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Numerical Methods for Determining Streamlines and Isopressures for Use in Fluid-Flow Studies

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Numerical Methods for Determining Streamlines and Isopressures for Use in Fluid-Flow Studies

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NUMERICAL METHODS FOR DETERMINING STREAMLINES AND ISOPRESSURES FOR USE IN FLUID-FLOW STUDIES

by

R. V. Higgins[1] and A. J. Leighton[2]

ABSTRACT

A numerical method is presented to calculate the isopressure (isobar) lines and streamlines for an oilfield from the pressure distribution. A knowledge of these lines is useful in the study of the flow of fluids in underground reservoirs, especially for those containing gaseous and/or liquid hydrocarbons. This work was done primarily to enable determination of the shape factors needed in the calculation of petroleum reservoir performance. However, it has application for the flow of water in aquifers, or electricity or heat in odd-shaped geometry.

Techniques previously developed were used to calculate the pressure distribution. From this pressure distribution, the isopressure lines were calculated accurately by the method presented in this paper. Then by successively projecting orthogonal lines from one isopressure line to another, the streamlines are determined. From the coordinates of the isopressures and the streamlines, the shape factors can then be determined by a published method.

Computer methods are presented to calculate the streamlines and isopressures for any well-spacing pattern existing within a field with multiple wells. The method reproduces the flow net for several well configurations having extensive geometrical variations. Such information provides the petroleum engineer with data from which he can compute oil recoveries for different patterns and thereby maximize the recovery of hydrocarbons from the reservoir.

INTRODUCTION

The use of isopressures[3] and streamlines in flow of fluids and electricity has been most useful in the past. These lines have been determined either by sophisticated mathematical methods for uniform patterns or by

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[1]Research supervisor.
[2]Petroleum engineer.

[3]In this report the term "isopressure" refers to a line or contour marking locations in a reservoir having the same pressure and is used synonymously with "isobar."

electrical techniques for uniform or nonuniform configuration. In oilfields the patterns often are not symmetrical, and the numerical method presented here is most useful. However, the main interest with this paper is primarily in the development of the lines to determine shape factors (geometric resistivity).

The authors (3)[4] have previously shown by their method, which uses shape factors, that one may determine quickly the waterflood potential of a normal pattern flood. The shape factors for several normal patterns have been published (1). In a field, often the patterns differ from the normal. There is no convenient published way to put in the parameters and end up with isopressures, streamlines, and the shape factor values for nonnormal patterns. This paper will accomplish the calculation of isopressures and streamlines for use in reservoir studies.

The isopressures and the streamlines, even without the shape factors, are usable information to guide the reservoir engineer about future drilling as related to poorly drained areas. With the use of the shape factors and the authors' (3) previously published methods, much more quantitative information can be obtained to guide the operator.

The winning of more oil from reservoirs should be aided by the information contained in the report. This Report of Investigations also will enable the Bureau of Mines Higgins-Leighton method to be expanded to include more reservoir configurations. This should aid in deciding the best locations of in-filled wells so as to maximize recovery of oil from the Nation's reserves.

A CDC 6600[5] was used in making the calculations. This size computer was used because of the access convenience. Since the storage required for the programs presented is not excessive, smaller computers can be used. FORTRAN IV was used to program the instructions.

An early search of the literature did not disclose a convenient method to determine streamlines of nonsymmetrical patterns. Muskat (8), Hurst (6), and Prats (9) have presented methods to determine streamlines for patterns that are symmetrical. Even for them, the mathematics used are more for scientists than petroleum engineers, and the working details are not published. The method presented here will determine the streamlines for any pattern, symmetrical or nonsymmetrical. Every engineer has been instructed some time or another in the mathematics used. Much ingenuity is required in getting all the components together and instructing the computer through a program to process the complex logic. After the method was developed but before the manuscript was completed, Le Blanc and Caudle (7) published a method based on the mathematics of potential flow. Their method has a different approach. The authors of this paper have not thoroughly investigated the merits of the

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[4]Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

[5]Reference to specific makes of equipment is for identification only and does not imply endorsement by the Bureau of Mines.

two methods, since the one presented here was satisfactory. Also, the results are directly usable in this Bureau of Mines series of reservoir calculation methods.

ISOPRESSURES

General Procedure

In the determination of the coordinates of an isopressure line, the line is started at a point of known pressure on an edge and projected stepwise throughout the field. In the iterative technique (5) used to determine the input pressure distribution, the pressures are calculated at the coordinates of a grid. The stepwise determination of each point for an isopressure contour proceeds as follows: (1) The line is extended into the pattern by means of vector models to determine direction and lookup statements to locate the next point in relation to the grid, (2) the constants of a second-order polynomial equation passing through the pressure points are calculated, and (3) then the coordinates of a point on the isopressure contour are determined by solving the equation. A third-order polynomial equation was also tried, but it did not improve the fit.

The usual procedure for calculating the constants of a second-order polynomial equation is by the use of simultaneous equations. To reduce the computer time, the constants were determined by short formulas. This was possible since the distance between any adjacent grid points is the same and was assumed to be 1.0. This equal distance is a carryover from the iterative technique (5) of determining the pressure distribution. The origin for the coordinates for the polynomial equation representing the pressure relationship to geometry was at the grid point in question. This is illustrated in figure 1. The equation for interpolating is $P = a_1 + a_2x + a_3x^2$.

When x = 0.0,

$$P_2 = a_1; \tag{1}$$

when x = 1,

$$P_3 = P_2 + a_2 + a_3; \tag{2}$$

and when x = -1,

$$P_1 = P_2 - a_2 + a_3. \tag{3}$$

Eliminating a_2 from equations 2 and 3,

$$a_3 = \frac{P_3 + P_1}{2} - P_2. \tag{4}$$

Eliminating a_3 from equations 2 and 3,

$$a_2 = \frac{P_3 - P_1}{2}. \tag{5}$$

Thus the constants, a_1, a_2, and a_3, for the second-order polynomial used to interpolate for the isopressures are easily obtained by use of equations 1, 4, and 5.

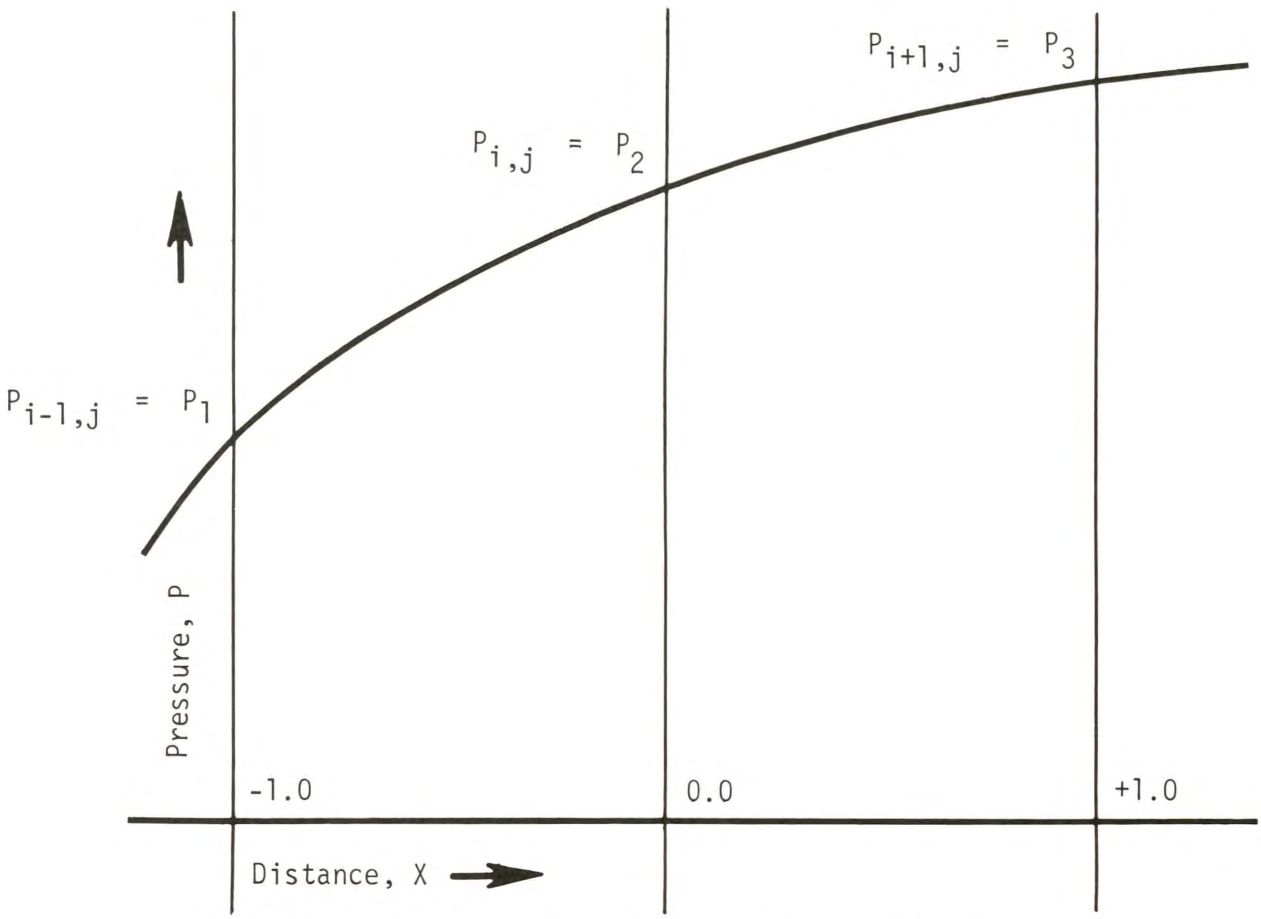


FIGURE 1. - Schematics for Solution of Polynomial Constants.

The pressures for this report were calculated at uniform grid points. This permitted the use of a polynomial for which the constants could be solved without the use of a quadratic equation and the test for the correct plus or minus value. Also, the quadratic occasionally results in sinusoid values between the intermediate points. If a nonuniform grid were used, a quadratic solution for the constants would be required for the solution for the constants for the polynomial.

Location of Successive Points

The program is written so as to advance the calculations for an isopressure line, one grid position at a time. The grid points, between which the isopressure values lie, are located by sets of vector models and a lookup subroutine. The FORTRAN statements for the MAIN program are listed with explanatory comments in table 1 and the flow diagram is shown in figure 2.

TABLE 1. - Isopressure MAIN program with explanatory comments

```
C       MAIN PROGRAM FOR ISOPRESSURE CALCULATION.

        DIMENSION Y(101), X(101), XSAVE(101), YSAVE(101)
        INTEGER XUP, YUP, TEST(101,101)
        COMMON/AQUI/ P(101,101), XUP, YUP, NWELL, IADD(4,5), IPLUS(4,5,4),
       1 ICALL(5,4), WORD(10)
        LOGICAL FIT, FORK

C       INITIALIZATION AND ROUTING TO START A PRESSURE LINE.
         READ 1030, ((P(I, J), J = 1, YUP), I = 1, XUP)         Read in pressures at grid points.
 1030   FORMAT ( 12F6.2 )
        PRINT 1031,((P(I,J), I = 1, XUP), J = 1, YUP)           Print pressures at the grid points.
 1031   FORMAT ( 2(20F6.2/),13F6.2 )
        DO 10 I = 1, XUP   }            Sets Test(I,J) to zero.  After coordinates of an isopressure point are determined,
        DO 10 J = 1, YUP   }              coordinates of the nearest grid point are recorded so as to avoid duplication or
  10    TEST(I, J) = 0     }              excessive isopressure density.

  12    DO 700 KK= 1, 5                                          All-inclusive DO setting an edge or infill for isopressure lines to start.
        PRINT 4000, (( TEST(IN, JN), IN = 1, XUP), JN = 1, YUP )  Shows density of isopressure lines.
 4000   FORMAT ( 1H1 ( / 53I2 ) )
        PRINT 1050, WORD(KK)       }                             Print label for the edge or infill at which a group of isopressure lines
 1050   FORMAT ( 1H1 50X, A10 )    }                               start.
        GO TO (  20,   20,   30,   30,   15 ),  KK               Routing to go where the initializations are made according to the one
                                                                   of the four edges or the sweep of entire pattern for missing values.1/
  15    I = XUP
        J = YUP                                                  Start infill at a corner.
  16    I = I - 1                                                Move to left one column.
  18    J = J - 1                                                Move up one row.
        IGO = 1                                                  Routing index for first part of an infill line.
        IF  ( TEST( I, J) .EQ. 1) GO TO 650                      If an isopressure line is near point I,J, bypass calculation.
        ITAL = 1
        NEND = 1
        GO TO 40
  20    NEND = YUP - 1      One less than highest y value because top or bottom edge values will be used later for starting isopressure values.
        GO TO 40
  30    NEND = XUP - 1            One less than highest x value because right or left edge was used previously for starting isopressure values.
  40    DO 700 LID = 1, NEND        Main DO for all isopressures starting from an edge, or infill sweep.
        IF ( KK.EQ.5 )   GO TO 80
        ITAL = 1                          Set tally for isopressure points to 1.
        GO TO ( 60, 60, 70, 70), KK       Routing according to edge used.
  60    J = YUP - LID         }           Starts at index reduced by one because first value for an isopressure line is the pressure at the
        IF ( KK.EQ.1 )  I = XUP }           edge; starts at bottom right at one less than the highest y index.  When KK=1, starts at right
        IF ( KK.EQ.2 )  I = 1   }           edge; when KK=2, starts at left edge.
        GO TO 80
  70    I = XUP - LID         }           I reduced by 1 to move over to next left column.
        IF ( KK.EQ.3 )  J = 1   }         When KK = 3, the isopressure starts at the top edge and proceeds downward.
        IF ( KK.EQ.4 )  J = YUP }         When KK = 4, the isopressure starts at the bottom edge and proceeds upward.
  80    IF ( TEST(I,J).EQ.1 )  GO TO 700  If the isopressure value is near a previously calculated one, Go to 700 to bypass calculation.
        AVP = P(I,J)                      Sets pressure value for line.
        Y(ITAL) = J                       Y coordinate for an isopressure point.
        X(ITAL) = I                       X coordinate for an isopressure point.
        TEST(I,J) = 1                     Shows that an isopressure line is at or near this grid point.
```

1/ When KK = 1, right edge; 2, left edge; 3, top; 4, bottom; and 5, sweep internal area for infill of sparse regions.

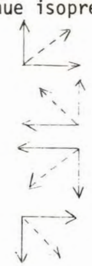
TABLE 1. - Isopressure MAIN program with explanatory comments--Continued

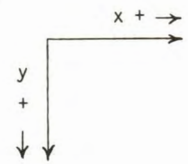
```
C     CALCULATIONS TO EXTEND PRESSURE LINE.
 100  DO 500 K = 1, 100                                     DO statement to extend isopressure line.
      IM = X(ITAL) + 0.5                                    Nearest grid point.
      JM = Y(ITAL) + 0.5                                    Nearest grid point.
      IF (ITAL .GT. 1) GO TO 200                            Bypass initializations.
       IB = IM + IADD(1, KK) }                              Set indexes at edge for initial lookup.  The IADD values give the starting and
      IE = IM + IADD(2, KK)  }                                ending x's for the x range.
      JB = JM + IADD(3, KK)  }                              Provides the y range for the first lookup.
      JE = JM + IADD(4,KK)   }
      GO TO ( 360, 360, 430, 430, 360 ),  KK
                          The following calculations are to continue isopressure line already started.
 200  IF( (X(ITAL) -X(ITAL-1)) .GE. 0.0 .AND. (Y(ITAL-1)-Y(ITAL) )
     1  .GE. 0.0)    L = 1                                      L = 1        Up and to the right.

      IF((X(ITAL)- X(ITAL-1))  .LE. 0.0 .AND. (Y(ITAL- 1) -Y(ITAL))
     1  .GE. 0.0)    L = 2                                      L = 2        Up to the left.

      IF ( (X(ITAL) -X(ITAL-1)) .LE. 0.0 .AND. (Y(ITAL-1)-Y(ITAL) )
     1  .LE. 0.0)    L = 3                                      L = 3        Down and to left.

      IF ( (X(ITAL) - X(ITAL -1)) .GE. 0.0 .AND. (Y(ITAL-1) - Y(ITAL))
     1  .LE. 0.0)    L = 4                                      L = 4        Down and to right.
```






```
      DO 300 M = 1, 5
      IB = IM + IPLUS(1,M,L) }
      IE = IM + IPLUS(2,M,L) }                   Picks various grid lines according to value of L which denotes the direction a pressure vector
      JB = JM + IPLUS(3,M,L) }                     is moving.  Without these, the lookup could reverse the direction.
      JE = JM + IPLUS(4,M,L) }
      IF   (ICALL(M,L) .EQ. 2) GO TO 260         Test if the lookup is to be on an x or y coordinate.
 230  FORK = .TRUE.                                                  Provides for lookup on x coordinate.
      CALL        LOOKUP (IB,IE,JB,JE,IP3,AVP,IT,JT,TEST,FIT,FORK)
      IF (FIT) GO TO 480                         If true, a successful lookup on a x coordinate.
      GO TO 300                                  Continued looking.
 260  FORK = .FALSE.                                                 Provides for lookup on y coordinate.
      CALL        LOOKUP (IB,IE,JB,JE,JP3,AVP,IT,JT,TEST,FIT,FORK)
      IF (FIT) GO TO 380                                             If true, a successful lookup on a y ordinate.
 300  CONTINUE
      GO TO 510                                  The following calculations are for the initiation of an isopressure line.
 360  FORK = .FALSE.
      CALL        LOOKUP (IB,IE,JB,JE,JP3,AVP,IT,JT,TEST,FIT,FORK)          Initial lookup on y coordinate.
      IF ( .NOT.FIT )  GO TO 510                                     If lookup unsuccessful, terminate and go to routing for a new line.
 380  CALL POLCON ( P(IT,JP3-2), P(IT,JP3-1), P(IT,JP3), AVP, YY )   Interpolate on y line.
      ITAL = ITAL +1                             Advance ITAL count.
      X ( ITAL ) = IT                            X coordinate lies on an x line.
      Y(ITAL) = YY + FLOAT(JP3-1)                Interpolated value plus the base is the y coordinate.
      IF ( YY.LE.0.5 ) TEST(IT,JP3-1) = 1        Nearest y ordinate of the grid has a isopressure value.
      IF ( YY.GT.0.5 ) TEST(IT,JP3) = 1
      IF ( IT.LE.1.OR.IT.GE.XUP .OR. Y(ITAL).LE.1..OR.Y(ITAL).GE.
     * FLOAT(YUP   ) ) GO TO 510                 If coordinates of isopressure lie outside the grid, go to 510 to terminate line.
 400  GO TO 500                                  To advance the isopressure line.

 430  FORK = .TRUE.
      CALL        LOOKUP (IB,IE,JB,JE,IP3,AVP,IT,JT,TEST,FIT,FORK)          Initial lookup on an x line.
      IF ( .NOT.FIT )  GO TO 510
```

```
 480  CALL POLCON ( P(IP3-2,JT), P(IP3-1,JT), P(IP3,JT), AVP, XX )      Interpolate on x.
      ITAL = ITAL +1
      Y(ITAL) = JT                                                       Y ordinate of isopressure point.
      X(ITAL) = XX + FLOAT (IP3-1)                                       Interpolated value plus base is the x coordinate.
      IF ( XX.LE.0.5 ) TEST(IP3-1,JT) = 1
      IF ( XX.GT.0.5 ) TEST(IP3,JT) = 1                 The nearest grid point has an isopressure point already determined nearby.
      IF ( X(ITAL).LE.1..OR.X(ITAL).GE.FLOAT(XUP) .OR. JT.LE.1.OR.
     * JT.GE.(YUP   ) ) GO TO 510                       If coordinates of isopressure lie outside the grid go to 510 to terminate.
 500  CONTINUE                                          Return to test for extended isopressure coordinates.

C     ROUTING AND DATA MANIPULATION TO COMPLETE INFILL LINES.
 510  IF ( ITAL.LT.2 ) GO TO 600                          If only the starting isopressure value, to to 600.
      IF ( KK.NE.5 )  GO TO 590                           If not the last sweep, go to 590 for a printing of coordinates.
      GO TO ( 520, 550 ),  IGO                            Routing to process first or second section of infill line.
 520  IGO = 2
      ITTAL = ITAL
      DO 530 IN = 1, ITTAL
      XSAVE(IN) = X(IN)                                   Reindexes coordinates of first section of isopressure line.
 530  YSAVE(IN) = Y(IN)
      X(1) = XSAVE(2)
      Y(1) = YSAVE(2)
      X(2) = XSAVE(1)                                     Reverses coordinates.
      Y(2) = YSAVE(1)
      ITAL = 2
      GO TO 100
 550  ITALM2 = ITAL - 2
      DO 560 IN = 1, ITALM2
      XSAVE(ITTAL+IN)= X(ITAL-IN+1)                       Reindexes coordinates of second section of isopressure line.
 560  YSAVE(ITTAL+IN)= Y(ITAL-IN+1)
      ITAL = ITALM2 + ITTAL                               Total number equals sum of first and second sections.
      DO 580 IN = 1, ITAL
      LN = IN - (ITAL-ITTAL)
      IF ( LN.LE.0 )  LN = IN + ITTAL                     Final indexing for all points in isopressure line.
      X(IN) = XSAVE(LN)
 580  Y(IN) = YSAVE(LN)

C     OUTPUT COORDINATES OF PRESSURE LINE AND ROUTING TO NEXT SITUATION.
 590  PRINT 2000, AVP, ITAL, X(1), Y(1), X(ITAL), Y(ITAL)
 2000 FORMAT (/ F15.5, I8,  2(5X, 2F10.3 )  )
C     PUNCH 2000, AVP, ITAL, X(1), Y(1), X(ITAL), Y(ITAL)      Identification card for isopressure line.
      PRINT 2001, (X(N), Y(N), N = 1, ITAL )
 2001 FORMAT ( 10F10.3 )
C     PUNCH 2002, (X(N), Y(N), N = 1, ITAL )
 2002 FORMAT ( 8F10.3 )
C     PUNCH 2000
      IF ( KK.EQ.5    .AND.   I.EQ.1.AND.J.EQ.1 )           At end of calculation, all test values should equal 1.
     1PRINT 4000, (( TEST(IN, JN), IN = 1, XUP), JN = 1, YUP )
 600  GO TO ( 700, 700, 700, 700, 650 ), KK
 650  CONTINUE
      IF ( J.GT.1 ) GO TO 18
      J = YUP + 1                                           Routing for sweep on infill.
      IF (  I.GT.1 ) GO TO 16
 700  CONTINUE
      STOP
      END
```

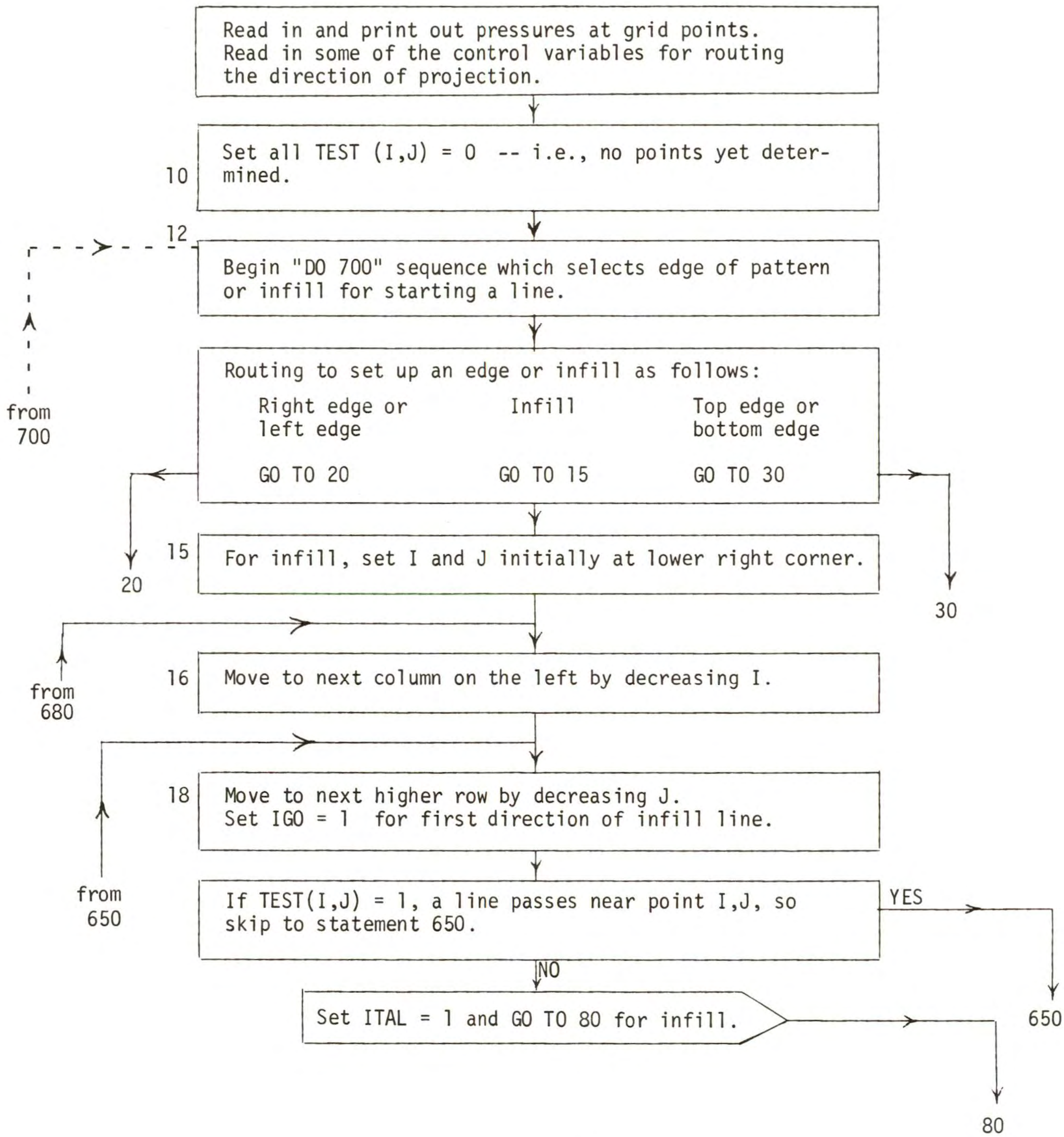


FIGURE 2. - Schematic Flow Diagram for Isopressure MAIN Program.

