDQ=QQ(M,J)+RAT*(QQI-QQ(M,J))
RHDQ=RHQ(M,J)+RAT*(RHQI-RHQ(M,J))
SIDQ=SIQ(M,J)+RAT*(SIQI-SIQ(M,J))
PHIDQ=PHIQ(M,J)+RAT*(PHIQI-PHIQ(M,J))
PHEDQ=PHEQ(M,J)+RAT*(PHEQI-PHEQ(M,J))
VD=QD*TAN(SID)
T1=DEL R/COS(PHED)
IF(XJ1.EQ.1.)T1=T1/ZD
IF(XJ.EQ.1.)T1=T1/R
T2=PDQ/RHD/QD
T3=TAN(SID)*QDQ
T4=QD*SIDQ/COS(SID)**2
T5=QD*COS(PHED)*XJ
1.QD*SIN(PHED)*XJ1
VC=VD-T1*(T2+TAN(SID)*(T3+T4+T5))*AAV
SPHEN=SIN(PHEN(M,J))
TSIN=TAN(SINN(M,J))
CSIN=COS(SINN(M,J))
CPHEN=COS(PHEN(M,J))
TT1=DEL R/CPHEN
IF(XJ1.GT.0.)TT1=TT1/ZN(M,J)
IF(XJ.GT.0.)TT1=TT1/RN
T22=PQN(M,J)/RQON(M,J)/QN(M,J)
T33=TSIN*QQN(M,J)
T44=QN(M,J)*SIQN(M,J)/CSIN
T55=QN(M,J)*(CPHEN*XJ+SPHEN*XJ1)
DVC=TT1*(T22+TSIN*(T33+T44+T55))*BAV
VC=VC-DVC
T11=DEL R*TAN(SINN(M,J))/COS(PHEN(M,J))
IF(XJ1.GT.0.)T11=T11/ZN(M,J)
IF(XJ.GT.0.)T11=T11/RN
T1=T1*TAN(SID)
T1=T1*A93+T11*B93
RHOZ=RHD-RHDQ*T1
PZ=PD-PDQ*T1
HZ=HD-HDQ*T1
PHIZ=PHID-PHIDQ*T1
TZ=FT(PZ,PHIZ,HZ)
GAMZ=FGAM(TZ,PZ,PHIZ)
I6=1
IF(M.EQ.I)I6=2
PI S(I6)=PI
PHEIS(I6)=PHEI
RHOZS(I6)=RHOZ
PZ S(I6)=PZ
GAMZS(I6)=GAMZ
QDQ S(I6)=QDQ
QD S(I6)=QD
SID S(I6)=SID
SIDQS(I6)=SIDQ

```

```

T1 S(I6)=T1
VC S(I6)=VC
HD S(I6)=HD
HDQ S(I6)=HDQ
PHIZS(I6)=PHIZ
IF(I6.EQ.2) GO TO 1690
35 M=I
ZI=ZB
PI=PB
HI=HB
OI=OB
RHI=RHB
PHI=PHB
GAMI=GAMB
PHEI=PHEB
SII=SIB
PQI=PQB
QQI=QOB
HQI=HQB
RHQI=RHOB
SIQI=SIQB
PHEQI=PHEQB
PHIQI=PHIQB
GO TO 13
1690 CONTINUE
ITT=1
M=I-1
N=I
I6=1
PN(M,J)=(A2*PA+B2*PB+(A1-B1)*DELR+PHEA-PHEB)/(A2+B2)
16 PN(N,J)=PN(M,J)
PHEN(N,J)=PHEIS(2)+B1*DELR-B2*(PIS(2)-PN(N,J))
PHEN(M,J)=PHEIS(1)+A1*DELR-A2*(PN(M,J)-PIS(1))
1600 RHON(M,J)=RHOZS(I6)*(PN(M,J)/P7S(I6)**(1./GAMZS(I6)))
T2=(QDQS(I6)+QDS(I6)*TAN(SIDS(I6))*SINQS(I6))/COS(SIDS(I6))
VVZ=QDS(I6)/COS(SIDS(I6))-T2*TIS(I6)
VVC=VVZ*VVZ+2.*GAMZS(I6)/(GAMZS(I6)-1.)*(PZS(I6)/RHOZS(I6))
I=PN(M,J)/RHON(M,J)
QN(M,J)=SQRT(VVC-VCS(I6)*VCS(I6))
SINN(M,J)=ATAN(VCS(I6)/QN(M,J))
HN(M,J)=HDS(I6)+(VVZ*VVZ-VVC)/2.-HDQS(I6)*TIS(I6)
PHIN(M,J)=PHIZS(I6)
IF((PHIN(M,J).LT.0.).AND.(PHIN(M,J).GT.-.01))PHIN(M,J)=0.
TN(M,J)=FT(PN(M,J),PHIN(M,J),HN(M,J))
GAMN(M,J)=FGAM(TN(M,J),PN(M,J),PHIN(M,J))
AN(M,J)=SQRT(GAMN(M,J)*PN(M,J)/RHON(M,J))
CALL XLAM(QN(M,J),AN(M,J),PHEN(M,J),XPLAMN(M,J),XMLAMN(M,J))
IF(I6.EQ.2) GO TO 1601
I6=2
M=I
GO TO 1600
1601 CONTINUE
M=I-1
I6=1
IF(J.EQ.1) BETAN(K,J)=PHEN(M,J)
IF(J.EQ.JMAX.AND.ISIM.EQ.1) BETAN(K,J)=PHEN(M,J)

```



```

JK=1
26 ZN(I,J)=Z(I,J)+(TAN(BETA(K,J))+TAN(BETAN(K,J)))*DELR/2.
ZN(I-1,J)=ZN(I,J)
IF(J.NE.JMAX+1) GO TO 4392
BDU=(BETAN(K,J)-RATC*BETAN(K,JMAX))/(1.-RATC)
ADU=ATAN(GX*SIN(BDU))
ALPHAN(K,J)=ADU+RATC*(ALPHAN(K,JMAX)-ADU)
GO TO 4483
4392 CONTINUE
IF(J.NE.JINT.AND.J.NE.JINT+1) CALL PSOLV(J,TALP,I)
ALPHAN(K,J)=ATAN(TALP*COS(BETAN(K,J)))
4483 CONTINUE
BPHE=BETAN(K,J)-PHEN(M,J)
ERP=TAN(SINN(M,J))*SIN(ALPHAN(K,J))+COS(ALPHAN(K,J))*SIN(BPHE)
IF(ABS(ERP).LT.1.E-10) GO TO 1402
IK=IK+1
IF(IK.GT.10)GO TO 100
IF(IK.GT.2)GO TO 28
E1=ERP
BT1=BETAN(K,J)
BETAN(K,J)=1.01*BETAN(K,J)+1.E-5
GO TO 26
1680 WRITE(6,1681)
1681 FORMAT(* ERROR IN PRESSURE ITERATION IN CSURF*)
CALL PNCH
100 WRITE(6,202)
202 FORMAT(* ERROR IN BETA ITERATION IN CSURF*)
CALL PNCH
28 DUM2=BT1-E1*(BETAN(K,J)-BT1)/(ERP-E1)
E1=ERP
BT1=BETAN(K,J)
BETAN(K,J)=DUM2
GO TO 26
1602 BETEST=PHEN(N,J)-ASIN(TAN(SINN(N,J))*TAN(ALPHAN(K,J)))
ERS=BTAN(K,J)-BETEST
IF(ABS(ERS).LT.1.E-10) GO TO 1403
ITT=ITT+1
IF(ITT.GT.15) GO TO 1680
IF(ITT.GT.2)GO TO 22
ER1=ERS
PH1=PN(M,J)
P N(M,J)=1.2 *P N(M,J)
GO TO 16
22 DUM1=PH1-ER1*(P N(M,J)-PH1)/(ERS-ER1)
ER1=ERS
PH1=P N(M,J)
P N(M,J)=DUM1
GO TO 16
1603 IF(J.NE.JINT.AND.J.NE.JINT+1) ALPN(K,J)=ATAN(TALP)
IF(J.EQ.JMAX+1)ALPN(K,J)=ATAN(TAN(ALPHAN(K,J))/COS(BETAN(K,J)))
1010 ZN(I,J)=Z(I,J)+(TAN(BETA(K,J))+TAN(BETAN(K,J)))*DELR/2.
ZN(I-1,J)=ZN(I,J)
ET=ABS(1.-BT/BETAN(K,J))
IF(IVY.EQ.0.OR.ET.LT.1.E-05) GO TO 10
KIL=KIL+1
IF(KIL.GT.10)GO TO 1493

```

A93=.5

R93=.5

RT=BETAN(K,J)

GO TO 2525

1493 WRITE(6,1393)

1393 FORMAT(* AVERAGING PROCESS DOES NOT CONVERGE IN CSURF *)

STOP

10 CONTINUE

XJ1=XJ1S

RETURN

END

```

SUBROUTINE HSHOCK(K,JL,JM,IFLG)
COMMON /FN/ FPN(40,10),FMN(40,10)
COMMON /AV/ AAV,BAV
COMMON /ALLR1/ TN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /IVY/ IVY,KCORR,IAV
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /I/ XJ
COMMON /K/ RN,DELR
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON/M/ IS(7,10)
COMMON/N/ SIG(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1QQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
COMMON /U/ ERZZZ
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /SA/ XJTS
1 DO 10 J=JL,JM
IF(J.GT.JINT) XJ1=0.
I=IS(K,J)
IF(JM.NE.JMAX+1.OR.IFLG.EQ.1) GO TO 3985
XT=Z
CALL SWALL(R,Z(I,J),XT,YT,GX,G7)
ZDOT=Z(I,J)+TAN(BETA(K,J))*DELR/(COS(ATAN(GX)))**2
XT=RN
CALL SWALL(RN,ZDOT,XT,YDU,GX,G7)
3985 CONTINUE
IT1=1
KIL=1
A93=1.
B93=0.
IF(BAV.GT.0.) A93=.5
IF(BAV.GT.0.) B93=.5
IF(BAV.EQ.0..AND.JL.NE.JMAX+1) BETAN(K,J)=BETA(K,J)
BET=BETAN(K,J)
IF(J.EQ.JMAX+1.AND.IFLG.EQ.1) BET=BETAN(K,JM)
BT=BET
4 IT=1
IF(J.NE.JMAX+1.OR.IFLG.EQ.0) GO TO 7999
RATS=(TH(JM)-YDU)/(TH(JMAX)-YDU)
RDU=(BET-RATS*BETAN(K,JMAX))/(1.-RATS)
ADU=ATAN(GX*SIN(BDU))
ALPHAN(K,J)=ADU+RATS*(ALPHAN(K,JMAX)-ADU)
7999 CONTINUE
CA=COS(ALPHAN(K,J))
SA=SIN(ALPHAN(K,J))
VT=QN(I,J)*COS(BET-PHEN(I,J))
VL=QN(I,J)*(CA*TAN(SINN(I,J))-SA*SIN(BET-PHEN(I,J)))
UL=QN(I,J)*(SA*TAN(SINN(I,J))+CA*SIN(BET-PHEN(I,J)))

```

```

U1=ABS(U1)
XMS=RHON(I,J)*U1
TN=FT(PN(I,J),PHIN(I,J),HN(I,J))
GN=FGAM(TN,PN(I,J),PHIN(I,J))
GP1=(GN+1.)
GM1=GN-1.
XM1=Uj*U1/GN/PN(I,J)*RHON(I,J)
U2=U1*(GM1*XM1+2.)/GP1/XM1
5 RH2P=XMS/U2
P2H=XMS*(U1-U2)+PN(I,J)
V2=VT**2+VL**2
V1=V2+U1**2
V2=V2+U2**2
H2=HN(I,J)+(V1-V2)/2.
RH2=RHEQ(H2,P2H,PHIN(I,J))
ER=(RH2-RH2P)/RHO(I,J)
IF(ABS(ER).LT.1.E-4)GO TO 7
IT=IT+1
IF(IT.GT.10)GO TO 100
IF(IT.GT.2)GO TO 6
ER2=ER
U22=U2
U2=.99*U2
GO TO 5
100 WRITE(6,200)
200 FORMAT(* ERROR IN HUGONIOT LOOP IN HSHOCK*)
CALL PNCH
6 DUM=U22-ER2*(U2-U22)/(ER-ER2)
ER2=ER
U22=U2
U2=DUM
GO TO 5
7 CONTINUE
CB=COS(BET)
SB=SIN(BET)
IF((K/2)*2.EQ.K)U2=-U2
QN2P=-U2*CA+VL*SA
UV=VT*CB-QN2P*SB
VV=VL*CA+U2*SA
WV=VT*SB+QN2P*CB
PHE2=ATAN(WV/UV)
Q2=SQRT(UV*UV+WV*WV)
V2=VV
SI2=ATAN(V2/Q2)
L=1
IF((K/2)*2.NE.K) L=-1
M=IS(K,J)+L
IF(
IFLG.EQ.1) GO TO 46
N=M+L
ZA=(Z(M,J)+Z(N,J))/2.
TK=1
40 RAT=(ZA-Z(M,J))/(Z(N,J)-Z(M,J))
ALAM=XPLAM(M,J)+RAT*(XPLAM(N,J)-XPLAM(M,J))
DUMP=A93*ALAM+B93*XPLAMN(M,J)
SLAM=DUMP
BLAM=XMLAM(M,J)+RAT*(XMLAM(N,J)-XMLAM(M,J))

```

```

DUM1=A93*BLAM+B93*XMLAMN(M,J)
IF(K.EQ.2)DUMP=DUM1
ZAT=ZN(M,J)-DUMP*DELR
EP=ABS((ZAT-ZA)/(Z(N,J)-Z(M,J)))
IF(EP.LT.ERZZZ)GO TO 9
ZA=ZAT
IK=IK+1
IF(IK.LE.10)GO TO 40
WRITE(6,101)
101 FORMAT(* ERROR IN A POINT LOOP IN HSHOCK*)
CALL PNCH
9 PA=P(M,J)+RAT*(P(N,J)-P(M,J))
QA=Q(M,J)+RAT*(Q(N,J)-Q(M,J))
HA=H(M,J)+RAT*(H(N,J)-H(M,J))
RHA=RHO(M,J)+RAT*(RHO(N,J)-RHO(M,J))
SIA=SI(M,J)+RAT*(SI(N,J)-SI(M,J))
PHEA=PHE(M,J)+RAT*(PHE(N,J)-PHE(M,J))
PHIA=PHI(M,J)+RAT*(PHI(N,J)-PHI(M,J))
TA=FT(PA,PHIA,HA)
GAMA=FGAM(TA,PA,PHIA)
AA=SQRT(GAMA*PA/RHA)
IF(J.NE.JMAX+1) GO TO 783
SI Q(M,J)=SI Q(M,J-1)
P Q(M,J)=P Q(M,J-1)
PHEQ(M,J)=PHEQ(M,J-1)
SI Q(N,J)=SI Q(N,J-1)
P Q(N,J)=P Q(N,J-1)
PHEQ(N,J)=PHEQ(N,J-1)
783 CONTINUE
CALL F (RHO(M,J),Q(M,J),R,Z(M,J),PHE(M,J),XPLAM(M,J),XMLAM(M,J),SI
1(M,J),
1A(M,J),SIQ(M,J),PG(M,J),PHEQ(M,J),FP1,FM1)
CALL F (RHO(N,J),Q(N,J),R,Z(N,J),PHE(N,J),XPLAM(N,J),XMLAM(N,J),SI
1(N,J),
1A(N,J),SIQ(N,J),PG(N,J),PHEQ(N,J),FP2,FM2)
FPA=FP1 +RAT*(FP2 -FP1)
FMA=FM1 +RAT*(FM2 -FM1)
RQ2=QN(M,J)*QN(M,J)*RHON(M,J)
A1=FPA/RHA/QA/QA*AAV+FPN(M,J)*BAV/RQ2
IF((K/2)*2.EQ.K) A1=FMA/RHA/QA/QA*AAV+FMN(M,J)*BAV/RQ2
A2=SQRT((QA/AA)**2-1.)/RHA/QA/QA
AC=B93*SQRT((QN(M,J)/AN(M,J))**2-1.)/RQ2
A2=A93*A2+ AC
DELR=RN-R
OPT=-1.
IF((K/2)*2.EQ.K) OPT=1.
PSH=PA+ OPT*(PHE2-PHEA -A1*DELR)/A2
ER3=(PSH-P2H)/P(M,J)
IF(ABS(ER3).LT.1.E-4)GO TO 19
IT1=IT1+1
IF(IT1.GT.15)GO TO 103
IF(IT1.GT.2)GO TO 14
ER1=ER3
RET1=RET
RET=1.01*BET
GO TO 15

```

```

103 WRITE(6,220)
220 FORMAT(* ERROR IN SHOCK ANGLE IN HSHOCK*)
CALL PNCH
14 DUM=BET1-ER1*(BET-BET1)/(ER3-ER1)
ER1=ER3
BET1=BET
BET=DUM
15 ZN(M,J)=Z(M,J)+.5*(TAN(BETA(K,J))+TAN(BET))*DELX
IS=IS(K,J)
ZN(IS,J)=ZN(M,J)
CALL FSHOCK(K,J,J)
GO TO 4
19 BETAN(K,J)=BET
ZN(M,J)=.5*(TAN(BETA(K,J))+TAN(BETAN(K,J)))*DELX+Z(M,J)
IS=IS(K,J)
ZN(IS,J)=ZN(M,J)
GO TO 29
46 CONTINUE
UWN(M)=UV
WWN(M)=WV
VWN(M)=VV
29 CONTINUE
PN(M,J)=P2H
QN(M,J)=Q2
HN(M,J)=H2
PHEN(M,J)=PHE2
RHON(M,J)=RH2
SINN(M,J)=SI2
PHIN(M,J)=PHIN(I,J)
TN(M,J)=FT(PN(M,J),PHIN(M,J),HN(M,J))
GAMN(M,J)=FGAM(TN(M,J),PN(M,J),PHIN(M,J))
AN(M,J)=SQRT(GAMN(M,J)*PN(M,J)/RHON(M,J))
CALL XLAM(QN(M,J),AN(M,J),PHEN(M,J),XPLAMN(M,J),XMLAMN(M,J))
FT=ABS(1.-BT/BETAN(K,J))
IF(IVY.EQ.0.OR.ET.LT.1.E-05) GO TO 10
KIL=KIL+1
IF(KIL.GT.5) GO TO 1493
A93=.5
B93=.5
RT=BETAN(K,J)
GO TO 4
1493 WRITE(6,1393)
1393 FORMAT(* AVERAGING PROCESS DOES NOT CONVERGE IN HSHOCK*)
STOP
10 CONTINUE
XJ1=XJ1S
RETURN
END

```

```

SURROUTINE PNCH
COMMON /IVY/ IVY,KCORR,IAV
COMMON /JF/ JFINAL
COMMON /G/ A1(3,9),A2(3,9),A3(3,9),RR1(3),RR2(3),RR3(3)
1,NUMLWS,NUMUWS,NUMSWS
COMMON /Q/ XCOWL
COMMON /XF/ XFIN
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PUI(40,10),RHO(40,10),GAM(40,10)
COMMON /SCLTM/ ZLIFTC,XTHRC,YMOMC,ZLIFTS,XTHRS,YMOMS
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)
COMMON /H/ ISIM
COMMON /I/ XJ
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1 XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON /M/ IS(7,10)
COMMON /N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1 IQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON/EX/ KTPUN(3)
COMMON /THR/ PINF,ZLIFT,XTHR,YMOM,JJI,ZSHIFT,XSHIFT
COMMON /IQ/ NUMEXP,ZSAV
COMMON /SPE/ KOUNTC
COMMON /WR/ IWRAP
COMMON /TEM/ T(40,10)
COMMON /STREAM/ XMAST,XENT,FSX,FSZ
COMMON/XSTP/XSTP
DIMENSION HF(10)
DATA HE/5H Y ,5H THETA,5H Z .3H = ,1HZ,1HR,1HY,3H THW,3H Y ,
13H Z /
BACKSPACE 7
73 CONTINUE
IF(XJ,EQ.0.) GO TO 513
WRITE(6,70) KOUNT,X1
70 FORMAT(1H1,10X,*KOUNT = *,I4,1AX,*R = *,E13.5//)
GO TO 503
513 WRITE(6,504) KOUNT,X1
504 FORMAT(1H1,10X,*KOUNT = *,I4,1AX,*X = *,E13.5//)
503 CONTINUE
ISWEEP=0
ISTART=1
WRITE(7,2929) KOUNTF,KOUNTP,ISTART,IVY,IAV,KCORR,JFINAL,
1(KTPUN(I),I=1,3),XSTP
2929 FORMAT(10I5,E10.2)
WRITE(7,2) JMAX,ISIM,ISIMEX,IWRAP,NUMEXP,ISWEEP,(IMAX(J),J=1,JMAX)
WRITE(7,310) R,XJ,XJ1,XCOWL,RCOWL,XFIN,ZSAV,PINF
310 FORMAT(8E10.3)
WRITE(7,79) KOUNT,R
WRITE(7,2) NUMLWS
DO 311 I=1,NUMLWS

```

```

311 WRITE(7,310) RR1(I),(A1(I,J),J=1,9)
WRITE(7,2) NUMUWS
DO 312 I=1,NUMUWS
312 WRITE(7,310) RR2(I),(A2(I,J),J=1,9)
IF(ISIM.EQ.1) GO TO 314
WRITE(7,2) NUMSWS
DO 313 I=1,NUMSWS
313 WRITE(7,310) RR3(I),(A3(I,J),J=1,9)
314 CONTINUE
WRITE(7,2) JINT,KOUNTC
WRITE(6,610) ZSHIFT,XSHIFT,XTHR,ZLIFT,YMOM
610 FORMAT(10X,*Z MOMENT AXIS = *,F11.3,5X,*X MOMENT AXIS = *,E11.3/
1 10X,*THRUST = *,F11.3,5X,*LIFT = *,E11.3,5X
1,*PITCHING MOMENT = *,E11.3)
IF(IS(3).NE.0.AND.ISIM.EQ.0) WRITE(6,621) XTHRC,ZLIFTC,YMOMC
621 FORMAT(* CONTACT * ,*THRUST = *,F11.3,5X,*LIFT = *,E11.3,5X
1,*PITCHING MOMENT = *,E11.3)
IF(IS(1).NE.0.AND.ISIM.EQ.0) WRITE(6,622) XTHRS,ZLIFTS,YMOMS
622 FORMAT(* SHOCK * ,*THRUST = *,F11.3,5X,*LIFT = *,E11.3,5X
1,*PITCHING MOMENT = *,E11.3)
WRITE(6,623)
623 FORMAT(/)
WRITE(7,9) XMAST,XENT,FSX,FSZ
9 FORMAT(4E13.5)
WRITE(7,1) ZLIFT,XTHR,YMOM,ZSHIFT,XSHIFT
DO 71 J=1,JW
IF(ISIM.EQ.0.AND.J.EQ.JW) GO TO 500
IF(J.GT.JINT) GO TO 2260
IF(XJ.NE.0.OR.XJ1.NE.0) GO TO 505
WRITE(6,506) J,HE(1),HE(4),TH(J),HE(5)
506 FORMAT(//10X,*J = *,I2,24X,A5,A3 ,E13.5,/4X,*I*,6X,A1 ,10X,
1*P*,10X,*Q*, 9X,*PHE*, 8X,*SI*,10X,*M*,10X,*H*, 9X,*PHI*
1,8X,*RHO*,8X,*GAM*,9X,*T*)
GO TO 510
505 IF(XJ1.EQ.0) GO TO 507
WRITE(6,506) J,HE(2),HE(4),TH(J),HE(6)
GO TO 510
507 CONTINUE
WRITE(6,506) J,HE(2),HE(4),TH(J),HE(5)
GO TO 510
2260 Z15=ZSAV-TH(J)
WRITE(6,506) J,HE(3),HE(4),Z15,HE(7)
510 CONTINUE
WRITE(7,1) TH(J)
GO TO 501
500 CONTINUE
IF(J.LT.JINT) GO TO 2270
WRITE(6,2300) JW,HE(10),HE(7)
2300 FORMAT(/// 40X,*SIDEWALL*/ 10X,*J = *,I2/11X,*X*,9X,A3
1,9X ,*U*,10X,*W*,10X,*V*/
14X,*I*,6X,A1 ,10X,
1*P*,10X,*Q*, 9X,*PHE*, 8X,*SI*,10X,*M*,10X,*H*, 9X,*PHI*
1,8X,*RHO*,8X,*GAM*,9X,*T*)
GO TO 6885
2270 CONTINUE
IF(XJ1.EQ.1) GO TO 6884

```



```

WRITE(6,2300) JW,HE(9),HE(5)
GO TO 6885
6884 WRITE(6,2300) JW,HE(8),HE(6)
6885 CONTINUE
WRITE(7,2) IMAX(J)
501 CONTINUE
IMAXJ=IMAX(J)
IF(ICOWLT.EQ.1) IMAXJ=IMAXJ+1
DO 172 I=1,IMAXJ
R =SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
EM=Q(I,J)/COS(SI(I,J))/8
IF(ISIM.EQ.1.OR.J.NE.JW) GO TO 502
EM=SQRT(UW(I)**2+VW(I)**2+WW(I)**2)/R
THWX=THW(I)*XJ
XW(I)=R*COS(THWX)
YW(I)=R*SIN(THWX)+(1.-XJ)*THW(I)
Z15=YW(I)
IF(J.GT.JINT) Z15=ZSAV-THW(I)
WRITE(6,302) XW(I),Z15,UW(I),WW(I),VW(I)
302 FORMAT(5X,5E11.3)
WRITE(7,1) UW(I),WW(I),VW(I),THW(I)
502 CONTINUE
Z15=Z(I,J)
WRITE(6,79) I,Z15,P(I,J),Q(I,J),PHE(I,J),SI(I,J),EM,H(I,J),
1PHI(I,J),RHO(I,J),GAM(I,J),T(I,J)
WRITE(7,3010) Z(I,J),P(I,J),Q(I,J),PHE(I,J),SI(I,J),EM,H(I,J),
1PHI(I,J),RHO(I,J),GAM(I,J),T(I,J)
3010 FORMAT(7E11.3)
172 CONTINUE
IF(ICOWLT.EQ.0) GO TO 71
WRITE(7,1) (ALP(M,J),M=1,7)
WRITE(7,1) (ALPHA(M,J),M=1,7)
WRITE(7,1) (BETA(M,J),M=1,7)
WRITE(7,2) (IS(M,J),M=1,7)
IF(IS(3).NE.0.AND.ISIM.EQ.0) WRITE(7,1) ZLIFTC,XTHRC,YMOMC
IF(IS(1).NE.0.AND.ISIM.EQ.0) WRITE(7,1) ZLIFTS,XTHRS,YMOMS
1 FORMAT(7E11.3)
2 FORMAT(16I5)
79 FORMAT(15,11E11.3)
71 CONTINUE
IF(ICOWLT.EQ.0) GO TO 100
WRITE(6,4005)
DO 4006 J=1,JW
WRITE(6,79) J,(ALP(M,J),M=1,7)
4006 CONTINUE
4005 FORMAT(/,10X,*ALP*/4X,*J*)
WRITE(6,4000)
DO 3003 J=1,JW
WRITE(6,79) J,(ALPHA(M,J),M=1,7)
3003 CONTINUE
WRITE(6,4001)
DO 3008 J=1,JW
WRITE(6,79) J,(BETA(M,J),M=1,7)
3008 CONTINUE
WRITE(6,4002)
DO 3009 J=1,JW

```

```
WRITE(6,4004) J,(IS(M,J),M=1,7)
3009 CONTINUE
IF(IWRAP.EQ.1) GO TO 1532
WRITE(7,2) IDUMMY
WRITE(7,1) (ZDUMMY(I),I=1,NUMEYP)
1532 CONTINUE
4000 FORMAT(//10X,*ALPHA*/4X,*J*)
4001 FORMAT(//10X,*BETA */4X,*J*)
4002 FORMAT(//10X,*IS */4X,*J*)
4004 FORMAT(I5,7(I4,7X))
100 CONTINUE
IF(KOUNT.NE.KOUNTF) GO TO 7744
IF(ICOWLT.EQ.1.AND.IWRAP.EQ.0) CALL WRAP(1)
7744 CONTINUE
ENDFILE 7
IF(KOUNT.EQ.KTPUN(1).OR.KOUNT.EQ.KTPUN(2).OR.KOUNT.EQ.KTPUN(3))
1 RETURN
CALL EXIT
END
```

