UNITED STATES DEPARTMENT OF THE INTERIOR

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Coal-seismic, desktop computer programs in BASIC; part 9--Compute static corrections using an ABC method applied to six-fold, two-way field data

by

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ABSTRACT

Processing of data taken with the U.S. Geological Survey's coal-seismic system is done with a desktop, stand-alone computer. Programs for this computer are written in the extended BASIC language used by the Tektronix 4051 Graphic System. This report presents computer programs to compute static corrections using a high-redundancy ABC method applied to data obtained with a six-fold, two-spread-direction field procedure.

INTRODUCTION

To achieve the lateral and vertical resolution required in coal-exploration and coal-mine-development seismics, high resolution (HR) techniques must be used. These techniques generally require higher frequency detectors, shorter detector spacings, higher frequency sources, and faster sampling rates than are used in oil and gas seismic exploration. Both oil and coal seismics use multi-fold (CDP) methods to improve reflection quality; thus, both require the removal of severe statics (Sheriff, 1973, p. 209) before effective stacking can proceed. However, because HR methods demand higher frequencies, small static shifts that might be dismissed in standard seismic oil prospecting cannot be ignored in HR surveys, for otherwise the stacked result will be smeared and thus the needed high frequency arrivals will be lost. Much of our coal-seismic research has concentrated on the use of shear-wave (S-wave) methods for which, according to Waters (1978, p. 95), statics are more pronounced than they are in standard longitudinal-wave (P-wave) work; thus, in shear-wave studies, greater attention must be given to the determination of static corrections.

Of the three most common techniques of static correction--uphole time, cross-trace data smoothing, and refraction techniques--only the latter is used in our shallow (depths limited to about 100 m) coal seismic investigations.

Uphole-time methods require shooting beneath the LVL (low velocity layer) and they are not used in our research because shotholes are expensive to permit and drill; generation, and to a lesser degree--detection, of SH (shear-horizontal) waves within a borehole are challenging technical problems; and lastly, use of a shothole drill rig defeats one of the objectives of our work: to develop a truly portable shallow seismic system that, if need be, can be operated by one person.

Trace-to-trace data smoothing (automatic statics procedures based upon various statistical approaches) cannot be used because the only seismic horizon that may exhibit reflection continuity in a coaliferous section is the coal itself--and it is the target. Thus, although the mathematically elegant automatic statics procedures produce a smoother looking seismic section, they may do so at the expense of hiding the very features that the coal seismic survey was undertaken to find.

Thus we are left with dependancy on refraction methods to develop the needed static corrections. However, because we are forced by field-operation, target-depth, and source-strength factors into using short spreads, refraction methods can be expected to produce only approximate statics--ray paths for first arrivals may reach only to the base of the LVL and therefore not reveal sub-LVL velocity variations that may contribute to the total static shift. Nevertheless, let us proceed with the use of refraction methods to achieve a first cut at the determination of statics. If, upon inspection of record sections, further static corrections seem to be necessary, then we will have to determine them through use of a screen-display interactive procedure, one not included in this report.

The field method used in our surface-to-surface, coal-seismic research is a melding of three principal techniques: (1) ABC for determination of statics, (2) CDP (common depth point) procedures for improving signal-to-noise ratios of reflections, and (3) common-offset methods for detection of near-surface features.

None of the constituent parts of either our field or computational methods can be considered as new. The method of differences (ABC procedure) of determining time in the LVL has been used since the early days of seismic prospecting (Edge and Laby, 1931, p. 339-341). Common depth-point methods (Mayne, 1956 and 1962), sometimes called common midpoint stacking (CMP), are now standard procedures throughout the seismic industry. A seismic field procedure called the "Roll-Along" technique (Shock, 1963) for implementation of the CDP concept followed shortly after the general introduction of CDP methods. Origins of the common offset seismic method rests in the distant past--the method seems to be one of those that has always been with us, as it is a seismic analog to fixed-electrode resistivity methods.

This report is limited to a discussion of the method and programs we use to compute static corrections using field data obtained with the USGS coal seismic system and a six-fold, two-spread-direction data acquisition field procedure.

COMMENTS ON THE PROGRAMS

In order to put the programs of this report to work, the user must know how to perform the following operations:

1. transcribe the programs into the computer,
2. store the programs on magnetic tape,
3. retrieve the programs from magnetic tape,
4. enter information from the keyboard, and
5. copy the screen display.

These tasks are documented in the computer's operator's manuals.

Four control characters (those that require the holding down of the control key as the letter is entered) are used in the programs: G (ring bell), K (move cursor up one line), L (erase screen and move cursor to the HOME position), and the RUB OUT (move cursor to the left margin and down one line). In the printed listing these control characters are shown as G_, K_, L_, and __, respectively.

Computer programs were written in an extended BASIC language developed by Tektronix, Inc. for use with their 4051 Graphic System. The programs require three pieces of Tektronix equipment: a 4051 Graphic System with a 32K-byte memory, a 4924 digital cartridge tape drive, and a 4631 Hard Copy unit.

All programs are self-prompting. In working through a sample problem, notice that the programs print requests and questions followed by a flashing question mark. The computer then waits for the user to enter a response from the keyboard. Replies entered in order to run a sample problem are enclosed in boxes that are hand drawn by the author on the figures of this report.

Four programs are required by the computation procedure--their functions are as follows:

1. enter surveying data,
2. enter first arrivals,
3. compute static corrections, and
4. plot adjusted first arrivals, ground and LVL elevations, and time to datum at each station.

NUMBERING SYSTEM USED IN THE PROCEDURE

The numbering system used in the field and in the programs is based on line numbers (LN) and position numbers (PN) of each source point and detector within a given area or prospect. If your computer has a larger memory or a rapid-access disk system, then these numbers can be used as pointers to tell the computer which particular set of data is to be retrieved and processed.

Surface position numbers along a line are incremented by two; thus all detector PN's along a traverse will be either odd or even. This ordering is done so that PN's of reflection points in the subsurface will be integers. If, for example, a SP (source point) is at PN 5 and a detector is at PN 11, then the reflection point at the midpoint in the subsurface would be at PN 8.

The programs require the entry of the PN interval (the distance between successive PN's) so that intervals between any pair of PN's can be converted to distance intervals. Because the computer programs use PN's as locators, computations are internally independent of a system of units. Only at final output to plots or tabulations is the conversion to distance units made. A common PN interval in much of our work is 1.5 m, equivalent to a single-detector group interval of 3 m.

SINGLE-SPREAD ABC METHOD

The equation used to compute the vertical time through the LVL is very simple (Sheriff, 1973, p. 1), a condition that usually implies that oversimplifying assumptions have been used. Here we develop the single-spread ABC equation so as to gain insight into the validity of those assumptions upon which the method rests.

Figure 1 shows a single, zero-offset spread of 12 detectors linking source points at the ends of the spread. The numbering system shown is the same as that used in the programs.

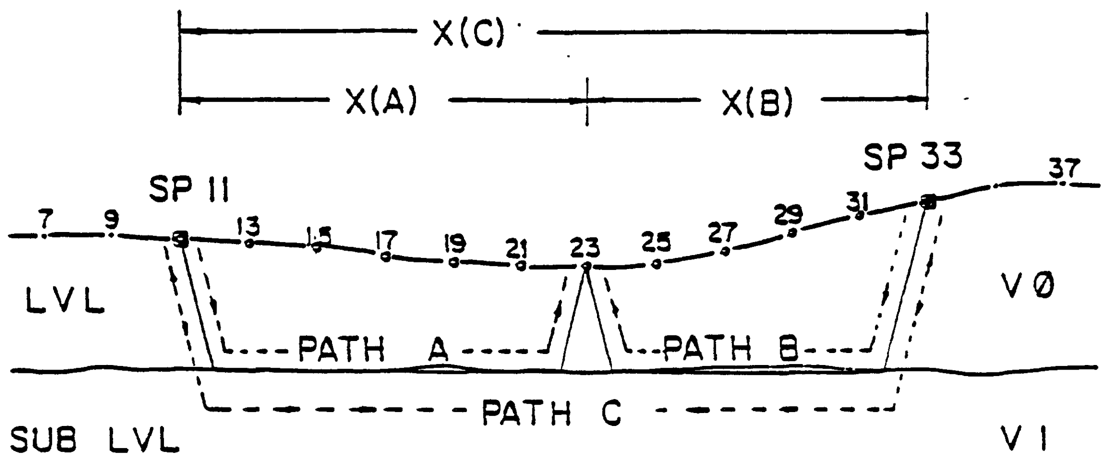


Figure 1. Sketch to illustrate the single-spread ABC method.

Letting T(A), T(B), and T(C) be refraction times along the forward path A, the reverse path B, and the common path C, respectively, and symbolizing the delay time under position N as D(N), then for the detector at PN 23 (fig. 1),

$$T(A) = X(A)/V1 + D(11) + D(23), \quad (1)$$

$$T(B) = X(B)/V1 + D(33) + D(23), \quad (2)$$

with a common-path (SP-to-SP) time of

$$T(C) = X(C)/V1 + D(11) + D(33). \quad (3)$$

Since $X(C) = X(A) + X(B)$,

$$T(A) + T(B) - T(C) = 2\ D(23), \quad (4)$$

where the delay time at the detector at PN 23 is D(23) given by

$$D(23) = t(23) \times \cos(A), \quad (5)$$

t(23) being the one-way vertical time in the LVL at PN 23 and A the critical angle, which from Snell's law is

$$A = \arcsin(V0 / V1). \quad (6)$$

Letting

$$K = 0.5 / \cos(A), \quad (7)$$

then

$$t(23) = K\ (T(A) + T(B) - T(C)). \quad (8)$$

If the crossover distance (Sheriff, 1973, p. 41) was equal to three detector positions, six PN's, then the single-spread ABC method could be used to find the time in the LVL at PN 17 through PN 27, but not at the other six detectors.

The following observations on the single-spread ABC can be made:

1. a single layer with an undulating top surface overlying a semi-infinite half space is assumed--a highly restrictive assumption,
2. spreads must be shot in two directions (forward and reverse),
3. detectors must be positioned at the SP's to find T(C), and
4. computation can be made only for those detectors whose offsets are equal to or greater than the crossover distance.

In practice, minor variations in elevations of the base of the LVL can be tolerated. But if a pronounced velocity gradient is present, ray paths will be curved and their penetration a function of offset resulting in the ABC method producing incorrect results (Waters, 1978, p. 143). Full discussion of this effect and the partial compensation that may obtain when six, spread-shifted (different offset) ABC computations are made at each interior station is beyond the scope of this report.

If the use of the ABC method is accepted, the user also accepts the fundamental limitations implicit in point 1; however, by design of the field procedure, much can be done about points 2 through 4--as discussed in the next section of this report.

MULTIPLE-SPREAD ABC METHOD

The computation procedure of this report requires that data be obtained with common offset spreads shot from two directions (forward and reverse) and that the offsets on the forward and reverse spread differ by one detector interval. In addition, the maximum offset must be equal to or less than the distance between the first and last detectors. Tests on the offset conditions are made within the computer program. As we use the terms, a forward spread is one for which the PN of the shotpoint is less than the PN's of the spread; a reverse spread is one for which the PN of the SP is greater than the PN's along the spread.

Choice of how much offset to be used is dictated by the results of wave tests (also called walkaways or noise tests). Generally the offsets range from 21 to 30 m in our shallow-coal investigations; thus, no detector is at the active-SP position at the time a particular spread is shot. However, as the SP/spread array is repeatedly shifted by two group intervals down the traverse, eventually a detector will occupy the position of this shotpoint (Waters, 1978, p. 143). This is the basis upon which the method is developed.

Figure 2 shows seven positions of a single SP-spread-SP array as if

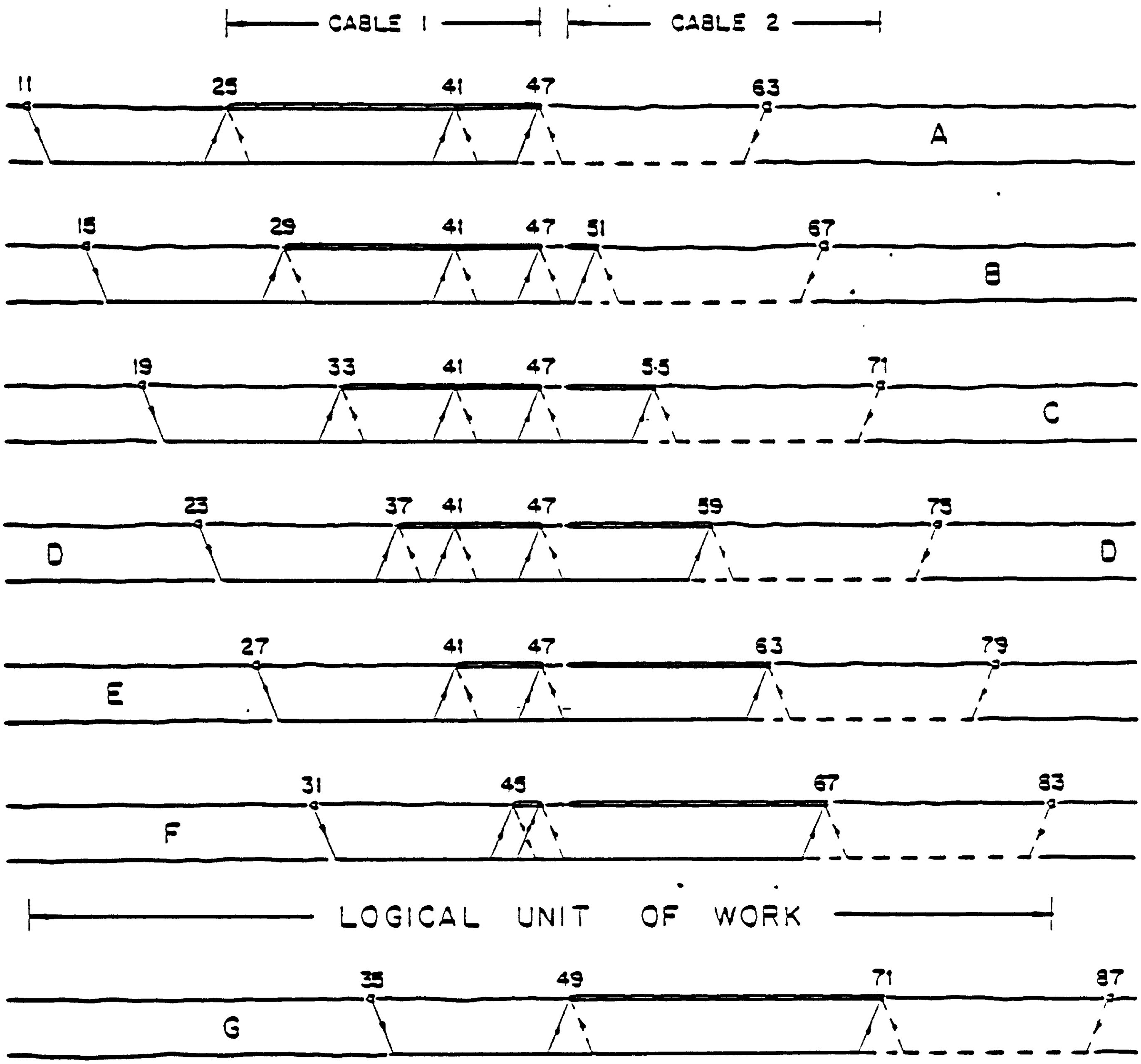


Figure 2. Sketch to illustrate multiple-spread ABC method. SP's are shown by squares. Segments of cables containing takeouts connected to the seismograph through a roll-along switch are shown by a double line; for example, for spread C, the last eight takeouts on cable 1 and the first four on cable 2. Numbering system is the same as that used in the illustrative example presented later. Only PN's of SP's and detectors germain to the discussion are labeled.

it were shifted along the traverse. In field practice, however, two or more cables are used, and array shifting is accomplished by use of a roll-along switch or a patch panel. Numbering on figure 2 is the same as in the illustrative example later in this report.

Let us first consider finding the vertical, one-way time in the LVL at PN 47. As in the development in the preceding section, T(A) is the refraction time on the forward spread (SP at PN 11 to detector at PN 47, SP at PN 15 to detector at PN 47, and so on until SP at PN 31 to detector at PN 47); T(B) is the refraction time on the reverse spread (starting at SP at 63 and ending at SP at 83 all into the detector at PN 47). Thus 12 refraction paths lead to the detector at PN 47.

