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ANALYSIS AND DESIGN OF THREE DIMENSIONAL SUPERSONIC NOZZLES

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

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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

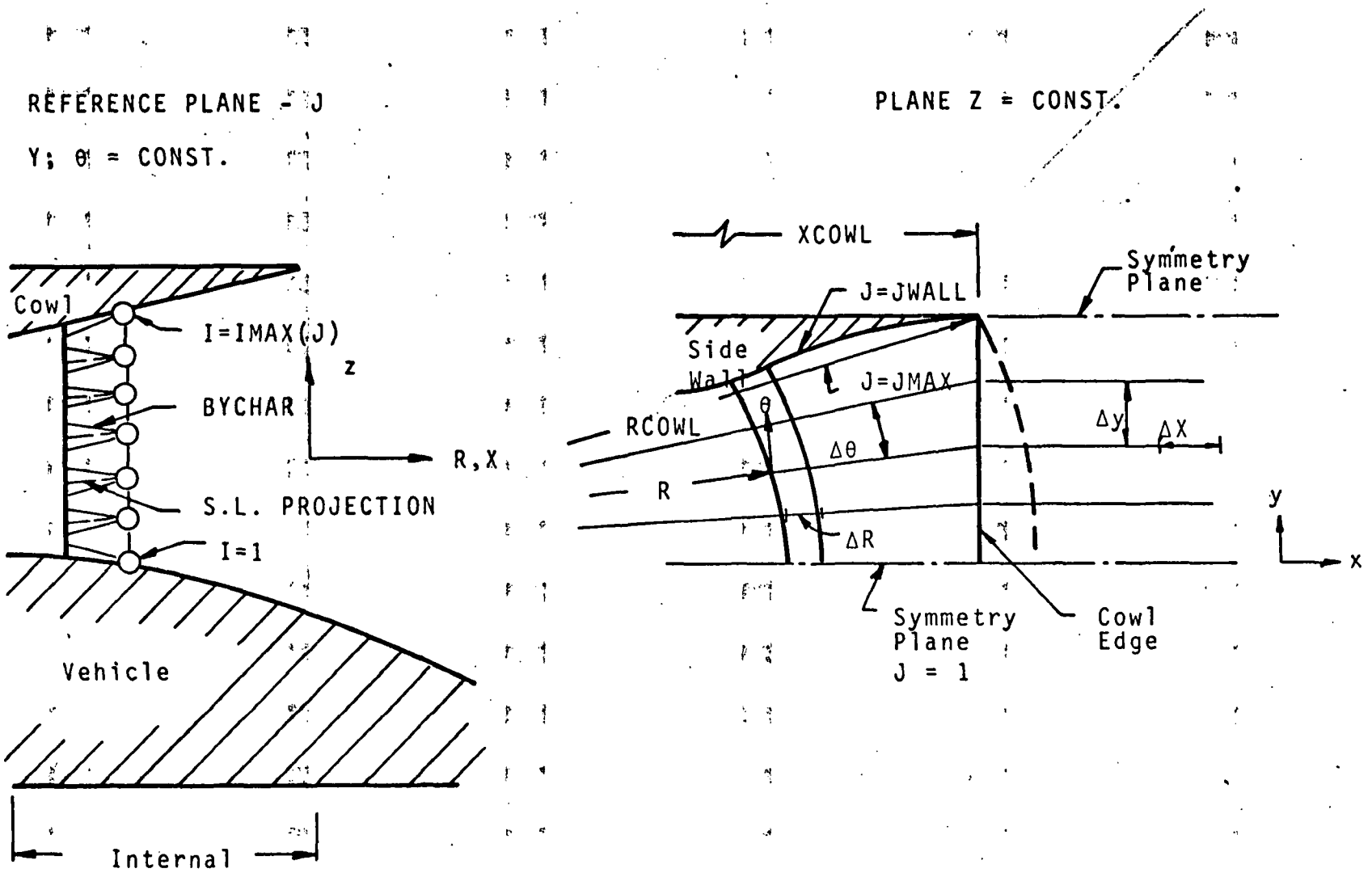


FIGURE 1a. NUMERICAL GRID-CARTESIAN OR LINE SOURCE

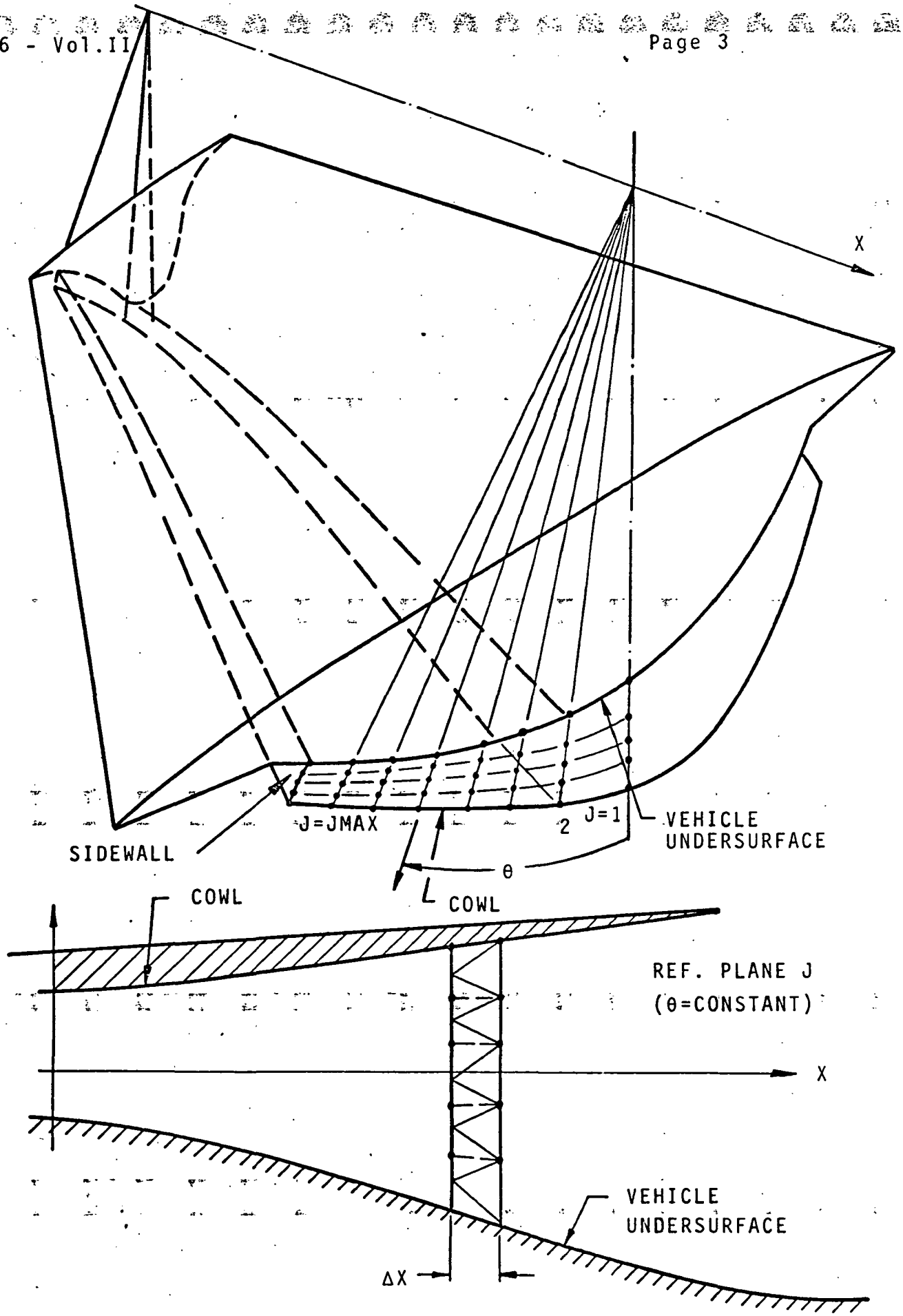


FIGURE 1b. NUMERICAL GRID-CYLINDRICAL

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 sumed to be zero.