```

SUBROUTINE FSHOCK(K,JL,JM)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /FN/ FPN(40,10),FMN(40,10)
COMMON /ALLR2/ PQN(40,10),HQN(40,10),QQN(40,10),SIGN(40,10),
IPHEQN(40,10),PHIQN(40,10),RHOQN(40,10),GAMQN(40,10)
COMMON /AV/ AAV,BAV
COMMON /ALLR1/ TN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
IXMLAMN(40,10)
COMMON /IVY/ IVY,KCORR,IAV
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHF(40,10),
I  Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /I/ XJ
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
IXMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /K/ RN,RELR
COMMON/M/ IS(7,10)
COMMON/N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
IQQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /U/ ERZZZ
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /SA/ XJ1S
DO 6 J=JL,JM
KIL=1
A93=.
B93=.
IF(BAV.GT.0.) A93=.5
IF(BAV.GT.0.) B93=.5
I=IS(K,J)
SIT=SINN(I,J)
PHET=PHEN(I,J)
PT=PN(I,J)
IF(J.GT.JINT) XJ1=0.
L=I+1
IF((K/2)*2.EQ.K) L=I-1
Z3=ZN(I,J)
IF(J.NE.JMAX+1) GO TO 3947
P  Q(I,JM)=P  Q(I,JMAX)
H  Q(I,JM)=H  Q(I,JMAX)
Q  Q(I,JM)=Q  Q(I,JMAX)
SI Q(I,JM)=SI Q(I,JMAX)
PHEQ(I,JM)=PHEQ(I,JMAX)
PHIQ(I,JM)=PHIQ(I,JMAX)
RHOQ(I,JM)=RHOQ(I,JMAX)
GAMQ(I,JM)=GAMQ(I,JMAX)
P  Q(L,JM)=P  Q(L,JMAX)
H  Q(L,JM)=H  Q(L,JMAX)
Q  Q(L,JM)=Q  Q(L,JMAX)
SI Q(L,JM)=SI Q(L,JMAX)
PHEQ(L,JM)=PHEQ(L,JMAX)
PHIQ(L,JM)=PHIQ(L,JMAX)
RHOQ(L,JM)=RHOQ(L,JMAX)
GAMQ(L,JM)=GAMQ(L,JMAX)
3947 CONTINUE
B  ZA= (Z(I,J)+Z(L,J))/2.

```

```

IT=1
10 RAT=(ZA-Z(I,J))/(Z(L,J)-Z(I,J))
ALAM=XPLAM(I,J)+RAT*(XPLAM(L,J)-XPLAM(I,J))
DUMP=A93*ALAM+B93*XPLAMN(I,J)
ZAT=Z3-DUMP*DELR
ERR=ABS((ZAT-ZA)/(Z(L,J)-Z(I,J)))
IF(ERR.LT.ERZZZ)GO TO 9
ZA=ZAT
IT=IT+1
IF(IT.LE.10)GO TO 10
WRITE(6,200)
200 FORMAT(* ERROR IN A POINT ITERATION IN FSHOCK*)
CALL PNCH
9 CONTINUE
PA=P(I,J)+RAT*(P(L,J)-P(I,J))
QA=Q(I,J)+RAT*(Q(L,J)-Q(I,J))
HA=H(I,J)+RAT*(H(L,J)-H(I,J))
RHA=RHO(I,J)+RAT*(RHO(L,J)-RHO(I,J))
SIA=SI(I,J)+RAT*(SI(L,J)-SI(I,J))
PHIA=PHI(I,J)+RAT*(PHI(L,J)-PHI(I,J))
PHEA=PHE(I,J)+RAT*(PHE(L,J)-PHE(I,J))
TA=FT(PA,PHIA,HA)
GAMA=FGAM(TA,PA,PHIA)
AA=SQRT(GAMA*PA/RHA)
CALL F (RHO(I,J),Q(I,J),R,Z(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J),SI
1(I,J),
1A(I,J),SIQ(I,J),PQ(I,J),PHEQ(I,J),FP1,FM1)
CALL F (RHO(L,J),Q(L,J),R,Z(L,J),PHE(L,J),XPLAM(L,J),XMLAM(L,J),SI
1(L,J),
1A(L,J),SIQ(L,J),PQ(L,J),PHEQ(L,J),FP2,FM2)
RQ2=QN(I,J)*QN(I,J)*RHON(I,J)
FMA=FP1+RAT*(FP2-FP1)
Q2=QA+QA
A1=FMA/RHA/Q2
A1=AAV*A1+BAV*FPN(I,J)/RQ2
AC=B93*SQRT((QN(I,J)/AN(I,J))**2-1.)/RQ2
A2=SQRT((QA/AA)**2-1.)/RHA/Q2
A2=A93*A2+AC
IT=1
ZB=(Z(I,J)+Z(L,J))/2.
12 RAT=(ZB-Z(I,J))/(Z(L,J)-Z(I,J))
BLAM=XMLAM(I,J)+RAT*(XMLAM(L,J)-XMLAM(I,J))
DUMP=A93*BLAM+B93*XMLAMN(I,J)
ZAT=Z3-DUMP*DELR
ERR=ABS((ZAT-ZB)/(Z(L,J)-Z(I,J)))
IF(ERR.LT.ERZZZ)GO TO 14
ZB=ZAT
IT=IT+1
IF(IT.LE.10)GO TO 12
WRITE(6,201)
201 FORMAT(* ERROR IN B POINT ITERATION IN FSHOCK*)
CALL PNCH
14 PB=P(I,J)+RAT*(P(L,J)-P(I,J))
QB=Q(I,J)+RAT*(Q(L,J)-Q(I,J))
HB=H(I,J)+RAT*(H(L,J)-H(I,J))
RHB=RHO(I,J)+RAT*(RHO(L,J)-RHO(I,J))

```

```

SIR=SI(I,J)+RAT*(SI(L,J)-SI(I,J))
PHIB=PHI(I,J)+RAT*(PHI(L,J)-PHI(I,J))
PHEB=PHE(I,J)+RAT*(PHE(L,J)-PHE(I,J))
TB=FT(PB,PHIB,HB)
GAMB=FGAM(TB,PB,PHIB)
AB=SQRT(GAMB*PB/RHB)
FMB=FM1+RAT*(FM2-FM1)
Q2=QB*QB
R1=FMB/RHB/Q2
R1=AAV*B1+BAV*FMN(I,J)/RQ2
R2=SQRT((QB/AB)**2-1.)/RHB/Q2
R2=A93*B2+AC
IT=1
ZD=(ZA+ZB)/2.
16 RAT=(ZD-ZA)/(ZP-ZA)
ALAMD=TAN(PHEA)+RAT*(TAN(PHEB)-TAN(PHEA))
DUMP=A93*ALAMD+B93*TAN(PHEN(I,J))
ZAT=Z3-DUMP*DELR
ERR=ABS((ZAT-ZD)/(ZB-ZA))
IF(ERR.LT.ERZZZ)GO TO 18
ZD=ZAT
IT=IT+1
IF(IT.LE.10)GO TO 16
WRITE(6,202)
202 FORMAT(* ERROR IN D POINT ITERATION IN FSHOCK*)
18 PD=PA+RAT*(PB-PA)
QD=QA+RAT*(QB-QA)
HD=HA+RAT*(HB-HA)
RHD=RHA+RAT*(RHB-RHA)
SID=SIA+RAT*(SIB-SIA)
PHID=PHIA+RAT*(PHIB-PHIA)
PHED=PHEA+RAT*(PHEB-PHEA)
TD=FT(PD,PHID,HD)
GAMD=FGAM(TD,PD,PHID)
AD=SQRT(GAMD*PD/RHD)
RAT=(ZD-Z(I,J))/(Z(L,J)-Z(I,J))
PDQ=PQ(I,J)+RAT*(PQ(L,J)-PQ(I,J))
QDQ=QQ(I,J)+RAT*(QQ(L,J)-QQ(I,J))
HDQ=HQ(I,J)+RAT*(HQ(L,J)-HQ(I,J))
RHDQ=RHOQ(I,J)+RAT*(RHOQ(L,J)-RHOQ(I,J))
SIDQ=SIQ(I,J)+RAT*(SIQ(L,J)-SIQ(I,J))
PHIDQ=PHIQ(I,J)+RAT*(PHIQ(L,J)-PHIQ(I,J))
PHEDQ=PHEQ(I,J)+RAT*(PHEQ(L,J)-PHEQ(I,J))
GAMDQ=GAMQ(I,J)+RAT*(GAMQ(L,J)-GAMQ(I,J))
PN(I,J)=(A2*PA+B2*PB+(A1-B1)*DELR+PHEA-PHEB)/(A2+B2)
PHEN(I,J)=PHEA-A2*(PN(I,J)-PA)+A1*DELR
VD=QD*TAN(SID)
T1=DELR/COS(PHED)
IF(XJ.EQ.1.)T1=T1/ZD
IF(XJ.EQ.1.)T1=T1/R
T2=PDQ/RHD/QD
T3=TAN(SID)*QDQ
T4=QD*SIDQ/COS(SID)**2
T5=QD*COS(PHED)*XJ
1+QD*SIN(PHED)*XJ1

```

```

VC=VD-T1*(T2+TAN(SID)*(T3+T4+TE))*AAV
SPHEN=SIN(PHEN(I,J))
TSIN=TAN(SINN(I,J))
CSIN=COS(SINN(I,J))
CPHEN=COS(PHEN(I,J))
TT1=DELR/CPHEN
IF(XJ1.GT.0.) TT1=TT1/ZN(I,J)
IF(XJ.GT.0.) TT1=TT1/RN
T22=PN(I,J)/RHON(I,J)/QN(I,J)
T33=TSIN*QQN(I,J)
T44=QN(I,J)*SION(I,J)/CSIN
T55=QN(I,J)*(CPHEN*XJ+SPHEN*XJ1)
DVC=TT1*(T22+TSIN*(T33+T44+T55))*BAV
VC=VC-DVC
T11=DELR*TAN(SIT)/COS(PHET)
IF(XJ1.GT.0.) T11=T11/ZN(I,J)
IF(XJ.GT.0.) T11=T11/RN
T1=T1*TAN(SID)
T1=T1*A93+T11*B93
RHOZ=RHD-RHDQ*T1
PZ=PD-PDQ*T1
GAMZ=GAMD-GAMDQ*T1
RHON(I,J)=RHOZ*(PN(I,J)/PZ)**(1./GAMZ)
T2=(QDQ+QD*TAN(SID)*SIDQ)/COS(SID)
VVZ=QD/COS(SID)-T2*T1
VVC=VVZ*VVZ+2.*GAMZ/(GAMZ-1.)*(PZ/RHOZ-PN(I,J)/RHON(I,J))
QN(I,J)=SQRT(VVC-VC*VC)
SINN(I,J)=ATAN(VC/QN(I,J))
HN(I,J)=HD-HDQ*T1+(VVZ*VVZ-VVC)/2.
PHIN(I,J)=PHID-PHIDQ*T1
EC=ABS(1.-PT/PN(I,J))
TN(I,J)=FT(PN(I,J),PHIN(I,J),HN(I,J))
GAMN(I,J)=FGAM(TN(I,J),PN(I,J),PHIN(I,J))
AN(I,J)=SQRT(GAMN(I,J)*PN(I,J)/RHON(I,J))
CALL XLAM(QN(I,J),AN(I,J),PHEN(I,J),XPLAMN(I,J),XMLAMN(I,J))
IF(EC.LT.1.E-04.OR.IVY.EQ.0) GO TO 6
SIT=SINN(I,J)
PHET=PHEN(I,J)
PT=PN(I,J)
KIL=KIL+1
IF(KIL.GT.5) GO TO 1493
A93=.5
R93=.5
GO TO 8
1493 WRITE(6,1393)
1393 FORMAT(* AVERAGING PROCESS DOES NOT CONVERGE IN FSHOCK*)
STOP
6 CONTINUE
XJ1=XJ1S
RETURN
END

```

SUBROUTINE WSHK(M,B)

COMMON /A/ XXI, THMAX, TH(10), R, Z(40,10), P(40,10), PHF(40,10),
1 Q(40,10), SI(40,10), H(40,10), PU(40,10), RHO(40,10), GAM(40,10)
COMMON /B/ PN(40,10), PHIN(40,10), RHON(40,10), HN(40,10), ZN(40,10)
COMMON /C/ IMAX(10), JMAX, ISTART, KOUNTF, KOUNTP
COMMON /D/ UW(40), VW(40), WW(40), XW(40), YW(40), THW(40)
COMMON /E/ UWN(40), VWN(40), WWN(40), XWN(40), YWN(40), THWN(40)

COMMON /I/ XJ

COMMON /K/ RN, DELR

COMMON /L/ ALPHAN(7,10), ALPHA(7,10), BETAN(7,10), BETA(7,10)

COMMON /M/ IS(7,10)

COMMON /O/ ALP(7,10), ALPN(7,10)

COMMON /V/ XJ1

COMMON /W/ ISIMEX, IDUMMY, JINT, DUMMY(40), THWW(2), JD1, JD2

COMMON /SA/ XJIS

JW=JMAX+1

IF(JW.GT.JINT) XJ1=0.

I=IS(M,JW)

K=IS(M,JMAX)

L=-1

IF((M/2)*2.EQ.M) L=1

Z3=ZN(K,JMAX)

Z1=Z(I,JW)

THWX=THW(I)*XJ

Y1=YW(I)

X1=XW(I)

THX=TH(JMAX)*XJ

Y3=RN*SIN(THX)+TH(JMAX)*(1.-XJ)

X3=RN*COS(THX)

X2=X3

FX1=TAN(BETA(M,JW))

FY1=TAN(ALP(M,JW))

FX2=TAN(BETAN(M,JW))

FY22=TAN(ALPHAN(M,JW))/COS(BETAN(M,JW))

DR=RN-R

11 Z2=ZN(I,JW)

IT=1

10 IF(XJ1.EQ.0.)

1CALL SWALL(RN,Z2,X2,Y2,GX2,GZ2)

IF(XJ1.GT.0.) CALL SWALL1(TH2,RN,Z2,GX2,GZ2)

IF(XJ1.EQ.0.)

1TH2=ATAN(Y2/X2)

IF(XJ.EQ.0.) TH2=Y2

TH2X=TH2*XJ

IF(XJ1.GT.0.) Y2=RN*SIN(TH2X)+TH2*(1.-XJ)

FY2=FX2*GX2-GZ2

Z2=ZN(I,JW)+(FY22+FY2)*(Y2-Y1)/2.

IT=IT+1

IF(IT.GT.2) GO TO 22

GO TO 10

22 CONTINUE

IF(IT.GT.3) GO TO 25

RAT=(Y1-Y2)/(Y3-Y2)

RDU=(BETAN(M,JW)-RAT*BETAN(M,JMAX))/(1.-RAT)

FX2=TAN(BDU)

GO TO 10

```
25 FR2=FY2
   IF (ABS(FY2).LT.1.E-06) FY2=0.
   ALP2=FY2
14 THWN(I)=TH2
   ZN(I,JW)=Z2
   ZN(I+L,JW)=Z2
   XWN(I)=X2
   YWN(I)=Y2
   THWN(I+L)=TH2
   XWN(I+L)=X2
   YWN(I+L)=Y2
   ALPN(M,JW)=ATAN(ALP2)
   B2=FR2
   BETAN(M,JW)=ATAN(B2)
   ALPHAN(M,JW)=ATAN(ALP2*COS(BETAN(M,JW)))
   XJ1=XJ1S
   RETURN
   END
```


SUBROUTINE COWL(MM,IFS,OPT)

```
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PDI(40,10),RHO(40,10),GAM(40,10)
COMMON /R/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)
COMMON /H/ ISIM
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1 XMLAM(40,10),FP(40),FM(40),E(40,10)
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON /M/ IS(7,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /P/ KC1,KC2,KS1,KS2
COMMON /Q/ XCOWL
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /SA/ XJ1S
COMMON /WR/ IWRAP
DIMENSION VL(9),VT(9),PM(9),UM(9),PHM(9),ZM(9),HM(9),RHM(9),BM( 9)
1,GM(9),QM(9),AL(10),SIGNVL(9)
CALL INDAT2(MM,IFS,AL)
JW=JMAX
DO 89 I=1,9
89 SIGNVL(I)=1.
IF(ISIM.EQ.0) JW=JMAX+1
DO 666 J=1,JW
IS(1,J)=IMAX(J)
J=IMAX(J)
ZN(I,J)=Z(I,J)
BETAN(1,J)=0.
666 CONTINUE
IF(IWRAP.EQ.0) CALL ALWRAP(1)
XW1=XCOWL
IF(ISIM.EQ.0) CALL SWALL(XCOWL,7(2,JW),XW1,YW1,GX,GZ)
DO 6 J=1,JW
IF(J.GT.JINT) XJ1=0.
I=IMAX(J)
1 IF(P(I+MM,J)-P(I,J)) 4,39,5
39 WRITE(6,300)
300 FORMAT(* 2 SHOCKS NECESSARY FROM COWL LIP*)
CALL PNCH
5 OPT=1.
KC1=3
KS2=2
K=KS2
L=IMAX(J)
M=L+MM
GO TO 8
4 OPT=-1.
KC1=3
KS1=1
K=KS1
M=IMAX(J)
L=M+MM
8 VTT=Q(L,J)*SQRT(1.+TAN(SI(L,J))**2)
XMU=ASIN( SQRT(GAM(L,J)*P(L,J)/RHO(L,J))/VTT)
```

ITT=1

IF(J.EQ.JINT.OR.J.EQ.JINT+1) AL(J)=ALPN(K,J)

ALPHA(K,J)=AL(J)

CA=COS(ALPHA(K,J))

BET=-OPT*(XMU+5./57.3+PHE(L,J))/CA

SA=SIN(ALPHA(K,J))

TSI=TAN(SI(L,J))

SPE=SIN(PHE(L,J))

CPE=COS(PHE(L,J))

IFAN1=MM

IFAN=IFAN1-3

KP=1

JJ=1

IF(KP.EQ.1) JJ=0

II=IFAN1

IF((K/2)*2.EQ.K) II=1

II=II-1

IF((K/2)*2.EQ.K) II=II+1

VL(II)=(Q(L,J)*(TSI*CA+SA*SPE))

IF(J.NE.JMAX+1) GO TO 5000

PE=ATAN(GX)

WB=Q(L,J)*SPE

UB=Q(L,J)*(COS(PE)*CPE+SIN(PE)*TSI)

VB=Q(L,J)*(TSI*COS(PE)-CPE*SIN(PE))

PHEB=ATAN(WB/UB)

QB=UB/COS(PHEB)

TSI=VB/QB

CA=1.

SA=0.

SPE=SIN(PHEB)

CPE=COS(PHEB)

VL(II)=VB

000 CONTINUE

SIGNVL(II)=SIGN(1.,VL(II))

VL(II)=VL(II)**2

ISAVE=II

ISAVE1=I1

3 IT=1

II=ISAVE

I1=ISAVE1

VT(II)=(Q(L,J)*(COS(BET)*CPE-SIN(BET)*(SA*TSI-SPE*CA)))**2

U1=Q(L,J)*(SIN(BET)*CPE+COS(BET)*(SA*TSI-CA*SPE))

IF(J.NE.JMAX+1) GO TO 5001

U1=QB*SIN(BET-PHEB)

VT(II)=(QB*COS(BET-PHEB))**2

001 CONTINUE

U1=ABS(U1)

GM1=GAM(L,J)-1.

GP1=GAM(L,J)+1.

XM1=U1/SQRT(GAM(L,J)*P(L,J)/RHO(L,J))

XMS=RHO(L,J)*U1

IF(IT.EQ.1)UM(II)=U1*(GM1*XM1*XM1+2.)/GP1/XM1/XM1

7 RH2=XMS/UM(II)

PM(II)=XMS*(U1-UM(II))+P(L,J)

V2=VT(II)+VL(II)

V1=V2+U1*U1

```

V2=V2+UM(II)**2
PHM(II)=PHI(L,J)
ZM(II)=Z(L,J)
HM(II)=H(L,J)+(V1-V2)/2.
RHM(II)=RHEQ(HM(II),PM(II),PHM(II))
FR=(RH2-RHM(II))/RHO(L,J)
IF(ABS(ER).LT.1.E-04) GO TO 6
IT=IT+1
IF(IT.GT.10) GO TO 100
IF(IT.GT.2) GO TO 11
ER2=ER
U2=UM(II)
UM(II)=UM(II)*.99
GO TO 7
100 WRITE(6,200)
200 FORMAT(* ERROR IN HUGONIOT LOOP IN COWL*)
CALL PNCH
101 WRITE(6,201)
201 FORMAT(* SUBSONIC EDGE IN COWL AROUND STATEMENT NUMBER 13*)
CALL PNCH
11 DUM2=U2-ER2*(UM(II)-U2)/(ER-ER2)
6020 ER2=ER
U2=UM(II)
UM(II)=DUM2
GO TO 7
9 PM(II)=PM(II)
HM(II)=HM(II)
ZM(II)=ZM(II)
RHM(II)=RHM(II)
PHM(II)=PHM(II)
VL(II)=VL(II)
SIGNVL(II)=SIGNVL(II)
VT(II)=VT(II)
BM(II)=BET
RM(II)=BET
UM(II)=-OPT*UM(II)
US2=SQRT(VT(II))*COS(BM(II))+UM(II)*SIN(BM(II))
WS2=SQRT(VT(II))*SIN(BM(II))-UM(II)*COS(BM(II))
PHES=ATAN(WS2/US2)
UM(II)=UM(II)
DP=(P(M,J)-PM(II))/FLOAT(IFAN-1)
VTT=(Q(M,J)**2)*(1.+TAN(SI(M,J))**2)
II=1
IF((K/2)*2.EQ.K) II=IFAN1
ZM(II)=Z(M,J)
HM(II)=H(M,J)
PM(II)=P(M,J)
RHM(II)=RHO(M,J)
GM(II)=GAM(M,J)
PHM(II)=PHI(M,J)
UM(II)=GM(II)*PM(II)/RHM(II)
VL(II)=(Q(M,J)*(CA*TAN(SI(M,J))+SA*SIN(PHE(M,J))))
IF(J.NE.JMAX+1) GO TO 5002
WB=Q(M,J)*SIN(PHE(M,J))
UB=Q(M,J)*(COS(PE)*COS(PHE(M,J))+SIN(PE)*TAN(SI(M,J)))
VB=Q(M,J)*(TAN(SI(M,J))*COS(PE)-COS(PHE(M,J))*SIN(PE))

```

```

PHEB=ATAN(WB/UR)
QB=UB/COS(PHEB)
VL(II)=VB
5002 CONTINUE
SIGNVL(II)=SIGN(1.,VL(II))
VL(II)=VL(II)**2
VT(II)=VTT-VL(II)-UM(II)
QM(II)=VTT-VL(II)
13 XMM=QM(II)/UM(II)
IF(XMM.LT.1.) GO TO 101
B=-SA*TAN(SI(M,J))+CA*SIN(PHE(M,J))
A=COS(PHE(M,J))
C=SQRT(VT(II))/Q(M,J)
D=SQRT(A*A+B*B)
BM(II)=OPT*ASIN(SQRT(1./XMM))+ATAN(B/A)
IF(J.EQ.JMAX+1)BM(II)=OPT*ASIN(SQRT(1./XMM))+PHEB
HTL=HM(II)+(VTT-VL(II))/2.
IFF=IFAN+1
IF1=IFF
IF((K/2)*2.EQ.K) IFF=IFAN1
DO 12 LL=2,IF1
N=LL
IF((K/2)*2.EQ.K) N=IFF-LL+1
KK=N-1
IF((K/2)*2.EQ.K) KK=N+1
IF((K/2)*2.NE.K.AND.N.EQ.IFF) DP=0.
IF((K/2)*2.EQ.K.AND.N.EQ.3) DP=0.
ZM(N)=ZM(KK)
PM(N)=PM(KK)-DP
ALNR=ALOG(PM(N)/PM(KK))/GM(KK)
RHM(N)=ALOG(RHM(KK))+ALNR
RHM(N)=EXP(RHM(N))
G1=SQRT((GM(KK)+1.)/(GM(KK)-1.))
G2=.5*GM(KK)/(GM(KK)-1.)
QM(N)=QM(KK)-G2*(PM(N)/RHM(N)-PM(KK)/RHM(KK))
HM(N)=HTL+( -QM(N))/2.
C1=UM(KK)*G1*G1+VT(KK)
PHM(N)=PHM(KK)
TM=FT(PM(N),PHM(N),HM(N))
GM(N)=FGAM(TM,PM(N),PHM(N))
UM(N)=GM(N)*PM(N)/RHM(N)
VL(N)=VL(KK)
SIGNVL(N)=SIGNVL(KK)
VT(N)=QM(N)-UM(N)
BM(N)=-OPT*G1*(ASIN(SQRT(VT(N)/C1))-ASIN(SQRT(VT(KK)/C1)))+BM(KK)
12 CONTINUE
XMU=SQRT(UM(N)/QM(N))
XMU=ASIN(XMU)
PHEP=BM(N)-OPT*XMU
ERR=PHEB-PHEP
IF(ABS(ERR).LT.1.E-04) GO TO 15
ITT=ITT+1
IF(ITT.GT.15) GO TO 102
IF(ITT.GT.2) GO TO 14
ERR1=ERR
RET1=RET

```

```

RET=1.01*BET
GO TO 3
102 WRITE(6,203)
203 FORMAT(* ERROR IN BETA SHOCK IN COWL*)
CALL PNCH
14 DUM1=BET1-ER1*(BET-BET1)/(ERR-FR1)
ER1=ERR
BET1=BET
BET=DUM1
GO TO 3
15 CONTINUE
DO 16 LL=1,IF1
N=LL
IF((K/2)*2.EQ.K) N=IFF-LL+1
UM(N)=OPT*SQRT(UM(N))
16 CONTINUE
ALP(K,J)=AL(J)
TB=TAN(BET)*COS(ALP(K,J))
IF(J.EQ.JMAX+1) TB=TAN(BET)*COS(PE)
RETAN(K,J)=ATAN(TB)
BETA(K,J)=BETAN(K,J)
IF(J.EQ.JMAX+1) ALP(K,J)=ATAN(TAN(BET)*GX)
ALPN(K,J)=ALP(K,J)
IF(J.EQ.JMAX+1) ALPHA(K,J)=ATAN(GX*SIN(BETA(K,J)))
ALPHAN(K,J)=ALPHA(K,J)
ALP(KC1,J)=AL(J)
TP=TAN(PHEP)*COS(ALP(KC1,J))
IF(J.EQ.JMAX+1) TP=TAN(PHEP)*COS(PE)
RETAN(KC1,J)=ATAN(TP)
BETA(KC1,J)=BETAN(KC1,J)
IF(J.EQ.JMAX+1) ALP(KC1,J)=ATAN(TAN(PHEP)*GX)
ALPHA(KC1,J)=ALPHA(K,J)
IF(J.EQ.JMAX+1) ALPHA(KC1,J)=ATAN(GX*SIN(BETA(KC1,J)))
ALPHAN(KC1,J)=ALPHA(KC1,J)
ISS=IMAX(J)
IMAX(J)=IMAX(J)+MM-1
IS(K,J)=IMAX(J)+1
IF((K/2)*2.EQ.K) IS(K,J)=IMAX(J)-MM+1
IS(KC1,J)=IS(K,J)-2
IF((K/2)*2.EQ.K) IS(KC1,J)=IS(K,J)+3
IK=ISS
IF((K/2)*2.EQ.K) IK=ISS+1
DO 29 KK=1,IFAN1
IF((K/2)*2.NE.K.AND.KK.GE.(IFAN1-2)) GO TO 19
IF((K/2)*2.EQ.K.AND.KK.GE.3) GO TO 19
IF(((K/KP)*KP+JJ).NE.KK) GO TO 29
19 P(IK,J)=PM(KK)
VTT=SQRT(UM(KK)*UM(KK)+VT(KK)+VL(KK))
CB=COS(BM(KK))
SB=SIN(BM(KK))
VV=+SA*CB*(UM(KK))-SB*SA*SQRT(VT(KK))+CA*SQRT(VL(KK))*SIGNVL(
1KK)
IF(J.NE.JMAX+1) GO TO 5003
UB=UM(KK)*SB*SQRT(VT(KK))*CB
VB=SQRT(VL(KK))*SIGNVL(KK)
VV=UR*SIN(PE)+VB*COS(PE)

```

5003 CONTINUE

SI (IK,J)=VV/VT
SI (IK,J)=ASIN(SI (IK,J))
WV=-CA*CA* (UM(KK))+SB*CA*SQRT(VT(KK))+SA*SQRT(VL(KK))*SIGNVL(

1KK)

UV=SB* (UM(KK))+CB*SQRT(VT(KK))
IF(J.EQ.JMAX+1)UV=UB*COS(PE)-VB*SIN(PE)

Q(IK,J)=SQRT(UV*UV+WV*WV)
PHE (IK,J)=ASIN(WV/Q (IK,J))

PHI (IK,J)=PHM(KK)

Z (IK,J)=ZM(KK)

RHO (IK,J)=RHM(KK)

H (IK,J)=HM(KK)

T=FT(PM(KK),PHM(KK),HM(KK))

GAM(IK,J)=FGAM(T,PM(KK),PHM(KK))

E(IK,J)=SQRT(GAM(IK,J)*P(IK,J)/RHO(IK,J))

CALL XLAM(Q(IK,J),E(IK,J),PHE(IK,J),XPLAM(IK,J),XMLAM(IK,J))

IF(J.NE.JMAX+1) GO TO 210

UW(IK)=Q(IK,J)*COS(PHE(IK,J))

WW(IK)=Q(IK,J)*SIN(PHE(IK,J))

XW(IK)=R

IF(XJ1.EQ.0.)

1CALL SWALL(R,Z(IK,J),XW(IK),YW(IK),FX,FZ)

IF(XJ1.GT.0.) CALL SWALL1(THX,R,Z(IK,J),FX,FZ)

VW(IK)=UW(IK)*FX+WW(IK)*FZ

VW(IK)=VW(IK)*Z(IK,JW)**XJ1

IF(XJ1.EQ.0.)

1THW(IK)=YW(IK)

IF(XJ1.GT.0.) THW(IK)=THX

SI(IK,J)=ATAN(VW(IK)/Q(IK,J))

210 CONTINUE

IK=IK+1

29 CONTINUE

IMAX(J)=IMAX(J)+IFS

6 CONTINUE

XJ1=XJ1S

RETURN

END

SUBROUTINE WDI&C(M)

COMMON /A/ XI,THMAX,TH(10),R,Z(40,10),P(40,10),PHF(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)

COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP

COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)

COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)

COMMON /I/ XJ

COMMON /J/ GN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1 XMLAM(40,10),FP(40),FM(40),A(40,10)

COMMON /K/ RN,RELK

COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)

COMMON /M/ IS(7,10)

COMMON /O/ ALP(7,10),ALPN(7,10)

COMMON /P/ KC1,KC2,KS1,KS2

COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL

COMMON /U/ ERZZZ

COMMON /V/ XJ1

COMMON /W/ ISIMEX, IDUMMY, JINT, IDUMMY(40), THWW(2), JD1, JD2

COMMON /SA/ XJIS

IF(JW.GT.JINT) XJ1=0.

I=IS(M,JW)

II=I

1=1

ITT=1

IF((M/2)+2.EQ.M) L=-1

K=I-L

LL=2*L

RAT=0.

WOU2=0.

PNK=0.

IF(I.EQ.IMAX(JW)-1) GO TO 41

IF(M.EQ.3) GO TO 42

RAT=(ZN(I,JW)-ZN(I+LL,JW))/(ZN(I+L,JW)-ZN(I+LL,JW))

PNK=PN(I+LL,JW)

41 PN(I,JW)=PN(I+LL,JW)+RAT*(PN(I+L,JW)-PNK)

WOU2=WWN(I+LL)/UWN(I+LL)

WOU1=WWN(I+L)/UWN(I+L)

WOU=WOU2+RAT*(WOU1-WOU2)

GO TO 10

42 RAT1=(THWN(I)-TH(JMAX))/(THW(I)-TH(JMAX))

I5=IS(3,JMAX-1)

PN(I,JW)=PN(I5,JMAX)+RAT1*(PN(I,JW)-PN(I5,JMAX))

PN(K,JW)=PN(I,JW)

10 CONTINUE

THX=THWN(II)*XJ

THDUM=THWN(II)

YWN(II)=RN*SIN(THX)+THWN(II)*(1.-XJ)

XWN(II)=RN*COS(THX)

IF(XJ1.EQ.0.)

1CALL SWALL(RN,ZN(II,JW),XWN(II),YWN(II),FX,FZ)

IF(XJ1.GT.0.) CALL SWALL1(THDUM,RN,ZN(II,JW),FX,FZ)

IF(M.NE.KC1.AND.M.NE.KC2) GO TO 11

C1=TAN(BETAN(M,JW))*COS(THX)+TAN(ALPN(M,JW))*SIN(THX)

C2=-TAN(BETAN(M,JW))*SIN(THX)+TAN(ALPN(M,JW))*COS(THX)

ZNXJ=1.