To complete the ABC calculation, we also need T(C)--the SP-to-SP refraction time--an arrival that does not appear on any individual record. We can find T(C), however, if we can be patient and wait until the fifth and sixth arrays are shot (labeled E and F on fig. 2), then we can get the forward refraction time difference between arrivals at PN 63 and PN 47. If we add the average of these two time differences to the time from SP at 11 to detector at 47, we can determine T(C) for the first (A) array. Similarly, we can find the SP-to-SP time for the second (B) array by adding the average of the PN 67/PN 51 time difference found from the F and G arrays to the refraction time from the SP at PN 15 to the detector at PN 51.

Because the reciprocal times from SP to SP should be equal, from array E onward we should be able to compute T(C)'s by use of the same scheme as described above applied to the reverse as well as to the forward spreads. After the systematic pattern of taking data is established, we will have four values of SP-to-SP time, T(C), to average in this example--two from the forward and two from the reverse spreads. In addition, we will have six determinations of static corrections for each of what we call the interior points--those for which the full statistical power of the prodecure is operative.

Let us now consider the determination of the vertical time in the LVL beneath the first four shotpoints (SP's at PN's 11, 15, 19, and 23 as shown on fig. 2). A similar procedure would be applied to the trailing four shotpoints.

Referring to spreads D and E on figure 2, note that from previous application of the ABC method, we know the delay times under PN's 27, 37, and 41. Thus we can compute the horizontal time in the sub LVL from PN 27 to PN 41, symbolized by T(41/27), from the equation

$$T(27/41) = T(A) - D(41) - D(27), \tag{9}$$

where T(A) is the refraction time from the SP at PN 27 to the detector at PN 41 and where D(N) is the delay time under PN(N). Now let us assume, as permitted by the two-layer assumption, that the horizontal time in the sub LVL from PN 23 to PN 37 equals that from PN 27 to PN 41; thus T(23/37) = T(27/41). Therefore the delay time under PN 23 would be found using

$$D(23) = T(A) - T(27/41) - D(37), \tag{10}$$

where T(A) is now the refraction time from the SP at PN 23 to the detector at PN 37. Upon of the application of the K factor as defined in (7) to the delay time, the vertical time in the LVL under PN 23 would be obtained.

Using a similar approach, vertical times in the LVL under all the other SP's can be computed.

STATIC CORRECTION TO DATUM

Once the vertical time in the LVL at each PN is determined and the elevations at each PN and the elevation of the fixed datum entered, then the static correction is computed by summing the time to datum at each SP and each detector at each spread. The program assumes a fixed (constant elevation) datum. If you require the use of a sloping or other type of reference datum surface, you will have to change the datum elevation (E3 in the program) from a numeric to an array variable and of course make provision to fill that array.

As we use the term "static corrections" we are considering the total strip-off times to datum, not just the time variations in the LVL. For example, the static correction for the detector at PN 25 on spread A as shot from the SP at PN 11 would be S(11,25) given by the sum of the datum time at the SP:

$$t(11) + (E(11) - V(0) \times t(11) - E(d)) / V(1), \qquad (11)$$

and the datum time at the detector:

$$t(25) + (E(25) - V(0) \times t(25) - E(d)) / V(1), \qquad (12)$$

where for the station at PN number N, t(N) is the one-way vertical time in the LVL and E(N) is the elevation, V(0) is the LVL velocity, V(1) is the velocity in the sub LVL--sometimes called the datum velocity, and E(d) is the elevation of the fixed datum. Details of this computation are given in most seismic exploration texts; for example, Telford and others (1976, p. 353-356).

LOGICAL UNIT OF WORK

The logical unit of work in the field consists of two cable layouts bracketed by six forward and six reverse source points as illustrated by arrays A through F on figure 2. This basic work unit was designed so as to make the most efficient use of a small-complement field crew operating with surface sources, a 12-channel signal-enhancement seismograph, and cables with 12 takeouts.

The quantity of records taken in the basic unit of work depends upon the types of sources and detectors used. If only P-wave recordings are made (vertical impact with hammer or "shotgun" source and vertical-component detectors), then 12 records are taken; if only one set of S-wave recordings are made (horizontal source struck in two directions and horizontal-component detectors), then 24 records are taken; if a five-source set of recordings are made-- vertical hammer into vertical detectors, radial source (two directions) into radial detectors, and transverse source (two directions) into transverse detectors, then 60 records are taken; and finally if a full set of data are taken (six source excitations into three-component detectors), then 216 records are made--even more if one also decides to rotate the shear souces incrementally. Clearly, judgment must be exercised in planning field work--particularly if YOU are to be the one-person field crew.

The data entry programs also were designed to conform to logical units of work. Two programs are required to enter data: one for area, line, spread, and elevation data (surveying data); one for seismic-record data (first arrival data). This separation of data-entry programs follows the natural division of labors in the field.

DISCUSSION OF PROGRAM TO CORRECT AND ENTER SURVEYING DATA

Correction and entry of surveying data is illustrated by the example shown in figure 3. The program begins by asking you if you want to correct existing data. Because in this report no data have as yet been entered, let us defer a Y response. Next you are prompted to enter the area information and line number, and then asked if you want to add cables to the line--let us answer with an N. The spread information entered on figure 3 is that required for the A through F spreads shown in figure 2. Finally you enter the elevations for each PN at and between the first and last source points (SP 11 and SP 87 respectively in this example). In order to save space on the magnetic tape, elevations are stored as a single-variable array; for example, E1(1) is the elevation at PN 11, E1(2) is the elevation at PN 13, and so on.

After elevations are entered, you are asked if you want to tabulate and plot them. The results of Y answers are shown on figures 4 and 5.

After viewing and then clearing the screen, you are asked if you want to accept the elevations as entered and in which file you want the data stored (fig. 6).

Usually topographic surveying is completed before the line is shot. However, after a line of data is interpreted, it may be deemed necessary to add stations or cable positions to the line. Negative PN's are allowed.

To show how stations are added both to the beginning and end of the line, let us assume that the original line extended from PN 11 to PN 87, as in figure 2., and that we now want to extend the coverage using one additional cable position tacked onto both ends. Thus, first and last SP's on the extended line would be at PN -13 and PN 107 respectively.

Figure 7 shows an example of how the program is used to add surveying data to the beginning of the line.

After the area identification and line number are entered, you are asked if you want to add cables to the line. Upon replying with a Y, you are asked if you want to add to the beginning of the line--let us answer with Y. Thereupon you are prompted to enter the number of the file containing the original segment of the line--in this case, file 21. Next you are asked to enter the number of cable position to be added.

```
CORRECT AND/OR ENTER SURVEYING DATA FOR 6-FOLD, 2-WAY STATICS PROCEDURE

DO YOU WANT TO CORRECT EXISTING DATA? (Y OR N) [N]

AREA (24 char) = [ILLUSTRATIVE EXAMPLE]
   LINE NUMBER = [3]

DO YOU WANT TO ADD CABLES TO LINE? (Y OR N) N

 NO. OF CABLES = [2]
TAKEOUTS/CABLE = [12]
PN INT. (M/PN) = [1.5]
PN OF FIRST SP = [11]
NEAR-DETECTOR O/S FOR FORWARD SPDS (M) = [21]
NEAR-DETECTOR O/S FOR REVERSE SPDS (M) = [24]
 PN OF LAST SP = 87

 PN    GROUND ELEV
 11     107.6
 13     107.2
 15     106.5
 17     106.1
 19     106.1
 21     106.2
 23     106.2
 25     106.2
 27     106.3
 29     106.3
 31     106.8
 33     106.9
 35     106.9
 37     107.1
 39     107.5
 41     108
 43     108.5
 45     109.1
 47     109.7
 49     110.2
 51     110.7
 53     111.1
 55     111.1
 57     111.3
 59     111.2
 61     111
 63     111
 65     110.3
 67     109.7
 69     108.8
 71     108
 73     107.4
 75     106.8
 77     106.3
 79     106.3
 81     106.3
 83     106.5
 85     106.8
 87     107.3

DO YOU WANT TO TABULATE ENTERED DATA? (Y OR N) [Y]
DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) [N]
```

Figure 3. Copy of screen display showing entry of surveying data.

```
AREA: ILLUSTRATIVE EXAMPLE   LINE NUMBER: 3
NO OF CABLES=2, TAKEOUTS/CABLE=12, NO OF STA=39
PN INT (M/PN)=1.5, FIRST SP PN=11, LAST SP PN=87
NEAR SEIS O/S FOR FORWARD SPD (M) = 21
NEAR SEIS O/S FOR REVERSE SPD (M) = 24

SURFACE ELEVATIONS:
```

PN	ELEV	PN	ELEV	PN	ELEV	PN	ELEV
11	107.6	13	107.2	15	106.5	17	106.1
19	106.1	21	106.2	23	106.2	25	106.2
27	106.3	29	106.3	31	106.8	33	106.9
35	106.9	37	107.1	39	107.5	41	108.0
43	108.5	45	109.1	47	109.7	49	110.2
51	110.7	53	111.1	55	111.1	57	111.3
59	111.2	61	111.0	63	111.0	65	110.3
67	109.7	69	108.8	71	108.0	73	107.4
75	106.8	77	106.3	79	106.3	81	106.3
83	106.5	85	106.8	87	107.3		

```
DO YOU WANT TO PLOT ELEVATIONS? (Y OR N) [Y]
```

Figure 4. Tabulation of surveying data for a logical unit of work.

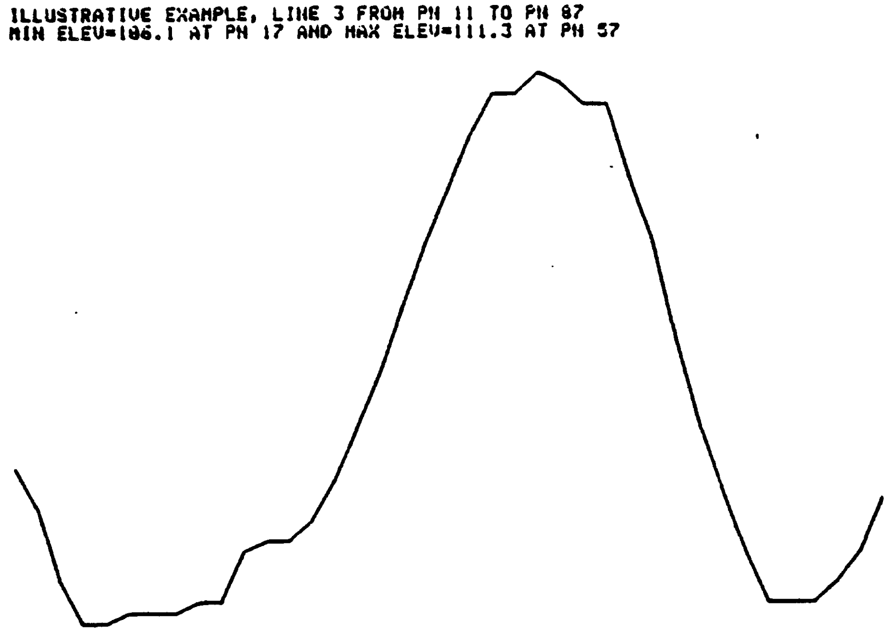


Figure 5. Plot of elevations for logical unit of work.

```
DO YOU WANT TO ACCEPT ENTERED ELEVATIONS? (Y OR N) [Y]
FILE NUMBER = [21]
REQUIRED FILE SPACE = 786
IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) [Y]
INSERT DATA TAPE IN 4924
ARE YOU READY TO PROCEED? (Y OR N) [Y]
PROGRAM COMPLETED
```

Figure 6. Copy of screen display showing program segment to correct and store surveying data.

```
CORRECT AND/OR ENTER SURVEYING DATA FOR 6-FOLD, 2-WAY STATICS PROCEDURE
DO YOU WANT TO CORRECT EXISTING DATA? (Y OR N) [N]
AREA (24 char) = [ILLUSTRATIVE EXAMPLE]
   LINE NUMBER = [3]
DO YOU WANT TO ADD CABLES TO LINE? (Y OR N) [Y]
DO YOU WANT TO ADD CABLES TO BEGINNING OF LINE? (Y OR N) [Y]
INSERT DATA TAPE IN 4924
NUMBER OF FILE CONTAINING OLD VALUES = [21]
NUMBER OF CABLES TO BE ADDED = [1]
   New PN of first SP = -13
 PN    GROUND ELEV
 -13       109.8
 -11       109.8
 -9      110
 -7      109.9
 -5      109.9
 -3      109.4
 -1      109.5
 1      109.4
 3      109.3
 5      108.9
 7      103.8
 9      107.9
DO YOU WANT TO TABULATE ENTERED DATA? (Y OR N) [Y]
DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) [N]
```

Figure 7. Example of surveying data added to beginning of the line.

The program then prints the PN of the new first SP on the screen and then prompts you to enter elevations for the added position numbers.

Upon entering the last of the elevations of the appended PN's, you are offered the options of tabulating the input data (fig. 8) and making a quick plot of the elevations along the total line (fig. 9). The plot

```
AREA: ILLUSTRATIVE EXAMPLE   LINE NUMBER: 3
NO OF CABLES=3, TAKEOUTS/CABLE=12, NO OF STA=51
PN INT (M/PN)=1.5, FIRST SP PN=-13, LAST SP PN=87
NEAR SEIS O/S FOR FORWARD SPD (M) = 21
NEAR SEIS O/S FOR REVERSE SPD (M) = 24

SURFACE ELEVATIONS:
```

PN	ELEV	PN	ELEV	PN	ELEV	PN	ELEV
-13	109.6	-11	109.8	-9	110.0	-7	109.9
-5	109.9	-3	109.4	-1	109.5	1	109.4
3	109.3	5	108.9	7	103.8	9	107.9
11	107.6	13	107.2	15	106.5	17	106.1
19	106.1	21	106.2	23	106.2	25	106.2
27	106.3	29	106.3	31	106.8	33	106.9
35	106.9	37	107.1	39	107.5	41	108.0
43	108.5	45	109.1	47	109.7	49	110.2
51	110.7	53	111.1	55	111.1	57	111.3
59	111.2	61	111.0	63	111.0	65	110.3
67	109.7	69	108.8	71	108.0	73	107.4
75	106.8	77	106.3	79	106.3	81	106.3
83	106.5	85	106.8	87	107.3		

```
DO YOU WANT TO PLOT ELEVATIONS? (Y OR N) [Y]
```

Figure 8. Tabulation of surveying data after one cable position was added to the beginning of the line.

```
ILLUSTRATIVE EXAMPLE, LINE 3 FROM PN -13 TO PN 87
MIN ELEV=103.8 AT PN 7 AND MAX ELEV=111.3 AT PN 57
```

Figure 9. Quick plot of elevations as entered on figure 7.

can be scanned to see if patent elevation errors have been entered; the tabulation can be scanned to locate the particular incorrect entry. In the sample of data entry (fig. 7) a wrong value (indicated by the arrow) was entered so that the correction procedure could be illustrated.

Figure 10 illustrates how a wrong entry of an elevation is corrected and how data are to be filed when the current file is too small.

```
DO YOU WANT TO ACCEPT ENTERED ELEVATIONS? (Y OR N) N
PN at elevation to be changed = 7
   Old value = 103.8
   New value = 103.3
DO YOU WANT TO CHANGE ANOTHER ELEVATION? (Y OR N) N

FILE NUMBER = 22

REQUIRED FILE SPACE = 986

IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) N

INSERT DATA TAPE IN 4051

ARE YOU READY TO PROCEED? (Y OR N) Y

INSERT DATA TAPE IN 4924

ARE YOU READY TO PROCEED? (Y OR N) Y
DO YOU WANT TO ADD CABLES TO END OF LINE? (Y OR N) N
```

Figure 10. Example showing procedure to correct entered elevations.

After those data from the appended line are filed, you are asked if you want to add cable positions to the end of the line. If you reply with an N (as was done in this example), then the program ends; if you enter a Y, then the program returns to that point immediately after where you had entered area and line information.

Let us now trace through the surveying data program to see how elevation data are added to the end of an established line. Figure 11

```
CORRECT AND/OR ENTER SURVEYING DATA FOR 6-FOLD, 2-WAY STATICS PROCEDURE

DO YOU WANT TO CORRECT EXISTING DATA? (Y OR N) N

AREA (24 char) = ILLUSTRATIVE EXAMPLE
   LINE NUMBER = 3

DO YOU WANT TO ADD CABLES TO LINE? (Y OR N) Y
DO YOU WANT TO ADD CABLES TO BEGINNING OF LINE? (Y OR N) N

INSERT DATA TAPE IN 4924
NUMBER OF FILE CONTAINING OLD VALUES = 22
NUMBER OF CABLES TO BE ADDED = 1
   New PN of last SP = 111

 PN    GROUND ELEV
 89       108.3
 91       109.1
 93       110
 95       110.4
 97       100.8
 99       100.9
 101       111.1
 103       111.2
 105       111.3
 107       111.1
 109       111
 111       110.9

DO YOU WANT TO TABULATE ENTERED DATA? (Y OR N) Y
DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) N
```

Figure 11. Example showing surveying data added to the end of a line.

is a screen copy showing an example of how these data are to be entered. The routine is essentially the same as for appending data to the beginning of an existing line except that new PN of the last SP is computed and printed rather than the new first SP.