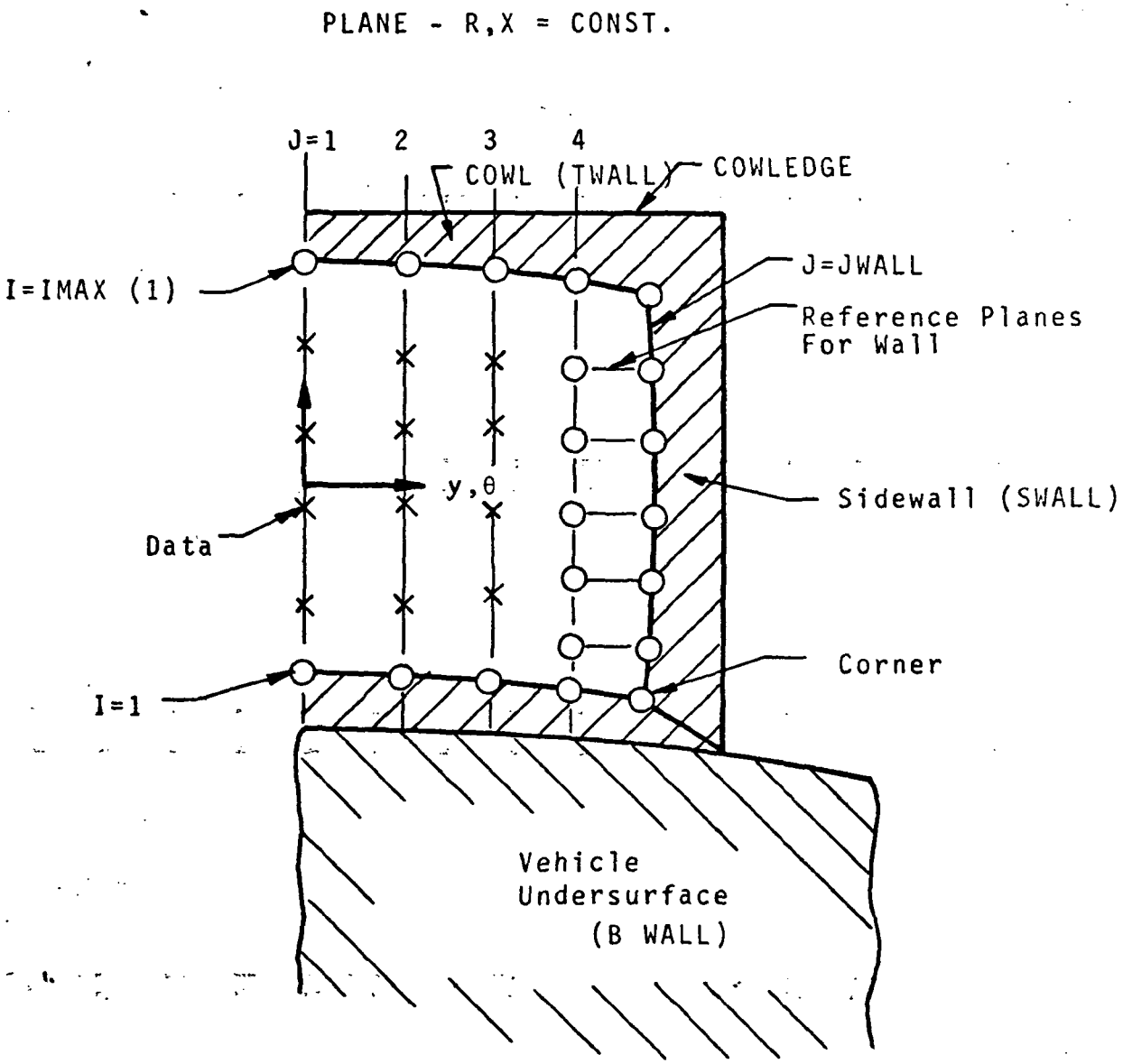


FIGURE 2. INTERNAL SIDEWALL GRID

(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 underexpansion 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.

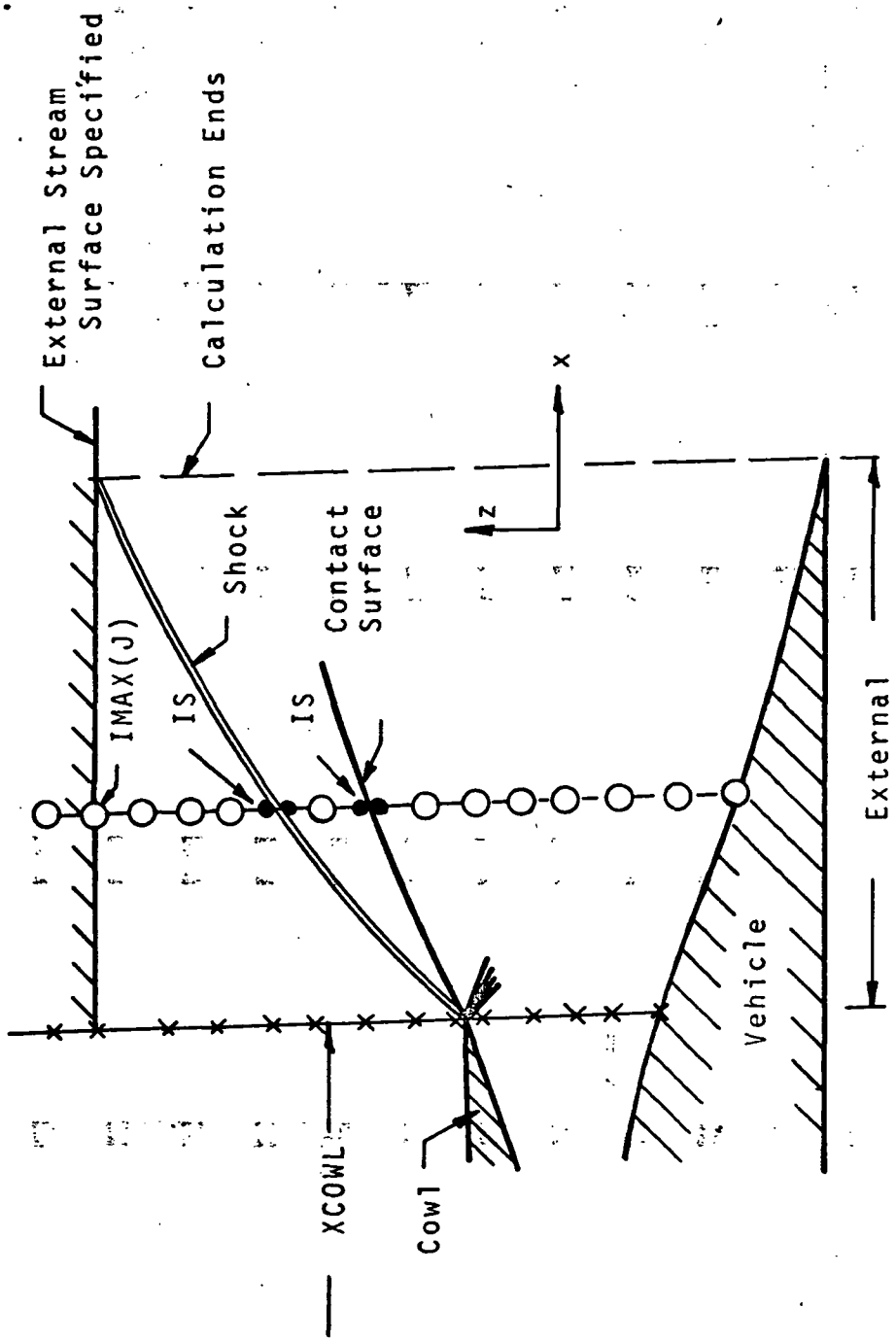


FIGURE 3. EXTERNAL FLOW-REFERENCE PLANE J

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 choses 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.

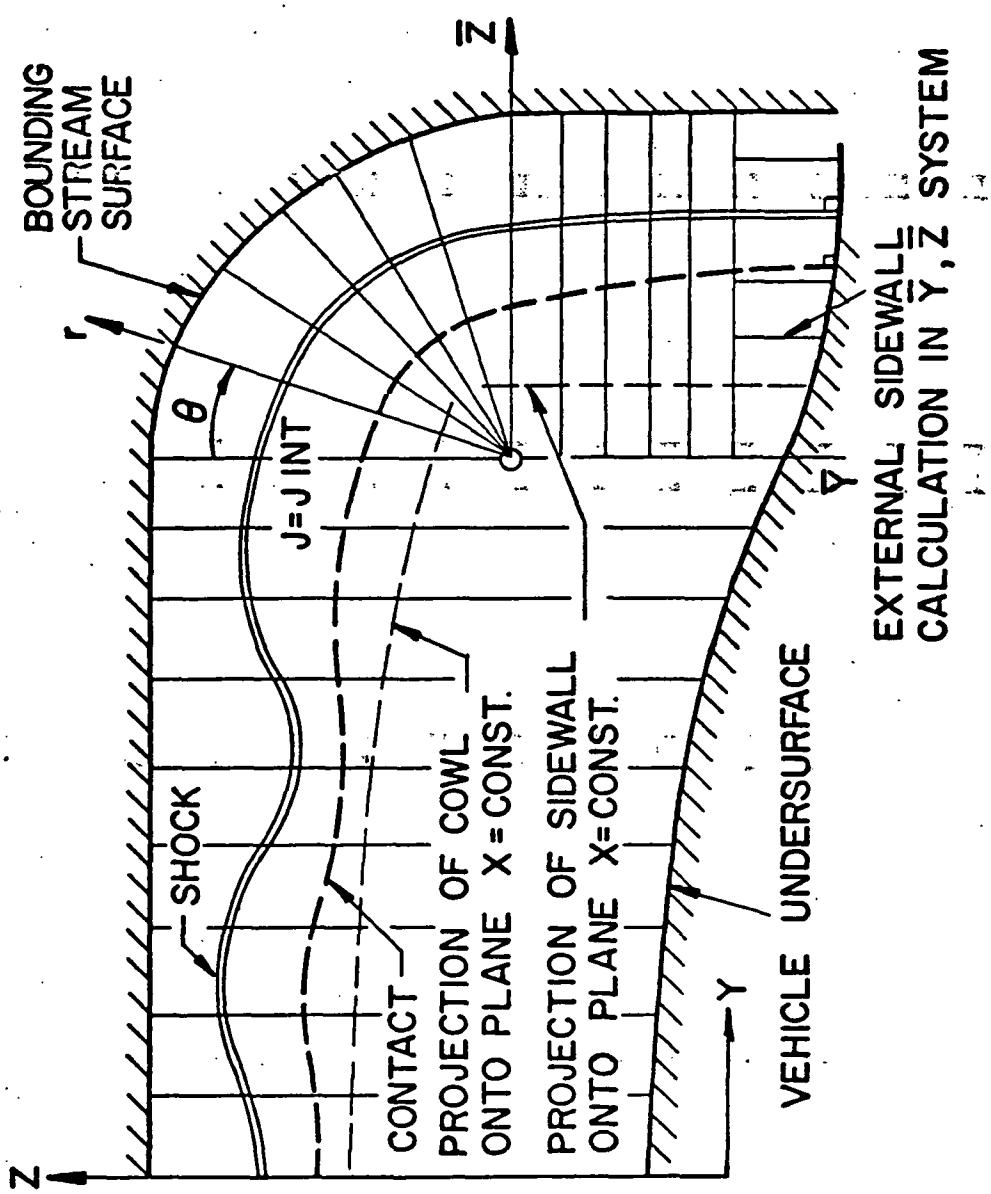


FIGURE 4. EXTERNAL FLOW-END MODULE

II. DESCRIPTION OF INPUT

A. Initial Input Data

Card Number	Format	Columns	Description
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 de-
	I5	46-50	sired, if any)
	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.

Card Number	Format	Columns	Description
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))

Card Number	Format	Columns	Description
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

Card Number	Format	Columns	Description
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)

Card Number	Format	Columns	Description
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.		

Card Number	Format	Columns	Description
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)

Card Number	Format	Columns	Description
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

$\Phi \geq 0.$ - equilibrium hydrogen-air
$\Phi = -1.$ - methane
$\Phi = -2.$ - 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.