```

IF(XJ1.GT.0.) ZNXJ=ZN(II,JW)
WOU=(C1+FX*C2*ZNXJ)/(1.-FZ*C2*ZNXJ)
11 VOU=FX+WOU*FZ
IF(XJ1.GT.0.) VOU=VOU*ZN(II,JW)
ZSL=Z(II,JW)
USL=UW(II)
VSL=VW(II)
WSL=WW(II)
XSL=XW(II)
TAUC=VOU
IT=1
IF(M.EQ.KC1.OR.M.EQ.KC2) GO TO 40
60 CONTINUE
IF(XJ1.EQ.0.)
ICALL SWALL(R,ZSL,XSL,YSL,FXSL,FZSL)
IF(XJ1.GT.0.) CALL SWALL1(THSL,R,ZSL,FXSL,FZSL)
DUM=(WOU+WSL/USL)/2.
ZSLT=ZN(I,JW)-DUM*(XWN(I)-XSL)
RAT=(ZSLT-Z(I,JW))/(Z(I+L,JW)-Z(I,JW))
WUSL=TAN(PHE(I,JW))+RAT*(TAN(PHE(I+L,JW))-TAN(PHE(I,JW)))
U1=Q(I,JW)*COS(PHE(I,JW))
U2=Q(I+L,JW)*COS(PHE(I+L,JW))
USL=U1+RAT*(U2-U1)
WSL=USL+WUSL
VU1=TAN(SI(I,JW))/COS(PHE(I,JW))
VU2=TAN(SI(I+L,JW))/COS(PHE(I+L,JW))
VUSL=VU1+RAT*(VU2-VU1)
VSL=VUSL+USL
ER=ABS((ZSLT-ZSL)/(Z(I+L,JW)-Z(I,JW)))
IF(ER.LT.ERZZZ) GO TO 40
ZSL=ZSLT
IT=IT+1
IF(IT.LT.10) GO TO 60
WRITE(6,1000)
000 FORMAT(* ERROR IN ITERATION LOOP IN WDISC*)
CALL PNCH
40 CONTINUE
IF(M.EQ.KC1.OR.M.EQ.KC2) RAT=0.
PSL=P(II,JW)+RAT*(P(II+L,JW)-P(II,JW))
HSL=H(II,JW)+RAT*(H(II+L,JW)-H(II,JW))
RHOSL=RHO(II,JW)+RAT*(RHO(II+L,JW)-RHO(II,JW))
PHISL=PHI(II,JW)+RAT*(PHI(II+L,JW)-PHI(II,JW))
TSL=FT(PSL,PHISL,HSL)
GAMSL=FGAM(TSL,PSL,PHISL)
PHIN(II,JW)=PHISL
RHON(II,JW)=RHOSL*(PN(II,JW)/PSL)**(1./GAMSL)
VVSL=USL*USL+VSL*VSL+WSL*WSL
VVC=VVSL+2.*GAMSL/(GAMSL-1.)*(PSL/RHOSL-PN(II,JW)/RHON(II,JW))
HTSL=HSL+.5*VVSL
HN(II,JW)=HTSL-.5*VVC
UWN(II)=SQRT(VVC/(1.+TAUC*TAUC+WOU*WOU))
VWN(II)=UWN(II)*TAUC
WWN(II)=UWN(II)*WOU
PHEN(II,JW)=WOU/(COS(THX)+VOU*SIN(THX))
PHEN(II,JW)=ATAN(PHEN(II,JW))
VB=VWN(II)*COS(THX)-UWN(II)*SIN(THX)

```



```
UB=VWN(II)*SIN(THX)+UWN(II)*COS(THX)
WB=WVN(II)
QN(II,JW)=SQRT(WB*WB+UB*UB)
SINN(II,JW)=ATAN(VB/QN(II,JW))
ITT=ITT+1
II=I-1
IF(ITT.GT.2) GO TO 80
IF(M.NE.KC1.AND.M.NE.KC2) CALL HSHOCK(M,JW,JW,1)
IF(M.EQ.KC1.OR.M.EQ.KC2) GO TO 10
80 XJ1=XJ1S
RETURN
END
```

```

SUBROUTINE PLANES(IND)
COMMON /ALLRI/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /JF/ JFINAL
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMA(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /H/ ISIM
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON/M/ IS(7,10)
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,PCOWL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(40),THWW(2),JD1,JD2
COMMON /IQ/ NUMEXP,ZSAV
COMMON/PS/ZR(40,2),PR(40,2),QR(40,2),HR(40,2),SIR(40,2),RHOR(40,2)
1,PHIR(40,2),PHER(40,2),THR(2),THWR(40)
COMMON /SPE/ KOUNTC
COMMON /PL/ DELTH
IF(IND.EQ.0) ZDUMMY(1)=Z(1,JINT)
IF(IND.EQ.1) ZDUMMY(1)=ZN(1,JINT)
J1=JINT
J2=JINT+1
IMAXJ=IMAX(J1)+1
DO 461 I=NUMEXP,IMAXJ
L=I
ZX=Z(I,JINT)
IF(IND.EQ.1) ZX=ZN(I,JINT)
IF(ZX      .GT.ZSAV) GO TO 465
461 CONTINUE
462 IDUMMY=L-1
IF(IND.EQ.1) GO TO 34
DELTH=1000.
DO 1000 J=J2,JMAX
I=JMAX+2-J
IF(JMAX.EQ.JW) I=I-1
DEL=Z(2,J)
IF(XJ1.GT.0.) DEL=ATAN(DEL/ZDUMMY(I))
IF(DEL.LT.DELTH) DELTH=DEL
1000 CONTINUE
DELTH=.9*DELTH
IF(DELTH.GT.TH(JINT)-TH(JINT-1)) DELTH=TH(JINT)-TH(JINT-1)
34 CONTINUE
ZDUM=DELTH
ZDUMS=ZDUM
J=1
DO 26 I=1,NUMEXP
IF(XJ1.GT.0.) ZDUM=ZDUMMY(I)*TAN(ZDUMS)
JM=JW-I+1
CALL TBL(ZDUM,PR(I,J),SIR(I,J),HR(I,J),PHIR(I,J),QR(I,J),PHER(I,J),
1,RH,GA,THX,JM,IMAX(JM),2)
RHOR(I,J)=RHEQ(HR(I,J),PR(I,J),PHIR(I,J))
T=FT(PR(I,J),PHIR(I,J),HR(I,J))
THWR(I) =FGAM(T,PR(I,J),PHIR(I,J))

```

```

7R(I,J)=ZDUMMY(I)
IF(XJ1.GT.0.) ZR(I,J)=ZR(I,J)/COS(ZDUMS)
IF(I.NE.1) GO TO 1500
IF(ISIM.EQ.1) GO TO 1500
XT=P
IF(XJ1.EQ.0.) CALL SWALL(R,ZDUM,XT,YT,FX,FZ)
IF(XJ1.GT.0.) CALL SWALL1(THX,P,ZDUM,FX,FZ)
TSI=COS(PHER(I,J))*FX+SIN(PHER(I,J))*FZ
SIR(I,J)=ATAN(TSI)
1500 CONTINUE
U1=QR(I,J)*COS(PHER(I,J))
IF(XJ1.GT.0.) GO TO 2001
V1=QR(I,J)*SIN(PHER(I,J))
W1=-QR(I,J)*TAN(SIR(I,J))
GO TO 2002
2001 WT=QR(I,J)*SIN(PHER(I,J))
VT=QR(I,J)*TAN(SIR(I,J))
V1=WT+COS(ZDUMS)+VT*SIN(ZDUMS)
W1=-VT*COS(ZDUMS)+WT*SIN(ZDUMS)
2002 CONTINUE
QR(I,J)=SQRT(U1*U1+W1*W1)
PHER(I,J)=ATAN(W1/U1)
SIR(I,J)=ATAN(V1/QR(I,J))
26 CONTINUE
J=2
DO 1001 I=1,IDUMMY
IF(IND.EQ.0) CALL TBLDUM(Z(I,JINT),PR(I,J),SIR(I,J),HR(I,J),PHIR
1(I,J),QR(I,J),PHER(I,J),RHOR(I,J),THWR(I),1,IDUMMY,I)
IF(IND.EQ.1) CALL TBLDUM(ZN(I,JINT),PR(I,J),SIR(I,J),HR(I,J),PHIR
1(I,J),QR(I,J),PHER(I,J),RHOR(I,J),THWR(I),1,IDUMMY,I)
IF(IND.EQ.0) ZR(I,2)=Z(I,JINT)
IF(IND.EQ.1) ZR(I,2)=ZN(I,JINT)
1001 CONTINUE
THR(2)=TH(JINT)+DELTH
RETURN
END

```

```

SUBROUTINE ALWRAP(M)
COMMON /A/ XI,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON/M/ IS(7,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /W/ ISIMEX, IDUMMY, JINT, IDUMMY(40), THWW(2), JD1, JD2
COMMON /IQ/ NUMEXP, ZSAV
COMMON /V/ XJ1
J1=JINT-1
J2=JINT
J3=JINT+1
J4=JINT+2
I1=IS(M, J1)
I2=IS(M, J2)
I3=IS(M, J3)
I4=IS(M, J4)
R2=ZN(I2, J2)-ZSAV
R3=ZN(I3, J3)
RQ2= (ZN(I2, J2)-ZN(I1, J1))/(TH(J2)-TH(J1))
RQ3= (ZN(I4, J4)-ZN(I3, J3))/(TH(J4)-TH(J3))
F1=1.5707963
F2=F1*F1
AL3=RQ3
AL2=RQ2
ALPN(M, J2)=ATAN(AL2)
ALPN(M, J3)=ATAN(AL3)
ALPHAN(M, J2)=ATAN(AL2*COS(BETAN(M, J2)))
ALPHAN(M, J3)=ATAN(AL3*COS(BETAN(M, J3)))
RETURN
END

```

SUBROUTINE ADDSUR

```
COMMON /ALLR1/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /TEM/ T(40,10)
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHF(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON /M/ IS(7,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL
COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(40),THWW(2),JD1,JD2
COMMON /IQ/ NUMEXP,ZSAV
COMMON /JF/ JFINAL
DELTH=TH(JMAX)-TH(JMAX-1)
IT=0
IMAXJ=IMAX(JW)
DO 510 I=1,IMAXJ
TEST=THW(I)-TH(JMAX)
TEST=TEST/DELTH
IF(TEST.GT.2.0) GO TO 520
IF(TEST.LT.0.5) GO TO 100
GO TO 510
520 IT=IT+1
510 CONTINUE
IF(IT.EQ.IMAX(JW)) GO TO 502
GO TO 600
100 JMAX=JMAX-1
JW=JW-1
JZ=JW+1
IF(ICOWL.EQ.0) GO TO 505
DO 30 I=3,NUMEXP
30 ZDUMMY(I-1)=ZDUMMY(I)
NUMEXP=NUMEXP-1
GO TO 505
502 IF(JW.LT.JFINAL) GO TO 36
WRITE(6,37)
37 FORMAT(* PROGRAM ATTEMPTING TO ADD REFERENCE PLANE - DIMENSION TOO
1 SMALL*)
C CALL PNCH
C STOP
GO TO 600
36 CONTINUE
JMAX=JMAX+1
JW=JW+1
IMAX(JW)=IMAX(JW-1)
JZ=JW-1
IF(ICOWL.EQ.0) GO TO 505
DO 40 I=2,NUMEXP
II=NUMEXP-I+2
III=II+1
```

```

40 ZDUMMY(I11)=ZDIJMMY(II)
NUMEXP=NUMEXP+1
505 CONTINUE
TH(JW)=TH(JZ)
IF(ICOWLT.EQ.1) IMAXJ=IMAXJ+1
DO 535 I=1,IMAXJ
Z(I,JW)=Z(I,JZ)
P(I,JW)=P(I,JZ)
PHE(I,JW)=PHE(I,JZ)
SI(I,JW)=SI(I,JZ)
H(I,JW)=H(I,JZ)
Q(I,JW)=Q(I,JZ)
PHI(I,JW)=PHI(I,JZ)
RHO(I,JW)=RHO(I,JZ)
L=JW
T(I,L)=FT(P(I,L),PHI(I,L),H(I,L))
GAM(I,L)=FGAM(T(I,L),P(I,L),PHI(I,L))
A(I,L)=SQRT(GAM(I,L)*P(I,L)/RHO(I,L))
CALL XLAM(Q(I,L),A(I,L),PHE(I,L),XPLAM(I,L),XMLAM(I,L))
535 CONTINUE
IF(ICOWLT.EQ.0) GO TO 20
DO 10 I12=1,7
ALP(I12,JW)=ALP(I12,JZ)
ALPHA(I12,JW)=ALPHA(I12,JZ)
BETA(I12,JW)=BETA(I12,JZ)
10 IS(I12,JW)=IS(I12,JZ)
20 CONTINUE
IF(JZ.GT.JW) GO TO 601
TH(JMAX)=TH(JMAX-1)+DELTH
IF(ICOWLT.EQ.1) ZDUMMY(2)=ZDUMMY(3)-DELTH
J=JMAX
J1=J-1
DO 540 I=1,IMAXJ
Z(I,J)=Z(I,JW)
IF(ICOWLT.EQ.1) GO TO 31
IF(I.EQ.1) CALL BWALL(R,TH(J),Z(I,J),DUM,DUM1)
IF(I.EQ.IMAX(JW)) CALL TWALL(R,TH(J),Z(I,J),DUM,DUM1)
GO TO 32
31 IF(I.NE.1) GO TO 32
Z(I,J)=0.
CALL TBL(ZDUMMY(2),P(I,J),SI(I,J),H(I,J),PHI(I,J),Q(I,J),PHE(I,J)
1,RHO(I,J),GAMX,THX,JINT,IDUMMY,2)
U1=Q(I,J)*COS(PHE(I,J))
V1=Q(I,J)*TAN(SI(I,J))
W1=Q(I,J)*SIN(PHE(I,J))
VT=-W1
WT=V1
Q(I,J)=SQRT(U1*U1+WT*WT)
PHE(I,J)=ATAN(WT/U1)
SI(I,J)=ATAN(VT/Q(I,J))
GO TO 33
32 CONTINUE
RAT=DELTH/(THW(I)-TH(JMAX-1))
P(I,J)=P(I,J1)+RAT*(P(I,JW)-P(I,J1))
SI(I,J)=SI(I,J1)+RAT*(SI(I,JW)-SI(I,J1))
Q(I,J)=Q(I,J1)+RAT*(Q(I,JW)-Q(I,J1))

```

```

H (I,J)=H (I,J1)+RAT*(H (I,JW)-H (I,J1))
PHE(I,J)=PHE(I,J1)+RAT*(PHE(I,JW)-PHE(I,J1))
PHI(I,J)=PHI(I,J1)+RAT*(PHI(I,JW)-PHI(I,J1))
RHO(I,J)=RHO(I,J1)+RAT*(RHO(I,JW)-RHO(I,J1))

```

```
33 CONTINUE
```

```
L=J
```

```
T(I,L)=FT(P(I,L),PHI(I,L),H(I,L))
```

```
GAM(I,L)=FGAM(T(I,L),P(I,L),PHI(I,L))
```

```
A(I,L)=SQRT(GAM(I,L)*P(I,L)/RHO(I,L))
```

```
CALL XLAM(Q(I,L),A(I,L),PHE(I,L),XPLAM(I,L),XMLAM(I,L))
```

```
IF(I.NE.IS(I,J)).AND.I.NE.IS(3,J1)) GO TO 540
```

```
M=1
```

```
IF(I.EQ.IS(3,J1)) M=3
```

```
TANALP=TAN(ALP(M,J1))+RAT*(TAN(ALP(M,JW))-TAN(ALP(M,J1)))
```

```
Z(I,J)=Z(I,J1)+(TAN(ALP(M,J1))+TANALP )*DELTH/2.
```

```
Z(I-1,J)=Z(I,J)
```

```
BETA(M,J)=ATAN(TAN(BETA(M,J1))+RAT*(TAN(BETA(M,JW))-TAN(BETA(M,J1))))
```

```
IS(M,J)=IS(M,J1)
```

```
ALP(M,J)=TANALP
```

```
ALPHA(M,J)=ATAN(ALP(M,J)*COS(BETA(M,J)))
```

```
ALP(M,J)=ATAN(ALP(M,J))
```

```
IF(M.EQ.3) GO TO 4021
```

```
CALL HSHOCK(M,J,J,1)
```

```
P (I-1,J)=P N(I-1,J)
```

```
Q (I-1,J)=Q N(I-1,J)
```

```
H (I-1,J)=H N(I-1,J)
```

```
T (I-1,J)=T N(I-1,J)
```

```
A (I-1,J)=A N(I-1,J)
```

```
SI (I-1,J)=SIN N(I-1,J)
```

```
PHE (I-1,J)=PHE N(I-1,J)
```

```
PHI (I-1,J)=PHI N(I-1,J)
```

```
RHO (I-1,J)=RHO N(I-1,J)
```

```
GAM (I-1,J)=GAM N(I-1,J)
```

```
XPLAM(I-1,J)=XPLAMN(I-1,J)
```

```
XMLAM(I-1,J)=XMLAMN(I-1,J)
```

```
GO TO 540
```

```
4021 CONTINUE
```

```
540 CONTINUE
```

```
GO TO 600
```

```
601 IF(IMAX(JMAX).EQ.IMAX(JW)) GO TO 600
```

```
DO 602 I=1,IMAXJ
```

```
CALL TBL(Z(I,JW),PN(I,JMAX),SINN(I,JMAX),HN(I,JMAX),PHIN(I,JMAX),
```

```
IGN(I,JMAX),PHEN(I,JMAX),RHON(I,JMAX),GATHX,JMAX,IMAX(JMAX),I)
```

```
602 CONTINUE
```

```
DO 603 I=1,IMAXJ
```

```
Z (I,JMAX)=Z (I,JW)
```

```
P (I,JMAX)=PN (I,JMAX)
```

```
H (I,JMAX)=HN (I,JMAX)
```

```
Q (I,JMAX)=QN (I,JMAX)
```

```
SI (I,JMAX)=SINN(I,JMAX)
```

```
PHE(I,JMAX)=PHEN(I,JMAX)
```

```
PHI(I,JMAX)=PHIN(I,JMAX)
```

```
RHO(I,JMAX)=RHON(I,JMAX)
```

```
L=JMAX
```

```
T(I,L)=FT(P(I,L),PHI(I,L),H(I,L))
```

```
GAM(I,L)=FGAM(T(I,L),P(I,L),PHI(I,L))
A(I,L)=SQRT(GAM(I,L)*P(I,L)/RHO(I,L))
CALL XLAM(Q(I,L),A(I,L),PHE(I,L),XPLAM(I,L),XMLAM(I,L))
603 CONTINUE
IMAX(JMAX)=IMAX(JW)
600 CONTINUE
RETURN
END
```


SUBROUTINE EMBED

```

COMMON /A/ XI,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHY(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMAJ(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1 XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON /M/ IS(7,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
DATA IM2/0/,IM7/0/
DPHES=7.5/57.3
DO 500 M=1,7
IF(M.NE.2.AND.M.NE.7) GO TO 500
IF(IM2.EQ.1.AND.M.EQ.2) GO TO 500
IF(IM7.EQ.1.AND.M.EQ.7) GO TO 500
DELJ=.E+06
DO 6 J=1,JW
DELRR=1.E+06
JM=IMAX(J)-1
DO 1 I=1,IM
DZ=Z(I+1,J)-Z(I,J)
IF(DZ.LT.1.E-04) GO TO 1
DZLAM=XPLAM(I,J)-XPLAM(I+1,J)
IF(M.EQ.2) DZLAM=XMLAM(I,J)-XMLAM(I+1,J)
IF(DZLAM.LT.1.E-10) GO TO 1
DI=DZ/DZLAM
IF(DI) 1,1,7
7 IF(DI-DELRR) 17,17,1
17 DELRR=DI
IS(M,J)=I+1
IF(M.EQ.2) IS(M,J)=I
1 CONTINUE
DJ=DELRR
IF(DJ-DELJ) 5,5,6
5 DELJ=DJ
JS=J
6 CONTINUE
IF(DELJ.GT.10. ) GO TO 502
K=IS(M,JS)
L=-1
IF(M.EQ.2) L=1
PHET=XPLAM(K,JS)-XPLAM(K+L,JS)
IF(M.EQ.2) PHET=XMLAM(K+L,JS)-XMLAM(K,JS)
IF(ABS(PHET/DPHES).GT.1.) GO TO 501
GO TO 502
501 J=JS
WRITE(6,503)
503 FORMAT(1H1)
IF(M.EQ.7) GO TO 506
WRITE(6,505) IS(M,J),J
505 FORMAT(10X,*DOWNRUNNING EMBEDDED SHOCK FOUND AT I = *,I3,6X,
1 *J = *,I2)
GO TO 11

```

```
506 WRITE(6,508) IS(M,J),J
508 FORMAT(10X,*UPRUNNING EMBEDDED SHOCK FOUND AT I = *,I3,6X,
1*J = *,I2)
11 CONTINUE
    IF(M.EQ.2) IM2=1
    IF(M.EQ.7) IM7=1
502 DO 509 J=1,JW
509 IS(M,J)=0
500 CONTINUE
    RETURN
    END
```

```

SUBROUTINE DERIVN(MM)
COMMON /IQ/ NUMEXP,ZSAV
COMMON /WR/ IWRAP
COMMON /ALLR1/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /ALLR2/ PQN(40,10),HQN(40,10),RQN(40,10),SIGN(40,10),
1PHEQN(40,10),PHIQN(40,10),RHOQN(40,10),GAMQN(40,10)
COMMON /A/ XI,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /H/ ISIM
COMMON /I/ XJ
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /K/ RN,DELTA
COMMON /M/ IS(7,10)
COMMON /N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1QQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /Q/ XCOWL
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /TB/ IMAXJ,IS1,IS2,ISL1,ISL2
COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2
COMMON /ISW1/ IFR
COMMON /ZNDERV/ DPZN(40),DUZN(40),DVZN(40),DWZN(40)
COMMON /JF/ JFINAL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
COMMON /PL/ DE TH
COMMON /V/ XJI
COMMON /PS/ ZR(40,2),PR(40,2),QR(40,2),HR(40,2),SIR(40,2),RHOR(40,2)
1,PHIR(40,2),PHER(40,2),THR(2),THWR(40)
COMMON /PSS/ GAMRR(40)
DO 10 J=1,JMAX
JSHOC=0
IF(J.GT.JCALC) GO TO 10
IF(J.EQ.JCALC.AND.IFR.EQ.1) GO TO 10
JM=J-1
JP=J+1
IF(J.EQ.JCALC) JP=J
IF(J.EQ.1) JM=JP
IF(ISIM.EQ.1.AND.J.EQ.JMAX) JP=JM
IMAX J =IMAX(J)
DO 20 I=1,IMAXJ
THJ1=THWN(I)
IF(JP.NE.JW) THJ1=TH(JP)
IF(ISIM.EQ.1.AND.JP.EQ.JMAX) THJ1=TH(JMAX)
IF(J.EQ.JINT.AND.I.LE.IDUMMY)GO TO 20
DZ=ZN(I,J)-ZN(I,JM)
DTH=TH(J)-TH(JM)
DUMZ=1.
IF(XJ1.GT.0.) DUMZ=.5*(ZN(I,J)+ZN(I,JM))
DUMR=1.
IF(XJ.GT.0.) DUMR=R

```

```

DS1=SQRT(DZ*DZ+(DTH*DUMZ*DUMR)**2)
IF(J.EQ.JINT.AND.I.GT.IDUMMY) GO TO 901
DZ=ZN(I,JP)-ZN(I,J)
DTH=THJ1-TH(J)
DUMZ=1.
IF(XJ1.GT.0.) DUMZ=.5*(ZN(I,J)+ZN(I,JP))
DS2=SQRT(DZ*DZ+(DTH*DUMZ*DUMR)**2)
IF(J.EQ.JINT+1) GO TO 900
D1=DS1/DS2
D2=DS2/DS1
D3=D1-D2
GO TO 902
901 D1=0.
    JP=J
    D2=1.
    D3=-1.
    IF(I.LT.IS(3,J)-1) GO TO 909
    JSHOC=1
    JP=J+1
    IA=IS(1,JP)+I-IS(1,J)
    RAV=(ZN(I,J)-ZSAV+ZN(IA,JP))/2.
    DS2=RAV*3.142/2.
    D1=DS1/DS2
    D2=DS2/DS1
    D3=D1-D2
909 CONTINUE
GO TO 902
900 D1=1.
    D2=0.
    D3=1.
    IF(I.LT.IS(3,J)-1) GO TO 910
    JSHOC=2
    IB=IS(1,JP)+I-IS(1,J)
    RAV=(ZN(I,J)+ZN(IB,JP)-ZSAV)/2.
    DS1=RAV*3.142/2.
    D1=DS1/DS2
    D2=DS2/DS1
    D3=D1-D2
910 CONTINUE
902 CONTINUE
M=I
N=I
IF(JSHOC.EQ.1) M=IA
IF(JSHOC.EQ.2) N=IB
DTHS=D1*THJ1-D3*TH(J)-D2*TH(JM)
IF(J.EQ.1) DTHS=TH(2)
IF(ISIM.EQ.1.AND.J.EQ.JMAX) DTHS=TH(JMAX)-TH(JMAX-1)
IF(JSHOC.EQ.1) DTHS=(ZN(I,J)-ZSAV)*3.142/2.*D1+(TH(J)-TH(JM))*D2
IF(JSHOC.EQ.2) DTHS=(TH(JP)-TH(J))*D1+ZN(I,J)*3.142/2.*D2
DZ S=D1*Z N(M,JP)-D3*Z N(I,J)-D2*Z N(N,JP)
IF(JSHOC.EQ.1) DZS=(ZN(I,J)-ZN(I,JP))*D2+(ZN(M,JP)-ZN(I,J)+ZSAV)*D
11
IF(JSHOC.EQ.2) DZS=(ZN(I,J)-ZN(IB,JP)+ZSAV)*D2+(ZN(I,JP)-ZN(I,J))*
101
DP S=D1*P N(M,JP)-D3*P N(I,J)-D2*P N(N,JP)
DH S=D1*H N(M,JP)-D3*H N(I,J)-D2*H N(N,JP)

```

