Title

Three-Dimensional Steady State Flow of Fluids in Porous Solids

Authors

Taylor, Robert
Doherty, William
Wilson, Edward

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THREE-DIMENSIONAL, STEADY STATE FLOW OF FLUIDS IN POROUS SOLIDS

by

Robert L. Taylor
William P. Doherty
and
Edward L. Wilson

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INTRODUCTION

The steady flow of water beneath the floor of a large barrage develops non-uniform pressures which cannot be accurately predicted by a two-dimensional analysis. In order to obtain predictive information for design the analysis must be completely three-dimensional and be able to include the various geologic factors encountered at most barrage sites. Some of these are stratification, lenses of highly pervious or impervious material, and material anisotropy.

In this report we present the necessary theory and discuss the development of a three-dimensional finite element computer program for the determination of fluid pressures and flows in a porous solid governed by a generalized Darcy law.

An elementary three-dimensional analysis is included to indicate the type of analytical capabilities possible with this computer program.

GENERAL THEORY

In this report the flow of liquids in a saturated porous solid is considered. The flows are specified by a generalized Darcy law expressed by [1]:

$$q_i = - K_{ij} (p,j - F_j) \qquad i,j = 1, 2, 3 \tag{2.1}$$

where q_i is the flow rate in the i-direction; p is the liquid pressure; F_j is the body force component in the j-direction; and K_{ij} is a symmetric, second rank tensor [2], which describes the local permeability of the solid. In this section cartesian tensor notation is employed (e.g. see [3]). Accordingly, a comma followed by a subscript denotes partial differentiation with respect to the subscript and a repeated index implies summation over the range of the subscript.

The body forces are usually restricted to gravity effects such that

$$F_j = \rho g_j$$

and ρ is the fluid mass density, g_j the component of acceleration in the j-direction.

Every solid possesses three orthogonal directions for which the local permeability tensor assumes the form (2)

$$\tilde{K}_{ij} (y) = \begin{bmatrix} K_I & 0 & 0 \\ 0 & K_{II} & 0 \\ 0 & 0 & K_{III} \end{bmatrix} \tag{2.2}$$

The y-directions are called the principle material directions. The local values of the permeability tensor are obtained from the principle values by a coordinate transformation. For example, in two cartesian reference frames x_i and y_i, where x_i is a global reference frame and y_i is the principal material frame, we have

$$x_j = a_{jk} y_k \tag{2.3}$$

where a_{jk} is an orthonormal transformation matrix of the direction cosines. Then if $\tilde{q}_m$ (y) are the flow rates in the principal directions we have

$$q_i = a_{im} \tilde{q}_m \tag{2.4}$$

also

$$\frac{\partial p}{\partial y_k} = \frac{\partial p}{\partial x_j} \frac{\partial x_j}{\partial y_k} = a_{jk} \frac{\partial p}{\partial x_j} \tag{2.5}$$

and

$$\tilde{F}_k = (a_{kj})^{-1} F_j = a_{jk} F_j \tag{2.6}$$

finally we obtain from (2.1)

$$q_i = a_{im} \tilde{K}_{mk} (y) a_{jk} \left(\frac{\partial p}{\partial x_j} - F_j (x) \right) \tag{2.7}$$

and hence

$$K_{ij} (x) = a_{im} \tilde{K}_{mk} a_{jk} \tag{2.8}$$

defines the transformation equation from one reference frame to another.

The steady flow of fluids through the porous solid is defined by the solution to the continuity equation

$$(\rho q_i)_{,i} = 0 \tag{2.9}$$

along with suitable boundary conditions. Substitution of the constitutive equation (2.1) into (2.9) yields

$$- (K_{ij} \rho (p,j - F_j))_{,i} = 0 \tag{2.10}$$

For an isotropic material the permeability tensor is independent of direction and may then be expressed in terms of a single parameter

$$K_{ij} = \delta_{ij} K \tag{2.11}$$

where

$$\delta_{ij} = \begin{cases} 1 & i = j \\ 0 & i \neq j \end{cases}$$

Hence, (2.10) reduces to

$$- (\rho K (p,i - F_i))_{,i} = 0 \tag{2.12}$$

By expressing the pressure gradient and body force by a potential

$$\phi,i = p,i - F_i \tag{2.13}$$

and assuming a homogeneous material, (2.12) reduces to a Laplace equation

$$\phi,ii = \nabla^2 \phi = 0 \tag{2.14}$$

Methods of potential theory may be used to solve some boundary value problems. However for arbitrary domains and/or non-homogeneous or stratified solids solutions become intractable. It is then desirable to consider numerical solutions.

In two-dimensional flows it has been traditional to obtain solutions to (2.14) by sketching flow nets [4] or by solving the finite difference model to (2.14). Finite element solutions have also been obtained and shown to be superior numerical solutions as compared to either of the other above cited methods [5,6]. A variational theorem whose Euler equation is (2.12) and whose natural and rigid boundary conditions coincide with the flow problem forms a solid basis for constructing a finite element model.

A VARIATIONAL THEOREM FOR FLUID FLOW IN POROUS SOLIDS

In this report the fluid pressure is chosen as the independent variable instead of the classical potential defined by (2.13). Fluid pressure along free boundaries can easily be computed or is zero. Along sealed boundaries the flow normal to the boundary is known to be zero (in some instances in finite element model refinements known boundary flow rates may be prescribed).

A variational theorem for fluid flow in porous solids governed by a Darcy law is given by

$$J\,(p) = \frac{1}{2} \int_V \rho\, p,i\, K_{ij}\, (\, p,j - 2\, F_j\,)\, d\, V + \oint_{S_q} \rho\, \bar{q}_i\, \eta_i\, p\, d\, S \tag{3.1}$$

where in addition to previously defined quantities η_i are direction cosines of the outward normal to the boundary with the i-direction, $\bar{q}_i$ are prescribed boundary flow rates (note $\bar{q}_i\, \eta_i = \bar{q}_\eta$) and S_q is that portion of the boundary on which flow rates are prescribed.

Proof of the variational theorem is obtained by setting

$$\delta\, J\,(p) = 0 \tag{3.2}$$

Accordingly

$$\delta\, J\,(p) = \int_V \rho\, \delta\, p,i\, K_{ij}\, (\, p,j - F_j\,)\, d\, V + \oint_{S_q} \rho\, \bar{q}_i\, \eta_i\, \delta\, p\, d\, S \tag{3.3}$$

Use of the divergence theorem yields

$$\delta J(p) = - \int_V \delta p \left(\rho K_{ij} (p,j - F_j) \right)_{,i} \, dV + \oint_{S_q} \delta p \, \rho \left(\bar{q}_i + K_{ij} (p,j - F_j) \right) \eta_i \, dS \tag{3.4}$$

The variational theorem is proved since the Euler equation is seen to coincide with (2.12) and the boundary conditions stipulate flows prescribed by (2.1) on S_q and pressures on the boundary conjugate to S_q. Consequently (3.1) is the equivalent variational formulation to the flow problem discussed in Section 2.

The construction of a finite element algorithm from (3.1) and the development of a three-dimensional finite element permeability matrix and flow vector are discussed in Appendix B. A users manual for the computer program (FLPM3D) is contained in Appendix A and a listing of the program appears in Appendix D. In order to illustrate the use of this program in connection with three-dimensional flow under barrages a sample problem is included in Appendix C.

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5. Zienkiewicz, O.C., Mayer, P. and Cheung, T.K., "Solution of Anisotropic Seepage by Finite Elements," J. Engr. Mech. Div., ASCE, Vol. 92, No EM1, Feb. 1966.

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APPENDIX A

USER MANUAL FOR COMPUTER PROGRAM FLPM3D

PROGRAM FOR THREE-DIMENSION FLOW OF INCOMPRESSIBLE FLUID IN ORTHOTROPICALLY PERMEABLE POROUS MEDIA

IDENTIFICATION

FLPM3D - Programmed June 1969 in FORTRAN IV for the CDC 6400.

DESCRIPTION

A finite element procedure is used to solve a generalized Darcy's Law for flow of an incompressible fluid in a three dimensional domian. The approximate solution consists of:

1) Nodal point fluid pressures
2) Components of flow (velocity) at element centroids. (nodal point components are optional)

The forcing 'function' of the formulation consists of specified nodal point flows and boundary surface flows. The unknowns are nodal point pressures. The governing equations are termed 'media permeability equations.' The residual vector is evaluated from the solution and given with the output as a partial check on accuracy.

The core storage requirements of the program are separated into fixed and variable parts with the fixed portion consisting of instructions, non-subscripted variables and those arrays which are not dependent on the size of an individual problem. The variable portion is controlled by the array A which appears in the blank COMMON statement of the main program. The variable MTOT which also appears in the main program is assigned the value of the dimension of A. In the program listing of Appendix D, MTOT has been set to 12,000. This device serves the following purposes:

1) The capacity of the program is altered by repunching the following two statements of the main program

```
COMMON A (12000)
MTOT = 12000
```

2) When data input to blank COMMON has been processed and no longer needed it is overwritten to conserve storage.

3) Storage requirements are computed and assigned during execution. In this way only the amount of storage needed for the particular problem being analysed need be reserved. In addition to allowing greater flexibility to the size of problem which can be handled, considerable savings are encountered in the solution of linear equations. In addition, options are included in the program which require no storage if not used.

The complete set of equations is divided into blocks of equations. The number of equations in a block is optimized during execution and depends on the value of MTOT and on the particular problem (in particular on the half-bandwidth). Since temporary storage units are used in the solution of equations the number of time consuming READ, WRITE, BACKSPACE and REWIND statements is decreased when:

a) Half-bandwidth is decreased

b) MTOT is increased

The program consists of two equation solving subroutines called GAUSS1 and GAUSS2. GAUSS1 applies when the number of equations in a block is greater than or equal to the half-bandwidth. The program causes the following quantities to be printed:

a) Total number of equations (equal to number of nodal points)

b) Half-bandwidth MM

For a given element ND = JMAX - JMIN + 1

where

JMAX = numerically largest nodal point for that element

JMIN = numerically smallest nodal point for that element

The value of MM is the largest value that occurs when evaluated for all elements

c) Number of equations per block

d) Number of blocks

e) The name of the subroutine used to solve equations

GAUSS1 is considerably more economical than GAUSS2. GAUSS2 allows the solution of very large systems. The equation solver that will be used for a given problem can be anticipated. (See SIZE LIMITATIONS, page A-15).

The region to be analysed is divided into elements with eight nodes. The most general admissible element has faces which are hyperbolic paraboloids, (figure 1). Let (X, Y, Z) be a right hand cartesian.

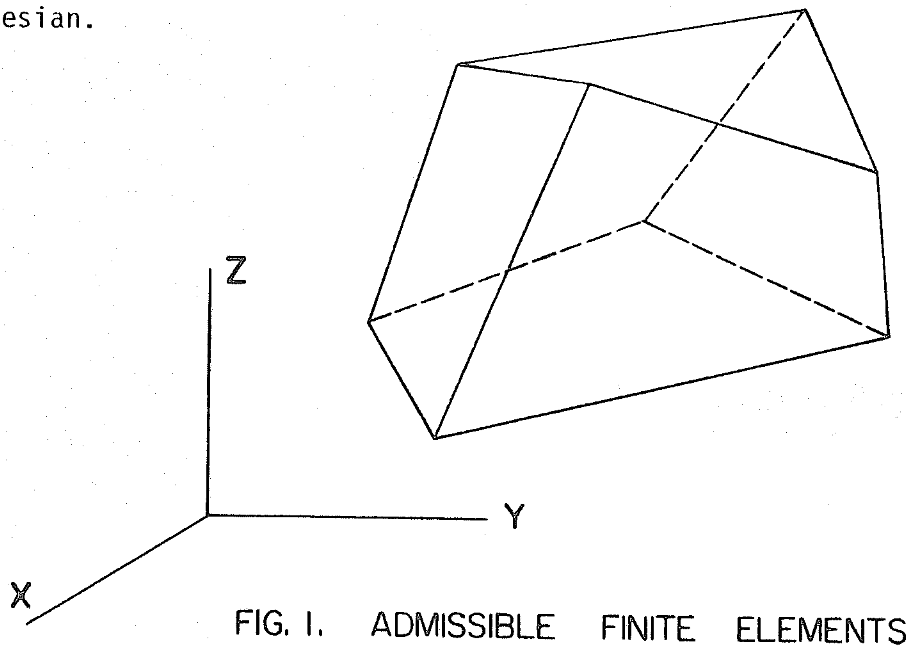


FIG. I. ADMISSIBLE FINITE ELEMENTS

coordinate frame. The complete geometry of an element is specified by eight interpolation functions and the global coordinates of the nodes.

$$\text{i.e}\quad X = \Sigma\ h_i(r, s, t)\ X_i \qquad i = 1...8$$

$$Y = \Sigma\ h_i(r, s, t)\ Y_i$$

$$Z = \Sigma\ h_i(r, s, t)\ Z_i$$

where

X, Y, Z	are global coordinates of an arbitrary point in the element
X_i, Y_i, Z_i	are global coordinates of the nodes
$h_i(r, s, t)$	are the same interpolation functions used in the derivation of the element permeability matrix (see Appendix B).

The interpolation functions map the finite element onto a cube with sides two units in length (figure 2). A scheme for ordering the nodal point numbers is required to match corresponding interpolation functions and global nodal coordinates.

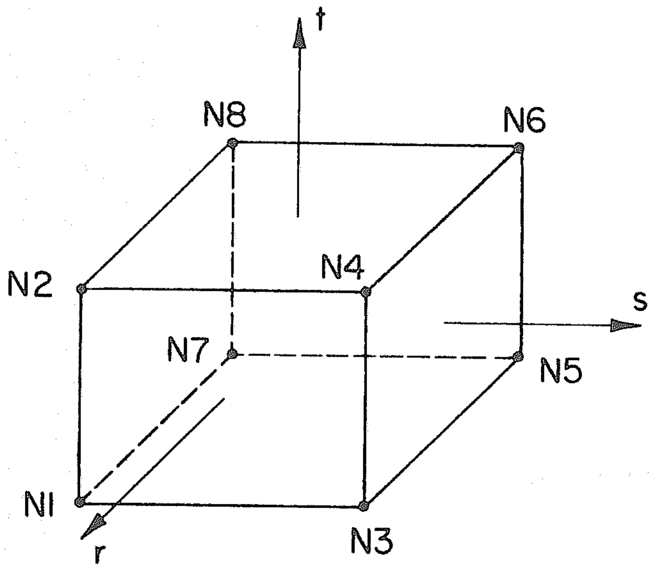


FIG. 2. MAPPED REGION

On the mapped region a right hand cartesian natural coordinate system (r, s, t) is selected arbitrarily. The equations of the six faces are $r = \pm 1$, $s = \pm 1$, $t = \pm 1$.

Face	Equation
1	$r = +1$
2	$r = -1$
3	$s = +1$
4	$s = -1$
5	$t = +1$
6	$t = -1$

Once the orientation of the (r, s, t) system is selected the nodal point sequence N1, N2---N8 must be as shown in figure 2. The nodes are numbered in pairs from the $t = -1$ face to the $t = +1$ face progressing around the t axis by the right hand screw rule. The first pair of nodes is determined by the intersection of the $r = +1$ and $s = -1$ faces. To recapitulate: (1) The arbitrary element is mapped onto a cube; (2) Three faces of the cube are chosen arbitrarily to define the (r, s, t) coordinates; (3) Once the (r, s, t) system is chosen the face numbers 1 to 6 are defined as above and the eight nodal point numbers N1, N2---N8 have a natural ordering which must be as shown in figure 2.

INPUT

The following sequence of punched cards numerically defines the media to be analysed:

A) START CARD (72H)

The characters FLPM3D must be punched in columns 1 to 6 of the first card for each problem. (There is no limit to the number of different problems). The remainder of the Hollerith field may contain information to be printed as titles on the output. If an error in the input data is detected by the program the current problem is dropped and a search for the next FLPM3D card is initiated.

B) CONTROL CARDS (9I5/4F10.0)

First Card

Columns

1 - 5 NP - Number of nodal points
6 - 10 NE - Number of elements
11 - 15 NM - Number of different 'media' (maximum = 50)
16 - 20 NF - Number of distributed boundary flow cards
21 - 25 ND - Number of sets of reference direction numbers
26 - 30 NL - Number of loading cases (maximum = 3)
31 - 35 NV - Element velocity option
36 - 40 NB - Limit on allowable half-bandwidth
41 - 45 NS - Number of temporary element storage blocks

Second Card

Columns

1 - 10	AX - Global X component of gravitational acceleration
11 - 20	AY - Global Y component of gravitational acceleration
21 - 30	AZ - Global Z component of gravitational acceleration
31 - 40	UW - Unit weight of fluid in media

By a 'media' is meant a unique set of principal permeability components of the generalized permeability tensor. These components are defined by Darcy's Law

$$\{q\} = - [K] (\{grad\ p\} + \{F\})$$

where

$\{q\} \equiv$ fluid velocity vector

$\{grad\ p\} \equiv$ pressure gradient vector

$\{F\} \equiv$ body force vector per unit volume due to gravitational acceleration

$[K] \equiv$ components of permeability tensor

Since principal components are input, the components of [K] must be transformed to components relative to the global basis. Direction numbers are input for this purpose (see section E).

If NV = 0, flows are derived from the pressure field at the centroid of each element and output. If NV = 1 the flows are also evaluated at element nodal points and averaged with adjacent elements. It is to be noted that for NV = 1 increased storage is required as well as a substantial increase in computation time.

ND is a safety device. If the upper limit on the half-bandwidth is exceeded by any element, execution of that problem is terminated. Since the program contains an equation solver that will handle very large systems an error on an element card resulting in an erroneously high half-bandwidth could prove to be costly if this device is not used.

Since elements are very often similar, considerable savings can be realized by utilizing the same element permeability matrix for all of its similar elements. For this reason it is possible to specify up to three temporary storage regions in which common element properties are stored for reference by other elements (see (J)). It is to be noted that storage is reserved only for the number of blocks specified by NS.

C) LOADING CASES CONTROL CARD (2I5)

One card is required for each loading case.

Columns

1 - 5 NPL - Number of specified non-zero nodal flows for this loading case

6 - 10 NEL - Number of element faces with distributed normal flows for this loading case

D) PRINCIPAL PERMEABILITY COMPONENTS (I5,3F10.0)

One card is required for each unique set of components.

Columns

1 - 5 N - Identification

6 - 15 KI
16 - 25 KII
26 - 35 KIII

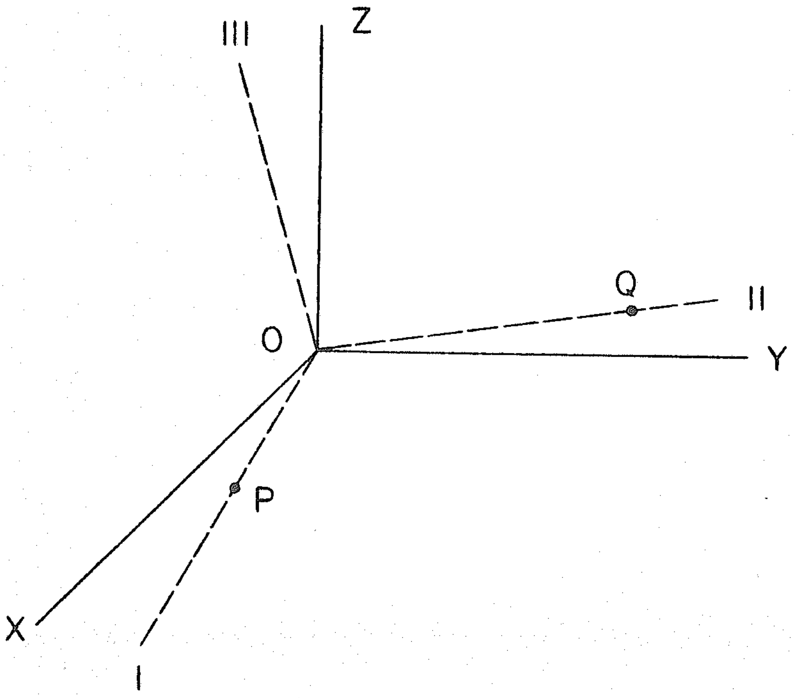
} Principal permeability components where I, II, III are right hand cartesian axes.

E) DIRECTION NUMBERS (I5,6F10.0)

One card is required for each unique set. These numbers are used to compute basis transformations between global and principal permeability axes.

<u>Columns</u>

1 - 5	N	- Identification
6 - 15	P1	Direction Numbers for I Axis
16 - 25	P2	
26 - 35	P3	
36 - 45	Q1	Direction Numbers for II Axis
46 - 55	Q2	
56 - 65	Q3	



Let P and Q be points on the I and II axes respectively. Let global coordinates of P be X(P), Y(P) and Z(P) with a similar notation for points 0 and Q. Then

$$P1 = X(P) - X(0)$$
$$P2 = Y(P) - Y(0)$$
$$P3 = Z(P) - Z(0)$$
$$Q1 = X(Q) - X(0)$$
$$Q2 = Y(Q) - Y(0)$$
$$Q3 = Z(Q) - Z(0)$$

Note that these numbers are not unique but serve to uniquely specify the I and II axes. The direction cosines for the III axes are obtained in the program by forming a vector (cross) product.

F) NODAL POINT CARDS (3I5,4F10.0,I5)

Columns

1 - 5	NI	- Nodal point identification number
6 - 10	K	- Nodal point data generation option
11 - 15	KD	- Boundary condition code
16 - 25	X	- Global X coordinate of NI
26 - 35	Y	- Global Y coordinate of NI
36 - 45	Z	- Global Z coordinate of NI
46 - 55	P	- Value of pressure boundary condition if KD = 1, otherwise blank
56 - 60	L	- Boundary value generation parameter

The value of KD is:

0 if nodal flow is specified

1 if nodal pressure is specified

Pressure boundary conditions must be the same for each loading case.

If a series of nodal points occur on a straight line only the first and last nodal point of the series need be input if:

1) each nodal point in the series is obtained from the previous by adding a fixed constant. The data generation option K is the value of this constant.

2) If the value of L is

a) 0 - KD is set to zero for each generated node
   - P is set to zero for each generated node if KD = 1 on input card

b) 1 - KD is set equal to that of the first node in the series
   - P is set equal to that of first node in series for each generated node if KD = 1

c) 2 - KD for each generated node is set equal to that of first node in series
   - P for each generated node is interpolated linearly between end nodes if KD = 1

Note that it is not necessary to input the nodal cards in numerical sequence (i.e. order of increasing nodal point numbers). Suppose nodal point data cards for nodes NI and NJ are input in succession. If the numerical quantitly NJ - NI is -

a) positive: nodal point data will be generated for nodes NI + K, NI + 2K,......NJ - K

b) negative: no nodal point generation

This option is illustrated in the examples given with this report.

G) NON-ZERO NODAL FLOW BOUNDARY CONDITIONS (I5,F10.0)

One set of cards is required for each loading case. The number of cards must be equal to NPL in (C). If NPL is zero for a particular

c case no cards are input for that loading.

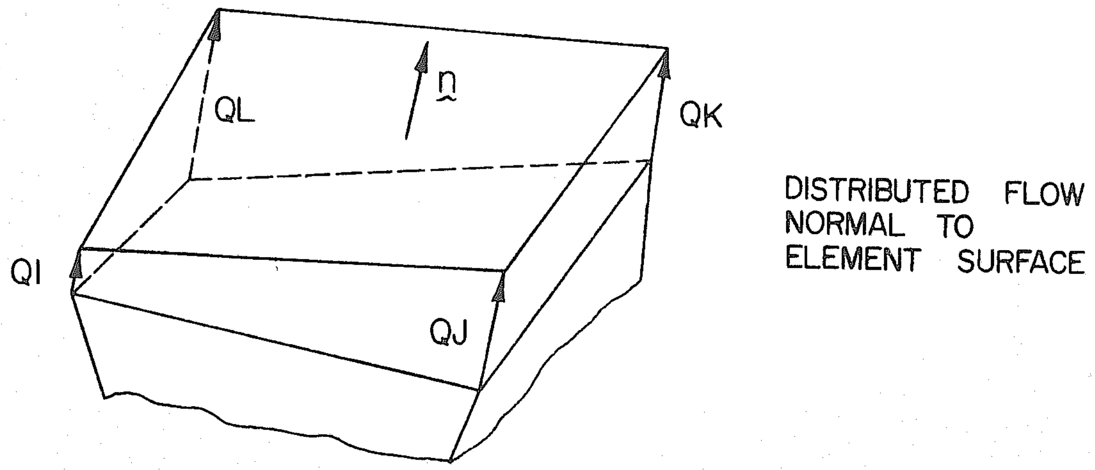
Columns

1 - 5 NI - Nodal point identification number

6 - 15 Q - Non-zero specified nodal flow (positive flow if fluid is added to node, otherwise negative)

H) SURFACE BOUNDARY FLOW TYPES (I5,4F10.0)

One card is required for each unique distribution of normal flow through an element surface.



Columns

1 - 5 N - Identification number

6 - 15 QI - Magnitude of outward normal flow at node NI

16 - 25 QJ - Magnitude of outward normal flow at node NJ

26 - 35 QK - Magnitude of outward normal flow at node NK

36 - 45 QL - Magnitude of outward normal flow at node NL

Note that nodes NI, NJ, NK, Nl must be ordered by right hand screw rule about the outward normal. Specifying four magnitudes allows a bilinear variation in normal flow. Equivalent nodal flows are evaluated by the program using numerical integration. Specifying nodal flows rather than surface distributions is computationally more economical.

I) SURFACE FLOW LOADING CASES (4I5)

One card is required for each element face in each loading condition that has surface flow. The number of cards must agree with NEL given in (C).

Columns

1 - 5 L - Loan case number (1, 2 or 3)
6 - 10 NE - Element identification number
11 - 15 NF - Face identification number (a number from 1 to 6 as described previously)
16 - 20 N - Identification number of loading type in (H) above

J) ELEMENT CARDS (18I4)

Columns

1 - 4 NE - Element identification number
5 - 8 N1 -
9 - 12 N2 -
13 - 16 N3 -
17 - 20 N4 -
21 - 24 N5 -
25 - 28 N6 -
29 - 32 N7 -
33 - 36 N8 -

Element nodal point numbers in sequence discussed previously

37 - 40	M -	Media identification number
41 - 44	ND -	Identification number of applicable direction numbers. If left blank the principal axes of permeability are taken to be coincident with global X, Y, Z axes
45 - 48	GET -	The element permeability matrix for this element will be obtained from storage block identified by the number GET
49 - 52	STORE -	The computed permeability matrix for this element will be stored in storage block identified by the number STORE for reference by elements input later whose GET is equal to this STORE
53 - 56	I1 -	Increment factor for 1 dimensional element generation
57 - 60	I2 -	Increment factor for 2 dimensional element generation
61 - 64	I3 -	Increment factor for 3 dimensional element
65 - 68	J1 -	Number of elements in a row when $I2 \neq 0$
69 - 72	J2 -	Number of elements in a plane when $I3 \neq 0$

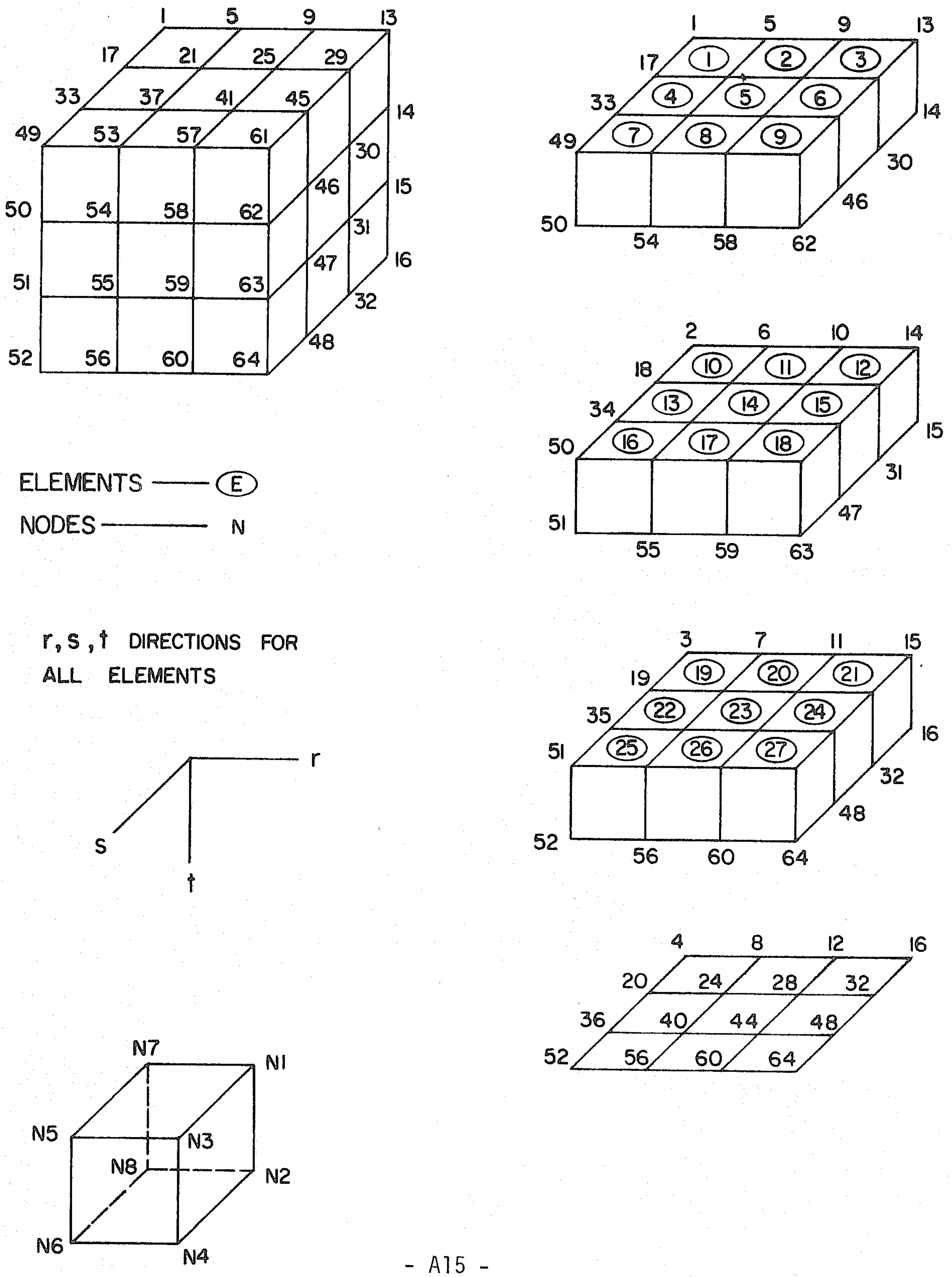
I1, I2, I3, J1 and J2 are used to generate rows, planes and three-dimensional arrays of similar elements. Two elements are similar if

1) one element can be obtained from the other by translations (no rotations) along the global axes;

2) the nodal point sequence N1, N2.......N8 is preserved under the above translation;

3) the element numbers of the generated sequence form an arithmetic progression with an increment of unity;

FIG. 3 ELEMENT GENERATION



4) the media and direction number identifications as well as the value of GET for each generated element are identical. If both GET and STORE are specified on an element data card then the STORE applies to the input element while the GET applies to the generated elements.

5) the surface boundary flow loadings must be identical for similar elements.

When such a sequence occurs only the first element need by input. That element whose identification number is equal to the number of elements must always be input.

The use of I1, I2, I3, J1 and J2 is illustrated by the following example (figure 3).

NE	N1	N2	N3	N4	N5	N6	N7	N8
1	5	6	21	22	17	18	1	2
2	9	10	25	26	21	22	5	6
3	13	14	29	30	25	26	9	10
4	21	22	37	38	33	34	17	18

I1 = 4

I2 = 8

9	45	46	61	62	57	58	41	42
10	6	7	22	23	18	19	2	3

I3 = - 39

a) Elements 1,2,3 form a row. The nodal point numbers of element 2 are obtained by adding 4 to each nodal point number of element 1. Element 3 is obtained similarly from element 2. Hence the value of I1 is 4. This applies to each set of 3 elements (1,2,3), (4,5,6).....(25,26,27).

b) Element 4 in the second row is obtained from element 3 in the first row by an increment factor of 8. Similarly element 7 is obtained from element 6. Hence value of I2 is 8 and since there are 3 elements per row the value of J2 is 3. This applies to each of the sets (3,4), (6,7), (9,10),....(24,25)

c) Element 10 in the second plane is obtained from element 9 in the first plane by an increment factor of -39. Element 19 is obtained similarly from element 18. Hence value of I3 is -39. Since there are 9 elements per plane the value of J3 is 9.

Consequently the 27 elements can be generated by inputing element 1 only (If element 27 is the last element in the media, it must also be input) as follows:

NE	N1	N2	N3	N4	N5	N6	N7	N8	I1	I2	I3	J2	J3
1	5	6	21	22	17	18	1	2	4	8	-39	3	9
27	47	48	63	64	59	60	44						

As an illustration of two-dimensional generation elements 11 through 18 can be generated from element 10 as follows:

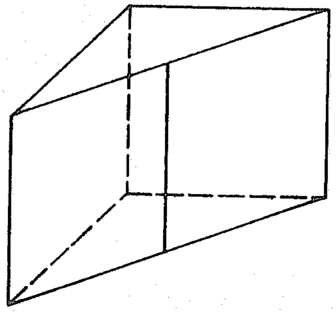
NE	N1	N2	N3	N4	N5	N6	N7	N8	I1	I2	I3	J2	J3
10	6	7	22	23	18	19	2	3	4	8		3	

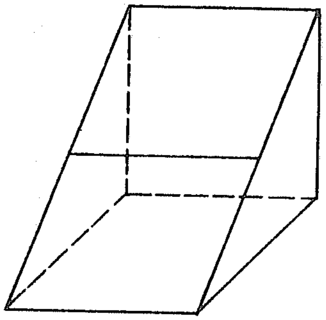
As an illustration of one-dimensional generation elements 11 and 12 can be generated from element 10, elements 14 and 15 from 13, and elements 17 and 18 from 16 as follows:

NE	N1	N2	N3	N4	N5	N6	N7	N8	I1	I2	I3	J2	J3
10	6	7	22	23	18	19	2	3	4				
13	22	23	38	39	34	35	18	19	4				
16	38	39	54	55	50	51	34	35	4				

"WEDGE" ELEMENTS

These elements are admissible and are useful for approximating irregular boundaries and for mesh gradation. Note that whenever a mesh contains one or more of these elements the velocity option parameter (NV on CONTROL CARD) must be zero (0).