Card Number	Format	Columns	Description
15b-20b			are the same as 15a-20a except properties are in the second reference plane
•			
•			
•			

Card Number	Format	Columns	Description
15n-20n			are the same as 15a-20a except properties are in the last reference plane
21			Same as 15a except at sidewall.
22			Same as 19a except at sidewall.
23			Same as 20a except at sidewall.
24			Same as 15a except velocity component in Cartesian X direction at sidewall (ft/sec).
25			Same as 15a except velocity component in Z direction at sidewall (ft/sec).

B.0. Cowl Input Data

Card Number	Format	Columns	Description
1	I5	1-5	number of external flow points (minimum is 3, cowl lip point, limiting external stream surface point and one dummy point)
	I5	6-10	number of points in Prandtl-Meyer fan including data downstream of shock (recommend 7, maximum 9)

Card Number	Format	Columns	Description

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.

Card Number	Format	Columns	Description
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			Same as 2a except values of SI (degrees).
7a			Same as 2a except values of H static enthalpy (ft^2/sec^2).
8a			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.
2n-8n			Same as 2a-8a except properties are in the last reference plane.

If input 3 on card 2 of Initial Input Section is one, cards 9-14 are omitted:

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.

C. Restarting Program

sweepback if this option was used.

Card Number	Format	Columns	Description
13	Same as 2a except velocity component in Cartesian X direction along vehicle undersurface.		
14	Same as 2a except velocity component in Cartesian Z direction along vehicle undersurface.		
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.

III. DESCRIPTION OF OUTPUT Variables

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

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) 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)

(3) Discontinuities

SI - angle associated with the direction cosine of Q and the velocity vector (degrees)

M - Mach number

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

H - static enthalpy (ft^2/sec^2)

PHI - fuel to air equivalence ratio

RHO - density ($slugs/ft^3$)

BETA - angle associated with the direction cosine between the intersection of discontinuity and reference plane where a discontinuity exist

GAM - isentropic exponent

T - temperature (^oR)

(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

A. Subroutines

Name	Description
1. INTER	Interpolates internal flow properties onto line X equals X coordinate of cowl
2. TB1	single table linear interpolation and extrapolation of flow properties to be used for derivatives normal to reference planes
3. STEP	computes marching step based on characteristic criteria
4. INDATA	accepts initial input data and program re start-data
5. INDAT2	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. USHOCK	computes properties downstream of all shock discontinuities in marching direction

Column 5 - second contact discontinuity

Column 6 - third downrunning shock wave

Column 7 - second uprunning shock wave

IV. SUBROUTINES AND FUNCTIONS

8. A. Subroutines

	Name	Description
1.	INTER	interpolates internal flow properties onto plane X equals X coordinate of cowl
2.	TBL	single table linear interpolation and extrapolation of flow properties to be used for derivatives normal to reference planes
3.	STEP	computes marching step based on characteristic criteria
4.	INDATA	accepts initial input data and program restart data
5.	INDAT2	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

	Name	Description
8.	MOTHER	computes integral correction factors for mass flow and total energy
9.	COWL	computes shock surface strength, contact surface strength and extent of Prandtl-Meyer expansion normal to cowl edge for under-expanded internal flow
10.	ALSHOC	computes angles associated with the direction cosine of a tangent to each discontinuity in the crosswise direction for each reference plane
11.	RHEQ	computes equilibrium density
12.	FSHOCK	computes flow properties upstream of shock at new marching station
13.	WALL	computes flow properties associated with sidewall
14a.	SWALL	locates sidewall at new marching step and computes direction cosines of sidewall for Cartesian or line source system
14b.	SWALL1	locates sidewall at new marching step and computes direction cosines of sidewall for cylindrical system

	Name	Description
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

	Name	Description
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^{o} 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

	Name	Description
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

	Name	Description
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

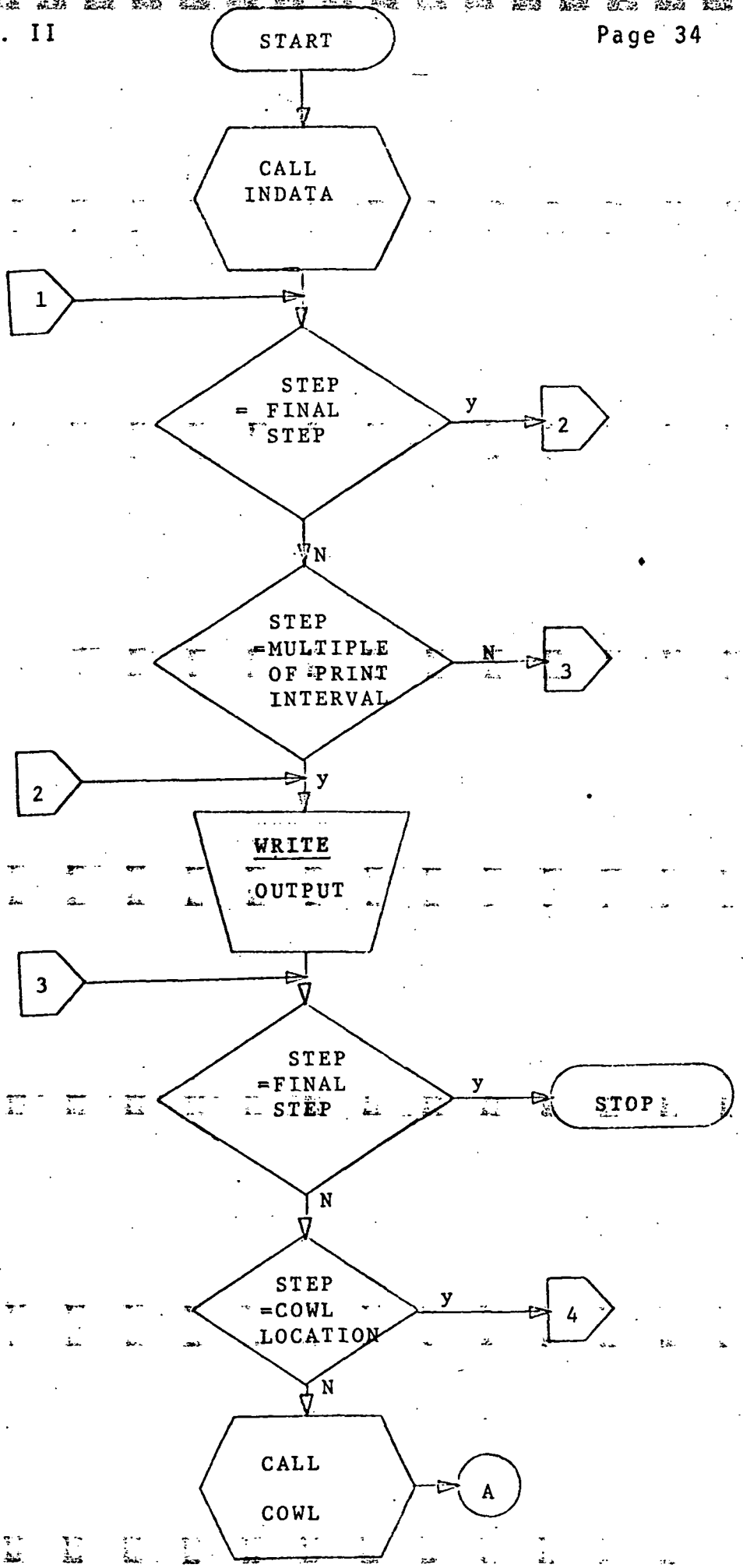
      (3) tape 7 - punched output

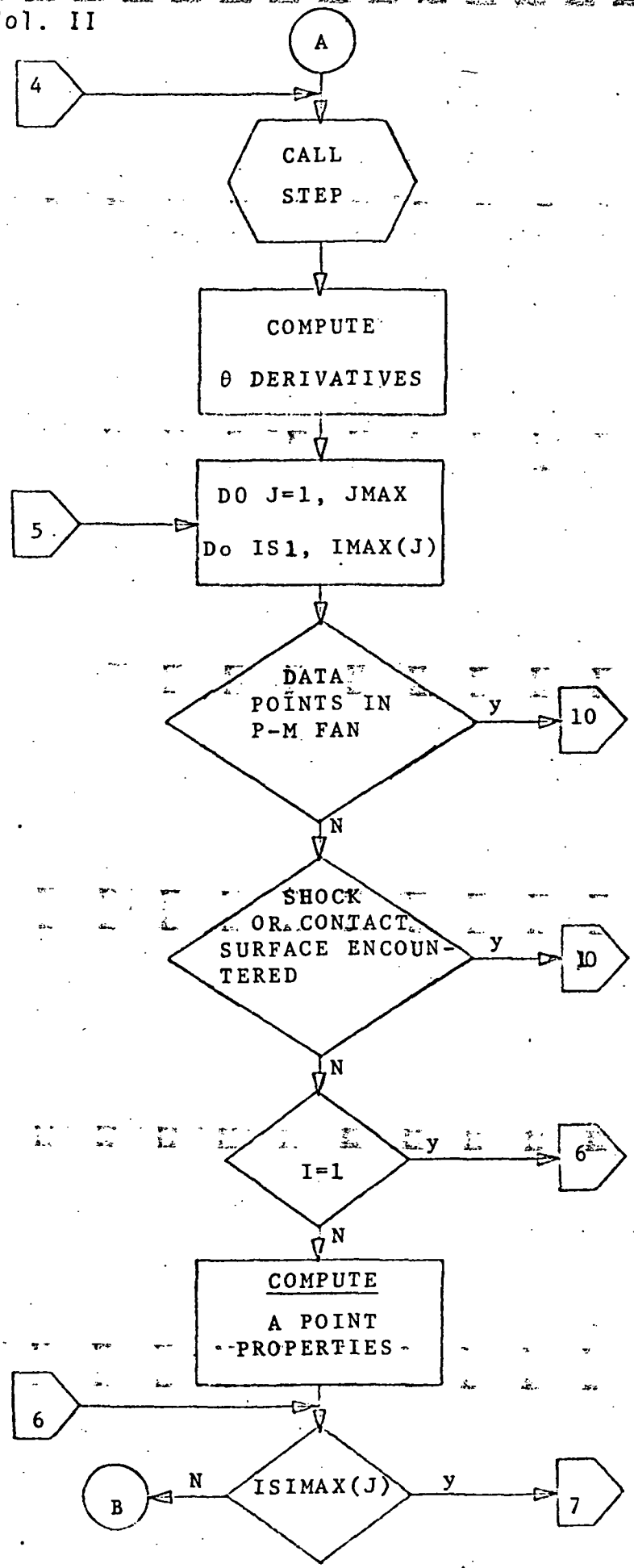
      (4) tape 55 - used temporarily during run to store primary flow properties interpolated along cowl edge