A tabulation and plot of the data entered in figure 11 are shown on figures 12 and 13 respectively, following which is a copy of the screen

AREA: ILLUSTRATIVE EXAMPLE LINE NUMBER: 3
NO OF CABLES=4, TAKEOUTS/CABLE=12, NO OF STA=63
PN INT (M/PN)=1.5, FIRST SP PN=-13, LAST SP PN=111
NEAR SEIS O/S FOR FORWARD SPD (M) = 21
NEAR SEIS O/S FOR REVERSE SPD (M) = 24

SURFACE ELEVATIONS:

PN	ELEV	PN	ELEV	PN	ELEV	PN	ELEV
-13	109.6	-11	109.8	-9	110.0	-7	109.9
-5	109.9	-3	109.4	-1	109.5	1	109.4
3	109.3	5	108.9	7	108.3	9	107.9
11	107.6	13	107.2	15	106.5	17	106.1
19	106.1	21	106.2	23	106.2	25	106.2
27	106.3	29	106.3	31	106.8	33	106.9
35	106.9	37	107.1	39	107.5	41	108.0
43	108.5	45	109.1	47	109.7	49	110.2
51	110.7	53	111.1	55	111.1	57	111.3
59	111.2	61	111.0	63	111.0	65	110.3
67	109.7	69	108.8	71	108.0	73	107.4
75	106.8	77	106.3	79	106.3	81	106.3
83	106.5	85	106.8	87	107.3	89	108.3
91	109.1	93	110.0	95	110.4	97	110.8
99	110.9	101	111.1	103	111.2	105	111.3
107	111.1	109	111.0	111	110.9		

DO YOU WANT TO PLOT ELEVATIONS? (Y OR N)[Y]

Figure 12. Tabulation of surveying data showing complete line after adding a cable position to the end of the existing line.

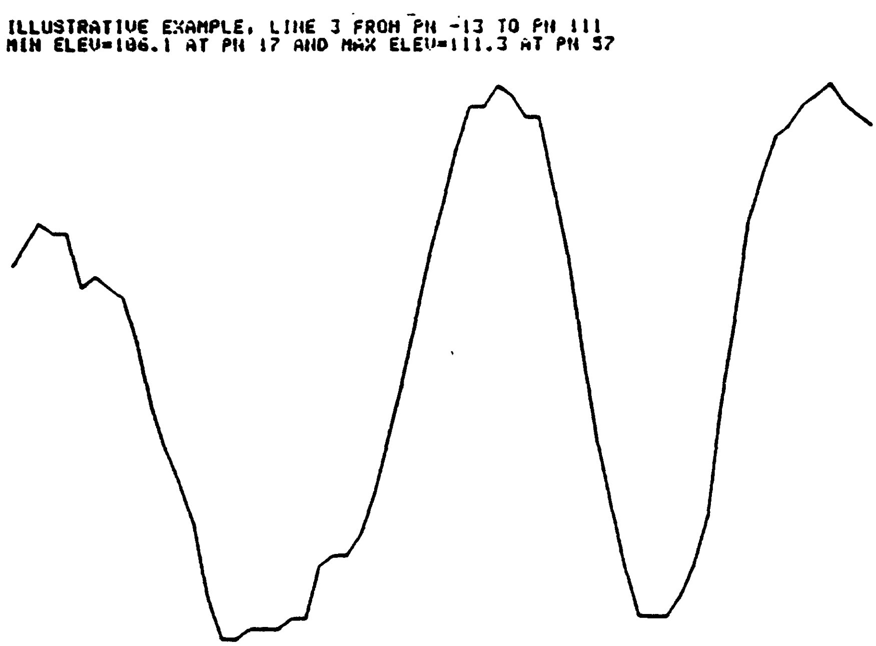


Figure 13. Elevation plot for the entire line after adding one cable position to the existing line.

display (fig. 14) of the procedure used to store these results.

```
DO YOU WANT TO ACCEPT ENTERED ELEVATIONS? (Y OR N) [Y]
FILE NUMBER =[23]
REQUIRED FILE SPACE = 1024
IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) [Y]
INSERT DATA TAPE IN 4924
ARE YOU READY TO PROCEED? (Y OR N) [Y]
PROGRAM COMPLETED
```

Figure 14. Example showing procedure to store appended line of data.

Figure 15 is an example of the procedure used to correct existing surveying data.

```
CORRECT AND/OR ENTER SURVEYING DATA FOR 6-FOLD, 2-WAY STATICS PROCEDURE
DO YOU WANT TO CORRECT EXISTING DATA? (Y OR N) [Y]
INSERT DATA TAPE IN 4924
NUMBER OF FILE CONTAINING OLD VALUES =[23]
PN at elevation to be changed = [15]
    Old value = 105.6
    New value =[106.5]
DO YOU WANT TO CHANGE ANOTHER ELEVATION? (Y OR N) [N]
 DO YOU WANT TO ENTER NEW ELEVATIONS? (Y OR N) [N]
PROGRAM COMPLETED
```

Figure 15. Example showing procedure to correct surveying data.

DISCUSSION OF PROGRAM TO CORRECT AND ENTER FIRST ARRIVALS

The program begins by asking if you want to correct existing first arrival data. Next, entry of a sufficient amount of location data is requested so that when the elevations and first arrival data tapes are entered into the statics-computation program, verficiation can be made by the program that both groups of data are from the same line in the same area. First arrival times on six forward spreads followed by first arrival times on six reverse spreads then are entered. After the input data are tabulated (optional), they are stored on magnetic tape.

Each first arrival data tape allocates space for 12 sets of first arrivals, a number representative of a logical unit of work (LUW) as previously discussed. Note on figure 2 that spread G is shot wholly into the cable 2 position. After spread F (the last spread in a LUW) has been shot, the cable occupying the cable 1 position can be picked up and moved to the cable 3 position beginning at PN 73 (fig. 2).

What happens if a logical unit of work has not been performed? And this well can happen; for example, assume spread G on figure 2 is the last spread on the line. Also, instrumentation failures necessitating cessation of field work have been known (at least in our work) to occur.

These two interruptions are handled differently. If field work has been halted temporarily, then you wait until work is resumed and enter the data after a logical unit of work has been accomplished. If the end of the line is reached before a full logical unit of work has been shot, you reply to the question: "Has a logical unit of work been shot?" with an N; enter the number of spreads shot, as prompted; and then proceed to enter what data you have taken--the program will assign zero values to fill the remaining allocated space within the dimensioned arrays.

Figure 16 is a copy of the screen display showing an example of

```
CORRECT AND/OR ENTER FIRST ARRIVAL DATA FOR 6-FOLD, 2-WAY STATICS
NOTE: LOGICAL UNIT OF WORK (LUW) REFERRED TO IN THIS PROGRAM
   CONSISTS OF RECORDS TAKEN USING TWO, 12-TAKEOUT CABLES
   SHOT FROM SIX FORWARD AND SIX REVERSE SOURCE POINTS.

DO YOU WANT TO CORRECT AN EXISTING FB DATA TAPE? (Y OR N) [N]

AREA (24 char) =[ILLUSTRATIVE EXAMPLE]
   LINE NUMBER =[3]

WAS A LOGICAL UNIT OF WORK PERFORMED? (Y OR N) [Y]

PN INT. (m/PN) = [1.5]
PN OF FIRST SP = [-13]
NEAR-TRACE O/S FOR FORWARD SPDS (m) =[21]
NEAR-TRACE O/S FOR REVERSE SPDS (m) =[24]
 PN OF LAST SP = 59

ARE YOU READY TO PROCEED? (Y OR N) [Y]


SP@PN:-13  SPREAD FROM PN:1 TO 23

TRACE   PN   OFFSET   FIRST ARRIVAL TIME
  1      1     21         34.7
  2      3     24         38.2
  3      5     27         40.3
  4      7     30         42.6
  5      9     33         45.1
  6     11     36          47.8
  7     13     39          50.6
  8     15     42          54.5
  9     17     45          55.9
 10      19     48          59.3
 11      21     51          62.8
 12      23     54          67.2
```

Figure 16. Example of first-arrival entries.

data as entered into the first arrival data entry program. In this sample, only data for the first spread (PN 1 through PN 23) as shot from the SP at PN -13 are shown.

After first arrival data are entered, you are asked if you want to tabulate what you have entered. If you reply with a Y, you are given the choice as to whether you want to tabulate on the printer or on the screen. A printer is not included in the list of the equipment required to run the programs of this report. However, its use will speed the operation of the programs and will save space in presentation of results of this report. Figure 17 is a reduced copy of the two screen displays, combined here on one page, to show a tabulation of the data entered for the first logical unit of work for the illustrative example.

Finally, you are given instructions and prompts (bottom of fig. 17) for storage of first-arrival data on tape. After storing, the program reads the tape to check on the retrievability of what was written on it.

```
AREA(A$): ILLUSTRATIVE EXAMPLE   LINE NUMBER(L0): 3
NO OF SPDS=6, NO OF TRACES=12, NO OF STA=37
PN INT(P0)=1.5, FIRST SP PN(P1)=-13, LAST SP PN=59
NEAR SEIS O/S FOR FORWARD SPD (X3) = 21
NEAR SEIS O/S FOR REVERSE SPD (X4) = 24

FIRST ARRIVAL TIMES FOR FORWARD SPREADS
SP@PN -13  SPREAD FROM PN 1 TO 23; T1(1,K)
      34.7        38.2        40.3        42.6
      45.1        47.8        50.6        54.5
      55.9        59.3        62.9        67.2
SP@PN -9  SPREAD FROM PN 5 TO 27; T1(2,K)
      34.5        36.8        39.3        42.6
      44.8        47.3        50.1        54.5
      57.0        61.0        64.3        67.2
SP@PN -5  SPREAD FROM PN 9 TO 31; T1(3,K)
      33.3        36.0        38.8        42.6
      44.1        47.4        51.0        54.5
      58.3        61.2        64.0        67.2
SP@PN -1  SPREAD FROM PN 13 TO 35; T1(4,K)
      32.1        34.6        37.4        42.6
      44.3        48.3        51.6        54.5
      57.3        61.0        64.0        67.2
SP@PN 3  SPREAD FROM PN 17 TO 39; T1(5,K)
      30.9        34.2        37.7        42.6
      45.1        48.0        50.8        54.5
      57.5        60.5        63.8        67.2
SP@PN 7  SPREAD FROM PN 21 TO 43; T1(6,K)
      30.2        34.2        37.6        42.6
      43.2        46.9        49.9        54.5
      56.3        59.6        63.0        67.2

FIRST ARRIVAL TIMES FOR REVERSE SPREADS
SP@PN 39  SPREAD FROM PN 1 TO 23; T2(1,K)
      69.6        67.2        63.3        59.6
      56.1        52.7        49.6        46.0
      42.9        40.2        37.7        35.8
SP@PN 43  SPREAD FROM PN 5 TO 27; T2(2,K)
      70.0        66.3        62.8        59.4
      56.3        52.7        49.6        46.9
      44.4        42.5        39.8        36.6
SP@PN 47  SPREAD FROM PN 9 TO 31; T2(3,K)
      70.0        66.6        63.5        60.8
      56.8        54.1        51.6        49.7
      47.0        43.9        40.7        38.4
SP@PN 51  SPREAD FROM PN 13 TO 35; T2(4,K)
      70.5        67.0        63.8        61.2
      58.7        56.7        54.1        50.9
      47.7        45.4        42.4        39.4
SP@PN 55  SPREAD FROM PN 17 TO 39; T2(5,K)
      69.8        67.2        64.7        62.7
      60.1        56.9        53.7        51.4
      48.4        45.4        42.8        40.1
SP@PN 59  SPREAD FROM PN 21 TO 43; T2(6,K)
      70.3        68.4        65.7        62.5
      59.4        57.1        54.1        51.1
      48.4        45.8        43.1        40.5

DO YOU WANT TO CHANGE AN ENTERED FB TIME? (Y OR N) [N]

FILE NUMBER = [23]
REQUIRED FILE SPACE = 1836
IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) [Y]
INSERT FB DATA TAPE IN 4924

ARE YOU READY TO PROCEED? (Y OR N) [Y]

PROGRAM COMPLETED
```

Figure 17. Tabulation of first arrivals for first logical unit of work.

Figures 18 and 19 show the first screen displays and tabulations of first-arrival data entered for the second and third logical work units used in the illustrative example.

Figure 20 shows examples of the procedure used to correct previously entered first arrivals. This program segment would have been brought in if you had answered the first question of the program with a Y.

```
CORRECT AND/OR ENTER FIRST ARRIVAL DATA FOR 6-FOLD, 2-WAY STATICS
NOTE: LOGICAL UNIT OF WORK (LUW) REFERRED TO IN THIS PROGRAM
   CONSISTS OF RECORDS TAKEN USING TWO, 12-TAKEOUT CABLES
   SHOT FROM SIX FORWARD AND SIX REVERSE SOURCE POINTS.

DO YOU WANT TO CORRECT AN EXISTING FB DATA TAPE? (Y OR N) N

AREA (24 char) = ILLUSTRATIVE EXAMPLE
   LINE NUMBER = 3

WAS A LOGICAL UNIT OF WORK PERFORMED? (Y OR N) Y

PN INT. (m/PN) = 1.5
PN OF FIRST SP = 11
NEAR-TRACE O/S FOR FORWARD SPDS (m) = 21
NEAR-TRACE O/S FOR REVERSE SPDS (m) = 24
 PN OF LAST SP = 83

ARE YOU READY TO PROCEED? (Y OR N) Y


  AREA(A$): ILLUSTRATIVE EXAMPLE   LINE NUMBER(L0): 3
  NO OF SPDS=6, NO OF TRACES=12, NO OF STA=37
  PN INT(P0)=1.5, FIRST SP PN(P1)=11, LAST SP PN=83
  NEAR SEIS O/S FOR FORWARD SPD (X3) = 21
  NEAR SEIS O/S FOR REVERSE SPD (X4) = 24

  FIRST ARRIVAL TIMES FOR FORWARD SPREADS
  SP@PN 11  SPREAD FROM PN 25 TO 47; T1(1,K)
       30.7       33.5       36.4       42.6
       43.0       46.0       49.4       54.5
       56.1       59.4       63.1       67.2
  SP@PN 15  SPREAD FROM PN 29 TO 51; T1(2,K)
       29.7       33.4       36.4       42.6
       42.7       46.0       49.4       54.5
       56.4       60.0       63.5       67.2
  SP@PN 19  SPREAD FROM PN 33 TO 55; T1(3,K)
       30.5       33.5       36.9       42.6
       43.6       46.9       50.6       54.5
       57.6       61.2       64.7       67.2
  SP@PN 23  SPREAD FROM PN 37 TO 59; T1(4,K)
       32.4       35.8       39.1       42.6
       46.2       49.7       53.2       54.5
       60.2       62.7       65.7       67.2
  SP@PN 27  SPREAD FROM PN 41 TO 63; T1(5,K)
       33.3       36.6       40.3       42.6
       47.4       50.9       54.4       54.5
       59.9       62.5       64.9       67.2
  SP@PN 31  SPREAD FROM PN 45 TO 67; T1(6,K)
       34.9       38.4       41.9       42.6
       48.9       54.1       54.4       54.5
       59.4       62.7       63.5       67.2

  FIRST ARRIVAL TIMES FOR REVERSE SPREADS
  SP@PN 63  SPREAD FROM PN 25 TO 47; T2(1,K)
       71.4       68.2       65.0       62.7
       59.7       56.7       54.1       51.4
       48.8       46.1       43.8       41.3
  SP@PN 67  SPREAD FROM PN 29 TO 51; T2(2,K)
       70.2       67.9       64.9       61.9
       59.2       56.5       53.9       51.2
       48.9       46.5       44.0       41.5
  SP@PN 71  SPREAD FROM PN 33 TO 55; T2(3,K)
       69.8       66.8       64.2       61.5
       58.9       56.2       53.9       51.4
       48.9       46.5       44.0       40.5
  SP@PN 75  SPREAD FROM PN 37 TO 59; T2(4,K)
       71.9       69.2       66.6       63.9
       61.6       59.1       56.7       54.2
       51.7       48.2       45.2       41.8
  SP@PN 79  SPREAD FROM PN 41 TO 63; T2(5,K)
       74.3       71.7       69.4       66.9
       64.4       61.9       59.4       55.9
       52.9       49.6       45.9       43.2
  SP@PN 83  SPREAD FROM PN 45 TO 67; T2(6,K)
       74.7       72.2       69.7       67.2
       64.7       61.2       58.2       54.9
       51.2       48.5       45.4       41.7

  DO YOU WANT TO CHANGE AN ENTERED FB TIME? (Y OR N) N

  FILE NUMBER = 25
  REQUIRED FILE SPACE = 1836
  IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) Y
  INSERT FB DATA TAPE IN 4924

  ARE YOU READY TO PROCEED? (Y OR N) Y

  PROGRAM COMPLETED
```