K) STOP card

Normal termination will result if the word STOP is punched in columns 1 to 4 on a sparate card following the last problem data.

SIZE LIMITATIONS

(a) $NP*(5 + NL) + 6*ND + 4*NEL + 99*NS + 4*NF \leq MTOT$

NP = Number of nodal points

NL = Number of load cases

ND = Number of sets of direction numbers

NS = Number of temporary element storage blocks

NEL = Total number of element faces with distributed normal surface flows for all loading cases

NF = Number of distributed boundary flow cards

(b) The number of rows of equations in a block is evaluated by the following logic using integer arithmetic.

```
    NC  = MM + NL
    NC1 = NC + 1
    NR2 = (MTOT - NL*NP)/NC1
    NR  = NR2/2
    IF  (NR2.GE.NP) NR = NP
    IF  (NR.LT.MM) GØ TØ 60
    ITYPE = 1
    GØ TØ 70
 60 ITYPE = 2
 70 NSET = (NP - 1)/NR + 1
```

where

MM = Half bandwidth

NR = Number of equations per block

NSET = Number of blocks

GAUSS1 will be called if ITYPE = 1

GAUSS2 will be called if ITYPE = 2

If ITYPE = 1 and NSET = 1 then N4 = NR*NC1 + NL*NP Otherwise N4 = NR*(2*NC + 1) + NL*NP

Three additional size limitations are

i) $N4 \leq MTOT$

ii) $NR*NC \geq NP$

iii) $NR \geq 2$

Actually ii) was imposed to allow for more efficient coding and hence does not result strictly from limitations on core storage.

The above four restrictions are checked by the program. Execution is terminated if any are violated.

CHANGING ALLOWABLE CAPACITY

Changing the overall capacity of the program has already been described. The only other limitation is on the number of different media (described as 50 herein). This limitation can be altered by changing the 50 in the following COMMON assignment in the 3 subroutines in which it occurs.

```
      COMMON / MATARG /
     1 UWT,ACCG,E(50,3)
```

TEMPORARY STORAGE UNITS

Logical units are assigned for temporary storage in the main program by the statements

```
      NTAPE1 = 1
      NTAPE2 = 2
        etc.
```

The number of temporary storage units required depends on the equation solver used and on the number of loading cases.

Number of Loading Cases	Equation Solver	Storage Units				
1	GAUSS1	NTAPE2,	NTAPE3,	NTAPE4		
	GAUSS2	NTAPE2,	NTAPE3,	NTAPE4,	NTAPE5	
2	GAUSS1	NTAPE2,	NTAPE3,	NTAPE4,	NTAPE5	
	GAUSS2	NTAPE2,	NTAPE3,	NTAPE4,	NTAPE5	
3	GAUSS1	NTAPE2,	NTAPE3,	NTAPE4,	NTAPE5,	NTAPE6
	GAUSS2	NTAPE2,	NTAPE3,	NTAPE4,	NTAPE5,	NTAPE6

NTAPE1 is required for all cases. Note that logical units 5 and 6 are the printer READ and WRITE units.

SUBROUTINE CPTIME

This subroutine calls the library routine SECOND(T) which returns the elapsed central processor time in seconds from the beginning of the job. Subroutine CPTIME is called six times by subroutine FPCALL. The values returned by these calls are used to evaluate the time log printed with the output.

SUMMARY OF INPUT (FLPM3D)

	10		20		30		40		50		60		70		80

A. START CARD (72H)

FLPM3D	

B. CONTROL CARDS (9I5/4F10.0)

NP	NE	NM	NF	ND	NL	NV	NB	NS

AX	AY	AZ	UW

C. LOADING CASES CONTROL CARDS (2I5) – ONE CARD FOR EACH LOADING CASE

NPL	NEL

D. PRINCIPAL PERMEABILITY COEFFICIETS (I5, 3F10.0)

N	KI	KII	KIII

E. DIRECTION NUMBERS (I5, 6F10.0)

N	P1	P2	P3	Q1	Q2	Q3

F. NODAL POINT CARDS (3I5, 4F10.0, I5)

NI	K	KD	X	Y	Z	P	L

G. NON-ZERO NODAL FLOWS (I5, F10.0)

NI	Q

H. SURFACE BOUNDARY FLOW TYPES (I5, 4F10.0)

N	QI	QJ	QK	QL

I. SURFACE FLOW LOADING CASES (4I5)

L	NE	NF	N

J. ELEMENT CARDS (18I4)

NE	N1	N2	N3	N4	N5	N6	N7	N8	M	ND	GET	STORE	I1	I2	I3	J2	J3

K. STOP CARD (4H) – FOLLOWS LAST PROBLEM DATA

STOP

APPENDIX B

DERIVATION OF FINITE ELEMENT PERMEABILITY MATRIX AND FLOW VECTOR FOR THREE-DIMENSIONAL FLOW IN POROUS MEDIA

The functional defining Darcy flow in a porous solid was given in Section 3 as:

$$J(p) = \frac{1}{2} \int_V \rho\, p_{,i}\, K_{ij}\, (p_{,j} - 2\, F_j)\, dV + \int_{S_q} \rho\, \bar{q}_i\, \eta_i\, p\, dS \qquad (B.1)$$

where:

p	is the fluid pressure
K_{ij}	is the local (engineering) permeability tensor
F_j	is a body force
$\bar{q}_i$	are prescribed boundary flows
η_i	are direction cosines of the outward normal to the boundary surfaces
ρ	is the mass density of the fluid
V	is the volume occupied by the solid
S_q	is that portion of the boundary surface for which flows are prescribed.

Application of the finite element method divides the volume into subregions (elements); the boundary surface is then defined by the surface of the elements.

$$V = \sum_{m=1}^{M} \Delta V_m$$

where M is the total number of elements

In using the finite element method to obtain approximate solutions from (B.1) we require p to be a continuous function and possess piecewise continuous first derivatives. In this report we take the three-dimensional finite elements as shown in Fig. A.1. Each element is defined by 8 corner nodes and the interior region (global coordinates x, y, z) lies within

$$-1 \le r \le 1 \qquad -1 \le s \le 1 \qquad -1 \le t \le 1$$

where r, s, t are natural coordinates as shown in Fig. A.2. The mapping between the global and natural coordinates is given by (A. 1) where

$$h_i\ (r, s, t) = (1 + r \cdot R_i)\ (1 + s \cdot S_i)\ (1 + t \cdot T_i) \qquad \text{(B.3)}$$

where:

$$R_i = < 1, 1, 1, 1, -1, -1, -1, -1 >$$

$$S_i = < -1, -1, 1, 1, 1, 1, -1, -1 >$$

$$T_i = < -1, 1, -1, 1, -1, 1, -1, 1 >$$

Since (A.1) produces a continuous mapping of the interior region of V, a continuous distribution of fluid pressure is also given by

$$p = \sum_{i=1}^{8} h_i\ P_i \qquad \text{(B.4)}$$

where P_i are the nodal values of the pressure.

The element permeability matrix and flow vector for each element are derived from

$$U_m\ (p) = \frac{1}{2} \int_{\Delta V_m} \rho < DP > [D] \left(\{DP\} - 2\ \{F\}\right)\ dV \qquad \text{(B.5)}$$

where:

$$< DP > \; = \; < \frac{\partial p}{\partial x}, \frac{\partial p}{\partial y}, \frac{\partial p}{\partial z} > \qquad \text{pressure gradients}$$

$$\{F\}^T \; = \; < F_x , F_y , F_z > \qquad \text{body forces}$$

$$[D] \; = \; \begin{bmatrix} K_{xx} & K_{xy} & K_{xz} \\ K_{xy} & K_{yy} & K_{yz} \\ K_{xz} & K_{yz} & K_{zz} \end{bmatrix} \qquad \text{local permeabilities in global coordinates}$$

Using (B.4) the pressure gradient vector can be expressed in terms of the nodal pressures as

$$\{DP\} \; = \; [B] \, \{P\} \tag{B.6}$$

where

$$[B] \; = \; \begin{bmatrix} \frac{\partial h_1}{\partial x} & \frac{\partial h_2}{\partial x} & \cdot & \cdot & \cdot & \cdot & \cdot & \frac{\partial h_8}{\partial x} \\ \frac{\partial h_1}{\partial y} & \frac{\partial h_2}{\partial y} & \cdot & \cdot & \cdot & \cdot & \cdot & \frac{\partial h_8}{\partial y} \\ \frac{\partial h_1}{\partial z} & \frac{\partial h_2}{\partial z} & \cdot & \cdot & \cdot & \cdot & \cdot & \frac{\partial h_8}{\partial z} \end{bmatrix} \tag{B.7}$$

$$\{P\}^T \; = \; < P_1 \;\; P_2 \; \cdot \; \cdot \; \cdot \; \cdot \; \cdot \; P_8 >$$

Now

$$U_m \, (p) \; = \; \frac{1}{2} < P > [QK] \, \{P\} - < P > \{Q\} \tag{B.8}$$

where

$$[QK] \; = \; \int_{V_m} \rho \, [B]^T \, [D] \, [B] \, dV \tag{B.9}$$

and

$$\{Q\} = \int_{V_m} \rho \, [B]^T \, [D] \, \{F\} \, dV \tag{B.10}$$

The elements of [B] are obtained by use of the chain rule for differentiation.

Accordingly,

$$\begin{Bmatrix} \frac{\partial}{\partial r} \\ \frac{\partial}{\partial s} \\ \frac{\partial}{\partial t} \end{Bmatrix} = [J] \begin{Bmatrix} \frac{\partial}{\partial x} \\ \frac{\partial}{\partial y} \\ \frac{\partial}{\partial z} \end{Bmatrix} \tag{B.11}$$

where

$$[J] = \begin{bmatrix} \frac{\partial x}{\partial r} & \frac{\partial y}{\partial r} & \frac{\partial z}{\partial r} \\ \frac{\partial x}{\partial s} & \frac{\partial y}{\partial s} & \frac{\partial z}{\partial s} \\ \frac{\partial x}{\partial t} & \frac{\partial y}{\partial t} & \frac{\partial z}{\partial t} \end{bmatrix} = [H\ D] \begin{bmatrix} X_1 & Y_1 & Z_1 \\ X_2 & Y_2 & Z_2 \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ X_8 & Y_8 & Z_8 \end{bmatrix} \tag{B.12}$$

and

$$[H\ D] = \begin{bmatrix} \frac{\partial h_1}{\partial r} & \frac{\partial h_2}{\partial r} & \cdot & \cdot & \cdot & \cdot & \cdot & \frac{\partial h_8}{\partial r} \\ \frac{\partial h_1}{\partial s} & \frac{\partial h_2}{\partial s} & \cdot & \cdot & \cdot & \cdot & \cdot & \frac{\partial h_8}{\partial s} \\ \frac{\partial h_1}{\partial t} & \frac{\partial h_2}{\partial t} & \cdot & \cdot & \cdot & \cdot & \cdot & \frac{\partial h_8}{\partial t} \end{bmatrix} \tag{B.13}$$

The pressure gradient vector may now be expressed as

$$\{DP\} = [J]^{-1} [HD] \{P\} = [B] \{P\} \qquad (B.14)$$

The determinant of [J] is the jacobian, XJAC, for each point (r,s,t) in the natural coordinate frame. By making a change in coordinates to the natural reference frame for (B.9) and (B.10) the integrals become

$$\int_{V_m} (\qquad) \, dV = \int_{-1}^{1} \int_{-1}^{1} \int_{-1}^{1} (\qquad) \, XJAC \, dr \, ds \, dt \qquad (B.15)$$

which can be accurately evaluated numerically using Gaussian formulae repeatedly in the three directions.

APPENDIX C

EXAMPLE PROBLEM

FLOW UNDER A BARRAGE
SUPPORTED ON VARIABLE MEDIA FOUNDATION

1.0 Problem Statement

A simplified problem of flow under a barrage supported on a two-media foundation and a finite element idealization is described in figures C-1 to C-5.

2.0 Graphical Results

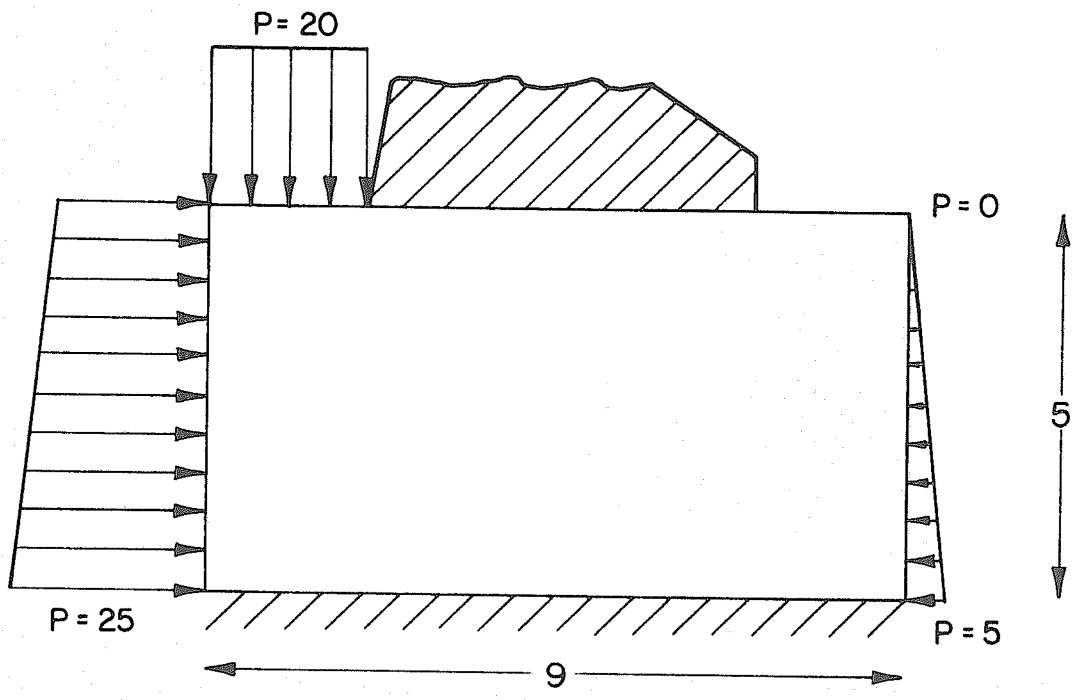
Pressure distributions along base of barrage obtained from computer program are plotted in figures C-6 and C-7.

3.0 Input Data

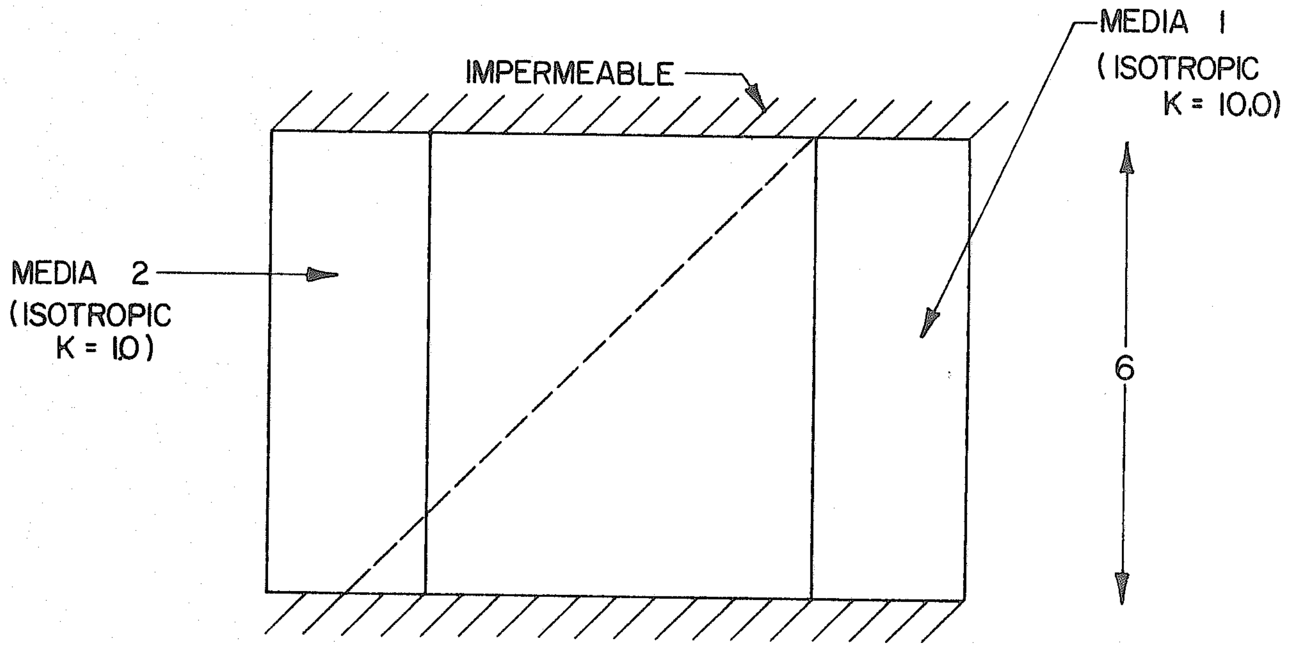
Pages C-8 to C-12 is a listing of data cards.

4.0 Computer Output

Computer output for the example problem begins on page C-13.



