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AN EULERIAN METHOD FOR CALCULATING STRENGTH DEPENDENT DEFORMATION

PART THREE

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PART THREE

THE FORTRAN IV PROGRAM AND INSTRUCTIONS FOR ITS USE

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1. INTRODUCTION

In PART ONE of the OIL-RPM report the equations of motion were derived from first principles and discussed from a fundamental point of view. PART TWO then described the difference equations, the equation of state, the constitutive equations and the differencing scheme for velocity gradients used in formulating the FORTRAN IV program. Here, in PART THREE, the computer program is listed in detail and the general information necessary to set up and run problems is provided. A dictionary of terms used in the program is also included, as well as a number of tables and charts describing the program in outline form. Forms for setting up a sample problem are also given. This information provides the user with a capability to run his own problems and, in addition, the intent is to describe the code in enough detail that any changes the user may require can be readily made.

The program is the result of contributions by quite a number of people whose names are cited in the references. Briefly, the techniques described here originated from the PIC particle-in-cell method developed at Los Alamos by Evans and Harlow(1) and programmed in machine language. The code was rewritten in FORTRAN and modified for application in the ORION program by Johnson(2) and the General Atomic version was called SHELL. At the suggestion of B. E. Freeman a continuous version was developed by Walsh and Johnson(3) for the solution of hypervelocity impact problems and called OIL. It made use of the equation of state programmed by Tillotson(4). To develop OIL, the particles were replaced by a continuously varying mass in each cell. The capability to run multi-material problems could not be conveniently retained (the particles in PIC could be of different materials). However, the cost of running problems was significantly reduced and the flow profiles were substantially smoother, making it practical to run impact and explosion problems out to a time when the shock pressure was down to a few kilobars. The lowest pressure that could be resolved with PIC was several hundred kilobars.

In order to compute crater size from an impact directly, the shear strength of the cratered material had to be accounted for. The necessary changes to OIL were made in an experimental way by Johnson, Walsh, and Dienes in 1965. This modified version of OIL was called OIL-RPM.(5)

Subsequently, when it had been shown that crater size could be calculated with satisfactory accuracy, the program was streamlined by the authors so it could be used in production runs, and additional editing features were incorporated. The current version has been used in calculating over 50 different problems and the results have generally compared well with experiments, analytical solutions and other hydrodynamic codes.

2. DESCRIPTION OF THE PROGRAM

The equations of motion are integrated in Phases 1, 2 and 3 which account for the effect of pressure, transport, and shear stresses respectively. In addition to these subroutines, ten others have been introduced for the various peripheral tasks. These include INPUT, SETUP, CARDS, CDT (computes time step), EDIT, MAP (provides displays), ES (equation of state), REZONE and ERROR. "RPM" is used to denote both the routine controlling the main flow and the entire program; the choice is generally made clear by the context. A summary of the subroutines is given in Table 1 in the order in which they appear in the listing provided in Section 6. Included in the table are the names of the subroutines calling and called by each of the others. A few general comments are made in the paragraphs below on each of the subroutines.

2.1. RPM

The overall flow of the program is controlled by RPM, as shown in the flow chart of Fig. 1. RPM controls whether additional information is printed at intermediate phases of the calculation cycle for diagnostic purposes and debugging. The variable "INTER" controls these intermediate prints. When INTER = 0, no intermediate prints are made. When INTER ≠ 0 EDIT is called and on print cycles EDIT prints are made after PH1 and PH3 as well as after CDT. Details of the Phase 2 calculation are obtained in addition to the EDIT prints by putting INTER = 7, which causes printing of the energy and mass transported as each cell is processed. For debugging of Phase 3 difficulties one puts INTER = 99 and thereby obtains detailed prints of stresses, strain rates and a few other parameters. These options should be used with extreme caution since an intermediate print uses considerable paper.

2.2. INPUT

Instructions for running problems are interpreted by INPUT, which can either start or restart a calculation. It calls SETUP and CARDS, as necessary, to prescribe the initial conditions and to read the input deck. A flow chart showing the relation of INPUT, CARDS, and SETUP is provided in Fig. 2.

TABLE 1

ORDER OF SUBROUTINES

Name	Called From	Calls
RPM	--	INPUT, CDT, EDIT PH1, PH2, PH3
INPUT	RPM	SETUP, CARDS
CARDS	INPUT, SETUP	--
SETUP	INPUT	CARDS, ERROR
CDT	RPM, EDIT	ES, ERROR
ES	CDT	--
EDIT	RPM, ERROR	MAP, REZONE, ERROR, CDT
MAP	EDIT	--
PH1	RPM	--
PH3	RPM	--
PH2	RPM	ERROR
REZONE	EDIT	--
ERROR	SETUP, CDT EDIT, PH2	EDIT

FLOW OF THE CONTROL SUBROUTINE "RPM"

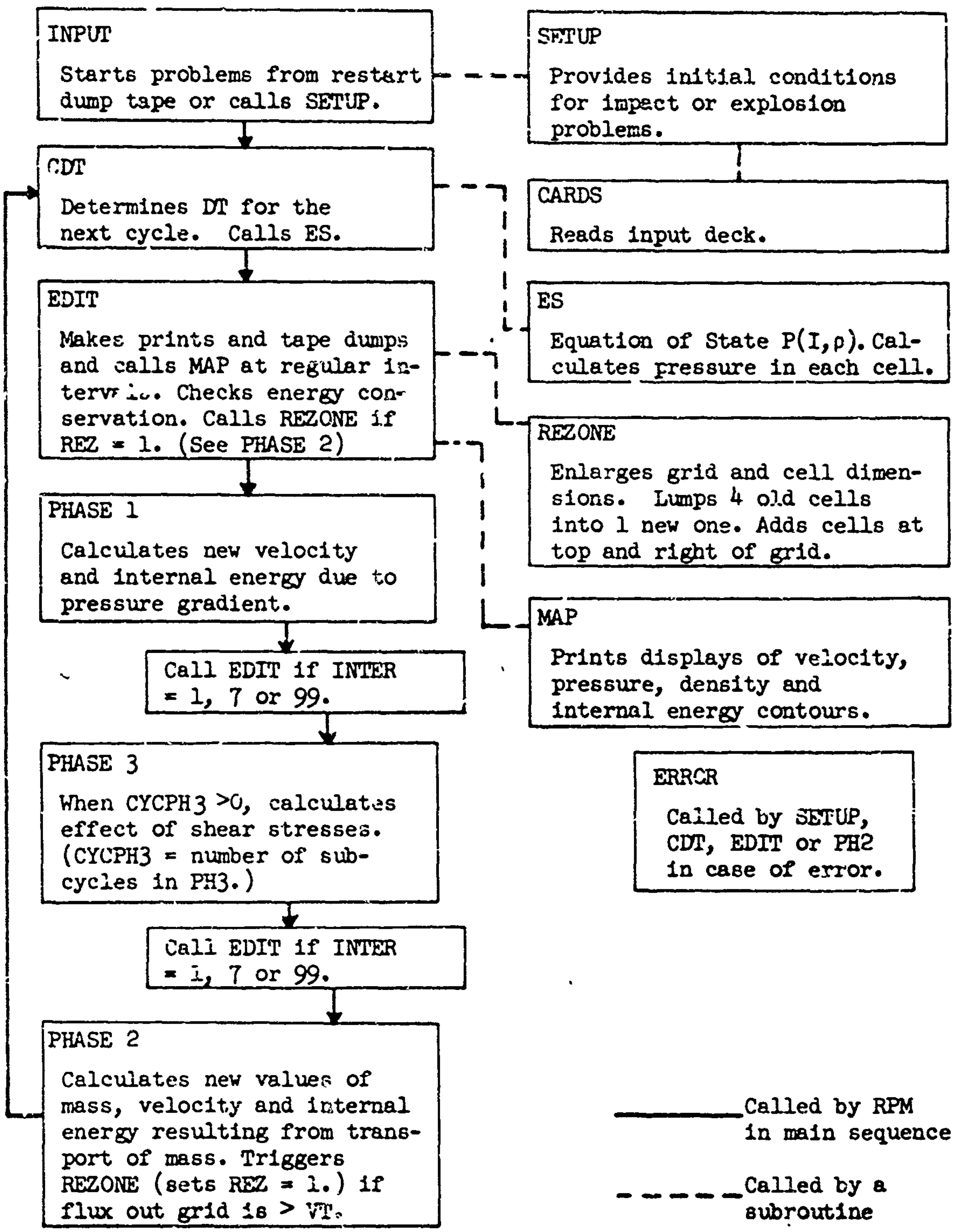


Fig. 1--Flow chart of main sequence

FLOW DIAGRAM OF INPUT, CARDS AND SETUP

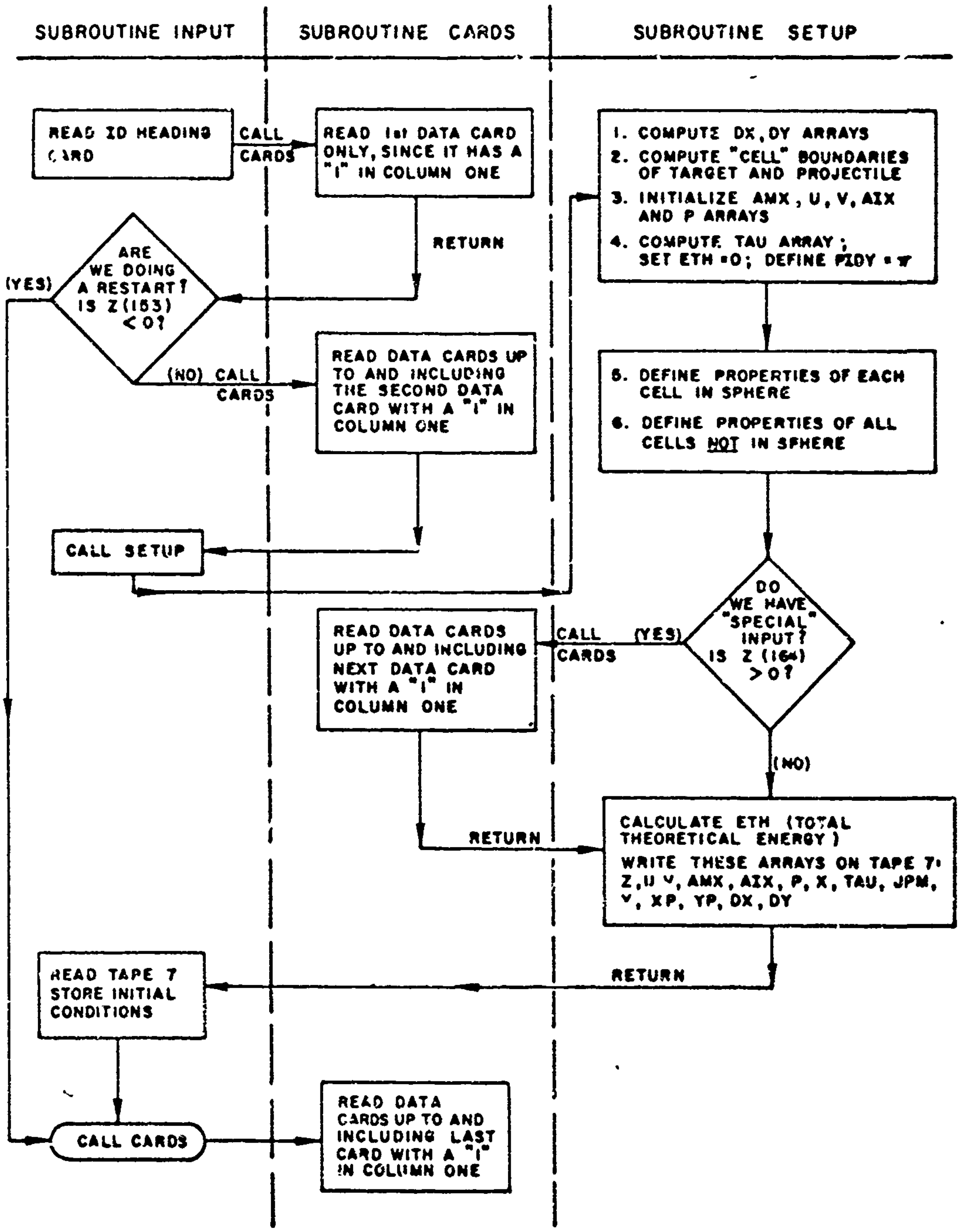


Fig. 2

2.3. CARDS

The reading of the input deck is called by this simple subroutine. Details are given in Fig. 2.

2.4. SETUP

The initial conditions for running problems are generated by SETUP. The most commonly used options are those in which a sphere or a cylinder (called the projectile) hits a target of finite thickness. The target of infinite thickness is an important special case. Another option is a geometry in which a sphere hits a thin plate (called the projectile) which has a filler behind it (typically void or of underdense "foamy" material) and then hits a second thin plate behind the filler. Further details are given in Section 3 describing how to set up various problems.

In an earlier report[3] describing the OIL code a description and FORTRAN listing of a special generator code, CLAM, was given. This program provides a very general method for specifying initial conditions and for setting up OIL-RPM problems. A few changes in CLAM are required to make the write statements for the CLAM dump tape compatible with the READ statements in OIL-RPM.

2.5. CDT

The principal function of this subroutine is to compute a time step which ensures stability of the finite difference equations. This is done by finding the minimum of $D/\dot{w}$ for all the cells. Here D denotes the minimum of the radial and axial cell dimensions, and w denotes the maximum of the radial velocity, axial velocity and sound speed. For vaporized material sound speed is computed by $\sqrt{\gamma p/\rho}$ and for solid materials by the approximate relation $C = C_0 + \overline{B}\sqrt{p}$ where p is the pressure in the cell. The coefficient $\overline{B}$ is obtained by determining a typical slope for the isentropes in Ref. 4 and using the relation

$$C = V\sqrt{-dp/dV}$$

to evaluate $\overline{B}$ at a particular point. The pressure array is updated in CDT by calling the equation of state subroutine ES.

The array JPM(I) which determines the location of the pressure maximum and hence the cells on which deviator stresses act is also computed in CDT.

Unrealistic behavior in free surface cells containing a small amount of mass would occur, in the absence of a special treatment, when a neighboring cell has a high pressure. This causes large accelerations of the mass in the cell containing a free surface, and eventually velocities which are physically unrealistic. This difficulty is alleviated by reducing the pressure computed by the equation of state by a factor which is the ratio of the smallest mass in an adjacent cell to the mass in the cell itself. This factor reduces the pressure at the interface to a value which accounts for the position of the free surface.

2.6. ES

The equation of state subroutine is called by CDT to evaluate the pressure as a function of density and internal energy. The general method was originally described in Ref. 4, but a number of modifications have been made since that report was written. A general discussion is given in Section 4 of PART TWO. Values of the parameters for a number of materials are listed in Table 2. Parameters for some materials not given in Ref. 4 are supplied in Refs 6 and 7.

2.7. EDIT

The pressure, velocities, density, specific internal energy, and mass for each cell are displayed by EDIT in a "long" print. It also prints out the total internal energy, kinetic energy, axial and radial momentum and mass above and below a dividing line which is the top of the cell whose J index is JPROJ. The changes in energy due to evaporation and losses out the boundaries are also accounted for in the EDIT prints. The crater depth is calculated by "packing down" material in each column to its normal density. This describes in a rough way the extent of the crater even while it still contains low density material.

"Short" EDIT prints display the integrated quantities, and the cell variables for the one column of cells that is adjacent to the axis. These

TABLE 2

EQUATION OF STATE CONSTANTS FOR SEVERAL MATERIALS

	a	b	A dynes/cm²	B dynes/cm²	E_0 ergs/g	α	β	E_s	ρ g/cm³	E'_s	
W	.5	1.04	3.08 x 10^12	2.5 x 10^12	.225 x 10^12	10	10	1.11 x 10^10	19.17	5.6 x 10^10	Ref. 4
Cu	.5	1.5	1.39	1.1	.325	5	5	1.38	8.9	6.9	
Fe	.5	1.5	1.28	1.05	.095	5	5	2.44	7.9	10.2	
Al	.5	1.63	.75	.65	.05	5	5	3.0	2.7	15.0	
Be	.55	.62	1.7	.55	.175	5	5	10.0	1.8	45.0	
Ti	.5	.60	1.03	.5	.07	5	5	3.5	4.5	12.5	
Ni	.5	1.33	1.91	1.5	.09	5	5	2.85	8.9	9.4	
Mo	.5	1.02	2.71	1.65	.045	5	5	2.8	10.2	9.0	
Th	.4	.86	.53	.5	.025	9	.88	2.0	11.7		
Granite*	.5	1.3	.18	.18	.16	5	5	3.5	2.7	.13 x 10^12	Ref. 1
Andesite*	.5	1.3	.18	.18	.15	5	5	3.5	2.7	.15	
Wet Tuff	.5	1.3	.10	.06	.11	5	5	3.2	2.0	.16	
Dry Tuff	.5	1.3	.045	.03	.06	5	5	3.2	1.7	.18	
Oil Shale	.5	1.0	.28	.11	.11	5	5	3.2	2.3	.15	
Dolomite	.5	.5	.85	.30	.10	5	5	2.5	2.8	.14	
Limestone	.5	.6	.4	.67	.10	5	5	2.5	2.7	.14	
Halite	.5	.6	.25	.30	.05	5	5	2.0	2.2	.15	
CH_2	.6	2.0	.075	.024	.07	10	5	2.4	.9	18.0	Ref. 3
Pb	.4	2.4	.466	.0025	.02	10	2	.25	11.3	.97	

*These fits include additional parameters short prints require only a few pages of printing, and hence are normally called for at more frequent intervals than the "long" prints.

Tracer points are positioned at the center of every other cell in SETUP, and the positions of these points are updated in PH2. The current position of each tracer point is printed in both the long and the short prints, providing the basis for a Lagrangian description of the flow. The positions are written on the restart dump tape and can be used by plot routines to make a plot of material deformation.

2.8. MAP

This sburoutine is called by EDIT and displays the properties of each cell in the active grid using an alphabetic scale. One obtains contour maps of the density, pressure, radial and axial velocities, and internal energy in the active grid.

2.9. PH1

The effect of the pressure gradient in updating the velocities and the internal energy is computed here. The calculation method is described in detail in Section 3.2 of PART TWO.

2.10. PH3

The deviator stresses acting on each cell edge and the hoop stress are determined in PH3 and the resulting velocity and energy increments are computed. Details are given in Section 5 of PART TWO. If CYCPH3 is -1, Phase 3 is bypassed and the effect of strength is not accounted for in the calculation. In this case the code is "hydrodynamic" in the classical sense.

2.11. PH2

Mass transport and the associated flux of momentum and energy are accounted for in PH2. The tracer points are also moved with velocities obtained by a simple weighting scheme.

2.12. REZONE

The masses of four cells are lumped into one in this subroutine. The JPM, DX, DY, X, Y, and TAU arrays are adjusted accordingly. Momentum and total energy are conserved, thereby converting some kinetic energy into internal in a process loosely called "thermalizing." Every other tracer point is deleted in rezone, and new tracer points are placed in the added cells, retaining constant the total number of tracer points.

2.13. ERROR

This subroutine, which is called in the case of certain error conditions tested on by the code, prints a message identifying the error conditions, calls EDIT for a long print and tape dump, and then calls EXIT.

2.14. TAPE DUMPS

Each OIL-RPM tape dump consists of eight or nine records depending on whether tracer points are used. (See list below.) The first record contains three words: 555.0, the value of CYCLE at the time of the dump, and the value of N3 (N3 = 1 when tracer points are used; otherwise, N3 = 0). The last record also contains three words: 666.0, 666.0, 666.0. However, before each dump after cycle 0, TAPE 7 is backspaced one record and this last record is written over. Therefore, this last record remains only on the last dump of a run and in that case is followed by an end of file mark.

On cycle 0, after all input cards but the last have been read and the properties of all cells have been defined, SETUP does a tape dump. Thereafter, all tape dumps are made by EDIT at set intervals defined by NDUMP7. However, when NODUMP ≠ 0. all tape dumps after cycle 0 are suppressed. This makes it possible to restart a problem from a dump tape without writing on the dump tape which is sometimes useful in special studies.

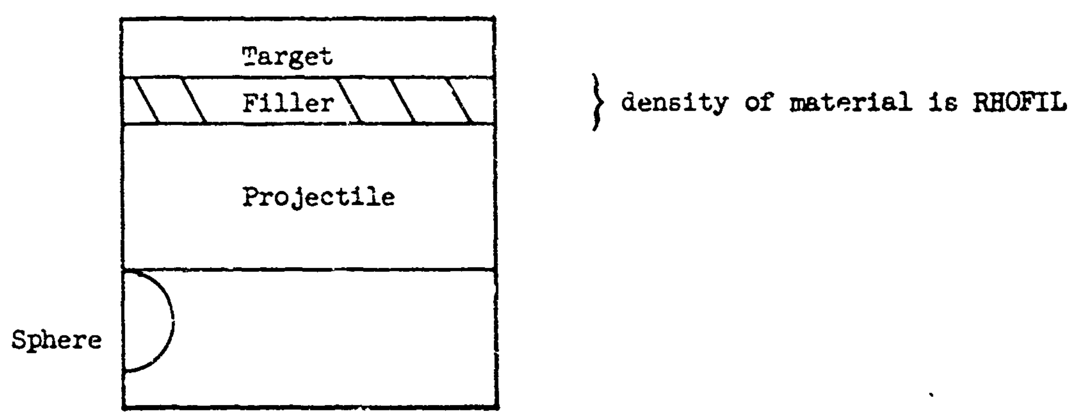
Record Number	Description
1	555.0, CYCLE, N3
2	Z(I), I = 1, MZT
3	U(I), V(I), AMX(I), AIX(I), P(I), I = 1, KMAX
4	X(0),(X(I), TAU(I), JPM(I), I = 1, IMAX)
5	Y(I), I = 0, JMAX
6	((XP(I,J), YP(I,J), I = 1, II), J = 1, JJ)
7	DX(I), I = 1, IMAX
8	DY(I), I = 1, JMAX
9	666.0, 666.0, 666.0

3. SET-UP OF PROBLEMS

Most calculations performed with the OIL-RPM code involve either a sphere or a cylinder hitting a target. Since the cylinder (which is called a "projectile" in the code) can be stationary, the set-up can also provide for a sphere hitting a two-layer target with or without filling material between the layers, as sketched in the diagram below.

The geometries described by the code are limited by the following requirements:

1. The Y-axis of the "sphere" must be on the Y-axis of the grid, i.e. the code cannot setup problems involving toroids.
2. The center of the sphere must coincide with a cell boundary. (Note: the center can be at the origin of the grid.)
3. The edge of the sphere should be contiguous with the projectile or target.
4. The projectile package is assumed to be below the target package.
5. The filler material can be placed only between the projectile package and the target package and extends out to the right boundary of the grid.
6. The right and top boundaries of the grid are transmittive, although the bottom boundary can be either reflective or transmittive.



The input cards for setting up an OIL-RPM problem define (1) the dimensions of the grid as well as the packages (sphere, projectile, and target); (2) the properties of the packages (density, velocity, and specific internal energy); (3) the physical constants used in the equation of state and yield-strength calculation; (4) the calculational constants used in defining various cutoffs and flags; (5) the frequency of printing and of writing on the restart tape; and (6) the time or cycle at which to stop execution.

Most of the input variables are equivalenced to an element in the Z-array, the first array in Blank Common. The variables, therefore, are identified on the input cards by their location in Blank Common (i.e., in the Z-array). The list that follows gives the variable name associated with each input number, its location in Blank Common, and a brief description of its function in the code.

Following this list will be a discussion of the format and order of the input cards, and the RPM Setup Sheets illustrating the input for a typical impact problem.

3.1. DEFINITION OF RPM INPUT VARIABLES

3.1.1. Identification

Variable Name	Location in Blank Common	Definition
PK(1)	151	The problem number can be any number with at most 2 places to the left and at most 4 to the right of the decimal point. (Range: 00.001 to 99.9999)
PROB	1	The problem number is repeated if this is a new problem just being set up. (It is not repeated for restarts from tape. See "RPM Input for Restart.")

3.1.2. Dimensions

Variable Name	Location in Blank Common	Definition
IMAX	33	The number of columns in the calculational mesh. IMAX ≤ 50 for the standard version. Unless IMAX = 1 for 1-D problem, IMAX must be even in order to rezone the grid.
JMAX	35	The number of rows in the calculational mesh. In the standard version JMAX ≤ 100, and IMAX times JMAX ≤ 2500. JMAX must be even to rezone the grid.
I1	47	The right-most column to be calculated initially. It should be two columns beyond the last column with non-zero energy (kinetic or internal). (I1 ≤ IMAX)
I2	48	The top row to be calculated initially. It should be two rows above the last column with non-zero energy. (I2 ≤ JMAX) I1 and I2 define the "active grid." I1 and I2 are automatically adjusted as the problem runs.
DXF	136	The value of all the DX's if DX is constant.
DYF	137	The value of all the DY's if DY is constant.
X(I)	269	The number of cms. from the axis to the right side of column I. The x-array is included in the input deck only if the radial dimension of the cells varies.
Y(J)	166	The number of cms. from the bottom of the grid to the top of row J. The Y-array is included in the input deck only if the axial dimension of the cells varies.

3.1.3. Projectile

Variable Name	Location in Blank Common	Definition
PRYBOT	67	The number of cms. from the bottom of the grid to the bottom of the projectile.
PRYTOP	68	The number of cms. from the bottom of the grid to the top of the projectile.
PRXRT	69	The number of cms. from the axis to the right of the projectile.
VINI	112	Initial axial velocity of the projectile.
PROJU	73	Initial radial velocity of the projectile.
PROJI	16	Initial specific internal energy of the projectile.
RHINI	111	Initial density of the projectile.

3.1.4. Target

Variable Name	Location in Blank Common	Definition
TAYBOT	88	The number of cms. between the bottom of the grid and the bottom of the target.
TAYTOP	89	The number of cms. between the bottom of the grid and the top of the target.
TAXRT	107	The number of cms. between the axis and the right of the target.
TARGV	52	Initial axial velocity of the target.
TARGI	72	Initial specific internal energy of the target.
RHINIT	15	Initial density of the target.

3.1.5. Sphere

Variable Name	Location in Blank Common	Definition
RADIUS	162	The radius (in cms.) of the sphere.
YCENTR	163	The number of cms. from the bottom of the grid to the center of the sphere. (Note: The center of the sphere must be on a cell boundary and on the axis of the grid.)
VINSPH	102	Initial axial velocity of the sphere.
SIESPH	101	Initial specific internal energy of the sphere.
RHOSPH	100	Initial density of the sphere.
RHOOUT	103	Initial density of material in the outside part of a cell cut by the sphere boundary.

3.1.6. Filler

Variable Name	Location in Blank Common	Definition
RHOFIL	51	Initial density of material between projectile and target.

3.1.7. Physical Constants

Variable Name	Location in Blank Common	Definition
AMDM	21	The lowest compression of material considered "solid." If $\rho/\rho_o \leq$ AMDM, and material is cold (specific internal energy < ES') stresses and pressure are zero.
CZERO(Y_o) STK1(Y_1) STK2(Y_2) STEZ(E_o)	42 11 28 29	Parameters used in yield-strength equation: $Y = (Y_o + Y_1\mu + Y_2\mu^2) \cdot (1 - E/E_o)$ where $\mu = \rho/\rho_o - 1$, and E = specific internal energy. However, (1) If $Y < 0$, stresses are set to 0. (2) If $E > E_o$, then $Y = 0$.

Variable Name	Location in Blank Common	Definition
BBAR	149	A constant used to approximate sound speed for the calculation of DT. $C = C_o + \overline{B} \cdot \sqrt{P(K)}$, where $C_o = \sqrt{A/\rho_o}$.
RHOZ	115	The normal density of the material. This value is used in the equation of state, the calculations of PMIN and C_o, the strength calculations, and the "slaving" process.
ESA(a)	116	Gruneisen ratio at high energy, ~ .5.
ESEZ(E_o)	117	A constant in Gruneisen ratio.
ESB(b)	118	A constant in Gruneisen ratio.
ESCAPA(A)	119	Bulk modulus.
ESESP(ES')	120	Heat to vaporize material; must be larger than ESES.
ESESQ(ESQ)	121	Used to test whether material is "cold;" usually identical to ESESP.
ESES(ES)	122	Heat to bring material to vapor temperature; must be smaller than ESESP.
ESALPH(α)	123	Usually 5.
ESBETA(β)	124	Usually 5.
ESCAPB(B)	125	Usually of the same order as A.

(ESA through ESCAPB: Equation of State constants, See Ref. 4 or Section 4, PART TWO)

3.1.8. Calculational Constants

Variable Name	Location in Blank Common	Definition
RHOMIN	138	The smallest density a cell can have and still influence the calculation of DT. (Usually RHOMIN = RHOZ * 10^{-3}.)

Variable Name	Location in Blank Common	Definition
DMIN	24	The allowable relative error in the energy sum. The error is the difference of the current total energy of all the cells and the total energy computed on cycle zero but adjusted for energy "evaporated" and lost across boundaries. The relative error is the difference divided by the total energy. If it exceeds DMIN, ERROR is called and the calculation is terminated.
DTMIN	144	The minimum value of DT (after STAB = FINAL) for the calculation to continue. DTMIN may be zero.
EVAP	75	This variable controls the "evaporation" of mass. If ρ < EVAP * RHINI, the cell mass is evaporated. The mass, energy and momentum of evaporated cells are accumulated in PH2 and printed in EDIT. (Usually EVAP = 10^{-4}.)
ROEPS	110	The "round-off epsilon" used in setting to zero certain calculated differences which could be due simply to machine round-off. (Usually ROEPS = 10^{-5} or 10^{-6}.)
STAB	139	The stability fraction used in determining DT. The input value of STAB is its initial value. If FINAL > 0., STAB is doubled on each cycle until it equals FINAL. However, if FINAL = 0., the initial value of STAB is used throughout the run. STAB is usually $\leq 10^{-3}$, but when all the energy is initially internal, setting STAB $\sim 10^{-8}$ is recommended.

Variable Name	Location in Blank Common	Definition
FINAL	113	FINAL is used in determining DT. If FINAL is > 0., then it is the largest value the stability fraction (STAB) will have. If FINAL = 0., the stability fraction will have the same value for each cycle. (FINAL is usually ~ .4.)
JSTR	25	JSTR (J strength) gives the value of I2 (active grid, J direction) at which stress calculations (PH3) are turned on and tensions are allowed.
N6	56	N6 specifies the J index of the cell behind which tensions (negative pressures) are to be allowed. If N6 = 0., tensions are allowed everywhere.
CYCPH3	70	CYCPH3 = -1. if no stress calculation is wanted. Otherwise, it is the number of subcycles of PH3 per time step. (Usually about 4.)
NUMREZ	12	The maximum number of times the grid will be rezoned.
NMPMAX	85	The maximum number of tracer points to be used.
Y2	81	Y2 = -2. if tracer points are to be calculated. Y2 = 0. if no tracer points are to be calculated.
REZFCT	71	REZFCT = 1. if rezones are allowed. REZFCT = 0. if rezones are not allowed.
SS4	130	SS4 = 1. if a rezone is to be forced on the second cycle of a run. (Often used to test the setup of problems to be rezoned.)

Variable Name	Location in Blank Common	Definition
SN	65	SN = 0., if negative specific internal energy is to be set to zero. SN = 1., if negative specific internal energy is to be left along.
CVIS	27	CVIS = 0., if the bottom boundary of the grid is to be reflective. CVIS = -1., if the bottom boundary of the grid is to be transmittive.
INTER	87	INTER = 0., gives no intermediate prints. INTER = 1., gives EDIT prints after PH1 and PH3, as well as CDT. INTER = 7., gives, in addition to the extra EDIT prints, details of PH2 calculations. INTER = 99., gives, in addition to the extra EDIT prints, details of PH3 stress and strain rates. CAUTION: INTER = 7., or = 99., gives <u>many</u> pages of output.
IVARDX	83	IVARDX = 0., if DX is constant and the X array is to be calculated from the value of DXF. IVARDX = 1., if DX varies and the X array is included in the input deck.
IVARDY	54	IVARDY = 0., if DY is to be constant and the Y array is to be calculated from the value of DYF. IVARDY = 1., if DY varies and the Y array is included in the input deck.

3.1.9. Output

Variable Name	Location in Blank Common	Definition
JPROJ	147	JPROJ is usually assigned the value of J at the top of the projectile. In EDIT, JPROJ is used as the zero in calculating the crater depth and is the division for the printout of total energy, mass and momentum.
PRDELT	45	The number of seconds between EDIT prints when printing on time. Otherwise 0.
IPCYCL	49	The number of cycles between EDIT prints when printing on cycles. Otherwise 0.
PRLIM	44	PRLIM is the time or cycle at which the EDIT print interval is to be increased. PRLIM is multiplied by PRFACT each time the print interval is adjusted.
PRFACT	46	The factor by which the print interval is increased. PRDELT (or IPCYCL) and PRLIM are multiplied by PRFACT when T = PRLIM.
NUMSCA	43	NUMSCA is the number of times the code will increase the interval time (or number of cycles) between EDIT prints.
NFRELP	5	NFRELP indicates the frequency of "long" EDIT prints. (A "long" print gives the velocities, pressure, mass, energy, density, and compression of all cells in the active grid; the "short" print gives this information only for the cells in the first column of the active grid.) A "long" print will occur every NFRELP short prints.

Variable Na e	Location in Blank Common	Definition
NDUMP7	6	NDUMP7 indicates the frequency of "tape dumps," where most of Blank Common is written on an output tape. A tape dump will occur every NDUMP7 EDIT prints. These "tape dumps" are used for restarting problems and for making automatic plots of tracer points.
NODUMP	96	NODUMP = 1. allows the user to pick up a run at some intermediate point on the restart tape without writing over the subsequent dumps on that tape.

3.1.10. Stopping

Variable Name	Location in Blank Common	Definition
ICSTOP	7	The cycle for execution to stop when stopping on cycles.
TSTOP	50	The value of T for execution to stop when stopping on time rather than cycles. NOTE: This card, because of its "1" in column one, must always be included in the initial input deck. If stopping on cycles set to zero.
Z(150)	150	Dummy end card. Used in the RPM input deck for setting up problems. (Do not include this card in an input deck when restarting a problem.)

3.2. FORMAT AND ORDER OF OIL-RPM INPUT CARDS

Except for the ID header card, all RPM input cards have the same format and are normally punched on 7-word data cards.

The RPM setup sheets provide the information to be punched in Col. 1, Cols. 2-6, and Col. 7 for each input variable. The values of the variables are punched in the seven 9-space fields in Cols. 8-70. These values must be punched with a decimal point even when they define integer variables. If the E-format is used, the exponent must be right-adjusted in the field. Only those variables which occur in consecutive order in Blank Common can be punched on the same card.

Col. 1	Cols. 2-6	Col. 7	Cols. 8-16	Cols. 17-25 etc.
Punch "1" on first and last two cards of deck. (See Setup Sheet.) Punch "2" on all cards defining integer variables. Otherwise no punch.	N Location in Blank Common of variable defined in Cols. 8-16.	Number of variables being defined on this card.	Z(N) Value of variable equi-valenced to Z(N).	Z(N+1) Value of variable equivalenced to Z(N+1).

For a normal setup deck, the only data cards which must be in a specific order are those listed on the Setup Sheet with a "1" in column one, and they must be the first and the last two cards in the deck.

3.3. OIL-RPM INPUT FOR "SPECIAL SETUPS"

The properties (density, velocity, internal energy) of each cell are defined by the subroutine SETUP according to the input parameters associated with the sphere, cylinder, filler and target (e.g., SIESPH, VINI, RHOFIL, TARGV). The RPM "special setup" allows the user to assign a special mass (not density), velocity or internal energy to specific cells in the grid.

To assign special properties to a specific cell the user must do the following:

1. Fine the I and J of the cell, then compute its K-index. (K = (J - 1)* IMAX + I + 1).

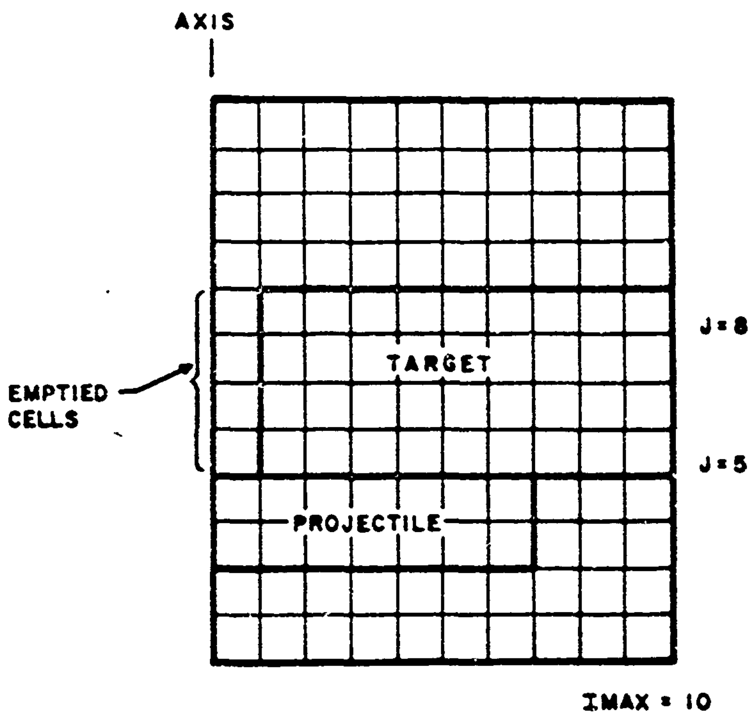
2. Find the location in Blank Common of AMX(K), U(K), V(K), and AIX(K), whichever is being specifically defined. (See Table 3, page 26, "Location of Arrays in Blank Common.")

3. Using the format of the other RPM input cards, punch a card with the location and value for each property being assigned.

Precede these input cards by a flag card which has a "1" in column one and which sets Z(164) = PK(14) = 1. (See Figure 2, page " Flow Diagrams of INPUT, CARDS and SETUP.") Place the special input cards in the

RPM input deck just before the card that defines ICSTOP(Z(7)). The flag card (PK(14) = 1.) must be the second card with a "1" in the column one in the input deck.

EXAMPLE: Suppose one column of cells in the target next to the axis is to be empty. The target is to range from J = 5 to J = 8, and IMAS = 10. (NOTE: This problem requires special input because RPM places all packages next to the axis of the grid.)



1. Compute the K-index of the empty cells.

I = 1,	J = 5,	K = 4*10 + 1 + 1 = 42
I = 1,	J = 6	K = 52
I = 1,	J = 7	K = 62
I = 1,	J = 8	K = 72

2. Find the location in Blank Common of members of the AMX array which store the masses of these cells. Table 3 indicates that 482 is the location of AMX (1) in Blank Common.

Variable Name	Location in Blank Common
AMX(42)	523
AMX(52)	533
AMX(62)	543
AMX(72)	553

3. The input deck would be organized as follows:

Description of card	Col. 1	Col. 2-6	Col. 7	Col. 8-16
ID CARD				IMPACT
PK(1)	1	151	1	3.2
Z(1)=PROB	blank		1	3.2
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
NODUMP	2	96	1	0.
PK(14)	1	164	1	1.
AMX(42)	blank	523	1	0.
AMX(52)	blank	533	1	0.
AMX(62)	blank	543	1	0.
AMX(72)	blank	553	1	0.
ICSTOP	2	7	1	0.
TSTOP	1	50	1	1. - 06
Dummy End	1	150	1	0.

TABLE 3

LOCATION OF ARRAYS IN BLANK COMMON*

Name of Array	Location of First Member of Array
Z	1
PK	151
YY Note: YY(1) = Y(0)	166
XX Note: XX(1) = X(0)	270
DDX Note: DDX(1) = DX(0)	324
DDY Note: DDY(1) = DY(0)	378
AMX	482
AIX	2984
U	5486
V	7988
P	10490
TAU	12992
JPM	13044
UL	13096
PL	13300
XP	13504
YP	14830
CMXP	16156
CMYP	16161

* These location numbers should not be used if the dimension of any array in Blank Common is changed.

4. SAMPLE PROBLEM

The impact of an aluminum sphere on a target of like material was described in an earlier report,[8] and the setup of the problem will be described in this section as an example. The sphere diameter was .4763 cms (3/16 in.), and its velocity was 7.35 km/sec. The zoning was chosen so that the sphere radius contained exactly 6 cells, the free surface of the target was 16 zones above the bottom of the grid, and the cells were square. It was found that after 16 microseconds the velocities were down to a value where the subsequent material motion would be negligible. The grid was rezoned twice during the computation. About two hours of computer time and about 450 cycles were required to complete the problem.

Details of the setup are given by the OIL-RPM Setup Sheets which list the appropriate values for the input parameters and describe the format of the data cards. Also, the main section of the printed output are illustrated and briefly discussed in addition to the control cards for the UNIVAX 1108.

7-WORD DATA
OIL-RPM SETUP SHEET

	2 LOC	7 N	8 **1**	17 **2**	26 **3**	35 **4**	44 **5** / **6**	62 **7**	71	73
					STANDARD	CRATER				

	LOC	N	1	
1	151	1	13.735	PK(1) = Problem number in the form 92.3456.
	1	1	13.735	PROB = Problem number (exactly the same as previous card).
2	33	1	42.	IMAX = Number of columns. An <u>even</u> number ≤ 50. unless IMAX = 1.
2	35	1	54.	JMAX = Number of rows. An <u>even</u> number ≤ 100.
2	47	1	8.	I1 = Number of columns in "active" grid + 2. (If IMAX = 1., I1 = 1.)
2	48	1	18.	I2 = Numbe. f rows in "active" grid + 2.
	136	1	.0397	DXF = DX if it is constant. If DX varies DXF = 0.
	137	1	.0397	DYF = DY if it is constant. If DY varies DYF = 0.

} IMAX * JMAX ≤ 2500 unless variable dimensions are changed.

Insert X-array only if DX varies. (See Page 31)   Insert Y-array only if DY varies. (See page 31)

	LOC	N	1	
	67	1	-1.	PRYBOT = Y-value (cm) of bottom of projectile. PRYBOT = -1., if no projectile.
	68	1	0.	PRYTOP = Y-value (cm) of top of projectile.
	69	1	0.	PRXRT = X-value (cm) of right of projectile.
	112	1	0.	VINI = Initial axial velocity of projectile.
	73	1	0.	PROJU = Initial radial velocity of projectile.
	16	1	0.	PROJI = Initial specific internal energy of projectile.
	111	1	2.7	RHINI = Initial density of projectile.
	88	1	.6352	TAYBOT = Y-value (cm) of bottom of target. TAYBOT = -1., if no target.
	89	1	1.0 +10	TAYTOP = Y-value (cm) of top of target.
	107	1	1.0 +10	TAXRT = X-value (cm) of right of target.
	52	1	0.	TARGV = Initial axial velocity of target.
	72	1	0.	TARGI = Initial specific internal energy of target.
	15	1	2.7	RHINIT = Initial density of target.

7-WORD DATA
OIL-RPM SETUP SHEET

2 LOC	7 N	8 — 1	17 — 2	26 — 3	35 — 4	44 — 5/6	62 — 7 / 71 / 73
462	1	.2382	RADIUS = radius (cm) of sphere. (RADIUS need not fall on cell boundary.)				
163	1	397	YCENTR = Y-center (cm) of sphere. (YCENTR must coincide with a cell boundary.)				
102	1	7.35 +05	VINSPH = Initial velocity of sphere.				
101	1	0.	SIESPH = Initial specific internal energy of sphere.				
100	1	2.7	RHOSPH = Initial density of sphere.				
103	1	0.	RHOOUT = Initial density of material adjacent to sphere.				
51	1	0.	RHOFIL = Initial density of filling material between projectile and target.				
21	1	.97	AMDM = Allowable expansion of material considered "solid." (Usually between .9 & .99.)				
42	1	2.39 +09	CZERO (Y_0) — Used in strength calculation: $Y = [Y_0 + \mu (Y_1 + Y_2\mu)](1 - E/E_C)$, $\mu = \rho/\rho_C - 1$				
11	1	2.4 +10	STK1 (Y_1) — Used in strength calculation				
28	1	4.1 +10	STK2 (Y_2) — Used in strength calculation				
29	1	7.9 +09	STEZ (E_0) — Used in strength calculation				
149	1	.5	BBAR = Constant in "local sound speed" calculation. ($C = C_0 + BBAR * \sqrt{P(K)}$)				
115	1	2.7	RHOZ = Normal density (ρ_0) for the equation of state.				
116	5	.5	5.0 +10	1.63	7.52 +11	1.3 +11	a, E_0, b, A, ES′ — Equation of State Constants. Normally ES=ESQ.
121	5	3.0 +10	3.0 +10	5.0	5.9	6.5 +11	ESQ, ES, α, β, B — Equation of State Constants. Normally ES=ESQ.
138	1	1.0 -03	RHOMIN = Minimum density for influencing DT. Usually 10^{-3} * RHOZ.				
24	1	1.0 -03	DMIN = Allowable relative error for total energy sum. Usually 10^{-3}.				
144	1	1.0 -09	DTMIN = Minimum value of DT for program to continue execution. DTMIN may be 0.				
75	1	1.0 -04	EVAP = Minimum allowable compression. If $\rho/\rho_0 <$ EVAP, mass of cell is "evaporated."				
110	1	1.0 -06	RCEPS = Round-off epsilon. Usually 10^{-5} or 10^{-6}.				
139	1	1.0 -03	STAB = Initial value of "stability fraction." Usually $< 10^{-3}$.				
113	1	.4	FINAL = Final value of "stability fraction." Usually = .4.				

7-WORD DATA
OIL-RPM SETUP SHEET

	2 LOC	7 N	8 1	17 2	26 3	35 4	44 5 ≈ 6	62 7	71	73
2	25	1	28.	JSTR = Value of I2 which triggers calculation of strength and negative pressures.						
2	56	1	14.	N6 = Value of J below which negative pressures are not allowed.						
	70	1	4.	CYCPH3 = Number of times of subcycle PH3. CYCPH3 = -1., for no PH3.						
2	12	1	2.	NUMREZ = Maximum number of rezones allowed.						
2	85	1	567.	NMPMAX = Maximum number of tracer points desired. NMPMAX ≤ 1250.						
	81	1	-2.	Y2 = -2., if tracer points are wanted. Y2 = 0. for no tracer points.						
	71	1	1.	REZFCT = 1. for allowing rezones. REZFCT = 0. for no rezones.						
	130	1	0.	SS4 = 1. for forcing rezone on second cycle of run. Usually SS4 = 0.						
	65	1	1.	SN = 1. leave negative S.I.E. alone. SN = 0. sets negative S.I.E. to 0.						
	27	1	-1.	CVIS = -1. for transmittive bottom boundary. CVIS = 0. for reflective bottom boundary.						
2	87	1	0.	INTER = Intermediate print flag.						
2	83	1	0.	IVARDX = 1. if DX varies and the X-array is read in. IVARDX = 0. if DX is constant.						
2	54	1	0.	IVARDY = 1. if DY varies and the Y-array is read in. IVARDY = 0. if DY is constant.						
2	147	1	16.	JPROJ = Usually the J-value of top row of projectile. Used in EDIT print, crater depth calculation.						
	45	1	2. -07	PRDELT = Time between EDIT prints. PRDELT = 0. if printing on cycles.						
2	49	1	0.	IPCYCL = Cycles between EDIT prints. IPCYCL = 0. if printing on time.						
	44	1	1. -06	PRLIM = Time or cycle at which to increase interval between prints.						
	46	1	2.	PRFACT = Factor by which to increase print interval.						
2	43	1	10.	NUMSCA = Maximum number of times print interval can be increased.						
2	5	1	5.	NFRELP = Ratio of "short" prints to "long" prints.						
2	6	1	1.	NDUMP7 = Ratio of prints to tape dumps.						
2	96	1	0.	NODUMP = 0. allows tape dumps. NODUMP = 1. suppresses tape dumps after cycle 0.						
2	7	1	0.	ICSTOP = Cycle to stop execution. ICSTOP = 0. if stopping on time.						
1	50	1	1.0 -06	TSTOP = Time (value of T) to stop execution. TSTOP = 0. if stopping on cycles.						
1	150	1	0.	Dummy end card.						

7-WORD DATA

OIL-RPM SETUP SHEET--X AND Y ARRAYS*

2 LOC	7 N	8 1	17 2	26 3	35 4	44 5	6	62 7	71	73
270	7									
277	7									X(0),... ,X(50) Input these values only if DX varies.
284	7									
291	7									
298	7									
305	7									
312	7									
319	2									
16[illegible]	7									
173	7									
180	7									Y(0),... , Y(100) Input these values only if DY varies.
187	7									
194	7									
201	7									
208	7									
215	7									
222	7									
229	7									
236	7									
243	7									
250	7									
257	7									
264	3									

*These location numbers (Cols. 2-6) must be changed if the dimension of Z, PK, or YY is changed.

4.1. OIL-RPM Output

The pages of OIL-RPM output which follow were produced by the sample problem, "Standard Crater," described above. The printed headings make most of the listing self-explanatory. Sections needing further description are numbered in the listing and discussed below.

1. The first few pages of the output for a setup run* display the input deck and describe the initial conditions of the problem. (Each time the CARDS routine is called "INPUT CARDS" is printed.)

2. When a sphere is placed, SETUP assures that the value of YCENTR is on a c_l boundary and prints the input and adjusted values of YCENTR.

3. On every cycle subroutine CDT prints the value of T, the time, and DT, the time step. The integers following "CDT" in the printout are the I and J of the cell controlling the time step. MAXCUV represents the maximum sound speed or velocity in the active grid. Likewise, MAXUV represents the maximum velocity. UMIN and PMIN are velocity and pressure cutoffs, respectively, used in MAP and PH2.