```

DQ S=D1*Q N(M,JP)-D3*Q N(I,J)-D2*Q N(N,JM)
DPHES=D1*PHEN(M,JP)-D3*PHEN(I,J)-D2*PHEN(N,JM)
DPHIS=D1*PHIN(M,JP)-D3*PHIN(I,J)-D2*PHIN(N,JM)
DRHOS=D1*RHON(M,JP)-D3*RHON(I,J)-D2*RHON(N,JM)
DGAMS=D1*GAMN(M,JP)-D3*GAMN(I,J)-D2*GAMN(N,JM)
DSI S=D1*SINN(M,JP)-D3*SINN(I,J)-D2*SINN(N,JM)
IF(J.EQ.1) DSI S=SINN(I,2)
IF(ISIM.EQ.1.AND.J.EQ.JMAX) DST S=-SINN(I,JMAX-1)
40 IF(I.EQ.1) GO TO 50
IF(I.EQ.IMAXJ) GO TO 50
IF(ICOWL.NE.1) GO TO 400
IF(I.LT.IS(1,J)-MM.OR.I.GT.IS(1,J)) GO TO 400
DP ZZN=0.
DH ZN=0.
DQ ZN=0.
DSI ZN=0.
DPHEZN=0.
DPHIZN=0.
DRHOZN=0.
DGAMZN=0.
GO TO 60
400 CONTINUE
IF(I.EQ.IS(1,J).OR.I.EQ.IS(1,J)-1) GO TO 50
IF(I.EQ.IS(3,J).OR.I.EQ.IS(3,J)-1) GO TO 50
IP=I+1
IM=I-1
DZ1=ZN(IP ,J)-ZN(I,J)
DZ2=ZN(I,J)-ZN(IM ,J)
D1=DZ1/DZ2
D2=DZ2/DZ1
D3=D1_D2
D1PD2=D1+D2
DP ZZN =(D1*P N(IP ,J)-D3*P N(I,J)-D2*P N(IM ,J))/D1PD2
DH ZN =(D1*H N(IP ,J)-D3*H N(I,J)-D2*H N(IM ,J))/D1PD2
DQ ZN =(D1*Q N(IP ,J)-D3*Q N(I,J)-D2*Q N(IM ,J))/D1PD2
DPHEZN =(D1*PHEN(IP ,J)-D3*PHEN(I,J)-D2*PHEN(IM ,J))/D1PD2
DPHIZN =(D1*PHIN(IP ,J)-D3*PHIN(I,J)-D2*PHIN(IM ,J))/D1PD2
DRHOZN =(D1*RHON(IP ,J)-D3*RHON(I,J)-D2*RHON(IM ,J))/D1PD2
DGAMZN =(D1*GAMN(IP ,J)-D3*GAMN(I,J)-D2*GAMN(IM ,J))/D1PD2
DSI ZN =(D1*SINN(IP ,J)-D3*SINN(I,J)-D2*SINN(IM ,J))/D1PD2
GO TO 60
50 CONTINUE
L=-1
IF(I.EQ.IMAXJ) GO TO 100
DO 421 M=1,7
IF((M/2)*2.NE.M.AND.I.EQ.IS(M,J)-1) GO TO 100
IF((M/2)*2.EQ.M.AND.I.EQ.IS(M,J)) GO TO 100
421 CONTINUE
L=1
100 IL=I+L
I2L=I+2*L
DZ=ZN(I,J)-ZN(IL ,J)
DZL=ZN(IL ,J)-ZN(I2L ,J)
IF(ABS(DZL).GT.1.E-10) GO TO 5000
DEL=0.
GO TO 5001

```

5000 DEL=D7/DZL

5001 DELLE=DEL*DEL

DELQ=1.+DEL

DELE=DELO*DELQ

DELE=(1.+2.*DEL)

DPZZN=(DELLE*P N(I2L ,J)-DELL*P N(IL ,J)+DELE*P N(I,J))/D
17/DELO

DH ZN=(DELLE*H N(I2L ,J)-DELL*H N(IL ,J)+DELE*H N(I,J))/D
17/DELO

DQ ZN=(DELLE*Q N(I2L ,J)-DELL*Q N(IL ,J)+DELE*Q N(I,J))/D
17/DELO

DPHE7N=(DELLE*PHEN(I2L ,J)-DELL*PHEN(IL ,J)+DELE*PHEN(I,J))/D
17/DELO

DPHIZN=(DELLE*PHIN(I2L ,J)-DELL*PHIN(IL ,J)+DELE*PHIN(I,J))/D
17/DELO

DRHO7N=(DELLE*RHON(I2L ,J)-DELL*RHON(IL ,J)+DELE*RHON(I,J))/D
17/DELO

DGAM7N=(DELLE*GAMN(I2L ,J)-DELL*GAMN(IL ,J)+DELE*GAMN(I,J))/D
17/DELO

DSIZN=(DELLE*SINN(I2L ,J)-DELL*SINN(IL ,J)+DELE*SINN(I,J))/D
17/DELO

60 CONTINUE

P QN(I,J)=(DP S-DP ZZN *DZS)/DTHS

H QN(I,J)=(DH S-DH ZN *DZS)/DTHS

Q QN(I,J)=(DQ S-DQ ZN *DZS)/DTHS

SI QN(I,J)=(DSI S-DSI ZN *DZS)/DTHS

PHEQN(I,J)=(DPHES-DPHEZN *DZS)/DTHS

PHIQN(I,J)=(DPHIS-DPHIZN *DZS)/DTHS

RHOQN(I,J)=(DRHOS-DRHOZN *DZS)/DTHS

GAMQN(I,J)=(DGAMS-DGAMZN *DZS)/DTHS

20 CONTINUE

10 CONTINUE

IF(IWRAP.EQ.1)GO TO 955

IF(ICOWL.EQ.1.OR.ICOWLT.EQ.0) GO TO 955

J2=JINT

J3=JINT+1

J4=JINT+2

IDU=IDUMMY+1

A1=ZSAV-ZN(IDU,J2)

A2=TH(J4)-TH(J3)

A1A2=A1/A2

A2A1=A2/A1

A1PA2=A1+A2

A12=A1A2-A2A1

UT=QN(IDU,J2)*COS(PHEN(IDU,J2))

VT=-QN(IDU,J2)*SIN(PHEN(IDU,J2))

WT=QN(IDU,J2)*TAN(SINN(IDU,J2))

QT=SQRT(UT*UT+WT*WT)

PHET=ATAN(WT/UT)

SIT=ATAN(VT/QT)

P QN(1,J3)=(PN(1,J4)*A1A2-PN(1,J3)*A12-PN(IDU,J2)*A2A1)/A1PA2

H QN(1,J3)=(HN(1,J4)*A1A2-HN(1,J3)*A12-HN(IDU,J2)*A2A1)/A1PA2

Q QN(1,J3)=(QN(1,J4)*A1A2-QN(1,J3)*A12-Q T *A2A1)/A1PA2

SI QN(1,J3)=(SINN(1,J4)*A1A2-SINN(1,J3)*A12-SI T *A2A1)/A1PA2

PHEQN(1,J3)=(PHEN(1,J4)*A1A2-PHEN(1,J3)*A12-PHET *A2A1)/A1PA2

PHIQN(1,J3)=(PHIN(1,J4)*A1A2-PHIN(1,J3)*A12-PHIN(IDU,J2)*A2A1)/A1P

1A2

RHOQN(1,J3)=(RHON(1,J4)*A1A2-RHON(1,J3)*A12-RHON(IDU,J2)*A2A1)/A1P

1A2

GAMQN(1,J3)=(GAMN(1,J4)*A1A2-GAMN(1,J3)*A12-GAMN(IDU,J2)*A2A1)/A1P

1A2

IMAXJ2=IMAX(J2-1)

DO 7979 I=1,IMAXJ2

Z R(I,1)=Z N(I,J2-1)

P R(I,1)=P N(I,J2-1)

Q R(I,1)=Q N(I,J2-1)

H R(I,1)=H N(I,J2-1)

SI R(I,1)=SINN(I,J2-1)

PHIR(I,1)=PHIN(I,J2-1)

PHER(I,1)=PHEN(I,J2-1)

RHOR(I,1)=RHON(I,J2-1)

7979 CONTINUE

DO 7878 I=1,IDIJMMY

DO 3535 IJ=1,IMAXJ2

GAMRR(IJ)=THWR(IJ)

3535 THWR(IJ)=GAMN(IJ,J2-1)

CALL TBLDUM(ZN(I,J2),P1,SI1,H1,PHI1,Q1,PHE1,RH01,GAM1, 1,IMAX(

1J2),2)

DO 3536 IJ=1,IMAXJ2

3536 THWR(IJ)=GAMRR(IJ)
CALL TBLDUM(ZN(I,J2),P2,SI2,H2,PHI2,Q2,PHE2,RH02,GAM2, 2,IMAX(

1J2),2)

D1=TH(J2)-TH(J2-1)

D2=THR(2) -1H(J2)

D1D2=D1/D2

D2D1=D2/D1

D12=D1D2-D2D1

D1PD2=D1+D2

P QN(I,J2)=(D1D2*P 2-D12*P N(I,J2)-D2D1*P 1)/D1PD2

H QN(I,J2)=(D1D2*H 2-D12*H N(I,J2)-D2D1*H 1)/D1PD2

Q QN(I,J2)=(D1D2*Q 2-D12*Q N(I,J2)-D2D1*Q 1)/D1PD2

SI QN(I,J2)=(D1D2*SI 2-D12*SINN(I,J2)-D2D1*SI 1)/D1PD2

PHIQN(I,J2)=(D1D2*PHI2-D12*PHIN(I,J2)-D2D1*PHI1)/D1PD2

PHEQN(I,J2)=(D1D2*PHE2-D12*PHEN(I,J2)-D2D1*PHE1)/D1PD2

RHOQN(I,J2)=(D1D2*RHO2-D12*RHON(I,J2)-D2D1*RHO1)/D1PD2

GAMQN(I,J2)=(D1D2*GAM2-D12*GAMN(I,J2)-D2D1*GAM1)/D1PD2

7878 CONTINUE

955 CONTINUE

IF(ISIM.EQ.1) RETURN

IMX1=IMAX(JW)-1

DO 1234 I=2,IMX1

IF(I.EQ.IS(3,JW)-1.OR.I.EQ.IS(3,JW).OR.I.EQ.IS(1,JW)-1.OR.I.EQ.

1IS(1,JW)) GO TO 1234

TSI=TAN(SINN(I,JMAX))

THJ=TH(JMAX)*XJ

STH=SIN(THJ)

CTH=COS(THJ)

CPHEP=COS(PHEN(I,JMAX))

UPI=QN(I,JMAX)*(CPHEP*CTH-TSI*STH)

VPI=QN(I,JMAX)*(CPHEP*STH+TSI*CTH)

WPI=QN(I,JMAX)*SIN(PHEN(I,JMAX))

YDUM=THWN(I)-THWN(I-1)

```

ZDUM=1.
IF(XJ1.GT.0.) ZDUM=(ZN(I,JW)+ZN(I-1,JW))/2.
IF(XJ1.EQ.0.) YDUM=YWN(I)-YWN(I-1)
DS1=(ZN(I,JW)-ZN(I-1,JW))**2+(YDUM*ZDUM)**2
DS1=SQRT(DS1)
YDUM=THWN(I+1)-THWN(I)
ZDUM=1.
IF(XJ1.GT.0.) ZDUM=(ZN(I+1,JW)+ZN(I,JW))/2.
IF(XJ1.EQ.0.) YDUM=YWN(I+1)-YWN(I)
DS2=(ZN(I+1,JW)-ZN(I,JW))**2+(YDUM*ZDUM)**2
DS2=SQRT(DS2)
D1=DS1/DS2
D2=DS2/DS1
D3=D1-D2
DY=THWN(J)-TH(JMAX)
Y1=TH(J)
IF(XJ.GT.0.) Y1=DN*SIN(Y1)
IF(XJ.GT.0.) DY=YWN(I)-Y1
DUY=(UWN(I)-UPI)/DY
DVY=(VWN(I)-VPI)/DY
DWY=(WWN(I)-WPI)/DY
DP Y=(P N(I,JW)-P N(I,JMAX))/DY
Y3=THWN(I+1)
IF(XJ.GT.0.) Y3=YWN(I+1)
Y2=THWN(I)
IF(XJ.GT.0.) Y2=YWN(I)
Y1=THWN(I-1)
IF(XJ.GT.0.) Y1=YWN(I-1)
DYS=D1*Y3-D3*Y2-D2*Y1
DZ S=D1*Z N(I+1,JW)-D3*Z N(I,JW)-D2*Z N(I-1,JW)
DP S=D1*P N(I+1,JW)-D3*P N(I,JW)-D2*P N(I-1,JW)
DUS=D1*UWN(I+1)-D3*UWN(I)-D2*UWN(I-1)
DVS=D1*VWN(I+1)-D3*VWN(I)-D2*VWN(I-1)
DWS=D1*WWN(I+1)-D3*WWN(I)-D2*WWN(I-1)
DP ZN(I) =(DP S-DP Y*DYS)/DZS
DUZN(I)=(DUS-DUY*DYS)/DZS
DVZN(I)=(DVS-DVY*DYS)/DZS
DWZN(I)=(DWS-DWY*DYS)/DZS
1234 CONTINUE
RETURN
END

```



```

SUBROUTINE WALL (RN,ICOWL,IIT,IITT)
COMMON /AV/ AAV,BAV
COMMON /ALLR1/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /ZNDERV/ DPZN(40),DUZN(40),DVZN(40),DWZN(40)
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /IVY/ IVY,KCORR,IAV
COMMON /TEM/ T(40,10)
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PDI(40,10),RHO(40,10),GAM(40,10)
COMMON /R/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /F/ XPW(40)
COMMON /I/ XJ
COMMON /M/ IS(7,10)
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL,T
COMMON /T/ PP(40,2),ZP(40,2),QP(40,2),SIP(40,2),PHEP(40,2),
1HP(40,2),RHOP(40,2),PHIP(40,2),GAMP(40,2),AP(40,2),THP(40,2),
2UP(40,2),VP(40,2),WP(40,2)
COMMON /U/ ERZ7Z
COMMON /V/ XJ1
COMMON /W/ ISIMEX, IDUMMY, JINT, IDUMMY(40), THWW(2), JD1, JD2
COMMON /SA/ XJ1S
COMMON /FWA/ ISOP
DIMENSION XPLN(40),BN(40)
JW=JMAX+1
IF(JW.GT.JINT) XJ1=0.
MMAX=JMAX(JMAX)
DO 5 J=JMAX,JW
JJ=1
IF(J.EQ.JW) JJ=2
II=2
DO 10 I=1,MMAX
IF(ICOWL.EQ.1.AND.I.GT.IITT.AND.I.LT.IIT) GO TO 10
DO 89 M=1,7
IF(IS(M,JMAX).EQ.0) GO TO 89
ITEST=IS(M,J)-1
IF((M/2)*2.EQ.M) ITEST=IS(M,J)
92 IF(I.NE.ITEST.AND.I.NE.ITEST+1) GO TO 89
II=I
RAT=1.
GO TO 200
89 CONTINUE
IF(I.EQ.1.OR.I.EQ.MMAX)GO TO 16
IF(J.EQ.JW) ZN(I,J)=ZN(I,JMAX)
12 IF(ZN(I,J).LE.7*(II,J)) GO TO 15
II=II+1
GO TO 12
15 RAT=(ZN(I,J)-Z(II-1,J))/(Z(II,J)-Z(II-1,J))
16 IF(I.EQ.1)RAT=0.
IF(I.EQ.MMAX)RAT=1.
IF(I.EQ.MMAX) II=I
200 IF(XJ1.EQ.0.)

```

```

IXPW(I)=XW(II-1)+RAT*(XW(II)-XW(II-1))
P P(I,JJ)=P (II-1,J)+RAT*(P (II,J)-P (II-1,J))
Z P(I,JJ)=Z (II-1,J)+RAT*(Z (II,J)-Z (II-1,J))
Q P(I,JJ)=Q (II-1,J)+RAT*(Q (II,J)-Q (II-1,J))
SI P(I,JJ)=SI (II-1,J)+RAT*(SI (II,J)-SI (II-1,J))
PHEP(I,JJ)=PHE(II-1,J)+RAT*(PHE(II,J)-PHE(II-1,J))
H P(I,JJ)=H (II-1,J)+RAT*(H (II,J)-H (II-1,J))
RHOP(I,JJ)=RHO(II-1,J)+RAT*(RHO(II,J)-RHO(II-1,J))
PHIP(I,JJ)=PHI(II-1,J)+RAT*(PHI(II,J)-PHI(II-1,J))
TP =FT(PP(I,JJ),PHIP(I,JJ),HP(I,JJ))
GAMP(I,JJ)=FGAM(TP,PP(I,JJ),PHIP(I,JJ))
AP(I,JJ)=SQRT(PP(I,JJ)*GAMP(I,JJ)/RHOP(I,JJ))
IF(JJ.EQ.1) THP(I,JJ)=TH(J)
IF(JJ.EQ.2) THP(I,JJ)=THW(II-1)+RAT*(THW(II)-THW(II-1))
IF(XJ1.EQ.1..AND..JJ.EQ.2) CALL SWALL1(THP(I,JJ),R,ZP(I,JJ),FX,FZ)
TSIP=TAN(SIP(I,JJ))
THJ=THP(I,JJ)*XJ
STH=SIN(THJ )
CTH=COS(THJ )
CPHEP=COS(PHEP(I,JJ))
UP(I,JJ)=QP(I,JJ)*(CPHEP*CTH-TSIP*STH)
VP(I,JJ)=QP(I,JJ)*(CPHEP*STH+TSIP*CTH)
WP(I,JJ)=QP(I,JJ)*SIN(PHEP(I,JJ))
10 CONTINUE
5 CONTINUE
6262 CONTINUE
IQ=MMAX-1
DO 20 I=2,IQ
KIL=1
A93=1.
R93=0.
IF(BAV.GT.0.) A93=.5
IF(BAV.GT.0.) R93=.5
PT=PN(I ,JW)
IF(B93.EQ.0.) XPLN(I)=XPLMN(I ,JW)
IF(ICOWL.EQ.1..AND..I.GT.IITT..AND..I.LT.IIT) GO TO 20
DO 189 M=1,7
IF(IS(M,JMAX).EQ.0) GO TO 189
ITEST=IS(M,J)-1
IF((M/2)*2.EQ.M) ITEST=IS(M,J)
192 IF(I.EQ.ITEST..OR..I.EQ.ITEST+1) GO TO 20
189 CONTINUE
IF(XJ1.EQ.0.)
1CALL SWALL(R,ZN(I,JW),XPW(I),YPW,FX,FZ)
IF(XJ1.EQ.1.) CALL SWALL1(THWN(I),RN,ZN(I,JW),FX,FZ)
IF(XJ.EQ.0.) GO TO 2
THWQ=ATAN(FX)
THPW=YPW/XPW(I)
XWN(I)=XPW(I)+(RN-R)*COS(THWQ)/COS(THWQ-THPW)
GO TO 4
2 IF(XJ1.EQ.1.) GO TO 9
XWN(I)=XPW(I)+(RN-R)
4 CONTINUE
CALL SWALL(RN,ZN(I,JW),XWN(I),YWN(I),FX,FZ)
IF(XJ.EQ.0.) GO TO 8
THWN(I)=ATAN(YWN(I)/XWN(I))

```

```

GO TO 9
8 THWN(I)=YWN(I)
9 CONTINUE
RAT=.E
IT=1
THA=TH(JMAX)+RAT*(THP(I,2)-TH(JMAX))
25 U A=U P(I,1)+RAT*(U P(I,2)-U P(I,1))
V A=V P(I,1)+RAT*(V P(I,2)-V P(I,1))
H A=H P(I,1)+RAT*(H P(I,2)-H P(I,1))
P A=P P(I,1)+RAT*(P P(I,2)-P P(I,1))
W A=W P(I,1)+RAT*(W P(I,2)-W P(I,1))
RHOA=RHOP(I,1)+RAT*(RHOP(I,2)-RHOP(I,1))
THAX=THA*XJ
XA=R*COS(THAX)
YA=R*SIN(THAX)+THA*(1.-XJ)
PHIA=PHIP(I,1)+RAT*(PHIP(I,2)-PHIP(I,1))
TA=FT(PA,PHIA,HA)
GAMA=FGAM(TA,PA,PHIA)
AA=SQRT(GAMA*PA/RHOA)
TAUA=VA/UA
UA2=UA*UA
AA2=AA*AA
VA2=VA*VA
BETA=SQRT((UA2 +VA2 )/(AA2 )-1.)
ALAM=(UA*VA+AA2 *BETA)/(UA2 -AA2 )
DUMP=A93*ALAM+B93*XPLN(I)
IF(XJ.EQ.0.) GO TO 32
THAT=YWN(I)-(XWN(I)-XA)*DUMP
THAT=A*SIN(THAT/R)
GO TO 33
32 IF(XJ.EQ.0.)
1THAT=YWN(I)-(XWN(I)-XA)*DUMP
IF(XJ.EQ.1.) THAT=THWN(I)-DUMP*(RN-R)/ZN(I,JW)
33 CONTINUE
EP=ABS(1.-THAT/THA)
IF(EP.LT.1.E-04) GO TO 30
THA=THAT
RAT=(THA-TH(JMAX))/(THP(I,2)-TH(JMAX))
IT=IT+1
IF(IT.GT.15)CALL ERROR(33)
GO TO 25
30 RAT2=(THA-TH(JMAX))/(THP(I+1,2)-TH(JMAX))
RAT1=(THA-TH(JMAX))/(THP(I-1,2)-TH(JMAX))
D2=ZP(I+1,1)-ZP(I,1)
D1=ZP(I,1)-ZP(I-1,1)
U2=UP(I+1,1)+RAT2*(UP(I+1,2)-UP(I+1,1))
V2=VP(I+1,1)+RAT2*(VP(I+1,2)-VP(I+1,1))
W2=WP(I+1,1)+RAT2*(WP(I+1,2)-WP(I+1,1))
P2=PP(I+1,1)+RAT2*(PP(I+1,2)-PP(I+1,1))
U1=UP(I-1,1)+RAT1*(UP(I-1,2)-UP(I-1,1))
V1=VP(I-1,1)+RAT1*(VP(I-1,2)-VP(I-1,1))
W1=WP(I-1,1)+RAT1*(WP(I-1,2)-WP(I-1,1))
P1=PP(I-1,1)+RAT1*(PP(I-1,2)-PP(I-1,1))
D1D2=D1/D2
D2D1=D2/D1
D1PD2=D1+D2

```

```

D12=D1D2-D2D1
DU=(U2*D1 D2-UA*D12 -U1*D2 D1)/(D1D2)
DV=(V2*D1 D2-VA*D12 -V1*D2 D1)/(D1D2)
DW=(W2*D1 D2-WA*D12 -W1*D2 D1)/(D1D2)
DP=(P2*D1 D2-PA*D12 -P1*D2 D1)/(D1D2)
IF(B93.EQ.0.)BN(I)=BETA
A22=A93*(RHOA*IA2/BETA)+B93*(RHON(I ,JW)*UWN(I)**2/BN(I))
FPA=ALAM*RHOA*WA*DU-RHOA*WA*DV-
I(ALAM-VA/UA)*(WA*DP+AA2 *RHOA*DW)*UA/(AA2 )
FPA=FPA/BETA
IF(BAV.EQ.0.)FPNN=FPA
IF(BAV.EQ.0.) GO TO 362
BN(I)=SQRT((UWN(I)**2+VWN(I)**2)/AN(I,JW)**2-1.)
XPLN(I)=(UWN(I)*VWN(I)+AN(I,JW)**2*BN(I))/(UWN(I)**2-AN(I,JW)**2)
FPNN=XPLN(I)*RHON(I,JW)*WWN(I)*DUZN(I)-RHON(I,JW)*WWN(I)*DVZN(I)-(
1XPLN(I)-VWN
I(I)/UWN(I))*(WWN(I)*DPZN(I) +AN(I,JW)**2*RHON(I,JW)*DWZN(I))*UWN
I(I)/AN(I,JW)/AN(I,JW)/BN(I)
362 CONTINUE
A1=AAV*FPA+BAV*FPNN
IT=1
WOU=WP(I,2)/UP(I,2)
35 VOU=FX+WOU*FZ
IF(XJ1.EQ.1.)VOU=VOU*ZN(I,JW)
ZSL=ZP(I,2)
USL=UP(I,2)
VSL=VP(I,2)
WSL=WP(I,2)
TAUC=VOU
ITT=1
60 II=I
IF(XJ1.EQ.1.) GO TO 64
IF(XJ.EQ.0.) GO TO 62
THWQ=ATAN(FX)
XSL=XWN(I)-(RN-R)*COS(THWQ)/COS(THWQ-THWN(I))
GO TO 63
62 XSL=XW(I)
63 CONTINUE
CALL SWALL(R,ZSL,XSL,YSL,FXSL,FZSL)
64 IF(XJ1.EQ.1.) CALL SWALL1(THSL,R,ZSL,FXSL,FZSL)
DUM=.5*(WOU+WSL/USL)
IF(DUM.GT.0.) II=II+1
IF(XJ1.EQ.0.)
1ZSLT=ZN(I,JW)-DUM*(XWN(I)-XSL)
IF(XJ1.GT.0.) ZSLT=ZN(I,JW)-(RN-R)*DUM
RAT=(ZSLT-ZP(II-1,2))/(ZP(II,2)-ZP(II-1,2))
USL=UP(II-1,2)+RAT*(UP(II,2)-UP(II-1,2))
VSL=VP(II-1,2)+RAT*(VP(II,2)-VP(II-1,2))
WSL=WP(II-1,2)+RAT*(WP(II,2)-WP(II-1,2))
EP=ABS((ZSLT-ZSL)/(ZP(II,2)-ZP(II-1,2)))
IF(EP.LT.ERZZZ) GO TO 40
ZSL=ZSLT
ITT=ITT+1
IF(ITT.GT.10) CALL ERROR(40)
GO TO 60
40 IF(XJ1.EQ.0.) PN(I,JW)=PA+A1 *(XWN(I)-XA)-A22*(TAUC-TAUA)

```

```

IF(XJ1.GT.0.) PN(I,JW)=PA+(A1*(RN-R)- A22* (TAUC-TAUA))
PSL=PP(I-1,2)+RAT*(PP(I,2)-PP(I-1,2))
HSL=HP(I-1,2)+RAT*(HP(I,2)-HP(I-1,2))
RHOSL=RHOP(I-1,2)+RAT*(RHOP(I,2)-RHOP(I-1,2))
PHISL=PHIP(I-1,2)+RAT*(PHIP(I,2)-PHIP(I-1,2))
TSL=FT(PSL,PHISL,HSL)
GAMSL=FGAM(TSL,PSL,PHISL)
PHIN(I,JW)=PHISL
RHON(I,JW)=RHOSL*(PN(I,JW)/PSL)**(1./GAMSL)
VVSL=USL**2+VSL**2+WSL**2
VVC= VVSL+2.*GAMSL/(GAMSL-1.)*(PSL/RHOSL-PN(I,JW)/RHON(I,JW))
HTSL=HSL+.5*VVSL
HN(I,JW)=HTSL-.5*VVC
UWN(I)=SQRT(VVC/(1.+TAUC**2+WOU**2))
VWN(I)=UWN(I)*TAUC
WWN(I)=UWN(I)*WOU
IF(XJ1.GT.0.) THD=THSL
IF(XJ.EQ.0..AND.XJ1.EQ.0.) THD=YSL
IF(XJ.GT.0.) THD=ATAN(YSL/XSL)
RATE=(THD-TH(JMAX))/(THP(I,2)-TH(JMAX))
PD=PP(I,1)+RAT*(PP(I,2)-PP(I,1))
WD=W P(I,1)+RAT*(W P(I,2)-W P(I,1))
UD=U P(I,1)+RAT*(U P(I,2)-U P(I,1))
VD=V P(I,1)+RAT*(V P(I,2)-V P(I,1))
RHOD=RHOP(I,1)+RAT*(RHOP(I,2)-RHOP(I,1))
QD=SQRT(UD*UD+VD*VD)
RAT2=(THD-TH(JMAX))/(THP(I+1,2)-TH(JMAX))
RAT1=(THD-TH(JMAX))/(THP(I-1,2)-TH(JMAX))
W2=WP(I+1,1)+RAT2*(WP(I+1,2)-WP(I+1,1))
P2=PP(I+1,1)+RAT2*(PP(I+1,2)-PP(I+1,1))
W1=WP(I-1,1)+RAT1*(WP(I-1,2)-WP(I-1,1))
P1=PP(I-1,1)+RAT1*(PP(I-1,2)-PP(I-1,1))
DW=(W2*D1 D2-WD*D12 -W1*D2 D1)/(D1*PD2)
DP=(P2*D1 D2-PD*D12 -P1*D2 D1)/(D1*PD2)
IF(XJ1.EQ.0.)
IDELS=SQRT((XWN(I)-XSL)**2+(YWN(I)-YSL)**2)
IF(XJ1.GT.0.) IDELS=SQRT(ZN(I,JW)**2*(THWN(I)-THD)**2+(RN-R)**2)
VDZN=0.
QNW=SQRT(UWN(I)**2+VWN(I)**2)
IF(XJ1.GT.0.) VDZN=(VD**2*A93+VWN(I)**2*B93)*DELS/ZN(I,JW)
WTEST=WD+VDZN
DWT=-((DP/RHOD/QD+WD*DW/QD)*AAV+(DPZN(I) /RHON(I,JW)/QNW)
1*BAV)*DELS
WTEST=WTEST+DWT
ERR=WWN(I)-WTEST
IT=IT+1
EP=ABS(WWN(I)-WTEST)/UW(I)
IF(EP.LT.1.E-10) GO TO 3611
IF(IT.GT.2) GO TO 80
WOU1=WOU
WOU=1.01*WOU
IF(WOU.LT.1.E-6) WOU=.001
ER1=ERR
GO TO 35
80 WOUN=WOU1-ER1*(WOU-WOU1)/(ERR-ER1)
ER1=ERR

```