ELEVATION



PLAN

FLUID UNIT WEIGHT ———— 1.0
GRAVITATIONAL ACCELERATION — 1.0

FIG. C-1 FLOW UNDER A TWO-MEDIA BARRAGE

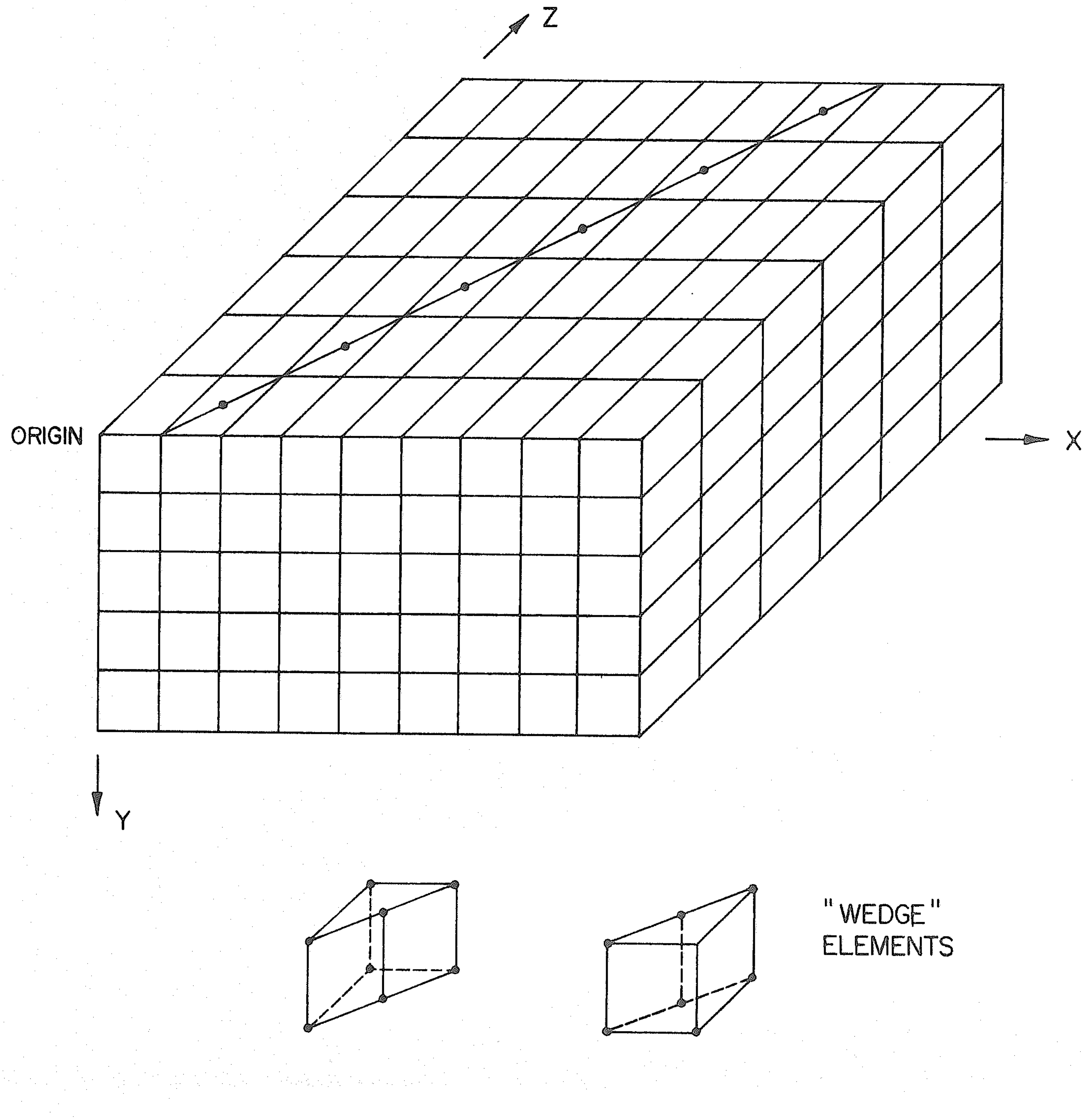


FIG. C-2 FINITE ELEMENT IDEALIZATION

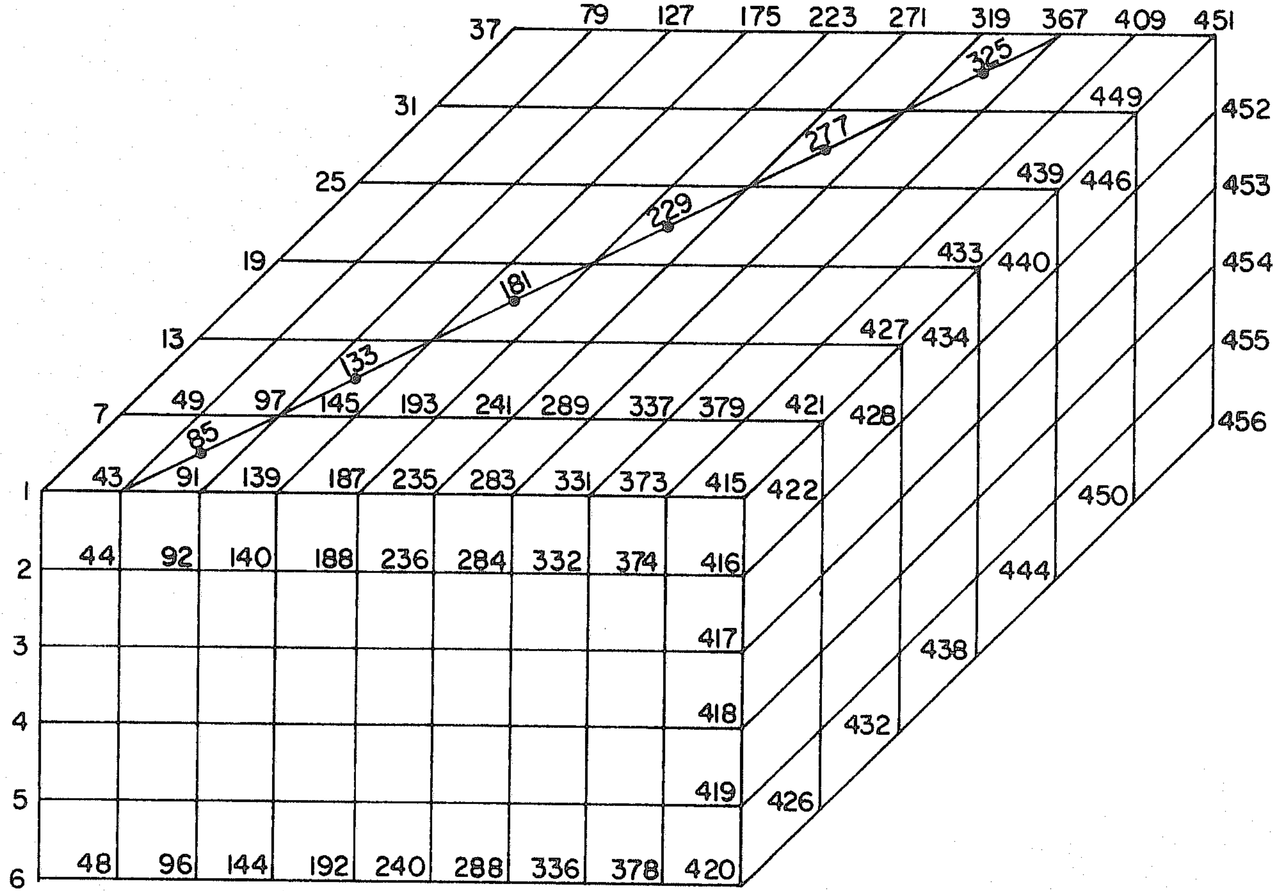


FIG. C-3 NODAL POINT IDENTIFICATION

$K_I = K_{II} = K_{III} = 10.0$

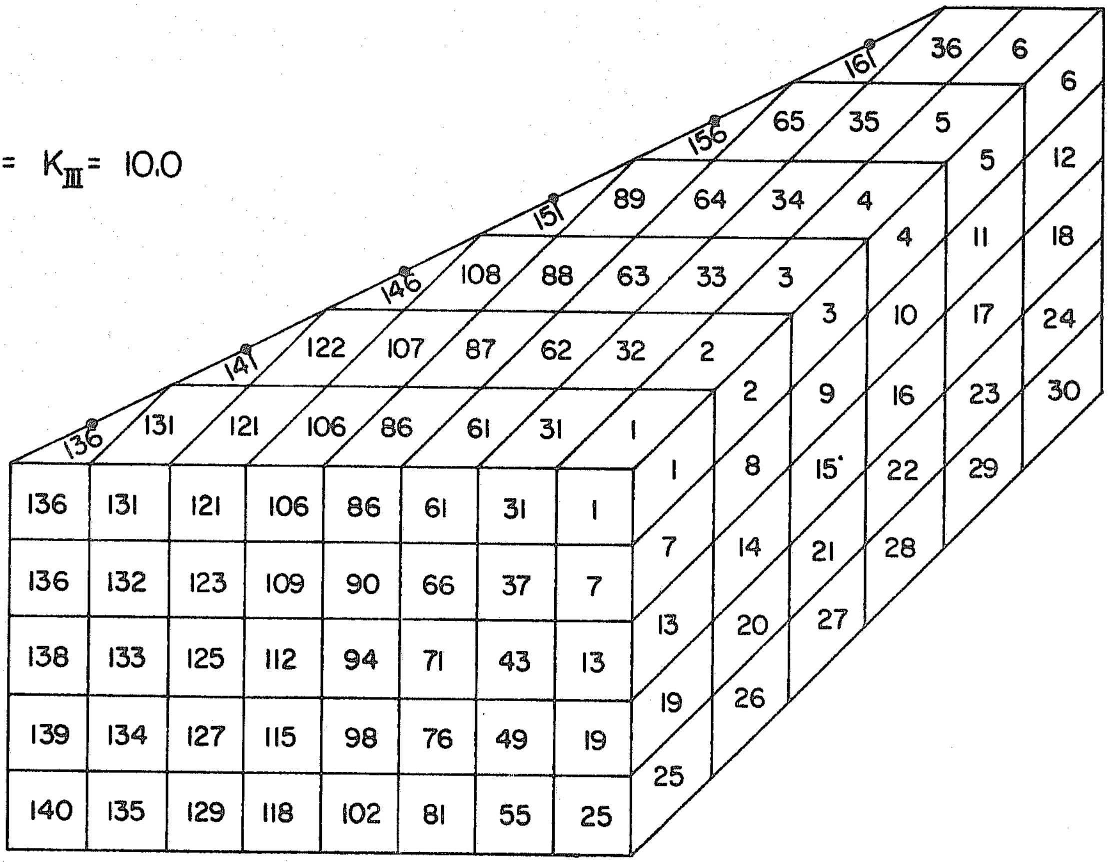


FIG. C-4 ELEMENT IDENTIFICATION- MEDIA I

$K_I = K_{II} = K_{III} = 1.0$

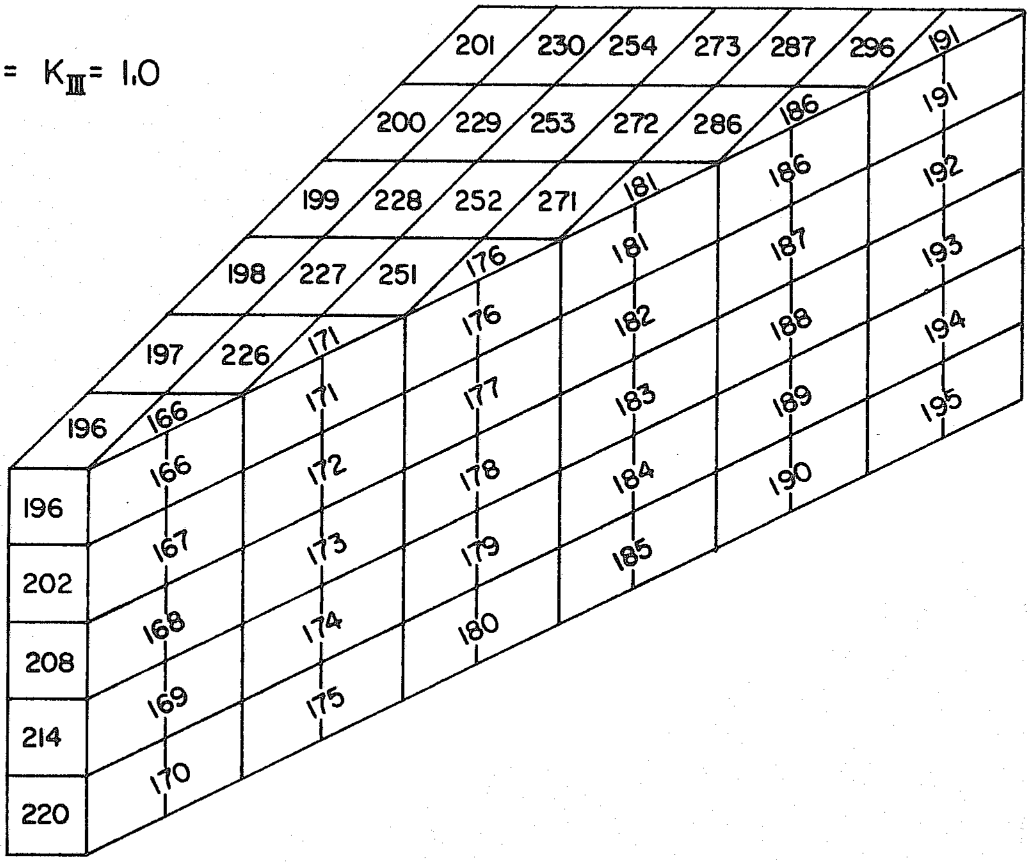


FIG. C-5 ELEMENT IDENTIFICATION — MEDIA 2

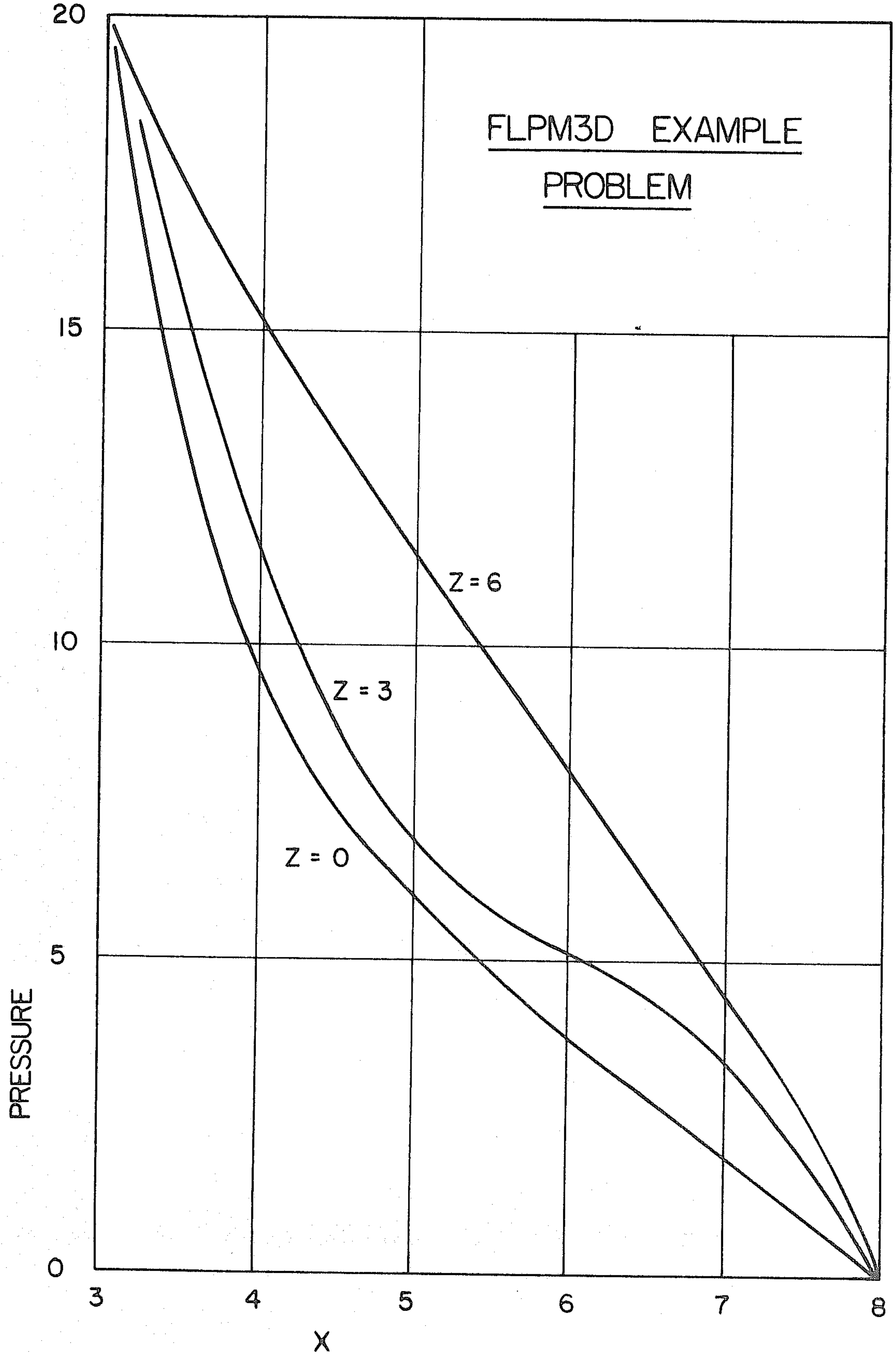


FIG. C-6 PRESSURE ON BASE OF BARRAGE

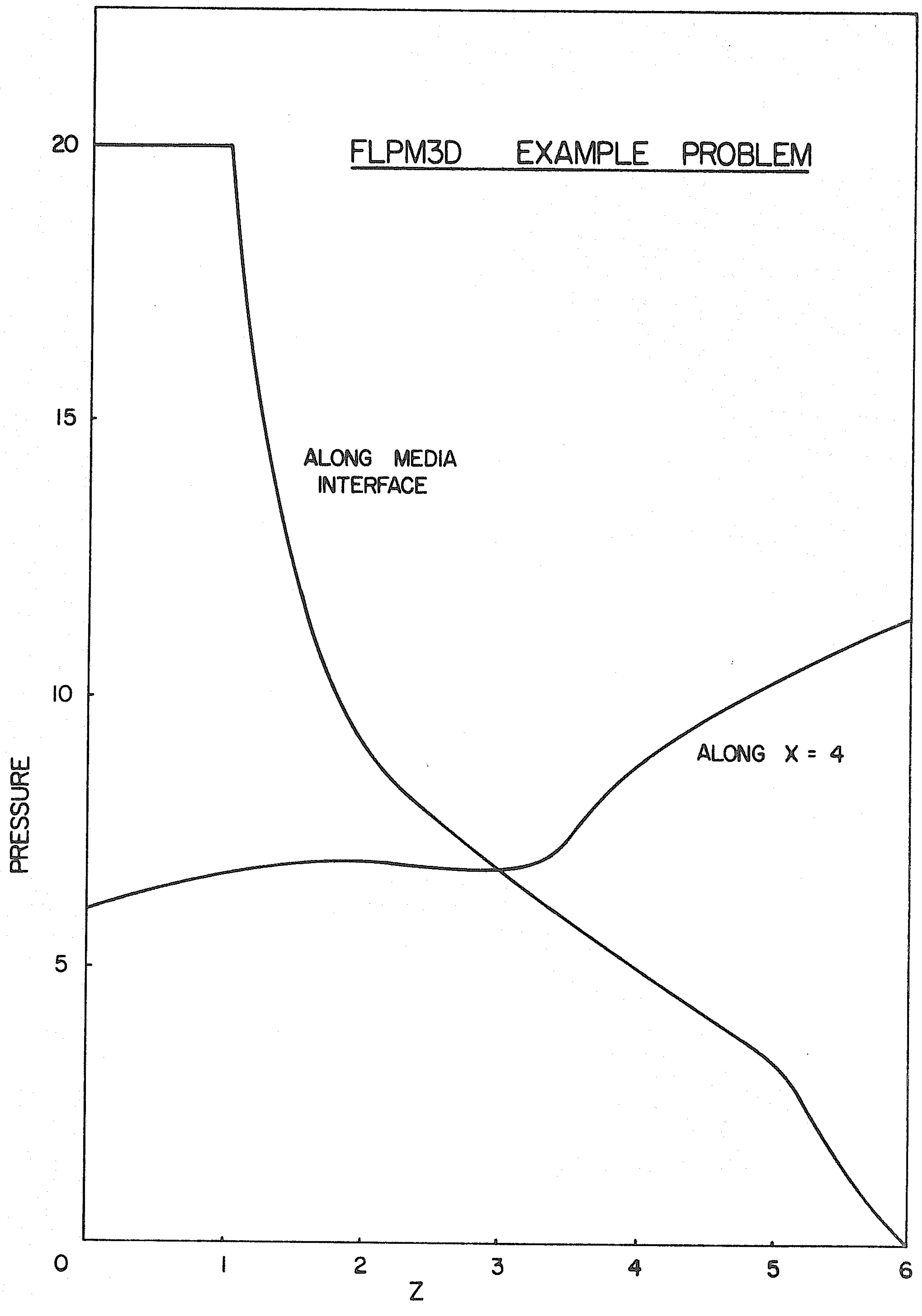


FIG. C-7 PRESSURE ON BASE OF BARRAGE

```
DATA CARDS      PAGE    1
FLPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

CARD   COLUMNS
NO.    1   5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
       .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
   1   FLPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
   2     456  300    2    0    0    1    0   70    1
   3           0.        0.        1.        1.
   4       0    0
   5       1      10.       10.       10.
   6       2        1.        1.        1.
   7       1    6    1        0.        0.        0.       20.    1
   8      37         1        0.        0.        6.       20.
   9       2    6    1        0.        1.        0.       21.    1
  10      38         1        0.        1.        6.       21.
  11       3    6    1        0.        2.        0.       22.    1
  12      39         1        0.        2.        6.       22.
  13       4    6    1        0.        3.        0.       23.    1
  14      40         1        0.        3.        6.       23.
  15       5    6    1        0.        4.        0.       24.    1
  16      41         1        0.        4.        6.       24.
  17       6    6    1        0.        5.        0.       25.    1
  18      42         1        0.        5.        6.       25.
  19      43    6    1        1.        0.        0.       20.    1
  20      79         1        1.        0.        6.       20.
  21      44    6             1.        1.        0.
  22      80                  1.        1.        6.
  23      45    6             1.        2.        0.
  24      81                  1.        2.        6.
  25      46    6             1.        3.        0.
  26      82                  1.        3.        6.
  27      47    6             1.        4.        0.
  28      83                  1.        4.        6.
  29      48    6             1.        5.        0.
  30      84                  1.        5.        6.
  31      85         1       1.5        0.       0.5       20.
  32      90                 1.5        5.       0.5
  33      91    6    1        2.        0.        0.       20.    1
  34     127         1        2.        0.        6.       20.
  35      92    6             2.        1.        0.
       .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
       1   5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
       COLUMNS
```

```
DATA CARDS     PAGE   2
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

CARD     COLUMNS
 NO.     1   5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
         .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
  36       128                   2.        1.        6.
  37        93    6              2.        2.        0.
  38       129                   2.        2.        6.
  39        94    6              2.        3.        0.
  4        130                   2.        3.        6.
  41        95    6              2.        4.        0.
  42       131                   2.        4.        6.
  43        96    6              2.        5.        0.
  44       132                   2.        5.        6.
  45       133                  2.5        0.       1.5
  46       138                  2.5        5.       1.5
  47       139    6              3.        0.        0.
  48       175                   3.        0.        6.
  49       140    6              3.        1.        0.
  5        176                   3.        1.        6.
  51       141    6              3.        2.        0.
  52       177                   3.        2.        6.
  53       142    6              3.        3.        0.
  54       178                   3.        3.        6.
  55       143    6              3.        4.        0.
  56       179                   3.        4.        6.
  57       144    6              3.        5.        0.
  58       180                   3.        5.        6.
  59       181                  3.5        0.       2.5
  6        186                  3.5        5.       2.5
  61       187    6              4.        0.        0.
  62       223                   4.        0.        6.
  63       188    6              4.        1.        0.
  64       224                   4.        1.        6.
  65       189    6              4.        2.        0.
  66       225                   4.        2.        6.
  67       190    6              4.        3.        0.
  68       226                   4.        3.        6.
  69       191    6              4.        4.        0.
  7        227                   4.        4.        6.
         .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
         1   5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
         COLUMNS
```

```
DATA CARDS      PAGE   3
FLPM30   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

CARD    COLUMNS
 NO.    1   5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
        .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
  71      192    6            4.        5.        0.
  72      228                 4.        5.        6.
  73      229                 4.5       0.        3.5
  74      234                 4.5       5.        3.5
  75      235    6            5.        0.        0.
  76      271                 5.        0.        6.
  77      236    6            5.        1.        0.
  78      272                 5.        1.        6.
  79      237    6            5.        2.        0.
  80      273                 5.        2.        6.
  81      238    6            5.        3.        0.
  82      274                 5.        3.        6.
  83      239    6            5.        4.        0.
  84      275                 5.        4.        6.
  85      240    6            5.        5.        0.
  86      276                 5.        5.        6.
  87      277                 5.5       0.        4.5
  88      282                 5.5       5.        4.5
  89      283    6            6.        0.        0.
  90      319                 6.        0.        6.
  91      284    6            6.        1.        0.
  92      320                 6.        1.        6.
  93      285    6            6.        2.        0.
  94      321                 6.        2.        6.
  95      286    6            6.        3.        0.
  96      322                 6.        3.        6.
  97      287    6            6.        4.        0.
  98      323                 6.        4.        6.
  99      288    6            6.        5.        0.
 100      324                 6.        5.        6.
 101      325                 6.5       0.        5.5
 102      330                 6.5       5.        5.5
 103      331    6    1       7.        0.        0.             0.   1
 104      367         1       7.        0.        6.             0.
 105      332    6            7.        1.        0.
        .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
        1   5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
        COLUMNS
```

```
DATA CARDS      PAGE   4
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

CARD    COLUMNS
NO.     1   5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
        .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
106       368                   7.        1.        6.
107       333    6              7.        2.        0.
108       369                   7.        2.        6.
109       334    6              7.        3.        0.
110       370                   7.        3.        6.
111       335    6              7.        4.        0.
112       371                   7.        4.        6.
113       336    6              7.        5.        0.
114       372                   7.        5.        6.
115       373    6    1         8.        0.        0.        0.    1
116       409         1         8.        0.        6.        0.
117       374    6              8.        1.        0.
118       410                   8.        1.        6.
119       375    6              8.        2.        0.
12        411                   8.        2.        6.
121       376    6              8.        3.        0.
122       412                   8.        3.        6.
123       377    6              8.        4.        0.
124       413                   8.        4.        6.
125       378    6              8.        5.        0.
126       414                   8.        5.        6.
127       415    6    1         9.        0.        0.        0.    1
128       451         1         9.        0.        6.        0.
129       416    6    1         9.        1.        0.        1.    1
13        452         1         9.        1.        6.        1.
131       417    6    1         9.        2.        0.        2.    1
132       453         1         9.        2.        6.        2.
133       418    6    1         9.        3.        0.        3.    1
134       454         1         9.        3.        6.        3.
135       419    6    1         9.        4.        0.        4.    1
136       455         1         9.        4.        6.        4.
137       420    6    1         9.        5.        0.        5.    1
138       456         1         9.        5.        6.        5.
139        1 416 415 422 421 380 379 374 373   1       1   1   6 -29 -76   6  30
14        61 332 331 338 337 290 289 284 283   1       1       6 -23       5

        .   .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
        1   5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
        COLUMNS
```

```
DATA CARDS      PAGE    5
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

CARD    COLUMNS
 NO.    1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
        .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
 141       86  284  283  290  289  242  241  236  235    1                   6  -17         4
 142      106  236  235  242  241  194  193  188  187    1         1         6  -11         3
 143      121  188  187  194  193  146  145  140  139    1         1         6   -5         2
 144      131  140  139  146  145   98   97   92   91    1         1
 145      136   92   91   98   97   86   85   44   43    1         1    1
 146      141  146  145  152  151  134  133   98   97    1         1
 147      146  200  199  206  205  182  181  152  151    1         1
 148      151  254  253  260  259  230  229  206  205    1         1
 149      156  308  307  314  313  278  277  260  259    1         1
 150      161  362  361  368  367  326  325  314  313    1         1
 151      166   86   85   98   97   50   49   44   43    2         1    1
 152      171  134  133  152  151  104  103   98   97    2         1
 153      176  182  181  206  205  158  157  152  151    2         1
 154      181  230  229  260  259  212  211  206  205    2         1
 155      186  278  277  314  313  266  265  260  259    2         1
 156      191  326  325  368  367  320  319  314  313    2         1
 157      196   44   43   50   49    8    7    2    1    2         1    1    6  -29         6
 158      226   98   97  104  103   56   55   50   49    2         1         6  -23         5
 159      251  152  151  158  157  110  109  104  103    2         1         6  -17         4
 160      271  206  205  212  211  164  163  158  157    2         1         6  -11         3
 161      286  260  259  266  265  218  217  212  211    2         1         6   -5         2
 162      296  314  313  320  319  272  271  266  265    2         1
 163      300  318  317  324  323  276  275  270  269    2         1
        .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .
        1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
        COLUMNS
```

```
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

NUMBER OF NODAL POINTS .....................          456
NUMBER OF ELEMENTS .........................          300
NUMBER OF MATERIALS ........................            2
NUMBER OF SURFACE FLOW TYPES ...............            0
NUMBER OF SETS OF DIRECTION RATIOS .........            0
NUMBER OF LOADING CASES ....................            1
ELEMENT VELOCITY OPTION ....................            0
LIMIT ON ALLOWABLE HALF BAND WIDTH .........           70
NUMBER OF ELEMENT STORAGE BLOCKS ...........            1
CONSTANT ACCELERATION IN X DIRECTION .......            0.
CONSTANT ACCELERATION IN Y DIRECTION .......            0.
CONSTANT ACCELERATION IN Z DIRECTION .......            1.00000
ACCELERATION DUE TO GRAVITY ................            1.00000
UNIT WEIGHT OF FLUID .......................            1.00000


LOAD CASE ..................................            1
NUMBER OF NODES WITH PRESCRIBED FLOW .......            0
NUMBER OF ELEMENT FACES WITH
PRESCRIBED SURFACE FLOWS ...................            0
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
MATERIAL          PRINCIPAL PERMEABILITIES
  TYPE           I                II                III
   1         .10000E+02       .10000E+02        .10000E+02
   2         .10000E+01       .10000E+01        .10000E+01
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                          GLOBAL COORDINATES                  PRESCRIBED
NODE          X                 Y               Z            PRESSURES
   1          0.                0.              0.            20.00000
   2          0.                1.00000         0.            21.00000
   3          0.                2.00000         0.            22.00000
   4          0.                3.00000         0.            23.00000
   5          0.                4.00000         0.            24.00000
   6          0.                5.00000         0.            25.00000
   7          0.                0.              1.00000       20.00000
   8          0.                1.00000         1.00000       21.00000
   9          0.                2.00000         1.00000       22.00000
  10          0.                3.00000         1.00000       23.00000
  11          0.                4.00000         1.00000       24.00000
  12          0.                5.00000         1.00000       25.00000
  13          0.                0.              2.00000       20.00000
  14          0.                1.00000         2.00000       21.00000
  15          0.                2.00000         2.00000       22.00000
  16          0.                3.00000         2.00000       23.00000
  17          0.                4.00000         2.00000       24.00000
  18          0.                5.00000         2.00000       25.00000
  19          0.                0.              3.00000       20.00000
  20          0.                1.00000         3.00000       21.00000
  21          0.                2.00000         3.00000       22.00000
  22          0.                3.00000         3.00000       23.00000
  23          0.                4.00000         3.00000       24.00000
  24          0.                5.00000         3.00000       25.00000
  25          0.                0.              4.00000       20.00000
  26          0.                1.00000         4.00000       21.00000
  27          0.                2.00000         4.00000       22.00000
  28          0.                3.00000         4.00000       23.00000
  29          0.                4.00000         4.00000       24.00000
  30          0.                5.00000         4.00000       25.00000
  31          0.                0.              5.00000       20.00000
  32          0.                1.00000         5.00000       21.00000
  33          0.                2.00000         5.00000       22.00000
  34          0.                3.00000         5.00000       23.00000
  35          0.                4.00000         5.00000       24.00000
  36          0.                5.00000         5.00000       25.00000
  37          0.                0.              6.00000       20.00000
  38          0.                1.00000         6.00000       21.00000
  39          0.                2.00000         6.00000       22.00000
  40          0.                3.00000         6.00000       23.00000
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                            GLOBAL COORDINATES                            PRESCRIBED
NODE          X                    Y                     Z                PRESSURES
 41         0.                   4.00000              6.00000              24.00000
 42         0.                   5.00000              6.00000              25.00000
 43         1.00000              0.                   0.                   20.00000
 44         1.00000              1.00000              0.
 45         1.00000              2.00000              0.
 46         1.00000              3.00000              0.
 47         1.00000              4.00000              0.
 48         1.00000              5.00000              0.
 49         1.00000              0.                   1.00000              20.00000
 50         1.00000              1.00000              1.00000
 51         1.00000              2.00000              1.00000
 52         1.00000              3.00000              1.00000
 53         1.00000              4.00000              1.00000
 54         1.00000              5.00000              1.00000
 55         1.00000              0.                   2.00000              20.00000
 56         1.00000              1.00000              2.00000
 57         1.00000              2.00000              2.00000
 58         1.00000              3.00000              2.00000
 59         1.00000              4.00000              2.00000
 60         1.00000              5.00000              2.00000
 61         1.00000              0.                   3.00000              20.00000
 62         1.00000              1.00000              3.00000
 63         1.00000              2.00000              3.00000
 64         1.00000              3.00000              3.00000
 65         1.00000              4.00000              3.00000
 66         1.00000              5.00000              3.00000
 67         1.00000              0.                   4.00000              20.00000
 68         1.00000              1.00000              4.00000
 69         1.00000              2.00000              4.00000
 70         1.00000              3.00000              4.00000
 71         1.00000              4.00000              4.00000
 72         1.00000              5.00000              4.00000
 73         1.00000              0.                   5.00000              20.00000
 74         1.00000              1.00000              5.00000
 75         1.00000              2.00000              5.00000
 76         1.00000              3.00000              5.00000
 77         1.00000              4.00000              5.00000
 78         1.00000              5.00000              5.00000
 79         1.00000              0.                   6.00000              20.00000
 80         1.00000              1.00000              6.00000
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                        GLOBAL COORDINATES                      PRESCRIBED
NODE           X                 Y                 Z            PRESSURES
  81       1.00000           2.00000           6.00000
  82       1.00000           3.00000           6.00000
  83       1.00000           4.00000           6.00000
  84       1.00000           5.00000           6.00000
  85       1.50000           0.                 .50000          20.00000
  86       1.50000           1.00000            .50000
  87       1.50000           2.00000            .50000
  88       1.50000           3.00000            .50000
  89       1.50000           4.00000            .50000
  90       1.50000           5.00000            .50000
  91       2.00000           0.                0.               20.00000
  92       2.00000           1.00000           0.
  93       2.00000           2.00000           0.
  94       2.00000           3.00000           0.
  95       2.00000           4.00000           0.
  96       2.00000           5.00000           0.
  97       2.00000           0.                1.00000          20.00000
  98       2.00000           1.00000           1.00000
  99       2.00000           2.00000           1.00000
 100       2.00000           3.00000           1.00000
 101       2.00000           4.00000           1.00000
 102       2.00000           5.00000           1.00000
 103       2.00000           0.                2.00000          20.00000
 104       2.00000           1.00000           2.00000
 105       2.00000           2.00000           2.00000
 106       2.00000           3.00000           2.00000
 107       2.00000           4.00000           2.00000
 108       2.00000           5.00000           2.00000
 109       2.00000           0.                3.00000          20.00000
 110       2.00000           1.00000           3.00000
 111       2.00000           2.00000           3.00000
 112       2.00000           3.00000           3.00000
 113       2.00000           4.00000           3.00000
 114       2.00000           5.00000           3.00000
 115       2.00000           0.                4.00000          20.00000
 116       2.00000           1.00000           4.00000
 117       2.00000           2.00000           4.00000
 118       2.00000           3.00000           4.00000
 119       2.00000           4.00000           4.00000
 120       2.00000           5.00000           4.00000
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                              GLOBAL COORDINATES                        PRESCRIBED
NODE              X                    Y                   Z            PRESSURES
121            2.00000            0.                  5.00000           20.00000
122            2.00000            1.00000             5.00000
123            2.00000            2.00000             5.00000
124            2.00000            3.00000             5.00000
125            2.00000            4.00000             5.00000
126            2.00000            5.00000             5.00000
127            2.00000            0.                  6.00000           20.00000
128            2.00000            1.00000             6.00000
129            2.00000            2.00000             6.00000
130            2.00000            3.00000             6.00000
131            2.00000            4.00000             6.00000
132            2.00000            5.00000             6.00000
133            2.50000            0.                  1.50000
134            2.50000            1.00000             1.50000
135            2.50000            2.00000             1.50000
136            2.50000            3.00000             1.50000
137            2.50000            4.00000             1.50000
138            2.50000            5.00000             1.50000
139            3.00000            0.                  0.
140            3.00000            1.00000             0.
141            3.00000            2.00000             0.
142            3.00000            3.00000             0.
143            3.00000            4.00000             0.
144            3.00000            5.00000             0.
145            3.00000            0.                  1.00000
146            3.00000            1.00000             1.00000
147            3.00000            2.00000             1.00000
148            3.00000            3.00000             1.00000
149            3.00000            4.00000             1.00000
150            3.00000            5.00000             1.00000
151            3.00000            0.                  2.00000
152            3.00000            1.00000             2.00000
153            3.00000            2.00000             2.00000
154            3.00000            3.00000             2.00000
155            3.00000            4.00000             2.00000
156            3.00000            5.00000             2.00000
157            3.00000            0.                  3.00000
158            3.00000            1.00000             3.00000
159            3.00000            2.00000             3.00000
160            3.00000            3.00000             3.00000
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                          GLOBAL COORDINATES                        PRESCRIBED
NODE             X                   Y                   Z          PRESSURES
161         3.00000             4.00000             3.00000
162         3.00000             5.00000             3.00000
163         3.00000             0.                  4.00000
164         3.00000             1.00000             4.00000
165         3.00000             2.00000             4.00000
166         3.00000             3.00000             4.00000
167         3.00000             4.00000             4.00000
168         3.00000             5.00000             4.00000
169         3.00000             0.                  5.00000
170         3.00000             1.00000             5.00000
171         3.00000             2.00000             5.00000
172         3.00000             3.00000             5.00000
173         3.00000             4.00000             5.00000
174         3.00000             5.00000             5.00000
175         3.00000             0.                  6.00000
176         3.00000             1.00000             6.00000
177         3.00000             2.00000             6.00000
178         3.00000             3.00000             6.00000
179         3.00000             4.00000             6.00000
180         3.00000             5.00000             6.00000
181         3.50000             0.                  2.50000
182         3.50000             1.00000             2.50000
183         3.50000             2.00000             2.50000
184         3.50000             3.00000             2.50000
185         3.50000             4.00000             2.50000
186         3.50000             5.00000             2.50000
187         4.00000             0.                  0.
188         4.00000             1.00000             0.
189         4.00000             2.00000             0.
190         4.00000             3.00000             0.
191         4.00000             4.00000             0.
192         4.00000             5.00000             0.
193         4.00000             0.                  1.00000
194         4.00000             1.00000             1.00000
195         4.00000             2.00000             1.00000
196         4.00000             3.00000             1.00000
197         4.00000             4.00000             1.00000
198         4.00000             5.00000             1.00000
199         4.00000             0.                  2.00000
200         4.00000             1.00000             2.00000
```

```
FI PM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                              GLOBAL COORDINATES                          PRESCRIBED
NO E               X                    Y                    Z            PRESSURES
201             4.00000              2.00000              2.00000
202             4.00000              3.00000              2.00000
203             4.00000              4.00000              2.00000
204             4.00000              5.00000              2.00000
205             4.00000              0.                   3.00000
206             4.00000              1.00000              3.00000
207             4.00000              2.00000              3.00000
208             4.00000              3.00000              3.00000
209             4.00000              4.00000              3.00000
210             4.00000              5.00000              3.00000
211             4.00000              0.                   4.00000
212             4.00000              1.00000              4.00000
213             4.00000              2.00000              4.00000
214             4.00000              3.00000              4.00000
215             4.00000              4.00000              4.00000
216             4.00000              5.00000              4.00000
217             4.00000              0.                   5.00000
218             4.00000              1.00000              5.00000
219             4.00000              2.00000              5.00000
220             4.00000              3.00000              5.00000
221             4.00000              4.00000              5.00000
222             4.00000              5.00000              5.00000
223             4.00000              0.                   6.00000
224             4.00000              1.00000              6.00000
225             4.00000              2.00000              6.00000
226             4.00000              3.00000              6.00000
227             4.00000              4.00000              6.00000
228             4.00000              5.00000              6.00000
229             4.50000              0.                   3.50000
230             4.50000              1.00000              3.50000
231             4.50000              2.00000              3.50000
232             4.50000              3.00000              3.50000
233             4.50000              4.00000              3.50000
234             4.50000              5.00000              3.50000
235             5.00000              0.                   0.
236             5.00000              1.00000              0.
237             5.00000              2.00000              0.
238             5.00000              3.00000              0.
239             5.00000              4.00000              0.
240             5.00000              5.00000              0.
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                            GLOBAL COORDINATES                       PRESCRIBED
NODE           X                  Y                  Z               PRESSURES
241         5.00000            0.                 1.00000
242         5.00000            1.00000            1.00000
243         5.00000            2.00000            1.00000
244         5.00000            3.00000            1.00000
245         5.00000            4.00000            1.00000
246         5.00000            5.00000            1.00000
247         5.00000            0.                 2.00000
248         5.00000            1.00000            2.00000
249         5.00000            2.00000            2.00000
250         5.00000            3.00000            2.00000
251         5.00000            4.00000            2.00000
252         5.00000            5.00000            2.00000
253         5.00000            0.                 3.00000
254         5.00000            1.00000            3.00000
255         5.00000            2.00000            3.00000
256         5.00000            3.00000            3.00000
257         5.00000            4.00000            3.00000
258         5.00000            5.00000            3.00000
259         5.00000            0.                 4.00000
260         5.00000            1.00000            4.00000
261         5.00000            2.00000            4.00000
262         5.00000            3.00000            4.00000
263         5.00000            4.00000            4.00000
264         5.00000            5.00000            4.00000
265         5.00000            0.                 5.00000
266         5.00000            1.00000            5.00000
267         5.00000            2.00000            5.00000
268         5.00000            3.00000            5.00000
269         5.00000            4.00000            5.00000
270         5.00000            5.00000            5.00000
271         5.00000            0.                 6.00000
272         5.00000            1.00000            6.00000
273         5.00000            2.00000            6.00000
274         5.00000            3.00000            6.00000
275         5.00000            4.00000            6.00000
276         5.00000            5.00000            6.00000
277         5.50000            0.                 4.50000
278         5.50000            1.00000            4.50000
279         5.50000            2.00000            4.50000
280         5.50000            3.00000            4.50000
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                          GLOBAL COORDINATES                          PRESCRIBED
NODE          X                  Y                  Z                 PRESSURES
281       5.50000            4.00000            4.50000
282       5.50000            5.00000            4.50000
283       6.00000            0.                 0.
284       6.00000            1.00000            0.
285       6.00000            2.00000            0.
286       6.00000            3.00000            0.
287       6.00000            4.00000            0.
288       6.00000            5.00000            0.
289       6.00000            0.                 1.00000
290       6.00000            1.00000            1.00000
291       6.00000            2.00000            1.00000
292       6.00000            3.00000            1.00000
293       6.00000            4.00000            1.00000
294       6.00000            5.00000            1.00000
295       6.00000            0.                 2.00000
296       6.00000            1.00000            2.00000
297       6.00000            2.00000            2.00000
298       6.00000            3.00000            2.00000
299       6.00000            4.00000            2.00000
300       6.00000            5.00000            2.00000
301       6.00000            0.                 3.00000
302       6.00000            1.00000            3.00000
303       6.00000            2.00000            3.00000
304       6.00000            3.00000            3.00000
305       6.00000            4.00000            3.00000
306       6.00000            5.00000            3.00000
307       6.00000            0.                 4.00000
308       6.00000            1.00000            4.00000
309       6.00000            2.00000            4.00000
310       6.00000            3.00000            4.00000
311       6.00000            4.00000            4.00000
312       6.00000            5.00000            4.00000
313       6.00000            0.                 5.00000
314       6.00000            1.00000            5.00000
315       6.00000            2.00000            5.00000
316       6.00000            3.00000            5.00000
317       6.00000            4.00000            5.00000
318       6.00000            5.00000            5.00000
319       6.00000            0.                 6.00000
320       6.00000            1.00000            6.00000
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                          GLOBAL COORDINATES                        PRESCRIBED
NODE            X                 Y                 Z               PRESSURES
321          6.00000           2.00000           6.00000
322          6.00000           3.00000           6.00000
323          6.00000           4.00000           6.00000
324          6.00000           5.00000           6.00000
325          6.50000           0.                5.50000
326          6.50000           1.00000           5.50000
327          6.50000           2.00000           5.50000
328          6.50000           3.00000           5.50000
329          6.50000           4.00000           5.50000
330          6.50000           5.00000           5.50000
331          7.00000           0.                0.                  0.
332          7.00000           1.00000           0.
333          7.00000           2.00000           0.
334          7.00000           3.00000           0.
335          7.00000           4.00000           0.
336          7.00000           5.00000           0.
337          7.00000           0.                1.00000             0.
338          7.00000           1.00000           1.00000
339          7.00000           2.00000           1.00000
340          7.00000           3.00000           1.00000
341          7.00000           4.00000           1.00000
342          7.00000           5.00000           1.00000
343          7.00000           0.                2.00000             0.
344          7.00000           1.00000           2.00000
345          7.00000           2.00000           2.00000
346          7.00000           3.00000           2.00000
347          7.00000           4.00000           2.00000
348          7.00000           5.00000           2.00000
349          7.00000           0.                3.00000             0.
350          7.00000           1.00000           3.00000
351          7.00000           2.00000           3.00000
352          7.00000           3.00000           3.00000
353          7.00000           4.00000           3.00000
354          7.00000           5.00000           3.00000
355          7.00000           0.                4.00000             0.
356          7.00000           1.00000           4.00000
357          7.00000           2.00000           4.00000
358          7.00000           3.00000           4.00000
359          7.00000           4.00000           4.00000
360          7.00000           5.00000           4.00000
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                        GLOBAL COORDINATES                      PRESCRIBED
NODE          X                Y                 Z              PRESSURES
361       7.00000          0.                5.00000             0.
362       7.00000          1.00000           5.00000
363       7.00000          2.00000           5.00000
364       7.00000          3.00000           5.00000
365       7.00000          4.00000           5.00000
366       7.00000          5.00000           5.00000
367       7.00000          0.                6.00000             0.
368       7.00000          1.00000           6.00000
369       7.00000          2.00000           6.00000
370       7.00000          3.00000           6.00000
371       7.00000          4.00000           6.00000
372       7.00000          5.00000           6.00000
373       8.00000          0.                0.                  0.
374       8.00000          1.00000           0.
375       8.00000          2.00000           0.
376       8.00000          3.00000           0.
377       8.00000          4.00000           0.
378       8.00000          5.00000           0.
379       8.00000          0.                1.00000             0.
380       8.00000          1.00000           1.00000
381       8.00000          2.00000           1.00000
382       8.00000          3.00000           1.00000
383       8.00000          4.00000           1.00000
384       8.00000          5.00000           1.00000
385       8.00000          0.                2.00000             0.
386       8.00000          1.00000           2.00000
387       8.00000          2.00000           2.00000
388       8.00000          3.00000           2.00000
389       8.00000          4.00000           2.00000
390       8.00000          5.00000           2.00000
391       8.00000          0.                3.00000             0.
392       8.00000          1.00000           3.00000
393       8.00000          2.00000           3.00000
394       8.00000          3.00000           3.00000
395       8.00000          4.00000           3.00000
396       8.00000          5.00000           3.00000
397       8.00000          0.                4.00000             0.
398       8.00000          1.00000           4.00000
399       8.00000          2.00000           4.00000
400       8.00000          3.00000           4.00000
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                            GLOBAL COORDINATES                       PRESCRIBED
NODE             X                    Y                   Z          PRESSURES
401          8.00000              4.00000             4.00000
402          8.00000              5.00000             4.00000
403          8.00000              0.                  5.00000          0.
404          8.00000              1.00000             5.00000
405          8.00000              2.00000             5.00000
406          8.00000              3.00000             5.00000
407          8.00000              4.00000             5.00000
408          8.00000              5.00000             5.00000
409          8.00000              0.                  6.00000          0.
410          8.00000              1.00000             6.00000
411          8.00000              2.00000             6.00000
412          8.00000              3.00000             6.00000
413          8.00000              4.00000             6.00000
414          8.00000              5.00000             6.00000
415          9.00000              0.                  0.               0.
416          9.00000              1.00000             0.               1.00000
417          9.00000              2.00000             0.               2.00000
418          9.00000              3.00000             0.               3.00000
419          9.00000              4.00000             0.               4.00000
420          9.00000              5.00000             0.               5.00000
421          9.00000              0.                  1.00000          0.
422          9.00000              1.00000             1.00000          1.00000
423          9.00000              2.00000             1.00000          2.00000
424          9.00000              3.00000             1.00000          3.00000
425          9.00000              4.00000             1.00000          4.00000
426          9.00000              5.00000             1.00000          5.00000
427          9.00000              0.                  2.00000          0.
428          9.00000              1.00000             2.00000          1.00000
429          9.00000              2.00000             2.00000          2.00000
430          9.00000              3.00000             2.00000          3.00000
431          9.00000              4.00000             2.00000          4.00000
432          9.00000              5.00000             2.00000          5.00000
433          9.00000              0.                  3.00000          0.
434          9.00000              1.00000             3.00000          1.00000
435          9.00000              2.00000             3.00000          2.00000
436          9.00000              3.00000             3.00000          3.00000
437          9.00000              4.00000             3.00000          4.00000
438          9.00000              5.00000             3.00000          5.00000
439          9.00000              0.                  4.00000          0.
440          9.00000              1.00000             4.00000          1.00000
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                        GLOBAL COORDINATES                       PRESCRIBED
NODE          X                 Y                 Z              PRESSURES
441       9.00000           2.00000           4.00000            2.00000
442       9.00000           3.00000           4.00000            3.00000
443       9.00000           4.00000           4.00000            4.00000
444       9.00000           5.00000           4.00000            5.00000
445       9.00000           0.                5.00000            0.
446       9.00000           1.00000           5.00000            1.00000
447       9.00000           2.00000           5.00000            2.00000
448       9.00000           3.00000           5.00000            3.00000
449       9.00000           4.00000           5.00000            4.00000
450       9.00000           5.00000           5.00000            5.00000
451       9.00000           0.                6.00000            0.
452       9.00000           1.00000           6.00000            1.00000
453       9.00000           2.00000           6.00000            2.00000
454       9.00000           3.00000           6.00000            3.00000
455       9.00000           4.00000           6.00000            4.00000
456       9.00000           5.00000           6.00000            5.00000
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FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                                                                              STORE IN    OBTAIN FROM
ELEMENT   N1    N2    N3    N4    N5    N6    N7    N8    MATERIAL    VOLUME         BLOCK        BLOCK
   1     416   415   422   421   380   379   374   373       1     .10000E+01        1            0
   2     422   421   428   427   386   385   380   379       1     .10000E+01        0            1
   3     428   427   434   433   392   391   386   385       1     .10000E+01        0            1
   4     434   433   440   439   398   397   392   391       1     .10000E+01        0            1
   5     440   439   446   445   404   403   398   397       1     .10000E+01        0            1
   6     446   445   452   451   410   409   404   403       1     .10000E+01        0            1
   7     417   416   423   422   381   380   375   374       1     .10000E+01        0            1
   8     423   422   429   428   387   386   381   380       1     .10000E+01        0            1
   9     429   428   435   434   393   392   387   386       1     .10000E+01        0            1
  10     435   434   441   440   399   398   393   392       1     .10000E+01        0            1
  11     441   440   447   446   405   404   399   398       1     .10000E+01        0            1
  12     447   446   453   452   411   410   405   404       1     .10000E+01        0            1
  13     418   417   424   423   382   381   376   375       1     .10000E+01        0            1
  14     424   423   430   429   388   387   382   381       1     .10000E+01        0            1
  15     430   429   436   435   394   393   388   387       1     .10000E+01        0            1
  16     436   435   442   441   400   399   394   393       1     .10000E+01        0            1
  17     442   441   448   447   406   405   400   399       1     .10000E+01        0            1
  18     448   447   454   453   412   411   406   405       1     .10000E+01        0            1
  19     419   418   425   424   383   382   377   376       1     .10000E+01        0            1
  20     425   424   431   430   389   388   383   382       1     .10000E+01        0            1
  21     431   430   437   436   395   394   389   388       1     .10000E+01        0            1
  22     437   436   443   442   401   400   395   394       1     .10000E+01        0            1
  23     443   442   449   448   407   406   401   400       1     .10000E+01        0            1
  24     449   448   455   454   413   412   407   406       1     .10000E+01        0            1
  25     420   419   426   425   384   383   378   377       1     .10000E+01        0            1
  26     426   425   432   431   390   389   384   383       1     .10000E+01        0            1
  27     432   431   438   437   396   395   390   389       1     .10000E+01        0            1
  28     438   437   444   443   402   401   396   395       1     .10000E+01        0            1
  29     444   443   450   449   408   407   402   401       1     .10000E+01        0            1
  30     450   449   456   455   414   413   408   407       1     .10000E+01        0            1
  31     374   373   380   379   338   337   332   331       1     .10000E+01        0            1
  32     380   379   386   385   344   343   338   337       1     .10000E+01        0            1
  33     386   385   392   391   350   349   344   343       1     .10000E+01        0            1
  34     392   391   398   397   356   355   350   349       1     .10000E+01        0            1
  35     398   397   404   403   362   361   356   355       1     .10000E+01        0            1
  36     404   403   410   409   368   367   362   361       1     .10000E+01        0            1
  37     375   374   381   380   339   338   333   332       1     .10000E+01        0            1
  38     381   380   387   386   345   344   339   338       1     .10000E+01        0            1
  39     387   386   393   392   351   350   345   344       1     .10000E+01        0            1
  40     393   392   399   398   357   356   351   350       1     .10000E+01        0            1
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FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                                                                                STORE IN   OBTAIN FROM
ELEMENT   N1    N2    N3    N4    N5    N6    N7    N8   MATERIAL    VOLUME      BLOCK       BLOCK
   41    399   398   405   404   363   362   357   356      1     .10000E+01      0           1
   42    405   404   411   410   369   368   363   362      1     .10000E+01      0           1
   43    376   375   382   381   340   339   334   333      1     .10000E+01      0           1
   44    382   381   388   387   346   345   340   339      1     .10000E+01      0           1
   45    388   387   394   393   352   351   346   345      1     .10000E+01      0           1
   46    394   393   400   399   358   357   352   351      1     .10000E+01      0           1
   47    400   399   406   405   364   363   358   357      1     .10000E+01      0           1
   48    406   405   412   411   370   369   364   363      1     .10000E+01      0           1
   49    377   376   383   382   341   340   335   334      1     .10000E+01      0           1
   50    383   382   389   388   347   346   341   340      1     .10000E+01      0           1
   51    389   388   395   394   353   352   347   346      1     .10000E+01      0           1
   52    395   394   401   400   359   358   353   352      1     .10000E+01      0           1
   53    401   400   407   406   365   364   359   358      1     .10000E+01      0           1
   54    407   406   413   412   371   370   365   364      1     .10000E+01      0           1
   55    378   377   384   383   342   341   336   335      1     .10000E+01      0           1
   56    384   383   390   389   348   347   342   341      1     .10000E+01      0           1
   57    390   389   396   395   354   353   348   347      1     .10000E+01      0           1
   58    396   395   402   401   360   359   354   353      1     .10000E+01      0           1
   59    402   401   408   407   366   365   360   359      1     .10000E+01      0           1
   60    408   407   414   413   372   371   366   365      1     .10000E+01      0           1
   61    332   331   338   337   290   289   284   283      1     .10000E+01      0           1
   62    338   337   344   343   296   295   290   289      1     .10000E+01      0           1
   63    344   343   350   349   302   301   296   295      1     .10000E+01      0           1
   64    350   349   356   355   308   307   302   301      1     .10000E+01      0           1
   65    356   355   362   361   314   313   308   307      1     .10000E+01      0           1
   66    333   332   339   338   291   290   285   284      1     .10000E+01      0           1
   67    339   338   345   344   297   296   291   290      1     .10000E+01      0           1
   68    345   344   351   350   303   302   297   296      1     .10000E+01      0           1
   69    351   350   357   356   309   308   303   302      1     .10000E+01      0           1
   70    357   356   363   362   315   314   309   308      1     .10000E+01      0           1
   71    334   333   340   339   292   291   286   285      1     .10000E+01      0           1
   72    340   339   346   345   298   297   292   291      1     .10000E+01      0           1
   73    346   345   352   351   304   303   298   297      1     .10000E+01      0           1
   74    352   351   358   357   310   309   304   303      1     .10000E+01      0           1
   75    358   357   364   363   316   315   310   309      1     .10000E+01      0           1
   76    335   334   341   340   293   292   287   286      1     .10000E+01      0           1
   77    341   340   347   346   299   298   293   292      1     .10000E+01      0           1
   78    347   346   353   352   305   304   299   298      1     .10000E+01      0           1
   79    353   352   359   358   311   310   305   304      1     .10000E+01      0           1
   80    359   358   365   364   317   316   311   310      1     .10000E+01      0           1
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FI PM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

EI EMENT   N1    N2    N3    N4    N5    N6    N7    N8   MATERIAL       VOLUME       STORE IN   OBTAIN FROM
                                                                                      BLOCK        BLOCK
   81     336   335   342   341   294   293   288   287      1        .10000E+01       0            1
   82     342   341   348   347   300   299   294   293      1        .10000E+01       0            1
   83     348   347   354   353   306   305   300   299      1        .10000E+01       0            1
   84     354   353   360   359   312   311   306   305      1        .10000E+01       0            1
   85     360   359   366   365   318   317   312   311      1        .10000E+01       0            1
   86     284   283   290   289   242   241   236   235      1        .10000E+01       0            1
   87     290   289   296   295   248   247   242   241      1        .10000E+01       0            1
   88     296   295   302   301   254   253   248   247      1        .10000E+01       0            1
   89     302   301   308   307   260   259   254   253      1        .10000E+01       0            1
   90     285   284   291   290   243   242   237   236      1        .10000E+01       0            1
   91     291   290   297   296   249   248   243   242      1        .10000E+01       0            1
   92     297   296   303   302   255   254   249   248      1        .10000E+01       0            1
   93     303   302   309   308   261   260   255   254      1        .10000E+01       0            1
   94     286   285   292   291   244   243   238   237      1        .10000E+01       0            1
   95     292   291   298   297   250   249   244   243      1        .10000E+01       0            1
   96     298   297   304   303   256   255   250   249      1        .10000E+01       0            1
   97     304   303   310   309   262   261   256   255      1        .10000E+01       0            1
   98     287   286   293   292   245   244   239   238      1        .10000E+01       0            1
   99     293   292   299   298   251   250   245   244      1        .10000E+01       0            1
  100     299   298   305   304   257   256   251   250      1        .10000E+01       0            1
  101     305   304   311   310   263   262   257   256      1        .10000E+01       0            1
  102     288   287   294   293   246   245   240   239      1        .10000E+01       0            1
  103     294   293   300   299   252   251   246   245      1        .10000E+01       0            1
  104     300   299   306   305   258   257   252   251      1        .10000E+01       0            1
  105     306   305   312   311   264   263   258   257      1        .10000E+01       0            1
  106     236   235   242   241   194   193   188   187      1        .10000E+01       0            1
  107     242   241   248   247   200   199   194   193      1        .10000E+01       0            1
  108     248   247   254   253   206   205   200   199      1        .10000E+01       0            1
  109     237   236   243   242   195   194   189   188      1        .10000E+01       0            1
  110     243   242   249   248   201   200   195   194      1        .10000E+01       0            1
  111     249   248   255   254   207   206   201   200      1        .10000E+01       0            1