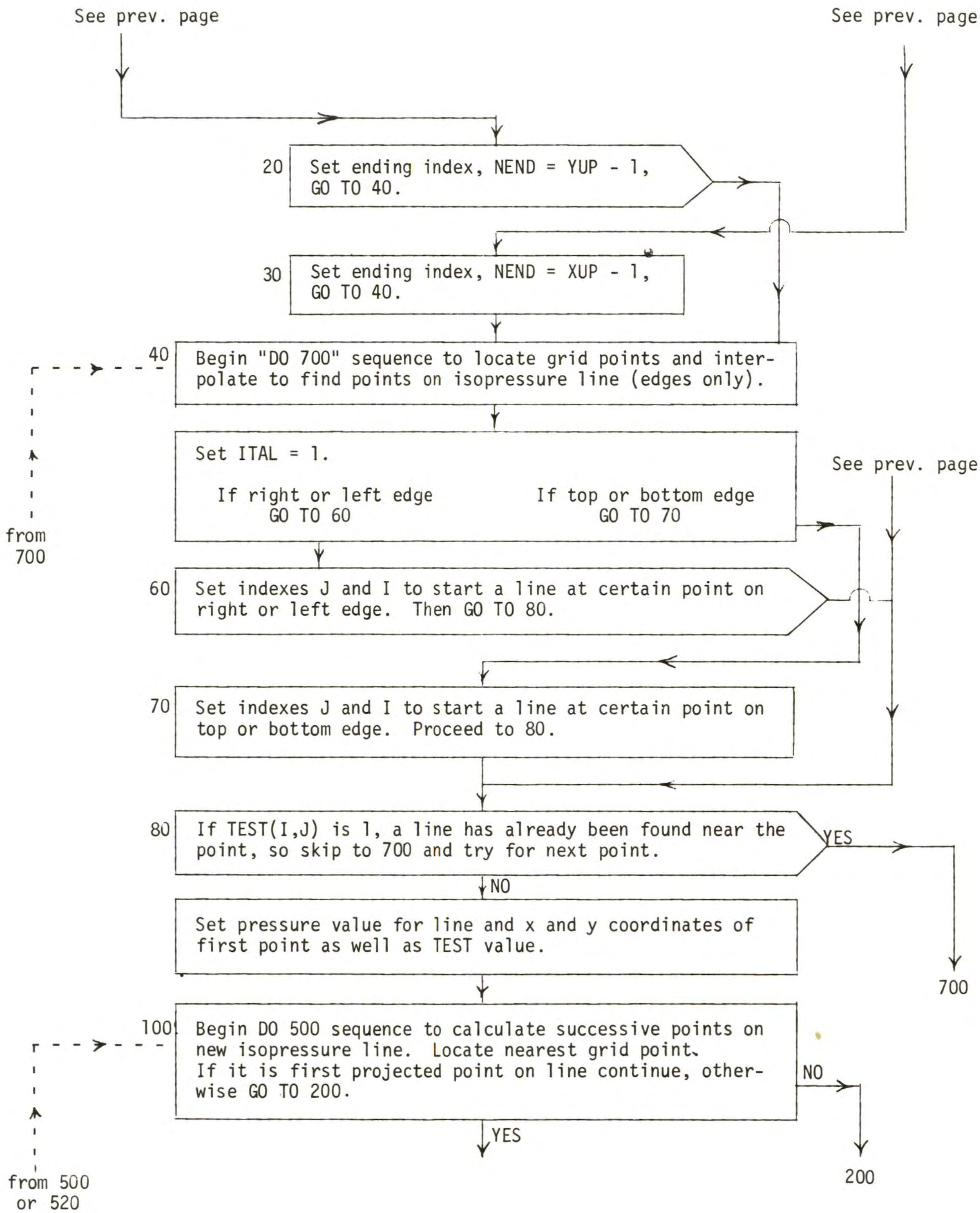


FIGURE 2. - Schematic Flow Diagram for Isopressure MAIN Program.—Continued

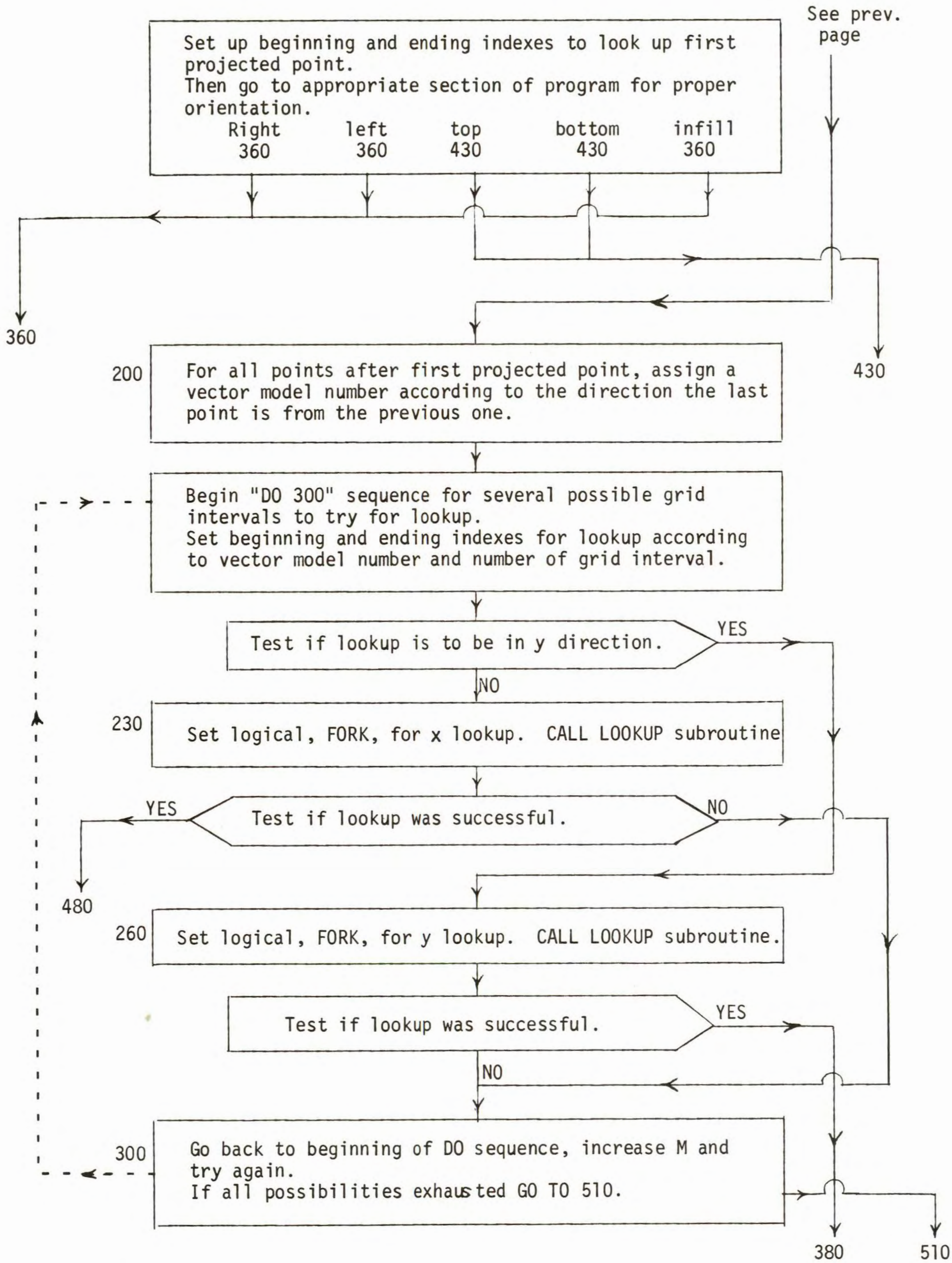


FIGURE 2. - Schematic Flow Diagram for Isopressure MAIN Program.–Continued

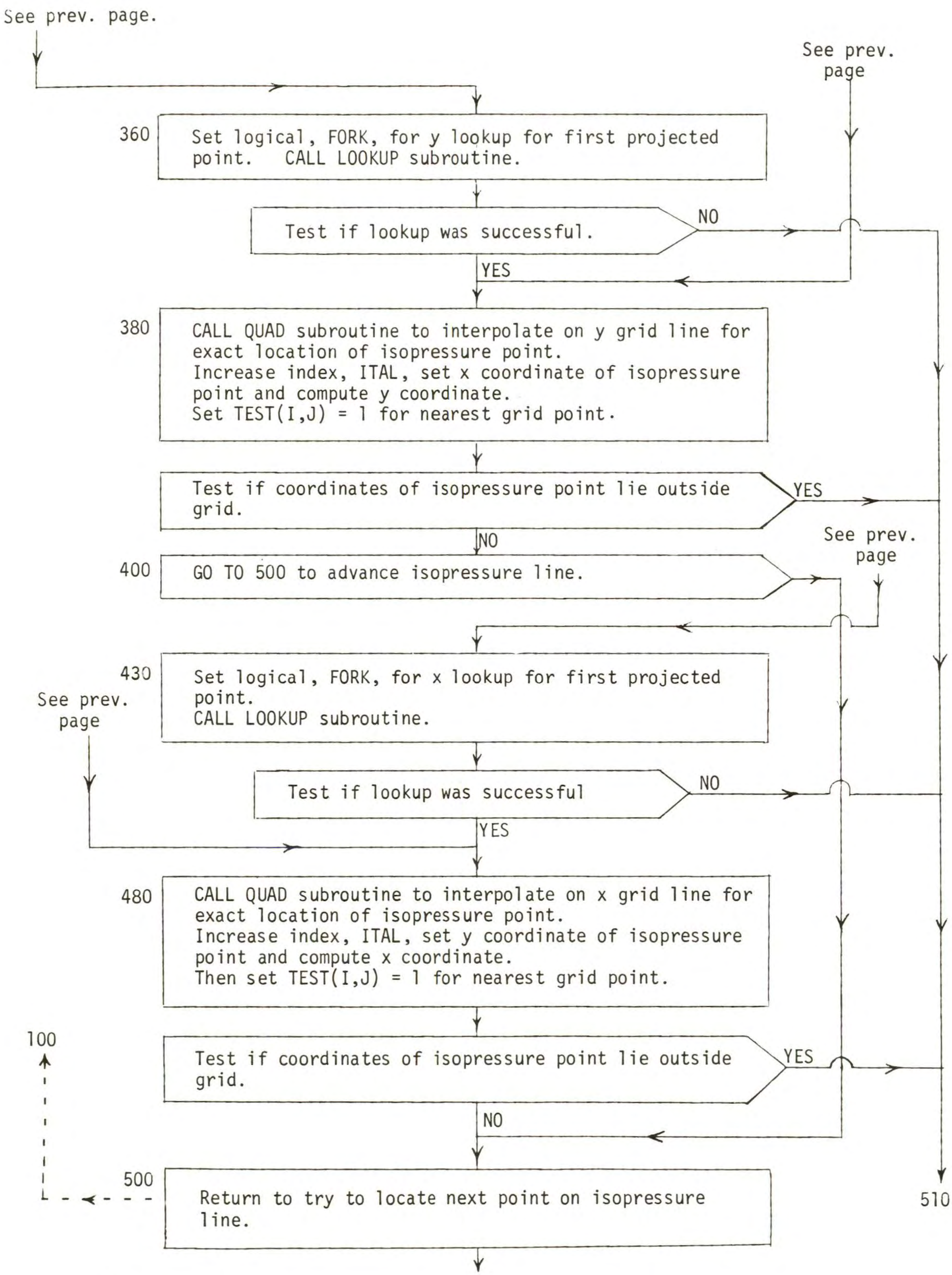


FIGURE 2. - Schematic Flow Diagram for Isopressure MAIN Program.–Continued

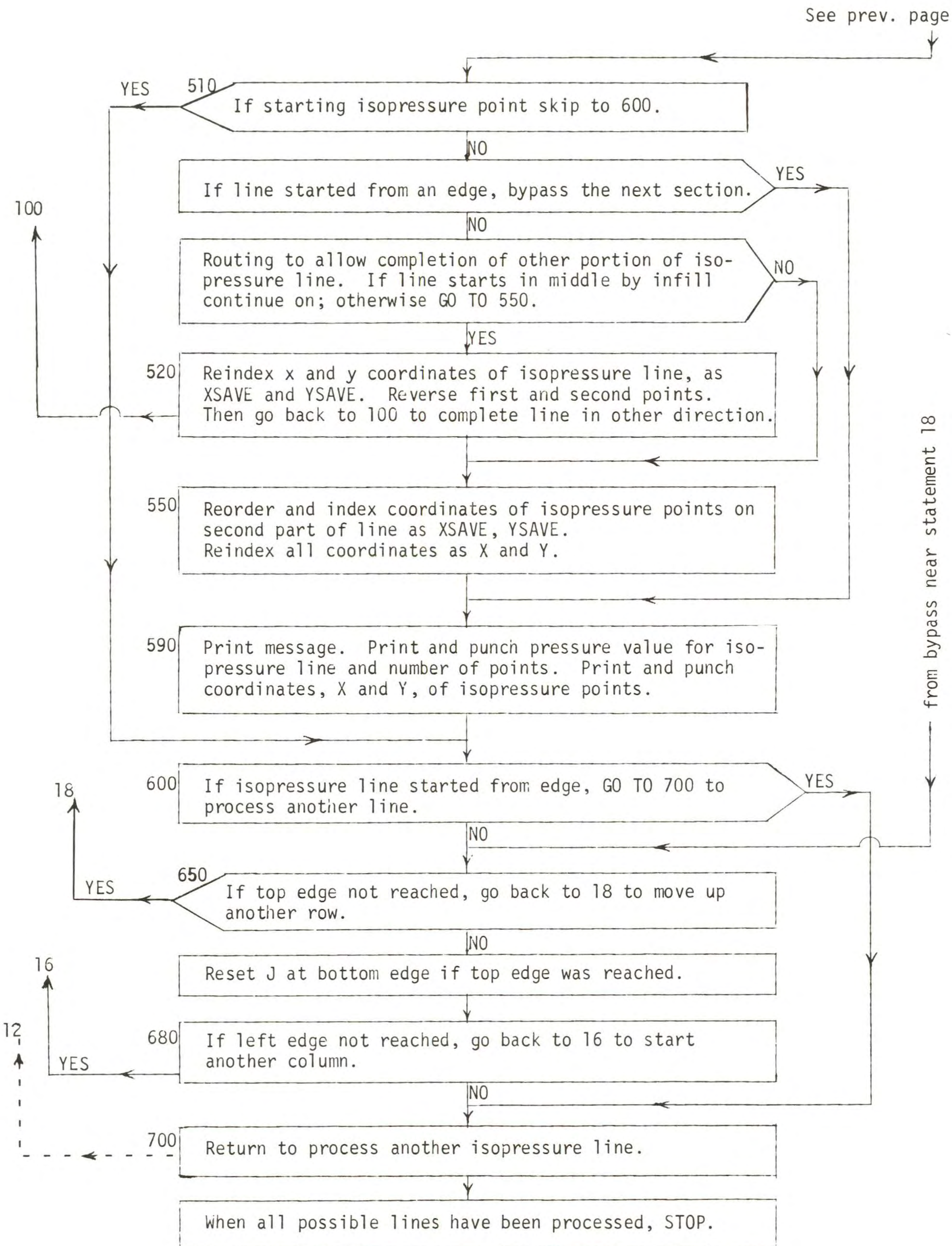


FIGURE 2. - Schematic Flow Diagram for Isopressure MAIN Program.—Continued

Vector Models

Experience has shown that the succeeding isopressure point may lie as many as three grid points away from the last one, or the line may start curving backwards. These types of locations complicate the computer logic. As a result, four vector models are used to find the proper direction. These

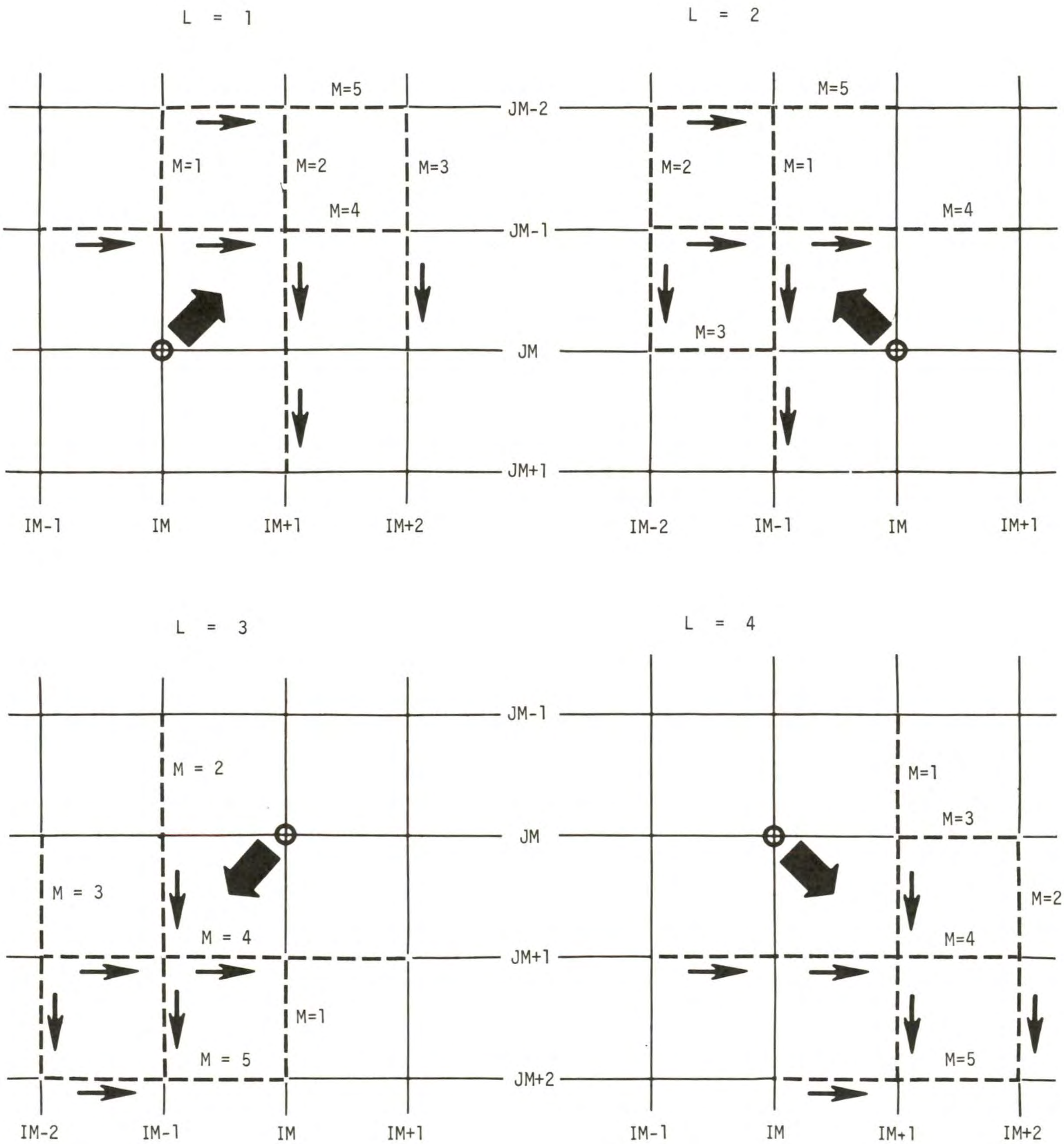


FIGURE 3. - Schematics for Vector Models.

models depend upon the direction the last isopressure is advancing; that is, up, down, right, or left. Also, the models have been designed so as to avoid locating an isopressure point that would start the line going backward. The models so chosen have worked satisfactorily for all the pressure grids that the authors have tested.

The choice of vector model is made by four computer statements beginning at 200 in the program. These tests determine the direction in which the last calculated isopressure line segment is moving. The assumption is that the lookup for pressures between which the isopressure lies will continue to be in a forward direction. Nevertheless, enough pressures at grid points are included in the model for an extensive range of angles, except in the reverse direction. Experience has shown that this is necessary.

After the direction has been determined by the computer test, the model index number is assigned to L. With this value of L, the DO 300 M = 1,5 etc.-sequence picks the grid lines and ranges of lookup on the grids.

The models are shown in figure 3 for the indexes of L and M. The large arrow shows the model direction. The dash lines are the portions of the grid asked for by the indexes and the small arrows denote the extended range built into the lookup subroutine. The values of indexes L and M are in the COMMON statement and are listed in table 2. The BLOCK DATA subprogram listed in table 3 contains the same data in a form usable by the computer. As can be seen in figure 3, no lookup is requested in the reverse direction.

TABLE 2. - Indexes for vector models used in lookup for isopressures

A IPLUS values that designate the grid points Grid point selection, M: 1	2	3	4	5	Model No. L
		PLUS			
0 0-1-1	1 1-1 1	2 2-1 0	-1 1-1-1	0 1-2-2	1
-1-1-1 1	-2-2-1 0	-2-2 0 0	-2 0-1-1	-2-1-2-2	2
0 0 2 2	-1-1 0 2	-2-2 1 2	-2 0 1 1	-2-1 2 2	3
1 1 0 2	2 2 1 2	1 1 0 0	-1 1 1 1	0 1 2 2	4

B
ICALL values that designate the X or Y coordinate selected for lookup

1	2	3	4	Model No. L
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	Model Section, M
2 2 2 1 1	2 2 1 1 1	2 2 2 1 1	2 2 1 1 1	X or Y, ICALL[1]

[1]When the index is 1, the lookup is on the X coordinate; when 2, the Y coordinate.

TABLE 3. - Block data subprogram containing vector-model and other built-in data

```
 BLOCK DATA
 INTEGER XUP, YUP
 COMMON/AQUI/ P(101,101), XUP, YUP, NWELL, IADD(4,5), IPLUS(4,5,4),
1 ICALL(4,5), WORD(10)

 DATA XUP, YUP, NWELL / 53, 91, 4 /                                   Limits of grid and number of wells.

 DATA IADD(1, 1), IADD(2,1), IADD(3,1), IADD( 4,1)/-1,-1,-1,+1/   }
 DATA IADD(1,2), IADD(2,2), IADD(3,2), IADD(4,2)/+1,+1,-1,+1/     }
 DATA IADD(1,3), IADD(2,3), IADD (3,3), IADD(4,3)/-1,+1,+1,+1  /  }  Provide the index ranges for the initial lookup for
 DATA IADD(1,4), IADD(2,4), IADD(3,4), IADD(4,4) /-1,+1,-1,-1/    }    each of the four edges.
 DATA IADD(1,5),  IADD(2,5), IADD(3,5), IADD(4,5) /-1,-1,+1,+1/   }

 DATA  (IPLUS(L), L = 1, 80 )     /
1   0, 0,-1,-1,  1, 1,-1, 1,  2, 2,-1, 0, -1, 1,-1,-1,  0, 1,-2,-2,  }
2  -1,-1,-1, 1, -2,-2,-1, 0, -2,-2, 0, 0, -2, 0,-1,-1, -2,-1,-2,-2,  }  Provide the index ranges for the lookup to locate
3   0, 0, 2, 2, -1,-1, 0, 2, -2,-2, 1, 2, -2, 0, 1, 1, -2,-1, 2, 2,  }     extended isopressure line.
4   1, 1, 0, 2,  2, 2, 1, 2,  1, 1, 0, 0, -1, 1, 1, 1,  0, 1, 2, 2/  }

 DATA  (ICALL(L), L = 1, 20 )     /                                   } Provides routing to x or y lookup.
1   2, 2, 2, 1, 1,  2, 2, 1, 1, 1,  2, 2, 2, 1, 1,  2, 2, 1, 1, 1 /   }

 DATA (WORD(I), I = 1, 5) / 10HRIGHT SIDE, 10H LEFT SIDE, 10H TOP S
1IDE , 10H BOT SIDE , 10H INFILL    /

 END
```

Lookup and Computation Procedure

Subroutine LOOKUP, listed in table 4, was designed to locate a pressure value within the grid. As shown by the flow diagram in figure 4, there are two branches, one for a lookup in the x direction and another one for a lookup in the y direction. All the other parameters are grouped for easy use in the subroutine.

TABLE 4. - Program for subroutine LOOKUP with explanatory comments

```
      SUBROUTINE LOOKUP (IB,IE,JB,JE,MP, AVP,IT,JT,TEST,FIT,FORK)
      LOGICAL FIT, FORK
      INTEGER XUP, YUP, TEST(101,101)
      COMMON/AQUI/ P(101,101), XUP, YUP, NWELL, IADD(4,5), IPLUS(4,5,4),
     1 ICALL(4,5), WORD(10)

      FIT = .FALSE.
      DO 100     JT = JB, JE                                  Limits for y lookup.
      DO 100     IT = IB, IE                                  Limits for x lookup.
      IF ( FORK ) GO TO 50                                    Routing to x or y lookup as required.
      IF ( IT .LT. 1 .OR. IT .GT. XUP) GO TO 100 }            Tests if lookup is outside of field.
      IF (JT .LT. 3 .OR. JT .GT. YUP) GO TO 100  }
      IF (P(IT,JT) .LE. AVP .AND. AVP .LF. P(IT, JT-1) ) FIT = .TRUE.  }
       IF (P(IT, JT) .GE. AVP .AND. AVP .GE. P(IT, JT-1)) FIT = .TRUE. }   Lookup in x direction.
      IF (FIT) GO TO 130                                                   Lookup is satisfied.
      GO TO 100

   50 IF (JT .LT. 1 .OR. JT .GT. YUP) GO TO 100      }                     Tests if lookup is outside of field.
      IF (IT .LT. 3 .OR. IT .GT.(XUP -1)) GO TO 100  }
      IF (P(IT,JT) .LE. AVP .AND. AVP .LE. P(IT+1, JT)) FIT = .TRUE.   }   Lookup in y direction.
       IF (P(IT, JT) .GE. AVP .AND. AVP .GE. P(IT+1,JT )) FIT = .TRUE. }
      IF (FIT) GO TO 140                                      Lookup is satisfied.
  100  CONTINUE
      RETURN                                                  No successful lookup.

  130 MP = JT                                                 Preserves located index.
      RETURN

  140 MP = IT + 1                                             Preserves located index.
      RETURN

      END
```

After the index for the grid point that has the proper pressure value has been determined, the second-order polynomial for the pressures at the grid points surrounding the prospective isopressure point is determined. Subroutine

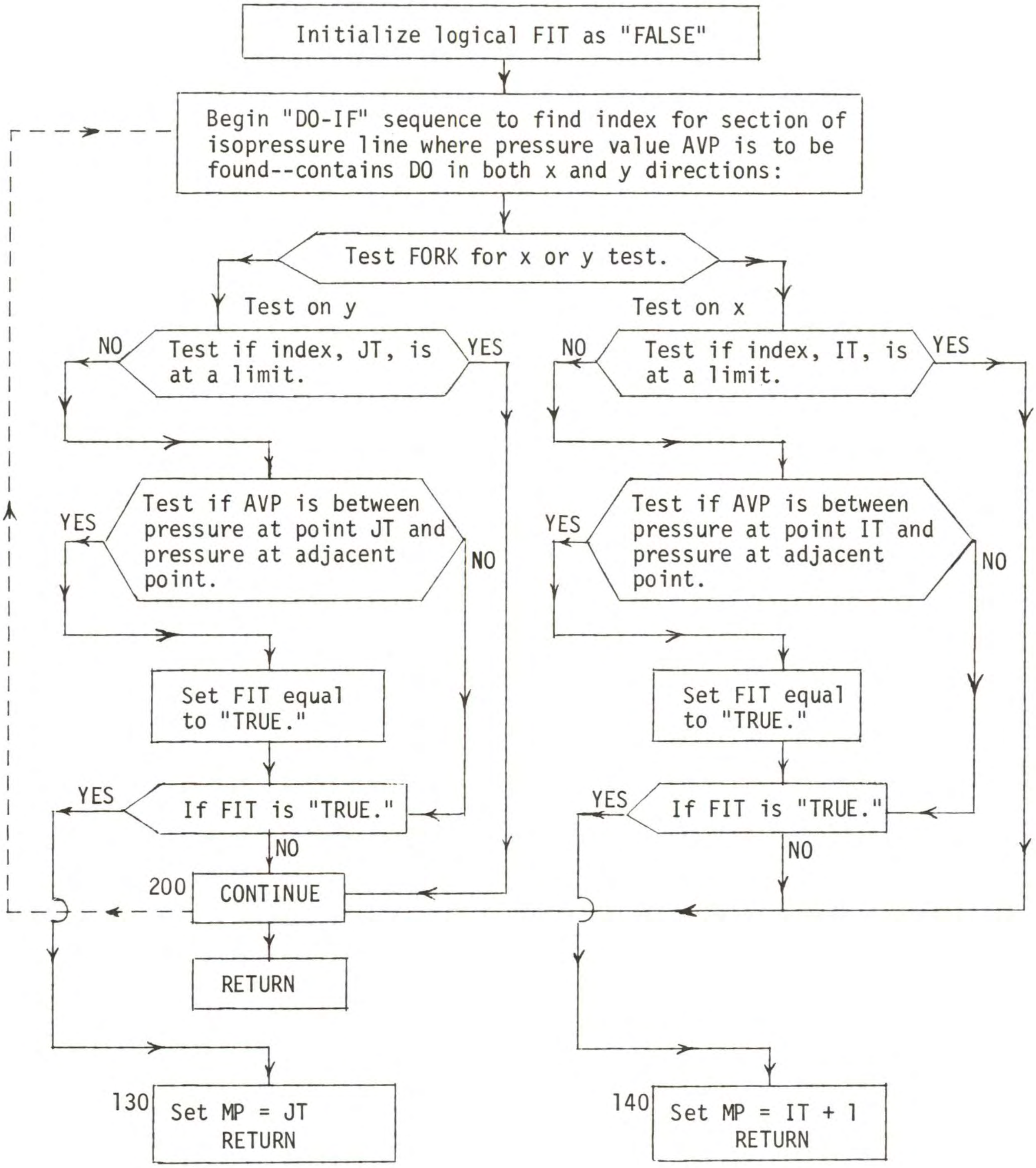


FIGURE 4. - Schematic Flow Diagram for Subroutine LOOKUP.

POLCON, listed in table 5, solves for the constants of the polynomial, then solves for the location in the grid where the isopressure value intersects. The exact coordinate value is then computed. The coordinate value in the opposite direction is that for the intersected grid line. These values are indexed and stored for subsequent output.