4. The first page printed by EDIT gives the total energies, mass and momenta of the cells above the JPROJ row and of the cells below and in the JPROJ row. (JPROJ is an input parameter, usually the J of the top row of the projectile package.)

5. On each cycle EDIT calculates the relative error in the total energy sum. On print cycles EDIT prints the maximum error calculated and the number of the cycle in which the maximum error occurred.

6. The total work done due to stresses calculated in PH3 is printed under "PLASTIC-WORK."

7. Also printed is a running total of the mass, energy, and axial and radial momentum lost when material crosses a transmittive boundary or is "evaporated" in PH2.

*For a restart run only the input deck is printed.

8. The "J OF PRESSURE MAXIMUM" describes the shock front by giving the location of the peak pressure in each column.

9. The tracer point coordinates are printed in centimeter units. The I and J of the cell in which a tracer point originated is also printed. This enables the user to follow the movement of a given tracer point. However, if the mass of a cell is "evaporated" the coordinates of the tracer points in that cell are set to zero and thereafter are not printed out.

10. The range of values assigned to the symbols on the contour maps are adjusted as the calculation proceeds. Therefore, a given symbol in the compression map, for instance, does not represent the same compression from one print to the next. A negative pressure, velocity, or internal energy is denoted by a symbol representing its absolute value and preceded by a minus sign.

11. The crater depth is measured from JPROJ. After a crater is formed, the negative values for the crater depth will describe the crater's "lip". The volume of the crater is printed along with the volume of a hemisphere of radius equal to the crater's depth in column one.

12. The J-index, radial velocity, axial velocity, pressure, mass, density, specific internal energy, compression, and distance (in cms.) from the bottom of the grid are printed for non-empty cells. The "long" EDIT print lists these properties for every column of the active grid, whereas the "short" EDIT print describes the non-empty cells in column one only.

13. Several error conditions are tested for during execution, and when one is detected, subroutine ERROR is called. ERROR in turn identifies the error test, prints the entire Z-array, and calls EDIT to do a long print and tape dump before stopping.

STANDARD CRATER

INPUT CARDS

(1.)

1	151	1	1.373500+01

INPUT CARDS

-0	1	1	1.373500+01				
2	33	1	4.200000+01				
2	35	1	5.390000+01				
2	47	1	6.000000+00				
2	46	1	1.600000+01				
-0	136	1	3.970000-02				
-0	137	1	3.970000-02				
-0	67	1	-1.000000+00				
-0	68	1	0.000000				
-0	69	1	0.000000				
-0	112	1	0.000000				
-0	73	1	0.000000				
-0	16	1	0.000000				
-0	111	1	2.700000+00				
-0	38	1	6.352000-01				
-0	39	1	1.000000+10				
-0	107	1	1.000000+10				
-0	52	1	0.000000				
-0	72	1	0.000000				
-0	15	1	2.700000+00				
-0	162	1	2.382000-01				
-0	163	1	3.970000-01				
-0	102	1	7.350000+05				
-0	101	1	0.000000				
-0	100	1	2.700000+00				
-0	103	1	0.000000				
-0	51	1	0.000000				
-0	21	1	9.700000-01				
-0	42	1	2.390000+09				
-0	11	1	2.400000+10				
-0	28	1	4.100000+10				
-0	29	1	7.000000+09				
-0	149	1	5.000000-01				
-0	115	1	2.700000+00				
-0	116	5	5.000000-01	5.000000+10	1.630000+00	7.520000+11	1.300000+11
-0	121	5	3.000000+10	3.000000+10	5.000000+00	5.000000+00	6.500000+11
-0	138	1	1.000000-03				
-0	24	1	1.000000-03				
-0	144	1	1.000000-09				
-0	75	1	1.000000-04				
-0	110	1	1.000000-06				
-0	139	1	1.000000-03				

```
  -0    113   1    4.000000-01
   2     25   1    2.000000+01
   2     50   1    1.000000+01
  -0     70   1    4.000000+00
   2     12   1    2.000000+00
   2     85   1    5.070000+02
  -0     81   1   -2.000000+00
  -0     71   1    1.000000+00
  -0    130   1    0.000000
  -0     65   1    1.000000+00
  -0     27   1   -1.000000+00
   2     87   1    0.000000
   2     83   1    0.000000
   2     54   1    0.000000
   2    147   1    1.600000+01
  -0     45   1    1.000000-06
   2     49   1    0.000000
  -0     44   1    1.000000-06
  -0     40   1    2.000000+00
   2     43   1    1.000000+01
   2      5   1    5.000000+00
   2      6   1    1.000000+00
   2     96   1    0.000000
   2      7   1    0.000000
   1     50   1    1.000000-06
```

(2) INPUT YCENTR = 3.970000-01   ADJUSTED YCENTR = 3.970000-01

```
                    INITIAL CONDITIONS

             SPHERE              PACKAGE 1   PACKAGE 2   FILLER

 DENSITY    2.7000+00           2.7000+00   2.7000+00   0.0000
  S.I.E.    0.0000              0.0000      0.0000
       V    7.3500+05           0.0000      0.0000
       U                        0.0000
  RADIUS    2.3620-01       TOP 0.0000      1.0000+10
 YCENTER    3.9700-01    BOTTOM-1.0000+00   6.3520-01
                          RIGHT 0.0000      1.0000+10

         INPUT CARDS


   1     150   1    0.000000


          NUMREZ= 2  JSTR= 28  N6= 10  IMAX= 42  JMAX= 54  I1=  8  I2= 18  JPROJ= 16  NMPMAX=  567  INTFR= 0  NUMSCA=10
 IPCYCL=  0  ICSTOP=   0  NFRELP=  5  NDUMP7=  1  NODUMP= 0  IVAROX= 0  IVARDY= 0
```

③

```
CUT 17  12  T= 5.7330342-07  DT= 1.7105428-08  MAXCUV= 9.2836024+05  MAXUV= 9.2836024+05  UMIN= 9.2836023-01  PMIN= 1.3228399+06
CUT 17  11  T= 5.9040084-07  DT= 1.7180432-08  MAXCUV= 9.2430734+05  MAXUV= 9.2430734+05  UMIN= 9.2430732-01  PMIN= 1.3170649+06
CUT 17  11  T= 6.0758927-07  DT= 1.7960208-08  MAXCUV= 8.8417683+05  MAXUV= 8.8417683+05  UMIN= 8.8417681-01  PMIN= 1.2598821+06
CUT 16  12  T= 6.2554947-07  DT= 1.7412566-08  MAXCUV= 9.1198503+05  MAXUV= 9.1198503+05  UMIN= 9.1198502-01  PMIN= 1.2995066+06
CUT 16  12  T= 6.4296203-07  DT= 1.6202935-08  MAXCUV= 8.7238675+05  MAXUV= 8.7238675+05  UMIN= 8.7238675-01  PMIN= 1.2430821+06
CUT 16  11  T= 6.6116496-07  DT= 1.8313324-08  MAXCUV= 8.6712820+05  MAXUV= 8.6712820+05  UMIN= 8.6712819-01  PMIN= 1.2355892+06
CUT 16  11  T= 6.7947629-07  DT= 1.9107477-08  MAXCUV= 8.3108822+05  MAXUV= 8.3108822+05  UMIN= 8.3108822-01  PMIN= 1.1842350+06
CUT 10  26  T= 6.9858576-07  DT= 1.9526046-08  MAXCUV= 8.1324770+05  MAXUV= 7.9660646+05  UMIN= 8.1324768-01  PMIN= 1.1588137+06
CUT  9  27  T= 7.1811241-07  DT= 1.9712737-08  MAXCUV= 8.0557049+05  MAXUV= 7.6116504+05  UMIN= 8.0557048-01  PMIN= 1.1478743+06
CUT 10  27  T= 7.3782514-07  DT= 1.9694013-08  MAXCUV= 8.0630364+05  MAXUV= 7.2520310+05  UMIN= 8.0630363-01  PMIN= 1.1489189+06
CUT  9  28  T= 7.5751995-07  DT= 1.9847581-08  MAXCUV= 8.0009749+05  MAXUV= 7.1909469+05  UMIN= 8.0009748-01  PMIN= 1.1400757+06
CUT 11  27  T= 7.7736752-07  DT= 1.9906493-08  MAXCUV= 7.9772964+05  MAXUV= 6.8658096+05  UMIN= 7.9772963-01  PMIN= 1.1367017+06
CUT 10  28  T= 7.9727402-07  DT= 1.9937062-09  MAXCUV= 7.9648253+05  MAXUV= 6.7095737+05  UMIN= 7.9648252-01  PMIN= 1.1349247+06
CUT 11  28  T= 8.1721167-07  DT= 2.0008527-08  MAXCUV= 7.9050096+05  MAXUV= 6.6599599+05  UMIN= 7.9050095-01  PMIN= 1.1264013+06
CUT 10  29  T= 8.3730020-07  DT= 2.0092037-08  MAXCUV= 7.9036286+05  MAXUV= 6.6331750+05  UMIN= 7.9036284-01  PMIN= 1.1262046+06
CUT 12  28  T= 8.5739223-07  DT= 2.0253253-08  MAXCUV= 7.8407156+05  MAXUV= 6.5883274+05  UMIN= 7.8407155-01  PMIN= 1.1172400+06
CUT 11  29  T= 8.7764547-07  DT= 2.0244983-08  MAXCUV= 7.8439185+05  MAXUV= 6.5202171+05  UMIN= 7.8439184-01  PMIN= 1.1176964+06
CUT 10  30  T= 8.9789046-07  DT= 2.0351241-08  MAXCUV= 7.8029636+05  MAXUV= 6.4354466+05  UMIN= 7.8029636-01  PMIN= 1.1118606+06
CUT 12  29  T= 9.1824169-07  DT= 2.0382380-08  MAXCUV= 7.7910425+05  MAXUV= 6.3772611+05  UMIN= 7.7910423-01  PMIN= 1.1101619+06
CUT 10  31  T= 9.3862407-07  DT= 2.0512106-08  MAXCUV= 7.7417693+05  MAXUV= 6.3620342+05  UMIN= 7.7417693-01  PMIN= 1.1031409+06
CUT 12  30  T= 9.5913617-07  DT= 2.0516787-08  MAXCUV= 7.7400029+05  MAXUV= 6.3356148+05  UMIN= 7.7400029-01  PMIN= 1.1028893+06
CUT 11  31  T= 9.7965295-07  DT= 2.0635466-08  MAXCUV= 7.6954887+05  MAXUV= 6.2956331+05  UMIN= 7.6954886-01  PMIN= 1.0965463+06
CUT 13  30  T= 9.9999999-07  DT= 2.0698330-08  MAXCUV= 7.6721163+05  MAXUV= 6.2401386+05  UMIN= 7.6721162-01  PMIN= 1.0932159+06
```

PROBLEM	TIME	CYCLE	TOT.EN.THEOR.	MAX.REL.ERROR-CYCLE		IE SET TO ZERO-PH1	IE SET TO ZERO-PH2	PLASTIC-WORK
13.7350	9 9999999-07	70	3.9972263+10	-8.3513908-06	70	0.0000000	-5.6878873+00	3.0655210+08

(5.) (6.)

(4.)	IE	KE	TOT.EN. (SUM)	MASS	MV	MV(POSITIVE)	MU	MU(POSITIVE)
J.GT.JPROJ	1.4164357+10	2.1862779+10	3.6047136+10	3.5606988+01	1.2888103+05	1.5801904+05	2.0767698+05	2.0768153+05
J.LE.JPROJ	1.9007980+09	2.0240066+09	3.9248052+09	1.2177211-01	-1.5975029+04	3.9293887+01	1.2597252+04	1.2621583+04
TOTALS	1.6065150+10	2.3886786+10	3.9971941+10	3.5728759+01	1.1290600+05	1.5805834+05	2.2027423+05	2.2030311+05

(7.) BOUNDARY	BOTTOM	RIGHT	TOP	$EVAPORATEDS
MASS OUT	0.0000000	0.0000000	0.0000000	8.0971186-04
ENERGY OUT	0.0000000	0.0000000	0.0000000	1.3158280+09
MU OUT	0.0000000	0.0000000	0.0000000	5.3098244+02
MV OUT	0.0000000	0.0000000	0.0000000	-5.6164385+02
WORK DONE	0.0000000	0.0000000	0.0000000	

J OF PRESSURE-MAXIMUM

(8.) 34 34 34 34 34 34 33 33 32 32 31 31 30 29 28 27 25 24 0 0 0 0 0 0 0
0 0 0 0

TAPE 7 DUMP ON CYCLE 70

(9.) TRACER POINTS - INITIAL LOCATION IN CELL COORDINATES (I,J) - CURRENT LOCATION IN CM. COORDINATES (X,Y)

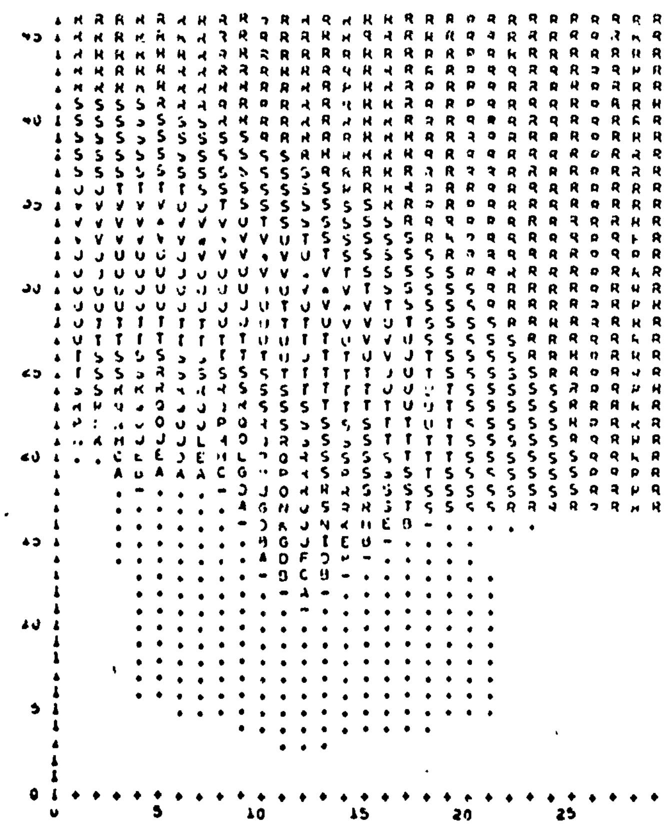
I	J	X	Y	I	J	X	Y	I	J	X	Y	I	J	X	Y	I	J	X	Y
1	7	3.17-02	8.39-01	3	7	1.57-01	8.51-01	5	7	2.52-01	8.29-01	1	9	2.65-02	8.82-01	3	9	1.60-01	8.78-01
5	9	2.65-01	8.26-01	1	11	2.55-02	9.16-01	3	11	1.65-01	9.03-01	5	11	3.13-01	8.22-01	1	13	2.93-02	9.47-01
3	13	1.76-01	9.25-01	5	13	3.47-01	8.00-01	1	15	4.08-02	9.71-01	3	15	1.99-01	9.40-01	5	15	3.82-01	7.48-01
1	17	4.09-02	9.65-01	3	17	2.17-01	9.41-01	5	17	3.83-01	7.55-01	7	17	4.21-01	5.79-01	9	17	4.46-01	5.57-01
11	17	4.75-01	5.76-01	13	17	5.20-01	6.12-01	15	17	5.85-01	6.34-01	17	17	6.57-01	6.48-01	19	17	7.34-01	6.54-01
21	17	8.14-01	6.55-01	23	17	8.93-01	6.55-01	25	17	9.73-01	6.55-01	27	17	1.05+00	6.55-01	29	17	1.13+00	6.55-01
31	17	1.21+00	6.55-01	33	17	1.29+00	6.55-01	35	17	1.37+00	6.55-01	37	17	1.45+00	6.55-01	39	17	1.53+00	6.55-01
41	17	1.61+00	6.55-01	1	19	4.55-02	1.00+00	3	19	1.99-01	9.70-01	5	19	3.39-01	8.68-01	7	19	4.05-01	7.66-01
9	19	4.43-01	7.26-01	11	19	4.81-01	7.15-01	13	19	5.32-01	7.19-01	15	19	5.96-01	7.25-01	17	19	6.64-01	7.31-01
19	19	7.37-01	7.34-01	21	19	8.14-01	7.34-01	23	19	8.93-01	7.34-01	25	19	9.73-01	7.34-01	27	19	1.05+00	7.34-01
29	19	1.13+00	7.34-01	31	19	1.21+00	7.34-01	33	19	1.29+00	7.34-01	35	19	1.37+00	7.34-01	37	19	1.45+00	7.34-01
39	19	1.53+00	7.34-01	41	19	1.61+00	7.34-01	1	21	3.97-02	1.02+00	3	21	1.71-01	1.00+00	5	21	2.91-01	9.46-01
7	21	3.70-01	8.83-01	9	21	4.25-01	8.44-01	11	21	4.79-01	8.25-01	13	21	5.36-01	8.17-01	15	21	5.99-01	8.14-01
17	21	6.67-01	8.15-01	19	21	7.38-01	8.14-01	21	21	8.14-01	8.14-01	23	21	8.93-01	8.14-01	25	21	9.73-01	8.14-01
27	21	1.05+00	8.14-01	29	21	1.13+00	8.14-01	31	21	1.21+00	8.14-01	33	21	1.29+00	8.14-01	35	21	1.37+00	8.14-01
37	21	1.45+00	8.14-01	39	21	1.53+00	8.14-01	41	21	1.61+00	8.14-01	1	23	2.69-02	1.05+00	3	23	1.48-01	1.04+00

COMPRESSION

(10.)

SYMBOL	.	-	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
MAXIMUM VALUE	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95	1.00

SYMBOL	S	T	U	V	W	X	Y	Z
MAXIMUM VALUE	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40



(11.)

DEPTH OF CRATER MEASURED FROM JPROJ

I	J OF CRATER BOTTOM	R	DEPTH IN CM, D(I)
1	20.4	1.9850-02	1.7399-01
2	20.6	5.9550-02	1.8264-01
3	20.4	9.9250-02	1.7633-01
4	20.1	1.3895-01	1.6342-01
5	20.2	1.7865-01	1.6594-01
6	20.2	2.1835-01	1.6736-01
7	20.1	2.5805-01	1.6258-01
8	19.6	2.9775-01	1.4321-01
9	18.5	3.3745-01	1.0159-01
10	16.8	3.7715-01	3.1806-02
11	14.9	4.1685-01	-4.3254-02
12	13.5	4.5655-01	-8.1702-02
13	14.1	4.9625-01	-7.4552-02
14	14.8	5.3595-01	-4.9472-02
15	15.3	5.7565-01	-2.8230-02
16	15.6	6.1535-01	-1.6319-02
17	15.5	6.5505-01	-7.2039-03
18	15.9	6.9475-01	-3.1113-03
19	16.0	7.3445-01	-1.9145-03
20	16.0	7.7415-01	-6.1621-04
21	16.0	8.1385-01	-1.9196-04
22	16.0	8.5355-01	-4.1127-05
23	16.0	8.9325-01	-9.1419-06

CRATER VOLUME
6.2707-02

CRATER VOLUME BASED ON (2/3) * PI * D(1)**3
1.1032-02

(12.)

I = 1 R(I) = .040 DR(1) = .3970000-01

J	U	V	P	AMA	RHO	AIY	COMP	Z
46	-0.000000	-0.000000	0.000000	5.307440-04	2.700000+00	-0.000000	1.000000+00	1.826700+00
45	-0.000000	-0.000000	0.000000	5.307440-04	2.700000+00	-0.000000	1.000000+00	1.786600+00
44	-0.000000	7.357571-01	0.000000	5.307448-04	2.700004+00	-0.000000	1.000001+00	1.746800+00
43	1.953747-01	4.520798+00	9.412925+06	5.307507-04	2.700034+00	1.012474+01	1.000013+00	1.707100+00
42	1.742703-01	2.190922+01	4.051160+07	5.307726-04	2.700145+00	2.208105+02	1.000054+00	1.667400+00
41	1.539405+00	9.450982+01	1.732542+08	5.308603-04	2.700622+00	4.323703+03	1.000230+00	1.627700+00
40	6.010741+00	4.029706+02	7.217932+08	5.312527-04	2.702580+00	7.767690+04	1.000953+00	1.588000+00
39	2.291742+01	1.042659+03	2.913524+09	5.327881-04	2.710399+00	1.433507+06	1.003451+00	1.548300+00
38	6.959536+01	6.370933+03	1.039897+10	5.383272-04	2.739577+00	2.090943+07	1.014288+00	1.508600+00
37	3.350507+02	2.214134+04	3.771520+10	5.552879-04	2.824859+00	2.584050+08	1.046244+00	1.468900+00
36	1.042815+03	6.000044+04	1.041870+11	5.909807-04	3.006476+00	1.665623+09	1.113510+00	1.429200+00
35	2.333843+03	1.038163+05	1.915145+11	6.294958-04	3.202370+00	4.469485+09	1.196063+00	1.389500+00
34	3.703115+03	1.321037+05	2.098914+11	6.365202-04	3.239134+00	5.228257+09	1.199309+00	1.349800+00
33	4.043902+03	1.243888+05	1.645387+11	6.193575-04	3.150794+00	3.220242+09	1.166961+00	1.310100+00
32	3.751922+03	1.174583+05	1.222793+11	6.028731-04	3.066935+00	1.254604+09	1.135902+00	1.270400+00
31	3.832057+03	1.211031+05	1.106218+11	6.003588-04	3.052618+00	2.042385+08	1.130590+00	1.230700+00
30	4.068259+03	1.370011+05	1.153054+11	6.035482-04	3.070369+00	-5.420134+08	1.137174+00	1.191000+00
29	4.259260+03	1.539992+05	1.124955+11	6.018959-04	3.061963+00	-1.500760+09	1.134051+00	1.151300+00
28	4.800599+03	1.682008+05	1.020793+11	5.958797-04	3.031358+00	-2.051599+09	1.122725+00	1.111600+00
27	6.504819+03	1.893803+05	9.526971+10	5.907145-04	3.005082+00	-8.823065+08	1.112903+00	1.071900+00
26	8.351507+03	2.235074+05	9.335653+10	5.830847-04	2.966267+00	2.091332+09	1.098617+00	1.032200+00
25	8.828305+03	2.694380+05	7.982581+10	5.653011-04	2.875799+00	4.104981+09	1.065111+00	9.924999-01
24	3.026308+03	3.175320+05	6.214010+10	5.493360-04	2.794581+00	6.403131+09	1.035032+00	9.527999-01
23	2.719302+03	3.698200+05	1.803368+10	5.194259-04	2.642422+00	6.615177+09	9.786750-01	9.130999-01
22	7.010433+03	4.280370+05	0.000000	4.550886-04	2.315126+00	5.384096+09	8.574560-01	8.733999-01
21	7.870803+03	4.632327+05	0.000000	4.115700-04	2.093738+00	4.255820+09	7.754546-01	8.336999-01
20	8.130330+03	4.699922+05	0.000000	3.030748-06	1.541802-02	4.091441+09	5.710376-03	7.939999-01

(13.)

*** ERROR EXIT - SEE STATEMENT NUMBER 65 IN CDT

I= 8 J= 16 K=705

Z-BLOCK

I	REAL FORMAT Z(I)	INTEGER FORMAT Z(I)
1	.137350+02	17831957626
2	-.100000+01	-17381195776
3	.000000	0
4	.000000	0
5	.500000-38	5
6	.500000-38	1
7	.000000	0
8	.314159+01	17553718998
9	.000000	0
10	.000000	0
11	.240000+11	21971239664
12	.500000-38	2
13	.000000	0
14	.000000	0
15	.270000+01	17536901606
16	.000000	0
17	.000000	0
18	.166740+01	17425984211
19	.500000-38	1
20	.500000-38	2
21	.970000-00	17310060380
22	.000000	0
23	.000000	0
24	.100000-02	16040629108
25	.500000-38	28
26	.000000	0
27	-.100000+01	-17381195776
28	.410000+11	22091785517
29	.700000+10	21718429208
30	-.500000-38	-1
31	.000000	0
32	.000000	0
33	.500000-38	42
34	.500000-38	43
35	.600000-38	54
36	.600000-38	55
37	.540000-38	2269
38	.540000-38	2270
39	.000000	0
40	.000000	0
41	.000000	0
42	.239000+10	21549523980
43	.500000-38	10
44	.100000-05	14700101096

4.2. UNIVAC 1108 CONTROL CARDS

```
∇ ASG P = 1184                          Program Tape
∇ ASG 7 = 2213                          Restart Tape*
∇ XQT CUR
  IN 7
  TRI P
  TOC
∇P HDG              STANDARD CRATER
∇ XQT RPM

        STANDARD CRATER

1       151      1      13.735                }
.        .       .        .                   }
.        .       .        .                   }  Input deck
         65      1       1.0                  }
.        .       .        .                   }
.        .       .        .                   }
1        50      1       1.0          -06     }
```

* Can assign a drum area for tape dumps instead of a tape by using:

    ∇D ASG 7 = 100000

5. RESTART OF PROBLEMS

Periodically during a calculation RPM writes on tape the problem parameters and the current state of the material in each cell. By reading this tape the user can "restart" and continue a calculation from an intermediate point. Because the initial conditions are saved on tape, SETUP is not called and the following three cards are the only ones which must be in the restart input deck:

Description of Card	Col. 1	Col. 2-6	Col. 7	Col. 8-16	Col. 17-25	Col. 26-34
ID CARD				IMPACT		
PK(1),PK(2), PK(3)	1	151	3	3.2	88.	-1.
TSTOP	1	50	1	1. - 06		

PK(1) = The same problem number used when the problem was initially setup. (NOTE: This can be any number between 00.0000 and 99.9999.)

PK(2) = The restart cycle number. The problem can be restarted on any cycle which is marked as a tape dump cycle in the printed output.

PK(3) = The restart flag. If it is -1. EDIT makes a long print of the restart cycle. However the user may wish to avoid making a long print on the restart cycle. He can do this by setting PK(3) = -2.

TSTOP = The new time at which execution will stop.

Other variables besides TSTOP may be redefined when restarting a problem. The copy of the "Setup Sheet for OIL-RPM Restarts" on page 44 lists those variables most likely to be redefined at an intermediate point in the calculation.

The cards in a restart input deck can be in any order as long as the first card is the ID card, the second card defines PK(1), PK(2) and PK(3) and has a "1" in column one, and the last card has a "1" in column one.

Examples:

1.

Description of Card	Col. 1	Col. 2-6*	Col. 7	Col. 8-16	Col. 17-25	Col. 26-34
ID CARD				IMPACT 1		
PK(1),PK(2) PK(3)	1	151	3	26.1	32.	-1.
INTER	2	87	1	0.		
RHOMIN		138	1	1. -03		
ICSTOP	2	7	1	135.		
TSTOP	1	50	1	0.		

2.

Description of Card	Col. 1	Col. 2-6*	Col. 7	Col. 8-16	Col. 17-25	Col. 26-34
ID CARD				IMPACT 2		
PK(1),PK(2) PK(3)	1	151	3	35.013	2019.	-2.
TSTOP	1	50	1	1.0 -05		

3.

Description of Card	Col. 1	Col. 2-6*	Col. 7	Col. 8-16	Col. 17-25	Col. 26-34
ID CARD				IMPACT 3		
PK(1),PK(2) PK(3)	1	151	3	8.2	128.	-2.
ICSTOP	2	7	1	200.		
TSTOP	1	50	1	0.		

*All numbers must be right-adjusted within the field.

7-WORD DATA
SETUP SHEET FOR OIL-RPM "RESTART"

	LOC (2)	N (7)	1 (8)	2 (17) – 7 (62), 71, 73
1	151	3		(a) Problem number. (b) Pickup cycle #. (c) Restart flag (-1. or -2.)
	70	1		CYCPH3 = Number of times to subcycle PH3.
	21	1		AMDM = Allowable expansion of material considered "solid": ~.95 to .99.
	138	1		RHOMIN = Minimum ρ for influencing DT.
	113	1		FINAL = Final value of "stability fraction."
	24	1		DMIN = Allowable relative error for total energy sum: ~ 10^{-4}.
	144	1		DTMIN = Minimum for DT.
	55	1		VT = Minimum Δρ from one cell across a grid boundary to trigger rezone.
	65	1		SN = 0., when negative S.I.E. is to be set to 0. If SN = 1., negative S.I.E. left alone.
	75	1		EVAP = ρ/ρ_o of cells to be "evaporated."
	110	1		ROEPS = Round-off epsilon.
2	147	1		JPROJ = Used in EDIT print and crater depth calculation.
2	5	1		NFRELP = Ratio of "short" print frequency to "long" print frequency.
2	6	1		NDUMP7 = Ratio of print frequency to tape dump frequency.
2	7	1		ICSTOP = Cycle to stop. Set to 0. if stopping on time.
1	50	1		TSTOP Time (value of T) to stop. Set to 0. if stopping on cycles. (This must be the last card of a restart deck.)

