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SIPB--A seismic refraction inverse modeling program for batch computer systems

by

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Abstract

SIPB is a Fortran computer program that was developed for use with a batch processing computer system with program control information and input data submitted on cards or tape and output data printed on a line printer. The program is an upgraded version of FSIP1 (Scott, Tibbetts, and Burdick, 1972) with several major improvements. It is a batch-mode version of SIPT which was developed recently for interactive timeshare computer systems (Scott, 1977). The most significant improvement was made in the procedure for handling data from in-line offset shotpoints beyond the end shotpoints of the geophone spread. The changes and improvements are described, additions to user's instructions are given, examples of input and output data for a test problem are presented, and the Fortran program is listed in this report.

Introduction

SIPB is a Fortran-4 computer program for inverse modeling of seismic refraction data. Output of the program is printed in tables and as a plotted vertical cross section representing velocity layering beneath a line of seismic spreads. SIPB evolved from FSIP1, a batch-mode Fortran program developed and described by Scott, Tibbetts, and Burdick (1972) and by Scott (1973). SIPB has been developed and tested on a DEC-1070 computer with an ANSI Standard Fortran Compiler, and should be operable with only minor modification on any similar machine with a virtual memory and a standard Fortran compiler.

This report describes the salient features of SIPB with emphasis on the changes and improvements that have been made over its predecessor FSIP1. An outline of user's instructions and examples of input and output data are presented along with a complete listing of the program.

Salient features of SIPB

The following basic assumptions apply to the inverse modeling procedure used in SIPB:

1. Layers are continuous and extend from one end of the line of refraction spreads to the other.
2. Layer velocity increases with layer depth.
3. Horizontal velocity is equal to or greater than vertical velocity for any given layer.
4. Although vertical and horizontal velocity for a given layer may be different from one another, both velocities are constant from one end of a spread to the other. Vertical and horizontal velocities may vary from one spread to another.

5. The program user determines and specifies the refraction layer that is represented by each arrival time entered as input data. If a refraction layer is not specified, that arrival time is not used in computing the depth model.

6. The program user determines and specifies the position (in 3-D space) of each shotpoint and geophone for which arrival times are entered as input data.

7. Limits of input data:

   Number of layers in a problem: 2-5.

   Number of geophone spreads in a problem: 1-5.

   Number of shotpoints per spread: 1-7.

   Number of geophones per spread: 2-25 (other ranges available).

   Number of problems per job: no limit.

The following changes and improvements over FSIP1 were made in developing SIPB:

1. Shotpoint explosive charges can be located in any layer in SIPB. In FSIP1 all shots were assumed to be in layer 1 which sometimes caused this layer to be distorted near the shotpoint when shots were located in deep holes.

2. In FSIP1 the refraction horizons were extrapolated beyond the end geophones of the end spreads using the dip that was determined for the horizon between the two end geophones. This procedure sometimes produced erroneous projections of refraction horizons, resulting in an unreasonable model, particularly when option JOFF=1 was selected, which caused

rays to be traced from distant in-line offset shotpoints along projected refraction horizons. In SIPB, under the JOFF=1 option, refraction horizons are extended beyond the spread ends to the actual entry point of the ray traced from the offset shotpoint into the refraction horizon during the previous iteration of ray tracing. Under the JOFF=0 option the refraction horizon is projected using the dip obtained by linear regression of depth points occurring under the half of the geophone spread in question. This procedure usually projects the refraction horizon at a much gentler and more reasonable dip. However, in cases where this approach still produces an unreasonable result, a new option called IDIP can be selected by placing a 1 (rather than zero or blank) in column 80 of the second control cord. This option (IDIP=1) causes the ray-tracing subroutine RAYUP to use the average slope of the ground surface along the geophone spread(s) in place of the computed dip of the refraction horizons in tracing a ray from a refractor to a target geophone or shotpoint, which is equivalent to making the assumption that the directions taken by rays entering and emerging from the refraction horizon are those that would occur if all layers were parallel with the ground surface. The model layers are not forced to be parallel with the surface by this option. However, the selection of this option cannot result in a completely valid model unless the refraction horizons are actually parallel with the ground surface, and it should not be used except as a last resort to obtain a reasonable model when large and uncorrectable errors are associated with input data. The IDIP option of SIPB replaces the IFILL option of FSIP1, an option that was seldom used and never needed since it merely changed the selection of characters used in producing the printer plot of the vertical cross-sectional model. Removal of the IFILL option has simplified subroutine PLOT, resulting in more efficient operation.

3. The option JOFF=0, obtained by putting a blank or zero in column 79 of the second control card in FSIP1, has been improved significantly in SIPB. The objective of this option is to reference the arrival times associated with offset shotpoints (beyond the spread end shotpoints) to the arrival times of the end shotpoints and then to trace the rays from the end shotpoints to the target geophones rather than from the offset shotpoints to the target geophones. This approach has the advantage of avoiding the need for an error-prone extrapolation of the refraction horizon beyond the end shotpoints (as described in item 2 above). However, one of the limitations of selecting this option with the old FSIP1 program was that the offset shotpoint arrival times could

not be referenced to the end shotpoint times for a given layer unless at least one of the geophones received refraction arrivals (representing the layer in question) from both the offset shotpoint and the end shotpoint. In the new program SIPB, if the arrival times from the two shotpoints from the refractor do not overlap, two lines are fitted (by least squares) to the arrival times that are recorded from the two shotpoints for the refraction horizon, and the reference time correction (which is later subtracted from the offset shotpoint arrival times) is taken as the time difference between the two fitted lines at a point midway between the two inner geophones, one receiving an arrival from the offset shotpoint, the other from the end shotpoint.

4. As an extension of item 3 (above), in FSIP1 if no arrivals from the deepest refraction horizon were obtained by shooting the end shotpoint, then there was no way of referencing the arrivals obtained from the offset shotpoint to those obtained from the end shotpoint for the option JOFF=0, and the option JOFF=1 had to be used to obtain an interpretation down to the deepest layer. In SIPB, this problem is overcome by determining a reference correction time under the assumption that the two deepest layers are parallel. If this assumption is made, the times representing the deepest layer can be referenced to the arrivals representing the next shallower

layer (obtained from the same shotpoint) by subtracting

$$\Delta t_{i+1} = \frac{V_i}{V_{i+1}} \cdot \Delta t_i$$

from the arrivals representing the deepest layer. In the above formula Δt_i represents the reference correction time for referencing the arrivals from the offset shotpoint to the end shotpoint for the next shallower layer i (Δt_i is obtained by the technique described in item 3 above). V_i and V_{i+1} represent the apparent velocities for the deepest layer i+1 and the next shallower layer i, and are determined by fitting lines (by least squares) to the arrival times representing the two layers.

5. A new option called XTRUE is available in SIPT. Its normal (default) value is zero and is obtained by placing a zero or blank in column 20 of the spread control card. The purpose of the option is to correct for the slope of the ground surface and to compute new inline coordinate values (x) for geophone and shotpoint locations for XTRUE=0. If the inline coordinate values for shotpoints and geophones are corrected for surface slope prior to entry into input data files, then the option XTRUE=1 should be selected to skip the correction. When the slope correction option XTRUE=0 is selected, the position of geophone number 1 is left unchanged and all other shotpoints and geophones are referenced to it. Users

should be aware that the XSHIFT option (4th word on spread control card or record) is not affected by this new option (XSHIFT is not corrected for slope of the ground surface when XTRUE=0) and it is the user's responsibility to correct XSHIFT for surface slope before it is entered into the input data file.

6. A new option called IPLOT is available for selecting the type of time-distance plot desired for printer output. In the old program FSIP1, the time-distance plot was selected automatically as a function of the exit number. The use of IPLOT makes it possible for the user to control this selection.

User's instructions

Data cards are prepared using formats described by Scott, Tibbets and Burdick (1972, Appendix A, p. 27-32) with the following additions:

1. The new control card option IPLOT, used to select the type of time-distance plot desired, is punched in column 4 of the second control card. IPLOT=1 is used to select a plot of raw times, IPLOT=2 gives a datum-corrected plot, IPLOT=3 gives a plot with offset shotpoint times tied to end shotpoint times, and IPLOT=4 gives a plot with layer 1 removed. If column 4 is left blank, the default value of IPLOT is the absolute value of the exit number, or 4, whichever is smaller.
2. The new control variable IDIP replaces IFILL in column 80 of the second control card. (See item 2 on p. 3-5 of this report.)

3. The new variable XTRUE is available for correcting x-distances for the slope of the ground surface—default action is to apply the correction (blank or zero, column 20, spread control card, see item 5, p. 7-8).

The program is executed by the same procedures used for FSIP1 (Scott, Tibbetts, and Burdick, 1972).

References

Scott, J. H., Tibbetts, B. L., and Burdick, R. G., 1972, Computer analysis of seismic refraction data: USBM R.I. 7595, 95 p.

Scott, J. H., 1973, Seismic refraction modeling by computer: Geophysics, v. 38, no. 2, p. 271-284.

Scott, J. H., 1977, SIPT--A seismic refraction inverse modeling program for timeshare terminal computer systems: U.S. Geol. Survey Open-File Rept. 77-365, 107 p.

APPENDIX A. -- Input data examples

Input data cards for two data sets are listed below. The two sets are identical except that the exit number for the first set is 6, and for the second set, -6. Output results for both sets are given in Appendix B.

SET 1.

```
SIPTST.J06  SPREADS S AND $     DEMONSTRATION OF EXIT 6
2 6 4 4  2.5   00
1  1520
2  5900
3  9500
4 15000
S  3 12
S  A   24869    -29          2
S  C   24930    400          2
S  B   25075    900          2
S  1   24856      0         13   2   69   3   97   4
S  2   24841     75         24   2   57   3   93   4
S  3   24840    150         36   2   47   3   87   4
S  4   24873    225        485   2   43   2   805  4
S  5   24902    300         62   3   37   2   85   4
S  6   24843    375         66   3   19   2   75   4
S  7   25010    450         78   3   25   2   75   4
S  8   24911    497         73   3   24   2   64   3
S  9   24987    600         91   4   43   2   60   3
S 10   25132    675         93   4   65   3   56   2
S 11   25005    775         91   4   69   3   34   2
S 12   25059    875         99   4   78   3   18   2
$  4 12         675
$  L   24869   -704          2
$  A   24987   - 75          2
$  C   25117    275          2
$  B   25499    563          2
$  1   25132      0         92   4   275  2   65   3   87   4
$  2   25003     50         86   4   275  2   50   3   74   4
$  3   25005    100         88   4   37   2   44   3   71   4
$  4   25024    150         96   4   465  2   40   2   72   4
$  5   25059    200         99   4   56   2   30   2   685  4
$  6   25096    250        995   4   57   4   19   2   62   4
$  7   25137    300        105   4   62   4   20   2   59   4
$  8   25174    350        107   4   645  4   30   2   55   4
$  9   25207    400        108   4   65   4   39   2   49   4
$ 10   25293    450        113   4   70   4   50   2   47   4
$ 11   25381    500       1165   4   74   4   55   3   45   2
$ 12   25445    525        119   4   77   4   60   3   46   1
END
```

SET 2

```
SIPTST.J06  SPREADS S AND $      DEMONSTRATION OF EXIT -6
2-6 4 4  2,5    00
1  1520
2  5900
3  9500
4 15000
S   3 12                 1
S   A  24869   -29                  2
S   C  24930   400                  2
S   B  25075   900                  2
S   1  24856     0                 13   2   69   3   97   4
S   2  24841    75                 24   2   57   3   93   4
S   3  24840   150                 36   2   47   3   87   4
S   4  24873   225                 485  2   43   2   865  4
S   5  24902   300                 62   3   37   2   86   4
S   6  24843   375                 66   3   19   2   75   4
S   7  25010   450                 78   3   25   2   75   4
S   8  24911   497                 73   3   24   2   64   3
S   9  24987   600                 81   4   43   2   60   3
S  10  25132   675                 93   4   65   3   56   2
S  11  25005   775                 91   4   69   3   34   2
S  12  25059   875                 99   4   78   3   18   2
$   4 12       675   1
$   L  24869  -704                 2
$   A  24987  - 75                 2
$   C  25117   275                 2
$   B  25499   563                 2
$   1  25132     0                 92   4   275  2   65   3   87   4
$   2  25003    50                 86   4   275  2   50   3   74   4
$   3  25005   100                 88   4   37   2   44   3   71   4
$   4  25024   150                 96   4   485  2   40   2   72   4
$   5  25059   200                 99   4   56   2   30   2   685  4
$   6  25096   250                 995  4   57   4   19   2   62   4
$   7  25137   300                105   4   62   4   20   2   59   4
$   8  25174   350                107   4   645  4   30   2   55   4
$   9  25207   400                108   4   65   4   39   2   49   4
$  10  25293   450                113   4   70   4   50   2   47   4
$  11  25381   500                1165  4   74   4   55   3   45   2
$  12  25445   525                119   4   77   4   60   3   46   1
END
```

APPENDIX B. -- Output data examples

Printer output for test problem SIPTST.J06 is given on the following pages. The first set shows the results obtained by selecting exit 6, and the second set, those obtained by selecting exit -6. The two sets are the same except that for exit -6 the amount of printout is reduced substantially. Input cards for both data sets are listed in Appendix A.

```
                                                    SIPT REV 20

SIPTST.J06  SPREADS S AND $     DEMONSTRATION OF EXIT 6

CONTROL CARD DATA              P L O T   S C A L E S    D A T U M   O V E R R I D E   V A L U E S

                                ELEV   HORIZ   TIME    P O I N T   1   P O I N T   2
SPRDS  EXIT  LAYERS  VCARDS  FT/COL  FT/ROW  MS/COL   ELEV    X POS   ELEV    X POS   SLOPE  INTCPT   BLIM    TLIM   TRACE OFF DIP
-----  ----  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ----- --- ---
  2      6     4       4       2.5     8.3     1.0     0.0     0.0     0.0     0.0  0.0000    0.0    0.50    10.0      0    0   0

VELOCITY CARDS
        SPREAD 1      SPREAD 2       SPREAD
 LAYER   VV     VH     VV     VH
 -----  ------ ------ ------ ------
   1     1520.    0.     0.     0.
   2     5900.    0.     0.     0.
   3     9500.    0.     0.     0.
   4    15000.    0.     0.     0.

SHOTPOINT AND GEOPHONE DATA

 SPREAD S, 3 SHOTPOINTS, 12 GEOPHONES, XSHIFT =      0.0, XTRUE = 1

 SP   ELEV     X LOC    Y LOC    DEPTH   UPHOLE T  FUDGE T   END SP
 -- ------- -------- -------- -------- -------- -------- --------
 A  2466.9    -29.0      0.0      2.0      0.0      0.0      0
 C  2493.0    400.0      0.0      2.0      0.0      0.0      0
 B  2507.5    900.0      0.0      2.0      0.0      0.0      0

                                    ARRIVAL TIMES + FUDGE T AND LAYERS REPRESENTED
 GEO  ELEV     X LOC    Y LOC         SP A        SP C        SP B        SP
 --- ------ -------- --------      -------     -------     -------
  1  2485.6      0.0      0.0      13.0 2      69.0 3      97.0 4
  2  2484.1     75.0      0.0      24.0 2      57.0 3      93.0 4
  3  2484.0    150.0      0.0      36.0 2      47.0 3      87.0 4
  4  2487.3    225.0      0.0      48.5 2      43.0 2      86.5 4
  5  2490.2    300.0      0.0      62.0 3      37.0 2      86.0 4
  6  2484.3    375.0      0.0      66.0 3      19.0 2      75.0 4
  7  2501.0    450.0      0.0      78.0 3      25.0 2      75.0 4
  8  2491.1    497.0      0.0      73.0 3      24.0 2      64.0 3
  9  2494.7    600.0      0.0      81.0 4      43.0 2      60.0 3
 10  2513.2    675.0      0.0      93.0 4      65.0 3      56.0 2
 11  2500.5    775.0      0.0      91.0 4      69.0 3      34.0 2
 12  2505.9    875.0      0.0      99.0 4      78.0 3      18.0 2
```

SET 1

SET 1 cont'.

```
SIPTST.J06  SPREADS 8 AND 8      DEMONSTRATION OF EXIT 6

SHOTPOINT AND GEOPHONE DATA

 SPREAD 8, 4 SHOTPOINTS, 12 GEOPHONES, XSHIFT =   675.0, XTRUE = 1

 SP   ELEV     X LOC    Y LOC     DEPTH  UPHOLE T  FUDGE T  END SP
 -- ------- -------- -------- -------- -------- -------- --------
  L  2486.9   -704.0      0.0      2.0      0.0      0.0      0
  A  2498.7    -75.0      0.0      2.0      0.0      0.0      0
  C  2511.7    275.0      0.0      2.0      0.0      0.0      0
  B  2549.9    563.0      0.0      2.0      0.0      0.0      0

                                      ARRIVAL TIMES + FUDGE T AND LAYERS REPRESENTED
GEO  ELEV     X LOC    Y LOC         SP L      SP A      SP C      SP B      SP
---  ------ -------- --------       -------   -------   -------   -------
  1  2513.2      0.0      0.0       92.0 4    27.5 2    65.0 3    87.0 4
  2  2500.3     50.0      0.0       86.0 4    27.5 2    50.0 3    74.0 4
  3  2499.5    100.0      0.0       88.0 4    37.0 2    44.0 3    71.0 4
  4  2502.4    150.0      0.0       96.0 4    48.5 2    40.0 2    72.0 4
  5  2505.9    200.0      0.0       99.0 4    56.0 2    30.0 2    68.5 4
  6  2509.6    250.0      0.0       99.5 4    57.0 4    19.0 2    62.0 4
  7  2513.7    300.0      0.0      105.0 4    62.0 4    20.0 2    59.0 4
  8  2517.4    350.0      0.0      107.0 4    64.5 4    30.0 2    55.0 4
  9  2520.7    400.0      0.0      108.0 4    65.0 4    39.0 2    49.0 4
 10  2529.3    450.0      0.0      113.0 4    70.0 4    50.0 2    47.0 4
 11  2538.1    500.0      0.0      116.5 4    74.0 4    55.0 3    45.0 2
 12  2544.5    525.0      0.0      119.0 4    77.0 4    60.0 3    46.0 1
```

SET 1 cont'.

```
SIPTST.J06  SPREADS S AND $     DEMONSTRATION OF EXIT 6

 V1 FOR DIRECT PAYS AND DIRECT DISTANCES DD

 SPREAD S       SP  GEO    DD       V1   AVG V1
                --  ---  ------  ------  ------

 SPREAD $       SP  GEO    DD       V1   AVG V1
                --  ---  ------  ------  ------
                 8   12    38.2    829.
                                           829.

AVG OF ALL   829.
```

SET 1 cont'.

```
SIPTST.J06  SPREADS S AND 8     DEMONSTRATION OF EXIT 6

ARRIVAL TIMES CORRECTED TO DATUM (DATUM ELEV =  2476.4 + (  0.0420)X), AND PLOT POSITIONS D

 SPREAD S                     SP A          SP C          SP B          SP

      ELEV . . . . .        2475.2        2493.2        2514.2
         .
         .    CORR T         -6.4           1.5           5.7
GEO      .               ---T-----D--- ---T-----D--- ---T-----D---
 1  2476.4    -6.0        0.6     0.0   64.4    -0.1   95.7    -0.3
 2  2479.6    -3.0       14.7    75.0   55.5    74.9   95.8    74.7
 3  2482.7    -0.8       28.8   150.0   47.6   149.8   91.9   149.6
 4  2485.9    -0.9       41.2   225.0   43.5   224.9   91.3   224.7
 5  2489.0    -0.8       54.9   300.0   37.7   300.0   91.0   299.8
 6  2492.2     5.2       64.8   375.0   25.6   373.5   85.9   374.5
 7  2495.3    -3.7       67.9   450.2   22.7   450.6   77.0   450.0
 8  2497.3     4.1       70.7   497.0   29.5   497.0   73.8   496.7
 9  2501.5     1.9       76.5   600.1   46.4   600.1   67.6   599.9
10  2504.8    -5.6       81.1   675.5   60.9   675.7   56.2   674.9
11  2509.0     5.6       90.2   775.1   76.0   775.1   45.3   774.8
12  2513.2     4.8       97.4   875.2   64.2   875.2   28.5   874.9

 SPREAD S                     SP L          SP A          SP C          SP B          SP

      ELEV . . . . .        2484.9        2501.6        2516.3        2528.4
         .
         .    CORR T          0.0           3.2           4.3         -12.8
GEO      .               ---T-----D--- ---T-----D--- ---T-----D--- ---T-----D---
 1  2504.8    -5.6       86.4   675.5   25.2   676.4   63.8   675.0   68.6   673.8
 2  2506.9     4.3       90.3   725.1   35.0   725.0   58.7   724.7   65.5   722.6
 3  2509.0     5.6       93.6   775.1   45.8   775.0   53.9   774.6   63.7   772.4
 4  2511.1     5.7      101.7   825.1   57.4   825.0   50.0   824.7   64.9   822.3
 5  2513.2     4.8      103.8   875.2   64.0   875.1   39.1   874.8   60.4   872.3
 6  2515.3     3.7      103.2   925.3   64.0   925.2   27.1   924.9   52.9   922.4
 7  2517.4     2.4      107.4   975.4   67.6   975.3   26.7   975.1   48.6   972.5
 8  2519.4     1.3      108.3  1025.4   69.1  1025.4   35.7  1025.2   43.5  1022.5
 9  2521.5     0.6      108.6  1075.5   68.8  1075.5   43.9  1075.3   36.7  1072.4
10  2523.6    -3.7      109.3  1125.8   69.5  1125.9   50.6  1125.9   30.4  1123.1
11  2525.7    -8.1      104.4  1176.1   69.1  1176.3   51.2  1176.5   24.0  1173.9
12  2526.8   -11.6      107.4  1201.3   68.6  1201.7   52.7  1202.1   46.0  1199.8
```

SET 1 cont'.

```
SIPTST.J06  SPREADS 5 AND 6     DEMONSTRATION OF EXIT 6
LAYER 2 VELOCITY AND TIME INTERCEPTS COMPUTED BY REGRESSION

 SPREAD 5   VEL    TIME   GEOS    SP     GEOS  TIME    VEL          AVG V   AVG T   PTS
           ------  ----  -----   ---    -----  ----  ------        ------  -----   ---
             000.   0.0   0  0    A      1  4  -4.3   5517.         5517.   -4.3    4.
            8320.  23.5   4  6    C      7  9  14.4   6284.         7160.   19.0    6.
            7227.  26.0  10 12    B      0  0   0.0    000.         7227.   26.0    3.

                                                               AVG  6572.           13.

 SPREAD 6   VEL    TIME   GEOS    SP     GEOS  TIME    VEL          AVG V   AVG T   PTS
           ------  ----  -----   ---    -----  ----  ------        ------  -----   ---
             000.   0.0   0  0    A      1  5  10.2   4974.         4974.   10.2    5.
            4364.  21.5   4  6    C      7 10  23.3   6295.         5291.   22.4    7.

                                                               AVG  5154.           12.

                                                                    -------         ---

                                                        AVG OF ALL  5805.           25.

LAYER 2 VELOCITY COMPUTED BY HOBSON-OVERTON METHOD

 SPREAD 6                                         5 HIGHEST EPS
     VEL     SPS    GEOS  TDSP  SE EP      EP    GEO     EP    GEO      EP    GEO      EP    GEO      EP    GEO
   ------    ---   -----  ----  -----   ---------    ---------    ---------    ---------    ---------
    5725.    A C    4  5 -10.0  0.000   -0.000   4   0.000   5   0.000   0   0.000   0   0.000   0

    AVG=  5725. FOR   2. POINTS

  AVG OF ALL=  5725. FOR   2. POINTS
OVERRIDE V2 =   5900.
```

SET 1 cont'.

```
SIPTST.J06  SPREADS S AND 8     DEMONSTRATION OF EXIT 6
LAYER 3 VELOCITY AND TIME INTERCEPTS COMPUTED BY REGRESSION

 SPREAD S   VEL    TIME   GEOS    SP    GEOS  TIME    VEL       AVG V    AVG T   PTS
          ------   ----   -----   ---   ----- ----  ------     ------   -----   ---
            000.    0.0   0  0     A     5  8 31.1  12987.     12987.    31.1    4.
           8920.   19.4   1  3     C    10 12 29.8   8554.      8733.    24.6    6.
          16764.   49.7   8  9     B     0  0  0.0    000.     16764.    49.7    2.

                                                           AVG 10769.             12.

 SPREAD 8   VEL    TIME   GEOS    SP    GEOS  TIME    VEL       AVG V    AVG T   PTS
          ------   ----   -----   ---   ----- ----  ------     ------   -----   ---
          10082.   36.4   1  3     C    11 12 38.1  17301.     12102.    37.3    5.

                                                           AVG 12102.              5.

                                                               -------            ---

                                                    AVG OF ALL 11129.             17.

LAYER 3 VELOCITY COMPUTED BY HOBSON-OVERTON METHOD

  NOT ENOUGH POINTS
OVERRIDE V3 =   9500.
```

SET 1 cont'.

```
SIPTST.J06  SPREADS S AND $     DEMONSTRATION OF EXIT 6
LAYER 4 VELOCITY AND TIME INTERCEPTS COMPUTED BY REGRESSION

 SPREAD S   VEL    TIME   GEOS    SP    GEOS  TIME    VEL        AVG V   AVG T    PTS
          ------   ----   -----   ---   -----  ----  ------      ------  -----    ---
            000.    0.0   0  0     A    9 12   27.2  12863.      12863.   27.2     4.
          26328.   64.3   1  7     B    0  0    0.0    000.      26328.   64.3     7.

                                                             AVG 19069.            11.

 SPREAD $   VEL    TIME   GEOS    SP    GEOS  TIME    VEL        AVG V   AVG T    PTS
          ------   ----   -----   ---   -----  ----  ------      ------  -----    ---
            000.    0.0   0  0     L    1 12   63.4  25117.      25117.   63.4    12.
            000.    0.0   0  0     A    6 12   61.8  74583.      74583.   61.8     7.
          11732.   24.5   1 10     B    0  0    0.0    000.      11732.   24.5    10.

                                                             AVG 20365.            29.

                                                                 -------          ---

                                                        AVG OF ALL 19992.          40.

LAYER 4 VELOCITY COMPUTED BY HOBSON-OVERTON METHOD

 SPREAD $                                              5 HIGHEST EPS
      VEL     SPS   GEOS   TDSP  SE EP     EP    GEO     EP    GEO     EP    GEO     EP    GEO     EP    GEO
    ------    ---   -----  ----  -----  ---------    ---------    ---------    ---------    ---------
    14655.    L B   1 10    7.5  0.709   1.001    2  -0.958    5   0.872    7  -0.807    3  -0.791    6
    14536.    A B   6 10   10.9  0.375   0.596    7  -0.509    6   0.208    8  -0.170    9  -0.126   10

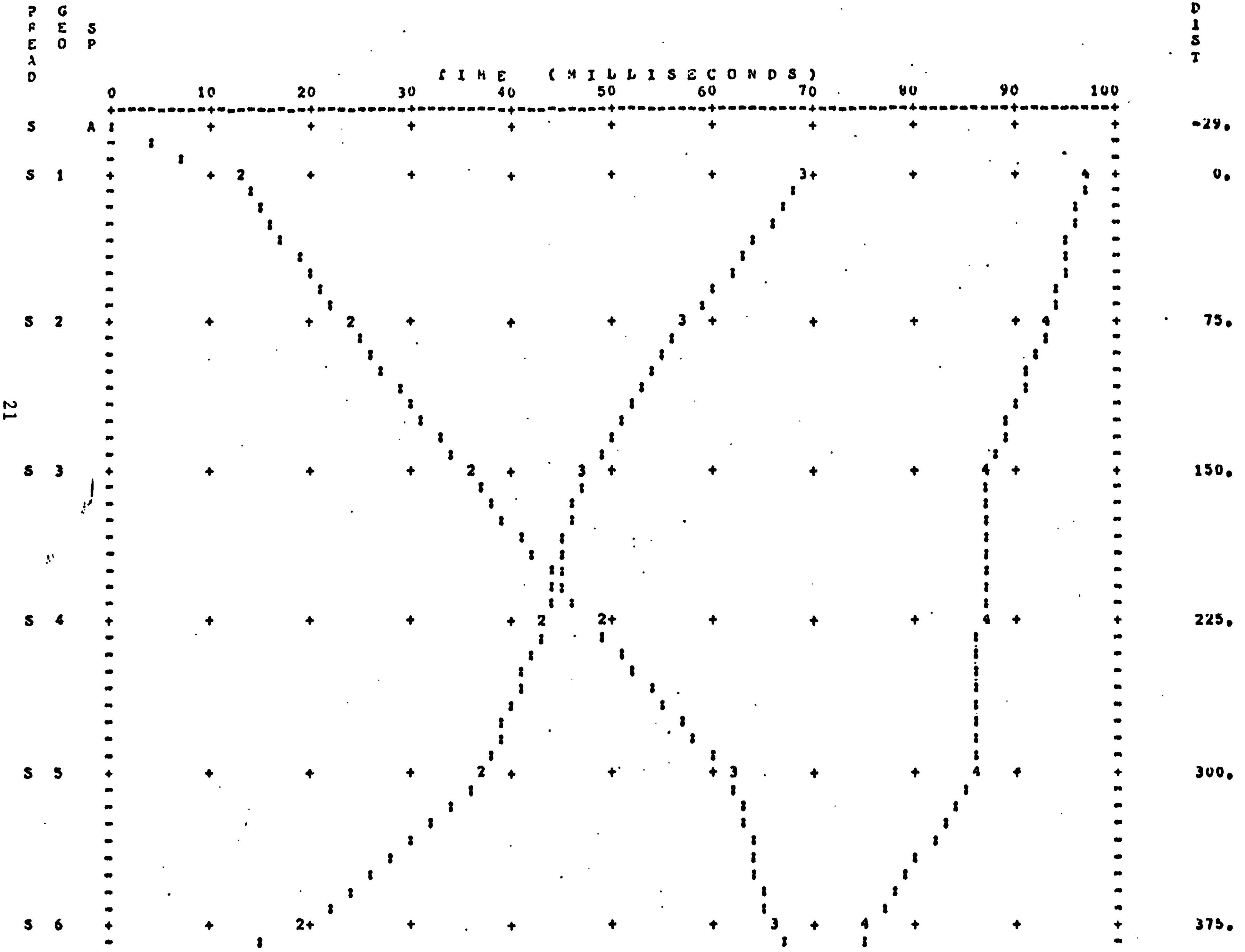
      AVG= 14615. FOR  15. POINTS

   AVG OF ALL= 14615. FOR  15. POINTS
OVERRIDE V4 =  15000.
```

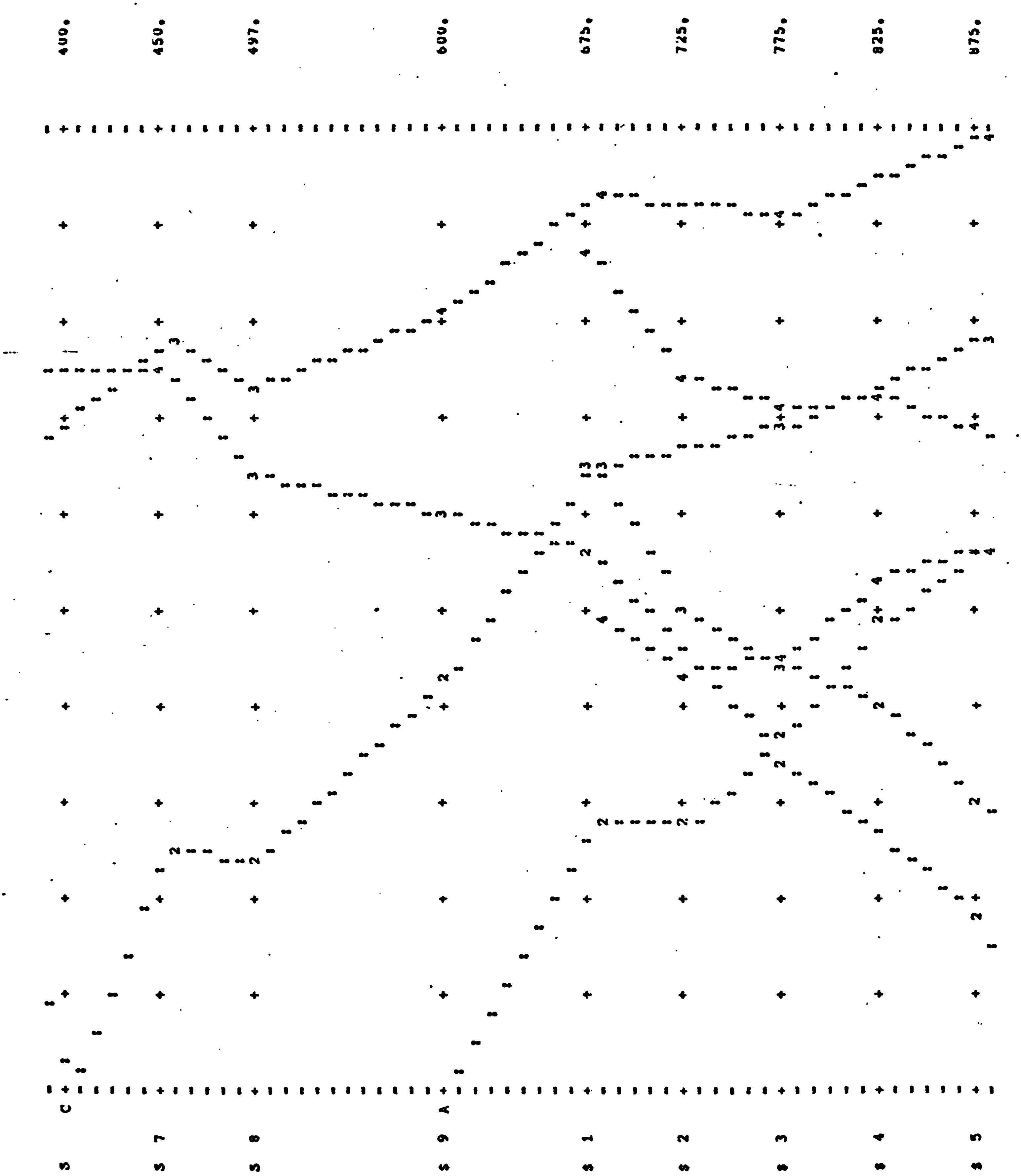
SET 1 cont'.