```

WOU1=WOU
WOU=WOUN
IF(IT.GT.10) CALL ERROR(80)
GO TO 35
3611 CONTINUE
ET=ABS(1.-PT/PN(I ,JW))
TN(I ,JW)=FT(PN(I ,JW),PHIN(I ,JW),HN(I ,JW))
GAMN(I ,JW)=FGAM(TN(I ,JW),PN(I ,JW),PHIN(I ,JW))
AN(I ,JW)=SQRT(GAMN(I ,JW)*PN(I ,JW)/RHON(I ,JW))
UW2=UWN(I)*UWN(I)
VW2=VWN(I)*VWN(I)
BN=SQRT((UW2+VW2)/ AN(I,JW)**2-1.)
XPLN=(UWN(I)*VWN(I)+AN(I,JW)**2*BN)/(UW2-AN(I,JW)**2)
IF(IVY.EQ.0.OR.ET.LT.1.E-04) GO TO 20
KIL=KIL+1
IF(KIL.GT.10)GO TO 1493
A93=.5
R93=.5
PT=PN(I ,JW)
GO TO 9
1493 WRITE(6,1393)
1393 FORMAT(* AVERAGING PROCESS DOES NOT CONVERGE IN WALL *)
WRITE(6,4949) KOUNT,I,AAV,A93
4949 FORMAT(* KOUNT=*I5,5X*I=*I5,5X*AAV=*E13.5,5X*A93=*E13.5)
STOP
20 CONTINUE
IDUM=MMAX-1
ZDUM1=ZN(1,JMAX)
ZDUM2=ZN(MMAX,JMAX)
IF(ICOWL.EQ.0)
1CALL CORNER(1,RN,THWN(2),ZDUM1)
IF(ISOP.NE.0) GO TO 250
IF(ICOWL.NE.1) THDUM=THWN(IDUM)
IF(ICOWL.EQ.1) THDUM=TH(JMAX)
CALL CORNER(IMAX(JW),RN,THDUM ,ZDUM2)
250 CONTINUE
XJ1=XJ1S
IMAXJ=IMAX(JW)
DO 7502 I=1,IMAXJ
THWNV=THWN(I)*XJ
PHEN(I,JW)=ATAN(WWN(I)/(UWN(I)*COS(THWNX )+VWN(I)*
1SIN(THWNX )))
VDUM=VWN(I)*COS(THWNX )-UWN(I)*SIN(THWNX )
QN(I,JW)=SQRT(UWN(I)**2+VWN(I)**2+WWN(I)**2-VDUM**2)
SINN(I,JW)=ATAN(VDUM/QN(I,JW))
7502 CONTINUE
RETURN
END

```

```

SUBROUTINE SWALL1 (TH,X1,Z1,FX,FZ)
COMMON /G/ A1(3,9),A2(3,9),A3(3,9),RR1(3),RR2(3),RR3(3)
1,NUMLWS,NUMUWS,NUMSWS
L=1
XTT=1.E+6
IF (L.LT.NUMSWS) XTT=RR3(L+1)
IF (X1.GE.XTT) L=L+1
IF (L.LT.NUMSWS) XTT=RR3(L+1)
IF (X1.GE.XTT.AND.L.LT.NUMSWS) L=L+1
X=X1
Z=Z1
ZZ=Z*Z
XX=X*X
Y=A3(L,1)*XX*ZZ+A3(L,2)*XX*Z+A3(L,3)*X*ZZ+A3(L,4)*XX+A3(L,5)*ZZ+
1A3(L,6)*X*Z+A3(L,7)*X+A3(L,8)*Z+A3(L,9)
TH=Y
FX=2.*A3(L,1)*X*ZZ+2.*A3(L,2)*Y*Z+A3(L,3)*Z*Z+2.*A3(L,4)*X+A3(L,6)
1*Z+A3(L,7)
FZ=2.*A3(L,1)*XX*Z+A3(L,2)*XX+2.*A3(L,3)*X*Z+2.*A3(L,5)*Z
1+A3(L,6)*X+A3(L,8)
RETURN
END

```

```

SUBROUTINE BWALL(R1,TH1,Z,FRI,FT1)
COMMON /G/ A1(3,9),A2(3,9),A3(3,9),RR1(3),RR2(3),RR3(3)
1,NUMLWS,NUMUWS,NUMSWS
COMMON /I/ XJ
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,PCOWL
COMMON /V/ XJ1
COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2
L=1
RTT=1.E+06
THX=TH1*XJ
R=R1*COS(THX)
R=R-XINSP(J)
IF(XJ.EQ.0.) T=TH1
IF(XJ.EQ.1.) T=R1*SIN(TH1)
IF(L.LT.NUMLWS) RTT=RR1(L+1)
IF(R.GE.RTT) L=L+1
IF(L.LT.NUMLWS) RTT=RR1(L+1)
IF(R.GE.RTT.AND.L.LT.NUMLWS) L=L+1
RR=R*R
TT=T*T
Z=A1(L,1)*RR*TT+A1(L,2)*RR*T+A1(L,3)*R*TT+A1(L,4)*RR+A1(L,5)*TT+
1A1(L,6)*R*T+A1(L,7)*R+A1(L,8)*T+A1(L,9)
FR=2.*A1(L,1)*R*TT+2.*A1(L,2)*R*T+A1(L,3)*TT+2.*A1(L,4)*R+A1(L,6)
1*T+A1(L,7)
FT=2.*A1(L,1)*RR*T+A1(L,2)*RR+2.*A1(L,3)*R*T+2.*A1(L,5)*T+A1(L,6)
1*R+A1(L,8)
FRI=FR*COS(THX)+FT*SIN(THX)
FT1=-FR*SIN(THX)+FT*COS(THX)
IF(XJ.EQ.1.)FT1=FT1/R1
IF(XJ1.EQ.1.)FT1=FT1/Z
RETURN
END

```



```

SUBROUTINE TBLNUM(ZX,PX,SIX,HX,PHIX,QX,PHEX,RHOX,GAMX,L,IMAX,I)
COMMON/PS/Z(40,2),P(40,2),Q(40,2),H(40,2),SI(40,2),RHO(40,2)
1,PHI(40,2),PHE(40,2),THR(2),GAM(40)
K=L
DO 10 J7=1,IMAX
J5=J7
IF(ZX-Z(J5,L)) 8,9,12
8 J6=J5-1
7 IF(I.EQ.1) J6=J5+1
RAT=(ZX-Z(J6,K))/(Z(J5,L)-Z(J6,K))
P X=P (J6,K)+(P (J5,L)-P (J6,K))*RAT
H X=H (J6,K)+(H (J5,L)-H (J6,K))*RAT
Q X=Q (J6,K)+(Q (J5,L)-Q (J6,K))*RAT
SI X=SI (J6,K)+(SI (J5,L)-SI (J6,K))*RAT
PHIX=PHI(J6,K)+(PHI(J5,L)-PHI(J6,K))*RAT
PHEX=PHE(J6,K)+(PHE(J5,L)-PHE(J6,K))*RAT
RHOX=RHO(J6,K)+(RHO(J5,L)-RHO(J6,K))*RAT
GAMX=GAM(J6 )+(GAM(J5 )-GAM(J6 ))*RAT
GO TO 11
9 CONTINUE
P X=P (J5,L)
H X=H (J5,L)
Q X=Q (J5,L)
SI X=SI (J5,L)
PHIX=PHI(J5,L)
PHEX=PHE(J5,L)
RHOX=RHO(J5,L)
GAMX=GAM(J5 )
GO TO 11
12 IF(J5.EQ.IMAX) GO TO 8
10 CONTINUE
11 RETURN
END

```

SUBROUTINE ALSHOC(K)

```

COMMON /A/ XI,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /H/ ISIM
COMMON /I/ XJ
COMMON /K/ RN,DELTA
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON /M/ IS(7,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,JDUMMY(40),THWW(2),JD1,JD2
COMMON /SA/ XJ1S
COMMON /WR/ IWRAP
DO 13 J=1,JMAX
IF(J.EQ.JINT.OR.J.EQ.JINT+1) GO TO 13
IF(J.GT.JINT) XJ1=0.
I=IS(K,J)
IF(ISIM.EQ.1.AND.J.EQ.JMAX) GO TO 100
IF(J.GT.1) GO TO 15
100 ALPN(K,J)=0.
ALPHAN(K,J)=0.
GO TO 16
15 JP=J+1
JM=J-1
IF(JP.NE.JMAX+1) THP=TH(JP)
IF(JP.EQ.JMAX+1) THP=THWN(I)
D2=THP -TH(J)
D1=TH(J)-TH(JM)
D1=ABS(D1)
D2=ABS(D2)
D1D2=D1/D2
D2D1=D2/D1
D1PD2=D1+D2
D12=D1D2-D2D1
I2=IS(K,JP)
I1=IS(K,JM)
IF(XJ1.EQ.0.)
1 ALPN(K,J)=(ZN(I2,JP)*D1D2-ZN(I,J)*D12-ZN(I1,JM)*D2D1)/D1PD2/RN**XJ
IF(XJ1.EQ.1.) ALPN(K,J)=(ALOG(ZN(I2,JP))*D1D2-ALOG(ZN(I,J))*D12
1-ALOG(ZN(I1,JM))*D2D1)/D1PD2
ALPHAN(K,J)=ATAN(ALPN(K,J)*COS(BETAN(K,J)))
ALPN(K,J)=ATAN(ALPN(K,J))
16 CONTINUE
13 CONTINUE
IF(IWRAP.EQ.0) CALL ALWRAP(K)
XJ1=XJ1S
RETURN
END

```

```

FUNCTION RHEQ(H,P1,F)
  TLEFT(P1,F,H)
  T=T1*5./9.
  P=P1*1.01325E+05/2116.
  IF(F.GT.T.0.) GO TO 2260
  FNM=1.53*F*F-5.895*F+28.965
  FNN=1.6*F*F-10.6*F+33.6
  IF(T.GT.2000.) GO TO 2030
  XM=FNM
  IF(F.LT.1.) GO TO 2160
  XM=FNN
  GO TO 2160
2030 FF=F*F
  AB=-2.3*FF+4.01*F+1.736
  B=8.61*FF-15.42*F-6.66
  C=-16.88*FF+33.21*F+14.58
  XN=-.4375*FF+.0625*F+2.08
  D=A*(ALOG(P)/2.3)**1.5+B*(ALOG(P)/2.3)+C
  XM=FNM-D*((T-2000.)/1000.)**XN
  IF(F.LT.1.) GO TO 2160
  A=-.822*FF+2.363*F+1.905
  B=2.76*FF-7.56*F-8.68
  C=-3.6*FF+7.36*F+27.15
  XN=-.47*FF+1.825*F+.35
  D=A*(ALOG(P)/2.3)**1.5+B*(ALOG(P)/2.3)+C
  XM=FNN-D*((T-2000.)/1000.)**XN
  GO TO 2160
2260 KF=F-.5
  IF(KF.EQ.-1)XM=16.043
  IF(KF.EQ.-2)XM=28.054
2160 RHEQ=P*XM/T/8314.3*6.2428E-02/32.174
  RETURN
  END

```

```

FUNCTION FGAM(T1,P1,F)
COMMON /THE/ A1,A2,A3,A4,A5,A6,XMM1
T=5.*T1/O.
T2=T*T
P=P1*1.01325E5/2116.
XM=0.
IF(F.LT.0.) GO TO 550
IF(T.LE.1000.) GO TO 440
XM=-2.15E-08*T2 +.000091*T-.0695
440 XN=4.E-09*T2 -.00002*T-.019
IF(F.LE.1.) GO TO 470
XN=.0339*SQRT(T)-.000391*T-.687
470 G=-1.833E-07*T2 +.000075*T+1.367
IF(T.LT.500.) GO TO 520
G=2.E-08*T2 -.000138*T+1.423
IF(T.LT.2000.) GO TO 520
G=7.267E-08*T2 -.000457*T+1.85
520 G=G+XM*(ALOG(P)/2.3-5.)+XN*(F-T.)
GO TO 530
550 T3=T2*T
T4=T3*T
CP=A1+A2*T+A3*T2+A4*T3+A5*T4
G=CP*(CP-1.)
530 CONTINUE
FGAM=G
RETURN
END

```

```
SUBROUTINE ERROR(I)
IF(I.EQ.17) GO TO 2
IF(I.EQ.20 ) GO TO 3
IF(I.EQ.30 ) GO TO 6
IF(I.EQ.50 ) GO TO 8
IF(I.EQ.18 ) GO TO 10
IF(I.EQ.16 ) GO TO 12
WRITE(6,1) I
1 FORMAT(* ERROR IN ITERATION LOOP IN WALL ROUTINE AT STATEMENT NUMB
1R*,15)
CALL PNCH
2 WRITE(6,4 )I
4 FORMAT(* ERROR IN V/U ITERATION IN MAIN - STATEMENT NUMBER *,15)
CALL PNCH
3 WRITE(6,5 )I
5 FORMAT(* ERROR IN SIDE WALL LOCATION IN CORNER - STATEMENT NUMBER
1*,15)
CALL PNCH
6 WRITE(6,7 )I
7 FORMAT(* ERROR IN THETA A PLANE IN CORNER - STATEMENT NUMBER *,15)
CALL PNCH
8 WRITE(6,9 )I
9 FORMAT(* ERROR IN A POINT ITERATION IN CORNER - STATEMENT NUMBER *
1,15)
CALL PNCH
10 WRITE(6,11)I
11 FORMAT(* ERROR IN D POINT ITERATION IN CSURF - STATEMENT NUMBER *
1,15)
CALL PNCH
12 WRITE(6,13)I
13 FORMAT(* ERROR IN NORMAL TO CONTACT SURFACE IN CSURF - STATEMENT N
UMBER *,15)
CALL PNCH
END
```

```
SUBROUTINE XLAM(Q,A,PHE,XPLAM,YMLAM)
```

```
CPHE=COS(PHE)
```

```
DUM1=(Q/A)**2
```

```
DUM=DUM1*CPHE *SIN(PHE)
```

```
DUM2=SQRT(DUM1-1.)
```

```
DUM3=DUM1*CPHE **2-1.
```

```
XPLAM=(DUM+DUM2)/DUM3
```

```
YMLAM=(DUM-DUM2)/DUM3
```

```
RETURN
```

```
END
```

```

SUBROUTINE F(RHO,0,R,Z,PHE,XPLAM,XMLAM,SI,A,SIQ,PQ,PHEQ,FP,FM)
COMMON /I/ XJ
COMMON /V/ XJ1
CPHE=COS(PHE)
SPHE=SIN(PHE)
TSI=TAN(SI)
TSI2=TSI*TSI
DUM1=RHO*Q*Q
IF(XJ1.EQ.1.)DUM1=DUM1/Z
IF(XJ.EQ.1.)DUM1=DUM1/R
DUM2P=SPHE-CPHE      *XPLAM
DUM2M=SPHE-CPHE      *XMLAM
DUM3=SIQ/COS(SI)**2+TSI      *PQ/RHO/A/A+CPHE*XJ
1+SPHE*XJ1
DUM4=TSI      *PHEQ
DUM5P=SPHE      *XPLAM+CPHE
DUM5M=SPHE      *XMLAM+CPHE
DUM6P=XPLAM*TSI2*XJ
1-TSI2*XJ1
DUM6M=XMLAM*TSI2*XJ
1-TSI2*XJ1
FP=DUM1*(DUM2P+DUM3-DUM4+DUM5P-DUM6P)
FM=DUM1*(DUM2M+DUM3-DUM4+DUM5M-DUM6M)
RETURN
END

```

SUBROUTINE INTER

COMMON /TEM/ T(40,10)

COMMON /JF/ JFINAL

COMMON /A/ X1, THMAX, TH(10), R, Z(40,10), P(40,10), PHE(40,10),

I Q(40,10), SI(40,10), H(40,10), PHI(40,10), RHO(40,10), GAM(40,10)

COMMON /B/ PN(40,10), PHIN(40,10), RHON(40,10), HN(40,10), ZN(40,10)

COMMON /C/ IMAX(10), JMAX, ISTART, KOUNTF, KOUNTP

COMMON /D/ UW(40), VW(40), WW(40), XW(40), YW(40), THW(40)

COMMON /E/ UWN(40), VWN(40), WWN(40), XWN(40), YWN(40), THWN(40)

COMMON /H/ ISIM

COMMON /I/ XJ

COMMON /J/ QN(40,10), PHEN(40,10), SINN(40,10), XPLAM(40,10),

IXMLAM(40,10), FP(40), FM(40), A(40,10)

COMMON /Q/ XCOWL

COMMON /R/ J, XCN, XC, XXI, JW, INT, ICOWL, RCOWL

COMMON /V/ XJ1

COMMON /W/ ISIMEX, IDUMMY, JINT, IDUMMY(40), THWW(2), JD1, JD2

COMMON /IQ/ NUMEXP, ZSAV

COMMON /WR/ IWRAP

COMMON /PS/ ZR(40,2), PR(40,2), QR(40,2), HR(40,2), SIR(40,2), RHOR(40,2)

I, PHIR(40,2), PHER(40,2), THR(2), THWR(40)

IMAXJ=IMAX(J)

THI=TH(J)

IF(XJ.NE.0.)THI=XXI*TAN(THI)

RAT=(XXI-XC)/(XCN-XC)

DO 3698 I=1,IMAXJ

Z I=Z (I,J)+RAT*(Z N(I,J)-Z (I,J))

P I=P (I,J)+RAT*(P N(I,J)-P (I,J))

Q I=Q (I,J)+RAT*(Q N(I,J)-Q (I,J))

H I=H (I,J)+RAT*(H N(I,J)-H (I,J))

SI I=SI (I,J)+RAT*(SINN(I,J)-SI (I,J))

RHOI=RHO(I,J)+RAT*(RHON(I,J)-RHO(I,J))

PHII=PHI(I,J)+RAT*(PHIN(I,J)-PHI(I,J))

PHEI=PHE(I,J)+RAT*(PHEN(I,J)-PHE(I,J))

IF(XJ.EQ.0.)GO TO 3697

UI=QI*COS(TH(J))*(COS(PHEI)-TAN(SII)*TAN(TH(J)))

VI=QI*COS(TH(J))*(COS(PHEI)*TAN(TH(J))+TAN(SII))

WI=QI*SIN(PHEI)

QI=SQRT(UI*UI+WI*WI)

SII=ATAN(VI/QI)

PHEI=ATAN(WI/UI)

3697 WRITE(55) ZI,PI,QI,HI,SII,RHOI,PHII,PHEI,THI

IF(J.LT.JMAX.OR.IWRAP.EQ.1) GO TO 3698

L=1

IF(J.EQ.JW) L=2

Z R(I,L)=Z I

P R(I,L)=P I

Q R(I,L)=Q I

H R(I,L)=H I

SI R(I,L)=SI I

RHOR(I,L)=RHOI

PHIR(I,L)=PHII

PHER(I,L)=PHEI

THR(L)=THI

IF(L.EQ.2) THWR(I)=THWN(I)

IF(L.EQ.2.AND.XJ.NE.0.) THWR(I)=XXI*TAN(THWN(I))

3698 CONTINUE

IF(J.LT.JW) RETURN

XJ=0.

INT=2

ICOWL=1

IF(IWRAP .EQ.1) GO TO 4

IMAXJJ=IMAX(JMAX)

DO 500 L=1,2

DO 500 I=1,IMAXJJ

JP=JMAX

IF(L.EQ.2) JP=JW

Z (I,JP)=Z R(I,L)

P (I,JP)=P R(I,L)

Q (I,JP)=Q R(I,L)

H (I,JP)=H R(I,L)

SI (I,JP)=SI R(I,L)

PHO(I,JP)=RHOR(I,L)

PHI(I,JP)=PHIR(I,L)

PHE(I,JP)=PHER(I,L)

TH(JP)=THR(L)

IF(L.EQ.2) THW(I)=THWR(I)

500 CONTINUE

JINT=JMAX

JWW=JW+NUMEXP-1

IMAXX=IMAX(JINT)

DO 461 I=1,IMAXX

L=I

IF(Z(I,JINT).GT.ZSAV) GO TO 462

461 CONTINUE

462 IDUMMY=L-1

IF(IDUMMY.LT.NUMEXP) IDUMMY=NUMEXP

IME=IDUMMY

IT=1

2 JS=JMAX

IF(IT.EQ.2) JS=JW

DEZ=ZSAV-Z(1,JMAX)

DO 3 I=1,NUMEXP

ZDUMMY(I)=Z(1,JMAX)+DEZ*FLOAT(I-1)/FLOAT(NUMEXP-1)

J=JWW-I+1

IF(J.EQ.JW) J=JFINAL

ZD=ZDUMMY(I)

IF(I.EQ.1.AND.JS.EQ.JW) ZD=Z(1,JW)

IF(XJ1.EQ.0.) GO TO 301

IR=1

302 CALL SWALL1(THG,R,ZD,FX,FZ)

ZDT=ZD/COS(THG-TH(JMAX))

CALL SWALL1(THGG,R,ZDT,FX,FZ)

EP=THGG-THG

IR=IR+1

IF(ABS(EP).LT.1.E-10) GO TO 301

IF(IR.GT.2) GO TO 303

DUM=1.01*ZD

ZD1=ZD

EP1=EP

ZD=DUM

GO TO 302

```

303 DUM=ZD1-EP1*(ZD1-ZD)/(EP1-EP)
      ZD1=ZD
      EP1=EP
      ZD=DUM
      IF (IP.LE.10) GO TO 302
      WRITE(6,304)
304 FORMAT(* ERROR IN ITERATION LOOP IN SUBROUTINE INTER*)
      CALL PNCH
301 CONTINUE
      CALL TBL(ZD ,P(IT,J),SI(IT,J),H(IT,J),PHI(IT,J),Q(IT,J),
      IPHE(IT,J),RHO(IT,J),GAM(IT,J),THX,JS,IMAX(J),I)
      Z(IT,J)=0.
      IF (XJ1.GT.0..AND.JS.EQ.JW) THX=THG
      IF (IT.EQ.2) Z(IT,J)=THX -TH(JMAX)
      IF (IT.EQ.2.AND.XJ1.GT.0.) Z(IT,J)=SIN(Z(IT,J))*ZD
      TH(J)=ZSAV-ZDUMMY(I)
      IF (I.EQ.1.AND.JS.EQ.JMAX) THWW(1)=ZSAV-Z(1,JMAX)
      THDUM=(THW(1)-TH(JMAX))*XJ1
      IF (I.EQ.1.AND.JS.EQ.JW) THWW(2)=ZSAV-Z(1,JW)*COS(THDUM)
      UT=Q(IT,J)*COS(PHE(IT,J))
      IF (XJ1.EQ.0) GO TO 306
      W1=Q(IT,J)*SIN(PHE(IT,J))
      V1=Q(IT,J)*TAN(SI(IT,J))
      DTHH=THX-TH(JMAX)
      WT=V1*COS(DTHH)+W1*SIN(DTHH)
      VT=V1*SIN(DTHH)-W1*COS(DTHH)
      GO TO 307
306 CONTINUE
      VT=Q(IT,J)*SIN(PHE(IT,J))
      WT=Q(IT,J)*TAN(SI(IT,J))
307 CONTINUE
      IF (I.NE.1) GO TO 300
      UW(IT)=UT
      VW(IT)=VT
      WW(IT)=WT
      XW(IT)=XCOWL
      YW(IT)=THWW(IT)
300 CONTINUE
      Q(IT,J)=SQRT(UT*UT+WT*WT)
      PHE(IT,J)=ATAN(WT/UT)
      SI(IT,J)=ATAN(VT/Q(IT,J))
      T(IT,J)=FT(P(IT,J),PHI(IT,J),H(IT,J))
      GAM(IT,J)=FGAM(T(IT,J),P(IT,J),PHI(IT,J))
      A(IT,J)=SQRT(GAM(IT,J)*P(IT,J)/RHO(IT,J))
      CALL XLAM(Q(IT,J),A(IT,J),PHE(IT,J),XPLAM(IT,J),XMLAM(IT,J))
      IMAX(J)=2
3 CONTINUE
      IF (IT.EQ.2) GO TO 4
      IT=2
      GO TO 2
4 CONTINUE
      RETURN
      END

```

SUBROUTINE L TH M

```

COMMON /A/ XI,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /SCLTM/ ZLIFTC,XTHRC,YMOMC,ZLIFTS,XTHRS,YMOMS
COMMON/M/ IS(7,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /I/ XJ
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1 XMLAM(40,10),FD(40),FM(40),A(40,10)
COMMON /K/ RN,DEL R
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL T
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /IQ/ NUMEXP,ZSAV
COMMON /WR/ IWRAP
COMMON /ISW/ JCALC,ISWEEP,XINSD(10),X2
COMMON /THR/ PINF,ZLIFT,XTHR,YMOM,JJI,ZSHIFT,XSHIFT
COMMON /WO/ XJSS
IF(ICOWL.EQ.1.AND.XJSS.GT.0.) RETURN
JJK=2
IF(XJ.EQ.0..OR.JJI.LT.2) GO TO 11
JJK=JJJ+1
IF(JJI.GE.JW) RETURN
11 CONTINUE
JWW=JW
DUMR=R
IF(XJ.EQ.0.) DUMR=1.
DUMRN=RN
IF(XJ.EQ.0.) DUMRN=1.
DUMX=(1.-XJ)*(1.-XJ1)
OPT=1.
K=1
SUMXJ=(XJ1+XJ)
12 CONTINUE
IF(K.GT.1) OPT=-1.
IF(ICOWL T.EQ.1.AND.IWRAP.EQ.0) JWW=JINT
DO 1 J=JJK,JWW
IF(J.GT.JCALC) GO TO 1
IF(J.NE.JMAX+1) THJ=TH(J)
IF(J.NE.JMAX+1) THJ1=THJ
II=IMAX(J)
II1=IMAX(J-1)
IF(K.GT.1) GO TO 50
II=1
II1=1
50 CONTINUE
IF(J.EQ.JMAX+1) THJ=THW(II)
IF(J.EQ.JMAX+1) THJ1=THWN(II)
THX=THJ*SUMXJ
THX1=THJ1*SUMXJ
THXX=TH(J-1)*SUMXJ
DUM1=Z(II,J)

```

```
DUM2=ZN(II,J)
DUM3=ZN(II1,J-1)
DUM4=Z(II1,J-1)
IF(XJ1.GT.0.) GO TO 51
```

```
DUM1=1.
DUM2=1.
DUM3=1.
DUM4=1.
```

51 CONTINUE

```
Y1=DUMR*DUM1*SIN(THX)+DUMX*THJ
Y2=DUMRN*DUM2*SIN(THX1)+DUMX*THJ1
Y3=DUMRN*DUM3*SIN(THXX)+DUMX*TH(J-1)
Y4=DUMR*DUM4*SIN(THXX)+DUMX*TH(J-1)
```

```
Z1=Z(II,J)
Z2=ZN(II,J)
Z3=ZN(II1,J-1)
Z4=Z(II1,J-1)
```

IF(XJ1.EQ.0.) GO TO 6

```
Z1=Z1*COS(THJ)
Z2=Z2*COS(THJ1)
Z3=Z3*COS(TH(J-1))
Z4=Z4*COS(TH(J-1))
```

6 CONTINUE

```
P1=P(II,J)-PINF
P2=PN(II,J)-PINF
P3=PN(II1,J-1)-PINF
P4=P(II1,J-1)-PINF
```

```
XX1=X1
XX2=X2
XX3=X2
XX4=X1
```

IF(XJ.EQ.0.) GO TO 3

```
XX1=R*COS(THJ)
XX2=RN*COS(THJ1)
XX3=RN*COS(TH(J-1))
XX4=R*COS(TH(J-1))
```

3 CONTINUE

```
TERM1=Y4-Y2
TERM3=Y3-Y1
DAX=((Z1-Z3)*TERM1+(Z4-Z2)*TERM3)/2.
DAZ=((XX1-XX3)*TERM1+(XX4-XX2)*TERM3)/2.
```

DAX=ARS(DAX)

DAZ=ARS(DAZ)

DAZ=-DAZ*OPT

PH1=PHE(II,J)

PH2=PHEN(II,J)

PH3=PHEN(II1,J-1)

PH4=PHE(II1,J-1)

PHAV=(PH1+PH2+PH3+PH4)/4.

OPT1=SIGN(1.,PHAV)

DAX=OPT1*DAX*OPT

PAV=(P1+P2+P3+P4)/4.

DL=PAV*DAZ

DT=PAV*DAX

XAV=(XX1+XX2+XX3+XX4)/4.

ZAV=(Z1+Z2+Z3+Z4)/4.