Figure 18. First page of data entry and tabulation of first arrivals for the second logical unit of work.

```
CORRECT AND/OR ENTER FIRST ARRIVAL DATA FOR 6-FOLD, 2-WAY STATICS
NOTE: LOGICAL UNIT OF WORK (LUW) REFERRED TO IN THIS PROGRAM
   CONSISTS OF RECORDS TAKEN USING TWO, 12-TAKEOUT CABLES
   SHOT FROM SIX FORWARD AND SIX REVERSE SOURCE POINTS.

DO YOU WANT TO CORRECT AN EXISTING FB DATA TAPE? (Y OR N) [N]

AREA (24 char) = [ILLUSTRATIVE EXAMPLE]
   LINE NUMBER = [3]

WAS A LOGICAL UNIT OF WORK PERFORMED? (Y OR N) [Y]

PN INT. (m/PN) = [1.5]
PN OF FIRST SP = [35]
NEAR-TRACE O/S FOR FORWARD SPDS (m) = [21]
NEAR-TRACE O/S FOR REVERSE SPDS (m) = [24]
 PN OF LAST SP = 107

ARE YOU READY TO PROCEED? (Y OR N) [Y]

   AREA(A8): ILLUSTRATIVE EXAMPLE   LINE NUMBER(L0): 3
   NO OF SPDS=6, NO OF TRACES=12, NO OF STA=37
   PN INT(P0)=1.5, FIRST SP PN(P1)=35, LAST SP PN=107
   NEAR SEIS O/S FOR FORWARD SPD (X3) = 21
   NEAR SEIS O/S FOR REVERSE SPD (X4) = 24

   FIRST ARRIVAL TIMES FOR FORWARD SPREADS
   SP0PN 35  SPREAD FROM PN 49 TO 71; T1(1,K)
        35.9       39.4       42.9       42.6
        48.4       51.1       53.4       54.5
        59.5       61.9       64.3       67.2
   SP0PN 39  SPREAD FROM PN 53 TO 75; T1(2,K)
        37.6       40.1       43.1       42.6
        48.1       51.4       54.2       54.5
        59.0       61.5       65.2       67.2
   SP0PN 43  SPREAD FROM PN 57 TO 79; T1(3,K)
        37.8       40.5       42.8       42.6
        48.9       51.2       53.7       54.5
        59.9       63.9       67.8       67.2
   SP0PN 47  SPREAD FROM PN 61 TO 83; T1(4,K)
        38.0       41.3       44.1       42.6
        48.9       51.4       55.1       54.5
        63.0       66.9       70.1       67.2
   SP0PN 51  SPREAD FROM PN 65 TO 87; T1(5,K)
        39.2       41.5       44.0       42.6
        50.1       54.2       58.1       54.5
        65.1       67.2       69.2       67.2
   SP0PN 55  SPREAD FROM PN 69 TO 91; T1(6,K)
        38.0       40.5       44.1       42.6
        52.1       55.9       59.1       54.5
        63.2       65.1       67.6       67.2

   FIRST ARRIVAL TIMES FOR REVERSE SPREADS
   SP0PN 87  SPREAD FROM PN 49 TO 71; T2(1,K)
        73.6       71.1       68.7       65.1

        62.1       58.8       55.1       52.5
        49.3       45.6       42.1       38.5
   SP0PN 91  SPREAD FROM PN 53 TO 75; T2(2,K)
        74.1       70.6       67.6       64.3
        60.6       57.9       54.8       51.1
        47.5       44.0       41.7       39.8
   SP0PN 95  SPREAD FROM PN 57 TO 79; T2(3,K)
        74.1       70.8       67.1       64.5
        61.3       57.6       54.1       50.5
        48.2       46.3       44.1       42.0
   SP0PN 99  SPREAD FROM PN 61 TO 83; T2(4,K)
        73.5       70.8       67.6       63.9
        60.4       56.9       54.6       52.6
        50.5       48.4       45.5       41.7
   SP0PN 103  SPREAD FROM PN 65 TO 87; T2(5,K)
        73.6       69.9       66.4       62.9
        60.6       58.6       56.5       54.4
        51.5       47.7       43.6       39.6
   SP0PN 107  SPREAD FROM PN 69 TO 91; T2(6,K)
        72.1       68.5       66.2       64.3
        62.1       60.0       57.2       53.3
        49.3       45.2       41.7       38.7

   DO YOU WANT TO CHANGE AN ENTERED FB TIME? (Y OR N) [N]

   FILE NUMBER = [26]
   REQUIRED FILE SPACE = 1836
   IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) [Y]
   INSERT FB DATA TAPE IN 4924

   ARE YOU READY TO PROCEED? (Y OR N) [Y]

   PROGRAM COMPLETED
```

Figure 19. First page of data entry and tabulation of first arrivals for the third logical unit of work.

```
CORRECT AND-OR ENTER FIRST ARRIVAL DATA FOR 6-FOLD, 2-WAY STATICS
NOTE: LOGICAL UNIT OF WORK (LUW) REFERRED TO IN THIS PROGRAM
   CONSISTS OF RECORDS TAKEN USING TWO, 12-TAKEOUT CABLES
   SHOT FROM SIX FORWARD AND SIX REVERSE SOURCE POINTS.

DO YOU WANT TO CORRECT AN EXISTING FB DATA TAPE? (Y OR N) [Y]
INSERT FB DATA TAPE IN 4924        FILE NO. =[24]
AREA: ILLUSTRATIVE EXAMPLE    LINE NUMBER: 3
DO YOU WANT TO CHANGE FB TIME ON FORWARD SPREAD? (Y OR N) [Y]
SPREAD NUMBER (1 THRU 6) WITHIN LUW = [3]
TRACE NUMBER = [6]
    Old value = 24.4
    New value = [47.4]
DO YOU WANT TO CHANGE ANOTHER VALUE? (Y OR N) [N]
DO YOU WANT TO CHANGE FB TIME ON REVERSE SPREAD? (Y OR N) [Y]
SPREAD NUMBER (1 THRU 6) WITHIN LUW = [1]
 TRACE NUMBER =[1]
    Old value = 38.7
    New value = [37.7]
DO YOU WANT TO CHANGE ANOTHER VALUE? (Y OR N) [N]

DO YOU WANT TO CORRECT ANOTHER FB DATA TAPE? (Y OR N) [Y]
INSERT FB DATA TAPE IN 4924        FILE NO. =[25]
AREA: ILLUSTRATIVE EXAMPLE    LINE NUMBER: 3
DO YOU WANT TO CHANGE FB TIME ON FORWARD SPREAD? (Y OR N) [N]
SPREAD NUMBER (1 THRU 6) WITHIN LUW =[2]
 TRACE NUMBER =[10]
    Old value = 19.5
    New value =[46.5]
DO YOU WANT TO CHANGE ANOTHER VALUE? (Y OR N) [N]

DO YOU WANT TO CORRECT ANOTHER FB DATA TAPE? (Y OR N) [N]
DO YOU WANT TO ENTER NEW FIRST ARRIVAL DATA? (Y OR N) [N]

PROGRAM COMPLETED
```

Figure 20. Copy of screen display showing examples of procedure to correct stored first arrivals.

Now that the surveying and first arrival data have been entered, stored, and corrected, let us use these values to compute static corrections at each detector position for each spread shot.

DISCUSSION OF PROGRAM TO COMPUTE STATIC CORRECTIONS

The program begins by reading a series (three for the illustrative example) of first arrival tapes each containing 12 sets of first break times--one logical unit of work. It then reorders these data to make them appear to the computer as if data for the complete line had been entered from one data tape. After determining the total number of PN's, the program asks for the surveying data tape to be inserted and then reads from it only those elevations that it needs for the computations.

The program then pauses and gives you time to verify that correct data sets have been entered. In the illustrative example, as shown on figure 21, first arrivals and elevations were all obtained along line 3 and the line extended from the SP at PN -13 to the SP at PN 107. Note that the logical units of work in this example (filed in files 24, 25, and 26) begin at SP's whose PN's are separated by a constant--in this illustrative example equal to 24. If the surveying coverage had been insufficient, an error message would have been printed on the screen. By replying with a Y to the question as to whether the data sets are in agreement you have given the program the signal to continue.

Although the example on figure 21 shows that we have requested a tabulation of the input data on the printer, in the interest of reducing the number of pages in this report, let us assume this has been done (the input data can be found in the previous examples--fig. 12 for the elevations, and fig. 17, 18, and 19 for the first arrivals), and go to the next set of entries.

```
COMPUTE STATICS USING SIX-FOLD, TWO-WAY PROCEDURE
NUMBER OF FIRST ARRIVAL DATA TAPES = [3]

INSERT # 1 FIRST ARRIVAL DATA TAPE IN 4924
FILE NUMBER OF # 1 FB DATA TAPE = [24]
AREA:ILLUSTRATIVE EXAMPLE; LINE:3; FIRST SP@PN -13; LAST SP@PN 59

INSERT # 2 FIRST ARRIVAL DATA TAPE IN 4924
FILE NUMBER OF # 2 FB DATA TAPE = [25]
AREA:ILLUSTRATIV EXAMPLE; LINE:3; FIRST SP@PN 11; LAST SP@PN 83

INSERT # 3 FIRST ARRIVAL DATA TAPE IN 4924
FILE NUMBER OF # 3 FB DATA TAPE = [26]
AREA:ILLUSTRATIVE EXAMPLE; LINE:3; FIRST SP@PN 35; LAST SP@PN 107

TOTAL NUMBER OF SPREADS SHOT = 18

INSERT SURVEYING-DATA TAPE IN 4924       FILE NO. = [23]
AREA:ILLUSTRATIVE EXAMPLE; LINE:3; FIRST SP@PN -13; LAST SP@PN 111

ARE DATA SETS IN AGREEMENT? (Y OR N) [Y]

DO YOU WANT TO TABULATE INPUT DATA? (Y OR N) [Y]
DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) [Y]
```

Figure 21. Screen copy showing first page of entries for the static correction program.

Here you are to enter the estimated velocity in the LVL, the estimated velocity immediately below the LVL (the sub LVL), and the assumed datum velocity. In the illustrative example these values are 0.5, 1.0, and 1.25 km/sec (m/msec) respectively, as shown on figure 22. A full discussion of how these velocity estimates are made is beyond the scope of this report; however, a brief mention may be in order.

```
    ESTIMATED LVL VEL = 0.5
ESTIMATED SUB-LVL VEL = 1.0
    ASSUMED DATUM VEL = 1.25
      DATUM ELEVATION = 90

DO YOU WANT TO TABULATE STATIC CORRECTIONS? (Y OR N) [Y]
DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) [Y]

DO YOU WANT TO STORE STATIC CORRECTIONS? (Y OR N) [Y]
FILE NUMBER = [27]

REQUIRED FILE SPACE = 11264

IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) [Y]

INSERT STATIC CORRECTIONS TAPE IN 4924
ARE YOU READY TO PROCEED? (Y OR N) [Y]

PROGRAM COMPLETED
```

Figure 22. Screen copy showing second page of entries for the static correction program.

The best procedure for determining velocities is to run a series of downhole velocity surveys to measure the vertical velocites and their lateral variations directly. In a coal-development prospect, these data may be obtainable by conducting downhole surveys in exploratory holes at scattered locations. If no holes are available, the next best course is to determine an approximate evaluation using refraction methods. Here you must be aware of severe anisotropy that may exist, particularly with shear-wave propagation. Another basic procedure is to view the final seismic section and observe if there exists a correlation (negative or positive) between the coal-horizon reflections and the topography. If the correspondence is untenable geologically, you can rerun the statics program with a different set of velocites and then review the new display of the seismic section.

A tabulation of the static corrections obtained with the velocites as entered on figure 22 is shown on figure 23. Here the printer was used, the results reduced in size, and both the static corrections for the forward and reverse spreads displayed on one page.

After tabulation, static corrections together with information needed to plot elevations and adjusted first arrivals are stored on tape. Because of the limited memory (32K bytes) of the computer for which these programs were written, the computation and plot programs were written as separate programs. If the user's computer has a larger memory, I suggest that these programs be combined.

DISCUSSION OF PROGRAM TO PLOT ADJUSTED FIRST ARRIVALS, GROUND AND LVL ELEVATIONS, AND TIME TO DATUM AT EACH STATION

Figure 24 is a copy of the screen display showing the three sets of plots (on one sheet) produced by the last program of this report. After inserting the data tape produced by the statics correction program in the 4924 and entering the number of the file in which the data are stored (27 in this this example), you are asked to supply the tickmark intervals you want on the plots. To assist you in these choices, differences between the minimum and maximum values (to the nearest integer) of the quantities to be plotted are printed. However, before these tickmark intervals are entered, let us discuss the quantities that are computed and plotted by this program--more is shown than the side labels (being limited to one size of lettering) of these working plots imply.