SIPTST.J06   SPREADS 5 AND 8   DEMONSTRATION OF EXIT 6

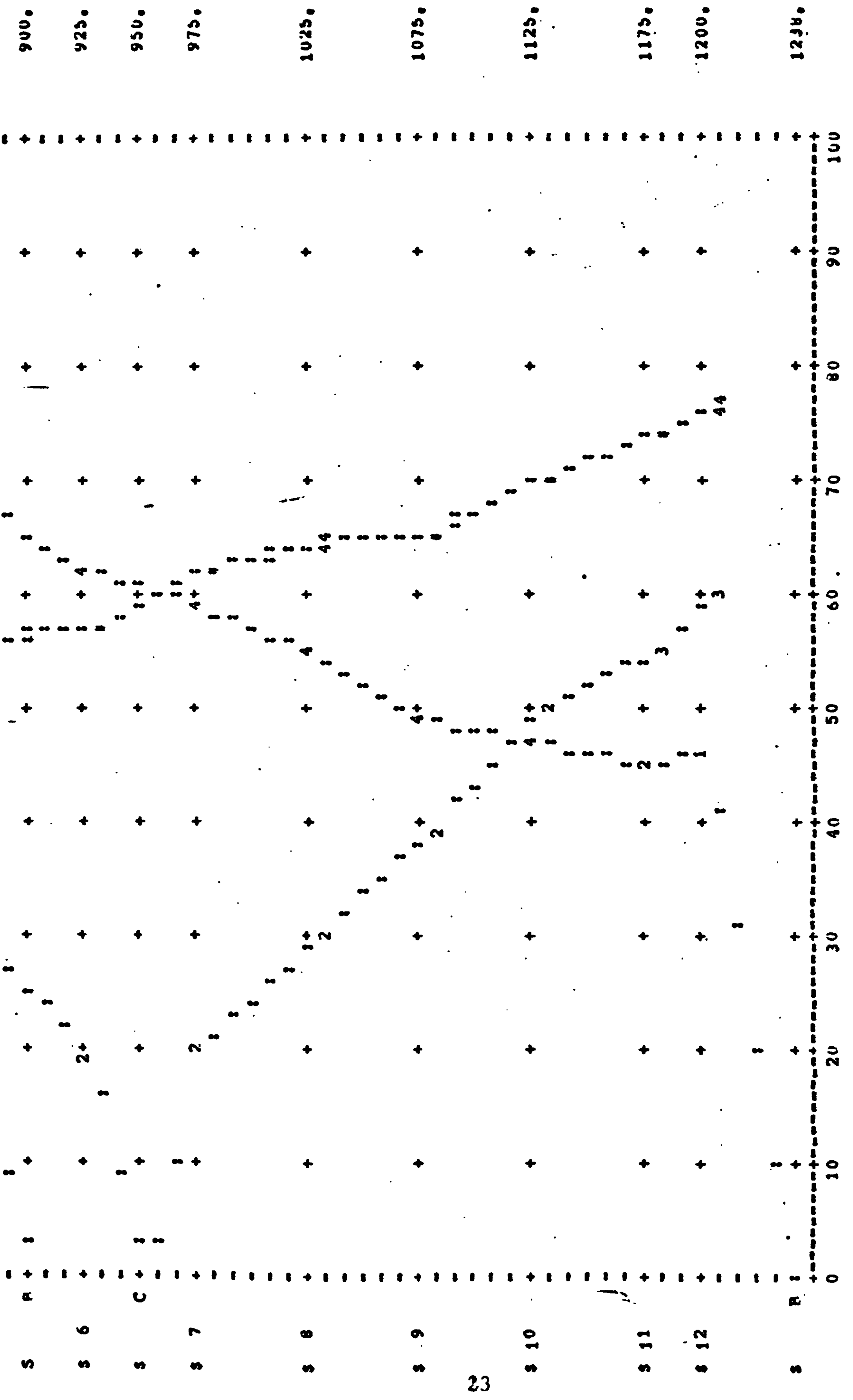
TIME-DISTANCE PLOT -- PRE-DEPTH VALUES WITH TIE CORR IF JJOFF=0



SET 1 cont'.



SET 1 cont'.



900.
925.
950.
975.
1025.
1075.
1125.
1175.
1200.
1238.
0
10
20
30
40
50
60
70
80
90
100
$ A
$ 6
$ C
$ 7
$ 8
$ 9
$ 10
$ 11
$ 12
$ B

SET 1. cont'.

```
SIPTST.J06  SPREADS 5 AND 8      DEMONSTRATION OF EXIT 6

ARRIVAL TIMES CORRECTED TO BASE OF LAYER 1, AND ELEV OF BASE OF LAYER 1

 SPREAD 5                    SP A          SP C          SP B          SP

      ELEV . . . . .      2475.6        2480.8        2494.2
          .
          :   CORR T         6.1           6.7           7.4
GEO       .             ---T-----D---  ---T-----D---  ---T-----D---
 1  2475.8       6.4      0.4     0.0   55.9    -0.1   83.1    -0.3
 2  2475.1       5.9     11.9    75.0   44.4    74.9   79.6    74.7
 3  2479.9       2.7     27.1   150.0   37.6   149.8   76.9   149.6
 4  2482.4       3.2     39.1   225.0   33.1   224.9   75.8   224.7
 5  2476.4       9.1     46.8   300.0   21.2   300.0   69.5   299.8
 6  2479.0       3.5     56.4   375.0    6.8   373.5   64.1   374.5
 7  2484.4      10.9     60.9   450.2    7.4   450.6   56.6   450.0
 8  2485.4       1.8     65.0   497.0   15.5   497.0   54.8   496.7
 9  2493.5       3.4     71.4   600.1   32.9   600.1   49.2   599.9
10  2493.6      12.9     74.0   675.5   45.1   675.7   35.7   674.9
11  2490.6       6.5     78.3   775.1   55.8   775.1   20.0   774.8
12  2491.9       9.2     83.6   875.2   62.1   875.2    1.4   874.9

 SPREAD 8                    Sp L          SP A          SP C          SP B          SP

      ELEV . . . . .         0.0        2493.5        2497.9        2518.4
          .
          :   CORR T         0.0           2.1           7.8          19.4
GEO       .             ---T-----D---  ---T-----D---  ---T-----D---  ---T-----D---
 1  2493.7    . 12.8     36.6   675.5   12.6   676.4   44.4   675.0   54.8   673.8
 2  2493.4       4.5     38.8   725.1   20.8   725.0   37.7   724.7   50.0   722.6
 3  2491.3       6.1     39.3   775.1   28.8   775.0   30.2   774.6   45.5   772.4
 4  2487.5       9.8     43.5   825.1   36.6   825.0   22.4   824.7   42.7   822.3
 5  2492.1       9.1     47.3   875.2   44.8   875.1  -13.2   874.8   40.0   872.3
 6  2496.3       0.8     46.1   925.3   46.1   925.2    2.5   924.9   33.6   922.4
 7  2499.4       9.4     53.0   975.4   50.5   975.3    2.8   975.1   30.2   972.5
 8  2501.8      10.2     54.1  1025.4   52.2  1025.4   12.0  1025.2   25.3  1022.5
 9  2504.7      10.5     54.8  1075.5   52.4  1075.5   20.7  1075.3   19.1  1072.4
10  2509.2      13.2     57.1  1125.9   54.7  1125.9   29.0  1125.9   14.4  1123.1
11  2513.8      16.0     57.9  1176.1   55.9  1176.3   31.3  1176.5    9.6  1173.9
12  2515.6      19.0     57.3  1201.3   55.9  1201.7   33.2  1202.1    0.0  1199.8
```

SET 1 cont.

```
SIPTST.J06  SPREADS 5 AND 8     DEMONSTRATION OF EXIT 6

SPREAD 5   RAY END POINTS BENEATH GEOPHONES
GEO                          SP A          SP C          SP B           SP
---                      ---------L-   ---------L-   ---------L-
 1               POS        -2.2 2        68.5 3        38.0 4
                ELEV      2476.1        2408.8        2391.8

 2               POS        72.4 2       128.8 3       129.7 4
                ELEV      2474.9        2420.2        2372.6

 3               POS       149.1 2       201.1 3       212.8 4
                ELEV      2479.9        2429.4        2354.4

 4               POS       224.0 2       226.0 2       296.7 4
                ELEV      2482.4        2482.4        2324.2

 5               POS       277.9 3       304.4 2       443.4 4
                ELEV      2446.5        2476.0        2314.0

 6               POS       350.9 3       376.9 2       553.6 4
                ELEV      2445.2        2478.5        2327.5

 7               POS       435.5 3       446.9 2       602.9 4
                ELEV      2464.0        2484.1        2350.7

 8               POS       481.0 3       496.2 2       516.6 3
                ELEV      2469.9        2488.3        2452.4

 9               POS       534.4 4       598.7 2       645.7 3
                ELEV      2346.8        2493.5        2425.5

10               POS       617.8 4       597.0 3       679.6 2
                ELEV      2372.8        2415.2        2493.7

11               POS       722.0 4       713.9 3       777.4 2
                ELEV      2388.8        2412.2        2490.7

12               POS       826.4 4       830.5 3       879.8 2
                ELEV      2396.5        2431.0        2492.6

RAY END POINTS BENEATH SHOTPOINTS

L=2    RIGHT     POS       -26.4         403.2           0.0
                ELEV      2475.9        2480.6           0.0

L=2    LEFT      POS         0.0         398.0         898.0
                ELEV         0.0        2480.2        2494.2

L=3    RIGHT     POS        32.4         442.0           0.0
                ELEV      2415.8        2439.9           0.0

L=3    LEFT      POS         0.0         378.9         857.1
                ELEV         0.0        2449.5        2434.0

L=4    RIGHT     POS         8.4           0.0           0.0
                ELEV      2392.1           0.0           0.0

L=4    LEFT      POS         0.0           0.0         838.9
                ELEV         0.0           0.0        2379.6
```

SET 1 cont.

```
SIPTST.J06   SPREADS 5 AND 8     DEMONSTRATION OF EXIT 6

SPPEAD 8   RAY END POINTS BENEATH GEOPHONES
GEO                        SP L          SP A          SP C          SP B           SP
---                    --------L-    --------L-    --------L-    --------L-
 1             POS      614.6 4       669.9 2       732.1 3       749.5 4
              ELEV     2306.5        2493.8        2428.7        2384.7

 2             POS      671.4 4       723.5 2       777.9 3       792.5 4
              ELEV     2381.7        2493.4        2435.4        2394.0

 3             POS      724.9 4       772.4 2       818.2 3       841.0 4
              ELEV     2393.2        2491.9        2444.2        2399.3

 4             POS      767.7 4       819.4 2       830.7 2       905.3 4
              ELEV     2382.7        2487.4        2487.5        2392.0

 5             POS      818.5 4       872.8 2       879.8 2       963.6 4
              ELEV     2384.1        2492.0        2492.6        2392.9

 6             POS      880.6 4       880.4 4       929.1 2      1007.8 4
              ELEV     2402.3        2402.1        2496.8        2418.0

 7             POS      925.0 4       926.7 4       972.0 2      1065.7 4
              ELEV     2395.3        2398.2        2499.4        2428.1

 8             POS      992.9 4       992.8 4      1021.5 2      1107.7 4
              ELEV     2413.2        2413.0        2501.6        2442.7

 9             POS     1057.3 4      1056.3 4      1071.3 2      1136.3 4
              ELEV     2437.9        2440.7        2504.4        2465.7

10             POS     1112.9 4      1113.8 4      1121.5 2      1171.3 4
              ELEV     2456.0        2458.8        2506.9        2480.1

11             POS     1172.7 4      1172.7 4      1163.7 3      1183.0 2
              ELEV     2487.9        2486.0        2494.5        2514.6

12             POS     1199.7 4      1198.7 4      1190.5 3         0.0 1
              ELEV     2504.6        2501.9        2500.5           0.0

RAY END POINTS BENEATH SHOTPOINTS

L=2    RIGHT   POS        0.0         601.0         953.6           0.0
              ELEV        0.0        2493.5        2498.3           0.0

L=2    LEFT    POS        0.0           0.0         947.8        1232.4
              ELEV        0.0           0.0        2497.9        2518.2

L=3    RIGHT   POS        0.0         639.7         991.7           0.0
              ELEV        0.0 *      2433.9        2462.7           0.0

L=3    LEFT    POS        0.0           0.0         930.2        1231.7
              ELEV        0.0           0.0        2453.6        2509.8

L=4    RIGHT   POS      669.3         669.3           0.0           0.0
              ELEV     2389.3 *      2389.3           0.0           0.0

L=4    LEFT    POS        0.0           0.0           0.0        1236.2
              ELEV        0.0           0.0           0.0        2505.8
```

SET 1 cont'.

```
SIPTST.J06  SPREADS 5 AND 8     DEMONSTRATION OF EXIT 6

 SPREAD 5   SMOOTHED POSITION OF LAYERS BENEATH SHOTPOINTS AND GEOPHONES

                                    LAYER 2             LAYER 3             LAYER 4             LAYER

 SP    POSITION   SURF ELEV      DEPTH  ELEV        DEPTH  ELEV        DEPTH  ELEV
 ---   --------   ---------    --------------     --------------     --------------
  A      -29.0      2486.9      11.3  2475.6       81.6  2405.3       95.3  2391.6
  C      400.0      2493.0      12.2  2480.9       42.0  2451.0      143.8  2349.2
  B      906.0      2507.5      13.3  2494.2       58.9  2448.6      109.5  2398.0

 GEO
 ---
  1        0.0      2485.6       9.8  2475.8       77.1  2408.5       98.1  2387.5
  2       75.0      2484.1       9.0  2475.1       67.8  2416.3      101.9  2382.2
  3      150.0      2484.0       4.1  2479.9       57.9  2426.1      118.0  2366.0
  4      225.0      2487.3       4.9  2482.4       51.8  2435.5      139.6  2347.7
  5      300.0      2490.2      13.8  2476.4       46.8  2443.4      153.3  2336.9
  6      375.0      2484.3       5.3  2479.0       35.8  2448.5      141.1  2343.2
  7      450.0      2501.0      16.6  2484.4       45.1  2455.9      139.8  2361.2
  8      497.0      2491.1       2.7  2488.4       38.6  2452.5      133.1  2358.0
  9      600.0      2498.7       5.2  2493.5       65.7  2433.0      139.0  2359.7
 10      675.0      2513.2      19.6  2493.6       87.7  2425.5      135.3  2377.9
 11      775.0      2500.5       9.9  2490.6       68.9  2431.6      111.8  2388.7
 12      875.0      2505.9      14.0  2491.9       61.2  2444.7      110.2  2395.7
VELOCITIES USED:
                 LAYER 1             LAYER 2             LAYER 3             LAYER 4             LAYER

       VERTICAL   1520.               5900.               9500.
     HORIZONTAL                       5900.               9500.              15000.
```

SET 1 cont.

```
SIPTST.J06   SPREADS 5 AND 8       DEMONSTRATION OF EXIT 6

 SPREAD 8   SMOOTHED POSITION OF LAYERS BENEATH SHOTPOINTS AND GEOPHONES

                                   LAYER 2           LAYER 3           LAYER 4           LAYER

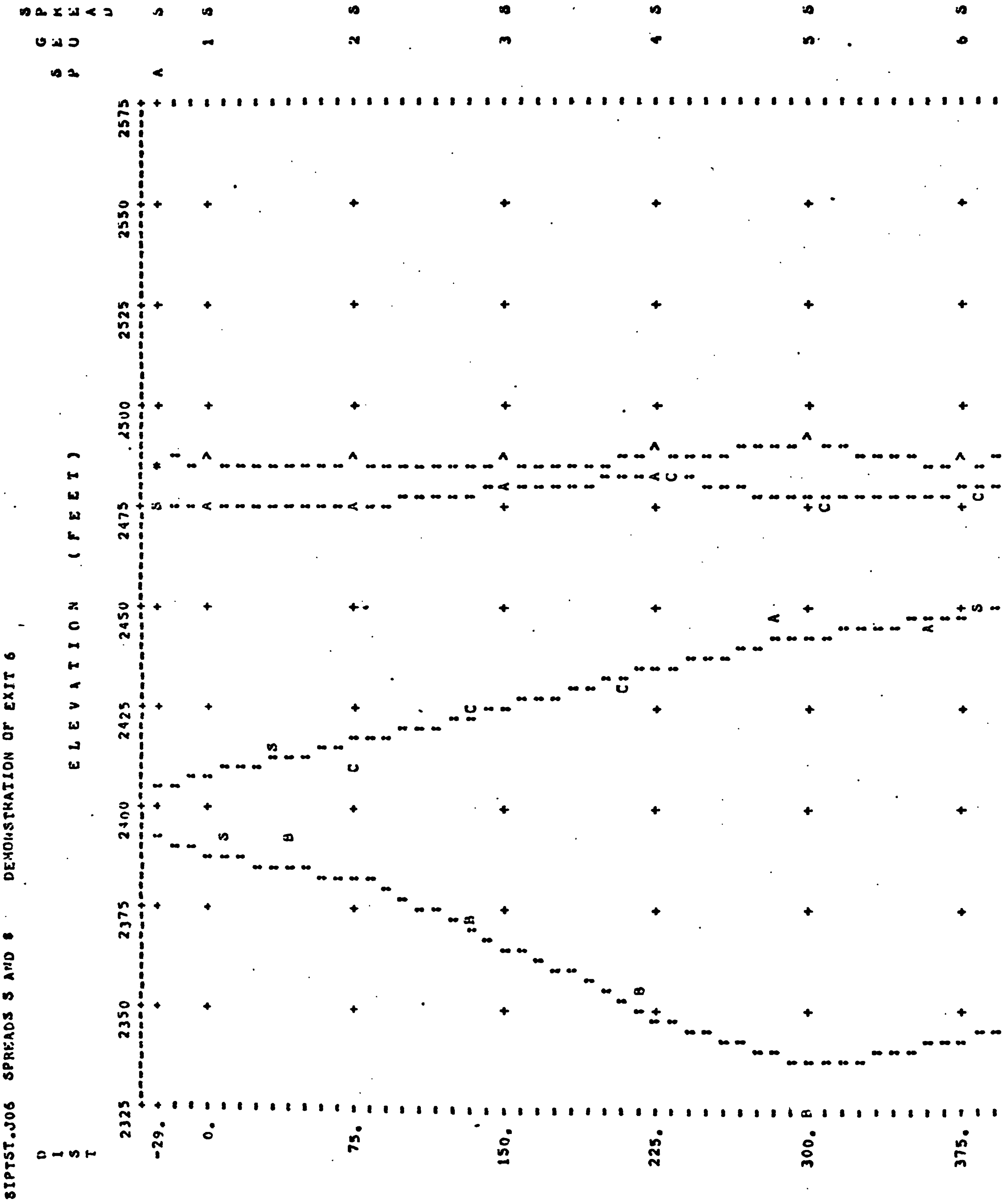
 SP   POSITION  SURF ELEV       DEPTH  ELEV       DEPTH  ELEV       DEPTH  ELEV
 ---  --------  ---------     -------------     -------------     -------------
  A      600.0     2498.7       5.2  2493.5      65.7  2433.0     139.0  2359.7
  C      950.0     2511.7      13.8  2497.9      55.4  2456.3     106.9  2404.8
  B     1238.0     2549.9      31.5  2518.4      41.4  2508.5      41.4  2508.5

 GEO
 ---
  1      675.0     2513.2      19.5  2493.7      87.7  2425.5     135.3  2377.9
  2      725.0     2500.3       6.9  2493.4      71.8  2428.5     117.0  2383.3
  3      775.0     2500.5       9.2  2491.3      68.9  2431.6     111.8  2388.7
  4      825.0     2502.4      14.9  2487.5      64.3  2438.1     110.2  2392.2
  5      875.0     2505.9      13.8  2492.1      61.2  2444.7     110.2  2395.7
  6      925.0     2509.6      13.3  2496.3      57.2  2452.4     109.4  2400.2
  7      975.0     2513.7      14.3  2499.4      53.5  2460.2     104.3  2409.4
  8     1025.0     2517.4      15.6  2501.8      47.9  2469.5      93.6  2423.8
  9     1075.0     2520.7      16.0  2504.7      42.1  2478.6      80.3  2440.4
 10     1125.0     2529.3      20.1  2509.2      41.5  2487.8      69.5  2459.6
 11     1175.0     2538.1      24.3  2513.8      41.1  2497.0      50.3  2487.8
 12     1200.0     2544.5      28.9  2515.6      43.0  2501.5      48.1  2496.4

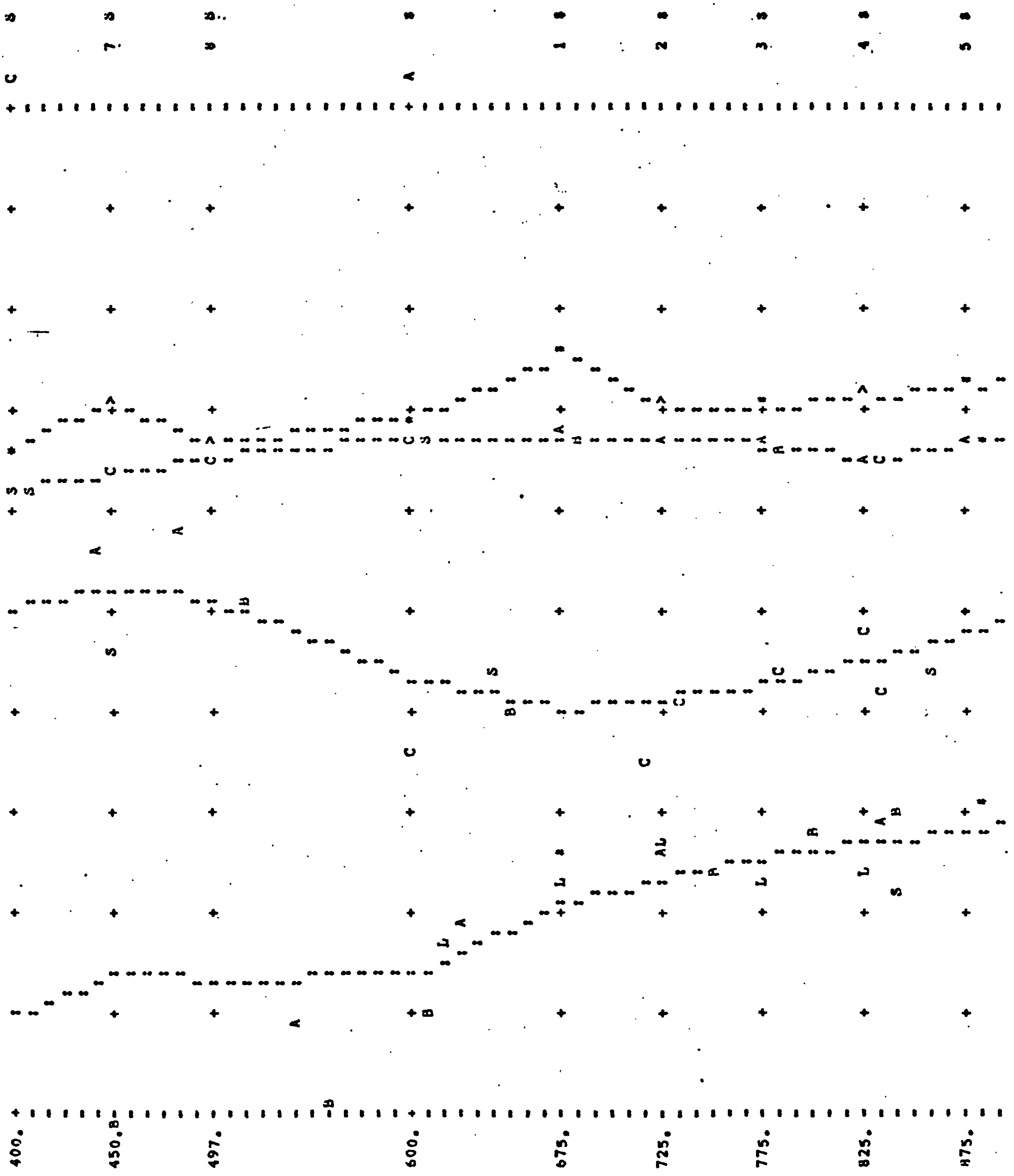
VELOCITIES USED:
                    LAYER 1           LAYER 2           LAYER 3           LAYER 4           LAYER

       VERTICAL     1520.              5900.             9500.
     HORIZONTAL                        5900.             9500.            15000.
```

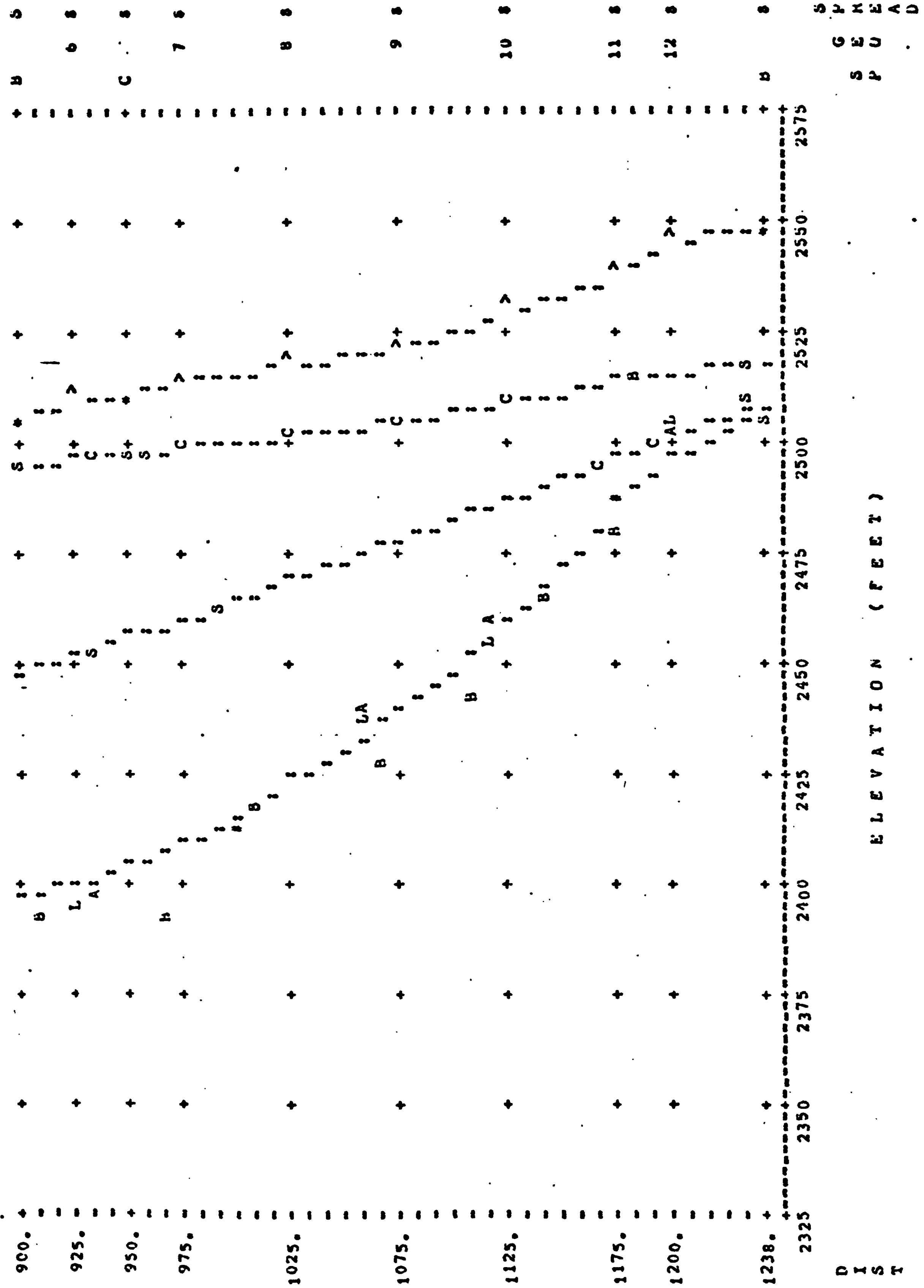
SET 1 cont.


SIPTST.J06 SPREADS 5 AND 6 DEMONSTRATION OF EXIT 6
ELEVATION (FEET)
DIST
SPREAD
GEO
SP
2325
2350
2375
2400
2425
2450
2475
2500
2525
2550
2575
-29.
0.
75.
150.
225.
300.
375.
5
15
25
38
45
55
65
1
2
3
4
5
6
A
S
B
C

SET 1 cont.



SET 1 cont.



DIST
900.
925.
950.
975.
1025.
1075.
1125.
1175.
1200.
1238.
ELEVATION (FEET)
2325
2350
2375
2400
2425
2450
2475
2500
2525
2550
2575
SPREAD
GEO.
SP
5
6
7
8
9
10
11
12
B
C

SET 2

```
                                                  SIPT REV 20

SIPTST.J06  SPREADS S AND S     DEMONSTRATION OF EXIT 6

CONTROL CARD DATA              P L O T  S C A L E S   D A T U M   O V E R R I D E   V A L U E S

                               ELEV    HORIZ   TIME    P O I N T  1    P O I N T  2
SPRDS  EXIT  LAYERS  VCARDS  FT/COL  FT/ROW  MS/COL   ELEV    X POS   ELEV    X POS   SLOPE  INTCPT   BLIM    TLIM   TRACE OFF DIP
-----  ----  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ------  ----- --- ---
  2     -6     4       4       2.5     8.3     1.0     0.0     0.0     0.0     0.0  0.0000    0.0    0.50    10.0     0    0   0

VELOCITY CARDS
        SPREAD 1      SPREAD 2      SPREAD
 LAYER   VV     VH     VV     VH
 -----  ------ ------ ------ ------
   1    1520.    0.     0.     0.
   2    5900.    0.     0.     0.
   3    9500.    0.     0.     0.
   4   15000.    0.     0.     0.

SHOTPOINT AND GEOPHONE DATA

 SPREAD S, 3 SHOTPOINTS, 12 GEOPHONES, XSHIFT =     0.0, XTRUE = 1

 SP   ELEV    X LOC    Y LOC    DEPTH  UPHOLE T  FUDGE T  END SP
 -- ------- -------- -------- -------- -------- -------- --------
  A  2486.9   -29.0      0.0      2.0      0.0      0.0      0
  C  2493.0   400.0      0.0      2.0      0.0      0.0      0
  B  2507.5   900.0      0.0      2.0      0.0      0.0      0

                                 ARRIVAL TIMES + FUDGE T AND LAYERS REPRESENTED
 GEO  ELEV    X LOC    Y LOC       SP A       SP C       SP B       SP
 --- ------ -------- --------    -------    -------    -------
  1  2485.6     0.0      0.0      13.0 2     69.0 3     97.0 4
  2  2484.1    75.0      0.0      24.0 2     57.0 3     93.0 4
  3  2484.0   150.0      0.0      36.0 2     47.0 3     87.0 4
  4  2487.3   225.0      0.0      48.5 2     43.0 2     86.5 4
  5  2490.2   300.0      0.0      62.0 3     37.0 2     86.0 4
  6  2484.3   375.0      0.0      66.0 3     19.0 2     75.0 4
  7  2501.0   450.0      0.0      78.0 3     25.0 2     75.0 4
  8  2491.1   497.0      0.0      73.0 3     24.0 2     64.0 3
  9  2498.7   600.0      0.0      81.0 4     43.0 2     60.0 3
 10  2513.2   675.0      0.0      93.0 4     65.0 3     56.0 2
 11. 2500.8   775.0      0.0      91.0 4     69.0 3     34.0 2
 12  2505.9   875.0      0.0      99.0 4     78.0 3     18.0 2
```

SET 2 cont.

```
SIPTST.J06  SPREADS 5 AND 6     DEMONSTRATION OF EXIT 6

SHOTPOINT AND GEOPHONE DATA

 SPREAD 6, 4 SHOTPOINTS, 12 GEOPHONES, XSHIFT =  675.0, XTRUE = 1

 SP   ELEV    X LOC    Y LOC    DEPTH  UPHOLE T  FUDGE T  END SP
 -- ------- -------- -------- -------- -------- -------- --------
  L  2486.9  -704.0      0.0      2.0      0.0      0.0     0
  A  2498.7   -75.0      0.0      2.0      0.0      0.0     0
  C  2511.7   275.0      0.0      2.0      0.0      0.0     0
  B  2549.9   563.0      0.0      2.0      0.0      0.0     0

                                   ARRIVAL TIMES + FUDGE T AND LAYERS REPRESENTED
 GEO  ELEV    X LOC    Y LOC        SP L      SP A      SP C      SP B     SP
 --- ------ -------- --------     -------   -------   -------   -------
  1  2513.2      0.0      0.0      92.0 4    27.5 2    65.0 3    87.0 4
  2  2500.3     50.0      0.0      86.0 4    27.5 2    50.0 3    74.0 4
  3  2500.5    100.0      0.0      88.0 4    37.0 2    44.0 3    71.0 4
  4  2502.4    150.0      0.0      96.0 4    48.5 2    40.0 2    72.0 4
  5  2505.9    200.0      0.0      99.0 4    56.0 2    30.0 2    68.5 4
  6  2509.6    250.0      0.0      99.5 4    57.0 4    19.0 2    62.0 4
  7  2513.7    300.0      0.0     105.0 4    62.0 4    20.0 2    59.0 4
  8  2517.4    350.0      0.0     107.0 4    64.5 4    30.0 2    55.0 4
  9  2520.7    400.0      0.0     108.0 4    65.0 4    39.0 2    49.0 4
 10  2529.3    450.0      0.0     113.0 4    70.0 4    50.0 2    47.0 4
 11  2538.1    500.0      0.0     116.5 4    74.0 4    55.0 3    45.0 2
 12  2544.5    525.0      0.0     119.0 4    77.0 4    60.0 3    46.0 1
```

```
SIPTST.J06  SPREADS 5 AND 6     DEMONSTRATION OF EXIT 6

 SPREAD 5   RAY END POINTS BENEATH GEOPHONES
 GEO                          SP A          SP C          SP B          SP
 ---                      ---------L-   ---------L-   ---------L-
  1             POS        -2.2 2        68.5 3        38.0 4
               ELEV     2476.1        2408.8        2391.8

  2             POS        72.4 2       128.8 3       129.7 4
               ELEV     2474.9        2426.2        2372.6

  3             POS       149.1 2       204.1 3       212.8 4
               ELEV     2479.9        2429.4        2354.4

  4             POS       224.0 2       226.0 2       296.7 4
               ELEV     2482.4        2482.4        2324.2

  5             POS       277.9 3       304.4 2       443.4 4
               ELEV     2446.5        2476.0        2314.0

  6             POS       350.9 3       376.9 2       553.6 4
               ELEV     2445.2        2478.5        2327.5

  7             POS       435.5 3       446.9 2       602.9 4
               ELEV     2464.0        2484.1        2350.7

  8             POS       481.0 3       496.2 2       516.6 3
               ELEV     2469.9        2488.3        2452.4

  9             POS       534.4 4       598.7 2       645.7 3
               ELEV     2346.8        2493.5        2425.5

 10             POS       617.8 4       597.0 3       679.6 2
               ELEV     2372.8        2415.2        2493.7

 11             POS       722.0 4       713.9 3       777.4 2
               ELEV     2388.8        2412.2        2490.7

 12             POS       826.4 4       830.5 3       879.8 2
               ELEV     2396.5        2431.0        2492.6

RAY END POINTS BENEATH SHOTPOINTS

L=2     RIGHT   POS       -26.4         403.2           0.0
               ELEV     2475.9        2480.6           0.0

L=2     LEFT    POS         0.0         398.0         898.0
               ELEV         0.0        2480.2        2494.2

L=3     RIGHT   POS        32.4         442.0           0.0
               ELEV     2415.8        2439.9           0.0

L=3     LEFT    POS         0.0         378.9         857.1
               ELEV         0.0        2449.5        2434.0

L=4     RIGHT   POS         8.4           0.0           0.0
               ELEV     2392.1           0.0           0.0

L=4     LEFT    POS         0.0           0.0         838.9
               ELEV         0.0           0.0        2379.6
```

SET 2 cont.