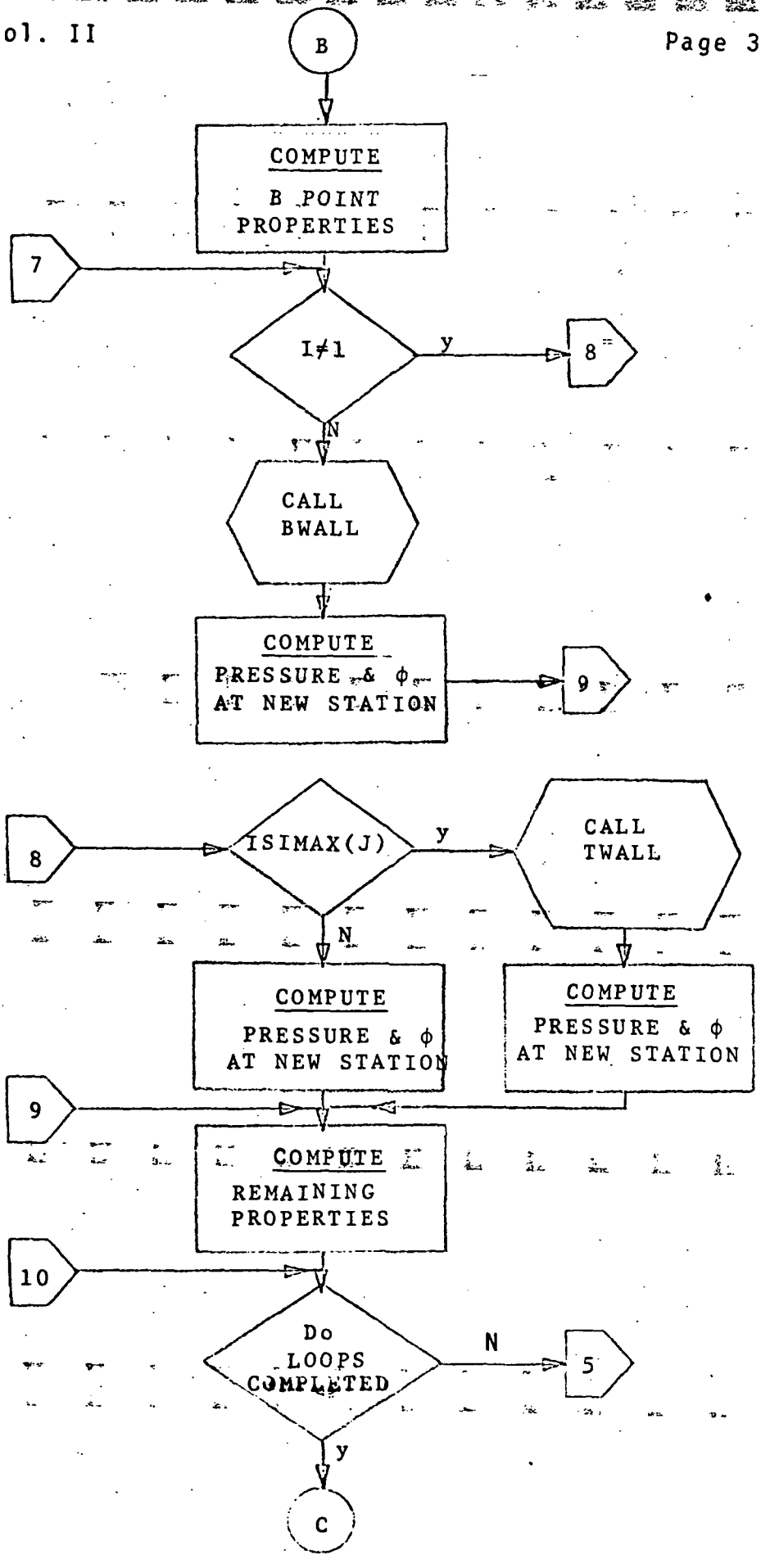
   (e) Printed output: variable depending on print interval and length of run.

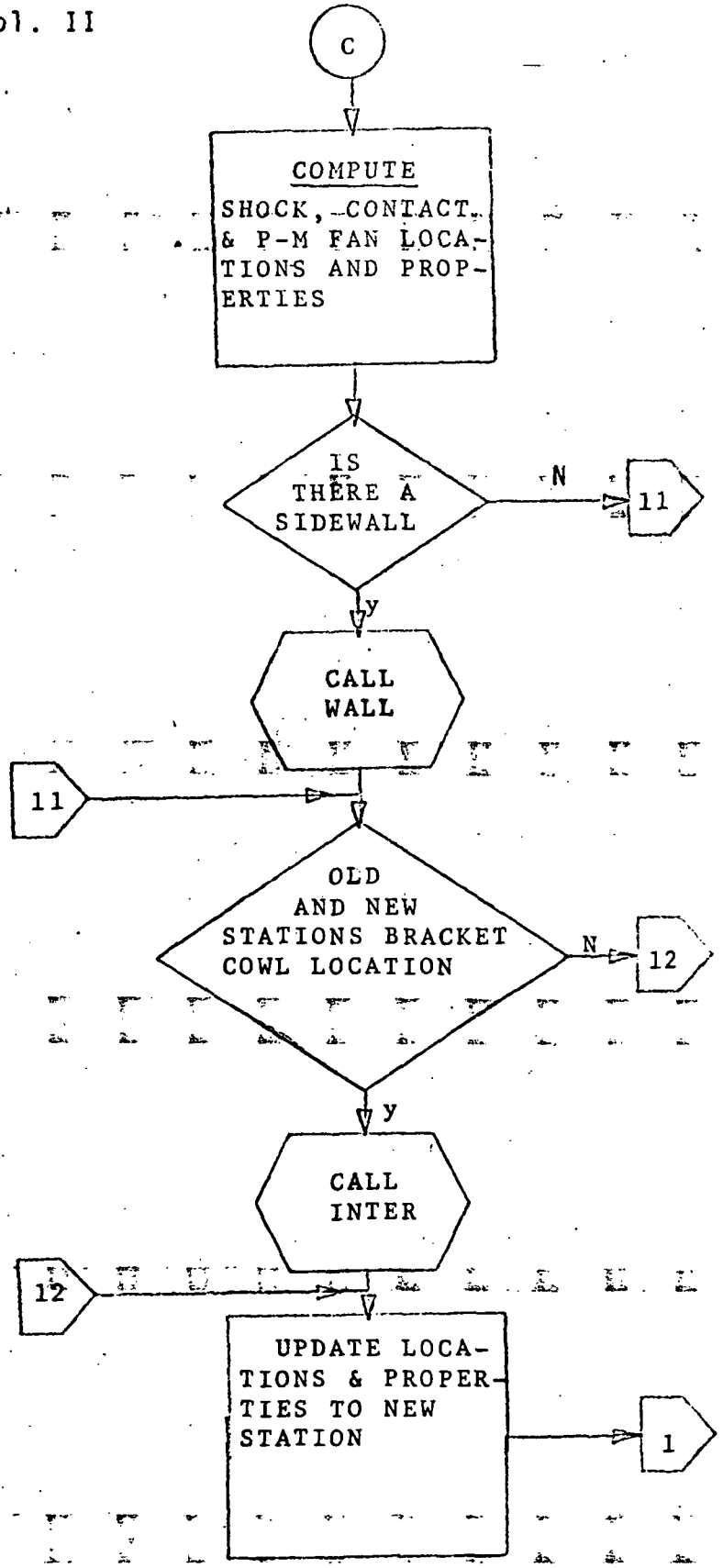
VI. FLOW CHART

The following is a flow chart of program CHAR3D.


START
CALL INDATA
1
STEP = FINAL STEP
y
2
N
STEP =MULTIPLE OF PRINT INTERVAL
N
3
2
y
WRITE OUTPUT
3
STEP =FINAL STEP
y
STOP
N
STEP =COWL LOCATION
y
4
N
CALL COWL
A


A
4
CALL STEP
COMPUTE θ DERIVATIVES
5
DO J=1, JMAX
Do IS1, IMAX(J)
DATA POINTS IN P-M FAN
y
10
N
SHOCK OR CONTACT SURFACE ENCOUNTERED
y
10
N
I=1
y
6
N
COMPUTE A POINT PROPERTIES
6
B
N
ISIMAX(J)
y
7


B
COMPUTE
B POINT
PROPERTIES
7
I≠1
y
8
N
CALL
BWALL
COMPUTE
PRESSURE & ϕ
AT NEW STATION
9
8
ISIMAX(J)
y
CALL
TWALL
N
COMPUTE
PRESSURE & ϕ
AT NEW STATION
COMPUTE
PRESSURE & ϕ
AT NEW STATION
9
COMPUTE
REMAINING
PROPERTIES
10
Do
LOOPS
COMPLETED
N
5
y
C


C
COMPUTE
SHOCK, CONTACT & P-M FAN LOCATIONS AND PROPERTIES
IS THERE A SIDEWALL
N
11
y
CALL WALL
11
OLD AND NEW STATIONS BRACKET COWL LOCATION
N
12
y
CALL INTER
12
UPDATE LOCATIONS & PROPERTIES TO NEW STATION
1