6. LISTING OF THF FORTRAN IV PROGRAM

This section consists simply of a listing of the FORTRAN IV program.

```
C     RPM
C     ..................................................................
C
C
      DIMENSION AMX(2502),AIX(2502),U(2502)   ,V(2502)   ,P(2502)   ,
     1          X(52)     ,XX(54)    ,TAU(52)   ,JPM(52)   ,
     2          Y(102)    ,YY(104)   ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),    Z(150)    ,
     5          XP(26,51),YP(26,51),
     6          PL(204)   ,UL(204)   ,PR(204)   ,
     7           RSN(52),    RST(52),
     8          CMXP(5)   ,CMYP(5)   ,IJ(5)     ,JK(5)     ,
     9          DX(52)    ,DDX(54)   ,DY(102)   ,DDY(104)  ,
     $          SNB(52)   ,STB(52)   ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C         *** DIMENSIONED ARRAYS
C         *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON     PK
      COMMON  YY,       XX
      COMMON  DDX,      DDY
      COMMON  AMX,      AIX,      U,      V,      P
      COMMON  TAU,      JPM
      COMMON  UL ,      PL
      COMMON  XP ,      YP,       CMXP, CMYP
C         *** NON-DIMENSIONED VARIABLES
      COMMON             AID     ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEL  ,DELER  ,DELET  ,DELM   ,DTODX  ,DXYMIN,EAMMP  ,EAMPY  ,
     2E      ,ERDUMP,I       ,I3     ,IWS    ,J      ,K      ,KA     ,KB     ,
     3LL     ,MD     ,ME     ,MZT    ,NERR   ,NK     ,NPRINT,
     4NR     ,NRZ    ,NULLE  ,PIOTS  ,SIEMIN,SNR    ,SNT    ,STR    ,SOLID  ,
     5SUM    ,TESTRH,TWOPI  ,URR    ,WS     ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
      COMMON     LAST
C
C         *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C             X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),   (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),   (DDY(2), DY(1))
C
C         *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE           (UL,FLEFT),          (UL(103),YAMC),
     1                      (PL,GAMC,PR),        (PL(103),SIGC)
C
C         *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE           (UL,RSN),
     1                      (PL,RST),            (P,UK),
     2                      (P(157),VK),         (P(313),SNB),
     3                      (P(365),STB),        (P(417),RHO)
C
C         *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),   (PR(6), JK)
C
C         *** Z-STORAGE EQUIVALENCES
```

```
C
      EQUIVALENCE                (Z(  1),PROB  ),(Z(  2),CYCLE ),
     1(Z(  3),DY    ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
     2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
     3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
     4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
     5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
     6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
     7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
     8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
     9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
      EQUIVALENCE
     1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
     2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
      EQUIVALENCE
     1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),
     3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
     4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
     5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
     8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
     9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
      EQUIVALENCE
     1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
     3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
      EQUIVALENCE
     1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
     2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
     9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
      EQUIVALENCE
     1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C     ...................................................................
C
C     END OF COMMON
C
C     ...................................................................
C
C          *** INIALIZE BLANK COMMON
      LAST = 1
      IQ = 0
    5 IQ = IQ+1
      Z(IQ) = 0.
      IF(LAST.NE.0) GO TO 5
```

```
10    CALL INPUT
20    CALL CDT
      CALL EDIT
C           *** ASK WFLAGL WHETHER THIS IS THE LAST CYCLE.
C               WFLAGL IS SET IN EDIT.
      IF (WFLAGL.GT.0.) GO TO 40
      CALL PH1
C           *** NPRINT=1 ON EDIT PRINT CYCLES.
C               INTER.NE.0 WHEN INTERMEDIATE EDIT PRINTS ARE WANTED.
      IF (INTER.NE.0.AND.NPRINT.EQ.1) CALL EDIT
C           *** CYCPH3=-1. WHEN PHASE 3 IS NOT USED. OTHERWISE,
C               CYCPH3=NUMBER OF TIMES PHASE 3 CALCULATIONS ARE
C               SUBCYCLED.
      IF (CYCPH3.EQ.(-1.)) GO TO 30
      CALL PH3
      IF (INTER.NE.0.AND.NPRINT.EQ.1) CALL EDIT
30    CALL PH2
      GO TO 20
40    CALL EXIT
      END
```

```
      SUBROUTINE INPUT
C     ..................................................................
C
      DIMENSION AMX(2502),AIX(2502),U(2502)   ,V(2502)   ,P(2502)   ,
     1          X(52)    ,XX(54)    ,TAU(52)   ,JPM(52)   ,
     2          Y(102)   ,YY(104)   ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)    ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)   ,PR(204)   ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)   ,IJ(5)     ,JK(5)     ,
     9          DX(52)   ,DDX(54)   ,DY(102)   ,DDY(104)  ,
     $          SNB(52)  ,STB(52)   ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C         *** DIMENSIONED ARRAYS
C         *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON      PK
      COMMON  YY,      XX
      COMMON  DDX,     DDY
      COMMON  AMX,     AIX,     U,     V,     P
      COMMON  TAU,     JPM
      COMMON  UL ,     PL
      COMMON  XP ,     YP,      CMXP, CMYP
C         *** NON-DIMENSIONED VARIABLES
      COMMON           AID    ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB  ,DELER  ,DELET  ,DELM   ,DTODX  ,DXYMIN,EAMMP  ,EAMPY  ,
     2E      ,ERDUMP,I      ,I3     ,IWS    ,J      ,K      ,KA     ,KB     ,
     3LL     ,MD     ,ME     ,MZT    ,NERR   ,NK     ,NPRINT,
     4NR     ,NRZ    ,NULLE  ,PIDTS  ,SIEMIN,SNR    ,SNT    ,STR    ,SOLID  ,
     5SUM    ,TESTRH,TWOPI  ,URR    ,WS     ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
C
C         *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C             X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C         *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE          (UL,FLEFT),          (UL(103),YAMC),
     1                     (PL,GAMC,PR),        (PL(103),SIGC)
C
C         *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE          (UL,RSN),
     1                     (PL,RST),            (P,UK),
     2                     (P(157),VK),         (P(313),SNB),
     3                     (P(365),STB),        (P(417),RHO)
C
C         *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C         *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                        (Z(  1),PROB  ),(Z(  2),CYCLE ),
```

```
1(Z(  3),DT     ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
 EQUIVALENCE
1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
 EQUIVALENCE
1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),
3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
 EQUIVALENCE
1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
 EQUIVALENCE
1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
 EQUIVALENCE
1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C     ...................................................................
C
C     END OF COMMON
C
C     ...................................................................
C
C           *** MZT MUST EQUAL NUMBER OF WORDS IN Z-ARRAY.
      MZT=150
C           *** SET WFLAGF=1. TO SAY THIS IS FIRST CYCLE OF THIS RUN.
      WFLAGF=1.
C           *** READ AND PRINT ID HEADING CARD (FIRST CARD IN
C               INPUT DECK)
      READ (5,370) IWS
      WRITE (6,370) IWS
```

```
C             *** CARDS ROUTINE WILL READ AND PRINT FIRST DATA CARD.      INP1140
      CALL CARDS                                                          INP1150
C             *** PK(3).LT.0. MEANS THIS PROBLEM IS BEING RESTARTED FROM  INP1152
C                 TAPE 7 AND SETUP IS NOT NEEDED.                         INP1155
      IF (PK(3).LT.0.) GO TO 70                                           INP1160
C             *** SINCE THE SETUP ROUTINE WRITES ON TAPE 7, MAKE          INP1170
C                 SURE THIS IS A SETUP AND NOT A RESTART RUN  TO AVOID    INP1180
C                 WRITING OVER A GOOD DUMP TAPE.                          INP1190
      CALL CARDS                                                          INP1190
C             *** Z(1)=PROB IS DEFINED BY THE SECOND CARD OF A SETUP      INP1200
C                 DECK,BUT IS NOT DEFINED IN A RESTART DECK.              INP1205
C                 THEREFORE IF Z(1)=0., THIS IS A RESTART RUN, AND IF     INP1210
C                 Z(1).NE.0.,THIS IS A SETUP RUN.                         INP1215
5     IF(PROB.EQ.0.)GO TO 230                                             INP1220
      CALL SETUP                                                          INP1230
      GO TO 70                                                            INP1240
10    CONTINUE                                                            INP1250
      CALL CARDS                                                          INP1260
C             *** INITIALIZE P-STORAGE.                                   INP1265
20    DO 30 K=1,KMAXA                                                     INP1270
30    P(K)=0.0                                                            INP1280
C             *** SET T AND NC SO THEY WILL EQUAL ZERO ON FIRST EDIT      INP1282
C                 PRINT AFTER BEING INCREMENTED BY CDT.                   INP1284
      T=T-DTNA                                                            INP1290
      NC=NC-1                                                             INP1300
C             *** CHECK FATAL INPUT ERRORS.                               INP1305
32    IF(RHOZ.LE.0.) GO TO 260                                            INP1310
34    IF(ESCAPA.LT.0.) GO TO 270                                          INP1320
36    IF(IMAX.EQ.0.OR.JMAX.EQ.0) GO TO 280                                INP1340
C             *** DEFINE CONSTANTS USED THROUGHOUT CALCULATION.           INP1345
      CNAUT=SQRT(ESCAPA/RHOZ)                                             INP1350
      WS=ESESP-ESES                                                       INP1360
      IF (WS.LE.0.) WS=1.                                                 INP1370
      SS1=1./WS                                                           INP1380
      TESTRH = .2*RHOZ                                                    INP1390
      CYCLE=NC                                                            INP1400
      NRZ=NREZ-NUMREZ                                                     INP1420
      SOLID=AMDM*RHOZ                                                     INP1430
      GAMMA=ESA+1.                                                        INP1440
      TWOPI=2.*PIDY                                                       INP1450
      PMIN=10.**6                                                         INP1460
      TRNSFC=.4                                                           INP1470
      VT=10.**(-5)                                                        INP1475
      SS2=1.                                                              INP1480
C             *** SET NUMBER OF SYMBOLS TO BE USED IN PRINTED CONTOUR     INP1482
C                 MAPS.                                                   INP1484
      IDNMAP=28.                                                          INP1490
      IPRMAP=26.                                                          INP1500
      IVMAP=26.                                                           INP1510
      IUMAP=26.                                                           INP1520
      IEMAP=26.                                                           INP1530
C             *** PRINT VALUES OF MOST INPUT PARAMETERS.                  INP1555
      WRITE (6,310) NUMREZ,JSTR,N6,IMAX,JMAX,I1,I2,JPROJ,NMPMAX,INTER,NUINP1560
     1MSCA,IPCYCL,ICSTOP,NFRELP,NDUMP7,NODUMP,IVARDX,IVARDY               INP1570
      WRITE(6,320) DXF,DYF,RHOMIN,TESTRH,RHOZ,RHINI,RHINIT,AMDM,SOLID, VINP1580
     1T,EVAP,ROEPS,SN,BBAR,CNAUT,FINAL,STAB,DMIN,CVIS,SS2,CYCPH3,CZERO,SINP1590
     2TK1,STK2,STEZ,ESA,ESB,ESCAPA,ESCAPB,ESALPH,ESBETA,ESEZ,ESES,ESESP,INP1600
```

```
     3ESESQ,REZFCT,SS4,Y2,TRNSFC,DTMIN,PRDELT,PRFACT,PRLIM,TSTOP
C          *** PRINT DX,DY ARRAYS WHEN THE CELL DIMENSIONS ARE
C               VARIABLE.
      IF (IVARDX.EQ.0) GO TO 40
      WRITE (6,330)
      WRITE (6,350) (I,DX(I),I=1,IMAX)
40    IF (IVARDY.EQ.0) GO TO 50
      WRITE (6,340)
      WRITE (6,350) (J,DY(J),J=1,JMAX)
50    CONTINUE
C          *** WHEN T.GT.0., PROBLEM IS BEING RESTARTED.
      IF (T.GT.0.) GO TO 60
C          *** DEFINE  TIME OF FIRST EDIT PRINT AFTER CYCLE 0.
      PRTIME=PRDELT
      GO TO 300
C          *** PRDELT = 0. WHEN PRINTING ON CYCLES RATHER TIME.
60    IF (PRDELT.EQ.0.) GO TO 300
C          *** DEFINE  TIME OF FIRST EDIT PRINT AFTER RESTART CYCLE.
      IWS=T/PRDELT+1.
      PRTIME=FLOAT(IWS)*PRDELT
      GO TO 300
C          *** READ DUMP TAPE 7.
70    CONTINUE
      IWS=0
80    REWIND 7
90    READ (7) PR(1),PR(2),N3
C          *** NR = NUMBER OF RECORDS WRITTEN BY EACH TAPE DUMP.
C               WHEN N3=1,TRACER POINTS ARE BEING USED AND MAKE UP
C               ANOTHER RECORD IN EACH TAPE DUMP.
      NR=N3+7
C          *** FIRST WORD OF FIRST RECORD OF EACH DUMP SHOULD BE
C               555.0. TEST THIS THREE TIMES BEFORE EXITING.
      IF (PR(1)-555.0) 100,110,100
100   IWS=IWS+1
      IF (MOD(IWS,3)) 220,220,80
110   IF (PR(2)) 100,120,120
C          *** WHEN SETTING UP A PROBLEM PR(2) = PK(2) = 0. WHEN
C               RESTARTING A PROBLEM, TAPE 7 IS READ UNTIL
C               PR(2).GE.PK(2), THE RESTART CYCLE NUMBER.
120   IF (PK(2)-PR(2)) 150,150,130
130   DO 140 L=2,NR
140   READ (7)
      GO TO 90
150   READ (7) (Z(I),I=1,MZT)
C          *** MAKE SURE PROBLEM NUMBER ON TAPE (PROB) MATCHES
C               PROBLEM NUMBER ON INPUT CARDS (PK(1)).
      IF (ABS(PROB-PK(1))-.01) 160,160,210
160   READ (7) (U(I),V(I),AMX(I),AIX(I),P(I),I=1,KMAXA)
      READ (7) X(0),(X(I),TAU(I),JPM(I),I=1,IMAX)
      READ (7) (Y(I),I=0,JMAX)
C          *** Y2=-1. WHEN TRACER POINTS ARE USED.
      IF (Y2.GT.(-1.)) GO TO 170
      READ (7) ((XP(I,J),YP(I,J),I=1,II),J=1,JJ)
170   READ (7) (DX(I),I=1,IMAX)
      READ (7) (DY(J),J=1,JMAX)
      READ (7) PR(1),PR(2),PR(3)
C          *** THE FIRST WORD OF THE LAST RECORD OF EACH DUMP SHOULD
```

```
      3ESESQ,REZFCT,SS4,Y2,TRNSFC,DTMIN,PRDELT,PRFACT,PRLIM,TSTOP
C           *** PRINT DX,DY ARRAYS WHEN THE CELL DIMENSIONS ARE
C                VARIABLE.
      IF (IVARDX.EQ.0) GO TO 40
      WRITE (6,330)
      WRITE (6,350) (I,DX(I),I=1,IMAX)
40    IF (IVARDY.EQ.0) GO TO 50
      WRITE (6,340)
      WRITE (6,350) (J,DY(J),J=1,JMAX)
50    CONTINUE
C           *** WHEN T.GT.0., PROBLEM IS BEING RESTARTED.
      IF (T.GT.0.) GO TO 60
C           *** DEFINE  TIME OF FIRST EDIT PRINT AFTER CYCLE 0.
      PRTIME=PRDELT
      GO TO 300
C           *** PRDELT = 0. WHEN PRINTING ON CYCLES RATHER TIME.
60    IF (PRDELT.EQ.0.) GO TO 300
C           *** DEFINE  TIME OF FIRST EDIT PRINT AFTER RESTART CYCLE.
      IWS=T/PRDELT+1.
      PRTIME=FLOAT(IWS)*PRDELT
      GO TO 300
C           *** READ DUMP TAPE 7.
70    CONTINUE
      IWS=0
80    REWIND 7
90    READ (7) PR(1),PR(2),N3
C           *** NR = NUMBER OF RECORDS WRITTEN BY EACH TAPE DUMP.
C                WHEN N3=1,TRACER POINTS ARE BEING USED AND MAKE UP
C                ANOTHER RECORD IN EACH TAPE DUMP.
      NR=N3+7
C           *** FIRST WORD OF FIRST RECORD OF EACH DUMP SHOULD BE
C                555.0. TEST THIS THREE TIMES BEFORE EXITING.
      IF (PR(1)-555.0) 100,110,100
100   IWS=IWS+1
      IF (MOD(IWS,3)) 220,220,80
110   IF (PR(2)) 100,120,120
C           *** WHEN SETTING UP A PROBLEM PR(2) = PK(2) = 0. WHEN
C                RESTARTING A PROBLEM, TAPE 7 IS READ UNTIL
C                PR(2).GE.PK(2), THE RESTART CYCLE NUMBER.
120   IF (PK(2)-PR(2)) 150,150,130
130   DO 140 L=2,NR
140   READ (7)
      GO TO 90
150   READ (7) (Z(I),I=1,MZT)
C           *** MAKE SURE PROBLEM NUMBER ON TAPE (PROB) MATCHES
C                PROBLEM NUMBER ON INPUT CARDS (PK(1)).
      IF (ABS(PROB-PK(1))-.01) 160,160,210
160   READ (7) (U(I),V(I),AMX(I),AIX(I),P(I),I=1,KMAXA)
      READ (7) X(0),(X(I),TAU(I),JPM(I),I=1,IMAX)
      READ (7) (Y(I),I=0,JMAX)
C           *** Y2=-1. WHEN TRACER POINTS ARE USED.
      IF (Y2.GT.(-1.)) GO TO 170
      READ (7) ((XP(I,J),YP(I,J),I=1,II),J=1,JJ)
170   READ (7) (DX(I),I=1,IMAX)
      READ (7) (DY(J),J=1,JMAX)
      READ (7) PR(1),PR(2),PR(3)
C           *** THE FIRST WORD OF THE LAST RECORD OF EACH DUMP SHOULD
```

```
C                 BE 555.0 OR 666.0.                                    INP2034
175   IF(PR(1)-555.0) 240,10,180                                        INP2040
180   IF(PR(2)-666.0) 250,10,250                                        INP2060
200   CALL CARDS                                                        INP2070
      CALL SETUP                                                        INP2080
      GO TO 20                                                          INP2090
C             *** PROBLEM NUMBER ON TAPE 7 NOT THE SAME AS PROBLEM      INP2092
C                 NUMBER ON INPUT CARDS.                                INP2094
210   NK=150                                                            INP2100
      GO TO 290                                                         INP2110
C             *** CANNOT FIND FIRST WORD OF FIRST RECORD.               INP2115
220   NK=100                                                            INP2120
      GO TO 290                                                         INP2130
C             *** NOT A RESTART AND YET Z(1) = 0.                       INP2135
230   NK=5                                                              INP2140
      GO TO 290                                                         INP2150
C             *** FIRST WORD OF LAST RECORD IS INCORRECT.               INP2155
240   NK=175                                                            INP2160
      GO TO 290                                                         INP2170
C             *** FIRST WORD OF LAST RECORD IS INCORRECT.               INP2175
250   NK=180                                                            INP2180
      GO TO 290                                                         INP2190
C                 *** RHOZ.LE.0.                                        INP2200
260   NK=32                                                             INP2210
      GO TO 290                                                         INP2220
C                 *** ESCAPA.LT.0.                                      INP2230
270   NK=34                                                             INP2240
      GO TO 290                                                         INP2250
C                  *** IMAX OR JMAX IS ZERO                             INP2260
280   NK=36                                                             INP2270
290   NR=1                                                              INP2280
C             *** PRINT FIRST THREE WORDS OF DUMP (PR(1),PR(2),N3)      INP2282
C                 AND Z(151),Z(152),Z(153).                             INP2284
      WRITE(6,360) PR(1), Z(151), PR(2), Z(152), N3, Z(153)
      CALL ERROR                                                        INP2300
300   RETURN                                                            INP2310
C                                                                       INP2320
310   FORMAT (//12X,9H  NUMREZ=,I2,7H  JSTR=,I3,5H  N6=I3,7H  IMAX=,I3,7INP2330
     1H  JMAX=,I3,5H  I1=,I3,5H  I2=,I3,8H  JPROJ=,I3,9H  NMPMAX=,I5,8H INP2340
     2 INTER=,I2,9H  NUMSCA=,I2,/8H IPCYCL=,I3,9H  ICSTOP=,I4,9H  NFRELPINP2350
     3=,I3,9H  NDUMP7=,I3,9H  NODUMP=,I2,9H  IVARDX=,I2,9H  IVARDY=,I2//INP2360
     4)                                                                 INP2370
320   FORMAT (1X,120H          DXF          DYF        RHOMIN       TESTRH  INP2380
     1     RHOZ         RHINI        RHI1         AMDM         SOLID    INP2390
     2 VT/1X,1P10E12.4//1X,120H                          PS          SN INP2400
     3   BBAR        CNAUT        FINAL        STAB         DMIN      CVIINP2410
     4S          SS2/1X,1P10E12.4//1X,120H        CYCPH3       CZERO    INP2420
     5 STK1        STK2         STEZ         ESA          ESB       ESCAPA INP2430
     6     ESCAPB       ESALPH/1X,1P10E12.4//1X,96H       ESBETA       ESINP2440
     7EZ         ESES         ESESP        ESESQ        REZFCT         SS4 INP2450
     8        Y2/1X,1P8E12.4//1X,72H       TRNSFC       DTMIN        PRDELT INP2460
     9      PRFACT        PRLIM        TSTOP/1X,1P6E12.4)               INP2470
330   FORMAT (//7(3H  I,6X,2HDR,7X))                                    INP2480
340   FORMAT (//7(3H  J,6X,2HDZ,7X))                                    INP2490
350   FORMAT (7(I4,2X,1PE9.3,3X))                                       INP2500
 360 FORMAT (1H1,5X,72H*** CHECK FIRST RECORD OF THE DUMP AND FIRST DAT
     1A CARD OF THE INPUT DECK // 4X,7HON TAPE,41X,8HON CARDS / 4X,
```

```
      24HWS =,F6.1,4X,7H(555.0),24X, 8HZ(151) =,F8.4,3X,16H(PROBLEM NUMBE
     3R) / 8H CYCLE =,F6.1,4X,18H(CYCLE BEING READ),13X, 8HZ(152) =F5.1,
     46X,15H(RESTART CYCLE) / 4X,4HN3 =,I4,6X,19H(TRACER POINT FLAG) ,
     512X, 8HZ(153) =,F5.1,6X,14H(RESTART FLAG))
 370  FORMAT (I1,71H                                                          INP2520
     1                )                                                       INP2530
      END                                                                     INP2540
```

```
      SUBROUTINE CARDS
      DIMENSION TABLE(1),CARD(7),LABLE(1)
      DIMENSION INPERR(1)
      COMMON     TABLE
      EQUIVALENCE(TABLE(1),LABLE(1))
      INPERR=0
      WRITE (6,80)
   10 READ (5,90) IEND,LOC,NUMWPC,(CARD(I),I=1,NUMWPC)
      WRITE (6,100) IEND,LOC,NUMWPC,(CARD(I),I=1,NUMWPC)
      IF (NUMWPC.LT.1) GO TO 50
      IF (LOC.LT.1) GO TO 70
      DO 30 I=1,NUMWPC
      J=LOC+I-1
      IF (IEND.NE.2) GO TO 20
      LABLE(J)=IFIX(CARD(I))
      GO TO 30
   20 TABLE(J)=CARD(I)
   30 CONTINUE
   40 IF (IEND.NE.1) GO TO 10
      IF (INPERR.EQ.0) RETURN
      STOP
   50 IF (LOC.NE.0) GO TO 70
      DO 60 I=1,7
      IF (CARD(I).NE.0.) GO TO 70
   60 CONTINUE
      WRITE (6,120)
      GO TO 40
   70 WRITE (6,110)
      INPERR=1
      GO TO 40
C               FORMATS
C
   80 FORMAT (/18H        INPUT CARDS///)
   90 FORMAT (I1,I5,I1,0P7E9.4)
  100 FORMAT (1H I4,I7,I3,1P7E14.6)
  110 FORMAT (//42H **** ERROR ON PRECEDING DATA CARD *******/)
  120 FORMAT (//18H BLANK CARD ******/)
      END
```

```
      SUBROUTINE SETUP
C     ***************************************************************
C
      DIMENSION AMX(2502),AIX(2502),U(2502)   ,V(2502)   ,P(2502)   ,
     1          X(52)     ,XX(54)    ,TAU(52)   ,JPM(52)   ,
     2          Y(102)    ,YY(104)   ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),    Z(150)    ,
     5          XP(26,51),YP(26,51),
     6          PL(204)   ,UL(204)   ,PR(204)   ,
     7           RSN(52),    RST(52),
     8          CMXP(5)   ,CMYP(5)   ,IJ(5)     ,JK(5)     ,
     9          DX(52)    ,DDX(54)   ,DY(102)   ,DDY(104)  ,
     $          SNB(52)   ,STB(52)   ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C             *** DIMENSIONED ARRAYS
C             *** Z-BLOCK IS SAVED ON TAPE.
      COMMON     Z
      COMMON     PK
      COMMON  YY,      XX
      COMMON  DDX,     DDY
      COMMON  AMX,     AIX,     U,      V,      P
      COMMON  TAU,     JPM
      COMMON  UL ,     PL
      COMMON  XP ,     YP,      CMXP, CMYP
C             *** NON-DIMENSIONED VARIABLES
      COMMON           AID     ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB ,DELER ,DELET ,DELM   ,DTODX ,DXYMIN,EAMMP ,EAMPY  ,
     2E      ,ERDUMP,I     ,I3    ,IWS    ,J     ,K     ,KA    ,KB     ,
     3LL     ,MD    ,ME    ,MZT   ,NERR   ,NK    ,NPRINT,
     4NR     ,NRZ   ,NULLE ,PIDTS ,SIEMIN,SNR   ,SNT   ,STR   ,SOLID  ,
     5SUM    ,TESTRH,TWOPI ,URR   ,WS     ,WSA   ,WSB   ,WSC   ,WFLAGF,
     6WFLAGL,WFLAGP
C
C             *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C                 X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),   (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C             *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE           (UL,FLEFT),          (UL(103),YAMC),
     1                      (PL,GAMC,PR),        (PL(103),SIGC)
C
C             *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE           (UL,RSN),
     1                      (PL,RST),            (P,UK),
     2                      (P(157),VK),         (P(313),SNB),
     3                      (P(365),STB),        (P(417),RHO)
C
C             *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),   (PR(6), JK)
C
C             *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                           (Z(  1),PROB  ),(Z(  2),CYCLE ),
```

```
     1(Z(  3),DT    ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
     2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
     3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
     4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
     5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
     6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
     7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
     8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
     9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
      EQUIVALENCE
     1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
     2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
      EQUIVALENCE
     1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),
     3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
     4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
     5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
     8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
     9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
      EQUIVALENCE
     1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
     3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
      EQUIVALENCE
     1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
     2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
     4(Z(107),TAXRT ),(Z(108),IONMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
     9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
      EQUIVALENCE
     1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C          *** SPECIAL EQUIVALENCES FOR SETUP ONLY
C
      EQUIVALENCE  (RADIUS,PK(12)), (YCENTR,PK(13)), (RHOSPH,Z(100)),
     1             (SIESPH,Z(101)), (VINSPH,Z(102)),(RHOOUT,Z(103))
C
      COMMON/ SPHERE / ADDVL, AREAFC, ISPHMX, JCENTR, JSPHBT, JSPHTP,
     1                 RSQRD, VOLSPH, XL2   , XR2   , YBOTTM, YC2   ,
     2                 YDIFFB, YDIFFI, YDIFFO, YDIFFT, YLINTA, YLINTB,
     3                 YLOWER, YRINTA, YRINTB, YTOP  , YUPPER
C
C     ..............................................................
C
C     END OF COMMON
C
```

```
C     ...................................................................SET1160
C                                                                        SET1170
      IF (IVARDY.GT.0) GO TO 30                                          SET1180
C                                                                        SET1190
C           *** IF DY VARIABLE,Y(I) WILL BE READ IN RATHER THAN          SET1200
C               CALCULATED.                                              SET1210
C                                                                        SET1220
      Y(1)=DYF                                                           SET1230
      DO 10 J=2,JMAX                                                     SET1240
      Y(J)=Y(J-1)+DYF                                                    SET1250
10    CONTINUE                                                           SET1260
C                                                                        SET1270
C           *** IF DY VARIABLE, DY(I) WILL BE CALCULATED FROM THE Y(I)   SET1280
C               READ IN.   IF DY CONSTANT, DY(I) WILL EQUAL DYF FOR      SET1290
C               ALL I.                                                   SET1300
C                                                                        SET1310
      DO 20 I=1,JMAX                                                     SET1320
20    DY(I)=DYF                                                          SET1330
      GO TO 50                                                           SET1340
C                                                                        SET1350
C            *** CALCULATE VARIABLE DY(I).                               SET1360
30    DO 40 I=1,JMAX                                                     SET1370
40    DY(I)=Y(I)-Y(I-1)                                                  SET1380
50    CONTINUE                                                           SET1390
C                                                                        SET1400
C          ***  IF DX VARIABLE, X(I) WILL BE READ IN RATHER THAN         SET1410
C               CALCULATED                                               SET1420
C                                                                        SET1430
      IF (IVARDX.GT.0) GO TO 80                                          SET1440
      X(1)=DXF                                                           SET1450
      DO 60 I=2,IMAX                                                     SET1460
      X(I)=X(I-1)+DXF                                                    SET1470
60    CONTINUE                                                           SET1480
C                                                                        SET1490
C           *** IF DX VARIABLE, DX(I)WILL BE CALCULATED FROM             SET1500
C               THE X(I) READ IN. IF DX CONSTANT, DX(I) WILL             SET1520
C               EQUAL DXF FOR ALL I.                                     SET1525
C                                                                        SET1530
      DO 70 I=1,IMAX                                                     SET1540
      DX(I)=DXF                                                          SET1550
70    CONTINUE                                                           SET1560
      GO TO 100                                                          SET1570
C                                                                        SET1580
C            ***  CALCULATE VARIABLE DX(I)                               SET1590
C                                                                        SET1600
80    DO 90 I=1,IMAX                                                     SET1610
90    DX(I)=X(I)-X(I-1)                                                  SET1620
C           *** MAKE SURE DX AND DY ARRAYS HAVE BEEN DEFINED.            SET1625
95    IF (DX(1).GT.0..AND.DY(1).GT.0.) GO TO 100                         SET1630
      GO TO 770                                                          SET1640
100   CONTINUE                                                           SET1650
C                                                                        SET1660
C           *** PK(3) = -3. WHEN RESTARTING FROM A CLAM TAPE.            SET1662
C               PROPERTIES OF CELLS HAVE ALREADY BEEN DEFINED            SET1664
C               BUT TRACER POINTS HAVE NOT.                              SET1666
      IF (PK(3).EQ.(-3.)) GO TO 700                                      SET1670
C           *** PRYBOT=-1. MEANS THE PROJECTILE PACKAGE                  SET1672
```

```
C                 IS NOT BEING USED.                                    SET1674
      IF (PRYBOT.LT.0.) GO TO 200                                       SET1680
C             *** DEFINE CELL BOUNDARIES (MB,MC,MR) OF PROJECTILE       SET1690
C                 PACKAGE.                                              SET1695
      IF (IVARDY.GT.0) GO TO 110                                        SET1700
C             *** CALCULATION FOR CONSTANT DY.                          SET1705
      MB=INT(PRYBOT/DYF+.5)+1                                           SET1710
      IF (MB.GT.JMAX) GO TO 200                                         SET1720
      M=1                                                               SET1730
      MC=INT(PRYTOP/DYF+.5)                                             SET1740
      IF (MC.GT.JMAX) MC=JMAX                                           SET1750
      GO TO 160                                                         SET1760
C             *** CALCULATION FOR VARIABLE DY.                          SET1765
 110  DYSUM=0.                                                          SET1770
      I=0                                                               SET1780
C             *** SEARCH FOR J-VALUE OF BOTTOM OF PROJECTILE (MB).      SET1785
      IF (PRYBOT.EQ.0.) GO TO 130                                       SET1790
      DO 120 I=1,JMAX                                                   SET1800
      DYSUM=DYSUM+DY(I)                                                 SET1810
      IF (PRYBOT.LT.DYSUM+.5*DY(I+1).AND.PRYBOT.GE.DYSUM-.5*DY(I)) GO TOSET1820
     1 130                                                              SET1830
 120  CONTINUE                                                          SET1840
      GO TO 200                                                         SET1850
 130  MB=MIN0(I+1,JMAX)                                                 SET1860
      M=1                                                               SET1870
C             *** SEARCH FOR J-VALUE OF TOP OF PROJECTILE (MC).         SET1875
      DO 140 I=MB,JMAX                                                  SET1880
      DYSUM=DYSUM+DY(I)                                                 SET1890
      IF (PRYTOP.GE.DYSUM-.5*DY(I).AND.PRYTOP.LT.DYSUM+.5*DY(I+1)) GO TOSET1900
     1 150                                                              SET1910
 140  CONTINUE                                                          SET1920
      MC=JMAX                                                           SET1930
      GO TO 160                                                         SET1940
 150  MC=I                                                              SET1950
C             *** CALCULATION OF I-VALUE OF RIGHT SIDE OF PROJECTILE (MR)SET1955
 160  IF (IVARDX.GT.0) GO TO 170                                        SET1960
C             *** CALCULATION FOR CONSTANT DX.                          SET1965
      MR=INT(PRXRT/DXF+.5)                                              SET1970
      IF (MR.GT.IMAX) MR=IMAX                                           SET1980
      GO TO 210                                                         SET1990
C             *** CALCULATION FOR VARIABLE DX.                          SET1995
 170  DXSUM=0.                                                          SET2000
      DO 180 I=1,IMAX                                                   SET2010
      DXSUM=DXSUM+DX(I)                                                 SET2020
      IF (PRXRT.GE.DXSUM-.5*DX(I).AND.PRXRT.LT.DXSUM+.5*DX(I+1)) GO TO 1SET2030
     190                                                                SET2040
 180  CONTINUE                                                          SET2050
      MR=IMAX                                                           SET2060
      GO TO 210                                                         SET2070
 190  MR=I                                                              SET2080
      GO TO 210                                                         SET2090
C             *** M=0 MEANS THE PROJECTILE PACKAGE IS NOT BEING USED.   SET2100
 200  M=0                                                               SET2110
C             *** TAYBOT=-1. MEANS THE TARGET PACKAGE IS NOT BEING USED. SET2115
 210  IF (TAYBOT.LT.0.) GO TO 310                                       SET2120
C             *** DEFINE CELL BOUNDARIES(MZ,N,ME) OF TARGET PACKAGE.    SET2130
      IF (IVARDY.GT.0) GO TO 220                                        SET2140
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C           *** CALCULATION FOR CONSTANT DY.                                SET2145
      MZ=INT(TAYBOT/DYF+.5)+1                                               SET2150
      IF (MZ.GT.JMAX) GO TO 310                                             SET2160
      MD=1                                                                  SET2170
      N=INT(TAYTOP/DYF+.5)                                                  SET2180
      IF (N.GT.JMAX) N=JMAX                                                 SET2190
      GO TO 270                                                             SET2200
C           *** CALCULATION FOR VARIABLE DY.                                SET2205
  220 DYSUM=0.                                                              SET2210
      I=0                                                                   SET2220
C           *** SEARCH FOR J-VALUE OF BOTTOM OF TARGET (MZ).                SET2225
      IF (TAYBOT.EQ.0.) GO TO 240                                           SET2230
      DO 230 I=1,JMAX                                                       SET2240
      DYSUM=DYSUM+DY(I)                                                     SET2250
      IF (TAYBOT.GE.DYSUM-.5*DY(I).AND.TAYBOT.LT.DYSUM+.5*DY(I+1)) GO TOSET2260
     1 240                                                                  SET2270
  230 CONTINUE                                                              SET2280
      GO TO 310                                                             SET2290
  240 MZ=MIN0(I+1,JMAX)                                                     SET2300
      MD=1                                                                  SET2310
C           *** SEARCH FOR J-VALUE OF TOP OF TARGET (N).                    SET2315
      DO 250 I=MZ,JMAX                                                      SET2320
      DYSUM=DYSUM+DY(I)                                                     SET2330
      IF (TAYTOP.GE.DYSUM-.5*DY(I).AND.TAYTOP.LT.DYSUM+.5*DY(I+1)) GO TOSET2340
     1 260                                                                  SET2350
  250 CONTINUE                                                              SET2360
      N=JMAX                                                                SET2370
      GO TO 270                                                             SET2380
  260 N=I                                                                   SET2390
C           *** CALCULATION OF I-VALUE OF RIGHT SIDE OF TARGET(ME).         SET2395
  270 IF (IVARDX.GT.0) GO TO 280                                            SET2400
C           *** CALCULATION FOR CONSTANT DX.                                SET2405
      ME=INT(TAXRT/DXF+.5)                                                  SET2410
      IF (ME.GT.IMAX) ME=IMAX                                               SET2420
      GO TO 320                                                             SET2430
C           *** CALCULATION FOR VARIABLE DX.                                SET2435
  280 DXSUM=0.                                                              SET2440
      DO 290 I=1,IMAX                                                       SET2450
      DXSUM=DXSUM+DX(I)                                                     SET2460
      IF (TAXRT.GE.DXSUM-.5*DX(I).AND.TAXRT.LT.DXSUM+.5*DX(I+1)) GO TO 3SET2470
     100                                                                    SET2480
  290 CONTINUE                                                              SET2490
      ME=IMAX                                                               SET2500
      GO TO 320                                                             SET2510
  300 ME=I                                                                  SET2520
      GO TO 320                                                             SET2530
C           *** MD = 0 MEANS THE TARGET PACKAGE IS NOT BEING USED.          SET2540
  310 MD=0                                                                  SET2550
  320 KMAX=IMAX*JMAX+1                                                      SET2560
      KMAXA=KMAX+1                                                          SET2570
      JMAXA=JMAX+1                                                          SET2580
      IMAXA=IMAX+1                                                          SET2590
C           *** INITIALIZE PROPERTY ARRAYS.                                 SET2595
      DO 330 K=1,KMAX                                                       SET2600
      U(K)=0.0                                                              SET2610
      V(K)=0.0                                                              SET2620
      P(K)=0.0                                                              SET2630
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```
      AMX(K)=0.0                                                        SET2640
      AIX(K)=0.0                                                        SET2650
  330 CONTINUE                                                          SET2660
      PIDY=3.1415927                                                    SET2670
      WS=X(1)**2                                                        SET2680
C          *** CALCULATE CELL-FACE AREA, THE AREA GENERATED BY SEGMENTSET2682
C               X(1),X(I+1) ROTATED ABOUT THE Z-AXIS.                   SET2684
      TAU(1)=PIDY*WS                                                    SET2690
      DO 340 I=2,IMAX                                                   SET2700
      WSA=X(I)**2                                                       SET2710
      TAU(I)=PIDY*(WSA-WS)                                              SET2720
      WS=WSA                                                            SET2730
  340 CONTINUE                                                          SET2740
      ETH=0.0                                                           SET2750
C          *** RADIUS.GT.0. MEANS SPHERE IS TO BE USED.                 SET2760
C               SEE SPECIAL EQUIVALENCES FOR SETUP FOR LOCATION         SET2770
C               OF PARAMETERS DEFINING DIMENSIONS AND PROPERTIES OF     SET2780
C               SPHERE.                                                 SET2790
      IF (RADIUS.LE.0.) GO TO 540                                       SET2850
C          *** COMPUTE ISPHMX, THE I-INDEX OF THE RIGHT-MOST COLUMN     SET2860
C               CONTAINING A PART OF THE SPHERE.                        SET2870
      DO 350 I=1,IMAX                                                   SET2900
      IF (X(I).GE.RADIUS-.000001*DX(I)) GO TO 360                       SET2910
  350 CONTINUE                                                          SET2920
  360 ISPHMX=I                                                          SET2930
      TOTSPH=0.                                                         SET2940
C          *** COMPUTE JCENTR=J-INDEX OF SPHERE-CENTER                  SET2950
      DO 370 J=0,JMAX                                                   SET2960
      IF ((Y(J)+.5*DY(J+1)).GT.YCENTR) GO TO 380                        SET2970
  370 CONTINUE                                                          SET2980
C               *** YCENTR SHOULD FALL ON CELL BOUNDARY,                SET2990
C               PRINT OUT INPUT VALUE AND ADJUSTED VALUE.               SET3000
  380 WRITE (6,790) YCENTR,Y(J)                                         SET3010
      YCENTR=Y(J)                                                       SET3020
      JCENTR=J                                                          SET3030
C          COMPUTE JRADA AND JRADB.                                     SET3035
C        *** JRADB = THE NUMBER OF CELLS CONTAINING A PART OF THE       SET3040
C                    SPHERE FROM THE CENTER TO BOTTOM EDGE              SET3050
C        *** JRADA = THE NUMBER OF CELLS CONTAINING A PART OF THE       SET3060
C                    SPHERE FROM THE CENTER TO TOP EDGE                 SET3070
      JRADB=0                                                           SET3080
      JRADA=0                                                           SET3090
      JB=JCENTR                                                         SET3100
      JA=JCENTR+1                                                       SET3110
      SUM1=0.                                                           SET3120
      SUM2=0.                                                           SET3130
      IF (JCENTR.EQ.0) GO TO 400                                        SET3140
  390 SUM1=SUM1+DY(JB)                                                  SET3150
      JB=JB-1                                                           SET3160
      JRADB=JRADB+1                                                     SET3170
      IF (SUM1.LT.(RADIUS-.000001*DY(JB))) GO TO 390                    SET3180
  400 SUM2=SUM2+DY(JA)                                                  SET3190
      JA=JA+1                                                           SET3200
      JRADA=JRADA+1                                                     SET3210
      IF (SUM2.LT.(RADIUS-.000001*DY(JA))) GO TO 400                    SET3220
C          *** COMPUTE(1)JSPHTP=J-INDEX OF UPPER-MOST ROW               SET3230
C          ***                WHICH CONTAINS PART OF THE SPHERE         SET3240
```

```
C           ***         (2)JSPHBT=J-INDEX OF LOWEST ROW
C           ***               WHICH CONTAINS PART OF THE SPHERE
      JSPHBT=MAX0(1,JCENTR-JRADB+1)
      JSPHTP=MIN0(JMAX,JCENTR+JRADA)
C
      YC2=YCENTR**2
      RSQRD=RADIUS**2
C           *** FOR EACH CELL IN RECTANGLE FROM X=0.
C           ***    TO X=(ISPHMX-1)*DXF AND FROM
C           ***    Y=(JSPHBT-1)*DYF TO Y=(JSPHTP)*DYF
C           ***    FIND VOLSPH=VOLUME OF SPHERE IN CELL K
C           ***    AND SET MASS AND SPEC. INT. ENERGY.
      DO 530 I=1,ISPHMX
      K=(JSPHBT-1)*IMAX+I+1
C           *** X(I-1)=VALUE OF X AT LEFT OF COLUMN
C           *** X(I)=VALUE OF X AT RIGHT OF COLUMN
      XL2=(X(I-1))**2
      XR2=(X(I))**2
C           *** YLINTA=Y-LEFT-INTERCEPT-ABOVE-CENTER
C           *** YLINTB=Y-LEFT-INTERCEPT-BELOW-CENTER
      WS=SQRT(RSQRD-XL2)
      YLINTA=YCENTR+WS
      YLINTB=YCENTR-WS
C           *** DOES CURVE INTERSECT X=X(I)
      IF (RSQRD.LE.XR2) GO TO 410
C           *** YES
      WS=SQRT(RSQRD-XR2)
      YRINTA=YCENTR+WS
      YRINTB=YCENTR-WS
      GO TO 420
 410  YRINTA=YCENTR
      YRINTB=YCENTR
 420  CONTINUE
      DO 520 J=JSPHBT,JSPHTP
C           *** SKIP IF SPECIAL CELL
      IF (AMX(K).NE.0.) GO TO 520
      YTOP=Y(J)
      YBOTTM=Y(J-1)
      YDIFFT=(YTOP-YCENTR)**2
      YDIFFB=(YBOTTM-YCENTR)**2
      YDIFFO=AMAX1(YDIFFT,YDIFFB)
      YDIFFI=AMIN1(YDIFFT,YDIFFB)
C           *** IS ALL OF CELL WITHIN SPHERE BOUNDARY.
      IF ((YDIFFO+XR2).GT.RSQRD) GO TO 430
C           *** YES. DEFINE VOLUME OF CELL.
      VOLSPH=TAU(I)*DY(J)
      GO TO 470
C           *** NO. IS ALL OF CELL OUTSIDE SPHERE BOUNDARY.
 430  IF ((YDIFFI+XL2).LT.RSQRD) GO TO 440
C           *** YES.
      VOLSPH=0.
      GO TO 510
C           *** NO. PART OF CELL IS WITHIN SPHERE. COMPUTE VOLUME
C                   OF PART OF CELL INSIDE THE SPHERE AND STORE
C                   IN VOLSPH.
 440  IF (J.GT.JCENTR) GO TO 450
      YLOWER=AMAX1(YBOTTM,YLINTB)
```

```
      YUPPER=AMIN1(YTOP,YRINTB)                                         SET3790
      ADDVL=(YTOP-YUPPER)*TAU(I)                                        SET3790
      GO TO 460                                                         SET3800
450   YLOWER=AMAX1(YBOTTM,YRINTA)                                       SET3810
      YUPPER=AMIN1(YTOP,YLINTA)                                         SET3820
      ADDVL=(YLOWER-YBOTTM)*TAU(I)                                      SET3830
460   VOLSPH=ADDVL+PIDY*((RSQRD-YC2-XL2)*(YUPPER-YLOWER)-(YUPPER**3-YLOWSET3840
     1ER**3)/3.+YCENTR*(YUPPER**2-YLOWER**2))                           SET3850
470   WS=VOLSPH*RHOSPH                                                  SET3860
      AMX(K)=WS                                                         SET3870
C           *** CHECK WHETHER THE CELL IS FULL                          SET3880
      WSA=TAU(I)*DY(J)                                                  SET3890
      WSB=WSA-VOLSPH                                                    SET3900
      IF (ABS(WSB/WSA).LT.ROEPS) GO TO 490                              SET3910
C           *** ADD RHOOUT MATERIAL TO CELL                             SET3920
      WSB=WSB*RHOOUT                                                    SET3930
      AMX(K)=WS+WSB                                                     SET3940
C                 *** CHECK WHETHER MASS IS TOO SMALL TO KEEP           SET3945
      IF(AMX(K)/WSA.LT.EVAP*RHINI) GO TO 510                            SET3950
C           *** USE A WEIGHTED AVERAGE OF THE PROPERTIES OF THE SPHERE SET3960
C                 AND THE PROJECTILE FOR CELLS PARTIALLY IN THE SPHERE. SET3965
      AIX(K)=(WS*SIESPH+WSB*PROJI)/AMX(K)                               SET3970
      V(K)=(WS*VINSPH+WSB*VINI)/AMX(K)                                  SET3980
      GO TO 500                                                         SET3990
C           *** ESSENTIALLY ALL OF CELL IS IN SPHERE                    SET4030
490   AIX(K)=SIESPH                                                     SET4040
      V(K)=VINSPH                                                       SET4050
C                 *** SUM SPHERE VOLUME                                 SET4060
500   TOTSPH=TOTSPH+VOLSPH                                              SET4070
      GO TO 520                                                         SET4080
510   AMX(K)=0.                                                         SET4090
C                 *** END OF J-LOOP                                     SET4100
520   K=K+IMAX                                                          SET4110
C                 *** END OF I-LOOP                                     SET4120
530   CONTINUE                                                          SET4130
540   WRITE (6,800) RHOSPH,RHINI,RHINIT,RHOFIL,SIESPH,PROJI,TARGI,VINSPHSET4140
     1,VINI,TARGV,PROJU,RADIUS,PRYTOP,TAYTOP,YCENTR,PRYBOT,TAYBOT,PRXRT,SET4150
     2TAXRT                                                             SET4160
C           *** RESET BORROWED Z-STORAGE TO ZERO.                       SET4162
      EVAPM = 0.                                                        SET4164
      EVAPEN = 0.                                                       SET4166
      EVAPMU = 0.                                                       SET4168
      EVAPMV = 0.                                                       SET4169
C           *** M=0 MEANS THE PROJECTILE PACKAGE IS NOT BEING USED.     SET4170
      IF (M.EQ.0) GO TO 610                                             SET4220
      DO 600 I=M,MR                                                     SET4230
      K=(MB-1)*IMAX+I+1                                                 SET4240
C           *** ASSIGN PROPERTIES TO CELLS IN PROJECTILE.               SET4250
      DO 590 J=MB,MC                                                    SET4260
      IF (AMX(K).NE.0.) GO TO 550                                       SET4270
      AMX(K)=RHINI*DY(J)*TAU(I)                                         SET4280
550   IF (V(K).NE.0.) GO TO 560                                         SET4290
      V(K)=VINI                                                         SET4300
560   IF (U(K).NE.0.) GO TO 570                                         SET4310
      U(K)=PROJU                                                        SET4320
570   IF (AIX(K).NE.0.) GO TO 580                                       SET4330
      AIX(K)=PROJI                                                      SET4340
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```
580   CONTINUE
590   K=K+IMAX
600   CONTINUE
C           *** MD=0 MEANS THE TARGET PACKAGE IS NOT BEING USED.
610   IF (MD.EQ.0) GO TO 650
C           *** ASSIGN PROPERTIES TO CELLS IN TARGET.
      DO 640 I=MD,ME
      K=(MZ-1)*IMAX+I+1
      DO 630 J=MZ,N
      IF (V(K).NE.0.) GO TO 620
      V(K)=TARGV
      IF (AMX(K).NE.0.) GO TO 630
      AMX(K)=RHINIT*DY(J)*TAU(I)
620   AIX(K)=TARGI
630   K=K+IMAX
640   CONTINUE
650   CONTINUE
C
      CYCLE=0.0
      DT=0.0
      NREZ=NUMREZ
      NZ=1
C           *** RHOFIL=0. WHEN THERE IS NO FILLER MATERIAL BETWEEN
C                 PROJECTILE AND TARGET.
      IF (RHOFIL.EQ.0.) GO TO 680
C           *** FILL BETWEEN PACKAGES WITH MATERIAL OF DENSITY=RHOFIL.
      MC=MC+1
      MZ=MZ-1
      DO 670 I=1,IMAX
      K=(MC-1)*IMAX+I+1
      DO 660 J=MC,MZ
      AMX(K)=RHOFIL*DY(J)*TAU(I)
660   K=K+IMAX
670   CONTINUE
680   N3=0
C           *** PK(14).GT.0. MEANS SOME CELLS WILL BE DEFINED
C                 AFTER PACKAGES ARE SET UP.
      IF (PK(14).GT.0.) CALL CARDS
C           *** CALCULATE INITIAL VALUE OF TOTAL ENERGY TO BE ADJUSTED
C                 WHEN MATERIAL IS EVAPORATED OR CROSSES A TRANSMITTIVE
C                 BOUNDARY AND TO BE USED IN EDIT TO CHECK ERROR IN
C                 ENERGY SUM.
      DO 690 K=2,KMAX
      ETH=ETH+AMX(K)*(.5*(U(K)**2+V(K)**2)+AIX(K))
690   CONTINUE
      XMAX=X(IMAX)
      TXMAX=XMAX*2.0
      YMAX=Y(JMAX)
      TYMAX=YMAX*2.0
700   IF (Y2.GT.(-1.)) GO TO 750
C           *** PUT TRACER POINT IN CENTER OF EVERY OTHER NONEMPTY CELL
C                 IN EVERY OTHER ROW. THE TRACER POINT COORDINATES OF
C                 EMPTY CELLS ARE (0,0).
      II=IMAX/2
      JJ=JMAX/2
      DO 720 J=1,JJ
      DO 720 I=1,II
```

```
      K=2*((J-1)*IMAX+I)                                                 SET4820
      IF (AMX(K).EQ.0.) GO TO 710                                        SET4830
      XP(I,J)=FLOAT(2*I-1)-.5                                            SET4840
      YP(I,J)=FLOAT(2*J-1)-.5                                            SET4850
  710 NMP=NMP+1                                                          SET4860
C          *** NMPMAX IS THE MAXIMUM NUMBER OF TRACER POINTS TO          SET4862
C              BE USED AND IS DEFINED IN THE INPUT DECK.                 SET4864
      IF (NMP.GE.NMPMAX) GO TO 730                                       SET4870
  720 CONTINUE                                                           SET4880
      GO TO 740                                                          SET4890
  730 JJ=J                                                               SET4900
C          *** N3=1 MEANS TRACER POINTS ARE BEING USED, ADDING           SET4902
C              ONE MORE RECORD TO EACH TAPE DUMP.                        SET4904
  740 N3=1                                                               SET4910
  750 REWIND 7                                                           SET4920
      WS=555.0                                                           SET4930
C     WRITE OUTPUT FOR OIL ON TAPE.                                      SET4940
      WRITE (7) WS,CYCLE,N3                                              SET4950
      WRITE (7) (Z(I),I=1,MZT)                                           SET4960
      WRITE (7) (U(I),V(I),AMX(I),AIX(I),P(I),I=1,KMAXA)                 SET4970
      WRITE (7) X(0),(X(I),TAU(I),JPM(I),I=1,IMAX)                       SET4980
      WRITE (7) (Y(I),I=0,JMAX)                                          SET4990
      IF (Y2.GT.(-1.)) GO TO 760                                         SET5000
      WRITE (7) ((XP(I,J),YP(I,J),I=1,II),J=1,JJ)                        SET5010
  760 WRITE (7) (DX(I),I=1,IMAX)                                         SET5020
      WRITE (7) (DY(J),J=1,JMAX)                                         SET5030
      WS=666.0                                                           SET5040
      WRITE (7) WS,WS,WS                                                 SET5050
      GO TO 780                                                          SET5060
C          *** DX AND/OR DY ARRAY NOT PROPERLY DEFINED.                  SET5062
C              CHECK VALUE OF DXF AND DYF IF ZONES ARE CONSTANT.         SET5064
C              IF VARIABLE, CHECK LOCATION NUMBERS USED FOR              SET5065
C              READING IN  X AND/OR Y ARRAY ESPECIALLY IF ANY            SET5066
C              VARIABLE DIMENSIONS WERE CHANGED.                         SET5068
  770 NK=95                                                              SET5070
      NR=2                                                               SET5080
      CALL ERROR                                                         SET5090
  780 RETURN                                                             SET5100
C                                                                        SET5110
  790 FORMAT (/5X,15HINPUT YCENTR = ,1PE12.6,6X,18HADJUSTED YCENTR = ,1PSET5120
     1E12.6)                                                             SET5130
  800 FORMAT (////17X,18HINITIAL CONDITIONS//11X,6HSPHERE,13X,9HPACKAGE SET5140
     11,21H   PACKAGE 2   FILLER//8H DENSITY,1P1E12.4,6X,1P3E12.4/8H   S.SET5150
     2I.E.,1P1E12.4,6X,1P2E12.4/8H        V,1P1E12.4,6X,1P2E12.4/8H      SET5160
     3 U,13X,1P1E12.4/8H  RADIUS,1P1E12.4,5X,3HTOP,1P1E10.4,1P1E12.4/8H SET5170
     4YCENTER,1P1E12.4,2X,6HBOTTOM,1P1E10.4,1P1E12.4/23X,5HRIGHT,1P1E10.SET5180
     54,1P1E12.4)                                                        SET5190
      END                                                                SET5200
```

```
      SUBROUTINE CDT
C     ..................................................................
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)   ,P(2502)   ,
     1          X(52)    ,XX(54)   ,TAU(52)  ,JPM(52)   ,
     2          Y(102)   ,YY(104)  ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)   ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)  ,PR(204)   ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)  ,IJ(5)     ,JK(5)     ,
     9          DX(52)   ,DDX(54)  ,DY(102)   ,DDY(104)  ,
     $          SNB(52)  ,STB(52)  ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C        *** DIMENSIONED ARRAYS
C        *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON     PK
      COMMON  YY,      XX
      COMMON  DDX,     DDY
      COMMON  AMX,     AIX,     U,     V,     P
      COMMON  TAU,     JPM
      COMMON  UL ,     PL
      COMMON  XP ,     YP,      CMXP, CMYP
C        *** NON-DIMENSIONED VARIABLES
      COMMON             AID     ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB ,DELER ,DELET ,DELM   ,DTODX ,DXYMIN,EAMMP ,EAMPY ,
     2E      ,ERDUMP,I      ,I3     ,IWS    ,J      ,K      ,KA     ,KB     ,
     3LL     ,MD     ,ME     ,MZT    ,NERR   ,NK     ,NPRINT,
     4NR     ,NRZ    ,NULLE ,PIDTS ,SIEMIN,SNR    ,SNT    ,STR    ,SOLID ,
     5SUM    ,TESTRH,TWOPI ,URR    ,WS     ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
C
C        *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C            X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C        *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE          (UL,FLEFT),         (UL(103),YAMC),
     1                     (PL,GAMC,PR),       (PL(103),SIGC)
C
C        *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE          (UL,RSN),
     1                     (PL,RST),           (P,UK),
     2                     (P(157),VK),        (P(313),SNB),
     3                     (P(365),STB),       (P(417),RHO)
C
C        *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C        *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                        (Z(  1),PROB  ),(Z(  2),CYCLE ),
```

```
     1(Z(  3),DT     ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
     2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
     3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
     4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
     5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
     6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
     7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
     8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
     9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
      EQUIVALENCE
     1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
     2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
      EQUIVALENCE
     1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),
     3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
     4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
     5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
     8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
     9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
      EQUIVALENCE
     1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
     3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
      EQUIVALENCE
     1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
     2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
     9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
      EQUIVALENCE
     1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C     ..................................................................
C
C     END OF COMMON
C
C     ..................................................................
C
C           *** SPECIAL EQUIV FOR ES AND CDT
      EQUIVALENCE (RHOW,NULLE)
C
C                     ***CHECK COURANT CONDITION AND PARTICLE VELOCITY.
C                     ***RECORD I AND J OF ZONE WHERE DT IS CONTROLLED.
C                     ***FIRST CALCULATE PRESSURES FROM EQ. OF ST.
C
C
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```
10     TRIAL=0.                                                         CDT1230
       SRATIO=10.**10                                                   CDT1240
C                **WSC WILL BE MAXIMUM U OR V                           CDT1250
       WSC=0.                                                           CDT1260
       DO 60 I=1,I1                                                     CDT1270
       K=I+1                                                            CDT1280
       DO 60 J=1,I2                                                     CDT1290
       RHOW=AMX(K)/(TAU(I)*DY(J))                                       CDT1330
       CALL ES                                                          CDT1340
C           *** IF DENSITY OF CELL K IS LESS THAN RHOMIN, IT'S          CDT1342
C               VELOCITY OR SOUND SPEED IS NOT USED IN DETERMINING DT.  CDT1344
       IF (RHOW.LT.RHOMIN) GO TO 60                                     CDT1350
       IF (ABS(P(K ).LT.PMIN) P(K)=0.                                   CDT1360
       IF (CNAUT.GT.0.) GO TO 20                                        CDT1370
C                                                                       CDT1380
C                    ***CALCULATE SOUND SPEED FOR POLYTOPIC GAS WITH    CDT1390
C                    ***GAMMA EQUAL TO ESA+1.                           CDT1400
       WS=SQRT(GAMMA*ABS(P(K))/RHOW)                                    CDT1410
       GO TO 40                                                         CDT1420
C                                                                       CDT1430
C                  ***CHECK FOR NEGATIVE PRESSURE.                      CDT1440
20     IF (P(K).GT.0.) GO TO 30                                         CDT1450
C           *** NEGATIVE PRESSURES NOT ALLOWED ALONG GRID BOUNDARY      CDT1452
C               AND NOT ALLOWED ANYWHERE UNTIL ACTIVE GRID REACHES      CDT1454
C               JSTR(INPUT PARAMETER FOR TURNING ON STRENGTH            CDT1456
C               CALCULATIONS).                                          CDT1458
       IF ((IMAX.NE.1.AND.I.EQ.IMAX).OR.J.EQ.JMAX.OR.I2.LT.JSTR) P(K)=0. CDT1460
C                                                                       CDT1470
C                  ***PRESSURE IS NEGATIVE OR ZERO                      CDT1480
       WS=CNAUT                                                         CDT1490
       GO TO 40                                                         CDT1500
C                                                                       CDT1510
C                        ***PRESSURE IS POSITIVE.                       CDT1520
30     WS=CNAUT+BBAR*SQRT(P(K))                                         CDT1530
       WSA=SQRT(GAMMA*P(K)/RHOW)                                        CDT1540
       WS=AMAX1(WS,WSA)                                                 CDT1550
C           *** WS IS SOUND SPEED OF CELL K.                            CDT1552
C           *** WSB IS MAXIMUM OF RADIAL AND AXIAL VELOCITY OF CELL K.  CDT1554
C           *** WSC STORES MAXIMUM VELOCITY OF CELLS USED TO DETERMINE  CDT1556
C               DT. PRINTED AS MAXUV.                                   CDT1558
40     WSB=AMAX1(ABS(U(K)),ABS(V(K)))                                   CDT1560
       WSC=AMAX1(WSC,WSB)                                               CDT1570
       WS=AMAX1(WS,WSB)                                                 CDT1580
C           *** TRIAL STORES MAXIMUM OF VELOCTY AND SOUND SPEED USED    CDT1582
C               TO DETERMINE DT. PRINTED AS MAXCUV.                     CDT1584
       IF (WS.LE.TRIAL) GO TO 50                                        CDT1590
       TRIAL=WS                                                         CDT1600
50     IF (WS.LE.0.) GO TO 60                                           CDT1610
       DXYMIN=AMIN1(DX(I),DY(J))                                        CDT1620
       RATIO=DXYMIN/WS                                                  CDT1630
       IF (RATIO.GT.SRATIO) GO TO 60                                    CDT1640
C           *** I AND J OF CELL CONTROLLING DT STORED IN N10 AND N11    CDT1642
C               FOR PRINTOUT.                                           CDT1644
       N10=I                                                            CDT1650
       N11=J                                                            CDT1660
C           *** SRATIO IS SMALLEST VALUE CALCULATED FOR RATIO.          CDT1665
       SRATIO=RATIO                                                     CDT1670
```

```
C                                                                       CDT1680
C                    ***END OF I, J LOOP                                CDT1690
60    K=K+IMAX                                                          CDT1700
C           *** IF TRIAL.LE.0. THERE IS PROBABLY AN ERROR IN THE INPUT CDT1702
C               PARAMETERS FOR THE INITIAL VELOCITY, ENERGY OR DENSITY CDT1704
C               OF THE PACKAGES.                                        CDT1706
65    IF (TRIAL.LE.0.) GO TO 170                                        CDT1710
C           *** IF FINAL.EQ.0.USE STAB FOR VALUE OF STABILITY FRACTION CDT1720
C               IF FINAL.GT.0.USE A GEOMETRIC PROGRESSION WITH STAB     CDT1730
C               AS THE INITIAL VALUE AND FINAL AS THE FINAL VALUE.      CDT1740
      IF (FINAL.EQ.0.) GO TO 70                                         CDT1750
      STAB=2.*STAB                                                      CDT1760
      STAB=AMIN1(STAB,FINAL)                                            CDT1770
70    DT=STAB*SRATIO                                                    CDT1780
      IF (STAB.LT.FINAL) GO TO 80                                       CDT1790
C           *** AFTER STAB.GE.FINAL CHECK ON SIZE OF DT. DTMIN IS AN    CDT1792
C               INPUT PARAMETER AND CAN BE SET TO 0.                    CDT1794
75    IF (DT.LE.DTMIN) GO TO 150                                        CDT1800
80    CONTINUE                                                          CDT1810
C                                                                       CDT1820
C           *** IS CONTROL-CELL ISOLATED                                CDT1830
      K=(N11-1)*IMAX+N10+1                                              CDT1840
      WS=0.                                                             CDT1850
      IF (N10.GT.1) WS=AMX(K-1)                                         CDT1860
      IF (N10.LT.IMAX) WS=AMX(K+1)+WS                                   CDT1870
      IF (N11.GT.1) WS=AMX(K-IMAX)+WS                                   CDT1880
      IF (N11.LT.JMAX) WS=AMX(K+IMAX)+WS                                CDT1890
      IF (WS.GT.0.) GO TO 90                                            CDT1900
C          *** ISOLATED, SO DESTROY IT.                                 CDT1910
      WS=(AIX(K)+(U(K)**2+V(K)**2)*.5)*AMX(K)                           CDT1920
      EVAPM=EVAPM+AMX(K)                                                CDT1930
      EVAPEN=EVAPEN+WS                                                  CDT1940
      ETH=ETH-WS                                                        CDT1950
      EVAPMU=EVAPMU+AMX(K)*U(K)                                         CDT1960
      EVAPMV=EVAPMV+AMX(K)*V(K)                                         CDT1970
      WRITE (6,290) N10,N11,T,DT,TRIAL,WSC,UMIN,PMIN                    CDT1980
      AMX(K)=0.                                                         CDT1990
      AIX(K)=0.                                                         CDT2000
      P(K)=0.                                                           CDT2010
      U(K)=0.                                                           CDT2020
      V(K)=0.                                                           CDT2030
C           *** RECALCULATE DT.                                         CDT2035
      GO TO 10                                                          CDT2040
C           *** INCREMENT TIME AND CYCLE.                               CDT2050
90    T=T+DTNA                                                          CDT2060
95    IF (T.LT.0.) GO TO 160                                            CDT2070
      NC=NC+1                                                           CDT2080
      CYCLE=NC                                                          CDT2090

C           *** RESET NPRINT. NPRINT=1 ON PRINT CYCLES.                 CDT2100
      NPRINT=0                                                          CDT2110
C           *** DEFINE VELOCITY AND ENERGY CUTOFFS USED IN MAP AND PH2.CDT2115
      UMIN=TRIAL*ROEPS                                                  CDT2120
      SIEMIN=UMIN**2                                                    CDT2130
      PMIN=RHOZ*CNAUT*UMIN                                              CDT2140
      IF (PMIN.LT.ROEPS) PMIN=UMIN*RHOZ*TRIAL                           CDT2150
      WRITE (6,290) N10,N11,T,DT,TRIAL,WSC,UMIN,PMIN                    CDT2160
```

```
      DTNA=DT
C           *** TESTRH = .2*RHOZ
C                THE PRESSURE OF COLD,FREE SURFACE CELLS IS REDUCED BY A
C                FACTOR,F, WHICH ACCOUNTS FOR THE EFFECT OF FREE SURFACE
C                LOCATION ON THE PRESSURE GRADIENT. F IS THE DENSITY OF
C                THE LOWEST DENSITY ADJACENT CELL DIVIDED BY THE NORMAL
C                DENSITY,OR F IS TESTRH - WHICHEVER IS SMALLEST
      WT=TESTRH
      DO 140 I=1,I1
      K=I+1
      DO 140 J=1,I2
      RHOW=AMX(K)/(DY(J)*TAU(I))
      WTB=WT
      IF (AIX(K).GE.ESESQ) GO TO 140
      IF (RHOW.LT.SOLID) GO TO 140
      IF (I.EQ.IMAX) GO TO 100
      WTA=AMX(K+1)/(DY(J)*TAU(I+1))
      IF (WTA.LT.WT) WTB=WTA
  100 IF (I.EQ.1) GO TO 110
      WTA=AMX(K-1)/(DY(J)*TAU(I-1))
      IF (WTA.LT.WTB) WTB=WTA
  110 IF (J.EQ.JMAX) GO TO 120
      KA=K+IMAX
      WTA=AMX(KA)/(DY(J+1)*TAU(I))
      IF (WTA.LT.WTB) WTB=WTA
  120 IF (J.EQ.1) GO TO 130
      KB=K-IMAX
      WTA=AMX(KB)/(DY(J-1)*TAU(I))
      IF (WTA.LT.WTB) WTB=WTA
  130 IF (WTB.LT.WT) P(K)=P(K)*WTB/RHOZ
  140 K=K+IMAX
      GO TO 190
C
C                   *** DT TOO SMALL
  150 NK=75
      GO TO 180
C                   *** T IS NEGATIVE
  160 NK=95
      GO TO 180
C           *** DT WILL BE NEGATIVE OR ZERO.
  170 NK=65
      GO TO 180
  180 NR=3
      CALL ERROR
C
C                      ***FIND THE MAXIMUM PRESSURE ON EACH COLUMN AND
C                      ***STORE ITS CELL NUMBER AS JPM. THIS WILL BE USED
C                      ***IN DETERMINING THE REGION IN WHICH PHASE 3 IS
C                      ***USED. WSA WILL BE A RUNNING MAXIMUM OF THE
C                      ***PRESSURE IN THE GRID.
  190 WSA=-1.E30
      DO 260 I=1,I1
C           *** WS WILL BE LOCAL MAXIMUM OF COLUMN I.
      WS=-1.E30
      K=(I2-1)*IMAX+I+1
      JP=I2
      JINTL=1
```

```
C               *** START AT TOP OF COLUMN AND LOOK FOR PRESSURE PEAK.         CDT2665
200   DO 210 J=JINTL,I2                                                       CDT2670
      IF (P(K).LT.WS) GO TO 220                                               CDT2680
      WS=P(K)                                                                 CDT2690
C               *** JP IS J-INDEX OF CELL WITH PEAK PRESSURE.                 CDT2695
      JP=JP-1                                                                 CDT2700
210   K=K-IMAX                                                                CDT2710
C               *** IF YOU FALL THROUGH,THEN THERE WAS NO MAXIMUM IN THIS     CDT2720
C                   COLUMN                                                    CDT2730
      GO TO 250                                                               CDT2740
C                                                                             CDT2750
C                    *** COME HERE IF PRESSURE HAS PASSED A LOCAL MAXIMUM     CDT2760
C               *** PTEMP IS PEAK PRESSURE OF COLUMN I.                       CDT2770
220   PTEMP=P(K+IMAX)                                                         CDT2780
      IF (PTEMP.LT.WSA) GO TO 230                                             CDT2790
C               *** WSA WILL BE PEAK PRESSURE IN ACTIVE GRID (ABSOLUTE        CDT2800
C                   MAXIMUM).                                                 CDT2805
      WSA=PTEMP                                                               CDT2810
      GO TO 240                                                               CDT2820
C                                                                             CDT2830
C                    *** PTEMP IS LOCAL MAXIMUM BUT IS LESS THAN ABSOLUTE     CDT2840
C                   MAXIMUM                                                   CDT2850
230   IF (PTEMP.GT.0.3*WSA) GO TO 240                                         CDT2860
C                                                                             CDT2870
C               *** THIS LOCAL MAXIMUM IS NOT BIG ENOUGH TO USE FOR JPM       CDT2880
C                                                                             CDT2890
      JINTL=J+1                                                               CDT2900
C                                                                             CDT2910
C                                                                             CDT2930
      JP=JP-1                                                                 CDT2940
C               ***  WE MAY HAVE REACHED BOTTOM OF COLUMN                     CDT2945
      IF (JINTL.GE.I2) GO TO 250                                              CDT2950
C               *** CONTINUE DOWN COLUMN SEARCHING FOR SUFFICIENTLY LARGE     CDT2952
C                   LOCAL MAXIMUM.                                            CDT2954
      WS=P(K)                                                                 CDT2960
      K=K-IMAX                                                                CDT2970
      GO TO 200                                                               CDT2980
C               *** IF POSITION OF PEAK PRESSURE IN COLUMN I DOES NOT         CDT2982
C                   ADVANCE FROM ONE CYCLE TO THE NEXT, DO NOT CHANGE         CDT2984
C                   VALUE OF JPM.                                             CDT2986
240   JP=JP+1                                                                 CDT2990
      IF (JP.LE.JPM(I)) GO TO 260                                             CDT3000
      JPM(I)=JP                                                               CDT3010
C                                                                             CDT3020
C                         ***IF JPM IS ZERO THE SHOCK HAS NEVER REACHED THIS  CDT3030
C                         ***LOCATION. IF IT IS NONZERO THE SHOCK HAS PASSED  CDT3040
C                         ***AND WE MUST   CONTINUE TO INCREASE I UNTIL THE   CDT3050
C                         ***RIGHT BOUNDARY OF THE SHOCK IS REACHED.          CDT3060
250   IF (JPM(I).LE.0) GO TO 270                                              CDT3070
C               *** END OF I LOOP.                                            CDT3075
260   CONTINUE                                                                CDT3080
C               *** IF PEAK PRESSURE OF COLUMN I HAS GONE BELOW A THIRD       CDT3090
C                   THE GRID MAXIMUM, AND IF JPM(I)=0. FROM THE PREVIOUS      CDT3100
C                   CYCLE, WE HAVE REACHED THE RIGHT EDGE OF THE SHOCK.       CDT3110
270   CONTINUE                                                                CDT3130
C                 *** JPM(I) MUST BE MONOTONIC DECREASING                     CDT3140
      K=I1-1                                                                  CDT3150
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```
      DO 280 IWS=1,K                                                    CDT3160
      I=I1-IWS                                                          CDT3170
280   IF (JPM(I).LT.JPM(I+1)) JPM(I)=JPM(I+1)                           CDT3180
      RETURN                                                            CDT3190
C                                                                       CDT3200
290   FORMAT (/4H CDT,I3,I4,4H  T=,1PE13.7,5H  DT=,1PE13.7,9H  MAXCUV=,1CDT3210
     1PE13.7,8H  MAXUV=,1PE13.7,7H  UMIN=,1PE13.7,7H  PMIN=,1PE13.7)   CDT3220
      END                                                               CDT3230-
```

```
      SUBROUTINE ES
C     •••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)  ,P(2502)  ,
     1          X(52)     ,XX(54)    ,TAU(52)   ,JPM(52)   ,
     2          Y(102)    ,YY(104)   ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),    Z(150)    ,
     5          XP(26,51),YP(26,51),
     6          PL(204)   ,UL(204)   ,PR(204)   ,
     7           RSN(52),    RST(52),
     8          CMXP(5)   ,CMYP(5)   ,IJ(5)     ,JK(5)     ,
     9          DX(52)    ,DDX(54)   ,DY(102)   ,DDY(104)  ,
     $          SNB(52)   ,STB(52)   ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C             *** DIMENSIONED ARRAYS
C             *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON     PK
      COMMON  YY,      XX
      COMMON  DDX,     DDY
      COMMON  AMX,     AIX,     U,      V,      P
      COMMON  TAU,     JPM
      COMMON  UL ,     PL
      COMMON  XP ,     YP,      CMXP, CMYP
C             *** NON-DIMENSIONED VARIABLES
      COMMON           AID    ,AMMV  ,AMMY  ,AMPY  ,AMUR  ,AMUT  ,AMVR  ,
     1AMVT  ,DELEB ,DELER ,DELET ,DELM  ,DTODX  DXYMIN,EAMMP ,EAMPY ,
     2E     ,ERDUMP,I     ,I3    ,IWS   ,J     ,K     ,KA    ,KB    ,
     3LL    ,MD    ,ME    ,MZT   ,NERR  ,NK    ,NPRINT,
     4NR    ,NRZ   ,NULLE ,PIDTS ,SIEMIN,SNR   ,SNT   ,STR   ,SOLID ,
     5SUM   ,TESTRH,TWOPI ,URR   ,WS    ,WSA   ,WSB   ,WSC   ,WFLAGF,
     6WFLAGL,WFLAGP
C
C             *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C                 X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C             *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE          (UL,FLEFT),         (UL(103),YAMC),
     1                     (PL,GAMC,PR),       (PL(103),SIGC)
C
C             *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE          (UL,RSN),
     1                     (PL,RST),           (P,UK),
     2                     (P(157),VK),        (P(313),SNB),
     3                     (P(365),STB),       (P(417),RHO)
C
C             *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C             *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                         (Z(  1),PROB  ),(Z(  2),CYCLE ),
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     1(Z(  3),DT     ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),  ES  590
     2(Z(  7),ICSTOP),(Z(  8),PIDY   ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),  ES  600
     3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),  ES  610
     4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),  ES  620
     5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),  ES  630
     6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),  ES  640
     7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),  ES  650
     8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),  ES  660
     9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )   ES  670
      EQUIVALENCE                                                        ES  680
     1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),  ES  690
     2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)   ES  700
      EQUIVALENCE                                                        ES  710
     1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),  ES  720
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),  ES  730
     3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),  ES  740
     4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),  ES  750
     5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),  ES  760
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),  ES  770
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),  ES  780
     8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),  ES  790
     9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )   ES  800
      EQUIVALENCE                                                        ES  810
     1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),  ES  820
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),  ES  830
     3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )   ES  840
      EQUIVALENCE                                                        ES  850
     1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),  ES  860
     2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),  ES  870
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),  ES  880
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),  ES  890
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),  ES  900