TABLE 5. - Program for subroutine POLCON with explanatory comments

```
      SUBROUTINE POLCON ( P1, P2, P3, AVP, YY )

      A  = (P3 + P1)/ 2.0 - P2     }
      B  = (P3 - P1)/ 2.0          }   Calculates constants of quadratic equation.
      C = P2 - AVP                 }
      IF ( P2.EQ.P3 ) GO TO 90         Function is zero.
      IF ( ABS(A).LE.0.0000001 ) GO TO 80   Function is linear.

      D = B**2 - 4.0* A*C
      PP= -B/(2.0*A)
      Q = SQRT (ABS(D))/(2.0*A)
      R1= PP+Q                     }
      R2 =PP- Q                    }   Roots of quadratic equation.
      BPOR = (AVP-P2) / (P3-P2)    }
   60 DR1 =ABS (BPOR -R1)          }
      DR2 = ABS(BPOR-R2)           }   Determines which root is correct.
      IF (DR1 .LE. DR2 ) YY =R1    }
      IF (DR2 .LT. DR1) YY= R2     }
      RETURN

   80 YY = - C / B                     Function is linear.
      RETURN

   90 YY = 0.                          Function is zero.
      RETURN

      END
```

Isopressure lines are computed starting from all four edges of the network according to the value of control index KK (KK = 1 through KK = 4). To fill in possible sparse areas, the grid is scanned by infill procedure (KK = 5). Any grid point without a nearby isopressure contour (denoted by TEST [I,J] = 0) will have a line started and projected to an edge. The 500 series of statements in the MAIN program are to complete such infill lines in the opposite direction.

The core storage required for the isopressure program is 23,600 words, and the CPU time for the 7-spot example is 15 seconds on the CDC 6600.

STREAMLINES

Orthogonality

The principles of orthogonality were used to determine the streamlines from the isopressure contours, since the streamlines are at right angles to isopressure lines at the points of intersection. The schematics of the procedure are shown in figure 5. A perpendicular from the intersection of the streamline and the lower or "first" isopressure contour is projected to the upper or second isopressure contour. A tangent line to the upper isopressure at this point is determined. From a point on this tangent line, a perpendicular is dropped such that it will intersect the perpendicular from the lower isopressure-line point, midway for both perpendiculars. The perpendiculars will be of equal length and therefore equidistant from the tangent line to the upper isopressure contour and the streamline intersection with the lower isopressure.

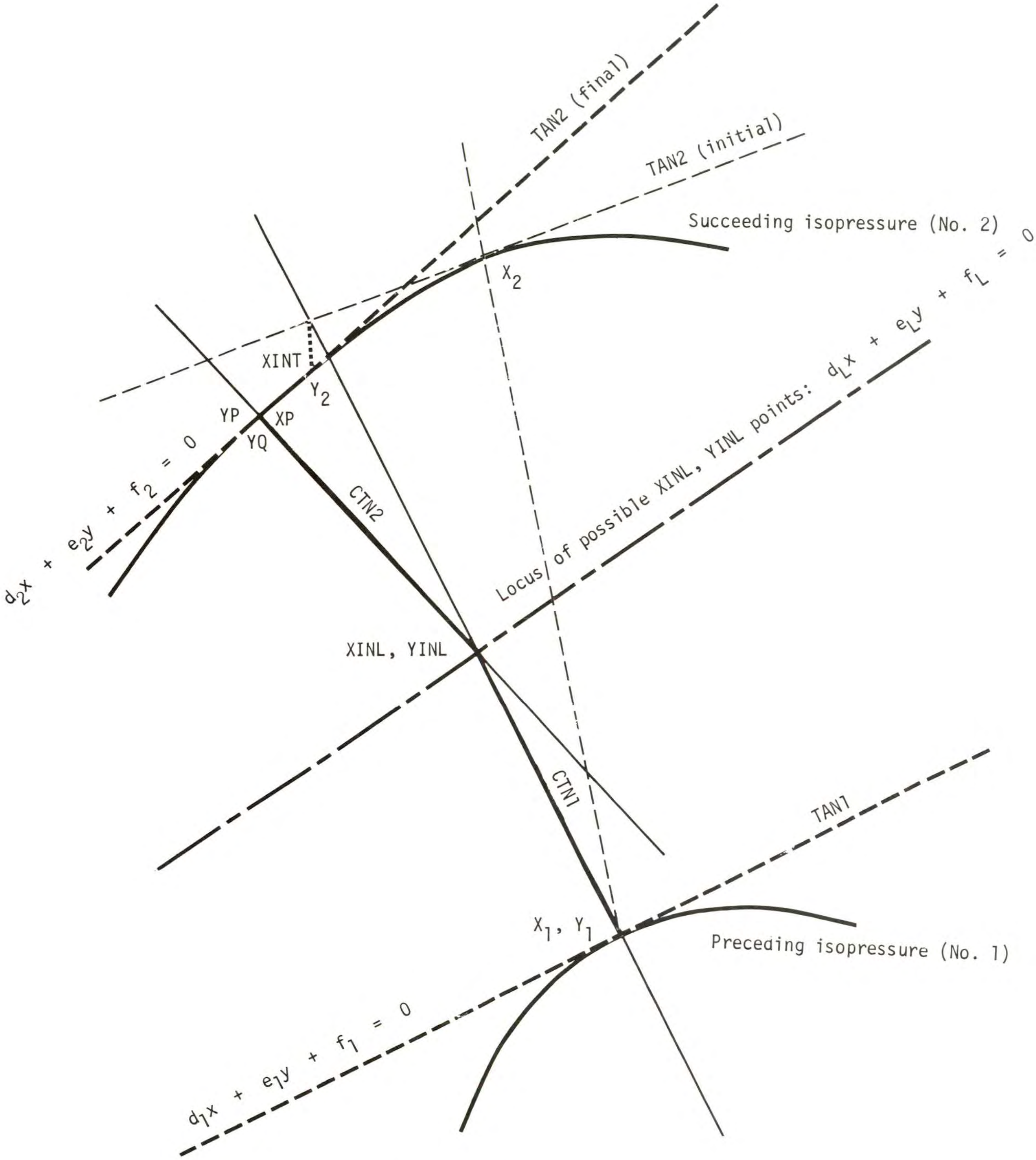


FIGURE 5. - Schematics for Intersection of Orthogonal Lines.

The point on the tangent line, from which this perpendicular is dropped, is seldom on the upper isopressure line, but the place where the perpendicular crosses the isopressure line is the starting point for the calculation of another tangent and perpendicular. The second iteration usually approaches coincidence for all practical purposes. However, the program permits 10 iterations.

This procedure has created streamlines that are (1) circles and (2) ellipses from the isopressures that are orthogonal to the circles and ellipses (as well as reproducing the streamlines for a 7-spot pattern). Therefore, the method must be basically sound; that is, a circle and an ellipse are known configurations. A method that accurately reproduces a known configuration as a streamline should successfully calculate more complex configurations.

The equation for the perpendicular distance d_1 from a line whose normal-form equation is $Ax + By + C = 0$ to the point x_1, y_1 is

$$d_1 = \frac{A_1 x_1 + B_1 y_1 + C_1}{\pm\sqrt{A_1^2 + B_1^2}} , \tag{6}$$

wherein the sign of the radical is opposite the sign of C_1. Since the calculations are always in the same quadrant, no change of sign is necessary. The A_1, B_1, and C_1 are the constants of the equation of a line from which the perpendicular is drawn. The perpendicular is used to determine the tangent to a point on a contour line. Similarly, the equation for the distance for the second perpendicular is

$$d_2 = \frac{A_2 x_1 + B_2 y_1 + C_2}{\pm\sqrt{A_2^2 + B_2^2}} . \tag{7}$$

Equations 6 and 7 are equated and solved for an equation in x_1 and y_1. The resulting equation is the locus of the equidistance points. With the equation for the perpendicular from the lower isopressure line and the equation of the locus, the values of x_1 and y_1 at the intersections of the perpendiculars can be calculated. Then the value of x_2 and y_2 at the point from where the perpendicular was dropped can be calculated. The value of x_2 is substituted in the equation for the upper isopressure segment. If the resulting y_3 lies near enough to y_2 by a predetermined amount, x_2 and y_3 are the coordinates of the point of the streamline passing through the isopressure line. Otherwise, another iteration is made. The foregoing is explained in detail in the next section.

Computer Solution for Streamline Intersection

The stepwise procedure for the computer program to solve for the coordinates of the intersection of a streamline and succeeding isopressure line is as follows (see fig. 5):

1. Estimates x coordinate, X_2, of intersection and looks up on succeeding isopressure line to determine index for the three surrounding points. (See subroutine LOCATE.)

2. Computes constants for the circle equation through the points.

3. Calculates slope and intercept of straight line (TAN2 initial) tangent to isopressure curve using derivative equation. Also computes

slope and intercept of normal line (CTN1) and tangent line (TAN1) to preceding isopressure.

4. Solves equation for intersection of the normal (CTN1) and TAN2 lines to obtain abscissa of intersection. (XINT.)

5. Redetermines indexes and constants for points on succeeding isopressure around XINT (see steps 1 and 2).

6. Calculates slope and intercept of new TAN2 line passing through XINT.

7. Using determinants and the normal equations for TAN1 and TAN2 lines, solves for equation of locus of points equidistant from the two lines. Then solves this equation for intersection of locus line with CTN1 line (XINL, YINL).

8. Using this point and slope of line normal to TAN2 (CTN2), computes intercept of CTN2 line.

9. Then solves for intersection of normal and tangent lines using equation similar to that used for step 4.

10. Calculates ordinate of intersection using tangent line equation and isopressure curve equation.

11. If the ordinate values are sufficiently close, prints out and goes on to next point. Otherwise, goes back to step 2 and repeats computations.

MAIN Program, Subroutines, and Operating Details

MAIN Program and Data Preparation

The MAIN program for calculating streamlines between an input-output well couplet is listed in table 6. The schematic flow diagram is shown in figure 6.

The first card carries the integer variables that control the data processing and computations. The first value, NLINE, is the number of isopressure lines to be used in the calculations. NSTREAM is the number of streamlines to be calculated and NINT provides for skipping some of the isopressure points to start a streamline. NSTART is the index of the isopressure line from which the streamlines are extended initially. This line is in the radial area near the injection well and contains sufficient points to start all the streamlines required. The remaining integers on the first card (IFLAG), if not zero, direct the program to one of the boundary options in subroutine BOUND.

TABLE 6. - Streamline MAIN program with explanatory comments

```
C       MAIN PROGRAM FOR STREAMLINE CALCULATION.

        COMMON / FIELD / XA(70,70), YA(70,70), XS(70), YS(70), LGO
        DIMENSION NITAL(70), IFLAG(20)

C       READ IN COORDINATES OF ISOPRESSURE LINES AND OTHER DATA.
        READ 1000, MLINE, NSTREAM, NINT, MSTART, (IFLAG(I), I=1, NSTREAM)
 1000   FORMAT (20I3 )                                              Indexes pertaining to whole flow net.
        DO 10 M = 1, MLINE
        READ 1001, AVP, NTAL                                        Pressure and number of points on isopressure line.
 1001   FORMAT (F15.5, I10)
        PRINT 1001, AVP, NTAL
        NITAL(M) = NTAL                                             Index number of points on isopressure line.
        READ 1002,  (XA(N,M), YA(N,M), N = 1, NTAL)                 X and Y coordinates of points on isopressure line.
 1002   FORMAT (8F10.3)
        PRINT 1002, (XA(N,M), YA(N,M), N = 1, NTAL)
   10   CONTINUE

C       START DO STATEMENT FOR A STREAMLINE.
        DO 100 IS = 1, NSTREAM, NINT
        IF ( IFLAG(IS).EQ.1 )  GO TO 85                             Go to 85 to handle boundary condition.
        X1 = XA(IS, MSTART)                                         Set starting point of streamline for projection.
        Y1 = YA(IS, MSTART)

        LGO = 1
        IPTAL = 2
        XS(2)           = X1                                        Index starting point leaving room for X and Y at injection well.
        YS(2)           = Y1
        NP3 = IS
        IF ( (IS+1).GE.NSTREAM .AND.NSTREAM.GT.2 )  NP3 = NSTREAM - 2
        CALL       QUAD ( NP3, MSTART, A1, B1, R1 )                 Determine constants for equation of isopressure line from which
        MLNM2 = MLINE - 2                                             streamline is extended ("First isopressure").

C       DO STATMENT FOR A POINT ON STREAMLINE.
        DO 80 MP = MSTART, MLNM2
        IF ( MP.EQ.MSTART ) GO TO 50
        A1 = A2
        B1 = B2                                                     After first segment of streamline is calculated, reset
        R1 = R2                                                       equation constants.

   50   NE = NITAL(MP+1)
        MP1 = MP+1
        JTAG = 0
        CALL       LOCATE ( IS, MP1, NE, NP3, X1, Y1, IPTAL, X2, JTAG )  Determine index for section of second isopressure probably
        IF ( LGO.EQ.2 ) GO TO 92                                      intersected.

        CALL       QUAD ( NP3, MP1, A2, B2, R2 )                    Constants for equation of second isopressure.

        CALL STRM (A1, B1, R1, A2, B2, R2, X1, Y1, XP, YQ, MP1,     Calculates projected normals and coordinates of intersection
       1 NE, NP3, IS, IPTAL, X2, JTAG )                               with isopressure line.
        IF ( LGO.EQ.2 ) GO TO 92                                    Bypasses indexing if no intersection found.
```

TABLE 6. - Streamline MAIN program with explanatory comments--Continued

```
      IPTAL = IPTAL + 1
      XS(IPTAL) = XP                                              Indexes point of intersection as a point on streamline.
      YS(IPTAL) = YQ
      IF (IFLAG(IS).EQ.2)  CALL BOUND (IFLAG, IPTAL, MSTART, MLINE,   Handles diagonal boundary.
     1 NTAL, NITAL, IS )
      X1 = XS(IPTAL)
      Y1 = YS(IPTAL)
   80 CONTINUE
      GO TO 90

   85 CALL BOUND ( IFLAG, IPTAL, MSTART, MLINE, NTAL, NITAL, IS )     Handles vertical boundary.
      GO TO 92

C     SET INITIAL AND FINAL POINTS ON STREAMLINE .
   90 IPTAL = IPTAL + 1
      XS(IPTAL) = XA(1, MLINE)                                    Coordinates of point near production well.
      YS(IPTAL) = YA(1, MLINE)
   92 XS(1) = XA(1,1)                                             Coordinates of point near injection well.
      YS(1) = YA(1,1)

C     PUNCH OUTPUT FOR SHAPE FACTOR PROGRAM.
      IN = MOD(IS+1, 2)  + 1                                      Every other value on every other streamline is omitted
      PUNCH 3000, (XS(IP), IP = 1, IPTAL, IN )                      because it is in interior of cell.
 3000 FORMAT ( 7F10.4 )
      PUNCH 3000, (YS(IP), IP = 1, IPTAL, IN )
      PUNCH 3000

C     PRINT OUT VALUES FOR STREAMLINE.
   95 PRINT 2010, IS
 2010 FORMAT ( *1    STREAMLINE * I2 / *     XS          YS    * )
      DO  100 IP = 1, IPTAL
  100 PRINT 2011, XS(IP), YS(IP)
 2011 FORMAT ( 2F10.3 )

      STOP
      END
```

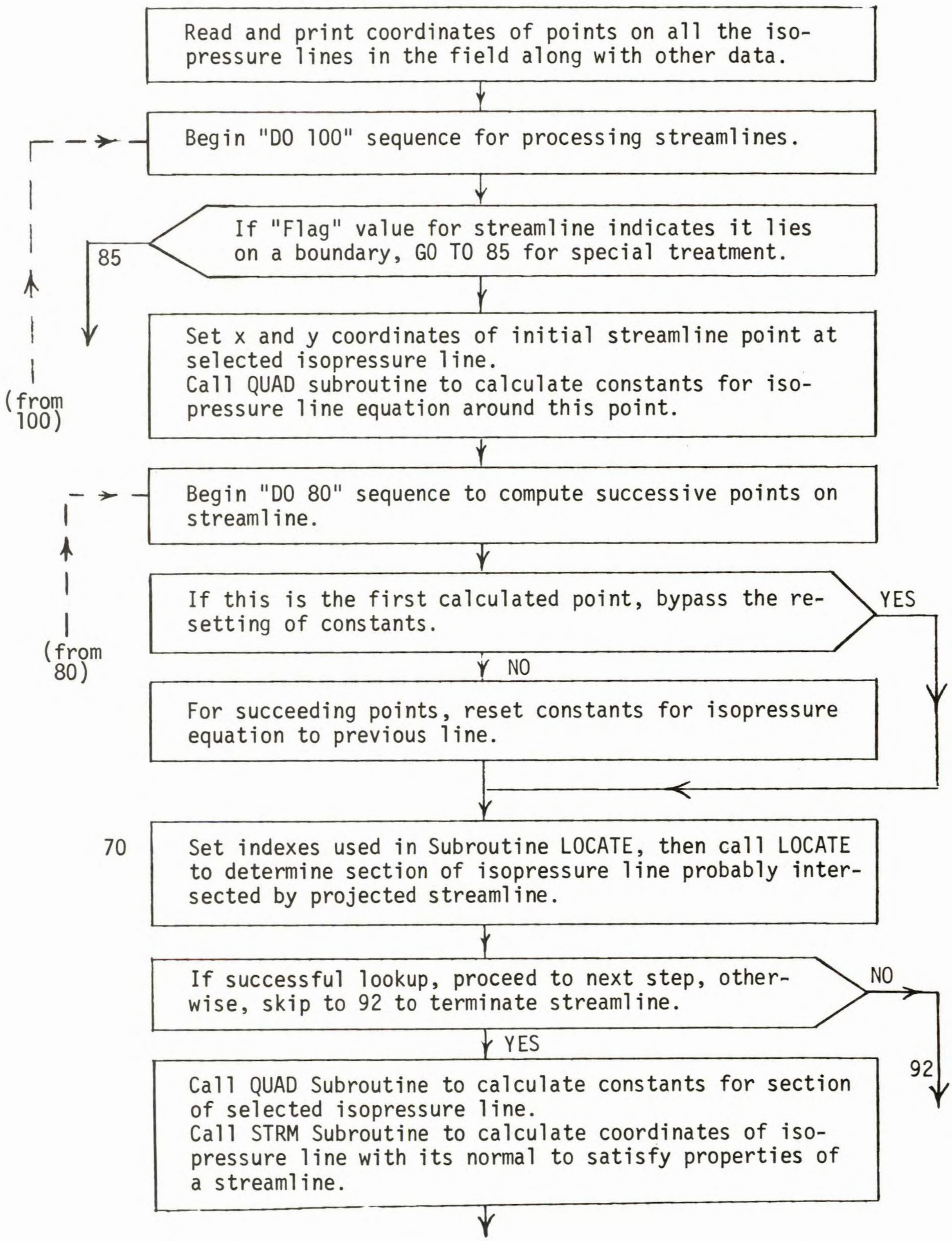


FIGURE 6. - Schematic Flow Diagram for Streamline MAIN Program.

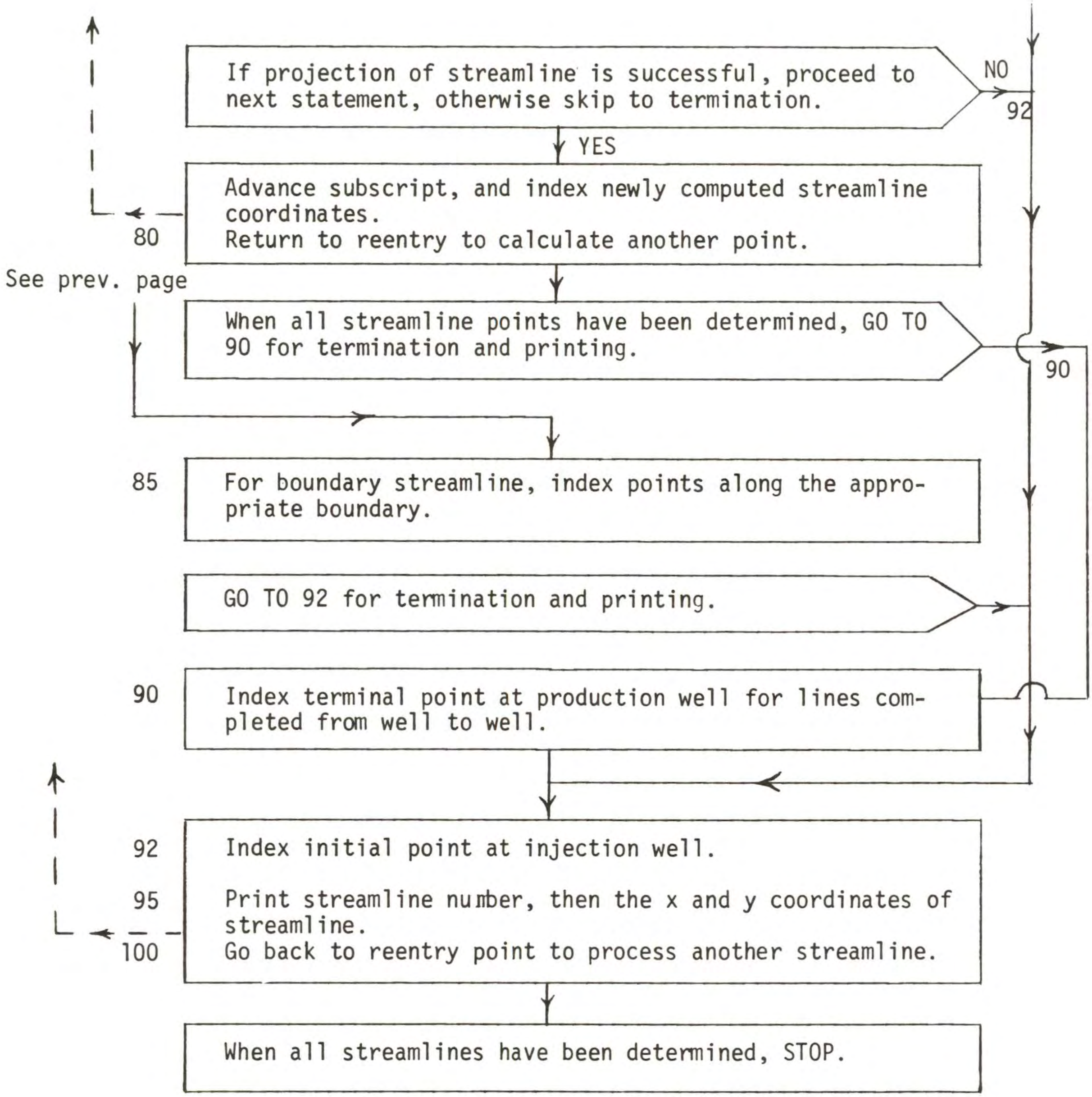


FIGURE 6. - Schematic Flow Diagram for Streamline MAIN Program.—Continued

The remaining data are the sets of isopressure coordinates determined using the isopressure program. The first or header card of each set contains the pressure, number of points, and the beginning and ending x and y coordinates of the isopressure line. The remaining cards contain the coordinates of all the points. Included is a one-value set each for the input and output wells. For the example presented in this paper, the data in the right side of the field (KK = 1) were used because a plot[6] of those isopressure lines

[6]The plot was made quickly and accurately by machine from data punched from computer memory.

showed apparently adequate coverage of the pattern element. If a higher density of lines in an area is desired, additional lines can be selected from data determined using the infill sweep (KK = 5) by aid of a complete plot and the data on the header card for each isopressure line.

For each streamline, the program processed the first projected point. Then in the DO 80 statement, each succeeding point is determined and the streamline is continued until the last isopressure line is intersected unless the calculation is terminated. The program then adds the coordinates of the input well and, if the streamline is complete, adds the coordinates of the output well. After all the streamlines have been determined, the coordinates are punched on cards and printed out according to the input format required by the shape factor calculation program published in Report of Investigations 6760 (2) or Report of Investigations 7111 (4).

Locating Index on Isopressure Line--Subroutine LOCATE

The index of the nearest point on an isopressure line intersected by a streamline is determined by use of the "IF" statements in subroute LOCATE, shown in table 7. The first set of IF statements attempts to locate a pair of isopressure points having x coordinates on either side of the estimated intersection. If this fails, the second set attempts a lookup along the y axis. When an index is found, the other coordinate is tested for closeness to insure that the points located are not on another section of the isopressure line.

When the isopressure line has a steep slope, it is frequently necessary to increase the streamline's estimated x coordinate to locate an intersection. The x increment is estimated initially in the first statements of the subroutine, and if necessary, the value is further increased. The flow diagram for the subroutine is shown in figure 7.

The procedure to obtain the orthogonal streamlines previously explained is programed in subroutine STRM shown in table 8. The flow diagram is in figure 8.

TABLE 7. - Program for subroutine LOCATE with explanatory comments

```
      SUBROUTINE LOCATE (  IS, MP, NE, NP3, X1, Y1, IPTAL, X2, JTAG )
      COMMON / FIELD / XA(70,70), YA(70,70), XS(70), YS(70), LGO

      NB = 1
      NEM1 = NE - 1                                                    Estimate of "step-out" on x equals unit grid length
      IF (IPTAL.LE.2 ) DEL = (X1-XA(1,1)) / SQRT ((X1-XA(1,1))**2 +      (not shown) times cosine of streamline angle from well.
     1  (Y1-YA(1,1))**2 )
      IF (IPTAL.GT.2 ) DEL = XS(IPTAL) - XS(IPTAL-1)                   Subsequently use previous x difference.
      IF ( JTAG.GT. 0 )   DEL = 0                                      In lookup from STRM, do not step out.
      XT = X1 + DEL  *  0.7                                            "Stepout" probably only goes part way.
      NNN = 0

10    CONTINUE
      DO 20  NT =  NB, NEM1
      IF (XA(NT,MP) .LE. XT.AND.XT.LT.XA(NT+1, MP)) GO TO 50           Lookup in x direction.
      IF (XA(NT,MP) .GE. XT.AND.XT.GT.XA(NT+1, MP)) GO TO 50
20    CONTINUE
      DO 30  NT = NB, NEM1
      IF (YA(NT,MP) .LE. Y1.AND.Y1.LT.YA(NT+1, MP)) GO TO 60           Lookup in y direction.
      IF (YA(NT, MP).GE. Y1.AND.Y1.GT.YA(NT+1, MP)) GO TO 60
30    CONTINUE

36    NB = 1                                               Start at beginning of pressure line with increased stepout.
      NNN = NNN + 1                                        Advance counter on "stepout" increase.
      IF ( NNN.GE.10) GO TO 90                             If more than 10 tries, probably cannot be located.  Go to 90 to
40     XT = XT + DEL/5.0                                      print message and return.
      GO TO 10

50    IF (IPTAL.LE.2 )  YS(IPTAL-1) = YS(IPTAL)          }
      YTEST = YS(IPTAL) + (YS(IPTAL) - YS(IPTAL-1) )     }  If located on x, check approximate y location.
      IF ( ABS(YA(NT,MP)-YTEST).GT.3.0 )  GO TO 80       }
      GO TO 70

60    IF (IPTAL.LE.2 )  XS(IPTAL-1) = XS(IPTAL)          }
      XTEST = XS(IPTAL) + (XS(IPTAL) - XS(IPTAL-1) )     }  If located on y, check approximate x location.
      IF ( ABS(XA(NT,MP)-XTEST).GT.1.5 )  GO TO 80       }
      XT = XA(NT,MP)                                        If located on y, an x value is needed.

70    NP3 = NT                                              Set index of nearby point;
      IF ( NP3.GT.(NE-2) )  NP3 = NE - 2                      change if too near end of pressure line.
      X2 = XT
      RETURN

80    NB = NT + 1                                           Advance starting index of lookup to try another portion of line.
      IF ( NB.LE.NEM1 )  GO TO 10
      GO TO 36                                              If at end of line, go through steps to increase stepout and
                                                               repeat lookup.
90    PRINT 9000, NE, MP
9000  FORMAT (   *1  FAILURE TO LOCATE     NE= * I3,  * MP= * I3  )
      LGO = 2
      RETURN
      END
```

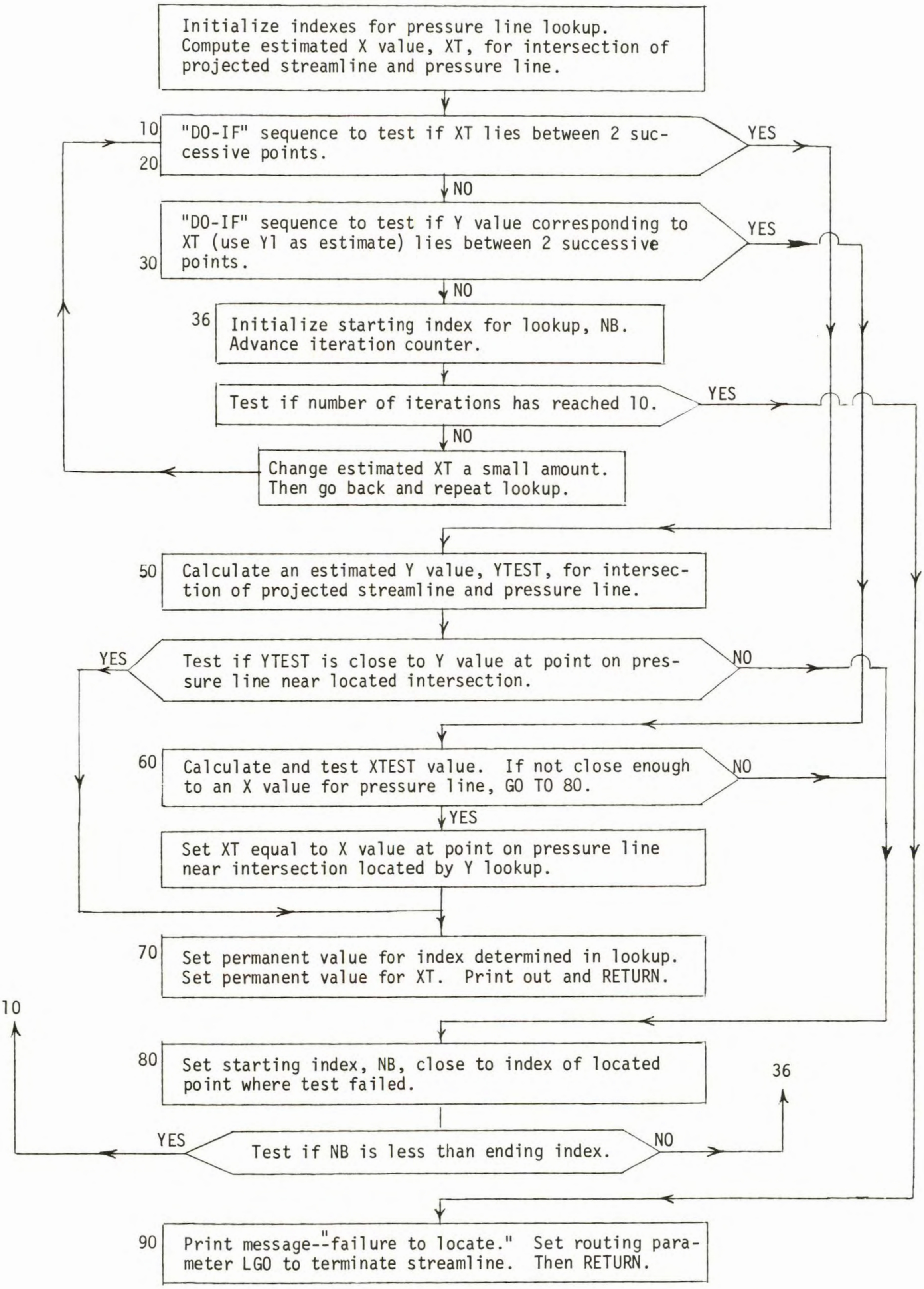


FIGURE 7. - Schematic Flow Diagram for Subroutine LOCATE.