  112     238   237   244   243   196   195   190   189      1        .10000E+01       0            1
  113     244   243   250   249   202   201   196   195      1        .10000E+01       0            1
  114     250   249   256   255   208   207   202   201      1        .10000E+01       0            1
  115     239   238   245   244   197   196   191   190      1        .10000E+01       0            1
  116     245   244   251   250   203   202   197   196      1        .10000E+01       0            1
  117     251   250   257   256   209   208   203   202      1        .10000E+01       0            1
  118     240   239   246   245   198   197   192   191      1        .10000E+01       0            1
  119     246   245   252   251   204   203   198   197      1        .10000E+01       0            1
  120     252   251   258   257   210   209   204   203      1        .10000E+01       0            1
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FLPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                                                                                  STORE IN    OBTAIN FROM
ELEMENT   N1    N2    N3    N4    N5    N6    N7    N8   MATERIAL       VOLUME       BLOCK         BLOCK
  121     188   187   194   193   146   145   140   139     1        .10000E+01       0             1
  122     194   193   200   199   152   151   146   145     1        .10000E+01       0             1
  123     189   188   195   194   147   146   141   140     1        .10000E+01       0             1
  124     195   194   201   200   153   152   147   146     1        .10000E+01       0             1
  125     190   189   196   195   148   147   142   141     1        .10000E+01       0             1
  126     196   195   202   201   154   153   148   147     1        .10000E+01       0             1
  127     191   190   197   196   149   148   143   142     1        .10000E+01       0             1
  128     197   196   203   202   155   154   149   148     1        .10000E+01       0             1
  129     192   191   198   197   150   149   144   143     1        .10000E+01       0             1
  130     198   197   204   203   156   155   150   149     1        .10000E+01       0             1
  131     140   139   146   145    98    97    92    91     1        .10000E+01       0             1
  132     141   140   147   146    99    98    93    92     1        .10000E+01       0             1
  133     142   141   148   147   100    99    94    93     1        .10000E+01       0             1
  134     143   142   149   148   101   100    95    94     1        .10000E+01       0             1
  135     144   143   150   149   102   101    96    95     1        .10000E+01       0             1
  136      92    91    98    97    86    85    44    43     1        .50000E+00       1             0
  137      93    92    99    98    87    86    45    44     1        .50000E+00       0             1
  138      94    93   100    99    88    87    46    45     1        .50000E+00       0             1
  139      95    94   101   100    89    88    47    46     1        .50000E+00       0             1
  140      96    95   102   101    90    89    48    47     1        .50000E+00       0             1
  141     146   145   152   151   134   133    98    97     1        .50000E+00       0             1
  142     147   146   153   152   135   134    99    98     1        .50000E+00       0             1
  143     148   147   154   153   136   135   100    99     1        .50000E+00       0             1
  144     149   148   155   154   137   136   101   100     1        .50000E+00       0             1
  145     150   149   156   155   138   137   102   101     1        .50000E+00       0             1
  146     200   199   206   205   182   181   152   151     1        .50000E+00       0             1
  147     201   200   207   206   183   182   153   152     1        .50000E+00       0             1
  148     202   201   208   207   184   183   154   153     1        .50000E+00       0             1
  149     203   202   209   208   185   184   155   154     1        .50000E+00       0             1
  150     204   203   210   209   186   185   156   155     1        .50000E+00       0             1
  151     254   253   260   259   230   229   206   205     1        .50000E+00       0             1
  152     255   254   261   260   231   230   207   206     1        .50000E+00       0             1
  153     256   255   262   261   232   231   208   207     1        .50000E+00       0             1
  154     257   256   263   262   233   232   209   208     1        .50000E+00       0             1
  155     258   257   264   263   234   233   210   209     1        .50000E+00       0             1
  156     308   307   314   313   278   277   260   259     1        .50000E+00       0             1
  157     309   308   315   314   279   278   261   260     1        .50000E+00       0             1
  158     310   309   316   315   280   279   262   261     1        .50000E+00       0             1
  159     311   310   317   316   281   280   263   262     1        .50000E+00       0             1
  160     312   311   318   317   282   281   264   263     1        .50000E+00       0             1
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FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

ELEMENT   N1   N2   N3   N4   N5   N6   N7   N8  MATERIAL     VOLUME     STORE IN  OBTAIN FROM
                                                                          BLOCK       BLOCK
  161    362  361  368  367  326  325  314  313     1     .50000E+00      0           1
  162    363  362  369  368  327  326  315  314     1     .50000E+00      0           1
  163    364  363  370  369  328  327  316  315     1     .50000E+00      0           1
  164    365  364  371  370  329  328  317  316     1     .50000E+00      0           1
  165    366  365  372  371  330  329  318  317     1     .50000E+00      0           1
  166     86   85   98   97   50   49   44   43     2     .50000E+00      0           1
  167     87   86   99   98   51   50   45   44     2     .50000E+00      1           0
  168     88   87  100   99   52   51   46   45     2     .50000E+00      0           1
  169     89   88  101  100   53   52   47   46     2     .50000E+00      0           1
  170     90   89  102  101   54   53   48   47     2     .50000E+00      0           1
  171    134  133  152  151  104  103   98   97     2     .50000E+00      0           1
  172    135  134  153  152  105  104   99   98     2     .50000E+00      0           1
  173    136  135  154  153  106  105  100   99     2     .50000E+00      0           1
  174    137  136  155  154  107  106  101  100     2     .50000E+00      0           1
  175    138  137  156  155  108  107  102  101     2     .50000E+00      0           1
  176    182  181  206  205  158  157  152  151     2     .50000E+00      0           1
  177    183  182  207  206  159  158  153  152     2     .50000E+00      0           1
  178    184  183  208  207  160  159  154  153     2     .50000E+00      0           1
  179    185  184  209  208  161  160  155  154     2     .50000E+00      0           1
  180    186  185  210  209  162  161  156  155     2     .50000E+00      0           1
  181    230  229  260  259  212  211  206  205     2     .50000E+00      0           1
  182    231  230  261  260  213  212  207  206     2     .50000E+00      0           1
  183    232  231  262  261  214  213  208  207     2     .50000E+00      0           1
  184    233  232  263  262  215  214  209  208     2     .50000E+00      0           1
  185    234  233  264  263  216  215  210  209     2     .50000E+00      0           1
  186    278  277  314  313  266  265  260  259     2     .50000E+00      0           1
  187    279  278  315  314  267  266  261  260     2     .50000E+00      0           1
  188    280  279  316  315  268  267  262  261     2     .50000E+00      0           1
  189    281  280  317  316  269  268  263  262     2     .50000E+00      0           1
  190    282  281  318  317  270  269  264  263     2     .50000E+00      0           1
  191    326  325  368  367  320  319  314  313     2     .50000E+00      0           1
  192    327  326  369  368  321  320  315  314     2     .50000E+00      0           1
  193    328  327  370  369  322  321  316  315     2     .50000E+00      0           1
  194    329  328  371  370  323  322  317  316     2     .50000E+00      0           1
  195    330  329  372  371  324  323  318  317     2     .50000E+00      0           1
  196     44   43   50   49    8    7    2    1     2     .50000E+00      0           1
  197     50   49   56   55   14   13    8    7     2     .10000E+01      1           0
  198     56   55   62   61   20   19   14   13     2     .10000E+01      0           1
  199     62   61   68   67   26   25   20   19     2     .10000E+01      0           1
  200     68   67   74   73   32   31   26   25     2     .10000E+01      0           1
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FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

ELEMENT    N1    N2    N3    N4    N5    N6    N7    N8   MATERIAL       VOLUME      STORE IN    OBTAIN FROM
                                                                                    BLOCK        BLOCK
  201      74    73    80    79    38    37    32    31      2        .10000E+01       0            1
  202      45    44    51    50     9     8     3     2      2        .10000E+01       0            1
  203      51    50    57    56    15    14     9     8      2        .10000E+01       0            1
  204      57    56    63    62    21    20    15    14      2        .10000E+01       0            1
  205      63    62    69    68    27    26    21    20      2        .10000E+01       0            1
  206      69    68    75    74    33    32    27    26      2        .10000E+01       0            1
  207      75    74    81    80    39    38    33    32      2        .10000E+01       0            1
  208      46    45    52    51    10     9     4     3      2        .10000E+01       0            1
  209      52    51    58    57    16    15    10     9      2        .10000E+01       0            1
  210      58    57    64    63    22    21    16    15      2        .10000E+01       0            1
  211      64    63    70    69    28    27    22    21      2        .10000E+01       0            1
  212      70    69    76    75    34    33    28    27      2        .10000E+01       0            1
  213      76    75    82    81    40    39    34    33      2        .10000E+01       0            1
  214      47    46    53    52    11    10     5     4      2        .10000E+01       0            1
  215      53    52    59    58    17    16    11    10      2        .10000E+01       0            1
  216      59    58    65    64    23    22    17    16      2        .10000E+01       0            1
  217      65    64    71    70    29    28    23    22      2        .10000E+01       0            1
  218      71    70    77    76    35    34    29    28      2        .10000E+01       0            1
  219      77    76    83    82    41    40    35    34      2        .10000E+01       0            1
  220      48    47    54    53    12    11     6     5      2        .10000E+01       0            1
  221      54    53    60    59    18    17    12    11      2        .10000E+01       0            1
  222      60    59    66    65    24    23    18    17      2        .10000E+01       0            1
  223      66    65    72    71    30    29    24    23      2        .10000E+01       0            1
  224      72    71    78    77    36    35    30    29      2        .10000E+01       0            1
  225      78    77    84    83    42    41    36    35      2        .10000E+01       0            1
  226      98    97   104   103    56    55    50    49      2        .10000E+01       0            1
  227     104   103   110   109    62    61    56    55      2        .10000E+01       0            1
  228     110   109   116   115    68    67    62    61      2        .10000E+01       0            1
  229     116   115   122   121    74    73    68    67      2        .10000E+01       0            1
  230     122   121   128   127    80    79    74    73      2        .10000E+01       0            1
  231      99    98   105   104    57    56    51    50      2        .10000E+01       0            1
  232     105   104   111   110    63    62    57    56      2        .10000E+01       0            1
  233     111   110   117   116    69    68    63    62      2        .10000E+01       0            1
  234     117   116   123   122    75    74    69    68      2        .10000E+01       0            1
  235     123   122   129   128    81    80    75    74      2        .10000E+01       0            1
  236     100    99   106   105    58    57    52    51      2        .10000E+01       0            1
  237     106   105   112   111    64    63    58    57      2        .10000E+01       0            1
  238     112   111   118   117    70    69    64    63      2        .10000E+01       0            1
  239     118   117   124   123    76    75    70    69      2        .10000E+01       0            1
  240     124   123   130   129    82    81    76    75      2        .10000E+01       0            1
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                                                                                        STORE IN   OBTAIN FROM
ELEMENT    N1    N2    N3    N4    N5    N6    N7    N8   MATERIAL        VOLUME         BLOCK       BLOCK
  241     101   100   107   106    59    58    53    52       2         .10000E+01         0           1
  242     107   106   113   112    65    64    59    58       2         .10000E+01         0           1
  243     113   112   119   118    71    70    65    64       2         .10000E+01         0           1
  244     119   118   125   124    77    76    71    70       2         .10000E+01         0           1
  245     125   124   131   130    83    82    77    76       2         .10000E+01         0           1
  246     102   101   108   107    60    59    54    53       2         .10000E+01         0           1
  247     108   107   114   113    66    65    60    59       2         .10000E+01         0           1
  248     114   113   120   119    72    71    66    65       2         .10000E+01         0           1
  249     120   119   126   125    78    77    72    71       2         .10000E+01         0           1
  250     126   125   132   131    84    83    78    77       2         .10000E+01         0           1
  251     152   151   158   157   110   109   104   103       2         .10000E+01         0           1
  252     158   157   164   163   116   115   110   109       2         .10000E+01         0           1
  253     164   163   170   169   122   121   116   115       2         .10000E+01         0           1
  254     170   169   176   175   128   127   122   121       2         .10000E+01         0           1
  255     153   152   159   158   111   110   105   104       2         .10000E+01         0           1
  256     159   158   165   164   117   116   111   110       2         .10000E+01         0           1
  257     165   164   171   170   123   122   117   116       2         .10000E+01         0           1
  258     171   170   177   176   129   128   123   122       2         .10000E+01         0           1
  259     154   153   160   159   112   111   106   105       2         .10000E+01         0           1
  260     160   159   166   165   118   117   112   111       2         .10000E+01         0           1
  261     166   165   172   171   124   123   118   117       2         .10000E+01         0           1
  262     172   171   178   177   130   129   124   123       2         .10000E+01         0           1
  263     155   154   161   160   113   112   107   106       2         .10000E+01         0           1
  264     161   160   167   166   119   118   113   112       2         .10000E+01         0           1
  265     167   166   173   172   125   124   119   118       2         .10000E+01         0           1
  266     173   172   179   178   131   130   125   124       2         .10000E+01         0           1
  267     156   155   162   161   114   113   108   107       2         .10000E+01         0           1
  268     162   161   168   167   120   119   114   113       2         .10000E+01         0           1
  269     168   167   174   173   126   125   120   119       2         .10000E+01         0           1
  270     174   173   180   179   132   131   126   125       2         .10000E+01         0           1
  271     206   205   212   211   164   163   158   157       2         .10000E+01         0           1
  272     212   211   218   217   170   169   164   163       2         .10000E+01         0           1
  273     218   217   224   223   176   175   170   169       2         .10000E+01         0           1
  274     207   206   213   212   165   164   159   158       2         .10000E+01         0           1
  275     213   212   219   218   171   170   165   164       2         .10000E+01         0           1
  276     219   218   225   224   177   176   171   170       2         .10000E+01         0           1
  277     208   207   214   213   166   165   160   159       2         .10000E+01         0           1
  278     214   213   220   219   172   171   166   165       2         .10000E+01         0           1
  279     220   219   226   225   178   177   172   171       2         .10000E+01         0           1
  280     209   208   215   214   167   166   161   160       2         .10000E+01         0           1
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

                                                                          STORE IN    OBTAIN FROM
ELEMENT    N1    N2    N3    N4    N5    N6    N7    N8   MATERIAL      VOLUME        BLOCK         BLOCK
  281     215   214   221   220   173   172   167   166      2        .10000E+01      0             1
  282     221   220   227   226   179   178   173   172      2        .10000E+01      0             1
  283     210   209   216   215   168   167   162   161      2        .10000E+01      0             1
  284     216   215   222   221   174   173   168   167      2        .10000E+01      0             1
  285     222   221   228   227   180   179   174   173      2        .10000E+01      0             1
  286     260   259   266   265   218   217   212   211      2        .10000E+01      0             1
  287     266   265   272   271   224   223   218   217      2        .10000E+01      0             1
  288     261   260   267   266   219   218   213   212      2        .10000E+01      0             1
  289     267   266   273   272   225   224   219   218      2        .10000E+01      0             1
  290     262   261   268   267   220   219   214   213      2        .10000E+01      0             1
  291     268   267   274   273   226   225   220   219      2        .10000E+01      0             1
  292     263   262   269   268   221   220   215   214      2        .10000E+01      0             1
  293     269   268   275   274   227   226   221   220      2        .10000E+01      0             1
  294     264   263   270   269   222   221   216   215      2        .10000E+01      0             1
  295     27    269   276   275   228   227   222   221      2        .10000E+01      0             1
  296     314   313   320   319   272   271   266   265      2        .10000E+01      0             1
  297     315   314   321   320   273   272   267   266      2        .10000E+01      0             1
  298     316   315   322   321   274   273   268   267      2        .10000E+01      0             1
  299     317   316   323   322   275   274   269   268      2        .10000E+01      0             1
  300     318   317   324   323   276   275   270   269      2        .10000E+01      0             1
  TOTAL VOLUME=      .27000E+03
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
 NODE         PRESSURE
   1        .20000E+02
   2        .21000E+02
   3        .22000E+02
   4        .23000E+02
   5        .24000E+02
   6        .25000E+02
   7        .20000E+02
   8        .21000E+02
   9        .22000E+02
  10        .23000E+02
  11        .24000E+02
  12        .25000E+02
  13        .20000E+02
  14        .21000E+02
  15        .22000E+02
  16        .23000E+02
  17        .24000E+02
  18        .25000E+02
  19        .20000E+02
  20        .21000E+02
  21        .22000E+02
  22        .23000E+02
  23        .24000E+02
  24        .25000E+02
  25        .20000E+02
  26        .21000E+02
  27        .22000E+02
  28        .23000E+02
  29        .24000E+02
  30        .25000E+02
  31        .20000E+02
  32        .21000E+02
  33        .22000E+02
  34        .23000E+02
  35        .24000E+02
  36        .25000E+02
  37        .20000E+02
  38        .21000E+02
  39        .22000E+02
  40        .23000E+02
  41        .24000E+02
  42        .25000E+02
  43        .20000E+02
  44        .14672E+02
  45        .11462E+02
  46        .10408E+02
  47        .10044E+02
  48        .99560E+01
  49        .20000E+02
  50        .17230E+02
```

```
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
 NODE        PRESSURE
  51        .15675E+02
  52        .15323E+02
  53        .15423E+02
  54        .15481E+02
  55        .20000E+02
  56        .18284E+02
  57        .17384E+02
  58        .17377E+02
  59        .17649E+02
  60        .17766E+02
  61        .20000E+02
  62        .18858E+02
  63        .18355E+02
  64        .18533E+02
  65        .18903E+02
  66        .19049E+02
  67        .20000E+02
  68        .19253E+02
  69        .19009E+02
  70        .19303E+02
  71        .19726E+02
  72        .19889E+02
  73        .20000E+02
  74        .19596E+02
  75        .19574E+02
  76        .19934E+02
  77        .20386E+02
  78        .20557E+02
  79        .20000E+02
  80        .20382E+02
  81        .20404E+02
  82        .20791E+02
  83        .21252E+02
  84        .21426E+02
  85        .20000E+02
  86        .13386E+02
  87        .10597E+02
  88        .95690E+01
  89        .91475E+01
  90        .90445E+01
  91        .20000E+02
  92        .11935E+02
  93        .94384E+01
  94        .83193E+01
  95        .78645E+01
  96        .77425E+01
  97        .20000E+02
  98        .12005E+02
  99        .99945E+01
 100        .89630E+01
```

```
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
 NODE        PRESSURE
 101        .85432E+01
 102        .84276E+01
 103        .20000E+02
 104        .14113E+02
 105        .12756E+02
 106        .12232E+02
 107        .12077E+02
 108        .12055E+02
 109        .20000E+02
 110        .15488E+02
 111        .14519E+02
 112        .14239E+02
 113        .14228E+02
 114        .14252E+02
 115        .20000E+02
 116        .16449E+02
 117        .15763E+02
 118        .15634E+02
 119        .15701E+02
 120        .15751E+02
 121        .20000E+02
 122        .17219E+02
 123        .16777E+02
 124        .16741E+02
 125        .16850E+02
 126        .16912E+02
 127        .20000E+02
 128        .18141E+02
 129        .17749E+02
 130        .17751E+02
 131        .17873E+02
 132        .17939E+02
 133        .12597E+02
 134        .10609E+02
 135        .90308E+01
 136        .83582E+01
 137        .80271E+01
 138        .79415E+01
 139        .95113E+01
 140        .90663E+01
 141        .74434E+01
 142        .66622E+01
 143        .62983E+01
 144        .61952E+01
 145        .98909E+01
 146        .95128E+01
 147        .81095E+01
 148        .74333E+01
 149        .71104E+01
 150        .70194E+01
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
 NODE         PRESSURE
 151        .91308E+01
 152        .89689E+01
 153        .82632E+01
 154        .78017E+01
 155        .75858E+01
 156        .75232E+01
 157        .11529E+02
 158        .11338E+02
 159        .10541E+02
 160        .10279E+02
 161        .10194E+02
 162        .10179E+02
 163        .12996E+02
 164        .12844E+02
 165        .12250E+02
 166        .12081E+02
 167        .12067E+02
 168        .12076E+02
 169        .14107E+02
 170        .14012E+02
 171        .13567E+02
 172        .13470E+02
 173        .13490E+02
 174        .13512E+02
 175        .15171E+02
 176        .15019E+02
 177        .14657E+02
 178        .14582E+02
 179        .14615E+02
 180        .14640E+02
 181        .78494E+01
 182        .77455E+01
 183        .74647E+01
 184        .72589E+01
 185        .71691E+01
 186        .71453E+01
 187        .60473E+01
 188        .58507E+01
 189        .54865E+01
 190        .51274E+01
 191        .49504E+01
 192        .48984E+01
 193        .67198E+01
 194        .65546E+01
 195        .62546E+01
 196        .59489E+01
 197        .57994E+01
 198        .57555E+01
 199        .69138E+01
 200        .68179E+01
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
 NODE          PRESSURE
 201         .66294E+01
 202         .64643E+01
 203         .63863E+01
 204         .63658E+01
 205         .67675E+01
 206         .67560E+01
 207         .67577E+01
 208         .67662E+01
 209         .67907E+01
 210         .68024E+01
 211         .88000E+01
 212         .87724E+01
 213         .87685E+01
 214         .87936E+01
 215         .88590E+01
 216         .88877E+01
 217         .10287E+02
 218         .10269E+02
 219         .10290E+02
 220         .10345E+02
 221         .10429E+02
 222         .10465E+02
 223         .11424E+02
 224         .11425E+02
 225         .11452E+02
 226         .11521E+02
 227         .11610E+02
 228         .11648E+02
 229         .58890E+01
 230         .59643E+01
 231         .61380E+01
 232         .63310E+01
 233         .64657E+01
 234         .65131E+01
 235         .37294E+01
 236         .37398E+01
 237         .37627E+01
 238         .37887E+01
 239         .38038E+01
 240         .38113E+01
  41         .45148E+01
 242         .45444E+01
 243         .45857E+01
 244         .46394E+01
 245         .46716E+01
 246         .46848E+01
 247         .49319E+01
 248         .49863E+01
 249         .50972E+01
 250         .52214E+01
```

```
FIPM30   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
  NODE          PRESSURE
  251         .53017E+01
  252         .53308E+01
  253         .50943E+01
  254         .51894E+01
  255         .53956E+01
  256         .56217E+01
  257         .57712E+01
  258         .58234E+01
  259         .50678E+01
  260         .52281E+01
  261         .55603E+01
  262         .59268E+01
  263         .61610E+01
  264         .62415E+01
  265         .67273E+01
  266         .68894E+01
  267         .72222E+01
  268         .75758E+01
  269         .78069E+01
  270         .78881E+01
  271         .79686E+01
  272         .80950E+01
  273         .84315E+01
  274         .87802E+01
  275         .90109E+01
  276         .90917E+01
  277         .41792E+01
  278         .44188E+01
  279         .50767E+01
  280         .56150E+01
  281         .59427E+01
  282         .60553E+01
  283         .18809E+01
  284         .20646E+01
  285         .24521E+01
  286         .27536E+01
  287         .29465E+01
  288         .30132E+01
  289         .27172E+01
  290         .28399E+01
  291         .32891E+01
  292         .36079E+01
  293         .38126E+01
  294         .38831E+01
  295         .31288E+01
  296         .32910E+01
  297         .38295E+01
  298         .42036E+01
  299         .44402E+01
  300         .45215E+01
```

```
FEPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
  NODE         PRESSURE
 301        .33356E+01
 302        .35338E+01
 303        .41688E+01
 304        .46206E+01
 305        .49064E+01
 306        .50040E+01
 307        .34012E+01
 308        .36566E+01
 309        .44126E+01
 310        .49697E+01
 311        .53162E+01
 312        .54338E+01
 313        .33572E+01
 314        .36129E+01
 315        .46428E+01
 316        .53247E+01
 317        .57417E+01
 318        .58825E+01
 319        .44771E+01
 320        .50189E+01
 321        .59281E+01
 322        .65910E+01
 323        .69927E+01
 324        .71301E+01
 325        .15262E+01
 326        .31408E+01
 327        .44157E+01
 328        .52024E+01
 329        .57006E+01
 330        .58710E+01
 331       0.
 332        .88879E+00
 333        .15877E+01
 334        .21364E+01
 335        .25041E+01
 336        .26388E+01
 337       0.
 338        .16794E+01
 339        .23931E+01
 340        .29639E+01
 341        .33393E+01
 342        .34766E+01
 343       0.
 344        .20407E+01
 345        .28855E+01
 346        .35013E+01
 347        .38995E+01
 348        .40439E+01
 349       0.
 350        .22369E+01
```

```
FEPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
 NODE          PRESSURE
 351         .31790E+01
 352         .38587E+01
 353         .42907E+01
 354         .44459E+01
 355        0.
 356         .23669E+01
 357         .34111E+01
 358         .41669E+01
 359         .46407E+01
 360         .48090E+01
 361        0.
 362         .25467E+01
 363         .37384E+01
 364         .45768E+01
 365         .50923E+01
 366         .52749E+01
 367        0.
 368         .29415E+01
 369         .42983E+01
 370         .51934E+01
 371         .57468E+01
 372         .59434E+01
 373        0.
 374         .33503E+00
 375         .12627E+01
 376         .20413E+01
 377         .26774E+01
 378         .29009E+01
 379        0.
 380         .10711E+01
 381         .20104E+01
 382         .28033E+01
 383         .34437E+01
 384         .36685E+01
 385        0.
 386         .12553E+01
 387         .23161E+01
 388         .31354E+01
 389         .37884E+01
 390         .40169E+01
 391        0.
 392         .13553E+01
 393         .24871E+01
 394         .33450E+01
 395         .40161E+01
 396         .42502E+01
 397        0.
 398         .14385E+01
 399         .26339E+01
 400         .35336E+01
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE   1
  NODE          PRESSURE
  401        .42258E+01
  402        .44665E+01
  403       0.
  404        .15706E+01
  405        .28747E+01
  406        .38102E+01
  407        .45229E+01
  408        .47699E+01
  409       0.
  410        .23050E+01
  411        .35936E+01
  412        .45515E+01
  413        .52708E+01
  414        .55200E+01
  415       0.
  416        .10000E+01
  417        .20000E+01
  418        .30000E+01
  419        .40000E+01
  420        .50000E+01
  421       0.
  422        .10000E+01
  423        .20000E+01
  424        .30000E+01
  425        .40000E+01
  426        .50000E+01
  427       0.
  428        .10000E+01
  429        .20000E+01
  430        .30000E+01
  431        .40000E+01
  432        .50000E+01
  433       0.
  434        .10000E+01
  435        .20000E+01
  436        .30000E+01
  437        .40000E+01
  438        .50000E+01
  439       0.
  440        .10000E+01
  441        .20000E+01
  442        .30000E+01
  443        .40000E+01
  444        .50000E+01
  445       0.
  446        .10000E+01
  447        .20000E+01
  448        .30000E+01
  449        .40000E+01
  450        .50000E+01
```

```
FLPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1
  NODE           PRESSURE
 451       0.
 452        .10000E+01
 453        .20000E+01
 454        .30000E+01
 455        .40000E+01
 456        .50000E+01
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

                          COORDINATES                                          VELOCITIES
ELEMENT          X             Y             Z             X              Y              Z
   1          8.50000        .50000        .50000     -.14846E+01    -.85154E+01     .81598E+01
   2          8.50000        .50000       1.50000      .81617E+00    -.10816E+02     .95395E+01
   3          8.50000        .50000       2.50000      .15266E+01    -.11527E+02     .97501E+01
   4          8.50000        .50000       3.50000      .19844E+01    -.11984E+02     .97921E+01
   5          8.50000        .50000       4.50000      .25225E+01    -.12523E+02     .96697E+01
   6          8.50000        .50000       5.50000      .46889E+01    -.14689E+02     .81640E+01
   7          8.50000       1.50000        .50000     -.33017E+01    -.96675E+01     .62905E+01
   8          8.50000       1.50000       1.50000      .16327E+01    -.10000E+02     .87752E+01
   9          8.50000       1.50000       2.50000      .35346E+01    -.10481E+02     .93228E+01
  10          8.50000       1.50000       3.50000      .47867E+01    -.10818E+02     .94251E+01
  11          8.50000       1.50000       4.50000      .62941E+01    -.11249E+02     .90676E+01
  12          8.50000       1.50000       5.50000      .10860E+02    -.11482E+02     .63669E+01
  13          8.50000       2.50000        .50000     -.47056E+01    -.89285E+01     .62256E+01
  14          8.50000       2.50000       1.50000      .66323E+00    -.90303E+01     .84056E+01
  15          8.50000       2.50000       2.50000      .32090E+01    -.91930E+01     .90486E+01
  16          8.50000       2.50000       3.50000      .49990E+01    -.93944E+01     .91614E+01
  17          8.50000       2.50000       4.50000      .71312E+01    -.95881E+01     .87064E+01
  18          8.50000       2.50000       5.50000      .12075E+02    -.97337E+01     .63496E+01
  19          8.50000       3.50000        .50000     -.75859E+01    -.81911E+01     .61791E+01
  20          8.50000       3.50000       1.50000     -.20730E+01    -.82335E+01     .83080E+01
  21          8.50000       3.50000       2.50000      .71237E+00    -.83103E+01     .89067E+01
  22          8.50000       3.50000       3.50000      .28014E+01    -.84080E+01     .90043E+01
  23          8.50000       3.50000       4.50000      .52315E+01    -.85121E+01     .85656E+01
  24          8.50000       3.50000       5.50000      .10389E+02    -.85800E+01     .62770E+01
  25          8.50000       4.50000        .50000     -.13274E+02    -.61210E+01     .61652E+01
  26          8.50000       4.50000       1.50000     -.77061E+01    -.61334E+01     .82671E+01
  27          8.50000       4.50000       2.50000     -.48208E+01    -.61565E+01     .88477E+01
  28          8.50000       4.50000       3.50000     -.26037E+01    -.61869E+01     .89352E+01
  29          8.50000       4.50000       4.50000     -.37433E-01    -.62190E+01     .84986E+01
  30          8.50000       4.50000       5.50000      .52090E+01    -.62401E+01     .62550E+01
  31          7.50000        .50000        .50000      .29052E+01    -.99360E+01     .61831E+01
  32          7.50000        .50000       1.50000      .34841E+01    -.15116E+02     .86364E+01
  33          7.50000        .50000       2.50000      .41673E+01    -.17221E+02     .92595E+01
  34          7.50000        .50000       3.50000      .45252E+01    -.18494E+02     .94671E+01
  35          7.50000        .50000       4.50000      .47616E+01    -.19807E+02     .92202E+01
  36          7.50000        .50000       5.50000      .40318E+01    -.23409E+02     .71771E+01
  37          7.50000       1.50000        .50000      .46742E+01    -.81989E+01     .23002E+01
  38          7.50000       1.50000       1.50000      .58642E+01    -.88966E+01     .66411E+01
  39          7.50000       1.50000       2.50000      .73207E+01    -.99488E+01     .80984E+01
  40          7.50000       1.50000       3.50000      .81982E+01    -.10784E+02     .85199E+01
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FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

                          COORDINATES                                      VELOCITIES
ELEMENT         X              Y              Z              X              Y              Z
  41         7.50000        1.50000        4.50000     .88639E+01    -.11839E+02     .77997F+01
  42         7.50000        1.50000        5.50000     .79528E+01    -.12853E+02     .39804E+01
  43         7.50000        2.50000         .50000     .24083E+01    -.67274E+01     .21430F+01
  44         7.50000        2.50000        1.50000     .36964E+01    -.69967E+01     .58312F+01
  45         7.50000        2.50000        2.50000     .53522E+01    -.74316E+01     .74213E+01
  46         7.50000        2.50000        3.50000     .65402E+01    -.79829E+01     .78108E+01
  47         7.50000        2.50000        4.50000     .76018E+01    -.85735E+01     .68632F+01
  48         7.50000        2.50000        5.50000     .74422E+01    -.90675E+01     .34084E+01
  49         7.50000        3.50000         .50000    -.54857E-01    -.50489E+01     .20222F+01
  50         7.50000        3.50000        1.50000     .13332E+01    -.51676E+01     .55640E+01
  51         7.50000        3.50000        2.50000     .31633E+01    -.53861E+01     .70351E+01
  52         7.50000        3.50000        3.50000     .45910E+01    -.56727E+01     .73591F+01
  53         7.50000        3.50000        4.50000     .59602E+01    -.59854E+01     .64117E+01
  54         7.50000        3.50000        5.50000     .61344E+01    -.62521E+01     .30992F+01
  55         7.50000        4.50000         .50000    -.18294E+01    -.18009E+01     .19828E+01
  56         7.50000        4.50000        1.50000    -.39578E+00    -.18374E+01     .54482F+01
  57         7.50000        4.50000        2.50000     .15210E+01    -.19052E+01     .68646E+01
  58         7.50000        4.50000        3.50000     .30695E+01    -.19956E+01     .71527E+01
  59         7.50000        4.50000        4.50000     .45795E+01    -.20962E+01     .62047E+01
  60         7.50000        4.50000        5.50000     .49345E+01    -.21882E+01     .29474E+01
  61         6.50000         .50000         .50000     .17336E+02    -.71865E+01     .39943F+01
  62         6.50000         .50000        1.50000     .20642E+02    -.10012E+02     .69401F+01
  63         6.50000         .50000        2.50000     .22529E+02    -.11595E+02     .83856E+01
  64         6.50000         .50000        3.50000     .23308E+02    -.12644E+02     .92038F+01
  65         6.50000         .50000        4.50000     .22786E+02    -.13562E+02     .97698F+01
  66         6.50000        1.50000         .50000     .10242E+02    -.56232E+01     .19793E+01
  67         6.50000        1.50000        1.50000     .10627E+02    -.63655E+01     .53868F+01
  68         6.50000        1.50000        2.50000     .11203E+02    -.74012E+01     .73206F+01
  69         6.50000        1.50000        3.50000     .11445E+02    -.84434E+01     .81781F+01
  70         6.50000        1.50000        4.50000     .10654E+02    -.10055E+02     .82660E+01
  71         6.50000        2.50000         .50000     .75542E+01    -.43497E+01     .16894E+01
  72         6.50000        2.50000        1.50000     .79657E+01    -.46989E+01     .45853E+01
  73         6.50000        2.50000        2.50000     .84952E+01    -.53033E+01     .64819F+01
  74         6.50000        2.50000        3.50000     .88903E+01    -.61108E+01     .71671E+01
  75         6.50000        2.50000        4.50000     .86419E+01    -.70829E+01     .66938E+01
  76         6.50000        3.50000         .50000     .54424E+01    -.28516E+01     .15419F+01
  77         6.50000        3.50000        1.50000     .59008E+01    -.30372E+01     .41979F+01
  78         6.50000        3.50000        2.50000     .65514E+01    -.33816E+01     .59205F+01
  79         6.50000        3.50000        3.50000     .71399E+01    -.38452E+01     .64575F+01
  80         6.50000        3.50000        4.50000     .71893E+01    -.43818E+01     .58947F+01
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FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

                        COORDINATES                                                  VELOCITIES
ELEMENT        X              Y              Z              X               Y               Z
  81        6.50000        4.50000         .50000      .42415E+01     -.10227E+01      .14775E+01
  82        6.50000        4.50000        1.50000      .47453E+01     -.10833E+01      .40161E+01
  83        6.50000        4.50000        2.50000      .54801E+01     -.11962E+01      .56451E+01
  84        6.50000        4.50000        3.50000      .61852E+01     -.13469E+01      .61186E+01
  85        6.50000        4.50000        4.50000      .63933E+01     -.15231E+01      .55207E+01
  86        5.50000         .50000         .50000      .17565E+02     -.86593E+00      .19962E+01
  87        5.50000         .50000        1.50000      .17501E+02     -.92245E+00      .56956E+01
  88        5.50000         .50000        2.50000      .17282E+02     -.12749E+01      .79625E+01
  89        5.50000         .50000        3.50000      .16631E+02     -.17723E+01      .94983E+01
  90        5.50000        1.50000         .50000      .14967E+02     -.22522E+01      .19005E+01
  91        5.50000        1.50000        1.50000      .14911E+02     -.28498E+01      .51372E+01
  92        5.50000        1.50000        2.50000      .14614E+02     -.37268E+01      .72914E+01
  93        5.50000        1.50000        3.50000      .14004E+02     -.48239E+01      .85748E+01
  94        5.50000        2.50000         .50000      .11684E+02     -.17502E+01      .15875E+01
  95        5.50000        2.50000        1.50000      .11534E+02     -.21771E+01      .44258E+01
  96        5.50000        2.50000        2.50000      .11284E+02     -.29404E+01      .63625E+01
  97        5.50000        2.50000        3.50000      .10832E+02     -.40037E+01      .73433E+01
  98        5.50000        3.50000         .50000      .94570E+01     -.11119E+01      .14026E+01
  99        5.50000        3.50000        1.50000      .94244E+01     -.13843E+01      .39114E+01
 100        5.50000        3.50000        2.50000      .93631E+01     -.18803E+01      .56177E+01
 101        5.50000        3.50000        3.50000      .91693E+01     -.25396E+01      .63654E+01
 102        5.50000        4.50000         .50000      .82904E+01     -.39485E+00      .13067E+01
 103        5.50000        4.50000        1.50000      .83288E+01     -.48514E+00      .36447E+01
 104        5.50000        4.50000        2.50000      .83875E+01     -.65066E+00      .52231E+01
 105        5.50000        4.50000        3.50000      .83415E+01     -.87004E+00      .58814E+01
 106        4.50000         .50000         .50000      .21610E+02      .80428E+00      .25842E+01
 107        4.50000         .50000        1.50000      .20072E+02      .44231E+00      .67092E+01
 108        4.50000         .50000        2.50000      .17633E+02     -.10537E+00      .96066E+01
 109        4.50000        1.50000         .50000      .18785E+02      .14999E+01      .22507E+01
 110        4.50000        1.50000        1.50000      .17607E+02      .84062E+00      .60214E+01
 111        4.50000        1.50000        2.50000      .15731E+02     -.32573E+00      .85804E+01
 112        4.50000        2.50000         .50000      .15102E+02      .14629E+01      .18416E+01
 113        4.50000        2.50000        1.50000      .14384E+02      .73244E+00      .50407E+01
 114        4.50000        2.50000        2.50000      .13204E+02     -.48433E+00      .71780E+01
 115        4.50000        3.50000         .50000      .12307E+02      .69822E+00      .15279E+01
 116        4.50000        3.50000        1.50000      .11912E+02      .28759E+00      .42134E+01
 117        4.50000        3.50000        2.50000      .11229E+02     -.44063E+00      .60603E+01
 118        4.50000        4.50000         .50000      .11080E+02      .18780E+00      .13817E+01
 119        4.50000        4.50000        1.50000      .10795E+02      .55386E-01      .38165E+01
 120        4.50000        4.50000        2.50000      .10295E+02     -.18112E+00      .54925E+01
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FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

                        COORDINATES                                   VELOCITIES
ELEMENT         X             Y             Z             X              Y              Z
 121         3.50000        .50000        .50000     .32022E+02     .29621E+01     .44938F+01
 122         3.50000        .50000       1.50000     .26243E+02     .20027E+01     .12117E+02
 123         3.50000       1.50000        .50000     .24964E+02     .92259E+01     .35384E+01
 124         3.50000       1.50000       1.50000     .21494E+02     .64936E+01     .93804E+01
 125         3.50000       2.50000        .50000     .17077E+02     .53056E+01     .24331F+01
 126         3.50000       2.50000       1.50000     .15776E+02     .40214E+01     .64691F+01
 127         3.50000       3.50000        .50000     .14195F+02     .25331E+01     .18661F+01
 128         3.50000       3.50000       1.50000     .13331E+02     .19155E+01     .51344F+01
 129         3.50000       4.50000        .50000     .13049E+02     .72512E+00     .16440F+01
 130         3.50000       4.50000       1.50000     .12330E+02     .54510E+00     .45588F+01
 131         2.50000        .50000        .50000     .64897E+02     .42208E+02     .77602F+01
 132         2.50000       1.50000        .50000     .23102E+02     .18833E+02     .56536F+01
 133         2.50000       2.50000        .50000     .17667E+02     .90198E+01     .36075F+01
 134         2.50000       3.50000        .50000     .15465E+02     .39033E+01     .27360E+01
 135         2.50000       4.50000        .50000     .14886E+02     .10795E+01     .24996F+01
 136         1.62500        .50000        .37500     .13923E+02     .70005E+02     .94146F+01
 137         1.62500       1.50000        .37500     .23384E+02     .26266E+02     .72918F+01
 138         1.62500       2.50000        .37500     .19321E+02     .10582E+02     .52403F+01
 139         1.62500       3.50000        .37500     .20028E+02     .41486E+01     .47010F+01
 140         1.62500       4.50000        .37500     .20499E+02     .10726E+01     .46487E+01
 141         2.62500        .50000       1.37500     .53777E+02     .26308E+02     .25749F+02
 142         2.62500       1.50000       1.37500     .22007E+02     .14245E+02     .11829F+02
 143         2.62500       2.50000       1.37500     .16463F+02     .71046E+01     .80001F+01
 144         2.62500       3.50000       1.37500     .14505E+02     .32240E+01     .60887F+01
 145         2.62500       4.50000       1.37500     .13848E+02     .88704E+00     .54605F+01
 146         3.62500        .50000       2.37500     .20756E+02     .93315E+00     .12124F+02
 147         3.62500       1.50000       2.37500     .18111E+02     .29333E+01     .10481E+02
 148         3.62500       2.50000       2.37500     .14502E+02     .20598E+01     .87033F+01
 149         3.62500       3.50000       2.37500     .12463E+02     .89784E+00     .66902F+01
 150         3.62500       4.50000       2.37500     .11602E+02     .23801E+00     .59784F+01
 151         4.62500        .50000       3.37500     .15917E+02    -.79787E+00     .10221F+02
 152         4.62500       1.50000       3.37500     .14400E+02    -.17846E+01     .92269E+01
 153         4.62500       2.50000       3.37500     .12350E+02    -.19853E+01     .78335F+01
 154         4.62500       3.50000       3.37500     .10692E+02    -.13569E+01     .66535F+01
 155         4.62500       4.50000       3.37500     .98976E+01    -.47978E+00     .60555F+01
 156         5.62500        .50000       4.37500     .16015E+02    -.22774E+01     .10614F+02
 157         5.62500       1.50000       4.37500     .13463E+02    -.69402E+01     .92005F+01
 158         5.62500       2.50000       4.37500     .10346E+02    -.53596E+01     .72521F+01
 159         5.62500       3.50000       4.37500     .89124E+01    -.33132E+01     .61942F+01
 160         5.62500       4.50000       4.37500     .81859F+01    -.11287E+01     .57055F+01
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FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

                          COORDINATES                                         VELOCITIES
ELEMENT         X              Y              Z              X              Y              Z
 161         6.62500         .50000        5.37500      .20673E+02    -.18396E+02     .94700E+01
 162         6.62500        1.50000        5.37500      .88966E+01    -.12133E+02     .61830E+01
 163         6.62500        2.50000        5.37500      .77039E+01    -.80053E+01     .46754E+01
 164         6.62500        3.50000        5.37500      .64852E+01    -.49601E+01     .41461E+01
 165         6.62500        4.50000        5.37500      .58573E+01    -.17259E+01     .38125E+01
 166         1.37500         .50000         .62500      .25891E+01     .56767E+01    -.25532E+00
 167         1.37500        1.50000         .62500      .54952E+01     .23912E+01    -.24276E+01
 168         1.37500        2.50000         .62500      .61445E+01     .86637E+00    -.36883E+01
 169         1.37500        3.50000         .62500      .67513E+01     .27627E+00    -.42784E+01
 170         1.37500        4.50000         .62500      .71132E+01     .62317E-01    -.45984E+01
 171         2.37500         .50000        1.62500      .89298E+01     .40079E+01    -.97719E+00
 172         2.37500        1.50000        1.62500      .48067E+01     .14129E+01    -.14230E+01
 173         2.37500        2.50000        1.62500      .45226E+01     .67261E+00    -.20763E+01
 174         2.37500        3.50000        1.62500      .44914E+01     .28024E+00    -.24321E+01
 175         2.37500        4.50000        1.62500      .45475E+01     .71410E-01    -.26167E+01
 176         3.37500         .50000        2.62500      .47797E+01     .11709E+00    -.14916E+01
 177         3.37500        1.50000        2.62500      .42638E+01     .44535E+00    -.14046E+01
 178         3.37500        2.50000        2.62500      .36837E+01     .23011E+00    -.14132E+01
 179         3.37500        3.50000        2.62500      .34803E+01     .91695E-01    -.15650E+01
 180         3.37500        4.50000        2.62500      .34083E+01     .22283E-01    -.16503E+01
 181         4.37500         .50000        3.62500      .36665E+01    -.49143E-01    -.10527E+01
 182         4.37500        1.50000        3.62500      .34007E+01    -.12592E+00    -.10380E+01
 183         4.37500        2.50000        3.62500      .30558E+01    -.14827E+00    -.10374E+01
 184         4.37500        3.50000        3.62500      .27952E+01    -.11468E+00    -.10607E+01
 185         4.37500        4.50000        3.62500      .26816E+01    -.42090E-01    -.10863E+01
 186         5.37500         .50000        4.62500      .33408E+01    -.20441E+00    -.67794E+00
 187         5.37500        1.50000        4.62500      .29413E+01    -.58822E+00    -.67492E+00
 188         5.37500        2.50000        4.62500      .24331E+01    -.48508E+00    -.67329E+00
 189         5.37500        3.50000        4.62500      .21678E+01    -.30249E+00    -.65718E+00
 190         5.37500        4.50000        4.62500      .20431E+01    -.10375E+00    -.65393E+00
 191         6.37500         .50000        5.62500      .34216E+01    -.13384E+01    -.40729E+00
 192         6.37500        1.50000        5.62500      .19492E+01    -.11427E+01    -.44125E+00
 193         6.37500        2.50000        5.62500      .15695E+01    -.75666E+00    -.33154E+00
 194         6.37500        3.50000        5.62500      .13719E+01    -.46758E+00    -.30879E+00
 195         6.37500        4.50000        5.62500      .12591E+01    -.16130E+00    -.29213E+00
 196          .50000         .50000         .50000      .25244E+01     .15244E+01     .36054E+00
 197          .50000         .50000        1.50000      .16216E+01     .62157E+00     .73667E+00
 198          .50000         .50000        2.50000      .12145E+01     .21451E+00     .85627E+00
 199          .50000         .50000        3.50000      .97214E+00    -.27856E-01     .90136E+00
 200          .50000         .50000        4.50000      .78774E+00    -.21226E+00     .91423E+00
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FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE   1

                           COORDINATES                                            VELOCITIES
ELEMENT         X               Y              Z               X               Y               Z
 201          .50000          .50000        5.50000      .50547E+00     -.49453E+00      .80350E+00
 202          .50000         1.50000         .50000      .67400E+01      .69131E+00     -.69273E+00
 203          .50000         1.50000        1.50000      .43567E+01      .11352E+00      .30937E+00
 204          .50000         1.50000        2.50000      .32797E+01     -.14933E+00      .61366E+00
 205          .50000         1.50000        3.50000      .26312E+01     -.31312E+00      .73782E+00
 206          .50000         1.50000        4.50000      .21419E+01     -.43358E+00      .77292E+00
 207          .50000         1.50000        5.50000      .15109E+01     -.50007E+00      .59605E+00
 208          .50000         2.50000         .50000      .92829E+01     -.14843E+00     -.12822E+01
 209          .50000         2.50000        1.50000      .60600E+01     -.61020E+00      .59264E-01
 210          .50000         2.50000        2.50000      .45876E+01     -.54273E+00      .46838E+00
 211          .50000         2.50000        3.50000      .37000E+01     -.61807E+00      .64397E+00
 212          .50000         2.50000        4.50000      .30449E+01     -.66346E+00      .70092E+00
 213          .50000         2.50000        5.50000      .23242E+01     -.68661E+00      .57840E+00
 214          .50000         3.50000         .50000      .10700E+02     -.43405E+00     -.15736E+01
 215          .50000         3.50000        1.50000      .70569E+01     -.59290E+00     -.69969E-01
 216          .50000         3.50000        2.50000      .53846E+01     -.66036E+00      .39763E+00
 217          .50000         3.50000        3.50000      .43839E+01     -.69797E+00      .60176E+00
 218          .50000         3.50000        4.50000      .36629E+01     -.71854E+00      .67717E+00
 219          .50000         3.50000        5.50000      .29094E+01     -.72814E+00      .56941E+00
 220          .50000         4.50000         .50000      .11774E+02     -.49234E+00     -.17258E+01
 221          .50000         4.50000        1.50000      .79203E+01     -.54366E+00     -.12789E+00
 222          .50000         4.50000        2.50000      .61582E+01     -.56595E+00      .36580E+00
 223          .50000         4.50000        3.50000      .51084E+01     -.57754E+00      .58438E+00
 224          .50000         4.50000        4.50000      .43606E+01     -.58373E+00      .66779E+00
 225          .50000         4.50000        5.50000      .35948E+01     -.58646E+00      .56645E+00
 226         1.50000          .50000        1.50000      .23488E+01      .45920E+01      .20954E+00
 227         1.50000          .50000        2.50000      .18851E+01      .33141E+01      .51258E+00
 228         1.50000          .50000        3.50000      .15434E+01      .24877E+01      .66103E+00
 229         1.50000          .50000        4.50000      .12952E+01      .18706E+01      .72187E+00
 230         1.50000          .50000        5.50000      .11546E+01      .11656E+01      .57306E+00
 231         1.50000         1.50000        1.50000      .49261E+01      .14554E+01     -.90822E+00
 232         1.50000         1.50000        2.50000      .40011E+01      .93229E+00     -.17064E+00
 233         1.50000         1.50000        3.50000      .33139E+01      .60072E+00      .18631E+00
 234         1.50000         1.50000        4.50000      .28058E+01      .34836E+00      .32713E+00
 235         1.50000         1.50000        5.50000      .25176E+01      .20821E+00      .12258E+00
 236         1.50000         2.50000        1.50000      .54537E+01      .47886E+00     -.14483E+01
 237         1.50000         2.50000        2.50000      .44760E+01      .15847E+00     -.47405E+00
 238         1.50000         2.50000        3.50000      .37612E+01     -.15749E-01     -.16068E-01
 239         1.50000         2.50000        4.50000      .32262E+01     -.12202E+00      .17086E+00
 240         1.50000         2.50000        5.50000      .29214E+01     -.17779E+00      .82925E-01
```