VII. PROGRAM LISTING

The following is a listing of the program.

```
      PROGRAM CHAR3D(INPUT,OUTPUT,      TAPE5=INPUT,TAPE6=OUTPUT,
     1TAPE7,TAPE55)
      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 /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,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 /ALLR1/ AN(40,10),TN(40,10),GAMN(40,10),XPLAMN(40,10),
     1YMLAMN(40,10)
      COMMON /ALLR2/ PQN(40,10),HQN(40,10),QQN(40,10),SIQN(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,ICOWLT
      COMMON /U/ ERZZZ
      COMMON /V/ XJ1
      COMMON /W/ ISIMEX,IDUMMY,JINT,DUMMY(40),THWW(2),JD1,JD2
      COMMON /Z/ ISTOP
      COMMON  /TB/ IMAXJ,IS1,IS2,ISL1,ISL2
      COMMON/EX/ KTPUN(3)
      COMMON /XF/ XFIN
      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/ IFR
      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),HR(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  ,5HTHETA,5H  Z  ,3H = ,1HZ,1HR,1HY,3HTHW,3H Y ,
     13H Z /
```

```
      DATA ICOWL/0/
      ILOCAL=15
      KOUNTC=10000
      ICOWLT=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.
      BAV=0.
  101 FORMAT(7E10.3)
      INT=0
      CALL INDATA
      IF(IAV.EQ.1) IVY=1
      CALL SETN(0)
      XJ1S=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/KOUNTP)*KOUNTP).NE.KOUNT) GO TO 3002
      IF(ICOWL.EQ.1.AND.ICOWLT.EQ.0) GO TO 3002
   73 CONTINUE
      IF(XJ.EQ.0.) GO TO 513
      WRITE(6,70) KOUNT,X1
   70 FORMAT(1H1,10X,*KOUNT = *,I4,10X,*R = *,E13.5//)
      GO TO 503
  513 WRITE(6,504) KOUNT,X1
  504 FORMAT(1H1,10X,*KOUNT = *,I4,10X,*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
     1FTC,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
     1IFTS,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=Q(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.ICOWLT.EQ.1) IMAXJ=IMAXJ+1
      DO 301 I=1,IMAXJ
      EM=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.ICOWLT.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),PHF(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
      ICOWLT=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
      IMAXX=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   ,IMAXX
      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.ICOWLT.EQ.1.AND.IWRAP.EQ.0) CALL WRAP(0)
      IF(KOUNT.EQ.KOUNTC+20) CALL MOTHER
      KOUNT=KOUNT+1
      IF(ICOWLT.EQ.1.AND.IWRAP.EQ.0) CALL PLANES(0)
      CALL        STEP(IFS,MM,       DELX,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 SWEEPT(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(ICOWLT.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),SIQ(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)
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```
      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(1,J9),PHIN(1,J9),
     1QN(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(1)=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=SINN(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
      RQ2=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=RHO(II,J)+RATA*(RHO(I,J)-RHO(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 B=FM (I)   +RATB*(FM (II)   -FM (I)   )
      RHOB=RHO(I,J)+RATB*(RHO(II,J)-RHO(I,J))
      Q  B=Q  (I,J)+RATB*(Q  (II,J)-Q  (I,J))
      A  B=A  (I,J)+RATB*(A  (II,J)-A  (I,J))
      P  B=P  (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*DELR)/B2
      GO TO 17
   16 IF(I.EQ.IMAX(J)                                ) GO TO 18
      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
      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*DELR)/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=DELR/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=DELR/CPHEN
      IF(XJ1.GT.0.) TT1=TT1/ZN(I,J)
```

```
      IF(XJ.GT.0.) TT1=TT1/RN
      T22=PQN(I,J)/RHON(I,J)/QN(I,J)
      T33=TSIN*QQN(I,J)
      T44=QN(I,J)*SIQN(I,J)/CSIN
      T55=QN(I,J)*(CPHEN*XJ+SPHEN*XJT)
      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*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
      RHON(I,J)=RHOZ*(PN(I,J)/PZ)**(1./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.) BETAN(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+1
      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=XPLAM(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+WWN(I)*FZ)
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      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(ICOWLT.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(
     1I,J),SINN(I,J),AN(I,J),SIQN(I,J),PQN(I,J),PHEQN(I,J),FPN(I,J),
     1FMN(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
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      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 X1=X2
      IFR=0
      IF(JW.GT.JCALC) CALL SWEEPT(2)
      R=RN
      IF(JW.GT.JCALC) GO TO 8759
      IF(              ISIM.EQ.0) CALL ADDSUB
 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/ 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 /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),
     1XMLAM(40,10),FP(40),FM(40),A(40,10)
      COMMON/M/ IS(7,10)
      COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
      COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(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
      LADR(I)=0
  400 LADD(I)=0
  402 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)
     1=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
```

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      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
      U W(I1)=U W(I2)
      V W(I1)=V W(I2)
      W W(I1)=W W(I2)
      X W(I1)=X W(I2)
      Y W(I1)=Y W(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 38
   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(IREDO.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
      IREDO=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(LADD(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),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 /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),
     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,DUMMY(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
      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*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=(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(IB,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=(DELLE*P  (I2L  ,J)-DELL*P  (IL ,J)+DELE*P  (I,J))/DZ/DELQ
      DH  Z=(DELLE*H  (I2L  ,J)-DELL*H  (IL ,J)+DELE*H  (I,J))/DZ/DELQ
      DQ  Z=(DELLE*Q  (I2L  ,J)-DELL*Q  (IL ,J)+DELE*Q  (I,J))/DZ/DELQ
      DPHEZ=(DELLE*PHE(I2L  ,J)-DELL*PHE(IL ,J)+DELE*PHE(I,J))/DZ/DELQ
      DPHIZ=(DELLE*PHI(I2L  ,J)-DELL*PHI(IL ,J)+DELE*PHI(I,J))/DZ/DELQ
      DRHOZ=(DELLE*RHO(I2L  ,J)-DELL*RHO(IL ,J)+DELE*RHO(I,J))/DZ/DELQ
      DGAMZ=(DELLE*GAM(I2L  ,J)-DELL*GAM(IL ,J)+DELE*GAM(I,J))/DZ/DELQ
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      DSI Z=(DELLE*SI (I2L  ,J)-DELL*SI (IL ,J)+DELE*SI (I,J))/DZ/DELQ
   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(
     1J2),2)
      DO 3536 IJ=1,IMAXJ2
```

```
3536 THWR(IJ)=GAMRR(IJ)
     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
     PHIQ(I,J2)=(D1D2*PHI2-D12*PHI(I,J2)-D2D1*PHI1)/D1PD2
     PHEQ(I,J2)=(D1D2*PHE2-D12*PHE(I,J2)-D2D1*PHE1)/D1PD2
     RHOQ(I,J2)=(D1D2*RHO2-D12*RHO(I,J2)-D2D1*RHO1)/D1PD2
     GAMQ(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),SIQN(40,10),
     1PHEQN(40,10),PHIQN(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/ XJTS
      DIMENSION PIS(2),PHEIS(2),RHOZS(2),PZS(2),GAMZS(2),QDQS(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)
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```
      RHOQ(II,J)=RHOQ(II,JMAX)
      GAMQ(II,J)=GAMQ(II,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,BLAM,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))
```

```
      BLAM=XMLAM(I,J)+RAT*(XMLAM(I+1,J)-XMLAM(I,J))
      DUMP=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.ERZZ)GO TO 9
      IT=IT+1
      ZB=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=FGAM(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,ZB,PHEB,ALAM,BLAM,SIB,AB,SIQB,PQB,PHEQB,FPB,FMB)
      B1=FMB/RHB/QB/QB
      B1=AAV*B1+BAV*FMN(I,J)/RQ2
      B2=SQRT((QB/AB)**2-1.)/RHB/QB/QB
      AC=B93*SQRT((QN(I,J)/AN(I,J))**2-1.)/RQ2
      B2=A93*B2+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.ERZZ)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,J))
      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=RHOQ(M,J)+RAT*(RHQI-RHOQ(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=DELR/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=DELR/CPHEN
      IF(XJ1.GT.0.) TT1=TT1/ZN(M,J)
      IF(XJ.GT.0.) TT1=TT1/RN
      T22=PQN(M,J)/RHQN(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=DELR*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
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      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
      QI=QB
      RHI=RHB
      PHII=PHIB
      GAMI=GAMB
      PHEI=PHEB
      SII=SIB
      PQI=PQB
      QQI=QQB
      HQI=HQB
      RHQI=RHQB
      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)/PZS(I6))**(1./GAMZS(I6))
      T2=(QDQS(I6)+QDS(I6)*TAN(SIDS(I6))*SIDQS(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)
     1-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)
```

```
      IK=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 1602
      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=BETAN(K,J)-BETEST
      IF(ABS(ERS).LT.1.E-10) GO TO 1603
      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(IVV.EQ.0.OR.ET.LT.1.E-05) GO TO 10
      KIL=KIL+1
      IF(KIL.GT.10)GO TO 1493
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```
      A93=.5
      B93=.5
      BT=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/ SN(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/ 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 /S/ RI,KOUNT,KOUNTS,ICOWLT
      COMMON /U/ ERZZZ
      COMMON /V/ XJ1
      COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(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=R
      CALL SWALL(R,Z(I,J),XT,YT,GX,GZ)
      ZDOT=Z(I,J)+TAN(BETA(K,J))*DELR/(COS(ATAN(GX)))**2
      XT=RN
      CALL SWALL(RN,ZDOT,XT,YDU,GX,GZ)
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)
      BDU=(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)))
      U1=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=U1*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=U2-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
      PHI2=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
      RLAM=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),PQ(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),PQ(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
      BET1=BET
      BET=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))*DELR
      I5=IS(K,J)
      ZN(I5,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)))*DELR+Z(M,J)
      I5=IS(K,J)
      ZN(I5,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))
      ET=ABS(1.-BT/BETAN(K,J))
      IF(IVV.EQ.0.OR.ET.LT.1.E-05) GO TO 10
      KIL=KIL+1
      IF(KI L.GT.5) GO TO 1493
      A93=.5
      B93=.5
      BT=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
```