SET 2 cmt.

```
SIPTST.J06  SPREADS 5 AND 8     DEMONSTRATION OF EXIT 6

 SPREAD 8   RAY END POINTS BENEATH GEOPHONES
 GEO                   SP L         SP A         SP C         SP B         SP
 ---                --------L-   --------L-   --------L-   --------L-
  1           POS     614.6 4      669.9 2      732.1 3      749.5 4
             ELEV    2366.5       2493.8       2428.7       2384.7

  2           POS     671.4 4      723.5 2      777.9 3      792.5 4
             ELEV    2381.7       2493.4       2435.4       2394.0

  3           POS     724.9 4      772.4 2      818.2 3      841.0 4
             ELEV    2393.2       2491.9       2444.2       2399.3

  4           POS     767.7 4      819.4 2      830.7 2      905.3 4
             ELEV    2382.7       2487.4       2487.5       2392.0

  5           POS     818.5 4      872.8 2      879.8 2      963.6 4
             ELEV    2384.1       2492.0       2492.6       2392.9

  6           POS     880.6 4      880.4 4      929.1 2     1007.8 4
             ELEV    2402.3       2402.1       2496.8       2418.0

  7           POS     925.0 4      926.7 4      972.0 2     1065.7 4
             ELEV    2395.3       2398.2       2499.4       2428.1

  8           POS     992.9 4      992.8 4     1021.5 2     1107.7 4
             ELEV    2413.2       2413.0       2501.6       2442.7

  9           POS    1057.3 4     1058.3 4     1071.3 2     1136.3 4
             ELEV    2437.9       2440.7       2504.4       2465.7

 10           POS    1112.9 4     1113.8 4     1121.5 2     1171.3 4
             ELEV    2456.0       2458.8       2508.9       2480.1

 11           POS    1172.7 4     1172.7 4     1163.7 3     1183.0 2
             ELEV    2487.9       2488.0       2494.5       2514.6

 12           POS    1199.7 4     1198.7 4     1190.5 3        0.0 1
             ELEV    2504.6       2501.9       2500.5          0.0

RAY END POINTS BENEATH SHOTPOINTS

L=2     RIGHT   POS       0.0        601.0        953.6          0.0
               ELEV       0.0       2493.5       2498.3          0.0

L=2     LEFT    POS       0.0          0.0        947.8       1232.4
               ELEV       0.0          0.0       2497.9       2518.2

L=3     RIGHT   POS       0.0        639.7        991.7          0.0
               ELEV       0.0 *     2433.9       2462.7          0.0

L=3     LEFT    POS       0.0          0.0        930.2       1231.7
               ELEV       0.0          0.0       2453.6       2509.8

L=4     RIGHT   POS     669.3        669.3          0.0          0.0
               ELEV    2389.3 *     2389.3          0.0          0.0

L=4     LEFT    POS       0.0          0.0          0.0       1236.2
               ELEV       0.0          0.0          0.0       2505.8
```

SET 2 cont'.

```
SIPTST.J06  SPREADS 5 AND 6     DEMONSTRATION OF EXIT 6                                        |
 SPREAD 5   SMOOTHED POSITION OF LAYERS BENEATH SHOTPOINTS AND GEOPHONES
                                           LAYER 2           LAYER 3           LAYER 4          |LAYER

 SP   POSITION  SURF ELEV          DEPTH  ELEV       DEPTH  ELEV       DEPTH  ELEV
 ---  --------  ---------        --------------    --------------    --------------
  A      -29,0     2486,9          11,3  2475,6      81,6  2405,3      95,3  2391,6
  C      400,0     2493,0          12,2  2480,8      42,0  2451,0     143,8  2349,2
  B      900,0     2507,5          13,3  2494,2      58,9  2448,6     109,5  2398,0

 GEO
 ---
  1        0,0     2485,6           9,8  2475,8      77,1  2408,5      98,1  2387,5
  2       75,0     2484,1           9,0  2475,1      67,8  2416,3     101,9  2382,2
  3      150,0     2484,0           4,1  2479,9      57,9  2426,1     118,0  2366,0
  4      225,0     2487,3           4,9  2482,4      51,8  2435,5     139,6  2347,7
  5      300,0     2490,2          13,8  2476,4      46,8  2443,4     153,3  2336,9
  6      375,0     2484,3           5,3  2479,0      35,8  2448,5     141,1  2343,2
  7      450,0     2501,0          16,6  2484,4      45,1  2455,9     139,8  2361,2
  8      497,0     2491,1           2,7  2488,4      38,6  2452,5     133,1  2358,0
  9      600,0     2498,7           5,2  2493,5      65,7  2433,0     139,0  2359,7
 10      675,0     2513,2          19,6  2493,6      87,7  2425,5     135,3  2377,9
 11      775,0     2500,5           9,9  2490,6      68,9  2431,6     111,8  2388,7
 12      875,0     2505,9          14,0  2491,9      61,2  2444,7     110,2  2395,7

VELOCITIES USED:
                    LAYER 1            LAYER 2           LAYER 3           LAYER 4          LAYER

        VERTICAL    1520.               5900.             9500.
      HORIZONTAL                        5900.             9500.            15000.
```

SET 2 cont.

```
SIPTST.J06  SPREADS 5 AND 6     DEMONSTRATION OF EXIT 6

 SPREAD 6   SMOOTHED POSITION OF LAYERS BENEATH SHOTPOINTS AND GEOPHONES

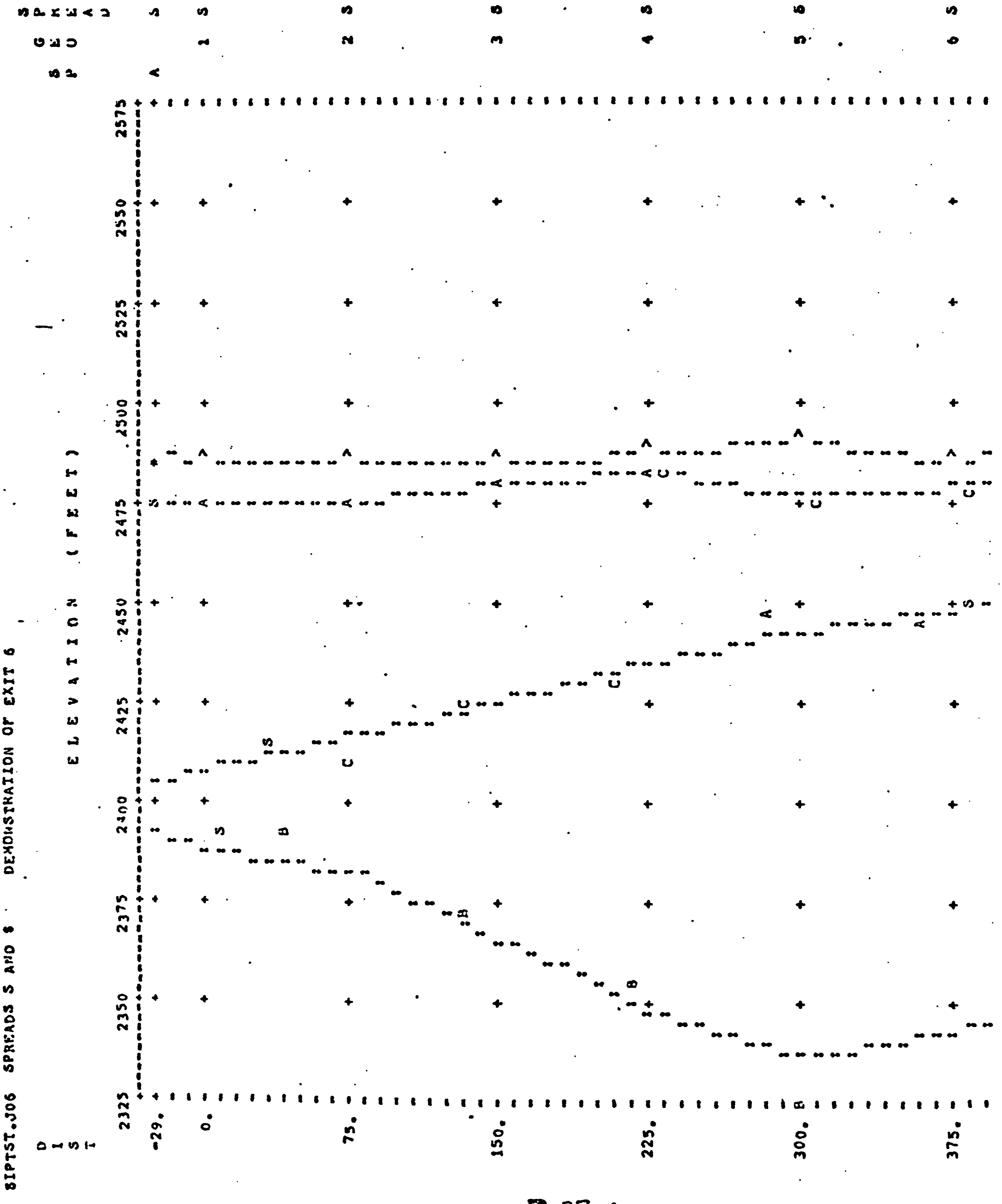
                                   LAYER 2            LAYER 3            LAYER 4            LAYER

 SP   POSITION  SURF ELEV       DEPTH  ELEV        DEPTH  ELEV        DEPTH  ELEV
 ---  --------  ---------     -------------      -------------      -------------
  A     600,0     2498,7        5,2  2493,5       65,7  2433.0      139,0  2359,7
  C     950,0     2511,7       13,8  2497,9       55,4  2456,3      106,9  2404,8
  B    1238,0     2549,9       31,5  2518,4       41,4  2508,5       41,4  2508,5

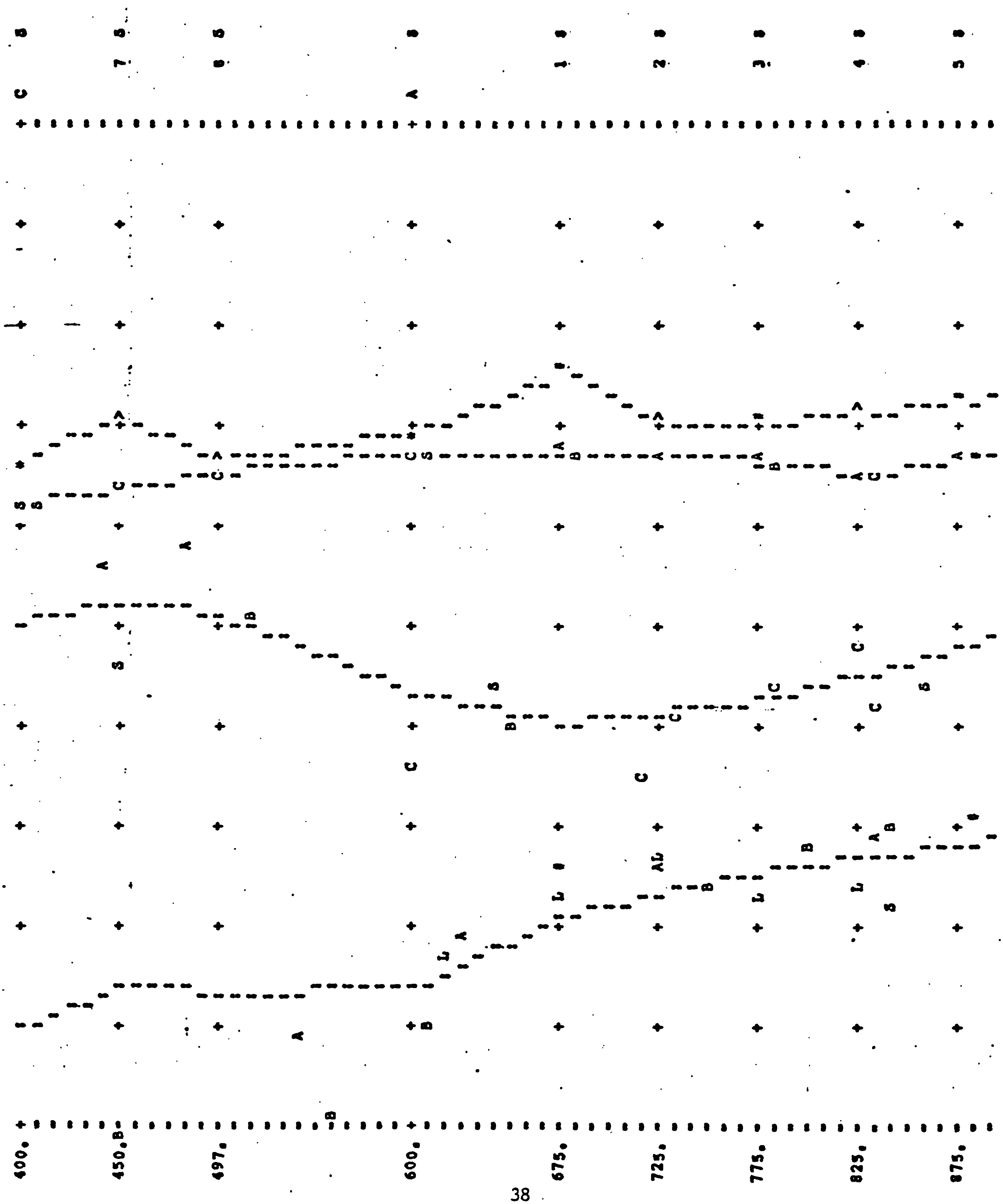
 GEO
 ---
  1     675,0     2513,2       19,5  2493,7       87,7  2425,5      135,3  2377,9
  2     725,0     2500.3        6,9  2493,4       71,8  2428,5      117,0  2383,3
  3     775,0     2500,5        9,2  2491,3       68,9  2431,6      111,8  2388,7
  4     825,0     2502,4       14,9  2487,5       64,3  2438,1      110,2  2392,2
  5     875,0     2505,9       13,8  2492,1       61,2  2444,7      110,2  2395,7
  6     925,0     2509,6       13,3  2496,3       57,2  2452,4      109,4  2400,2
  7     975,0     2513,7       14,3  2499,4       53,5  2460,2      104,3  2409,4
  8    1025,0     2517,4       15,6  2501,8       47,9  2469,5       93,6  2423,8
  9    1075,0     2520,7       16,0  2504,7       42,1  2478,6       80,3  2440,4
 10    1125,0     2529,3       20,1  2509,2       41,5  2487,8       69,5  2459,8
 11    1175,0     2538,1       24,3  2513,8       41,1  2497,0       50,3  2487,8
 12    1200,0     2544,5       28,9  2515,6       43,0  2501,5       46,1  2496,4
VELOCITIES USED:
                LAYER 1            LAYER 2            LAYER 3            LAYER 4            LAYER

      VERTICAL   1520,               5900,              9500,
    HORIZONTAL                       5900,              9500,             15000,
```

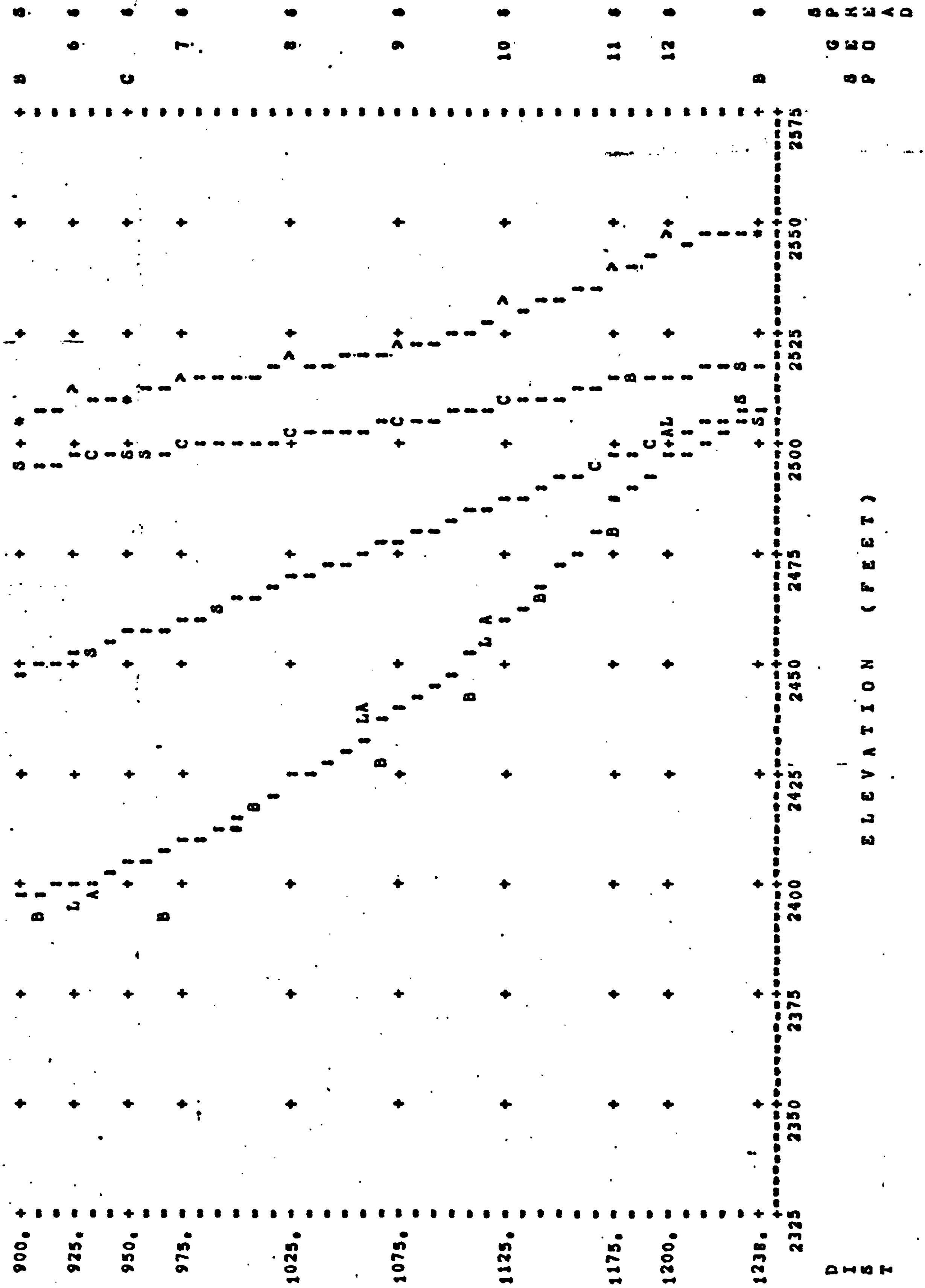
SET 2 cont.


SIPTST.J06 SPREADS 5 AND 6 DEMONSTRATION OF EXIT 6
ELEVATION (FEET)
DIST
SPREAD
GEO
SP
2325
2350
2375
2400
2425
2450
2475
2500
2525
2550
2575
-29.
0.
75.
150.
225.
300.
375.
5
1 5
2 5
3 5
4 5
5 5
6 5
A
S
B
C

SET 2 cont.



SET 2 cont.


SPREAD
GEO
SP
B
C
B
6
7
8
9
10
11
12
DIST
900.
925.
950.
975.
1025.
1075.
1125.
1175.
1200.
1238.
2325
2350
2375
2400
2425
2450
2475
2500
2525
2550
2575
ELEVATION (FEET)