The upper set of curves on figure 24 are the adjusted FB's (first arrivals) versus spread distance in meters for each of the 18 forward and 18 reverse spreads of the illustrative example. Adjusted FB times are those after delay time at the SP and delay times at each detector position have been subtracted from the observed first arrival times. The inverse slopes of these curves thus equal the horizontal component of the sub-LVL velocity. Because in the illustrative example a forward modeling program based on the same assumptions as used in the statics computation procedure was used to compute first arrival times, the plotted adjusted FB's on figure 24 appear with a smoothness and parallelism that you could not expect to obtain with real data. The value of this display will become patently evident after you work with real data. For example, an incorrect entry of a FB time will be revealed as a bump on one of the curves, a change in sub-LVL velocity along the traverse will be shown as a set of slope differences, and an occurence of a body of limited extent and anomalously low velocity within the LVL will be

```
AREA: ILLUSTRATIVE EXAMPLE  LINE NO 3

STATIC CORRECTIONS FOR FORWARD SPREADS
SP 0 PN -13  SPREAD FROM PN 1 TO 23
   1   56.7    2   57.0    3   56.0    4   55.1
   5   54.4    6   53.9    7   53.5    8   52.6
   9   52.1   10   52.4   11   52.8   12   53.5
SP 0 PN -9  SPREAD FROM PN 5 TO 27
   1   57.4    2   56.5    3   55.5    4   54.8
   5   54.3    6   53.9    7   53.0    8   52.6
   9   52.8   10   53.2   11   53.9   12   54.2
SP 0 PN -5  SPREAD FROM PN 9 TO 31
   1   56.4    2   55.4    3   54.8    4   54.3
   5   53.8    6   52.9    7   52.5    8   52.7
   9   53.1   10   53.9   11   54.1   12   54.1
SP 0 PN -1  SPREAD FROM PN 13 TO 35
   1   54.6    2   54.0    3   53.5    4   53.0
   5   52.1    6   51.7    7   51.9    8   52.3
   9   53.1   10   53.3   11   53.3   12   53.2
SP 0 PN 3  SPREAD FROM PN 17 TO 39
   1   53.4    2   53.0    3   52.5    4   51.6
   5   51.2    6   51.4    7   51.8    8   52.6
   9   52.8   10   52.8   11   52.7   12   53.6
SP 0 PN 7  SPREAD FROM PN 21 TO 43
   1   51.8    2   50.6    3   49.7    4   49.3
   5   49.5    6   49.9    7   50.7    8   50.9
   9   50.9   10   50.7   11   51.7   12   51.7
SP 0 PN 11  SPREAD FROM PN 25 TO 47
   1   49.5    2   48.5    3   48.1    4   48.3
   5   48.8    6   49.5    7   49.7    8   49.7
   9   49.6   10   50.6   11   50.5   12   50.5
SP 0 PN 15  SPREAD FROM PN 29 TO 51
   1   47.2    2   46.8    3   47.0    4   47.4
   5   48.2    6   48.4    7   48.4    8   48.2
   9   49.2   10   49.2   11   49.2   12   49.6
SP 0 PN 19  SPREAD FROM PN 33 TO 55
   1   46.5    2   46.8    3   47.2    4   47.9
   5   48.2    6   48.2    7   48.8    8   49.0
   9   49.0   10   49.0   11   49.4   12   49.9
SP 0 PN 23  SPREAD FROM PN 37 TO 59
   1   47.9    2   48.4    3   49.1    4   49.3
   5   49.3    6   49.2    7   50.2    8   50.2
   9   50.2   10   50.6   11   51.1   12   51.8
SP 0 PN 27  SPREAD FROM PN 41 TO 63
   1   48.6    2   49.3    3   49.6    4   49.5
   5   49.4    6   50.4    7   50.4    8   50.4
   9   50.8   10   51.3   11   52.8   12   52.6
SP 0 PN 31  SPREAD FROM PN 45 TO 67
   1   50.2    2   50.4    3   50.4    4   50.3
   5   51.3    6   51.2    7   51.2    8   51.6
   9   52.2   10   52.8   11   53.5   12   54.4
SP 0 PN 35  SPREAD FROM PN 49 TO 71
   1   50.4    2   50.4    3   50.2    4   51.2
   5   51.2    6   51.2    7   51.6    8   52.2
   9   52.8   10   53.4   11   54.4   12   55.3
SP 0 PN 39  SPREAD FROM PN 53 TO 75
   1   51.3    2   51.2    3   52.2    4   52.2
   5   52.2    6   52.6    7   53.1    8   53.0
   9   54.4   10   55.4   11   56.2   12   57.0
SP 0 PN 43  SPREAD FROM PN 57 TO 79
   1   52.5    2   53.5    3   53.4    4   53.4
   5   53.8    6   54.4    7   55.0    8   55.7
   9   56.6   10   57.5   11   58.2   12   59.8
SP 0 PN 47  SPREAD FROM PN 61 TO 83
   1   55.3    2   55.3    3   55.3    4   55.7
   5   56.2    6   56.9    7   57.5    8   58.4
   9   59.3   10   60.1   11   60.8   12   61.5
SP 0 PN 51  SPREAD FROM PN 65 TO 87
   1   56.8    2   56.8    3   57.2    4   57.7
   5   58.4    6   59.0    7   60.0    8   60.8
   9   61.6   10   62.3   11   63.0   12   62.6
SP 0 PN 55  SPREAD FROM PN 69 TO 91
   1   57.1    2   57.5    3   58.0    4   58.7
   5   59.3    6   60.3    7   61.1    8   61.9
   9   62.6   10   63.3   11   63.0   12   63.2

STATIC CORRECTIONS FOR REVERSE SPREADS
SP 0 PN 39  SPREAD FROM PN 1 TO 23
   1   54.3    2   54.6    3   53.6    4   52.7
   5   52.0    6   51.5    7   51.1    8   50.2
   9   49.7   10   49.9   11   50.4   12   51.1
SP 0 PN 43  SPREAD FROM PN 5 TO 27
   1   55.8    2   54.9    3   53.9    4   53.3
   5   52.8    6   52.4    7   51.4    8   51.0
   9   51.2   10   51.7   11   52.4   12   52.6
SP 0 PN 47  SPREAD FROM PN 9 TO 31
   1   56.7    2   55.8    3   55.1    4   54.6
   5   54.2    6   53.2    7   52.8    8   52.0
   9   53.5   10   54.2   11   54.4   12   54.4
SP 0 PN 51  SPREAD FROM PN 13 TO 35
   1   57.3    2   56.6    3   56.1    4   55.7
   5   54.8    6   54.3    7   54.5    8   55.0
   9   55.7   10   56.0   11   55.9   12   55.8
SP 0 PN 55  SPREAD FROM PN 17 TO 39
   1   56.9    2   56.4    3   56.0    4   55.1
   5   54.6    6   54.9    7   55.3    8   56.0
   9   56.3   10   56.2   11   56.1   12   57.1
SP 0 PN 59  SPREAD FROM PN 21 TO 43
   1   56.3    2   55.9    3   54.9    4   54.5
   5   54.7    6   55.2    7   55.9    8   56.1
   9   56.1   10   56.0   11   57.0   12   56.9
SP 0 PN 63  SPREAD FROM PN 25 TO 47
   1   55.4    2   54.5    3   54.1    4   54.3
   5   54.7    6   55.5    7   55.7    8   55.7
   9   55.6   10   56.5   11   56.5   12   56.5
SP 0 PN 67  SPREAD FROM PN 29 TO 51
   1   52.9    2   52.4    3   52.7    4   53.1
   5   53.8    6   54.1    7   54.0    8   53.9
   9   54.9   10   54.9   11   54.9   12   55.3
SP 0 PN 71  SPREAD FROM PN 33 TO 55
   1   50.4    2   50.6    3   51.0    4   51.8
   5   52.0    6   52.0    7   51.8    8   52.8
   9   52.8   10   52.8   11   53.2   12   53.8
SP 0 PN 75  SPREAD FROM PN 37 TO 59
   1   50.8    2   51.3    3   52.0    4   52.2
   5   52.2    6   52.1    7   53.1    8   53.0
   9   53.0   10   53.4   11   54.0   12   54.6
SP 0 PN 79  SPREAD FROM PN 41 TO 63
   1   52.1    2   52.8    3   53.0    4   53.0
   5   52.9    6   53.9    7   53.8    8   53.8
   9   54.2   10   54.8   11   55.4   12   56.1
SP 0 PN 83  SPREAD FROM PN 45 TO 67
   1   52.5    2   52.7    3   52.7    4   52.6
   5   53.6    6   53.5    7   53.5    8   53.9
   9   54.5   10   55.1   11   55.8   12   56.7
SP 0 PN 87  SPREAD FROM PN 49 TO 71
   1   51.9    2   51.9    3   51.8    4   52.8
   5   52.7    6   52.7    7   53.1    8   53.7
   9   54.3   10   55.0   11   55.9   12   56.0
SP 0 PN 91  SPREAD FROM PN 53 TO 75
   1   52.9    2   52.8    3   53.0    4   53.8
   5   53.8    6   54.2    7   54.7    8   55.4
   9   56.0   10   57.0   11   57.8   12   58.6
SP 0 PN 95  SPREAD FROM PN 57 TO 79
   1   54.2    2   55.2    3   55.1    4   55.1
   5   55.5    6   56.1    7   56.8    8   57.4
   9   58.3   10   59.2   11   59.9   12   60.7
SP 0 PN 99  SPREAD FROM PN 61 TO 83
   1   55.9    2   55.0    3   55.8    4   56.2
   5   56.0    6   57.4    7   58.0    8   59.8
   9   59.9   10   60.6   11   61.4   12   62.1
SP 0 PN 103  SPREAD FROM PN 65 TO 87
   1   56.0    2   56.0    3   56.4    4   57.0
   5   57.6    6   58.3    7   59.2    8   60.1
   9   60.0   10   61.6   11   62.3   12   61.9
SP 0 PN 107  SPREAD FROM PN 69 TO 91
   1   55.7    2   56.1    3   56.7    4   57.3
   5   57.9    6   58.9    7   59.0    8   60.5
   9   61.3   10   62.0   11   61.6   12   61.8
```

Figure 23. Tabulation of static corrections for each record.

PLOT ADJ. FB'S, ELEV, LVL, & STATIC CORR. FOR 6-FOLD, 2-WAY PROCEDURE

INSERT DATA TAPE IN 4924 FILE NO.=27

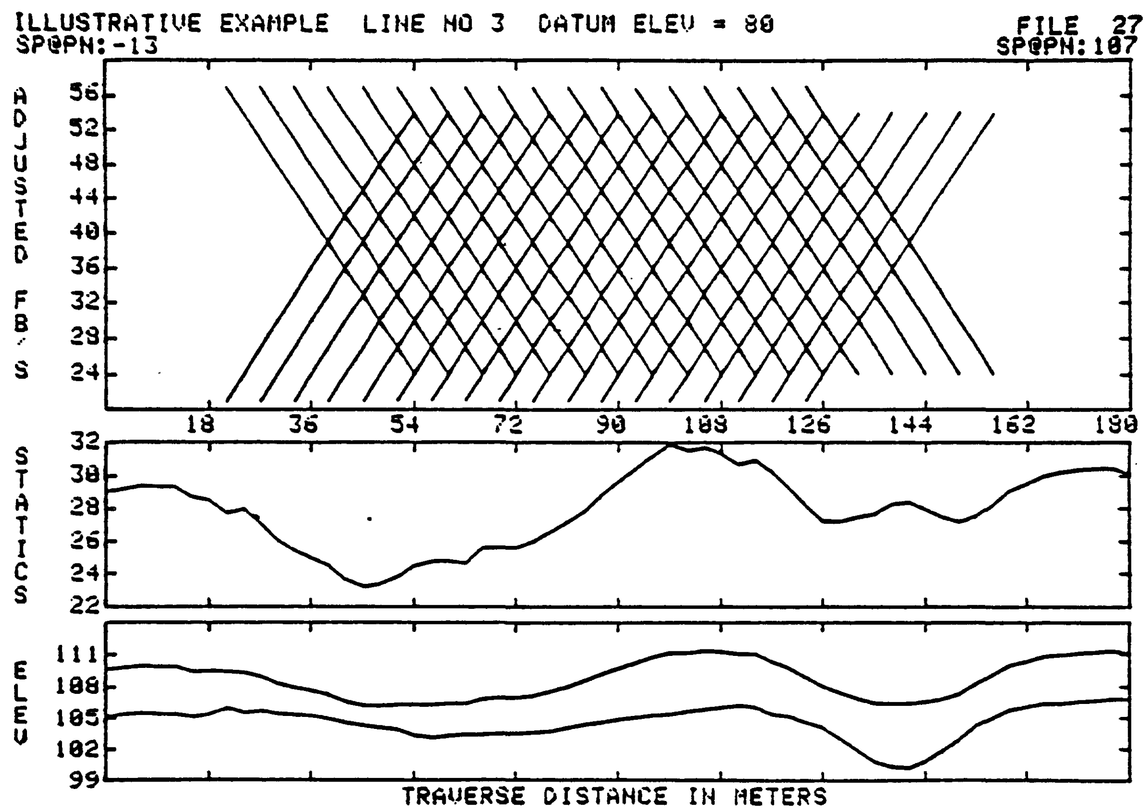
SELECT TICKMARK INTERVALS

Elevation difference = 11
Elevation TM interval = 3

Total traverse distance = 180
Traverse TM interval = 18

Arrival time difference = 36
Arrival time TM interval = 4

Static corr. difference = 9
Static corr. TM interval = 2



DO YOU WANT TO REPLOT WITH NEW TICKMARK INTERVALS? (Y OR N) N
PROGRAM COMPLETED

Figure 24. Copy of screen display showing entries required and three three set of plots produced by the plot program.

shown as a bulge on all curves whose detector positions overlie its central location.

The middle curve labeled "STATICS" is the strip-off time to datum at each station occupied by either a SP or detector. Addition of strip-off times at the SP and the detector yields the static correction.

The bottom curve labeled "ELEV" shows the elevation of both the topography and the base of the LVL along the traverse. You can think of this presentation as a two-layer interpretation of near-surface conditions as revealed by a high redundancy ABC method. Thus, although the principal topic of this report is a discussion of the determination of first-approximation static corrections, you also should be aware that the program can be used to meet other exploration objectives.

After the plots are scanned and copied and the screen cleared , you are asked if you want to replot with a new set of tickmark intervals (bottom line on fig. 24). If you reply with an N, the program ends; if you reply with a Y, the program returns to that section of the report in which the tickmark intervals are selected.

CONCLUSIONS

The computer programs of this report when supplied data from a six-fold, two-spread-direction field procedure can be used to compute an acceptable set of first-approximation static corrections. In addition to their use in determining statics, the data obtained with the field procedure can be used for shallow-reflection surveying and for location of near-surface features through employment of common-offset methods. Thus, the programs of this report can be considered to be the first step in a total seismic study.