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),  ES  910
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),  ES  920
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),  ES  930
     9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )   ES  940
      EQUIVALENCE                                                        ES  950
     1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),  ES  960
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),  ES  970
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG), ES  980
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),  ES  990
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )   ES 1000
C                                                                        ES 1010
C              *** SPECIAL EQUIV FOR ES AND CDT                          ES 1012
      EQUIVALENCE (RHOW,NULLE)                                           ES 1014
C     ...................................................................ES 1020
C                                                                        ES 1030
C     END OF COMMON                                                      ES 1040
C                                                                        ES 1050
C     ...................................................................ES 1060
C              *** P(K) CALCULATED FROM RHOW AND AIX(K).                 ES 1065
C                  RHOW IS CALCULATED IN CDT                             ES 1070
C                                                                        ES 1070
      IF (ESCAPA.LE.0.) GO TO 30                                         ES 1110
      ETA=RHOW/RHOZ                                                      ES 1120
      VOW=1./ETA                                                         ES 1130
      IF (AIX(K).LE.0.) GO TO 20                                         ES 1140
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C           *** P1 AND P4 ARE THERMAL PRESSURE TERMS.                     ES 1145
      P1=AIX(K)*RHOW*ESA                                                  ES 1150
      P4=ESB/(AIX(K)/(ESEZ*ETA**2)+1.)*AIX(K)*RHOW                        ES 1160
C           *** P5 IS MECHANICAL PRESSURE TERM                            ES 1165
 10   P5=ESCAPA*(ETA-1.)                                                  ES 1170
      P2=-1.                                                              ES 1180
C           *** IF MATERIAL IS UNDER-DENSE AND ITS ENERGY IS BETWEEN      ES 1182
C               ESES AND ESESP, A COMBINATION OF THE EXPANDED AND         ES 1184
C               CONDENSED EQUATIONS OF STATE IS USED.                     ES 1186
      IF (ETA.GE.1.) GO TO 50                                             ES 1190
C           *** ESESP = ENERGY TO VAPORIZE MATERIAL. MUST EXCEED ESES.    ES 1195
      IF (AIX(K).GT.ESESP) GO TO 40                                       ES 1200
C           *** ESES = ENERGY TO BRING MATERIAL TO VAPOR TEMPERATURE.     ES 1205
      IF (AIX(K).GT.ESES) P2=1.                                           ES 1210
C           *** P2=1 MEANS BOTH THE EXPANDED AND COMPRESSED               ES 1212
C                     FORMULATIONS WILL BE USED.  OTHERWISE, P2=-1.       ES 1214
      GO TO 50                                                            ES 1220
C           *** WHEN SPECIFIC INTERNAL ENERGY OF CELL IS NEGATIVE,        ES 1222
C               THERMAL PRESSURES ARE SET TO ZERO.                        ES 1224
 20   P1=0.                                                               ES 1230
      P4=0.                                                               ES 1240
C           *** WHEN SPECIFIC INTERNAL ENERGY IS NEGATIVE OR ZERO AND     ES 1242
C               DENSITY IS LESS THAN SOLID, SET PRESSURE TO ZERO.         ES 1244
      IF (ETA.LT.AMDM) GO TO 80                                           ES 1250
      GO TO 10                                                            ES 1260
C           *** IDEAL GAS                                                 ES 1265
 30   P(K)=ESA*RHOW*AIX(K)                                                ES 1270
      GO TO 90                                                            ES 1280
C           *** EXPANDED STATE                                            ES 1290
 40   P8=(1.-VOW)                                                         ES 1300
      P9=EXP(ESALPH*P8)                                                   ES 1310
      P12=EXP(-ESBETA*P8**2)                                              ES 1320
      P(K)=P1+(P4+P5*P9)*P12                                              ES 1330
      IF (P2.LT.0.) GO TO 70                                              ES 1340
      P1=SS1*(AIX(K)-ESES)                                                ES 1350
      P(K)=P1*P(K)+(1.-P1)*P3                                             ES 1360
      GO TO 70                                                            ES 1370
C           *** CONDENSED STATE                                           ES 1380
C               P6 IS MECHANICAL PRESSURE TERM.                           ES 1385
 50   P6=ESCAPB*((ETA-1.)**2)                                             ES 1390
      P(K)=P1+P4+P5+P6                                                    ES 1400
      IF (P2.LT.0.) GO TO 60                                              ES 1410
C           *** USING COMBINATION OF CONDENSED AND EXPANDED EQUATIONS     ES 1412
C               OF STATE.                                                 ES 1414
      IF (P(K).LT.0.) P(K)=0.                                             ES 1420
      P3=P(K)                                                             ES 1430
      GO TO 40                                                            ES 1440
C           *** USING CONDENSED EQUATION OF STATE                         ES 1445
 60   IF (P(K).GE.0.) GO TO 90                                            ES 1450
C           *** IF MATERIAL IS EXPANDED  OR J-INDEX OF CELL IS LESS       ES 1452
C               THAN N6, SET NEGATIVE PRESSURE TO ZERO. (N6 IS INPUT      ES 1454
C               PARAMETER)                                                ES 1456
      IF (J.LE.N6.OR.ETA.LE.AMDM) GO TO 80                                ES 1460
      GO TO 90                                                            ES 1470
C           *** SET NEGATIVE PRESSURES TO ZERO  WHEN USING COMBINED       ES 1472
C                               OR EXPANDED EQUATIONS OF STATE.           ES 1474
 70   IF (P(K).GE.0.) GO TO 90                                            ES 1480
```

```
80    P(K)=0.
90    RETURN
      END
```

```
      SUBROUTINE EDIT
C     ................................................................
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)  ,P(2502)  ,
     1          X(52)    ,XX(54)   ,TAU(52)  ,JPM(52)  , CRAD(52),
     2          Y(102)   ,YY(104)  ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)    ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)  ,PR(204)  ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)  ,IJ(5)    ,JK(5)    ,
     9          DX(52)   ,DDX(54)  ,DY(102)  ,DDY(104) ,
     $          SNB(52)  ,STB(52)  ,UK(52,3) ,VK(52,3) ,RHO(52,3)
C         *** DIMENSIONED ARRAYS
C         *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON      PK
      COMMON    YY,      XX
      COMMON    DDX,     DDY
      COMMON    AMX,     AIX,     U,      V,      P
      COMMON    TAU,     JPM
      COMMON    UL ,     PL
      COMMON    XP ,     YP,      CMXP, CMYP
C         *** NON-DIMENSIONED VARIABLES
      COMMON           AID     ,AMMV    ,AMMY    ,AMPY    ,AMUR    ,AMUT    ,AMVR    ,
     1AMVT    ,DELEB  ,DELER  ,DELET  ,DELM    ,DTODX   ,DXYMIN,EAMMP  ,EAMPY   ,
     2E       ,ERDUMP,I       ,I3      ,IWS     ,J       ,K       ,KA      ,KB      ,
     3LL      ,MD     ,ME     ,MZT     ,NERR    ,NK      ,NPRINT,
     4NR      ,NRZ    ,NULLE  ,PIDTS   ,SIEMIN,SNR     ,SNT     ,STR     ,SOLID   ,
     5SUM     ,TESTRH,TWOPI  ,URR     ,WS      ,WSA     ,WSB     ,WSC     ,WFLAGF,
     6WFLAGL,WFLAGP
C
C         *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C             X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C         *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE          (UL,FLEFT),          (UL(103),YAMC),
     1                     (PL,GAMC,PR),        (PL(103),SIGC)
C
C         *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE          (UL,RSN),
     1                     (PL,RST),            (P,UK),
     2                     (P(157),VK),         (P(313),SNB),
     3                     (P(365),STB),        (P(417),RHO)
C
C         *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK),  (UL(103),CRAD)
C
C         *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                         (Z(  1),PROB  ),(Z(  2),CYCLE ),
```

```
1(Z(  3),DT    ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
 EQUIVALENCE
1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
 EQUIVALENCE
1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),
3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
 EQUIVALENCE
1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
 EQUIVALENCE
1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
 EQUIVALENCE
1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C      ...........................................................
C
C      END OF COMMON
C
C      ...........................................................
C
C           *** SPECIAL EQUIV. FOR EDIT
      EQUIVALENCE (PR(1),TIETAR),(PR(2),TKETAR),(PR(3),TETAR ),
     1            (PR(4),TARMAS),(PR(5),TARMV ),(PR(6),TARMVP),
     2            (PR(7),RAMOMA),(PR(8),PRAMOA),(PR(9),TIEPRO),
     3            (PR(10),TKEPRO),(PR(11),TEPRO),(PR(12),PRMAS),
     4            (PR(13),PRMV  ),(PR(14),PRMVP),(PR(15),RAMOMB),
     5            (PR(16),PRAMOB)
      DIMENSION  PROPI(50)
```

```
C
C           *** ERDUMP=1. WHEN ERROR CALLS EDIT FOR A TAPE DUMP ONLY
      IF (ERDUMP.GT.0.) GO TO 150
C           *** ENERGY SUM (ESUM) AND RELATIVE ERROR IN SUM (RELERR)
C               COMPUTED.  ECK IS LARGEST ERROR COMPUTED AND ON PRINT
C               CYCLES IS PRINTED AND COMPARED TO DMIN, MAXIMUM
C               ALLOWABLE  ERROR.
      ESUM=0.
      DO 10 K=2,KMAX
10    ESUM=ESUM+AMX(K)*(.5*(U(K)**2+V(K)**2)+AIX(K))
      RELERR=(ESUM-ETH)/ETH
      IF (ABS(RELERR).LT.ABS(ECK)) GO TO 20
      ECK=RELERR
      NECYCL=NC
20    CONTINUE
C           *** NPRINT = 1  WHEN EDIT IS CALLED TO DO AN INTERMEDIATE
C               PRINT. SKIP TESTS ON TIME TO STOP, PRINT, REZONE,ETC.
C               WHICH ALREADY HAVE BEEN DONE FOR THIS CYCLE.
      IF (NPRINT.EQ.1) GO TO 190
C           *** I3=1 SIGNALS A SHORT PRINT
      I3=1
C           *** IF THIS IS FIRST CYCLE OF RUN, WFLAGF=1.
      IF (WFLAGF.GT.0.) GO TO 120
C           *** IS THIS THE TIME OR CYCLE TO STOP EXECUTION
      IF (ICSTOP.LE.NC.AND.ICSTOP.GT.0) GO TO 30
      IF (T*(1.+ROEPS).GE.TSTOP.AND.TSTOP.GT.0.) GO TO 30
C           *** SHOULD THE GRID BE REZONED
      IF ((REZ.NE.0..AND.REZFCT.NE.0..AND.NUMREZ.GT.0).OR.SS4.NE.0.) GO
     1TO 190
C
      GO TO 40
C               *** SET WFLAGL=1. TO SAY THIS IS LAST CYCLE OF RUN
30    WFLAGL=1.
      I3=I1
      NPRINT=1
      NUMSPT=NDUMP7
      NUMSP=0
      GO TO 190
40    ASSIGN 140 TO LOCA
      ASSIGN 110 TO LOCB
C           *** ARE WE PRINTING ON TIME OR CYCLE INTERVALS
      IF (PRDELT.NE.0.) GO TO 50
45    IF (IPCYCL.NE.0) GO TO 100
      GO TO 430
C           *** PRINTING ON TIME. IS IT TIME TO PRINT
50    IF (T*(1.+ROEPS).GE.PRTIME) GO TO 70
C           *** NO. BUT WILL NEXT CYCLE BYPASS THE PRINT TIME
      IF (PRTIME.GE.T+DT) GO TO 60
      DT=PRTIME-T
      DTNA=DT
60    GO TO LOCA, (140,130)
C           *** YES, IT IS TIME TO PRINT. NPRINT=1 FLAGS THIS AS A
C               PRINT CYCLE.
70    NPRINT=1
C           *** AVOID TRUNCATION
      T=PRTIME
C           *** IS IT TIME TO RESCALE PRINT INTERVAL
```

```
      IF (T*(1.+ROEPS).LT.PRLIM.OR.NUMSCA.LE.0) GO TO 80
C           *** CHANGE PRINT INTERVAL AND THE TIME FOR THE NEXT
C               RESCALING.
      PRDELT=PRDELT*PRFACT
      PRLIM=PRLIM*PRFACT
      NUMSCA=NUMSCA-1
C           *** DEFINE TIME FOR NEXT PRINT.
80    PRTIME=T+PRDELT
      IWS=(PRTIME+.5*PRDELT)/PRDELT
      WS=IWS
      PRTIME=WS*PRDELT
C           *** WILL WE BYPASS TIME TO PRINT
      IF (PRTIME.GE.T+DT) GO TO 90
C           *** YES, ADJUST DT
      DT=PRTIME-T
      DTNA=DT
90    GO TO LOCB, (110,130)
C           *** PRINTING ON CYCLES. IS THIS A PRINT CYCLE
100   IF (MOD(NC,IPCYCL).NE.0) GO TO LOCA, (140,130)
C           *** YES. NPRINT = 1 FLAGS THIS AS A PRINT CYCLE.
      NPRINT=1
C           *** IS THIS THE CYCLE TO RESCALE PRINT INTERVAL
      IF (NC.LT.PRLIM.OR.NUMSCA.LE.0) GO TO LOCB, (110,130)
C
C           *** YES. MULTIPLY NUMBER OF CYCLES BETWEEN PRINTS BY PRFACT
C
      IPCYCL=INT(PRFACT)*IPCYCL
      PRLIM=PRFACT*PRLIM
      NUMSCA=NUMSCA-1
      GO TO LOCB, (110,130)
C                 *** TEST FOR SHORT OR LONG PRINT
C           *** NUMSP COUNTS NUMBER OF SHORT PRINTS SINCE LAST LONG
C               PRINT. NUMSPT COUNTS NUMBER OF CYCLES SINCE LAST
C               TAPE DUMP.
110   NUMSP=NUMSP+1
      NUMSPT=NUMSPT+1
      IF (NUMSP.NE.NFRELP) GO TO 190
      NUMSP=0
C                 *** I3=I1 SIGNALS A LONG PRINT
120   I3=I1
C           *** PRINT OF RESTART CYCLE WILL BE SHORT IF PK(3).LT.-1.
      IF (PK(3).LT.-1..AND.WFLAGF.GT.0.) I3=1
      GO TO 190
C                 *** CHECK FOR ENERGY DISCREPANCY
130   IF (ABS(ECK).GT.DMIN) GO TO 440
C                 *** IF LAST CYCLE, REWIND TAPE
140   IF (WFLAGL.EQ.0.) GO TO 470
      REWIND 7
      GO TO 470
150   NUMSPT=0
      IF (NODUMP.NE.0) GO TO 170
      BACKSPACE 7
      WS=555.0
      WRITE (7) WS,CYCLE,N3
      WRITE (7) (Z(L),L=1,MZT)
      WRITE (7) (U(K),V(K),AMX(K),AIX(K),P(K),K=1,KMAXA)
      WRITE (7) X(0),(X(K),TAU(K),JPM(K),K=1,IMAX)
```

```
      WRITE (7) (Y(K),K=0,JMAX)
C           *** ARE TRACER POINTS BEING GENERATED
      IF (Y2.GT.(-1.)) GO TO 160
C           *** YES. WRITE TRACER POINT COORDINATES (XP,YP) ON TAPE.
      WRITE (7) ((XP(I,J),YP(I,J),I=1,II),J=1,JJ)
160   WRITE (7) (DX(I),I=1,IMAX)
      WRITE (7) (DY(J),J=1,JMAX)
      WS=666.0
      WRITE (7) WS,WS,WS
      WRITE (6,550) NC
      IF (WFLAGL.EQ.0.) GO TO 170
      END FILE 7
170   CONTINUE
      IF (ERDUMP.GT.0.) CALL EXIT
      GO TO 280
180   N=2
      GO TO 220
C           *** INITIALIZE PR ARRAY, TEMPORARY STORAGE FOR ENERGY,MASS
C               AND MOMENTUM TOTALS PRINTED OUT.
190   DO 200 I=1,16
200   PR(I)=0.
C
C     RAMOMA=RADTAL MOMENTUM ABOVE JPROJ
C     RAMOMA=RADTAL MOMENTUM BELOW JPROJ
C     PRAMOA=POSITIVE RADIAL MOMENTUM ABOVE JPROJ
C     PRAMOB=POSITIVE RADIAL MOMENTUM BELOW JPROJ
C
      IF (JPROJ.EQ.0) GO TO 180
      N=IMAX*JPROJ+1
      DO 210 K=2,N
      WS=AMX(K)
      PRMAS=PRMAS+WS
      TIEPRO=TIEPRO+WS*AIX(K)
      TKEPRO=TKEPRO+.5*WS*(U(K)**2+V(K)**2)
      WSA=WS*V(K)
      PRMV=PRMV+WSA
      IF (WSA.GT.0.) PRMVP=PRMVP+WSA
      RAMOMB=RAMOMB+AMX(K)*U(K)
      IF (U(K).GT.0.) PRAMOB=PRAMOB+AMX(K)*U(K)
210   CONTINUE
      N=N+1
220   DO 230 K=N,KMAX
      WS=AMX(K)
      TARMAS=TARMAS+WS
      TIETAR=TIETAR+WS*AIX(K)
      TKETAR=TKETAR+.5*WS*(U(K)**2+V(K)**2)
      WSA=WS*V(K)
      TARMV=TARMV+WSA
      IF (WSA.GT.0.) TARMVP=TARMVP+WSA
      RAMOMA=RAMOMA+AMX(K)*U(K)
      IF (U(K).GT.0.) PRAMOA=PRAMOA+AMX(K)*U(K)
230   CONTINUE
      TETAR=TIETAR+TKETAR
      TEPRO=TIEPRO+TKEPRO
      DO 240 J=1,8
      PR(J+16)=PR(J)+PR(J+8)
240   CONTINUE
```

```
      IF (IMAX.GT.1) GO TO 260
C
C          *** IF DOING A 1-D PROBLEM DIVIDE TOTALS BY NZ WHERE
C              NZ=4**(NUMBER OF TIMES THE GRID HAS BEEN REZONED.)
C
      PROPI(1)=ETH/NZ
      PROPI(2)=ECK/NZ
      PROPI(4)=EZPH1/NZ
      PROPI(5)=EZPH2/NZ
      PROPI(6)=BBOUND/NZ
      DO 250 J=1,24
250   PROPI(J+6)=PR(J)/NZ
      PROPI(31)=BOTM/NZ
      PROPI(32)=RTM/NZ
      PROPI(33)=TOPM/NZ
      PROPI(34)=EVAPM/NZ
      PROPI(35)=EMOB/NZ
      PROPI(36)=EMOR/NZ
      PROPI(37)=EMOT/NZ
      PROPI(38)=EVAPEN/NZ
      PROPI(39)=BOTMU/NZ
      PROPI(40)=RTMU/NZ
      PROPI(41)=TOPMU/NZ
      PROPI(42)=EVAPMU/NZ
      PROPI(43)=BOTMV/NZ
      PROPI(44)=RTMV/NZ
      PROPI(45)=TOPMV/NZ
      PROPI(46)=EVAPMV/NZ
      PROPI(47)=EOB/NZ
      PROPI(48)=EOR/NZ
      PROPI(49)=EOT/NZ
      WRITE (6,530) PROB,T,NC,PROPI(1),PROPI(2),NECYCL,(PROPI(J),J=4,6)
      WRITE (6,540) (PROPI(J),J=7,49)
      GO TO 270
260   WRITE (6,530) PROB,T,NC,ETH,ECK,NECYCL,EZPH1,EZPH2,BBOUND
      WRITE (6,540) ((PR(J),J=1,24),BOTM,RTM,TOPM,EVAPM,EMOB,EMOR,EMOT,E
     1VAPEN,BOTMU,RTMU,TOPMU,EVAPMU,BOTMV,RTMV,TOPMV,EVAPMV,EOB,EOR,EOT)
270   WRITE (6,580) (JPM(I),I=1,I1)
C          *** ENERGY TOTALS STORED FOR LATER USE IN TRACER POINT
C              PLOTS.
      XIENRG=PR(17)
      XKENRG=PR(18)
      XTENRG=PR(19)
C          *** IS THIS A TAPE DUMP OR REZONE CYCLE
      IF (NUMSPT.EQ.NDUMP7.OR.(REZ.NE.0..AND.REZFCT.NE.0..AND.NUMREZ.GT.
     10)) GO TO 150
C          *** ARE TRACER POINTS BEING GENERATED
280   IF (Y2.GT.(-1.)) GO TO 305
C          *** YES, PRINT TRACER POINT COORDINATES IN CM.
      WRITE (6,590)
      N=0
      DO 300 J=1,JJ
      DO 300 I=1,II
      IF (XP(I,J).LE.0..AND.YP(I,J).LE.0.) GO TO 300
      IP=INT(XP(I,J))
      JP=INT(YP(I,J))
      KK=JP*IMAX+IP+2
```

```
      IF (AMX(KK).GT.0.) GO TO 290
      XP(I,J)=0.
      YP(I,J)=0.
      GO TO 300
290   N=N+1
      CMXP(N)=X(IP)+DX(IP+1)*(XP(I,J)-INT(XP(I,J)))
      CMYP(N)=Y(JP)+DY(JP+1)*(YP(I,J)-INT(YP(I,J)))
C
C              *** IJ, JK  = THE I AND J OF THE CELL THE TRACER POINT
C                     ORIGINATED IN .  (TRACER POINTS CHANGE POSITION IN
C                     XP AND YP ARRAYS WHEN THEY ARE WEEDED OUT
C                     DURING REZONE.)
C
      IJ(N)=2**(NRZ+1)*(I-1)+1
      JK(N)=2**(NRZ+1)*(J-1)+1
      IF (N.LT.5) GO TO 300
      WRITE (6,510) (IJ(M),JK(M),CMXP(M),CMYP(M),M=1,N)
      N=0
300   CONTINUE
      IF (N.EQ.0) GO TO 305
      WRITE (6,510) (IJ(M),JK(M),CMXP(M),CMYP(M),M=1,N)
305   IF (IMAX.EQ.1) GO TO 370
C              *** PRINT SYMBOLIC CONTOUR MAPS OF COMPRESSION, PRESSURE,
C                  VELOCITY, AND INTERNAL ENERGY UNLESS DOING A 1-D
C                  PROBLEM.
      CALL MAP
C              *** COMPUTE CRATER DEPTH AND VOLUME. AID SUMS DEPTH.
      AID = 0.
      WRITE(6,490)
C              *** START AT AXIS
      DO 330 I =1,I1
      CRAD(I) = .5*DX(I)+X(I-1)
      PL(I) = 0.
      UL(I) = 0.
      DO 320 J =1,I2
      K=(J-1)*IMAX + I + 1
C              *** WS IS COMPRESSION
      WS = AMX(K)/(TAU(I)*DY(J)*RHOZ)
      IF(WS.LT.(.99)) GO TO 310
      GO TO 325
  310 AID = AID + 1.-WS
C              *** NOT AT BOTTOM OF CRATER YET
  320 CONTINUE
  325 IAID = INT(AID)
C              *** UL(I) IS CM. DEPTH OF CRATER IN COLUMN I
C              *** PL(I) IS CELL DEPTH OF CRATER IN COLUMN I
      UL(I) = Y(IAID) + DY(IAID+1)*(AID-FLOAT(IAID)) - Y(JPROJ)
      IF(UL(I).GT.0..OR.UL(I).LT.0.) PL(I) = AID
      AID = 0.
  330 CONTINUE
C              *** PRINT CRATER DEPTHS
      DO 340 I=1,I1
      IF(UL(I).LT.0..OR.UL(I).GT.0.) GO TO 335
      GO TO 340
  335 WRITE(6,495) I, PL(I), CRAD(I), UL(I)
  340 CONTINUE
C              *** COMPUTE  CRATER VOLUME AND VOLUME OF HEMISPHERE WITH
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C                 RADIUS=UL(1). PRINT VOLUMES WHEN THEY ARE POSITIVE.
      WSB=0.
      DO 345 I=1,I1
      IF(UL(I).LT.0.) GO TO 350
C           *** WSB GIVES CRATER VOLUME
      WSB = UL(I)*TAU(I)+WSB
  345 CONTINUE
  350 CONTINUE
C           *** PRINT CRATER VOLUME ONLY WHEN GREATER THAN ZERO
      IF(WSB.GT.0.) GO TO 355
      GO TO 360
C           *** WSC GIVES VOLUME OF HEMISPHERE
355   WSC=2.0944*(UL(1))**3
      WRITE(6,500) WSB, WSC
  360 CONTINUE
C           *** SHORT PRINT MEAN  I3=1 AND PROPERTIES ARE PRINTED ONLY
C                 FOR CELLS IN FIRST COLUMN. LONG PRINT MEANS I3=I1 AND
C                 PROPERTIES ARE PRINTED FOR ALL CELLS IN ACTIVE GRID.
370   DO 420 I=1,I3
      KSPACE=0
      WFLAGP=1.
      J=I2+1
      K=I2*IMAX+I+1
      DO 410 L=1,I2
      J=J-1
      K=K-IMAX
375   IF (AMX(K)) 450,400,380
380   IF (WFLAGP.EQ.0.) GO TO 390
      WRITE (6,560) I,X(I),DX(I)
      WFLAGP=0.
390   WS=AMX(K)/(TAU(I)*DY(J))
      WSA=WS/RHOZ
      WSC=P(K)
      WRITE (6,520) J,U(K),V(K),WSC,AMX(K),WS,AIX(K),WSA,Y(J)
      KSPACE=0
      GO TO 410
400   KSPACE=KSPACE+1
      IF (KSPACE.GT.1) GO TO 410
      WRITE (6,570)
410   CONTINUE
420   CONTINUE
      IF (NPRINT.EQ.1) GO TO 130
      ASSIGN 130 TO LOCA
      ASSIGN 130 TO LOCB
      IF (PRDELT.NE.0.) GO TO 50
      GO TO 100
C                   *** PRINT DELTA NOT SPECIFIED IN INPUT
430   NK=45
      GO TO 460
C           *** ENERGY CHECK
440   NK=130
      GO TO 460
C                   *** NEGATIVE MASS
450   NK=375
460   NR=5
      CALL ERROR
470   WFLAGP=0.
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```
      WFLAGF=0.
C           *** SHOULD GRID BE REZONED ON THIS CYCLE
      IF ((REZ.NE.0..AND.REZFCT.NE.0..AND.NUMREZ.GT.0).OR.SS4.NE.0.) GO
     1TO 480
      RETURN
480   CALL REZONE
C           *** MUST CALL CDT TO RECALCULATE PRESSURES
      TNOW=T
      DTNOW=DT
      REZ=0.
      SS4=0.
      CALL CDT
      T=TNOW
      DT=DTNOW
      DTNA=DT
      NUMREZ=NUMREZ-1
C
C          *** NREZ = NUMBER OF REZONES ALLOWED (INPUT VALUE OF NUMREZ)
C              NUMREZ = NUMBER OF REZONES ALLOWED MINUS THE NUMBER
C                       OF REZONES PERFORMED  SINCE T=0.
C
      NRZ=NREZ-NUMREZ
C           *** NZ USED IN PRINTOUT OF TOTALS FOR 1-D PROBLEMS
      NZ=4.**NRZ
C
      NUMSPT=NDUMP7
      GO TO 120
C
C                   FORMATS
C
490   FORMAT (1H0,17X,35HDEPTH OF CRATER MEASURED FROM JPROJ//12X,1HI,5X
     1,18HJ OF CRATER BOTTOM,12X,1HR,11X,17HDEPTH IN CM. D(I)//)
495   FORMAT (I13,9X,0PF6.1,13X,1PE10.4,9X,1PE10.4)
500   FORMAT (//6X,13HCRATER VOLUME,11X,43HCRATER VOLUME BASED ON (2/3)
     1* PI * D(1)**3/7X,1PE10.4,26X,1PE10.4)
510   FORMAT (5(I4,I4,1P2E9.2))
520   FORMAT (I4,1X,1P2E14.6,3E15.6,E14.6,E15.6,E14.6)
530   FORMAT(8H1PROBLEM,6X,4HTIME,8X,5HCYCLE,3X,13HTOT.EN.THEOR.3X,
     1        19HMAX.REL.ERROR-CYCLE,3X,18HIE SET TO ZERO-PH1,3X,
     2         18HIE SET TO ZERO-PH2,3X,12HPLASTIC-WORK/1F8.4,2X,1PE13.7,
     3         3X,I4,4X,1PE13.7,3X,1PE13.7,1X,I4,6X,1PE13.7,8X,1PE13.7,6X,
     4         1PE13.7/)
540   FORMAT (18X,2HIE,14X,2HKE,7X,13HTOT.EN. (SUM),7X,4HMASS,12X,2HMV,8
     1X,12HMV(POSITIVE),8X,2HMU,8X,12HMU(POSITIVE)/11H J.GT.JPROJ,1P8E15
     2.7/11H J.LE.JPROJ,1P8E15.7/14X,12H------------,3X,12H------------,
     33X,12H------------,3X,12H------------,3X,12H------------,3X,12H---
     4---------,3X,12H------------,3X,12H------------,3X/7H TOTALS,4X,1P
     58E15.7///9H BOUNDARY,9X,6HBOTTOM,9X,5HRIGHT,10X,3HTOP,8X,12H$EVAPO
     6RATED$//9H MASS OUT,2X,1P4E15.7/11H ENERGY OUT,1P4E15.7/7H MU OUT,
     74X,1P4E15.7/7H MV OUT,4X,1P4E15.7//11H WORK DONE ,1P3E15.7//)
550   FORMAT (1H0//21H TAPE 7 DUMP ON CYCLEI5////)
560   FORMAT (1H ///4H I =I3,6X,6HR(I) =F12.3,6X,7HDR(I) =E14.7//3H  J8X
     1,1HU13X,1HV13X,3H P 12X,3HAMX12X,3HRHO11X,3HAIX12X,4HCOMP11X,2H Z/
     2)
570   FORMAT (1H0)
580   FORMAT (//22H J OF PRESSURE-MAXIMUM/(25I5))
590   FORMAT(//103H TRACER POINTS - INITIAL LOCATION IN CELL COORDINATES
```

```
1 (I,J) - CURRENT LOCATION IN CM. COORDINATES (X,Y)// 5(4H   I,3X,      4612
21HJ,5X,1HX,8X,1HY,3X))                                                  4614
 END                                                                     4620-
```

```
      SUBROUTINE MAP
C     ••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••••
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)  ,P(2502)  ,
     1          X(52)    ,XX(54)   ,TAU(52)   ,JPM(52)   ,
     2          Y(102)   ,YY(104)  ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)   ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)  ,PR(204)   ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)  ,IJ(5)     ,JK(5)     ,
     9          DX(52)   ,DDX(54)  ,DY(102)   ,DDY(104)  ,
     $          SNB(52)  ,STB(52)  ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C        *** DIMENSIONED ARRAYS
C        *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON     PK
      COMMON  YY,      XX
      COMMON  DDX,     DDY
      COMMON  AMX,     AIX,     U,      V,      P
      COMMON  TAU,     JPM
      COMMON  UL ,     PL
      COMMON  XP ,     YP,      CMXP, CMYP
C        *** NON-DIMENSIONED VARIABLES
      COMMON          AID    ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB  ,DELER  ,DELET  ,DELM   ,DTODX  ,DXYMIN,EAMMP  ,EAMPY  ,
     2E      ,ERDUMP,I       ,I3     ,IWS    ,J      ,K      ,KA     ,KB     ,
     3LL     ,MD     ,ME     ,MZT    ,NERR   ,NK     ,NPRINT,
     4NR     ,NRZ    ,NULLE  ,PIDTS  ,SIEMIN,SNR     ,SNT    ,STR    ,SOLID  ,
     5SUM    ,TESTRH,TWOPI  ,URR    ,WS     ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
C
C        *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C            X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C        *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE            (UL,FLEFT),          (UL(103),YAMC),
     1                       (PL,GAMC,PR),        (PL(103),SIGC)
C
C        *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE            (UL,RSN),
     1                       (PL,RST),            (P,UK),
     2                       (P(157),VK),         (P(313),SNB),
     3                       (P(365),STB),        (P(417),RHO)
C
C        *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C        *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                          (Z(  1),PROB  ),(Z(  2),CYCLE ),
```

```
      1(Z(  3),DT    ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
      2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
      3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
      4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
      5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
      6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
      7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
      8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
      9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
       EQUIVALENCE
      1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
      2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
       EQUIVALENCE
      1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IFCYCL),(Z( 50),TSTOP ),
      2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IPARDY),
      3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
      4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
      5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
      6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
      7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
      8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
      9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
       EQUIVALENCE
      1(Z( 83),VARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
      2(Z( 87),NTER  ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
      3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
       EQUIVALENCE
      1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
      2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
      3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
      4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
      5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
      6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
      7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
      8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
      9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
       EQUIVALENCE
      1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
      2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
      3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
      4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
      5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C        ..............................................................
C
C        END OF COMMON
C
C        ..............................................................
C
         DIMENSION VALUE(40)
         DIMENSION ALE(41)
         DATA ALE/2H  ,2H .,2H -,2H A,2H B,2H C,2H D,2H E,2H F,
     1            2H G,2H H,2H I,2H J,2H K,2H L,2H M,2H N,2H O,
     2            2H P,2H Q,2H R,2H S,2H T,2H U,2H V,2H W,2H X,
     3            2H Y,2H Z,2H +,2H *,2H 1,2H 2,2H 3,2H 4,2H 5,
     4            2H 6,2H 7,2H 8,2H 9,2H 0/
         DIMENSION XUM(41)
```

```
      DATA XUM/2H  ,2H-.,2H--,2H-A,2H-B,2H-C,2H-D,2H-E,2H-F,                    MAP1160
     1         2H-G,2H-H,2H-I,2H-J,2H-K,2H-L,2H-M,2H-N,2H-O,                    MAP1170
     2         2H-P,2H-Q,2H-R,2H-S,2H-T,2H-U,2H-V,2H-W,2H-X,                    MAP1180
     3         2H-Y,2H-Z,2H-+,2H-*,2H-1,2H-2,2H-3,2H-4,2H-5,                    MAP1190
     4         2H-6,2H-7,2H-8,2H-9,2H 0/                                        MAP1200
C                                                                               MAP1210
C          *** SEARCH FOR MINIMUM AND MAXIMUM COMPRESSIONS                      MAP1220
C              TO SCALE COMPRESSION MAP                                         MAP1230
C                                                                               MAP1240
      IDL=I1                                                                    MAP1250
      JDL=I2                                                                    MAP1260
      IF (NC.NE.0) GO TO 10                                                     MAP1270
      IDL=MIN0(IMAX,55)                                                         MAP1280
      JDL=JMAX                                                                  MAP1290
10    WSMAX=0.                                                                  MAP1300
      WSMIN=10.                                                                 MAP1310
C                                                                               MAP1320
      DO 20 J=1,JDL                                                             MAP1330
      K=(J-1)*IMAX+1                                                            MAP1340
      DO 20 I=1,IDL                                                             MAP1350
      K=K+1                                                                     MAP1360
      WSA=AMX(K)/(TAU(I)*DY(J)*RHOZ)                                            MAP1370
      IF (WSA.EQ.0.) GO TO 20                                                   MAP1380
      WSMAX=AMAX1(WSMAX,WSA)                                                    MAP1390
      WSMIN=AMIN1(WSMIN,WSA)                                                    MAP1400
20    CONTINUE                                                                  MAP1410
      IF (WSMIN.LT.WSMAX) GO TO 30                                              MAP1420
      WSMIN=0.                                                                  MAP1430
C                                                                               MAP1440
C          *** DEFINE LINEAR SCALE FACTOR  AND  PRINT KEY TO                    MAP1480
C              COMPRESSION MAP.                                                 MAP1485
30    DSCALE=(WSMAX-WSMIN)/FLOAT(IDNMAP)                                        MAP1510
      IF ((AINT(DSCALE*100.)).LT.(DSCALE*100.)) GO TO 50                        MAP1520
      DSCALE=AINT(DSCALE*100.)/100.                                             MAP1530
      GO TO 60                                                                  MAP1540
50    DSCALE=AINT(DSCALE*100.+1.)/100.                                          MAP1550
60    CONTINUE                                                                  MAP1560
      DO 70 I=1,IDNMAP                                                          MAP1570
70    VALUE(I)=WSMIN+FLOAT(I)*DSCALE                                            MAP1580
      WRITE (6,860)                                                             MAP1590
      ILIM1=1                                                                   MAP1600
      ILIM2=20                                                                  MAP1610
80    IF (IDNMAP.LT.ILIM2) ILIM2=IDNMAP                                         MAP1620
      WRITE (6,870) (ALE(I+1),I=ILIM1,ILIM2)                                    MAP1630
      WRITE (6,960) (VALUE(I),I=ILIM1,ILIM2)                                    MAP1640
      IF (IDNMAP.EQ.ILIM2) GO TO 90                                             MAP1650
      ILIM1=ILIM2+1                                                             MAP1660
      ILIM2=ILIM2+20                                                            MAP1670
      GO TO 80                                                                  MAP1680
90    CONTINUE                                                                  MAP1690

      WRITE (6,980)                                                             MAP1700
C                                                                               MAP1710
      J=JDL                                                                     MAP1720
100   K=(J-1)*IMAX+1                                                            MAP1730
C                                                                               MAP1740
      DO 150 I=1,IDL                                                            MAP1750
```

```
      K=K+1                                                             MAP1760
      IF (AMX(K).GT.0.) GO TO 110                                       MAP1770
      GO TO 130                                                         MAP1780
  110 WSA=AMX(K)/(TAU(I)*DY(J)*HOZ)                                     MAP1790
      IF (WSA.GT.WSMIN) GO TO 120                                       MAP1800
C           *** PRINT A DOT TO REPRESENT SMALLEST COMPRESSION.          MAP1805
      MA=2                                                              MAP1810
      GO TO 140                                                         MAP1820
  120 TMA=(WSA-WSMIN)/DSCALE+1.                                         MAP1830
      MA=TMA                                                            MAP1840
      IF (WSA.GT.FLOAT(MA-1)*DSCALE+WSMIN) MA=MA+1                      MAP1850
      GO TO 140                                                         MAP1860
C           *** PRINT A BLANK FOR EMPTY CELLS.                          MAP1865
  130 MA=1                                                              MAP1870
  140 PR(I)=ALE(MA)                                                     MAP1880
  150 CONTINUE                                                          MAP1890
C           *** PRINT J-VALUE ALONG Y-AXIS WHEN IT IS A MULTIPLE OF 5.  MAP1895
      IF (MOD(J,5).NE.0) GO TO 160                                      MAP1900
      WRITE (6,880) J,(PR(I),I=1,IDL)                                   MAP1910
      GO TO 170                                                         MAP1920
  160 WRITE (6,890) (PR(I),I=1,IDL)                                     MAP1930
  170 J=J-1                                                             MAP1940
      IF (J.GT.0) GO TO 100                                             MAP1950
C           *** PRINT AND LABEL X-AXIS OF MAP.                          MAP1960
      PR(1)=ALE(30)                                                     MAP1970
      WRITE (6,880) J,(PR(1),I=1,IDL)                                   MAP1980
      WRITE (6,900) (I,I=0,IDL,5)                                       MAP1990
C                                                                       MAP2000
C           *** SEARCH FOR MINIMUM AND MAXIMUM PRESSURES                MAP2010
C               TO SCALE PRESSURE MAP                                   MAP2020
C                                                                       MAP2030
      WSMAX=0.                                                          MAP2040
C                                                                       MAP2050
      DO 180 J=1,JDL                                                    MAP2060
      DO 180 I=1,IDL                                                    MAP2070
      K=(J-1)*IMAX+I+1                                                  MAP2080
      WSA=ABS(P(K))                                                     MAP2090
      IF (WSA.EQ.0.) GO TO 180                                          MAP2100
      WSMAX=AMAX1(WSMAX,WSA)                                            MAP2110
  180 CONTINUE                                                          MAP2120
      WSMIN=10.*PMIN                                                    MAP2130
      WRITE (6,910)                                                     MAP2140
C           *** PRINT KEY TO MAP ONLY IF THERE ARE NON-ZERO PRESSURES.  MAP2145
      IF (WSMAX.NE.0.) GO TO 190                                        MAP2150
      J=JDL                                                             MAP2160
      GO TO 260                                                         MAP2170
C                                                                       MAP2180
C           *** DEFINE LOGARITHMIC SCALE FACTOR AND PRINT KEY TO        MAP2220
C               PRESSURE MAP.                                           MAP2230
  190 MAXEXP=INT(ALOG10(WSMAX))                                         MAP2240
      MINEXP=INT(ALOG10(WSMIN))                                         MAP2250
      PSCLE=FLOAT(MAXEXP-MINEXP+1)/FLOAT(IPRMAP)                        MAP2260
      IF ((AINT(PSCLE*1000.)).LT.(PSCLE*1000.)) GO TO 210               MAP2270
      PSCLE=AINT(PSCLE*1000.)/1000.                                     MAP2280
      GO TO 220                                                         MAP2290
  210 PSCLE=AINT(PSCLE*1000.+1.)/1000.                                  MAP2300
  220 CONTINUE                                                          MAP2310
```

```
      DO 230 I=1,IPRMAP
230   VALUE(I)=10.**(MINEXP+FLOAT(I)*PSCLE)
      ILIM1=1
      ILIM2=10
240   IF (IPRMAP.LT.ILIM2) ILIM2=IPRMAP
      WRITE (6,920) (ALE(I+3),I=ILIM1,ILIM2)
      WRITE (6,970) (VALUE(I),I=ILIM1,ILIM2)
      IF (IPRMAP.EQ.ILIM2) GO TO 250
      ILIM1=ILIM2+1
      ILIM2=ILIM2+10
      GO TO 240
250   CONTINUE
      WRITE (6,980)
C
      J=JDL
260   K=(J-1)*IMAX+1
C
      DO 320 I=1,IDL
      K=K+1
      IF (AMX(K).GT.0.) GO TO 270
C           *** PRINT A BLANK FOR EMPTY CELLS.
      MA=1
      GO TO 310
270   IF (P(K).NE.0.) GO TO 280
C           *** PRINT A ZERO FOR NONEMPTY CELLS WITH ZERO PRESSURE.
      MA=41
      GO TO 310
280   FLOTMA=(ALOG10(ABS(P(K)))-FLOAT(MINEXP))/PSCLE+3.
      INTMA=INT(FLOTMA)
      IF (FLOTMA.GT.FLOAT(INTMA)) GO TO 290
      MA=INTMA
      GO TO 300
290   MA=INTMA+1
C           *** DO NOT USE DOT AND DASH IN PRESSURE MAP.
300   IF (MA.LE.3) MA=4
310   CONTINUE
      PR(I)=ALE(MA)
C           *** USE XUM ARRAY OF SYMBOLS FOR NEGATIVE PRESSURES.
320   IF (P(K).LT.0.) PR(I)=XUM(MA)
C
      IF (MOD(J,5).NE.0) GO TO 330
      WRITE (6,880) J,(PR(I),I=1,IDL)
      GO TO 340
330   WRITE (6,890) (PR(I),I=1,IDL)
340   J=J-1
      IF (J.GT.0) GO TO 260
C           *** PRINT AND LABEL X-AXIS OF MAP.
      PR(1)=ALE(30)
      WRITE (6,880) J,(PR(1),I=1,IDL)
      WRITE (6,900) (I,I=0,IDL,5)
C
C           *** SEARCH FOR MINIMUM AND MAXIMUM RADIAL
C               VELOCITIES TO DEFINE SCALE FACTOR OF
C               RADIAL VELOCITY MAP
C
      WSMAX=0.
C
```

```
      DO 350 J=1,JDL                                                    MAP2850
      DO 350 I=1,IDL                                                    MAP2860
      K=(J-1)*IMAX+I+1                                                  MAP2870
      WSA=ABS(U(K))                                                     MAP2880
      IF (WSA.EQ.0.) GO TO 350                                          MAP2890
      WSMAX=AMAX1(WSMAX,WSA)                                            MAP2900
  350 CONTINUE                                                          MAP2910
      WSMIN=10.*UMIN                                                    MAP2920
      WRITE (6,930)                                                     MAP2930
C           *** PRINT KEY TO MAP ONLY IF THERE ARE NON-ZERO VALUES.     MAP2935
      IF (WSMAX.NE.0.) GO TO 360                                        MAP2940
      J=JDL                                                             MAP2950
      GO TO 430                                                         MAP2960
C                                                                       MAP2970
C                                                                       MAP3020
C           *** USCLE IS LOGARITHMIC SCALE FACTOR OF RADIAL VELOCITY    MAP3030
C               MAP.                                                    MAP3040
  360 MAXEXP=INT(ALOG10(WSMAX))                                         MAP3050
      MINEXP=INT(ALOG10(WSMIN))                                         MAP3060
      USCLE=FLOAT(MAXEXP-MINEXP+1)/FLOAT(IUMAP)                         MAP3070
      IF ((AINT(USCLE*1000.)).LT.(USCLE*1000.)) GO TO 380               MAP3080
      USCLE=AINT(USCLE*1000.)/1000.                                     MAP3090
      GO TO 390                                                         MAP3100
  380 USCLE=AINT(USCLE*1000.+1.)/1000.                                  MAP3110
  390 CONTINUE                                                          MAP3120
C           *** PRINT KEY TO MAP.                                       MAP3125
      DO 400 I=1,IUMAP                                                  MAP3130
  400 VALUE(I)=10.**(MINEXP+FLOAT(I)*USCLE)                             MAP3140
      ILIM1=1                                                           MAP3150
      ILIM2=10                                                          MAP3160
  410 IF (IUMAP.LT.ILIM2) ILIM2=IUMAP                                   MAP3170
      WRITE (6,920) (ALE(I,3),I=ILIM1,ILIM2)                            MAP3180
      WRITE (6,970) (VALUE(I),I=ILIM1,ILIM2)                            MAP3190
      IF (IUMAP.EQ.ILIM2) GO TO 420                                     MAP3200
      ILIM1=ILIM2+1                                                     MAP3210
      ILIM2=ILIM2+10                                                    MAP3220
      GO TO 410                                                         MAP3230
  420 CONTINUE                                                          MAP3240
      WRITE (6,980)                                                     MAP3250
C                                                                       MAP3260
      J=JDL                                                             MAP3270
  430 K=(J-1)*IMAX+1                                                    MAP3280
C                                                                       MAP3290
      DO 490 I=1,IDL                                                    MAP3300
      K=K+1                                                             MAP3310
      IF (AMX(K).GT.0.) GO TO 440                                       MAP3320
C           *** EMPTY CELL.                                             MAP3325
      MA=1                                                              MAP3330
      GO TO 480                                                         MAP3340
  440 IF (U(K).NE.0.) GO TO 450                                         MAP3350
C           *** ZERO RADIAL VELOCITY.                                   MAP3355
      MA=41                                                             MAP3360
      GO TO 480                                                         MAP3370
  450 FLOTMA=(ALOG10(ABS(U(K)))-FLOAT(MINEXP))/USCLE+3.                 MAP3380
      INTMA=INT(FLOTMA)                                                 MAP3390
      IF (FLOTMA.GT.FLOAT(INTMA)) GO TO 460                             MAP3400
      MA=INTMA                                                          MAP3410
```

```
      GO TO 470
400   MA=INTMA+1
C           *** DO NOT USE DOT OR DASH IN RADIAL VELOCITY MAP.
470   IF (MA.LE.3) MA=4
480   CONTINUE
      PR(I)=ALE(MA)
C           *** USE XUM ARRAY FOR NEGATIVE RADIAL VELOCITIES.
490   IF (U(K).LT.0.) PR(I)=XUM(MA)
C           *** PRINT J-VALUE ALONG Y-AXIS WHEN IT IS A MULTIPLE
C                 OF 5.
      IF (MOD(J,5).NE.0) GO TO 500
      WRITE (6,880) J,(PR(I),I=1,IDL)
      GO TO 510
500   WRITE (6,890) (PR(I),I=1,IDL)
510   J=J-1
      IF (J.GT.0) GO TO 430
C           *** PRINT AND LABEL X-AXIS OF MAP.
      PR(1)=ALE(30)
      WRITE (6,880) J,(PR(1),I=1,IDL)
      WRITE (6,900) (I,I=0,IDL,5)
C
C           *** SEARCH FOR MINIMUM AND MAXIMUM AXIAL
C               VELOCITES TO DEFINE SCALE FACTOR OF
C               AXIAL VELOCITY MAP
C
      WSMAX=0.
C
      DO 520 J=1,JDL
      DO 520 I=1,IDL
      K=(J-1)*IMAX+I+1
      WSA=ABS(V(K))
      IF (WSA.EQ.0.) GO TO 520
      WSMAX=AMAX1(WSMAX,WSA)
520   CONTINUE
      WSMIN=10.*UMIN
      WRITE (6,940)
C           *** PRINT KEY TO MAP ONLY IF THERE ARE NON-ZERO VALUES.
      IF (WSMAX.NE.0.) GO TO 530
      J=JDL
      GO TO 600
C
C
C           *** VSCLE IS LOGARITHMIC SCALE FACTOR FOR AXIAL VELOCITY
C                 MAP.
530   MAXEXP=INT(ALOG10(WSMAX))
      MINEXP=INT(ALOG10(WSMIN))
      VSCLE=FLOAT(MAXEXP-MINEXP+1)/FLOAT(IVMAP)
      IF ((AINT(VSCLE*1000.)).LT.(VSCLE*1000.)) GO TO 550
      VSCLE=AINT(VSCLE*1000.)/1000.
      GO TO 560
550   VSCLE=AINT(VSCLE*1000.+1.)/1000.
560   CONTINUE
C           *** PRINT KEY TO AXIAL VELOCITY MAP.
      DO 570 I=1,IVMAP
570   VALUE(I)=10.**(MINEXP+FLOAT(I)*VSCLE)
      ILIM1=1
      ILIM2=10
```

```
 580    IF (IVMAP.LT.ILIM2) ILIM2=IVMAP                                  MAP3970
        WRITE (6,920) (ALE(I+3),I=ILIM1,ILIM2)                           MAP3980
        WRITE (6,970) (VALUE(I),I=ILIM1,ILIM2)                           MAP3990
        IF (IVMAP.EQ.ILIM2) GO TO 590                                    MAP4000
        ILIM1=ILIM2+1                                                    MAP4010
        ILIM2=ILIM2+10                                                   MAP4020
        GO TO 580                                                        MAP4030
 590    CONTINUE                                                         MAP4040
        WRITE (6,980)                                                    MAP4050
 C                                                                       MAP4060
        J=JDL                                                            MAP4070
 600    K=(J-1)*IMAX+1                                                   MAP4080
 C                                                                       MAP4090
        DO 660 I=1,IDL                                                   MAP4100
        K=K+1                                                            MAP4110
        IF (AMX(K).GT.0.) GO TO 610                                      MAP4120
 C             *** EMPTY CELL.                                           MAP4125
        MA=1                                                             MAP4130
        GO TO 650                                                        MAP4140
 610    IF (V(K).NE.0.) GO TO 620                                        MAP4150
 C             *** ZERO AXIAL VELOCITY.                                  MAP4155
        MA=41                                                            MAP4160
        GO TO 650                                                        MAP4170
 620    FLOTMA=(ALOG10(ABS(V(K)))-FLOAT(MINEXP))/VSCLE+3.                MAP4180
        INTMA=INT(FLOTMA)                                                MAP4190
        IF (FLOTMA.GT.FLOAT(INTMA)) GO TO 630                            MAP4200
        MA=INTMA                                                         MAP4210
        GO TO 640                                                        MAP4220
 630    MA=INTMA+1                                                       MAP4230
 C             *** DO NOT USE DOT OR DASH IN AXIAL VELOCITY MAP.         MAP4235
 640    IF (MA.LE.3) MA=4                                                MAP4240
 650    CONTINUE                                                         MAP4250
        PR(I)=ALE(MA)                                                    MAP4260
 C             *** USE XUM ARRAY FOR NEGATIVE AXIAL VELOCITIES.          MAP4265
 660    IF (V(K).LT.0.) PR(I)=XUM(MA)                                    MAP4270
 C             *** PRINT J-VALUE ALONG Y-AXIS WHEN IT IS A MULTIPLE OF 5. MAP4280
        IF (MOD(J,5).NE.0) GO TO 670                                     MAP4290
        WRITE (6,880) J,(PR(I),I=1,IDL)                                  MAP4300
        GO TO 680                                                        MAP4310
 670    WRITE (6,890) (PR(I),I=1,IDL)                                    MAP4320
 680    J=J-1                                                            MAP4330
        IF (J.GT.0) GO TO 600                                            MAP4340
 C             *** PRINT AND LABEL X-AXIS OF MAP.                        MAP4350
        PR(1)=ALE(30)                                                    MAP4360
        WRITE (6,880) J,(PR(1),I=1,IDL)                                  MAP4370
        WRITE (6,900) (I,I=0,IDL,5)                                      MAP4380
 C                                                                       MAP4390
 C             *** SEARCH FOR MINIMUM AND MAXIMUM  SPECIFIC INTERNAL     MAP4400
 C                 ENERGIES TO DEFINE SCALE FACTOR OF ENERGY MAP         MAP4410
 C                                                                       MAP4420
        WSMAX=0.                                                         MAP4430
 C                                                                       MAP4440
        DO 690 J=1,JDL                                                   MAP4450
        DO 690 I=1,IDL                                                   MAP4460
        K=(J-1)*IMAX+I+1                                                 MAP4470
        WSA=ABS(AIX(K))                                                  MAP4480
        IF (WSA.EQ.0.) GO TO 690                                         MAP4490
```

```
      WSMAX=AMAX1(WSMAX,WSA)                                           MAP4500
690   CONTINUE                                                         MAP4510
      WSMIN=10.*SIEMIN                                                 MAP4520
      WRITE (6,950)                                                    MAP4530
C            *** PRINT KEY TO MAP ONLY IF THERE ARE NON-ZERO VALUES.   MAP4535
      IF (WSMAX.NE.0.) GO TO 700                                       MAP4540
      J=JDL                                                            MAP4550
      GO TO 770                                                        MAP4560
C                                                                      MAP4570
C                                                                      MAP4610
C            *** ESCLE IS LOGARITHMIC SCALE FACTOR FOR INTERNAL ENERGY MAP4620
C                MAP.                                                  MAP4630
700   MAXEXP=INT(ALOG10(WSMAX))                                        MAP4640
      MINEXP=INT(ALOG10(WSMIN))                                        MAP4650
      ESCLE=FLOAT(MAXEXP-MINEXP+1)/FLOAT(IEMAP)                        MAP4660
      IF ((AINT(ESCLE*1000.)).LT.(ESCLE*1000.)) GO TO 720              MAP4670
      ESCLE=AINT(ESCLE*1000.)/1000.                                    MAP4680
      GO TO 730                                                        MAP4690
720   ESCLE=AINT(ESCLE*1000.+1.)/1000.                                 MAP4700
C            *** PRINT KEY TO INTERNAL ENERGY MAP.                     MAP4705
730   CONTINUE                                                         MAP4710
      DO 740 I=1,IEMAP                                                 MAP4720
740   VALUE(I)=10.**(MINEXP+FLOAT(I)*ESCLE)                            MAP4730
      ILIM1=1                                                          MAP4740
      ILIM2=10                                                         MAP4750
750   IF (IEMAP.LT.ILIM2) ILIM2=IEMAP                                  MAP4760
      WRITE (6,920) (ALE(I+3),I=ILIM1,ILIM2)                           MAP4770
      WRITE (6,970) (VALUE(I),I=ILIM1,ILIM2)                           MAP4780
      IF (IEMAP.EQ.ILIM2) GO TO 760                                    MAP4790
      ILIM1=ILIM2+1                                                    MAP4800
      ILIM2=ILIM2+10                                                   MAP4810
      GO TO 750                                                        MAP4820
760   CONTINUE                                                         MAP4830
      WRITE (6,980)                                                    MAP4840
C                                                                      MAP4850
      J=JDL                                                            MAP4860
770   K=(J-1)*IMAX+1                                                   MAP4870
C                                                                      MAP4880
      DO 830 I=1,IDL                                                   MAP4890
      K=K+1                                                            MAP4900
      IF (AMX(K).GT.0.) GO TO 780                                      MAP4910
C            *** EMPTY CELL.                                           MAP4915
      MA=1                                                             MAP4920
      GO TO 820                                                        MAP4930
780   IF (AIX(K).NE.0.) GO TO 790                                      MAP4940
C            *** ZERO INTERNAL ENERGY.                                 MAP4945
      MA=41                                                            MAP4950
      GO TO 820                                                        MAP4960
790   FLOTMA=(ALOG10(ABS(AIX(K)))-FLOAT(MINEXP))/ESCLE+3.              MAP4970
      INTMA=INT(FLOTMA)                                                MAP4980
      IF (FLOTMA.GT.FLOAT(INTMA)) GO TO 800                            MAP4990
      MA=INTMA                                                         MAP5000
      GO TO 810                                                        MAP5010
800   MA=INTMA+1                                                       MAP5020
C            *** DO NOT USE DOT AND DASH IN INTERNAL ENERGY MAP.       MAP5025
810   IF (MA.LE.3) MA=4                                                MAP5030
820   CONTINUE                                                         MAP5040
```

```
      PR(I)=ALE(MA)
830   IF (AIX(K).LT.0.) PR(I)=XUM(MA)
C             *** PRINT J-VALUE ALONG Y-AXIS WHEN IT IS A MULTIPLE OF 5.
      IF (MOD(J,5).NE.0) GO TO 840
      WRITE (6,880) J,(PR(I),I=1,IDL)
      GO TO 850
840   WRITE (6,890) (PR(I),I=1,IDL)
850   J=J-1
      IF (J.GT.0) GO TO 770
C             *** PRINT AND LABEL X-AXIS OF MAP.
      PR(1)=ALE(30)
      WRITE (6,880) J,(PR(1),I=1,IDL)
      WRITE (6,900) (I,I=0,IDL,5)
C
C
      RETURN
C
C             *** FORMATS
860   FORMAT (1H1,4X,15HCOMPRESSION    //)
870   FORMAT (16H    SYMBOL       ,20(3X,A2))
880   FORMAT (I10,2H I,54A2)
890   FORMAT (10X,2H I,54A2)
900   FORMAT (I12,10I10////)
910   FORMAT (1H1,4X,15HPRESSURE       //)
920   FORMAT (16H    SYMBOL       ,10(3X,A2,5X))
930   FORMAT (1H1,4X,15HRADIAL VELOCITY//)
940   FORMAT (1H1,4X,15HAXIAL VELOCITY //)
950   FORMAT (1H1,4X,15HINTERNAL ENERGY//)
960   FORMAT (16H  MAXIMUM VALUE ,20(F5.2))
970   FORMAT (16H  MAXIMUM VALUE ,1P10E10.2)
980   FORMAT (//)
      END
```

```
      SUBROUTINE PH1
C     ......................................................................
C
      DIMENSION AMX(2502),AIX(2502),U(2502)   ,V(2502)   ,P(2502)   ,
     1          X(52)     ,XX(54)    ,TAU(52)   ,JPM(52)   ,
     2          Y(102)    ,YY(104)   ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),    Z(150)      ,
     5          XP(26,51),YP(26,51),
     6          PL(204)   ,UL(204)   ,PR(204)   ,
     7           RSN(52),    RST(52),
     8          CMXP(5)   ,CMYP(5)   ,IJ(5)     ,JK(5)     ,
     9          DX(52)    ,DDX(54)   ,DY(102)   ,DDY(104)  ,
     $          SNB(52)   ,STB(52)   ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C             *** DIMENSIONED ARRAYS
C             *** Z-BLOCK IS SAVED ON TAPE.
      COMMON       Z
      COMMON       PK
      COMMON    YY,       XX
      COMMON    DDX,      DDY
      COMMON    AMX,      AIX,      U,      V,      P
      COMMON    TAU,      JPM
      COMMON    UL ,      PL
      COMMON    XP ,      YP,       CMXP, CMYP
C             *** NON-DIMENSIONED VARIABLES
      COMMON            AID     ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB  ,DELER  ,DELET  ,DELM   ,DTODX  ,DXYMIN,EAMMP  ,EAMPY  ,
     2E      ,ERDUMP,I      ,I3     ,IWS    ,J      ,K      ,KA     ,KB     ,
     3LL     ,MD     ,ME     ,MZT    ,NERR   ,NK     ,NPRINT,
     4NR     ,NRZ    ,NULLE  ,PIDTS  ,SIEMIN,SNR    ,SNT    ,STR    ,SOLID  ,
     5SUM    ,TESTRH,TWOPI  ,URR    ,WS     ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
C
C             *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C                 X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C             *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE           (UL,FLEFT),          (UL(103),YAMC),
     1                      (PL,GAMC,PR),        (PL(103),SIGC)
C
C             *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE           (UL,RSN),
     1                      (PL,RST),            (P,UK),
     2                      (P(157),VK),         (P(313),SNB),
     3                      (P(365),STB),        (P(417),RHO)
C
C             *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C             *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                         (Z(  1),PROB  ),(Z(  2),CYCLE ),
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```
     1(Z(   3),DT    ),(Z(   4),NUMSP ),(Z(   5),NFRELP),(Z(   6),NDUMP7), PH1 590
     2(Z(   7),ICSTOP),(Z(   8),PIDY  ), (Z(   9),TOPMU ),(Z(  10),RTMU  ), PH1 600
     3(Z(  11),STK1  ),(Z(  12),NUMREZ), (Z(  13),ETH   ),(Z(  14),UN14  ), PH1 610
     4(Z(  15),RHINIT),(Z(  16),PROJI ), (Z(  17),UN17  ),(Z(  18),XMAX  ), PH1 620
     5(Z(  19),NZ    ),(Z(  20),NREZ  ), (Z(  21),AMDM  ),(Z(  22),UVMAX ), PH1 630
     6(Z(  23),UN23  ),(Z(  24),DMIN  ), (Z(  25),JSTR  ),(Z(  26),DTNA  ), PH1 640
     7(Z(  27),CVIS  ),(Z(  28),STK2  ), (Z(  29),STEZ  ),(Z(  30),NC    ), PH1 650
     8(Z(  31),UN31  ),(Z(  32),NRC   ), (Z(  33),IMAX  ),(Z(  34),IMAXA ), PH1 660
     9(Z(  35),JMAX  ),(Z(  36),JMAXA ), (Z(  37),KMAX  ),(Z(  38),KMAXA )  PH1 670
      EQUIVALENCE                                                          PH1 680
     1(Z(  39),BOTM  ),(Z(  40),BOTMV ), (Z(  41),NUMSPT),(Z(  42),CZERO ), PH1 690
     2(Z(  43),NUMSCA),(Z(  44),PRLIM ), (Z(  45),PRDELT),(Z(  46),PRFACT)  PH1 700
      EQUIVALENCE                                                          PH1 710
     1(Z(  47),I1    ),(Z(  48),I2    ), (Z(  49),IPCYCL),(Z(  50),TSTOP ), PH1 720
     2(Z(  51),RHOFIL),(Z(  52),TARGV ), (Z(  53),N3    ),(Z(  54),IVARDY), PH1 730
     3(Z(  55),VT    ),(Z(  56),N6    ), (Z(  57),RTM   ),(Z(  58),RTMV  ), PH1 740
     4(Z(  59),UN59  ),(Z(  60),N10   ), (Z(  61),N11   ),(Z(  62),GAMMA ), PH1 750
     5(Z(  63),TOPM  ),(Z(  64),BOTMU ), (Z(  65),SN    ),(Z(  66),TOPMV ), PH1 760
     6(Z(  67),PRYBOT),(Z(  68),PRYTOP), (Z(  69),PRXRT ),(Z(  70),CYCPH3), PH1 770
     7(Z(  71),REZFCT),(Z(  72),TARGI ), (Z(  73),PROJU ),(Z(  74),BBOUND), PH1 780
     8(Z(  75),EVAP  ),(Z(  76),ECK   ), (Z(  77),NECYCL),(Z(  78),II    ), PH1 790
     9(Z(  79),JJ    ),(Z(  80),NMP   ), (Z(  81),Y2    ),(Z(  82),EZPH1 )  PH1 800
      EQUIVALENCE                                                          PH1 810
     1(Z(  83),IVARDX),(Z(  84),T     ), (Z(  85),NMPMAX),(Z(  86),PMIN  ), PH1 820
     2(Z(  87),INTER ),(Z(  88),TAYBOT), (Z(  89),TAYTOP),(Z(  90),IEMAP ), PH1 830
     3(Z(  91),MC    ),(Z(  92),MR    ), (Z(  93),MZ    ),(Z(  94),MB    )  PH1 840
      EQUIVALENCE                                                          PH1 850
     1(Z(  95),REZ   ),(Z(  96),NODUMP), (Z(  97),UN97  ),(Z(  98),UN98  ), PH1 860
     2(Z(  99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU), PH1 870
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ), PH1 880
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ), PH1 890
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ), PH1 900
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ), PH1 910
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ), PH1 920
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ), PH1 930
     9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )  PH1 940
      EQUIVALENCE                                                          PH1 950
     1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ), PH1 960
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN), PH1 970
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),PH1 980
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ), PH1 990
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )  PH11000
C                                                                       PH11010
C     ..................................................................PH11020
C                                                                       PH11030
C     END OF COMMON                                                     PH11040
C                                                                       PH11050
C     ..................................................................PH11060
C                                                                       
C              *** PH1 COMPUTES THE EFFECT OF THE PRESSURE GRADIENTS ON PH11062
C                  UPDATING THE VELOCITIES AND INTERNAL ENERGIES.       PH11064
C                                                                       PH11070
C              *** NRT AND NRC ARE USED TO ADVANCE THE ACTIVE GRID.     PH11075
      NRT=0                                                             PH11080
      NRC=0                                                             PH11090
C              *** VEL=1. FLAGS FIRST PASS. ON SECOND PASS, VEL = 0.    PH11095
      VEL=1.0                                                           PH11100
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C          *** RC = DISTANCE FROM AXIS TO CENTER OF CELL K.                 PH11102
C              RR = DISTANCE FROM AXIS TO CENTER OF CELL K+1.               PH11104
10    RC=DX(1)/2.0                                                          PH11110
      RR=RC+(DX(1)+DX(2))/2.0                                               PH11120
      K=2                                                                   PH11130
C          *** FOR ALL CELLS IN COLUMN NEXT TO AXIS, SET PRESSURE           PH11132
C              AT LEFT SIDE OF CELL = PRESSURE IN CELL, AND SET             PH11134
C              RADIAL VELOCITY AT LEFT SIDE OF CELL = 0.                    PH11136
      DO 20 J=1,JMAX                                                        PH11140
      PL(J)=P(K)                                                            PH11150
      UL(J)=0.0                                                             PH11160
20    K=K+IMAX                                                              PH11170
      DO 140 I=1,I1                                                         PH11180
      K=I+1                                                                 PH11190
C          *** DEFINE PRESSURE AND AXIAL VELOCITY AT BOTTOM                 PH11192
C              BOUNDARY OF GRID.                                            PH11194
      VBLO=V(K)                                                             PH11200
      PBLO=P(K)                                                             PH11210
C          *** IF BOTTOM BOUNDARY OF GRID IS REFLECTIVE, SET                PH11212
C              AXIAL VELOCITY AT THAT BOUNDARY = 0.                         PH11214
      IF (CVIS.GT.(-.5)) VBLO=0.                                            PH11220
      TAUDTS=TAU(I)*DT                                                      PH11230
      DO 130 J=1,I2                                                         PH11240
      N=K+IMAX                                                              PH11250
      PIDTS=1.0/(PIDY*DT*DY(J))                                             PH11260
      IF (AMX(K).LE.0.) GO TO 30                                            PH11270
      IF (I.LT.IMAX) GO TO 50                                               PH11280
C          *** FOR ALL CELLS IN LAST COLUMN OF GRID, SET PRESSURE           PH11282
C              AT RIGHT OF CELL = PRESSURE IN CELL.    COMPUTE              PH11284
C              ENERGY LOST ACROSS RIGHT BOUNDARY AND SUBTRACT IT            PH11286
C              FROM ETH, THEORETICAL ENERGY TOTAL.                          PH11288
      PRR=P(K)                                                              PH11290
      E=PRR*U(K)/PIDTS*X(I)                                                 PH11300
      ETH=ETH-E                                                             PH11310
      EOR=EOR-E                                                             PH11320
      GO TO 40                                                              PH11330
C          *** CELL K IS EMPTY                                              PH11335
30    PL(J)=0.                                                              PH11340
      UL(J)=U(K+1)*RR                                                       PH11350
      PBLO=0.                                                               PH11360
      VBLO=V(N)                                                             PH11370
      GO TO 130                                                             PH11380
40    URR=RC*U(K)                                                           PH11390
      GO TO 70                                                              PH11400
C                 *** IF CELL ON RIGHT IS EMPTY SET SPECIAL P AND U         PH11410
50    IF (AMX(K+1).GT.0.) GO TO 60                                          PH11420
      PRR=0.                                                                PH11430
      URR=U(K)*RC                                                           PH11440
      GO TO 70                                                              PH11450
60    PRR=(P(K)+P(K+1))/2.                                                  PH11460
      URR=(U(K)*RC+U(K+1)*RR)/2.                                            PH11470
70    IF (J.LT.JMAX) GO TO 80                                               PH11480
C          *** FOR ALL CELLS IN TOP ROW OF GRID, SET PRESSURE AND           PH11482
C              AXIAL VELOCITY AT TOP OF CELL = PRESSURE AND AXIAL           PH11484
C              VELOCITY IN CELL. COMPUTE ENERGY LOST ACROSS TOP             PH11486
C              BOUNDARY.                                                    PH11486
      PABOVE=P(K)                                                           PH11490
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      E=PABOVE*V(K)/2.*TAUDTS
      ETH=ETH-E
      EOT=EOT-E
      VABOVE=V(K)
      GO TO 110
C                ***  IF CELL ABOVE IS EMPTY SET SPECIAL P AND V
80    IF (AMX(N).GT.0.) GO TO 90
      PABOVE=0.
      VABOVE=V(K)
      GO TO 100
90    PABOVE=(P(K)+P(N))/2.
      VABOVE=(V(K)+V(N))/2.
100   IF (J.GT.1) GO TO 110
C            *** IF BOTTOM BOUNDARY OF GRID IS REFLECTIVE, ADD TO ETH
C                 THE ENERGY GENERATED BY PRESSURE AT THAT BOUNDARY.
      IF (CVIS.GT.-.5) GO TO 110
      E=PBLO*V(K)/2.*TAUDTS
      ETH=ETH+E
      EOB=EOB+E
110   IF (VEL.EQ.0.) GO TO 120
C            *** COMPUTE UPDATED VELOCITIES ON FIRST PASS (VEL = 1.)
      V(K)=V(K)+(PBLO-PABOVE)*TAUDTS/(AMX(K))
      U(K)=U(K)+(PL(J)-PRR)/(AMX(K))*RC/PIDTS*2.0
120   CONTINUE
C            *** AIX(X) CHANGED ON BASIS OF GRADIENTS COMPUTED IN FIRST
C                 PASS.  ON  SECOND PASS AIX(K) CHANGED AGAIN ON BASIS
C                 OF GRADIENTS CACULATED FROM THE UPDATED VELOCITIES.
      WS-(VBLO-VABOVE)*TAUDTS/2.
      WS=(UL(J)-URR)/PIDTS+WS
      WSA=AIX(K)+WS*P(K)/AMX(K)
      AIX(K)=WSA
      VBLO=VABOVE
      PL(J)=PRR
      UL(J)=URR
      PBLO=PABOVE
C            *** RC, N, RR REDEFINED FOR NEXT CELL IN ROW J.
130   K=N
      RC=RR
140   RR=(X(I+1)+X(I+2))/2.0
      IF (VEL.EQ.0.) GO TO 150
      VEL=0.0
      GO TO 10
150   DO 190 I=1,I1
      K=I+1
      DO 180 J=1,I2
C            *** SN = 0 (INPUT PARAMETER) SETS NEGATIVE INTERNAL
C                 ENERGIES TO ZERO.
      IF (AIX(K).GE.0..OR.SN.GT.0.) GO TO 170
      E=AIX(K)*AMX(K)
      ETH=ETH-E
      EZPH1=EZPH1-E
      IF (INTER.EQ.0) GO TO 160
C            *** PRINT PROPERTIES OF CELLS WHOSE NEGATIVE ENERGY IS
C                SET TO ZERO WHEN DOING INTERMEDIATE PRINTS (INTER.GT.0).
      WRITE (6,240) I,J,AMX(K),AIX(K),U(K),V(K)
160   AIX(K)=0.0
170   IF (I.NE.I1) GO TO 180
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C           *** ENLARGE ACTIVE GRID IN I-DIRECTION IF A CELL IN THE I1 PH11952
C                   COLUMN HAS NONZERO VELOCITY OR ENERGY.               PH11954
      IF (U(K).NE.0..OR.V(K).NE.0..OR.AIX(K).NE.0.) NRC=1                PH11960
180   K=K+IMAX                                                           PH11970
      LL=K-2*IMAX                                                        PH11980
C           *** ENLARGE ACTIVE GRID IN J-DIRECTION IF A CELL IN THE I2 PH11982
C                   ROW HAS NONZERO VELOCITY OR ENERGY.                  PH11984
      IF (U(LL).NE.0..OR.V(LL).NE.0..OR.AIX(LL).NE.0.) NRT=1             PH11990
190   CONTINUE                                                           PH12000
      I1=I1+NRC                                                          PH12010
      I2=I2+NRT                                                          PH12020
C           *** DONT ALLOW ACTIVE GRID TO EXCEED IMAX BY JMAX GRID.      PH12025
      IF (I1-IMAX) 210,210,200                                           PH12030
200   I1=IMAX                                                            PH12040
210   IF (I2-JMAX) 230,230,220                                           PH12050
220   I2=JMAX                                                            PH12060
230   RETURN                                                             PH12070
C                                                                        PH12080
240   FORMAT (4H PH1,2I4,4H  M=,1PE15.8,6H  SIE=,1PE15.8,4H  U=,1PE15.8,PH12090
     14H  V=,1PE15.8,18H   SIE SET TO ZERO)                              PH12100
      END                                                                PH12110-
```

```
      SUBROUTINE PH3
C     ..................................................................
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)  ,P(2502)  ,
     1          X(52)    ,XX(54)   ,TAU(52)  ,JPM(52)  ,
     2          Y(102)   ,YY(104)  ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)   ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)  ,PR(204)  ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)  ,IJ(5)    ,JK(5)    ,
     9          DX(52)   ,DDX(54)  ,DY(102)  ,DDY(104) ,
     $          SNB(52)  ,STB(52)  ,UK(52,3) ,VK(52,3) ,RHO(52,3)
C           *** DIMENSIONED ARRAYS
C           *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON    PK
      COMMON   YY,      XX
      COMMON   DDX,     DDY
      COMMON   AMX,     AIX,     U,      V,      P
      COMMON   TAU,     JPM
      COMMON   UL ,     PL
      COMMON   XP ,     YP,      CMXP, CMYP
C           *** NON-DIMENSIONED VARIABLES
      COMMON            AID    ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB ,DELER ,DELET ,DELM  ,DTODX ,DXYMIN,EAMMP ,EAMPY ,
     2E      ,ERDUMP,I     ,I3    ,IWS   ,J     ,K     ,KA    ,KB    ,
     3LL     ,MD    ,ME    ,MZT   ,NERR  ,NK    ,NPRINT,
     4NR     ,NRZ   ,NULLE ,PIDTS ,SIEMIN,SNR   ,SNT   ,STR   ,SOLID ,
     5SUM    ,TESTRH,TWOPI ,URR   ,WS    ,WSA   ,WSB   ,WSC   ,WFLAGF,
     6WFLAGL,WFLAGP
C
C           *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C               X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C           *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE           (UL,FLEFT),          (UL(103),YAMC),
     1                      (PL,GAMC,PR),        (PL(103),SIGC)
C
C           *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE           (UL,RSN),
     1                      (PL,RST),            (P,UK),
     2                      (P(157),VK),         (P(313),SNB),
     3                      (P(365),STB),        (P(417),RHO)
C
C           *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C           *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                         (Z(  1),PROB  ),(Z(  2),CYCLE ),
```

```
     1(Z(  3),DT     ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
     2(Z(  7),ICSTOP),(Z(  8),PIDY   ), (Z(  9),TOPMU ),(Z( 10),RTMU   ),
     3(Z( 11),STK1   ),(Z( 12),NUMREZ), (Z( 13),ETH    ),(Z( 14),UN14   ),
     4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17   ),(Z( 18),XMAX   ),
     5(Z( 19),NZ     ),(Z( 20),NREZ  ), (Z( 21),AMDM   ),(Z( 22),UVMAX ),
     6(Z( 23),UN23   ),(Z( 24),DMIN  ), (Z( 25),JSTR   ),(Z( 26),DTNA   ),
     7(Z( 27),CVIS   ),(Z( 28),STK2  ), (Z( 29),STEZ   ),(Z( 30),NC     ),
     8(Z( 31),UN31   ),(Z( 32),NRC   ), (Z( 33),IMAX   ),(Z( 34),IMAXA ),
     9(Z( 35),JMAX   ),(Z( 36),JMAXA ), (Z( 37),KMAX   ),(Z( 38),KMAXA )
      EQUIVALENCE
     1(Z( 39),BOTM   ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
     2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
      EQUIVALENCE
     1(Z( 47),I1     ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3     ),(Z( 54),IVARDY),
     3(Z( 55),VT     ),(Z( 56),N6    ), (Z( 57),RTM    ),(Z( 58),RTMV  ),
     4(Z( 59),UN59   ),(Z( 60),N10   ), (Z( 61),N11    ),(Z( 62),GAMMA ),
     5(Z( 63),TOPM   ),(Z( 64),BOTMU ), (Z( 65),SN     ),(Z( 66),TOPMV ),
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
     8(Z( 75),EVAP   ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II     ),
     9(Z( 79),JJ     ),(Z( 80),NMP   ), (Z( 81),Y2     ),(Z( 82),EZPH1 )
      EQUIVALENCE
     1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
     3(Z( 91),MC     ),(Z( 92),MR    ), (Z( 93),MZ     ),(Z( 94),MB     )
      EQUIVALENCE
     1(Z( 95),REZ    ),(Z( 96),NODUMP), (Z( 97),UN97   ),(Z( 98),UN98  ),
     2(Z( 99),UN99   ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL    ),(Z(106),STL    ),
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB    ),
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES   ),
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
     9(Z(127),SS1    ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4    )
      EQUIVALENCE
     1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT    ),(Z(134),EOB    ),
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF    ),(Z(138),RHOMIN),
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT   ),
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB   )
C
C     ..................................................................
C
C     END OF COMMON
C
C     ..................................................................
      DX(0)=-DX(1)
      DY(0)=-DY(1)
C
C            *** TURN ON R-P TREATMENT WHEN ACTIVE-GRID REACHES JSTR
      IF (I2.LT.JSTR) GO TO 400
C            *** TURN OFF JSTR
      JSTR=0
      PW=0.
C            *** USE P-STORAGE FOR U,V,SIE BEING CALC.
```

```
      DO 10 K=2,KMAX
10    P(K)=0.
C           *** CALCULATE SUBCYCLE DT
      ICP3 = INT(CYCPH3)
C           *** CALCULATE FACTOR FOR VARIABLE DT
      N=ICP3*(ICP3+1)
      DTFACT=2./FLOAT(N)
C           *** LOOP THRU SUBCYCLES
      DO 380 NN=1,ICP3
C           *** DECREASING DT
      WS=ICP3-NN+1
      DTSTR=WS*DTFACT*DT
C
C           *** INITIALIZE UK,VK FOR ROW1,2 AND BORDER BELOW
C           *** NOTE THAT THESE ARE STORED WITH AN EXTRA CELL TO
C               RIGHT AND LEFT OF MESH. SO K = 2 IS AXIS CELL.
C
      VFACT=-1.
C           ***     IF REFLECTIVE,PUT NEG. V IN BORDER CELLS
      IF (CVIS.LT.0.) VFACT=1.
C           *** BUT IF TRANS., USE V
      NKB=1
      NK=2
      NKA=3
C           *** SET LIMITS USED IN PH3
      M=I1+1
      LL=I1-1
      DO 20 K=2,M
      L=K+IMAX
      I=K-1
C           *** SET VALUES ADJOINING BOTTOM ROW
      RHO(K,NK)=AMX(K)/(TAU(I)*DY(1))
      RHO(K,NKB)=RHO(K,NK)
      RHO(K,NKA)=AMX(L)/(TAU(I)*DY(2))
      UK(K,NK)=U(K)
      UK(K,NKB)=U(K)
      UK(K,NKA)=U(L)
      VK(K,NK)=V(K)
      VK(K,NKB)=V(K)*VFACT
20    VK(K,NKA)=V(L)
C           *** BORDER CELL TO LEFT
      DO 30 N=1,3
      RHO(1,N)=RHO(2,N)
      UK(1,N)=UK(2,N)
30    VK(1,N)=VK(2,N)
C           *** SNB AND STB HAVE BEEN SET TO 0. BY SETTING ALL
C               P STORAGE TO 0.
C           *** SET NORMAL STRESSES ON BOTTOM IF REFLECTIVE
      IF (CVIS.LT.0.) GO TO 100
      IF (IMAX.GT.1) GO TO 40
C           ***IMAX=1
      WSA=1.-AIX(2)/STEZ
      IF (WSA.LT.0) WSA=0.
      WSB=AMX(2)/(TAU(1)*DY(1)*RHOZ)-1.
      STRENG=(CZERO+WSB*(STK1+WSB*STK2))*WSA
      IF (STRENG.LT.0.) STRENG=0.
      SNB(2)=STRENG*SQRT(2)*ABS(V(2))/V(2)
```

```
      GO TO 100
C
C           ***PUT IWS = RIGHT BOUNDARY OF JPM ARRAY
40    IWS=1
      DO 50 I=1,IMAX
      IF (JPM(I).EQ.0) GO TO 60
      IWS=IWS+1
50    CONTINUE
C
60    DO 90 K=2,IWS
      WSA=.5*DX(K)+DX(K-1)+.5*DX(K-2)
      DUODX=(U(K+1)-U(K-1))/WSA
      DVODX=(V(K+1)-V(K-1))/WSA
      DVODY=2*V(K)/DY(1)
      UOX=2*U(K)/(X(K-1)+X(K-2))
      WSA=DUODX+DVODY+UOX
      THO3=WSA/3.
      WS=DUODX**2+DVODY**2+UOX**2+.5*(DVODX**2)-THO3*WSA
      IF (WS.LE.0.) GO TO 70
      WSA=1.-AIX(K)/STEZ
      IF (WSA.LT.0.) WSA=0.
      WSB=AMX(K)/(TAU(K-1)*DY(1)*RHOZ)-1.
      STRENG=(CZERO+WSB*(STK1+WSB*STK2))*WSA
      IF (STRENG.LT.0.) STRENG=0.
      B=STRENG*SQRT(2./WS)
      GO TO 80
70    B=0.
80    SNB(K)=B*(DVODY-THO3)
90    CONTINUE
100   L=I2-1
C           *** DO ROWS
      DO 370 J=1,L
      K=(J-1)*IMAX+2
C           *** STRESS AT AXIS =0.
      SNL=0.
      STL=0.
C           *** LOOP ON CELLS ACROSS ROW
      DO 330 I=1,LL
      IK=I+1
C           *** IF NOT SOLID, SKIP STRESS CALCULATION
      IF (RHO(IK,NK).LT.SOLID) GO TO 170
C           *** IF ABOVE JPM(I)+1 WE ARE DONE WITH THIS ROW UNLESS ALSO
C                 BELOW JPM(I-1)
      JFLAG=0
      IF (J.LE.JPM(I)+1) GO TO 110
      IF (I.EQ.1) GO TO 340
      IF (J.GT.JPM(I-1)) GO TO 340
      JFLAG=1
C           *** CALCULATE STRENGTH
110   WSA=1.-AIX(K)/STEZ
      IF (WSA.LT.0.) GO TO 170
      WSB=RHO(IK,NK)/RHOZ-1.
      STRENG=(CZERO+WSB*(STK1+WSB*STK2))*WSA
      IF (STRENG.LT.0.) GO TO 170
C
C     ..................................................................
C                 *** HOOP STRESS***
```

```
C     ...................................................................
      HOOP=0.
      IF (J.EQ.JPM(I)+1.OR.JFLAG.EQ.1) GO TO 170
C           *** SKIP HOOP AND RT CALC IF 1-D
      IF (IMAX.EQ.1) GO TO 140
C           *** DIFFERENCES ARE CENTERED AT CELL-CENTER
      UOX=UK(IK,NK)/(X(I)+X(I-1))*2.
      WS=1./(.5*DX(I+1)+DX(I)+.5*DX(I-1))
      DUODX=(UK(IK+1,NK)-UK(IK-1,NK))*WS
      DVODX=(VK(IK+1,NK)-VK(IK-1,NK))*WS
      WS=1./(.5*DY(J+1)+DY(J)+.5*DY(J-1))
      DUODY=(UK(IK,NKA)-UK(IK,NKB))*WS
      DVODY=(VK(IK,NKA)-VK(IK,NKB))*WS
      ASSIGN 120 TO LOCA
      GO TO 240
C          *** CALCULATED THO3,B
120   HOOP=B*(UOX-THO3)
C     ...................................................................
C     ......*** END OF HOOP CALC.
C     ...................................................................
C           *** IF THE CELL ON RIGHT IS NOT SOLID, STRESSES ARE ZERO
      IF (RHO(IK+1,NK).LT.SOLID.OR.IK.EQ.LL) GO TO 140
C           *** DIFFERENCES ARE CENTERED AT RIGHT EDGE OF CELL
      WS=2./(DX(I)+DX(I+1))
      DUODX=(UK(IK+1,NK)-UK(IK,NK))*WS
      DVODX=(VK(IK+1,NK)-VK(IK,NK))*WS
      WS=1./(DY(J+1)+2.*DY(J)+DY(J-1))
      DUODY=(UK(IK,NKA)+UK(IK+1,NKA)-UK(IK,NKB)-UK(IK+1,NKB))*WS
      DVODY=(VK(IK,NKA)+VK(IK+1,NKA)-VK(IK,NKB)-VK(IK+1,NKB))*WS
      UOX=(UK(IK+1,NK)+UK(IK,NK))/X(I)*.5
C
      ASSIGN 130 TO LOCA
C           *** CALC. THO3 AND B
      GO TO 240
130   SNR=B*(DUODX-THO3)
      STR=B*(DUODY+DVODX)*.5
      GO TO 150
140   SNR=0.
      STR=0.
C                   *** IF THE CELL ABOVE IS NOT SOLID, STRESSES ABOVE ARE
150   IF (RHO(IK,NKA).LT.SOLID.OR.J.EQ.L) GO TO 180
C
C           *** DIFFERENCES ARE CENTERED AT TOP EDGE OF CELL
      WS=2./(DY(J+1)+DY(J))
      DUODY=(UK(IK,NKA)-UK(IK,NK))*WS
      DVODY=(VK(IK,NKA)-VK(IK,NK))*WS
      WS=1./(DX(I+1)+2.*DX(I)+DX(I-1))
      DUODX=(UK(IK+1,NK)+UK(IK+1,NKA)-UK(IK-1,NK)-UK(IK-1,NKA))*WS
      DVODX=(VK(IK+1,NK)+VK(IK+1,NKA)-VK(IK-1,NK)-VK(IK-1,NKA))*WS
      UOX=(UK(IK,NKA)+UK(IK,NK))/(X(I)+X(I-1))
      ASSIGN 160 TO LOCA
      GO TO 240
160   SNT=B*(DVODY-THO3)
      STT=B*(DUODY+DVODX)*.5
      GO TO 190
170   SNR=0.
      STR=0.
```

```
180   SNT=0.
      STT=0.
      IF (AMX(K).GT.0.) GO TO 190
      GO TO 230
190   IF (INTER.NE.99) GO TO 200
      WRITE (6,410) I,J,IK,NKB,NK,NKA,HOOP,SNL,STL,SNR,STR,STRENG,SNB(IK
     1),STB(IK),SNT,STT
C                 *** ALL STRESSES ON CELL K HAVE BEEN CALCULATED. NOW T
C           ***   NEW VALUES OF U,V, AND S.I.E. CAN BE DETERMINED.
200   SNLX=SNL*X(I-1)
      WS=TWOPI*DTSTR/AMX(K)
      IF (IMAX.EQ.1) GO TO 210
      DELU=WS*(DY(J)*(SNR*X(I)-SNLX)+TAU(I)/TWOPI*(STT-STB(IK))-HOOP*DX(
     1I)*DY(J))
210   STLX=STL*X(I-1)
      DELV=WS*((SNT-SNB(IK))*TAU(I)/TWOPI+DY(J)*(STR*X(I)-STLX))
C
C                 *** NOW CALC. CHANGE OF ENERGY
C           *** UKT AND VKT ARE TEMPORARY STORAGE
      UKT=UK(IK,NK)
      VKT=VK(IK,NK)
      WS=TAU(1)*.5*(((UKT+UK(IK,NKA))*STT+(VKT+VK(IK,NKA))*SNT)-((UKT+UK
     1(IK,NKB))*STB(IK)+(VKT+VK(IK,NKB))*SNB(IK)))
      WSA=PIDY*DY(J)*(X(I)*((UK(IK+1,NK)+UKT)*SNR+(VK(IK+1,NK)+VKT)*STR)
     1-(X(I-1)*((UKT+UK(IK-1,NK))*SNL+(VKT+VK(IK-1,NK))*STL)))
      WSB=(WSA+WS)/AMX(K)*DTSTR
      WSC=DELU*(UKT+DELU/2.)+DELV*(VKT+DELV/2.)
      DELI=WSB-WSC
      IF (INTER.NE.99) GO TO 220
      WRITE (6,420) I,J,IK,DELU,DELV,DELI
220   U(K)=U(K)+DELU
      V(K)=V(K)+DELV
      AIX(K)=AIX(K)+DELI

      BBOUND=BBOUND+DELI*AMX(K)
C           *** CELL K IS DONE. MOVE TOP TO BOTTOM AND RIGHT TO LEFT
230   SNB(IK)=SNT
      STB(IK)=STT
      SNL=SNR
      STL=STR
      GO TO 280
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C           *** CALCULATE THO3 AND B
C
240   WSA=DUODX+DVODY+UOX
      THO3=WSA/3.
      WS=DUODX**2+DVODY**2+UOX**2+.5*(DUODY+DVODX)**2-THO3*WSA
      IF (WS.LE.0.) GO TO 250
      B=STRENG*SQRT(2./WS)
      GO TO 260
250   B=0.
260   IF (INTER.NE.99) GO TO 270
      WRITE (6,430) DUODX,DVODY,UOX,THO3,DUODY,DVODX,WS,B,LOCA
C
270   GO TO LOCA, (130,160,120)
C
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