APPENDIX C. -- Fortran program listing

The Fortran program for SIPB is given on the following pages.

```
C PROGRAM  SIPB  REV 20  2-10-77   DEC-10 (USGS DENVER)
C
C THIS PROGRAM INTERPRETS REFRACTION SEISMIC DATA FOR UP TO 5 SPREADS
C OF UP TO 25 GEOS AND 7 SPS EACH, AND FOR 2 TO 5 LAYERS.
C
C PART 1 COMPUTES ELEVATION CORRECTIONS AND PLOTS CORRECTED T-D GRAPH.
C
C PART 2 COMPUTES VELOCITIES, MAKES WEATH CORR, AND REPLOTS T-D GRAPH.
C
C PART 3 COMPUTES MIGRATED DEPTHS AND MAKES SMOOTHED DEPTH INTERP.
C
C
C UNLABLED COMMON
C
      COMMON IBL,IQUES,IP,IT,ICOLN,IPLUS,ISQ,IDASH,IS,IAST,IDEE,IL,NL,
     1LN,P,TSCALE,XSCALE,XSCO2,ESCALE,XLIM1,XLIM2,IPLOT,IDENT
C
C LABLED COMMON
C
      COMMON/BLKO/LG
     1       /BLK1/NM,NJ,NK
     2       /BLK2/XG,ERP,SLOPE,IDIP
     3       /BLK3/TA,TR,DSG
     4       /BLK4/VVA,VHA
     5       /BLK5/IDSPR,IDSP,KL,KR,D
     6       /BLK6/TRP,JJOFF
     7       /BLK7/JA,JB,TRS,ERS,XSP,ESP,LS
     8       /BLK8/PRG,ERG,KRG,PRS2,ERS2,KRS2,ZRSP,ZRG
     9       /BLK9/EG,ES
     9       /BLK10/BLIM,ITRACE,TANSG
     9       /BLK11/VREG,PREG
     9       /BLK12/VHOB,PHOB
C
      DIMENSION IDENT(16),IP(103),IT(53),
     1 IL(5),VREG(5),VHOB(5),PREG(5),PHOB(5),ZSG(4),
     2 IDSPR(5),NJ(5),NK(5),XSHIFT(5),JA(5),JB(5),3L(5),
     2 VVA(5,5),VHA(5,5),
     3 TVS(7),AVVDD(7),ZRSP(7),
     4 IDSP(7,5),ESP(7,5),XSP(7,5),YSP(7,5),ZSP(7,5),TUH(7,5),EDSP(7,5),
     4 TFUDGE(7,5),ES(7,5),KL(7,5),KR(7,5),SPTC(7,5),SPPT(7,5),LS(7,5),
     4 ZRG(25,7),
     4 PS2(7,5,2),ES2(7,5,2),TRS2(7,5,2),
     5 ERS(7,5,4),TRS(7,5,4),
     5 ERS2(7,5,4,2),PRS2(7,5,4,2),KRS2(7,5,4,2),
     6 TVG(25),XVG(25),DSG(25),PRP(25),XS(25),ERX(25),
     6 PRG2(25,2),ERG2(25,2),TRG2(25,2),
     7 TCG(25,2),XCG(25,2),XINTG(25,2),EINTG(25,2),
     8 EDG(25,5),EG(25,5),XG(25,5),YG(25,5),
     8 GTC(25,5),GPT(25,5),
     8 PG2(25,5,2),EG2(25,5,2),TG2(25,5,2),
     9 ERP(25,5,4),TRP(25,5,4),
     9 TA(25,7,5),TR(25,7,5),LG(25,7,5),D(25,7,5),VDD(25,7,5),P(25,7,5),
     9 PRG(25,7,5),ERG(25,7,5),TRG(25,7,5),KRG(25,7,5)
C
C CONSTANTS
C
      DATA IEND,IBL,IS,ISQ,IAST,IPLUS,IDASH,ICOLN,IDEE,IQUES,IBEE,IX/
     1'END ',' ','S ','# ','* ','+ ','- ',': ',
     2'> ','? ','B ','X '/
      DATA IL/'1 ','2 ','3 ','4 ','5 '/
      DATA MM,MJ,MK,ML,ML1,IZ,I1,IN1,BIG/5,7,25,5,4,0,1,10,9999999./
C
C***********************************************************************
C PART 1
C***********************************************************************
C
C  INITIALIZE
C
    1 DO 2 K=1,MK
      TVG(K)=0.
      XVG(K)=0.
      DSG(K)=0.
      PRP(K)=0.
      XS(K)=0.
      DO 2 LR=1,2
      PRG2(K,LR)=0.
      ERG2(K,LR)=0.
      TRG2(K,LR)=0.
      TCG(K,LR)=0.
      XCG(K,LR)=0.
      XINTG(K,LR)=0.
    2 EINTG(K,LR)=0.
      DO 5 J=1,MJ
      AVVDD(J)=0.
      DO 5 M=1,MM
      IDSP(J,M)=IBL
      SPTC(J,M)=0.0
      SPPT(J,M)=0.0
      LS(J,M)=1
      ESP(J,M)=0.
      XSP(J,M)=0.
      YSP(J,M)=0.
      ZSP(J,M)=0.
      TUH(J,M)=0.
      EDSP(J,M)=0.
      TFUDGE(J,M)=0.
      ES(J,M)=0.
      KL(J,M)=0
      KR(J,M)=0
      DO 3 LR=1,2
      PS2(J,M,LR)=0.
      ES2(J,M,LR)=0.
    3 TR(J,M,LR)=0.
      DO 4 L=1,ML1
      ERS(J,M,L)=0.0
      TRS(J,M,L)=0.0
      DO 4 LR=1,2
      ERS2(J,M,L,LR)=0.0
      PRS2(J,M,L,LR)=0.0
      KRS2(J,M,L,LR)=IBL
    4 CONTINUE
      DO 5 K=1,MK
      PRG(K,J,M)=0.0
      ERG(K,J,M)=0.0
      TRG(K,J,M)=0.0
      KRG(K,J,M)=IBL
      VDD(K,J,M)=0.0
      D(K,J,M)=0.0
      LG(K,J,M)=0
      TR(K,J,M)=0.
      TA(K,J,M)=0.
      P(K,J,M)=0.
    5 CONTINUE
      DO 6 M=1,MM
      DO 6 L=1,ML
      VVA(M,L)=0.0
      VHA(M,L)=0.0
    6 CONTINUE
      DO 8 M=1,MM
      JA(M)=0
      JB(M)=0
      NJ(M)=0
      NK(M)=0
      XSHIFT(M)=0.
      DO 8 K=1,MK
      GTC(K,M)=0.0
      GPT(K,M)=0.0
      DO 7 LR=1,2
      PG2(K,M,LR)=0.
      EG2(K,M,LR)=0.
    7 TG2(K,M,LR)=0.
      DO 8 L=1,ML1
      ERP(K,M,L)=0.0
      TRP(K,M,L)=0.0
    8 CONTINUE
      IXTRUE=0
      IREP=0
      DMY0=0.
      DMY1=0.
      DMY2=0.
      DMY3=0.
C
C READ INPUT CARDS AND PRINT INPUT DATA
C
      READ(IN1,9) IDENT
    9 FORMAT (16A5)
      IF (IDENT(1).EQ.IEND) GO TO 9999
      READ(IN1,11)NM,IEXIT,IPLOT,NL,NV,ESCALE,XSCALE,TSCALE,
     1 EDAT1,XDAT1,EDAT2,XDAT2,SLOPE,A,BLIM,TLIM,ITRACE,JJOFF,IDIP
   11 FORMAT (I1,I2,2I1,1X,I1,1X,3(F4.0,1X),4F7.1,F7.4,F7.1,F7.2,F4.1,1X
     1,3I1)
C
C SET DEFAULT VALUES FOR IPLOT
C
      IF(IPLOT.LE.0) IPLOT=IABS(IEXIT)+1
      IF(IPLOT.GT.4) IPLOT=4
      IXIT=0
      IF (IABS(IEXIT).LE.6) IXIT=IEXIT
      IF (NL.LE.1) NL=2
      IF (NM.EQ.0) NM=1
      IF (BLIM.EQ.0.0) BLIM=0.5
      IF (ESCALE.EQ.0.) ESCALE=5.0
      IF (XSCALE.EQ.0.) XSCALE=8.33333333
      IF (TSCALE.EQ.0.) TSCALE=1.0
      IF (TLIM.EQ.0.0) TLIM=10.0
      LN=NL-1
C
      PRINT 13,IDENT,NM,IXIT,NL,IPLOT,NV,ESCALE,XSCALE,TSCALE
     1,EDAT1,XDAT1,EDAT2,XDAT2,SLOPE,A,BLIM,TLIM,ITRACE,JJOFF,IDIP
   13 FORMAT (1H1,50X,12H SIPB REV 20/1H0,16A5/1H0,17HCONTROL CARD DATA,
     1 13X,20HP L O T  S C A L E S,5X,9HD A T U M,4X,15HO V E R R I D E,
     2 4X,11HV A L U E S/1H0,30X,4HELEV,4X,5HHORIZ,
     3 2X,4HTIME,5X,29HP O I N T   1   P O I N T   2/1H ,5HSPRDS,1X,
     4 'EXIT LAYERS PLOT VCARDS FT/COL FT/ROW MS/COL ',
     5 2(3X,4HELEV,4X,5HX POS),3X,28HSLOPE  INTCPT   BLIM    TLIM,3X,
     6 13HTRACE OFF DIP/' ----- ---- ------ ----',4(' ------'),1X,
     7 8('  ------'),2X,'----- --- ---'/1X,I3,4I6,2X,3F7.1,4F8.1,
     8 F8.4,F7.1,F8.2,F8.1,I6,I5,I4)
      NIXIT=0
      IF(IXIT.GE.0) GO TO 14
      IXIT=IABS(IXIT)
      NIXIT=1
   14 IF (NV.EQ.0) GO TO 25
      PRINT 15, (M,M=1,NM)
   15 FORMAT (1H0,14HVELOCITY CARDS/4X,5(6X,'SPREAD',I2))
      PRINT 10014, (IBL,M=1,NM)
10014 FORMAT(2X,'LAYER',5(A3,'VV      VH  '))
      PRINT 11014, (IBL,M=1,NM)
11014 FORMAT(2X,'----- ',5(A1,'------ ------'))
      DO 20 I=1,NV
      READ(IN1,17) L,(VVA(M,L),VHA(M,L),M=1,NM)
   17 FORMAT (I1,10F6.0)
      PRINT 19,L,(VVA(M,L),VHA(M,L),M=1,NM)
   19 FORMAT (4X,I1,2X,10F7.0)
      DO 20 M=1,NM
      VVA(M,L)=VVA(M,L)/1000.
      VHA(M,L)=VHA(M,L)/1000.
   20 CONTINUE
   25 DO 60 M=1,NM
      READ(IN1,27) IDSPR(M),NJ(M),NK(M),XSHIFT(M),IXTRUE
   27 FORMAT (A1,2I3,F11.1,1X,I1)
      PRINT 29, IDSPR(M),NJ(M),NK(M),XSHIFT(M),IXTRUE
   29 FORMAT (/28H SHOTPOINT AND GEOPHONE DATA//2X,6HSPREAD,1X,A1,1H,,
     1I2,1X,11HSHOTPOINTS,,I3,1X,19HGEOPHONES, XSHIFT =,F8.1,', XTRUE ='
     2,I2//2X,55HSP   ELEV     X LOC     Y LOC     DEPTH  UPHOLE T  FUDGE T
     3,2X,6HEND SP/2X,10H-- -------,6(1X,8H--------))
      XLAST=-BIG
      JN=NJ(M)
      DO 35 J=1,JN
      READ(IN1,31) IDTEST,IDSP(J,M),ESP(J,M),XSP(J,M)
     1,YSP(J,M),ZSP(J,M),TUH(J,M),TFUDGE(J,M),JC
   31 FORMAT (A1,2X,A1,3F7.1,3F5.1,1X,I1)
      IF (IDTEST.NE.IDSPR(M).OR.XSP(J,M).LT.XLAST) GO TO 9993
      PRINT 33, IDSP(J,M),ESP(J,M),XSP(J,M),YSP(J,M)
     1,ZSP(J,M),TUH(J,M),TFUDGE(J,M),JC
   33 FORMAT (1H ,2X,A1,F8.1,5F9.1,I6)
      ES(J,M)=ESP(J,M)-ZSP(J,M)
      IF (JC.EQ.1) JA(M)=J
      IF (JC.EQ.2) JB(M)=J
      XLAST=XSP(J,M)
   35 CONTINUE
      PRINT 41, (IDSP(J,M),J=1,JN)
   41 FORMAT (1H0,33X,46HARRIVAL TIMES + FUDGE T AND LAYERS REPRESENTED/
     129H  GEO  ELEV     X LOC     Y LOC,2X,7(5X,'SP ',A1))
      PRINT 42, (IBL,J=1,JN)
   42 FORMAT('  --- ------',2(' --------'),2X,7(A2,'-------'))
      XLAST=-BIG
      KN=NK(M)
      DO 55 K=1,KN
      READ(IN1,43)IDTEST,KTEST,EG(K,M),XG(K,M),YG(<,M)
     1,(TA(K,J,M),LG(K,J,M),J=1,JN)
   43 FORMAT (A1,I3,3F7.1,7(F5.1,1X,I1))
      IF (IDTEST.NE.IDSPR(M).OR.KTEST.NE.K.OR.XG(K,M).LT.XLAST)
     1 GO TO 9990
      DO 44 J=1,JN
      IF (TA(K,J,M).NE.0.0)  TA(K,J,M)=TA(K,J,M)+TFUDGE(J,M)
      IF (TA(K,J,M).LE.0.) LG(K,J,M)=0
      TR(K,J,M)=TA(K,J,M)
   44 CONTINUE
      PRINT 45, K,EG(K,M),XG(K,M),YG(K,M),(TA(K,J,M),LG(K,J,M),J=1,JN)
   45 FORMAT (2X,I2,F8.1,2F9.1,2X,7(F7.1,I2))
      XLAST=XG(K,M)
   55 CONTINUE
      IF(M.NE.NM.OR.NIXIT.EQ.0)PRINT 57, IDENT
   57 FORMAT (1H1,16A5)
   60 CONTINUE
C
C IF IXTRUE=0, CORRECT X-DISTANCES. IXTRUE=0 IMPLIES THAT X-DISTANCES
C FOR SPS & GEOS ARE MEASURED ALONG GROUND SURFACE AND NO CORRECTION HAS
C BEEN MADE FOR SLOPE.
C
      IF(IXTRUE.NE.0) GO TO 95
      DO 90 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      XS(1)=XG(1,M)
      DO 62 K=2,KN
      XS(K)=XS(K-1)+SQRT((XG(K,M)-XG(K-1,M))**2-(EG(K,M)-EG(K-1,M))**2)
   62 CONTINUE
      DO 64 J=1,JN
      IF(XSP(J,M).GT.XG(1,M)) GO TO 66
   64 CONTINUE
      J=JN+1
   66 J1=J-1
      IF(J1.EQ.0) GO TO 70
      XTIE=XS(1)
      XREF=XG(1,M)
      EREF=EG(1,M)
      DO 68 J=1,J1
      JR=J1-J+1
      XTIE=XTIE-SQRT((XREF-XSP(JR,M))**2-(EREF-ESP(JR,M))**2)
      XREF=XSP(JR,M)
      EREF=ESP(JR,M)
      XSP(JR,M)=XTIE
   68 CONTINUE
   70 J1=J1+1
      DO 72 J=J1,JN
      IF(XSP(J,M).GT.XG(KN,M)) GO TO 74
      DO 71 K=2,KN
      IF(XG(K,M).LT.XSP(J,M)) GO TO 72
      XSP(J,M)=XS(K-1)+(XS(K)-XS(K-1))*(XSP(J,M)-XG(K-1,M))/
     1(XG(K,M)-XG(K-1,M))
   71 CONTINUE
   72 CONTINUE
      GO TO 78
   74 J1=J
      XTIE=XS(KN)
      XREF=XG(KN,M)
      EREF=EG(KN,M)
      DO 76 J=J1,JN
      XTIE=XTIE+SQRT((XSP(J,M)-XREF)**2-(ESP(J,M)-EREF)**2)
      XREF=XSP(J,M)
      EREF=ESP(J,M)
      XSP(J,M)=XTIE
   76 CONTINUE
   78 DO 80 K=1,KN
   80 XG(K,M)=XS(K)
   90 CONTINUE
C
C COMPUTE V1 USING DIRECT DIST DD FROM SHOT TO GEOS FOR WHICH LG=1
C
   95 IF (NIXIT.EQ.0) PRINT 100
  100 FORMAT (1H0,1X,42HV1 FOR DIRECT RAYS AND DIRECT DISTANCES DD)
      SUM1=0.0
      PTS1=0.0
      DO 150 M=1,NM
      SUM2=0.0
      PTS2=0.0
      JN=NJ(M)
      DO 120 J=1,JN
      SUM3=0.0
      PTS3=0.0
      KN=NK(M)
      DO 110 K=1,KN
      IF (LG(K,J,M).NE.1) GO TO 110
      D(K,J,M)=SQRT ((EG(K,M)-ES(J,M))**2+(XG(K,M)-XSP(J,M))**2+(YG(K,M)
     1-YSP(J,M))**2)
      VDD(K,J,M)=D(K,J,M)/TA(K,J,M)
      PTS3=PTS3+1.0
      SUM3=SUM3+VDD(K,J,M)
      PTS2=PTS2+1.0
      SUM2=SUM2+VDD(K,J,M)
      PTS1=PTS1+1.0
      SUM1=SUM1+VDD(K,J,M)
  110 CONTINUE
      IF (PTS3.EQ.0.) GO TO 115
      AVVDD(J)=SUM3/PTS3
      GO TO 120
  115 AVVDD(J)=0.0
  120 CONTINUE
      IF (PTS2.EQ.0.) GO TO 126
      SUM2=SUM2/PTS2
  126 IF (NIXIT.EQ.1) GO TO 150
      PRINT 130,IDSPR(M)
  130 FORMAT(/2X,'SPREAD',1X,A1,5X,'SP  GEO    DD       V1    AVG V1'/
     115X,'--  ---',3('  ------'))
      DO 140 J=1,JN
      DO 134 K=1,KN
      IF(VDD(K,J,M).EQ.0.) GO TO 134
      PRINT 132, IDSP(J,M),K,D(K,J,M),VDD(K,J,M)
  132 FORMAT(16X,A1,I5,F8.1,3PF8.0)
  134 CONTINUE
      IF(AVVDD(J).NE.0.) PRINT 136, AVVDD(J)
  136 FORMAT(38X,3PF8.0)
  140 CONTINUE
  150 CONTINUE
      IF (PTS1.EQ.0.) GO TO 152
      SUM1=SUM1/PTS1
  152 VREG(1)=SUM1
      IF (VREG(1).LE.0.0) VREG(1)=1.5
  156 IF (NIXIT.EQ.0) PRINT 157, SUM1
  157 FORMAT (1H0,10HAVG OF ALL,3PF7.0)
C
C APPLY XSHIFT TO XSP AND XG ARRAYS
C  ALSO COMPUTE DIR DIST BETWEEN (XSP,YSP,ESP) AND (XG,YG,EG) IF LG.NE.1
C  AND COMPUTE PLOT POSITIONS P
C
      DO 180 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 165 K=1,KN
      XG(K,M)=XG(K,M)+XSHIFT(M)
  165 CONTINUE
      DO 175 J=1,JN
      XSP(J,M)=XSP(J,M)+XSHIFT(M)
      DO 170 K=1,KN
      IF (LG(K,J,M).NE.1) D(K,J,M)=SQRT((XG(K,M)-XSP(J,M))**2+(YG(K,M)-
     1 YSP(J,M))**2+(EG(K,M)-ESP(J,M))**2)
      IF (XG(K,M)-XSP(J,M)) 168,166,167
  166 IF (K.EQ.KN) GO TO 168
  167 P(K,J,M)=XSP(J,M)+D(K,J,M)
      GO TO 170
  168 P(K,J,M)=XSP(J,M)-D(K,J,M)
  170 CONTINUE
  175 CONTINUE
  180 CONTINUE
C
C FIND NUMBER OF GEO TO THE LEFT, KL(J,M), AND RIGHT, KR(J,M) OF EACH SP
C     IF NONE, KL OR KR SET TO ZERO.
C
      DO 188 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 186 J=1,JN
      IF (XSP(J,M).LE.XG(1,M)) GO TO 183
      IF (XSP(J,M).GE.XG(KN,M)) GO TO 184
      DO 181 K=2,KN
      IF (XG(K,M).GT.XSP(J,M)) GO TO 182
  181 CONTINUE
  182 KL(J,M)=K-1
      KR(J,M)=K
      GO TO 186
  183 KL(J,M)=0
      KR(J,M)=1
      GO TO 186
  184 KL(J,M)=KN
      KR(J,M)=0
  186 CONTINUE
  188 CONTINUE
C
C FIND END SPS FOR EACH SPREAD AND SET LIMITS OF X AXIS FOR T-D GRAPH
C
      XSCO2=XSCALE/2.0
      DO 200 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      IF (JA(M).NE.0) GO TO 192
      DO 190 J=1,JN
      IF (XSP(J,M).LE.XG(1,M)) GO TO 190
      JA(M)=J-1
      IF (J.GT.1) GO TO 192
      JA(M)=1
      IF (M.EQ.1) XLIM1=XG(1,1)
      GO TO 194
  190 CONTINUE
      JA(M)=JN
  192 IF (M.NE.1) GO TO 195
      J=JA(M)
      XLIM1=AMIN1(XSP(J,1),XG(1,1))
  194 XLIM1=XLIM1+XSCO2
  195 IF (JB(M).NE.0) GO TO 197
      DO 196 J=1,JN
      IF (XSP(J,M).LT.XG(KN,M)) GO TO 196
      JB(M)=J
      GO TO 197
  196 CONTINUE
      JB(M)=JN
      IF (M.NE.NM) GO TO 200
      XLIM2=XG(KN,NM)
      GO TO 200
  197 IF (M.NE.NM) GO TO 200
      J=JB(M)
      XLIM2=AMAX1(XSP(J,NM),XG(KN,NM))
  200 CONTINUE
C
C TEST FOR DOING RAW TIME T-D PLOT
C
      IF(IPLOT.EQ.1.AND.NIXIT.EQ.0) CALL PLOT(1)
      IF (IXIT.EQ.0) GO TO 1
C
C FIT STRAIGHT LINE THRU GEO ELEVATIONS
C
  205 IF (SLOPE.NE.0.0.OR.A.NE.0.0) GO TO 225
      IF (XDAT1.NE.0.0.OR.XDAT2.NE.0.0) GO TO 220
      SUM1=0.0
      SUM2=0.0
      PTS=0.0
      DO 212 M=1,NM
      KN=NK(M)
      DO 210 K=1,KN
      SUM1=SUM1+XG(K,M)
      SUM2=SUM2+EG(K,M)
      PTS=PTS+1.0
  210 CONTINUE
  212 CONTINUE
      XBAR=SUM1/PTS
      EBAR=SUM2/PTS
      SUM1=0.0
      SUM2=0.0
      DO 216 M=1,NM
      KN=NK(M)
      DO 214 K=1,KN
      DIFF=XG(K,M)-XBAR
      SUM1=SUM1+DIFF*EG(K,M)
      SUM2=SUM2+DIFF**2
  214 CONTINUE
  216 CONTINUE
      SLOPE=SUM1/SUM2
      A=EBAR-SLOPE*XBAR
      GO TO 225
  220 SLOPE=(EDAT2-EDAT1)/(XDAT2-XDAT1)
      A=EDAT1-SLOPE*XDAT1
  225 DO 230 M=1,NM
      KN=NK(M)
      DO 226 K=1,KN
      EDG(K,M)=A+SLOPE*XG(K,M)
  226 CONTINUE
      JN=NJ(M)
      DO 227 J=1,JN
  227 EDSP(J,M)=ES(J,M)
      J1=JA(M)
      J2=JB(M)
      DO 228 J=J1,J2
      EDSP(J,M)=A+SLOPE*XSP(J,M)
  228 CONTINUE
  230 CONTINUE
C
C VELOCITY OVERRIDE CARD ANALYSIS -- SET ANY ZERO VH=VV IF VV NONZERO
C
      IOVER=0
      IF (VVA(1,1).NE.0.0) GO TO 242
      DO 240 M=1,NM
      VVA(M,1)=VREG(1)
  240 CONTINUE
      GO TO 246
  242 IOVER=1
      IF (NM.LE.1) GO TO 246
      DO 244 M=2,NM
      IF (VVA(M,1).EQ.0.0) VVA(M,1)=VVA(1,1)
  244 CONTINUE
  246 DO 250 L=2,NL
      IF (VVA(1,L).EQ.0.0) GO TO 250
      IF (VHA(1,L).EQ.0.0) VHA(1,L)=VVA(1,L)
      IF (NM.LE.1) GO TO 250
      DO 248 M=2,NM
      IF (VVA(M,L).EQ.0.0) VVA(M,L)=VVA(1,L)
      IF (VHA(M,L).EQ.0.0) VHA(M,L)=VHA(1,L)
  248 CONTINUE
  250 CONTINUE
C
C COMPUTE AND APPLY VERTICAL TIME CORRECTIONS TO DATUM -- PRINT RESULTS
C
  300 IF(NIXIT.EQ.1) GO TO 303
      PRINT 57, IDENT
      PRINT 302, A, SLOPE
  302 FORMAT (1H0,46HARRIVAL TIMES CORRECTED TO DATUM (DATUM ELEV =,F8.1
     1,4H + (,F8.4,25H)X), AND PLOT POSITIONS D)
  303 DO 400 M=1,NM
      VV=VVA(M,1)
      JN=NJ(M)
      KN=NK(M)
C FIRST PRECOMPUTE GEO TIME CORR
      DO 304 K=1,KN
      TVG(K)=(EDG(K,M)-EG(K,M))/VV
  304 CONTINUE
C THEN COMPUTE SP TIME CORR
      DO 306 J=1,JN
      TVS(J)=0.
      IF (J.LT.JA(M).OR.J.GT.JB(M)) GO TO 306
      TVS(J)=(EDSP(J,M)-ES(J,M))/VV
      IF (TUH(J,M).NE.0.0) TVS(J)=TVS(J)*TUH(J,M)*VV/ZSP(J,M)
  306 CONTINUE
C APPLY DATUM CORRECTIONS
  312 DO 332 J=1,JN
      DO 330 K=1,KN
      IF (LG(K,J,M).NE.1.AND.TR(K,J,M).NE.0.0) TA(K,J,M)=TR(K,J,M) +
     1 TVS(J) + TVG(K)
  330 CONTINUE
  332 CONTINUE
C PRINT RESULTS
      IF (NIXIT.EQ.1) GO TO 400
      PRINT 383, IDSPR(M),(IDSP(J,M),J=1,JN)
  383 FORMAT (1H0,1X,7HSPREAD ,A1,7X,7(10X,'SP ',A1))
      PRINT 384, (EDSP(J,M),J=1,JN)
  384 FORMAT(/7X,'ELEV . . . . .',7(F10.1,4X))
      PRINT 385, (TVS(J),J=1,JN)
  385 FORMAT (9X,1H./9X,1H.,3X,6HCORR T,7(F12.1,2X))
      PRINT 387, (IBL,J=1,JN)
  387 FORMAT (' GEO      .',10X,7(A1,'---T-----D---'))
      DO 390 K=1,KN
      PRINT 389, K,EDG(K,M),TVG(K),(TA(K,J,M),P(K,J,M),J=1,JN)
  389 FORMAT (1X,I2,2F8.1,1X,14F7.1)
  390 CONTINUE
  400 CONTINUE
C
C EXIT POINT TEST AND BRANCH
C
C PLOT T-D GRAPH
C
  450 IF(IPLOT.EQ.2.AND.NIXIT.EQ.0) CALL PLOT(1)
C
      IF (IXIT.EQ.1) GO TO 1
C
C*********************************************************************
C PART 2
C*********************************************************************
C
C DO REGRESSION VELOCITY COMPUTATION FOR TOP OF LAYER 2
C
 1000 IF (NIXIT.EQ.0) PRINT 57, IDENT
      L1=1
      L2=2
      CALL REGV(L2,NIXIT)
      IF(PREG(2).GT.0.0) GO TO 1005
      IF (VVA(1,2).GT.0.0) GO TO 1020
 1001 IF (NIXIT.NE.0) GO TO 1
      PRINT 1002, L2
 1002 FORMAT (/1X,46HNOT ENOUGH POINTS TO DEFINE VELOCITY FOR LAYER,I2,
     118H USE OVERRIDE CARD)
      GO TO 1
C
C DO HOBSON-OVERTON VEL COMPUTATION FOR TOP OF LAYER 2
C
 1005 CALL HOBV(L2,NIXIT)
C
      IF (VVA(1,2).NE.0.0) GO TO 1020
      VV=(VREG(2)*PREG(2)+2.0*VHOB(2)*PHOB(2))/(PREG(2)+2.0*PHOB(2))
      DO 1008 M=1,NM
      VVA(M,2)=VV
      VHA(M,2)=VV
 1008 CONTINUE
C
      IF(NIXIT.NE.0) GO TO 1094
      PRINT 1011,L2,VV
 1011 FORMAT('0WTD AVG VELOCITY FOR LAYER',I2,' =',3PF7.0/' -'
     1,6('-------'))
      GO TO 1094
C
 1020 IF(NIXIT.NE.0) GO TO 1094
      PRINT 1021, L2,VVA(1,L2)
 1021 FORMAT (1X,'OVERRIDE V',I1,' =',3PF8.0)
C
C COMPUTE VELOCITIES FOR DEEPER LAYERS BY REGRESSION AND HOBSON METHOD
C
 1094 DO 1100 L=3,NL
      IF(NIXIT.EQ.0) PRINT 57, IDENT
      LCALL=L
      CALL REGV(LCALL,NIXIT)
      IF (PREG(L).GT.0.) GO TO 1096
      IF(VVA(1,L).GT.0.) GO TO 1100
      L2=L
      GO TO 1001
 1096 LCALL=L
      CALL HOBV(LCALL,NIXIT)
      IF(VVA(1,L).NE.0.) GO TO 1098
      VV=(VREG(L)*PREG(L)+2.*VHOB(L)*PHOB(L))/(PREG(L)+2.*PHOB(L))
      DO 1097 M=1,NM
      VVA(M,L)=VV
      VHA(M,L)=VV
 1097 CONTINUE
      IF(NIXIT.NE.0) GO TO 1100
      PRINT 1011, L,VV
      GO TO 1100
C
 1098 IF(NIXIT.NE.0) GO TO 1100
      PRINT 1021, L,VVA(1,L)
 1100 CONTINUE
C
C MAKE TIE CORRECTION IF JJOFF.EQ.0
C
      IF(JJOFF.NE.0) GO TO 1150
      DO 1145 M=1,NM
      MCALL=M
      KN=NK(M)
      J=JA(M)
      IF(XG(1,M).GE.XSP(J,M)) GO TO 1120
C SET D NEGATIVE FOR GEOS LEFT OF LEFT END SP
      K2=KL(J,M)
      DO 1118 K=1,K2
      D(K,J,M)=-D(K,J,M)
 1118 CONTINUE
 1120 JJ=J-1
      IF(JJ.LT.1) GO TO 1130
      JJTIE=0
      DO 1125 L=2,NL
      LCALL=L
      CALL KENDS(LCALL,MCALL,JJ,KR(JJ,M),KN,K11,K22)
      IF(K11.EQ.0) GO TO 1125
      KT1=KR(J,M)
      IF(KT1.EQ.0) GO TO 1125
      CALL TIE(LCALL,MCALL,J,JJ,K11,K22,KT1,KN,KN,1,JJTIE)
 1125 CONTINUE
      J=J-1
      GO TO 1120
 1130 J=JB(M)
      JN=NJ(M)
      IF(XG(KN,M).LE.XSP(J,M)) GO TO 1135
C SET D NEGATIVE FOR GEOS RIGHT OF RIGHT END SP
      K1=KR(J,M)
      DO 1132 K=K1,KN
      D(K,J,M)=-D(K,J,M)
 1132 CONTINUE
 1135 JJ=J+1
      IF(JJ.GT.JN) GO TO 1145
      JJTIE=0
      DO 1140 L=2,NL
      LCALL=L
      CALL KENDS(LCALL,MCALL,JJ,1,KL(JJ,M),K11,K22)
      IF(K11.EQ.0) GO TO 1140
      KT2=KL(J,M)
      IF(KT2.EQ.0) GO TO 1140
      CALL TIE(LCALL,MCALL,J,JJ,K11,K22,1,KT2,KN,2,JJTIE)
 1140 CONTINUE
      J=J+1
      GO TO 1135
 1145 CONTINUE
C
C PLOT T-D GRAPH OF PRE-DEPTH TIME VALUES
C
 1150 DO 1160 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 1160 J=1,JN
      DO 1160 K=1,KN
 1160 TA(K,J,M)=TR(K,J,M)
C
      IF(IPLOT.EQ.3.AND.NIXIT.EQ.0) CALL PLOT(1)
C
C COMPUTE DEPTH PTS AT BASE OF LAYER 1 (FOR IREP=1,IFLAG=0)
C (IREP.GE.2 IS DONE IN PART 3)
C
C SPREAD LOOP STARTS HERE----------------------------LOOP ENDS AT 1060
C
 1025 IF (ITRACE.NE.0.AND.IXIT.GE.4) PRINT 1027, L2
 1027 FORMAT (1H1,45HINTERMEDIATE RESULTS OF RAY TRACING FOR LAYER,I2)
      IFLAG=0
      RADS=SQRT(1.+SLOPE**2)
      DO 1060 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      VV=VVA(M,L1)
      HV=VHA(M,L2)
      IF (HV.LE.VV) GO TO 9992
      RAD=SQRT(HV**2-VV**2)
      TANSG=VV/RAD
      VOCOSG=TANSG*HV
      VVCOSG=VV*RAD/HV
      DENEX=HV*RADS
      IF (JJOFF.NE.0) GO TO 1029
      J1=JA(M)
      J2=JB(M)
      GO TO 1030
 1029 J1=1
      J2=NJ(M)
C
C PRECOMPUTE DATUM ELEV CORR FOR ALL GEOS AND STORE V AND TRIG CONSTS
 1030 DO 1034 K=1,KN
C I=1 FOR RIGHT-GOING RAYS, 2 FOR LEFT-GOING
      DO 1033 I=1,2
      ICALL=I
      CALL ELCOR(TANSG,VV,HV,XG(K,M),EG(K,M),A,SLOPE,ICALL,TCG(K,I),
     1 XCG(K,I),XINTG(K,I),EINTG(K,I))
 1033 CONTINUE
 1034 CONTINUE
C
C SHOT POINT LOOP STARTS HERE------------------------LOOP ENDS AT 1049
C
      DO 1049 J=J1,J2
      JJ=J
C
C INITIALIZE FOR RIGHT-GOING RAYS
C
      I=1
      II=2
      K1=KR(J,M)
      IF (K1.EQ.0) GO TO 1046
      K2=KN
C
C COMPUTE ELEV TIME CORR AND DIRECT DISTS
C
 1036 MCALL=M
      JCALL=J
      CALL KENDS(2,MCALL,JCALL,K1,K2,K11,K22)
      IF (K11.EQ.0) GO TO (1046,1049),I
      CALL ELCOR(TANSG,VV,HV,XSP(J,M),ES(J,M),A,SLOPE,II,TC,XC,XINT,EINT
     1)
C
C RE-ENTRY POINT FOR OUTLYING SHOTPOINTS
C
 1037 DO 1038 K=K11,K22
      IF (LG(K,JJ,M).NE.2) GO TO 1038
      TA(K,JJ,M)=TR(K,JJ,M)+TC+TCG(K,I)
      DSG(K)=D(K,J,M)+XC+XCG(K,I)
 1038 CONTINUE
C
C EXTRAP TIME AT SP AND COMPUTE COORD OF END PT OF RAY BENEATH SP
C
      MCALL=M
      CALL REGRES(K11,K22,JJ,MCALL,2,V,T,PT,D)
      IF (PT.EQ.0.) GO TO (1046,1049),I
      Z=T*VOCOSG
      TS=Z/VVCOSG
      ZTAN=Z*TANSG
      RAY=SQRT(Z**2+ZTAN**2)
      B=SLOPE
      IF(I.EQ.1) B=-B
      XTRU=RAY*(VV-B*RAD)/DENEX
      ZTRU=RAY*(RAD+VV*B)/DENEX
      IF(I.EQ.2) XTRU=-XTRU
 1039 PRS2(JJ,M,1,I)=XINT+XTRU
```

```
      IF(I.EQ.2) ZTAN=-ZTAN
      PRSH=XINT+ZTAN/RADS
      ERS2(JJ,M,1,I)=EINT-ZTRU
      TRS2(JJ,M,I)=TS
      PS2(JJ,M,I)=XSP(J,M)
      ES2(JJ,M,I)=ES(J,M)
      IF (TRS2(JJ,M,I).GE.0.) GO TO 1041
      TS=0.
      Z=0.
      TRS2(JJ,M,I)=0.