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FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

                               COORDINATES                                           VELOCITIES
ELEMENT        X              Y              Z             X              Y              Z
  241       1.50000        3.50000        1.50000     .59894E+01     .50613E-01    -.17706E+01
  242       1.50000        3.50000        2.50000     .49215E+01    -.11911E+00    -.64188E+00
  243       1.50000        3.50000        3.50000     .41655E+01    -.21209E+00    -.11544E+00
  244       1.50000        3.50000        4.50000     .36055E+01    -.26266E+00     .11338E+00
  245       1.50000        3.50000        5.50000     .32869E+01    -.28611E+00     .61188E-01
  246       1.50000        4.50000        1.50000     .63038E+01    -.92994E-02    -.19184E+01
  247       1.50000        4.50000        2.50000     .51886E+01    -.66478E-01    -.72101E+00
  248       1.50000        4.50000        3.50000     .44086E+01    -.95838E-01    -.15864E+00
  249       1.50000        4.50000        4.50000     .38359E+01    -.11152E+00     .90319E-01
  250       1.50000        4.50000        5.50000     .35116E+01    -.11842E+00     .53903E-01
  251       2.50000         .50000        2.50000     .71589E+01     .26878E+01    -.53532E+00
  252       2.50000         .50000        3.50000     .58079E+01     .21012E+01     .16276E-01
  253       2.50000         .50000        4.50000     .49273E+01     .16445E+01     .23778E+00
  254       2.50000         .50000        5.50000     .42627E+01     .12218E+01     .25197E+00
  255       2.50000        1.50000        2.50000     .44415E+01     .95718E+00    -.94594E+00
  256       2.50000        1.50000        3.50000     .38117E+01     .76148E+00    -.35546E+00
  257       2.50000        1.50000        4.50000     .33838E+01     .54161E+00    -.67037E-01
  258       2.50000        1.50000        5.50000     .31577E+01     .41000E+00     .24356E-02
  259       2.50000        2.50000        2.50000     .42150E+01     .38198E+00    -.11313E+01
  260       2.50000        2.50000        3.50000     .37509E+01     .21002E+00    -.53773E+00
  261       2.50000        2.50000        4.50000     .33867E+01     .10805E+00    -.20660E+00
  262       2.50000        2.50000        5.50000     .31853E+01     .51752E-01    -.45910E-01
  263       2.50000        3.50000        2.50000     .42287E+01     .11661E+00    -.13109E+01
  264       2.50000        3.50000        3.50000     .37954E+01     .10909E-01    -.63578E+00
  265       2.50000        3.50000        4.50000     .34546E+01    -.65593E-01    -.26703E+00
  266       2.50000        3.50000        5.50000     .32641E+01    -.71250E-01    -.67437E-01
  267       2.50000        4.50000        2.50000     .42826E+01     .18750E-01    -.14028E+01
  268       2.50000        4.50000        3.50000     .38541E+01    -.17053E-01    -.68541E+00
  269       2.50000        4.50000        4.50000     .35173E+01    -.35521E-01    -.29236E+00
  270       2.50000        4.50000        5.50000     .33292E+01    -.43487E-01    -.75725E-01
  271       3.50000         .50000        3.50000     .44025E+01     .95350E-01    -.75561E+00
  272       3.50000         .50000        4.50000     .39577E+01     .72907E-01    -.31570E+00
  273       3.50000         .50000        5.50000     .37260E+01     .65599E-01    -.90894E-01
  274       3.50000        1.50000        3.50000     .39796E+01     .34821E+00    -.81077E+00
  275       3.50000        1.50000        4.50000     .36435E+01     .25547E+00    -.37571E+00
  276       3.50000        1.50000        5.50000     .34547E+01     .18992E+00    -.10375E+00
  277       3.50000        2.50000        3.50000     .35164E+01     .99304E-01    -.88727E+00
  278       3.50000        2.50000        4.50000     .32929E+01     .46507E-01    -.44475E+00
  279       3.50000        2.50000        5.50000     .31673E+01     .11934E-01    -.13484E+00
  280       3.50000        3.50000        3.50000     .33529E+01     .25521E-02    -.94252E+00
```

```
FEPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

                                  COORDINATES                                          VELOCITIES
ELEMENT           X                 Y                 Z               X                  Y                 Z
 281           3.50000           3.50000           4.50000        .31704E+01       -.38697E-01       -.48354E+00
 282           3.50000           3.50000           5.50000        .30635E+01       -.56406E-01       -.14833E+00
 283           3.50000           4.50000           3.50000        .32940E+01       -.88650E-02       -.98080E+00
 284           3.50000           4.50000           4.50000        .31262E+01       -.23902E-01       -.50155E+00
 285           3.50000           4.50000           5.50000        .30267E+01       -.30021E-01       -.15415E+00
 286           4.50000            .50000           4.50000        .35539E+01       -.69299E-01       -.57607E+00
 287           4.50000            .50000           5.50000        .34311E+01       -.68195E-01       -.18502E+00
 288           4.50000           1.50000           4.50000        .33000E+01       -.17046E+00       -.58529E+00
 289           4.50000           1.50000           5.50000        .31995E+01       -.17912E+00       -.18335E+00
 290           4.50000           2.50000           4.50000        .29780E+01       -.20012E+00       -.59594E+00
 291           4.50000           2.50000           5.50000        .28995E+01       -.20659E+00       -.18783E+00
 292           4.50000           3.50000           4.50000        .27390E+01       -.15356E+00       -.60405E+00
 293           4.50000           3.50000           5.50000        .26826E+01       -.15859E+00       -.19122E+00
 294           4.50000           4.50000           4.50000        .26356E+01       -.56584E-01       -.60980E+00
 295           4.50000           4.50000           5.50000        .25882E+01       -.58970E-01       -.19288E+00
 296           5.50000            .50000           5.50000        .33036E+01       -.27148E+00       -.24318E+00
 297           5.50000           1.50000           5.50000        .28589E+01       -.65212E+00       -.27652E+00
 298           5.50000           2.50000           5.50000        .23808E+01       -.51178E+00       -.24130E+00
 299           5.50000           3.50000           5.50000        .21309E+01       -.32014E+00       -.23142E+00
 300           5.50000           4.50000           5.50000        .20127E+01       -.11002E+00       -.22658E+00
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE   1

NODE         RESIDUAL
   1      0.
   2      0.
   3      0.
   4      0.
   5      0.
   6      0.
   7      0.
   8      0.
   9      0.
  10      0.
  11      0.
  12      0.
  13      0.
  14      0.
  15      0.
  16      0.
  17      0.
  18      0.
  19      0.
  20      0.
  21      0.
  22      0.
  23      0.
  24      0.
  25      0.
  26      0.
  27      0.
  28      0.
  29      0.
  30      0.
  31      0.
  32      0.
  33      0.
  34      0.
  35      0.
  36      0.
  37      0.
  38      0.
  39      0.
  40      0.
  41      0.
  42      0.
  43       .11369E-12
  44       .85265E-12
  45       .78160E-12
  46       .10232E-11
  47       .10090E-11
  48       .11084E-11
  49      0.
  50       .17337E-11
```