TABLE 8. - Program for subroutine STRM with explanatory comments

Program	Explanatory comments
`      SUBROUTINE STRM (A1, B1, R1, A2, B2, R2, X1, Y1, XP, YQ, MP,`	
`     1 NE, NP3, IS, IPTAL, X2, JTAG )`	
`      COMMON / FIELD / X (70,70), Y (70,70), XS(70), YS(70), LGO`	
`C     FUNCTION DEFINITIONS`	
`      CTN (TANN) = -1.0/TANN`	Cotangent from tangent.
`      AS ( Y , TANN, X ) = Y  - TANN * X`	Y intercept in a linear equation.
`C     CALCULATES FIRST VALUE OF INTERSECTION`	
`      TAN1 =TN(A1, R1, X1, Y1, Y1, B1 )`	Tangent to isopressure line (previous or No. 1) at coordinates of streamline.[1]
`      IF ( ABS(TAN1).GT.1.0E+4  )  GO TO 92`	
`      AS1 = AS ( Y1, TAN1, X1 )`	Y intercept for tangent.
`      CTN1 = CTN(TAN1)`	Cotangent.
`      ACTN1 = AS ( Y1, CTN1, X1 )`	Y intercept for cotangent equation.
`      TAN2 = TN(A2, R2, X2, Y(NP3,MP),  Y(NP3+1,MP), B2 )`	Tangent to isopressure line (succeeding or No. 2) at nearly the same X as for isopressure No. 1.
`      IF ( ABS(TAN2).GT.1.0E+4  )  GO TO 94`	Test if isopressure No. 2 is vertical.
`      Y2 = Y VALUE ( A2, B2, R2, X2,   Y(NP3,MP), Y(NP3+1,MP) )`	Value of Y for isopressure No. 2 at nearly the same X as for isopressure No. 1.
`      AS2 = AS ( Y2, TAN2, X2 )`	Value of Y intercept for equation of tangent to isopressure No. 2.
`      XINT = ( ACTN1 - AS2 ) / ( TAN2 - CTN1 )`	Value of X where the cotangent for isopressure No.1 intersects the tangent to isopressure No. 2.
`      ITER = 0`	
`      JTAG = 1`	
`      CALL      LOCATE ( IS, MP, NE, NP3, XINT, Y1, IPTAL, X2, JTAG )`	Verify or refine lookup of section of isopressure line at intersection.
`      XINT = X2`	
`   50 CALL      QUAD ( NP3, MP,  A2, B2, R2 )`	Obtains constants of circle equation for improved position on isopressure No. 2.
`      IF ( (R2**2 - (XINT-A2)**2 ) .LE.0.0 )  GO TO 85`	Test if x value falls outside of circle comprising section of isopressure line.
`C     CALCULATES ITERATED VALUE FOR INTERSECTION`	
`   60 TAN2 =TN(A2, R2, XINT, Y(NP3,MP), Y(NP3+1,MP), B2 )`	New tangent at the improved location.
`      IF ( ABS(TAN2).GT.1.0E+4  )  GO TO 94`	Tests if isopressure line No. 2 is vertical.
`      Y2 = Y VALUE ( A2, B2, R2, XINT, Y(NP3,MP), Y(NP3+1,MP) )`	Value of Y at point of intersection of perpendicular (cotangent) from isopressure No. 1 to isopressure No. 2 at improved location.
`      AS2 = AS ( Y2, TAN2, XINT )`	New Y intercept for tangent equation at foregoing point.
`      DM1 = SQRT ( TAN1 ** 2 + 1.0 )`	Denominator of equation for length of a perpendicular from a line - isopressure No. 1.
`      DM2 = SQRT ( TAN2 ** 2 + 1.0 )`	Denominator of equation for length of a perpendicular from a line - isopressure No. 2.

TABLE 8. - Program for subroutine STRM with explanatory comments--Continued

Program	Explanatory comments
ASD1 = AS1 / D M1 ASD2 = AS2 / D M2 TAND1 = TAN1 / D M1 TAND2 = TAN2 / D M2	Denominators are divided into coefficients of numerator terms of the equation for the length of perpendiculars from a line. In the equation $d_1 = \frac{a_1x_1 + b_1y_1 + c_1}{\pm\sqrt{a_1^2 + b_1^2}}$ $DM1 = \sqrt{(TAN1)^2 + (-1.0)^2}$ a_1 = TAN1 a_2 = TAN2 b_1 = -1.0 b_2 = -1.0 c_1 = AS1 c_2 = AS2
YD1 = -1.0 / DM1 YD2 = -1.0 / DM2 ASC = ASD1 + ASD2	$d_1 = -d_2$ therefore $\frac{a_1x_1 + b_1y_1 + c_1}{DM1} = \frac{-a_2x_2 - b_2y_2 - c_2}{DM2}$ or $\frac{a_1x_1}{DM1} + \frac{a_2x_1}{DM2} + \frac{b_1y_1}{DM1} + \frac{b_2y_1}{DM2} + \frac{c_1}{DM1} + \frac{c_2}{DM2} = 0$ or TANC*X1 + YC*Y1 + ASC = 0, the equation of the locus of the equal perpendiculars.
TANC = TAND1 + TAND2	$\overset{d_1}{-\,TANC} * X - \overset{e_1}{YC} * Y = \overset{f_1}{ASC}$ equation of locus
YC = YD1 + YD2	$\overset{d_2}{-\,CTN1} * X + \overset{e_2}{(1)} * Y = \overset{f_2}{ACTN1}$ equation of first cotangent
C FINDS VALUES OF X AND Y AT INTERSECTION OF LOCUS AND COTANGENT C NUMBER 1 BY DETERMINANTS.	
DEM = (-TANC - (-CTN1 * (- YC))) XINL = (ASC -(-YC)*ACTN1) / DEM YINL = (-TANC * ACTN1 - ASC*(-CTN1)) / DEM	$XINL = x = \frac{\begin{vmatrix} f_1 & e_1 \\ f_2 & e_2 \end{vmatrix}}{\begin{vmatrix} d_1 & e_1 \\ d_2 & e_2 \end{vmatrix}}$, where $DEM = \begin{vmatrix} d_1 & e_1 \\ d_2 & e_2 \end{vmatrix}$, and $YINL = y = \frac{\begin{vmatrix} d_1 & f_1 \\ d_2 & f_2 \end{vmatrix}}{DEM}$
C FINDS THE VALUE OF X AND Y ON TANGENT NUMBER 2.	
CTN2 = CTN (TAN2)	Cotangent.
ACTN2 = AS (YINL, CTN2, XINL)	Y intercept using coordinates of y and x at the point junction of the two cotangents.
XP = (ACTN2 - AS2) / (TAN2 - CTN2)	Value of x at the base of perpendicular from the tangent to isopressure No. 2. This perpendicular intersects the perpendicular from isopressure No. 1 so that the length of perpendiculars are equal.
YP = AS2 + TAN2 * XP	Value of y at the same point for x above.
IF ((R2**2 - (XP -A2)**2) .LE.0.0) GO TO 85	Test if x value is outside of circle.
YQ = Y VALUE (A2, B2, R2, XP, Y(NP3,MP), Y(NP3+1,MP))	Value of y using isopressure line equation corresponding to x above.
C TESTS Y VALUES FOR CONVERGENCE AND PREPARES TO ITERATE IF REQUIRED	
IF (ABS(YP-YQ) .LT. 0.0100) LGO = 1 IF (ABS (YP - YQ) .LT. 0.0100) RETURN	If YP from perpendiculars is close enough to isopressure No. 2, return; otherwise another iteration is made.

TABLE 8. - Program for subroutine STRM with explanatory comments--Continued

```
 70  XINT = XP
     TAN2 = TN(A2, R2, XP, Y(NP3,MP),  Y(NP3+1,MP), B2 )            Tangent at calculated point.
     IF ( ABS(TAN2).GT.1.0E+4  )  GO TO 94                           Test if isopressure line is vertical.

     ITER = ITER + 1                                                 Advance iteration counter and proceed if less than 10.
     IF ( ITER .GT. 10 ) GO TO 90

     CALL       LOCATE ( IS, MP, NE, NP3, XINT, YQ, IPTAL, X2, JTAG )  Locate index of isopressure line section and go to 50 to complete
     GO TO 50                                                          another iteration.


C    PROVISIONS FOR HANDLING IRREGULAR SITUATIONS

 85  PRINT 8500                                                      x value falls outside of circle comprising section of
8500 FORMAT (  *   ABSCISSA INCOMPATABLE WITH CIRCLE EQUATION   *  )    isopressure line.
     LGO = 2
     RETURN

 90  PRINT 9000                                                      If 10 iterations do not provide convergence on an intersection,
9000 FORMAT (  *   FAILURE TO CONVERGE  *  )                            there is probably an error in data.
     LGO = 2
     RETURN

 92  YQ = Y1 + .01                       Horizontal streamline directed slightly upward.
     GO TO 95
 94  YQ = Y1 - .01                       Horizontal streamline directed slightly downward.
 95  XP = X(NP3,MP)
     LGO = 1
     RETURN

     END
```

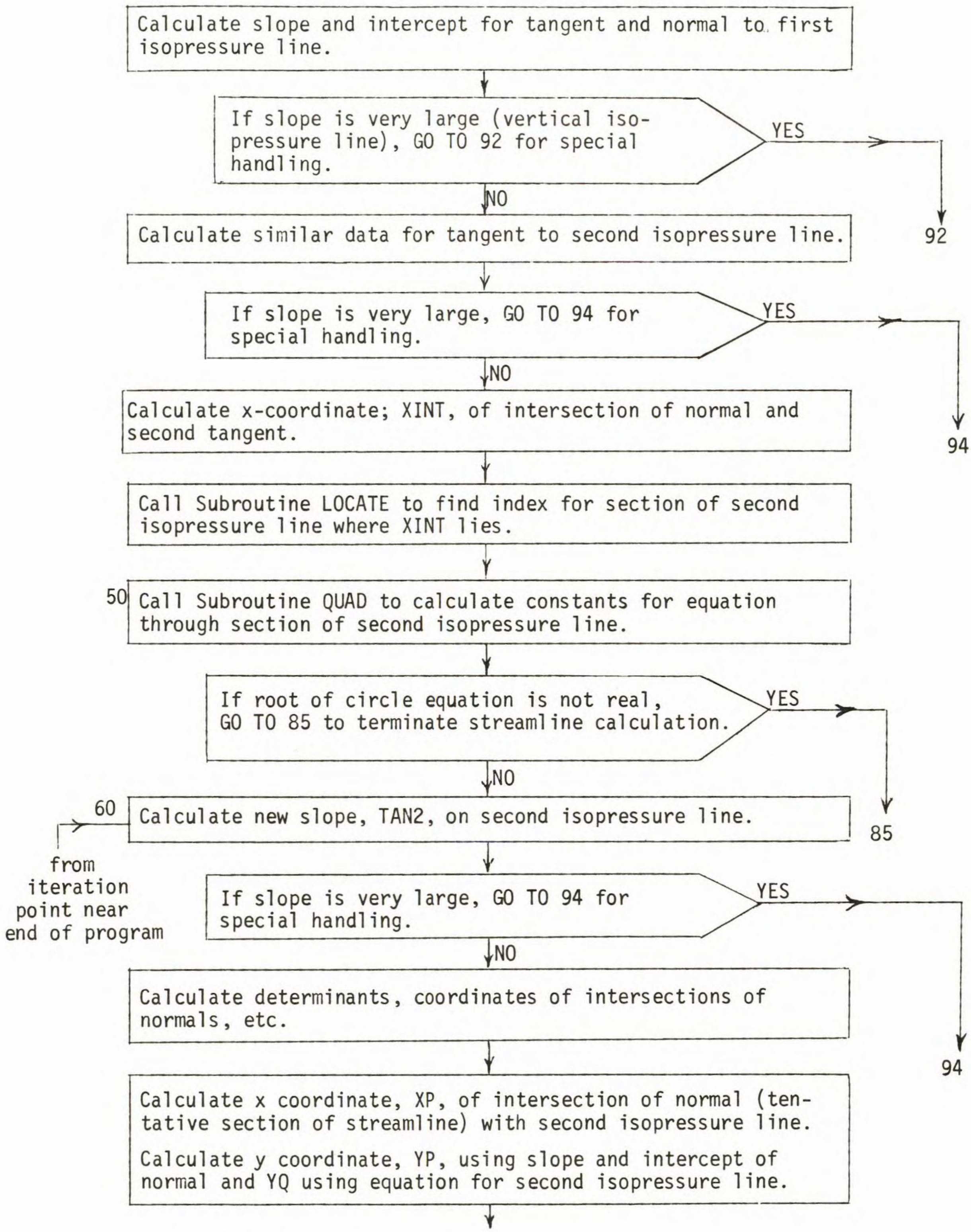


FIGURE 8. - Schematic Flow Diagram for Subroutine STRM.

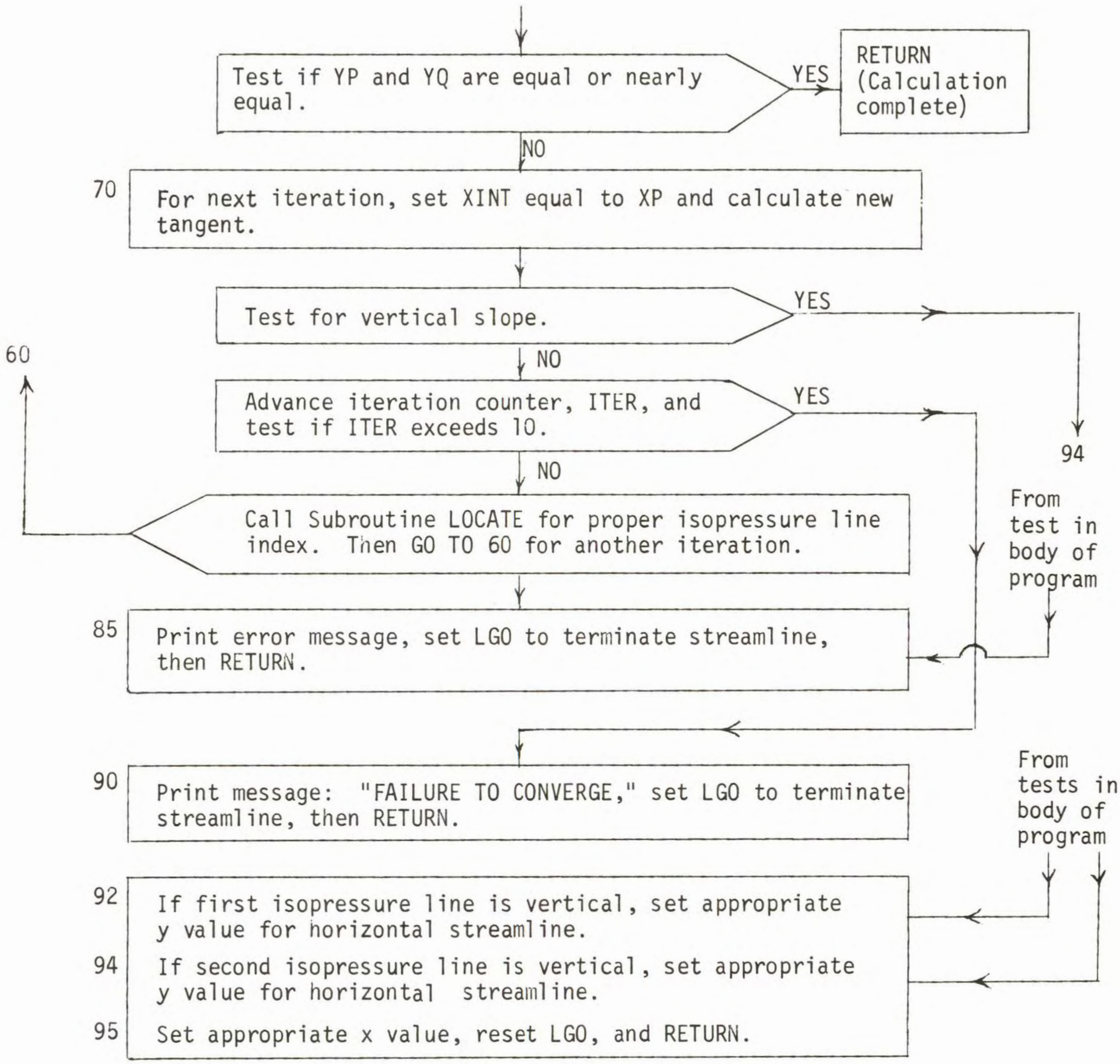


FIGURE 8. - Schematic Flow Diagram for Subroutine STRM.—Continued

Circle Equation Between Isopressure Points-- Subroutine QUAD

Subroutine QUAD solves for the constants of the equation of circle passing through the three points near the intersection. This subroutine is listed in table 9. This type of equation was used because of the circular shape of isopressures around wells and because the previously used quadratic equation proved occasionally to interpolate nonmonotonically for a steep-sloping isopressure line.

TABLE 9. - Program for subroutine QUAD with explanatory comments

```
SUBROUTINE QUAD ( NP3, MP, A, B, R )
COMMON / FIELD / X (70,70), Y (70,70), XS(70), YS(70), LGO

DELX12 = X(NP3,MP) - X(NP3+1,MP)
DELX23 = X(NP3+1,MP) - X(NP3+2,MP)
DELY12 = Y(NP3,MP) - Y(NP3+1,MP)
DELY23 = Y(NP3+1,MP) - Y(NP3+2,MP)                  Differences used to solve for constants.
DXSQ12 = X(NP3,MP)**2 - X(NP3+1,MP)**2
DXSQ23 = X(NP3+1,MP)**2 - X(NP3+2,MP)**2
DYSQ12 = Y(NP3,MP)**2 - Y(NP3+1,MP)**2
DYSQ23 = Y(NP3+1,MP)**2 - Y(NP3+2,MP)**2

IF ( DELX12.EQ.0. )  DELX12 = 0.1E-10
IF ( DELY12.EQ.0. )  DELY12 = 0.1E-10
IF ( DELY23.EQ.0. )  DELY23 = 0.1E-9

B = ( DELX23*(DXSQ12+DYSQ12) - DELX12*(DXSQ23+DYSQ23) )  /
1 2.0 / (DELY12*DELX23 - DELY23*DELX12)             Constants A, B, and R to satisfy
A = (DXSQ12 + DYSQ12 - 2.0*B*DELY12) / 2.0 / DELX12    R**2 = (X - A)**2 + (Y - B)**2
X1 = X(NP3,MP)                                       for X and Y at points IP3, IP3+1, and IP3+2.
Y1 = Y(NP3,MP)
R = SQRT((X1-A)**2 + (Y1-B)**2 )
IF ( R.GT.1.0E+5 )  R = R + 1.0

RETURN
END
```

Irregular, Discontinuous, and Extreme Conditions--
Subroutine BOUND

The principal use of the isopressure and streamline programs presented in this paper is for determination of the potentiometric flow net for any field. Before the streamline calculation can be started, the destination (output well) of each prospective streamline must be determined by aid of a plot of the isopressure lines. Each streamline starts at one of the points on the starting isopressure line (indexed NSTART), and all the isopressures to be intersected on the way to the output well can be grouped. A separate run should be made for each group of streamlines (input-output well couplet) and its group of isopressure lines. The selections can be made by aid of a plot of all the isopressures and the data on each isopressure line's header card.

In addition to using read-in points on the starting isopressure line, additional points may be selected. One or more points should be chosen at or near the streamline dividing any two injection-production-well couplets. When the exact location of the dividing streamline is not known, nearby streamlines can be calculated from estimated starting points. Then the procedure can be repeated with the adjusted starting point until the true dividing line is traced. A plot of these neighboring streamlines will reveal that the streamlines surrounding a dividing streamline will either approach a boundary or diverge abruptly to one or the other output well.

Subroutine BOUND in table 10 is a compilation of statements designed to accomplish the foregoing procedure and to handle other irregular situations. The subroutine was designed for the basic element of 7-spot pattern which is the example used in this paper. For any other flow net, many of the statements would be different.

TABLE 10. - Program for subroutine BOUND with explanatory comments

```
      SUBROUTINE BOUND ( IFLAG, IPTAL, MSTART, MLINE, NTAL, NITAL, IS )

      COMMON / FIELD / XA(70,70), YA(70,70), XS(70), YS(70), LGO
      DIMENSION NITAL(70), IFLAG(20)

      IF ( IFLAG(IS).GT.1 )   GO TO 20

C     SETS VALUES FOR VERTICAL BOUNDARY.
      IPTAL = 1
      DO 10 M = MSTART, MLINE     )
      IPTAL = IPTAL + 1           }   These XA and YA values are on vertical boundary of element.
      XS(IPTAL) = XA(IS, M)       }
      YS(IPTAL) = YA(IS, M)       )
   10 CONTINUE
      RETURN

   20 IF ( YS(IPTAL) .LE. 46.198 )   GO TO 25          Tests if above or below corner of element.

C     ADJUSTS VALUES TO COINCIDE WITH LOWER DIAGONAL LINE.
      DELTA = XS(IPTAL) * 1.7308 - YS(IPTAL)           Difference between ordinate of diagonal line (lower) from
      IF ( ABS(DELTA) .LE. 0.01 )   RETURN                injection well and calculated ordinate.
      XS(IPTAL) = XS(IPTAL) - 0.43316 * DELTA          Adjust XS by cosine of diagonal angle times difference.
      YS(IPTAL) = YS(IPTAL) + 0.25028 * DELTA            "    YS  "  sine  "    "     "     "      "
      RETURN

C     ADJUSTS VALUES TO COINCIDE WITH UPPER DIAGONAL LINE.
   25 DELTA = 61.622 - 0.57777*XS(IPTAL) - YS(IPTAL)   Difference between ordinate of diagonal line (upper) to
      IF ( ABS(DELTA) .LE. 0.01 )   RETURN                production well and calculated ordinate.
      XS(IPTAL) = XS(IPTAL) + 0.25028 * DELTA          Adjust XS and YS as described above.
      YS(IPTAL) = YS(IPTAL) + 0.43316 * DELTA
      RETURN

      END
```

Streamline number 1 shown in figure 9 is the connecting streamline between the injection and production wells in the element. Because the streamline is vertical and is at the ends of the isopressure lines, its path did not follow the straight vertical line but drifted outside the element. The first section of subroutine BOUND sets all the values of streamline 1 to the coordinates of the vertical line.

No other irregularities were encountered until the dividing streamline (No. 7) was run. Previous trial runs which showed mirror images confirmed the necessary symmetry. In the example, however, the exact location of the dividing streamline and its starting point were calculated analytically. As each point on this streamline was determined, a test in subroutine BOUND compared the point's coordinates with the corresponding point on the actual boundary. If the two points differed appreciably, the calculated point was adjusted until it coincided with the analytical point.

In the area of widest spacing of isopressure lines, streamline 7 terminated in subroutine LOCATE, owing to inability to locate an intersection with the proper isopressure line. The coordinates of the last point were used as the starting point for the second straight line (streamline 7b), and the computer run was restarted. A dummy point was selected to aid in estimating the distance for the first projection. Then streamline 7b to the output well was computed and adjusted in the same manner as 7a. It was necessary to change the first IF statement in subroutine LOCATE for processing 7b by deleting the denominator of the expression. The statement then reads "IF (IPTAL.LE.2) DEL = (X1-XA(1,1))." This procedure is to estimate the initial "stepout," DEL, based on the "pseudo" initial x coordinate read in (XA(1,1) = 22,000). The foregoing procedure could have been avoided by inserting some of the isopressure lines from the infill (KK = 5) determination.

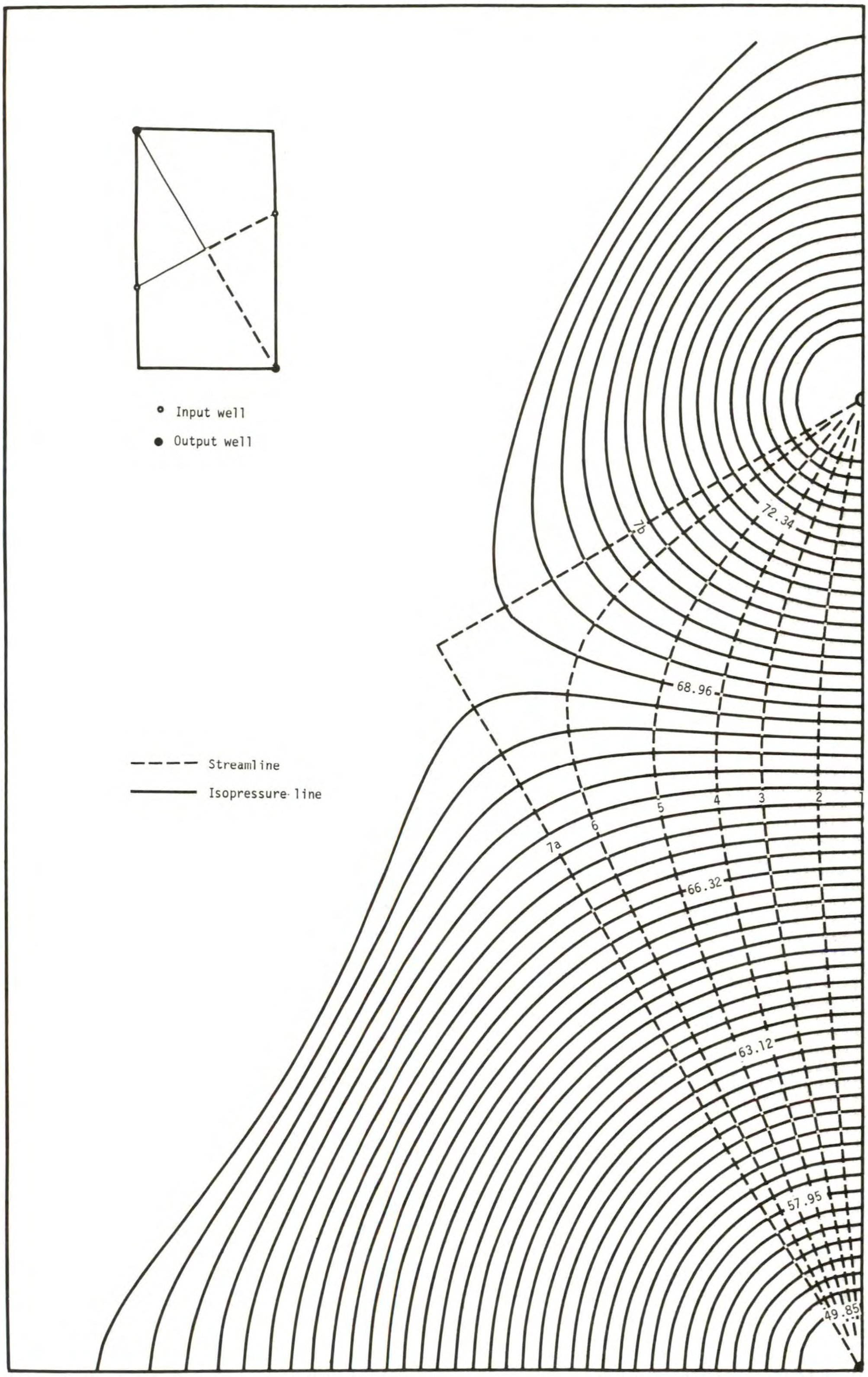


FIGURE 9. - Calculated Isopressure Lines and Streamlines for 7-Spot Element. Sketch in upper left corner shows relative locations of the wells.