```

DL=-DL
DT=-DT
ZAV=ZAV-ZSHIFT
XAV=XAV-XSHIFT
XAV=-XAV
ZAV=-ZAV
DM=-DL*XAV+DT*ZAV
ZLIFT=ZLIFT+DL
XTHR=XTHR+DT
YMOM=YMOM+DM
1 CONTINUE
K=K+1
IF(ICOWLT.EQ.1) K=3
IF(K.EQ.2) GO TO 12
IF(JW.EQ.JMAX) RETURN
J=JMAX+1
IF(J.GT.JCALC) RETURN
IMAXX=IMAX(J)
DO 2 I=2,IMAXX
THX=THW(I)*SUMXJ
THXN=THWN(I)*SUMXJ
THX1=THW(I-1)*SUMXJ
THXN1=THWN(I-1)*SUMXJ
DUM1=Z(I,J)
DUM2=ZN(I,J)
DUM3=ZN(I-1,J)
DUM4=Z(I-1,J)
IF(XJ1.GT.0.) GO TO 8
DUM1=1.
DUM2=1.
DUM3=1.
DUM4=1.
8 YS1=DUMR*DUM1*SIN(THX)+DUMX*THW(I)
YS2=DUMRN*DUM2*SIN(THXN)+DUMX*THWN(I)
YS3=DUMRN*DUM3*SIN(THXN1)+DUMX*THWN(I-1)
YS4=DUMR*DUM4*SIN(THX1)+DUMX*THW(I-1)
XX1=X1
XX2=X2
XX3=X2
XX4=X1
IF(XJ,EQ.0.) GO TO 10
XX1=R*COS(THX)
XX2=RN*COS(THXN)
XX3=RN*COS(THXN1)
XX4=R*COS(THX1)
10 P1=P(I,J)-PINF
P2=PN(I,J)-PINF
P3=PN(I-1,J)-PINF
P4=P(I-1,J)-PINF
ZS1=Z(I,J)
ZS2=ZN(I,J)
ZS3=ZN(I-1,J)
ZS4=Z(I-1,J)
IF(XJ1.GT.0.) GO TO 7
CALL SWALL(R,ZS1, XX1,YZ,FX1,FZ1)
CALL SWALL(RN,ZS2, XX2,YZ,FX2,FZ2)

```

```

CALL SWALL(RN,ZS3, XX3,YZ,FX3,FZ3)
CALL SWALL(R,ZS4, XX4,YZ,FX4,FZ4)
GO TO 9
7 CALL SWALL1(THZ,R,ZS1,FX1,FZ1)
CALL SWALL1(THZ,RN,ZS2,FX2,FZ2)
CALL SWALL1(THZ,RN,ZS3,FX3,FZ3)
CALL SWALL1(THZ,R,ZS4,FX4,FZ4)
ZS1=ZS1*COS(THX)
ZS2=ZS2*COS(THXN)
ZS3=ZS3*COS(THXN1)
ZS4=ZS4*COS(THX1)
9 FX=(FX1+FX2+FX3+FX4)/4.
FZ=(FZ1+FZ2+FZ3+FZ4)/4.
IIWRAP=1
IF(IIWRAP.EQ.0.AND.ICOWLT.EQ.1)IIWRAP=0
TH1=0.
IF(IIWRAP.EQ.0)TH1=TH(JINT)
Z 1=ZS1*FLOAT(IIWRAP)+(ZSAV-YS1)*FLOAT(1-IIWRAP)
Z 2=ZS2*FLOAT(IIWRAP)+(ZSAV-YS2)*FLOAT(1-IIWRAP)
Z 3=ZS3*FLOAT(IIWRAP)+(ZSAV-YS3)*FLOAT(1-IIWRAP)
Z 4=ZS4*FLOAT(IIWRAP)+(ZSAV-YS4)*FLOAT(1-IIWRAP)
Y 4=YS4*FLOAT(IIWRAP)+(TH1+ZS4)*FLOAT(1-IIWRAP)
Y 3=YS3*FLOAT(IIWRAP)+(TH1+ZS3)*FLOAT(1-IIWRAP)
Y2=YS2*FLOAT(IIWRAP)+(TH1+ZS2)*FLOAT(1-IIWRAP)
Y 1=YS1*FLOAT(IIWRAP)+(TH1+ZS1)*FLOAT(1-IIWRAP)
TERM1=Y2-Y4
TERM3=Y3-Y1
DAX=((Z1-Z3)*TERM1+(Z2-Z4)*TERM3)/2.
DAZ=((XX1-XX3)*TERM1+(XX2-XX4)*TERM3)/2.
DAX=ARS(DAX)
DAZ=ARS(DAZ)
OPT3=1.
OPT4=1.
IF(ICOWLT.EQ.0)OPT3=SIGN(1.,FX)
IF(ICOWLT.EQ.0)OPT4=SIGN(1.,FZ)
DAZ=-OPT4*DAZ
DAX=-OPT3*DAX
PAV=(P1+P2+P3+P4)/4.
DL=PAV*DAZ
DT=PAV*DAX
XAV=(XX1+XX2+XX3+XX4)/4.
ZAV=(Z1+Z2+Z3+Z4)/4.
DL=-DL
DT=-DT
ZAV=ZAV-ZSHIFT
XAV=XAV-XSHIFT
XAV=-XAV
ZAV=-ZAV
DM=-DL*XAV+DT*ZAV
ZLIFT=ZLIFT+DL
XTHR=XTHR+DT
YMOM=YMOM+DM
IF(I.EQ.IS(3,J)-1) GO TO 132
IF(I.EQ.IS(1,J)-1) GO TO 92
GO TO 2
132 ZLIFTC=ZLIFT

```

```
XTHR=CXTHR  
YMOM=CYMOM  
GO TO 2  
92 ZLIFT=CZLIFT  
XTHR=CXTHR  
YMOM=CYMOM  
2 CONTINUE  
RETURN  
END
```

```

SUBROUTINE MOTHER
COMMON /STREAM/ XMAST,XENT,FSX,FSZ
COMMON /H/ ISIM
COMMON /M/ IS(7,10)
COMMON /THR/ PINF,ZLIFT,XTHR,YMOM,JJI,ZSHIFT,XSHIFT
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL
COMMON /A/ Q1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /I/ XJ
COMMON /V/ XJ1
COMMON /WRTOMO/ XO(3),X1(3),P1W(20),Q1W(20),H1W(20),S1W(20),
1PH1W(20),PHE1W(20),RHO1W(20)
COMMON /PS/ ZR(40,2),PR(40,2),OR(40,2),HR(40,2),SIR(40,2),RHOR(40,2)
1,PHIR(40,2),PHER(40,2),THR(2),THWR(40)
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /IQ/ NUMEXP,ZSAV
COMMON /WR/ IWRAP
XJ2=1.-XJ
XJ3=1.-XJ1
IF(IWRAP.EQ.1.OR.ICOWL.EQ.0) GO TO 50
IMAS=IMAX(JINT)+1
DO 51 I=1,IMAS
Z R(I,1)=Z (I,JINT)
P R(I,1)=P (I,JINT)
Q R(I,1)=Q (I,JINT)
H R(I,1)=H (I,JINT)
SI R(I,1)=SI (I,JINT)
PHIR(I,1)=PHI(I,JINT)
PHER(I,1)=PHE(I,JINT)
RHOR(I,1)=RHO(I,JINT)
Z R(I,2)=Z (I,JINT+1)
P R(I,2)=P (I,JINT+1)
Q R(I,2)=Q (I,JINT+1)
H R(I,2)=H (I,JINT+1)
SI R(I,2)=SI (I,JINT+1)
PHIR(I,2)=PHI(I,JINT+1)
PHER(I,2)=PHE(I,JINT+1)
RHOR(I,2)=RHO(I,JINT+1)
51 CONTINUE
XJ1S=XJ1
XJ2S=XJ2
XJ3S=XJ3
XJS=XJ
50 CONTINUE
300 XMASS=0.
ICHECK=1
2 CONTINUE
JQ=JMAX-1
IF(ISIM.EQ.0) JQ=JMAX
DO 1 J=1,JQ
I=0
NUMZ=1.
IF(XJ1.GT.0.) NUMZ=.5*(Z(I+1,J)+Z(I+1,J+1))

```



```

DZ=Z(I+1,J)-Z(I+1,J+1)
IF(ISIM.NE.0.OR.J.NE.JMAX) THP3=TH(J+1)
IF(ISIM.EQ.0.AND.J.EQ.JMAX) THP3=THW(I+1)
DTH=THP3-TH(J)
IF(J.EQ.JINT.AND.ICOWLT.EQ.1) DTH=3.1415926/18.
DUMR=1.
IF(XJ.GT.0.) DUMR=R
S3=DZ*DZ+(DTH*DUMZ*DUMR)**2
S3=SQRT(S3)
IMAX1=IMAX(J)-1
IF(ICOWLT.EQ.1) IMAX1=IS(3,J)-2
IF(J.EQ.JINT.AND.ICOWLT.EQ.1) IMAX1=IS(3,J)-IDUMMY-1
IF(J.NE.JINT.OR.ICOWLT.EQ.0) GO TO 53
XJ1=1.
XJ=0.
XJ2=1.
XJ3=0.
IS3J=IS(3,J)-1
IDUMMI=IDUMMY+1
DO 55 I=IDUMMI,IS3J
L=I-IDUMMY+1
Z(L,J)=Z(I,J)-ZSAV
P(L,J)=P(I,J)
Q(L,J)=Q(I,J)
H(L,J)=H(I,J)
SI(L,J)=SI(I,J)
PHI(L,J)=PHI(I,J)
PHE(L,J)=PHE(I,J)
RHO(L,J)=RHO(I,J)
55 CONTINUE
Z(I,J)=Z R(I,2)
P(I,J)=P R(I,2)
Q(I,J)=Q R(I,2)
H(I,J)=H R(I,2)
SI(I,J)=SI R(I,2)
PHI(I,J)=PHIR(I,2)
PHE(I,J)=PHER(I,2)
RHO(I,J)=RHOR(I,2)
KK=1
56 KK=KK+1
THT=DTH*FLOAT(KK-1)
DO 54 I=IDUMMI,IS3J
L=I-IDUMMY+1
C=(ZR(I,1)-ZSAV)/X0(1)
D=C*X1(1)
D2=D*D
RDUM=X0(1)*C
DUM=RDUM*SQRT(RDUM*RDUM+D2)
R3=C*(X0(1)+X1(1)*THT)
S=.5/D*(R3*SQRT(R3*R3+D2)-DUM)
P(L,J+1)=P R(I,1)+P 1W(L)*S
Q(L,J+1)=Q R(I,1)+Q 1W(L)*S
H(L,J+1)=H R(I,1)+H 1W(L)*S
SI(L,J+1)=SI R(I,1)+SI 1W(L)*S
PHI(L,J+1)=PHIR(I,1)+PHI1W(L)*S
PHE(L,J+1)=PHER(I,1)+PHE1W(L)*S

```

```

RHO(L,J+1)=RHOR(I,1)+RHO1W(L)*C
7(L,J+1)=R3
54 CONTINUE
7(1,J+1)=Z(1,J)
P(1,J+1)=P(1,J)
H(1,J+1)=H(1,J)
Q(1,J+1)=Q(1,J)
SI(1,J+1)=SI(1,J)
PHI(1,J+1)=PHI(1,J)
PHE(1,J+1)=PHE(1,J)
RHO(1,J+1)=RHO(1,J)
53 CONTINUE
DO 6 I=1,IMAX1
IF(J.EQ.1) S2=Z(I+1,J)-Z(I,J)
S1=S3
S4=S2
DUMZ=1.
IF(XJ1.GT.0.) DUMZ=.5*(Z(I+1,J)+Z(I+1,J+1))
DZ=Z(I+1,J)-Z(I+1,J+1)
IF(ISIM.NE.0.OR.J.NE.JMAX) THP3=TH(J+1)
IF(ISIM.EQ.0.AND.J.EQ.JMAX) THP3=THW(I+1)
IF(XJ1.GT.0.AND.ISIM.EQ.0.AND.J.EQ.JMAX) THP3=(THW(I+1)+THW(I))/2.
DTH=THP3-TH(J)
IF(J.EQ.JINT.AND.ICOWL.T.EQ.1) DTH=3.1415926/18.
S3=DZ*DZ+(DTH*DUMZ*DUMR)**2
S3=SQRT(S3)
IF(ISIM.NE.0.OR.J.NE.JMAX) THP2=TH(J+1)
IF(ISIM.EQ.0.AND.J.EQ.JMAX) THP2=THW(I)
XX2=(XJ2+XJ*COB(THP2*XJ))*R
YY2=XJ2*THP2+XJ*R*SIN(THP2*XJ)+XJ1*Z(I,J+1)*SIN(THP2*XJ1)
ZZ2=(XJ3+XJ1*COB(THP2*XJ1))*Z(I,J+1)
XX3=(XJ2+XJ*COB(THP3*XJ))*R
YY3=XJ2*THP3+XJ*R*SIN(THP3*XJ)+XJ1*Z(I+1,J+1)*SIN(THP3*XJ1)
ZZ3=(XJ3+XJ1*COB(THP3*XJ1))*Z(I+1,J+1)
DZ=ZZ3-ZZ2
DY=YY3-YY2
DX=XX3-XX2
S2=DZ*DZ+DY*DY+DX*DX
S2=SQRT(S2)
ST=S1+S2+S3+S4
U1=Q(I,J)*COB(PHE(I,J))
IF(XJ.GT.0.) U1=U1*COB(TH(J))-Q(I,J)*TAN(SI(I,J))*SIN(TH(J))
RU1=RHO(I,J)*U1
U2=Q(I,J+1)*COB(PHE(I,J+1))
IF(XJ.GT.0.) U2=U2*COB(THP2)-Q(I,J+1)*TAN(SI(I,J+1))*SIN(THP2)
RU2=RHO(I,J+1)*U2
U3=Q(I+1,J+1)*COB(PHE(I+1,J+1))
IF(XJ.GT.0.) U3=U3*COB(THP3)-Q(I+1,J+1)*TAN(SI(I+1,J+1))*SIN(THP3)
RU3=RHO(I+1,J+1)*U3
U4=Q(I+1,J)*COB(PHE(I+1,J))
IF(XJ.GT.0.) U4=U4*COB(TH(J))-Q(I+1,J)*TAN(SI(I+1,J))*SIN(TH(J))
RU4=RHO(I+1,J)*U4
RU=(RU1+RU2)*S1+(RU2+RU3)*S2+(RU3+RU4)*S3+(RU4+RU1)*S4)/2./ST
ZZ1=(XJ3+XJ1*COB(TH(J)*XJ1))*Z(I,J)
ZZ4=(XJ3+XJ1*COB(TH(J)*XJ1))*Z(I+1,J)
YY1=XJ2*TH(J)+XJ*R*SIN(TH(J)*XJ)+XJ1*Z(I,J)*SIN(TH(J)*XJ1)

```

YY4= XJ2*TH(J)+XJ*R*SIN(TH(J)*XJ)+XJ1*Z(I+1,J)*SIN(TH(J)*XJ1)
DAX=((ZZ1-ZZ3)*(YY2-YY4)+(ZZ2-ZZ4)*(YY3-YY1))/2.

DAX=ABS(DAX)

IF(XJ1.EQ.0.) GO TO 60

ZL=(Z(I,J)+Z(I,J+1))/2.

ZU=(Z(I+1,J)+Z(I+1,J+1))/2.

DAX=(7U*ZU-ZL*7L)*DTH/2.

60 CONTINUE

GO TO (3,4,5),ICHECK

3 DM=RU*DAX

XMASS=XMASS+DM

GO TO 6

4 V1=(Q(I,J)/COS(SI(I,J)))**2

H1=(H(I,J)+V1/2.)*RU1

V2=(Q(I,J+1)/COS(SI(I,J+1)))**2

H2=(H(I,J+1)+V2/2.)*RU2

V3=(Q(I+1,J+1)/COS(SI(I+1,J+1)))**2

H3=(H(I+1,J+1)+V3/2.)*RU3

V4=(Q(I+1,J)/COS(SI(I+1,J)))**2

H4=(H(I+1,J)+V4/2.)*RU4

HT=C1*((H1+H2)*S1+(H2+H3)*S2+(H3+H4)*S3+(H4+H1)*S4)/2./ST

DHT=HT*DAX

XEN=XEN+DHT

GO TO 6

5 RUU1=RU1*U1

W1=Q(I,J)*SIN(PHE(I,J))

IF(XJ1.GT.0.) W1=W1*COS(TH(J))-Q(I,J)*TAN(SI(I,J))*SIN(TH(J))

RUW1=RU1*W1

RUU2=RU2*U2

W2=Q(I,J+1)*SIN(PHE(I,J+1))

IF(XJ1.GT.0.) W2=W2*COS(TH(J))-Q(I,J+1)*TAN(SI(I,J+1))*SIN(TH(J))

RUW2=RU2*W2

RUU3=RU3*U3

W3=Q(I+1,J+1)*SIN(PHE(I+1,J+1))

IF(XJ1.GT.0.) W3=W3*COS(TH(J))-Q(I+1,J+1)*TAN(SI(I+1,J+1))*SIN(TH(J))

RUW3=RU3*W3

RUU4=RU4*U4

W4=Q(I+1,J)*SIN(PHE(I+1,J))

IF(XJ1.GT.0.) W4=W4*COS(TH(J))+Q(I+1,J)*TAN(SI(I+1,J))*SIN(TH(J))

RUW4=RU4*W4

RUU=(RUU1+RUU2)*S1+(RUU2+RUU3)*S2+(RUU3+RUU4)*S3+(RUU4+RUU1)*S4

1/2./ST

RUW=(RUW1+RUW2)*S1+(RUW2+RUW3)*S2+(RUW3+RUW4)*S3+(RUW4+RUW1)*S4

1/2./ST

PAV=((P(I,J)+P(I,J+1))*S1+(P(I,J+1)+P(I+1,J+1))*S2+(P(I+1,J+1)+

P(I+1,J))*S3+(P(I+1,J)+P(I,J))*S4)

1/2./ST

PAV=PAV-PINF

XX1=(XJ2+XJ*COS(TH(J)*XJ))*R

XX4=XX1

DAX=((ZZ1-ZZ3)*(YY2-YY4)+(ZZ2-ZZ4)*(YY3-YY1))/2.

DAX=ABS(DAX)

IF(XJ1.EQ.0.) GO TO 61

ZL=(Z(I,J)+Z(I,J+1))/2.

```

7U=(Z(I+1,J)+Z(I+1,J+1))/2.
DAX=(7U*7U-ZL*7L)*DTH/2.
61 CONTINUE
DAZ=((XX1-XX3)*(YY2-YY4)+(XX2-XX4)*(YY3-YY1))/2.
DAZ=ABS(DAZ)
DMVX=RUU*DAX+PAV*DAX
DMVZ=RUW*DAX+PAV*DAZ
FSX=FSX+DMVX
FSZ=FSZ+DMVZ
6 CONTINUE
IF(J.NE.JINT.OR.ICOWLT.EQ.0) GO TO 1
IF(KK.GE.9) GO TO 64
IMAX11=IMAX1+1
DO 62 I=1,IMAX11
7 (I,J)=Z (I,J+1)
P (I,J)=P (I,J+1)
Q (I,J)=Q (I,J+1)
H (I,J)=H (I,J+1)
SI (I,J)=SI (I,J+1)
PHI(I,J)=PHI(I,J+1)
PHE(I,J)=PHE(I,J+1)
RHO(I,J)=RHO(I,J+1)
62 CONTINUE
GO TO 56
64 DO 65 I=1,IMAS
Z (I,J)=Z R(I,1)
P (I,J)=P R(I,1)
Q (I,J)=Q R(I,1)
H (I,J)=H R(I,1)
SI (I,J)=SI R(I,1)
PHI(I,J)=PHIR(I,1)
PHE(I,J)=PHER(I,1)
RHO(I,J)=RHOR(I,1)
Z (I,J+1)=Z R(I,2)
P (I,J+1)=P R(I,2)
Q (I,J+1)=Q R(I,2)
H (I,J+1)=H R(I,2)
SI (I,J+1)=SI R(I,2)
PHI(I,J+1)=PHIR(I,2)
PHE(I,J+1)=PHER(I,2)
RHO(I,J+1)=RHOR(I,2)
65 CONTINUE
XJ=XJS
XJ1=XJ1S
XJ2=XJ2S
XJ3=XJ3S
1 CONTINUE
GO TO (10,11,12),ICHECK
10 IF(KOINT.EQ.0) XMAST=XMASS
C1=XMAST/XMASS
XEN=0.
ICHECK=2
GO TO 2
11 IF(KOINT.EQ.0) XENT=XEN
C2=XENT/XEN
IF(KOINT.NE.0) CALL UNOWAT(C1,C2)

```

IF (KOUNT.NE.0) GO TO 12

FSX=0.

FSZ=0.

ICHECK=3

GO TO 2

12 CONTINUE

RETURN

END

SUBROUTINE SETN(IQ)

```

COMMON /WR/ IWRAP
COMMON /ZNDERV/ DPZN(40),DUZN(40),DVZN(40),DWZN(40)
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /ALLR1/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1XMLAMN(40,10)
COMMON /ALLR2/ PQN(40,10),HQN(40,10),RQ(40,10),SIGN(40,10),
1PHEQN(40,10),PHIQN(40,10),RHOQN(40,10),GAMQN(40,10)
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /H/ ISIM
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)
COMMON /M/ IS(7,10)
COMMON /N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1QQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /O/ ALP(7,10),ALPN(7,10)
COMMON /Q/ XCOWL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL,T
COMMON /TEM/ T(40,10)
COMMON /FN/ FPN(40,10),FMN(40,10)
IF(IQ.EQ.1) GO TO 1
IF(R.GE.RCOWL) GO TO 100
DO 7615 M=1,7
DO 7677 J=1,10
ALP(M,J)=0.
ALPN(M,J)=0.
ALPHAN(M,J)=0.
BETAN(M,J)=0.
ALPHA(M,J)=0.
BETA(M,J)=0.
7677 IS(M,J)=0
7615 CONTINUE
100 DO 3535 M=1,40
DO 3536 J=1,10
FPN(M,J)=0.
FMN(M,J)=0.
P Q(M,J)=0.
H Q(M,J)=0.
Q Q(M,J)=0.
SI Q(M,J)=0.
PHIQ(M,J)=0.
PHEQ(M,J)=0.
RHOQ(M,J)=0.
GAMQ(M,J)=0.
3536 CONTINUE
DPZN(M)=0.
DUZN(M)=0.
DVZN(M)=0.
DWZN(M)=0.
3535 CONTINUE

```

1 CONTINUE

```
JW=JMAX+1
IF (JSIM.EQ.1) JW=JMAX
DO 2 J=1,JW
  IMAXJ=IMAX(J)
  IF (R.AT.XCOWL-1.E-06.AND.ICOWL.T.EQ.1) IMAXJ=IMAXJ+1
DO 3 I=1,IMAXJ
  Z N(I,J)=Z (I,J)
  P N(I,J)=P (I,J)
  Q N(I,J)=Q (I,J)
  H N(I,J)=H (I,J)
  A N(I,J)=A (I,J)
  T N(I,J)=T (I,J)
  SINN(I,J)=SI (I,J)
  PHEN(I,J)=PHE(I,J)
  PHIN(I,J)=PHI(I,J)
  RHON(I,J)=RHO(I,J)
  GAMN(I,J)=GAM(I,J)
  XPLAMN(I,J)=XPLM(I,J)
  XMLAMN(I,J)=XMLAM(I,J)
  PQ N(I,J)=PQ (I,J)
  HQ N(I,J)=HQ (I,J)
  QQ N(I,J)=QQ (I,J)
  SION(I,J)=SIQ(I,J)
  PHIQ N(I,J)=PHIQ (I,J)
  PHEQN(I,J)=PHEQ(I,J)
  RHQQ N(I,J)=RHQQ (I,J)
  GAMQ N(I,J)=GAMQ (I,J)
  IF (J.NE.JMAX+1) GO TO 3
  U WN(I)=U W(I)
  V WN(I)=V W(I)
  W WN(I)=W W(I)
  X WN(I)=X W(I)
  Y WN(I)=Y W(I)
  THWN(I)=THW(I)
```

3 CONTINUE

```
DO 4 M=1,7
  ALP N(M,J)=ALP (M,J)
  BETA N(M,J)=BETA (M,J)
  ALPHAN(M,J)=ALPHA(M,J)
```

4 CONTINUE

2 CONTINUE

RETURN

END

SUBROUTINE INDATA

COMMON /STREAM/ XMAST,XENT,FSX,FSZ

COMMON /JF/ JFINAL

COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),

1 XMLAM(40,10),FP(40),FM(40),A(40,10)

COMMON /TEM/ T(40,10)

COMMON /IVY/ IVY,KCORR,IAV

COMMON /A/ XI,THMAX,TH(10),R,Z(40,10),P(40,10),PHE(40,10),

1 Q(40,10),SI(40,10),H(40,10),PLI(40,10),RHO(40,10),GAM(40,10)

COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP

COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)

COMMON /G/ A1(3,9),A2(3,9),A3(3,9),RR1(3),RR2(3),RR3(3)

1,NUMLWS,NUMUWS,NUMSWS

COMMON /H/ ISIM

COMMON /I/ XJ

COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BETAN(7,10),BETA(7,10)

COMMON /M/ IS(7,10)

COMMON /O/ ALP(7,10),ALPN(7,10)

COMMON /P/ KC1,KC2,KS1,KS2

COMMON /Q/ XCOWL

COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL

COMMON /S/ RI,KOUNT,KOUNTS,ICOWL

COMMON /V/ XJ1

COMMON /W/ ISIMEX,IDUMMY,JINT,JDUMMY(40),THWW(2),JD1,JD2

COMMON /EX/ KTPUN(3)

COMMON /THR/ PINF,ZLIFT,XTHR,YMOM,JJI,ZSHIFT,XSHIFT

COMMON /XF/ XFIN

COMMON /IQ/ NUMEXP,ZSAV

COMMON /WR/ IWRAP

COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2

COMMON /SPE/ KOUNTC

COMMON /ISE/ KOUNSP

COMMON /WO/ XJSS

COMMON /SCLTM/ ZLIFTC,XTHRC,YMOMC,ZLIFTS,XTHRS,YMOMS

COMMON /XSTP/ XSTP

DATA XINSP/10*0.,KOUNSP/0/

DATA THW/40*0./

100 FORMAT(16I5)

101 FORMAT(7E10.3)

102 FORMAT(8E10.3)

KOUNT=0

JCALC=100

READ(5,9100) KOUNTF,KOUNTP,ISTART,IVY,IAV,KCORR,JFINAL,

1 (KTPUN(I),I=1,3),XSTP

9100 FORMAT(10I5,E10.0)

READ(5,100) JMAX,ISIM,ISIMEX,IWRAP,NUMEXP,ISWEEP,(IMAX(J),J=1,JMAX

1)

READ(5,102) R,XJ,XJ1,XCOWL,RCOWL,XFIN,ZSAV,PINF

XJSS=XJ

RI=R

IF(ISTART.EQ.1) READ(5,210) KOUNT,R

210 FORMAT(I5,E11.3)

IF(R.GT.RCOWL) ISIM=ISIMEX

JW=JMAX+1

IF(ISIM.EQ.1) JW=JMAX

IF(ISWEEP.EQ.1) READ(5,101) (XTNSP(J),J=1,JW)


```

IF (ISWEEP.EQ.1) KOUNSP=10000
KOUNTS=KOUNT
X1=P
IF (ISTART.EQ.1) GO TO 211
IF (ISWEEP.NE.1) GO TO 1900
JCALC=1
JMAX=JMAX+1
JW=JW+1
IMAX(JMAX)=IMAX(JMAX-1)
1900 CONTINUE
READ(5,101) ZLIFT,XTHR,YMOM,ZSHIFT,XSHIFT
DO 5 J=1,JMAX
IF (ISWEEP.EQ.1.AND.J.EQ.2) GO TO 5
MMAX=IMAX(J)
READ(5,101) TH(J),(Z(I,J),I=1,MMAX)
IF (XJ.EQ.0..AND.XJ1.EQ.0.)GO TO 5
TH(J)=TH(J)/57.3
5 CONTINUE
IF (ISIM.EQ.0)
1 READ(5,106) MMAX ,(Z(I,JW),I=1,MMAX)
106 FORMAT(15,(7E10.3))
IMAX(JW)=MMAX
211 CONTINUE
WRITE(6,400)
400 FORMAT(1H1,24X,*T H R E E   D I M E N S I O N A L   C H A R A C T
I E R I S T I C S*///)
IF (XJ.EQ.0.) WRITE(6,401) RI,R
IF (XJ.NE.0.) WRITE(6,402) RI,R
401 FORMAT(10X,*THE INITIAL CARTESIAN X COORDINATE IS*,E13.5//10X,
1*THIS RUN STARTED AT X COORDINATE*,E13.5/)
402 FORMAT(10X,*THE INITIAL RADIUS OF CURVATURE IS*,E13.5//10X,
1*THIS RUN STARTED WITH A RADIUS OF*,E13.5/)
WRITE(6,403) KOUNT,KOUNTF,KOUNTP
403 FORMAT(10X,*THIS RUN WAS STARTED AT KOUNT =*,I5,* WILL RUN TO KOU
INT =*,I5,* AND WILL PRINT EVERY*,I5,* KOUNTS*/ )
ISIMP=ISIM+1
WRITE(6,404) ISIMP
404 FORMAT(10X,*THERE ARE*,I5,* WALLS OF SYMMETRY IN THE INTERNAL FLO
1W*/ )
WRITE(6,405) XCOWL
405 FORMAT(10X,*THE X COORDINATE OF THE COWL IS*,E13.5/)
IF (XJ.NE.0.) WRITE(6,406) RCOWL
406 FORMAT(10X,*THE RADIAL DISTANCE TO INTERSECTION OF COWL LIP AND SI
IDE WALL IS*,E13.5/)
WRITE(6,2072) XFIN
2072 FORMAT(10X,*THE X COORDINATE OF THE END OF THE VEHICLE UNDERSURFAC
IF IS*,E13.5)
C LOWER WALL GEOMETRY
READ(5,100) NUMLWS
DO 250 I=1,NUMLWS
READ(5,102) RR1(I),(A1(I,J),J=1,9)
250 CONTINUE
C UPPER WALL GEOMETRY
READ(5,100) NUMUWS
DO 251 I=1,NUMUWS
READ(5,102) RR2(I),(A2(I,J),J=1,9)

```