```
      SUBROUTINE 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),PHI(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),
     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 /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
      COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
      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 /IQ/ NUMEXP,ZSAV
      COMMON /SPE/ KOUNTC
      COMMON /WR/ IWRAP
      COMMON /TEM/ T(40,10)
      COMMON /STREAM/ XMAST,XENT,FSX,FSZ
      COMMON/XSTP/XSTP
      DIMENSION HE(10)
      DATA HE/5H  Y  ,5HTHETA,5H  Z  ,3H = ,1HZ,1HR,1HY,3HTHW,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 = *,I4,1RX,*R = *,E13.5//)
      GO TO 503
  513 WRITE(6,504) KOUNT,X1
  504 FORMAT(1H1,10X,*KOUNT = *,I4,1RX,*X = *,E13.5//)
  503 CONTINUE
      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
```

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  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 = *,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.ISIM.EQ.0) WRITE(6,621) XTHRC,ZLIFTC,YMOMC
  621 FORMAT(* CONTACT  *      ,*THRUST = *,E11.3,5X,*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 = *,E11.3,5X,*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
      B     =SQRT(GAM(I,J)*P(I,J)/RHO(I,J))
      EM=Q(I,J)/COS(SI(I,J))/B
      IF(ISIM.EQ.1.OR.J.NE.JW) GO TO 502
      EM=SQRT (UW(I)**2+VW(I)**2+WW(I)**2)/B
      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(I5,11E11.3)
   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,NUMEXP)
 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),SIQN(40,10),
     1PHEQN(40,10),PHIQN(40,10),RHOQN(40,10),GAMQN(40,10)
      COMMON /AV/ AAV,BAV
      COMMON /ALLR1/ ZN(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 /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/M/ IS(7,10)
      COMMON/N/ SIQ(40,10),PQ(40,10),PHEQ(40,10),HQ(40,10),PHIQ(40,10),
     100Q(40,10),RHOQ(40,10),GAMQ(40,10)
      COMMON /U/ ERZZZ
      COMMON /V/ XJ1
      COMMON /W/ ISIMEX,IDUMMY,JINT,JDUMMY(40),THWW(2),JD1,JD2
      COMMON /SA/ XJIS
      DO 6 J=JL,JM
      KIL=1
      A93=1.
      B93=0.
      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
    8 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))
```

```
      SIB=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
      B1=FMB/RHB/Q2
      B1=AAV*B1+BAV*FMN(I,J)/RQ2
      B2=SQRT((QB/AB)**2-1.)/RHB/Q2
      B2=A93*B2+AC
      IT=1
      ZD=(ZA+ZB)/2.
   16 RAT=(ZD-ZA)/(ZB-ZA)
      ALAMD=TAN(PHEA)+RAT*(TAN(PHEB)-TAN(PHEA))
      DUMP=A93*ALAMD+B93*TAN(PHEN(I,J))
      ZAT=ZB-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*)
      CALL PNCH
   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(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+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=PON(I,J)/RHON(I,J)/QN(I,J)
      T33=TSIN*QQN(I,J)
      T44=QN(I,J)*SIGN(I,J)/CSIN
      T55=QN(I,J)*(CPHEN*XJ+SPHEN*XJT)
      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
      B93=.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/XX1,THMAX,TH(10),R     ,Z(40,10),P(40,10),PHF(40,10),
     1 Q(40,10),SI(40,10),H(40,10),PSI(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,ZDUMMY(40),THWW(2),JD1,JD2
      COMMON /SA/ XJTS
      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)
      BDU=(BETAN(M,JW)-RAT*BETAN(M,JMAX))/(1.-RAT)
      FX2=TAN(BDU)
      GO TO 10
```

```
25 FR2=FX2
   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),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,KOUNTE,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),
     1XMLAM(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,ZDUMMY(40),THWW(2),JD1,JD2
      COMMON /SA/ XJIS
      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)
      I=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,Z(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
      I1=II-1
      IF((K/2)*2.EQ.K) I1=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))
      ER=(RH2-RHM(II))/RHO(L,J)
      IF(ABS(ER).LT.1.E-04) GO TO 9
      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
      BM(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/UB)
      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.))
      G=2.*GM(KK)/(GM(KK)-1.)
      QM(N)=QM(KK)-G*(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=PHES-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
      ER1=ERR
      RET1=RET
```

```
      BET=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-ER1)
      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)
      BETAN(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)
      BETAN(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(((KK/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=UB*SIN(PE          )+VB*COS(PE          )
```

```
5003 CONTINUE
     SI   (IK,J)=VV/VTT
     SI   (IK,J)=ASIN(SI   (IK,J))
     WV=-CB*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 WDISC(M)
      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 /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),
     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 /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,ZDUMMY(40),THWW(2),JD1,JD2
      COMMON /SA/ XJIS
      IF(JW.GT.JINT) XJ1=0.
      I=IS(M,JW)
      II=I
      L=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(XJI.EQ.0.)
     1CALL SWALL(RN,ZN(II,JW),XWN(II),YWN(II),FX,FZ)
      IF(XJI.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.)
     1CALL 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=WWN(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 /ALLR1/ 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/ IMAX(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,RCOWL
      COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
      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 462
  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))
```

```
      ZR(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=R
      IF(XJ1.EQ.0.) CALL SWALL(R,ZDUM,XT,YT,FX,FZ)
      IF(XJ1.GT.0.) CALL SWALL1(THX,R,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/ 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 /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,DUMMY(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),PHT(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,ICOWLT
      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(ICOWLT.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(ICOWLT.EQ.0) GO TO 505
      DO 40 I=2,NUMEXP
      II=NUMEXP-I+2
      III=II+1
```

```
 40 ZDUMMY(II1)=ZDUMMY(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,I))
    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,I),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,1))
      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,1),XPLAM(I,L),XMLAM(I,L))
      IF(I.NE.IS(1,J1).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))+TAN ALP        )*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
     1))))
      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),
     1QN(I,JMAX),PHEN(I,JMAX),RHON(I,JMAX),GA,THX,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,1))
```

```
      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/ 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 /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 /O/ ALP(7,10),ALPN(7,10)
      COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
      COMMON /W/ ISIMEX,IDUMMY,JINT,JDUMMY(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=1.E+06
      DO 6 J=1,JW
      DELRR=1.E+06
      IM=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),
     1YMLAMN(40,10)
      COMMON /ALLR2/ PQN(40,10),HQN(40,10),QQN(40,10),SIQN(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 /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/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,ZDUMMY(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/ 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,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,JM)+I-IS(1,J)
      RAV=(ZN(I,J)+ZN(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*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,JM)
      IF(JSHOC.EQ.1) DZS=(ZN(I,J)-ZN(I,JM))*D2+(ZN(M,JP)-ZN(I,J)+ZSAV)*D
     11
      IF(JSHOC.EQ.2) DZS=(ZN(I,J)-ZN(IB,JM)+ZSAV)*D2+(ZN(I,JP)-ZN(I,J))*
     1D1
      DP  S=D1*P  N(M,JP)-D3*P  N(I,J)-D2*P  N(N,JM)
      DH  S=D1*H  N(M,JP)-D3*H  N(I,J)-D2*H  N(N,JM)
```

```
      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(ISYM.EQ.1.AND.J.EQ.JMAX) DSI 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=DZ/DZL
5001 DELLE=DEL*DEL
     DELQ=1.+DEL
     DELL=DELQ*DELQ
     DELE=(1.+2.*DEL)
     DPZZN      =(DELLE*P  N(I2L  ,J)-DELL*P  N(IL ,J)+DELE*P  N(I,J))/D
    1Z/DELQ
     DH ZN      =(DELLE*H  N(I2L  ,J)-DELL*H  N(IL ,J)+DELE*H  N(I,J))/D
    1Z/DELQ
     DQ ZN      =(DELLE*Q  N(I2L  ,J)-DELL*Q  N(IL ,J)+DELE*Q  N(I,J))/D
    1Z/DELQ
     DPHEZN      =(DELLE*PHEN(I2L ,J)-DELL*PHEN(IL ,J)+DELE*PHEN(I,J))/D
    1Z/DELQ
     DPHIZN      =(DELLE*PHIN(I2L ,J)-DELL*PHIN(IL ,J)+DELE*PHIN(I,J))/D
    1Z/DELQ
     DRHOZN      =(DELLE*RHON(I2L ,J)-DELL*RHON(IL ,J)+DELE*RHON(I,J))/D
    1Z/DELQ
     DGAMZN      =(DELLE*GAMN(I2L ,J)-DELL*GAMN(IL ,J)+DELE*GAMN(I,J))/D
    1Z/DELQ
     DSIZN      =(DELLE*SINN(I2L  ,J)-DELL*SINN(IL ,J)+DELE*SINN(I,J))/D
    1Z/DELQ
   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,IDUMMY
      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,RHO1,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,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  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(ISYM.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))
      UP1=QN(I,JMAX)*(CPHEP*CTH-TSI*STH)
      VP1=QN(I,JMAX)*(CPHEP*STH+TSI*CTH)
      WP1=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(I)-TH(JMAX)
      Y1=TH(J)
      IF(XJ.GT.0.) Y1=RN*SIN(Y1)
      IF(XJ.GT.0.) DY=YWN(I)-Y1
      DUY=(UWN(I)-UP1)/DY
      DVY=(VWN(I)-VP1)/DY
      DWY=(WWN(I)-WP1)/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/ ZN(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),PSI(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 /I/ XJ
      COMMON/M/ IS(7,10)
      COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
      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/ ERZZZ
      COMMON/V/XJ1
      COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(40),THWW(2),JD1,JD2
      COMMON /SA/ XJTS
      COMMON /FWA/ ISOP
      DIMENSION XPLN(40),BN(40)
      JW=JMAX+1