It was done to illustrate the flexibility of the method and the use of plotting and restarting.

Two function subprograms used in subroutine STRM are listed in table 11.

Input Data and Results

The input data for determining isopressure lines are the pressures at points on a grid. For the example used in this paper, the pressures are on a 90- by 27-unit grid superimposed on a four-well pattern which is the smallest unit to produce a 7-spot element. The configuration is shown in the upper left hand section of figure 9. The pressures, shown in table 12, were calculated using a previously published method by the authors (5).

The x and y coordinates of each isopressure line calculated by the program are shown in table 13. The values are for the section started along the right side (KK = 1) and cover the smallest unit, or element, of a 7-spot pattern. The pressure value, AVP, number of points on the isopressure line, ITAL, and the x and y coordinates of the beginning and end of the line are printed and punched on a "header" card before each set of coordinates. All these data are used as input to the streamline program.

Table 14 contains the coordinates of the streamlines determined by the streamline program. Streamline 1 is along the right vertical boundary and streamlines 2 through 6 move through the element upward and to the left. Streamline 7 is the dividing streamline between the element and its mirror images and is shown as 7a and 7b in its two-component, straight-line sections. The first value of 7b (x = 22.000, y = 48.911) is the dummy value and should be ignored. Figure 9 is a plot of the isopressure lines and streamlines for the element. The flow net obtained using these methods agrees well with that obtained by complex higher mathematics or by potentiometric models. For the example given in the report, the calculated flow net duplicated the published one (8) well within the accuracy of the potentiometric model.

The core storage required for the streamline program is 13,000 words, and the CPU time for the 7-spot example is 5 seconds on the CDC 6600.

TABLE 11. - Listings of function subprograms used in subroutine STRM[1]

```
FUNCTION  TN ( A, R, X, V1, V2, B )

TN    =    ( X - A )  /       SQRT ( R**2 - (X-A)**2 )
IF ((V1+V2)/2.0 .GT. B )  TN = - TN
IF ( ABS(TN) .EQ. 0. )   TN = 0.1E-10

RETURN
END
```

```
FUNCTION YVALUE ( A, B, R, X, V1, V2 )

TERM   =                      SQRT ( R**2 - (X-A)**2 )
IF ((V1+V2)/2.0 .LE. B )  TERM = - TERM
YVALUE = B + TERM

RETURN
END
```

[1] These functions give values of first derivative (tangent) and ordinate for circle equation representing isopressure line.

TABLE 12. - Pressure input data for isopressure program

26.00	38.50	44.17	47.51	49.85	51.65	53.11	54.34	55.41	56.35	57.19	57.95	58.64	59.28	59.87	60.42	60.93	61.42	61.87	62.30
62.71	63.10	63.47	63.82	64.16	64.48	64.79	65.08	65.36	65.64	65.90	66.15	66.38	66.61	66.83	67.04	67.23	67.42	67.59	67.76
67.91	68.05	68.18	68.31	68.41	68.51	68.59	68.67	68.72	68.77	68.80	68.82	68.83							
38.50	41.92	45.33	48.02	50.12	51.81	53.22	54.42	55.47	56.39	57.23	57.98	58.67	59.30	59.89	60.44	60.95	61.43	61.89	62.31
62.72	63.11	63.48	63.83	64.17	64.49	64.80	65.09	65.37	65.64	65.90	66.15	66.39	66.61	66.83	67.04	67.24	67.42	67.60	67.76
67.92	68.06	68.19	68.31	68.42	68.51	68.60	68.67	68.73	68.78	68.81	68.83	68.84							
44.17	45.33	47.22	49.11	50.80	52.27	53.54	54.66	55.65	56.54	57.34	58.08	58.75	59.37	59.95	60.49	61.00	61.47	61.92	62.35
62.75	63.14	63.50	63.85	64.19	64.51	64.81	65.11	65.39	65.66	65.92	66.17	66.40	66.63	66.85	67.06	67.25	67.44	67.61	67.78
67.93	68.08	68.21	68.33	68.44	68.54	68.62	68.69	68.75	68.80	68.83	68.85	68.86							
47.51	48.02	49.11	50.40	51.70	52.91	54.02	55.02	55.94	56.77	57.53	58.23	58.89	59.49	60.05	60.58	61.07	61.54	61.99	62.40
62.80	63.18	63.55	63.89	64.23	64.54	64.85	65.14	65.42	65.69	65.95	66.19	66.43	66.66	66.88	67.08	67.28	67.46	67.64	67.80
67.96	68.10	68.24	68.36	68.47	68.56	68.65	68.72	68.78	68.83	68.86	68.88	68.89							
49.85	50.12	50.80	51.70	52.68	53.66	54.60	55.48	56.31	57.07	57.78	58.45	59.06	59.64	60.18	60.70	61.18	61.64	62.07	62.48
62.87	63.25	63.60	63.95	64.27	64.59	64.89	65.18	65.46	65.73	65.98	66.23	66.47	66.70	66.91	67.12	67.31	67.50	67.68	67.85
68.00	68.15	68.28	68.40	68.51	68.61	68.69	68.77	68.83	68.88	68.91	68.93	68.94							
51.65	51.81	52.27	52.91	53.66	54.45	55.24	56.00	56.73	57.43	58.08	58.70	59.28	59.83	60.35	60.84	61.31	61.75	62.18	62.58
62.96	63.33	63.68	64.02	64.34	64.65	64.95	65.24	65.51	65.78	66.03	66.28	66.52	66.74	66.96	67.16	67.36	67.55	67.73	67.89
68.05	68.19	68.33	68.45	68.57	68.66	68.75	68.83	68.89	68.93	68.97	68.99	69.00							
53.11	53.22	53.54	54.02	54.60	55.24	55.89	56.55	57.20	57.82	58.42	58.99	59.54	60.06	60.55	61.02	61.46	61.89	62.30	62.69
63.06	63.42	63.77	64.10	64.42	64.72	65.02	65.30	65.57	65.84	66.09	66.34	66.57	66.80	67.01	67.22	67.42	67.61	67.78	67.95
68.11	68.26	68.39	68.52	68.63	68.73	68.82	68.90	68.96	69.01	69.04	69.07	69.07							
54.34	54.42	54.66	55.02	55.48	56.00	56.55	57.12	57.69	58.24	58.79	59.31	59.82	60.30	60.77	61.21	61.64	62.05	62.44	62.82
63.19	63.53	63.87	64.19	64.51	64.81	65.10	65.38	65.65	65.91	66.16	66.40	66.64	66.86	67.08	67.29	67.49	67.67	67.85	68.02
68.18	68.33	68.47	68.60	68.71	68.81	68.91	68.98	69.05	69.10	69.13	69.15	69.16							
55.41	55.47	55.65	55.94	56.31	56.73	57.20	57.69	58.18	58.68	59.17	59.65	60.11	60.57	61.00	61.43	61.83	62.23	62.60	62.97
63.32	63.66	63.98	64.30	64.61	64.90	65.19	65.47	65.73	65.99	66.24	66.48	66.71	66.94	67.15	67.36	67.56	67.75	67.93	68.10
68.26	68.42	68.56	68.69	68.80	68.91	69.00	69.08	69.15	69.20	69.24	69.26	69.27							
56.35	56.40	56.54	56.77	57.07	57.43	57.82	58.24	58.68	59.12	59.56	60.00	60.43	60.85	61.26	61.65	62.04	62.41	62.78	63.13
63.47	63.79	64.11	64.42	64.72	65.01	65.29	65.56	65.82	66.08	66.33	66.57	66.80	67.02	67.24	67.45	67.65	67.84	68.02	68.19
68.36	68.51	68.66	68.79	68.91	69.02	69.11	69.19	69.26	69.31	69.35	69.38	69.39							
57.19	57.23	57.34	57.54	57.78	58.08	58.42	58.79	59.17	59.56	59.96	60.36	60.75	61.14	61.52	61.90	62.26	62.62	62.96	63.30
63.62	63.94	64.25	64.55	64.84	65.12	65.40	65.66	65.92	66.18	66.42	66.66	66.89	67.11	67.33	67.54	67.74	67.93	68.12	68.29
68.46	68.62	68.76	68.90	69.02	69.14	69.24	69.32	69.39	69.45	69.49	69.51	69.52							
57.95	57.98	58.08	58.24	58.45	58.70	58.99	59.31	59.65	60.00	60.36	60.72	61.08	61.44	61.80	62.14	62.49	62.82	63.16	63.48
63.79	64.09	64.39	64.68	64.97	65.24	65.51	65.77	66.03	66.28	66.52	66.76	66.99	67.21	67.43	67.64	67.84	68.04	68.23	68.40
68.57	68.73	68.89	69.03	69.16	69.27	69.37	69.46	69.54	69.59	69.64	69.66	69.67							
58.64	58.67	58.75	58.89	59.06	59.28	59.53	59.81	60.11	60.43	60.75	61.08	61.41	61.74	62.07	62.40	62.72	63.04	63.36	63.66
63.96	64.26	64.55	64.83	65.10	65.37	65.64	65.90	66.15	66.39	66.63	66.87	67.09	67.32	67.53	67.75	67.95	68.15	68.34	68.52
68.70	68.86	69.02	69.16	69.30	69.42	69.52	69.62	69.70	69.76	69.80	69.83	69.84							
59.28	59.30	59.37	59.49	59.64	59.83	60.05	60.30	60.56	60.84	61.14	61.44	61.74	62.05	62.36	62.66	62.97	63.27	63.57	63.86
64.15	64.43	64.71	64.98	65.25	65.51	65.77	66.02	66.27	66.51	66.75	66.98	67.21	67.43	67.65	67.86	68.07	68.27	68.46	68.65
68.83	69.00	69.16	69.31	69.45	69.58	69.69	69.79	69.87	69.94	69.99	70.01	70.03							
59.87	59.89	59.95	60.05	60.18	60.35	60.54	60.76	61.00	61.25	61.52	61.79	62.07	62.36	62.64	62.93	63.21	63.50	63.78	64.06
64.33	64.60	64.87	65.14	65.39	65.65	65.90	66.15	66.39	66.63	66.87	67.10	67.32	67.55	67.77	67.98	68.19	68.39	68.59	68.78
68.97	69.15	69.31	69.47	69.62	69.75	69.87	69.98	70.07	70.14	70.19	70.22	70.23							
60.42	60.44	60.49	60.58	60.70	60.84	61.02	61.21	61.42	61.65	61.89	62.14	62.40	62.66	62.93	63.19	63.46	63.73	64.00	64.26
64.52	64.78	65.04	65.29	65.55	65.79	66.04	66.28	66.52	66.76	66.99	67.22	67.45	67.67	67.89	68.10	68.32	68.52	68.73	68.92
69.12	69.30	69.48	69.64	69.80	69.94	70.07	70.18	70.28	70.36	70.41	70.45	70.46							
60.94	60.95	61.00	61.08	61.18	61.31	61.46	61.64	61.83	62.03	62.25	62.48	62.72	62.96	63.21	63.46	63.71	63.96	64.21	64.47
64.71	64.97	65.21	65.46	65.70	65.94	66.18	66.42	66.65	66.89	67.12	67.35	67.57	67.80	68.02	68.24	68.45	68.66	68.87	69.07
69.27	69.47	69.65	69.83	69.99	70.15	70.28	70.41	70.51	70.60	70.66	70.70	70.71							
61.42	61.44	61.48	61.54	61.64	61.75	61.89	62.04	62.22	62.40	62.60	62.81	63.03	63.25	63.49	63.72	63.96	64.19	64.43	64.67
64.91	65.15	65.39	65.62	65.86	66.09	66.33	66.56	66.79	67.02	67.25	67.47	67.70	67.92	68.15	68.37	68.59	68.80	69.02	69.23
69.43	69.63	69.83	70.02	70.20	70.36	70.51	70.65	70.77	70.86	70.93	70.97	70.98							

TABLE 12. - Pressure input data for isopressure program--Continued

61.88	61.89	61.93	61.99	62.07	62.18	62.30	62.44	62.59	62.77	62.95	63.14	63.34	63.55	63.76	63.98	64.20	64.42	64.65	64.88
65.10	65.33	65.56	65.79	66.02	66.25	66.47	66.70	66.93	67.15	67.38	67.60	67.83	68.05	68.28	68.50	68.72	68.95	69.17	69.39
69.60	69.81	70.02	70.22	70.41	70.59	70.76	70.91	71.04	71.14	71.22	71.27	71.28							
62.31	62.32	62.36	62.41	62.49	62.58	62.69	62.81	62.96	63.11	63.28	63.45	63.64	63.83	64.03	64.23	64.44	64.65	64.87	65.08
65.30	65.52	65.74	65.96	66.18	66.40	66.62	66.84	67.06	67.29	67.51	67.73	67.96	68.18	68.41	68.64	68.86	69.09	69.32	69.55
69.77	70.00	70.22	70.43	70.64	70.84	71.03	71.19	71.34	71.46	71.55	71.60	71.62							
62.72	62.74	62.76	62.81	62.88	62.96	63.06	63.18	63.31	63.45	63.60	63.76	63.93	64.11	64.30	64.49	64.68	64.88	65.08	65.29
65.49	65.70	65.91	66.12	66.34	66.55	66.77	66.98	67.20	67.42	67.64	67.86	68.09	68.31	68.54	68.77	69.00	69.24	69.47	69.71
69.94	70.18	70.42	70.65	70.88	71.10	71.31	71.50	71.66	71.80	71.91	71.97	71.99							
63.12	63.12	63.15	63.19	63.26	63.33	63.42	63.53	63.65	63.77	63.91	64.06	64.22	64.39	64.56	64.73	64.92	65.10	65.30	65.49
65.69	65.88	66.09	66.29	66.50	66.70	66.91	67.12	67.34	67.55	67.77	67.99	68.22	68.44	68.67	68.90	69.14	69.38	69.62	69.87
70.12	70.37	70.62	70.88	71.13	71.37	71.61	71.82	72.02	72.18	72.31	72.39	72.41							
63.49	63.50	63.52	63.56	63.62	63.69	63.77	63.86	63.97	64.09	64.22	64.36	64.50	64.65	64.81	64.98	65.15	65.33	65.50	65.69
65.87	66.07	66.26	66.45	66.65	66.85	67.05	67.26	67.47	67.68	67.90	68.12	68.34	68.57	68.80	69.03	69.27	69.52	69.77	70.03
70.29	70.56	70.83	71.11	71.38	71.65	71.92	72.17	72.40	72.60	72.75	72.85	72.88							
63.85	63.86	63.88	63.91	63.96	64.03	64.10	64.19	64.29	64.39	64.51	64.64	64.77	64.91	65.06	65.22	65.38	65.54	65.71	65.88
66.06	66.24	66.43	66.61	66.81	67.00	67.20	67.40	67.60	67.81	68.02	68.24	68.46	68.69	68.92	69.16	69.40	69.65	69.92	70.18
70.46	70.74	71.03	71.33	71.64	71.94	72.25	72.54	72.82	73.06	73.26	73.38	73.43							
64.19	64.20	64.22	64.25	64.30	64.36	64.42	64.50	64.59	64.69	64.80	64.91	65.04	65.17	65.31	65.45	65.60	65.76	65.91	66.08
66.24	66.42	66.59	66.77	66.95	67.14	67.33	67.53	67.73	67.93	68.14	68.36	68.58	68.80	69.03	69.28	69.52	69.78	70.05	70.33
70.61	70.92	71.23	71.55	71.89	72.24	72.58	72.94	73.27	73.58	73.82	73.99	74.05							
64.53	64.53	64.55	64.58	64.62	64.67	64.73	64.80	64.89	64.98	65.08	65.18	65.30	65.42	65.55	65.68	65.82	65.96	66.11	66.27
66.43	66.59	66.76	66.93	67.10	67.28	67.47	67.66	67.85	68.05	68.26	68.47	68.69	68.91	69.15	69.39	69.64	69.90	70.18	70.46
70.76	71.08	71.41	71.76	72.13	72.52	72.93	73.34	73.75	74.14	74.48	74.71	74.80							
64.85	64.85	64.87	64.90	64.93	64.98	65.03	65.10	65.17	65.26	65.34	65.44	65.55	65.66	65.78	65.90	66.03	66.17	66.30	66.45
66.60	66.76	66.91	67.08	67.24	67.42	67.60	67.78	67.97	68.16	68.36	68.57	68.79	69.01	69.24	69.49	69.74	70.01	70.29	70.58
70.89	71.23	71.58	71.96	72.36	72.79	73.25	73.75	74.25	74.76	75.23	75.58	75.72							
65.16	65.16	65.18	65.20	65.23	65.27	65.33	65.38	65.45	65.52	65.61	65.70	65.79	65.89	66.01	66.12	66.24	66.36	66.50	66.63
66.77	66.92	67.07	67.22	67.38	67.55	67.72	67.90	68.08	68.27	68.47	68.67	68.88	69.10	69.34	69.58	69.83	70.10	70.38	70.68
71.01	71.35	71.72	72.12	72.56	73.03	73.56	74.13	74.76	75.43	76.10	76.66	76.92							
65.46	65.46	65.47	65.50	65.52	65.56	65.61	65.66	65.72	65.79	65.86	65.95	66.03	66.13	66.22	66.33	66.44	66.56	66.68	66.81
66.94	67.08	67.22	67.36	67.52	67.68	67.84	68.01	68.19	68.37	68.56	68.76	68.97	69.19	69.42	69.66	69.91	70.18	70.46	70.77
71.09	71.45	71.83	72.25	72.71	73.23	73.81	74.47	75.22	76.10	77.07	78.05	78.64							
65.75	65.75	65.77	65.78	65.81	65.84	65.88	65.93	65.99	66.04	66.11	66.18	66.27	66.35	66.44	66.54	66.64	66.74	66.86	66.97
67.10	67.23	67.36	67.50	67.65	67.79	67.95	68.11	68.29	68.46	68.65	68.84	69.05	69.26	69.49	69.72	69.97	70.24	70.53	70.83
71.16	71.52	71.91	72.34	72.82	73.36	73.98	74.70	75.58	76.66	78.04	79.80	81.56							
66.04	66.04	66.05	66.07	66.09	66.12	66.15	66.20	66.24	66.30	66.35	66.42	66.49	66.57	66.65	66.74	66.83	66.93	67.03	67.14
67.25	67.37	67.50	67.63	67.77	67.91	68.06	68.22	68.38	68.55	68.73	68.92	69.11	69.32	69.54	69.77	70.02	70.28	70.56	70.87
71.19	71.55	71.94	72.38	72.86	73.41	74.04	74.79	75.72	76.92	78.64	81.56	88.00							
66.32	66.32	66.33	66.34	66.36	66.38	66.42	66.45	66.49	66.54	66.59	66.65	66.71	66.78	66.86	66.93	67.02	67.11	67.20	67.30
67.41	67.51	67.63	67.75	67.88	68.02	68.16	68.30	68.46	68.62	68.80	68.98	69.17	69.37	69.58	69.81	70.05	70.31	70.59	70.88
71.20	71.55	71.94	72.36	72.84	73.37	73.99	74.71	75.58	76.66	78.05	79.80	81.56							
66.59	66.59	66.60	66.61	66.63	66.65	66.67	66.71	66.74	66.78	66.82	66.88	66.93	66.99	67.05	67.13	67.20	67.28	67.36	67.46
67.55	67.65	67.76	67.87	67.99	68.12	68.25	68.39	68.54	68.69	68.86	69.03	69.21	69.41	69.61	69.83	70.07	70.32	70.58	70.87
71.18	71.52	71.89	72.30	72.75	73.26	73.83	74.48	75.23	76.10	77.07	78.04	78.64							
66.86	66.86	66.87	66.87	66.89	66.90	66.93	66.95	66.98	67.01	67.05	67.09	67.14	67.19	67.25	67.31	67.38	67.45	67.52	67.60
67.69	67.78	67.88	67.98	68.10	68.21	68.34	68.47	68.61	68.75	68.91	69.07	69.25	69.43	69.63	69.84	70.07	70.30	70.56	70.84
71.14	71.46	71.81	72.19	72.61	73.07	73.59	74.15	74.77	75.43	76.10	76.66	76.92							
67.12	67.13	67.13	67.14	67.15	67.16	67.17	67.20	67.22	67.25	67.28	67.31	67.35	67.39	67.44	67.49	67.55	67.61	67.67	67.75
67.82	67.91	68.00	68.09	68.19	68.30	68.41	68.54	68.67	68.81	68.95	69.11	69.27	69.45	69.63	69.84	70.05	70.28	70.52	70.78
71.06	71.37	71.69	72.05	72.43	72.84	73.29	73.77	74.27	74.77	75.23	75.58	75.71							
67.39	67.39	67.39	67.39	67.40	67.41	67.42	67.44	67.45	67.47	67.50	67.52	67.55	67.59	67.63	67.67	67.72	67.77	67.83	67.89
67.95	68.03	68.11	68.19	68.28	68.38	68.49	68.60	68.72	68.85	68.99	69.13	69.29	69.45	69.63	69.82	70.02	70.23	70.46	70.71
70.97	71.25	71.55	71.87	72.22	72.58	72.97	73.36	73.76	74.14	74.47	74.70	74.79							
67.65	67.65	67.65	67.65	67.65	67.66	67.66	67.67	67.68	67.70	67.71	67.73	67.75	67.78	67.81	67.84	67.88	67.92	67.97	68.02
68.08	68.14	68.21	68.29	68.37	68.46	68.55	68.66	68.76	68.88	69.01	69.15	69.29	69.45	69.61	69.79	69.97	70.17	70.39	70.62
70.86	71.12	71.39	71.68	71.98	72.30	72.63	72.96	73.27	73.57	73.81	73.97	74.03							

TABLE 12. - Pressure input data for isopressure program--Continued

67.91	67.91	67.91	67.91	67.91	67.91	67.91	67.91	67.91	67.92	67.93	67.94	67.95	67.96	67.99	68.01	68.04	68.07	68.11	68.15
68.20	68.25	68.31	68.37	68.45	68.52	68.61	68.70	68.80	68.91	69.03	69.15	69.28	69.43	69.58	69.74	69.92	70.10	70.30	70.51
70.73	70.96	71.21	71.47	71.74	72.01	72.29	72.56	72.82	73.04	73.23	73.35	73.39							
68.17	68.17	68.16	68.16	68.16	68.15	68.15	68.15	68.14	68.14	68.14	68.14	68.14	68.15	68.16	68.17	68.19	68.21	68.24	68.27
68.31	68.35	68.40	68.46	68.52	68.59	68.66	68.74	68.83	68.93	69.03	69.15	69.27	69.40	69.54	69.69	69.85	70.02	70.20	70.39
70.59	70.80	71.02	71.25	71.48	71.72	71.95	72.18	72.39	72.57	72.71	72.80	72.83							
68.43	68.43	68.42	68.42	68.41	68.40	68.39	68.38	68.37	68.36	68.35	68.34	68.33	68.33	68.33	68.33	68.34	68.35	68.37	68.39
68.42	68.45	68.49	68.53	68.58	68.64	68.70	68.77	68.85	68.94	69.03	69.13	69.25	69.36	69.49	69.62	69.77	69.92	70.09	70.26
70.44	70.63	70.82	71.02	71.23	71.43	71.63	71.81	71.98	72.13	72.24	72.31	72.34							
68.69	68.69	68.68	68.68	68.66	68.65	68.63	68.61	68.59	68.57	68.55	68.54	68.52	68.51	68.49	68.49	68.48	68.49	68.49	68.50
68.52	68.54	68.57	68.60	68.64	68.69	68.74	68.80	68.87	68.94	69.02	69.12	69.21	69.32	69.43	69.55	69.68	69.82	69.97	70.12
70.28	70.45	70.62	70.80	70.97	71.14	71.31	71.47	71.61	71.73	71.81	71.87	71.89							
68.96	68.96	68.95	68.94	68.92	68.90	68.88	68.85	68.82	68.79	68.76	68.73	68.71	68.68	68.66	68.64	68.63	68.61	68.61	68.61
68.61	68.62	68.64	68.66	68.69	68.73	68.77	68.82	68.88	68.94	69.01	69.09	69.17	69.26	69.37	69.47	69.59	69.71	69.84	69.98
70.12	70.26	70.42	70.57	70.72	70.86	71.01	71.14	71.25	71.35	71.42	71.47	71.48							
69.23	69.23	69.22	69.21	69.18	69.16	69.12	69.09	69.05	69.01	68.97	68.93	68.89	68.85	68.82	68.79	68.76	68.74	68.72	68.71
68.70	68.70	68.71	68.72	68.74	68.76	68.79	68.83	68.87	68.93	68.98	69.05	69.12	69.21	69.29	69.39	69.49	69.60	69.71	69.83
69.95	70.08	70.21	70.34	70.47	70.59	70.71	70.82	70.92	71.00	71.05	71.09	71.10							
69.52	69.51	69.50	69.48	69.45	69.41	69.37	69.33	69.28	69.23	69.18	69.12	69.07	69.02	68.98	68.93	68.90	68.86	68.83	68.81
68.79	68.78	68.77	68.77	68.78	68.79	68.81	68.83	68.87	68.91	68.96	69.01	69.07	69.14	69.21	69.29	69.38	69.47	69.57	69.67
69.78	69.89	70.00	70.11	70.22	70.33	70.43	70.52	70.60	70.66	70.71	70.74	70.75							
69.80	69.80	69.78	69.76	69.72	69.68	69.63	69.57	69.51	69.45	69.38	69.32	69.25	69.19	69.13	69.08	69.02	68.98	68.93	68.90
68.87	68.84	68.82	68.82	68.81	68.81	68.82	68.83	68.85	68.88	68.92	68.96	69.01	69.06	69.12	69.19	69.26	69.35	69.43	69.52
69.61	69.70	69.79	69.89	69.98	70.07	70.15	70.23	70.29	70.35	70.39	70.41	70.42							
70.11	70.10	70.08	70.05	70.00	69.95	69.89	69.82	69.74	69.67	69.59	69.51	69.43	69.35	69.28	69.21	69.15	69.09	69.03	68.98
68.94	68.90	68.88	68.85	68.84	68.82	68.82	68.82	68.84	68.85	68.88	68.90	68.94	68.98	69.03	69.09	69.15	69.21	69.28	69.35
69.43	69.51	69.59	69.67	69.74	69.82	69.89	69.95	70.00	70.05	70.08	70.10	70.11							
70.42	70.41	70.39	70.35	70.29	70.23	70.15	70.07	69.98	69.89	69.79	69.70	69.61	69.52	69.43	69.35	69.26	69.19	69.12	69.06
69.01	68.96	68.92	68.88	68.85	68.83	68.82	68.81	68.81	68.82	68.82	68.84	68.87	68.90	68.93	68.98	69.02	69.08	69.13	69.19
69.25	69.32	69.38	69.45	69.51	69.57	69.63	69.68	69.72	69.76	69.78	69.80	69.80							
70.75	70.74	70.71	70.66	70.60	70.52	70.43	70.33	70.22	70.11	70.00	69.89	69.78	69.67	69.57	69.47	69.38	69.29	69.21	69.14
69.07	69.01	68.96	68.91	68.87	68.83	68.81	68.79	68.78	68.77	68.77	68.78	68.79	68.81	68.83	68.86	68.90	68.93	68.98	69.02
69.07	69.12	69.18	69.23	69.28	69.33	69.37	69.41	69.45	69.48	69.50	69.51	69.52							
71.10	71.09	71.05	71.00	70.92	70.82	70.71	70.59	70.47	70.34	70.21	70.08	69.95	69.83	69.71	69.60	69.49	69.39	69.29	69.21
69.12	69.05	68.98	68.93	68.87	68.83	68.79	68.76	68.74	68.72	68.71	68.70	68.70	68.71	68.72	68.74	68.76	68.79	68.82	68.85
68.89	68.93	68.97	69.01	69.05	69.09	69.12	69.16	69.18	69.21	69.22	69.23	69.23							
71.48	71.47	71.42	71.35	71.25	71.14	71.01	70.86	70.72	70.57	70.42	70.26	70.12	69.98	69.84	69.71	69.59	69.47	69.37	69.26
69.17	69.09	69.01	68.94	68.88	68.82	68.77	68.73	68.69	68.66	68.64	68.62	68.61	68.61	68.61	68.61	68.63	68.64	68.66	68.68
68.71	68.73	68.76	68.79	68.82	68.85	68.88	68.90	68.92	68.94	68.95	68.96	68.96							
71.89	71.87	71.81	71.73	71.61	71.47	71.31	71.14	70.97	70.80	70.62	70.45	70.28	70.12	69.97	69.82	69.68	69.55	69.43	69.32
69.21	69.12	69.02	68.94	68.87	68.80	68.74	68.69	68.64	68.60	68.57	68.54	68.52	68.50	68.49	68.49	68.48	68.49	68.49	68.51
68.52	68.54	68.55	68.57	68.59	68.61	68.63	68.65	68.66	68.68	68.68	68.69	68.69							
72.34	72.31	72.24	72.13	71.98	71.81	71.63	71.43	71.23	71.02	70.82	70.63	70.44	70.26	70.09	69.92	69.77	69.62	69.49	69.36
69.25	69.13	69.03	68.94	68.85	68.77	68.70	68.64	68.58	68.53	68.49	68.45	68.42	68.39	68.37	68.35	68.34	68.33	68.33	68.33
68.33	68.34	68.35	68.36	68.37	68.38	68.39	68.40	68.41	68.42	68.42	68.43	68.43							
72.83	72.80	72.71	72.57	72.39	72.18	71.95	71.72	71.48	71.25	71.02	70.80	70.59	70.39	70.20	70.02	69.85	69.69	69.54	69.40
69.27	69.15	69.03	68.93	68.83	68.74	68.66	68.59	68.52	68.46	68.40	68.35	68.31	68.27	68.24	68.21	68.19	68.17	68.16	68.15
68.14	68.14	68.14	68.14	68.14	68.15	68.15	68.15	68.16	68.16	68.16	68.17	68.17							
73.39	73.35	73.23	73.04	72.82	72.56	72.29	72.01	71.74	71.47	71.21	70.96	70.73	70.51	70.30	70.10	69.92	69.74	69.58	69.43
69.28	69.15	69.03	68.91	68.80	68.70	68.61	68.52	68.45	68.37	68.31	68.25	68.20	68.15	68.11	68.07	68.04	68.01	67.99	67.96
67.95	67.94	67.93	67.92	67.91	67.91	67.91	67.91	67.91	67.91	67.91	67.91	67.91							
74.03	73.97	73.81	73.57	73.27	72.96	72.63	72.30	71.98	71.68	71.39	71.12	70.86	70.62	70.39	70.17	69.97	69.79	69.61	69.45
69.29	69.15	69.01	68.88	68.76	68.66	68.55	68.46	68.37	68.29	68.21	68.14	68.08	68.02	67.97	67.92	67.88	67.84	67.81	67.78
67.75	67.73	67.71	67.70	67.68	67.67	67.66	67.66	67.65	67.65	67.65	67.65	67.65							