```
C                END OF THO3 AND B CALCULATION
C   - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - -- - --
C
280   IF (INTER.NE.99) GO TO 330
      E=0.
      DO 290 LJD=2,KMAX
      E=E+AMX(LJD)*(.5*(U(LJD)**2+V(LJD)**2)+AIX(LJD))
290   CONTINUE
      WRITE (6,440) I,J,E
      DO 300 LJD=2,IK
      UBAR=.5*(UK(LJD,NK)+UK(LJD,NKA))
      VBAR=.5*(VK(LJD,NK)+VK(LJD,NKA))
300   E=E-TAU(LJD-1)*(UBAR*STB(LJD)+VBAR*SNB(LJD))*DTSTR
      IKK=IK+1
      DO 310 LJD=IKK,I1
      IF (J.GT.JPM(LJD-2)) GO TO 320
      UBAR=.5*(UK(LJD,NK)+UK(LJD,NKB))
      VBAR=.5*(VK(LJD,NK)+VK(LJD,NKB))
310   E=E-TAU(LJD-1)*(UBAR*STB(LJD)+VBAR*SNB(LJD))*DTSTR
320   UBAR=.5*(UK(IK+1,NK)+UK(IK,NK))
      VBAR=.5*(VK(IK+1,NK)+VK(IK,NK))
      E=E-TWOPI*DY(J)*X(I)*(UBAR*SNL+VBAR*STL)*DTSTR
      WRITE (6,440) I,J,E
      PW=PW+DELI*AMX(K)
      WRITE (6,450) PW
330   K=K+1
C                *** END OF LOOP ON I
C            *** MOVE NK-POINTERS AND STORE A NEW ROW OF VELOCITIES
340   IF (J.EQ.L) GO TO 370
      NKA=NKA+1
      NK=NK+1
      NKB=NKB+1
      IF (NKA.GT.3) NKA=1
      IF (NK.GT.3) NK=1
      IF (NKB.GT.3) NKB=1
      K=(J+1)*IMAX+2
      DO 350 I=1,I1
      IK=I+1
      UK(IK,NKA)=U(K)
      VK(IK,NKA)=V(K)
      RHO(IK,NKA)=AMX(K)/(TAU(I)*DY(J+1))
350   K=K+1
C                *** END LOOP
      IF (IMAX.NE.1) GO TO 360
      UK(3,NKA)=UK(2,NKA)
      VK(3,NKA)=VK(2,NKA)
      RHO(3,NKA)=RHO(2,NKA)
C
360   UK(1,NKA)=UK(2,NKA)
      VK(1,NKA)=VK(2,NKA)
      RHO(1,NKA)=RHO(2,NKA)
C                *** END OF J-LOOP
370   CONTINUE
C                *** END OF RIGID-PLASTIC CALCULATION FOR ONE DTSTR
380   CONTINUE
      DO 390 K=2,KMAX
390   P(K)=0.
```