      ERS2(JJ,M,1,I)=ES(J,M)
      PRS2(JJ,M,1,I)=XSP(J,M)
      PRSH=XSP(J,M)
C
C COMPUTE COORD OF RAY END PTS AT GEOS
C
 1041 ZRSP(JJ)=Z
      DO 1043 K=K11,K22
      IF (LG(K,JJ,M).NE.2) GO TO 1043
      EDIF=SLOPE*(XINTG(K,I)-PRSH)
      KCALL=K
      JCALL=J
      MCALL=M
      CALL HTIME(KCALL,JCALL,MCALL,PRSH,0.,XINTG(K,I),EDIF,HV,TH)
      PG2(K,M,I)=XG(K,M)
      EG2(K,M,I)=EG(K,M)
      Z=(TA(K,JJ,M)-TS-TH)*VOCOSG
      ZTAN=Z*TANSG
      RAY=SQRT(Z**2+ZTAN**2)
      B=SLOPE
      IF(I.EQ.2) B=-B
      XTRU=RAY*(VV-B*RAD)/DENEX
      ZTRU=RAY*(RAD+VV*B)/DENEX
      IF(I.EQ.1) XTRU=-XTRU
      ERG(K,JJ,M)=EINTG(K,I)-ZTRU
      IF (EG(K,M).GT.ERG(K,JJ,M)) GO TO 1042
      Z=0.
      ERG(K,JJ,M)=EG(K,M)
      PRG(K,JJ,M)=XG(K,M)
      TRG(K,JJ,M)=0.00001
      GO TO 11043
 1042 TRG(K,JJ,M)=Z/VVCOSG
      PRG(K,JJ,M)=XINTG(K,I)+XTRU
11043 ZRG(K,JJ)=Z
 1043 CONTINUE
C
C TEST FOR DOING OUTLYING SPS LEFT OF SPREAD, RIGHT-GOING RAYS
C
      IF (I.EQ.2) GO TO 1047
      IF (JJOFF.NE.0.OR.JJ.GT.J1) GO TO 1046
 1044 JJ=JJ-1
      IF (JJ.GT.0) GO TO 1045
      SUM1=0.
      SUM2=0.
      SUM3=0.
      PTS1=0.
      JJJ=0
      DO 2045 JJ=1,J1
      IF(ERS2(JJ,M,L1,1).EQ.0.) GO TO 2045
      SUM1=SUM1+TRS2(JJ,M,1)
      SUM2=SUM2+PRS2(JJ,M,L1,1)
      SUM3=SUM3+ERS2(JJ,M,L1,1)
      PTS1=PTS1+1.
      IF(JJJ.EQ.0) JJJ=JJ
 2045 CONTINUE
      IF(PTS1.EQ.0.) GO TO 1046
      TBAR=SUM1/PTS1
      PBAR=SUM2/PTS1
      EBAR=SUM3/PTS1
      DO 3045 JJ=JJJ,J1
      TRS2(JJ,M,1)=TBAR
      PRS2(JJ,M,L1,1)=PBAR
      ERS2(JJ,M,L1,1)=EBAR
      IF(JJ.LT.J1) KRS2(JJ,M,L1,1)=IAST
 3045 CONTINUE
      GO TO 1046
 1045 MCALL=M
      CALL KENDS(2,MCALL,JJ,KR(JJ,M),KN,K11,K22)
      IF (K11.EQ.0) GO TO 1044
      GO TO 1037
C
C INITIALIZE FOR LEFT-GOING RAYS
C
 1046 I=2
      II=1
      K1=1
      K2=KL(J,M)
      IF (K2.NE.0) GO TO 1036
C
C TEST FOR DOING OUTLYING SPS RIGHT OF SPREAD, LEFT-GOING RAYS
C
 1047 IF (JJOFF.NE.0.OR.JJ.LT.J2) GO TO 1049
 1048 JJ=JJ+1
      IF (JJ.LE.JN) GO TO 4048
      SUM1=0.
      SUM2=0.
      SUM3=0.
      PTS1=0.
      DO 2048 JJ=J2,JN
      IF(ERS2(JJ,M,L1,2).EQ.0.) GO TO 2048
      SUM1=SUM1+TRS2(JJ,M,2)
      SUM2=SUM2+PRS2(JJ,M,L1,2)
      SUM3=SUM3+ERS2(JJ,M,L1,2)
      PTS1=PTS1+1.
      JJJ=JJ
 2048 CONTINUE
      IF(PTS1.EQ.0.) GO TO 1049
      TBAR=SUM1/PTS1
      PBAR=SUM2/PTS1
      EBAR=SUM3/PTS1
      DO 3048 JJ=J2,JJJ
      TRS2(JJ,M,2)=TBAR
      PRS2(JJ,M,L1,2)=PBAR
      ERS2(JJ,M,L1,2)=EBAR
      IF(JJ.GT.J2) KRS2(JJ,M,L1,2)=IAST
 3048 CONTINUE
      GO TO 1049
 4048 MCALL=M
      CALL KENDS(2,MCALL,JJ,1,KL(JJ,M),K11,K22)
      IF (K11.EQ.0) GO TO 1048
      GO TO 1037
 1049 CONTINUE
 1C60 CONTINUE
C
C COMPUTE AVG ELEV OF BASE OF LAYER 1 BENEATH EACH GEO
C
C-------------------------------------ENTER AFTER RETURNING FROM PART 3
C
 1200 DO 1400 M=1,NM
      VV=VVA(M,1)
      TANSG=VV/SQRT(VHA(M,2)**2-VV**2)
      MCALL=M
      IF (IFLAG.EQ.0) CALL ADMIG(L1,MCALL,BL(M))
      JN=NJ(M)
      KN=NK(M)
      DG2=(XG(KN,M)-XG(1,M))/FLOAT(KN+KN-2)
      DO 1255 K=1,KN
      ERX(K)=0.
      ERP(K,M,1)=0.
      TRP(K,M,1)=0.
      PRP(K)=0.
      ERX(K)=0.
      IF (K.EQ.1) GO TO 1235
      X1=(XG(K,M)+XG(K-1,M))/2.
      GO TO 1240
 1235 X1=XG(1,M)-DG2
 1240 IF (K.EQ.KN) GO TO 1245
      X2=(XG(K+1,M)+XG(K,M))/2.
      GO TO 1250
 1245 X2=XG(KN,M)+DG2
 1250 CALL AVG(X1,X2,2,PRP(K),ERX(K))
 1255 CONTINUE
      DO 1285 K=1,KN
      IF(ERX(K).EQ.0.) GO TO 1285
      KK=K
      IF (PRP(K).GT.XG(K,M)) GO TO 1270
 1260 KK=KK+1
      IF (KK.GT.KN) GO TO 1278
      IF(ERX(K).EQ.0.) GO TO 1260
      GO TO 1275
 1270 KK=KK-1
      IF (KK.LT.1) GO TO 1278
      IF(ERX(K).EQ.0.) GO TO 1270
 1275 ERP(K,M,1)=TERP(PRP(K),ERX(K),PRP(KK),ERX(KK),XG(K,M))
      GO TO 1285
 1278 ERP(K,M,1)=ERX(K)-(PRP(K)-XG(K,M))*SLOPE
 1285 CONTINUE
      DO 1290 K=1,KN
      IF(ERX(K).EQ.0.) GO TO 1290
      PRP(K)=XG(K,M)
      TRP(K,M,1)=(EG(K,M)-ERP(K,M,1))/VV
      DEPTH=EG(K,M)-ERP(K,M,1)
 1290 CONTINUE
      DO 1325 J=1,JN
      TRS(J,M,1)=0.
      ERS(J,M,1)=0.
 1325 CONTINUE
 1400 CONTINUE
C
C FILL IN MISSING POINTS
```

```
C
      CALL FILLIN(L1)
C L1 SET TO 0 IN FILLIN IF NO PTS ARE DEFINED FOR LAYER L1
      IF(L1.EQ.0) GO TO 1
      IF (IFLAG.EQ.2.OR.IXIT.LE.3.OR.(IFLAG.EQ.1.AND.IXIT.EQ.4))
     1 GO TO 1061
      IFLAG=IFLAG+1
      L1=1
      L2=2
      IREP=IFLAG+1
      GO TO 2002
C
C----------------------------------------------------------GO TO PART 3
C
 1061 IF (NIXIT.EQ.1) GO TO 1070
C
C PRINT HEADING FOR RESULTS
C
      PRINT 57, IDENT
      PRINT 1068
 1068 FORMAT (1H0,48HARRIVAL TIMES CORRECTED TO BASE OF LAYER 1, AND ,
     1 23HELEV OF BASE OF LAYER 1)
C
C COMPUTE CORRECTED TA FOR T-D PLOT
C
 1070 DO 1092 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 1082 J=1,JN
      IF (J.GE.JA(M).OR.JJOFF.NE.0) GO TO 1075
      JJ=JA(1)
      GO TO 1076
 1075 IF (J.LE.JB(M).OR.JJOFF.NE.0) GO TO 1077
      JJ=JB(NM)
 1076 TRS(J,M,1)=TRS(JJ,M,1)
 1077 DO 1080 K=1,KN
      IF (LG(K,J,M).EQ.1.OR.TR(K,J,M).EQ.0.0) GO TO 1078
      TA(K,J,M)=TR(K,J,M)-TRP(K,M,1)-TRS(J,M,1)
      GO TO 1080
 1078 TA(K,J,M)=0.0
 1080 CONTINUE
 1082 CONTINUE
C
C PRINT RESULTS
C
      IF (NIXIT.EQ.1) GO TO 1092
      PRINT 383, IDSPR(M),(IDSP(J,M),J=1,JN)
      PRINT 384, (ERS(J,M,1),J=1,JN)
      PRINT 385, (TRS(J,M,1),J=1,JN)
      PRINT 387, (IBL,J=1,JN)
      DO 1090 K=1,KN
      PRINT 389, K,ERP(K,M,1),TRP(K,M,1),(TA(K,J,M),P(K,J,M),J=1,JN)
 1C90 CONTINUE
 1092 CONTINUE
C
C PLOT T-D GRAPH (LAYER 1 REMOVED)
C
 1110 IF(IPLOT.EQ.4.AND.NIXIT.EQ.0) CALL PLOT(1)
      IF (IXIT.EQ.2) GO TO 1
C
```

```
C***********************************************************************
C PART 3
C***********************************************************************
C
C COMPUTE DEPTH POINTS AT BASE OF LAYER L, L.GT.2
C
C LAYER LOOP -- REFR HORIZ IS BETWEEN L1 AND L2 -- LOOP ENDS AT 2190
C
 2000 IF (NL.LE.2) GO TO 2200
      L2=3
 2001 L1=L2-1
      IF (ITRACE.NE.0) PRINT 1027, L2
      LL=L1-1
      IFLAG=0
      IF (IREP.EQ.4) GO TO 2002
      IREP=1
C
C SPREAD LOOP STARTS HERE---------------------- LOOP ENDS AT 2090 + 3
C
C-----ENTRY POINT FROM PART 2  (FOR IREP.GE.2, IFLAG.NE.0, L1=1,L2=2)
C
 2002 M=1
      IXREP=IXIT-IREP
C
 2003 JN=NJ(M)
      KN=NK(M)
      HV=VHA(M,L2)
      HV2=HV**2
      VV=VVA(M,L1)
      IF (HV.LE.VV) GO TO 9992
      TANSG=VV/SQRT(HV2-VV**2)
      VOCOSG=TANSG*HV
      IF(IREP.NE.2) BL(M)=0.
      IF (JJOFF.EQ.0) GO TO 2004
      J1=1
      J2=JN
      GO TO 2007
 2004 J1=JA(M)
      J2=JB(M)
C
C PRECOMPUTE TIME AND MIGR CORR FOR ALL GEOS, SPREAD M
C ALSO CLEAR WORKING STORAGE
C
 2007 DO 2011 K=1,KN
      DO 2008 LR=1,2
      PRG2(K,LR)=0.0
      ERG2(K,LR)=0.0
      TRG2(K,LR)=0.0
 2008 CONTINUE
      IF (IREP.GT.1) GO TO 2011
      DO 2009 LR=1,2
      PG2(K,M,LR)=0.0
      EG2(K,M,LR)=0.0
      TG2(K,M,LR)=0.0
 2009 CONTINUE
      RAD=SQRT(HV2-VVA(M,1)**2)
      TVG(K)=TRP(K,M,1)*HV/RAD
      XVG(K)=(EG(K,M)-ERP(K,M,1))*VVA(M,1)/RAD
      IF (LL.LE.1) GO TO 2011
      DO 2010 L=2,LL
      RAD=SQRT(HV2-VVA(M,L)**2)
      TVG(K)=TVG(K)+TRP(K,M,L)*HV/RAD
      XVG(K)=XVG(K)+(ERP(K,M,L-1)-ERP(K,M,L))*VVA(M,L)/RAD
 2C10 CONTINUE
 2011 CONTINUE
C
C SHOT POINT LOOP STARTS HERE---------------------- LOOP ENDS AT 2090
C
      J=J1
 2012 JJ=J
C
C COMPUTE TIME AND MIGR CORR AT SP J
C
      ISPLT=0
      IF (IFLAG.NE.0) GO TO 12018
      IF (ES(J,M).LE.ERS(J,M,LL)) GO TO 2016
      TC=0.0
      XC=0.0
      NONE=0
      DO 2015 L=1,LL
      IF (ES(J,M).LT.ERS(J,M,L)) GO TO 2015
      IF (IREP.EQ.1) GO TO 2013
      LS(J,M)=L
      GO TO 2018
 2013 V1=VVA(M,L)
      RAD=SQRT (HV2-V1**2)
      IF (NONE.EQ.0) GO TO 2014
      XC=XC+(ERS(J,M,L-1)-ERS(J,M,L))*V1/RAD
      TC=TC+TRS(J,M,L)*HV/RAD
      GO TO 2015
 2014 XC=(ES(J,M)-ERS(J,M,L))*V1/RAD
      TC=((ES(J,M)-ERS(J,M,L))*HV)/(V1*RAD)
      LS(J,M)=L
      NONE=1
 2015 CONTINUE
      GO TO 2017
 2016 LS(J,M)=L1
      IF(IREP.EQ.1) GO TO 12017
      IF(ES(J,M).GE.ERS(J,M,L1)) GO TO 2018
      LS(J,M)=L2
      ISPLT=2
      GO TO 2018
12017 DZ=ERS(J,M,LL)-ES(J,M)
      ISPLT=1
 2017 IF (ISPLT.EQ.0) GO TO 2018
      TC=-DZ*VOCOSG/VV**2
      ELLS=ERS(J,M,LL)
      DS=-DZ*TANSG
      XC=DS
      GO TO 2018
C
C INITIALIZE FOR RIGHT-GOING RAYS
C
12018 IF(LS(J,M).EQ.2) ISPLT=1
 2018 I=1
      II=2
      SGN=1.0
      IF(KR(J,M).EQ.0) GO TO 2040
      CALL KENDS(L2,M,J,KR(J,M),KN,K11,K22)
C
```

```
C ENTRY POINT AFTER INITIALIZATION FOR RIGHT- OR LEFT-GOING RAYS
C
C--------------------TRACE SHOTPOINT RAYS, IREP=1-----
C
 2019 IF (IREP.GT.1) GO TO 2021
      XLLS=XSP(J,M)+XC*SGN
      TLLS=TC
      IF(ISPLT.NE.0) GO TO 2023
      IF(ITRACE.NE.0)PRINT 2C20,IREP,IDSPR(M),IDSP(J,M)
     1,IZ,II,L2,L1,LS(J,M),XSP(J,M),ES(J,M),XLLS,ELLS,TLLS,DMY1,DMY2
     2,DMY3,BL(M)
 2020 FORMAT(1H0,35HIREP SPR SP  G  I  L LL LO   XO/XL1,7X,2HE0,6X,3HXLL
     1,6X,3HELL,6X,3HTLL,7X,2HXL,7X,2HEL,7X,2HTL,3X,17HBLL/BL   EPS    N
     2/1X,I3,2(3X,A1),5I3,8F9.1,F9.4)
      CALL RAYUP(L2,L1,LS(J,M),J,M,II,XSP(J,M),ES(J,M),XLLS,
     1 ELLS,TLLS,DMY1,DMY2,DMY3,BL(M))
      DS=(XLLS-XSP(J,M))*SGN
      GO TO 2023
C
C--------------------TRACE SHOTPOINT RAYS, IREP.GT.1-----
C
 2021 IF((JJOFF.EQ.0.AND.J.EQ.J1.AND.I.EQ.1).OR.(JJOFF.EQ.0.AND.J.EQ.J2.
     1AND.I.EQ.2)) GO TO 12021
      IF(K11.EQ.0) GO TO 2031
12021 IF (ISPLT.EQ.2) GO TO 2022
      IF(ITRACE.NE.0)PRINT 2020,IREP,IDSPR(M),IDSP(J,M)
     1,IZ,II,L2,L2,LS(J,M),XSP(J,M),ES(J,M),PS2(J,M,I),ES2(J,M,I),DMY0
     2,PRS2(J,M,L1,I),ERS2(J,M,L1,I),TRS2(J,M,I),BL(M)
      CALL RAYUP(L2,L2,LS(J,M),J,M,II,XSP(J,M),ES(J,M),
     1 PS2(J,M,I),ES2(J,M,I),DMY0,PRS2(J,M,L1,I),ERS2(J,M,L1,I),
     2 TRS2(J,M,I),BL(M))
      GO TO 2023
 2022 PRS2(J,M,L1,I)=XSP(J,M)
      ERS2(J,M,L1,I)=ERS(J,M,L1)
C
C RE-ENTRY PT FOR OUTLYING SHOTPOINTS
C
 2023 IF(K11.EQ.0) GO TO 2031
      IF(KRS2(JJ,M,L1,I).EQ.IBEE) KRS2(JJ,M,L1,I)=IBL
      DO 2030 K=K11,K22
      IF (LG(K,JJ,M).NE.L2) GO TO 2030
C
C--------------------TRACE GEOPHONE RAYS, IREP=1-----
C
      IF (IREP.GT.1) GO TO 2026
      IF (TG2(K,M,I).NE.0.0) GO TO 2025
      PG2(K,M,I)=XG(K,M)-XVG(K)*SGN
      TG2(K,M,I)=TVG(K)
      IF(ITRACE.NE.0)PRINT 2020,IREP,IDSPR(M),IDSP(JJ,M)
     1,K,I,L2,L1,I1,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),TG2(K,M,I)
     2,DMY1,DMY2,DMY3,BL(M)
      CALL RAYUP(L2,L1,1,J,M,I,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),
     1 TG2(K,M,I),DMY1,DMY2,DMY3,BL(M))
 2025 DG=(XG(K,M)-PG2(K,M,I))*SGN
      TA(K,JJ,M)=TR(K,JJ,M)-TLLS-TG2(K,M,I)
      DSG(K)=ABS(D(K,J,M))-DS-DG
      GO TO 2030
C
C--------------------TRACE GEOPHONE RAYS, IREP.GT.1-----
C
```

```
 2026 IF (TRG2(K,I).NE.0.0) GO TO 2028
      PRG2(K,I)=PRG(K,JJ,M)
      ERG2(K,I)=ERG(K,JJ,M)
      TRG2(K,I)=TRG(K,JJ,M)
      IF(ITRACE.NE.0)PRINT 2020,IREP,IDSPR(M),IDSP(JJ,M)
     1,K,I,L2,L2,I1,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),DMYO,PRG2(K,I)
     2,ERG2(K,I),TRG2(K,I),BL(M)
      CALL RAYUP(L2,L2,1,J,M,I,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),
     1 DMYO,PRG2(K,I),ERG2(K,I),TRG2(K,I),BL(M))
      IF(ISPLT.NE.2) GO TO 2028
      IF(ABS((PRG2(K,I)-XSP(J,M))/(ERG2(K,I)-ES(J,M))).GT.100.)
     1 GO TO 2028
      DMYO=BIG
      PRG2(K,I)=(XSP(J,M)+2.*PRG2(K,I))/3.
      IF(ITRACE.NE.0) PRINT 2020,IREP,IDSPR(M),
     1IDSP(JJ,M),K,I,L2,L2,I1,XG(K,M),EG(K,M),PG2(<,M,I),EG2(K,M,I),
     2DMYO,PRG2(K,I),ERG2(K,I),TRG2(K,I),BL(M)
      CALL RAYUP(L2,L2,1,J,M,I,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I)
     1,DMYO,PRG2(K,I),ERG2(K,I),TRG2(K,I),BL(M))
 2C28 PRG(K,JJ,M)=PRG2(K,I)
      ERG(K,JJ,M)=ERG2(K,I)
      TRG(K,JJ,M)=TRG2(K,I)
 2030 CONTINUE
C
C--------------------IREP=1  OR  IREP.GT.1----------
C
 2031 IF(IREP.GT.1) GO TO 2035
C
C--------------------IREP=1----------
C
C REGRESSION OF END AND OUTLYING SP TIMES TO GET INTERCEPT T WHEN
C IREP=1.  IF JJOFF=0 OUTLYING SP TIMES ARE TIED TO END SP TIMES.
C
      KT1=K11
      KT2=K22
      JT=JJ
      S1=0.
      S2=0.
      PT=0.
      T=0.
12033 IF(KT1.EQ.0) GO TO 12037
      DO 12036 K=KT1,KT2
      IF(LG(K,JT,M).NE.L2) GO TO 12036
      IF(JT.EQ.JJ) GO TO 12035
      IF(TG2(K,M,I).NE.0.) GO TO 12034
      PG2(K,M,I)=XG(K,M)-XVG(K)*SGN
      TG2(K,M,I)=TVG(K)
      IF(ITRACE.NE.0)PRINT 2020,IREP,IDSPR(M),IDSP(JT,M)
     1,K,I,L2,L1,I1,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),TG2(K,M,I)
     2,DMY1,DMY2,DMY3,BL(M)
      CALL RAYUP(L2,L1,1,JT,M,I,XG(K,M),EG(K,M),PG2(K,M,I),EG2(K,M,I),
     1 TG2(K,M,I),DMY1,DMY2,DMY3,BL(M))
12034 DG=(XG(K,M)-PG2(K,M,I))*SGN
      DSG(K)=ABS(D(K,J,M))-DS-DG
      TA(K,JT,M)=TR(K,JT,M)-TLLS-TG2(K,M,I)
12035 S1=S1+DSG(K)
      S2=S2+TA(K,JT,M)
      PT=PT+1.
12036 CONTINUE
12C37 IF(JJOFF.NE.0) GO TO 2032
```

```
      IF(I.EQ.2) GO TO 12040
      IF(JJ.NE.J1) GO TO 2032
      JT=JT-1
      IF(JT.LT.1) GO TO 12042
      KRS2(JT,M,L1,1)=IAST
      CALL KENDS(L2,M,JT,KR(JT,M),KN,KT1,KT2)
      GO TO 12033
12040 IF(JJ.NE.J2) GO TO 2032
      JT=JT+1
      IF(JT.GT.JN) GO TO 12042
      KRS2(JT,M,L1,2)=IAST
      CALL KENDS(L2,M,JT,1,KL(JT,M),KT1,KT2)
      GO TO 12033
C
12042 IF(PT.EQ.0.) GO TO 2040
      IF(PT.EQ.1.) GO TO 12055
      XBAR=S1/PT
      TBAR=S2/PT
      S1=0.
      S2=0.
      KT1=K11
      KT2=K22
      JT=JJ
12043 IF(KT1.EQ.0) GO TO 12046
      DO 12045 K=KT1,KT2
      IF(LG(K,JT,M).NE.L2) GO TO 12045
      XD=DSG(K)-XBAR
      S1=S1+XD*TA(K,JT,M)
      S2=S2+XD**2
12045 CONTINUE
12046 IF(I.EQ.2) GO TO 12050
      JT=JT-1
      IF(JT.LT.1) GO TO 12052
      CALL KENDS(L2,M,JT,KR(JT,M),KN,KT1,KT2)
      GO TO 12043
12050 JT=JT+1
      IF(JT.GT.JN) GO TO 12052
      CALL KENDS(L2,M,JT,1,KL(JT,M),KT1,KT2)
      GO TO 12043
C
12052 T=(TBAR-XBAR*S1/S2)/2.
      GO TO 12060
C
12055 T=(S2-S1/VHA(M,L2))/2.
      GO TO 12060
C
C--------------------IREP=1----------
C
C COMPUTE HORIZ TIME AND FIRST APPROX DEPTHS
C
 2032 IF(K11.EQ.0) GO TO 2040
      CALL REGRES(K11,K22,JJ,M,L2,V,T,PT,0)
      IF(PT.EQ.0.) GO TO 2040
12060 Z=T*VOCOSG
      TS=Z*VOCOSG/VV**2
      TRS2(JJ,M,I)=TLLS+TS
      ERS2(JJ,M,L1,I)=ELLS-Z
      PRS2(JJ,M,L1,I)=XLLS+Z*TANSG*SGN
 2033 ZRSP(JJ)=Z
      DO 2034 K=K11,K22
      IF (LG(K,JJ,M).NE.L2) GO TO 2034
      EDIF=SLOPE*(PG2(K,M,I)-PRS2(JJ,M,L1,I))
      KCALL=K
      CALL HTIME(KCALL,J,M,PRS2(JJ,M,L1,I),0.,PG2(K,M,I),EDIF,HV,TH)
      Z=(TA(K,JJ,M)-TS-TH)*VOCOSG
      IF (Z.LT.0.0) Z=0.0
      ZRG(K,JJ)=Z
      TG=Z*VOCOSG/VV**2
      TRG(K,JJ,M)=TG2(K,M,I)+TG
      ERG(K,JJ,M)=EG2(K,M,I)-Z
      PRG(K,JJ,M)=PG2(K,M,I)-Z*TANSG*SGN
 2034 CONTINUE
      GO TO 2040
C
C--------------------IREP.GT.1----------
C
C COMPUTE HORIZ TIME, COMPUTE TOTAL RAY TIME, AND ADJUST DEPTHS
C TO MAKE COMPUTED TIME AGREE WITH MEASURED TIME
C
 2035 IF(K11.EQ.0) GO TO 2040
      SUM1=0.
      PTS1=0.
      IF(ISPLT.EQ.2) GO TO 3035
      P1=PRS2(J,M,L1,I)
      E1=ERS2(J,M,L1,I)
      GO TO 3135
 3035 P1=XSP(J,M)
      E1=ES(J,M)
      KRS2(JJ,M,L1,I)=IBEE
 3135 DO 2037 K=K11,K22
      IF (LG(K,JJ,M).NE.L2) GO TO 2037
      KRG(K,JJ,M)=IBL
      P2=PRG2(K,I)
      E2=ERG2(K,I)
 3036 KCALL=K
      CALL HTIME(KCALL,J,M,P1,E1,P2,E2,HV,TH)
      TCOR=TR(K,JJ,M)-TRS2(JJ,M,I)-TH-TRG2(K,I)
      IF(ISPLT.EQ.0) TCOR=TCOR/2.
      TCALL=TCOR
      IF(ABS(TCOR).LE.TLIM) GO TO 2036
      TCALL=SIGN(TLIM,TCOR)
      KRG(K,JJ,M)=IQUES
 2036 CALL RAYCOR(PG2(K,M,I),P2,EG2(K,M,I),E2,VV,HV,TCALL)
      PRG(K,JJ,M)=P2
      ERG(K,JJ,M)=E2
      TRG(K,JJ,M)=TRG2(K,I)+TCALL
      PTS1=PTS1+1.0
      SUM1=SUM1+TCOR
      IF (IXREP.GT.2.OR.L2.EQ.2) GO TO 2037
      GTC(K,M)=GTC(K,M)+TCOR
      GPT(K,M)=GPT(K,M)+1.0
 2037 CONTINUE
      IF (PTS1.EQ.0..OR.ISPLT.EQ.2) GO TO 2040
      IF (IXREP.GT.2.OR.L2.EQ.2) GO TO 2038
      SPTC(JJ,M)=SPTC(JJ,M)+SUM1
      SPPT(JJ,M)=SPPT(JJ,M)+PTS1
 2038 TCOR=SUM1/PTS1
      IF(KRS2(JJ,M,L1,I).EQ.IQUES) KRS2(JJ,M,L1,I)=IBL
      IF(ABS(TCOR).LE.TLIM) GO TO 2039
      IF(KRS2(JJ,M,L1,I).EQ.IBL) KRS2(JJ,M,L1,I)=IQUES
      TCOR=SIGN(TLIM,TCOR)
 2C39 CALL RAYCOR(PS2(J,M,I),P1,ES2(J,M,I),E1,VV,HV,TCOR)
      TRS2(JJ,M,I)=TRS2(JJ,M,I)+TCOR
      PRS2(JJ,M,L1,I)=P1
      ERS2(JJ,M,L1,I)=E1
C
C TEST FOR DOING OUTLYING SPS LEFT OF SPREADS, RIGHT-GOING RAYS
C
 2040 IF (I.NE.1) GO TO 2070
      IF (JJOFF.NE.0.OR.JJ.GT.J1) GO TO 2046
 2041 JJ=JJ-1
      IF (JJ.GT.0) GO TO 2042
      IF(IREP.EQ.1.OR.J1.EQ.1) GO TO 2046
      SUM1=0.
      SUM2=0.
      SUM3=0.
      PTS1=0.
      JJJ=0
      DO 3041 JJ=1,J1
      IF(ERS2(JJ,M,L1,I).EQ.0..OR.KRS2(JJ,M,L1,I).EQ.IQUES) GO TO 3041
      SUM1=SUM1+TRS2(JJ,M,I)
      SUM2=SUM2+PRS2(JJ,M,L1,I)
      SUM3=SUM3+ERS2(JJ,M,L1,I)
      PTS1=PTS1+1.
      IF(JJJ.EQ.0) JJJ=JJ
 3041 CONTINUE
      IF(PTS1.EQ.0.) GO TO 2046
      TBAR=SUM1/PTS1
      PBAR=SUM2/PTS1
      EBAR=SUM3/PTS1
      DO 4041 JJ=JJJ,J1
      TRS2(JJ,M,I)=TBAR
      PRS2(JJ,M,L1,I)=PBAR
      ERS2(JJ,M,L1,I)=EBAR
 4041 CONTINUE
      GO TO 2046
 2042 CALL KENDS(L2,M,JJ,KR(JJ,M),KN,K11,K22)
      IF (K11.EQ.0) GO TO 2041
 2043 TRS2(JJ,M,I)=TRS2(J,M,I)
      PRS2(JJ,M,L1,I)=PRS2(J,M,L1,I)
      ERS2(JJ,M,L1,I)=ERS2(J,M,L1,I)
      GO TO 2023
C
C INITIALIZE FOR LEFT-GOING RAYS
C
 2046 I=2
      II=1
      SGN=-1.0
      IF(KL(J,M).EQ.0) GO TO 2090
      CALL KENDS(L2,M,J,1,KL(J,M),K11,K22)
      GO TO 2019
C
C TEST FOR DOING OUTLYING SPS RIGHT OF SPREADS, LEFT-GOING RAYS
C
 2070 IF (JJOFF.NE.0.OR.JJ.LT.J2) GO TO 2090
 2072 JJ=JJ+1
      IF (JJ.LE.JN) GO TO 2074
      IF(IREP.EQ.1.OR.J2.EQ.JN) GO TO 2090
      SUM1=0.
      SUM2=0.
      SUM3=0.
      PTS1=0.
      DO 2073 JJ=J2,JN
      IF(ERS2(JJ,M,L1,I).EQ.0..OR.KRS2(JJ,M,L1,I).EQ.IQUES) GO TO 2073
      SUM1=SUM1+TRS2(JJ,M,I)
      SUM2=SUM2+PRS2(JJ,M,L1,I)
      SUM3=SUM3+ERS2(JJ,M,L1,I)
      PTS1=PTS1+1.
      JJJ=JJ
 2073 CONTINUE
      IF(PTS1.EQ.0.) GO TO 2090
      TBAR=SUM1/PTS1
      PBAR=SUM2/PTS1
      EBAR=SUM3/PTS1
      DO 3073 JJ=J2,JJJ
      TRS2(JJ,M,I)=TBAR
      PRS2(JJ,M,L1,I)=PBAR
      ERS2(JJ,M,L1,I)=EBAR
 3073 CONTINUE
      GO TO 2090
 2074 CALL KENDS(L2,M,JJ,1,KL(JJ,M),K11,K22)
      IF (K11.EQ.0) GO TO 2072
      GO TO 2043
C
 2090 J=J+1
      IF (J.LE.J2) GO TO 2012
      IF (IREP.EQ.1)CALL ADMIG(L1,M,BL(M))
      M=M+1
      IF (M.LE.NM) GO TO 2003
      IF (IFLAG.NE.0) GO TO 1200
C
C-------------------------------------FOR FLAG.NE.0  RETURN TO PART 2
C
C END OF SP LOOP AT 2090, END OF SPREAD LOOP AT 2090 + 3.
C
C COMPUTE AVG COORDS(P1,E1),(P2,E2) IN ADJACENT INTERVALS BETWEEN GEOS,
C  AND THEN INTERPOLATE TO FIND SMOOTHED ELEV PTS (ERP) AT GEO POS (XG)
C  BETWEEN THE TWO INTERVALS.  THEN COMPUTE LAYER VERT TRAVEL TIME (TRP)
C
      DO 2096 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 2094 J=1,JN
      TRS(J,M,L1)=0.0
      ERS(J,M,L1)=0.0
 2094 CONTINUE
      DO 2095 K=1,KN
      TRP(K,M,L1)=0.0
      ERP(K,M,L1)=0.0
 2095 CONTINUE
 2096 CONTINUE
C
      M=0
      X1=2.*XG(1,1)-XG(2,1)
 2100 M=M+1
      IF (M.GT.NM) GO TO 2114
      M1=M
      KN=NK(M)
      K=1
 2102 KK=K
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      X2=XG(K,M)
      IF (X2.LE.X1) GO TO 2104
      CALL AVG(X1,X2,L2,P1,E1)
      IF (E1.NE.0.0) GO TO 2105
C
C CONDITION IN WHICH (P1,E1) IS NOT YET DEFINED
C
      X1=X2
 2104 K=K+1
      IF (K.GT.KN) GO TO 2100
      GO TO 2102
C
C CONDITION IN WHICH (P1,E1) IS DEFINED AND (P2,E2) IS SOUGHT
C
 2105 ERP(KK,M1,L1)=E1
      TRP(KK,M1,L1)=(ERP(KK,M1,LL)-ERP(KK,M1,L1))/VVA(M1,L1)
 2106 X1=X2
 2108 K=K+1
      IF (K.LE.KN) GO TO 2109
      M=M+1
      IF (M.GT.NM) GO TO 2113
      KN=NK(M)
      K=1
 2109 X2=XG(K,M)
      IF (X2.LE.X1) GO TO 2108
      CALL AVG(X1,X2,L2,P2,E2)
      IF (E2.EQ.0.0) GO TO 2106
 2110 ERP(KK,M1,L1)=TERP(P1,E1,P2,E2,XG(KK,M1))
      TRP(KK,M1,L1)=(ERP(KK,M1,LL)-ERP(KK,M1,L1))/VVA(M1,L1)
      KK=KK+1
      IF (M.NE.M1) GO TO 2111
      IF (KK.EQ.K) GO TO 2112
      GO TO 2110
 2111 IF (KK.LE.NK(M1)) GO TO 2110
      M1=M
      KK=K
      ERP(KK,M1,L1)=TERP(P1,E1,P2,E2,XG(KK,M1))
      TRP(KK,M1,L1)=(ERP(KK,M1,LL)-ERP(KK,M1,L1))/VVA(M1,L1)
 2112 P1=P2
      E1=E2
      GO TO 2106
 2113 X2=2.*XG(KN,NM)-XG(KN-1,NM)
      CALL AVG(X1,X2,L2,P2,E2)
      IF (E2.EQ.0.0) GO TO 2114
      ERP(KN,NM,L1)=TERP(P1,E1,P2,E2,XG(KN,NM))
      TRP(KN,NM,L1)=(ERP(KN,M1,LL)-ERP(KN,M1,L1))/VVA(M1,L1)
 2114 CALL FILLIN(L1)
C L1 SET TO 0 IN FILLIN IF NO PTS ARE DEFINED FOR LAYER L1
      IF(L1.EQ.0) GO TO 1
C
C REPEAT IF IREP=1 OR IREP=2
C
      IF (IXREP.LE.3) GO TO 2190
      IREP=IREP+1
      GO TO 2002
C
 2190 L2=L2+1
      IF (L2.LE.NL) GO TO 2001
C
C END OF LAYER LOOP AT 2190
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C
C FINAL FILTER -- TRIM-UP TIME ADJUST AT BASE OF LAYER 1
C
      IF (IREP.EQ.4.OR.IXIT.LE.3) GO TO 2200
      IREP=4
C
      DO 2196 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 2192 J=1,JN
      IF (SPPT(J,M).EQ.0.0) GO TO 2192
      TCOR=SPTC(J,M)/SPPT(J,M)
      ERS(J,M,1)=ERS(J,M,1)-TCOR*VVA(M,1)
      IF (ERS(J,M,1).GT.ESP(J,M)) ERS(J,M,1)=ESP(J,M)
 2192 CONTINUE
      DO 2194 K=1,KN
      IF (GPT(K,M).EQ.0.0) GO TO 2194
      TCOR=GTC(K,M)/GPT(K,M)
      ERP(K,M,1)=ERP(K,M,1)-TCOR*VVA(M,1)
      IF (ERP(K,M,1).GT.EG(K,M)) ERP(K,M,1)=EG(K,M)
 2194 CONTINUE
 2196 CONTINUE
      GO TO 2000
C
C PRINT RESULTS -- DEPTHS COMPUTED FROM REFRACTION ARRIVALS
C
 2200 DO 2222 M=1,NM
      PRINT 57, IDENT
      JN=NJ(M)
      PRINT 2201, IDSPR(M),(IDSP(J,M),J=1,JN)