TABLE 12. - Pressure input data for isopressure program--Continued

74.79	74.70	74.47	74.14	73.76	73.36	72.97	72.58	72.22	71.87	71.55	71.25	70.97	70.71	70.46	70.23	70.02	69.82	69.63	69.45
69.29	69.13	68.99	68.85	68.72	68.60	68.49	68.38	68.28	68.19	68.11	68.03	67.95	67.89	67.83	67.77	67.72	67.67	67.63	67.59
67.55	67.52	67.50	67.47	67.45	67.44	67.42	67.41	67.40	67.39	67.39	67.39	67.39							
75.71	75.58	75.23	74.77	74.27	73.77	73.29	72.84	72.43	72.05	71.69	71.37	71.06	70.78	70.52	70.28	70.05	69.84	69.63	69.45
69.27	69.11	68.95	68.81	68.67	68.54	68.41	68.30	68.19	68.09	68.00	67.91	67.82	67.75	67.67	67.61	67.55	67.49	67.44	67.39
67.35	67.31	67.28	67.25	67.22	67.20	67.17	67.16	67.15	67.14	67.13	67.13	67.12							
76.92	76.66	76.10	75.43	74.77	74.15	73.59	73.07	72.61	72.19	71.81	71.46	71.14	70.84	70.56	70.30	70.07	69.84	69.63	69.43
69.25	69.07	68.91	68.75	68.61	68.47	68.34	68.21	68.10	67.98	67.88	67.78	67.69	67.60	67.52	67.45	67.38	67.31	67.25	67.19
67.14	67.09	67.05	67.01	66.98	66.95	66.93	66.90	66.89	66.87	66.87	66.86	66.86							
78.64	78.04	77.07	76.10	75.23	74.48	73.83	73.26	72.75	72.30	71.89	71.52	71.18	70.87	70.58	70.32	70.07	69.83	69.61	69.41
69.21	69.03	68.86	68.69	68.54	68.39	68.25	68.12	67.99	67.87	67.76	67.65	67.55	67.46	67.36	67.28	67.20	67.13	67.05	66.99
66.93	66.88	66.82	66.78	66.74	66.71	66.67	66.65	66.63	66.61	66.60	66.59	66.59							
81.56	79.80	78.05	76.66	75.58	74.71	73.99	73.37	72.84	72.36	71.94	71.55	71.20	70.88	70.59	70.31	70.05	69.81	69.58	69.37
69.17	68.98	68.80	68.62	68.46	68.30	68.16	68.02	67.88	67.75	67.63	67.51	67.41	67.30	67.20	67.11	67.02	66.93	66.86	66.78
66.71	66.65	66.59	66.54	66.49	66.45	66.42	66.38	66.36	66.34	66.33	66.32	66.32							
88.00	81.56	78.64	76.92	75.72	74.79	74.04	73.41	72.86	72.38	71.94	71.55	71.19	70.87	70.56	70.28	70.02	69.77	69.54	69.32
69.11	68.92	68.73	68.55	68.38	68.22	68.06	67.91	67.77	67.63	67.50	67.37	67.25	67.14	67.03	66.93	66.83	66.74	66.65	66.57
66.49	66.42	66.35	66.30	66.24	66.20	66.15	66.12	66.09	66.07	66.05	66.04	66.04							
81.56	79.80	78.04	76.66	75.58	74.70	73.98	73.36	72.82	72.34	71.91	71.52	71.16	70.83	70.53	70.24	69.97	69.72	69.49	69.26
69.05	68.84	68.65	68.46	68.29	68.11	67.95	67.79	67.65	67.50	67.36	67.23	67.10	66.97	66.86	66.74	66.64	66.54	66.44	66.35
66.27	66.18	66.11	66.04	65.99	65.93	65.88	65.84	65.81	65.78	65.77	65.75	65.75							
78.64	78.05	77.07	76.10	75.22	74.47	73.81	73.23	72.71	72.25	71.83	71.45	71.09	70.77	70.46	70.18	69.91	69.66	69.42	69.19
68.97	68.76	68.56	68.37	68.19	68.01	67.84	67.68	67.52	67.36	67.22	67.08	66.94	66.81	66.68	66.56	66.44	66.33	66.22	66.13
66.03	65.95	65.86	65.79	65.72	65.66	65.61	65.56	65.52	65.50	65.47	65.46	65.46							
76.92	76.66	76.10	75.43	74.76	74.13	73.56	73.03	72.56	72.12	71.72	71.35	71.01	70.68	70.38	70.10	69.83	69.58	69.34	69.10
68.88	68.67	68.47	68.27	68.08	67.90	67.72	67.55	67.38	67.22	67.07	66.92	66.77	66.63	66.50	66.36	66.24	66.12	66.01	65.89
65.79	65.70	65.61	65.52	65.45	65.38	65.33	65.27	65.23	65.20	65.18	65.16	65.16							
75.72	75.58	75.23	74.76	74.25	73.75	73.25	72.79	72.36	71.96	71.58	71.23	70.89	70.58	70.29	70.01	69.74	69.49	69.24	69.01
68.79	68.57	68.36	68.16	67.97	67.78	67.60	67.42	67.24	67.08	66.91	66.76	66.60	66.45	66.30	66.17	66.03	65.90	65.78	65.66
65.55	65.44	65.34	65.26	65.17	65.10	65.03	64.98	64.93	64.90	64.87	64.85	64.85							
74.80	74.71	74.48	74.14	73.75	73.34	72.93	72.52	72.13	71.76	71.41	71.08	70.76	70.46	70.18	69.90	69.64	69.39	69.15	68.91
68.69	68.47	68.26	68.05	67.85	67.66	67.47	67.28	67.10	66.93	66.76	66.59	66.43	66.27	66.11	65.96	65.82	65.68	65.55	65.42
65.30	65.18	65.08	64.98	64.89	64.80	64.73	64.67	64.62	64.58	64.55	64.53	64.53							
74.05	73.99	73.82	73.58	73.27	72.94	72.58	72.24	71.89	71.55	71.23	70.92	70.61	70.33	70.05	69.78	69.52	69.28	69.03	68.80
68.58	68.36	68.14	67.93	67.73	67.53	67.33	67.14	66.95	66.77	66.59	66.42	66.24	66.08	65.91	65.76	65.60	65.45	65.31	65.17
65.04	64.91	64.80	64.69	64.59	64.50	64.42	64.36	64.30	64.25	64.22	64.20	64.19							
73.43	73.38	73.26	73.06	72.82	72.54	72.25	71.94	71.64	71.33	71.03	70.74	70.46	70.18	69.92	69.65	69.40	69.16	68.92	68.69
68.46	68.24	68.02	67.81	67.60	67.40	67.20	67.00	66.81	66.61	66.43	66.24	66.06	65.88	65.71	65.54	65.38	65.22	65.06	64.91
64.77	64.64	64.51	64.39	64.29	64.19	64.10	64.03	63.96	63.91	63.88	63.86	63.85							
72.88	72.85	72.75	72.60	72.40	72.17	71.92	71.65	71.38	71.11	70.83	70.56	70.29	70.03	69.77	69.52	69.27	69.03	68.80	68.57
68.34	68.12	67.90	67.68	67.47	67.26	67.05	66.85	66.65	66.45	66.26	66.07	65.87	65.69	65.50	65.33	65.15	64.98	64.81	64.65
64.50	64.36	64.22	64.09	63.97	63.86	63.77	63.69	63.62	63.56	63.52	63.50	63.49							
72.41	72.39	72.31	72.18	72.02	71.82	71.61	71.37	71.13	70.88	70.62	70.37	70.12	69.87	69.62	69.38	69.14	68.90	68.67	68.44
68.22	67.99	67.77	67.55	67.34	67.12	66.91	66.70	66.50	66.29	66.09	65.88	65.69	65.49	65.30	65.10	64.92	64.73	64.56	64.39
64.22	64.06	63.91	63.77	63.65	63.53	63.42	63.33	63.26	63.19	63.15	63.12	63.12							
71.99	71.97	71.91	71.80	71.66	71.50	71.31	71.10	70.88	70.65	70.42	70.18	69.94	69.71	69.47	69.24	69.00	68.77	68.54	68.31
68.09	67.86	67.64	67.42	67.20	66.98	66.77	66.55	66.34	66.12	65.91	65.70	65.49	65.29	65.08	64.88	64.68	64.49	64.30	64.11
63.93	63.76	63.60	63.45	63.31	63.18	63.06	62.96	62.88	62.81	62.76	62.74	62.72							
71.62	71.60	71.55	71.46	71.34	71.19	71.03	70.84	70.64	70.43	70.22	70.00	69.77	69.55	69.32	69.09	68.86	68.64	68.41	68.18
67.96	67.73	67.51	67.29	67.06	66.84	66.62	66.40	66.18	65.96	65.74	65.52	65.30	65.08	64.87	64.65	64.44	64.23	64.03	63.83
63.64	63.45	63.28	63.11	62.96	62.81	62.69	62.58	62.49	62.41	62.36	62.32	62.31							
71.28	71.27	71.22	71.14	71.04	70.91	70.76	70.59	70.41	70.22	70.02	69.81	69.60	69.39	69.17	68.95	68.72	68.50	68.28	68.05
67.83	67.60	67.38	67.15	66.93	66.70	66.47	66.25	66.02	65.79	65.56	65.33	65.10	64.88	64.65	64.42	64.20	63.98	63.76	63.55
63.34	63.14	62.95	62.77	62.59	62.44	62.30	62.18	62.07	61.99	61.93	61.89	61.88							

TABLE 12. - Pressure input data for isopressure program--Continued

70.98	70.97	70.93	70.86	70.77	70.65	70.51	70.36	70.20	70.02	69.83	69.63	69.43	69.23	69.02	68.80	68.59	68.37	68.15	67.92
67.70	67.47	67.25	67.02	66.79	66.56	66.33	66.09	65.86	65.62	65.39	65.15	64.91	64.67	64.43	64.19	63.96	63.72	63.49	63.25
63.03	62.81	62.60	62.40	62.22	62.04	61.89	61.75	61.64	61.54	61.48	61.44	61.42							
70.71	70.70	70.66	70.60	70.51	70.41	70.28	70.15	69.99	69.83	69.65	69.47	69.27	69.07	68.87	68.66	68.45	68.24	68.02	67.80
67.57	67.35	67.12	66.89	66.65	66.42	66.18	65.94	65.70	65.46	65.21	64.97	64.71	64.47	64.21	63.96	63.71	63.46	63.21	62.96
62.72	62.48	62.25	62.03	61.83	61.64	61.46	61.31	61.18	61.08	61.00	60.95	60.94							
70.46	70.45	70.41	70.36	70.28	70.18	70.07	69.94	69.80	69.64	69.48	69.30	69.12	68.92	68.73	68.52	68.32	68.10	67.89	67.67
67.45	67.22	66.99	66.76	66.52	66.28	66.04	65.79	65.55	65.29	65.04	64.78	64.52	64.26	64.00	63.73	63.46	63.19	62.93	62.66
62.40	62.14	61.89	61.65	61.42	61.21	61.02	60.84	60.70	60.58	60.49	60.44	60.42							
70.23	70.22	70.19	70.14	70.07	69.98	69.87	69.75	69.62	69.47	69.31	69.15	68.97	68.78	68.59	68.39	68.19	67.98	67.77	67.55
67.32	67.10	66.87	66.63	66.39	66.15	65.90	65.65	65.39	65.14	64.87	64.60	64.33	64.06	63.78	63.50	63.21	62.93	62.64	62.36
62.07	61.79	61.52	61.25	61.00	60.76	60.54	60.35	60.18	60.05	59.95	59.89	59.87							
70.03	70.01	69.99	69.94	69.87	69.79	69.69	69.58	69.45	69.31	69.16	69.00	68.83	68.65	68.46	68.27	68.07	67.86	67.65	67.43
67.21	66.98	66.75	66.51	66.27	66.02	65.77	65.51	65.25	64.98	64.71	64.43	64.15	63.86	63.57	63.27	62.97	62.66	62.36	62.05
61.74	61.44	61.14	60.84	60.56	60.30	60.05	59.83	59.64	59.49	59.37	59.30	59.28							
69.84	69.83	69.80	69.76	69.70	69.62	69.52	69.42	69.30	69.16	69.02	68.86	68.70	68.52	68.34	68.15	67.95	67.75	67.53	67.32
67.09	66.87	66.63	66.39	66.15	65.90	65.64	65.37	65.10	64.83	64.55	64.26	63.96	63.66	63.36	63.04	62.72	62.40	62.07	61.74
61.41	61.08	60.75	60.43	60.11	59.81	59.53	59.28	59.06	58.89	58.75	58.67	58.64							
69.67	69.66	69.64	69.59	69.54	69.46	69.37	69.27	69.16	69.03	68.89	68.73	68.57	68.40	68.23	68.04	67.84	67.64	67.43	67.21
66.99	66.76	66.52	66.28	66.03	65.77	65.51	65.24	64.97	64.68	64.39	64.09	63.79	63.48	63.16	62.82	62.49	62.14	61.80	61.44
61.08	60.72	60.36	60.00	59.65	59.31	58.99	58.70	58.45	58.24	58.08	57.98	57.95							
69.52	69.51	69.49	69.45	69.39	69.32	69.24	69.14	69.02	68.90	68.76	68.62	68.46	68.29	68.12	67.93	67.74	67.54	67.33	67.11
66.89	66.66	66.42	66.18	65.92	65.66	65.40	65.12	64.84	64.55	64.25	63.94	63.62	63.30	62.96	62.62	62.26	61.90	61.52	61.14
60.75	60.36	59.96	59.56	59.17	58.79	58.42	58.08	57.78	57.54	57.34	57.23	57.19							
69.39	69.38	69.35	69.31	69.26	69.19	69.11	69.02	68.91	68.79	68.66	68.51	68.36	68.19	68.02	67.84	67.65	67.45	67.24	67.02
66.80	66.57	66.33	66.08	65.82	65.56	65.29	65.01	64.72	64.42	64.11	63.79	63.47	63.13	62.78	62.41	62.04	61.65	61.26	60.85
60.43	60.00	59.56	59.12	58.68	58.24	57.82	57.43	57.07	56.77	56.54	56.40	56.35							
69.27	69.26	69.24	69.20	69.15	69.08	69.00	68.91	68.80	68.69	68.56	68.42	68.26	68.10	67.93	67.75	67.56	67.36	67.15	66.94
66.71	66.48	66.24	65.99	65.73	65.47	65.19	64.90	64.61	64.30	63.98	63.66	63.32	62.97	62.60	62.23	61.83	61.43	61.00	60.57
60.11	59.65	59.17	58.68	58.18	57.69	57.20	56.73	56.31	55.94	55.65	55.47	55.41							
69.16	69.15	69.13	69.10	69.05	68.98	68.91	68.81	68.71	68.60	68.47	68.33	68.18	68.02	67.85	67.67	67.49	67.29	67.08	66.86
66.64	66.40	66.16	65.91	65.65	65.38	65.10	64.81	64.51	64.19	63.87	63.53	63.19	62.82	62.44	62.05	61.64	61.21	60.77	60.30
59.82	59.31	58.79	58.24	57.69	57.12	56.55	56.00	55.48	55.02	54.66	54.42	54.34							
69.07	69.07	69.04	69.01	68.96	68.90	68.82	68.73	68.63	68.52	68.39	68.26	68.11	67.95	67.78	67.61	67.42	67.22	67.01	66.80
66.57	66.34	66.09	65.84	65.57	65.30	65.02	64.72	64.42	64.10	63.77	63.42	63.06	62.69	62.30	61.89	61.46	61.02	60.55	60.06
59.54	58.99	58.42	57.82	57.20	56.55	55.89	55.24	54.60	54.02	53.54	53.22	53.11							
69.00	68.99	68.97	68.93	68.89	68.83	68.75	68.66	68.57	68.45	68.33	68.19	68.05	67.89	67.73	67.55	67.36	67.16	66.96	66.74
66.52	66.28	66.03	65.78	65.51	65.24	64.95	64.65	64.34	64.02	63.68	63.33	62.96	62.58	62.18	61.75	61.31	60.84	60.35	59.83
59.28	58.70	58.08	57.43	56.73	56.00	55.24	54.45	53.66	52.91	52.27	51.81	51.65							
68.94	68.93	68.91	68.88	68.83	68.77	68.69	68.61	68.51	68.40	68.28	68.15	68.00	67.85	67.68	67.50	67.31	67.12	66.91	66.70
66.47	66.23	65.98	65.73	65.46	65.18	64.89	64.59	64.27	63.95	63.60	63.25	62.87	62.48	62.07	61.64	61.18	60.70	60.18	59.64
59.06	58.45	57.78	57.07	56.31	55.48	54.60	53.66	52.68	51.70	50.80	50.12	49.85							
68.89	68.88	68.86	68.83	68.78	68.72	68.65	68.56	68.47	68.36	68.24	68.10	67.96	67.80	67.64	67.46	67.28	67.08	66.88	66.66
66.43	66.19	65.95	65.69	65.42	65.14	64.85	64.54	64.23	63.89	63.55	63.18	62.80	62.40	61.99	61.54	61.07	60.58	60.05	59.49
58.89	58.23	57.53	56.77	55.94	55.02	54.02	52.91	51.70	50.40	49.11	48.02	47.51							
68.86	68.85	68.83	68.80	68.75	68.69	68.62	68.54	68.44	68.33	68.21	68.08	67.93	67.78	67.61	67.44	67.25	67.06	66.85	66.63
66.40	66.17	65.92	65.66	65.39	65.11	64.81	64.51	64.19	63.85	63.50	63.14	62.75	62.35	61.92	61.47	61.00	60.49	59.95	59.37
58.75	58.08	57.34	56.54	55.65	54.66	53.54	52.27	50.80	49.11	47.22	45.33	44.17							
68.84	68.83	68.81	68.78	68.73	68.67	68.60	68.51	68.42	68.31	68.19	68.06	67.92	67.76	67.60	67.42	67.24	67.04	66.83	66.61
66.39	66.15	65.90	65.64	65.37	65.09	64.80	64.49	64.17	63.83	63.48	63.11	62.72	62.31	61.89	61.43	60.95	60.44	59.89	59.30
58.67	57.98	57.23	56.39	55.47	54.42	53.22	51.81	50.12	48.02	45.33	41.92	38.50							
68.83	68.82	68.80	68.77	68.72	68.67	68.59	68.51	68.41	68.31	68.18	68.05	67.91	67.76	67.59	67.42	67.23	67.04	66.83	66.61
66.38	66.15	65.90	65.64	65.36	65.08	64.79	64.48	64.16	63.82	63.47	63.10	62.71	62.30	61.87	61.42	60.93	60.42	59.87	59.28
58.64	57.95	57.19	56.35	55.41	54.34	53.11	51.65	49.85	47.51	44.17	38.50	26.00							

TABLE 13. - Input data for streamline program[1]

RIGHT SIDE

38.50000	2		53.000	90.000	52.000	91.000			
53.000	90.000	52.000	91.000						
44.17000	3		53.000	89.000	51.000	91.000			
53.000	89.000	52.000	89.365	51.000	91.000				
47.51000	4		53.000	88.000	50.000	91.000			
53.000	88.000	52.000	88.208	51.000	88.853	50.000	91.000		
49.85000	6		53.000	87.000	49.000	91.000			
53.000	87.000	52.000	87.140	51.000	87.578	50.000	88.425	49.578	89.000
49.000	91.000								
51.65000	7		53.000	86.000	48.000	91.000			
53.000	86.000	52.000	86.102	51.000	86.439	50.000	87.040	49.000	88.053
48.439	89.000	48.000	91.000						
53.11000	8		53.000	85.000	47.000	91.000			
53.000	85.000	52.000	85.084	51.000	85.352	50.000	85.827	49.000	86.566
48.000	87.728	47.352	89.000	47.000	91.000				
54.34000	10		53.000	84.000	46.000	91.000			
53.000	84.000	52.000	84.071	51.000	84.298	50.000	84.689	49.000	85.283
48.000	86.139	47.000	87.436	46.689	88.000	46.298	89.000	46.000	91.000
55.41000	11		53.000	83.000	45.000	91.000			
53.000	83.000	52.000	83.060	51.000	83.252	50.000	83.588	49.000	84.082
48.000	84.780	47.000	85.737	46.000	87.144	45.588	88.000	45.252	89.000
45.000	91.000								
56.35000	12		53.000	82.000	44.000	91.000			
53.000	82.000	52.000	82.057	51.000	82.222	50.000	82.515	49.000	82.949
48.000	83.526	47.000	84.305	46.000	85.359	45.000	86.899	44.517	88.000
44.222	89.000	44.000	91.000						
57.19000	13		53.000	81.000	43.000	91.000			
53.000	81.000	52.000	81.051	51.000	81.193	50.000	81.466	49.000	81.835
48.000	82.351	47.000	83.016	46.000	83.879	45.000	85.021	44.000	86.657
43.457	88.000	43.193	89.000	43.000	91.000				
57.95000	15		53.000	80.000	42.000	91.000			
53.000	80.000	52.000	80.042	51.000	80.183	50.000	80.423	49.000	80.755
48.000	81.204	47.000	81.788	46.000	82.527	45.000	83.467	44.000	84.685
43.000	86.417	42.755	87.000	42.407	88.000	42.183	89.000	42.000	91.000
58.64000	17		53.000	79.000	41.000	91.000			
53.000	79.000	52.000	79.045	51.000	79.169	50.000	79.394	49.000	79.694
48.000	80.100	47.000	80.620	46.000	81.278	45.000	82.081	44.000	83.091
43.000	84.402	42.618	85.000	42.000	86.226	41.694	87.000	41.390	88.000
41.169	89.000	41.000	91.000						
59.28000	17		53.000	78.000	40.000	91.000			
53.000	78.000	52.000	78.033	51.000	78.149	50.000	78.358	49.000	78.629
48.000	79.000	47.000	79.468	46.000	80.059	45.000	80.774	44.000	81.636
43.000	82.715	42.000	84.091	41.000	86.000	40.629	87.000	40.358	88.000
40.149	89.000	40.000	91.000						
59.87000	18		53.000	77.000	39.000	91.000			
53.000	77.000	52.000	77.035	51.000	77.142	50.000	77.327	49.000	77.579
48.000	77.925	47.000	78.353	46.000	78.881	45.000	79.524	44.000	80.298
43.000	81.225	42.000	82.368	41.000	83.820	40.000	85.823	39.579	87.000
39.327	88.000	39.142	89.000	39.000	91.000				
60.42000	19		53.000	76.000	38.000	91.000			
53.000	76.000	52.000	76.038	51.000	76.133	50.000	76.308	49.000	76.548
48.000	76.860	47.000	77.247	46.000	77.741	45.000	78.314	44.000	79.024
43.000	79.846	42.000	80.833	41.000	82.031	40.000	83.551	39.000	85.638
38.548	87.000	38.310	88.000	38.133	89.000	38.000	91.000		
60.94000	23		53.000	75.000	36.980	91.000			
53.000	75.000	52.000	75.020	51.000	75.121	50.000	75.288	49.000	75.505
48.000	75.792	47.000	76.173	46.000	76.605	45.000	77.139	44.000	77.758
43.000	78.516	42.000	79.389	41.000	80.424	40.000	81.686	39.000	83.249
38.616	84.000	38.000	85.438	37.792	86.000	37.505	87.000	37.269	88.000
37.122	89.000	37.000	90.333	36.980	91.000				
61.42000	24		53.000	74.000	36.000	91.000			
53.000	74.000	52.000	74.042	51.000	74.128	50.000	74.263	49.000	74.486
48.000	74.752	47.000	75.092	46.000	75.520	45.000	76.000	44.000	76.581
3.000	77.266	42.000	78.056	41.000	78.970	40.000	80.067	39.000	81.376
8.590	82.000	38.000	83.045	37.517	84.000	37.000	85.248	36.752	86.000
36.486	87.000	36.259	88.000	36.108	89.000	36.000	91.000		

[1]First card in each group contains pressure value and x and y coordinates at beginning and ending of isopressure line. Remaining cards contain alternating x and y values for all points on isopressure line.