```
FLPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE   1

NODE        RESIDUAL
 51          .13927E-11
 52          .11937E-11
 53          .85265E-12
 54          .13074E-11
 55         0.
 56          .28848E-11
 57          .31974E-11
 58          .19327E-11
 59          .16769E-11
 60          .11546E-11
 61         0.
 62          .18900E-11
 63          .27569E-11
 64          .23448E-11
 65          .26006E-11
 66          .13252E-11
 67         0.
 68          .23377E-11
 69          .29061E-11
 70          .22098E-11
 71          .37659E-11
 72          .13287E-11
 73         0.
 74          .33751E-11
 75          .30198E-11
 76          .31051E-11
 77          .36309E-11
 78          .13571E-11
 79         0.
 80          .22808E-11
 81          .57554E-12
 82          .11866E-11
 83          .94502E-12
 84          .66791E-12
 85         0.
 86          .14239E-10
 87          .10687E-10
 88          .94786E-11
 89          .99192E-11
 90          .37517E-11
 91         0.
 92          .23022E-11
 93         -.27853E-11
 94         -.51159E-12
 95         0.
 96         -.11369E-11
 97         0.
 98         -.11987E-10
 99         -.10616E-10
100         -.18062E-10
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE        RESIDUAL
101       -.15135E-10
102       -.75744E-11
103       0.
104        .15490E-11
105        .92371E-13
106        .84555E-12
107        .58265E-12
108        .99476E-13
109       0.
110        .25722E-11
111       -.42633E-13
112       -.17621E-11
113       -.92371E-12
114       -.14566E-12
115       0.
116        .22169E-11
117       -.97344E-12
118       -.13145E-11
119       -.67502E-12
120       -.43343E-12
121       0.
122        .12861E-11
123       -.49738E-13
124       -.33396E-12
125       -.29132E-12
126       -.32685E-12
127       0.
128        .78160E-13
129       -.48317E-12
130       -.13145E-11
131       -.10871E-11
132       -.54712E-12
133        .55707E-11
134        .17394E-10
135        .10942E-10
136        .56133E-11
137        .51159E-11
138        .37659E-11
139        .39222E-11
140        .27285E-11
141       -.11653E-11
142       -.15916E-11
143        .21032E-11
144        .93792E-12
145        .18190E-11
146       -.32685E-11
147       -.12534E-10
148       -.28422E-11
149       -.39790E-11
150       -.19043E-11
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE        RESIDUAL
151       -.87255E-11
152       -.14637E-10
153       -.13372E-10
154       -.11092E-10
155       -.13188E-10
156       -.84412E-11
157       -.43343E-12
158        .14921E-12
159       -.13323E-11
160       -.50093E-12
161       -.11973E-11
162       -.24869E-13
163       -.14211E-13
164        .51159E-12
165       -.86686E-12
166       -.75318E-12
167       -.19895E-11
168       -.11369E-12
169       -.11369E-12
170       -.59686E-12
171       -.83844E-12
172       -.17764E-11
173       -.49738E-12
174       -.16165E-12
175       -.42633E-12
176        .99476E-13
177       -.65370E-12
178       -.83844E-12
179       -.13642E-11
180       -.32685E-12
181        .21743E-11
182        .34106E-11
183        .39719E-11
184        .24727E-11
185        .42490E-11
186        .30695E-11
187       -.39790E-12
188       -.88107E-12
189       -.68212E-12
190       -.31264E-12
191       -.88107E-12
192       -.45475E-12
193       -.34106E-12
194       -.42633E-12
195       -.13927E-11
196        .48317E-12
197       -.44906E-11
198       -.16200E-11
199       -.19327E-11
200        .18758E-11
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE        RESIDUAL
201        .13358E-11
202       -.17053E-12
203       -.63665E-11
204       -.32827E-11
205       -.62741E-11
206       -.14268E-10
207       -.12555E-10
208       -.12790E-10
209       -.12875E-10
210       -.50377E-11
211       -.54001E-12
212       -.12186E-11
213       -.52580E-12
214       -.17337E-11
215       -.11653E-11
216        .23093E-13
217       -.99476E-13
218       -.10161E-11
219       -.10374E-11
220       -.11795E-11
221       -.10800E-11
222       -.72120E-12
223       -.39790E-12
224       -.11653E-11
225       -.84199E-12
226       -.11759E-11
227       -.11475E-11
228       -.25224E-12
229        .43343E-12
230        .34319E-11
231        .10161E-11
232        .11795E-11
233        .54712E-12
234        .11440E-11
235       -.25580E-12
236       -.14211E-11
237       -.68212E-12
238       -.31264E-12
239        .34106E-12
240       -.36948E-12
241       -.39790E-12
242       -.14779E-11
243       -.30980E-11
244       -.19611E-11
245       -.35243E-11
246       -.88107E-12
247       -.19895E-12
248       -.31264E-12
249       -.13642E-11
250       -.21885E-11
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE        RESIDUAL
251      -.29843E-12
252      -.71054E-12
253      -.85265E-13
254      -.49170E-11
255      -.27285E-11
256      -.34390E-11
257      -.19327E-11
258      -.19327E-11
259      -.34888E-11
260      -.10374E-10
261      -.11489E-10
262      -.73115E-11
263      -.11219E-10
264      -.39293E-11
265      -.78160E-13
266      -.56133E-12
267       .49738E-13
268      -.60751E-12
269      -.57909E-12
270      -.67235E-12
271      -.22737E-12
272      -.57554E-12
273      -.68567E-12
274      -.48672E-12
275      -.65015E-12
276      -.85265E-13
277      -.19185E-12
278       .36238E-12
279       .24158E-12
280      -.18048E-11
281      -.54001E-12
282      -.42633E-13
283      -.62528E-12
284      -.11653E-11
285      -.17337E-11
286      -.20179E-11
287      -.85265E-12
288      -.19895E-12
289      -.28422E-13
290      -.15064E-11
291      -.40643E-11
292      -.30127E-11
293      -.25437E-11
294      -.61107E-12
295       .56843E-12
296      -.14211E-11
297      -.23306E-11
298      -.73896E-12
299      -.23022E-11
300      -.12790E-11
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE         RESIDUAL
301        -.85265E-12
302         .11084E-11
303        -.25011E-11
304        -.44622E-11
305        -.48033E-11
306        -.11084E-11
307         .62528E-12
308        -.68212E-12
309        -.25580E-12
310        -.21885E-11
311        -.47748E-11
312        -.34106E-12
313        -.27711E-11
314        -.55280E-11
315        -.74891E-11
316        -.70557E-11
317        -.10974E-10
318        -.40679E-11
319        -.15277E-12
320        -.20250E-12
321        -.41922E-12
322        -.65015E-12
323        -.47251E-12
324        -.11369E-12
325        -.60396E-12
326        -.15774E-11
327        -.16271E-11
328        -.22098E-11
329        -.13927E-11
330        -.10090E-11
331        0.
332        -.17053E-11
333        -.14779E-11
334        -.20179E-11
335        -.68212E-12
336        -.72475E-12
337        0.
338        -.12790E-11
339        -.25295E-11
340        -.24158E-12
341        -.21316E-11
342        -.46896E-12
343        0.
344        -.15916E-11
345        -.11653E-11
346        -.26432E-11
347        -.15632E-12
348        -.24301E-11
349        0.
350        -.45475E-12
```

```
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE         RESIDUAL
351        -.12221E-11
352        -.16200E-11
353        -.38796E-11
354        -.20179E-11
355        0.
356        -.24727E-11
357        -.23874E-11
358        -.24727E-11
359        -.35385E-11
360        -.16200E-11
361        0.
362        -.76739E-12
363        -.79581E-12
364         .11937E-11
365        -.54001E-12
366        -.10090E-11
367        0.
368         .47073E-13
369        -.15765E-11
370        -.27178E-11
371        -.11133E-11
372        -.15157E-11
373        0.
374        -.39790E-12
375        -.14211E-12
376         .95213E-12
377         .15632E-11
378         .85265E-12
379        0.
380         .88107E-12
381         .21743E-11
382         .85265E-12
383         .38867E-11
384         .20179E-11
385        0.
386        -.34106E-12
387         .17053E-12
388        -.24158E-12
389         .93792E-12
390         .65370E-12
391        0.
392        -.28422E-12
393         .76739E-12
394        -.24158E-12
395         .14566E-11
396        -.42633E-13
397        0.
398        -.54001E-12
399        -.17053E-12
400        0.
```

```
FLPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE        RESIDUAL
401        .27001E-12
402       -.10090E-11
403       0.
404        .22737E-12
405       -.11369E-12
406       -.28422E-12
407       -.54001E-12
408        .36948E-12
409       0.
410        .17053E-12
411       -.34106E-12
412        .61107E-12
413        .48317E-12
414       -.28422E-13
415       0.
416       0.
417       0.
418       0.
419       0.
420       0.
421       0.
422       0.
423       0.
424       0.
425       0.
426       0.
427       0.
428       0.
429       0.
430       0.
431       0.
432       0.
433       0.
434       0.
435       0.
436       0.
437       0.
438       0.
439       0.
440       0.
441       0.
442       0.
443       0.
444       0.
445       0.
446       0.
447       0.
448       0.
449       0.
450       0.
```

```
FIPM3D   FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION
LOAD CASE  1

NODE          RESIDUAL
451     0.
452     0.
453     0.
454     0.
455     0.
456     0.
```

```
FIPM3D    FLOW UNDER DAM SUPPORTED ON TWO MEDIA FOUNDATION

          TIME LOG

TIME IN FPIN  =     1.768          TIME PER NODE     =  .388E-02
TIME IN FPEL  =     4.400          TIME PER ELEMENT  =  .147E-01
TIME IN FPST  =    14.810          TIME PER NODE     =  .325E-01
TIME IN GAUSS =    15.968          TIME PER NODE     =  .350E-01
TIME IN FPRE  =     6.426          TIME PER NODE     =  .141E-01

TOTAL TIME =   43.372



NUMBER OF EQUATIONS ..........................   456
HALF BAND WIDTH ..............................    56
NUMBER OF EQUATIONS PER BLOCK ................    39
NUMBER OF BLOCKS .............................    12
EQUATION SOLVER ..............................GAUSS2
LENGTH OF BLANK COMMON (MTOT) ................  5000
```

APPENDIX D

LISTING FOR COMPUTER PROGRAM FLPM3D

```
      PROGRAM FPM3D
C
C     DIRECT SOLUTION OF THREE DIMENSIONAL FLOW OF INCOMPRESSIBLE FLUID
C     IN ORTHOTROPICALLY PERMEABLE POROUS MEDIA USING 8 POINT F.E.
C
     1 (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,
     2 TAPE1,TAPE2,TAPE3,TAPE7,TAPE8,TAPE9)
C
      COMMON / GENCON /
     1 HED(13),WORD(2),NUMEL,NUMNP,NUMMAT,ISTOP,MAXBAN,NSTRES,NPT
     2,LNSTOR,NUMDC,NST
      COMMON / GAUSEQ /
     1 NJ,MM,LL,NR,NC,NSET,NRNC
     2,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      COMMON / BUFFER /
     1 LNREC,LNBUFF,NTAPE1,BUFF(2640)
      COMMON A(12000)
C
C     ASSIGN LENGTH OF BLANK COMMON - MTOT
C     ASSIGN LENGTH OF ONE RECORD ON INTERNAL BUFFER - LNREC
C     ASSIGN NUMBER OF RECORDS ON INTERNAL BUFFER - NUMREC
C     ASSIGN LENGTH OF ELEMENT STORAGE BLOCKS - LNSTOR
C     ASSIGN TEMPORARY STORAGE UNITS - NTAPE1,NTAPE2,NTAPE3
C                                      NTAPE4,NTAPE5
C
      NTAPE1=1
      NTAPE2=2
      NTAPE3=3
      NTAPE4=7
      NTAPE5=8
      NTAPE6=9
      MTOT=12000
      LNREC=132
      LNSTOR=99
      NUMREC=20
```

```
      LNBUFF=NUMREC*LNREC                                                FPM   36
      CALL FPCALL (A,MTOT)                                               FPM   37
      STOP                                                               FPM   38
      END                                                                FPM   39
```

```
      SUBROUTINE FPCALL (A,MTOT)
C
C      THIS SUBROUTINE FORMS CALLING SEQUENCE FOR EACH PROBLEM
C     DIMENSIONS BLANK COMMON AND EVALUATES TIME LOG
C
      COMMON / GENCON /
     1 HED(13),WORD(2),NUMEL,NUMNP,NUMMAT,ISTOP,MAXBAN,NSTRES,NPT
     2,LNSTOR,NUMDC,NST
      COMMON / GAUSEQ /
     1 NEQ,MM,LL,NR,NC,NSET,NRNC
     2,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      COMMON / BUFFER /
     1 LNREC,LNBUFF,NTAPE1,BUFF(2040)
      COMMON / MATARG /
     1 UWT,ACCG,E(50,3)
      COMMON / LODARG /
     1 NUMPC,ACCX,ACCY,ACCZ,NPLD(3),NELD(3),NNEL,NNPL,IDLDFC(3,6)
      COMMON / ELFLOW /
     1 PPT(9),SPT(9),TPT(9),XPT(9),YPT(9),ZPT(9),QV(6,9),BB(8)
      DIMENSION A(MTOT)
      DIMENSION TIME(11),SEC(6)
      DATA WORD /6HFLPM3D,6HSTOP  /
C
C     SEARCH FOR START OR STOP CARD
C
   10 READ  (5,1000) HED
      IF ( HED(1) .EQ. WORD(1) ) GO TO 15
      IF ( HED(1) .EQ. WORD(2) ) STOP
      GO TO 10
   15 ISTOP=0
      CALL CPTIME(SEC(1))
C
C     READ AND PRINT CONTROL INFORMATION
C
      READ  (5,1001) NUMNP,NUMEL,NUMMAT,NUMPC,NUMDC,LL,NSTRES,MAXBAN
```

```
     2,NSTOR                                                            CALL  36
      READ  (5,1003) ACCX,ACCY,ACCZ,UWT                                 CALL  37
      ACCG=SQRT(ACCX*ACCX+ACCY*ACCY+ACCZ*ACCZ)                          CALL  38
      IF ( ACCG .EQ. 0.0 ) ACCG=1.0                                     CALL  39
      NW=NUMNP                                                          CALL  40
      NPT=1+NSTRES*8                                                    CALL  41
      WRITE (6,3000) HED                                                CALL  42
      IF ( LL .EQ. 0 ) LL=1                                             CALL  43
      IF ( NUMMAT .EQ. 0 ) NUMMAT=1                                     CALL  44
      IF ( MAXBAN .EQ. 0 ) MAXBAN=500                                   CALL  45
      WRITE (6,2001) NUMNP,NUMEL,NUMMAT,NUMPC,NUMDC,LL,NSTRES,MAXBAN    CALL  46
     2,NSTOR,ACCX,ACCY,ACCZ,ACCG,UWT                                    CALL  47
      IF( (NUMNP.GT.0).AND.(NUMEL.GT.0) ) GO TO 20                      CALL  48
      WRITE (6,4000)                                                    CALL  49
      GO TO 10                                                          CALL  50
   20 CONTINUE                                                          CALL  51
C                                                                       CALL  52
      NSTOR1=1                                                          CALL  53
      NSTOR2=1                                                          CALL  54
      NSTOR3=1                                                          CALL  55
      IF ( NSTOR .EQ. 3 ) GO TO 22                                      CALL  56
      NSTOR3=0                                                          CALL  57
      IF ( NSTOR .EQ. 2 ) GO TO 22                                      CALL  58
      NSTOR2=0                                                          CALL  59
      IF ( NSTOR .EQ. 1 ) GO TO 22                                      CALL  60
      NSTOR1=0                                                          CALL  61
   22 CONTINUE                                                          CALL  62
      DO 25 L=1,LL                                                      CALL  63
      READ  (5,1002)    NPLD(L),NELD(L)                                 CALL  64
      WRITE (6,2002)  L,NPLD(L),NELD(L)                                 CALL  65
   25 CONTINUE                                                          CALL  66
      NNPL=0                                                            CALL  67
      NNEL=0                                                            CALL  68
      DO 30 L=1,LL                                                      CALL  69
      NNEL=NNEL+NELD(L)                                                 CALL  70
```

```
      NNPL=NNPL+NPLD(L)                                                 CALL  71
   30 CONTINUE                                                          CALL  72
C                                                                       CALL  73
C     DIMENSION BLANK COMMON                                            CALL  74
C                                                                       CALL  75
      M1=1                                                              CALL  76
      M2=M1+LL*NQ                                                       CALL  77
      M3=M2+NUMNP                                                       CALL  78
      M4=M3+NUMNP                                                       CALL  79
      M5=M4+NUMNP                                                       CALL  80
      M6=M5+NUMNP                                                       CALL  81
      M7=M6+NUMNP                                                       CALL  82
      M8=M7+6*NUMDC                                                     CALL  83
      M9=M8+4*NUMPC                                                     CALL  84
      M10=M9+4*NNEL                                                     CALL  85
      M11=M10+LNSTOR*NSTOR1                                             CALL  86
      M12=M11+LNSTOR*NSTOR2                                             CALL  87
      M13=M12+LNSTOR*NSTOR3                                             CALL  88
      IF ( M13 .LE. MTOT ) GO TO 50                                     CALL  89
      WRITE (6,4001) MTOT,M13                                           CALL  90
      GO TO 10                                                          CALL  91
   50 CONTINUE                                                          CALL  92
C                                                                       CALL  93
C     INPUT ALL DATA EXCEPT ELEMENT IDENTIFICATION                      CALL  94
C                                                                       CALL  95
      CALL FPIN                                                         CALL  96
     1 (A(M1),A(M2),A(M3),A(M4),A(M5),A(M6),A(M7),A(M8),A(M9)           CALL  97
     2,NQ,NUMPC,NNEL,NUMDC)                                             CALL  98
      IF ( ISTOP .EQ. 1 ) GO TO 10                                      CALL  99
      CALL CPTIME(SEC(2))                                               CALL 100
C                                                                       CALL 101
C     INPUT ELEMENT IDENTIFICATION                                      CALL 102
C                                                                       CALL 103
      CALL FPEL                                                         CALL 104
     1 (A(M1),A(M2),A(M3),A(M4),A(M5),A(M6),A(M7),A(M8),A(M9),A(M10)    CALL 105
```

```
     2 ,A(M11),A(M12),NQ,NUMPC,NNEL,NUMDC)                             CALL 106
      IF ( ISTOP .EQ. 1 ) GO TO 10                                      CALL 107
      CALL CPTIME(SEC(3))                                               CALL 108
C                                                                       CALL 109
C     DETERMINE OPTIMAL NUMBER OF EQUATIONS IN ONE SET AND CHOOSE       CALL 110
C     CORRESPONDING EQUATION SOLVER                                     CALL 111
C                                                                       CALL 112
      NC=MM+LL                                                          CALL 113
      NC1=NC+1                                                          CALL 114
      MRES=LL*NQ                                                        CALL 115
      MAVC=MTOT-MRES                                                    CALL 116
      NR2=MAVC/NC1                                                      CALL 117
      NR=NR2/2                                                          CALL 118
      IF ( NR2 .GE. NQ ) NR=NQ                                          CALL 119
      IF ( NR .LT. MM ) GO TO 60                                        CALL 120
      ITYPE=1                                                           CALL 121
      GO TO 70                                                          CALL 122
   60 ITYPE=2                                                           CALL 123
   70 NSET=(NQ-1)/NR+1                                                  CALL 124
      IF ( NR .GE. 2 ) GO TO 90                                         CALL 125
      WRITE (6,3003) NQ,MM,NR,NSET,ITYPE,MTOT                           CALL 126
      WRITE (6,4002) MM                                                 CALL 127
      GO TO 10                                                          CALL 128
   90 CONTINUE                                                          CALL 129
      NRNC=NR*NC                                                        CALL 130
      IF ( NQ .LE. NRNC ) GO TO 100                                     CALL 131
      WRITE (6,4003) NQ,NRNC                                            CALL 132
      GO TO 10                                                          CALL 133
  100 CONTINUE                                                          CALL 134
      N1=MRES+1                                                         CALL 135
      N2=N1+NRNC                                                        CALL 136
      N3=N2+NRNC                                                        CALL 137
      IF ( ( ITYPE .EQ. 1 ) .AND. ( NR .EQ. NQ ) ) N3=N2                CALL 138
      N4=N3+NR                                                          CALL 139
      IF ( N4 .LE. MTOT ) GO TO 110                                     CALL 140
```

```
      WRITE (6,4001) MTOT,N4                                            CALL 141
      GO TO 10                                                          CALL 142
  110 CONTINUE                                                          CALL 143
      L1=1                                                              CALL 144
      L2=L1+MRES                                                        CALL 145
      L3=L2+NQ                                                          CALL 146
      L4=L3+NUMNP*NSTRES                                                CALL 147
      L5=L4+3*NUMNP*NSTRES                                              CALL 148
      IF ( L5 .LE. MTOT ) GO TO 115                                     CALL 149
      WRITE (6,4004) L5                                                 CALL 150
      GO TO 10                                                          CALL 151
  115 CONTINUE                                                          CALL 152
C                                                                       CALL 153
C     RE-DIMENSION BLANK COMMON                                         CALL 154
C     FORM DISPLACEMENT EQUATIONS OF EQUILIBRIUM BY DIRECT STIFFNESS    CALL 155
C                                                                       CALL 156
      REWIND NTAPE2                                                     CALL 157
      CALL FPST                                                         CALL 158
     1 (A(M1),A(M2),NQ,NR,NC)                                           CALL 159
      CALL CPTIME(SEC(4))                                               CALL 160
C                                                                       CALL 161
C     RE-DIMENSION BLANK COMMON                                         CALL 162
C     SOLVE EQUATIONS                                                   CALL 163
C                                                                       CALL 164
      IF ( ITYPE .EQ. 1 ) CALL GAUSS1                                   CALL 165
     1 (A(N1),A(N2),A(N3),NR,NC,NQ,MM,LL,NTAPE2,NTAPE3)                 CALL 166
C                                                                       CALL 167
      IF ( ITYPE .EQ. 2 ) CALL GAUSS2                                   CALL 168
     1 (A(N1),A(N2),A(N3),NR,NC,NQ,MM,LL,NTAPE2,NTAPE3,NTAPE4,NTAPE5)   CALL 169
      CALL CPTIME(SEC(5))                                               CALL 170
C                                                                       CALL 171
C     RE-DIMENSION                                                      CALL 172
C     ASSIGN NATURAL COORDINATES OF VELOCITY POINTS                     CALL 173
C     EXTRACT FLOW VELOCITIES FROM PRESSURE FIELD                       CALL 174
C                                                                       CALL 175
```

```
      PPT(1)=0.0                                                        CALL 176
      SPT(1)=0.0                                                        CALL 177
      TPT(1)=0.0                                                        CALL 178
      DO 120 I=2,9                                                      CALL 179
      PPT(I)= 1.0                                                       CALL 180
      SPT(I)=-1.0                                                       CALL 181
      TPT(I)= 1.0                                                       CALL 182
  120 CONTINUE                                                          CALL 183
      DO 130 I=1,4                                                      CALL 184
      J=2*I                                                             CALL 185
      PPT(I+5)=-1.0                                                     CALL 186
      SPT(I+3)=1.0                                                      CALL 187
      TPT(J)=-1.0                                                       CALL 188
  130 CONTINUE                                                          CALL 189
C                                                                       CALL 190
C                                                                       CALL 191
      CALL FPRE                                                         CALL 192
     1 (A(L1),A(L2),A(L3),A(L4),NUMNP)                                  CALL 193
      CALL CPTIME(SEC(6))                                               CALL 194
C                                                                       CALL 195
C     PRINT TIME LOG                                                    CALL 196
C                                                                       CALL 197
      DO 140 I=1,5                                                      CALL 198
      J=6-I                                                             CALL 199
  140 TIME(J)=SEC(J+1)-SEC(J)                                           CALL 200
      DO 150 I=1,5                                                      CALL 201
  150 TIME(I+5)=TIME(I)/NUMNP                                           CALL 202
      TIME(7)=TIME(2)/NUMEL                                             CALL 203
      TIME(11)=TIME(1)+TIME(2)+TIME(3)+TIME(4)+TIME(5)                  CALL 204
      WRITE (6,3000) HED                                                CALL 205
      WRITE (6,3001) (TIME(I),TIME(I+5),I=1,5),TIME(11)                 CALL 206
      WRITE (6,3003) NQ,MM,NR,NSET,ITYPE,MTOT                           CALL 207
C                                                                       CALL 208
C     GO TO NEXT PROBLEM                                                CALL 209
C                                                                       CALL 210
```

```
      GO TO 10                                                          CALL 211
C                                                                       CALL 212
 1000 FORMAT(13A6)                                                      CALL 213
 1001 FORMAT(9I5)                                                       CALL 214
 1002 FORMAT(2I5)                                                       CALL 215
 1003 FORMAT(4F10.0)                                                    CALL 216
 2001 FORMAT(/                                                          CALL 217
     1/10X,46H  NUMBER OF NODAL POINTS .....................,I5         CALL 218
     2/10X,46H  NUMBER OF ELEMENTS .........................,I5         CALL 219
     3/10X,46H  NUMBER OF MATERIALS ........................,I5         CALL 220
     4/10X,46H  NUMBER OF SURFACE FLOW TYPES ...............,I5         CALL 221
     5/10X,46H  NUMBER OF SETS OF DIRECTION RATIOS .........,I5         CALL 222
     6/10X,46H  NUMBER OF LOADING CASES ....................,I5         CALL 223
     7/10X,46H  ELEMENT VELOCITY OPTION ....................,I5         CALL 224
     8/10X,46H  LIMIT ON ALLOWABLE HALF BAND WIDTH .........,I5         CALL 225
     9/10X,46H  NUMBER OF ELEMENT STORAGE BLOCKS ...........,I5         CALL 226
     1/10X,46H  CONSTANT ACCELERATION IN X DIRECTION .......,F12.5      CALL 227
     2/10X,46H  CONSTANT ACCELERATION IN Y DIRECTION .......,F12.5      CALL 228
     3/10X,46H  CONSTANT ACCELERATION IN Z DIRECTION .......,F12.5      CALL 229
     4/10X,46H  ACCELERATION DUE TO GRAVITY ................,F12.5      CALL 230
     5/10X,46H  UNIT WEIGHT OF FLUID .......................,F12.5 )    CALL 231
 2002 FORMAT(//                                                         CALL 232
     1/10X,46H  LOAD CASE ..................................,I5         CALL 233
     2/10X,46H  NUMBER OF NODES WITH PRESCRIBED FLOW .......,I5         CALL 234
     3/10X,46H  NUMBER OF ELEMENT FACES WITH                            CALL 235
     4/10X,46H  PRESCRIBED SURFACE FLOWS ...................,I5 )       CALL 236
 3000 FORMAT(1H1,10X,13A6)                                              CALL 237
 3001 FORMAT(/20X,9H TIME LOG  /                                        CALL 238
     1/10X,16H TIME IN FPIN  =,F9.3,10X,19H TIME PER NODE    =,E10.3    CALL 239
     2/10X,16H TIME IN FPEL  =,F9.3,10X,19H TIME PER ELEMENT =,E10.3    CALL 240
     3/10X,16H TIME IN FPST  =,F9.3,10X,19H TIME PER NODE    =,E10.3    CALL 241
     4/10X,16H TIME IN GAUSS =,F9.3,10X,19H TIME PER NODE    =,E10.3    CALL 242
     5/10X,16H TIME IN FPRE  =,F9.3,10X,19H TIME PER NODE    =,E10.3    CALL 243
     6//10X,13H TOTAL TIME =,F9.3 )                                     CALL 244
 3003 FORMAT(///                                                        CALL 245
```

```
     1/10X,46H NUMBER OF EQUATIONS .........................,I6        CALL 246
     2/10X,46H HALF BAND WIDTH .............................,I6        CALL 247
     3/10X,46H NUMBER OF EQUATIONS PER BLOCK ...............,I6        CALL 248
     4/10X,46H NUMBER OF BLOCKS ............................,I6        CALL 249
     5/10X,51H EQUATION SOLVER .............................GAUSS,I1   CALL 250
     6/10X,46H LENGTH OF BLANK COMMON (MTOT) ...............,I6)       CALL 251
 4000 FORMAT(20H0 CONTROL CARD ERROR    )                              CALL 252
 4001 FORMAT( 36H DIMENSIONED LENGTH OF BLANK COMMON=I6//              CALL 253
     1 34H REQUESTED LENGTH OF BLANK COMMON=I6//                       CALL 254
     2 36H EXECUTION TERMINATED               )                        CALL 255
 4002 FORMAT(23H0 REQUIRED BANDWIDTH OF ,I5,17H IS TOO LARGE FOR       CALL 256
     1 15H AVAILABLE CORE)                                             CALL 257
 4003 FORMAT(27H  STORAGE CAPACITY EXCEEDED,/20HNUMBER OF EQUATIONS=,  CALL 258
     1 I5,/31H ALLOWABLE NUMBER OF EQUATIONS=,I5)                      CALL 259
 4004 FORMAT(25H0 BLANK COMMON STORAGE OF,I8,17H INSUFFICIENT TO       CALL 260
     1/53H CONTAIN ONE LOAD VECTOR AFTER SOLUTION OF EQUATIONS        )CALL 261
      END                                                              CALL 262
```

```
      SUBROUTINE FPIN                                                   FPIN   1
C                                                                       FPIN   2
C     THIS SUBROUTINE READS AND PRINTS PERMEABILITY COMPONENTS.         FPIN   3
C     DIRECTION NUMBERS, NODAL POINT DATA, AND APPLIED FLOWS            FPIN   4
C                                                                       FPIN   5
     1 (BCF,BC,X,Y,Z,KODE,DC,PBC,IDLD,N1,N2,N3,N4)                      FPIN   6
C                                                                       FPIN   7
      COMMON / GENCON /                                                 FPIN   8
     1 HED(13),WORD(2),NUMEL,NUMNP,NUMMAT,ISTOP,MAXBAN,NSTRES,NPT       FPIN   9
     2,LNSTOR,NUMDC,NST                                                 FPIN  10
      COMMON / GAUSEQ /                                                 FPIN  11
     1 NQ,MM,LL,NR,NC,NSET,NRNC                                         FPIN  12
     2,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6                               FPIN  13
      COMMON / BUFFER /                                                 FPIN  14
     1 LNREC,LNBUFF,NTAPE1,BUFF(2640)                                   FPIN  15
      COMMON / LODARG /                                                 FPIN  16
     1 NUMPC,ACCX,ACCY,ACCZ,NPLD(3),NELD(3),NNEL,NNPL,IDLDFC(3,6)       FPIN  17
      COMMON / MATARG /                                                 FPIN  18
     1 UWT,ACCG,E(50,3)                                                 FPIN  19
      COMMON / ELEARG /                                                 FPIN  20
     1 Q(24),QK(8,8),D(3,3),RHO,VOL,NODF(9),XX(8),YY(8),ZZ(8)           FPIN  21
      DIMENSION BCF(N1,1),BC(1),X(1),Y(1),Z(1),KODE(1),PBC(N2,1)        FPIN  22
     2,IDLD(N3,1),DC(N4,1)                                              FPIN  23
C                                                                       FPIN  24
C     READ AND PRINT PRINCIPAL PERMEABILITY COMPONENTS                  FPIN  25
C                                                                       FPIN  26
      MPRINT=0                                                          FPIN  27
      WRITE (6,3000) HED                                                FPIN  28
      WRITE (6,3008)                                                    FPIN  29
      DO 10 M=1,NUMMAT                                                  FPIN  30
      MPRINT=MPRINT+1                                                   FPIN  31
      IF ( MPRINT .LE. 50 ) GO TO 5                                     FPIN  32
      WRITE (6,3000) HED                                                FPIN  33
      WRITE (6,3008)                                                    FPIN  34
      MPRINT=1                                                          FPIN  35
```

```
    5 CONTINUE                                                          FPIN  36
      READ  (5,1008) N,E(N,1),E(N,2),E(N,3)                             FPIN  37
      WRITE (6,2008) N,E(N,1),E(N,2),E(N,3)                             FPIN  38
   10 CONTINUE                                                          FPIN  39
C                                                                       FPIN  40
C     READ AND PRINT REFERENCE SET OF DIRECTION COSINES                 FPIN  41
C                                                                       FPIN  42
      IF ( NUMDC .EQ. 0 ) GO TO 30                                      FPIN  43
      MPRINT=0                                                          FPIN  44
      WRITE (6,3000) HED                                                FPIN  45
      WRITE (6,3001)                                                    FPIN  46
      DO 25 I=1,NUMDC                                                   FPIN  47
      MPRINT=MPRINT+1                                                   FPIN  48
      IF ( MPRINT .LE. 40 ) GO TO 15                                    FPIN  49
      WRITE (6,3000) HED                                                FPIN  50
      WRITE (6,3001)                                                    FPIN  51
      MPRINT=1                                                          FPIN  52
   15 CONTINUE                                                          FPIN  53
      READ  (5,1001) N,(DC(N,J),J=1,6)                                  FPIN  54
      WRITE (6,2001) N,(DC(N,J),J=1,6)                                  FPIN  55
      DJ=0.0                                                            FPIN  56
      DK=0.0                                                            FPIN  57
      DO 20 J=1,3                                                       FPIN  58
      K=J+3                                                             FPIN  59
      DJ=DJ+DC(N,J)*DC(N,J)                                             FPIN  60
      DK=DK+DC(N,K)*DC(N,K)                                             FPIN  61
   20 CONTINUE                                                          FPIN  62
      DJ=SQRT(DJ)                                                       FPIN  63
      DK=SQRT(DK)                                                       FPIN  64
      DO 21 J=1,3                                                       FPIN  65
      K=J+3                                                             FPIN  66
      DC(N,J)=DC(N,J)/DJ                                                FPIN  67
      DC(N,K)=DC(N,K)/DK                                                FPIN  68
   21 CONTINUE                                                          FPIN  69
   25 CONTINUE                                                          FPIN  70
```

```
   30 CONTINUE
C                                                                       FPIN  71
C     READ AND PRINT NODAL POINT IDENTIFICATION                         FPIN  72
C                                                                       FPIN  73
      WRITE (6,3000) HED                                                FPIN  74
      WRITE (6,3003)                                                    FPIN  75
      ICOUNT=0                                                          FPIN  76
   40 READ  (5,1003) NL,INCL,KODE(NL),X(NL),Y(NL),Z(NL),BC(NL),IBCL     FPIN  77
      IF ( INCL .EQ. 0 ) INCL=1                                         FPIN  78
      ICOUNT=ICOUNT+1                                                   FPIN  79
      IF ( ICOUNT .EQ. 1 ) GO TO 60                                     FPIN  80
      DEN=(NL-NF)/INCF                                                  FPIN  81
      IF ( DEN .LE. 0.0 ) GO TO 60                                      FPIN  82
      DX=(X(NL)-X(NF))/DEN                                              FPIN  83
      DY=(Y(NL)-Y(NF))/DEN                                              FPIN  84
      DZ=(Z(NL)-Z(NF))/DEN                                              FPIN  85
      DP=(BC(NL)-BC(NF))/DEN                                            FPIN  86
      N=NF                                                              FPIN  87
   50 N=N+INCF                                                          FPIN  88
      IF ( N .EQ. NL ) GO TO 60                                         FPIN  89
      IF ( N .GT. NUMNP ) GO TO 70                                      FPIN  90
      M=N-INCF                                                          FPIN  91
      X(N)=X(M)+DX                                                      FPIN  92
      Y(N)=Y(M)+DY                                                      FPIN  93
      Z(N)=Z(M)+DZ                                                      FPIN  94
      KODE(N)=0                                                         FPIN  95
      IF ( IBCF .NE. 0 ) KODE(N)=KODE(M)                                FPIN  96
      BC(N)=0.0                                                         FPIN  97
      IF ( IBCF .EQ. 1 ) BC(N)=BC(M)                                    FPIN  98
      IF ( IBCF .EQ. 2 ) BC(N)=BC(M)+DP                                 FPIN  99
      ICOUNT=ICOUNT+1                                                   FPIN 100
      GO TO 50                                                          FPIN 101
   60 NF=NL                                                             FPIN 102
      INCF=INCL                                                         FPIN 103
      IBCF=IBCL                                                         FPIN 104
                                                                        FPIN 105
```