```
400   RETURN                                                                    PH34000
C                                                                               PH34010
410   FORMAT (/6I5,/7H  HOOP=,1PE12.6,7H  SNL =,1PE12.6,7H  STL =,1PE12.PH34020
     16,7H  SNR =,1PE12.6,7H  STR =,1PE12.6,/7HSTRENG=,1PE12.6,7H  SNB =PH34030
     2,1PE12.6,7H  STB =,1PE12.6,7H  SNT =,1PE12.6,7H  STT =,1PE12.6/)  PH34040
420   FORMAT (/3I5,/7H  DELU=,1PE12.6,7H  DELV=,1PE12.6,7H  DELI=,1PE12.PH34050
     16/)                                                                       PH34060
430   FORMAT (7H DUODX=,1PE12.6,7H DVODY=,1PE12.6,7H  UOX =,1PE12.6,7H TPH34070
     1HO3 =,1PE12.6,/7H DUODY=,1PE12.6,7H DVODX=,1PE12.6,7H WS   =,1PE12PH34080
     2.6,7H  B    =,1PE12.6,I7)                                             PH34090
440   FORMAT (4X,2HI=I2,4X,2HJ=I2,4X,2HE=1PE13.7)                              PH34100
450   FORMAT (4X,3HPW=1PE12.6)                                                  PH34110
      END                                                                       PH34120-
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```
      SUBROUTINE PH2
C     ..................................................................
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)  ,P(2502)   ,
     1          X(52)    ,XX(54)   ,TAU(52)  ,JPM(52)  ,
     2          Y(102)   ,YY(104)  ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)   ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)  ,PR(204)  ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)  ,IJ(5)    ,JK(5)    ,
     9          DX(52)   ,DDX(54)  ,DY(102)  ,DDY(104) ,
     S          SNB(52)  ,STB(52)  ,UK(52,3) ,VK(52,3) ,RHO(52,3)
C           *** DIMENSIONED ARRAYS
C           *** Z-BLOCK IS SAVED ON TAPE.
      COMMON     Z
      COMMON    PK
      COMMON  YY,      XX
      COMMON  DDX,     DDY
      COMMON  AMX,     AIX,     U,      V,      P
      COMMON  TAU,     JPM
      COMMON  UL ,     PL
      COMMON  XP ,     YP,      CMXP, CMYP
C           *** NON-DIMENSIONED VARIABLES
      COMMON           AID     ,AMMV    ,AMMY    ,AMPY    ,AMUR    ,AMUT    ,AMVR    ,
     1AMVT    ,DELEB  ,DELER  ,DELET  ,DELM    ,DTODX  ,DXYMIN,EAMMP  ,EAMPY  ,
     2E       ,ERDUMP,I       ,I3      ,IWS     ,J      ,K      ,KA     ,KB     ,
     3LL      ,MD     ,ME     ,MZT     ,NERR    ,NK     ,NPRINT,
     4NR      ,NRZ    ,NULLE  ,PIDTS  ,SIEMIN,SNR    ,SNT    ,STR    ,SOLID ,
     5SUM     ,TESTRH,TWOPI  ,URR     ,WS      ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
C
C           *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C               X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C           *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE           (UL,FLEFT),          (UL(103),YAMC),
     1                      (PL,GAMC,PR),        (PL(103),SIGC)
C
C           *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE           (UL,RSN),
     1                      (PL,RST),            (P,UK),
     2                      (P(157),VK),         (P(313),SNB),
     3                      (P(365),STB),        (P(417),RHO)
C
C           *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C           *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                         (Z(   1),PROB   ),(Z(   2),CYCLE ),
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     1(Z(  3),DT     ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
     2(Z(  7),ICSTOP),(Z(  8),PIDY   ), (Z(  9),TOPMU ),(Z( 10),RTMU   ),
     3(Z( 11),STK1   ),(Z( 12),NUMREZ), (Z( 13),ETH    ),(Z( 14),UN14   ),
     4(Z( 15),RHINIT),(Z( 16),PROJI  ), (Z( 17),UN17   ),(Z( 18),XMAX   ),
     5(Z( 19),NZ     ),(Z( 20),NREZ   ), (Z( 21),AMDM   ),(Z( 22),UVMAX ),
     6(Z( 23),UN23   ),(Z( 24),DMIN   ), (Z( 25),JSTR   ),(Z( 26),DTNA   ),
     7(Z( 27),CVIS   ),(Z( 28),STK2   ), (Z( 29),STEZ   ),(Z( 30),NC     ),
     8(Z( 31),UN31   ),(Z( 32),NRC    ), (Z( 33),IMAX   ),(Z( 34),IMAXA ),
     9(Z( 35),JMAX   ),(Z( 36),JMAXA ), (Z( 37),KMAX   ),(Z( 38),KMAXA )
      EQUIVALENCE
     1(Z( 39),BOTM   ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
     2(Z( 43),NUMSCA),(Z( 44),PRLIM  ), (Z( 45),PRDELT),(Z( 46),PRFACT)
      EQUIVALENCE
     1(Z( 47),I1     ),(Z( 48),I2     ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3     ),(Z( 54),IVARDY),
     3(Z( 55),VT     ),(Z( 56),N6     ), (Z( 57),RTM    ),(Z( 58),RTMV   ),
     4(Z( 59),UN59   ),(Z( 60),N10    ), (Z( 61),N11    ),(Z( 62),GAMMA ),
     5(Z( 63),TOPM   ),(Z( 64),BOTMU ), (Z( 65),SN     ),(Z( 66),TOPMV ),
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
     8(Z( 75),EVAP   ),(Z( 76),ECK    ), (Z( 77),NECYCL),(Z( 78),II     ),
     9(Z( 79),JJ     ),(Z( 80),NMP    ), (Z( 81),Y2     ),(Z( 82),EZPH1 )
      EQUIVALENCE
     1(Z( 83),IVARDX),(Z( 84),T      ), (Z( 85),NMPMAX),(Z( 86),PMIN   ),
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
     3(Z( 91),MC     ),(Z( 92),MR     ), (Z( 93),MZ     ),(Z( 94),MB     )
      EQUIVALENCE
     1(Z( 95),REZ    ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98   ),
     2(Z( 99),UN99   ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL    ),(Z(106),STL    ),
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
     6(Z(115),RHOZ  ),(Z(116),ESA    ), (Z(117),ESEZ  ),(Z(118),ESB    ),
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES   ),
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
     9(Z(127),SS1    ),(Z(128),SS2    ), (Z(129),UMIN  ),(Z(130),SS4    )
      EQUIVALENCE
     1(Z(131),PRTIME),(Z(132),EOR    ), (Z(133),EOT    ),(Z(134),EOB    ),
     2(Z(135),EMOR  ),(Z(136),DXF    ), (Z(137),DYF    ),(Z(138),RHOMIN),
     3(Z(139),STAB), (Z(140  XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
     4(Z(143),STT    ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT   ),
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C           *** SPECIAL EQUIVALENCE FOR PH2
      EQUIVALENCE (WSOUT,UOTK)
C
C     ..................................................................
C
C     END OF COMMON
C
C     ..................................................................
C
      SUME=0.
C           *** ARE TRACER POINTS BEING GENERATED
      IF (Y2.GT.(-1.)) GO TO 260
C           *** YES. CALCULATE NEW POSITIONS OF POINTS IN ACTIVE GRID.
      DO 250 J=1,JJ
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      DO 250 I=1,II                                                    PH21120
      IF (XP(I,J).LE.0.) GO TO 250                                     PH21130
      IX=XP(I,J)                                                       PH21140
      IY=YP(I,J)                                                       PH21150
      IF (IX.GT.I1) GO TO 250                                          PH21160
      IF (IY.GT.I2) GO TO 250                                          PH21170
      K=IY*IMAX+IX+2                                                   PH21180
C           *** SKIP CALCULATION IF POINT IS IN EMPTY CELL             PH21190
C               (AHEAD OF THE MASS IT REPRESENTS).                     PH21195
      IF (AMX(K).EQ.0.) GO TO 250                                      PH21200
C           *** FRX AND FRY GIVE LOCATION OF TRACER POINT IN           PH21202
C               CELL(IX+1,IY+1).                                       PH21204
      FRX=XP(I,J)-AINT(XP(I,J))                                        PH21210
      FRY=YP(I,J)-AINT(YP(I,J))                                        PH21220
C                                                                      PH21230
C           *** IWS=1 FLAGS TRACER POINTS IN CELLS ON RIGHT OR         PH21230
C                     LEFT BOUNDARY OF GRID.                           PH21232
C               IWS=2 FLAGS TRACER POINTS IN CELLS ON TOP OR           PH21234
C                     BOTTOM BOUNDARY OF GRID.                         PH21236
C               IWS=0 FLAGS TRACER POINTS IN CELLS WHICH ARE NOT       PH21240
C                     ON A GRID BOUNDARY.                              PH21245
      IWS=0                                                            PH21250
C           *** SEE IF TRACER POINT IS IN A BOUNDARY CELL.             PH21255
      IF (IX.LT.1) GO TO 130                                           PH21260
      IF (IX.GT.IMAX-2) GO TO 110                                      PH21270
      IF (IY.LT.1) GO TO 160                                           PH21280
      IF (IY.GT.JMAX-2) GO TO 140                                      PH21290
C           *** NOT IN BOUNDARY CELL. IS POINT ON LEFT SIDE OF CELL    PH21295
10    IF (FRX.LT..5) GO TO 40                                          PH21300
C           *** POINT IS ON RIGHT SIDE OF CELL. IS CELL ON RIGHT EMPTY PH21305
20    IF (AMX(K+1).EQ.0.) GO TO 30                                     PH21310
C           *** RADIAL COMPONENT BASED ON AVERAGE OF RADIAL VELOCITIES PH21312
C               OF CELL K AND CELL ON RIGHT OR LEFT.                   PH21314
      UEFF=(FRX-.5)*U(K+1)+(1.5-FRX)*U(K)                              PH21320
      GO TO 50                                                         PH21330
C           *** CELL ON RIGHT OR LEFT EMPTY-USE RADIAL COMPONENT       PH21342
C               OF CELL K.                                             PH21344
30    UEFF=U(K)                                                        PH21340
      GO TO 50                                                         PH21350
C           *** POINT IS ON LEFT SIDE OF CELL. IS CELL ON LEFT EMPTY   PH21355
40    IF (AMX(K-1).EQ.0.) GO TO 30                                     PH21360
C           *** RADIAL COMPONENT BASED ON AVERAGE OF TWO CELLS.        PH21365
      UEFF=(.5-FRX)*U(K-1)+(.5+FRX)*U(K)                               PH21370
C           *** WHEN IWS = 2 AXIAL COMPONENT OF CELL HAS ALREADY BEEN  PH21372
C               CALCULATED.                                            PH21374
50    IF (IWS.GT.1) GO TO 100                                          PH21380
C           *** IS POINT IN BOTTOM HALF OF CELL                        PH21385
60    IF (FRY.LT..5) GO TO 90                                          PH21390
C           *** POINT IS IN TOP HALF. IS CELL ABOVE EMPTY              PH21395
70    KA=K+IMAX                                                        PH21400
      IF (AMX(KA).EQ.0.) GO TO 80                                      PH21410
C           *** AXIAL COMPONENT BASED ON AVERAGE OF AXIAL VELOCITIES   PH21412
C               OF CELL K AND CELL ABOVE OR BELOW.                     PH21414
      VEFF=(FRY-.5)*V(KA)+(1.5-FRY)*V(K)                               PH21420
      GO TO 100                                                        PH21430
C           *** CELL ABOVE OR BELOW IS EMPTY. USE AXIAL COMPONENT OF   PH21432
C               CELL K.                                                PH21434
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80    VEFF=V(K)                                                         PH21440
      GO TO 100                                                         PH21450
90    KA=K-IMAX                                                         PH21460
      IF (AMX(KA).EQ.0.) GO TO 80                                       PH21470
      VEFF=(.5-FRY)*V(KA)+(.5+FRY)*V(K)                                 PH21480
C         *** IX+1 IS I-INDEX AND IY+1 IS J-INDEX OF CELL TRACER        PH21482
C              POINT IS IN. COMPUTE NEW LOCATION OF TRACER POINT.       PH21484
100   DTODX=DT/DX(IX+1)                                                 PH21490
      XP(I,J)=XP(I,J)+UEFF*DTODX                                        PH21500
      DTODY=DT/DY(IY+1)                                                 PH21510
      YP(I,J)=YP(I,J)+VEFF*DTODY                                        PH21520
C         ***IWS.LT.1 MEANS TRACER POINT WAS NOT IN BOUNDARY CELL       PH21522
C              BEFORE BEING MOVED, AND ITS  NEW  POSITION NEED NOT      PH21524
C              BE CHECKED - GO TO END OF LOOP.                          PH21526
      IF (IWS.LT.1) GO TO 250                                           PH21530
      GO TO 200                                                         PH21540
C         *** POINT IN CELL ON RIGHT BOUNDARY.                          PH21542
110   IF (FRX.LT..5) GO TO 40                                           PH21550
      IWS=1                                                             PH21560
      UEFF=U(K)                                                         PH21570
C         *** IS POINT IN CELL ON BOTTOM BOUNDARY                       PH21575
120   IF (IY.LT.1) GO TO 170                                            PH21580
C         *** IS POINT IN CELL ON TOP BOUNDARY                          PH21585
      IF (IY.GT.JMAX-2) GO TO 190                                       PH21590
      GO TO 60                                                          PH21600
C         *** POINT IN CELL ON AXIS.                                    PH21605
130   IF (FRX.GT..5) GO TO 20                                           PH21610
      IWS=1                                                             PH21620
      UEFF=2.*FRX*U(K)                                                  PH21630
      GO TO 120                                                         PH21640
C         *** POINT IN CELL ON TOP BOUNDARY.                            PH21645
140   IF (FRY.LT..5) GO TO 10                                           PH21650
      IWS=2                                                             PH21660
150   VEFF=V(K)                                                         PH21670
      GO TO 10                                                          PH21680
C         *** POINT IN CELL ON BOTTOM BOUNDARY. RADIAL COMPONENT        PH21682
C              HAS NOT BEEN COMPUTED.                                   PH21684
160   IF (FRY.GT..5) GO TO 10                                           PH21690
      IWS=2                                                             PH21700
      IF (CVIS.LT.0.) GO TO 150                                         PH21710
      VEFF=2.*FRY*V(K)                                                  PH21720
      GO TO 10                                                          PH21730
C         *** POINT IN CELL ON BOTTOM BOUNDARY.   XIAL COMPONENT        PH21732
C              HAS BEEN COMPUTED.                                       PH21734
170   IF (FRY.GT..5) GO TO 70                                           PH21740
C         *** COMPUTE AXIAL COMPONENT ON BASIS OF BOTTOM BOUNDARY       PH21742
C              CONDITION.                                               PH21744
      IF (CVIS.LT.0.) GO TO 180                                         PH21750
C         *** REFLECTIVE.                                               PH21755
      VEFF=2.*FRY*V(K)                                                  PH21760
      GO TO 100                                                         PH21770
C         *** TRANSMITTIVE.                                             PH21775
180   VEFF=V(K)                                                         PH21780
      GO TO 100                                                         PH21790
C         *** POINT IN CELL ON TOP BOUNDARY.                            PH21795
190   IF (FRY.LT..5) GO TO 90                                           PH21800
      GO TO 180                                                         PH21810
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C             *** SPECIAL TESTS FOR TRACER POINTS WHICH WERE IN               PH21812
C                 BOUNDARY CELLS BEFORE BEING MOVED.                           PH21814
C             *** IF POINT MOVED BELOW GRID, TEST ON BOTTOM BOUNDARY          PH21816
C                 CONDITION, IF REFLECTIVE MOVE POINT BACK INTO GRID,         PH21818
C                 IF TRANSMITTIVE SET X-COORDINATE TO -1.                     PH21819
 200    IF (YP(I,J).LT.0.) GO TO 220                                          PH21820
C             *** IF POINT CROSSED TOP BOUNDARY SET ITS X-COORDINATE          PH21822
C                 TO -1.                                                      PH21824
        IF (INT(YP(I,J)).LT.JMAX) GO TO 230                                   PH21830
 210    XP(I,J)=-1.                                                           PH21840
        GO TO 250                                                             PH21850
 220    IF (CVIS.LT.0.) GO TO 210                                             PH21860
C             *** REFLECTIVE.                                                 PH21865
        YP(I,J)=-YP(I,J)                                                      PH21870
C             *** ADJUST X-COORDINATE IF ITS CALCULATED POSITION IS           PH21872
C                 NEGATIVE.                                                   PH21874
 230    IF (XP(I,J).LT.0.) GO TO 240                                          PH21880
C             *** IF POINT CROSSED RIGHT BOUNDARY SET ITS X-COORDINATE        PH21882
C                 TO -1.                                                      PH21884
        IF (INT(XP(I,J)).LT.IMAX) GO TO 250                                   PH21890
        GO TO 210                                                             PH21900
 240    XP(I,J)=-XP(I,J)                                                      PH21910
C             *** END OF LOOP FOR TRACER POINT MOVEMENT.                      PH21915
 250    CONTINUE                                                              PH21920
C
C             *** SET TO ZERO ACTIVE GRID AND REZONE FLAGS.                   PH21925
 260    NRT=0                                                                 PH21930
        NRC=0                                                                 PH21940
        REZ=0.0                                                               PH21950
        PIDTS=1.0/(PIDY*DT)                                                   PH21960
        TWOPDT=2./PIDTS                                                       PH21970
        K=2                                                                   PH21980
C             *** CALCULATE FLUXES ON LEFT SIDE OF CELLS IN AXIS COLUMN.      PH21985
        DO 310 J=1,JMAX                                                       PH21990
        IF (AMX(K).LE.0.) GO TO 270                                           PH22000
        IF (U(K).LT.0.) GO TO 280                                             PH22010
 270    FLEFT(J)=0.                                                           PH22020
        GO TO 300                                                             PH22030
 280    GAMC(J)=AMX(K)*U(K)*DT/DX(1)                                          PH22040
        IF ((GAMC(J)+AMX(K)).GE.0.) GO TO 290                                 PH22050
        GAMC(J)=-AMX(K)                                                       PH22060
 290    FLEFT(J)=2.*GAMC(J)*U(K)/SS2                                          PH22070
 300    GAMC(J)=0.                                                            PH22080
        YAMC(J)=0.                                                            PH22090
        SIGC(J)=0.                                                            PH22100
 310    K=K+IMAX                                                              PH22110
C             *** DO LOOP IN I-DIRECTION - MOVE UP COLUMNS - SPECIAL          PH22112
C                 TREATMENT FOR FLUXES AT BOTTOM BOUNDARY OCCURS BEFORE       PH22114
C                 J-LOOP BEGINS.                                              PH22116
        DO 1150 I=1,I1                                                        PH22120
        J=1                                                                   PH22130
        K=I+1                                                                 PH22140
 315    IF(AMX(K)) 1220, 330, 320                                             PH22150
 320    IF (-V(K).GT.UMIN) GO TO 340                                          PH22160
 330    AMMV=0.0                                                              PH22170
        GO TO 390                                                             PH22180
 340    AMMY=AMX(K)*V(K)*DT/DY(J)                                             PH22190
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      IF (AMMY+AMX(K)) 350,360,360
350   AMMY=-AMX(K)
360   IF (CVIS) 370,380,380
C           *** BOTTOM BOUNDARY IS TRANSMITTIVE, MATERIAL IS MOVING
C                 OUT, REMOVE ITS ENERGY FROM ETH.
370   AMMU=AMMY*U(K)
      AMMV=AMMY*V(K)
      DELEB=AIX(K)+(U(K)**2+V(K)**2)/2.0
      DELEB=AMMY*DELEB
      EMOB=EMOB-DELEB
      ETH=ETH+DELEB
      BOTM=BOTM-AMMY
      BOTMV=BOTMV-AMMV
      BOTMU=BOTMU-AMMU
      GO TO 400
C           *** BOTTOM BOUNDARY IS REFLECTIVE, NET MOMENTUM CHANGE
C                 IN Z DIRECTION IS 2*MV/SS2.
380   IF (V(K).GE.0.) GO TO 390
      AMMV=2.*AMMY*V(K)/SS2
390   AMMY=0.0
      AMMU=0.
      DELEB=0.0
C           *** BEGIN DO LOOP IN J(Z) DIRECTION.
400   DO 1140 J=1,I2
      MSLAVE=0
      NSLAVE=0
      IF (J.EQ.JMAX) GO TO 420
C                       NOT AT TOP OF MESH
C                       L IS INDEX OF CELL ABOVE K
      L=K+IMAX
C                       IS CELL K EMPTY
      IF (AMX(K).GT.0.) GO TO 540
C                       IF CELL ABOVE IS ALSO EMPTY THEN FLUX=0 OR
C                       IF FLUX WOULD BE OUT OF EMPTY CELL, THEN FLUX=0.
      IF (AMX(L).EQ.0..OR.V(L).GE.0.) GO TO 430
C                       CELL ABOVE NOT EMPTY, MASS MOVING IN DIRECTION OF
C                       CELL K WHICH IS EMPTY.
C                       IS CELL ABOVE COLD AND SOLID
      IF (AIX(L).GT.ESESQ.OR.AMX(L)/(TAU(I)*DY(J+1)).GE.RHOZ) GO TO 410
C                       COLD, BUT NOT UP TO NORMAL DENSITY
C                       IS NEXT CELL ABOVE C OLD
      IF ((J+1).EQ.JMAX) GO TO 410
      LA=L+IMAX
      IF (AIX(LA).LT.ESESQ.AND.AMX(LA)/(TAU(I)*DY(J+1)).GT.SOLID) GO TO
     1430
C                       CELL ABOVE IS HOT.  DO NOT HOLD BACK.
410   M=L
      VABOVE=V(L)
      WDIF=DY(J+1)
      GO TO 460
C                       TOP OF MESH, IS MASS MOVING OUT.
420   IF (V(K).GT.0.) GO TO 440
C                       SET FLUX TERMS TO ZERO.
430   AMPY=0.
      GO TO 590
C                       MASS MOVING OUT OF TOP BOUNDARY
440   VABOVE=V(K)
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      WDYF=DY(J)
450   M=K
C                 CALCULATE MASS FLUX AT TOP OF CELL
460   IF (ABS(VABOVE).LE.UMIN) GO TO 430
      UVMAX=TRNSFC*DY(J)/DT
      IF (ABS(VABOVE).LT.UVMAX) GO TO 480
      IF (VABOVE.GT.0.) GO TO 470
      VABOVE=-UVMAX
      GO TO 480
470   VABOVE=UVMAX
480   AMPY=AMX(M)*VABOVE*DT/WDYF
      IF (MSLAVE.NE.0) GO TO 500
490   EAMPY=.5*(U(M)**2+V(M)**2)+AIX(M)
      UAMPY=U(M)
      VAMPY=V(M)
      GO TO 590
500   IF (VABOVE.GT.0.) GO TO 510
      M=L
      GO TO 490
510   M=K
      GO TO 490
520   WSA=.5*(V(K)+V(L))
      WSB=1.0+(V(L)-V(K))*DT/((DY(J+1)+DY(J))/2.0)
      WDYF=(DY(J)+DY(J+1))/2.
      VABOVE=WSA/WSB
      IF (MSLAVE.NE.0) GO TO 460
      IF (VABOVE) 530,430,450
530   M=L
      GO TO 460
C                 CELL K IS NOT EMPTY. HOW ABOUT CELL ABOVE K.
540   IF (AMX(L).GT.0.) GO TO 550
C                 CELL ABOVE IS EMPTY. IS FLUX INTO IT.
      IF (V(K).LE.0.) GO TO 430
C                 FLUX TOWARD EMPTY CELL
      IF (J.EQ.1) GO TO 440
C                 SHOULD MASS BE HELD UP UNTIL CELL IS FULL
      LB=K-IMAX
      IF (AIX(LB).GT.ESESQ.OR.AIX(K).GT.ESESQ.OR.AMX(LB)/(TAU(I)*DY(J-1)
     1).LT.SOLID.OR.AMX(K)/(TAU(I)*DY(J)).GT.SOLID) GO TO 440
      GO TO 430
550   IF (V(K).GT.0..AND.V(L).LT.0.) GO TO 560
      IF ((J+1).EQ.JMAX) GO TO 580
      LA=L+IMAX
      IF (AMX(LA).GT.0..OR.V(K).GE.0..OR.V(L).GE.0.) GO TO 570
C                 K AND L NOT EMPTY BUT CELL ABOVE L IS EMPTY
C                 TEST FOR SLAVING L TO K
      IF (AMX(L)/(TAU(I)*DY(J+1)).GE.RHOZ.OR.AIX(K).GT.ZSESQ.OR.AIX(L).G
     1T.ESESQ) GO TO 520
C                 YES, SLAVE L TO K
      MSLAVE=L
      M=K
      GO TO 520
C               *** $$REFLECTIVE$$ TREATMENT
560   VMK=V(K)*AMX(K)
      VML=V(L)*AMX(L)
      WSA=VMK+VML
      AMPY=WSA*DT/((DY(J)+DY(J+1))/2.0)
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      VAMPY=(VMK*V(K)+VML*V(L))/WSA
      UAMPY=(VMK*U(K)+VML*U(L))/WSA
      SAVEK=AIX(K)+.5*(U(K)**2+V(K)**2)
      EAMPY=(VMK*SAVEK+VML*(AIX(L)+.5*(U(L)**2+V(L)**2)))/WSA
      GO TO 590
  570 IF (J.EQ.1) GO TO 520
  580 LB=K-IMAX
      IF (AMX(LB).NE.0..OR.V(L).LE.0..OR.V(K).LE.0.) GO TO 520
C                   SHOULD K BE SLAVED TO L
      IF (AMX(K)/(TAU(I)*DY(J)).GE.RHOZ.OR.AIX(L).GE.ESESQ.OR.AIX(K).GT.
     1ESESQ) GO TO 520
C                   YES. SLAVE K TO L.
      MSLAVE=K
      M=L
      GO TO 520
C                *** CHECK FOR ONE-D
  590 IF (ABS(AMPY).LT.ROEPS*AMX(K).AND.ABS(AMPY).LT.ROEPS*AMX(K+IMAX))
     1AMPY=0.
      IF (IMAX.EQ.1) GO TO 620
      IF (I.EQ.IMAX) GO TO 610
C                   NOT AT RIGHT BOUNDARY
C                   IS CELL K.EMPTY