TABLE 13. - Input data for streamline program--Continued

61.88000		25	53.000	73.000	34.977	91.000			
53.000	73.000	52.000	73.023	51.000	73.113	50.000	73.251	49.000	73.445
48.000	73.705	47.000	74.024	46.000	74.400	45.000	74.875	44.000	75.398
43.000	76.027	42.000	76.746	41.000	77.576	40.000	78.548	39.000	79.696
38.000	81.081	37.000	82.758	36.421	84.000	36.000	85.067	35.705	86.000
35.448	87.000	35.253	88.000	35.091	89.000	35.000	90.438	34.977	91.000
62.31000		24	53.000	72.000	33.976	91.000			
53.000	72.000	52.000	72.024	51.000	72.120	50.000	72.242	49.000	72.437
48.000	72.680	47.000	72.975	46.000	73.333	45.000	73.757	44.000	74.243
43.000	74.829	42.000	75.504	41.000	76.276	40.000	77.163	39.000	78.175
38.000	79.346	37.000	80.783	36.000	82.535	35.000	84.924	34.680	86.000
34.421	87.000	34.222	88.000	34.000	90.000	33.976	91.000		
62.72000		27	53.000	71.000	32.975	91.000			
53.000	71.000	52.000	71.050	51.000	71.101	50.000	71.229	49.000	71.413
48.000	71.635	47.000	71.920	46.000	72.243	45.000	72.655	44.000	73.140
43.000	73.664	42.000	74.273	41.000	75.000	40.000	75.803	39.000	76.728
38.000	77.781	37.000	79.000	36.000	80.488	35.706	81.000	35.000	82.333
34.682	83.000	34.000	84.755	33.635	86.000	33.388	87.000	33.204	88.000
33.000	90.000	32.975	91.000						
63.12000		28	53.000	70.000	31.947	91.000			
53.000	70.000	52.000	70.000	51.000	70.079	50.000	70.186	49.000	70.375
48.000	70.571	47.000	70.835	46.000	71.166	45.000	71.546	44.000	71.971
43.000	72.489	42.000	73.062	41.000	73.713	40.000	74.444	39.000	75.321
38.000	76.265	37.000	77.370	36.000	78.652	35.000	80.200	34.537	81.000
34.000	82.061	33.575	83.000	33.000	84.538	32.574	86.000	32.351	87.000
32.160	88.000	32.000	89.628	31.947	91.000				
63.49000		30	53.000	69.000	30.944	91.000			
53.000	69.000	52.000	69.027	51.000	69.082	50.000	69.193	49.000	69.368
48.000	69.562	47.000	69.804	46.000	70.117	45.000	70.478	44.000	70.875
43.000	71.347	42.000	71.873	41.000	72.504	40.000	73.205	39.000	74.000
38.000	74.885	37.000	75.880	36.000	77.043	35.000	78.381	34.000	79.941
33.000	81.859	32.507	83.000	32.000	84.343	31.804	85.000	31.546	86.000
31.314	87.000	31.168	88.000	31.000	89.333	30.972	90.000	30.944	91.000
63.85000		30	53.000	68.000	29.914	91.000			
53.000	68.000	52.000	68.029	51.000	68.086	50.000	68.173	49.000	68.324
48.000	68.533	47.000	68.760	46.000	69.030	45.000	69.375	44.000	69.756
43.000	70.194	42.000	70.700	41.000	71.276	40.000	71.929	39.000	72.667
38.000	73.505	37.000	74.445	36.000	75.478	35.000	76.687	34.000	78.050
33.000	79.633	32.000	81.600	31.406	83.000	31.000	84.192	30.760	85.000
30.507	86.000	30.295	87.000	30.000	89.000	29.943	90.000	29.914	91.000
64.19000		32	53.000	67.000	28.908	91.000			
53.000	67.000	52.000	67.030	51.000	67.089	50.000	67.179	49.000	67.330
48.000	67.523	47.000	67.722	46.000	68.000	45.000	68.319	44.000	68.667
43.000	69.100	42.000	69.575	41.000	70.105	40.000	70.721	39.000	71.412
38.000	72.157	37.000	73.042	36.000	74.000	35.000	75.093	34.000	76.344
33.000	77.773	32.000	79.412	31.670	80.000	31.000	81.429	30.745	82.000
30.000	84.000	29.725	85.000	29.473	86.000	29.250	87.000	29.000	89.000
28.938	90.000	28.908	91.000						
64.53000		35	53.000	66.000	27.843	91.000			
53.000	66.000	52.000	66.000	51.000	66.061	50.000	66.153	49.000	66.284
48.000	66.452	47.000	66.649	46.000	66.900	45.000	67.200	44.000	67.537
43.000	67.932	42.000	68.397	41.000	68.889	40.000	69.462	39.000	70.117
38.000	70.830	37.000	71.625	36.000	72.522	35.000	73.545	34.000	74.695
33.000	75.946	32.000	77.405	31.647	78.000	31.000	79.125	30.517	80.000
30.000	81.154	29.637	82.000	29.000	83.792	28.633	85.000	28.391	86.000
28.192	87.000	28.000	88.268	27.933	89.000	27.875	90.000	27.843	91.000
64.85000		33	53.000	65.000	26.796	91.000			
53.000	65.000	52.000	65.000	51.000	65.063	50.000	65.160	49.000	65.261
48.000	65.427	47.000	65.600	46.000	65.838	45.000	66.137	44.000	66.453
43.000	66.827	42.000	67.222	41.000	67.708	40.000	68.231	39.000	68.840
38.000	69.525	37.000	70.296	36.000	71.133	35.000	72.093	34.000	73.146
33.000	74.305	32.000	75.638	31.000	77.122	30.000	78.863	29.000	80.923
28.556	82.000	28.000	83.528	27.575	85.000	27.337	86.000	27.000	88.000
26.870	89.000	26.830	90.000	26.796	91.000				
65.16000		36	53.000	64.000	25.714	91.000			
53.000	64.000	52.000	64.000	51.000	64.067	50.000	64.133	49.000`	64.236
48.000	64.379	47.000	64.575	46.000	64.786	45.000	65.036	44.000	65.365
43.000	65.688	42.000	66.075	41.000	66.543	40.000	67.039	39.000	67.605
38.000	68.254	37.000	68.957	36.000	69.747	35.000	70.647	34.000	71.625
33.000	72.705	32.000	73.943	31.000	75.288	30.000	76.859	29.000	78.608
28.000	80.657	27.469	82.000	27.000	83.321	26.789	84.000	26.504	85.000
26.283	86.000	26.000	87.438	25.930	88.000	25.824	89.000	25.753	90.000
25.714	91.000								

TABLE 13. - Input data for streamline program--Continued

65.46000	38		53.000	63.000	24.651	91.000			
53.000	63.000	52.000	63.000	51.000	63.034	50.000	63.137	49.000	63.207
48.000	63.349	47.000	63.540	46.000	63.718	45.000	63.963	44.000	64.227
43.000	64.565	42.000	64.924	41.000	65.365	40.000	65.836	39.000	66.380
38.000	66.957	37.000	67.636	36.000	68.375	35.000	69.196	34.000	70.150
33.000	71.154	32.000	72.322	31.000	73.581	30.000	75.000	29.000	76.570
28.000	78.357	27.671	79.000	27.000	80.432	26.769	81.000	26.375	82.000
26.000	83.111	25.708	84.000	25.407	85.000	25.000	87.000	24.854	88.000
24.744	89.000	24.671	90.000	24.651	91.000				

65.75000	39		53.000	62.000	23.582	91.000			
53.000	62.000	52.000	62.000	51.000	62.069	50.000	62.105	49.000	62.210
48.000	62.321	47.000	62.481	46.000	62.667	45.000	62.892	44.000	63.153
43.000	63.440	42.000	63.806	41.000	64.167	40.000	64.603	39.000	65.130
38.000	65.682	37.000	66.323	36.000	67.048	35.000	67.800	34.000	68.678
33.000	69.660	32.000	70.717	31.000	71.940	30.000	73.235	29.000	74.688
28.000	76.279	27.600	77.000	27.000	78.154	26.582	79.000	26.000	80.169
25.654	81.000	25.000	82.768	24.620	84.000	24.342	85.000	24.000	86.576
23.776	88.000	23.658	89.000	23.582	90.000	23.582	91.000		

66.04000	39		53.000	61.000	22.450	91.000			
53.000	61.000	52.000	61.000	51.000	61.036	50.000	61.107	49.000	61.181
48.000	61.293	47.000	61.407	46.000	61.601	45.000	61.800	44.000	62.000
43.000	62.284	42.000	62.603	41.000	62.960	40.000	63.385	39.000	63.854
38.000	64.369	37.000	64.953	36.000	65.630	35.000	66.356	34.000	67.204
33.000	68.108	32.000	69.165	31.000	70.283	30.000	71.492	29.000	72.875
28.000	74.326	27.000	76.000	26.000	77.846	25.000	79.917	24.548	81.000
24.000	82.431	23.803	83.000	23.485	84.000	23.000	85.821	22.764	87.000
22.625	88.000	22.530	89.000	22.445	90.000	22.450	91.000		

66.32000	41		53.000	60.000	21.261	91.000			
53.000	60.000	52.000	60.000	51.000	60.036	50.000	60.074	49.000	60.148
48.000	60.227	47.000	60.379	46.000	60.515	45.000	60.680	44.000	60.917
43.000	61.125	42.000	61.422	41.000	61.773	40.000	62.136	39.000	62.551
38.000	63.048	37.000	63.600	36.000	64.206	35.000	64.904	34.000	65.722
33.000	66.592	32.000	67.562	31.000	68.654	30.000	69.812	29.000	71.125
28.000	72.533	27.000	74.069	26.000	75.714	25.000	77.573	24.000	79.626
23.417	81.000	23.000	82.111	22.671	83.000	22.333	84.000	22.000	85.333
21.839	86.000	21.630	87.000	21.464	88.000	21.348	89.000	21.300	90.000
21.261	91.000								

66.59000	43		53.000	59.000	20.089	91.000			
53.000	59.000	52.000	59.000	51.000	59.037	50.000	59.075	49.000	59.151
48.000	59.229	47.000	59.316	46.000	59.471	45.000	59.605	44.000	59.795
43.000	60.000	42.000	60.261	41.000	60.545	40.000	60.905	39.000	61.286
38.000	61.755	37.000	62.255	36.000	62.829	35.000	63.500	34.000	64.222
33.000	65.059	32.000	66.000	31.000	67.000	30.000	68.125	29.000	69.392
28.000	70.733	27.000	72.200	26.000	73.786	25.000	75.452	24.713	76.000
24.000	77.324	23.671	78.000	23.000	79.353	22.713	80.000	22.000	81.768
21.522	83.000	21.000	84.714	20.682	86.000	20.489	87.000	20.309	88.000
20.177	89.000	20.091	90.000	20.089	91.000				

66.86000	44		53.000	58.000	18.863	91.000			
53.000	58.000	52.000	58.000	51.000	58.038	50.000	58.038	49.000	58.115
48.000	58.157	47.000	58.277	46.000	58.370	45.000	58.500	44.000	58.647
43.000	58.826	42.000	59.091	41.000	59.323	40.000	59.625	39.000	60.000
38.000	60.362	37.000	60.846	36.000	61.375	35.000	62.000	34.000	62.681
33.000	63.478	32.000	64.375	31.000	65.326	30.000	66.445	29.000	67.635
28.000	68.935	27.000	70.357	26.000	71.857	25.000	73.509	24.000	75.231
23.565	76.000	23.000	77.083	22.522	78.000	22.000	79.091	21.571	80.000
21.000	81.321	20.727	82.000	20.000	84.000	19.714	85.000	19.466	86.000
19.238	87.000	19.000	88.667	18.860	90.000	18.863	91.000		

67.12000	43		53.000	57.000	17.579	91.000			
53.000	57.000	52.000	57.038	51.000	57.038	50.000	57.077	49.000	57.117
48.000	57.156	47.000	57.205	46.000	57.324	45.000	57.422	44.000	57.552
43.000	57.700	42.000	57.866	41.000	58.095	40.000	58.350	39.000	58.656
38.000	59.052	37.000	59.444	36.000	59.941	35.000	60.478	34.000	61.121
33.000	61.863	32.000	62.740	31.000	63.674	30.000	64.714	29.000	65.857
28.000	67.143	27.000	68.550	26.000	70.000	25.000	71.571	24.000	73.224
23.000	75.000	22.000	76.827	21.000	78.758	20.000	80.895	19.551	82.000
19.000	83.394	18.813	84.000	18.482	85.000	18.000	87.000	17.808	88.000
17.684	89.000	17.612	90.000	17.579	91.000				

67.39000	47		53.000	56.000	16.165	91.000			
53.000	56.000	52.000	56.000	51.000	56.000	50.000	56.000	49.000	56.040
48.000	56.080	47.000	56.122	46.000	56.212	45.000	56.261	44.000	56.358
43.000	56.506	42.000	56.619	41.000	56.800	40.000	57.000	39.000	57.263
38.000	57.556	37.000	57.941	36.000	58.360	35.000	58.817	34.000	59.453
33.000	60.132	32.000	60.857	31.000	61.792	30.000	62.792	29.000	63.931
28.000	65.220	27.000	66.580	26.000	68.074	25.000	69.615	24.000	71.231
23.000	72.923	22.000	74.657	21.000	76.471	20.700	77.000	20.000	78.353
19.661	79.000	19.000	80.400	18.719	81.000	18.000	82.667	17.512	84.000
17.000	85.479	16.846	86.000	16.585	87.000	16.389	88.000	16.274	89.000
16.167	90.000	16.165	91.000						

TABLE 13. - Input data for streamline program--Continued

67.65000	46		53.000	55.000	14.660	91.000			
53.000	55.000	52.000	55.000	51.000	55.000	50.000	55.000	49.000	55.000
48.000	55.040	47.000	55.041	46.000	55.085	45.000	55.130	44.000	55.221
43.000	55.281	42.000	55.381	41.000	55.500	40.000	55.690	39.000	55.889
38.000	56.114	37.000	56.419	36.000	56.756	35.000	57.130	34.000	57.674
33.000	58.293	32.000	59.000	31.000	59.851	30.000	60.833	29.000	62.000
28.000	63.245	27.000	64.583	26.000	66.080	25.000	67.624	24.000	69.231
23.000	70.923	22.000	72.615	21.000	74.385	20.657	75.000	20.000	76.161
19.000	78.000	18.000	79.909	17.000	82.000	16.533	83.000	16.000	84.298
15.765	85.000	15.458	86.000	15.000	87.725	14.775	89.000	14.688	90.000
14.660	91.000								
67.91000	48		53.000	54.000	13.000	91.000			
53.000	54.000	52.000	54.000	51.000	54.000	50.000	54.000	49.000	54.000
48.000	54.000	47.000	54.000	46.000	54.000	45.000	54.000	44.000	54.045
43.000	54.093	42.000	54.146	41.000	54.204	40.000	54.272	39.000	54.451
38.000	54.595	37.000	54.817	36.000	55.067	35.000	55.429	34.000	55.846
33.000	56.308	32.000	57.000	31.000	57.758	30.000	58.636	29.000	59.727
28.000	61.000	27.000	62.364	26.000	63.913	25.000	65.510	24.000	67.167
23.000	68.917	22.000	70.615	21.000	72.385	20.631	73.000	20.000	74.080
19.000	75.846	18.000	77.583	17.000	79.353	16.656	80.000	16.000	81.204
15.618	82.000	15.000	83.239	14.654	84.000	14.000	85.648	13.600	87.000
13.326	88.000	13.133	89.000	13.000	91.000				
68.17000	51		53.000	53.000	11.077	91.000			
53.000	53.000	52.000	53.000	51.000	52.962	50.000	52.962	49.000	52.960
48.000	52.920	47.000	52.917	46.000	52.913	45.000	52.872	44.000	52.866
43.000	52.860	42.000	52.850	41.000	52.842	40.000	52.889	39.000	52.943
38.000	53.000	37.000	53.133	36.000	53.286	35.000	53.538	34.000	53.833
33.000	54.258	32.000	54.736	31.000	55.400	30.000	56.200	29.000	57.222
28.000	58.444	27.000	59.889	26.000	61.489	25.673	62.000	25.000	63.189
24.000	64.913	23.000	66.765	22.000	68.583	21.000	70.394	20.631	71.000
20.000	72.077	19.000	73.846	18.000	75.509	17.000	77.161	16.000	78.833
15.000	80.545	14.000	82.213	13.563	83.000	13.000	84.135	12.616	85.000
12.000	86.409	11.851	87.000	11.518	88.000	11.316	89.000	11.159	90.000
11.077	91.000								
68.43000	55		53.000	52.000	8.815	91.000			
53.000	52.000	52.000	52.000	51.000	51.961	50.000	51.962	49.000	51.919
48.000	51.880	47.000	51.830	46.000	51.779	45.000	51.723	44.000	51.661
43.000	51.594	42.000	51.556	41.000	51.474	40.000	51.451	39.000	51.368
38.000	51.382	37.000	51.349	36.000	51.446	35.000	51.500	34.000	51.636
33.000	51.904	32.000	52.208	31.000	52.679	30.000	53.359	29.000	54.262
28.000	55.405	27.000	56.772	26.000	58.516	25.000	60.375	24.700	61.000
24.000	62.333	23.678	63.000	23.000	64.385	22.661	65.000	22.000	66.374
21.682	67.000	21.000	68.250	20.609	69.000	20.000	70.077	19.000	71.846
18.000	73.529	17.000	75.149	16.000	76.684	15.000	78.242	14.000	79.742
13.000	81.290	12.000	82.877	11.000	84.484	10.708	85.000	10.000	86.354
9.736	87.000	9.385	88.000	9.000	89.438	8.889	90.000	8.815	91.000
68.69000	53		53.000	51.000	5.600	91.000			
53.000	51.000	52.000	51.000	51.000	50.963	50.000	50.961	49.000	50.885
48.000	50.837	47.000	50.764	46.000	50.667	45.000	50.565	44.000	50.455
43.000	50.333	42.000	50.206	41.000	50.108	40.000	49.941	39.000	49.813
38.000	49.674	37.000	49.529	36.000	49.394	35.000	49.273	34.000	49.200
33.000	49.111	32.000	49.125	31.000	49.301	30.000	49.521	29.000	50.000
28.000	51.000	27.000	52.250	26.610	53.000	26.000	54.250	25.678	55.000
25.000	56.623	24.000	59.000	23.611	60.000	23.000	61.516	22.000	63.787
21.000	66.000	20.000	68.000	19.000	69.851	18.000	71.615	17.000	73.224
16.000	74.780	15.000	76.286	14.000	77.684	13.000	79.077	12.000	80.343
11.000	81.667	10.000	83.000	9.000	84.239	8.000	85.554	7.000	87.000
6.000	89.000	5.685	90.000	5.600	91.000				
68.96000	58		53.000	50.000	53.000	5.352			
53.000	50.000	52.000	50.000	51.000	49.962	50.000	49.926	49.000	49.844
48.000	49.773	47.000	49.662	46.000	49.542	45.000	49.391	44.000	49.227
43.000	49.048	42.000	48.839	41.000	48.611	40.000	48.353	39.000	48.128
38.000	47.810	37.000	47.490	36.000	47.173	35.000	46.710	34.000	46.250
33.000	45.728	32.000	45.000	31.000	44.000	30.576	43.000	30.301	42.000
30.262	41.000	30.222	40.000	30.300	39.000	30.427	38.000	30.624	37.000
31.000	35.250	31.313	34.000	31.588	33.000	32.000	31.628	32.211	31.000
32.583	30.000	33.000	28.889	33.369	28.000	34.000	26.488	35.000	24.353
36.000	22.462	37.000	20.714	38.000	19.069	39.000	17.608	40.000	16.273
41.000	14.931	42.000	13.721	43.000	12.538	44.000	11.481	45.000	10.455
46.000	9.466	47.000	8.556	48.000	7.761	49.000	7.000	50.000	6.421
51.000	5.844	52.000	5.521	53.000	5.352				
69.23000	57		53.000	49.000	53.000	8.657			
53.000	49.000	52.000	49.000	51.000	48.964	50.000	48.925	49.000	48.815
48.000	48.712	47.000	48.555	46.000	48.417	45.000	48.217	44.000	48.000
43.000	47.745	42.000	47.456	41.000	47.111	40.000	46.744	39.000	46.333
38.000	45.865	37.000	45.264	36.000	44.600	35.000	43.750	34.000	42.576
33.679	42.000	33.000	40.562	32.844	40.000	32.667	39.000	32.624	38.000
32.571	37.000	32.639	36.000	32.750	35.000	33.000	33.500	33.105	33.000
33.305	32.000	33.583	31.000	34.000	29.536	34.177	29.000	34.552	28.000
35.000	26.870	35.333	26.000	36.000	24.573	36.292	24.000	37.000	22.684
37.375	22.000	38.000	20.935	39.000	19.400	40.000	18.000	41.000	16.733
42.000	15.533	43.000	14.475	44.000	13.483	45.000	12.500	46.000	11.700
47.000	10.928	48.000	10.325	49.000	9.736	50.000	9.282	51.000	8.916
52.000	8.753	53.000	8.657						

TABLE 13. - Input data for streamline program--Continued

69.52000	47		53.000	48.000	53.000	11.000			
53.000	48.000	52.000	47.965	51.000	47.926	50.000	47.855	49.000	47.737
48.000	47.593	47.000	47.423	46.000	47.205	45.000	46.956	44.000	46.682
43.000	46.339	42.000	45.947	41.000	45.507	40.000	45.000	39.000	44.357
38.000	43.633	37.000	42.710	36.000	41.390	35.000	39.424	34.600	38.000
34.438	37.000	34.402	36.000	34.389	35.000	34.462	34.000	34.550	33.000
34.719	32.000	35.000	30.551	35.130	30.000	35.422	29.000	36.000	27.321
37.000	25.000	38.000	23.000	39.000	21.333	40.000	19.813	41.000	18.537
42.000	17.306	43.000	16.235	44.000	15.300	45.000	14.426	46.000	13.632
47.000	13.000	48.000	12.390	49.000	11.874	50.000	11.500	51.000	11.205
52.000	11.071	53.000	11.000						
69.80000	46		53.000	47.000	53.000	12.775			
53.000	47.000	52.000	47.000	51.000	46.932	50.000	46.860	49.000	46.711
48.000	46.551	47.000	46.346	46.000	46.080	45.000	45.750	44.000	45.409
43.000	44.952	42.000	44.474	41.000	43.882	40.000	43.192	39.000	42.308
38.000	41.189	37.000	39.639	36.694	39.000	36.346	38.000	36.056	37.000
35.897	36.000	35.820	35.000	35.813	34.000	35.869	33.000	36.000	31.725
36.124	31.000	36.329	30.000	36.565	29.000	37.000	27.654	37.229	27.000
38.000	25.161	39.000	23.200	40.000	21.563	41.000	20.176	42.000	18.947
43.000	17.837	44.000	16.849	45.000	16.000	46.000	15.274	47.000	14.618
48.000	14.055	49.000	13.595	50.000	13.227	51.000	13.000	52.000	12.832
53.000	12.775								
70.11000	43		53.000	46.000	53.000	14.406			
53.000	46.000	52.000	45.967	51.000	45.902	50.000	45.797	49.000	45.613
48.000	45.424	47.000	45.149	46.000	44.846	45.000	44.453	44.000	44.000
43.000	43.476	42.000	42.829	41.000	42.060	40.000	41.071	39.000	39.825
38.507	39.000	38.000	37.865	37.710	37.000	37.434	36.000	37.269	35.000
37.174	34.000	37.163	33.000	37.238	32.000	37.351	31.000	37.528	30.000
38.000	28.118	38.361	27.000	39.000	25.462	40.000	23.525	40.308	23.000
41.000	21.946	42.000	20.604	43.000	19.456	44.000	18.456	45.000	17.583
46.000	16.817	47.000	16.194	48.000	15.656	49.000	15.194	50.000	14.856
51.000	14.606	52.000	14.494	53.000	14.406				
70.42000	40		53.000	45.000	53.000	15.835			
53.000	45.000	52.000	44.969	51.000	44.904	50.000	44.766	49.000	44.577
48.000	44.341	47.000	44.036	46.000	43.649	45.000	43.200	44.000	42.652
43.000	42.000	42.000	41.161	41.000	40.128	40.000	38.758	39.577	38.000
39.000	36.589	38.832	36.000	38.588	35.000	38.476	34.000	38.389	33.000
38.401	32.000	38.509	31.000	38.629	30.000	39.000	28.484	39.453	27.000
40.000	25.675	40.321	25.000	41.000	23.765	42.000	22.263	43.000	21.000
44.000	19.953	45.000	19.045	46.000	18.269	47.000	17.619	48.000	17.043
49.000	16.619	50.000	16.258	51.000	16.042	52.000	15.874	53.000	15.835
70.75000	36		53.000	44.000	53.000	17.153			
53.000	44.000	52.000	43.970	51.000	43.878	50.000	43.732	49.000	43.527
48.000	43.227	47.000	42.867	46.000	42.403	45.000	41.878	44.000	41.221
43.000	40.350	42.000	39.300	41.000	37.856	40.547	37.000	40.000	35.446
39.686	34.000	39.599	33.000	39.556	32.000	39.624	31.000	39.737	30.000
40.000	28.768	40.220	28.000	40.556	27.000	41.000	25.933	42.000	24.056
43.000	22.625	44.000	21.440	45.000	20.464	46.000	19.649	47.000	18.961
48.000	18.394	49.000	17.927	50.000	17.586	51.000	17.342	52.000	17.191
53.000	17.153								
71.10000	32		53.000	43.000	53.000	18.412			
53.000	43.000	52.000	42.973	51.000	42.862	50.000	42.705	49.000	42.443
48.000	42.123	47.000	41.693	46.000	41.141	45.000	40.505	44.000	39.657
43.000	38.585	42.000	37.136	41.473	36.000	41.135	35.000	40.870	34.000
40.748	33.000	40.697	32.000	40.722	31.000	41.000	29.135	41.268	28.000
42.000	26.130	43.000	24.350	44.000	22.957	45.000	21.882	46.000	21.000
47.000	20.253	48.000	19.686	49.000	19.208	50.000	18.861	51.000	18.595
52.000	18.446	53.000	18.412						
71.48000	29		53.000	42.000	53.000	19.602			
53.000	42.000	52.000	41.974	51.000	41.839	50.000	41.652	49.000	41.358
48.000	40.969	47.000	40.469	46.000	39.828	45.000	39.000	44.000	37.954
43.000	36.453	42.347	35.000	42.060	34.000	41.887	33.000	41.807	32.000
41.814	31.000	42.000	29.378	42.361	28.000	43.000	26.405	44.000	24.682
45.000	23.389	46.000	22.397	47.000	21.575	48.000	20.938	49.000	20.445
50.000	20.060	51.000	19.798	52.000	19.647	53.000	19.602		
71.89000	27		53.000	41.000	53.000	20.738			
53.000	41.000	52.000	40.952	51.000	40.807	50.000	40.588	49.000	40.234
48.000	39.781	47.000	39.183	46.000	38.414	45.000	37.375	44.000	35.899
43.569	35.000	43.000	33.000	42.877	32.000	42.876	31.000	42.951	30.000
43.149	29.000	43.434	28.000	44.000	26.644	45.000	25.000	46.000	23.830
47.000	22.905	48.000	22.207	49.000	21.652	50.000	21.247	51.000	20.947
52.000	20.793	53.000	20.738						
72.34000	25		53.000	40.000	53.000	21.841			
53.000	40.000	52.000	39.935	51.000	39.778	50.000	39.514	49.000	39.119
48.000	38.573	47.000	37.853	46.000	36.861	45.000	35.446	44.368	34.000
44.093	33.000	43.954	32.000	43.914	31.000	44.000	30.000	44.203	29.000
44.511	28.000	45.000	26.911	46.000	25.349	47.000	24.273	48.000	23.466
49.000	22.846	50.000	22.392	51.000	22.071	52.000	21.887	53.000	21.841