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PROGRAM TO ENTER SURVEYING DATA

```
100 PRINT "L_CORRECT AND/OR ENTER SURVEYING DATA FOR 6-FOLD, 2-WAY ";
110 PRINT "STATICS PROCEDURE"
120 INIT
130 DIM A$(24),G$(1)
140 DATA 1,1
150 READ Q1,Q2
160 REM ** CORRECT EXISTING SURVEYING DATA
170 GOSUB 2430
180 REM ** ENTER SPREAD INFORMATION
190 GOSUB 300
200 REM ** ENTER OR APPEND ELEVATIONS
210 GOSUB 600
220 REM ** TABULATE ENTERED DATA
230 GOSUB 720
240 REM ** PLOT ELEVATIONS
250 GOSUB 1150
260 REM ** ACCEPT ELEVATIONS AND STORE ENTERED DATA
270 GOSUB 1330
280 PRINT "G_G_G___PROGRAM COMPLETED"
290 END
300 REM ** SUB: ENTER SPREAD INFORMATION
310 PRINT "__AREA (24 char) = ";
320 INPUT A$
330 PRINT "   LINE NUMBER = ";
340 INPUT L0
350 GOSUB 1740
360 PRINT "_ NO. OF CABLES = ";
370 INPUT N1
380 PRINT "TAKEOUTS/CABLE = ";
390 INPUT N2
400 PRINT "PN INT. (m/PN) = ";
410 INPUT P0
420 PRINT "PN OF FIRST SP = ";
430 INPUT P1
440 PRINT "NEAR-DETECTOR O/S FOR FORWARD SPOS (m) = ";
450 INPUT X3
460 PRINT "NEAR-DETECTOR O/S FOR REVERSE SPOS (m) = ";
470 INPUT X4
480 IF ABS(X3-X4)=2*P0 THEN 510
490 PRINT "G_G_G_OFFSETS MUST DIFFER BY ";2*P0
500 GO TO 440
510 C9=2*(N2-2)*P0
520 IF X3 AND X4<=C9 THEN 550
530 PRINT "__G_G_G_OFFSET(S) TOO LARGE FOR PROCEDURE--MUST BE <= ";C9
540 GO TO 300
550 P2=P1+(X3+X4)/P0+2*(N1*N2-1)
560 PRINT " PN OF LAST SP = ";P2
570 N3=0.5*(P2-P1)+1
580 DIM E1(N3)
590 RETURN
600 REM ** SUB: ENTER ELEVATIONS
610 E1=0
620 N7=1
630 N8=N3
640 P9=P1-2
650 PRINT "_ PN   GROUND ELEV"
660 FOR J=N7 TO N8
670 P9=P9+2
680 PRINT " ";P9;"       ";
690 INPUT E1(J)
700 NEXT J
```

```
710 RETURN
720 REM ** SUB: TABULATE ENTERED DATA
730 PRINT "__DO YOU WANT TO TABULATE ENTERED DATA? (Y OR N) ";
740 INPUT G$
750 IF G$="N" THEN 1140
760 PRINT "DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) ";
770 INPUT G$
780 IF G$="N" THEN 810
790 U=51
800 GO TO 820
810 U=32
820 PRINT @U:"L_AREA: ";A$;"   LINE NUMBER: ";L0
830 PRINT @U:"NO OF CABLES=";N1;", TAKEOUTS/CABLE=";N2;", NO OF STA=";N3
840 PRINT @U:"PN INT (m/PN)=";P0;", FIRST SP PN=";P1;", LAST SP PN=";P9
850 PRINT @U:"NEAR SEIS O/S FOR FORWARD SPD (m) = ";X3
860 PRINT @U:"NEAR SEIS O/S FOR REVERSE SPD (m) = ";X4
870 PRINT @U:" "
880 PRINT @U:"SURFACE ELEVATIONS:"
890 N4=INT(N3/4)
900 N5=N3-4*N4
910 IMAGE X,4(3D,3X,4D.D,3X)
920 IMAGE X, (3D,3X,4D.D,3X)
930 IMAGE X,2(3D,3X,4D.D,3X)
940 IMAGE X,3(3D,3X,4D.D,3X)
950 PRINT @U:"  PN     ELEV    PN     ELEV    PN     ELEV";
960 PRINT @U:"    PN     ELEV"
970 P=P1-8
980 K=-3
990 FOR J=1 TO N4
1000 P=P+8
1010 K=K+4
1020 PRINT @U: USING 910:P,E1(K),P+2,E1(K+1),P+4,E1(K+2),P+6,E1(K+3)
1030 NEXT J
1040 IF N5=0 THEN 1130
1050 IF N5=1 THEN 1080
1060 IF N5=2 THEN 1100
1070 IF N5=3 THEN 1120
1080 PRINT @U: USING 920:P+8,E1(K+4)
1090 GO TO 1130
1100 PRINT @U: USING 930:P+8,E1(K+4),P+10,E1(K+5)
1110 GO TO 1130
1120 PRINT @U: USING 940:P+8,E1(K+4),P+10,E1(K+5),P+12,E1(K+6)
1130 PRINT @U:" "
1140 RETURN
1150 REM ** SUB: PLOT ELEVATIONS
1160 PRINT "__DO YOU WANT TO PLOT ELEVATIONS? (Y OR N) ";
1170 INPUT G$
1180 IF G$="N" THEN 1320
1190 CALL "MIN",E1,E3,I3
1200 I3=P1+2*(I3-1)
1210 CALL "MAX",E1,E4,I4
1220 I4=P1+2*(I4-1)
1230 WINDOW 1,N3,E3,E4
1240 VIEWPORT 0,130,0,90
1250 PRINT "L_";A$;", LINE ";L0;" FROM PN ";P1;" TO PN ";P9
1260 PRINT "MIN ELEV=";E3;" AT PN ";I3;" AND MAX ELEV=";E4;" AT PN ";I4
1270 CALL "DISP",E1
1280 WINDOW 0,130,0,100
1290 VIEWPORT 0,130,0,100
1300 MOVE 0,0
1310 PRINT
```

```
1320 RETURN
1330 REM ** SUB: ACCEPT ELEVATIONS AND STORE ENTERED DATA
1340 PRINT "__DO YOU WANT TO ACCEPT ENTERED ELEVATIONS? (Y OR N) ";
1350 INPUT G$
1360 IF G$="Y" THEN 1500
1370 PRINT "PN at elevation to be changed = ";
1380 INPUT P6
1390 N6=1+0.5*(P6-P1)
1400 PRINT "    Old value = ";E1(N6)
1410 PRINT "    New value = ";
1420 INPUT E1(N6)
1430 PRINT "DO YOU WANT TO CHANGE ANOTHER ELEVATION? (Y OR N) ";
1440 INPUT G$
1450 IF G$="N" THEN 1470
1460 GO TO 1370
1470 IF Q2=1 THEN 1500
1480 F0=F2
1490 GO TO 1630
1500 PRINT "__FILE NUMBER = ";
1510 INPUT F0
1520 F1=(1+INT((140+10*N3)/256))*256
1530 PRINT "__REQUIRED FILE SPACE = ";F1
1540 PRINT "__IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) ";
1550 INPUT G$
1560 IF G$="Y" THEN 1610
1570 PRINT "__G_G_G_INSERT DATA TAPE IN 4051"
1580 GOSUB 1690
1590 FIND F0
1600 MARK 1,F1
1610 PRINT "G_G_G___INSERT DATA TAPE IN 4924"
1620 GOSUB 1690
1630 FIND @2:F0
1640 WRITE @2:A$,L0,N1,N2,N3,P0,P1,P9,X3,X4,E1
1650 PRINT @2,2:
1660 FIND @2:F0
1670 READ @2:A$,L0,N1,N2,N3,P0,P1,P9,X3,X4,E1
1680 RETURN
1690 REM ** SUB: READY TO PROCEED?
1700 PRINT "__ARE YOU READY TO PROCEED? (Y OR N) ";
1710 INPUT G$
1720 IF G$="N" THEN 1700
1730 RETURN
1740 REM ** SUB: ADD CABLES TO LINE
1750 PRINT "__DO YOU WANT TO ADD CABLES TO LINE? (Y OR N) ";
1760 INPUT G$
1770 IF G$="N" THEN 1730
1780 PRINT "DO YOU WANT TO ADD CABLES TO BEGINNING OF LINE? (Y OR N) ";
1790 INPUT G$
1800 IF G$="N" THEN 2080
1810 GOSUB 2280
1820 N3=N3+N6
1830 P1=P1-2*N6
1840 PRINT "    New PN of first SP = ";P1
1850 DIM E2(N3)
1860 E2=0
1870 K=0
1880 FOR J=N6+1 TO N3
1890 K=K+1
1900 E2(J)=E1(K)
1910 NEXT J
1920 DELETE E1
```

```
1930 DIM E1(N3)
1940 E1=E2
1950 DELETE E2
1960 N7=1
1970 N8=N6
1980 GOSUB 640
1990 GOSUB 720
2000 GOSUB 1150
2010 GOSUB 1330
2020 IF Q1=2 THEN 280
2030 GOSUB 2050
2040 GO TO 280
2050 PRINT "DO YOU WANT TO ADD CABLES TO END OF LINE? (Y OR N) ";
2060 INPUT G$
2070 IF G$="N" THEN 280
2080 GOSUB 2280
2090 Q1=2
2100 N3=N3+N6
2110 P3=P2+2*N6
2120 PRINT "   New PN of last SP = ";P3
2130 DIM E2(N3)
2140 E2=0
2150 K=0
2160 FOR J=1 TO N3-N6
2170 E2(J)=E1(J)
2180 NEXT J
2190 DELETE E1
2200 DIM E1(N3)
2210 E1=E2
2220 DELETE E2
2230 N7=N3-N6+1
2240 N8=N3
2250 P9=P2
2260 GOSUB 630
2270 GO TO 1990
2280 REM ** SUB: APPEND CABLES, COMMON SUB
2290 PRINT "G_G_G___INSERT DATA TAPE IN 4924"
2300 PRINT "NUMBER OF FILE CONTAINING OLD VALUES = ";
2310 INPUT F2
2320 FIND @2:F2
2330 READ @2:A$,L0,N1,N2,N3,P0,P1,P9,X3,X4
2340 P2=P9
2350 DIM E1(N3)
2360 READ @2:E1
2370 IF Q2=2 THEN 2420
2380 PRINT "NUMBER OF CABLES TO BE ADDED = ";
2390 INPUT N6
2400 N1=N1+N6
2410 N6=N6*N2
2420 RETURN
2430 REM ** SUB: CORRECT EXISTING SURVEYING DATA
2440 PRINT "__DO YOU WANT TO CORRECT EXISTING DATA? (Y OR N) ";
2450 INPUT G$
2460 IF G$="N" THEN 2530
2470 Q2=2
2480 GOSUB 2290
2490 GOSUB 1370
2500 PRINT "__ DO YOU WANT TO ENTER NEW ELEVATIONS? (Y OR N) ";
2510 INPUT G$
2520 IF G$="N" THEN 280
2530 RETURN
```

PROGRAM TO ENTER FIRST ARRIVALS

```
100 PRINT "L_CORRECT AND/OR ENTER FIRST ARRIVAL DATA FOR 6-FOLD, 2-WAY";
110 PRINT " STATICS"
120 INIT
130 PRINT "NOTE: LOGICAL UNIT OF WORK (LUW) REFERRED TO IN THIS PROGRAM"
140 PRINT "   CONSISTS OF RECORDS TAKEN USING TWO, 12-TAKEOUT CABLES"
150 PRINT "   SHOT FROM SIX FORWARD AND SIX REVERSE SOURCE POINTS. "
160 DATA 6,12,6,32
170 READ N1,N2,N4,U
180 DIM A$(24),F$(18),G$(1),S$(18),T1(N1,N2),T2(N1,N2)
190 PRINT "__DO YOU WANT TO CORRECT AN EXISTING FB DATA TAPE? (Y OR N) ";
200 INPUT G$
210 IF G$="N" THEN 250
220 PRINT "G_G_G_INSERT FB DATA TAPE IN 4924      FILE NO. = ";
230 INPUT F0
240 GOSUB 2130
250 PRINT @U:"AREA: ";A$;"    LINE NUMBER: ";L0
260 GOSUB 1640
270 GOSUB 2090
280 PRINT "__DO YOU WANT TO CORRECT ANOTHER FB DATA TAPE? (Y OR N) ";
290 INPUT G$
300 IF G$="N" THEN 320
310 GO TO 220
320 PRINT "DO YOU WANT TO ENTER NEW FIRST ARRIVAL DATA? (Y OR N) ";
330 INPUT G$
340 IF G$="N" THEN 460
350 REM ** ENTER SPREAD INFORMATION
360 GOSUB 480
370 GOSUB 2170
380 REM ** ENTER FIRST ARRIVAL TIMES
390 GOSUB 720
400 REM ** TABULATE ENTERED DATA
410 GOSUB 1150
420 REM ** CORRECT ENTERED VALUES
430 GOSUB 1600
440 REM ** STORE ENTERED DATA
450 GOSUB 1950
460 PRINT "G_G_G___PROGRAM COMPLETED"
470 END
480 REM ** SUB: ENTER SPREAD INFORMATION
490 PRINT "__AREA (24 char) = ";
500 INPUT A$
510 PRINT "   LINE NUMBER = ";
520 INPUT L0
530 PRINT "__WAS A LOGICAL UNIT OF WORK PERFORMED? (Y OR N) ";
540 INPUT G$
550 IF G$="Y" THEN 580
560 PRINT "NO. OF TWO-WAY SPREADS SHOT = ";
570 INPUT N4
580 PRINT "__PN INT. (m/PN) = ";
590 INPUT P0
600 PRINT "PN OF FIRST SP = ";
610 INPUT P1
620 PRINT "NEAR-TRACE O/S FOR FORWARD SPDS (m) = ";
630 INPUT X3
640 PRINT "NEAR-TRACE O/S FOR REVERSE SPDS (m) = ";
650 INPUT X4
660 P2=P1+(X3+X4)/P0+2*(N2-1)+4*(N4-1)
670 PRINT " PN OF LAST SP = ";P2
680 N3=0.5*(P2-P1)+1
690 T1=0
700 T2=0
710 RETURN
720 REM ** SUB: ENTER FIRST ARRIVAL TIMES
730 REM ** FIRST ARRIVAL TIMES FOR FORWARD SPREADS
740 P3=P1+X3/P0
750 P4=2*P0
760 P6=P1-4
770 P7=P3-4
780 P8=P7+2*(N2-1)
790 FOR J=1 TO N4
```

```
800 P6=P6+4
810 P7=P7+4
820 P8=P8+4
830 P9=P7-2
840 X1=X3-P4
850 PRINT "L__SP@PN:";P6;"  SPREAD FROM PN:";P7;" TO ";P8
860 PRINT "__TRACE    PN    OFFSET    FIRST ARRIVAL TIME"
870 FOR K=1 TO N2
880 P9=P9+2
890 X1=X1+P4
900 PRINT "  ";K;"       ";P9;"       ";X1;"              ";
910 INPUT T1(J,K)
920 NEXT K
930 NEXT J
940 REM ** FIRST ARRIVAL TIMES FOR REVERSE SPREADS
950 P5=P1+X3/P0+(N2-1)*2+X4/P0
960 P6=P5-4
970 P7=P3-4
980 P8=P7+2*(N2-1)
990 FOR J=1 TO N4
1000 P6=P6+4
1010 P7=P7+4
1020 P8=P8+4
1030 P9=P7-2
1040 X2=X4+(N2-1)*P4+P4
1050 PRINT "L__SP@PN:";P6;"  SPREAD FROM PN:";P7;" TO ";P8
1060 PRINT "__TRACE    PN    OFFSET    FIRST ARRIVAL TIME"
1070 FOR K=1 TO N2
1080 P9=P9+2
1090 X2=X2-P4
1100 PRINT "  ";K;"       ";P9;"       ";X2;"              ";
1110 INPUT T2(J,K)
1120 NEXT K
1130 NEXT J
1140 RETURN
1150 REM ** SUB: TABULATE ENTERED DATA
1160 PRINT "__DO YOU WANT TO TABULATE ENTERED DATA? (Y OR N) ";
1170 INPUT G$
1180 IF G$="N" THEN 1590
1190 PRINT "DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) ";
1200 INPUT G$
1210 IF G$="N" THEN 1230
1220 U=51
1230 PRINT @U:"L__AREA(A$): ";A$;"   LINE NUMBER(L0): ";L0
1240 PRINT @U:"NO OF SPDS=";N1;", NO OF TRACES=";N2;", NO OF STA=";N3
1250 PRI @U:"PN INT(P0)=";P0;", FIRST SP PN(P1)=";P1;", LAST SP PN=";P2
1260 PRINT @U:"NEAR SEIS O/S FOR FORWARD SPD (X3) = ";X3
1270 PRINT @U:"NEAR SEIS O/S FOR REVERSE SPD (X4) = ";X4
1280 PRINT @U:" "
1290 PRINT @U:"FIRST ARRIVAL TIMES FOR FORWARD SPREADS"
1300 IMAGE 4(3X,4D.D)
1310 P3=P1+X3/P0
1320 P6=P1-4
1330 P7=P3-4
1340 P8=P7+2*(N2-1)
1350 FOR J=1 TO N4
1360 P6=P6+4
1370 P7=P7+4
1380 P8=P8+4
1390 PRI @U:"SP@PN ";P6;"  SPREAD FROM PN ";P7;" TO ";P8;";  T1(";J;",K)"
1400 FOR K=1 TO N2 STEP 4
1410 PRINT @U: USING 1300:T1(J,K),T1(J,K+1),T1(J,K+2),T1(J,K+3)
1420 NEXT K
1430 NEXT J
1440 PRINT @U:"  "
1450 PRINT @U:"FIRST ARRIVAL TIMES FOR REVERSE SPREADS"
1460 P5=P1+X3/P0+(N2-1)*2+X4/P0
1470 P6=P5-4
1480 P7=P3-4
1490 P8=P7+2*(N2-1)
1500 FOR J=1 TO N4
```

```
1510 P6=P6+4
1520 P7=P7+4
1530 P8=P8+4
1540 PRI @U:"SP@PN ";P6;"  SPREAD FROM PN ";P7;" TO ";P8;";  T2(";J;",K)"
1550 FOR K=1 TO N2 STEP 4
1560 PRINT @U: USING 1300:T2(J,K),T2(J,K+1),T2(J,K+2),T2(J,K+3)
1570 NEXT K
1580 NEXT J
1590 RETURN
1600 REM *** SUB* CORRECT ENTERED VALUES
1610 PRINT "__DO YOU WANT TO CHANGE AN ENTERED FB TIME? (Y OR N) ";
1620 INPUT G$
1630 IF G$="N" THEN 1940
1640 PRINT "DO YOU WANT TO CHANGE FB TIME ON FORWARD SPREAD? (Y OR N) ";
1650 INPUT G$
1660 IF G$="N" THEN 1820
1670 PRINT "SPREAD NUMBER (1 THRU 6) WITHIN LUW = ";
1680 INPUT N6
1690 PRINT "TRACE NUMBER = ";
1700 INPUT N7
1710 PRINT "     Old value = ";T1(N6,N7)
1720 PRINT "     New value = ";
1730 INPUT T1(N6,N7)
1740 PRINT "DO YOU WANT TO CHANGE ANOTHER VALUE?";
1750 PRINT " (Y OR N) ";
1760 INPUT G$
1770 IF G$="N" THEN 1790
1780 GO TO 1670
1790 PRINT "DO YOU WANT TO CHANGE FB TIME ON REVERSE SPREAD? (Y OR N) ";
1800 INPUT G$
1810 IF G$="N" THEN 1940
1820 PRINT "SPREAD NUMBER (1 THRU 6) WITHIN LUW = ";
1830 INPUT N6
1840 PRINT " TRACE NUMBER =";
1850 INPUT N7
1860 PRINT "     Old value = ";T2(N6,N7)
1870 PRINT "     New value = ";
1880 INPUT T2(N6,N7)
1890 PRINT "DO YOU WANT TO CHANGE ANOTHER VALUE?";
1900 PRINT " (Y OR N) ";
1910 INPUT G$
1920 IF G$="N" THEN 1940
1930 GO TO 1820
1940 RETURN
1950 REM *** SUB: STORE ENTERED DATA
1960 PRINT "__FILE NUMBER = ";
1970 INPUT F0
1980 F1=(1+INT(20*N1*N2+140)/256)*256
1990 PRINT "REQUIRED FILE SPACE = ";F1
2000 PRINT "IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) ";
2010 INPUT G$
2020 IF G$="Y" THEN 2070
2030 PRINT "G_G_G_INSERT FB DATA TAPE IN 4051"
2040 GOSUB 2170
2050 FIND F0
2060 MARK 1,F1
2070 PRINT "G_G_G_INSERT FB DATA TAPE IN 4924"
2080 GOSUB 2170
2090 FIND @2:F0
2100 WRITE @2:A$,L0,N1,N2,N3,P0,P1,P2,X3,X4
2110 WRITE @2:T1,T2
2120 PRINT @2,2:
2130 FIND @2:F0
2140 READ @2:A$,L0,N1,N2,N3,P0,P1,P2,X3,X4
2150 READ @2:T1,T2
2160 RETURN
2170 REM *** SUB: READY TO PROCEED?
2180 PRINT "__ARE YOU READY TO PROCEED? (Y OR N) ";
2190 INPUT G$
2200 IF G$="N" THEN 2180
2210 RETURN
```