```

251 CONTINUE
C   IF(ISIM.EQ.1) GO TO 53
    SIDE WALL GEOMFTRY
    READ(5,100) NUMSWS
    DO 252 I=1,NUMSWS
      READ(5,102) RR3(I),(A3(I,J),J=1,9)
252 CONTINUE
53 CONTINUE
    WRITE(6,2010)
2010 FORMAT(/,35X,*LOWER WALL COORDINATES*)
    WRITE(6,2071)
    DO 2040 I=1,NUMLWS
      IF((I+1).GT.NUMLWS) GO TO 2041
      WRITE(6,2042) RR1(I),RR1(I+1),(A1(I,J),J=1,9)
      GO TO 2040
2041 WRITE(6,2043) RR1(I),(A1(I,J),J=1,9)
2040 CONTINUE
    WRITE(6,2020)
2020 FORMAT(/,35X,*UPPER WALL COORDINATES*)
    WRITE(6,2071)
    DO 2050 I=1,NUMUWS
      IF((I+1).GT.NUMUWS) GO TO 2051
      WRITE(6,2042) RR2(I),RR2(I+1),(A2(I,J),J=1,9)
      GO TO 2050
2051 WRITE(6,2043) RR2(I),(A2(I,J),J=1,9)
2050 CONTINUE
    IF(ISIM.EQ.1) GO TO 54
    WRITE(6,2030)
2030 FORMAT(/,35X,*SIDE WALL COORDINATES*)
    IF(XJ.EQ.0.) WRITE(6,2071)
    IF(XJ.GT.0.) WRITE(6,2070)
    DO 2060 I=1,NUMSWS
      IF((I+1).GT.NUMSWS) GO TO 2061
      WRITE(6,2042) RR3(I),RR3(I+1),(A3(I,J),J=1,9)
      GO TO 2060
2061 WRITE(6,2043) RR3(I),(A3(I,J),J=1,9)
2060 CONTINUE
2042 FORMAT(10X,E11.3)
2043 FORMAT(10X,E11.3,4X,*END*,4X,9E11.3)
2070 FORMAT(15X,*R*,4X,*TO*,4X,*R*,45X,*COORDINATES*)
2071 FORMAT(15X,*X*,4X,*TO*,4X,*X*,45X,*COORDINATES*)
54 CONTINUE
    IF(ISTART.EQ.1) GO TO 212
    TEMP=0.
    TTEMP=0.
    DO 6 J=1,JMAX
      IF(ISWEEP.EQ.1.AND.J.EQ.2) GO TO 6
      MMAX=JMAX(J)
      READ(5,101) (P(I,J),I=1,MMAX)
      READ(5,101) (PHE(I,J),I=1,MMAX)
      READ(5,101) (Q(I,J),I=1,MMAX)
      READ(5,101) (SI(I,J),I=1,MMAX)
      READ(5,101) (H(I,J),I=1,MMAX)
      READ(5,101) (PHI(I,J),I=1,MMAX)
      DO 531 I=1,MMAX
        PHE(I,J)=PHE(I,J)/57.3

```

```

SI(I,J)=SI(I,J)/57.3
IF(H(I,J).LT.10000.)TEMP=1.
IF(H(I,J).LT.10000.)TTEMP=H(I,J)
T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
IF(TEMP.EQ.1.)H(I,J)=T(I,J)
IF(TEMP.EQ.1.)T(I,J)=TTEMP
TEMP=0.
TTEMP=0.
RHO(I,J)=RHEQ(H(I,J),P(I,J),PHI(I,J))
GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))
A(I,J)=SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))
531 CONTINUE
6 CONTINUE
IF(ISIM.EQ.1) RETURN
J=JW
MMAX=IMAX(J)
READ(5,101) (P(I,J),I=1,MMAX)
READ(5,101) (H(I,J),I=1,MMAX)
READ(5,101) (PHI(I,J),I=1,MMAX)
READ(5,101) (UW(I),I=1,MMAX)
READ(5,101) (WW(I),I=1,MMAX)
DO 7 I=1,MMAX
THG=TH(JMAX)*XJ
XW(I)=R*COS(THG)
IF(XJ1.EQ.0.)
1CALL SWALL(R,Z(I,J),XW(I),YW(I),FX,FZ)
IF(XJ1.EQ.1.)
1CALL SWALL1(YW(I),R,Z(I,J),FX,FZ)
IF(XJ.EQ.0.) GO TO 200
THW(I)=ATAN(YW(I)/XW(I))
GO TO 201
200 THW(I)=YW(I)
201 CONTINUE
VW(I)=UW(I)*FX+WW(I)*FZ
IF(XJ1.EQ.1.)VW(I)=VW(I)*Z(I,J)
THWG=THW(I)*XJ
UT=UW(I)*COS(THWG)+VW(I)*SIN(THWG)
VT=VW(I)*COS(THWG)-UW(I)*SIN(THWG)
Q(I,J)=SQRT(UT*UT+WW(I)*WW(I))
PHE(I,J)=ATAN(WW(I)/UT)
SI(I,J)=ATAN(VT/Q(I,J))
IF(H(I,J).LT.10000.)TEMP=1.
IF(H(I,J).LT.10000.)TTEMP=H(I,J)
T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
IF(TEMP.EQ.1.)H(I,J)=T(I,J)
IF(TEMP.EQ.1.)T(I,J)=TTEMP
TEMP=0.
TTEMP=0.
RHO(I,J)=RHEQ(H(I,J),P(I,J),PHI(I,J))
GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))
A(I,J)=SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))
7 CONTINUE
TH(J)=THW(1)
RETURN

```

```

212 IF(R.GT.(RCOWL-1.E-05)) ISIM=ISIMEX
    READ(5,100) JINT,KOUNTC
    READ(5,9) XMAST,XENT,FSX,FSZ
    9 FORMAT(4E13.5)
    READ(5,216) ZLIFT,XTHR,YMOM,ZSHIFT,XSHIFT
    DO 213 J=1,JW
    IF(ISJM.EQ.1.OR.J.NE.JW) GO TO 300
    READ(5,100) IMAX(J)
    GO TO 301
300 CONTINUE
    READ(5,216) TH(J)
301 CONTINUE
    IF(R.GT.RCOWL) IMAX(J)=IMAX(J)+1
    IMAXJ=IMAX(J)
    DO 214 I=1,IMAXJ
    IF(ISIM.EQ.1.OR.J.NE.JW) GO TO 303
    READ(5,302)                UW(I),WW(I),VW(I),THW(I)
302 FORMAT(6E11.3)
303 CONTINUE
    READ(5,215) Z(I,J),P(I,J),Q(I,J),PHE(I,J),SI(I,J),H(I,J),
    1PHI(I,J),RHO(I,J)
631 CONTINUE
    T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
    GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))
    A(I,J)=SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
    CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))
215 FORMAT(5E11.3,11X,E11.3/2E11.3)
214 CONTINUE
    IF(R.LT.RCOWL) GO TO 213
    IMAX(J)=IMAX(J)-1
    READ(5,216) (ALP (M,J),M=1,7)
    READ(5,216) (ALPHA(M,J),M=1,7)
    READ(5,216) (BETA (M,J),M=1,7)
    READ(5,217) (IS (M,J),M=1,7)
    IF(IS(3).NE.0.AND.ISIM.EQ.0) READ(5,216) ZLIFTC,XTHRC,YMOMC
    IF(IS(1).NE.0.AND.ISIM.EQ.0) READ(5,216) ZLIFTS,XTHRS,YMOMS
213 CONTINUE
    IF(R.LT.RCOWL) RETURN
    ICOWL=1
    INT=2
    KCI=3
    IF(IWRAP .EQ.1) RETURN
    READ(5,217) IDUMMY
    READ(5,216) (ZDUMMY(I),I=1,NUMEXP)
216 FORMAT(7E11.3)
217 FORMAT(7I5)
    RETURN
    END

```

```

SUBROUTINE TBL(ZX,PX,SIX,HX,PHIX,QX,PHEX,RHOX,GAMX,THX,L,IMAX,I)
COMMON /A/ XI,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /DER/ J5
COMMON /H/ ISIM
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /TB/ IMAXJ,ISI,IS2,ISL1,ISL2
THL=0.
K=L
IF(L.NE.JW.OR.ISIM.EQ.1) THL=TH(L)
DO 10 J7=1,IMAX
J5=J7
IF(ZX-Z(J5,L)) 8,9,10
8 J6=J5-1
7 IF(I .EQ.1) J6=J5+1
12 CONTINUE
RAT=(ZX-Z(J6,K))/(Z(J5,L)-Z(J6,K))
P X=P (J6,K)+(P (J5,L)-P (J6,K))*RAT
H X=H (J6,K)+(H (J5,L)-H (J6,K))*RAT
Q X=Q (J6,K)+(Q (J5,L)-Q (J6,K))*RAT
SI X=SI (J6,K)+(SI (J5,L)-SI (J6,K))*RAT
PHIX=PHI(J6,K)+(PHI(J5,L)-PHI(J6,K))*RAT
PHEX=PHE(J6,K)+(PHE(J5,L)-PHE(J6,K))*RAT
RHOX=RHO(J6,K)+(RHO(J5,L)-RHO(J6,K))*RAT
GAMX=GAM(J6,K)+(GAM(J5,L)-GAM(J6,K))*RAT
IF(K.NE.JW.OR.ISIM.EQ.1)
1THX=TH(K)+RAT*(THL-TH(K))
IF(K.NE.JW.OR.ISIM.EQ.1) GO TO 11
THX=THW(J6)+RAT*(THW(J5)-THW(J6))
GO TO 11
9 IF(ICOWL.EQ.1) J5=I
P X=P (J5,L)
H X=H (J5,L)
Q X=Q (J5,L)
SI X=SI (J5,L)
PHIX=PHI(J5,L)
PHEX=PHE(J5,L)
RHOX=RHO(J5,L)
GAMX=GAM(J5,L)
THX=THL
IF(L.NE.JW.OR.ISIM.EQ.1) GO TO 11
THX=THW(J5)
GO TO 11
10 CONTINUE
11 RETURN
END

```

```

SUBROUTINE WRAP(M)
COMMON /A/ Q1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMAV(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON/M/ IS(7,10)
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
COMMON /W/ ISIMEX,IDUMMY,JINT,TDUMMY(40),THWW(2),JD1,JD2
COMMON /IQ/ NUMEXP,ZSAV
COMMON /WRTOMO/ X0(3),X1(3),P1W(20),Q1W(20),H1W(20),S11W(20),
1PHI1W(20),PHE1W(20),RHO1W(20)
IF(M.EQ.0) GO TO 321
WRITE(6,1201)
1201 FORMAT(1H1,30X,*EXTERNAL WRAP AROUND REGION*)
321 CONTINUE
J2=JINT
J3=J2+1
PI2=2./3.1415926
PI1=3.1415926/18.
IMAX2=IMAX(J2)
IMAX1=IMAX(J3)
ISS=IS(1,J2)
ISS1=IS(1,J3)
IC=IS(3,J2)
IC1=IS(3,J3)
X0(1)=Z(IC,J2)-ZSAV
Y1(1)=(Z(IC1,J3)-X0(1))*PI2
X0(2)=Z(ISS,J2)-Z(IC,J2)
Y1(2)=(Z(ISS1,J3)-Z(IC1,J3)-X0(2))*PI2
Y0(3)=Z(IMAX2,J2)-Z(ISS,J2)
X1(3)=(Z(IMAX1,J3)-Z(ISS1,J3)-Y0(3))*PI2
I1=IDUMMY+1
IF(M.EQ.0) IMAx2=IC-1
DO 100 I=I1,IMAX2
IF(I.GT.IC) GO TO 1
ZL=ZSAV
XN0=X0(1)
XN1=X1(1)
G1=0.
C=(Z(I,J2)-ZL)/XN0
D=C*X1(1)+G1
T1=X0(1)*C
T2=X1(1)*C
GO TO 2
1 IF(I.GT.ISS) GO TO 3
ZL=Z(IC,J2)
XN0=X0(2)
XN1=X1(2)
G1=X1(1)
C=(Z(I,J2)-ZL)/XN0
D=C*X1(2)+G1
T1=X0(1)+X0(2)*C
T2=X1(1)+X1(2)*C
GO TO 2
3 ZL=Z(ISS,J2)
XN0=X0(3)
XN1=X1(3)

```

```

G1=X1(1)+X1(2)
C=(Z(I,J2)-ZL)/XN0
D=C*X1(3)+G1
T1=X0(1)+X0(2)+X0(3)*C
T2=X1(1)+X1(2)+X1(3)*C
2 CONTINUE
R3=T1+T2/PI2
R2=T1
D2=D*D
DUM=R2*SQR(T(R3*R3+D2)
ST=.5/D*(R3*SQR(T(R3*R3+D2)-DUM)
CALL TBL(R3,PS,SIS,HS,PHIS,QS,PHE,S,RHOS,GAMS,THX,J3,IMAX(J3)+1,2)
P S=(P S-P (I,J2))/ST
Q S=(Q S-Q (I,J2))/ST
H S=(H S-H (I,J2))/ST
SI S=(SI S-SI (I,J2))/ST
PHIS=(PHIS-PHI(I,J2))/ST
PHE S=(PHE S-PHE(I,J2))/ST
RHOS=(RHOS-RHO(I,J2))/ST
GAMS=(GAMS-GAM(I,J2))/ST
IF(I.GE.IC.OR.M.NE.0) GO TO 322
I2=I-IDUMMY+1
P 1W(I2)=P S
Q 1W(I2)=Q S
H 1W(I2)=H S
SI 1W(I2)=SI S
PHI 1W(I2)=PHIS
PHE 1W(I2)=PHE S
RHO 1W(I2)=RHOS
322 IF(M.FQ.0) GO TO 100
WRITE(6,1200) I
1200 FORMAT(/,10X,*I = *,I2/6X,*R*,9X,*TH*,10X,*P*,10X,*Q*,8X,*PHE*,9X,
1*SI*,9X,*H*,9X,*PHI*,8X,
1*RHO*,8X,*GAM*)
DO 101 K=1,10
THT=PI1*FLOAT(K-1)
R3=T1+T2*THT
S=.5/D*(R3*SQR(T(R3*R3+D2)-DUM)
P B=P (I,J2)+P S*S
Q B=Q (I,J2)+Q S*S
H B=H (I,J2)+H S*S
SI B=SI (I,J2)+SI S*S
PHIB=PHI(I,J2)+PHIS*S
PHEB=PHE(I,J2)+PHE S*S
RHOB=RHO(I,J2)+RHOS*S
GAMB=GAM(I,J2)+GAMS*S
WRITE(6,1202) R3,THT,PB,QB,PHER,SIB,HR,PHIB,RHOB,GAMB
1202 FORMAT(10E11,3)
101 CONTINUE
100 CONTINUE
RETURN
END

```

SUBROUTINE INDATA(MM,IFS,BM)

COMMON /TEM/ T(40,10)

COMMON /JF/ JFINAL

COMMON /A/ X1,THMAX,TH(10),R,Z(40,10),P(40,10),PHE(40,10),

Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)

COMMON /C/ IMAV(10),JMAX,ISTART,KOUNTF,KOUNTP

COMMON /D/ UW(40),VW(40),WW(40),XW(40),YW(40),THW(40)

COMMON /G/ A1(3,9),A2(3,9),A3(3,9),RR1(3),RR2(3),RR3(3)

1,NUMLWS,NUMUWS,NUMSWS

COMMON /H/ ISIM

COMMON /I/ XJ

COMMON /J/ GN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),

YMLAM(40,10),FP(40),FM(40),A(40,10)

COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL

COMMON /V/ XJ1

COMMON /W/ ISIMEX,IDUMMY,JINT,DUMMY(40),THWW(2),JD1,JD2

COMMON /SA/ XJTS

COMMON /IQ/ NUMEXP,ZSAV

COMMON /WR/ IWRAP

DIMENSION BM(10)

102 FORMAT(8E10,3)

REWIND 55

DO 5333 J=1,JW

IMAXJ=IMAX(J)

DO 5333 I=1,IMAXJ

READ(55) Z(I,J),P(I,J),Q(I,J),H(I,J),SI(I,J),RHO(I,J),PHI(I,J),PHE(I,J),TH(J)

T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))

GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))

A(I,J)=SQRT(GAM(I,J)*P(I,J)/RHO(I,J))

CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))

5333 CONTINUE

CALL MOTHER

READ(5,104) IFSS,MM

104 FORMAT(8I5)

IFS=IFSS-1

IF(IWRAP.EQ.1) GO TO 2

L=JFINAL

DO 1600 I=1,2

T(I,JW)=T(I,L)

Z(I,JW)=Z(I,L)

P(I,JW)=P(I,L)

H(I,JW)=H(I,L)

Q(I,JW)=Q(I,L)

A(I,JW)=A(I,L)

SI(I,JW)=SI(I,L)

PHI(I,JW)=PHI(I,L)

PHE(I,JW)=PHE(I,L)

RHO(I,JW)=RHO(I,L)

GAM(I,JW)=GAM(I,L)

XPLAM(I,JW)=XPLAM(I,L)

1600 XMLAM(I,JW)=XMLAM(I,L)

IMAX(JW)=IMAX(L)

TH(JW)=TH(L)

THW(1)=THWW(1)

THW(2)=THWW(2)


```

JW=JW+NUMEXP-1
2 CONTINUE
ISIM=ISIMEX
JMAX=JW
IF (ISIM.EQ.0) JMAX=JW-1
DO 500 J=1,JMAX
IMMM=IMAX(J)+MM
IMMMM=IMMM+IFSS-1
READ(5,103) (Z (I,J),I=IMMM,IMMMM)
READ(5,103) (P (I,J),I=IMMM,IMMMM)
READ(5,103) (PHE(I,J),I=IMMM,IMMMM)
READ(5,103) (Q (I,J),I=IMMM,IMMMM)
READ(5,103) (SI (I,J),I=IMMM,IMMMM)
READ(5,103) (H (I,J),I=IMMM,IMMMM)
READ(5,103) (PHI(I,J),I=IMMM,IMMMM)
103 FORMAT(7E10.3)
DO 1 I=IMMM,IMMMM
IF (J.GT.JINT.AND.I.LT.IMMMM-1) Z(I,J)=Z(2,J)
RHO(I,J)=RHEQ(H(I,J),P(I,J),PHI(I,J))
PHE(I,J)=PHE(I,J)/57.3
SI(I,J)=SI(I,J)/57.3
T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))
A(I,J)=SORT(GAM(I,J)*P(I,J)/RHO(I,J))
CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))
1 CONTINUE
500 CONTINUE
IF (ISIMEX.EQ.1) GO TO 600
J=JW
IMMM=IMAX(J)+MM
IMMMM=IMMM+IFSS-1
READ(5,103) (Z (I,J),I=IMMM,IMMMM)
READ(5,103) (P (I,J),I=IMMM,IMMMM)
READ(5,103) (H (I,J),I=IMMM,IMMMM)
READ(5,103) (PHI(I,J),I=IMMM,IMMMM)
READ(5,103) (UW(I),I=IMMM,IMMMM)
READ(5,103) (WW(I),I=IMMM,IMMMM)
600 CONTINUE
READ(5,103) (BM(J10),J10=1,JW)
DO 7639 J11=1,JW
7639 BM(J11)=BM(J11)/57.3
READ(5,104) NUMUWS
DO 251 I=1,NUMUWS
251 READ(5,102) RR2(I),(A2(I,J),J=1,9)
IF (ISIMEX.EQ.1) GO TO 3
READ(5,104) NUMSWS
DO 252 I=1,NUMSWS
252 READ(5,102) RR3(I),(A3(I,J),J=1,9)
J=JW
XJ1=0.
DO 7 I=IMMM,IMMMM
IF (I.LT.IMMMM-1) Z(I,J)=Z(2,J)
RHO(I,J)=RHEQ(H(I,J),P(I,J),PHI(I,J))
THG=TH(JMAX)*XJ
XW(I)=R*COS(THG)
IF (XJ1.EQ.0.)

```

```

1CALL SWALL(R,Z(I,J),XW(I),YW(I),FX,FZ)
IF(XJ1.GT.0.)
1CALL SWALL1(YW(I),R,Z(I,J),FX,FZ)
IF(XJ.EQ.0.) GO TO 200
THW(I)=ATAN(YW(I)/XW(I))
GO TO 201
200 THW(I)=YW(I)
201 CONTINUE
VW(I)=UW(I)*FX+WW(I)*FZ
IF(XJ1.EQ.1.) VW(I)=VW(I)*Z(I,J)
THWG=THW(I)*XJ
UT=UW(I)*COS(THWG)+VW(I)*SIN(THWG)
VT=VW(I)*COS(THWG)-UW(I)*SIN(THWG)
Q(I,J)=SQRT(UT*UT+WW(I)*WW(I))
PHE(I,J)=ATAN(WW(I)/UT)
SI(I,J)=ATAN(VT/Q(I,J))
T(I,J)=FT(P(I,J),PHI(I,J),H(I,J))
GAM(I,J)=FGAM(T(I,J),P(I,J),PHI(I,J))
A(I,J)=SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
CALL XLAM(Q(I,J),A(I,J),PHE(I,J),XPLAM(I,J),XMLAM(I,J))
7 CONTINUE
XJ1=XJ1S
3 CONTINUE
RETURN
END

```

```

FUNCTION FH(P1,F,T1)
COMMON /THE/ A1,A2,A3,A4,A5,A6,XMM1
P=P1*1.01325E5/2116.
T=T1*5./9.
F2=F*F
IF(F.LT.0.) GO TO 400
IF(T.GT.2000.) GO TO 190
IF(F.GT.1.) GO TO 191
120 A=1.E-07*(-.1042*F2 +.8242*F+.987)
    B=.001*(.01167*F2 +.1503*F+.938)
    C=-.0284*F2 +.6731*F+.4293
    GO TO 290
191 A=1.E-07*(1.787*F2 -5.48*F+5.4)
    B=.001*(-.1867*F2 +1.11*F+.176)
    C=-.0033*F2 +3.975*F-2.808
    GO TO 290
190 IF(F.GT.1.) GO TO 192
    A=.000001*(1.702*F2 +.3983*F+.31)
    B=.001*(-9.05*F2 -.07917*F+.245)
    C=10.86*F2 -.1183*F+.97
    GO TO 290
192 A=.000001*(4.81*F2 -13.9*F+11.59)
    B=.001*(-23.08*F2 +66.82*F-52.61)
    C=27.05*F2 -73.73*F+58.39
290 H1=A*T*T+B*T+C
    IF(T.LE.2000.) GO TO 370
    A10=ALOG(P)/2.3-5.
    T9=.125*A10*A10 -.275*A10
    H1=H1*(1.+(1.+F)*(T/2000.-1.)*T9)
370 H1=H1*1.E+06
    GO TO 340
400 T2=T*T
    T3=T2*T
    T4=T3*T
    T5=T4*T
    H1=A1*T+A2*T2/2.+A3*T3/3.+A4*T4/4.+A5*T5+A6
    H1=H1*8314./XMM1
340 CONTINUE
    FH=H1*10.7639
    RETURN
END

```

SUBROUTINE SOLVE(A11,A12,A13,A21,A22,A23,A31,A32,A33,DET)

DET=A11*(A22*A33-A32*A23)-A12*(A21*A33-A31*A23)+A13*(A21*A32-A22*A

131)

RETURN

END

RETURN
END

```

SUBROUTINE SWAI(L(R1,Z1,X1,Y1,FY,FZ)
COMMON /G/ A1(3,9),A2(3,9),A3(3,9),RR1(3),RR2(3),RR3(3)
1,NUMLWS,NUMUWS,NUMSWS
COMMON /I/ XJ
L=1
RTT=1.E+06
IF(L.LT.NUMSWS) RTT=RR3(L+1)
IF(R1.GE.RTT) L=L+1
IF(L.LT.NUMSWS) RTT=RR3(L+1)
IF(R1.GE.RTT.AND.L.LT.NUMSWS) L=L+1
X=X1
Y=Y1
ZZ=Z*Z
IT=1
21 XX=X*X
Y=A3(L,1)*X*Z+A3(L,2)*X*X+A3(L,3)*Y*ZZ+A3(L,4)*X+A3(L,5)*ZZ+
1A3(L,6)*X*Z+A3(L,7)*X+A3(L,8)*Z+A3(L,9)
IF(XJ.EQ.0.) GO TO 20
RT=SQRT(X**2+Y**2)
ERR=(RT-R1)/R1
IF(ABS(ERR).LT.1.E-10) GO TO 20
IT=IT+1
IF(IT.GT.2) GO TO 22
ER1=ERR
X11=X
X=1.01*X+1.E-5
GO TO 21
22 DUM=XJ1-ER1*(X-X11)/(ERR-ER1)
ER1=ERR
X11=X
Y=DUM
IF(IT.GT.10) CALL ERROR(22)
GO TO 21
20 CONTINUE
X1=X
Y1=Y
FX=2.*A3(L,1)*Y*ZZ+2.*A3(L,2)*Y*Z+A3(L,3)*ZZ+2.*A3(L,4)*X+A3(L,6)
1*Z+A3(L,7)
FY=2.*A3(L,1)*X*Z+A3(L,2)*X*X+2.*A3(L,3)*X*Z+2.*A3(L,5)*Z
1+A3(L,6)*X+A3(L,8)
RETURN
END

```

```

SUBROUTINE TWALL(R1,TH1,Z,FR1,FT1)
COMMON /G/ A1(3,9),A2(3,9),A3(3,9),RR1(3),RR2(3),RR3(3)
1,NUMLWS,NUMUWS,NUMSWS
COMMON /I/ XJ
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /V/ XJ1
COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2
L=1
RTT=1.E+06
THX=TH1*XJ
R=R1*COS(THX)
R=R-XINSP(J)
IF(XJ.EQ.0.) T=TH1
IF(XJ.EQ.1.) T=R1*SIN(TH1)
IF(L.LT.NUMUWS) RTT=RR2(L+1)
IF(R.GE.RTT) L=L+1
IF(L.LT.NUMUWS) RTT=RR2(L+1)
IF(R.GE.RTT.AND.L.LT.NUMUWS) L=L+1
RR=R*R
TT=T*T
7=A2(L,1)*RR*TT+A2(L,2)*RR*T+A2(L,3)*R*TT+A2(L,4)*RR+A2(L,5)*TT+
1A2(L,6)*R*T+A2(L,7)*R+A2(L,8)*T+A2(L,9)
FR =2.*A2(L,1)*R*TT+2.*A2(L,2)*R*T+A2(L,3)*TT+2.*A2(L,4)*R+A2(L,6)
1*T+A2(L,7)
FT =2.*A2(L,1)*RR*T+A2(L,2)*RR+2.*A2(L,3)*R*T+2.*A2(L,5)*T+A2(L,6)
1*R+A2(L,8)
FR1=FR*COS(THX)+FT*SIN(THX)
FT1=-FR*SIN(THX)+FT*COS(THX)
IF(XJ.EQ.1.)FT1=FT1/R1
IF(XJ1.EQ.1.)FT1=FT1/Z
RETURN
END

```

```

SUBROUTINE SWEEP(II35)
COMMON /TEM/ T(40,10)
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
IXMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /H/ ISIM
COMMON /N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
1QQ(40,10),RHOQ(40,10),GAMQ(40,10)
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /S/ RI,KOUNT,KOUNTS,ICOWL
COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2
COMMON /ISW1/ IFR
COMMON /PS/ ZR(40,2),PR(40,2),OR(40,2),WR(40,2),SIR(40,2),RHOR(40,2)
1,PHIR(40,2),PHER(40,2),THR(2),THWR(40)
COMMON /ISE/ KOUNSP
IF(II35.EQ.1) GO TO 1
JK=JCALC+2
JC=JCALC+1
X6=X2-R1
RAT=(X6-XINSP(JCALC))/(XINSP(JC)-XINSP(JCALC))
IF(RAT.GT.1.-1.E-10) RAT=1.
TH(JC)=THR(1      ),RAT*(TH(JK)-THR(1      ))
IM=IMAX(JCALC)
DO 3 I=1,IM
P  (I,JC)=P  R(I,1)+RAT*(P  (I,JK)-P  R(I,1))
H  (I,JC)=H  R(I,1)+RAT*(H  (I,JK)-H  R(I,1))
Q  (I,JC)=Q  R(I,1)+RAT*(Q  (I,JK)-Q  R(I,1))
Z  (I,JC)=Z  R(I,1)+RAT*(Z  (I,JK)-Z  R(I,1))
SI (I,JC)=SI R(I,1)+RAT*(SI (I,JK)-SI R(I,1))
PHI(I,JC)=PHIR(I,1)+RAT*(PHI(I,JK)-PHIR(I,1))
PHE(I,JC)=PHER(I,1)+RAT*(PHE(I,JK)-PHER(I,1))
RHO(I,JC)=RHOR(I,1)+RAT*(RHO(I,JK)-RHOR(I,1))
L=JC
T(I,L)=FT(P(I,L),PHI(I,L),H(I,L))
GAM(I,L)=FGAM(T(I,L),P(I,L),PHI(I,L))
A(I,L)=SQRT(GAM(I,L)*P(I,L)/RHO(I,L))
CALL XLAM(Q(I,L),A(I,L),PHE(I,L),XPLAM(I,L),XMLAM(I,L))
3 CONTINUE
IF(RAT.LT.1.-1.E-10) RETURN
JCALC=JCALC+1
IFR=1
IF(JCALC.LT.JW-1) GO TO 1
IFR=0
JCALC=100
JW=JW-1
JMAX=JW
IF(ISIM.EQ.0) JMAX=JW-1
KOUNSP=KOUNT
ISWEEP=0
RETURN
1 IMAXJ=IMAX(1)
DO 2 I=1,IMAXJ
P  Q(I,JCALC)=0.
H  Q(I,JCALC)=0.

```