TABLE 13. - Input data for streamline program--Continued

72.83000	22		53.000	39.000	53.000	22.898			
53.000	39.000	52.000	38.942	51.000	38.759	50.000	38.431	49.000	37.977
48.000	37.325	47.000	36.419	46.000	35.041	45.489	34.000	45.165	33.000
44.980	32.000	44.940	31.000	45.020	30.000	45.241	29.000	46.000	27.158
47.000	25.720	48.000	24.732	49.000	24.023	50.000	23.511	51.000	23.166
52.000	22.958	53.000	22.898						
73.39000	20		53.000	38.000	53.000	23.932			
53.000	38.000	52.000	37.930	51.000	37.710	50.000	37.331	49.000	36.751
48.000	35.929	47.000	34.688	46.629	34.000	46.238	33.000	46.035	32.000
45.966	31.000	46.052	30.000	46.286	29.000	47.000	27.448	48.000	26.123
49.000	25.256	50.000	24.648	51.000	24.240	52.000	24.018	53.000	23.932
74.03000	17		53.000	37.000	53.000	24.969			
53.000	37.000	52.000	36.909	51.000	36.649	50.000	36.185	49.000	35.473
48.000	34.330	47.321	33.000	47.059	32.000	46.985	31.000	47.074	30.000
47.347	29.000	48.000	27.729	49.000	26.565	50.000	25.809	51.000	25.335
52.000	25.060	53.000	24.969						
74.79000	14		53.000	36.000	53.000	25.988			
53.000	36.000	52.000	35.886	51.000	35.561	50.000	34.969	49.000	33.961
48.430	33.000	48.100	32.000	48.000	31.000	48.111	30.000	49.000	28.062
50.000	27.046	51.000	26.428	52.000	26.100	53.000	25.988		
75.71000	11		53.000	35.000	53.000	26.990			
53.000	35.000	52.000	34.863	51.000	34.434	50.000	33.602	49.569	33.000
49.000	31.267	49.131	30.000	50.000	28.418	51.000	27.569	52.000	27.131
53.000	26.990								
76.92000	8		53.000	34.000	53.000	28.000			
53.000	34.000	52.000	33.789	51.000	33.154	50.000	31.000	50.206	30.000
51.000	28.852	52.000	28.205	53.000	28.000				
78.64000	6		53.000	33.000	53.000	29.000			
53.000	33.000	52.000	32.659	51.000	31.000	51.366	30.000	52.000	29.361
53.000	29.000								
81.56000	3		53.000	32.000	53.000	30.000			
53.000	32.000	52.000	31.000	53.000	30.000				
71.28000	32		53.000	19.000	53.000	42.516			
53.000	19.000	52.000	19.032	51.000	19.191	50.000	19.453	49.000	19.808
48.000	20.300	47.000	20.895	46.000	21.671	45.000	22.600	44.000	23.769
43.000	25.267	42.610	26.000	42.000	27.387	41.797	28.000	41.542	29.000
41.343	30.000	41.261	31.000	41.236	32.000	41.303	33.000	41.445	34.000
42.000	35.772	43.000	37.624	44.000	38.866	45.000	39.797	46.000	40.517
47.000	41.097	48.000	41.572	49.000	41.916	50.000	42.193	51.000	42.372
52.000	42.493	53.000	42.516						
70.23000	41		53.000	15.000	53.000	45.605			
53.000	15.000	52.000	15.045	51.000	15.189	50.000	15.420	49.000	15.766
48.000	16.229	47.000	16.766	46.000	17.381	45.000	18.143	44.000	19.049
43.000	20.050	42.000	21.268	41.000	22.640	40.000	24.333	39.647	25.000
39.000	26.432	38.789	27.000	38.469	28.000	38.000	29.807	37.811	31.000
37.700	32.000	37.645	33.000	37.696	34.000	37.790	35.000	38.000	36.000
38.282	37.000	39.000	38.710	40.000	40.220	41.000	41.313	42.000	42.163
43.000	42.907	44.000	43.478	45.000	43.960	46.000	44.385	47.000	44.714
48.000	45.000	49.000	45.201	50.000	45.396	51.000	45.512	52.000	45.573
53.000	45.605								
69.67000	50		53.000	12.000	53.000	47.451			
53.000	12.000	52.000	12.062	51.000	12.192	50.000	12.493	49.000	12.817
48.000	13.300	47.000	13.888	46.000	14.537	45.000	15.283	44.000	16.165
43.000	17.114	42.000	18.232	41.000	19.412	40.000	20.750	39.000	22.333
38.600	23.000	38.000	24.154	37.586	25.000	37.000	26.280	36.720	27.000
36.365	28.000	36.000	29.146	35.783	30.000	35.571	31.000	35.402	32.000
35.282	33.000	35.194	34.000	35.202	35.000	35.215	36.000	35.346	37.000
35.570	38.000	35.870	39.000	36.348	40.000	37.000	41.111	38.000	42.364
39.000	43.293	40.000	44.000	41.000	44.647	42.000	45.158	43.000	45.594
44.000	46.000	45.000	46.300	46.000	46.600	47.000	46.846	48.000	47.037
49.000	47.182	50.000	47.318	51.000	47.384	52.000	47.444	53.000	47.451
69.39000	51		53.000	10.000	53.000	48.453			
53.000	10.000	52.000	10.080	51.000	10.309	50.000	10.597	49.000	11.000
48.000	11.509	47.000	12.141	46.000	12.810	45.000	13.608	44.000	14.508
43.000	15.485	42.000	16.544	41.000	17.756	40.000	19.000	39.000	20.467
38.647	21.000	38.000	22.071	37.000	23.923	36.000	26.000	35.610	27.000
35.000	28.595	34.576	30.000	34.323	31.000	34.000	32.469	33.904	33.000
33.778	34.000	33.679	35.000	33.625	36.000	33.639	37.000	33.746	38.000
33.926	39.000	34.245	40.000	35.000	41.667	36.000	43.000	37.000	43.913
38.000	44.657	39.000	45.273	40.000	45.775	41.000	46.222	42.000	46.632
43.000	46.953	44.000	47.273	45.000	47.522	46.000	47.746	47.000	47.923
48.000	48.077	49.000	48.222	50.000	48.329	51.000	48.393	52.000	48.424
53.000	48.453								

TABLE 13. - Input data for streamline program--Continued

69.16000	55		53.000	8.000	53.000	49.252			
53.000	8.000	52.000	8.104	51.000	8.292	50.000	8.612	49.000	9.095
48.000	9.736	47.000	10.403	46.000	11.159	45.000	12.000	44.000	13.000
43.000	14.000	42.000	15.067	41.000	16.267	40.000	17.570	39.000	18.933
38.000	20.475	37.671	21.000	37.000	22.149	36.000	24.000	35.530	25.000
35.000	26.097	34.657	27.000	34.000	28.667	33.524	30.000	33.000	31.833
32.728	33.000	32.514	34.000	32.312	35.000	32.197	36.000	32.071	37.000
32.080	38.000	32.083	39.000	32.266	40.000	32.431	41.000	33.000	42.217
34.000	43.742	35.000	44.569	36.000	45.300	37.000	45.905	38.000	46.376
39.000	46.800	40.000	47.181	41.000	47.500	42.000	47.804	43.000	48.097
44.000	48.318	45.000	48.522	46.000	48.708	47.000	48.837	48.000	49.000
49.000	49.076	50.000	49.185	51.000	49.219	52.000	49.256	53.000	49.252
69.07000	56		53.000	7.000	53.000	49.584			
53.000	7.000	52.000	7.000	51.000	7.359	50.000	7.679	49.000	8.208
48.000	8.908	47.000	9.657	46.000	10.427	45.000	11.382	44.000	12.308
43.000	13.365	42.000	14.475	41.000	15.674	40.000	17.000	39.000	18.333
38.000	19.853	37.000	21.500	36.000	23.308	35.630	24.000	35.000	25.343
34.676	26.000	34.000	27.654	33.460	29.000	33.000	30.298	32.789	31.000
32.480	32.000	32.000	34.000	31.761	35.000	31.571	36.000	31.437	37.000
31.333	38.000	31.352	39.000	31.412	40.000	31.525	41.000	31.761	42.000
33.000	44.000	34.000	44.882	35.000	45.556	36.000	46.189	37.000	46.633
38.000	47.071	39.000	47.400	40.000	47.712	41.000	48.000	42.000	48.258
43.000	48.530	44.000	48.727	45.000	48.913	46.000	49.083	47.000	49.205
48.000	49.351	49.000	49.418	50.000	49.519	51.000	49.551	52.000	49.588
53.000	49.584								
69.00000	58		53.000	6.000	53.000	49.847			
53.000	6.000	52.000	6.140	51.000	6.446	50.000	6.893	49.000	7.472
48.000	8.217	47.000	9.000	46.000	9.825	45.000	10.818	44.000	11.782
43.000	12.846	42.000	14.000	41.000	15.205	40.000	16.542	39.000	17.870
38.000	19.349	37.000	21.000	36.000	22.769	35.000	24.718	34.000	26.895
33.551	28.000	33.000	29.361	32.770	30.000	32.421	31.000	32.000	32.377
31.824	33.000	31.563	34.000	31.326	35.000	31.000	36.382	30.926	37.000
30.758	38.000	30.700	39.000	30.667	40.000	30.761	41.000	30.865	42.000
31.317	43.000	32.000	44.217	33.000	45.152	34.000	45.750	35.000	46.311
36.000	46.825	37.000	47.161	38.000	47.550	39.000	47.867	40.000	48.118
41.000	48.389	42.000	48.625	43.000	48.860	44.000	49.045	45.000	49.217
46.000	49.375	47.000	49.495	48.000	49.620	49.000	49.688	50.000	49.778
51.000	49.812	52.000	49.849	53.000	49.847				
68.89000	59		53.000	4.000	53.000	50.259			
53.000	4.000	52.000	4.236	51.000	4.646	50.000	5.200	49.000	6.000
48.000	6.865	47.000	7.796	46.000	8.815	45.000	9.831	44.000	10.913
43.000	12.000	42.000	13.220	41.000	14.437	40.000	15.792	39.000	17.137
38.000	18.608	37.000	20.214	36.000	21.923	35.000	23.742	34.000	25.818
33.455	27.000	33.000	28.111	32.625	29.000	32.000	30.625	31.500	32.000
31.000	33.576	30.571	35.000	30.293	36.000	30.000	37.333	29.825	38.000
29.612	39.000	29.458	40.000	29.286	41.000	29.167	42.000	29.372	43.000
30.000	44.702	31.000	45.750	32.000	46.167	33.000	46.714	34.000	47.117
35.000	47.400	36.000	47.758	37.000	48.076	38.000	48.279	39.000	48.570
40.000	48.765	41.000	49.000	42.000	49.204	43.000	49.381	44.000	49.545
45.000	49.696	46.000	49.833	47.000	49.957	48.000	50.039	49.000	50.115
50.000	50.189	51.000	50.222	52.000	50.259	53.000	50.259		
68.86000	60		53.000	3.000	53.000	50.370			
53.000	3.000	52.000	3.372	51.000	4.000	50.000	4.646	49.000	5.521
48.000	6.446	47.000	7.472	46.000	8.525	45.000	9.568	44.000	10.647
43.000	11.788	42.000	13.000	41.000	14.220	40.000	15.580	39.000	16.929
38.000	18.408	37.000	20.000	36.000	21.692	35.000	23.490	34.739	24.000
34.000	25.545	33.000	27.768	32.482	29.000	32.000	30.250	31.690	31.000
31.000	33.000	30.701	34.000	30.357	35.000	30.000	36.298	29.844	37.000
29.557	38.000	29.311	39.000	29.000	40.500	28.685	42.000	28.750	43.000
28.791	44.000	30.000	45.667	31.000	46.372	32.000	46.667	33.000	47.132
34.000	47.458	35.000	47.700	36.000	48.000	37.000	48.301	38.000	48.491
39.000	48.756	40.000	48.941	41.000	49.167	42.000	49.356	43.000	49.524
44.000	49.682	45.000	49.826	46.000	49.958	47.000	50.081	48.000	50.157
49.000	50.231	50.000	50.304	51.000	50.333	52.000	50.370	53.000	50.370
68.84000	61		53.000	2.000	53.000	50.444			
53.000	2.000	52.000	2.562	51.000	3.372	50.000	4.236	49.000	5.179
48.000	6.152	47.000	7.243	46.000	8.322	45.000	9.385	44.000	10.466
43.000	11.642	42.000	12.856	41.000	14.074	40.000	15.437	39.000	16.786
38.000	18.273	37.000	19.861	36.000	21.538	35.000	23.324	34.652	24.000
34.000	25.364	33.682	26.000	33.000	27.542	32.000	30.000	31.585	31.000
31.000	32.648	30.578	34.000	30.000	35.697	29.685	37.000	29.374	38.000
29.000	39.438	28.882	40.000	28.589	41.000	28.352	42.000	28.250	43.000
28.303	44.000	29.000	46.000	30.000	46.333	31.000	46.702	32.000	47.000
33.000	47.390	34.000	47.679	35.000	47.900	36.000	48.167	37.000	48.446
38.000	48.635	39.000	48.878	40.000	49.059	41.000	49.278	42.000	49.456
43.000	49.619	44.000	49.773	45.000	49.913	46.000	50.042	47.000	50.163
48.000	50.236	49.000	50.308	50.000	50.380	51.000	50.407	52.000	50.444
53.000	50.444								

TABLE 14. - Streamline coordinates calculated by stream program

STREAMLINE 1		STREAMLINE 2		STREAMLINE 3		STREAMLINE 4	
XS	YS	XS	YS	XS	YS	XS	YS
53.000	91.000	53.000	91.000	53.000	91.000	53.000	91.000
53.000	80.000	52.000	80.042	51.000	80.183	50.000	80.423
53.000	79.000	51.912	79.052	50.806	79.207	49.734	79.464
53.000	78.000	51.827	78.047	50.606	78.224	49.467	78.491
53.000	77.000	51.741	77.055	50.413	77.243	49.199	77.522
53.000	76.000	51.655	76.062	50.226	76.263	48.931	76.567
53.000	75.000	51.565	75.056	50.038	75.281	48.661	75.592
53.000	74.000	51.476	74.081	49.842	74.295	48.401	74.637
53.000	73.000	51.384	73.073	49.648	73.312	48.132	73.667
53.000	72.000	51.287	72.090	49.463	72.341	47.869	72.715
53.000	71.000	51.198	71.085	49.272	71.359	47.600	71.744
53.000	70.000	51.115	70.068	49.080	70.360	47.321	70.743
53.000	69.000	51.031	69.079	48.901	69.385	47.059	69.788
53.000	68.000	50.961	68.088	48.711	68.383	46.804	68.807
53.000	67.000	50.900	67.095	48.520	67.422	46.551	67.842
53.000	66.000	50.826	66.074	48.331	66.393	46.278	66.825
53.000	65.000	50.739	65.088	48.162	65.400	46.016	65.834
53.000	64.000	50.661	64.085	47.980	64.383	45.768	64.837
53.000	63.000	50.577	63.082	47.790	63.390	45.529	63.831
53.000	62.000	50.506	62.078	47.612	62.380	45.289	62.823
53.000	61.000	50.452	61.075	47.469	61.344	45.065	61.787
53.000	60.000	50.394	60.055	47.335	60.330	44.828	60.723
53.000	59.000	50.352	59.057	47.201	59.293	44.601	59.679
53.000	58.000	50.322	58.030	47.090	58.267	44.415	58.582
53.000	57.000	50.296	57.065	46.965	57.210	44.263	57.516
53.000	56.000	50.270	55.996	46.840	56.139	44.116	56.344
53.000	55.000	50.270	56.000	46.760	55.051	44.028	55.220
53.000	54.000	50.270	55.000	46.759	55.000	43.978	54.046
53.000	53.000	50.270	52.962	46.753	52.919	43.954	52.866
53.000	52.000	50.275	51.966	46.777	51.819	44.005	51.661
53.000	51.000	50.288	50.969	46.855	50.750	44.122	50.469
53.000	50.000	50.321	49.943	46.965	49.658	44.290	49.276
53.000	49.000	50.367	48.947	47.103	48.570	44.513	48.116
53.000	48.000	50.432	47.891	47.284	47.476	44.798	46.906
53.000	47.000	50.504	46.906	47.482	46.452	45.126	45.792
53.000	46.000	50.592	45.869	47.742	45.356	45.533	44.670
53.000	45.000	50.705	44.869	48.014	44.345	45.949	43.628
53.000	44.000	50.834	43.858	48.310	43.326	46.402	42.597
53.000	43.000	50.952	42.857	48.617	42.333	46.881	41.632
53.000	42.000	51.087	41.853	48.941	41.338	47.378	40.673
53.000	41.000	51.247	40.850	49.296	40.349	47.883	39.719
53.000	40.000	51.411	39.855	49.653	39.393	48.388	38.803
53.000	39.000	51.576	38.881	50.016	38.437	48.891	37.916
53.000	38.000	51.752	37.889	50.385	37.498	49.416	37.017
53.000	37.000	51.932	36.897	50.764	36.558	49.930	36.145
53.000	36.000	52.116	35.910	51.146	35.623	50.448	35.273
53.000	35.000	52.301	34.932	51.527	34.699	50.966	34.414
53.000	34.000	52.500	33.938	51.925	33.758	51.502	33.538
53.000	33.000	52.713	32.956	52.323	32.831	52.033	32.680
53.000	31.000	53.000	31.000	53.000	31.000	53.000	31.000

TABLE 14. - Streamline coordinates calculated by stream program--Continued

STREAMLINE 5

XS	YS
53.000	91.000
49.000	80.755
48.638	79.829
48.270	78.891
47.907	77.961
47.545	77.024
47.185	76.099
46.809	75.170
46.434	74.225
46.080	73.302
45.710	72.355
45.340	71.412
44.991	70.481
44.633	69.508
44.283	68.560
43.919	67.567
43.566	66.613
43.210	65.615
42.871	64.607
42.526	63.614
42.155	62.551
41.795	61.493
41.450	60.408
41.144	59.285
40.858	58.128
40.587	56.875
40.345	55.623
40.137	54.256
40.028	52.888
40.081	51.462
40.301	49.987
40.610	48.506
41.030	47.121
41.562	45.762
42.142	44.548
42.812	43.363
43.470	42.327
44.155	41.335
44.860	40.398
45.576	39.500
46.272	38.646
46.964	37.822
47.638	37.035
48.329	36.234
49.000	35.473
49.685	34.708
50.355	33.963
51.046	33.197
51.665	32.451
53.000	31.000

STREAMLINE 6

XS	YS
53.000	91.000
48.000	81.204
47.548	80.319
47.087	79.423
46.630	78.536
46.173	77.650
45.708	76.753
45.256	75.868
44.808	74.968
44.358	74.058
43.922	73.178
43.452	72.248
43.002	71.346
42.546	70.416
42.101	69.525
41.633	68.569
41.170	67.623
40.708	66.681
40.240	65.716
39.745	64.735
39.244	63.735
38.734	62.678
38.236	61.642
37.694	60.505
37.181	59.366
36.645	58.086
36.120	56.714
35.588	55.210
35.088	53.518
34.747	51.522
34.711	49.254
35.303	46.838
36.390	44.878
37.623	43.319
38.792	42.100
39.939	41.007
40.968	40.091
41.970	39.262
42.920	38.489
43.846	37.757
44.756	37.067
45.628	36.406
46.479	35.775
47.319	35.155
48.149	34.540
48.977	33.930
49.789	33.335
50.589	32.736
51.368	32.152
53.000	31.000

STREAMLINE 7a[1]

XS	YS
53.000	91.000
47.183	81.664
46.690	80.812
46.187	79.941
45.685	79.072
45.182	78.201
44.676	77.326
44.181	76.469
43.676	75.594
43.172	74.723
42.670	73.853
42.158	72.967
41.650	72.087
41.134	71.195
40.631	70.324
40.099	69.403
39.569	68.485
39.045	67.578
38.509	66.651
37.962	65.705
37.390	64.715
36.809	63.709
36.222	62.694
35.601	61.619
34.957	60.504
34.255	59.289
33.497	57.977
32.667	56.540
31.726	54.912
30.590	52.946
28.986	50.169

STREAMLINE 7b[1]

XS	YS
22.000	48.911
26.692	46.198
30.920	43.856
33.789	42.209
35.757	41.005
37.258	40.102
38.666	39.287
39.891	38.576
41.030	37.907
42.091	37.297
43.135	36.693
44.124	36.119
45.074	35.575
45.998	35.038
46.900	34.518
47.792	34.003
48.684	33.489
49.556	32.981
50.412	32.484
51.256	31.991
53.000	31.000

[1]Results for streamline 7a - 7b were determined using modifications described in text.

CONCLUDING STATEMENT

Computer methods are presented to calculate the coordinates of isopressure lines and streamlines for a field using pressures at grid intersections. The resulting flow nets agree well with those obtained using other methods, especially for the 7-spot pattern used as an example calculation in this paper. The methods have been tested on a wide range of flow geometries and should work for any field.

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APPENDIX A.--NOMENCLATURE FOR ISOPRESSURE PROGRAM

A = Term used in solving quadratic equation in subroutine POLCON for location of point on extended pressure line.

AQUI = Name assigned to labeled common block containing grid pressures and other data.

AVP = Value of pressure for a given line.

B = Term used in solving quadratic equation.

BPOR = Term used in solving quadratic equation.

C = Term used in solving quadratic equation.

D = Term used in solving quadratic equation.

DR1, DR2 = Terms used in solving quadratic equation.

FIT = Logical variable used to route program according to whether proper grid location has been found for an extended pressure line.

FORK = Logical variable used to route program according to whether lookup is in x or y direction.

I = Index of vertical grid line, goes with x.

IADD = Set of parameters used to calculate spread of lookup locations for first extended point.

IB = Starting index for successive lookup between pairs of vertical grid lines.

ICALL = Set of parameters used to aid routing to x or y lookup depending upon which vector the model applies.

IE = Ending index for successive lookup between pairs of vertical lines.

IGO = Routing parameter used in reindexing points on pressure line.

II = Additional (substitute) index for columns on vertical grid lines.

IM = Index of vertical grid line near possible point on pressure line.

IPLUS = Set of parameters used to calculate spread of lookup locations for various vector models.

IP3 = Index of vertical grid line located by lookup near pressure line.

IT = Index of vertical grid line in subroutine LOOKUP.

ITAL = Number of points on a pressure line which have been determined, also cumulative index of the points.

ITALM2 = ITAL - 2.

ITTAL = Temporary storage for ITAL.

J = Index of horizontal grid line.

JB = Starting index for successive lookup between pairs of horizontal grid lines.

JE = Ending index for successive lookup between pairs of horizontal grid lines.

JJ = Additional (substitute) index for rows or horizontal grid lines.

JM = Index of horizontal grid line near possible point on pressure line.

JP3 = Index of horizontal grid line located by lookup near pressure line.

JT = Index of horizontal grid line in subroutine LOOKUP.

K = Index or counter for points on pressure lines originating on an edge.

KK = Index denoting origin of pressure line at a particular edge or interior.

L = Index denoting to which vector model pressure line is conforming.

L1D = Index indicating number of grid lines passed.

LOOKUP = Name of subroutine which looks up location of grid lines closest to extended pressure line.

M = Index controlling orientation of grid locations to enter lookup.

MP	=	Name of IP3 or JP3 in subroutine LOOKUP.
NEND	=	Total number of grid lines on an edge to be scanned for starting pressure lines.
P	=	Pressure at a grid point.
P1, P2, P3	=	Pressure values in subroutine POLCON.
POLCON	=	Name of subroutine which solves quadratic equation.
PP	=	Term used in solving quadratic equation.
Q	=	Term used in solving quadratic equation.
R1, R2	=	Roots of quadratic equation; usually one of them is fractional distance along grid line to where pressure line crosses.
TEST	=	Integer at a grid point indicating whether a pressure line passes close enough for proper density.
WORD	=	Storage for labels of groups of lines originating at different edges or interior.
X	=	Distance in horizontal direction, goes with I. Also abscissas of points on pressure line.
XSAVE	=	Temporary storage for abscissas of pressure lines.
XUP	=	Number of vertical grid lines (horizontal extent of pattern).
XX	=	Fractional distance along horizontal grid line to where pressure line crosses.
Y	=	Distance in vertical direction, goes with J. Also ordinates of points on pressure line.
YSAVE	=	Temporary storage for ordinates of pressure lines.
YUP	=	Number of horizontal grid lines (vertical extent of pattern).
YY	=	Fractional distance along vertical grid line to where pressure line crosses.

APPENDIX B.--NOMENCLATURE FOR STREAMLINE PROGRAM

A, A1, A2 = Constant in circle equation for segment of isopressure line in subroutine QUAD, and for preceding and succeeding isopressure lines in MAIN program, respectively.

ACTN1, ACTN2 = Intercept on x axis of cotangent line for preceding and next pressure lines, respectively. (See CTN1, CTN2.)

AS = Function to calculate intercept of a line.

AS1, AS2 = Intercept on x axis of line tangent to preceding and succeeding pressure lines, respectively.

ASC = Sum of ASD1 and ASD2 in subroutine STRM.

ASD1, ASD2 = Terms used in determinant solution for intersection in subroutine STRM.

AVP = Value of pressure for an isopressure line.

B, B1, B2 = Constant in circle equation for segment of isopressure line in subroutine QUAD, and for preceding and succeeding isopressure lines in MAIN program, respectively.

BOUND = Name of subroutine to process streamlines near a boundary.

CTN = Function to calculate slope of line normal to isopressure line (cotangent line).

CTN1, CTN2 = Slope of line normal to isopressure line (cotangent line) for preceding and succeeding isopressures, respectively.

DEL = Estimated x increment between preceding and succeeding pressure lines.

DELTA = Difference between streamline ordinate and ordinate of point on diagonal boundary being tracked--used in subroutine BOUND.

DELX12, DELX23 = Difference in x values used in subroutine QUAD.

DXSQ12, DXSQ23 = Differences in x^2 used in subroutine QUAD.

DELY12, DELY23 = Differences in y values used in subroutine QUAD.

DYSQ12, DYSQ23 = Differences in y^2 used in subroutine QUAD.

DEM = Term used in determinant solution for coordinates of midpoint in subroutine STRM.

DM1, DM2	=	Terms used in determinant solution for coordinates of midpoint.
FIELD	=	Name assigned to labeled common block containing coordinates of isopressure lines and other data.
IFLAG	=	Index for streamline to route program to normal or boundary calculation.
IN	=	Index to skip unnecessary alternate values when punching streamline coordinates.
IP	=	Index used in printing and punching streamline coordinates.
IPTAL	=	Number of points on a streamline.
IS	=	Index of a point on streamline.
ITER	=	Counter indicating number of iterations completed in converging on correct location of streamline intersection.
JTAG	=	Integer parameter to determine whether estimated abscissa for intersection should be incremented in subroutine LOCATE.
LGO	=	Routing index for terminating calculation of a streamline when trouble occurs.
LOCATE	=	Name of subroutine to find index of intersection of projected streamline with isopressure line.
MLINE	=	Number of isopressure lines used.
MLNM2	=	NLINE - 2.
MP	=	Index of an isopressure line.
MP1	=	Index of succeeding isopressure line.
MSTART	=	Index of pressure line from which streamline calculation starts initially.
N	=	Index for a point on isopressure line.
NB	=	Starting index for lookup along an isopressure line.
NE	=	Ending index for lookup along an isopressure line.
NEM1	=	NE - 1.
NINT	=	Interval between successive streamline starting points.

NITAL = Temporary storage for NTAL indexed for subsequent use.

NTAL = Number of points on an isopressure line.

NNN = Counter for number of times starting point advanced for new lookup in subroutine LOCATE.

NP3 = Index of point on isopressure line just preceding intersection with streamline.

NSTREAM = Number of streamlines to be determined.

NT = Index of point on isopressure line used in subroutine LOCATE.

QUAD = Name of subroutine to calculate constants for equation of segment of pressure line.

R, R1, R2 = Constant in circle equation in subroutine QUAD, and for preceding and succeeding isopressure lines in MAIN program, respectively.

STRM = Name of subroutine to calculate orthogonals to isopressure lines.

TANC = Term used in solving determinant in subroutine STRM.

TAN1, TAN2 = Slope of pressure line at intersection with streamline for preceding and succeeding lines, respectively.

TAND1, TAND2 = Terms used in solving determinant in subroutine STRM.

TERM = Parameter used in calculating constants for isopressure line equation.

TN = Function used to calculate slope of pressure line from equation.

V1, V2 = Dummy variables for y ordinates in function subprograms.

X = Abscissa of a point.

XA = Abscissas of points given on pressure line.

XINL = Abscissa of midpoint where two projected orthogonal lines meet.

XINT = Abscissa of tentative intersection of projected streamline and succeeding pressure line.

XP = Abscissa of intersection calculated using linear equation.

XS = Abscissa of an indexed point on streamline.

XT = Temporary abscissa used in subroutine LOCATE.

X1 = Abscissa of preceding intersection.

X2 = Estimated x coordinate of intersection.

Y = Ordinate of a point.

YA = Ordinates of points given on isopressure line.

YC = Term used in solving determinant.

YD1, YD2 = Term used in solving determinant.

YINL = Ordinate of midpoint where two projected orthogonal lines meet.

YP = Ordinate of intersection calculated using linear equation of orthogonal.

YQ = Ordinate of intersection calculated using circle equation of isopressure line.

YS = Ordinate of an indexed point on streamline.

YTEST = Ordinate calculated from projecting previous ordinate used to check location of possible point in subroutine LOCATE.

YVALUE = Function used to calculate ordinates of pressure line using circle equation.

Y1 = Ordinate of preceding intersection.

Y2 = Ordinate of tentative intersection.

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