 2201 FORMAT (1H0,8H SPREAD ,A1,3X,32HRAY END POINTS BENEATH GEOPHONES/
     1 '  GEO',14X,7(8X,'SP ',A1))
      PRINT 2202, (IBL,J=1,JN)
 2202 FORMAT('  ---',17X,7(A2,'--------L-'))
C
      KN=NK(M)
C
      DO 2210 K=1,KN
      PRINT 2203, K, (PRG(K,J,M),LG(K,J,M),J=1,JN)
 2203 FORMAT (1H ,I3,15X,3HPOS,7(F9.1,I2,1X))
      PRINT 2205, (ERG(K,J,M),KRG(K,J,M),J=1,JN)
 2205 FORMAT (1H ,17X,4HELEV,7(F9.1,1X,A1,1X))
      PRINT 2207
 2207 FORMAT (1X)
 2210 CONTINUE
C
      PRINT 2211
 2211 FORMAT (' RAY END POINTS BENEATH SHOTPOINTS')
C
      DO 2220 L2=2,NL
      L=L2-1
      PRINT 2213, L2,(PRS2(J,M,L,1),J=1,JN)
 2213 FORMAT (1H0,2HL=,I1,4X,5HRIGHT,6X,3HPOS,F9.1,6F12.1)
      PRINT 2205, (ERS2(J,M,L,1),KRS2(J,M,L,1),J=1,JV)
      PRINT 2217, L2,(PRS2(J,M,L,2),J=1,JN)
 2217 FORMAT (1H0,2HL=,I1,4X,4HLEFT,7X,3HPOS,F9.1,5F12.1)
      PRINT 2205, (ERS2(J,M,L,2),KRS2(J,M,L,2),J=1,JN)
 2220 CONTINUE
 2222 CONTINUE
C
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C PRINT RESULTS -- INTERP-EXTRAP PTS AT SPS AND GEOS
C
      DO 2260 M=1,NM
      IF (JJOFF.EQ.0) GO TO 2225
      J1=1
      GO TO 2226
 2225 J1=JA(M)
 2226 IF (JJOFF.EQ.0) GO TO 2227
      J2=NJ(M)
      GO TO 2228
 2227 J2=JB(M)
 2228 PRINT 57, IDENT
      PRINT 2231, IDSPR(M),(L,L=2,NL)
 2231 FORMAT (1H0,8H SPREAD ,A1,3X,28HSMOOTHED POSITION OF LAYERS ,
     1 32HBENEATH SHOTPOINTS AND GEOPHONES/1H0,24X,4(11X,'LAYER',I2))
C
      PRINT 2233, (IBL,L=2,NL)
 2233 FORMAT('0 SP   POSITION  SURF ELEV ',4(A1,5X,')EPTH  ELEV '))
      PRINT 2234, (IBL,L=2,NL)
 2234 FORMAT('  ---  --------  ---------',4(A4,'--------------'))
C
      DO 2246 J=J1,J2
      DO 2240 L=1,LN
      ZSG(L)=0.0
      IF (ERS(J,M,L).NE.0.0) ZSG(L)=ESP(J,M)-ERS(J,M,L)
 2240 CONTINUE
      PRINT 2243, IDSP(J,M),XSP(J,M),ESP(J,M),(ZSG(L),ERS(J,M,L),L=1,LN)
 2243 FORMAT(3X,A1,2F11.1,4(2X,2F8.1))
 2246 CONTINUE
C
      PRINT 2249
 2249 FORMAT('0 GEO'/'  ---')
      KN=NK(M)
      DO 2256 K=1,KN
      DO 2252 L=1,LN
      IF (ERP(K,M,L).NE.0.0) ZSG(L)=EG(K,M)-ERP(K,M,L)
 2252 CONTINUE
      PRINT 2255, K,XG(K,M),EG(K,M),(ZSG(L),ERP(K,M,L),L=1,LV)
 2255 FORMAT (1X,I3,2F11.1,4(2X,2F8.1))
 2256 CONTINUE
      PRINT 2257,(L,L=1,NL)
 2257 FORMAT(/' VELOCITIES USED:'/7X,5(11X,'LAYER',I2))
      PRINT 2258,(VVA(M,L),L=1,LN)
      PRINT 2259,(VHA(M,L),L=2,NL)
 2258 FORMAT(/8X,'VERTICAL',3PF9.0,4F18.0)
 2259 FORMAT(6X,'HORIZONTAL',9X,3P4F18.0)
 2260 CONTINUE
C
C PLOT DEPTH GRAPH
C
      CALL PLOT(2)
      GO TO 1
C
 9990 PRINT 9991
 9991 FORMAT (/1X,41H ERROR ON INPUT CARDS, COMPUTATION HALTED)
      GO TO 9999
C
 9992 PRINT 9993, L1,L2
 9993 FORMAT (/1X,25HVELOCITY INVERSION, LAYER,I2,10H AND LAYER,I2,
     1 19H COMPUTATION HALTED)
 9999 STOP
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE RAYUP(L,LL,LO,J,M,I,XO,EO,XLL,ELL,TLL,XL,EL,TL,BLL)
      COMMON IBL
      COMMON/BLK1/NM,NJ,NK
     2      /BLK2/XG,ERP,SLOPE,IDIP
     4      /BLK4/VVA,VHA
     6      /BLK6/TRP,JJOFF
     7      /BLK7/JA,JB,TRS,ERS,XSP,ESP,LS
     9      /BLK9/EG,ES
     9      /BLK10/BLIM,ITRACE,TANSG
C  IN PROGRAM SIPB
C TRACES RAY FROM STARTING POINT ON TOP OF LAYER L OR LL TO ENDING POINT
C (XO,EO) WITHIN OR ON THE UPPER BOUNDARY OF LAYER LO.  REFRACTING HORIZ
C IS THE TOP OF LAYER L.  COMPUTES AND RETURNS CORRECTED COORD OF START
C POINT AND TOTAL TRAVEL TIME. FOR IREP=1, LL=L-1, AND RAY START POINT
C IS TAKEN AS (XLL,ELL) ON TOP OF LAYER LL,  FOR IREP=2 OR 3, LL=L, AND
C START POINT IS TAKEN AS (XL,EL) ON TOP OF LAYER L. ALSO FOR IREP=2 OR
C 3, RAY INTERSECTION WITH TOP OF LAYER L-1 IS OUTPUTTED AS (XLL,ELL)
C AND TIME FROM THIS POINT AS TLL. INPUT PARAMETER BLL IS PRECOMPUTED
C AS AVG DIP OF REFRACTOR OVER ENTIRE SPREAD. IF BLL IS NONZERO ON INPUT
C IT IS USED IN PLACE OF INTERVAL DIP BETWEEN  GEO PAIRS WHICH IS
C CTHERWISE COMPUTED INTERNALLY. INPUT PARAMETER I IS PRESET TO 1 FOR
C RAYS GOING UP AND RIGHT, 2 FOR RAYS GOING UP AND LEFT.
C
C FOR THE CASE WHERE SHOT IS BELOW REFRACTOR (ES(J,M).LT.ERS(J,M,L1)),
C TLL=BIG ON INPUT AND RAY IS TRACED FROM SHOT TO GEO.
C
      DIMENSION NK(5),XG(25,5),ERP(25,5,4),VVA(5,5),VHA(5,5),NJ(5),JA(5)
     1,JB(5),TRS(7,5,4),ERS(7,5,4),XSP(7,5),ESP(7,5),LS(7,5),ES(7,5)
     2,EG(25,5),TRP(25,5,4)
C
      DATA BIG,SMALL/999999.,0.000001/
C
C INITIALIZE
C
      NONE=0
      XLLS=XLL
      TLLS=TLL
      XLS=XL
      TLS=TL
      IF (L.EQ.LL) XLL=XL
    2 IBLSW=0
    3 XREFL=XLL
      XREFLL=XLL
      TLL=0.0
      TL=0.0
      M1=M
      L2=LL
      L1=L2-1
C COMPUTE SLOPE OF RAY FROM STARTING POINT
      INVAL=0
      MFLAG=0
      IF(BLL.NE.0.) BL=BLL
C FIRST FIND K CF GEOS BOUNDING XLL
    4 KN=NK(M1)
      K3=KN-1
      K1=1
      K2=2
      IF (XLL.LT.XG(1,M1)) GO TO 8
      K1=KN-1
      K2=KN
      IF (XLL.GT.XG(KN,M1)) GO TO 11
      DO 6 K1=1,K3
      K2=K1+1
      IF (XLL.LE.XG(K2,M1)) GO TO 15
    6 CONTINUE
      GO TO 14
C CASE OF XLL LEFT OF SPREAD M1
    8 IF (M1.EQ.1) GO TO 9
      IF (INVAL.GT.0) GO TO 15
      INVAL=-1
      M1=M1-1
      GO TO 4
C CASE OF XLL LEFT OF SPREAD 1
    9 IF(BLL.NE.0..OR.IDIP.NE.0) GO TO 10
      KMID=KN/2
      K1=1
      K2=2
      IF(KMID-K1.LT.5) KMID=K1+5
      IF(KMID.GT.KN) KMID=KN
      CALL DIP(L1,M1,K1,KMID,K1,A,BL)
   10 IF(JJOFF.EQ.0) GO TO 310
      J2=JA(1)
      IF(XLL.GE.XSP(J2,1).OR.J2.LE.1) GO TO 310
  110 J1=J2-1
      IF(XLL.GE.XSP(J1,1).OR.J1.EQ.1) GO TO 210
      J2=J2-1
      GO TO 110
  210 ELL=TERP(XSP(J1,1),ERS(J1,1,L1),XSP(J2,1),ERS(J2,1,L1),XLL)
      GO TO 410
  310 IF(IDIP.NE.0.AND.BLL.EQ.0.) BL=SLOPE
      IF(BL.GT.BLIM) BL=BLIM
      IF(BL.LT.-BLIM) BL=-BLIM
      ELL=ERP(K1,M1,L1)+BL*(XLL-XG(K1,M1))
  410 MFLAG=1
      GO TO 16
C CASE OF XLL RIGHT OF SPREAD M1
   11 IF (M1.EQ.NM) GO TO 12
      IF (INVAL.LT.0) GO TO 15
      INVAL=1
      M1=M1+1
      GO TO 4
C CASE OF XLL RIGHT OF SPREAD NM
   12 IF(BLL.NE.0..OR.IDIP.NE.0) GO TO 13
      KMID=KN/2+1
      K1=KN-1
      K2=KN
      IF(K2-KMID.LT.5) KMID=K2-5
      IF(KMID.LT.1) KMID=1
      CALL DIP(L1,M1,KMID,K2,K2,A,BL)
   13 IF(JJOFF.EQ.0) GO TO 313
      JN=NJ(NM)
      J1=JB(NM)
      IF(XLL.LE.XSP(J1,NM).OR.J1.GE.JN) GO TO 313
  113 J2=J1+1
      IF(XLL.LE.XSP(J2,NM).OR.J2.EQ.JN) GO TO 213
      J1=J1+1
      GO TO 113
  213 ELL=TERP(XSP(J1,NM),ERS(J1,NM,L1),XSP(J2,NM),ERS(J2,NM,L1),XLL)
      GO TO 413
  313 IF(IDIP.NE.0.AND.BLL.EQ.0.) BL=SLOPE
      IF(BL.GT.BLIM) BL=BLIM
      IF(BL.LT.-BLIM) BL=-BLIM
      ELL=ERP(K2,M1,L1)+BL*(XLL-XG(K2,M1))
  413 MFLAG=2
      GO TO 16
   14 K1=KN-1
      K2=KN
C K1, K2, AND M1 NOW KNOWN. COMPUTE ELL AND BL FOR LAYER L1 AT XLL.
   15 ELL=TERP(XG(K1,M1),ERP(K1,M1,L1),XG(K2,M1),ERP(K2,M1,L1),XLL)
   16 EL=ELL
      EREFL=ELL
      EREFLL=ELL
      IF (NONE.NE.0) GO TO 17
      ELLS=ELL
      ELS=ELL
   17 IF (BLL.EQ.0.0) GO TO 18
      BL=BLL
      GO TO 19
   18 IF (IBLSW.NE.0) GO TO 19
      DENOM=XG(K2,M1)-XG(K1,M1)
      IF (DENOM.GT.0.1) GO TO 118
      BL=SLOPE
      GO TO 19
  118 IF(MFLAG.NE.0) GO TO 119
      BL=(ERP(K2,M1,L1)-ERP(K1,M1,L1))/DENOM
  119 IF (BL.GT.BLIM) BL=BLIM
      IF (BL.LT.-BLIM) BL=-BLIM
   19 BLREF=BL
      IF(TLLS.LT.BIG) GO TO 219
C
C RAY TRACED FROM ES WHEN ES IS BELOW REFRACTOR.
C
      DENOM=SQRT(((XLL-XSP(J,M))**2+(ELL-ES(J,M))**2)*(1.+BL**2))
      IF(DENOM.LT.0.001) GO TO 219
      SINR=(ELL-ES(J,M)-BL*(XLL-XSP(J,M)))/DENOM
      IF(ABS(SINR).GT.0.999) GO TO 219
      SINI=SINR*VVA(M1,L1)/VHA(M1,L)
      TANI=SINI/SQRT(1.-SINI**2)
      GO TO 120
  219 TANI=VVA(M1,L1)/SQRT(VHA(M1,L)**2-VVA(M1,L1)**2)
C COMPUTE SLOPE OF RAY EMERGING FROM L2
  120 IF (I.EQ.2) TANI=-TANI
C ENTRY PT FOR RAYS AFTER 1ST ONE
   20 DENOM=TANI-BL
C DECREMENT L1 IN PREPARATION FOR FINDING INTERSECTION W/ HORIZON ABOVE
      L1=L1-1
      L2=L2-1
C VERTICAL RAY TEST
      IF (ABS(DENOM).LT.SMALL) GO TO 39
C NONVERTICAL RAY
      BRAY=(TANI*BL+1.0)/DENOM
      ARAY=ELL-BRAY*XLL
C TEST FOR UPPERMOST RAY -- IF SO COMPUTE XL1, TLL, TL, AND THEN EXIT
      IF (L2.GT.L0) GO TO 23
      XL1=(E0-ARAY)/BRAY
      T=SQRT ((XL1-XLL)**2+(EO-ELL)**2)/VVA(M1,L2)
      IF (EO.GT.ELL) GO TO 22
  121 T=0.00001
   21 L3=L2+1
      T=T*VVA(M1,L2)/VVA(M1,L3)
   22 TLL=TLL+T
      TL=TL+T
      GO TO 46
C NOT UPPERMOST RAY -- COMPUTE TENTATIVE INTERSECTION W/ HORIZON ABOVE
   23 INVAL=0
   24 IF(BLL.NE.0.) GO TO 25
      DENOM=XG(K2,M1)-XG(K1,M1)
      IF(DENOM.GT.0.1) GO TO 124
      BL=SLOPE
      GO TO 25
  124 IF(MFLAG.EQ.0) GO TO 125
      IF(IDIP.EQ.0) GO TO 224
      BL=SLOPE
      GO TO 25
  224 IF(MFLAG.EQ.2) GO TO 225
C MFLAG=1 (XLL OR XL1 LEFT OF SPREAD M1)
  324 KMID=KN/2
      K1=1
      K2=1
      IF(KMID-K1.LT.5) KMID=K1+5
      IF(KMID.GT.KN) KMID=KN
      CALL DIP(L1,M1,K1,KMID,K1,A,BL)
      IF(JJOFF.EQ.0.OR.INVAL.EQ.0) GO TO 25
      J2=JA(1)
      IF(XL1.GE.XSP(J2,1).OR.J2.LE.1) GO TO 25
  424 J1=J2-1
      IF(XL1.GE.XSP(J1,1).OR.J1.EQ.1) GO TO 524
      J2=J1
      GO TO 424
  524 BL=(ERS(J2,M1,L1)-ERS(J1,M1,L1))/(XSP(J2,M1)-XSP(J1,M1))
      GO TO 25
C MFLAG=2 (XLL OR XL1 RIGHT OF SPREAD M1)
  225 KMID=KN/2+1
      K1=KN
      K2=KN
      IF(K2-KMID.LT.5) KMID=K2-5
      IF(KMID.LT.1) KMID=1
      CALL DIP(L1,M1,KMID,K2,K2,A,BL)
      IF(JJOFF.EQ.0.OR.INVAL.EQ.0) GO TO 25
      JN=NJ(NM)
      J1=JB(NM)
      IF(XL1.LE.XSP(J1,NM).OR.J1.GE.JN) GO TO 25
  625 J2=J1+1
      IF(XL1.LE.XSP(J2,NM).OR.J2.EQ.JN) GO TO 524
      J1=J2
      GO TO 625
  125 BL=(ERP(K2,M1,L1)-ERP(K1,M1,L1))/DENOM
   25 IF(BL.GT.BLIM) BL=BLIM
      IF(BL.LT.-BLIM) BL=-BLIM
      AL=ERP(K1,M1,L1)-BL*XG(K1,M1)
C TEST FOR RAY PARALLEL WITH HORIZON ABOVE
      DENOM=BRAY-BL
      IF (ABS (DENOM).GE.SMALL) GO TO 28
      IF (BRAY) 32,26,36
   26 GO TO (36,32), I
```

```
C TEST FOR VALID INTERSECTION
   28 XL1=(AL-ARAY)/DENOM
      IF(K1.EQ.K2) GO TO 30
      IF (XL1.LT.XG(K1,M1)) GO TO 32
      IF (XL1.GT.XG(K2,M1)) GO TO 36
C VALID INTERSECTION FOUND
   30 EL1=AL+BL*XL1
      IF (ABS (BRAY).LT.SMALL) BRAY=SIGN(SMALL,BRAY)
      IF (BL.GT.BLIM) BL=BLIM
      IF (BL.LT.-BLIM) BL=-BLIM
      DENOM=1.-BL/BRAY
      IF(ABS(DENOM).LT.SMALL) GO TO 52
      TANR=(BL+1.0/BRAY)/DENOM
      T=SQRT ((XL1-XLL)**2+(EL1-ELL)**2)/VVA(M1,L2)
   31 TL=TL+T
C TEST FOR CASE WHERE TLL STARTS ACCUMULATING AT L-1, NOT L
      IF (LL.EQ.L.AND.L2.EQ.(L-1)) GO TO 43
      TLL=TLL+T
      GO TO 44
C INTERSECTION NOT VALID -- SEARCH TO LEFT
   32 IF (INVAL.GT.U) GO TO 30
      IF (K1.EQ.1) GO TO 34
      K2=K1
      K1=K2-1
   33 INVAL=-1
      GO TO 24
   34 IF (M1.EQ.1) GO TO 35
      M1=M1-1
      KN=NK(M1)
      K2=KN
      K1=K2-1
      INVAL=-1
      GO TO 24
C CASE OF XL1 LEFT OF SPREAD 1
   35 INVAL=1
      MFLAG=1
      GO TO 324
C INTERSECTION NOT VALID -- SEARCH TO RIGHT
   36 IF (INVAL.LT.0) GO TO 30
      IF (K2.EQ.KN) GO TO 38
      K1=K2
      K2=K1+1
   37 INVAL=1
      GO TO 24
   38 IF (M1.EQ.NM) GO TO 138
      M1=M1+1
      KN=NK(M1)
      K1=1
      K2=2
      INVAL=1
      GO TO 24
C CASE OF XL1 RIGHT OF SPREAD NM
  138 INVAL=-1
      MFLAG=2
      GO TO 225
C VERTICAL RAY -- TEST IF UPPERMOST -- IF SO COMPJTE TL, TLL AND EXIT.
   39 XL1=XLL
      IF (L2.GT.LO) GO TO 40
      T=(EO-ELL)/VVA(M1,L2)
      IF(T.LE.0.) GO TO 121
      GO TO 22
C VERTICAL RAY -- NOT UPPERMOST ONE
   40 IF(BLL.NE.0.) GO TO 141
      DENOM=XG(K2,M1)-XG(K1,M1)
      IF(DENOM.GT.0.1) GO TO 41
      BL=SLOPE
      GO TO 141
   41 BL=(ERP(K2,M1,L1)-ERP(K1,M1,L1))/DENOM
      IF (BL.GT.BLIM) BL=BLIM
      IF (BL.LT.-BLIM) BL=-BLIM
  141 AL=ERP(K1,M1,L1)-BL*XG(K1,M1)
   42 EL1=AL+BL*XL1
      TANR=BL
      T=(EL1-ELL)/VVA(M1,L2)
      GO TO 31
C
   43 XREFLL=XL1
      EREFLL=EL1
      ELLS=EL1
C PREPARE TO CONTINUE TRACING RAY UPWARD
   44 XLL=XL1
      ELL=EL1
      SINI=VVA(M1,L1)*TANR/(SQRT(1.0+TANR**2)*VVA(M1,L2))
      TANI=SINI/SQRT (1.0-SINI**2)
      GO TO 20
C EXIT FROM RAY-TRACE ROUTINE -- PREPARE TO TRACE MORE RAYS IF NECESSARY
   46 IF (NONE.GT.0) GO TO 50
C FIRST RAY TRACED -- STORE RESULTS
      NONE=NONE+1
      XS1=X0-XL1
      XRLL1=XREFLL
      XRL1=XREFL
      ERL1=EREFL
      ERLL1=EREFLL
      TL1=TL
      TLL1=TLL
      BLREF1=BLREF
      EPSS=ABS(XS1)
      IF (ITRACE.NE.0) PRINT 47, XL1,XREFLL,EREFLL,TLL
     1,XREFL,EREFL,TL,XS1,NONE
   47 FORMAT (1H ,25X,F10.1,9X,6F9.1,F15.1,I5)
      IF (ABS (XS1).LT.0.5) GO TO 67
   49 XLL=XREFL+XS1
      GO TO 2
C SECOND RAY TRACED -- STORE RESULTS
   50 NONE=NONE+1
      XS2=X0-XL1
      XRL2=XREFL
      XRLL2=XREFLL
      ERL2=EREFL
      ERLL2=EREFLL
      TL2=TL
      TLL2=TLL
      BLREF2=BLREF
      IF (ABS(XS2).GE.EPSS) GO TO 51
      EPSS=ABS(XS2)
      XLLS=XREFLL
      ELLS=EREFLL
      TLLS=TLL
      XLS=XREFL
      ELS=EREFL
      TLS=TL
   51 IF (ITRACE.NE.0) PRINT 47, XL1,XREFLL,EREFLL,TLL
     1,XREFL,EREFL,TL,XS2,NONE
C MAKE TESTS FOR ACCEPTING FIRST TWO RAYS TRACED
      IF (XS1*XS2.LT.0.0) GO TO 53
C THE TWO RAYS ARE ON SAME SIDE OF SP OR GEO
      IF (ABS (XS2).LT.ABS (XS1)) GO TO 54
C THE 2ND RAY IS NOT CLOSER TO SP OR GEO THAN 1ST RAY
      IF (NONE.GT.4) GO TO 52
      XLL=XREFL+XS1
      GO TO 56
C GIVE UP AND RESORT TO USING SAVED INPUT VALUES, THEN RETURV
   52 XLL=XLLS
      ELL=ELLS
      TLL=TLLS
      XL=XLS
      EL=ELS
      TL=TLS
      GO TO 63
C TEST IF 2ND RAY COMES WITHIN 10 FT OF OBJECTIVE
   53 IF (ABS(XS2).LE.10.0) GO TO 58
C NOT WITHIN 10 FT. IF 4 OR LESS RAYS TRACED TRY ONCE MORE AFTER
C INTERPOLATING BL. IF MORE THAN 4 RAYS TRACED, ACCEPT LAST PAIR.
      IF (NONE.GT.4) GO TO 58
      IBLSW=1
      XLL=(XRL1*XS2-XRL2*XS1)/(XS2-XS1)
      BL=TERP(XRL1,BLREF1,XRL2,BLREF2,XLL)
      XRL1=XRL2
      XRLL1=XRLL2
      ERL1=ERL2
      ERLL1=ERLL2
      TL1=TL2
      TLL1=TLL2
      XS1=XS2
      GO TO 3
C TEST IF EXTRAPOLATION IS PERMISSIBLE
   54 IF (ABS (XS2).LE.ABS (XS1-XS2)) GO TO 57
      IF (NONE.GT.4) GO TO 52
C READJUST STARTING POINT AND THEN RETRACE 2ND RAY
   55 XLL=TERP(XS1,XRL1,XS2,XRL2,0.0)
   56 XRL1=XRL2
      XRLL1=XRLL2
      ERL1=ERL2
      ERLL1=ERLL2
      TL1=TL2
      TLL1=TLL2
      XS1=XS2
      BLREF1=BLREF2
      GO TO 2
C TEST IF 2ND RAY WITHIN 10 FT OF OBJECTIVE
   57 IF (ABS(XS2).LE.10.0) GO TO 58
C NOT WITHIN 10 FT. IF 4 OR LESS RAYS TRACED TRY ONCE MORE, OTHERWISE
C ACCEPT THE LAST PAIR TRACED.
      IF (NONE.GT.4) GO TO 58
      GO TO 55
C INTERPOLATE OR EXTRAPOLATE TO OBTAIN XLL,ELL,TLL,XL,EL,TL, THEN RETURN
   58 XL=TERP(XS1,XRL1,XS2,XRL2,0.0)
      XLL=TERP(XS1,XRLL1,XS2,XRLL2,0.0)
      ELL=TERP(XRLL1,ERLL1,XRLL2,ERLL2,XLL)
      EL=TERP(XRL1,ERL1,XRL2,ERL2,XL)
      TLL=TERP(XRLL1,TLL1,XRLL2,TLL2,XLL)
      TL=TERP(XRL1,TL1,XRL2,TL2,XL)
      IF (TL.LT.TLL) GO TO 52
   63 IF (ITRACE.NE.0) PRINT 65, XLL,ELL,TLL,XL,EL,TL,BL
   65 FORMAT (45X,6F9.1,F9.4)
      IF(TLLS.GE.BIG) TLL=0.
      RETURN
C VERY CLOSE APPROXIMATION (.LT.0.5 FT). NO FURTHER RAY TRACING NEEDED
   67 XLL=XREFLL
      XL=XREFL
      ELL=EREFLL
      EL=EREFL
      GO TO 63
      END
C
C-----------------------------------------------------------------------
C
      FUNCTION TERP(X1,Y1,X2,Y2,X)
C  IN PROGRAM SIPB
C COMPUTES INTERPOLATED VALUE OF Y CORRESPONDING TO X, GIVEN THE 2 PTS
C (X1,Y1) AND (X2,Y2)
C
      IF (ABS (X2-X1).LT.0.1) GO TO 2
      TERP=((X-X1)*(Y2-Y1))/(X2-X1)+Y1
    1 RETURN
    2 TERP=(Y1+Y2)/2.0
      GO TO 1
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE KENDS(L,M,J,K1,K2,K11,K22)
      COMMON/BLKD/LG
C  IN PROGRAM SIPB
C FINDS INDEX OF LEFTMOST (K11) AND RIGHTMOST (K22) GEO REPRESENTING
C LAYER L FOR SP J, SPREAD M. K1 AND K2 ARE END PTS OF RANGE TO BE
C TESTED, AND ARE INPUT VALUES.K11 AND K22 ARE END PTS FOUND (OUTPUT).
C BOTH K11 AND K22 SET TO ZERO IF NO PTS FOUND
C
      DIMENSION LG(25,7,5)
      K11=0
      K22=0
      IF (K1.EQ.0.OR.K2.EQ.0) GO TO 12
      DO 1 K=K1,K2
      IF (LG(K,J,M).NE.L) GO TO 1
      K11=K
      GO TO 3
    1 CONTINUE
      GO TO 12
    3 DO 5 K=K11,K2
      IF(LG(K,J,M).EQ.L) K22=K
    5 CONTINUE
   12 RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE REGRES(K1,K2,J,M,L,V,T,PT,IT)
      COMMON/BLKD/LG
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     3       /BLK3/TA,TR,D
     4       /BLK4/VVA,VHA
C  IN PROGRAM SIPB
C COMPUTES VELOCITY V BY REGRESSION OF TIME PTS (TA) AT DISTANCES D FROM
C SP J TO GEOS BETWEEN INDICES K1 AND K2 FOR LAYER L, SPREAD M.
C ONLY NONZERO TA FOR WHICH LG=L ARE USED IN REGRESSION.
C HALF INTERCEPT TIME AT SP J IS GIVEN BY T, NUM OF REGRESSE) PTS IS PT.
C
      DIMENSION D(25),TA(25,7,5),TR(25,7,5),LG(25,7,5),VHA(5,5),VVA(5,5)
     1,TAR(25)
C
      IF(IT.EQ.1) GO TO 2
      DO 1 K=K1,K2
    1 TAR(K)=TA(K,J,M)
      GO TO 4
    2 DO 3 K=K1,K2
    3 TAR(K)=TR(K,J,M)
    4 S1=0.0
      S2=0.0
      PT=0.0
      T=0.0
      V=0.0
      DO 5 K=K1,K2
      IF (LG(K,J,M).NE.L) GO TO 5
      S1=S1+D(K)
      S2=S2+TAR(K)
      PT=PT+1.0
    5 CONTINUE
C
      IF (PT.LE.1.0) GO TO 15
      XBAR=S1/PT
      TBAR=S2/PT
      S1=0.0
      S2=0.0
      DO 10 K=K1,K2
      IF (LG(K,J,M).NE.L) GO TO 10
      XD=D(K)-XBAR
      S1=S1+XD*TAR(K)
      S2=S2+XD**2
   10 CONTINUE
      V=ABS (S2/S1)
      T=(TBAR-XBAR*S1/S2)/2.0
   12 RETURN
C
   15 IF (PT.EQ.0.0) GO TO 12
      V=VHA(M,L)
      IF (V.LE.0.0) GO TO 12
      T=(S2-S1/V)/2.0
      GO TO 12
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE REGV(L,NIXIT)
      COMMON IBL
      COMMON/BLK0/LG
     1       /BLK1/NM,NJ,NK
     3       /BLK3/TA,TR,DSG
     5       /BLK5/IDSPR,IDSP,KL,KR,D
     9       /BLK11/VREG,PREG
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C  IN PROGRAM SIPB
C COMPUTES AND PRINTS REGRESSION VELOCITIES AND INTERCEPT T FOR LAYER L
C
      DIMENSION NJ(5),NK( 5),KL(7,5),KR(7,5),D(25,7,5),IDSPR(5),
     1IDSP(7,5),VREG(5),PREG(5),LG(25,7,5),TA(25,7,5),TR(25,7,5),DSG(25)
C
      IF (NIXIT.EQ.0) PRINT 1, L
    1 FORMAT (' LAYER',I2,' VELOCITY AND TIME INTERCEPTS COMPUTED BY',
     1' REGRESSION')
      SUM1=0.0
      PTS1=0.0
      DO 50 M=1,NM
      MCALL=M
      NONE=0
      JN=NJ(M)
      KN=NK(M)
      SUM2=0.0
      PTS2=0.0
      DO 40 J=1,JN
      JCALL=J
      CALL KENDS(L,MCALL,JCALL,1,KL(J,M),KL1,KL2)
      IF (KL1.EQ.0) GO TO 10
      DO 5 K=KL1,KL2
      DSG(K)=D(K,J,M)
    5 CONTINUE
      CALL REGRES(KL1,KL2,JCALL,MCALL,L,VL,TLF,PT,0)
      IF (PT.LE.1.0) GO TO 10
      TLF=TLF+TLF
      SUM3=PT/VL
      PTS3=PT
      GO TO 15
   10 VL=0.0
      TLF=0.0
      SUM3=0.0
      PTS3=0.0
C
   15 CALL KENDS(L,MCALL,JCALL,KR(J,M),KN,KR1,KR2)
      IF (KR1.EQ.0) GO TO 23
      DO 20 K=KR1,KR2
      DSG(K)=D(K,J,M)
   20 CONTINUE
      CALL REGRES(KR1,KR2,JCALL,MCALL,L,VR,TRT,PT,0)
      IF (PT.LE.1.0) GO TO 23
      TRT=TRT+TRT
      PTS3=PTS3+PT
      SUM3=SUM3+PT/VR
      GO TO 24
   23 VR=0.0
      TRT=0.0
      AVGT=TLF
   24 SUM2=SUM2+SUM3
      PTS2=PTS2+PTS3
      SUM1=SUM1+SUM3
      PTS1=PTS1+PTS3
      IF (PTS3.EQ.0.0) GO TO 40
      IF (TLF.EQ.0.0) AVGT=TRT
      IF (TLF.NE.0.0.AND.TRT.NE.0.0) AVGT=(TLF+TRT)/2.0
      IF (NONE.NE.0) GO TO 27
      NONE=1
      IF (NIXIT.EQ.0) PRINT 25, IDSPR(M)
   25 FORMAT (1H0,8H SPREAD ,A1,3X,22HVEL    TIME    GEOS    SP,5X,
     1 17HGEOS   TIME     VEL,8X,19HAVG V    AVG T    PTS/1H ,10X,6H------,
     2 2X,4H----,2X,5H-----,3X,3H---,3X,5H-----,2X,4H----,2X,6H------,
     3 6X,6H------,3X,5H-----,3X,3H---)
   27 SUM3=PTS3/SUM3
      IF (NIXIT.EQ.1) GO TO 4C
      PRINT 31, VL,TLF,KL1,KL2,IDSP(J,M),KR1,KR2,TRT,VR,SUM3,AVGT,PTS3
   31 FORMAT (1H ,3PF16.0,0PF6.1,1X,2I3,4X,A1,3X,2I3,F6.1,3PF8.0,F12.0,
     1 0PF8.1,F6.0)
   40 CONTINUE
C
      IF (NONE.EQ.0) GO TO 50
      SUM2=PTS2/SUM2
      IF (NIXIT.EQ.1) GO TO 50
      PRINT 41, SUM2,PTS2
   41 FORMAT (1H0,59X,3HAVG,3PF7.0,0PF14.0)
   42 FORMAT (1H0,52X,1CHAVG OF ALL,3PF7.0,0PF14.0)
C
   50 CONTINUE
C
      IF (PTS1.EQ.0.0) GO TO 56
      VREG(L)=PTS1/SUM1
      PREG(L)=PTS1
      IF (NM.EQ.1.OR.NIXIT.EQ.1) GO TO 60
      PRINT 55
   55 FORMAT (1H0,63X,7H-------,10X,3H---)
      PRINT 42, VREG(L),PTS1
      GO TO 60
   56 VREG(L)=0.0
      PREG(L)=0.0
C
      IF (NIXIT.EQ.0) PRINT 57
   57 FORMAT(/////1H0,8H--NONE--)
C
   60 RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE HOBV(L,NIXIT)
      COMMON IBL
      COMMON/BLK0/LG
     1       /BLK1/NM,NJ,NK
     3       /BLK3/TA,TR,DSG
     5       /BLK5/IDSPR,IDSP,KL,KR,D
     9       /BLK12/VHOB,PHOB
C  IN PROGRAM SIPB
C COMPUTES HORIZ VEL OF LAYER L BY HOBSON-OVERTON METHOD
C
      DIMENSION EP(25),DX(25),DT(25),NJ(5),NK(5),IDSPR(5),LG(25,7,5),
     1 TA(25,7,5),KR(7,5),KL(7,5),IDSP(7,5),VHOB(5),PHOB(5),D(25,7,5) ,
     2 DSG(25),KI(5),PE(5),TR(25,7,5)
C
      IF (NIXIT.EQ.0) PRINT 2, L
    2 FORMAT (1H0,'LAYER',I2,' VELOCITY COMPUTED BY HOBSON-OVERTON ',
     1'METHOD')
      SUM2=0.0
      PTS2=0.0
C
      DO 22 M=1,NM
      MCALL=M
      NONE=0
      JN=NJ(M)
      KN=NK(M)
      SUM3=0.0
      PTS3=0.0
      J2=JN-1
C
      DO 18 J=1,J2
      JCALL=J
      CALL KENDS(L,MCALL,JCALL,KR(J,M),KN,KR1,KR2)
      IF (KR1.EQ.0) GO TO 18
      J1=J+1
C
      DO 16 JJ=J1,JN
      JJCALL=JJ
      CALL KENDS(L,MCALL,JJCALL,1,KL(JJ,M),KL1,KL2)
      K1=MAX0(KR1,KL1)
      K2=MIN0(KR2,KL2)
      IF (KL1.EQ.0.OR.(K2-K1).LE.0) GO TO 16
C
C BEGIN HOBSON-OVERTON ROUTINE
C
      SDX=0.0
      SDX2=0.0
      SDT=0.0
      SDTDX=0.0
      SEEP=0.0
      PT=0.0
      DO 3 K=1,12
      EP(K)=0.0
    3 CONTINUE
      DO 4 K=K1,K2
      IF (LG(K,J,M).NE.L.OR.LG(K,JJ,M).NE.L) GO TO 4
      DX(K)=ABS(D(K,J,M))-ABS(D(K,JJ,M))
      SDX=SDX+DX(K)