PROGRAM TO COMPUTE STATIC CORRECTIONS

```
100 PRINT "L_COMPUTE STATICS USING SIX-FOLD, TWO-WAY PROCEDURE"
110 INIT
120 DIM A$(24),G$(1)
130 REM *** ENTER FIRST ARRIVALS FROM SET OF DATA TAPES
140 GOSUB 370
150 REM *** ENTER SURVEYING DATA FROM DATA TAPE
160 GOSUB 730
170 REM *** VERIFY DATA-SET AGREEMENT
180 GOSUB 850
190 REM *** TABULATE INPUT DATA
200 GOSUB 910
210 REM *** ESTABLISH COMPUTATION PARAMETERS
220 GOSUB 1570
230 REM *** COMPUTE SP-TO-SP REFRACTION TIMES
240 GOSUB 1920
250 REM *** COMPUTE DELAY TIMES USING ABC PROCEDURE
260 GOSUB 2680
270 REM *** COMPUTE DELAY TIMES AT EXTERIOR POSITIONS
280 GOSUB 3240
290 REM *** COMPUTE STATIC CORRECTIONS
300 GOSUB 3480
310 REM *** TABULATE STATIC CORRECTIONS
320 GOSUB 3710
330 REM *** STORE STATIC CORRECTIONS
340 GOSUB 4100
350 PRINT "__G_G_G_PROGRAM COMPLETED"
360 END
370 REM *** SUB: ENTER FIRST ARRIVALS FROM SET OF DATA TAPES
380 PRINT "NUMBER OF FIRST ARRIVAL DATA TAPES = ";
390 INPUT N0
400 N0=6*N0
410 DIM T1(N0,12),T2(N0,12)
420 T1=0
430 T2=0
440 DIM T3(6,12),T4(6,12)
450 T3=0
460 T4=0
470 I=0
480 FOR L=1 TO N0/6
490 PRINT "G_G_G___INSERT # ";L;" FIRST ARRIVAL DATA TAPE IN 4924"
500 PRINT "FILE NUMBER OF # ";L;" FB DATA TAPE = ";
510 INPUT F1
520 FIND @2:F1
530 READ @2:A$,L0,N1,N2,N4,P0,P1,P2,X3,X4,T3,T4
540 PRINT "AREA:";A$;"; LINE:";L0;"; FIRST SP@PN ";P1;"; LAST SP@PN ";P2
550 IF L>1 THEN 570
560 P3=P1
570 FOR J=1 TO 6
580 I=I+1
590 FOR K=1 TO 12
600 IF T3(J,K)=0 THEN 690
610 T1(I,K)=T3(J,K)
620 T2(I,K)=T4(J,K)
630 NEXT K
640 NEXT J
650 NEXT L
660 DELETE T3,T4
670 P1=P3
680 P4=P2
690 N1=I
700 PRINT "__TOTAL NUMBER OF SPREADS SHOT = ";N1
```

```
710 N3=1+0.5*(P4-P3)
720 RETURN
730 REM ** SUB: ENTER SURVEYING DATA FROM DATA TAPE
740 PRINT "__G_G_G_INSERT SURVEYING-DATA TAPE IN 4924       FILE NO. = ";
750 INPUT F0
760 FIND @2:F0
770 READ @2:A$,L0,N9,N2,N4,P0,P1,P9,X3,X4
780 PRINT "AREA:";A$;";  LINE:";L0;";  FIRST SP@PN ";P1;";  LAST SP@PN ";P9
790 IF N3<=N4 THEN 820
800 PRI "G_G_G___ERROR: INSUFFICIENT NUMBER OF STATIONS HAVE BEEN SURVEYED"
810 GO TO 350
820 DIM E1(N3)
830 READ @2:E1
840 RETURN
850 REM ** SUB: VERIFY DATA-SET COMPATIBILITY
860 PRINT "__ARE DATA SETS IN AGREEMENT? (Y OR N) ";
870 INPUT G$
880 IF G$="Y" THEN 900
890 PRINT "G_G_G___E_RROR: DATA SETS ARE NOT COMPATIBLE"
900 RETURN
910 REM ** SUB: TABULATE INPUT DATA
920 U=32
930 PRINT "__DO YOU WANT TO TABULATE INPUT DATA? (Y OR N) ";
940 INPUT G$
950 IF G$="N" THEN 1560
960 PRINT "DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) ";
970 INPUT G$
980 IF G$="N" THEN 1000
990 U=51
1000 PRINT @U:"L_AREA: ";A$;",  LINE NUMBER: ";L0
1010 PRI @U:"NO OF SPOS:";N1;",NO OF SEIS/SPO:";N2;",NO OF STATIONS:";N3
1020 PRINT @U:"PN INT(m/PN)=";P0;",  FIRST SP PN=";P1;",. LAST SP PN=";P2
1030 PRINT @U:"O/S TO NEAREST DETECTOR ON FORWARD SPREAD = ";X3
1040 PRINT @U:"O/S TO NEAREST DETECTOR ON REVERSE SPREAD = ";X4
1050 PRINT @U:" "
1060 PRINT @U:"SURFACE ELEVATIONS:"
1070 N4=INT(N3/4)
1080 N5=N3-4*N4
1090 IMAGE X,4(3D,3X,4D.D,3X)
1100 PRINT @U:"  PN      ELEV     PN      ELEV     PN      ELEV";
1110 PRINT @U:"     PN      ELEV"
1120 P=P1-8
1130 K=-3
1140 FOR J=1 TO N4
1150 P=P+8
1160 K=K+4
1170 PRINT @U: USING 1090:P,E1(K),P+2,E1(K+1),P+4,E1(K+2),P+6,E1(K+3)
1180 NEXT J
1190 IF N5=0 THEN 1290
1200 IF N5=1 THEN 1230
1210 IF N5=2 THEN 1250
1220 IF N5=3 THEN 1270
1230 PRINT @U:" ";P+8;"     ";E1(K+4)
1240 GO TO 1290
1250 PRINT @U:" ";P+8;"     ";E1(K+4);"     ";P+10;"     ";E1(K+5)
1260 GO TO 1290
1270 PRINT @U:" ";P+8;"     ";E1(K+4);"     ";P+10;"     ";E1(K+5);" ";
1280 PRINT @U:" ";P+12;"     ";E1(K+6)
1290 PRINT @U:" "
1300 PRINT @U:"REFRACTION TIMES ON FORWARD SPREADS"
1310 IMAGE 4(4D.D,3X)
1320 P7=P1-4
```

```
1330 P8=P1+X3/P0-4
1340 FOR J=1 TO N1
1350 P7=P7+4
1360 P8=P8+4
1370 P9=P8+(N2-1)*2
1380 PRINT @U:"SP@PN:";P7;"  SPREAD FROM PN:";P8;" TO ";P9
1390 FOR K=1 TO N2 STEP 4
1400 PRINT @U: USING 1310:T1(J,K),T1(J,K+1),T1(J,K+2),T1(J,K+3)
1410 NEXT K
1420 NEXT J
1430 PRINT @U:" "
1440 PRINT @U:"REFRACTION TIMES ON REVERSE SPREADS"
1450 P7=P1+X3/P0+(N2-1)*2+X4/P0-4
1460 P8=P1+X3/P0-4
1470 FOR J=1 TO N1
1480 P7=P7+4
1490 P8=P8+4
1500 P9=P8+(N2-1)*2
1510 PRINT @U:"SP@PN:";P7;"  SPREAD FROM PN:";P8;" TO ";P9
1520 FOR K=1 TO N2 STEP 4
1530 PRINT @U: USING 1310:T2(J,K),T2(J,K+1),T2(J,K+2),T2(J,K+3)
1540 NEXT K
1550 NEXT J
1560 RETURN
1570 REM ** SUB: ESTABLISH COMPUTATION PARAMETERS
1580 MOVE 0,0
1590 PRINT
1600 PRINT "_     ESTIMATED LVL VEL = ";
1610 INPUT V0
1620 PRINT "ESTIMATED SUB-LVL VEL = ";
1630 INPUT V1
1640 PRINT "     ASSUMED DATUM VEL = ";
1650 INPUT V2
1660 PRINT "       DATUM ELEVATION = ";
1670 INPUT E3
1680 M1=1
1690 M2=INT((P2-P1+1)/2)+1
1700 P3=P1+X3/P0
1710 M3=INT((P3-P1+1)/2)+1
1720 P4=P2-X4/P0
1730 M4=INT((P4-P1+1)/2)+1
1740 P5=P1+X3/P0+(N2-1)*2+X4/P0
1750 M5=INT((P5-P1+1)/2)+1
1760 P6=P5-X4/P0
1770 M6=INT((P6-P1+1)/2)+1
1780 DIM G1(N1),G2(N1),S1(N1),S2(N1),T3(N1),T4(N1)
1790 T3=0
1800 T4=0
1810 G1(1)=M3
1820 G2(1)=M3+N2-1
1830 S1(1)=M1
1840 S2(1)=M5
1850 FOR J=2 TO N1
1860 G1(J)=G1(J-1)+2
1870 G2(J)=G2(J-1)+2
1880 S1(J)=S1(J-1)+2
1890 S2(J)=S2(J-1)+2
1900 NEXT J
1910 RETURN
1920 REM ** SUB: COMPUTE SP-TO-SP REFRACTION TIMES
1930 REM ** COMPUTE SP-TO-SP TIMES FOR FORWARD SPREADS
1940 J=1
```

```
1950 FOR K=1 TO N1
1960 IF G1(K)<=G2(1) AND G2(K)=>S2(1) THEN 1980
1970 NEXT K
1980 G3=G2(1)-G1(K)+1
1990 G4=G3+M5-M6
2000 G5=G3
2010 G6=G4
2020 G7=K
2030 GOSUB 2120
2040 FOR J=2 TO N1
2050 G7=G7+1
2060 IF G7>N1 THEN 2260
2070 K=G7
2080 G3=G5
2090 G4=G6
2100 GOSUB 2120
2110 NEXT J
2120 REM ** SUB: REPEATED COMPUTATION -- FORWARD SPREADS
2130 L=1
2140 T5=T1(K,G4)-T1(K,G3)
2150 IF K>N1 THEN 2240
2160 G3=G3-2
2170 IF G3<1 THEN 2240
2180 G4=G4-2
2190 K=K+1
2200 IF K>N1 THEN 2240
2210 L=L+1
2220 T5=T5+T1(K,G4)-T1(K,G3)
2230 GO TO 2160
2240 T3(J)=T5/L+T1(J,N2)
2250 RETURN
2260 REM ** COMPUTE SP-TO-SP TIMES FOR REVERSE SPREADS
2270 J=N1
2280 FOR K=N1 TO 1 STEP -1
2290 IF G1(K)<=S1(N1) AND G2(K)=>G1(N1) THEN 2310
2300 NEXT K
2310 G3=S1(N1)-G1(K)+1
2320 G4=G3+M3-M1
2330 G5=G3
2340 G6=G4
2350 G7=K
2360 GOSUB 2450
2370 FOR J=N1-1 TO 1 STEP -1
2380 G7=G7-1
2390 IF G7<1 THEN 2590
2400 K=G7
2410 G3=G5
2420 G4=G6
2430 GOSUB 2450
2440 NEXT J
2450 REM ** SUB: REPEATED COMPUTATION -- REVERSE SPREADS
2460 L=1
2470 T5=T2(K,G3)-T2(K,G4)
2480 IF K<1 THEN 2570
2490 G3=G3+2
2500 G4=G4+2
2510 IF G4>N2 THEN 2570
2520 K=K-1
2530 IF K<1 THEN 2570
2540 L=L+1
2550 T5=T5+T2(K,G3)-T2(K,G4)
2560 GO TO 2490
```

```
2570 T4(J)=T5/L+T2(J,1)
2580 RETURN
2590 REM ** COMPUTE AVERAGE OF FORWARD & BACK SP-TO-SP TIMES
2600 FOR J=1 TO N1
2610 IF T3(J)=0 THEN 2650
2620 IF T4(J)=0 THEN 2660
2630 T3(J)=0.5*(T3(J)+T4(J))
2640 GO TO 2660
2650 T3(J)=T4(J)
2660 NEXT J
2670 RETURN
2680 REM ** SUB: COMPUTE DELAY TIMES USING ABC PROCEDURE
2690 DIM D(N3),D1(N1,N2)
2700 D=0
2710 D1=0
2720 FOR J=1 TO N1
2730 FOR K=1 TO N2
2740 D1(J,K)=0.5*(T1(J,K)+T2(J,K)-T3(J))
2750 NEXT K
2760 NEXT J
2770 REM ** REORDER AND COMPUTE AVERAGE DELAY TIMES
2780 J1=M3
2790 J2=J1+N2-2
2800 J3=0
2810 FOR J=J1 TO J2 STEP 2
2820 J3=J3+1
2830 L1=1
2840 L2=J-M3+1
2850 L3=L2+1
2860 D2=D1(L1,L2)
2870 D3=D1(L1,L3)
2880 IF J3=1 THEN 2960
2890 FOR L=1 TO J3-1
2900 L1=L1+1
2910 L2=L2-2
2920 L3=L3-2
2930 D2=D2+D1(L1,L2)
2940 D3=D3+D1(L1,L3)
2950 NEXT L
2960 D(J)=D2/J3
2970 D(J+1)=D3/J3
2980 NEXT J
2990 REM ** REORDER REST OF DELAY TIMES
3000 L5=1
3010 J1=J2+2
3020 J2=M4
3030 FOR J=J1 TO J2 STEP 2
3040 L5=L5+1
3050 L1=L5
3060 L2=11
3070 L3=12
3080 D2=D1(L1,L2)
3090 D3=D1(L1,L3)
3100 L4=1
3110 FOR L=1 TO 5
3120 L1=L1+1
3130 IF L1>N1 THEN 3200
3140 L2=L2-2
3150 L3=L3-2
3160 L4=L4+1
3170 D2=D2+D1(L1,L2)
3180 D3=D3+D1(L1,L3)
```

```
3190 NEXT L
3200 D(J)=D2/L4
3210 D(J+1)=D3/L4
3220 NEXT J
3230 RETURN
3240 REM ** SUB: COMPUTE DELAY TIMES AT EXTERIOR SP POSITIONS
3250 REM ** COMPUTE FOR SP'S NEAR BEGINNING OF LINE
3260 FOR M=1 TO N1
3270 IF S1(M)=>M3 THEN 3290
3280 NEXT M
3290 K=S1(M)
3300 L=M3-M1
3310 M=M+1
3320 FOR J=K TO 3 STEP -2
3330 M=M-1
3340 D(J-2)=T1(M-1,1)-T1(M,1)+D(J)-D(J+L-2)+D(J+L)
3350 NEXT J
3360 REM ** COMPUTE FOR SP'S NEAR END OF LINE
3370 FOR M=N1 TO 1 STEP -1
3380 IF S2(M)<=M4 THEN 3400
3390 NEXT M
3400 K=S2(M)
3410 L=M2-M4
3420 M=M-1
3430 FOR J=K TO M2-2 STEP 2
3440 M=M+1
3450 D(J+2)=T2(M+1,N2)-T2(M,N2)+D(J)-D(J+2-L)+D(J-L)
3460 NEXT J
3470 RETURN
3480 REM ** SUB: COMPUTE STATIC CORRECTIONS
3490 DELETE T4,T5
3500 DIM T4(N3),T5(N1,N2),T6(N1,N2)
3510 SET DEGREES
3520 A1=ASN(V0/V1)
3530 C1=1/COS(A1)
3540 T4=C1*D
3550 L=M1-2
3560 M=M5-2
3570 N=M3-2
3580 FOR J=1 TO N1
3590 L=L+2
3600 M=M+2
3610 N=N+1
3620 T7=T4(L)+(E1(L)-V0*T4(L)-E3)/V2
3630 T8=T4(M)+(E1(M)-V0*T4(M)-E3)/V2
3640 FOR K=1 TO N2
3650 T9=T4(N+K)+(E1(N+K)-V0*T4(N+K)-E3)/V2
3660 T5(J,K)=T7+T9
3670 T6(J,K)=T8+T9
3680 NEXT K
3690 NEXT J
3700 RETURN
3710 REM ** SUB: TABULATE STATIC CORRECTIONS
3720 Q1=2
3730 PRINT "__DO YOU WANT TO TABULATE STATIC CORRECTIONS? (Y OR N) ";
3740 INPUT G$
3750 IF G$="N" THEN 3980
3760 Q1=1
3770 DIM T(N1,N2)
3780 PRINT "DO YOU WANT TO TABULATE ON PRINTER? (Y OR N) ";
3790 INPUT G$
3800 IF G$="N" THEN 3820
```

```
3810 U=51
3820 IMAGE 4(3X,2D,2X,3D.D)
3830 PRINT @U:"L_AREA: ";A$;"  LINE NO ";L0
3840 PRINT @U:" "
3850 PRINT @U:"STATIC CORRECTIONS FOR FORWARD SPREADS"
3860 P6=P1-4
3870 P7=P3-4
3880 P8=P7+2*(N2-1)
3890 T=T5
3900 GOSUB 3990
3910 PRINT @U:" "
3920 PRINT @U:"STATIC CORRECTIONS FOR REVERSE SPREADS"
3930 P6=P5-4
3940 P7=P3-4
3950 P8=P7+2*(N2-1)
3960 T=T6
3970 GOSUB 3990
3980 RETURN
3990 REM *** SUB: TABULATION FORMAT
4000 FOR J=1 TO N1
4010 P6=P6+4
4020 P7=P7+4
4030 P8=P8+4
4040 PRINT @U:"SP @ PN ";P6;"  SPREAD FROM PN ";P7;" TO ";P8
4050 FOR K=1 TO N2 STEP 4
4060 PRI @U: USI 3820:K,T(J,K),K+1,T(J,K+1),K+2,T(J,K+2),K+3,T(J,K+3)
4070 NEXT K
4080 NEXT J
4090 RETURN
4100 REM *** SUB: STORE STATIC CORRECTIONS
4110 PRINT "__DO YOU WANT TO STORE STATIC CORRECTIONS? (Y OR N) ";
4120 INPUT G$
4130 IF G$="N" THEN 4360
4140 PRINT "FILE NUMBER = ";
4150 INPUT F2
4160 F1=(1+INT((40*N3+40*N1*N2+140)/256))*256
4170 PRINT "__REQUIRED FILE SPACE = ";F1
4180 PRINT "__IS RESERVED FILE SPACE SUFFICIENT? (Y OR N) ";
4190 INPUT G$
4200 IF G$="Y" THEN 4250
4210 PRINT "__G_G_G_INSERT STATIC CORRECTIONS TAPE IN 4051"
4220 GOSUB 4370
4230 FIND F2
4240 MARK 1,F1
4250 PRINT "G_G_G___INSERT STATIC CORRECTIONS TAPE IN 4924"
4260 GOSUB 4370
4270 FIND @2:F2
4280 WRITE @2:A$,E3,L0,N1,N2,N3,P0,P1,P2,V0,V1,V2,X3,X4
4290 WRITE @2:E1,S1,S2,T1,T2,T4,T5,T6
4300 PRINT @2,2:
4310 FIND @2:F2
4320 READ @2:A$,E3,L0,N1,N2,N3,P0,P1,P2,V0,V1,V2,X3,X4
4330 READ @2:E1,S1,S2,T1,T2,T4,T5,T6
4340 IF Q1=2 THEN 4360
4350 PRINT @U:"STATIC CORRECTIONS STORED ON FILE ";F2
4360 RETURN
4370 REM *** SUB: READY TO PROCEED?
4380 PRINT "ARE YOU READY TO PROCEED? (Y OR N) ";
4390 INPUT G$
4400 IF G$="N" THEN 4380
4410 RETURN
```