      IF (AMX(K).GT.0.) GO TO 730
C                   SET FLUX=0 IF CELL ON RIGHT IS EMPTY
C                   OR IF VELOCITY IS AWAY FROM EMPTY CELL K
      IF (AMX(K+1).EQ.0..OR.U(K+1).GE.0.) GO TO 620
C                   CELL TO RIGHT IS NOT EMPTY. SHALL WE LET MASS MOVE
C                   INTO CELL K WHICH IS EMPTY.
      IF (AIX(K+1).GT.ESESQ.OR.AMX(K+1)/(TAU(I+1)*DY(J)).GT.RHOZ) GO TO
     1600
C                   COLD AND NOT UP TO NORMAL DENSITY
C                   IS NEXT CELL TO RIGHT COLD
      IF ((I+1).EQ.IMAX) GO TO 600
      IF (AIX(K+2).LT.ESESQ.AND.AMX(K+2)/(TAU(I+2)*DY(J)).GT.SOLID) GO T
     1O 620
C                ***CELL ON RIGHT IS HOT. DO NOT HOLD BACK
  600 M=K+1
      URR=U(M)
      N=I+1
      GO TO 650
C                   RIGHT EDGE OF MESH
  610 IF (U(K).GT.0.) GO TO 630
C                   NO MASS COMES IN FROM OUTSIDE
C                   SET FLUX TERMS TO ZERO
  620 AMMP=0.
      GO TO 790
C                   MASS MOVING OUT OF RIGHT EDGE
  630 URR=U(K)
  640 N=I
      M=K
C                   CALCULATE MASS FLUX AT RIGHT OF CELL
  650 IF (ABS(URR).LE.UMIN) GO TO 620
      UVMAX=TRNSFC*DX(I)/DT
      IF (ABS(URR).LT.UVMAX) GO TO 670
      IF (URR.GT.0.) GO TO 660
      URR=-UVMAX
```

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      GO TO 670
 660  URR=UVMAX
 670  AMMP=AMX(M)/TAU(N)*TWOPDT*X(I)*URR
C                  SET SPECIFIC ENERGY + MOMENTUM
      IF (NSLAVE.NE.0) GO TO 690
 680  EAMMP=.5*(U(M)**2+V(M)**2)+AIX(M)
      UAMMP=U(M)
      VAMMP=V(M)
      GO TO 790
 690  IF (URR.GT.0.) GO TO 700
      M=K+1
      GO TO 680
 700  M=K
      GO TO 680
 710  WSA=.5*(U(K)+U(K+1))
      WSB=1.+(U(K+1)-U(K))*DT/((DX(I+1)+DX(I))/2.0)
      URR=WSA/WSB
      IF (NSLAVE.NE.0) GO TO 650
      IF (URR) 720,620,640
 720  M=K+1
      N=I+1
      GO TO 650
C                  CELL K IS NOT EMPTY
 730  IF (AMX(K+1).GT.0.) GO TO 750
C                  CELL ON RIGHT OF K IS EMPTY
      IF (U(K).LE.0.) GO TO 620
C                  SHOULD MASS GO INTO EMPTY CELL
      IF (I.EQ.1) GO TO 740
      IF (AIX(K-1).GT.ESESQ.OR.AIX(K).GT.ESESQ.OR.AMX(K-1)/(TAU(I-1)*DY(
     1J)).LT.SOLID.OR.AMX(K)/(TAU(I)*DY(J)).GT.SOLID) GO TO 630
      GO TO 620
 740  IF (AIX(K).GE.ESESQ.OR.AMX(K)/(TAU(I)*DY(J)).GE.RHOZ) GO TO 630
      GO TO 620
 750  IF (U(K).GT.0..AND.U(K+1).LT.0.) GO TO 760
      IF ((I+1).EQ.IMAX) GO TO 780
      IF (AMX(K+2).GT.0..OR.U(K).GE.0..OR.U(K+1).GE.0.) GO TO 770
C                  K AND K+1 NOT EMPTY BUT CELL K+2
C                  IS EMPTY. TEST FOR SLAVING K+1 TO K
      IF (AIX(K).GE.ESESQ.OR.AIX(K+1).GE.ESESQ.OR.AMX(K+1)/(TAU(I)*DY(J)
     1).GE.RHOZ) GO TO 710
C                  YES, SLAVE K+1 TO K
      NSLAVE=K+1
      N=I
      M=K
      GO TO 710
C                *** $$REFLECTIVE$$ TREATMENT
 760  UMK=U(K)*AMX(K)
      UMKP=U(K+1)*AMX(K+1)
      WSA=TWOPDT*X(I)
      UOTK=UMK/TAU(I)
      UOTKP=UMKP/TAU(I+1)
      WSB=UOTK+UOTKP
      AMMP=WSB*WSA
      UAMMP=(UOTK*U(K)+UOTKP*U(K+1))/WSB
      VAMMP=(UOTK*V(K)+UOTKP*V(K+1))/WSB
      SAVEK=AIX(K)+.5*(U(K)**2+V(K)**2)
      EAMMP=(UOTK*SAVEK+UOTKP*(AIX(K+1)+.5*(U(K+1)**2+V(K+1)**2)))/WSB
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      GO TO 790                                                         PH24470
  770 IF (I.EQ.1) GO TO 710                                             PH24480
  780 IF (AMX(K-1).NE.0..OR.U(K+1).LE.0..OR.U(K).LE.0.) GO TO 710       PH24490
C                       SHOULD K BE SLAVED TO K+1                       PH24500
      IF (AIX(K).GE.ESESQ.OR.AIX(K+1).GE.ESESQ.OR.AMX(K)/(TAU(I)*DY(J)).PH24510
     1GE.RHOZ) GO TO 710                                                PH24520
C                       YES, SLAVE K TO K+1                             PH24530
      NSLAVE=K                                                          PH24540
      N=I+1                                                             PH24550
      M=K+1                                                             PH24560
      GO TO 710                                                         PH24570
C                       WILL K BECOME MORE THAN EMPTY                   PH24580
  790 IF (ABS(AMMP).LT.AMX(K)*ROEPS.AND.ABS(AMMP).LT.ROEPS*AMX(K+1)) AMMPH24590
     1P=0.                                                              PH24600
      WSOUT=0.                                                          PH24610
      WSA=0.                                                            PH24620
      WSB=0.                                                            PH24630
      IF (AMMP.GT.0.) GO TO 830                                         PH24640
      WSA=-AMMP                                                         PH24650
  800 IF (AMPY.GT.0.) GO TO 840                                         PH24660
      WSA=WSA-AMPY                                                      PH24670
  810 IF (GAMC(J).LT.0.) GO TO 850                                      PH24680
      WSA=WSA+GAMC(J)                                                   PH24690
  820 IF (AMMY.LT.0.) GO TO 860                                         PH24700
      WSA=WSA+AMMY                                                      PH24710
      GO TO 870                                                         PH24720
  830 WSB=AMMP                                                          PH24730
      GO TO 800                                                         PH24740
  840 WSB=WSB+AMPY                                                      PH24750
      GO TO 810                                                         PH24760
  850 WSOUT=-GAMC(J)                                                    PH24770
      GO TO 820                                                         PH24780
  860 WSOUT=WSOUT-AMMY                                                  PH24790
  870 DELM=WSA-WSB-WSOUT                                                PH24800
      IF (AMX(K)+DELM.GE.0.) GO TO 970                                  PH24810
C            *** INTERMEDIATE PRINT FOR CELLS OVER-EMPTYING.            PH24815
      IF (INTER.EQ.0) GO TO 880                                         PH24820
      WRITE (6,1290) I,J,AMX(K),DELM,AMMY,GAMC(J),AMPY,AMMP             PH24830
  880 IF (WSOUT.GT.AMX(K)) GO TO 920                                    PH24840
C            *** OTHERWISE,MAKE WSB PLUS WSOUT EXACTLY                  PH24850
C            ***    EQUAL TO AMX(K)                                     PH24860
      WS=AMX(K)-WSOUT                                                   PH24870
      IF (AMMP.GT.0.) GO TO 900                                         PH24880
      AMPY=WS                                                           PH24890
  890 DELM=WSA-WSOUT-AMMP-AMPY                                          PH24900
C            *** INTERMEDIATE PRINT FOR OVER-EMPTIED CELL AFTER         PH24902
C            *** RIGHT AND/OR TOP FLUXES ADJUSTED.                      PH24904
      IF(INTER.EQ.0) GO TO 970                                          PH24906
      WRITE(6,1350) AMX(K),DELM,AMMY,GAMC(J),AMPY,AMMP                  PH24908
      GO TO 970                                                         PH24910
  900 IF (AMPY.GT.0.) GO TO 910                                         PH24920
      AMMP=WS                                                           PH24930
      GO TO 890                                                         PH24940
  910 AMMP=WS/(AMMP+AMPY)*AMMP                                          PH24950
      AMPY=WS-AMMP                                                      PH24960
      GO TO 890                                                         PH24970
C          *** CELL OVER-EMPTIED DOWN OR LEFT. PUT IT BACK.             PH24980
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  920  IF (AMMP.LT.0.) GO TO 930                                        PH24990
       AMMP=0.                                                          PH25000
       AMUR=0.                                                          PH25010
       AMVR=0.                                                          PH25020
       DELER=0.                                                         PH25030
  930  IF (AMPY.LT.0.) GO TO 940                                        PH25040
       AMPY=0.                                                          PH25050
       AMUT=0.                                                          PH25060
       AMVT=0.                                                          PH25070
       DELET=0.                                                         PH25080
  940  MASS=AMX(K)                                                      PH25090
       UMOM=MASS*U(K)                                                   PH25100
       VMOM=MASS*V(K)                                                   PH25110
       ENGY=MASS*(.5*U(K)**2+.5*V(K)**2+AIX(K))                         PH25120
       MASS=MASS-AMMP                                                   PH25130
       UMOM=UMOM-AMMP*U(K+1)                                            PH25140
       VMOM=VMOM-AMMP*V(K+1)                                            PH25150
       ENGY=ENGY-AMMP*(.5*U(K+1)**2+.5*V(K+1)**2+AIX(K+1))              PH25160
       MASS=MASS-AMPY                                                   PH25170
       UMOM=UMOM-AMPY*U(L)                                              PH25180
       VMOM=VMOM-AMPY*V(L)                                              PH25190
       ENGY=ENGY-AMPY*(.5*U(L)**2+.5*V(L)**2+AIX(L))                    PH25200
       MASS=MASS+AMMY                                                   PH25210
       UMOM=UMOM+AMMU                                                   PH25220
       VMOM=VMOM+AMMV                                                   PH25230
       ENGY=ENGY+DELEB                                                  PH25240
       MASS=MASS+GAMC(J)                                                PH25250
       UMOM=UMOM+FLEFT(J)                                               PH25260
       VMOM=VMOM+YAMC(J)                                                PH25270
       ENGY=ENGY+SIGC(J)                                                PH25280
       WSA=-AMIN1(0.,GAMC(J))/WSOUT                                     PH25290
       WSB=-AMIN1(0.,AMMY)/WSOUT                                        PH25300
       LB=K-IMAX                                                        PH25310
       IF (LB.LT.0) WSA=1.                                              PH25320
       IF (LB.LT.0) GO TO 950                                           PH25330
       IF (AMMY.EQ.0..OR.WSB.EQ.0.) GO TO 950                           PH25340
       WSC=AMX(LB)+WSB*MASS                                             PH25350
       WSD=AIX(LB)+.5*(U(LB)**2+V(LB)**2)                               PH25360
       U(LB)=(AMX(LB)*U(LB)+WSB*UMOM)/WSC                               PH25370
       V(LB)=(AMX(LB)*V(LB)+WSB*VMOM)/WSC                               PH25380
       AIX(LB)=(AMX(LB)*WSD+WSB*ENGY)/WSC-.5*(U(LB)**2+V(LB)**2)        PH25390
       AMX(LB)=WSC                                                      PH25400
  950  IF (GAMC(J).EQ.0..OR.WSA.EQ.0.) GO TO 960                        PH25410
       WSC=AMX(K-1)+WSA*MASS                                            PH25420
       WSD=AIX(K-1)+.5*(U(K-1)**2+V(K-1)**2)                            PH25430
       U(K-1)=(AMX(K-1)*U(K-1)+WSA*UMOM)/WSC                            PH25440
       V(K-1)=(AMX(K-1)*V(K-1)+WSA*VMOM)/WSC                            PH25450
       AIX(K-1)=(AMX(K-1)*WSD+WSA*ENGY)/WSC-.5*(U(K-1)**2+V(K-1)**2)    PH25460
       AMX(K-1)=WSC                                                     PH25470
C               *** INTERMEDIATE PRINT FOR OVER-EMPTIED CELLS AFTER     PH25472
C                   MASS PUT BACK.                                      PH25474
  960  IF (INTER.EQ.0) GO TO 1100                                       PH25480
       WRITE(6,1360) AMX(K), DELM, AMMY, GAMC(J), AMPY, AMMP            PH25490
       GO TO 1100                                                       PH25500
  970  IF (AMPY.EQ.0.) GO TO 960                                        PH25510
C                    CALCULATE ENERGY AND MOMENTUM FLUX AT TOP          PH25520
       AMUT=AMPY*UAMPY                                                  PH25530
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      AMVT=AMPY*VAMPY                                                   PH25540
      DELET=AMPY*EAMPY                                                  PH25550
C                          IS THIS AT TOP BOUNDARY                      PH25560
      IF (J.NE.JMAX) GO TO 990                                          PH25570
C                          YES,TOP. ADJUST ENERGY.                      PH25580
      ETH=ETH-DELET                                                     PH25590
      EMOT=EMOT+DELET                                                   PH25600
      TOPM=TOPM+AMPY                                                    PH25610
      TOPMV=TOPMV+AMVT                                                  PH25620
      TOPMU=TOPMU+AMUT                                                  PH25630
C                          IS AMPY LARGE ENOUGH TO TRIGGER REZONE       PH25640
      IF (AMPY/(TAU(I)*DY(J)).GE.VT) REZ=1.                             PH25650
      GO TO 990                                                         PH25660
C                          AMPY=0. SET MOMENTUM AND ENERGY FLUX=0.      PH25670
980   AMUT=0.                                                           PH25680
      AMVT=0.                                                           PH25690
      DELET=0.                                                          PH25700
990   IF (AMMP.EQ.0.) GO TO 1000                                        PH25710
C                          CALCULATE ENERGY + MOMENTUM FLUX AT RIGHT    PH25720
      AMUR=AMMP*UAMMP                                                   PH25730
      AMVR=AMMP*VAMMP                                                   PH25740
      DELER=AMMP*EAMMP                                                  PH25750
C                          IS THIS AT RIGHT BOUNDARY                    PH25760
      IF (I.NE.IMAX) GO TO 1010                                         PH25770
C                          YES, RIGHT. ADJUST ENERGY.                   PH25780
      ETH=ETH-DELER                                                     PH25790
      EMOR=EMOR+DELER                                                   PH25800
      RTM=RTM+AMMP                                                      PH25810
      RTMV=RTMV+AMVR                                                    PH25820
      RTMU=RTMU+AMUR                                                    PH25830
C                          IS AMMP LARGE ENOUGH TO TRIGGER REZONE       PH25840
      IF (AMMP/(TAU(I)*DY(J)).GE.VT) REZ=1.                             PH25850
      GO TO 1010                                                        PH25860
C                          AMMP=0. SET MOMENTUM AND ENERGY FLUX=0.      PH25870
1000  AMUR=0.                                                           PH25880
      AMVR=0.                                                           PH25890
      DELER=0.                                                          PH25900
C                          REPARTITION ENERGY + MOMENTUM                PH25910
1010  IF (DELM.EQ.0.) GO TO 1080                                        PH25920
1020  WSA=.5*(U(K)**2+V(K)**2)                                          PH25930
      SIGMU=-AMUT-AMUR+AMMU+FLEFT(J)                                    PH25940
      SIGMV=-AMVT-AMVR+AMMV+YAMC(J)                                     PH25950
      WS=DELM+AMX(K)                                                    PH25960
      IF (WS.LE.0.) GO TO 1070                                          PH25970
      UNEW=(SIGMU+AMX(K)*U(K))/WS                                       PH25980
      DELU=UNEW-U(K)                                                    PH25990
      IF (ABS(DELU).LT.UMIN) GO TO 1030                                 PH26000
      U(K)=UNEW                                                         PH26010
1030  VNEW=(SIGMV+AMX(K)*V(K))/WS                                       PH26020
      DELV=VNEW-V(K)                                                    PH26030
      IF (ABS(DELV).LT.UMIN) GO TO 1040                                 PH26040
      V(K)=VNEW                                                         PH26050
1040  WSB=-DELET-DELER+DELEB+SIGC(J)                                    PH26060
      SIENEW=((AIX(K)+WSA)*AMX(K)+WSB)/WS-.5*(U(K)**2+V(K)**2)          PH26070
      DELI=SIENEW-AIX(K)                                                PH26080
      IF (ABS(DELI).GT.SIEMIN) GO TO 1050                               PH26090
C            *** SUME SUMS ENERGY FLUXES TOO SMALL TO USE. SUME IS      PH26092
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C                SUBTRACTED FROM ETH AT THE END OF THIS ROUTINE.          PH26094
      SUME=SUME+DELI*WS                                                   PH26100
      GO TO 1060                                                          PH26110
1050  AIX(K)=SIENEW                                                       PH26120
1060  AMX(K)=WS                                                           PH26130
      GO TO 1090                                                          PH26140
1070  AMX(K)=0.                                                           PH26150
      AIX(K)=0.                                                           PH26160
      U(K)=0.                                                             PH26170
      V(K)=0.                                                             PH26180
      GO TO 1100                                                          PH26190
C                  DELM=0. BUT IS THERE INDIVIDUAL FLOW                   PH26200
1080  IF (AMMP.NE.0.) GO TO 1020                                          PH26210
      IF (AMPY.NE.0.) GO TO 1020                                          PH26220
      IF (AMMY.NE.0.) GO TO 1020                                          PH26230
      IF (GAMC(J).NE.0.) GO TO 1020                                       PH26240
1090  IF (I.NE.I1) GO TO 1100                                             PH26250
      IF (U(K).NE.0..OR.V(K).NE.0..OR.AIX(K).NE.0.) NRC=1                 PH26260
C           *** SPECIAL INTERMEDIATE PRINT FOR CHECKING ENERGY            PH26262
C                CONSERVATION - PRINTS ONLY IF INTER = 7 IN INPUT DECK.   PH26264
1100  IF (INTER.NE.7) GO TO 1130                                          PH26270
      ENERGY=DELER+DELET-SIGC(J)                                          PH26280
      DO 1110 NN=1,JMAX                                                   PH26290
      ENERGY=ENERGY+SIGC(NN)                                              PH26300
1110  CONTINUE                                                            PH26310
      DO 1120 LJD=2,KMAX                                                  PH26320
      ENERGY=ENERGY+AMX(LJD)*(AIX(LJD)+.5*(U(LJD)**2+V(LJD)**2))          PH26330
1120  CONTINUE                                                            PH26340
      WRITE (6,1300) I,J,ENERGY                                           PH26350
      WRITE (6,1310) AMPY,AMMP,AMMY,GAMC(J)                               PH26360
      WRITE (6,1320) DELET,DELER,DELEB,SIGC(J)                            PH26370
1130  CONTINUE                                                            PH26380
      GAMC(J)=AMMP                                                        PH26390
      FLEFT(J)=AMUR                                                       PH26400
      YAMC(J)=AMVR                                                        PH26410
      SIGC(J)=DELER                                                       PH26420
      AMMY=AMPY                                                           PH26430
      AMMU=AMUT                                                           PH26440
      AMMV=AMVT                                                           PH26450
      DELEB=DELET                                                         PH26460
C
C           *** END OF J-LOOP.                                            PH26465
C
1140  K=K+IMAX                                                            PH26470
      LL=K-IMAX                                                           PH26480
      IF (U(LL).NE.0..OR.V(LL).NE.0..OR.AIX(LL).NE.0.) NRT=1              PH26490
C
C           *** END OF I-LOOP.                                            PH26495
C
1150  CONTINUE                                                            PH26500
C           *** ADVANCE ACTIVE GRID.                                      PH26505
      I1=I1+NRC                                                           PH26510
      I2=I2+NRT                                                           PH26520
      IF (IMAX-I1) 1160,1170,1180                                         PH26530
1160  I1=IMAX                                                             PH26540
1170  CONTINUE                                                            PH26550
1180  IF (JMAX-I2) 1190,1200,1210                                         PH26560
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1190  I2=JMAX                                                          PH26570
1200  CONTINUE                                                         PH26580
1210  GO TO 1230                                                       PH26590
C                  *** NEGATIVE MASS                                   PH26600
1220  NK=315                                                           PH26610
      NR=9                                                             PH26620
      CALL ERROR                                                       PH26630
1230  SUM=0.0                                                          PH26640
C           *** EVAPORATE LOW-DENSE CELLS ON BASIS OF EVAP, INPUT      PH26642
C               PARAMETER.                                             PH26644
      DO 1280 I=1,I1                                                   PH26650
      K=I+1                                                            PH26660
      DO 1270 J=1,I2                                                   PH26670
      IF (AMX(K).EQ.0.) GO TO 1270                                     PH26680
      IF (AMX(K)/(TAU(1)*DY(J)).GT.EVAP*RHIN3) GO TO 1250              PH26690
      WS=(U(K)**2+V(K)**2)/2.0                                         PH26700
      EVAPM=EVAPM+AMX(K)                                               PH26710
      WS=AMX(K)*(AIX(K)+WS)                                            PH26720
      EVAPEN=EVAPEN+WS                                                 PH26730
      ETH=ETH-WS                                                       PH26740
      EVAPMU=EVAPMU+AMX(K)*U(K)                                        PH26750
      EVAPMV=EVAPMV+AMX(K)*V(K)                                        PH26760
C           *** INTERMEDIATE PRINT FOR CELLS EVAPORATED.               PH26765
      IF (INTER.EQ.0) GO TO 1240                                       PH26770
      WRITE(6,1340) I,J,AMX(K),AIX(K),U(K),V(K)                        PH26780
1240  AMX(K)=0.0                                                       PH26790
      AIX(K)=0.0                                                       PH26800
      P(K)=0.0                                                         PH26810
      U(K)=0.0                                                         PH26820
      V(K)=0.0                                                         PH26830
      GO TO 1270                                                       PH26840
C           *** SET NEGATIVE INTERNAL ENERGIES TO ZERO WHEN SN=0.      PH26842
C               (INPUT PARAMETER).                                     PH26844
1250  IF (AIX(K).GE.0..OR.SN.GT.0.) GO TO 1270                         PH26850
C           *** SUM SUMS NEGATIVE INTERNAL ENERGY SET TO ZERO.         PH26855
      SUM=SUM+AIX(K)*AMX(K)                                            PH26860
C           *** INTERMEDIATE PRINT FOR CELLS WHOSE NEGATIVE            PH26862
C               INTERNAL ENERGY IS SET TO ZERO.                        PH26864
      IF (INTER.EQ.0) GO TO 1260                                       PH26870
      WRITE (6,1330) I,J,AMX(K),AIX(K),U(K),V(K)                       PH26880
1260  AIX(K)=0.                                                        PH26890
1270  K=K+IMAX                                                         PH26900
1280  CONTINUE                                                         PH26910
C           *** ETH = THEORETICAL ENERGY SUM, USED IN EDIT FOR         PH26912
C                      ENERGY CHECK.                                   PH26914
C           *** EZPH2 = ENERGY SET TO ZERO  IN PH2 SINCE  TIME=0.      PH26916
C           *** SUM  = NEGATIVE INTERNAL ENERGY SET TO ZERO ON THIS    PH26917
C                       CYCLE.                                         PH26918
C           *** SUME = SUM OF THE ENERGY FLUXES IGNORED ON THIS CYCLE. PH26919
      ETH=ETH-SUM-SUME                                                 PH26920
      EZPH2=EZPH2-SUME-SUM                                             PH26930
      RETURN                                                           PH26940
C                                                                      PH26950
1290  FORMAT (5H NEGM,I3,I4,4H  M=,1PE14.7,6H DELM=,1PE14.7,6H  BOT=,1PEPH26960
     114.7,7H  LEFT=,1PE14.7,6H  TOP=,1PE14.7,5H  RT=,1PE14.7)          PH26970
1300  FORMAT (5H  I= I3,6X,5H  J= I3,6X,9H  ENERGY=1PE15.8)            PH26980
1310  FORMAT (7H  AMPY=1PE15.8,6X,6H AMMP=1PE15.8,6X,6H AMMY=1PE15.8,9H PH26990
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     1GAMC(J)=1PE15.8)                                                  PH27000
1320 FORMAT (7H DELET=1PE15.8,6X,6HDELER=1PE15.8,6X,6HDELEB=1PE15.8,9H PH27010
     1SIGC(J)=1PE15.8)                                                  PH27020
1330 FORMAT (4H PH2,2I4,4H  M=,1PE15.8,6H  SIE=,1PE15.8,4H  U=,1PE15.8,PH27030
     14H  V=,1PE15.8,18H   SIE SET TO ZERO)                             PH27040
1340 FORMAT (4H PH2,2I4,4H  M=,1PE15.8,6H  SIE=,1PE15.8,4H  U=,1PE15.8,PH27042
     14H  V=,1PE15.8,19H    CELL EVAPORATED)                            PH27044
1350 FORMAT (12H ADJUST FLUX,4H  M=,1PE14.7,6H DELM=,1PE14.7,6H  BOT=, PH27045
     11PE14.7,7H  LEFT=,1PE14.7,6H  TOP=,1PE14.7,5H  RT=,1PE14.7)       PH27046
1360 FORMAT (12H ADJUST MASS,4H  M=,1PE14.7,6H DELM=,1PE14.7,6H  BOT=, PH27047
     11PE14.7,7H  LEFT=,1PE14.7,6H  TOP=,1PE14.7,5H  RT=,1PE14.7)       PH27048
     END                                                                PH27050-
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      SUBROUTINE REZONE
C     ......................................................................
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)  ,P(2502)  ,
     1          X(52)    ,XX(54)   ,TAU(52)  ,JPM(52)  ,
     2          Y(102)   ,YY(104)  ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)   ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)  ,PR(204)  ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)  ,IJ(5)    ,JK(5)    ,
     9          DX(52)   ,DDX(54)  ,DY(102)  ,DDY(104) ,
     $          SNB(52)  ,STB(52)  ,UK(52,3) ,VK(52,3) ,RHO(52,3)
C           *** DIMENSIONED ARRAYS
C           *** Z-BLOCK IS SAVED ON TAPE.
      COMMON     Z
      COMMON    PK
      COMMON   YY,     XX
      COMMON   DDX,    DDY
      COMMON   AMX,    AIX,    U,     V,     P
      COMMON   TAU,    JPM
      COMMON   UL ,    PL
      COMMON   XP ,    YP,      CMXP, CMYP
C           *** NON-DIMENSIONED VARIABLES
      COMMON          AID    ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB  ,DELER  ,DELET  ,DELM   ,DTODX  ,DXYMIN,EAMMP  ,EAMPY  ,
     2E      ,ERDUMP,I       ,I3     ,IWS    ,J      ,K      ,KA     ,KB     ,
     3LL     ,MD     ,ME     ,MZT    ,NERR   ,NK     ,NPRINT,
     4NR     ,NRZ    ,NULLE  ,PIDTS  ,SIEMIN,SNR     ,SNT    ,STR    ,SOLID  ,
     5SUM    ,TESTRH,TWOPI  ,URR    ,WS     ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
C
C           *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C               X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C           *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE            (UL,FLEFT),         (UL(103),YAMC),
     1                       (PL,GAMC,PR),       (PL(103),SIGC)
C
C           *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE            (UL,RSN),
     1                       (PL,RST),           (P,UK),
     2                       (P(157),VK),        (P(313),SNB),
     3                       (P(365),STB),       (P(417),RHO)
C
C           *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C           *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                          (Z(  1),PROB  ),(Z(  2),CYCLE ),
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```
     1(Z(  3),DT    ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
     2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
     3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
     4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
     5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
     6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
     7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
     8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
     9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
      EQUIVALENCE
     1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
     2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
      EQUIVALENCE
     1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),
     3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
     4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
     5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
     8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
     9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
      EQUIVALENCE
     1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
     3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
      EQUIVALENCE
     1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
     2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),RCEPS ),
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAPB),(Z(126),IUMAP ),
     9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
      EQUIVALENCE
     1(Z(131),FRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C     ................................................................
C
C     END OF COMMON
C
C     ................................................................
C
C           *** INITIALIZE P-STORAGE. CDT CALLED AGAIN AND PRESSURES
C               RECALCULATED AFTER GRID REZONED AND BEFORF PH1,PH3
C               AND PH2 ARE CALLED.

      DO 10 K=2,KMAX
      P(K)=0.
10    CONTINUE
      NJMAX=JMAX/2
```

```
      IF (IMAX.EQ.1) GO TO 20                                           REZ1120
      NIMAX=IMAX/2                                                      REZ1130
      GO TO 70                                                          REZ1140
C             *** 1-D                                                   REZ1145
 20   IMAX=2                                                            REZ1150
      NIMAX=1                                                           REZ1160
      K=2                                                               REZ1170
      L=2*JMAX+2                                                        REZ1180
C             *** STORE PROPERTIES TEMPORARILY IN UNUSED PART OF ARRAYS. REZ1185
      DO 30 J=1,JMAX                                                    REZ1190
      AMX(L)=AMX(K)                                                     REZ1200
      U(L)=U(K)                                                         REZ1210
      V(L)=V(K)                                                         REZ1220
      AIX(L)=AIX(K)                                                     REZ1230
      K=K+1                                                             REZ1240
      L=L+1                                                             REZ1250
 30   CONTINUE                                                          REZ1260
      K=2                                                               REZ1270
      L=2*JMAX+2                                                        REZ1280
C             *** ADD ANOTHER COLUMN OF CELLS. EACH CELL IN NEW COLUMN  REZ1282
C                 WILL HAVE SAME VELOCITIES AND SIE AND 3 TIMES THE     REZ1284
C                 MASS OF AXIS CELL.                                    REZ1286
      DO 50 J=1,JMAX                                                    REZ1290
      DO 40 I=1,2                                                       REZ1300
      AMX(K)=AMX(L)                                                     REZ1310
      U(K)=U(L)                                                         REZ1320
      V(K)=V(L)                                                         REZ1330
      AIX(K)=AIX(L)                                                     REZ1340
      K=K+1                                                             REZ1350
      AMX(L)=3.*AMX(L)                                                  REZ1360
 40   CONTINUE                                                          REZ1370
 50   L=L+1                                                             REZ1380
      L=2*JMAX+1                                                        REZ1390
C             *** ADJUST ETH BY ADDING ENERGY OF CELLS IN NEW COLUMN.   REZ1395
      DO 60 K=3,L,2                                                     REZ1400
      ETH=ETH+AMX(K)*(AIX(K)+(V(K)**2)/2.)                              REZ1410
 60   CONTINUE                                                          REZ1420
 70   DO 120 J=1,NJMAX                                                  REZ1430
      K=(J-1)*NIMAX+2                                                   REZ1440
      L=(J-1)*2*IMAX+2                                                  REZ1450
      DO 110 I=1,NIMAX                                                  REZ1460
      M=L+IMAX                                                          REZ1470
C             *** SUM MASS OF FOUR CELLS TO BE MADE INTO ONE CELL.      REZ1475
      WSA=AMX(L)+AMX(M)+AMX(L+1)+AMX(M+1)                               REZ1480
      IF (WSA.EQ.0.) GO TO 80                                           REZ1490
C             *** SUM KINETIC ENERGY OF FOUR CELLS.                     REZ1495
      WSB=AMX(L)*(U(L)**2+V(L)**2)+AMX(M)*(U(M)**2+V(M)**2)+AMX(L+1)*(U(REZ1500
     1L+1)**2+V(L+1)**2)+AMX(M+1)*(U(M+1)**2+V(M+1)**2)                 REZ1510
C             *** COMPUTE VELOCITIES OF NEW CELL FROM VELOCITIES OF     REZ1512
C                 THE FOUR CELLS.                                       REZ1514
      U(K)=(U(L)*AMX(L)+U(M)*AMX(M)+U(L+1)*AMX(L+1)+U(M+1)*AMX(M+1))/WSAREZ1520
      V(K)=(V(L)*AMX(L)+V(M)*AMX(M)+V(L+1)*AMX(L+1)+V(M+1)*AMX(M+1))/WSAREZ1530
C             *** COMPUTE INTERNAL ENERGY OF NEW CELL.                  REZ1535
      AIX(K)=AIX(L)*AMX(L)+AIX(M)*AMX(M)+AIX(L+1)*AMX(L+1)+AMX(M+1)*AIX(REZ1540
     1M+1)                                                              REZ1550
      AMX(K)=WSA                                                        REZ1560
      WS=U(K)**2+V(K)**2                                                REZ1570
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      E=AIX(K)+WSB/2.0                                                  REZ1580
C           *** COMPUTE SIE OF NEW CELL.                                REZ1585
      AIX(K)=E/AMX(K)-.5*WS                                             REZ1590
      IF (K-2) 100,100,90                                               REZ1600
C           *** NEW CELL EMPTY.                                         REZ1605
 80   AMX(K)=0.                                                         REZ1610
      AIX(K)=0.                                                         REZ1620
      U(K)=0.                                                           REZ1630
      V(K)=0.                                                           REZ1640
C           *** INITIALIZE STORAGE OF CELL QUANTIES OF OLD GRID.        REZ1650
 90   AMX(L)=0.0                                                        REZ1660
      U(L)=0.0                                                          REZ1670
      V(L)=0.0                                                          REZ1680
      AIX(L)=0.0                                                        REZ1690
      AMX(M)=0.0                                                        REZ1700
      U(M)=0.0                                                          REZ1710
      V(M)=0.0                                                          REZ1720
      AIX(M)=0.0                                                        REZ1730
      AMX(L+1)=0.0                                                      REZ1740
      U(L+1)=0.0                                                        REZ1750
      V(L+1)=0.0                                                        REZ1760
      AIX(L+1)=0.0                                                      REZ1770
      AMX(M+1)=0.0                                                      REZ1780
      U(M+1)=0.0                                                        REZ1790
      V(M+1)=0.0                                                        REZ1800
      AIX(M+1)=0.0                                                      REZ1810
 100  K=K+1                                                             REZ1820
      L=L+2                                                             REZ1830
C           *** END OF I-LOOP                                           REZ1835
 110  CONTINUE                                                          REZ1840
C           *** END OF J-LOOP                                           REZ1845
 120  CONTINUE                                                          REZ1850
C           *** OLD PART OF ENLARGED GRID HAS NOW BEEN REZONED.         REZ1852
C               PROPERTIES OF NEW PART OF GRID WILL BE ASSIGNED         REZ1854
C               BELOW.                                                  REZ1856
C
C           *** CALCULATE NEW DY'S UP TO  EDGE OF OLD GRID BY           REZ1860
C               COMBINING THE OLD DY'S . CALCULATE NEW Y'S FROM         REZ1862
C               THE NEW DY'S.                                           REZ1864
      DO 130 J=1,NJMAX                                                  REZ1870
      DY(J)=DY(2*J-1)+DY(2*J)                                           REZ1880
      Y(J)=Y(J-1)+DY(J)                                                 REZ1890
 130  CONTINUE                                                          REZ1900
C           *** ASSIGN THE VALUE OF THE LAST DY CALCULATED ABOVE        REZ1902
C               TO ALL CELLS ABOVE THE OLD GRID.                        REZ1904
      NJMAX1=NJMAX+1                                                    REZ1910
      DO 140 J=NJMAX1,JMAX                                              REZ1920
      DY(J)=DY(NJMAX)                                                   REZ1930
      Y(J)=Y(J-1)+DY(J)                                                 REZ1940
 140  CONTINUE                                                          REZ1950
C           *** IMAX IS  SET TO 2 IF DOING A 1-D PROBLEM                REZ1955
      IF (IMAX.EQ.2) DX(2)=DX(1)                                        REZ1960
      DX(1)=DX(1)+DX(2)                                                 REZ1970
      X(1)=DX(1)                                                        REZ1980
      WS=X(1)**2                                                        REZ1990
      TAU(1)=PIDY*WS                                                    REZ2000
C           *** ARE YOU DOING A 1-D PROBLEM                             REZ2005
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```
      IF (IMAX.EQ.2) GO TO 300
C           *** CALCULATE NEW DX'S OUT TO EDGE OF OLD GRID BY
C                COMBINING OLD DX'S. CALCULATE NEW X'S AND CELL-FACE
C                AREAS FROM THE NEW DX'S.
      DO 150 I=2,NIMAX
      DX(I)=DX(2*I-1)+DX(2*I)
      X(I)=X(I-1)+DX(I)
      WSA=X(I)**2
      TAU(I)=PIDY*(WSA-WS)
      WS=WSA
 150  CONTINUE
C           *** ASSIGN THE VALUE OF THE LAST DX CALCULATED ABOVE
C                TO ALL CELLS TO THE RIGHT OF THE OLD GRID.
      NIMAX1=NIMAX+1
      DO 160 I=NIMAX1,IMAX
      DX(I)=DX(NIMAX)
      X(I)=X(I-1)+DX(I)
      WSA=X(I)**2
      TAU(I)=PIDY*(WSA-WS)
      WS=WSA
 160  CONTINUE
C
C           *** INITIALIZE CELL BOUNDARIES
C
      JPB=0
      JPA=0
      JTB=0
      JTA=0
      IPRT=0
      ITRT=0
C
      IF (PRYTOP.LE.Y(NJMAX).AND.PRXRT.LE.X(NIMAX).AND.TAYTOP.LE.Y(NJMAX
     1).AND.TAXRT.LE.X(NIMAX)) GO TO 300
C
C           *** COMPUTE JPB, JPA - BOTTOM AND TOP CELL BOUNDARIES OF
C                PROJECTILE
C
      IF (PRYBOT.LT.0..OR.(PRYTOP.LE.Y(NJMAX).AND.PRXRT.LE.X(NIMAX))) GO
     1 TO 230
      J=0
      IF (PRYBOT.EQ.0.) GO TO 180
      DYSUM=0.
      DO 170 J=1,JMAX
      DYSUM=DYSUM+DY(J)
      IF (PRYBOT.GE.DYSUM-.5*DY(J).AND.PRYBOT.LT.DYSUM+.5*DY(J+1)) GO TO
     1 180
 170  CONTINUE
      GO TO 230
 180  JPB=MIN0(J+1,JMAX)
      DO 190 J=JPB,JMAX
      DYSUM=DYSUM+DY(J)
      IF (PRYTOP.GE.DYSUM-.5*DY(J).AND.PRYTOP.LT.DYSUM+.5*DY(J+1)) GO TO
     1 200
 190  CONTINUE
 200  JPA=J
C
C           *** COMPUTE IPRT - RIGHT CELL BOUNDARY OF PROJECTILE
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```
C
      DXSUM=0.
      DO 210 I=1,IMAX
      DXSUM=DXSUM+DX(I)
      IF (PRXRT.GE.DXSUM-.5*DX(I).AND.PRXRT.LT.DXSUM+.5*DX(I+1)) GO TO 2
     120
210   CONTINUE
220   IPRT=I
C
C             *** COMPUTE JTB, JTA - BOTTOM AND TOP CELL BOUNDARIES OF
C                   TARGET
C
230   IF (TAYBOT.LT.0..OR.(TAYTOP.LE.Y(NJMAX).AND.TAXRT.LE.X(NIMAX))) GO
     1 TO 300
      J=0
      IF (TAYBOT.EQ.0.) GO TO 250
      DYSUM=0.
      DO 240 J=1,JMAX
      DYSUM=DYSUM+DY(J)
      IF (TAYBOT.GE.DYSUM-.5*DY(J).AND.TAYBOT.LT.DYSUM+.5*DY(J+1)) GO TO
     1 250
240   CONTINUE
      GO TO 300
250   JTB=MIN0(J+1,JMAX)
      DO 260 J=JTB,JMAX
      DYSUM=DYSUM+DY(J)
      IF (TAYTOP.GE.DYSUM-.5*DY(J).AND.TAYTOP.LT.DYSUM+.5*DY(J+1)) GO TO
     1 270
260   CONTINUE
270   JTA=J
C
C             *** COMPUTE ITRT - RIGHT CELL BOUNDARY OF TARGET
C
      DXSUM=0.
      DO 280 I=1,IMAX
      DXSUM=DXSUM+DX(I)
      IF (TAXRT.GE.DXSUM-.5*DX(I).AND.TAXRT.LT.DXSUM+.5*DX(I+1)) GO TO 2
     190
280   CONTINUE
290   ITRT=I
300   CONTINUE
C             *** REDEFINE IMAX AND JMAX   FOR ORDERING THE K ARRAYS
C                 BELOW.
      IMAX=NIMAX
      JFILB=JPA+1
      JFILA=JTB-1
      JMAX=NJMAX
      I1=I1/2
      I2=I2/2
C             *** IS THIS A 1-D PROBLEM
      IF (IMAX.GT.1) GO TO 320
C             *** YES.ADD TARGET MATERIAL
      JMP1=JMAX+1
      JMAX=2*JMAX
      DO 310 J=JMP1,JMAX
      K=J+1
      AMX(K)=RHINIT*TAU(1)*DY(J)
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      IF (TARGI.GT.0.) I2=J                                             REZ3060
      AIX(K)=TARGI                                                      REZ3070
      ETH=ETH+AMX(K)*AIX(K)                                             REZ3080
  310 CONTINUE                                                          REZ3090
      JPROJ=JPROJ/2                                                     REZ3100
      I1=1                                                              REZ3110
      GO TO 520                                                         REZ3120
C          *** PREPARE TO SHUFFLE K ARRAYS SUCH AS TO PRESERVE          REZ3130
C              K=(J-1)*IMAX+I+1, THEN ADD MATERIAL TO NEW  PART         REZ3140
C              OF GRID.                                                 REZ3145
  320 DO 360 N=1,JMAX                                                   REZ3150
      J=JMAX+1-N                                                        REZ3160
      K=(J-1)*IMAX+1+IMAX                                               REZ3170
      L=(J-1)*(IMAX+IMAX)+1+IMAX                                        REZ3180
      DO 350 I=1,IMAX                                                   REZ3190
      AMX(L)=AMX(K)                                                     REZ3200
      AIX(L)=AIX(K)                                                     REZ3210
      U(L)=U(K)                                                         REZ3220
      V(L)=V(K)                                                         REZ3230
      IF (J-1) 340,340,330                                              REZ3240
  330 AMX(K)=0.0                                                        REZ3250
      AIX(K)=0.0                                                        REZ3260
      V(K)=0.0                                                          REZ3270
      U(K)=0.0                                                          REZ3280
  340 K=K-1                                                             REZ3290
      L=L-1                                                             REZ3300
  350 CONTINUE                                                          REZ3310
  360 CONTINUE                                                          REZ3320
C          *** REDEFINE IMAX,JMAX SO THEY WILL REPRESENT NUMBER         REZ3322
C              OF COLUMNS AND ROWS IN NEW GRID (SAME AS IN OLD GRID).   REZ3324
      IMAX=NIMAX*2                                                      REZ3330
      JMAX=NJMAX*2                                                      REZ3340
      IL=NIMAX+1                                                        REZ3350
      JL=NJMAX+1                                                        REZ3360
      IF (PRYTOP.LE.Y(NJMAX).AND.PRXRT.LE.X(NIMAX).AND.TAYTOP.LE.Y(NJMAXREZ3370
     1).AND.TAXRT.LE.X(NIMAX)) GO TO 510                                REZ3380
C          *** ADD APPROPRIATE MATERIAL                                 REZ3390
C              IN CELLS ABOVE (BUT NOT TO THE RIGHT OF) OLD GRID.       REZ3395
      DO 430 I=1,NIMAX                                                  REZ3400
      K=(JL-1)*IMAX+I+1                                                 REZ3410
      DO 420 J=JL,JMAX                                                  REZ3420
      IF (PRYBOT.LT.0.) GO TO 370                                       REZ3430
      IF (J.GE.JPB.AND.J.LE.JPA.AND.I.LE.IPRT) GO TO 390                REZ3440
C          *** NOT PROJECTILE-MATERIAL                                  REZ3450
  370 IF (RHOFIL.EQ.0.) GO TO 380                                       REZ3460
      IF (J.GE.JFILB.AND.J.LE.JFILA) GO TO 400                          REZ3470
C          *** NOT FILLER-MATERIAL                                      REZ3480
  380 IF (TAYBOT.LT.0.) GO TO 420                                       REZ3490
      IF (J.GE.JTB.AND.J.LE.JTA.AND.I.LE.ITRT) GO TO 410                REZ3500
C          *** NOT TARGET. THUS,VACUUM.                                 REZ3510
      GO TO 420                                                         REZ3520
C              *** ADD PROJ. MATERIAL                                   REZ3530
  390 AMX(K)=RHINI*TAU(I)*DY(J)                                         REZ3540
      IF (PROJU.EQ.0..AND.VINI.EQ.0..AND.PROJI.EQ.0.) GO TO 420         REZ3550
      IF (I.GT.I1) I1=I                                                 REZ3560
      IF (J.GT.I2) I2=J                                                 REZ3570
      U(K)=PROJU                                                        REZ3580
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      V(K)=VINI                                                         REZ3590
      AIX(K)=PROJI                                                      REZ3600
      GO TO 420                                                         REZ3610
C                    *** ADD FILLER                                     REZ3620
400   AMX(K)=RHOFIL*TAU(I)*DY(J)                                        REZ3630
      GO TO 420                                                         REZ3640
C                    *** ADD TARGET MATERIAL                            REZ3650
410   AMX(K)=RHINIT*TAU(I)*DY(J)                                        REZ3660
      IF (TARGV.EQ.0..AND.TARGI.EQ.0.) GO TO 420                        REZ3670
      IF (I.GT.I1) I1=I                                                 REZ3680
      IF (J.GT.I2) I2=J                                                 REZ3690
      V(K)=TARGV                                                        REZ3700
      AIX(K)=TARGI                                                      REZ3710
420   K=K+IMAX                                                          REZ3720
430   CONTINUE                                                          REZ3730
C              *** ADD APPROPRIATE MATERIAL TO CELLS ON THE RIGHT       REZ3732
C                  OF THE OLD GRID.                                     REZ3734
      DO 500 I=IL,IMAX                                                  REZ3740
      K=I+1                                                             REZ3750
      DO 490 J=1,JMAX                                                   REZ3760
      IF (PRYBOT.LT.0.) GO TO 440                                       REZ3770
      IF (J.GE.JPB.AND.J.LE.JPA.AND.I.LE.IPRT) GO TO 460                REZ3780
C              *** NOT PROJECTILE MATERIAL.                             REZ3785
440   IF (RHOFIL.EQ.0.) GO TO 450                                       REZ3790
      IF (J.GE.JFILB.AND.J.LE.JFILA) GO TO 470                          REZ3800
C              *** NOT FILLER MATERIAL.                                 REZ3805
450   IF (TAYBOT.LT.0.) GO TO 490                                       REZ3810
      IF (J.GE.JTB.AND.J.LE.JTA.AND.I.LE.ITRT) GO TO 480                REZ3820
C              *** NOT TARGET MATERIAL. THUS,VACUUM.                    REZ3825
      GO TO 490                                                         REZ3830
C              *** ADD PROJECTILE MATERIAL.                             REZ3835
460   AMX(K)=RHINI*TAU(I)*DY(J)                                         REZ3840
      IF (PROJU.EQ.0..AND.VINI.EQ.0..AND.PROJI.EQ.0.) GO TO 490         REZ3850
      IF (I.GT.I1) I1=I                                                 REZ3860
      IF (J.GT.I2) I2=J                                                 REZ3870
      U(K)=PROJU                                                        REZ3880
      V(K)=VINI                                                         REZ3890
      AIX(K)=PROJI                                                      REZ3900
      GO TO 490                                                         REZ3910
C              *** ADD FILLER.                                          REZ3915
470   AMX(K)=RHOFIL*TAU(I)*DY(J)                                        REZ3920
      GO TO 490                                                         REZ3930
C              *** ADD TARGET MATERIAL.                                 REZ3935
480   AMX(K)=RHINIT*TAU(I)*DY(J)                                        REZ3940
      IF (TARGV.EQ.0..AND.TARGI.EQ.0.) GO TO 490                        REZ3950
      IF (I.GT.I1) I1=I                                                 REZ3960
      IF (J.GT.I2) I2=J                                                 REZ3970
      V(K)=TARGV                                                        REZ3980
      AIX(K)=TARGI                                                      REZ3990
490   K=K+IMAX                                                          REZ4000
500   CONTINUE                                                          REZ4010
C              *** REDEFINE JPROJ,USUALLY J-INDEX OF TOP CELL IN        REZ4012
C                  PROJECTILE (INPUT PARAMETER).                        REZ4014
510   JPROJ=JPROJ/2                                                     REZ4020
C              *** REDEFINE ACTIVE GRID MARKERS.                        REZ4030
C                                                                       REZ4040
      I1=I1+2                                                           REZ4050
```

```
520   I2=I2+2                                                          REZ4060
      IF (I1.GT.IMAX) I1=IMAX                                          REZ4070
      IF (I2.GT.JMAX) I2=JMAX                                          REZ4080
C          *** CALL TO REZONE AND CDT COUNTED AS A CALCULATIONAL       REZ4082
C              CYCLE, SO NC AND T ARE INCREMENTED BEFORE PROCEEDING    REZ4084
C              ON TO PH1,PH3 AND PH2.                                  REZ4086
      WS=T+DTNA                                                        REZ4090
      NK=NC+1                                                          REZ4100
C                                                                      REZ4110
      WRITE (6,620) WS,NK,DX(1)                                        REZ4120
C          *** REDEFINE CONSTANTS AND CELL LIMITS FOR CALCULATING      REZ4122
C              TENSIONS AND STRESSES.                                  REZ4124
      KMAX=IMAX*JMAX+1                                                 REZ4130
      IMAXA=IMAX+1                                                     REZ4140
      JMAXA=JMAX+1                                                     REZ4150
      KMAXA=KMAX+1                                                     REZ4160
      N6=N6/2                                                          REZ4170
      JSTR=JSTR/2                                                      REZ4180
      IF (NUMREZ.GT.NREZ) NREZ=NUMREZ                                  REZ4190
      NPLACE=NREZ-NUMREZ+2                                             REZ4200
C          *** CALCULATE NEW ETI                                       REZ4210
      ETH=0.                                                           REZ4230
      DO 530 K=2,KMAX                                                  REZ4240
      ETH=ETH+AMX(K)*(AIX(K)+.5*(U(K)**2+V(K)**2))                     REZ4250
530   CONTINUE                                                         REZ4260
C                 ***DIVIDE JPM(1) BY 2 TO GET NEW PEAK PRESSURE CELLS.REZ4270
      DO 550 I=1,IMAX                                                  REZ4280
      L=2*I                                                            REZ4290
      IF (L.GT.IMAX) GO TO 540                                         REZ4300
      JPM(I)=JPM(L)/2                                                  REZ4310
      GO TO 550                                                        REZ4320
540   JPM(I)=0                                                         REZ4330
550   CONTINUE                                                         REZ4340
      IF (Y2.GT.(-1.)) GO TO 610                                       REZ4350
C                                                                      REZ4360
C         *** SCALE EXISTING TRACER POINTS                             REZ4370
C                                                                      REZ4380
      DO 560 J=1,JJ                                                    REZ4390
      DO 560 I=1,II                                                    REZ4400
      XP(I,J)=XP(I,J)/2.                                               REZ4410
      YP(I,J)=YP(I,J)/2.                                               REZ4420
560   CONTINUE                                                         REZ4430
C                                                                      REZ4440
C          *** REMOVE TRACER POINTS FROM EVERY OTHER CELL AND EVERY    REZ4450
C              OTHER ROW                                               REZ4460
C                                                                      REZ4470
      NMP=0                                                            REZ4480
      M=0                                                              REZ4490
      DO 570 J=1,JJ,2                                                  REZ4500
      M=M+1                                                            REZ4510
      L=0                                                              REZ4520
      DO 570 I=1,II,2                                                  REZ4530
      L=L+1                                                            REZ4540
      XP(L,M)=XP(I,J)                                                  REZ4550
      YP(L,M)=YP(I,J)                                                  REZ4560
570   NMP=NMP+1                                                        REZ4570
      JTPB=1                                                           REZ4580
```

```
      JTPT=INT(FLOAT(JJ)/2.+.6)                                         REZ4590
      ITPL=INT(FLOAT(II)/2.+.6)+1                                       REZ4600
C                                                                       REZ4610
C            *** INITIALIZE REMAINING TRACER POINT STORAGE AND          REZ4620
C            *** PLACE NEW TRACER POINTS FIRST IN NEW CELLS ABOVE OLD   REZ4630
C                GRID THEN IN NEW CELLS TO THE RIGHT OF OLD GRID.       REZ4635
C                                                                       REZ4640
  580 DO 600 J=JTPB,JTPT                                                REZ4650
      DO 600 I=ITPL,II                                                  REZ4660
      XP(I,J)=0.                                                        REZ4670
      YP(I,J)=0.                                                        REZ4680
      K=2*((J-1)*IMAX+I)                                                REZ4690
      IF (AMX(K).EQ.0.) GO TO 590                                       REZ4700
      ICELL=2*I-1                                                       REZ4710
      JCELL=2*J-1                                                       REZ4720
C            *** PLACE NEW TRACER POINTS IN CELLS SO THEY LINE UP       REZ4722
C                WITH EXISTING TRACER POINTS BY USING NPLACE WHICH      REZ4724
C                IS A FUNCTION OF THE NUMBER OF REZONES PERFORMED.      REZ4726
      XP(I,J)=FLOAT(ICELL-1)+1./2.**NPLACE                              REZ4730
      YP(I,J)=FLOAT(JCELL-1)+1./2.**NPLACE                              REZ4740
  590 NMP=NMP+1                                                         REZ4750
  600 CONTINUE                                                          REZ4760
      IF (J.GE.JJ) GO TO 610                                            REZ4770
C            *** GO BACK THROUGH LOOPS ADDING POINTS ON RIGHT SIDE OF   REZ4772
C                OLD GRID.                                              REZ4774
      JTPB=JTPT+1                                                       REZ4780
      JTPT=JJ                                                           REZ4790
      ITPL=1                                                            REZ4800
      GO TO 580                                                         REZ4810
  610 RETURN                                                            REZ4820
C                                                                       REZ4830
  620 FORMAT (1H ////22H PROBLEM REZONED AT T=,1PE12.6,6X,5HCYCLEI4,6X,6REZ4840
     1HDX(1)=,E12.6////)                                                REZ4850
      END                                                               REZ4860-
```

```
      SUBROUTINE ERROR
C     ****************************************************************
C
      DIMENSION AMX(2502),AIX(2502),U(2502)  ,V(2502)  ,P(2502)  ,
     1          X(52)   ,XX(54)   ,TAU(52)  ,JPM(52)  ,
     2          Y(102)  ,YY(104)  ,FLEFT(102), YAMC(102), SIGC(102),
     3          GAMC(102),
     4          PK(15),   Z(150)    ,
     5          XP(26,51),YP(26,51),
     6          PL(204)  ,UL(204)  ,PR(204)   ,
     7           RSN(52),   RST(52),
     8          CMXP(5)  ,CMYP(5)  ,IJ(5)     ,JK(5)     ,
     9          DX(52)   ,DDX(54)  ,DY(102)   ,DDY(104)  ,
     $          SNB(52)  ,STB(52)  ,UK(52,3)  ,VK(52,3)  ,RHO(52,3)
C           *** DIMENSIONED ARRAYS
C           *** Z-BLOCK IS SAVED ON TAPE.
      COMMON      Z
      COMMON     PK
      COMMON  YY,      XX
      COMMON  DDX,     DDY
      COMMON  AMX,     AIX,     U,     V,     P
      COMMON  TAU,     JPM
      COMMON  UL ,     PL
      COMMON  XP ,     YP,      CMXP, CMYP
C           *** NON-DIMENSIONED VARIABLES
      COMMON           AID    ,AMMV   ,AMMY   ,AMPY   ,AMUR   ,AMUT   ,AMVR   ,
     1AMVT   ,DELEB  ,DELER  ,DELET  ,DELM   ,DTODX  ,DXYMIN,EAMMP  ,EAMPY  ,
     2E      ,ERDUMP,I      ,I3     ,IWS    ,J      ,K      ,KA     ,KB     ,
     3LL     ,MD     ,ME     ,MZT    ,NERR   ,NK     ,NPRINT,
     4NR     ,NRZ    ,NULLE  ,PIDTS  ,SIEMIN,SNR    ,SNT    ,STR    ,SOLID  ,
     5SUM    ,TESTRH,TWOPI  ,URR    ,WS     ,WSA    ,WSB    ,WSC    ,WFLAGF,
     6WFLAGL,WFLAGP
C
C           *** THE FOLLOWING EQUIVALENCES MAKE AVAILABLE
C               X(0), Y(0), DX(0), DY(0)
C
      EQUIVALENCE (XX(2), X(1)),  (YY(2), Y(1))
      EQUIVALENCE (DDX(2), DX(1)),  (DDY(2), DY(1))
C
C           *** SPECIAL EQUIVALENCES FOR PH2 ONLY
C
      EQUIVALENCE          (UL,FLEFT),          (UL(103),YAMC),
     .                     (PL,GAMC,PR),        (PL(103),SIGC)
C
C           *** SPECIAL EQUIVALENCES FOR PH3 ONLY
C
      EQUIVALENCE          (UL,RSN),
     1                     (PL,RST),            (P,UK),
     2                     (P(157),VK),         (P(313),SNB),
     3                     (P(365),STB),        (P(417),RHO)
C
C           *** SPECIAL EQUIVALENCES FOR EDIT
C
      EQUIVALENCE (PR(1), IJ),  (PR(6), JK)
C
C           *** Z-STORAGE EQUIVALENCES
C
      EQUIVALENCE                      (Z(  1),PROB  ),(Z(  2),CYCLE ),
```

```
     1(Z(  3),DT     ),(Z(  4),NUMSP ),(Z(  5),NFRELP),(Z(  6),NDUMP7),
     2(Z(  7),ICSTOP),(Z(  8),PIDY  ), (Z(  9),TOPMU ),(Z( 10),RTMU  ),
     3(Z( 11),STK1  ),(Z( 12),NUMREZ), (Z( 13),ETH   ),(Z( 14),UN14  ),
     4(Z( 15),RHINIT),(Z( 16),PROJI ), (Z( 17),UN17  ),(Z( 18),XMAX  ),
     5(Z( 19),NZ    ),(Z( 20),NREZ  ), (Z( 21),AMDM  ),(Z( 22),UVMAX ),
     6(Z( 23),UN23  ),(Z( 24),DMIN  ), (Z( 25),JSTR  ),(Z( 26),DTNA  ),
     7(Z( 27),CVIS  ),(Z( 28),STK2  ), (Z( 29),STEZ  ),(Z( 30),NC    ),
     8(Z( 31),UN31  ),(Z( 32),NRC   ), (Z( 33),IMAX  ),(Z( 34),IMAXA ),
     9(Z( 35),JMAX  ),(Z( 36),JMAXA ), (Z( 37),KMAX  ),(Z( 38),KMAXA )
      EQUIVALENCE
     1(Z( 39),BOTM  ),(Z( 40),BOTMV ), (Z( 41),NUMSPT),(Z( 42),CZERO ),
     2(Z( 43),NUMSCA),(Z( 44),PRLIM ), (Z( 45),PRDELT),(Z( 46),PRFACT)
      EQUIVALENCE
     1(Z( 47),I1    ),(Z( 48),I2    ), (Z( 49),IPCYCL),(Z( 50),TSTOP ),
     2(Z( 51),RHOFIL),(Z( 52),TARGV ), (Z( 53),N3    ),(Z( 54),IVARDY),
     3(Z( 55),VT    ),(Z( 56),N6    ), (Z( 57),RTM   ),(Z( 58),RTMV  ),
     4(Z( 59),UN59  ),(Z( 60),N10   ), (Z( 61),N11   ),(Z( 62),GAMMA ),
     5(Z( 63),TOPM  ),(Z( 64),BOTMU ), (Z( 65),SN    ),(Z( 66),TOPMV ),
     6(Z( 67),PRYBOT),(Z( 68),PRYTOP), (Z( 69),PRXRT ),(Z( 70),CYCPH3),
     7(Z( 71),REZFCT),(Z( 72),TARGI ), (Z( 73),PROJU ),(Z( 74),BBOUND),
     8(Z( 75),EVAP  ),(Z( 76),ECK   ), (Z( 77),NECYCL),(Z( 78),II    ),
     9(Z( 79),JJ    ),(Z( 80),NMP   ), (Z( 81),Y2    ),(Z( 82),EZPH1 )
      EQUIVALENCE
     1(Z( 83),IVARDX),(Z( 84),T     ), (Z( 85),NMPMAX),(Z( 86),PMIN  ),
     2(Z( 87),INTER ),(Z( 88),TAYBOT), (Z( 89),TAYTOP),(Z( 90),IEMAP ),
     3(Z( 91),MC    ),(Z( 92),MR    ), (Z( 93),MZ    ),(Z( 94),MB    )
      EQUIVALENCE
     1(Z( 95),REZ   ),(Z( 96),NODUMP), (Z( 97),UN97  ),(Z( 98),UN98  ),
     2(Z( 99),UN99  ),(Z(100),EVAPM ), (Z(101),EVAPEN),(Z(102),EVAPMU),
     3(Z(103),EVAPMV),(Z(104),EZPH2 ), (Z(105),SNL   ),(Z(106),STL   ),
     4(Z(107),TAXRT ),(Z(108),IDNMAP), (Z(109),IPRMAP),(Z(110),ROEPS ),
     5(Z(111),RHINI ),(Z(112),VINI  ), (Z(113),FINAL ),(Z(114),IVMAP ),
     6(Z(115),RHOZ  ),(Z(116),ESA   ), (Z(117),ESEZ  ),(Z(118),ESB   ),
     7(Z(119),ESCAPA),(Z(120),ESESP ), (Z(121),ESESQ ),(Z(122),ESES  ),
     8(Z(123),ESALPH),(Z(124),ESBETA), (Z(125),ESCAP3),(Z(126),IUMAP ),
     9(Z(127),SS1   ),(Z(128),SS2   ), (Z(129),UMIN  ),(Z(130),SS4   )
      EQUIVALENCE
     1(Z(131),PRTIME),(Z(132),EOR   ), (Z(133),EOT   ),(Z(134),EOB   ),
     2(Z(135),EMOR  ),(Z(136),DXF   ), (Z(137),DYF   ),(Z(138),RHOMIN),
     3(Z(139),STAB), (Z(140),XIENRG),  (Z(141),XKENRG), (Z(142),XTENRG),
     4(Z(143),STT   ),(Z(144),DTMIN ), (Z(145),TRNSFC),(Z(146),EMOT  ),
     5(Z(147),JPROJ ),(Z(148),CNAUT ), (Z(149),BBAR  ),(Z(150),EMOB  )
C
C     ..................................................................
C
C     END OF COMMON
C
C     ..................................................................
C
      IF (NERR.EQ.1) GO TO 120
      GO TO (10,20,30,40,50,60,70,80,90,100), NR
 10   WRITE (6,130) NK
      GO TO 110
 20   WRITE (6,140) NK
      GO TO 110
 30   WRITE (6,150) NK
      GO TO 110
```

```
40      WRITE (6,160) NK                                                ERR1160
        GO TO 110                                                       ERR1170
50      WRITE (6,170) NK                                                ERR1180
        GO TO 110                                                       ERR1190
60      WRITE (6,180) NK                                                ERR1200
        GO TO 110                                                       ERR1210
70      WRITE (6,190) NK                                                ERR1220
        GO TO 110                                                       ERR1230
80      WRITE (6,200) NK                                                ERR1240
        GO TO 110                                                       ERR1250
90      WRITE (6,210) NK                                                ERR1260
        GO TO 110                                                       ERR1270
100     WRITE (6,220) NK                                                ERR1280
110     WRITE (6,230) I,J,K,(M,Z(M),Z(M),M=1,150)                       ERR1290
C             *** IF NR=1, ERROR IS IN INPUT DECK                       ERR1292
        IF(NR.EQ.1) GO TO 120                                           ERR1294
C             *** IF NR=5 AND NK=130, EDIT PRINT HAS JUST BEEN DONE. BY ERR1296
C                 SETTING ERDUMP=1.,EDIT WILL DO A TAPE DUMP BUT NOT    ERR1298
C                 ANOTHER PRINT.                                        ERR1300
        IF (NR.EQ.5.AND.NK.EQ.130) ERDUMP=1.                            ERR1310
        NERR = 1                                                        ERR1315
        I3=I1                                                           ERR1320
        NPRINT=1                                                        ERR1330
        WFLAGL=1.                                                       ERR1340
        NUMSPT=NDUMP7                                                   ERR1350
        CALL EDIT                                                       ERR1360
120     CALL EXIT                                                       ERR1370
C                                                                       ERR1380
C                                                                       ERR1390
130     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1400
       1 INPUT )                                                        ERR1410
140     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1420
       1 SETUP )                                                        ERR1430
150     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1440
       1 CDT   )                                                        ERR1450
160     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1460
       1 ES    )                                                        ERR1470
170     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1480
       1 EDIT  )                                                        ERR1490
180     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1500
       1 MAP   )                                                        ERR1510
190     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1520
       1 PH1   )                                                        ERR1530
200     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1540
       1 PH3   )                                                        ERR1550
210     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1560
       1 PH2   )                                                        ERR1570
220     FORMAT (1H1,5X,38H*** ERROR EXIT - SEE STATEMENT NUMBER ,I5,10H INERR1580
       1 REZONE)                                                        ERR1590
230     FORMAT (//5X,6H    I=,I3,6H    J=I3,6H    K=I3//16X,7HZ-BLOCK//6X,ERR1600
       115H  REAL FORMAT  ,5X,15H INTEGER FORMAT/2X,1HI,8X,4HZ(I),17X,4HZ(ERR1610
       2I)//(I4,2X,E15.6,5X,I15))                                       ERR1620
        END                                                             ERR1630
```

7. DICTIONARY

This section includes a description of the use and location of each of the variables in the program. The following terminology is used in the dictionary:

"Local"	Means name is local to subroutine (not in Blank Common).
"Local$^{(C)}$"	Means name is in Blank Common (or equivalenced to a variable in Blank Common), but its value is never passed to another subroutine.
"Global"	Means name is in Blank Common (or equivalenced to a variable in Blank Common) and its value is passed from one routine to another.
= Z(N)	Means variable is equivalenced to a member of the Z-array, the first array in Blank Common. These variables are usually used in setting up and restarting.

ADDVL	Local	Used in SETUP. Used in finding volume of cells containing sphere-boundary.
AID	Local$^{(C)}$	Used in EDIT in calculation of crater depth.
AIX	Global	Specific internal energy in a cell. (IMAX by JMAX array.)
ALE	Constants	Used in MAP. This array has alphabetic characters for pressure, density, velocity, and energy maps. (Defined in DATA statement.)
AMDM	= Z(21)	INPUT parameter. A cell with compression > AMDM is considered solid. Usual value: 0.95 to 0.99. Used in ES in testing whether to allow negative pressures (tensions). Used in INPUT to calculate SOLID = AMDM * RHOZ, which is used in CPT and PH3.
AMMP	Local	Used in PH2. Mass moving across right boundary of a cell. (See Appendix B)

AMMU	Local	Used in PH2. Radial momentum transported across the bottom boundary of a cell. (See Appendix B)
AMMV	Local(C)	Used in PH2. Axial momentum transported across the bottom boundary of a cell. (See Appendix B)
AMMY	Local(C)	Used in PH2. Amount of mass moving across bottom of a cell. (See Appendix B)
AMPY	Local(C)	Used in PH2. Amount of mass moving across top of a cell. (See Appendix B)
AMUR	Local(C)	Used in PH2. Radial momentum transported across right boundary of a cell. (See Appendix B)
AMUT	Local(C)	Used in PH2. Radial momentum transported across top boundary of cell. (See Appendix B)
AMVR	Local(C)	Used in PH2. Axial momentum transported across right boundary of a cell. (See Appendix B)
AMVT	Local(C)	Used in PH2. Axial momentum transported across top boundary of a cell. (See Appendix B)
AMX	Global	Mass in a cell. (IMAX by JMAX array.)
AREAFC	Local(C)	Used in SETUP. Area of a cell-face. Used in setting up a sphere. Equivalenced to DELEB.
B	Local	Used and calculated in PH3
BBAR	= Z(149)	Used in CDT. An INPUT parameter used in local sound-speed calculation whose value depends on the kind of material. (Local sound-speed is approximated as $C_0 + (BBAR) \cdot \sqrt{P(K)}$.)
BBOUND	= Z(74)	Calculated in PH3. Printed in EDIT under "Plastic-Work." Total work done by the plastic stresses.
BOTM	= Z(39)	Calculated in PH2. Printed in EDIT. Total mass lost out bottom of grid.
BOTMU	= Z(64)	Calculated in PH2. Printed in EDIT. Total radial-momentum lost out bottom of grid.

BOTMV	= Z(40)	Calculated in PH2. Printed in EDIT. Total axial-momentum lost out bottom of grid.
CMXP	Local(c)	Used and calculated in EDIT for printing the centimeter coordinates of the tracer points.
CMYP	Local(c)	(see CMXP)
CNAUT	= Z(148)	Used in CDT, INPUT. Approximate sound-speed of material; calculated in INPUT as $C_0 = \sqrt{\frac{ESCAPA}{RHOZ}} = \sqrt{A/\rho}$.
CRAD	Local(c)	Used in EDIT for printing radii of crater depths. Equivalenced to UL array.
CVIS	= Z(27)	INPUT parameter. Used to describe the bottom boundary-condition. Used in PH1, PH2, PH3. Bottom boundary is transmittive when CVIS = -1., reflective when CVIS = 0.
CYCLE	= Z(2)	Used in INPUT, SETUP, CDT, EDIT. Cycle number (an integer value in floating point form).
CYCPH3	= Z(70)	Used in MAIN and PH3. INPUT parameter: Number of times to subcycle PH3. If value is -1., PH3 is omitted.
CZERO	= Z(42)	INPUT parameter. Value of Y_0 for yield strength calculation. Used in PH3. (See STRENG)
DDX	Global	An array equivalenced to the DX array such that DDX(1) = DX(0).
DDY	Global	An array equivalenced to the DY array such that DDY(1) = DY(0).
DELEB	Local(c)	Used in PH2. Total energy associated with mass transported across bottom boundary of a cell. (See Appendix B)
DELER	(Local(c)	Used in PH2. Total energy associated with mass transported across right boundary of a cell. (See Appendix B)
DELET	Local(c)	Used in PH2. Total energy associated with mass transported across top boundary of a cell. (See Appendix B)

DELI	Local	Used in PH2, PH3. Change of specific internal energy of a cell.
DELM	Local(c)	Used in PH2 for total mass moving into or out of a cell.
DELU	Local	Used in PH2, PH3. Change of radial velocity of a cell.
DELV	Local	Used in PH2, PH3. Change of axial velocity of a cell.
DMIN	= Z(24)	INPUT parameter. Allowable relative error in energy sum. If error is > DMIN then calculation is terminated. Used in EDIT. If everything is working right you should be able to use 10^{-3} for DMIN.
DSCALE	Local	Used in MAP as linear scale factor for compression map.
DT	= Z(3)	Time step. Calculated in CDT. Used in SETUP, EDIT, PH1, PH2 and PH3.
DTFACT	Local	Used in PH3 in calculating a variable time step when subcycling the PH3 calculations.
DTMIN	= Z(144)	INPUT parameter. Used in CDT. After STAB = FINAL, if DT < DTMIN execution is stopped.
DTNA	= Z(26)	DT from previous time cycle. Used in INPUT, CDT, EDIT, REZONE and PH1.
DTNOW	Local	Used in EDIT. Used for saving DT when calling CDT to recalculate pressures after a REZONE.
DTODX	Local(c)	Used in PH2 for DT/DX.
DTODY	Local	Used in PH2 for DT/DY.
DTSTR	Local	Used in PH3. DT for recycling through PH3.
DUODX	Local	Used in PH3. DU/DX.
DUODY	Local	Used in PH3. DU/DY.
DVODX	Local	Used in PH3. DV/DX

DVODY	Local	Used in PH3. DV/DY.
DX	Global	The radial dimension of cells. Equivalenced to DDX such that DDX(1) = DX(0).
DXF	= Z(136)	An INPUT parameter used to calculate the DX array if the radial dimension of the cells is uniform.
DXSUM	Local	Used in SETUP and REZONE to find cell dimensions of packages when DX is not constant.
DXYMIN	Local(c)	Used in CDT. Minimum (DX, DY) of a cell. Used in calculation of SRATIO and DT.
DY	Global	The axial-dimension of cells. Equivalenced to DDY so that DDY(1) = DY(0).
DYF	= Z(137)	INPUT parameter. DY of all cells, if DY is constant.
DYSUM	Local	Used in SETUP and REZONE to find cell dimensions of packages when DY is not constant.
E	Local(c)	Used in REZONE, PH1, and PH3. Temporary storage for energy calculations.
EAMMP	Local(c)	Used in PH2. Specific internal energy of mass moving across right edge of cell.
EAMPY	Local(c)	Used in PH2. Specific internal energy of mass moving across top of cell.
ECK	= Z(76)	Used in EDIT. Relative error in energy sum. If $\|ECK\| > DMIN$, execution is stopped.
EMOB	= Z(150)	Calculated in PH2. Printed in EDIT. Energy change out of bottom of mesh.
EMOR	= Z(135)	Calculated in PH2. Printed in EDIT. Energy change out right side of mesh.
EMOT	= Z(146)	Calculated in PH2. Printed in EDIT. Energy change out of top of mesh.
ENERGY	Local	Used in PH2 to sum energy of cells.
ENGY	Local	Used in PH2 as temporary storage for energy of a cell.