```
      IF ( ICOUNT .LT. NUMNP ) GO TO 40                                 FPIN 106
      GO TO 80                                                          FPIN 107
   70 WRITE (6,4001) N                                                  FPIN 108
      ISTOP=1                                                           FPIN 109
   80 MPRINT=0                                                          FPIN 110
      DO 90 K=1,NUMNP                                                   FPIN 111
      MPRINT=MPRINT+1                                                   FPIN 112
      IF ( MPRINT .LE. 40 ) GO TO 85                                    FPIN 113
      MPRINT=1                                                          FPIN 114
      WRITE (6,3000) HED                                                FPIN 115
      WRITE (6,3003)                                                    FPIN 116
   85 CONTINUE                                                          FPIN 117
      IF ( KODE(K) .EQ. 0 ) WRITE (6,2003) K,X(K),Y(K),Z(K)             FPIN 118
      IF ( KODE(K) .EQ. 1 ) WRITE (6,2003) K,X(K),Y(K),Z(K),BC(K)       FPIN 119
   90 CONTINUE                                                          FPIN 120
C                                                                       FPIN 121
C     READ AND PRINT NON-ZERO NODAL POINT FLOWS FOR EACH LOAD CASE      FPIN 122
C                                                                       FPIN 123
      DO 120 L=1,LL                                                     FPIN 124
      DO 120 I=1,NQ                                                     FPIN 125
  120 BCF(I,L)=0.0                                                      FPIN 126
      IF ( NNPL .EQ. 0 ) GO TO 140                                      FPIN 127
      WRITE (6,3000) HED                                                FPIN 128
      MPRINT=0                                                          FPIN 129
      DO 135 L=1,LL                                                     FPIN 130
      J=NPLD(L)                                                         FPIN 131
      IF ( J .EQ. 0 ) GO TO 135                                         FPIN 132
      WRITE (6,3004) L                                                  FPIN 133
      DO 130 I=1,J                                                      FPIN 134
      READ  (5,1004) N,BCF(N,L)                                         FPIN 135
      MPRINT=MPRINT+1                                                   FPIN 136
      IF ( MPRINT .LE. 50 ) GO TO 125                                   FPIN 137
      MPRINT=1                                                          FPIN 138
      WRITE (6,3000) HED                                                FPIN 139
      WRITE (6,3004) L                                                  FPIN 140
```

```
  125 CONTINUE                                                          FPIN 141
  130 WRITE (6,2004) N,BCF(N,L)                                         FPIN 142
  135 CONTINUE                                                          FPIN 143
  140 CONTINUE                                                          FPIN 144
C                                                                       FPIN 145
C     READ AND PRINT SURFACE FLOW TYPES                                 FPIN 146
C                                                                       FPIN 147
      IF ( NUMPC .EQ. 0 ) GO TO 160                                     FPIN 148
      PI=180.0/(4.0*ATAN(1.0))                                          FPIN 149
      WRITE (6,3000) HED                                                FPIN 150
      WRITE (6,3005)                                                    FPIN 151
      MPRINT=0                                                          FPIN 152
      DO 150 N=1,NUMPC                                                  FPIN 153
      READ  (5,1005) N,(PBC(N,J),J=1,4)                                 FPIN 154
      MPRINT=MPRINT+1                                                   FPIN 155
      IF ( MPRINT .LE. 50 ) GO TO 145                                   FPIN 156
      MPRINT=1                                                          FPIN 157
      WRITE (6,3000) HED                                                FPIN 158
      WRITE (6,3005)                                                    FPIN 159
  145 CONTINUE                                                          FPIN 160
      WRITE (6,2005) N,(PBC(N,J),J=1,4)                                 FPIN 161
  150 CONTINUE                                                          FPIN 162
  160 CONTINUE                                                          FPIN 163
C                                                                       FPIN 164
C     READ AND PRINT SURFACE FLOW LOADING CASES                         FPIN 165
C                                                                       FPIN 166
      IF ( NNEL .EQ. 0 ) GO TO 170                                      FPIN 167
      WRITE (6,3000) HED                                                FPIN 168
      WRITE (6,3006)                                                    FPIN 169
      MPRINT=0                                                          FPIN 170
      DO 165 I=1,NNEL                                                   FPIN 171
      READ  (5,1006) (IDLD(I,J),J=1,4)                                  FPIN 172
      MPRINT=MPRINT+1                                                   FPIN 173
      IF ( MPRINT .LE. 50 ) GO TO 164                                   FPIN 174
      MPRINT=1                                                          FPIN 175
```

```
      WRITE (6,3000) HED                                                FPIN 176
      WRITE (6,3006)                                                    FPIN 177
  164 CONTINUE                                                          FPIN 178
      WRITE (6,2006) (IDLD(I,J),J=1,4)                                  FPIN 179
  165 CONTINUE                                                          FPIN 180
  170 CONTINUE                                                          FPIN 181
      RETURN                                                            FPIN 182
C                                                                       FPIN 183
 1001 FORMAT(I5,6F10.0)                                                 FPIN 184
 1003 FORMAT(3I5,4F10.0,I5)                                             FPIN 185
 1004 FORMAT(I5,F10.0)                                                  FPIN 186
 1005 FORMAT(I5,4F10.0)                                                 FPIN 187
 1006 FORMAT(4I5)                                                       FPIN 188
 1008 FORMAT(I5,2F10.0)                                                 FPIN 189
 2001 FORMAT(10X,I4,X,6E15.5)                                           FPIN 190
 2003 FORMAT(10X,I3,2X,4F15.5)                                          FPIN 191
 2004 FORMAT(10X,I4,2X,E20.5)                                           FPIN 192
 2005 FORMAT(10X,I4,X,4F15.5)                                           FPIN 193
 2006 FORMAT(10X,I4,I8,I9,I7)                                           FPIN 194
 2008 FORMAT(10X,I6,4X,3E15.5)                                          FPIN 195
 3000 FORMAT(1H1,10X,13A6)                                              FPIN 196
 3001 FORMAT(31X,35H REFERENCE SET OF DIRECTION NUMBERS                 FPIN 197
     1/10X,5H TYPE,5X,2HXP,13X,2HYP,13X,2HZP,13X,2HXQ,13X,2HYQ,13X,2HZQ)FPIN 198
 3003 FORMAT(/                                                          FPIN 199
     1/10X,20X,19H GLOBAL COORDINATES,15X,11H PRESCRIBED                FPIN 200
     2/10X,4HNODE,10X,1HX,14X,1HY,14X,1HZ,9X,10H PRESSURES   )          FPIN 201
 3004 FORMAT(//10X,31H NODE   NODAL FLOWS - LOAD CASE,I2)               FPIN 202
 3005 FORMAT(35X,28H BILINEAR SURFACE FLOW TYPES                        FPIN 203
     1/10X, 5H TYPE,9X,2HQI,13X,2HQJ,13X,2HQK,13X,2HQL)                 FPIN 204
 3006 FORMAT(//20X,14H SURFACE FLOWS  /                                 FPIN 205
     1/10X,5H LOAD/10X,29H CASE   ELEMENT   FACE   TYPE)                FPIN 206
 3008 FORMAT(10X,43H MATERIAL           PRINCIPAL PERMEABILITIES        FPIN 207
     1/10X, 7H   TYPE,8X,1HI,14X,2HII,14X,3HIII)                        FPIN 208
 4001 FORMAT(44H0 ERROR IN  NODAL POINT GENERATOR OPTION  N=,I5)        FPIN 209
C                                                                       FPIN 210
```

```
      END                                                           FPIN 211
```

```
      SUBROUTINE FPEL
C
C     THIS SUBROUTINE READS AND PRINTS ELEMENT DATA. TRANSFORMS
C     PERMEABILITY COMPONENTS, FORMS ELEMENT PERMEABILITY EQUATIONS
C     BY CALLING SUBROUTINE PIPFD, MODIFIES THESE EQUATIONS FOR B.C.
C     AND STORES THIS INFORMATION ON NTAPE1 BY CALLING SUBROUTINE WRITBF
C     WHICH BUFFERS TAPE WRITES
C
     1 (BCF,BC,X,Y,Z,KODE,DC,PBC,IDLD,STORE1,STORE2,STORE3,N1,N2,N3,N4)
C
      COMMON / GENCON /
     1 HED(13),WORD(2),NUMEL,NUMNP,NUMMAT,ISTOP,MAXBAN,NSTRES,NPT
     2,LNSTOR,NUMDC,NST
      COMMON / GAUSEQ /
     1 NQ,MM,LL,NR,NC,NSET,NRNC
     2,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      COMMON / MATARG /
     1 UWT,ACCG,E(50,3)
      COMMON / BUFFER /
     1 LNREC,LNBUFF,NTAPE1,BUFF(2640)
      COMMON / ELEARG /
     1 Q(24),QK(8,8),D(3,3),RHO,VOL,NODF(9),XX(8),YY(8),ZZ(8)
      COMMON / LODARG /
     1 NUMPC,ACCX,ACCY,ACCZ,NPLD(3),NELD(3),NNEL,NNPL,IDLDFC(3,6)
      COMMON / ELFLOW /
     1 PPT(9),SPT(9),TPT(9),XPT(9),YPT(9),ZPT(9),QV(6,9),BB(8)
      DIMENSION BCF(N1,1),BC(1),X(1),Y(1),Z(1),KODE(1),PBC(N2,1)
     1,IDLD(N3,1),DC(N4,1),STORE1(1),STORE2(1),STORE3(1),NODL(9),JK(8)
      INTEGER GETF,GETL,STORE
C
      MM=0
      MMF=0
      IND=1
      TVL=0.0
      MPRINT=0
```

```
      MMS=0                                                             FPEL  36
      ISTOR=0                                                           FPEL  37
      DO 10 I=1,3                                                       FPEL  38
      DO 10 J=1,3                                                       FPEL  39
      D(I,J)=0.0                                                        FPEL  40
   10 CONTINUE                                                          FPEL  41
C                                                                       FPEL  42
C     READ ELEMENT IDENTIFICATION                                       FPEL  43
C                                                                       FPEL  44
      WRITE (6,3000) HED                                                FPEL  45
      WRITE (6,3001)                                                    FPEL  46
  100 READ  (5,1000) MML,(NODL(I),I=1,9),NDCL,GFTL,STORE                FPEL  47
     1               ,INCL1,INCL2,INCL3,JUMPL2,JUMPL3                   FPEL  48
      IF ( INCL1 .EQ. 0 ) INCL1=1                                       FPEL  49
      IF ( INCL2 .EQ. 0 ) INCL2=1                                       FPEL  50
      IF ( INCL3 .EQ. 0 ) INCL3=1                                       FPEL  51
      ICNT2=0                                                           FPEL  52
      ICNT3=0                                                           FPEL  53
      IF ( NODL(9) .EQ. 0 ) NODL(9)=1                                   FPEL  54
      IF ( STORE .NE. 0 ) MMS=MML                                       FPEL  55
  110 MMF=MMF+1                                                         FPEL  56
      INCF=INCF1                                                        FPEL  57
      ICNT2=ICNT2+1                                                     FPEL  58
      ICNT3=ICNT3+1                                                     FPEL  59
      IF ( ICNT2 .NE. JUMPF2 ) GO TO 101                                FPEL  60
      ICNT2=0                                                           FPEL  61
      INCF=INCF2                                                        FPEL  62
  101 CONTINUE                                                          FPEL  63
      IF ( ICNT3 .NE. JUMPF3 ) GO TO 102                                FPEL  64
      ICNT2=0                                                           FPEL  65
      ICNT3=0                                                           FPEL  66
      INCF=INCF3                                                        FPEL  67
  102 CONTINUE                                                          FPEL  68
      IF (MML-MMF) 400,120,140                                          FPEL  69
  400 WRITE (6,4000) MML                                                FPEL  70
```

```
      ISTOP=1
  120 GETF=GETL
      NDCF=NDCL
      DO 130 I=1,9
  130 NODF(I)=NODL(I)
      GO TO 160
  140 DO 150 I=1,8
  150 NODF(I)=NODF(I)+INCF
  160 CONTINUE
C
C     OBTAIN ELEMENT PERMEABILITY FROM PREVIOUS COMPUTATIONS
C
      IF( (ISTOP.EQ.1).OR.(GETF.EQ.0).OR.(STORE.NE.0) ) GO TO 116
      IF ( GETF .NE. 1 ) GO TO 112
      DO 111 I=1,LNSTOR
  111 Q(I)=STORE1(I)
  112 CONTINUE
      IF ( GETF .NE. 2 ) GO TO 114
      DO 113 I=1,LNSTOR
  113 Q(I)=STORE2(I)
  114 CONTINUE
      IF ( GETF .NE. 3 ) GO TO 116
      DO 115 I=1,LNSTOR
  115 Q(I)=STORE3(I)
  116 CONTINUE
      DO 170 I=1,8
      J=NODF(I)
      XX(I)=X(J)
      YY(I)=Y(J)
  170 ZZ(I)=Z(J)
C
C     TRANSFORM MATERIAL PERMEABILITY FROM PRINCIPAL TO GLOBAL COORDS
C
      IF ( ( GETF .NE. 0 ) .AND. ( STORE .EQ. 0 ) ) GO TO 275
      MTYPE=NODF(9)
```

```
      RHO=UWT/ACCG                                                     FPEL 106
      D(1,1)=E(MTYPE,1)                                                FPEL 107
      D(2,2)=E(MTYPE,2)                                                FPEL 108
      D(3,3)=E(MTYPE,3)                                                FPEL 109
      IF ( NDCF .EQ. 0 ) GO TO 555                                     FPEL 110
      Q1=DC(NDCF,1)                                                    FPEL 111
      Q4=DC(NDCF,2)                                                    FPEL 112
      Q7=DC(NDCF,3)                                                    FPEL 113
      Q2=DC(NDCF,4)                                                    FPEL 114
      Q5=DC(NDCF,5)                                                    FPEL 115
      Q8=DC(NDCF,6)                                                    FPEL 116
      Q3=Q4*Q8-Q5*Q7                                                   FPEL 117
      Q6=Q2*Q7-Q1*Q8                                                   FPEL 118
      Q9=Q1*Q5-Q2*Q4                                                   FPEL 119
      QM=SQRT(Q3*Q3+Q6*Q6+Q9*Q9)                                       FPEL 120
      Q3=Q3/QM                                                         FPEL 121
      Q6=Q6/QM                                                         FPEL 122
      Q9=Q9/QM                                                         FPEL 123
      D1=D(1,1)                                                        FPEL 124
      D2=D(2,2)                                                        FPEL 125
      D3=D(3,3)                                                        FPEL 126
      P1=D1*Q1                                                         FPEL 127
      P2=D2*Q2                                                         FPEL 128
      P3=D3*Q3                                                         FPEL 129
      P4=D1*Q4                                                         FPEL 130
      P5=D2*Q5                                                         FPEL 131
      P6=D3*Q6                                                         FPEL 132
      P7=D1*Q7                                                         FPEL 133
      P8=D2*Q8                                                         FPEL 134
      P9=D3*Q9                                                         FPEL 135
      D(1,1)=Q1*P1+Q2*P2+Q3*P3                                         FPEL 136
      D(2,1)=Q4*P1+Q5*P2+Q6*P3                                         FPEL 137
      D(3,1)=Q7*P1+Q8*P2+Q9*P3                                         FPEL 138
      D(2,2)=Q4*P4+Q5*P5+Q6*P6                                         FPEL 139
      D(3,2)=Q7*P4+Q8*P5+Q9*P6                                         FPEL 140
```

```
      D(3,3)=Q7*P7+Q8*P8+Q9*P9                                          FPEL 141
      D(1,2)=D(2,1)                                                     FPEL 142
      D(1,3)=D(3,1)                                                     FPEL 143
      D(2,3)=D(3,2)                                                     FPEL 144
  255 CONTINUE                                                          FPEL 145
  275 CONTINUE                                                          FPEL 146
C                                                                       FPEL 147
C     DETERMINE CONTRIBUTION TO BANDWIDTH (MM)                          FPEL 148
C                                                                       FPEL 149
      JMIN=100000                                                       FPEL 150
      JMAX=0                                                            FPEL 151
      DO 290 I=1,8                                                      FPEL 152
      II=NODF(I)                                                        FPEL 153
      IF ( II .LT. JMIN ) JMIN=II                                       FPEL 154
      IF ( II .GT. JMAX ) JMAX=II                                       FPEL 155
  290 CONTINUE                                                          FPEL 156
      MBD=JMAX-JMIN+1                                                   FPEL 157
      IF ( MBD .GT. MM ) MM=MBD                                         FPEL 158
      IF ( MBD .LE. MAXBAN ) GO TO 295                                  FPEL 159
      WRITE (6,4002) MBD,MMF                                            FPEL 160
      ISTOP=1                                                           FPEL 161
  295 CONTINUE                                                          FPEL 162
C                                                                       FPEL 163
C     IDENTIFY SURFACE FLOWS ON ELEMENT                                 FPEL 164
C     IF NST=1 ELEMENT HAS SURFACE FLOWS                                FPEL 165
C     IF L=LOAD CASE, J=FACE NUMBER, N=SURFACE FLOW IDENTIFICATION      FPEL 166
C     NUMBER THEN IDLDFC(L,J)=N                                         FPEL 167
C                                                                       FPEL 168
      NST=0                                                             FPEL 169
      IF ( NUMPC .EQ. 0 ) GO TO 299                                     FPEL 170
      DO 297 L=1,LL                                                     FPEL 171
      DO 297 J=1,6                                                      FPEL 172
  297 IDLDFC(L,J)=0                                                     FPEL 173
      DO 298 I=1,NNEL                                                   FPEL 174
      IF ( IDLD(I,2) .NE. MMF ) GO TO 298                               FPEL 175
```

```
      NST=1                                                             FPEL 176
      L=IDLD(I,1)                                                       FPEL 177
      J=IDLD(I,3)                                                       FPEL 178
      IDLDFC(L,J)=IDLD(I,4)                                             FPEL 179
  298 CONTINUE                                                          FPEL 180
  299 CONTINUE                                                          FPEL 181
      IF ( ( GETF .NE. 0 ) .AND. ( STORE .EQ. 0 ) ) GO TO 500           FPEL 182
C                                                                       FPEL 183
C     FORM PARALLELPIPED PERMEABILITY MATRIX (IF ISTOP=0)               FPEL 184
C                                                                       FPEL 185
      IF ( ISTOP .EQ. 1 ) GO TO 390                                     FPEL 186
      CALL PIPED (IND,NST,PBC,NUMPC,NPT)                                FPEL 187
      IF ( VOL .GT. 0.0 ) GO TO 500                                     FPEL 188
      ISTOP=1                                                           FPEL 189
      WRITE (6,4001) MMF                                                FPEL 190
      GO TO 390                                                         FPEL 191
C                                                                       FPEL 192
C     STORE ELEMENT PERMEABILITY FOR FUTURE REFFRENCE                   FPEL 193
C                                                                       FPEL 194
  500 CONTINUE                                                          FPEL 195
      ISTOR=0                                                           FPEL 196
      IF ( STORE .EQ. 0 ) GO TO 600                                     FPEL 197
      IF ( MMS .NE. MMF ) GO TO 600                                     FPEL 198
      IF ( STORE .NE. 1 ) GO TO 510                                     FPEL 199
      DO 505 I=1,LNSTOR                                                 FPEL 200
  505 STORE1(I)=Q(I)                                                    FPEL 201
      ISTOR=1                                                           FPEL 202
  510 CONTINUE                                                          FPEL 203
      IF ( STORE .NE. 2 ) GO TO 520                                     FPEL 204
      DO 515 I=1,LNSTOR                                                 FPEL 205
  515 STORE2(I)=Q(I)                                                    FPEL 206
      ISTOR=2                                                           FPEL 207
  520 CONTINUE                                                          FPEL 208
      IF ( STORE .NE. 3 ) GO TO 530                                     FPEL 209
      DO 525 I=1,LNSTOR                                                 FPEL 210
```

```
  525 STORE3(I)=Q(I)
      ISTOR=3
  520 CONTINUE
  600 CONTINUE
      TVL=TVL+VOL
C
C     MODIFY ELEMENT PERMEABILITY FOR PRESSURE B.C.
C     ADD ELEMENT GENERALIZED FLOWS TO NODAL FLOW VECTOR
C
      DO 300 I=1,8
      J=NODF(I)
  300 JK(I)=KODE(J)
      DO 380 N=1,8
      KD=1
      II=NODF(N)
      KK=JK(N)
      IF (KK-KD) 335,340,340
C
C        1.0   ADD GENERALIZED FLOWS
C
  335 DO 336 L=1,LL
      IQ=N+8*(L-1)
  336 BCF(II,L)=BCF(II,L)+Q(IQ)
      GO TO 380
C
C        2.0   PRESSURE BOUNDARY CONDITIONS
C
  340 DISP=BC(II)
      DO 370 K=1,8
      JJ=NODF(K)
      IF (JJ-II) 345,355,345
  345 CONTINUE
      IF ( JK(K) .EQ. 1 ) GO TO 365
      DO 350 L=1,LL
  350 BCF(JJ,L)=BCF(JJ,L)-QK(K,N)*DISP
```

```
      GO TO 365                                                         FPEL 246
  355 DO 360 L=1,LL                                                     FPEL 247
  360 BCF(JJ,L)=BCF(JJ,L)+DISP                                          FPEL 248
  365 QK(N,K)=0.0                                                       FPEL 249
  370 QK(K,N)=0.0                                                       FPEL 250
      QK(N,N)=1.0                                                       FPEL 251
  380 CONTINUE                                                          FPEL 252
  390 CONTINUE                                                          FPEL 253
C                                                                       FPEL 254
C     PRINT ELEMENT DATA                                                FPEL 255
C                                                                       FPEL 256
      MPRINT=MPRINT+1                                                   FPEL 257
      IF ( MPRINT .LE. 40 ) GO TO 395                                   FPEL 258
      MPRINT=1                                                          FPEL 259
      WRITE (6,3000) HED                                                FPEL 260
      WRITE (6,3001)                                                    FPEL 261
  395 CONTINUE                                                          FPEL 262
      IGET=GETF                                                         FPEL 263
      IF ( ISTOR .NE. 0 ) IGET=0                                        FPEL 264
      WRITE (6,2000) MMF,(NODF(I),I=1,9),     VOL,ISTOR,IGET            FPEL 265
      ISTOR=0                                                           FPEL 266
C                                                                       FPEL 267
C     STORE ELEMENT TRANSFORMATIONS AND IDENTIFICATION ON NTAPF1        FPEL 268
C                                                                       FPEL 269
      IF ( ISTOP .EQ. 1 ) GO TO 399                                     FPEL 270
      CALL WRITBF (Q,BUFF,LNREC.LNBUFF,MMF,NUMEL,NTAPE1)                FPEL 271
  399 CONTINUE                                                          FPEL 272
      IF ( MMF .EQ. NUMEL ) GO TO 420                                   FPEL 273
      IF ( MMF .NE. MML ) GO TO 110                                     FPEL 274
      INCF1=INCL1                                                       FPEL 275
      INCF2=INCL2                                                       FPEL 276
      INCF3=INCL3                                                       FPEL 277
      JUMPF2=JUMPL2                                                     FPEL 278
      JUMPF3=JUMPL3                                                     FPEL 279
      GO TO 100                                                         FPEL 280
```

```
  420 CONTINUE                                                          FPEL 281
      IF ( ISTOP .EQ. 1 ) RETURN                                        FPEL 282
      WRITE (6,3002) TVL                                                FPEL 283
      RETURN                                                            FPEL 284
 1000 FORMAT(18I4)                                                      FPEL 285
 2000 FORMAT(10X,I5,I8,7I5,I7,4X, E13.5,I7,I12)                         FPEL 286
 3000 FORMAT(1H1,10X,13A6)                                              FPEL 287
 3001 FORMAT(/83X,23H STORE IN   OBTAIN FROM                            FPEL 288
     1/10X,58H ELEMENT   N1   N2   N3   N4   N5   N6   N7   N8   MATERIALFPEL 289
     2,35H     VOLUME        BLOCK        BLOCK    )                    FPEL 290
 3002 FORMAT(10X,15H  TOTAL VOLUME=,E15.5)                              FPEL 291
 4000 FORMAT(49H0 ERROR IN ELEMENT DATA CARD SEQUENCE   ELEMENT...I3)   FPEL 292
 4001 FORMAT(40H0 NEGATIVE OR ZERO VOLUME    ELEMENT....,I3)            FPEL 293
 4002 FORMAT(14H0 BANDWIDTH OF,I8,12H FOR ELEMENT,I5/                   FPEL 294
     1 42H EXCEEDS UPPER LIMIT GIVEN ON CONTROL CARD   )                FPEL 295
      END                                                               FPEL 296
```

```
      SUBROUTINE PIPED
C
     1 (IND,NST,PBC,NN1,NPT)
C
C      EIGHT POINT TRILINEAR FINITE ELEMENT
C      EIGHT POINT GAUSSIAN INTEGRATION
C      IF IND=1 COMPUTES ELEMENT PERMEABILITY
C      IF IND=2 COMPUTES FLOW VELOCITIES (QV) AT NPT POINTS OF THE
C               ELEMENT GIVEN THE EIGHT NODAL POINT PRESSURES (BB)
C      IF NST=1 ELEMENT HAS SURFACE FLOW B.C. OTHERWISE NST=0
C
      COMMON / ELEARG /
     1 Q(24),QK(8,8),D(3,3),RHO,VOL,NODF(9),XX(8),YY(8),ZZ(8)
      COMMON / LODARG /
     1 NUMPC,ACCX,ACCY,ACCZ,NPLD(3),NELD(3),NNEL,NNPL,IDLDFC(3,6)
      COMMON / GAUSEQ /
     1 NQ,MM,LL,NR,NC,NSET,NRNC
     2,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      COMMON / ELFLOW /
     1 PPT(9),SPT(9),TPT(9),XPT(9),YPT(9),ZPT(9),QV(6,9),BB(8)
      DIMENSION H(8),HD(24),B(24),DB(24),DF(3)
      DIMENSION PINT(8),SINT(8),TINT(8)
      DATA PINT /  1., 1., 1., 1.,-1.,-1.,-1.,-1. /
      DATA SINT / -1.,-1., 1., 1., 1., 1.,-1.,-1. /
      DATA TINT / -1., 1.,-1., 1.,-1., 1.,-1., 1. /
C
      WT=1.0
      SR3=1.0/SQRT(3.0)
      F1=-ACCX*RHO
      F2=-ACCY*RHO
      F3=-ACCZ*RHO
      DO 1 I=1,3
    1 DF(I)=D(I,1)*F1+D(I,2)*F2+D(I,3)*F3
      DO 2 I=1,24
      Q(I)=0.0
```

```
    2 B(I)=0.0                                                          FP8   36
      IF ( IND .EQ. 2 ) GO TO 6                                         FP8   37
      DO 3 I=1,8                                                        FP8   38
      DO 3 J=1,8                                                        FP8   39
    3 QK(I,J)=0.0                                                       FP8   40
      VOL=0.0                                                           FP8   41
      DO 110 II=1,8                                                     FP8   42
      P=PINT(II)*SR3                                                    FP8   43
      S=SINT(II)*SR3                                                    FP8   44
      T=TINT(II)*SR3                                                    FP8   45
      GO TO 7                                                           FP8   46
    6 JJ=0                                                              FP8   47
  500 JJ=JJ+1                                                           FP8   48
      P=PPT(JJ)                                                         FP8   49
      S=SPT(JJ)                                                         FP8   50
      T=TPT(JJ)                                                         FP8   51
C                                                                       FP8   52
    7 CONTINUE                                                          FP8   53
C                                                                       FP8   54
      PM=1.0-P                                                          FP8   55
      SM=1.0-S                                                          FP8   56
      TM=1.0-T                                                          FP8   57
      PP=1.0+P                                                          FP8   58
      SP=1.0+S                                                          FP8   59
      TP=1.0+T                                                          FP8   60
      PMSM=PM*SM*0.125                                                  FP8   61
      PMSP=PM*SP*0.125                                                  FP8   62
      PMTM=PM*TM*0.125                                                  FP8   63
      PMTP=PM*TP*0.125                                                  FP8   64
      PPSM=PP*SM*0.125                                                  FP8   65
      PPSP=PP*SP*0.125                                                  FP8   66
      PPTM=PP*TM*0.125                                                  FP8   67
      PPTP=PP*TP*0.125                                                  FP8   68
      SMTM=SM*TM*0.125                                                  FP8   69
      SMTP=SM*TP*0.125                                                  FP8   70
```

```
      SPTM=SP*TM*0.125                                                  FP8  71
      SPTP=SP*TP*0.125                                                  FP8  72
C                                                                       FP8  73
C     COMPUTE CARTESIAN COORDINATES OF POINTS WHERE VELOCITIES          FP8  74
C     ARE TO BE CALCULATED                                              FP8  75
C                                                                       FP8  76
      IF ( IND .EQ. 1 ) GO TO 9                                         FP8  77
      H(1)=PP*SM*TM*0.125                                               FP8  78
      H(2)=PP*SM*TP*0.125                                               FP8  79
      H(3)=PP*SP*TM*0.125                                               FP8  80
      H(4)=PP*SP*TP*0.125                                               FP8  81
      H(5)=PM*SP*TM*0.125                                               FP8  82
      H(6)=PM*SP*TP*0.125                                               FP8  83
      H(7)=PM*SM*TM*0.125                                               FP8  84
      H(8)=PM*SM*TP*0.125                                               FP8  85
      D1=0.0                                                            FP8  86
      D2=0.0                                                            FP8  87
      D3=0.0                                                            FP8  88
      DO 8 I=1,8                                                        FP8  89
      HI=H(I)                                                           FP8  90
      D1=D1+HI*XX(I)                                                    FP8  91
      D2=D2+HI*YY(I)                                                    FP8  92
      D3=D3+HI*ZZ(I)                                                    FP8  93
    8 CONTINUE                                                          FP8  94
      XPT(JJ)=D1                                                        FP8  95
      YPT(JJ)=D2                                                        FP8  96
      ZPT(JJ)=D3                                                        FP8  97
    9 CONTINUE                                                          FP8  98
C                                                                       FP8  99
C     FORM DERIVATIVES OF DISP. EXPANSIONS IN NATURAL COORDINATES       FP8 100
C                                                                       FP8 101
      HD( 1)= SMTM                                                      FP8 102
      HD( 2)=-PPTM                                                      FP8 103
      HD( 3)=-PPSM                                                      FP8 104
      HD( 4)= SMTP                                                      FP8 105
```

```
      HD( 5)=-PPTP                                                      FP8  106
      HD( 6)= PPSM                                                      FP8  107
      HD( 7)= SPTM                                                      FP8  108
      HD( 8)= PPTM                                                      FP8  109
      HD( 9)=-PPSP                                                      FP8  110
      HD(10)= SPTP                                                      FP8  111
      HD(11)= PPTP                                                      FP8  112
      HD(12)= PPSP                                                      FP8  113
      HD(13)=-SPTM                                                      FP8  114
      HD(14)= PMTM                                                      FP8  115
      HD(15)=-PMSP                                                      FP8  116
      HD(16)=-SPTP                                                      FP8  117
      HD(17)= PMTP                                                      FP8  118
      HD(18)= PMSP                                                      FP8  119
      HD(19)=-SMTM                                                      FP8  120
      HD(20)=-PMTM                                                      FP8  121
      HD(21)=-PMSM                                                      FP8  122
      HD(22)=-SMTP                                                      FP8  123
      HD(23)=-PMTP                                                      FP8  124
      HD(24)= PMSM                                                      FP8  125
C                                                                       FP8  126
C     FORM AND INVERT JACOBIAN                                          FP8  127
C                                                                       FP8  128
      XP=0.0                                                            FP8  129
      XS=0.0                                                            FP8  130
      XT=0.0                                                            FP8  131
      YP=0.0                                                            FP8  132
      YS=0.0                                                            FP8  133
      YT=0.0                                                            FP8  134
      ZP=0.0                                                            FP8  135
      ZS=0.0                                                            FP8  136
      ZT=0.0                                                            FP8  137
      DO 10 K=1,8                                                       FP8  138
      K3=3*K                                                            FP8  139
      XK=XX(K)                                                          FP8  140
```

```
      YK=YY(K)
      ZK=ZZ(K)
      D1=HD(K3-2)
      D2=HD(K3-1)
      D3=HD(K3)
      XP=XP+D1*XK
      XS=XS+D2*XK
      XT=XT+D3*XK
      YP=YP+D1*YK
      YS=YS+D2*YK
      YT=YT+D3*YK
      ZP=ZP+D1*ZK
      ZS=ZS+D2*ZK
      ZT=ZT+D3*ZK
   10 CONTINUE
      XJAC=XP*(YS*ZT-YT*ZS)+XS*(YT*ZP-YP*ZT)+XT*(YP*ZS-YS*ZP)
      VOL=VOL+WT*XJAC
      XJI=1.0/XJAC
      XJ1=(YS*ZT-YT*ZS)*XJI
      XJ4=(YT*ZP-YP*ZT)*XJI
      XJ7=(YP*ZS-YS*ZP)*XJI
      XJ2=(XT*ZS-XS*ZT)*XJI
      XJ5=(XP*ZT-XT*ZP)*XJI
      XJ8=(XS*ZP-XP*ZS)*XJI
      XJ3=(XS*YT-XT*YS)*XJI
      XJ6=(XT*YP-XP*YT)*XJI
      XJ9=(XP*YS-XS*YP)*XJI
C
C     FORM PRESSURE TO PRESSURE-GRADIENT TRANSFORMATION
C
      DO 60 J=1,8
      J3=3*J
      J2=J3-1
      J1=J3-2
      D1=HD(J1)
```

```
      D2=HD(J2)
      D3=HD(J3)
      B(J1)=XJ1*D1+XJ4*D2+XJ7*D3
      B(J2)=XJ2*D1+XJ5*D2+XJ8*D3
      B(J3)=XJ3*D1+XJ6*D2+XJ9*D3
   60 CONTINUE
C
C     FORM ELEMENT PERMEABILITY QK(8,8) AND FLOW VECTOR Q(8)
C
      FAC=WT*XJAC*RHO
      DO 70 I=1,3
      D1=D(I,1)
      D2=D(I,2)
      D3=D(I,3)
      DO 70 J=1,8
      L=3*(J-1)
   70 DB(I+L)= D1*B(1+L)+D2*B(2+L)+D3*B(3+L)
      IF ( IND .EQ. 1 ) GO TO 75
C
C     COMPUTE VELOCITIES
C
      DO 320 I=1,3
      QV(I,JJ)=-DF(I)
      DO 320 K=1,8
      J=I+(K-1)*3
      QV(I,JJ)=QV(I,JJ)-DB(J)*BR(K)
  320 CONTINUE
      IF ( JJ .EQ. NPT ) RETURN
      GO TO 500
C
   75 CONTINUE
      DO 80 J=1,8
      I=(J-1)*3
      D1=DB(1+I)
      D2=DB(2+I)
```