```
0 Q(I,JCALC)=0.  
SI Q(I,JCALC)=0.  
PHIQ(I,JCALC)=0.  
PHEQ(I,JCALC)=0.  
RHOO(I,JCALC)=0.  
GAMQ(I,JCALC)=0.
```

```
2 CONTINUE
```

```
RETURN
```

```
END
```

```
FUNCTION FT(P1,F,H5)
COMMON /C/ IMAX(21),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
COMMON /THE/ A1,A2,A3,A4,A5,A6,XMM1
```

```
DATA I63/0/
P=P1*.01325E5/2116.
H=H5/10.7639/1.E+06
```

```
F2=F*F
A10=A1*LOG(P)/2.3-5.
T9=.125*A10*A10 -.275*A10
```

```
IT=1
IF(I63.E0.1) GO TO 1000
I63=1
```

```
T=1500.
T0=1500.
IF(F.GE.0.) GO TO 120
T=600.
T0=T
```

```
1000 IF(F.LT.0.) GO TO 400
```

```
GO TO 120
50 E0=(H-H1)/H
IF(ABS(E0).LT.1.E-04) GO TO 345
T=T0*1.1
```

```
IT=2
IF(F.LT.0.) GO TO 400
GO TO 120
```

```
100 E1=(H-H1)/H
IF(ABS(E1).LT.1.E-04) GO TO 345
IT=IT+1
IF(IT.LT.21) GO TO 10
WRITE(6,11)
```

```
11 FORMAT(* ERROR IN TEMPERATURE ITERATION IN FT*)
STOP
```

```
10 T9=T0-E0*(T-T0)/(E1-E0)
E0=E1
T0=T
T=T9
```

```
IF(F.LT.0.) GO TO 400
```

```
120 A=1.E-07*(-.1042*F2 +.8242*F+.987)
B=.001*(.01167*F2 +.1503*F+.932)
C=-.0284*F2 +.6731*F+.4293
IF(F.LE.1.) GO TO 190
A=1.E-07*(1.787*F2 -5.48*F+5.4)
B=.001*(-.1867*F2 +1.11*F+.176)
C=-.0933*F2 +3.975*F-2.808
```

```
190 IF(T.LE.2000.) GO TO 290
A=.000001*(1.792*F2 +.3983*F+.31)
B=.001*(-9.05*F2 -.07917*F+.245)
C=10.86*F2 -.1183*F+.97
```

```
IF(F.LE.1.) GO TO 290
A=.000001*(4.81*F2 -13.9*F+11.59)
B=.001*(-23.08*F2 +66.82*F-52.61)
C=27.75*F2 -73.73*F+58.39
```

```
290 H1=A*T*T+B*T+C
IF(T.LE.2000.) GO TO 370
H1=H1*(1.+(1.+F)*(T/2000.-1.)*79)
```

370 CONTINUE

GO TO 350

400 T2=T*T

T3=T2*T

T4=T3*T

T5=T4*T

IF (F.L.T.-1.5) GO TO 450

XMM1=16.043

A1=4.2497678

A2=-6.9126562E-03

A3=3.1602134E-05

A4=-2.9715432E-08

A5=9.5103580E-12

A6=-1.0186632E+04

GO TO 460

450 CONTINUE

A1=1.1202436

A2=1.3905716E-02

A3=2.6568374E-06

A4=-1.1560272E-08

A5=5.2386929E-12

A6=5.3328896E+03

XMM1=28.054

460 H1=A1*T+A2*T2/2.+A3*T3/3.+A4*T4/4.+A5*T5+A6

H1=H1*8314./XMM1/1.E+06

350 IF (IT.EQ.1) GO TO 50

GO TO 100

340 T0=T

FT=9.*T/5.

RETURN

END

```

SUBROUTINE STEP(IFS,MM,      DELX,X2,KOUNT)
COMMON /XF/ XFIN
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /H/ ISIM
COMMON /I/ XJ
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1YMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /K/ RN,RELR
COMMON /L/ ALPHAN(7,10),ALPHA(7,10),BFTAN(7,10),BETA(7,10)
COMMON/M/ IS(7,10)
COMMON/P/ KC1,KC2,KS1,KS2
COMMON / Q/ XCOWL
COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,PCOWL
COMMON /S/ RI,KO NT,KOUNTS,ICOWLT
COMMON /V/ XJ1
COMMON /W/ ISIMEX,IDUMMY,JINT,7DUMMY(40),THWW(2),JD1,JD2
COMMON /SA/ XJTS
COMMON /Z/ ISTOP
COMMON /TB/ IMAXJ,IS1,IS2,ISL1,ISL2
COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X9
COMMON /SPE/ KOUNTC
COMMON /ISE/ KOUNSP
COMMON /PL/ DE TH
COMMON/XSTP/XSTP
DY=1000.
IOUT=1
IFLAG=0
1 DELX=1.E+06
DELR=1.E+06
IF(IFLAG.EQ.1) IOUT=0
DO 3 J=1,JMAX
IF(J.GT.JCALC)GO TO 3
IF(J.GT.JINT) XJ1=0.
IMAXJ=IMAX(J)
IF(IMAXJ.LT.39) GO TO 1111
1112 ISTOP=1
RETURN
1111 CONTINUE
JM=J-1
JP=J+1
IF(ISWEEP.EQ.1.AND.J.EQ.JCALC) JP=J+2
IF(J.EQ.1) JM=JP
IF(ISIM.EQ.1.AND.J.EQ.JMAX) JP=JM
IF(IS(1,1).EQ.0) GO TO 5777
IS1=IS(3,J)
IS2=IS(1,J)
5777 CONTINUE
IIT=IMAX(J)-IFS+1
IITT=IIT-MM-1
DO 4 I=2,IMAXJ
IF(ICOWL.EQ.1.AND.I.GT.IITT.AND.I.LE.IIT) GO TO 4
DO 5 M=1,7

```

```

IF (IS(M,1).EQ.0) GO TO 5
ITEST=IS(M,J)
IF ((M/2)*2.EQ.M) ITEST=IS(M,J)+1
IF (IS(M,J).LE.2.OR.IS(M,J).GT.(IMAX(J)-1)) GO TO 1112
IF (I.EQ.ITEST) GO TO 4
5 CONTINUE
DZ=Z(I,J)-Z(I-1,J)
IF (J.LT.JMAX) DY1=TH(JP)-TH(J)
IF (ISIM.EQ.0.AND.J.EQ.JMAX) DY1=THW(I)-TH(JMAX)
IF (ISIM.EQ.1.AND.J.EQ.JMAX) DY1=TH(JMAX)-TH(JM)
IF (J.GT.1) DY2=TH(J)-TH(JM)
IF (J.EQ.1) DY2=TH(JP)-TH(1)
IF (J.EQ.JINT) DY1=DETH
IF (J.EQ.JINT.AND.I.GT.IDUMMY) DY1=DY2
IF (J.EQ.JINT.AND.XJ1.GT.0.) DY1=DY1*Z(I,J)
IDU=IDUMMY+1
IF (J.EQ.JINT+1) DY2=DY1
DY=DY1
IF (DY2.LT.DY1) DY=DY2
IF (J.LT.JMAX.OR.ISIM.EQ.1) GO TO 6
IF (IS(1,1).EQ.0) GO TO 6
IF (I.EQ.IS1.OR.I.EQ.(IS1-1)) GO TO 6
IF (I.EQ.IS2.OR.I.EQ.(IS2-1)) GO TO 6
IMAXJM=IMAX(JM)
ISL1=IS(3,JM)
ISL2=IS(1,JM)
IF (ICOWL.EQ.1) ISL1=0
CALL TBL(Z(I,J),P1,SI1,H1,PHI1,Q1,PHE1,RHO1,GAM1,THX,JM,IMAX JM ,I
1)
IMAXJP=IMAX(JP)
ISL1=IS(3,JP)
ISL2=IS(1,JP)
IF (ICOWL.EQ.1) ISL1=0
CALL TBL(Z(I,J),P2,SI2,H2,PHI2,Q2,PHE2,RHO2,GAM2,THX,JP,IMAX JP ,I
1)
D2=THX-TH(J)
D1=TH(J)-THY
D1=ABS(D1)
D2=ABS(D2)
IF (JP.EQ.JMAX+1) TH(JP)=THX
IF (D2.LT.ABS(TH(JP)-TH(J))-1.E-05) D2=D2/2.
IF (D1.LT.ABS(TH(JM)-TH(J))-1.E-05) D1=D1/2.
DY=AMIN1(DY,D1,D2)
DY=DY*.75
6 CONTINUE
IF (XJ1.GT.1..AND.J.LT.JINT) DY=DY*Z(I,J)
IF (XJ1.EQ.1.) DY=DY*R
IF (DZ.GT.DY) DZ=DY
DR=(DZ
)/(XPLAM(I-1,J)-XPLAM(I ,J))
IF (DR.LT.DELR) DELR=DR
4 CONTINUE
DX=DELR
IF (DX.LT.DELX) DELX=DX
3 CONTINUE
XJ1=XJ1S
DELX=DELX*XSTP

```

```
DELX=.9*DELX
X2=X1+DELX
IF(X2.GT.XFIN) DELX=XFIN-X1
IF(X2.GT.XFIN) X2=XFIN
IF(INT.EQ.2) GO TO 340
IF(ISWEEP.EQ.0) GO TO 341
IF(X2.LE.XINSP(JCALC+1)+RI-1.E-05)GO TO 340
X2=XINSP(JCALC+1)+RI
DELX=XINSP(JCALC+1)-X1+RI
GO TO 340
341 CONTINUE
IF(X2.LE.(RCOWL-1.E-05)) GO TO 340
X2=RCOWL
DELX=RCOWL-X1
340 CONTINUE
RN=X2
RETURN
END
```

```

SUBROUTINE CORNER(IC,R1,TH1,Z1)
COMMON /AV/ AAV,BAV
COMMON /ALLR1/ TN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
1YMLAMN(40,10)
COMMON /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
1XMLAM(40,10),FP(40),FM(40),A(40,10)
COMMON /IVY/ IVY,KCORR,IAV
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHF(40,10),
1Q(40,10),SI(40,10),H(40,10),PUI(40,10),RHO(40,10),GAM(40,10)
COMMON /B/ PN(40,10),PHIN(40,10),RHON(40,10),HN(40,10),ZN(40,10)
COMMON /C/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /E/ UWN(40),VWN(40),WWN(40),XWN(40),YWN(40),THWN(40)
COMMON /I/ XJ
COMMON /K/ RN,dELR
COMMON/T/ PP(40,2),ZP(40,2),OP(40,2),SIP(40,2),PHEP(40,2),
1HP(40,2),RHOP(40,2),PHIP(40,2),GAMP(40,2),AP(40,2),THP(40,2),
2UP(40,2),VP(40,2),WP(40,2)
COMMON /U/ ERZZZ
COMMON/V/XJ1
DIMENSION YPLAM(2),YMLAM(2)
KIL=1
A93=1.
R93=0.
IF(BAV.GT.0.) A93=.5
IF(BAV.GT.0.) R93=.5
JW=JMAX+1
PT=PN(IC,JW)
XPLN=XPLAMN(IC,JW)
II=IC-1
IF(IC.EQ.1) II=IC+1
IF(XJ1.EQ.0.)
1XWN(IC)=XWN(II)
IT=1
THG=TH1
5 CONTINUE
THGX=THG*XJ
X=R1*COS(THGX)
Y=R1*SIN(THGX)+THG*(1.-XJ)
IF(IC.EQ.1) CALL RWALL(R1,THG,71,FR,FTH)
IF(IC.NE.1) CALL TWALL(R1,THG,71,FR,FTH)
IF(XJ1.EQ.0.)
1CALL SWALL(R1,Z1,X,YT,FX,FZ)
IF(XJ1.GT.0.) CALL SWALL1(YT,R1,Z1,FX,FZ)
ERR=(Y-YT)/R1**XJ
IF(ABS(ERR).LT.1.E-10) GO TO 10
IT=IT+1
IF(IT.GT.2) GO TO 20
TH2=THG
ER2=ERR
THG=1.01*THG+1.E-4
GO TO 5
20 NUM=TH2-ER2*(THG-TH2)/(ERR-ER2)
ER2=ERR
TH2=THG
THG=NUM

```

```

IF (IT.GT.10) CALL ERROR(20)
GO TO 5
10 CONTINUE
THGX=THG*XJ
THWN(IC)=THG
IF (XJ).EQ.0.)
1XWN(IC)=X
IF (XJ).EQ.0.)
1YWN(IC)=Y
ZN(IC,JW)=Z1
ZDUM=1.
IF (XJ).EQ.1.) ZDUM=Z1
WOU=(FR*(COS(THGX)+FX*SIN(THGX))+FTH*ZDUM*
1 (FX*COS(THGX)-SIN(THGX
2)))/(1.-FZ*(FR*SIN(THGX)+FTH*COS(THGX))*ZDUM)
VOU=FX+WOU*FZ
VOU=VOU*ZDUM
C CORNER PRESSURE (Z=CONST)
IMAXJ=IMAX(JMAX)
ID=IMAXJ+1
ZD=ZN(IC,JW)
DO 3 JJ=1,2
RATE=(ZD-ZP(II,JJ))/(ZP(IC,JJ)-ZP(II,JJ))
UP(ID,JJ)=UP(II,JJ)+RATE*(UP(IC,JJ)-UP(II,JJ))
VP(ID,JJ)=VP(II,JJ)+RATE*(VP(IC,JJ)-VP(II,JJ))
WP(ID,JJ)=WP(II,JJ)+RATE*(WP(IC,JJ)-WP(II,JJ))
PP(ID,JJ)=PP(II,JJ)+RATE*(PP(IC,JJ)-PP(II,JJ))
HP(ID,JJ)=HP(II,JJ)+RATE*(HP(IC,JJ)-HP(II,JJ))
RHOP(ID,JJ)=RHOP(II,JJ)+RATE*(RHOP(IC,JJ)-RHOP(II,JJ))
PHIP(ID,JJ)=PHIP(II,JJ)+RATE*(PHIP(IC,JJ)-PHIP(II,JJ))
THP(ID,JJ)=THP(II,JJ)+RATE*(THP(IC,JJ)-THP(II,JJ))
IF (JJ.EQ.1) THP(ID,JJ)=TH(JMAX)
ZP(ID,JJ)=ZD
D1=ZD-ZP(II,JJ)
IF (JJ.EQ.2) GO TO 4
DU1=(UP(ID,JJ)-UP(II,JJ))/D1
DV1=(VP(ID,JJ)-VP(II,JJ))/D1
DW1=(WP(ID,JJ)-WP(II,JJ))/D1
DP1=(PP(ID,JJ)-PP(II,JJ))/D1
GO TO 3
4 DU2=(UP(ID,JJ)-UP(II,JJ))/D1
DV2=(VP(ID,JJ)-VP(II,JJ))/D1
DW2=(WP(ID,JJ)-WP(II,JJ))/D1
DP2=(PP(ID,JJ)-PP(II,JJ))/D1
3 CONTINUE
RATE=.5
I=ID
IT=1
THA=TH(JMAX)+RATE*(THW(IC)-TH(JMAX))
25 U A=U P(I,1)+RATE*(U P(I,2)-U P(I,1))
V A=V P(I,1)+RATE*(V P(I,2)-V P(I,1))
H A=H P(I,1)+RATE*(H P(I,2)-H P(I,1))
P A=P P(I,1)+RATE*(P P(I,2)-P P(I,1))
W A=W P(I,1)+RATE*(W P(I,2)-W P(I,1))
RHOA=RHOP(I,1)+RATE*(RHOP(I,2)-RHOP(I,1))
THAX=THA*XJ

```



```

XA=R*COS(THAX)
YA=R*SIN(THAX)+THA*(1.-XJ)
PSV=PA
PHIA=PHIP(I,1)+RAT*(PHIP(I,2)-PHIP(I,1))
TA=FT(PA,PHIA,UA)
GAMA=FGAM(TA,PA,PHIA)
AA=SQRT(GAMA*PA/RHOA)
TAUA=VA/UA
UA2=UA*UA
AA2=AA*AA
VA2=VA*VA
BETA=SQRT((UA2+VA2)/(AA2)-1.)
ALAM=(UA*VA+AA2*BETA)/(UA2-AA2)
DUMP=A93*ALAM+B93*XPLN
IF(XJ.EQ.0.) GO TO 32
THAT=YWN(IC)-(XWN(IC)-XA)*DUMP
THAT=ASIN(THAT/R)
GO TO 33
32 IF(XJ1.EQ.0.)
1THAT=YWN(IC)-(XWN(IC)-XA)*DUMP
IF(XJ1.GT.0.) THAT=THWN(IC)-DUMP*(R1-R)/ZN(IC,JW)
33 CONTINUE
EPEARS(1.-THAT/THA)
IF(EP.LT.1.E-04) GO TO 30
THA=THAT
RAT=(THA-TH(JMAX))/(THP(I,2)-TH(JMAX))
IT=IT+1
IF(IT.GT.15)CALL ERROR(30)
GO TO 25
30 DU=DU1+RAT*(DU2-DU1)
DV=DV1+RAT*(DV2-DV1)
DW=DW1+RAT*(DW2-DW1)
DP=DP1+RAT*(DP2-DP1)
IF(B93.EQ.0.) BN=BETA
A22=A93*(RHOA*(UA2/BETA)+B93*(RHON(IC,JW)*UWN(IC)**2/BN)
FPA=ALAM*RHOA*WA*DU-RHOA*WA*DV-
1(ALAM-VA/UA)*(WA*DP+AA2*RHOA*DW)*UA/(AA2)
FPA=FPA/BETA
TAUC=VOU
THWNX=THWN(IC)*XJ
THAX=THA*XJ
TSV1=(VOU-TAN(THWNX))/(1.+VOU*TAN(THWNX))
TSV2=(VA/UA-TAN(THAX))/(1.+VA/UA*TAN(THAX))
DVOU=TSV1-TSV2
IF(XJ1.EQ.0.) DRRR=XWN(IC)-XA
IF(XJ1.EQ.1.) DRRR=RN-R
PC1=PA+FPA*DRRR-A22*(TAUC-TAUA)
C CORNER PRESSURE (THETA = CONSTANT)
THT=THWN(IC)
DTH=THT-TH(JMAX)
DO 40 IK=1,2
I=IK
IF(IC.EQ.IMAXJ) I=IMAXJ-IK+1
RAT=DTH/(THP(I,2)-THP(I,1))
HP(I,2)=H P(I,1)+RAT*(H P(I,2)-H P(I,1))
PP(I,2)=P P(I,1)+RAT*(P P(I,2)-P P(I,1))

```

```

RHOP(I,2)=RHOP(I,1)+RAT*(RHOP(I,2)-RHOP(I,1))
ZP(I,2)=ZP(I,1)+RAT*(ZP(I,2)-ZP(I,1))
QP(I,2)=QP(I,1)+RAT*(QP(I,2)-QP(I,1))
SIP(I,2)=SIP(I,1)+RAT*(SIP(I,2)-SIP(I,1))
PHEP(I,2)=PHEP(I,1)+RAT*(PHEP(I,2)-PHEP(I,1))
PHIP(I,2)=PHIP(I,1)+RAT*(PHIP(I,2)-PHIP(I,1))
J=2
T=FT(PP(I,J),PHIP(I,J),HP(I,J))
GAMP(I,J)=FGAMP(T,PP(I,J),PHIP(I,J))
AP=SQRT(GAMP(I,J)*PP(I,J)/RHOP(I,J))
40 CALL XLAM(QP(I,J),AP,PHIP(I,J),YPLAM(IK),YMLAM(IK))
CONTINUE
THT=THT*XJ
PHEN1=ATAN(WOU/(COS(THT)+VOU*SIN(THT)))
I=IC
ZA=.5*(ZP(II,2)+ZP(I,2))
IT=1
50 RATA=(ZA-ZP(II,2))/(ZP(I,2)-ZP(II,2))
IT=IT+1
ALAM=YPLAM(2)+RATA*(YPLAM(I)-YPLAM(2))
BLAM=YMLAM(2)+RATA*(YMLAM(I)-YMLAM(2))
CLAM=ALAM*A93+B93*XPLAMN(IC,JW)
IF(IC.EQ.1) CLAM=BLAM*A93+B93*YMLAMN(IC,JW)
ZAT=ZN(I,JW)-CLAM*DELR
ER=ABS((ZAT-ZA)/(ZP(I,2)-ZP(II,2)))
IF(ER.LT.ERZZZ) GO TO 55
ZA=ZAT
IF(IT.LT.10) GO TO 50
CALL ERROR(50)
55 RATZ=(ZA-Z(II,JMAX))/(Z(I,JMAX)-Z(II,JMAX))
QA=QP(II,2)+RATA*(QP(I,2)-QP(II,2))
PA=PP(II,2)+RATA*(PP(I,2)-PP(II,2))
GAMA=GAMP(II,2)+RATA*(GAMP(I,2)-GAMP(II,2))
SIA=SIP(II,2)+RATA*(SIP(I,2)-SIP(II,2))
PHEA=PHEP(II,2)+RATA*(PHEP(I,2)-PHEP(II,2))
RHOA=RHOP(II,2)+RATA*(RHOP(I,2)-RHOP(II,2))
AA=SQRT(GAMA*PA/RHOA)
PA1=PP(II,JMAX)+RATZ*(PP(I,JMAX)-PP(II,JMAX))
SIA1=SIP(II,JMAX)+RATZ*(SIP(I,JMAX)-SIP(II,JMAX))
PHEA1=PHEP(II,JMAX)+RATZ*(PHEP(I,JMAX)-PHEP(II,JMAX))
DPA=(PA-PA1)/DTH
DSIA=(SIA-SIA1)/DTH
DPHE=(PHEA-PHEA1)/DTH
CALL F(RHOA,QA,R,ZA,PHEA,ALAM,BLAM,SIA,AA,DSI,DP,DPHE,FPC,FMC)
RQ2=QN(IC,JW)*QN(IC,JW)*RHON(IC,JW)
QA2=QA*QA
A1=FPC/(RHOA*QA2)
B1=FMFC/(RHOA*QA2)
A2=SQRT((QA/AA)**2-1.)/(RHOA*QA2)
A2=A2*A93+SQRT((QN(IC,JW)/AN(IC,JW))**2-1.)*B93/RQ2
IF(IC.EQ.IMAXJ) PC2=PA+(PHEA-PHEN1+A1*DELR)/A2
IF(IC.EQ.1) PC2=PA+(PHEN1-PHEA-B1*DELR)/A2
DWOU=TAN(PHEN1)-TAN(PHEA)
DVU=ABS(DVU)
DWU=ABS(DWOU)
DANG=DVU+DWU

```

```

IF (DANG.EQ.0.) GO TO 60
RAT1=DVU/DANG
PAT2=DWU/DANG
GO TO 70
60 RAT1=.5
   PAT2=.5
70 P1=PSV*RAT1+PA*RAT2
   DP1=(PC1-P1)/P1
   DP2=(PC2-P1)/P1
   DPC=RAT1*DP1+RAT2*DP2
   PN(I,JW)=P1*(1.+DPC)
   RHON(IC,JW)=RHO(IC,JW)*(PN(IC,JW)/P(IC,JW))**(1./GAM(IC,JW))
   VVSL=UW(IJ)**2+VW(IC)**2+WU(IC)**2
   VVC=VVSL+.2.*GAM(IC,JW)/(GAM(IC,JW)-1.)*(P(IC,JW)/RHO(IC,JW)-
1PN(IC,JW)/RHON(IC,JW))
   UWN(IJ)=SQRT(VVC/(1.+VOU*VOU+WOU*WOU))
   VWN(IC)=VOU*UWN(IC)
   WWN(IC)=WOU*UWN(IC)
   HN(IC,JW)=H(IC,JW)+.5*(VVSL-VVC)
   PHIN(IC,JW)=PHI(IC,JW)
   THWNX=THWN(IC)*XJ
   PHEDE=WWN(IC)/(UWN(IC)*COS(THWNX)+VWN(IC)*SIN(THWNX))
   PHEN(IC,JW)=ATAN(PHEDE)
   VDUM=VWN(IC)*COS(THWNX)-UWN(IC)*SIN(THWNX)
   QN(IC,JW)=SQRT(VVC-VDUM**2)
   SINN(IC,JW)=ATAN(VDUM/QN(IC,JW))
   TN(IC,JW)=FT(PN(IC,JW),PHIN(IC,JW),HN(IC,JW))
   GAMN(IC,JW)=FGAM(TN(IC,JW),PN(IC,JW),PHIN(IC,JW))
   AN(IC,JW)=SQRT(GAMN(IC,JW)*PN(IC,JW)/RHON(IC,JW))
   CALL XLAM(QN(IC,JW),AN(IC,JW),PHEN(IC,JW),XPLAMN(IC,JW),XMLAMN(IC
1,JW))
   ET=ABS((PT-PN(IC,JW))/P(IC,JW))
   IF (IVY.EQ.0.OR.ET.LT.1.E-04) GO TO 2648
   KIL=KIL+1
   IF (KIL.GT.5) GO TO 2648
   A93=.5
   B93=.5
   PT=PN(IC,JW)
   UNA2=(UWN(IC)*UWN(IC)
   VNA2=(VWN(IC)*VWN(IC)
   ANA2=AN(IC,JW)*AN(IC,JW)
   BETTN=SQRT((UNA2+VNA2)/ANA2-1.)
   XPLN=(UWN(IC)*VWN(IC)+ANA2*BETTN)/(UNA2-ANA2)
   GO TO 3
1493 WRITE(6,1393)
1393 FORMAT(* AVERAGING PROCESS DOES NOT CONVERGE IN CORNER*)
   STOP
2648 CONTINUE
   RETURN
   END

```

```
VW(I)=U1*SSI+V1*CSI  
WW(I)=W1  
GO TO 1  
88 UW(I)=U1  
VW(I)=V1  
WW(I)=W1  
1 CONTINUE  
RETURN  
END
```

```

SUBROUTINE UNOWAT(C1,C2)
COMMON/M/ IS(7,10)
COMMON /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
COMMON /V/ XJ1
COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
COMMON /A/ X1,THMAX,TH(10),R      ,Z(40,10),P(40,10),PHE(40,10),
1 Q(40,10),SI(40,10),H(40,10),PHI(40,10),RHO(40,10),GAM(40,10)
COMMON /C/ IMAV(10),JMAX,ISTART,KOUNTF,KOUNTP
COMMON /R/ JQ,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
COMMON /TEM/ T(40,10)
DO 1 J=1,JW
IMAXj=IMAX(J)
IF(ICOWL.EQ.1) IMAX1=IS(3,J)
DO 1 I=1,IMAX1
KIT=1
H1=H(I,J)
C4=C2*(H(I,J)+(Q(I,J)/COS(SI(I,J)))**2/2.)
C3=C1+RHO(I,J)*Q(I,J)/COS(SI(I,J))
C5=P(I,J)/RHO(I,J)/T(I,J)
C6=P(I,J)/RHO(I,J)**GAM(I,J)
2 V1=SQRT(2.*(C4-H1))
RH1=C3/V1
P1=C4+RH1**GAM(I,J)
T1=P1/RH1/C5
H2=FH(P1,PHI(I,J),T1)
ERR=(H2-H1)/H(I,J)
IF(ABS(ERR).LT.1.E-05) GO TO 4
KIT=KIT+1
IF(KIT.GT.5) GO TO 4
IF(KIT.GT.2) GO TO 6
ERR1=ERR
H11=H1
H1=1.01*H1
GO TO 2
10 WRITE(6,11)
11 FORMAT(* ERROR IN ENTHALPY ITERATION IN SUBROUTINE UNOWAT*)
STOP
6 DUM=H11-ERR1*(H1-H11)/(ERR-ERR1)
ERR1=ERR
H11=H1
H1=DUM
GO TO 2
4 CONTINUE
P(I,J)=P1
H(I,J)=H1
T(I,J)=T1
RHO(I,J)=RH1
Q(I,J)=V1*COS(SI(I,J))
IF(J.NE.JMAX+1) GO TO 1
U1=Q(I,J)*COS(PHE(I,J))
V1=Q(I,J)*TAN(SI(I,J))
W1=Q(I,J)*SIN(PHE(I,J))
IF(XJ1.GT.0.) GO TO 88
CSI=COS(THW(I))
SSI=SIN(THW(I))
UW(I)=U1*CSI-V1*SSI

```