EOB	= Z(134)	Calculated in PH1. Printed in EDIT. Energy change due to work done at bottom boundary.
EOR	= Z(132)	Calculated in PH1. Printed in EDIT. Energy change due to work done at right boundary.
EOT	= Z(133)	Calculated in PH1. Printed in EDIT. Energy change due to work done at top boundary.
ERDUMP	Local[(c)]	Used in EDIT and ERROR. Flags EDIT to stop execution because ERROR has been called.
ESA	= Z(116)	INPUT parameter. Value of "a" in equation of state. Used in ES. (= $\gamma - 1$ when using perfect gas equation of state.)
ESALPH	= Z(123)	INPUT parameter. Value of "α" in equation of state. Used in ES.
ESB	= Z(118)	INPUT parameter. Value of "b" in equation of state. Used in ES.
ESBETA	= Z(124)	INPUT parameter. Value of "β" in equation of state. Used in ES.
ESCAPA	= Z(119)	INPUT parameter. Value of "A" in equation of state. Used in ES.
ESCAPB	= Z(125)	INPUT parameter. Value of "B" in equation of state. Used in ES.
ESCLE	Local	Used in MAP as a logrithmic scale factor for energy map.
ESES	= Z(122)	INPUT parameter. Value of ES in equation of state. Used in ES.
ESESP	= Z(120)	INPUT parameter. Value of ES′ in equation of state. Used in ES.
ESESQ	= Z(121)	INPUT parameter. ESESQ is usually equal to ESESP. It is used to test whether a cell should be considered hot or cold in free-surface treatment. Used in CDT and PH2.

ESEZ	= Z(117)	INPUT parameter. Value of "E_o" in equation of state. Used in ES.
ESUM	Local	Used in EDIT to sum energy and calculate relative error of energy sum.
ETA	Local	Used and calculated in ES. = ρ/ρ_o.
ETH	= Z(13)	Theoretical value of total energy in the mesh. Used in SETUP, EDIT, REZONE, PH1, PH2, PH3. Calculated in SETUP initially; in PH2 thereafter. It is redefined in REZONE.
EVAP	= Z(75)	INPUT parameter. Used in PH2. Any cell with density less than EVAP times initial density of "projectile" is "evaporated" and its energy subtracted from theoretical energy of system. (10^{-3} to 10^{-8} are appropriate values.)
EVAPEN	= Z(101)	Calculated in PH2 and CDT. Printed in EDIT. Sum of energy lost through "evaporation" described under EVAP. Adjusted in CDT when "evaporating" energy of isolated cells. Initialized in SETUP. Equivalenced to SIESPH in SETUP.
EVAPM	= Z(100)	Calculated in PH2. Printed in EDIT. Sum of mass lost through "evaporation" described under EVAP. Used in PH2 and CDT when "evaporating" mass of isolated cells. Initialized in SETUP. Equivalenced to RHOSPH in SETUP.
EVAPMU	= Z(102)	Calculated in PH2. Printed in EDIT. Sum of radial momenta lost through "evaporation." Used in PH2 and CDT when "evaporating" momentum of isolated cells. Initialized in SETUP. Equivalenced to VINSPH in SETUP.
EVAPMV	= Z(103)	Calculated in PH2. Sum of axial momenta lost through "evaporation". Printed in EDIT. Used in PH2 and CDT when "evaporating" momentum of isolated cells. Initialized in SETUP. Equivalenced to RHOOUT in SETUP.

EZPH1	= Z(82)	Energy gained through setting negative internal energies to zero in PH1. Printed in EDIT.
EZPH2	= Z(104)	Calculated in PH2. Sum of specific internal energy fluxes less than SIEMIN and negative internal energies set to zero. Printed in EDIT.
FINAL	= Z(113)	INPUT parameter. Maximum value of stability fraction (STAB). If FINAL = 0; the stability fraction will be constant. Used in CDT.
FLEFT	Local(C)	Used in PH2. Radial momentum of mass moving across left side of cell. Equivalenced to UL array. (See Appendix B)
FLOTMA	Local	Used in MAP.
FRX	Local	Used in PH2 for moving tracer-points.
FRY	Local	Used in PH2 for moving tracer-points.
GAMC	Local(C)	Used in PH2. Mass moving across left side of cell. Equivalenced to PL and PR arrays. (See Appendix B)
GAMMA	= Z(62)	Calculated value of GAMMA = ESA +1. Calculated in INPUT. Used in CDT.
HOOP	Local	Used in PH3. Hoop stress.
I	Local (C)	Used in most subroutines as index in radial direction.
IAID	Local	Used in EDIT in crater depth calculation.
ICELL	Local	Used in REZONE when placing tracer points in new cells.
ICP3	Local	Used in PH3: = INT(CYCPH3).
ICSTOP	= Z(7)	INPUT parameter. Used in EDIT. Execution stops on ICSTOP cycle when stopping on cycles rather than time.
IDL	Local	Used in MAP. Number of columns in maps. On cycle 0, IDL = IMAX; otherwise IDL = I1.

IDNMAP	= Z(108)	Defined in INPUT. Used in MAP to specify the number of symbols to be used in the density, energy, pressure, u-velocity, and v-velocity maps, respectively.
IEMAP	= Z(90)	
IPRMAP	= Z(109)	
IUMAP	= Z(116)	
IVMAP	= Z(114)	
II	= Z(78)	Used in REZONE, EDIT, and SETUP. The number of tracer points in each row.
IJ	Local[(c)]	Used in EDIT. Used to identify which column a tracer point originated in. Equivalenced to PR(1) in EDIT.
IK	Local	Used in PH3 as index, = I + 1.
IKK	Local	Used in PH3, = IK + 1.
ILIM1	Local	Used in MAP as index for printing values of symbols.
ILIM2	Local	See ILIM1.
IMAX	= Z(33)	INPUT parameter. Number of columns in mesh. IMAX must be an even number if grid is to be rezoned with the exception that IMAX = 1 for a 1-D problem. Used in SETUP, CDT, REZONE, EDIT, PH1, PH2, and PH3.
IMAXA	= Z(34)	IMAX + 1. Used in SETUP and REZONE.
INTER	= Z(87)	INPUT parameter. If INTER ≠ 0, EDIT will print after CDT, PH1 and PH3. If INTER = 99, in addition to extra EDIT prints, stresses are printed in PH3. (LOTS of printing.) If INTER = 7, energy totals are printed in PH2 in addition to the extra EDIT prints. Used in MAIN, EDIT, PH1 and Ph2 and PH3.
INTMA	Local	Used in MAP.
IP	Local	Used in EDIT. The column a tracer point is in.
IPCYCL	= Z(49)	INPUT parameter. Used in EDIT. The number of cycles between EDIT prints when printing on cycles rather than time.
IPRT	Local	Used in REZONE. Number of columns in projectile after rezoning.

ISPHMX	Local	Used in SETUP. I-index of right-most column which contains sphere material.
ITPL	Local	Used in REZONE for adding tracer-points in added cells.
ITRT	Local(c)	Used in REZONE. Number of columns in target after rezoning.
IVARDX	= Z(83)	Used in SETUP. Flag for variable radial dimension of cells.
IVARDY	= Z(54)	Used in SETUP. Flag for variable axial dimension of cells.
IWS	Local(c)	Used as local index in INPUT, SETUP, CDT, EDIT, PH2 and PH3.
IX	Local	Used as index in PH2 for tracer-point movement.
IY	Local	Used as index in PH2 for tracer-point movement.
I1	= Z(47)	INPUT parameter. I1 is used to limit calculation in radial direction to "active mesh." Beyond I1 nothing is yet disturbed from initial conditions. I1 is specified initially as (2 + the column-number of the last column in which there is a non-zero velocity or internal energy). However, I1 is never larger than IMAX. I1 is increased automatically as inactive cells beome active. If IMAX = 1, then I1 = 1. Used in CDT, EDIT, REZONE, PH1, PH2 and PH3.
I2	= Z(48)	INPUT parameter. Like I1 but for axial-disturbance-limit. I2 is specified initially as (2 + the number of the upper-most row in which there is a non-zero velocity or internal energy). I2 is increased automatically as inactive cells become active. However, I2 is never larger than JMAX. Used in SETUP, CDT, EDIT, REZONE, PH1, PH2, PH3.
I3	Local(c)	Used in EDIT as a flag for "short" or "long" prints.
J	Local(c)	Used as row-index in most subroutines.

JA	Local	Used in SETUP to calculate J-index of top of sphere.
JB	Local	Used in SETUP to calculate J-index of bottom of sphere.
JCELL	Local	Used in REZONE when placing tracer points in added cells.
JCENTR	Local	Used in SETUP. J-index of row just below center of sphere.
JDL	Local	Used in MAP. Number of rows in maps. On cycle 0, JDL = JMAX; otherwise, JDL = I2.
JFILA	Local	Used in REZONE. The J-index of the row immediately below the target.
JFILB	Local	Used in REZONE. The J-index of the row immediately above the projectile.
JFLAG	Local	Used in PH3. Used in connection with JPM for deciding where to stop calculating stresses.
JINTL	Local	Used in CDT in defining JPM array.
JJ	= Z(79)	Used in REZONE, EDIT and SETUP. Number of tracer points in each column.
JK	Local(C)	Used in EDIT. Used to identify which row a tracer point originated in. Equivalenced to PR(6).
JMAX	= Z(35)	INPUT parameter. Number of rows in mesh. JMAX must be an even number if grid is to be rezoned. Used in SETUP, CDT, EDIT, REZONE, PH1, PH2, PH3.
JMAXA	= Z(36)	JMAX + 1. Used in SETUP and REZONE.
JMP1	Local	Used in REZONE. Limit on do-loop, = JMAX/2 + 1.
JP	Local	Used as an index in CDT. Used in EDIT. The row a tracer point is in.
JPA	Local	Used in REZONE. The J-index of the top row of projectile.
JPB	Local	Used in REZONE. The J-index of the bottom row of projectile.

JPM	Global	Calculated in CDT; used in PH3. Initialized, adjusted and saved on tape in SETUP, INPUT, EDIT and REZONE. JPM(I) is J-index of cell with local maximum pressure in column I.
JPROJ	= Z(147)	INPUT parameter. Usually the J-index of top cell in projectile. Used in SETUP and EDIT. Adjusted in REZONE. The zero point in the crater depth calculation. A division for printout of total energies, mass and momenta.
JRADA	Local	Used in SETUP. The J-index of the top cell on the axis containing a part of the sphere.
JRADB	Local	Used in SETUP. The J-index of the bottom cell on the axis containing a part of the sphere.
JSPHBT	Local	Used in SETUP as index in placing sphere.
JSPHTP	Local	Used in SETUP as index in placing sphere.
JSTR	= Z(25)	INPUT parameter. When active-grid gets to JSTR in J direction, stress calculations begin and negative pressures are permitted. JSTR needs to be large enough so that a shock can become well established before stress calculations begin and negative pressures are allowed. Otherwise, meaningless perturbations are calculated in material which is still at rest. Used in PH3, CDT and REZONE.
JTA	Local	Used in REZONE as index.
JTB	Local	Used in REZONE as index.
JTPB	Local	Used in REZONE. Index for "weeding out" and adding tracer points.
JTPT	Local	Used in REZONE. See JTPB.
K	Local(c)	Used as cell-index in all subroutines.
KA	Local(c)	Used as index in CDT and PH2.
KB	Local(c)	Used as index in CDT.

KK	Local	Used as index in EDIT to remove tracer points from empty cells.
KMAX	= Z(37)	Calculated in SETUP (IMAX*JMAX+1). Used in PH3, SETUP, EDIT, REZONE. Largest value of K (cell-index).
KMAXA	= Z(38)	Calculated in SETUP (KMAX+1). Used in INPUT, SETUP, EDIT and REZONE.
KSPACE	Local	Used in EDIT for spacing printed output.
L	Local	Used as index in EDIT, INPUT, PH2, PH3, REZONE.
LA	Local	Used as index in PH2.
LB	Local	Used as index in PH2.
LJD	Local	Used as index in PH2 and PH3.
LL	Local(C)	Used as index in PH1, PH2 and PH3.
LOCA	Local	Used in EDIT and PH3 in assigned GO TO statements.
LOCB	Local	Used in EDIT in assigned GO TO statements.
M	Local	Used as index in SETUP, EDIT, PH2, REZONE, PH3, ERROR.
MA	Local	Used in MAP to specify symbol to be printed for each cell.
MASS	Local	Used in PH2 for temporary storage of the mass of a cell.
MAXEXP	Local	Used in MAP to define logarithmic scale factor for each map.
MB	= Z(94)	Used and calculated in SETUP. The J-index of the bottom row of projectile.
MC	= Z(91)	Used and calculated in SETUP. The J-index of the top row of projectile.
MD	Local(C)	Used in SETUP. Flag indicating whether or not there is a target.

ME	Local[c]	Used and calculated in SETUP. The number of columns in the target. (If target extends beyond mesh, ME = IMAX.)
MINEXP	Local	Used in MAP to define logarithmic scale factor for each map.
MR	= Z(92)	Used and calculated in SETUP. The number of columns in the projectile.
MSLAVE	Local	Used in PH2 as storage for slaved-cell index when transporting mass across top edge of cell.
MZ	= Z(93)	Used and calculated in SETUP. The J-index of the bottom row of the target.
MZT	Global	Defined in INPUT (MZT = 150). Used in SETUP and EDIT. The number of Z-block words.
N	Local	Used as an index in PH3, PH1, PH2, REZONE and EDIT. In SETUP, N is the J-index of the top row of the target.
N3	= Z(53)	Defi..ed in SETUP. Used in SETUP, EDIT, INPUT in reading and writing tapes. = 0 if there are no tracer points; = 1 if tracer points are used.
N6	= Z(56)	INPUT parameter. Used in ES. Negative pressures are allowed in cells above J = N6 after active-J reaches JSTR value. The value of N6 is reset in REZONE. N6 = 0 allows negative pressures everywhere. On the other hand, to make sure that negative pressures are always set to zero give N6 a very large value (many times as large as JMAX) since in REZONE N6 is cut in half in order to keep it at the same distance (in cm.) from the bottom of the grid.
N10	Global	Used in CDT to identify I-index of cell which controls DT.
N11	Global	Used in CDT to identify J-index of cell which controls DT.

NC	= Z(30)	Cycle number. Set initially to -1 in INPUT. Incremented thereafter in CDT.
NDUMP7	= Z(6)	INPUT parameter. Used in EDIT to control frequency of tape dumps. A tape dump will occur every (NDUMP7) EDIT prints.
NECYCL	= Z(77)	Defined and printed in EDIT. The cycle number associated with the largest relative error in the energy sum.
NERR	Global	Used in ERROR as exit flag. Prevents ERROR from being called more than once during a single run.
NFRELP	= Z(5)	INPUT parameter. Used in EDIT to control frequency of "long" prints. A "long" print will occur every (NFRELP) "short" prints.
NIMAX	Local	Used in REZONE as storage for IMAX/2 when IMAX > 1. NIMAX = 1 when IMAX = 1.
NIMAX1	Local	Used in REZONE as storage for NIMAX + 1.
NJMAX	Local	Used in REZONE as storage for JMAX/2.
NJMAX1	Local	Used in REZONE as storage for NJMAX + 1.
NK	Global	Used in PH2, PH3, EDIT, INPUT, CDT, REZONE and ERROR. Tells which statement of a subroutine caused ERROR to be called.
NKA	Local	Used in PH3 as index.
NKB	Local	Used in PH3 as index.
NMP	= Z(80)	Number of tracer points in use. Used in INPUT, SETUP, REZONE, EDIT and PH2. Initially calculated in SETUP; recalculated in REZONE.
NMPMAX	= Z(85)	INPUT parameter. Maximum number of tracer points to be generated. If fewer points are needed, NMP will have the number actually generated. NMPMAX must not be larger than the number allowed in dimensions of XP and YP. Used in SETUP and REZONE.

NN	Local	Used as index in PH3 and PH2.
NODUMP	= Z(96)	INPUT parameter. Used in EDIT. When NODUMP = 1, no tape dumps are made except on cycle 0. Allows user to restart a problem without writing on the restart tape.
NPLACE	Local	Used in REZONE for lining up added tracer points with original ones.
NPRINT	Global	Used in MAIN, CDT and EDIT. Prevents DT and PRTIME from being altered on intermediate prints. Also, NPRINT = 1 flags EDIT to print and check energy discrepancy.
NR	Global	Used in PH2, EDIT, SETUP and CDT to identify which subroutine called ERROR. Used in ERROR for printing error message.
NRC	= Z(32)	Used in PH1 and PH2 in advancing active grid.
NREZ	= Z(20)	Defined in SETUP. Equals maximum number of rezones allowed. Used in REZONE to line up new tracer points with those already in grid. Used in EDIT to determine the original I and J of each tracer point.
NRT	Local	Used in PH1 and PH2 in advancing active grid.
NRZ	Global	Initialized in SETUP. Equals number of rezones so far performed. Used in EDIT for printout of 1-D problems and for determining the original I and J of each tracer point.
NSLAVE	Local	Used in PH2 as storage for slaved-cell index when transporting mass across right edge of cell.
NULLE	Global	Equivalenced to RHOW in CDT and ES.
NUMREZ	= Z(12)	INPUT parameter. Initially equals number of rezones allowed in one run. Diminished by one after each rezone. Used in EDIT and REZONE.

NUMSCA	= Z(43)	INPUT parameter. Number of times the print interval is to be rescaled. Used in EDIT. See PRDELT for further details.
NUMSP	= Z(4)	Used in EDIT to count the number of "short" prints since the last "long" print.
NUMSPT	= Z(41)	Used in EDIT to count the number of prints (short and long) since the last tape dump.
NZ	= Z(19)	Defined and used in EDIT for 1-D problems. NZ = 4**NRZ. After rezoning the grid NZ is used to scale the values printed by EDIT for the total mass, energy and momentum.
P	Global	Cell-pressure. IMAX by JMAX array. Calculated in ES. Used by PH1. The P-storage space is used for UK, VK, and RHO storage in PH3. The P-array is initialized at the beginning of PH3.
P1	Local	Used in ES as storage for various terms in the pressure equations.
P2	Local	
P3	Local	
P4	Local	
P5	Local	
P6	Local	
P8	Local	
P9	Local	
P12	Local	
PABOVE	Local	Used in PH1 as storage for pressure at top of cell.
PBLO	Local	Used in PH1 as storage for pressure at bottom of cell.
PIDTS	Local(C)	Defined and used in PH1 as 1./(π*DT*DY). Defined and used in PH2 as 1./(π*DT).
PIDY	= Z(8)	Defined in INPUT: = π. Used in REZONE, SETUP, PH1, PH2, and PH3.
PK	Global	Used in SETUP and INPUT for defining input parameters. (See Appendix A.) PK(3) used in EDIT to signal a "long" or "short" print on first cycle of a restart run.

PL	Local(C)	Used in PH1 for saving pressures on left side of cell. Used in EDIT for crater depth printout. Equivalenced in standard OIL-RPM as follows: PL = RST (for PH3) PL = PR = GAMC (for PH2) PL(103) = SIGC (for PH2)
PMIN	= Z(86)	Used as a pressure cut-off. Calculated and printed in CDT as $(C_0) \cdot (\rho_0) \cdot (U_{min})$. Initially defined in INPUT as 10^6.
PR	Local(C)	Used in INPUT and EDIT for temporary storage.
PRAMOA	Local	Printed and calculated in EDIT. The positive radial momentum above JPROJ. Equivalenced to PR(8) in EDIT only.
PRAMOB	Local	Printed and calculated in EDIT. The positive radial momentum below JPROJ. Equivalenced to PR(16) in EDIT only.
PRDELT	= Z(45)	INPUT parameter. Gives the initial time interval between EDIT prints. There are five parameters which control printing frequency: PRDELT, IPCYCL, PRLIM, PRFACT, and NUMSCA. If the user is printing on time (PRDELT ≠ 0. and IPCYCL = 0.), DT will be adjusted so that a print will occur exactly every PRDELT seconds. If the user is printing on cycles (PRDELT = 0., IPCYCL ≠ 0.), a print will occur every IPCYCL cycles. PRLIM, PRFACT and NUMSCA are used to increase the print interval. PRLIM is the time (or cycle) at which PRDELT (or IPCYCL) and PRLIM are multiplied by PRFACT. The new value of PRLIM establishes the next time (or cycle) when the print interval will be rescaled. This process continues at most NUMSCA times. EXAMPLE: You wish to print every 1×10^{-8} sec. until you reach 1×10^{-7} sec., then every 1×10^{-7} sec. until 1×10^{-6} sec. and every 1×10^{-6} sec. thereafter: PRDELT = $1. \times 10^{-8}$ PRFACT = 10. PRLIM = $1. \times 10^{-7}$ NUMSCA = 2.

PRFACT	= Z(46)	INPUT parameter. Used in EDIT as a factor for rescaling PRDELT, IPCYCL, and PRLIM when PRLIM-time or cycle is reached. (See PRDELT.) Should be > 1.
PRLIM	= Z(44)	INPUT parameter: time or cycle at which to rescale PRDELT (or IPCYCL) and PRLIM by PRFACT. (See PRDELT.)
PRMAS	Local(C)	Used and calculated in EDIT. Total mass below JPROJ. Equivalenced to PR(12) in EDIT only.
PRMV	Local(C)	Used and calculated in EDIT. Total axial momentum below JPROJ. Equivalenced to PR(12) in EDIT only.
PRMVP	Local(C)	Used and calculated in EDIT. Total positive axial momentum below JPROJ. Equivalenced to PR(14) in EDIT only.
PROB	= Z(1)	INPUT parameter. Identifying problem number. Used in EDIT and INPUT.
PROJI	= Z(16)	INPUT parameter. Initial specific internal energy of projectile. Used in SETUP and REZONE.
PROJU	= Z(73)	INPUT parameter. Initial radial velocity of projectile. (Usually = 0) Used in SETUP and REZONE.
PROPI	Local	Calculated and used in EDIT. For 1-D problems the totals for energy, mass, momentum per unit area are printed. (i.e., they are divided by 4** (Number of rezones)) and stored in PROPI for printing.
PRR	Local	Used in PH1 as temporary storage of pressure and pressure averages.
PRTIME	= Z(131)	Initially set to PRDELT in INPUT. Thereafter calculated in EDIT. When T = PRTIME, it is time to print.
PRXRT	= Z(69)	INPUT parameter. The outer radius of projectile (in cms.). PRXRT must be at a cell-boundary. Used in SETUP and REZONE.
PRYBOT	= Z(67)	INPUT parameter. Y-value of bottom of projectile (in cms.). PRYBOT should be at a cell-boundary. If no "projectile" is to be generated, PRYBOT should be set to -1. Used in SETUP and REZONE.

PSCLE	Local	Used in MAP as a logarithmic scale factor for the pressure maps.
PTEMP	Local	Used in CDT when calculating JPM array (the maximum pressure location in each column).
PW	Local	Used in PH3 to calculate plastic work when INTER = 99.
RADIUS	= PK(12) = Z(162)	INPUT parameter. Radius of sphere (in cms.). The radius need not be a multiple of DX. Used in SETUP. Equivalenced to PK(12) in SETUP.
RAMOMA	Local	Printed and calculated in EDIT. Total radial momentum above JPROJ. Equivalenced to PR(7) in EDIT only.
RATIO	Local	Used in CDT in calculation of DT. Ratio of $(DX,DY)_{min}$ to $(U,V,\text{ local sound speed})_{max}$.
RC	Local	Used and calculated in PH1 as distance from axis to center of a cell.
RELERR	Local	Used in EDIT for storing and printing maximum relative error in the energy sum.
REZ	= Z(95)	Flag defined in PH2 and used in EDIT. Signals when the REZONE subroutine should be called. (The rezone flag is turned on when material begins to flow out through transmittive boundaries. In REZONE each set of four cells in the mesh is made into one cell. The new mass is the sum of masses in the four original cells. Momentum and total energy are conserved but in so doing some kinetic energy is changed to internal. (The result is that rezoning has a stabilizing influence.) When all permitted rezones have been done, material is allowed to flow out through transmittive boundaries and the mass and energy are lost from the system.
REZFCT	= Z(71)	INPUT flag for rezoning. If = 1., the grid is rezoned (NUMREZ) times. If = 0., no rezoning is done. Tested in PH2 and EDIT.

RHINI	= Z(111)	INPUT parameter. Initial density of projectile. Used in SETUP and REZONE. In PH2 it is used to determine whether material should be evaporated. (See EVAP)
RHINIT	= Z(15)	INPUT parameter. Initial density of target. Used in SETUP and REZONE.
RHO	Local(c)	Used in PH3 for temporary storage of cell density.
RHOFIL	= Z(51)	INPUT parameter. Initial density of filler material between the projectile and target. Used in SETUP and REZONE.
RHC[illegible]	= Z(138)	INPUT parameter. Cells with ρ < RHOMIN are by-passed in calculation of DT.
RHOOUT	= Z(103)	INPUT parameter. Used in SETUP. In cells containing sphere boundary RHOOUT is the density of material outside sphere. Equivalenced to Z(103) and EVAPMV in SETUP.
RHOSPH	= Z(100)	INPUT parameter. Used in SETUP as the initial density of sphere. Equivalenced to Z(100) and EVAPM in SETUP.
RHOW	Global	Density of cell. Calculated in CDT, used in ES. Equivalenced to NULLE in CDT and ES.
RHOZ	= Z(115)	INPUT parameter. Normal density. Used in INPUT, CDT, ES, EDIT, PH2 and PH3.
ROEPS	= Z(110)	INPUT parameter. Round-off epsilon used in calculating cutoffs. Used in CDT to calculate UMIN. UMIN = (ROEPS)(|maximum u or v|) Used in SETUP, EDIT and PH2.
RR	Local	Used and calculated in PH1. Distance (cms.) from axis to center of cell on the right.
RTM	= Z(57)	Calculated in PH2. Printed in EDIT. Total mass lost out right side of grid.

RTMU	= Z(10)	Calculated in PH2. Printed in EDIT. Total radial-momentum lost out right side of grid.
RTMV	= Z(58)	Calculated in PH2. Printed in EDIT. Total axial-momentum lost out right side of grid.
SAVEK	Local	Used and calculated in PH2. Factor used in calculation of energy fluxes across right and top boundaries of cells on reflective boundaries.
SIEMIN	Global	Used in MAP, PH2. Calculated in CDT. SIE cut-off value = $(UMIN)^2$.
SIENEW	Local	Used and calculated in PH2. New value of specific internal energy.
SIESPH	= Z(101)	INPUT parameter. Initial value of specific internal energy of sphere. Equivalenced to Z(101) and EVAPEN in SETUP.
SIGC	Local(C)	Used in PH2 for energy carried by mass moving across left side of cell. Equivalenced to PL(103). (See Appendix B.)
SIGMU	Local	Used in PH2 for radial momentum moving across cell-boundaries.
SIGMV	Local	Used in PH2 for axial momentum moving across cell-boundaries.
SN	= Z(65)	INPUT flag: When = 0. negative internal energy is to be set to 0. When = 1. negative internal energy is to be left alone. Used in PH1 and PH2.
SNB	Local(C)	Used in PH3 for normal stress at bottom of a cell. Equivalenced to P(313).
SNL	= Z(105)	Used in PH3 for normal stress at left of a cell.
SNLX	Local	Used in PH3. = SNL * X(I-1).
SNR	Local(C)	Used in PH3 for normal stress at right of a cell. (= S_{11} at right.)
SNT	Local(C)	Used in PH3 for normal stress at top of a cell. (= S_{22} at top.)

SOLID	Global	Calculated in INPUT as (RHOZ * AMDM). Used in PH2, PH3 and CDT.
SRATIO	Local	Used in CDT to calculate DT. The smallest ratio of minimum cell dimension to maximum velocity.
SS1	= Z(127)	Calculated in INPUT. Used in ES: = 1./(ESESP-ESES).
SS2	= Z(128)	INPUT parameter controlling reflective (and axis) boundary treatment. Usually = 1. Used in PH2.
SS4	= Z(130)	INPUT parameter. If SS4 $\neq$ 0., REZONE is called on second cycle of run. Used in EDIT.
STAB	= Z(139)	INPUT parameter. Used in CDT. Initial value of "stability fraction" for the calculation of DT. If FINAL = 0., STAB is constant. Otherwise its value progresses from STAB to FINAL in a geometric progression.
STB	Local(c)	Used in PH3 for shear stress at bottom of cell. Equivalenced to P(365).
STEZ	= Z(29)	INPUT parameter: E_0. Used in yield-strength calculation in PH3. See STRENG.
STK1	= Z(11)	INPUT parameter: Y_1. Used in yield-strength calculation in PH3. See STRENG.
STK2	= Z(28)	INPUT parameter: Y_2. Used in yield-strength calculation in PH3. See STRENG.
STL	= Z(106)	Used in PH3 for shear stress at left of cell.
STLX	Local	Used in PH3. = STL * X(I-1).
STR	Local(c)	Used in PH3 for shear stress at right of cell.
STRENG	Local	Calculated and used in PH3: yield strength of material. (Y_0, Y_1, Y_2 supplied by user.) $\text{STRENG} = (Y_0 + Y_1\mu + Y_2\mu^2) \cdot (1 - \frac{E}{E_0})$

		If STRENG < 0., stresses are set to 0. If $E > E_0$, STRENG = 0. Y_0 is SZERO, Y_1 is STK1, Y_2 is STK2, ρ_0 is RHOZ, E is AIX of cell, E_0 is STEZ, ρ is density of cell, $\mu = \rho/\rho_0 - 1$.
STT	= Z(143)	Used in PH3 for shear stress at top of cell.
SUM	Local(c)	Used in PH2. Sums negative internal energy when negative internal energy is set to zero.
SUME	Local	Used in PH2. Sums energy changes.
SUM1	Local	Used in SETUP to define JRADA.
SUM2	Local	Used in SETUP to define JRADB.
T	= Z(84)	Time in seconds. Initially defined in INPUT. Incremented in CDT. Adjusted in EDIT for printing. Printed by CDT, EDIT, REZONE.
TARGI	= Z(72)	INPUT parameter. Initial value of specific internal energy of target. Used in SETUP and REZONE.
TARGV	= Z(52)	INPUT parameter. Initial value of axial-velocity of target. Used in SETUP and REZONE.
TARMAS	Local(c)	Used in EDIT. Total mass above JPROJ. Equivalenced to PR(4) in EDIT only.
TARMV	Local(c)	Used in EDIT. Total axial momentum above JPROJ. Equivalenced to PR(5) in EDIT only.
TARMVP	Local(c)	Used in EDIT. Total positive axial momentum above JPROJ. Equivalenced to PR(6) in EDIT only.
TAU	Global	Calculated in SETUP and REZONE. Area of cell face: $= \pi(X(I)^2 - X(I-1)^2)$. Used in most subroutines.

TAUDTS	Local	Used and calculated in PH1: = TAU*DT.
TAXRT	= Z(107)	INPUT parameter. Outer radius of target (in cms.). TAXRT should be at a cell-boundary. Used in SETUP and REZONE.
TAYBOT	= Z(88)	INPUT parameter. Axial location of bottom of target (in cms). TAYBOT should be at a cell-boundary. If no "target," TAYBOT = -1. Used in SETUP and REZONE.
TAYTOP	= Z(89)	INPUT parameter. Axial location of top of target (in cms). TAYTOP should be at a cell-boundary. Used in SETUP and REZONE.
TEPRO	Local(c)	Used in EDIT. Total energy below JPROJ. Equivalenced to PR(11) in EDIT only.
TESTRH	Global	Calculated in INPUT: = (.2)*RHOZ. Used in CDT in defining pressure scale factor.
TETAR	Local(c)	Used in EDIT. Total energy above JPROJ. Equivalenced to PR(3) in EDIT only.
THO3	Local	Used and calculated in PH3: $= \frac{1}{3}\left(\frac{\partial u}{\partial r} + \frac{\partial r}{\partial z} + \frac{u}{r}\right)$.
TIEPRO	Local(c)	Used in EDIT. Total internal energy below JPROJ. Equivalenced to PR(9) in EDIT only.
TIETAR	Local(c)	Used in EDIT. Total internal energy above JPROJ. Equivalenced to PR(1) in EDIT only.
TKEPRO	Local(c)	Used in EDIT. Total kinetic energy below JPROJ. Equivalenced to PR(10) in EDIT only.
TKETAR	Local(c)	Used in EDIT. Total kinetic energy above JPROJ. Equivalenced to PR(2) in EDIT only.
TMA	Local	Used in MAP to associate a given density with the printed symbol.
TNOW	Local	Used in EDIT: = time now; saved when EDIT calls CDT after calling REZONE.
TOPM	= Z(63)	Calculated in PH2. Printed in EDIT. Total mass lost out top of grid.

TOPMU	= Z(9)	Calculated in PH2. Printed in EDIT. Total radial-momentum lost out top of grid.
TOPMV	= Z(66)	Calculated in PH2. Printed in EDIT. Total axial-momentum lost out top of grid.
TOTSPH	Local	Used in SETUP. Total volume of sphere.
TRIAL	Local	Used in CDT. Maximum sound-speed or velocity used to define DT.
TRNSFC	= Z(145)	Defined in INPUT: = .4. Used in PH2 to define maximum transport velocity. (See UVMAX.)
TSTOP	= Z(50)	INPUT parameter. Value of T at which execution stops when stopping on time rather than cycles.
TWOPDT	Local	Calculated and used in PH2: = 2*π*DT.
TWOPI	Global	Calculated in INPUT. Used in PH3: = 2π.
U	Global	Radial velocity of cell. (IMAX by JMAX array.)
UAMMP	Local	Used in PH2 for U of mass moving across right cell-edge.
UAMPY	Local	Used in PH2 for U of mass moving across top cell-edge.
UBAR	Local	Used in PH3 in calculating energy sum.
UEEF	Local	Used in PH2 to move tracer-points.
UK	Local$^{(c)}$	Used in PH3. Temporary storage for part of U array.
UKT	Local	Used in PH3. Temporary storage for U(K).
UL	Local$^{(c)}$	Used in PH1 for U on left. Used in EDIT for crater depth printout. Equivalenced as follows in standard OIL-RPM: UL(103) = CRAD (for EDIT) UL = RSH (for PH3) UL = FLEFT (for PH2) UL(103) = YAMC (for PH2)
UMIN	= Z(129)	Calculated in CDT. Used as velocity cutoff in PH2,PH3, and MAP: = (ROEPS)*(maximum sound-speed or velocity).

UMK	Local	Calculated and used in PH2. Temporary storage for U(K)*AMX(K).
UMKP	Local	Calculated and used in PH2. Temporary storage for U(K+1)*AMX(K+1).
UMOM	Local	Calculated and used in PH2: = MASS*U(K).
UNxxx	= Z(xxx)	Unused Z-storage.
UNEW	Local	Calculated and used in PH2. New value of U.
UOTK	Local	Calculated and used in PH2: = UMK/TAU(I).
UOTKP	Local	Calculated and used in PH2: = UMKP/TAU(I+1).
UOX	Local	Used in PH3: = U/X.
URR	Local(C)	Used in PH_ and PH2. Temporary storage for velocity and velocity averages.
USCLE	Local	Used in MAP as logarithmic scale factor of radial velocity map.
UVMAX	= Z(22)	Used and calculated in PH2. Maximum transport velocity. In radial direction UVMAX = TRNSFC*DX(I)/DT. In axial direction UVMAX = TRNSFC*DY(J)/DT.
V	Global	Axial velocity of cell. (IMAX by JMAX array.)
VABOVE	Local	Used in PH1 and PH2 as storage for velocity at top of cell.
VALUE	Local	Used in MAP in printing maximum value of each map symbol.
VAMMP	Local	Used in PH2 for axial velocity of mass moving across right cell-edge.
VAMPY	Local	Used in PH2 for axial velocity of mass moving across top cell-edge.
VBAR	Local	Used in PH3 in calculating energy sum.
VBLO	Local	Used in PH1 as storage for velocity at bottom of cell.
VEFF	Local	Used in PH2 to move tracer points.

VEL	Local	Used in PH1 as subcycle flag.
VFACT	Local	Used in PH3 in setting boundary conditions.
VINI	= Z(112)	INPUT parameter. Initial axial velocity of projectile. Used in SETUP and REZONE.
VINSPH	= Z(102)	INPUT parameter. Initial axial velocity of sphere. Used in SETUP. Equivalenced to Z(102) and EVAPMU in SETUP.
VK	Local(C)	Used in PH3. Temporary storage for part of V array.
VKT	Local	Used in PH3. Temporary storage for V(K).
VMK	Local	Calculated and used in PH2: = V(K)*AMX(K).
VML	Local	Calculated and used in PH2: = V(K+IMAX)*AMX(K+IMAX).
VNEW	Local	Calculated and used in PH2. New value of V.
VOLSPH	Local	Calculated and used in SETUP. Volume of toroid generated by a cell. Used in setting up sphere.
VOW	Local	Calculated and used in ES. = (normal density)/(density of cell).
VSCLE	Local	Used in MAP as logarithmic scale factor for axial velocity map.
VT	= Z(55)	INPUT parameter. Used in PH2 as minimum mass flux (across top or right side of one boundary cell in one cycle) needed to trigger a rezone. Usually $VT \sim \rho_0 \times 10^{-4}$.
WDYF	Local	Used in PH2 as temporary storage for DY(J) or DY(J+1).
WFLAGF	Gobal	Used in INPUT and EDIT. Flags first cycle. Set = 1. in INPUT. Set = 0. in EDIT.
WFLAGL	Global	Used in MAIN and EDIT. Flags last cycle. Set = 1. in EDIT.
WFLAGP	Local(C)	Used in EDIT. Flags beginning of printout of properties for each cell in a given column.

WS	Local$^{(C)}$	Used in most subroutines for local working storage.
WSA	Local$^{(C)}$	Used in most subroutines for local working storage.
WSB	Local$^{(C)}$	Used in most subroutines for local working storage.
WSC	Local$^{(C)}$	Used in most subroutines for local working storage.
WSD	Local	Used in PH2 local working storage.
WSMAX	Local	Used in MAP to define scale factors.
WSMIN	Local	Used in MAP to define scale factors.
WSOUT	Local	Used in PH2 for adjusting over-emptied cells.
WT	Local	Used in CDT for local working storage.
WTA	Local	See WT.
WTB	Local	See WT.
X	Global	Distance (cms) from axis to outside of cell. Equivalenced to XX array such that X(0) = XX(1).
XIENRG	= Z(140)	Total internal energy. Calculated in EDIT and used for printing labels on tracer point plots.
XKENRG	= Z(141)	Total kinetic energy. Calculated in EDIT and used for printing labels on tracer point plots.
XL2	Local	Calculated and used in SETUP for placing sphere: $= (X(I-1))^2$.
XMAX	= Z(18)	Calculated in SETUP: = X(IMAX).
XP	Global	Tracer-point x-coordinates. Used in INPUT, SETUP, EDIT, PH2 and REZONE.
XR2	Local	Calculated and used in SETUP for placing sphere: $= (X(I))^2$.
XTENRG	= Z(142)	Total energy. Calculated in EDIT and used for printing labels on tracer point plots.
XUM	Constants	Used in MAP. Has negative alphabetic characters for maps. Defined in DATA statement.

XX	Global	Equivalenced to X array so as to make X(0) available.
Y	Global	Distance (cms) from bottom of grid to top of cell. Equivalenced to YY array such that Y(0) = YY(1).
Y2	= Z(81)	INPUT tracer point flag: when = -2, tracer points are calculated; when = 0, tracer points not calculated.
YAMC	Local(c)	Calculated and used in PH2. Axial momentum of mass moving across 1 ft side of cell. Equivalenced to UL(103). (See Appendix B)
YBOTTM	Local	Calculated and used in SETUP in placing sphere: = Y(J-1).
YC2	Local	Calculated and used in SETUP in placing sphere: = $(YCENTR)^2$.
YCENTR	= PK(13) = Z(163)	INPUT parameter. Distance (cms) of center of sphere from bottom of grid. YCENTR must be at a cell-boundary. Used in SETUP. Equivalenced to PK(13) in SETUP only.
YDIFFB	Local	Calculated and used in SETUP in placing sphere.
YDIFFI	Local	Calculated and used in SETUP in placing sphere.
YDIFFO	Local	Calculated and used in SETUP in placing sphere.
YDIFFT	Local	Calculated and used in SETUP in placing sphere.
YLINTA	Local	Calculated and used in SETUP in placing sphere.
YLINTB	Local	Calculated and used in SETUP in placing sphere.
YLOWER	Local	Calculated and used in SETUP in placing sphere.
YMAX	Local	Calculated in SETUP: = Y(JMAX).
YP	Global	Tracer-point y-coordinates. Used in INPUT, SETUP, EDIT, PH2 and REZONE.
YRINTA	Local	Calculated and used in SETUP in placing sphere.
YRINTB	Local	Calculated and used in SETUP in placing sphere.
YTOP	Local	Calculated and used in SETUP in placing sphere.

YUPPER	Local	Calculated and used in SETUP in placing sphere.
YY	Global	Equivalenced to Y array so as to make Y(0) available.
Z	Special Global	Storage for most of the input parameters. The Z-array (150 words) is written on tape for restarts. Used in INPUT, MAIN, and SETUP. (See Appendix A)

APPENDIX A
Z-STORAGE LISTED NUMERICALLY

See Dictionary for meaning and use.

*1.	PROB	30.	NC	59.	UN59
2.	CYCLE	31	UN31	60.	N10
3.	DT	32.	NRC	61.	N11
4.	NUMSP	2*33.	IMAX	62.	GAMMA
2*5.	NFRELP	34.	IMAXA	63.	TOPM
2*6.	NDUMP7	2*35.	JMAX	64.	BOTMU
2*7.	ICSTOP	36.	JMAXA	*65.	SN
8.	PIDY	37.	KMAX	66.	TOPMV
9.	TOPMU	38.	KMAXA	*67.	PRYBOT
10.	RTMU	39.	BOTM	*68.	PRYTOP
*11.	STK1	40.	BOTMV	*69.	PRXRT
2*12.	NUMREZ	41.	NUMSPT	*70.	CYCPH3
13.	ETH	*42.	CZERO	*71.	REZFCT
14.	UN14	2*43.	NUMSCA	*72.	TARGI
*15.	RHINIT	*44.	PRLIM	*73.	PROJU
*16.	PROJI	*45.	REDELT	74.	BBOUND
17.	UN17	*46.	PRFACT	*75.	EVAP
18.	XMAX	2*47.	I1	76.	ECK
19.	NZ	2*48.	I2	77.	NECYCL
20.	NREZ	2*49.	IPCYCL	78.	II
*21.	AMDM	1*R 50.	TSTOP	79.	JJ
22.	UVMAX	*51.	RHOFIL	80.	NMP
23.	UN23	*52.	TARGV	*81.	Y2
*24.	DMIN	53.	N3	82.	EZPH1
2*25.	JSTR	2*54.	IVARDY	2*83.	IVARDX
26.	DTNA	55.	VT	84.	T
*27.	CVIS	2*56.	N6	2*85.	NMPMAX
*28.	STK2	57.	RTM	86.	PMIN
*29.	STEZ	58.	RTMV	2*87.	INTER

* User-supplied input-values.
2* Must have a "2" in column 1.
1* Must have a "1" in column 1.
R Must be included in a restart input input deck.

*88. TAYBOT

*89. TAYTOP

90. IEMAP

91. MC

92. MR

93. MZ

94. MB

95. REZ

2*96. NODUMP

97. UN97

98. UN98

99. UN99

*100. EVAPM(RHOSPH)

*101. EVAPEN(SIESPH)

*102. EVAPMU(VINSPH)

*103. EVAPMV(RHOOUT)

104. EZPH2

105. SNL

106. STL

*107. TAJRT

108. IDNMAP

109. IPRMAP

*110. ROEPS

*111. RHINI

*112. VINI

*113. FINAL

114. IVMAP

*115. RHOZ

*116. ESA

*117. ESEZ

*118. ESB

*119. ESCAPA

*120. ESESP

*121. ESESQ

*122. ESES

*123. ESALPH

*124. ESBETA

*125. ESCAPB

126. IUMAP

127. SS1

128. SS2

129. UMIN

*130. SS4

131. PRTIME

132. EOR

133. EOT

134. EOB

135. EMOR

*136. DXF

*137. DYF

*138. RHOMIN

*139. STAB

140. XIENRG

141. XKENRG

142. XTENRG

143. STT

*144. DTMIN

145. TRNSFC

146. EMOT

2*147. JPROJ

148. CNAUT

*149. BBAR

1*150. EMOB = 0 (Last card of input unless restarting from tape.)

PK array follows the Z array in Blank Common; so PK(1) from the beginning of Blank Common is equivalent to Z(151).

1*R151. PK(1) should be the same as PROB.

*R152. Cycle to restart on.

*R153. PK(3): When = -1., program will restart from tape and do a "long" EDIT print of the pickup cycle. When = -2., program will restart from tape and do a "short" EDIT print of the pickup cycle.

*162. Radius of sphere (RADIUS).

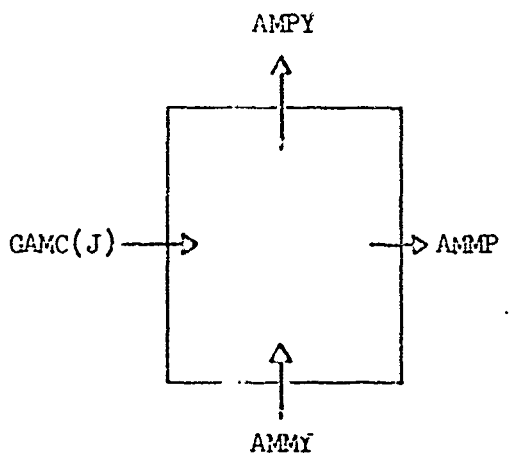
*163. Y-center of sphere (YCENTR).

1*164. When Z(164) > 0. CARDS will be called by SETUP to read "special" input. (See "OIL-RPM Input for Special Setup" on page 23.)

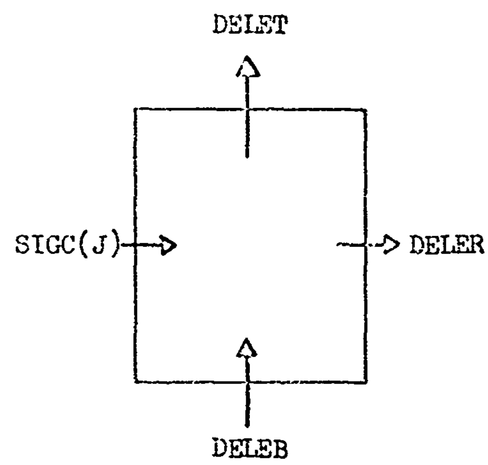
APPENDIX B

VARIABLES USED FOR FLUXES ACROSS CELL BOUNDARIES

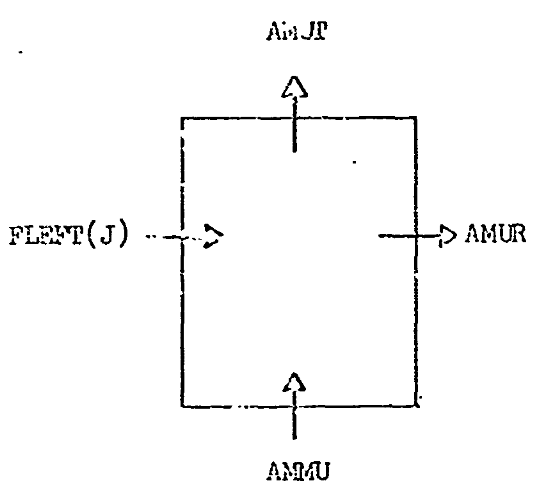
Mass



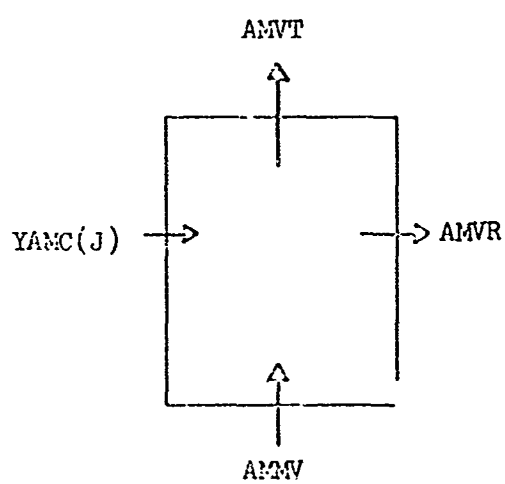
Energy



Radial Momentum



Axial Momentum



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