      SDX2=SDX2+DX(K)**2
      DT(K)=TA(K,J,M)-TA(K,JJ,M)
      SDT=SDT+DT(K)
      SDTDX=SDTDX+DX(K)*DT(K)
      PT=PT+1.0
    4 CONTINUE
      IF (PT.LE.1.0) GO TO 9
      V=(SDX2-SDX**2/PT)/(SDTDX-(SDX*SDT)/PT)
      TDSP=(SDT-SDX/V)/PT
      DO 6 K=K1,K2
      IF (LG(K,J,M).NE.L.OR.LG(K,JJ,M).NE.L) GO TO 6
      EP(K)=DT(K)-DX(K)/V-TDSP
      SEEP=SEEP+EP(K)**2
    6 CONTINUE
      SEEP=SQRT (SEEP/PT)
      DO 8 IK=1,5
      KI(IK)=0
      PE(IK)=0.
      DO 7 K=K1,K2
      IF(ABS(EP(K)).LE.ABS(PE(IK))) GO TO 7
      PE(IK)=EP(K)
      KI(IK)=K
    7 CONTINUE
      IF(KI(IK).EQ.0) GO TO 8
      K=KI(IK)
      EP(K)=0.
    8 CONTINUE
      GO TO 10
    9 V=0.0
      PT=0.0
C
C END HOBSON-OVERTON ROUTINE
C
   10 IF (PT.EQ.0.0) GO TO 16
      SUM3=SUM3+V*PT
      PTS3=PTS3+PT
      IF (NIXIT.EQ.1) GO TO 16
      IF (NONE.NE.0) GO TO 12
      NONE=1
      PRINT 11, IDSPR(M)
   11 FORMAT('0 SPREAD ',A1,40X,'5 HIGHEST EPS'/7X,'VEL   SPS   GEOS',
     1'  TDSP  SE EP',5(4X,'EP   GEO')/5X,'------',2X,'---  -----  ----'
     2,2X,'-----',5(3X,'---------'))
   12 PRINT 13, V,IDSP(J,M),IDSP(JJ,M),K1,K2,TDSP,SEEP,
     1(PE(K),KI(K),K=1,5)
   13 FORMAT (1H ,3PF10.0,2X,A1,1X,A1,1X,2I3,0PF6.1,F7.3,5(F8.3,I4))
   16 CONTINUE
   18 CONTINUE
C
      SUM2=SUM2+SUM3
      PTS2=PTS2+PTS3
      IF (PTS3.EQ.0.0) GO TO 22
      SUM3=SUM3/PTS3
      IF (NIXIT.EQ.0) PRINT 20, SUM3,PTS3
   20 FORMAT (1H0,5X,4HAVG=,3PF7.0,4H FOR,0PF5.0,7H POINTS)
   22 CONTINUE
C
      IF (PTS2.EQ.0.0) GO TO 26
      SUM2=SUM2/PTS2
      IF (NM.EQ.1.OR.NIXIT.EQ.1) GO TO 28
      PRINT 25, SUM2,PTS2
   25 FORMAT('0  AVG OF ALL',3PF7.0,4H FOR,0PF5.0,7H POINTS)
      GO TO 28
   26 IF(NIXIT.EQ.0) PRINT 27
   27 FORMAT(1H0,2X,17HNOT ENOUGH POINTS)
C
   28 VHOB(L)=SUM2
      PHOB(L)=PTS2
C
      RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE EXTRP(L,M,K1,K2,A,B,VV)
      COMMON/BLK2/XG,ERP,SLOPE,IDIP
     6      /BLK6/TRP,JJOFF
     9      /BLK9/EG,ES
C  IN PROGRAM SIPB
C COMPUTES ERP AND TRP BETWEEN GEOS K1 AND K2 USING EQUATION CONSTS A,B
C
      DIMENSION XG(25,5),ERP(25,5,4),TRP(25,5,4),EG(25,5),ES(7,5)
C
      DO 2 K=K1,K2
      ERP(K,M,L)=A+B*XG(K,M)
      IF (L.EQ.1) GO TO 1
      TRP(K,M,L)=(ERP(K,M,L-1)-ERP(K,M,L))/VV
      GO TO 2
    1 TRP(K,M,L)=(EG(K,M)-ERP(K,M,L))/VV
    2 CONTINUE
      RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE ELCOR(TANI,VV,HV,XSG,ESG,AD,BD,I,TC,XC,XINT,EINT)
      COMMON/BLK1/NM,NJ,NK
C  IN PROGRAM SIPB
C COMPUTES TIME CORR (TC) AND X CORR (XC) FOR SURF-TO-DATUM SLANT RAYS
C FOR LAYER 1, GIVEN X POS OF SHOT OR GEO (XSG), ELEV OF SHOT OR GEO
C (ESG), INTCPT AND SLOPE OF DATUM (AD AND BD), AND SIGN OF 3OA=COT I
C (I=1 FOR PLUS, 2 FOR MINUS). XINT,EINT IS COORD OF INTERSECTION OF
C RAY AND DATUM.
C
      DIMENSION NJ(5),NK(5)
      BI=TANI
      IF(I.EQ.2) BI=-BI
      BOA=(1.-BI*BD)/(BI-BD)
      AOA=ESG-BOA*XSG
      XINT=(AD-AOA)/(BOA-BD)
      EINT=AD+BD*XINT
      OA=SQRT ((XSG-XINT)**2+(ESG-EINT)**2)
      TC=OA/VV
      XC=OA*VV/HV
      IF (ESG.LE.EINT) GO TO 4
    3 TC=-TC
      XC=-XC
    4 RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE DIP(L,M,K1,K2,KK,A,B)
      COMMON/BLK2/XG,ERP,SLOPE,IDIP
C  IN PROGRAM SIPB
C COMPUTES EQUATION CONSTANTS A AND B (Y=A+BX) FOR REGRESSION LINE
C FITTED TO ERP OVER GEOS K1 TO K2 WITH LINE PASSING THROUGH POINT
C XG(KK,M),ERP(KK,M,L)
C
      DIMENSION XG(25,5),ERP(25,5,4)
C
      IF (IDIP.EQ.0.AND.XG(K1,M).LT.XG(K2,M)) GO TO 1
      A=ERP(KK,M,L)
      B=SLOPE
      GO TO 4
    1 SUM1=0.0
      SUM2=0.0
      DO 2 K=K1,K2
      SUM1=SUM1+XG(K,M)
      SUM2=SUM2+1.0
    2 CONTINUE
      XBAR=SUM1/SUM2
      SUM1=0.0
      SUM2=0.0
      DO 3 K=K1,K2
      XD=XG(K,M)-XBAR
      SUM1=SUM1+XD*ERP(K,M,L)
      SUM2=SUM2+XD**2
    3 CONTINUE
      B=SUM1/SUM2
      A=ERP(KK,M,L)-B*XG(KK,M)
    4 RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE AVG(X1,X2,L2,PA,EA)
      COMMON IBL
      COMMON/BLKO/LG
     1       /BLK1/NM,NJ,NK
     8       /BLK8/PRG,ERG,KRG,PRS2,ERS2,KRS2,ZRSP,ZRG
C  IN PROGRAM SIPB
C COMPUTES AVG COORD (PA,EA) OF ALL PTS IN ARRAYS (PRG,ERG) AND
C (PRS2,ERS2) WHOSE X POSITION IS GE X1 .AND. LT X2. AND WHOSE REFRACTOR
C IS LAYER L2. IF PTS.LE.2.AND.L2.GT.2 INTERVAL IS EXPANDED BY
C DX=X2-X1 ON EACH SIDE.
C
      DIMENSION LG(25,7,5),NJ(5),NK(5),PRG(25,7,5),ERG(25,7,5),
     1 KRG(25,7,5),PRS2(7,5,4,2),ERS2(7,5,4,2),KRS2(7,5,4,2),ZRSP(7),
     2 ZRG(25,7)
C
      SUM1=0.0
      SUM2=0.0
      PTS=0.0
      L1=L2-1
      X11=X1
      X22=X2
      DX=0.0
C
    1 DO 14 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 12 J=1,JN
      I=1
    2 IF (ERS2(J,M,L1,I).EQ.0..OR.KRS2(J,M,L1,I).NE.IBL) GO TO 3
      E1=ERS2(J,M,L1,I)
      P1=PRS2(J,M,L1,I)
      GO TO 10
    3 IF (I.EQ.2) GO TO 5
    4 I=2
      GO TO 2
    5 K=1
    6 IF (LG(K,J,M).NE.L2.OR.ERG(K,J,M).EQ.0.0.OR.KRG(K,J,M).NE.IBL) GO
     1 TO 8
      E1=ERG(K,J,M)
      P1=PRG(K,J,M)
      I=3
      GO TO 10
    8 K=K+1
      IF (K.GT.KN) GO TO 12
      GO TO 6
   10 IF (P1.LT.X11.OR.P1.GE.X22) GO TO 11
      SUM1=SUM1+P1
      SUM2=SUM2+E1
      PTS=PTS+1.0
   11 GO TO (4,5,8),I
   12 CONTINUE
   14 CONTINUE
      IF (PTS.EQ.0.0) GO TO 18
      IF (PTS.LE.2..AND.L2.GT.2) GO TO 19
      PA=SUM1/PTS
      EA=SUM2/PTS
   16 RETURN
   18 PA=0.0
      EA=0.0
      GO TO 16
   19 DX=X22-X11
      X11=X11-DX
      X22=X22+DX
      GO TO 1
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE ADMIG(L1,M,B)
      COMMON IBL
      COMMON/BLKO/LG
     1       /BLK1/NM,NJ,NK
     2       /BLK2/XG,ERP,SLOPE,IDIP
     5       /BLK5/IDSPR,IDSP,KL,KR,D
     6       /BLK6/TRP,JJOFF
     7       /BLK7/JA,JB,TRS,ERS,XSP,ESP,LS
     8       /BLK8/PRG,ERG,KRG,PRS2,ERS2,KRS2,ZRSP,ZRG
     9       /BLK9/EG,ES
     9       /BLK10/BLIM,ITRACE,TANSG
C IN PROGRAM SIPB
C COMPUTES TAN OF AVG ANGLE OF DIP (B) OF BOTTOM OF L1 FOR S?READ M
C BY REGRESSION OF POINTS (PRS2,ERS2) AND (PRG,ERG).
C
      DIMENSION NJ(5),NK(5),KL(7,5),KR(7,5),LG(25,7,5),LS(7,5),
     1 PRS2(7,5,4,2),ERS2(7,5,4,2),KRS2(7,5,4,2),PRG(25,7,5),
     2 ERG(25,7,5),IDSPR(5),IDSP(7,5),ERS(7,5,4),XSP(7,5),ESP(7,5),
     3 D(25,7,5),KRG(25,7,5),TRP(25,5,4),JA(5),JB(5),TRS(7,5,4),XG(25,5)
     4,EG(25,5),ES(7,5),ERP(25,5,4),ZRSP(7),ZRG(25,7)
C
      B=0.
      JN=NJ(M)
      KN=NK(M)
      L0=L1-1
      L2=L1+1
C
C COMPUTE AVERAGE PRG AND PRS2 (XBAR)
C
      S1=0.
      S2=0.
      P1=0.
      P2=0.
C
      DO 22 J=1,JN
      JCALL=J
C
C UP-RIGHT AND DOWN-LEFT RAYS
C
      IF(KR(J,M).EQ.0) GO TO 18
      CALL KENDS(L2,M,JCALL,KR(J,M),KN,K11,K22)
      IF(K11.EQ.0) GO TO 18
      DO 17 K=K11,K22
      IF(LG(K,J,M).NE.L2) GO TO 17
      S1=S1+PRG(K,J,M)
      P1=P1+1.
   17 CONTINUE
      IF((JJOFF.EQ.0.AND.J.LT.JA(M)).OR.KRS2(J,M,L1,1).NE.IBL) GO TO 18
      S2=S2+PRS2(J,M,L1,1)
      P2=P2+1.
C
C UP-LEFT AND DOWN-RIGHT RAYS
C
   18 IF(KL(J,M).EQ.0) GO TO 22
      CALL KENDS(L2,M,JCALL,1,KL(J,M),K11,K22)
      IF(K11.EQ.0) GO TO 22
      DO 20 K=K11,K22
      IF(LG(K,J,M).NE.L2) GO TO 20
      S2=S2+PRG(K,J,M)
      P2=P2+1.
   20 CONTINUE
      IF((JJOFF.EQ.0.AND.J.GT.JB(M)).OR.KRS2(J,M,L1,2).NE.IBL) GO TO 22
      S1=S1+PRS2(J,M,L1,2)
      P1=P1+1.
   22 CONTINUE
C
      IF((P1+P2).LT.2.) GO TO 99
      XBAR1=0.
      XBAR2=0.
      IF(P1.NE.0.) XBAR1=S1/P1
      IF(P2.NE.0.) XBAR2=S2/P2
C
C COMPUTE AVERAGE DIP (B)
C
      S1=0.
      S2=0.
      SS1=0.
      SS2=0.
      P1=0.
      P2=0.
      DO 52 J=1,JN
      JCALL=J
C
C UP-RIGHT AND DOWN-LEFT RAYS
C
      IF (KR(J,M).EQ.0) GO TO 48
      CALL KENDS(L2,M,JCALL,KR(J,M),KN,K11,K22)
      IF (K11.EQ.0) GO TO 48
      DO 47 K=K11,K22
      IF(LG(K,J,M).NE.L2.OR.XBAR1.EQ.0.) GO TO 47
      X=PRG(K,J,M)-XBAR1
      S1=S1+X*ERG(K,J,M)
      SS1=SS1+X**2
      P1=P1+1.
   47 CONTINUE
      IF((JJOFF.EQ.0.AND.J.LT.JA(M)).OR.KRS2(J,M,L1,1).NE.IBL.OR.
     1 XBAR2.EQ.0.) GO TO 48
      X=PRS2(J,M,L1,1)-XBAR2
      S2=S2+X*ERS2(J,M,L1,1)
      SS2=SS2+X**2
      P2=P2+1.
C
C UP-LEFT AND DOWN-RIGHT RAYS
C
   48 IF(KL(J,M).EQ.0) GO TO 52
      CALL KENDS(L2,M,JCALL,1,KL(J,M),K11,K22)
      IF(K11.EQ.0) GO TO 52
      DO 50 K=K11,K22
      IF(LG(K,J,M).NE.L2.OR.XBAR2.EQ.0.) GO TO 50
      X=PRG(K,J,M)-XBAR2
      S2=S2+X*ERG(K,J,M)
      SS2=SS2+X**2
      P2=P2+1.
   50 CONTINUE
      IF((JJOFF.EQ.0.AND.J.GT.JB(M)).OR.KRS2(J,M,L1,2).NE.IBL.OR.
     1 XBAR1.EQ.0.) GO TO 52
      X=PRS2(J,M,L1,2)-XBAR1
      S1=S1+X*ERS2(J,M,L1,2)
      SS1=SS1+X**2
      P1=P1+1.
   52 CONTINUE
C
      R1=0.
      R2=0.
      IF(SS1.NE.0.) R1=S1/SS1
      IF(SS2.NE.0.) R2=S2/SS2
      B=(P1*R1+P2*R2)/(P1+P2)
      IF(IDIP.NE.0) B=SLOPE
      IF(B.GT.BLIM) B=BLIM
      IF(B.LT.-BLIM) B=-BLIM
C
C MIGRATE RAY END POINTS
C
      B1=B
      IF(L1.EQ.1) B1=(B-SLOPE)/(1.+B*SLOPE)
      COSA=1./SQRT(1.+B1**2)
      ZRK=(1.+B1*TANSG)*COSA-1.
      XRK=TANSG-COSA*(TANSG-B1)
      ZLK=(1.-B1*TANSG)*COSA-1.
      XLK=TANSG-COSA*(TANSG+B1)
C
      DO 72 J=1,JN
C
C UP-RIGHT AND DOWN-LEFT RAYS
C
      JCALL=J
      IF(KR(J,M).EQ.0) GO TO 68
      CALL KENDS(L2,M,JCALL,KR(J,M),KN,K11,K22)
      IF(K11.EQ.0) GO TO 68
      DO 67 K=K11,K22
      IF(LG(K,J,M).NE.L2.OR.XBAR1.EQ.0.) GO TO 67
      ERG(K,J,M)=ERG(K,J,M)-ZRG(K,J)*ZRK
      PRG(K,J,M)=PRG(K,J,M)+ZRG(K,J)*XRK
   67 CONTINUE
      IF(XBAR2.EQ.0..OR.KRS2(J,M,L1,1).NE.IBL) GO TO 68
      ERS2(J,M,L1,1)=ERS2(J,M,L1,1)-ZRSP(J)*ZLK
      PRS2(J,M,L1,1)=PRS2(J,M,L1,1)-ZRSP(J)*XLK
C
C UP-LEFT AND DOWN-RIGHT RAYS
C
```

```
   68 IF(KL(J,M).EQ.0) GO TO 72
      CALL KENDS(L2,M,JCALL,1,KL(J,M),K11,K22)
      IF(K11.EQ.0) GO TO 72
      DO 70 K=K11,K22
      IF(LG(K,J,M).NE.L2.OR.XBAR2.EQ.0) GO TO 70
      ERG(K,J,M)=ERG(K,J,M)-ZRG(K,J)*ZLK
      PRG(K,J,M)=PRG(K,J,M)-ZRG(K,J)*XLK
   70 CONTINUE
      IF(XBAR1.EQ.0..OR.KRS2(J,M,L1,2).NE.IBL) GO TO 72
      ERS2(J,M,L1,2)=ERS2(J,M,L1,2)-ZRSP(J)*ZRK
      PRS2(J,M,L1,2)=PRS2(J,M,L1,2)+ZRSP(J)*XRK
   72 CONTINUE
C
   99 RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE RAYCOR(X1,X2,E1,E2,VV,HV,TCOR)
C  IN PROGRAM  SIPB
C ADJUSTS COORDINATES OF BOTTOM END POINT OF RAY ENTERING OR LEAVING THE
C REFRACTING HORIZON SO THAT TOTAL TIME OF COMPUTER-TRACED RAY AGREES
C WITH TOTAL OBSERVED TIME.
C
      DX=X1-X2
      DE=E1-E2
      DENOM=SQRT (DX**2+DE**2)/VV-ABS (DX)/HV
      IF (DENOM.LT.0.1) DENOM=0.1
      FCTR=TCOR/DENOM
      X2=X2-DX*FCTR
      E2=E2-DE*FCTR
    5 RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE FILLIN(L)
      COMMON IBL
      COMMON/BLK1/NM,NJ,NK
     2       /BLK2/XG,ERP,SLOPE,IDIP
     4       /BLK4/VVA,VHA
     5       /BLK5/IDSPR,IDSP,KL,KR,D
     6       /BLK6/TRP,JJOFF
     7       /BLK7/JA,JB,TRS,ERS,XSP,ESP,LS
     8       /BLK8/PRG,EPG,KRG,PRS2,ERS2,KRS2,ZRSP,ZRS
     9       /BLK9/EG,ES
     9       /BLK10/BLIM,ITRACE,TANSG
C  IN PROGRAM SIPB
C COMPUTES MISSING (ZERO) ELEV AND TIMES AT GEOS (ERP AND TRP) AND AT
C SPS (ERS AND TRS) BY INTERP OR EXTRAP OF NONZERO VALUES OF ERP AND TRP
C
      DIMENSION KA(5),KB(5),NJ(5),NK(5),XG(25,5),ES(25,5),TRP(25,5,4),
     1 ERP(25,5,4),TRS(7,5,4),ERS(7,5,4),XSP(7,5),ESP(7,5),JA(5),JB(5),
     2 ES(7,5),VVA(5,5),VHA(5,5),LS(7,5),PRG(25,7,5),ERG(25,7,5),
     3 KRG(25,7,5),PRS2(7,5,4,2),ERS2(7,5,4,2),KRS2(7,5,4,2),IDSPR(5),
     4 IDSP(7,5),KL(7,5),KR(7,5),D(25,7,5),ZRSP(7),ZRG(25,7)
C
C
C FIRST INTERP TO FILL IN GAPS WITHIN EACH SPREAD
C
```

```
      DO 20 M=1,NM
      KN=NK(M)
C SEARCH FOR 1ST NONZERO VALUE
      DO 4 K=1,KN
      IF (TRP(K,M,L).NE.0.0) GO TO 6
    4 CONTINUE
      KA(M)=0
      KB(M)=0
      GO TO 20
C NONZERO VALUE FOUND -- SEARCH FOR ZERO VALUE
    6 KA(M)=K
      KB(M)=K
      K1=K+1
    8 IF (K1.GT.KN) GO TO 20
      DO 10 K=K1,KN
      IF (TRP(K,M,L).EQ.0.0) GO TO 12
      KB(M)=K
   10 CCNTINUE
      GO TO 20
C ZERO VALUE FOUND -- STORE INDEX OF PRECEDING NONZERO VALUE AND SEARCH
C FOR NEXT NONZERO VALUE
   12 K11=K-1
      K1=K+1
      IF (K1.GT.KN) GO TO 20
      DO 14 K=K1,KN
      IF (TRP(K,M,L).NE.0.0) GO TO 16
   14 CONTINUE
      GO TO 20
   16 K22=K
      KB(M)=K
      K1=K11+1
      K2=K22-1
      DO 18 K=K1,K2
      ERP(K,M,L)=TERP(XG(K11,M),ERP(K11,M,L),XG(K22,M),ERP(K22,M,L),
     1 XG(K,M))
      TRP(K,M,L)=TERP(XG(K11,M),TRP(K11,M,L),XG(K22,M),TRP(K22,M,L),
     1 XG(K,M))
   18 CONTINUE
      K1=K22+1
      GO TO 8
   20 CONTINUE
C
C CONNECT PTS BETWEEN SPREADS
C
      IF (NM.NE.1) GO TO 21
      M111=1
      M222=1
      GO TO 100
   21 M=NM-1
      DO 52 M1=1,M
      KN1=NK(M1)
      M2=M1+1
      KN2=NK(M2)
      K1=KB(M1)
      K2=KA(M2)
      IF (K1.EQ.0.OR.K2.EQ.0) GO TO 52
      IF (XG(1,M2).GE.XG(KN1,M1)) GO TO 44
C END GEOS OF THE TWO SPREADS OVERLAP
      IF (XG(K2,M2).LT.XG(K1,M1)) GO TO 30
C END PTS WHERE ERP IS DEFINED DONT OVERLAP -- INTERPOLATE IN THIS INTVL
```

```
      K11=K1+1
      KK1=K1
      IF (K11.GT.KN1) GO TO 24
      DO 22 K=K11,KN1
      IF (XG(K,M1).GT.XG(K2,M2)) GO TO 24
      ERP(K,M1,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(K2,M2),ERP(K2,M2,L),
     1 XG(K,M1))
      TRP(K,M1,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
     1 XG(K,M1))
      KK1=K
   22 CONTINUE
   24 K22=K2-1
      KK2=K2
      IF (K22.LT.1) GO TO 28
      NONE=0
      DO 26 K=1,K22
      IF (XG(K,M2).LT.XG(K1,M1)) GO TO 26
      ERP(K,M2,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(K2,M2),ERP(K2,M2,L),
     1 XG(K,M2))
      TRP(K,M2,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
     1 XG(K,M2))
      IF (NONE.EQ.1) GO TO 26
      NONE=1
      KK2=K
   26 CONTINUE
   28 K1=KK1
      KB(M1)=K1
      K2=KK2
      KA(M2)=K2
C NOW THE END PTS DO OVERLAP
C FIRST FILL IN SPREAD M1 GOING TO THE RIGHT
      K22=KB(M2)-1
   30 K11=K1+1
      IF (K11.GT.KN1.OR.K22.LT.1) GO TO 37
      DO 36 K=K11,KN1
      DO 32 KK=K2,K22
      IF (XG(K,M1).GE.XG(KK,M2).AND.XG(K,M1).LE.XG(KK+1,M2)) GO TO 34
   32 CONTINUE
      GO TO 36
   34 IF (TRP(KK,M2,L).EQ.0.0.OR.TRP(KK+1,M2,L).EQ.0.0) GO TO 36
      ERP(K,M1,L)=TERP(XG(KK,M2),ERP(KK,M2,L),XG(KK+1,M2),ERP(KK+1,M2,L)
     1,XG(K,M1))
      TRP(K,M1,L)=TERP(XG(KK,M2),TRP(KK,M2,L),XG(KK+1,M2),TRP(KK+1,M2,L)
     1,XG(K,M1))
      KB(M1)=K
   36 CONTINUE
C THEN FILL IN SPREAD M2 GOING TO THE LEFT
   37 K11=KA(M1)+1
      K22=K2-1
      IF (K11.GT.KN1) GO TO 52
      IF (K22.LT.1) GO TO 52
      NONE=0
      DO 42 K=1,K22
      DO 38 KK=K11,K1
      IF (XG(K,M2).GE.XG(KK-1,M1).AND.XG(K,M2).LE.XG(KK,M1)) GO TO 40
   38 CONTINUE
      GO TO 42
   40 IF (TRP(KK-1,M1,L).EQ.0.0.OR.TRP(KK,M1,L).EQ.0.0) GO TO 42
      ERP(K,M2,L)=TERP(XG(KK-1,M1),ERP(KK-1,M1,L),XG(KK,M1),ERP(KK,M1,L)
     1,XG(K,M2))
```

```
      TRP(K,M2,L)=TERP(XG(KK-1,M1),TRP(KK-1,M1,L),XG(KK,M1),TRP(KK,M1,L)
     1,XG(K,M2))
      IF (NONE.NE.0) GO TO 42
      NONE=1
      KA(M2)=K
   42 CCNTINUE
      GO TO 52
C
C END GEOS DONT OVERLAP -- INTERPOLATE BETWEEN NONZERO END PTS
C FIRST GO RIGHT ON SPREAD M1
   44 K11=K1+1
      IF (K11.GT.KN1) GO TO 48
      DO 46 K=K11,KN1
      ERP(K,M1,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(K2,M2),ERP(K2,M2,L),
     1 XG(K,M1))
      TRP(K,M1,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
     1 XG(K,M1))
   46 CONTINUE
      KB(M1)=KN1
C THEN GO LEFT ON SPREAD M2
   48 K22=K2-1
      IF (K22.LT.1) GO TO 52
      DO 50 K=1,K22
      ERP(K,M2,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(K2,M2),ERP(K2,M2,L),
     1 XG(K,M2))
      TRP(K,M2,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
     1 XG(K,M2))
   50 CONTINUE
      KA(M2)=1
   52 CONTINUE
C
C FILL IN INTERMEDIATE SPREADS WITH NO DEPTH PTS DEFINED
C
      DO 54 M1=1,NM
      IF (KA(M1).NE.0) GO TO 58
   54 CONTINUE
      PRINT 56, L
   56 FORMAT (/1X,30HNO DEPTH PTS DEFINED FOR LAYER,I2,
     1 17H.  QUIT IN FILLIN)
      L=0
      GO TO 200
   58 M111=M1
   60 M11=M1+1
      IF (M11.GE.NM) GO TO 80
      DO 62 MM=M11,NM
      IF (KA(MM).EQ.0) GO TO 64
      M1=MM
   62 CONTINUE
C NO SUCH SPREADS OCCUR
      GO TO 80
   64 MM=MM+1
      DO 66 M2=MM,NM
      IF (KA(M2).NE.0) GO TO 68
   66 CONTINUE
      GO TO 80
C SUCH A SPREAD DOES OCCUR
   68 K1=KB(M1)
      K2=KA(M2)
      M11=M1+1
      M22=M2-1
      DO 72 MM=M11,M22
      KN=NK(MM)
      DO 70 K=1,KN
      ERP(K,MM,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(K2,M2),ERP(K2,M2,L),
     1 XG(K,MM))
      TRP(K,MM,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(K2,M2),TRP(K2,M2,L),
     1 XG(K,MM))
   70 CONTINUE
      KA(MM)=1
      KB(MM)=KN
   72 CONTINUE
      M1=M2
      GO TO 60
C
C FILL IN INTERMEDIATE SPREADS WITH ONLY ONE DEPTH PT DEFINED
C
   80 DO 88 M=M111,NM
      KN=NK(M)
      IF (KA(M).EQ.0) GO TO 90
      KK=KA(M)
      IF (KK.NE.KB(M)) GO TO 88
      IF (M.EQ.M111) GO TO 84
C DO TO THE LEFT OF PT
      M1=M-1
      K1=KB(M1)
      K2=KK-1
      IF (K2.LT.1) GO TO 84
      DO 82 K=1,K2
      ERP(K,M,L)=TERP(XG(K1,M1),ERP(K1,M1,L),XG(KK,M),ERP(KK,M,L),
     1 XG(K,M))
      TRP(K,M,L)=TERP(XG(K1,M1),TRP(K1,M1,L),XG(KK,M),TRP(KK,M,L),
     1 XG(K,M))
   82 CONTINUE
      KA(M)=1
C DO TO THE RIGHT OF PT
   84 M2=M+1
      IF (M2.GT.NM) GO TO 88
      IF (KA(M2).EQ.0) GO TO 92
      K1=KK+1
      IF (K1.GT.KN) GO TO 88
      K2=KA(M2)
      DO 86 K=K1,KN
      ERP(K,M,L)=TERP(XG(KK,M),ERP(KK,M,L),XG(K2,M2),ERP(K2,M2,L),
     1 XG(K,M))
      TRP(K,M,L)=TERP(XG(KK,M),TRP(KK,M,L),XG(K2,M2),TRP(K2,M2,L),
     1 XG(K,M))
   86 CONTINUE
      KB(M)=KN
   88 CONTINUE
      M222=NM
      GO TO 100
   90 M=M-1
   92 M222=M
C
C EXTRAPOLATE END GEOS AND END SPREADS
C
C  LEFT OF SPREAD
C
  100 KMID=(KB(M111)-KA(M111))/2
      IF(KMID-KA(M111).LT.5) KMID=KA(M111)+5
      IF(KMID.GT.KB(M111)) KMID=KB(M111)
      CALL DIP(L,M111,KA(M111),KMID,KA(M111),A1,B1)
      K1=KA(M111)-1
      IF (K1.LT.1) GO TO 102
      CALL EXTRP(L,M111,1,K1,A1,B1,VVA(M111,L))
  102 IF (M111.EQ.1) GO TO 106
      M11=M111-1
      DO 104 M=1,M11
      MCALL=M
      CALL EXTRP(L,MCALL,1,NK(M),A1,B1,VVA(M,L))
  104 CONTINUE
C
C RIGHT OF SPREAD
C
  106 KMID=(KB(M222)-KA(M222))/2+1
      IF(KB(M222)-KMID.LT.5) KMID=KB(M222)-5
      IF(KMID.LT.KA(M222)) KMID=KA(M222)
      CALL DIP(L,M222,KMID,KB(M222),KB(M222),A2,B2)
      KN=NK(M222)
      K2=KB(M222)+1
      IF (K2.GT.KN) GO TO 108
      CALL EXTRP(L,M222,K2,KN,A2,B2,VVA(M222,L))
  108 IF (M222.EQ.NM) GO TO 112
      M22=M222+1
      DO 110 M=M22,NM
      MCALL=M
      CALL EXTRP(L,MCALL,1,NK(M),A2,B2,VVA(M,L))
  110 CONTINUE
C
C INTERP-EXTRAP ELEV AND TIME AT SPS AND PREVENT CRISS-CROSS OF LAYERS
C
  112 DO 160 M=1,NM
      IF (JJOFF.EQ.0) GO TO 113
      J1=1
      J2=NJ(M)
      GO TO 116
  113 J1=JA(M)
      J2=JB(M)
  116 KN=NK(M)
      DO 146 J=J1,J2
      MM=M
      KNM=NK(M)
      IF (TRS(J,M,L).NE.0.0) GO TO 142
      IF (XSP(J,M).GE.XG(1,MM)) GO TO 118
  117 IF (MM.EQ.1) GO TO 136
      MM=MM-1
      KNM=NK(MM)
      IF (XSP(J,M).LT.XG(1,MM)) GO TO 117
      GO TO 122
  118 IF (XSP(J,M).LE.XG(KNM,MM)) GO TO 122
  119 IF (MM.EQ.NM) GO TO 138
      MM=MM+1
      KNM=NK(MM)
      IF (XSP(J,M).GT.XG(KNM,MM)) GO TO 119
C
  122 IF (XG(2,MM).GE.XSP(J,M)) GO TO 128
      IF (XG(KNM-1,MM).LE.XSP(J,M)) GO TO 126
      DO 124 K=2,KNM
      IF (XG(K,MM).GE.XSP(J,M)) GO TO 134
  124 CONTINUE
```

```
C
  126 K1=KNM-1
      X1=XG(K1,MM)
      E1=ERP(K1,MM,L)
      X2=XG(KNM,MM)
      E2=ERP(KNM,MM,L)
      GO TO 140
C
  128 X1=XG(1,MM)
      E1=ERP(1,MM,L)
      X2=XG(2,MM)
      E2=ERP(2,MM,L)
      GO TO 140
C
  134 K1=K-1
      X1=XG(K1,MM)
      E1=ERP(K1,MM,L)
      X2=XG(K,MM)
      E2=ERP(K,MM,L)
      GO TO 140
C
C CASE WHERE MM=1
C
  136 KMID=KNM/2
      IF(KMID.LT.6) KMID=6
      IF(KMID.GT.KNM) KMID=KNM
      CALL DIP(L,1,1,KMID,1,A1,B1)
      IF(JJOFF.EQ.0.OR.J.GE.JA(1)) GO TO 7136
      E1=0.
      JJ2=J-1
      IF(JJ2.LT.1) GO TO 2136
      DO 1136 JJ=1,JJ2
      JR=JJ2-JJ+1
      IF(ERS2(JR,1,L,1).EQ.0) GO TO 1136
      X1=PRS2(JR,1,L,1)
      E1=ERS2(JR,1,L,1)
      GO TO 2136
 1136 CONTINUE
 2136 JJ1=J
      JJ2=JA(1)-1
 3136 DO 4136 JJ=JJ1,JJ2
      IF(ERS2(JJ,1,L,1).EQ.0.) GO TO 4136
      X2=PRS2(JJ,1,L,1)
      E2=ERS2(JJ,1,L,1)
      JLAST=JJ
      GO TO 6136
 4136 CONTINUE
      IF(E1.EQ.0.) GO TO 7136
 5136 X2=XG(1,1)
      E2=ERP(1,1,L)
      GO TO 140
 6136 IF(E1.NE.0) GO TO 140
      X1=X2
      E1=E2
      JJ1=JLAST+1
      IF(JJ1.LE.JJ2) GO TO 3136
      GO TO 5136
 7136 ERS(J,M,L)=ERP(1,MM,L)-B1*(XG(1,MM)-XSP(J,M))
      GO TO 142
C
```

```
C CASE WHERE MM=NM
C
  138 KMID=KNM/2+1
      IF(KNM-KMID.LT.5) KMID=KNM-5
      IF(KMID.LT.1) KMID=1
      CALL DIP(L,NM,KMID,KNM,KNM,A2,B2)
      IF(JJOFF.EQ.0.OR.J.LE.JB(NM)) GO TO 7138
      E2=0.
      JN=NJ(NM)
      JJ1=J+1
      IF(JJ1.GT.JN) GO TO 2138
      DO 1138 JJ=JJ1,JN
      IF(ERS2(JJ,NM,L,2).EQ.0.) GO TO 1138
      X2=PRS2(JJ,NM,L,2)
      E2=ERS2(JJ,NM,L,2)
      GO TO 2138
 1138 CONTINUE
 2138 JJ2=J
      JJ1=JB(NM)+1
 3138 DO 4138 JJ=JJ1,JJ2
      JR=JJ2-JJ+JJ1
      IF(ERS2(JR,NM,L,2).EQ.0.) GO TO 4138
      X1=PRS2(JR,NM,L,2)
      E1=ERS2(JR,NM,L,2)
      JLAST=JR
      GO TO 6138
 4138 CONTINUE
      IF(E2.EQ.0.) GO TO 7138
 5138 X1=XG(KNM,NM)
      E1=ERP(KNM,NM,L)
      GO TO 140
 6138 IF(E2.NE.0.) GO TO 140
      X2=X1
      E2=E1
      JJ2=JLAST-1
      IF(JJ1.LE.JJ2) GO TO 3138
      GO TO 5138
 7138 ERS(J,M,L)=ERP(KNM,MM,L)+B2*(XSP(J,M)-XG(KNM,MM))
      GO TO 142
C
  140 ERS(J,M,L)=TERP(X1,E1,X2,E2,XSP(J,M))
C
  142 IF (L.EQ.1) GO TO 144