      IF(JW.GT.JINT) XJ1=0.
      MMAX=IMAX(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.Z(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.)
```

```
      1XPW(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(XJI.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.
       B93=0.
       IF(BAV.GT.0.) A93=.5
       IF(BAV.GT.0.) B93=.5
       PT=PN(I  ,JW)
       IF(B93.EQ.0.)XPLN(I)=XPLAMN(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(XJI.EQ.0.)
      1CALL SWALL(R,ZN(I,JW),XPW(I),YPW,FX,FZ)
       IF(XJI.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(XJI.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))
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```
      GO TO 9
    8 THWN(I)=YWN(I)
    9 CONTINUE
      RAT=.5
      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=ASIN(THAT/R)
      GO TO 33
   32 IF(XJ1.EQ.0.)
     1THAT=YWN(I)-(XWN(I)-XA)*DUMP
      IF(XJ1.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
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      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*AA2/BETA)+B93*(RHON(I ,JW)*UWN(I)**2/BN(I))
      FPA=ALAM*RHOA*WA*DU-RHOA*WA*DV-
     1(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
     1(I)/UWN(I))*(WWN(I)*DPZN(I)    +AN(I,JW)**2*RHON(I,JW)*DWZN(I))*UWN
     1(I)/AN(I,JW)/AN(I,JW)/BN(I)
  362 CONTINUE
      A1=AAV*FPA+BAV*FPNN
      ITT=1
      WOU=WP(I,2)/UP(I,2)
   35 VOU=FX+WOU*FZ
      IF(XJI.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(XJI.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(XJI.EQ.1.) CALL SWALL1(THSL,R,ZSL,FXSL,FZSL)
      DUM=.5*(WOU+WSL/USL)
      IF(DUM.GT.0.) II=II+1
      IF(XJI.EQ.0.)
     1ZSLT=ZN(I,JW)-DUM*(XWN(I)-XSL)
      IF(XJI.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(XJI.EQ.0.) PN(I,JW)=PA+A1 *(XWN(I)-XA)-A22*(TAUC-TAUA)
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```
      IF(XJ1.GT.0.) PN(I,JW)=PA+(A1 *(RN-R)-  A22*    (TAUC-TAUA))
      PSL=PP(II-1,2)+RAT*(PP(II,2)-PP(II-1,2))
      HSL=HP(II-1,2)+RAT*(HP(II,2)-HP(II-1,2))
      RHOSL=RHOP(II-1,2)+RAT*(RHOP(II,2)-RHOP(II-1,2))
      PHISL=PHIP(II-1,2)+RAT*(PHIP(II,2)-PHIP(II-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)
      RAT=(THD-TH(JMAX))/(THP(I,2)-TH(JMAX))
      PD=PP(I,1)+RAT*(PP(I,2)-PP(I,1))
      W  D=W  P(I,1)+RAT*(W  P(I,2)-W  P(I,1))
      U  D=U  P(I,1)+RAT*(U  P(I,2)-U  P(I,1))
      V  D=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)/(D1D2)
      DP=(P2*D1 D2-PD*D12          -P1*D2 D1)/(D1D2)
      IF(XJ1.EQ.0.)
     1DELS=SQRT((XWN(I)-XSL)**2+(YWN(I)-YSL)**2)
      IF(XJ1.GT.0.) DELS=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
      B93=.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(ICOWLT.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
      THWNX=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)*X*Z+A3(L,3)*ZZ+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,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.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)*RR*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)
      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 TBLDUM(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))
      PX=P  (J6,K)+(P  (J5,L)-P  (J6,K))*RAT
      HX=H  (J6,K)+(H  (J5,L)-H  (J6,K))*RAT
      QX=Q  (J6,K)+(Q  (J5,L)-Q  (J6,K))*RAT
      SIX=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
      PX=P  (J5,L)
      HX=H  (J5,L)
      QX=Q  (J5,L)
      SIX=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/ 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,KOUNTE,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,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,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.)
     1ALPN(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)
      T1=FT(P1,F,H)
      T=T1*5./9.
      P=P1*1.01325E+05/2116.
      IF(F.LT.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
      A=-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.*T1/9.
      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-.681
  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-1.)
      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.171) 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
     1ER*,I5)
      CALL PNCH
    2 WRITE(6,4 )I
    4 FORMAT(* ERROR IN V/U ITERATION IN MAIN - STATEMENT NUMBER *,I5)
      CALL PNCH
    3 WRITE(6,5 )I
    5 FORMAT(* ERROR IN SIDE WALL LOCATION IN CORNER - STATEMENT NUMBER
     1*,I5)
      CALL PNCH
    6 WRITE(6,7 )I
    7 FORMAT(* ERROR IN THETA A PLANE IN CORNER - STATEMENT NUMBER *,I5)
      CALL PNCH
    8 WRITE(6,9 )I
    9 FORMAT(* ERROR IN A POINT ITERATION IN CORNER - STATEMENT NUMBER *
     1,I5)
      CALL PNCH
   10 WRITE(6,11)I
   11 FORMAT(* ERROR IN D POINT ITERATION IN CSURF - STATEMENT NUMBER *
     1,I5)
      CALL PNCH
   12 WRITE(6,13)I
   13 FORMAT(* ERROR IN NORMAL TO CONTACT SURFACE IN CSURF - STATEMENT N
     1UMBER *,I5)
      CALL PNCH
      END
```

```
      SUBROUTINE XLAM(Q,A,PHE,XPLAM,XMLAM)
      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
      XMLAM=(DUM-DUM2)/DUM3
      RETURN
      END
```

```
      SUBROUTINE F(RHO,Q,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),
     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 /J/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
     1XMLAM(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,JDUMMY(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)
     1,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)
     RHO(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
     IM=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(XJ.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(IR.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),
   1PHE(IT,J),RHO(IT,J),GAM(IT,J),THX,JS,IMAX(JC),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/ 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 /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),
     1XMLAM(40,10),FP(40),FM(40),A(40,10)
      COMMON /K/ RN,DELR
      COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
      COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
      COMMON /V/ XJ1
      COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(40),THWW(2),JD1,JD2
      COMMON /IQ/ NUMEXP,ZSAV
      COMMON /WR/ IWRAP
      COMMON /ISW/ JCALC,ISWEEP,XINSP(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=JJI+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(ICOWLT.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)
      III=IMAX(J-1)
      IF(K.GT.1) GO TO 50
      II=1
      III=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)
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```
      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=ABS(DAX)
      DAZ=ABS(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)
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      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(IWRAP.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=ABS(DAX)
      DAZ=ABS(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
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      XTHRC=XTHR
      YMOMC=YMOM
      GO TO 2
   92 ZLIFTS=ZLIFT
      XTHRS=XTHR
      YMOMS=YMOM
    2 CONTINUE
      RETURN
      END
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      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,ICOWLT
      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/ X0(3),X1(3),P1W(20),Q1W(20),H1W(20),SI1W(20),
     1PHI1W(20),PHE1W(20),RHO1W(20)
      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 /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
      COMMON /W/ ISIMEX,IDUMMY,JINT,DUMMY(40),THWW(2),JD1,JD2
      COMMON /IQ/ NUMEXP,ZSAV
      COMMON /WR/ IWRAP
      XJ2=1.-XJ
      XJ3=1.-XJ1
      IF(IWRAP.EQ.1.OR.ICOWLT.EQ.0) GO TO 50
      IMAS=IMAX(JINT)+1
      DO 51 I=1,IMAS
      ZR(I,1)=Z  (I,JINT)
      PR(I,1)=P  (I,JINT)
      QR(I,1)=Q  (I,JINT)
      HR(I,1)=H  (I,JINT)
      SIR(I,1)=SI (I,JINT)
      PHIR(I,1)=PHI(I,JINT)
      PHER(I,1)=PHE(I,JINT)
      RHOR(I,1)=RHO(I,JINT)
      ZR(I,2)=Z  (I,JINT+1)
      PR(I,2)=P  (I,JINT+1)
      QR(I,2)=Q  (I,JINT+1)
      HR(I,2)=H  (I,JINT+1)
      SIR(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
      DUMZ=1.
      IF(XJ1.GT.0.) DUMZ=.5*(Z(I+1,J)+Z(I+1,J+1))
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      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
      IDUMM1=IDUMMY+1
      DO 55 I=IDUMM1,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  (1,J)=Z  R(1,2)
      P  (1,J)=P  R(1,2)
      Q  (1,J)=Q  R(1,2)
      H  (1,J)=H  R(1,2)
      SI (1,J)=SI R(1,2)
      PHI(1,J)=PHIR(1,2)
      PHE(1,J)=PHER(1,2)
      RHO(1,J)=RHOR(1,2)
      KK=1
56    KK=KK+1
      THT=DTH*FLOAT(KK-1)
      DO 54 I=IDUMM1,IS3J
      L=I-IDUMMY+1
      C=(ZR(I,1)-ZSAV)/XO(1)
      D=C*X1(1)
      D2=D*D
      RDUM=XO(1)*C
      DUM=RDUM*SQRT(RDUM*RDUM+D2)
      R3=C*(XO(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
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      RHO(L,J+1)=RHOR(I,1)+RHO1W(L)*S
      Z(L,J+1)=R3
   54 CONTINUE
      Z(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.ICOWLT.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*COS(THP2*XJ))*R
      YY2=XJ2*THP2+XJ*R*SIN(THP2*XJ)+XJ1*Z(I,J+1)*SIN(THP2*XJ1)
      ZZ2=(XJ3+XJ1*COS(THP2*XJ1))*Z(I,J+1)
      XX3=(XJ2+XJ*COS(THP3*XJ))*R
      YY3=XJ2*THP3+XJ*R*SIN(THP3*XJ)+XJ1*Z(I+1,J+1)*SIN(THP3*XJ1)
      ZZ3=(XJ3+XJ1*COS(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)*COS(PHE(I,J))
      IF(XJ.GT.0.) U1=U1*COS(TH(J))-Q(I,J)*TAN(SI(I,J))*SIN(TH(J))
      RU1=RHO(I,J)*U1
      U2=Q(I,J+1)*COS(PHE(I,J+1))
      IF(XJ.GT.0.) U2=U2*COS(THP2)-Q(I,J+1)*TAN(SI(I,J+1))*SIN(THP2)
      RU2=RHO(I,J+1)*U2
      U3=Q(I+1,J+1)*COS(PHE(I+1,J+1))
      IF(XJ.GT.0.) U3=U3*COS(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)*COS(PHE(I+1,J))
      IF(XJ.GT.0.) U4=U4*COS(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*COS(TH(J)*XJ1))*Z(I,J)
      ZZ4=(XJ3+XJ1*COS(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)
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      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=(ZU*ZU-ZL*ZL)*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
     1(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
     1(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)+
     1P(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.
```

```
      ZU=(Z(I+1,J)+Z(I+1,J+1))/2.
      DAX=(ZU*ZU-ZL*ZL)*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