```
      D3=DB(3+I)
      DO 80 K=1,J
      L=3*(K-1)
   80 QK(K,J)=QK(K,J)+(D1*B(1+L)+D2*B(2+L)+D3*B(3+L))*FAC
      DO 85 I=1,8
      J=(I-1)*3
      Q(I)=Q(I)+(DB(1+J)*ACCX+DB(2+J)*ACCY+DB(3+J)*ACCZ)*FAC*RHO
   85 CONTINUE
  110 CONTINUE
C
      DO 120 J=1,8
      Q(J+8)=Q(J)
      Q(J+16)=Q(J)
      DO 120 K=1,J
  120 QK(J,K)=QK(K,J)
      IF ( NST .NE. 0 ) CALL SQLOAD(PBC,NN1,LL)
  400 RETURN
      END
```

```
      SUBROUTINE SQLOAD
C
C     THIS SUBROUTINE EVALUATES GENERALIZED NODAL FLOWS DUE TO
C     BILINEARLY DISTRIBUTED NORMAL FLOW ON AN ELEMENT FACE
C
     1 (PBC,NN1,LL)
      COMMON / ELEARG /
     1 Q(24),QK(8,8),D(3,3),RHO,VOL,NOUF(9),XX(8),YY(8),ZZ(8)
      COMMON / LODARG /
     1 NUMPC,ACCX,ACCY,ACCZ,NPLD(3),NELD(3),NNEL,NNPL,IDLDFC(3,6)
      DIMENSION PBC(NN1,1),NFACE(6,4),SINT(4),TINT(4),A(3),B(3),C(3)
     1 ,H(4),XG(4),YG(4),ZG(4),XL(4),YL(4),ZL(4)
      DATA SINT / -1.,1.,1.,-1. / , TINT / -1.,-1.,1.,1. /
      DATA NFACE / 1,5,3,7,2,1,3,7,5,1,4,7,4,8,6,2,6,5,2,6,4,8,8,3/
C
      SR3=1.0/SQRT(3.0)
      WI=1.0
C
      DO 300 IFACE=1,6
      LD=0
      DO 10 L=1,LL
   10 LD=LD+IDLDFC(L,IFACE)
C
C     FORM COORD TRANSFORMATION FOR ELEMENT FACES WITH DIST. FLOW
C
      IF ( LD .EQ. 0 ) GO TO 300
      DO 20 I=1,4
      J=NFACE(IFACE,I)
      XG(I)=XX(J)
      YG(I)=YY(J)
      ZG(I)=ZZ(J)
   20 CONTINUE
      A(1)=XG(2)-XG(1)
      A(2)=YG(2)-YG(1)
      A(3)=ZG(2)-ZG(1)
```

```
      B(1)=XG(4)-XG(1)                                                  SQL   36
      B(2)=YG(4)-YG(1)                                                  SQL   37
      B(3)=ZG(4)-ZG(1)                                                  SQL   38
      C(1)=A(2)*B(3)-B(2)*A(3)                                          SQL   39
      C(2)=A(3)*B(1)-B(3)*A(1)                                          SQL   40
      C(3)=A(1)*B(2)-B(1)*A(2)                                          SQL   41
      B(1)=C(2)*A(3)-A(2)*C(3)                                          SQL   42
      B(2)=C(3)*A(1)-A(3)*C(1)                                          SQL   43
      B(3)=C(1)*A(2)-A(1)*C(2)                                          SQL   44
      AM=0.0                                                            SQL   45
      BM=0.0                                                            SQL   46
      CM=0.0                                                            SQL   47
      DO 30 I=1,3                                                       SQL   48
      AM=AM+A(I)*A(I)                                                   SQL   49
      BM=BM+B(I)*B(I)                                                   SQL   50
      CM=CM+C(I)*C(I)                                                   SQL   51
   30 CONTINUE                                                          SQL   52
      DO 40 I=1,3                                                       SQL   53
      A(I)=A(I)/SQRT(AM)                                                SQL   54
      B(I)=B(I)/SQRT(BM)                                                SQL   55
      C(I)=C(I)/SQRT(CM)                                                SQL   56
   40 CONTINUE                                                          SQL   57
      DO 50 I=1,4                                                       SQL   58
      XL (I)=A(1)*XG(I)+A(2)*YG(I)+A(3)*ZG(I)                           SQL   59
      YL (I)=B(1)*XG(I)+B(2)*YG(I)+B(3)*ZG(I)                           SQL   60
      ZL (I)=C(1)*XG(I)+C(2)*YG(I)+C(3)*ZG(I)                           SQL   61
   50 CONTINUE                                                          SQL   62
C                                                                       SQL   63
C     OBTAIN INTERPOLATION FUNCTIONS AND JACOBIAN DETERMINANT           SQL   64
C                                                                       SQL   65
      DO 200 II=1,4                                                     SQL   66
      S=SINT(II)*SR3                                                    SQL   67
      T=TINT(II)*SR3                                                    SQL   68
      SM=1.0-S                                                          SQL   69
      SP=1.0+S                                                          SQL   70
```

```
      TM=1.0-T                                                          SQL   71
      TP=1.0+T                                                          SQL   72
      H(1)=0.25*SM*TM                                                   SQL   73
      H(2)=0.25*SP*TM                                                   SQL   74
      H(3)=0.25*SP*TP                                                   SQL   75
      H(4)=0.25*SM*TP                                                   SQL   76
      XS=0.25*(TM*(XL(2)-XL(1)) + TP*(XL(3)-XL(4)) )                    SQL   77
      YS=0.25*(TM*(YL(2)-YL(1)) + TP*(YL(3)-YL(4)) )                    SQL   78
      XT=0.25*(SM*(XL(4)-XL(1)) + SP*(XL(3)-XL(2)) )                    SQL   79
      YT=0.25*(SM*(YL(4)-YL(1)) + SP*(YL(3)-YL(2)) )                    SQL   80
      XJAC=1.0/(XS*YT-XT*YS)                                            SQL   81
C                                                                       SQL   82
C     OBTAIN GENERALIZED FLOWS FOR EACH LOADING CASE                    SQL   83
C                                                                       SQL   84
      DO 100 L=1,LL                                                     SQL   85
      LD=IDLDFC(L,IFACE)                                                SQL   86
      IF ( LD .EQ. 0 ) GO TO 100                                        SQL   87
      QL=PBC(LD,1)*H(1)+PBC(LD,2)*H(2)+PBC(LD,3)*H(3)+PBC(LD,4)*H(4)    SQL   88
      FAC=RHO*WT*XJAC*QL                                                SQL   89
      DO 90 I=1,4                                                       SQL   90
      J=NFACE(IFACE,I)+8*(L-1)                                          SQL   91
      QJ=-FAC*H(I)                                                      SQL   92
      Q(J)=Q(J)+QJ                                                      SQL   93
   90 CONTINUE                                                          SQL   94
  100 CONTINUE                                                          SQL   95
  200 CONTINUE                                                          SQL   96
  300 CONTINUE                                                          SQL   97
      RETURN                                                            SQL   98
      END                                                               SQL   99
```

```
      SUBROUTINE FPST                                                   FPST   1
C                                                                       FPST   2
C     THIS SUBROUTINE ASSEMBLES GLOBAL PERMEABILITY EQUATIONS           FPST   3
C                                                                       FPST   4
     1 (BCF,A,N1,N2,N3)                                                 FPST   5
C                                                                       FPST   6
      COMMON / GENCON /                                                 FPST   7
     1 HED(13),WORD(2),NUMEL,NUMNP,NUMMAT,ISTOP,MAXBAN,NSTRES,NPT       FPST   8
     2,LNSTOR,NUMDC,NST                                                 FPST   9
      COMMON / ELEARG /                                                 FPST  10
     1 Q(24),QK(8,8),D(3,3),RHO,VOL,NODF(9),XX(8),YY(8),ZZ(8)           FPST  11
      COMMON / GAUSEQ /                                                 FPST  12
     1 NQ,MM,LL,NR,NC,NSET,NRNC                                         FPST  13
     2,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6                               FPST  14
      COMMON / BUFFER /                                                 FPST  15
     1 LNREC,LNBUFF,NTAPE1,BUFF(2040)                                   FPST  16
      DIMENSION BCF(N1,1),A(N2,N3)                                      FPST  17
C                                                                       FPST  18
      DO 70 NS=1,NSET                                                   FPST  19
      DO 10 I=1,NR                                                      FPST  20
      DO 10 J=1,NC                                                      FPST  21
   10 A(I,J)=0.0                                                        FPST  22
      NRS=NR*(NS-1)                                                     FPST  23
      NR1=NRS+1                                                         FPST  24
      NR2=NRS+NR                                                        FPST  25
      IF ( NR2 .GT. NQ ) NR2=NQ                                         FPST  26
      NOD1=NR1                                                          FPST  27
      NOD2=NR2                                                          FPST  28
C                                                                       FPST  29
C     ADD ELEMENT PERMEABILITY TO STRUCTURE PERMEABILITY                FPST  30
C                                                                       FPST  31
      DO 35 N=1,NUMEL                                                   FPST  32
      CALL READBF (Q,BUFF,LNREC,LNBUFF,N,NUMEL,NTAPE1)                  FPST  33
      DO 30 I=1,8                                                       FPST  34
      II=NODF(I)                                                        FPST  35
```

```
      IF ( (II.LT.NR1) .OR. (II.GT.NR2) ) GO TO 30
      IJ=II-NRS
      DO 20 J=1,8
      JJ=NODF(J)-II+1
      IF (JJ .LE. 0 ) GO TO 20
      A(IJ,JJ)=A(IJ,JJ) + QK(I,J)
   20 CONTINUE
   30 CONTINUE
   35 CONTINUE
C
C     ADD FLOW VECTORS
C
      DO 60 I=1,NR
      IN=I+NRS
      IF ( IN .GT. NQ ) GO TO 65
      DO 60 L=1,LL
   60 A(I,L+MM)=BCF(IN,L)
   65 WRITE (NTAPE2) A
   70 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE FPRE
C
C     THIS SUBROUTINE PRINTS RESULTS
C
     1 (RE,B,ICOUNT,AVGQV,N1)
C
      COMMON / GENCON /
     1 HED(13),WORD(2),NUMEL,NUMNP,NUMMAT,ISTOP,MAXBAN,NSTRES,NPT
     2,LNSTOR,NUMDC,NST
      COMMON / GAUSEQ /
     1 NQ,MM,LL,NR,NC,NSET,NRNC
     2,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      COMMON / ELEARG /
     1 Q(24),QK(8,8),D(3,3),RHO,VOL,NODF(9),XX(8),YY(8),ZZ(8)
      COMMON / BUFFER /
     1 LNREC,LNBUFF,NTAPE1,BUFF(2640)
      COMMON / ELFLOW /
     1 PPT(9),SPT(9),TPT(9),XPT(9),YPT(9),ZPT(9),QV(6,9),BB(8)
      DIMENSION RE(N1,1),B(1),ICOUNT(1),AVGQV(N1,1)
C
      NST=0
      IND=2
      NUMPC=0
      MPRINT=0
C
C     FOR EACH LOAD CASE
      DO 300 L=1,LL
C
C     INITIALIZE
C
      IF ( NSTRES .EQ. 0 ) GO TO 7
      DO 6 I=1,NUMNP
      ICOUNT(I)=0
      DO 6 J=1,3
      AVGQV(I,J)=0.0
```

```
    6 CONTINUE                                                          FPRE  36
    7 CONTINUE                                                          FPRE  37
C                                                                       FPRE  38
C     PRINT NODAL PRESSURES                                             FPRE  39
C                                                                       FPRE  40
      WRITE (6,3000) HED                                                FPRE  41
      WRITE (6,3005) L                                                  FPRE  42
      WRITE (6,3001)                                                    FPRE  43
      ITAPE=L+6                                                         FPRE  44
      READ (ITAPE) (B(I),I=1,NQ)                                        FPRE  45
      DO 10 I=1,NUMNP                                                   FPRE  46
      MPRINT=MPRINT+1                                                   FPRE  47
      IF ( MPRINT .LE. 50 ) GO TO 20                                    FPRE  48
      MPRINT=1                                                          FPRE  49
      WRITE (6,3000) HED                                                FPRE  50
      WRITE (6,3005) L                                                  FPRE  51
      WRITE (6,3001)                                                    FPRE  52
   20 CONTINUE                                                          FPRE  53
      WRITE (6,2001) I,B(I)                                             FPRE  54
   10 CONTINUE                                                          FPRE  55
C                                                                       FPRE  56
C     EVALUATE AND PRINT ELEMENT VELOCITIES                             FPRE  57
C                                                                       FPRE  58
      WRITE (6,3000) HED                                                FPRE  59
      WRITE (6,3005) L                                                  FPRE  60
      WRITE (6,3002)                                                    FPRE  61
      MPRINT=0                                                          FPRE  62
      DO 50 N=1,NUMEL                                                   FPRE  63
      CALL READBF (Q,BUFF,LNREC,LNBUFF,N,NUMEL,NTAPE1)                  FPRE  64
      DO 30 I=1,8                                                       FPRE  65
      J=NODF(I)                                                         FPRE  66
   30 BB(I)=B(J)                                                        FPRE  67
      DO 40 I=1,8                                                       FPRE  68
      M=NODF(I)                                                         FPRE  69
      S=0.0                                                             FPRE  70
```

```
      DO 35 K=1,8                                                       FPRE  71
   35 S=S+QK(I,K)*BB(K)                                                 FPRE  72
      RE(M,L)=RE(M,L)-S                                                 FPRE  73
   40 CONTINUE                                                          FPRE  74
      CALL PIPED (IND,NST,PBC,NUMPC,NPT)                                FPRE  75
      MPRINT=MPRINT+1                                                   FPRE  76
      IF ( MPRINT .LE. 40 ) GO TO 41                                    FPRE  77
      MPRINT=1                                                          FPRE  78
      WRITE (6,3000) HED                                                FPRE  79
      WRITE (6,3005) L                                                  FPRE  80
      WRITE (6,3002)                                                    FPRE  81
   41 CONTINUE                                                          FPRE  82
      WRITE (6,2002) N,XPT(1),YPT(1),ZPT(1),(QV(I,1),I=1,3)             FPRE  83
      IF ( NSTRES .EQ. 0 ) GO TO 50                                     FPRE  84
      DO 45 I=1,8                                                       FPRE  85
      J=NODF(I)                                                         FPRE  86
      ICOUNT(J)=ICOUNT(J)+1                                             FPRE  87
      DO 45 K=1,3                                                       FPRE  88
      AVGQV(J,K)=AVGQV(J,K)+QV(K,I+1)                                   FPRE  89
   45 CONTINUE                                                          FPRE  90
   50 CONTINUE                                                          FPRE  91
C                                                                       FPRE  92
C     AVERAGE NODAL POINT VELOCITIES ( IF NSTRES=1)                     FPRE  93
C                                                                       FPRE  94
      IF ( NSTRES .EQ. 0 ) GO TO 85                                     FPRE  95
      DO 60 I=1,NUMNP                                                   FPRE  96
      DEN=ICOUNT(I)                                                     FPRE  97
      DO 60 J=1,3                                                       FPRE  98
      AVGQV(I,J)=AVGQV(I,J)/DEN                                         FPRE  99
   60 CONTINUE                                                          FPRE 100
      WRITE (6,3000) HED                                                FPRE 101
      WRITE (6,3005) L                                                  FPRE 102
      WRITE (6,3003)                                                    FPRE 103
      MPRINT=0                                                          FPRE 104
      DO 80 I=1,NUMNP                                                   FPRE 105
```

```
      MPRINT=MPRINT+1                                                   FPRE 106
      IF ( MPRINT .LE. 50 ) GO TO 70                                    FPRE 107
      MPRINT=1                                                          FPRE 108
      WRITE (6,3000) HED                                                FPRE 109
      WRITE (6,3005) L                                                  FPRE 110
      WRITE (6,3003)                                                    FPRE 111
   70 CONTINUE                                                          FPRE 112
      V1=AVGQV(I,1)                                                     FPRE 113
      V2=AVGQV(I,2)                                                     FPRE 114
      V3=AVGQV(I,3)                                                     FPRE 115
      VR=SQRT(V1*V1+V2*V2+V3*V3)                                        FPRE 116
      WRITE (6,2003) I,V1,V2,V3,VR                                      FPRE 117
   80 CONTINUE                                                          FPRE 118
   85 CONTINUE                                                          FPRE 119
C                                                                       FPRE 120
C     PRINT RESIDUALS                                                   FPRE 121
C                                                                       FPRE 122
      WRITE (6,3000) HED                                                FPRE 123
      WRITE (6,3005) L                                                  FPRE 124
      WRITE (6,3004)                                                    FPRE 125
      MPRINT=0                                                          FPRE 126
      DO 100 I=1,NUMNP                                                  FPRE 127
      MPRINT=MPRINT+1                                                   FPRE 128
      IF ( MPRINT .LE. 50 ) GO TO 90                                    FPRE 129
      MPRINT=1                                                          FPRE 130
      WRITE (6,3000) HED                                                FPRE 131
      WRITE (6,3005) L                                                  FPRE 132
      WRITE (6,3004)                                                    FPRE 133
   90 CONTINUE                                                          FPRE 134
      WRITE (6,2004) I,RE(I,L)                                          FPRE 135
  100 CONTINUE                                                          FPRE 136
C                                                                       FPRE 137
  300 CONTINUE                                                          FPRE 138
      RETURN                                                            FPRE 139
 2001 FORMAT(10X,I5,X, E15.5)                                           FPRE 140
```

```
2002 FORMAT(10X,I5,5X,3F15.5,3F15.5)                                          FPRE 141
2003 FORMAT(10X,I4,X,4E15.5)                                                  FPRE 142
2004 FORMAT(10X,I4,X, E15.5)                                                  FPRE 143
3000 FORMAT(1H1,10X,13A6)                                                     FPRE 144
3001 FORMAT(12X,20H NODE         PRESSURE   )                                 FPRE 145
3002 FORMAT(                                                                  FPRE 146
    1/10X,28X,12H COORDINATES,34X,11H VELOCITIES                              FPRE 147
    2/10X, 8H ELEMENT,11X,1HX,14X,1HY,14X,1HZ,10X,1HX,14X,1HY,14X,1HZ)        FPRE 148
3003 FORMAT(22X,26H AVERAGED NODAL VELOCITIES,16X,10H RESULTANT               FPRE 149
    1/10X,5H NODE,5X,1HX,14X,1HY,14X,1HZ)                                     FPRE 150
3004 FORMAT(/10X,20H NODE        RESIDUAL    )                                FPRE 151
3005 FORMAT(10X,10H LOAD CASE,I3)                                             FPRE 152
     END                                                                      FPRE 153
```

```
      SUBROUTINE GAUSS1 (AT,AB,B,NR,NC,NQ,MM,LL,NORIG,NBCKSB)
C
C***  GAUSSIAN ELIMINATION OF BANDED EQUATIONS WHEN NUMBER OF
C     EQUATIONS IN A BLOCK IS GREATER THAN OR EQUAL TO BANDWIDTH.
C***  TAPES USED ARE
C        1) NORIG  EQUATIONS ARE READ FROM THIS TAPE SUCH THAT ONE
C                  BLOCK OF (NR) EQUATIONS IS ONE LOGICAL RECORD.
C        2) NBCKSB USED FOR TEMPORARY STORAGE OF BACK SUB. EQUATIONS
C        3) L+6    L=1,.....LL   (LL=NUMBER OF LOAD CASES)
C***  SOLUTION VECTOR FOR LOAD CASE L IS STORED ON TAPE (L+6)
C
      DIMENSION AT(NR,NC),AB(NR,NC),B(NR)
      NCOUNT=NR*NC
      NSET=(NQ-1)/NR+1
C
      REWIND NORIG
      REWIND NBCKSB
      DO 10 L=1,LL
      ITAPE=L+6
   10 REWIND ITAPE
C
C        1.0  REDUCTION
C
      READ (NORIG) AT
      IF ( NSET .NE. 1 ) READ (NORIG) AB
      DO 80 N=1,NSET
      DO 60 KK=1,NR
      D=AT(KK,1)
      IF ( D .EQ. 0 ) GO TO 60
      K=KK+1
      KN=K+(N-1)*NR
      IF ( KN .GT. NQ ) GO TO 100
      KM=KK+MM
      I2=KM-1
      DO 50 I=K,I2
```

```
      IK=I-KK
      J2=KM-I
      C=AT(KK,IK+I)/D
      IF ( C .EQ. 0.0 ) GO TO 50
      IF ( I .GT. NR ) GO TO 30
      DO 20 L=1,LL
      ML=MM+L
   20 AT(I,ML)=AT(I,ML)-C*AT(KK,ML)
      DO 25 J=1,J2
   25 AT(I,J)=AT(I,J)-C*AT(KK,J+IK)
      GO TO 50
   30 II=I-NR
      DO 40 L=1,LL
      ML=MM+L
   40 AB(II,ML)=AB(II,ML)-C*AT(KK,ML)
      DO 45 J=1,J2
   45 AB(II,J)=AB(II,J)-C*AT(KK,J+IK)
   50 CONTINUE
   60 CONTINUE
C
C     WRITE BACK SUB SETS ON TAPE NBCKSB
C
      IF ( N .EQ. NSET ) GO TO 100
      WRITE (NBCKSB) AT
      DO 70 I=1,NCOUNT
   70 AT(I)=AB(I)
      IF ( N .EQ. (NSET-1) ) GO TO 80
      READ (NORIG) AB
   80 CONTINUE
C
C        2.0  BACK SUBSTITUTION
C
  100 J1=MM+1
      IF ( NSET .EQ. 1 ) GO TO 111
      DO 110 I=1,NR
```

```
      DO 110 J=J1,NC
  110 AB(I,J)=0.0
  111 CONTINUE
      DO 190 M=1,NSET
      I=NR+1
  120 I=I-1
      IF ( I .EQ. 0 )  GO TO 160
      IF ( AT(I,1) .EQ. 0.0 ) GO TO 120
      II=I-1
      DO 150 L=1,LL
      ML=MM+L
      S=AT(I,ML)
      DO 140 J=2,MM
      IJ=II+J
      IF ( IJ .GT. NR ) GO TO 130
      S=S-AT(I,J)*AT(IJ,ML)
      GO TO 140
  130 IN=IJ-NR
      IF ( NSET .EQ. 1 ) GO TO 140
      S=S-AT(I,J)*AB(IN,ML)
  140 CONTINUE
  150 AT(I,ML)=S/AT(I,1)
      GO TO 120
  160 DO 180 L=1,LL
      ITAPE=L+6
      ML=MM+L
      DO 170 I=1,NR
      B(I)=AT(I,ML)
      IF ( NSET .EQ. 1 ) GO TO 170
      AB(I,ML)=B(I)
  170 CONTINUE
  180 WRITE (ITAPE) (B(I),I=1,NR)
      IF ( M .EQ. NSET ) GO TO 500
      BACKSPACE NBCKSB
      READ (NBCKSB) AT
```

```
      BACKSPACE NBCKSB                                                  GS1  106
  190 CONTINUE                                                          GS1  107
C                                                                       GS1  108
C         3.0  STORE SOLUTIONS ON TAPE ITAPE                            GS1  109
C                                                                       GS1  110
  200 CONTINUE                                                          GS1  111
      DO 220 L=1,LL                                                     GS1  112
      ITAPE=L+6                                                         GS1  113
      REWIND ITAPE                                                      GS1  114
      DO 210 N=1,NSET                                                   GS1  115
      M1=(NSET-N)*NR+1                                                  GS1  116
      M2=M1+NR-1                                                        GS1  117
  210 READ (ITAPE) (AT(M),M=M1,M2)                                      GS1  118
      REWIND ITAPE                                                      GS1  119
      WRITE (ITAPE) (AT(I),I=1,NQ)                                      GS1  120
      REWIND ITAPE                                                      GS1  121
  220 CONTINUE                                                          GS1  122
  240 RETURN                                                            GS1  123
      END                                                               GS1  124
```

```
      SUBROUTINE GAUSS2 (AT,AB,B,NR,NC,NQ,MM,LL,NORIG,NBCKSB,NT1,NT2)    GS2
C                                                                        GS2
C***  GAUSSIAN ELIMINATION OF BANDED EQUATIONS WHEN NUMBER OF             GS2
C     EQUATIONS IN A BLOCK IS LESS THAN BANDWIDTH                        GS2
C***  TAPES USED ARE                                                      GS2
C        1) NORIG  EQUATIONS ARE READ FROM THIS TAPE SUCH THAT ONE       GS2
C                  BLOCK OF (NR) EQUATIONS IS ONE LOGICAL RECORD.        GS2
C        2) NBCKSB USED FOR TEMPORARY STORAGE OF BACK SUB. EQUATIONS     GS2
C        3) L+6    L=1.....LL    (LL=NUMBER OF LOAD CASES)               GS2
C        4)NT1,NT2  TEMPURARY STORAGE TAPES THAT CAN BE IDENTICAL TO L+6GS2
C***  SOLUTION VECTOR FOR LOAD CASE L IS STORED ON TAPE (L+6)             GS2
C                                                                        GS2
      DIMENSION AT(NR,NC),AB(NR,NC),B(NR),ITP(2),JTP(2)                  GS2
      DATA ITP /2,1/                                                     GS2
C                                                                        GS2
      JTP(1)=NT1                                                         GS2
      JTP(2)=NT2                                                         GS2
      NCOUNT=NR*NC                                                       GS2
      NSET=(NQ-1)/NR+1                                                   GS2
      MN=MM+NR                                                           GS2
      MN1=MN-1                                                           GS2
      MMP1=MM+1                                                          GS2
      MMM1=MM-1                                                          GS2
      NR1=NR+1                                                           GS2
      REWIND NT1                                                         GS2
      REWIND NT2                                                         GS2
      REWIND NORIG                                                       GS2
      REWIND NBCKSB                                                      GS2
C                                                                        GS2
C        1.0  REDUCTION                                                  GS2
C                                                                        GS2
      KTP=1                                                              GS2
      DO 120 N=1,NSET                                                    GS2
      NT1=JTP(KTP)                                                       GS2
      KTP=ITP(KTP)                                                       GS2
                                                                         GS2
```

```
      NT2=JTP(KTP)                                                      GS2   36
      NQLF=NQ-(N-1)*NR                                                  GS2   37
      IF ( NQLF .GT. MN1 ) NQLF=MN1                                     GS2   38
      NBKS=(NQLF-1)/NR+1                                                GS2   39
      IF ( N .NE. 1 ) GO TO 20                                          GS2   40
      DO 10 NB=1,NBKS                                                   GS2   41
      READ (NORIG) AT                                                   GS2   42
   10 WRITE (NT1) AT                                                    GS2   43
   20 REWIND NT1                                                        GS2   44
      REWIND NT2                                                        GS2   45
      READ (NT1) AT                                                     GS2   46
C                                                                       GS2   47
C     REDUCE AT                                                         GS2   48
C                                                                       GS2   49
      I2=NR                                                             GS2   50
      IF ( NQLF .LT. NR ) I2=NQLF                                       GS2   51
      IF ( I2 .EQ. 1 ) I2=2                                             GS2   52
      DO 60 K=2,I2                                                      GS2   53
      KN=K+(N-1)*NR                                                     GS2   54
      IF ( KN .GT. NQ ) GO TO 120                                       GS2   55
      KK=K-1                                                            GS2   56
      D=AT(KK,1)                                                        GS2   57
      IF ( D .EQ. 0.0 ) GO TO 60                                        GS2   58
      DD=SQRT(D)                                                        GS2   59
      DO 25 I=1,NC                                                      GS2   60
   25 AT(KK,I)=AT(KK,I)/DD                                              GS2   61
      KM=KK+MM                                                          GS2   62
      DO 50 I=K,I2                                                      GS2   63
      IK=I-KK                                                           GS2   64
      J2=KM-I                                                           GS2   65
      C=AT(KK,IK+1)                                                     GS2   66
      IF ( C .EQ. 0.0 ) GO TO 50                                        GS2   67
      DO 30 L=1,LL                                                      GS2   68
      ML=MM+L                                                           GS2   69
   30 AT(I,ML)=AT(I,ML)-C*AT(KK,ML)                                     GS2   70
```

```
      DO 40 J=1,J2
   40 AT(I,J)=AT(I,J)-C*AT(KK,IK+J)
   50 CONTINUE
   60 CONTINUE
      D=AT(I2,1)
      IF ( D .EQ. 0.0 ) GO TO 65
      DD=SQRT(D)
      DO 61 I=1,NC
   61 AT(I2,I)=AT(I2,I)/DD
   62 CONTINUE
      IF ( N .EQ. NSET ) GO TO 130
      WRITE (NBCKSB) AT
      READ (NT1) AB
C
C     REDUCE AB
C
      NRR=NR
      DO 110 I=NR1,NQLF
      II=I-NRR
      IF ( II .LE. NR ) GO TO 70
      WRITE (NT2) AB
      READ  (NT1) AB
      NRR=NRR+NR
      II=1
   70 CONTINUE
      KKMIN=I-MMM1
      IF ( KKMIN .LT. 1 ) KKMIN=1
      DO 100 KK=KKMIN,NR
      D=AT(KK,1)
      IF ( D .EQ. 0.0 ) GO TO 100
      IK=I-KK
      C=AT(KK,IK+1)
      IF ( C .EQ. 0.0 ) GO TO 100
      K=KK+1
      KM=KK+MM
```

```
      J2=KM-I
      DO 80 L=1,LL
      ML=MM+L
   80 AB(II,ML)=AB(II,ML)-C*AT(KK,ML)
      DO 90 J=1,J2
   90 AB(II,J)=AB(II,J)-C*AT(KK,J+IK)
  100 CONTINUE
  110 CONTINUE
C
      WRITE (NT2) AB
      IF ((N+NBKS-1) .GE. NSET ) GO TO 120
      READ (NORIG) AB
      WRITE (NT2) AB
  120 CONTINUE
C
C        2.0  BACK SUBSTITUTION
C
  130 DO 140 L=1,LL
      ITAPE=L+6
  140 REWIND ITAPE
      DO 150 I=1,NCOUNT
  150 AB(I)=0.0
      DO 190 M=1,NSET
      IF ( M .EQ. 1 ) GO TO 155
      BACKSPACE NBCKSB
      READ (NBCKSB) AT
      BACKSPACE NBCKSB
  155 CONTINUE
      DO 190 L=1,LL
      ITAPE=L+6
      ML=MM+L
      MNL=MN*(L-1)
      MJ=MNL+MMP1
      DO 160 I=1,MM
      J=MJ-I
```

```
  160 AB(NR+J)=AB(J)                                                    GS2 141
      DO 165 I=1,NR                                                     GS2 142
  165 AB(I+MNL)=AT(I,ML)                                                GS2 143
      DO 175 II=1,NR                                                    GS2 144
      JJ=NR-II                                                          GS2 145
      I=JJ+1                                                            GS2 146
      JM=JJ+MNL                                                         GS2 147
      IF ( AT(I,1) .EQ. 0.0 ) GO TO 175                                 GS2 148
      S=AB(I+MNL)                                                       GS2 149
      DO 170 J=2,MM                                                     GS2 150
  170 S=S-AT(I,J)*AB(J+JM)                                              GS2 151
      AB(I+MNL)=S/AT(I,1)                                               GS2 152
  175 B(I)=AB(I+MNL)                                                    GS2 153
      WRITE (ITAPE) B                                                   GS2 154
  190 CONTINUE                                                          GS2 155
C                                                                       GS2 156
C         3.0  STORE SOLUTIONS ON TAPE ITAPE                            GS2 157
C                                                                       GS2 158
      DO 220 L=1,LL                                                     GS2 159
      ITAPE=L+6                                                         GS2 160
      REWIND ITAPE                                                      GS2 161
      DO 210 N=1,NSET                                                   GS2 162
      M1=(NSET-N)*NR+1                                                  GS2 163
      M2=M1+NR-1                                                        GS2 164
  210 READ (ITAPE) (AT(M),M=M1,M2)                                      GS2 165
      REWIND ITAPE                                                      GS2 166
      WRITE (ITAPE) (AT(I),I=1,NQ)                                      GS2 167
      REWIND ITAPE                                                      GS2 168
  220 CONTINUE                                                          GS2 169
  240 RETURN                                                            GS2 170
      END                                                               GS2 171
```

```
      SUBROUTINE CPTIME(T)                                              CPT    1
      CALL SECOND(T)                                                    CPT    2
      RETURN                                                            CPT    3
      END                                                               CPT    4
```

```
      SUBROUTINE WRITBF (REC,BUFF,LNREC,LNBUFF,N,NUMEL,NTAPE)
      DIMENSION REC(LNREC),BUFF(LNBUFF)
      IF ( N .NE. 1 ) GO TO 10
      REWIND NTAPE
      M=0
   10 MM=M+LNREC
      DO 20 I=1,LNREC
      II=I+M
   20 BUFF(II)=REC(I)
      M=MM
      IF ( N .EQ. NUMEL ) GO TO 30
      IF ( (M+LNREC) .LE. LNBUFF ) GO TO 40
   30 WRITE (NTAPE) BUFF
      M=0
   40 RETURN
      END
```

```
      SUBROUTINE READBF (REC,BUFF,LNREC,LNBUFF,N,NUMEL,NTAPE)
      DIMENSION REC(LNREC),BUFF(LNBUFF)
      IF ( N .NE. 1 ) GO TO 10
      REWIND NTAPE
      READ (NTAPE) BUFF
      M=0
   10 MM=M+LNREC
      DO 20 I=1,LNREC
      II=I+M
   20 REC(I)=BUFF(II)
      M=MM
      IF( N .EQ. NUMEL ) GO TO 40
      IF ( (M+LNREC) .LE. LNBUFF ) GO TO 40
   30 READ (NTAPE) BUFF
      M=0
   40 RETURN
      END
```