      IF (ERS(J,M,L).LE.ERS(J,M,L-1)) GO TO 143
      ERS(J,M,L)=ERS(J,M,L-1)-.00001
      TRS(J,M,L)=0.00001
      GO TO 146
  143 TRS(J,M,L)=(ERS(J,M,L-1)-ERS(J,M,L))/VVA(M,L)
      GO TO 146
  144 IF (ERS(J,M,L).LE.ES(J,M)) GO TO 145
      LS(J,M)=2
      TRS(J,M,L)=C.00001
      IF (ERS(J,M,L).GT.ESP(J,M)) ERS(J,M,L)=ESP(J,M)-.00001
      GO TO 146
  145 TRS(J,M,L)=(ES(J,M)-ERS(J,M,1))/VVA(M,L)
C
  146 CONTINUE
C
      IF (L.EQ.1) GO TO 150
      DO 148 K=1,KN
      IF (ERP(K,M,L-1)-ERP(K,M,L).GE.0.00001) GO T) 148
      ERP(K,M,L)=ERP(K,M,L-1)-0.00001
      TRP(K,M,L)=0.00001
  148 CONTINUE
      GO TO 160
C
  150 DO 152 K=1,KN
      IF (EG(K,M)-ERP(K,M,L).GE.0.00001) GO TO 152
      TRP(K,M,L)=0.00001
      ERP(K,M,L)=EG(K,M)-0.00001
  152 CONTINUE
C
  160 CONTINUE
C
  200 IF(ITRACE.EQ.0) GO TO 300
      DO 260 M=1,NM
      KN=NK(M)
      L2=L+1
      IF(JJOFF.NE.0) GO TO 206
      J1=JA(M)
      J2=JB(M)
      GO TO 208
  206 J1=1
      J2=NJ(M)
  208 PRINT 210, L2,IDSPR(M)
  210 FORMAT(/' OUTPUT OF SUBR FILLIN FOR LAYER',I2,'  SPREAD ',A1)
      DO 230 J=J1,J2
      PRINT 220, IDSP(J,M),XSP(J,M),ESP(J,M),ERS(J,M,L),TRS(J,M,L)
  220 FORMAT('  SP=',1X,A1,'  XSP=',F8.1,'  ESP=',F8.1,'  ERS=',F12.4,
     1'  TPS=',F12.4)
  230 CONTINUE
      DO 250 K=1,KN
      PRINT 240, K,XG(K,M),EG(K,M),ERP(K,M,L),TRP(K,M,L)
  240 FORMAT('  K=',I2,'   XG=',F8.1,'   EG=',F8.1,'  ERP=',F12.4,
     1'  TRP=',F12.4)
  250 CONTINUE
  260 CONTINUE
  300 RETURN
      END
C
C---------------------------------------------------------------------
C
      SUEROUTINE PLOT(IGOTO)
C  IN PROGRAM  SIPB
C PLOTS T-D GRAPH (IGOTO=1) OR DEPTH GRAPH (IGOTO=2)
C
      COMMON IBL,IQUES,IP,IT,ICOLN,IPLUS,ISQ,IDASH,IS,IAST,IDEE,IL,NL,
     1LN,P,TSCALE,XSCALE,XSCO2,ESCALE,XLIM1,XLIM2,IPLOT,IDENT
      COMMON/BLK0/LG
     1      /BLK1/NM,NJ,NK
     2      /BLK2/XG,ERP,SLOPE,IDIP
     3      /BLK3/TA,TR,DSG
     5      /BLK5/IDSPR,IDSP,KL,KR,D
     6      /BLK6/TRP,JJOFF
     7      /BLK7/JA,JB,TRS,ERS,XSP,ESP,LS
     8      /BLK8/PRG,ERG,KRG,PRS2,ERS2,KRS2,ZRSP,ZRG
     9      /BLK9/EG,ES
C
C COMMON ARRAYS
C
```

```
      DIMENSION IDENT(16),IL(5),IDSPR(5),JA(5),JB(5),NJ(5),NK(5),
     1 XSP(7,5),ESP(7,5),ES(7,5),IDSP(7,5),KL(7,5),KR(7,5),IP(103),
     2 IT(53),ERS(7,5,4),PRS2(7,5,4,2),ERS2(7,5,4,2),KRS2(7,5,4,2),
     3 XG(25,5),EG(25,5),P(25,7,5),TA(25,7,5),LG(25,7,5), DSG(25),
     4 PRG(25,7,5),ERG(25,7,5),KRG(25,7,5),ERP(25,5,4),D(25,7,5),
     5 TRS(7,5,4),TRP(25,5,4),LS(7,5),TR(25,7,5),ZRSP(7),ZRG(25,7)
C
C INTERNAL ARRAYS
C
      DIMENSION LB(11),PRGALL(875),ERGALL(875),ISYMBL(875),
     1 PRSALL(280),ERSALL(280),JSYMBL(280) ,
     1 ENEXT(4),ELAST(4),ERITE(4),
     2 JPTR(5),KPTR(5),
     4 KJPT(7,5)
       DATA BIG/9999999./
C
C
      GO TO (500,3000),IGOTO
C
C T-D PLOT ROUTINE
C
  500 LBINC=IFIX (10.0*TSCALE)
C
C MAIN T-D GRAPH PLOT LOOP
C
      LB(1)=0
      DO 510 I=2,11
      LB(I)=LB(I-1)+LBINC
  510 CONTINUE
      PRINT 57, IDENT
   57 FORMAT (1H1,16A5)
      GO TO (515,520,525,530),IPLOT
  515 PRINT 516
  516 FORMAT (1H0,' S',20X,'TIME-DISTANCE PLOT  --  RAW DATA WITH NO'
     1,' CORRECTIONS APPLIED')
      GO TO 540
  520 PRINT 521
  521 FORMAT (1H0,' S',20X,'TIME-DISTANCE PLOT  --  TIMES CORRECTED TO'
     1,' DATUM ELEVATION')
      GO TO 540
  525 PRINT 526
  526 FORMAT('0 S',20X,'TIME-DISTANCE PLOT -- PRE-DEPTH VALUES WITH'
     1,' TIE CORR IF JJOFF=0')
      GO TO 540
  530 PRINT 531
  531 FORMAT (1H0,2H S,40X,39HTIME-DISTANCE PLOT  --  LAYER 1 REMOVED)
  540 PRINT 541
  541 FORMAT (1H ,5H P  G,62X,50X,1HD/1H ,8H R  E  S,59X,50X,1HI/1H ,
     1 8H E  O  P,59X,50X,1HS/1H ,2H A,62X,53X,1HT/1H ,2H D,40X,
     238HT I M E    ( M I L L I S E C O N D S ))
      PRINT 584, (LB(I),I=1,11)
  584 FORMAT (1H ,11I10)
      PRINT 585
  585 FORMAT (1H ,9X,1H+,10(10H---------+))
C
C INITIALIZE POINTERS AND XLIM
C   JPTR(M) FOR SP LABELS
C   KPTR(M) FOR GEO LABELS
C   KJPT(J,M) FOR ARRIVAL TIMES
C
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```
      DO 595 M=1,NM
      KPTR(M)=1
      IF (M.EQ.1.OR.JJOFF.EQ.0) GO TO 586
      J=1
      GO TO 587
  586 J=JA(M)
  587 IF (XSP(J,M).GE.(XLIM1-XSCALE)) GO TO 588
      J=J+1
      IF (J.LE.NJ(M)) GO TO 587
      J=NJ(M)
  588 JPTR(M)=J
      JN=NJ(M)
      DO 590 J=1,JN
      KJPT(J,M)=1
  590 CONTINUE
  595 CONTINUE
      XLIM=XLIM1
      XMIN=XLIM1-XSCALE
  627 KFLAG=0
      LBLJ=IBL
      LBLM=IBL
      XMID=XLIM-XSCO2
C SET TYPE FOR PRINTING LBLM (SPREAD) AND LBLJ (SP), ALSO SET KFLAG
C
C     KFLAG=-1 FOR M AND J LABEL
C     KFLAG= 0 FOR NO LABEL (BLANK)
C     KFLAG= 1 FOR M, K AND J LABEL
C
      DO 645 M=1,NM
      KN=NK(M)
      JN=NJ(M)
      IF (M.EQ.NM) JN=JB(NM)
      KP=KPTR(M)
      IF (KP.GT.KN) GO TO 635
      IF (XG(KP,M).GE.XLIM) GO TO 635
      KFLAG=1
      LBLM=IDSPR(M)
      LK=KP
      DIST=XG(KP,M)
      KPTR(M)=KPTR(M)+1
  635 JP=JPTR(M)
      IF (JP.GT.JN) GO TO 645
      IF (XSP(JP,M).GE.XLIM.OR.XSP(JP,M).LT.XMIN) GO TO 645
      IF (KFLAG.EQ.1) GO TO 638
      KFLAG=-1
  638 LBLM=IDSPR(M)
      LBLJ=IDSP(JP,M)
      DIST=XSP(JP,M)
      JPTR(M)=JPTR(M)+1
  645 CONTINUE
C
C SET TYPE FOR BACKGROUND AND BORDER OF GRAPH
C
      DO 650 I=1,103
      IP(I)=IBL
  650 CONTINUE
      DO 655 II=1,53
  655 IT(II)=IBL
      IF (KFLAG.EQ.0) GO TO 662
      DO 660 I=2,102,10
  660 IP(I)=IPLUS
      DO 661 II=2,52,10
  661 IT(II)=IPLUS
      GO TO 665
  662 IP(2)=IDASH
      IP(102)=IDASH
      IT(2)=IDASH
      IT(52)=IDASH
C
C SET TYPE FOR ARRIVAL TIMES
C
  665 DO 710 M=1,NM
      KN=NK(M)
      JN=NJ(M)
      DO 700 J=1,JN
      KK=KJPT(J,M)
      IF (KK.GT.KN) GO TO 668
      IF (P(KK,J,M).GE.XLIM) GO TO 666
      I=IFIX(TA(KK,J,M)/TSCALE + 2.5)
      II=(I-2)/2+2
      GO TO 677
  666 IF (KK.NE.1) GO TO 669
C
C PREPARE TO INTERP BETWEEN TIME=0 AT JA(M) AND TA(1,J,M)
C
      IF (J.NE.JA(M)) GO TO 700
      T2=TA(1,J,M)
      IF (T2.EQ.0.0) GO TO 700
      P1=XSP(J,M)
      P2=P(1,J,M)
      T1=0.0
      GO TO 674
C
C PREPARE TO INTERP BETWEEN TIME=0 AT JB(M) AND TA(KN,J,M)
C
  668 IF (J.NE.JB(M)) GO TO 700
      T1=TA(KN,J,M)
      IF (T1.EQ.0.0) GO TO 700
      P1=P(KN,J,M)
      P2=XSP(J,M)
      T2=0.0
      GO TO 674
C
C PREPARE TO INTERP FOR KK=K2=2 TO KN AND K1=K2-1 USING TA(K1,..TA(K2,..
C
  669 K2=KK
      K1=K2-1
  670 T1=TA(K1,J,M)
      IF (T1.NE.0.0) GO TO 671
      IF (K1.EQ.KR(J,M).OR.K1.EQ.KL(J,M)) GO TO 700
      K1=K1-1
      IF (K1.LT.1) GO TO 700
      GO TO 670
C
  671 T2=TA(K2,J,M)
      IF (T2.NE.0.0) GO TO 672
      IF (K2.EQ.KR(J,M).OR.K2.EQ.KL(J,M)) GO TO 700
      K2=K2+1
      IF (K2.GT.KN) GO TO 700
      GO TO 671
```

```
C
C NONZERO PAIR OF TA FOUND -- TEST IF SP J OCCURS BETWEEN P1 AND P2
C   IF SO PREPARE TO INTERP BETWEEN TIME=0 AT SP AND APPROPRIATE TA
C   IF NOT PREPARE TO INTERP BETWEEN TA PAIR
  672 P1=P(K1,J,M)
      P2=P(K2,J,M)
      IF (XSP(J,M).GT.P2.OR.XSP(J,M).LT.P1) GO TO 674
      IF (XMID.LE.XSP(J,M)) GO TO 673
      P1=XSP(J,M)
      T1=0.0
      GO TO 674
C
  673 P2=XSP(J,M)
      T2=0.0
C
C INTERPOLATE TO COMPUTE I AND THEN SET IP(I)
C
  674 IF(XMID.LT.P1.OR.XMID.GT.P2) GO TO 700
      I=IFIX (TERP(P1,T1,P2,T2,XMID)/TSCALE+2.5)
      II=(I-2)/2+2
      IF (I.LT.2.OR.I.GT.102) GO TO 700
      IF (IP(I).EQ.IBL.OR.IP(I).EQ.IPLUS.OR.IP(I).EQ.IDASH) IP(I)=ICOLN
      IF(IT(II).EQ.IBL.OR.IT(II).EQ.IPLUS.OR.IT(II).EQ.IDASH)
     1 IT(II)=ICOLN
      GO TO 700
  677 IF (I.GT.1) GO TO 678
      I=1
      II=1
      GO TO 684
  678 IF (I.LT.103) GO TO 681
      I=103
      II=53
  684 IP(I)=ISQ
      IT(II)=ISQ
      GO TO 690
  681 IF(IP(I).NE.IBL.AND.IP(I).NE.IPLUS.AND.IP(I).NE.IDASH) IP(I)=ISQ
      IF(IT(II).NE.IBL.AND.IT(II).NE.IPLUS.AND.IT(II).NE.IDASH)
     1IT(II)=ISQ
  686 LGP=LG(KK,J,M)
      IF (LGP.EQ.0) GO TO 687
      IF(IP(I).NE.ISQ)IP(I)=IL(LGP)
      IF(IT(II).NE.ISQ)IT(II)=IL(LGP)
      GO TO 690
  687 IF(IP(I).NE.ISQ)IP(I)=IDSP(J,M)
      IF(IT(II).NE.ISQ)IT(II)=IDSP(J,M)
  690 KJPT(J,M)=KJPT(J,M)+1
  700 CONTINUE
  710 CONTINUE
C
C PRINT A LINE OF GRAPH
C
      IF (KFLAG) 725,720,730
  720 PRINT 722, (IP(I),I=1,103)
  722 FORMAT (1H ,8X,50A1,53A1)
      GO TO 745
  725 PRINT 727, LBLM,LBLJ,(IP(I),I=1,103),DIST
  727 FORMAT (1H ,1X,A1,5X,51A1,53A1,F10.0)
      GO TO 745
  730 PRINT 732, LBLM,LK,LBLJ,(IP(I),I=1,103),DIST
  732 FORMAT (1H ,1X,A1,I3,2X,51A1,53A1,F10.0)
```

```
C
C INCREMENT XLIM FOR NEXT LINE AND LOOP BACK UNLESS GRAPH IS COMPLETE
C
  745 IF (XLIM.GT.XLIM2) GO TO 750
      XLIM=XLIM+XSCALE
      GO TO 627
C
C GRAPH IS COMPLETE -- PRINT BOTTOM BORDER
C
  750 PRINT 585
      PRINT 584, (LB(I),I=1,11)
  800 RETURN
C
C END OF T-D PLOT ROUTINE
C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
C DEPTH PLOT ROUTINE
C
C FIRST FIND HIGHEST SURFACE ELEV (EMAX)
C
 3000 EMAX=-BIG
      DO 3014 M=1,NM
      KN=NK(M)
      IF (JJOFF.EQ.0) GO TO 3002
      J1=1
      J2=NJ(M)
      GO TO 3008
 3002 J1=JA(1)
      J2=JB(M)
 3008 DO 3010 J=J1,J2
      IF (ESP(J,M).GT.EMAX) EMAX=ESP(J,M)
 3010 CONTINUE
      DO 3012 K=1,KN
      IF (EG(K,M).GT.EMAX) EMAX=EG(K,M)
 3C12 CONTINUE
 3014 CONTINUE
C
C COMPUTE ELEV SCALE LABELS LB(I) -- COMPUTE EMIN
C
      LBINC=IFIX (10.0*ESCALE+0.5)
      LMAX=LBINC*(IFIX (EMAX+ESCALE)/LBINC+1)
      LB(1)=LMAX-10*LBINC
      EMIN=FLOAT (LB(1))
      DO 3016 I=2,11
      LB(I)=LB(I-1)+LBINC
 3016 CONTINUE
C
C PRINT HEADING AND LABELS
C
      PRINT 57, IDENT
      PRINT 3018
 3018 FORMAT (1H ,60X,58X,1HS/1H ,4X,1HD,60X,50X,4HG  P/1H ,4X,1HI,60X,
     1 47X,7HS  E  R/1H ,4X,1HS,38X,32HE L E V A T I O N    ( F E E T ),
     2 37X,7HP  O  E/1H ,4X,1HT,60X,53X,1HA/1H ,60X,58X,1HD)
      PRINT 584, (LB(I),I=1,11)
      PRINT 585
C
C SORT PRG(K,J,M),ERG(K,J,M) ARRAYS INTO PRGALL(KJM),ERGALL(<JM) COLUMNS
C
```

```
 3024 KJM=1
 3030 PMIN=BIG
      DO 3034 M=1,NM
      JN=NJ(M)
      KN=NK(M)
      DO 3033 J=1,JN
      DO 3032 K=1,KN
      IF (PRG(K,J,M).GE.PMIN.OR.ERG(K,J,M).EQ.0.0) GO TO 3032
      PMIN=PRG(K,J,M)
      K1=K
      J1=J
      M1=M
 3032 CONTINUE
 3033 CONTINUE
 3034 CONTINUE
C
      IF (PMIN.EQ.BIG) GO TO 3040
      PRGALL(KJM)=PMIN
      ERGALL(KJM)=ERG(K1,J1,M1)
      ISYMBL(KJM)=KRG(K1,J1,M1)
      IF (ISYMBL(KJM).EQ.IBL) ISYMBL(KJM)=IDSP(J1,M1)
      KJM=KJM+1
C
      ERG(K1,J1,M1)=0.0
      GO TO 3030
C
 3040 NKJM=KJM-1
C
C SORT AND MERGE 4-D ARRAYS PRS2(J,M,L,I) AND ERS2(J,M,L,I) INTO COLUMN
C ARRAYS PRSALL(JML) AND ERSALL(JML).
C
      JML=1
 3050 PMIN=BIG
      DO 3056 M=1,NM
      JN=NJ(M)
      DO 3055 J=1,JN
      DO 3054 L=1,LN
      DO 3052 LR=1,2
 3051 IF (PRS2(J,M,L,LR).GT.PMIN.OR.ERS2(J,M,L,LR).EQ.0.) GO TO 3052
      PMIN=PRS2(J,M,L,LR)
      J1=J
      M1=M
      L1=L
      I=LR
C
 3052 CONTINUE
 3054 CONTINUE
 3055 CONTINUE
 3056 CONTINUE
C
      IF (PMIN.EQ.BIG) GO TO 3070
      PRSALL(JML)=PMIN
      ERSALL(JML)=ERS2(J1,M1,L1,I)
      JSYMBL(JML)=KRS2(J1,M1,L1,I)
      ERS2(J1,M1,L1,I)=0.0
      IF (JSYMBL(JML).EQ.IBL) JSYMBL(JML)=IS
      JML=JML+1
      GO TO 3050
C
 3070 NJML=JML-1
```

```
C
C SET POINTERS TO INITIAL VALUES -- JPTR(M) FOR SP  LABELS AND PLOT PTS
C                                   KPTR(M) FOR GEO LABELS AND PLOT PTS
C  AND INITIALIZE XLIM              JML     FOR PRSALL(JML)
C  AFTER EXTENDING XLIM1 AND XLIM2  KJM     FOR PRGALL(KJM)
C  TC RANGE XSP(J1,1)-XSP(J2,NM)
C  OR PRGALL(1)-PRGALL(NKJM), WHICHEVER IS LARGER
C
      KN=NK(1)
      DX=XG(KN,1)-XG(1,1)
      DX3=DX+DX+DX
      J1=JA(1)
      J2=JB(NM)
      IF(JJOFF.EQ.0) GO TO 3071
      J1=1
      J2=NJ(NM)
 3071 XLIM=XSP(J1,1)
      DO 13071 KJM=1,NKJM
      IF(ISYMBL(KJM).NE.IQUES) GO TO 13072
13071 CONTINUE
      KJM=NKJM
13072 IF(PRGALL(KJM).LT.XLIM) XLIM=PRGALL(KJM)
      IF (XLIM.LT.XLIM1-DX3) XLIM=XLIM1-DX3
      IF (XLIM1.LE.XLIM) GO TO 3072
      XLIM1=XLIM+XSCO2
 3072 XLIM=XSP(J2,NM)
      DO 3073 KJM=1,NKJM
      KJMR=NKJM-KJM+1
      IF(ISYMBL(KJMR).NE.IQUES) GO TO 13073
 3073 CONTINUE
      KJMR=1
13073 IF(PRGALL(KJMR).GT.XLIM) XLIM=PRGALL(KJMR)
      IF (XLIM.GT.XLIM2+DX3) XLIM=XLIM2+DX3
      IF (XLIM2.LT.XLIM) XLIM2=XLIM
C
 3074 DO 3080 M=1,NM
      KPTR(M)=1
      IF (JJOFF.EQ.0) GO TO 3076
      J=1
      GO TO 3077
 3076 J=JA(M)
 3077 IF (XSP(J,M).GE.(XLIM1-XSCALE)) GO TO 3078
      J=J+1
      IF (J.LE.NJ(M)) GO TO 3077
      J=NJ(M)
 3078 JPTR(M)=J
 3080 CONTINUE
      JML=1
      KJM=1
      XLIM=XLIM1
      XMIN=XLIM1-XSCALE
      XMID=XLIM-XSCO2
      PLAST=XLIM1
      PLSUR=PLAST
      ELSUR=ESP(1,1)
      IF(JJOFF.NE.0) GO TO 3084
      JLEFT=JA(1)
      JRITE=JB(NM)
      GO TO 3086
 3084 JLEFT=1
```

```
      JRITE=NJ(NM)
 3086 PJB=XSP(JRITE,NM)
      B1=SLOPE
      B2=SLOPE
      DO 3090 L=1,LN
      IF(IDIP.NE.0) GO TO 3088
      KMID=NK(1)/2
      IF(KMID.LT.6) KMID=6
      IF(KMID.GT.NK(1)) KMID=NK(1)
      LCALL=L
      CALL DIP(LCALL,1,1,KMID,1,A,B1)
      KMID=NK(NM)/2+1
      IF(KMID.LT.7) KMID=NK(NM)-5
      IF(KMID.LT.1) KMID=1
      CALL DIP(LCALL,NM,KMID,NK(NM),NK(NM),A,B2)
 3088 ELAST(L)=ERS(JLEFT,1,L)-B1*(XSP(JLEFT,1)-XLIM1)
      ERITE(L)=ERS(JRITE,NM,L)+B2*(XLIM2-PJB)
 3090 CONTINUE
      ELSUR=ESP(JLEFT,1)-SLOPE*(XSP(JLEFT,1)-XLIM1)
C
C MAIN PLOT LOOP
C
 3100 KFLAG=0
      LBLJ=IBL
      LBLM=IBL
      DO 3122 I=1,103
 3122 IP(I)=IBL
      DO 3123 I=1,53
 3123 IT(I)=IBL
      IP(2)=IDASH
      IP(102)=IDASH
      IT(2)=IDASH
      IT(102)=IDASH
C
C SET TYPE FOR PRINTING SPREAD AND SP LABELS, DIST, AND PLOT PTS
C
C SET KFLAG=-1 FOR M AND J LAPELS AND DIST
C      KFLAG= 0 FOR NO LABELS
C      KFLAG= 1 FOR M, J AND K LABELS AND DIST
C
      DO 3120 M=1,NM
      KN=NK(M)
      IF (JJOFF.EQ.0) GO TO 3101
      JN=NJ(M)
      GO TO 3102
 3101 JN=JB(M)
 3102 JP=JPTR(M)
      IF (JP.GT.JN) GO TO 3110
      IF (XSP(JP,M).GE.XLIM) GO TO 3110
      IF(XSP(JP,M).LT.XMIN) GO TO 3108
      KFLAG=-1
      LBLM=IDSPR(M)
      LBLJ=IDSP(JP,M)
      DIST=XSP(JP,M)
      DO 3103 I=2,102,10
 3103 IP(I)=IPLUS
      DO 3104 I=2,52,10
 3104 IT(I)=IPLUS
      ELSUR=ESP(JP,M)
      PLSUR=XSP(JP,M)
      CALL SETIP(ES(JP,M),EMIN,ESCALE,IAST)
      DO 3105 L=1,LN
      CALL SETIP(ERS(JP,M,L),EMIN,ESCALE,ICOLN)
      ELAST(L)=ERS(JP,M,L)
 3105 CONTINUE
      PLAST=XSP(JP,M)
C
 3108 JPTR(M)=JPTR(M)+1
      GO TO 3102
C
 3110 KP=KPTR(M)
      IF (KP.GT.KN) GO TO 3120
      IF (XG(KP,M).GE.XLIM) GO TO 3120
      IF(XG(KP,M).LT.XMIN) GO TO 3118
      IF (KFLAG.NE.0) GO TO 3115
C
      DIST=XG(KP,M)
      DO 3111 I=2,102,10
 3111 IF(IP(I).EQ.IBL) IP(I)=IPLUS
      DO 3112 I=2,52,10
 3112 IF(IT(I).EQ.IBL) IT(I)=IPLUS
C
 3115 LK=KP
      LBLM=IDSPR(M)
      KFLAG=1
      E=EG(KP,M)+ESCALE
      CALL SETIP(E,EMIN,ESCALE,IDEE)
      ELSUR=EG(KP,M)
      PLSUR=XG(KP,M)
      DO 3117 L=1,LN
      CALL SETIP(ERP(KP,M,L),EMIN,ESCALE,ICOLN)
      ELAST(L)=ERP(KP,M,L)
 3117 CONTINUE
      PLAST=XG(KP,M)
C
 3118 KPTR(M)=KPTR(M)+1
      GO TO 3110
 3120 CONTINUE
C
 3124 IF (JML.GT.NJML) GO TO 3126
      IF (PRSALL(JML).GE.XLIM) GO TO 3126
      CALL SETIP(ERSALL(JML),EMIN,ESCALE,JSYMBL(JML))
      JML=JML+1
      GO TO 3124
C
 3126 IF (KJM.GT.NKJM) GO TO 3128
      IF (PRGALL(KJM).GE.XLIM) GO TO 3128
      CALL SETIP(ERGALL(KJM),EMIN,ESCALE,ISYMBL(KJM))
      KJM=KJM+1
      GO TO 3126
C
C INTERPOLATE TO FIND LAYER BOUNDARIES BETWEEN SPS AND GEOS
C
 3128 IF (KFLAG.NE.0) GO TO 3171
      IF(XLIM.LE.PJB) GO TO 13129
      PNEXT=XLIM2
      DO 13128 L=1,LN
13128 ENEXT(L)=ERITE(L)
      PNSUR=XLIM2
      ENSUR=ESP(JRITE,NM)+SLOPE*(XLIM2-PJB)
      GO TO 3140
13129 PNEXT=BIG
      PNSUR=BIG
      KNM=NK(NM)
      DO 3138 M=1,NM
      JP=JPTR(M)
      KP=KPTR(M)
      IF (JJOFF.EQ.0) GO TO 3129
      JN=NJ(M)
      GO TO 3130
 3129 JN=JB(M)
 3130 KN=NK(M)
      IF (JP.GT.JN.OR.KP.GT.KN) GO TO 3131
      IF (XG(KP,M).LE.XSP(JP,M)) GO TO 3132
      GO TO 3134
 3131 IF(KP.GT.KN.AND.JP.GT.JN) GO TO 3138
      IF(KP.GT.KN) GO TO 3134
      IF(JP.GT.JN) GO TO 3132
      IF(XSP(JP,M).LT.XG(KP,M)) GO TO 3134
 3132 IF (XG(KP,M).GT.PNEXT) GO TO 3138
      PNEXT=XG(KP,M)
      PNSUR=PNEXT
      ENSUR=EG(KP,M)
      DO 3133 L=1,LN
 3133 ENEXT(L)=ERP(KP,M,L)
      GO TO 3138
C
 3134 IF (XSP(JP,M).GT.PNEXT.AND.XSP(JP,M).LE.XG(KVM,NM)) GO TO 3138
      PNEXT=XSP(JP,M)
      PNSUR=PNEXT
      ENSUR=ESP(JP,M)
      DO 3135 L=1,LN
 3135 ENEXT(L)=ERS(JP,M,L)
 3138 CONTINUE
C
C
 3140 I1=2+IFIX ((TERP(PLSUR,ELSUR,PNSUR,ENSUR,XMID)-EMIN)/ESCALE+0.5)
      I2=(I1-2)/2+2
      IF (I1.LE.0) I1=1
      IF(I2.LE.0) I2=1
      IF(I2.GT.53) I2=53
      IF (I1.GT.103) I1=103
      IF(IT(I2).EQ.IBL) IT(I2)=ICOLN
      IF (IP(I1).EQ.IBL) IP(I1)=ICOLN
      DO 3169 L=1,LN
      I1=2+IFIX ((TERP(PLAST,ELAST(L),PNEXT,ENEXT(L),XMID)-EMIN)/ESCALE
     1 +0.5)
      I2=(I1-2)/2+2
      IF (I1.LE.0) I1=1
      IF(I2.LE.0) I2=1
      IF (I1.GT.103) I1=103
      IF(I2.GT.53) I2=53
      IF (IP(I1).EQ.IBL) IP(I1)=ICOLN
      IF(IT(I2).EQ.IBL) IT(I2)=ICOLN
 3169 CONTINUE
C
C PRINT A LINE OF GRAPH
C
 3171 IF (KFLAG) 3172,3176,3180
 3172 PRINT 3174, DIST,(IP(I),I=1,103),LBLJ,LBLM
 3174 FORMAT (1H ,F8.0,50A1,53A1,1X,A1,5X,A1)
      GO TO 3200
 3176 PRINT 3178, (IP(I),I=1,103)
 3178 FORMAT (1H ,8X,50A1,53A1)
      GO TO 3200
 3180 PRINT 3182, DIST,(IP(I),I=1,103),LBLJ,LK,LBLM
 3182 FORMAT (1H ,F8.0,50A1,53A1,1X,A1,I3,2X,A1)
C
C PREPARE TO LOOP BACK TO COMPUTE NEXT LINE, OR IF DONE PRINT BORDER
C
 3200 IF (XLIM.GT.XLIM2) GO TO 3210
      XMIN=XLIM
      XLIM=XLIM+XSCALE
      XMID=XLIM-XSCO2
      KN=NK(NM)
      JN=JB(NM)
      IF(JJOFF.NE.0) JN=NJ(NM)
      GO TO 3100
C
 3210 PRINT 585
      PRINT 584, (LB(I),I=1,11)
      PRINT 3018
      RETURN
      END
C
C-----------------------------------------------------------------------
C
      SUBROUTINE SETIP(E,EMIN,ESCALE,ISYM)
C  IN PROGRAM SIPB
C SETS TYPE FOR LINE OF DEPTH PT GRAPH
C
      COMMON IBL,IQUES,IP,IT,ICOLN,IPLUS,ISQ,IDASH
C
      DIMENSION IP(103),IT(53)
C
      I=2+IFIX ((E-EMIN)/ESCALE+0.5)
      II=(I-2)/2+2
      IF (I.GT.0) GO TO 1
      I=1
      II=1
      GO TO 2
C
    1 IF (I.LE.103) GO TO 2
      I=103
      II=53
C
    2 IPI=IP(I)
      ITI=IT(II)
      IF(IPI.EQ.IBL.OR.IPI.EQ.ICOLN.OR.IPI.EQ.IPLUS.OR.IPI.EQ.IDASH)
     1 GO TO 4
      IP(I)=ISQ
      GO TO 6
    4 IP(I)=ISYM
    6 IF(ITI.EQ.IBL.OR.ITI.EQ.ICOLN.OR.ITI.EQ.IPLUS.OR.ITI.EQ.IDASH)
     1 GO TO 8
      IT(II)=ISQ
      GO TO 10
    8 IT(II)=ISYM
   10 RETURN
      END
```

```
C
C-----------------------------------------------------------------------
C
      SUBROUTINE HTIME(K,J,M,P1,E1,P2,E2,HV,TH)
C  IN PROGRAM SIPB
      COMMON/BLK2/XG,ERP,SLOPE,IDIP
     5      /BLK5/IDSPR,IDSP,KL,KR,D
     7      /BLK7/JA,JB,TRS,ERS,XSP,ESP,LS
     9      /BLK9/EG,ES
     9      /BLK10/BLIM,ITRACE,TANSG
C
      DIMENSION XG(25,5),ERP(25,5,4),JA(5),JB(5),TRS(7,5,4),ERS(7,5,4)
     1,XSP(7,5),ESP(7,5),LS(7,5),EG(25,5),ES(7,5),IDSPR(5),IDSP(7,5)
     2,KL(7,5),KR(7,5),D(25,7,5)
C
      DE=E2-E1
      DP=P2-P1
      DSX=XG(K,M)-XSP(J,M)
      DSE=EG(K,M)-ES(J,M)
      SH=SQRT(DSX**2+DSE**2)
      D1=D(K,J,M)
      DP=SIGN(DP,DSX*DP*D1)
      IF (DSX.EQ.0..OR.DP.EQ.0.) GO TO 10
      IF (ABS(DE/DP).GT.BLIM) DE=BLIM*DP
      TH=SIGN(D1*SQRT(DP**2+DE**2)/SH,DP)/HV
      RETURN
   10 DH=D1-ABS(P1-XSP(J,M))-ABS(P2-XG(K,M))
      TH=SIGN(SQRT(DH**2+DE**2),DH)/HV
      RETURN
      END.
C
C-----------------------------------------------------------------------
C
      SUBROUTINE TIE(L2,M,J,JJ,K11,K22,KT1,KT2,KN,I,JJTIE)
      COMMON IBL,IQUES,IP,IT,ICOLN,IPLUS,ISQ,IDASH,IS,IAST,IDEE,IL,NL
      COMMON/BLK0/LG
     1      /BLK3/TA,TR,DSG
     2      /BLK4/VVA,VHA
     3      /BLK5/IDSPR,IDSP,KL,KR,D
C
C  IN PROGRAM  SIPB
C MAKES TIE CORRECTION FOR OUTLYING SP JJ TO NEXT INNER SP J
      DIMENSION LG(25,7,5),TA(25,7,5),DSG(25),TR(25,7,5),D(25,7,5),
     1IP(103),IT(53),IL(5),IDSPR(5),IDSP(7,5),KL(7,5),KR(7,5),VVA(5,5)
     2,VHA(5,5)
C
      CALL KENDS(L2,M,J,KT1,KT2,KT11,KT22)
      IF (KT11.EQ.0) GO TO 99
      DO 10 K=1,KN
   10 DSG(K)=ABS(D(K,J,M))
      SUM1=0.
      PTS1=0.
      K1=MAX0(K11,KT11)
      K2=MIN0(K22,KT22)
      IF(K2.LT.K1) GO TO 50
C
C OVERLAP BETWEEN J AND JJ ARRIVALS
C
   20 DO 30 K=K1,K2
      IF (LG(K,JJ,M).NE.L2) GO TO 30
      SUM1=SUM1+TR(K,JJ,M)-TR(K,J,M)
      PTS1=PTS1+1.
   30 CONTINUE
      IF (PTS1.EQ.0.) GO TO 50
      SUM1=SUM1/PTS1
   35 DO 40 K=K11,K22
      IF (LG(K,JJ,M).EQ.L2) TR(K,JJ,M)=TR(K,JJ,M)-SUM1
   40 CONTINUE
      IF(JJTIE.EQ.0) GO TO 60
      IF(I.EQ.2) GO TO 44
      KK=K22+1
      IF(KK.GT.KN) GO TO 99
      DO 42 K=KK,KN
      IF(TR(K,JJ,M).NE.0) TR(K,JJ,M)=TR(K,JJ,M)-SUM1
   42 CONTINUE
      GO TO 99
   44 KK=K11-1
      IF(KK.LT.1) GO TO 99
      DO 46 K=1,KK
      IF(TR(K,JJ,M).NE.0) TR(K,JJ,M)=TR(K,JJ,M)-SUM1
   46 CONTINUE
      GO TO 99
C
C GAP BETWEEN J AND JJ ARRIVALS
C
   50 CALL REGRES(KT11,KT22,J,M,L2,VJ,TJ,PT,1)
      IF(PT.EQ.0.) GO TO 99
      CALL REGRES(K11,K22,JJ,M,L2,VJJ,TJJ,PT,1)
      IF(PT.EQ.0.) GO TO 99
      IF(I.EQ.2) GO TO 54
      DMID=(DSG(K22)+DSG(KT11))/2
   52 SUM1=(TJJ+TJJ+DMID/VJJ)-(TJ+TJ+DMID/VJ)
      GO TO 35
   54 DMID=(DSG(K11)+DSG(KT22))/2
      GO TO 52
C
C TIE DOWN POINTS FOR DEEPER LAYERS L2+1 THRU NL (SP JJ)
C
   60 LNEXT=L2+1
      IF(LNEXT.GT.NL) GO TO 99
      DT1=SUM1
      DO 80 L=LNEXT,NL
      L1=L-1
      DT2=DT1*VHA(M,L1)/VHA(M,L)
      DO 70 K=1,KN
      IF(LG(K,JJ,M).EQ.L) TR(K,JJ,M)=TR(K,JJ,M)-DT2
   70 CONTINUE
      DT1=DT2
   80 CONTINUE
      JJTIE=1
C
   99 RETURN
      END
```