PROGRAM TO PLOT ADJUSTED FIRST ARRIVALS, GROUND AND LVL ELEVATIONS, AND TIME TO DATUM AT EACH STATION

```
100 PRINT "L_PLOT ADJ. FB'S, ELEV, LVL & STATIC CORR. ";
110 PRINT " FOR 6-FOLD, 2-WAY PROCEDURE"
120 INIT
130 DIM A$(24),D$(16),E$(4),F$(27),G$(1),S$(7)
140 REM *** READ AND CONDITION DATA FROM STATIC CORRECTION DATA TAPE
150 GOSUB 440
160 REM *** ESTABLISH PLOT PARAMETERS
170 GOSUB 740
180 REM *** COMPUTE STATIC CORRECTION AT EACH STATION
190 GOSUB 1160
200 REM *** SELECT TICKMARK INTERVALS
210 GOSUB 1250
220 REM *** PLOT AND LABEL BORDERS
230 GOSUB 1400
240 REM *** PLOT TICKMARKS
250 GOSUB 1820
260 REM *** PLOT ADJUSTED FIRST ARRIVALS FOR FORWARD SPREADS
270 GOSUB 2630
280 REM *** PLOT ADJUSTED FIRST ARRIVALS FOR REVERSE SPREADS
290 GOSUB 2830
300 REM *** PLOT STATIC CORRECTIONS AT EACH STATION
310 GOSUB 2950
320 REM *** PLOT GROUND AND LVL ELEVATIONS AT EACH STATION
330 GOSUB 3080
340 WINDOW 0,130,0,100
350 VIEWPORT 0,130,0,100
360 MOVE 0,0
370 PRINT
380 PRI "DO YOU WANT TO REPLOT WITH NEW TICKMARK INTERVALS? (Y OR N) ";
390 INPUT G$
400 IF G$="N" THEN 420
410 GO TO 200
420 PRINT "G_G_G_PROGRAM COMPLETED"
430 END
440 REM *** SUB: READ AND CONDITION DATA FROM STATIC CORRECTION DATA TAPE
450 PRINT "G_G_G___INSERT DATA TAPE IN 4924     FILE NO. =";
460 INPUT F1
470 FIND @2:F1
480 READ @2:A$,E0,L0,N1,N2,N3,P0,P1,P2,V0,V1,V2,X3,X4
490 DIM E1(N3),S1(N1),S2(N1),T4(N3)
500 DIM T1(N1,N2),T2(N1,N2),T5(N1,N2),T6(N1,N2)
510 READ @2:E1,S1,S2,T1,T2,T4,T5,T6
520 FOR J=1 TO N3
530 IF T4(J)<>0 THEN 550
540 T4(J)=0.5*(T4(J-1)+T4(J+1))
550 NEXT J
560 DELETE T5,T6
570 SET DEGREES
580 C=COS(ASN(V0/V1))
590 DIM E2(N3),T3(N3),T7(N1,N2),T8(N1,N2)
600 T3=C*T4
610 FOR J=1 TO N3
620 E2(J)=E1(J)-V0*T4(J)
630 NEXT J
640 FOR J=1 TO N1
650 P=S1(J)+0.5*X3/P0-1
660 FOR K=1 TO N2
670 P=P+1
680 T7(J,K)=T1(J,K)-T3(S1(J))-T3(P)
690 T8(J,K)=T2(J,K)-T3(S2(J))-T3(P)
700 NEXT K
710 NEXT J
```

```
720 DELETE T1, T2, T3
730 RETURN
740 REM ** SUB: ESTABLISH PLOT PARAMETERS
750 RESTORE 760
760 DATA 48, 6, 26, 52, 95, 29, 10, 126, 1.306, 2.857, 1
770 READ B0, B1, B2, B4, B5, B9, C1, C2, K3, K4, Q1
780 B3=B2-B1
790 B6=B5-B4
800 C3=C2-C1
810 D$="ADJUSTED FB'S"
820 E$="ELEV"
830 F$="TRAVERSE DISTANCE IN METERS"
840 S$="STATICS"
850 DIM T1(N2), T2(N2), T3(N1), T5(N1), T6(N1), T9(N1)
860 FOR J=1 TO N1
870 FOR K=1 TO N2
880 T1(K)=T7(J,K)
890 T2(K)=T8(J,K)
900 NEXT K
910 CALL "MAX", T1, J1, I1
920 CALL "MIN", T1, J2, I2
930 CALL "MAX", T2, J3, I1
940 CALL "MIN", T2, J4, I2
950 T3(J)=J1
960 T5(J)=J2
970 T6(J)=J3
980 T9(J)=J4
990 NEXT J
1000 DELETE T1, T2
1010 CALL "MAX", T3, J1, I1
1020 CALL "MAX", T6, J2, I2
1030 J3=J1 MAX J2
1040 CALL "MIN", T5, J1, I1
1050 CALL "MIN", T9, J2, I2
1060 J2=J1 MIN J2
1070 J1=J3-J2
1080 J7=J3-J2
1090 DELETE T3, T5, T6, T9
1100 D1=P0*(P2-P1)
1110 K1=C3/D1
1120 CALL "MAX", E1, E4, I1
1130 CALL "MIN", E2, E3, I2
1140 E7=E4-E3
1150 RETURN
1160 REM ** SUB: COMPUTE STATIC CORRECTION AT EACH STATION
1170 DIM T5(N3)
1180 FOR J=1 TO N3
1190 T5(J)=T4(J)+(E1(J)-V0*T4(J)-E0)/V2
1200 NEXT J
1210 CALL "MIN", T5, T1, I1
1220 CALL "MAX", T5, T2, I2
1230 J5=T2-T1
1240 RETURN
1250 REM ** SUB: SELECT TICKMARK (TM) INTERVALS
1260 PRINT "__SELECT TICKMARK INTERVALS"
1270 PRINT "__     Elevation difference = "; INT(0.5+E7)
1280 PRINT "    Elevation TM interval = ";
1290 INPUT I4
1300 PRINT "__ Total traverse distance = "; INT(0.5+D1)
1310 PRINT "     Traverse TM interval = ";
1320 INPUT I6
1330 PRINT "__ Arrival time difference = "; INT(0.5+J7)
1340 PRINT "Arrival time TM interval = ";
```

```
1350 INPUT I5
1360 PRINT "__ Static corr. difference = ";INT(0.5+J5)
1370 PRINT "Static corr. TM interval = ";
1380 INPUT I7
1390 RETURN
1400 REM ** SUB: PLOT AND LABEL BORDERS
1410 PRINT "L_";A$;"  LINE NO ";L0;"  DATUM ELEV = ";E0
1420 MOVE C2-7*K3,B5+3
1430 PRINT "FILE  ";F1
1440 MOVE C1,B5
1450 DRAW C2,B5
1460 DRAW C2,B4
1470 DRAW C1,B4
1480 DRAW C1,B5
1490 MOVE C1,B0
1500 DRAW C2,B0
1510 DRAW C2,B9
1520 DRAW C1,B9
1530 DRAW C1,B0
1540 MOVE C1,B2
1550 DRAW C2,B2
1560 DRAW C2,B1
1570 DRAW C1,B1
1580 DRAW C1,B2
1590 MOVE C1-5.3*K3,B5+0.5
1600 IMAGE "SP@PN:",3D
1610 PRINT USING 1600:P1
1620 MOVE C2-8.3*K3,B5+0.5
1630 PRINT USING 1600:P2
1640 MOVE 0.5*(C1+C2-K3*LEN(F$)),3
1650 PRINT F$
1660 MOVE 0,0.5*(B4+B5+K4*LEN(D$))-K4
1670 FOR K=1 TO LEN(D$)
1680 G$=SEG(D$,K,1)
1690 PRINT G$
1700 NEXT K
1710 MOVE 0,0.5*(B0+B9+K4*LEN(S$))-K4
1720 FOR K=1 TO LEN(S$)
1730 G$=SEG(S$,K,1)
1740 PRINT G$
1750 NEXT K
1760 MOVE 0,0.5*(B1+B2+K4*LEN(E$))-K4
1770 FOR K=1 TO LEN(E$)
1780 G$=SEG(E$,K,1)
1790 PRINT G$
1800 NEXT K
1810 RETURN
1820 REM ** SUB: PLOT TIC MARKS
1830 IMAGE 2D
1840 IMAGE 3D
1850 IMAGE 4D
1860 REM ** TICKMARKS FOR TRAVERSE DISTANCE
1870 D2=INT(D1/I6)
1880 D3=I6*K1
1890 MOVE C1,B1
1900 D6=0
1910 FOR K=1 TO D2
1920 D6=D6+I6
1930 RMOVE D3,0
1940 RDRAW 0,1
1950 RMOVE 0,B3-2
1960 RDRAW 0,1
1970 RMOVE 0,B9-B2
```

```
1980 RDRAW 0,1
1990 RMOVE 0,B0-B9-2
2000 RDRAW 0,1
2010 RMOVE -2.3*K3,0.5*(B4-B0)-K4*11/32
2020 PRINT USING 1840:D6
2030 RMOVE 2.3*K3,0.5*(B4-B0)+K4*11/32
2040 RDRAW 0,1
2050 RMOVE 0,B6-2
2060 RDRAW 0,1
2070 RMOVE 0,B1-B5
2080 NEXT K
2090 REM ** TICKMARKS FOR ELEVATIONS
2100 E5=INT(E3/I4)*I4
2110 E6=INT(E4/I4+1)*I4
2120 MOVE C1-4*K3,B1-K4*11/32
2130 PRINT USING 1850:E5
2140 MOVE C1,B1
2150 D8=(E6-E5)/I4
2160 K5=B3/(E6-E5)
2170 D9=K5*I4
2180 D7=E5
2190 FOR K=1 TO D8-1
2200 D7=D7+I4
2210 RMOVE 0,D9
2220 RMOVE -4*K3,-K4*11/32
2230 PRINT USING 1850:D7
2240 RMOVE 4*K3,+K4*11/32
2250 RDRAW 1,0
2260 RMOVE C3-2,0
2270 RDRAW 1,0
2280 RMOVE -C3,0
2290 NEXT K
2300 REM ** TICKMARKS FOR STATIC CORRECTIONS
2310 T1=INT(T1/I7)*I7
2320 T2=INT(1+T2/I7)*I7
2330 MOVE C1-3*K3,B9-K4*11/32
2340 PRINT USING 1840:T1
2350 MOVE C1,B9
2360 D4=1+(T2-T1)/I7
2370 D5=I7*(B0-B9)/(T2-T1)
2380 REM
2390 MOVE C1,B9
2400 I3=I7
2410 D7=T1
2420 GOSUB 2510
2430 REM ** TICKMARKS FOR ADJUSTED FB'S
2440 D6=(1+INT(J3/I5))*I5
2450 D7=INT(J2/I5)*I5
2460 D4=(D6-D7)/I5
2470 D5=I5*B6/(D6-D7)
2480 D0=D7
2490 MOVE C1,B4
2500 I3=I5
2510 FOR K=1 TO D4-1
2520 D7=D7+I3
2530 RMOVE 0,D5
2540 RMOVE -3*K3,-K4*11/32
2550 PRINT USING 1840:D7
2560 RMOVE 3*K3,+K4*11/32
2570 RDRAW 1,0
2580 RMOVE C3-2,0
2590 RDRAW 1,0
```

```
2600 RMOVE -C3,0
2610 NEXT K
2620 RETURN
2630 REM ** SUB: PLOT ADJUSTED FIRST ARRIVALS FOR FORWARD SPREADS
2640 N4=N2
2650 B7=B4
2660 B8=B5
2670 DIM A(N4)
2680 K6=2*P0
2690 K7=2*K1*K6
2700 C4=K1*X3-K7+C1
2710 C5=C4
2720 C6=K1*(X3+K6*(N2-1))-K7+C1
2730 C7=C6
2740 FOR J=1 TO N1
2750 C5=C5+K7
2760 C7=C7+K7
2770 FOR K=1 TO N2
2780 A(K)=T7(J,K)
2790 NEXT K
2800 GOSUB 3180
2810 NEXT J
2820 RETURN
2830 REM ** SUB: PLOT ADJUSTED FIRST ARRIVALS FOR REVERSE SPREADS
2840 C5=C4
2850 C7=C6
2860 FOR J=1 TO N1
2870 C5=C5+K7
2880 C7=C7+K7
2890 FOR K=1 TO N2
2900 A(K)=T8(J,K)
2910 NEXT K
2920 GOSUB 3180
2930 NEXT J
2940 RETURN
2950 REM ** SUB: PLOT STATIC CORRECTIONS AT EACH STATION
2960 DELETE A
2970 N4=N3
2980 DIM A(N4)
2990 C5=C1
3000 C7=C2
3010 B7=B9
3020 B8=B0
3030 D0=T1
3040 D6=T2
3050 A=T5
3060 GOSUB 3180
3070 RETURN
3080 REM ** SUB: PLOT GROUND AND LVL ELEVATIONS AT EACH STATION
3090 B7=B1
3100 B8=B2
3110 D0=E5
3120 D6=E6
3130 A=E1
3140 GOSUB 3180
3150 A=E2
3160 GOSUB 3180
3170 RETURN
3180 REM ** SUB: PLOT ROM
3190 VIEWPORT C5,C7,B7,B8
3200 WINDOW 1,N4,D0,D6
3210 CALL "DISP",A
3220 RETURN
```