      Z   (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(KOUNT.EQ.0      ) XMAST=XMASS
      C1=XMAST/XMASS
      XEN=0.
      ICHECK=2
      GO TO 2
   11 IF(KOUNT.EQ.0      ) XENT=XEN
      C2=XENT/XEN
      IF(KOUNT.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),QQN(40,10),SIQN(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,ICOWLT
      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(ISIM.EQ.1) JW=JMAX
      DO 2 J=1,JW
      IMAXJ=IMAX(J)
      IF(R.GT.XCOWL-1.E-06.AND.ICOWLT.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)=XPLAM(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)
      SIQN(I,J)=SIQ(I,J)
      PHIQ N(I,J)=PHIQ (I,J)
      PHEQN(I,J)=PHEQ(I,J)
      RHOQ N(I,J)=RHOQ (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),
     1XMLAM(40,10),FP(40),FM(40),A(40,10)
      COMMON /TEM/ T(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),PSI(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,ICOWLT
      COMMON /V/ XJ1
      COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(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) (XINSP(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)
     1READ(5,106) MMAX     ,(Z(I,JW),I=1,MMAX)
  106 FORMAT(I5,(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
     1E 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
     1NT =*,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
     1DE WALL IS*,E13.5/)
      WRITE(6,2072) XFIN
 2072 FORMAT(10X,*THE X COORDINATE OF THE END OF THE VEHICLE UNDERSURFAC
     1E 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
      IF(ISIM.EQ.1) GO TO 53
C     SIDE WALL GEOMETRY
      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,11E11.3)
 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=IMAX(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(ISIM.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
    ICOWLT=1
    INT=2
    KC1=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/ 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 /D/ UW (40),VW (40),WW (40),XW (40),YW (40),THW (40)
      COMMON /DER/ JE
      COMMON /H/ ISIM
      COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
      COMMON  /TB/ IMAXJ,IS1,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/ IMAX(10),JMAX,ISTART,KOUNTF,KOUNTP
      COMMON/M/ IS(7,10)
      COMMON /S/ RI,KOUNT,KOUNTS,ICOWLT
      COMMON /W/ ISIMEX,IDUMMY,JINT,ZDUMMY(40),THWW(2),JD1,JD2
      COMMON /IQ/ NUMEXP,ZSAV
      COMMON /WRTOMO/ XO(3),X1(3),P1W(20),Q1W(20),H1W(20),SI1W(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)
      XO(1)=Z(IC,J2)-ZSAV
      X1(1)=(Z(IC1,J3)-XO(1))*PI2
      XO(2)=Z(ISS,J2)-Z(IC,J2)
      X1(2)=(Z(ISS1,J3)-Z(IC1,J3)-XO(2))*PI2
      XO(3)=Z(IMAX2,J2)-Z(ISS,J2)
      X1(3)=(Z(IMAX1,J3)-Z(ISS1,J3)-XO(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=XO(1)
      XN1=X1(1)
      G1=0.
      C=(Z(I,J2)-ZL)/XN0
      D=C*X1(1)+G1
      T1=XO(1)*C
      T2=X1(1)*C
      GO TO 2
    1 IF(I.GT.ISS) GO TO 3
      ZL=Z(IC,J2)
      XN0=XO(2)
      XN1=X1(2)
      G1=X1(1)
      C=(Z(I,J2)-ZL)/XN0
      D=C*X1(2)+G1
      T1=XO(1)+XO(2)*C
      T2=X1(1)+X1(2)*C
      GO TO 2
    3 ZL=Z(ISS,J2)
      XN0=XO(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*SQRT(R2*R2+D2)
      ST=.5/D*(R3*SQRT(R3*R3+D2)-DUM)
      CALL TBL(R3,PS,SIS,HS,PHIS,QS,PHES,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
      PHES=(PHES-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
      PHI1W(I2)=PHIS
      PHE1W(I2)=PHES
      RHO1W(I2)=RHOS
  322 IF(M.EQ.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*SQRT(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)+PHES*S
      RHOB=RHO(I,J2)+RHOS*S
      GAMB=GAM(I,J2)+GAMS*S
      WRITE(6,1202) R3,THT,PB,QB,PHEB,SIB,HB,PHIB,RHOB,GAMB
 1202 FORMAT(10E11.3)
  101 CONTINUE
  100 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INDATP(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),
     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 /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/ QN(40,10),PHEN(40,10),SINN(40,10),XPLAM(40,10),
     1YMLAM(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,ZDUMMY(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),P
     1HE(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) (ST  (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),PHT(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),PHT(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))
    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),PHT(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),PHT(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=-.0933*F2 +3.975*F-2.808
      GO TO 290
  190 IF(F.GT.1.) GO TO 192
      A=.000001*(1.792*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.
      Z9=.125*A10*A10              -.275*A10
      H1=H1*(1.+(1.+F)*(T/2000.-1.)*Z9)
  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 SWALL(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
      Z=Z1
      ZZ=Z*Z
      IT=1
   21 XX=X*X
      Y=A3(L,1)*XX*ZZ+A3(L,2)*XX*Z+A3(L,3)*Y*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)
      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
      Y=1.01*X+1.E-5
      GO TO 21
   22 DUM=X11-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
      FY=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)
      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 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
      Z=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 SWEEPT(II35)
      COMMON /TEM/ T(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 /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,ICOWLT
      COMMON /ISW/ JCALC,ISWEEP,XINSP(10),X2
      COMMON /ISW1/ IFR
      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 /ISE/ KOUNSP
      IF(II35.EQ.1) GO TO 1
      JK=JCALC+2
      JC=JCALC+1
      X6=X2-RI
      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.
```

```
      Q(I,JCALC)=0.
      Q(I,JCALC)=0.
      PHIQ(I,JCALC)=0.
      PHEQ(I,JCALC)=0.
      RHOQ(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*1.01325E5/2116.
      H=H5/10.7639/1.E+06
      F2=F*F
      A10=ALOG(P)/2.3-5.
      Z9=.125*A10*A10              -.275*A10
      IT=1
      IF(I63.EQ.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+.938)
      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-52.41)
      C=27.05*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.)*Z9)
```

```
370 CONTINUE
    GO TO 350
400 T2=T*T
    T3=T2*T
    T4=T3*T
    T5=T4*T
    IF(F.LT.-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),
     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/P/ KC1,KC2,KS1,KS2
      COMMON / Q/ XCOWL
      COMMON /R/ J,XCN,XC,XXI,JW,INT,ICOWL,RCOWL
      COMMON /S/ RI,KO NT,KOUNTS,ICOWLT
      COMMON /V/ XJ1
      COMMON /W/ ISIMEX,IDUMMY,JINT,YDUMMY(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(IS1M.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(IS1M.EQ.0.AND.J.EQ.JMAX) DY1=THW(I)-TH(JMAX)
      IF(IS1M.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,THY,JM,IMAXJM ,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,IMAXJP ,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(XJ .EQ.1.)DY=DY*R
      IF(DZ.GT.DY) DZ=DY
      DR=(DZ                )/(XPLAM(I-1,J)-XMLAM(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/ RN(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),
     1 Q(40,10),SI(40,10),H(40,10),PWI(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),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/ ERZZZ
      COMMON/V/XJ1
      DIMENSION YPLAM(2),YMLAM(2)
      KIL=1
      A93=1.
      B93=0.
      IF(BAV.GT.0.) A93=.5
      IF(BAV.GT.0.) B93=.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,Z1,FR,FTH)
      IF(IC.NE.1) CALL TWALL(R1,THG,Z1,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 DUM=TH2-ER2*(THG-TH2)/(ERR-ER2)
      ER2=ERR
      TH2=THG
      THG=DUM
```

```
      IF(IT.GT.10) CALL ERROR(20)
      GO TO 5
   10 CONTINUE
      THGX=THG*XJ
      THWN(IC)=THG
      IF(XJ1.EQ.0.)
     1XWN(IC)=X
      IF(XJ1.EQ.0.)
     1YWN(IC)=Y
      ZN(IC,JW)=Z1
      ZDUM=1.
      IF(XJ1.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
      RAT=(ZD-ZP(II,JJ))/(ZP(IC,JJ)-ZP(II,JJ))
      UP(ID,JJ)=UP(II,JJ)+RAT*(UP(IC,JJ)-UP(II,JJ))
      VP(ID,JJ)=VP(II,JJ)+RAT*(VP(IC,JJ)-VP(II,JJ))
      WP(ID,JJ)=WP(II,JJ)+RAT*(WP(IC,JJ)-WP(II,JJ))
      PP(ID,JJ)=PP(II,JJ)+RAT*(PP(IC,JJ)-PP(II,JJ))
      HP(ID,JJ)=HP(II,JJ)+RAT*(HP(IC,JJ)-HP(II,JJ))
      RHOP(ID,JJ)=RHOP(II,JJ)+RAT*(RHOP(IC,JJ)-RHOP(II,JJ))
      PHIP(ID,JJ)=PHIP(II,JJ)+RAT*(PHIP(IC,JJ)-PHIP(II,JJ))
      THP(ID,JJ)=THP(II,JJ)+RAT*(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
      RAT=.5
      I=ID
      IT=1
      THA=TH(JMAX)+RAT*(THW(IC) -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)
      PSV=PA
      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
      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
      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(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 )=Q  P(I,1)+RAT*(Q  P(I,2)-Q  P(I,1))
      SIP(I,2 )=SI P(I,1)+RAT*(SI P(I,2)-SI P(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)=FGAM(T     ,PP(I,J),PHIP(I,J))
      A P   =SQRT(GAMP(I,J)*PP(I,J)/RHOP(I,J))
      CALL XLAM(QP(I,J),AP     ,PHEP(I,J),YPLAM(IK ),YMLAM(IK ))
   40 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))
      Q  A=Q  P(II,2 )+RATA*(Q  P(I,2 )-Q  P(II,2 ))
      P  A=P  P(II,2 )+RATA*(P  P(I,2 )-P  P(II,2 ))
      GAMA=GAMP(II,2 )+RATA*(GAMP(I,2 )-GAMP(II,2 ))
      SI A=SI P(II,2 )+RATA*(SI P(I,2) -SI P(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)
      P  A1=P  (II,JMAX )+RATZ*(P  (I,JMAX)-P  (II,JMAX))
      SI A1=SI (II,JMAX )+RATZ*(SI (I,JMAX)-SI (II,JMAX))
      PHEA1=PHE(II,JMAX )+RATZ*(PHE(I,JMAX)-PHE(II,JMAX))
      DP  =(P  A-P  A1)/DTH
      DSI =(SI A-SI A1)/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=FMC/(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(DVOU)
      DWU=ABS(DWOU)
      DANG=DVU+DWU
```

```
      IF(DANG.EQ.0.)GO TO 60
      RAT1=DVU/DANG
      RAT2=DWU/DANG
      GO TO 70
   60 RAT1=.5
      RAT2=.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(IC)**2+VW(IC)**2+WW(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(IC)=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/ IMAX(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
      IMAX1=IMAX(J)
      IF(ICOWLT.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=C6*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
```