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GEOLOGICAL SURVEY

Three data-reduction programs in planetary altimetry

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[Pages in each part are numbered separately]

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PROGRAM HP9ØØ4:

ALTIMETRIC ELEVATION CALCULATION

by

M. A. M. Donzeau

U.S. Geological Survey
Jiddah, Saudi Arabia

1980

Part 1 of 3

The work on which this report is based was performed in accordance with a cooperative agreement between the U. S. Geological Survey and the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia.

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

Program Documentation Manual

Program Number	:	HP9ØØ4
Program Name	:	Altimetric Elevation Calculation
Programmer	:	M. A. M. Donzeau
Language	:	BASIC
Computer/System	:	HP983ØA programmable calculator* with string variables ROM
Date	:	23 July 1977
Institution	:	U. S. Geological Survey/Saudi Arabian Project
Location	:	Jiddah, Saudi Arabia

*Hewlett-Packard. Trade names in this report are used for descriptive purposes only and do not constitute endorsement by the U.S. Geological Survey.

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PROGRAM HP9ØØ4: ALTIMETRIC ELEVATION CALCULATION

by

M. A. M. Donzeau

ABSTRACT

This program is designed to calculate elevations of roving and base stations in a survey network from altimetric data reduced by the program "Single Base Altimetry Data Reduction (HP9ØØ1)".* Base station numbers, roving station numbers, elevation differences (in meters), and uncertainty estimates of these differences, usually stored on a cassette file, are the data input for the program.

Program HP9ØØ4 reads either a cassette file or allows the user to enter data from the keyboard. The first step is to find known points (points of known elevation, such as sea level, geodetic points, and so forth); then calculate the altitude of the base stations that contain a known point in their loop. Finally, the altitudes of the roving stations of the loop are calculated. The next steps follow the same procedure, but begin by locating roving stations of known computed altitude (that is, loop-to-loop ties, rather than known points) to calculate the altitude of unknown base stations.

When there are several roving stations of known altitude in the same loop, the altitude of the unknown base station is calculated from all known roving stations. When there are several measurements of the elevation difference between an unknown roving station and a known base station in the same loop, the altitude of the roving station is calculated using all these measurements.

Input-output is interactive via the HP983Ø keyboard and display. The final output is a printed tabulation of the altitude, standard deviation, and probable error of altitude of the roving and base stations.

* Gettings, This open-file rept., part 2.

ACKNOWLEDGMENTS

This work was performed under the provisions of a work agreement between the Ministry of Petroleum and Minerals, Kingdom of Saudi Arabia, and the U. S. Geological Survey. G. S. Pitts made several suggestions which resulted in program improvements and corrections.

SOURCE CODE LOCATION AND UPDATE STATUS

The source program HP9ØØ4 is on cassettes USGS-HP-1Ø1 and USGS-HP-6Ø1 on file in the offices of the geophysics section, USGS/SAP, Jiddah, Saudi Arabia.

There are no updates at this time.

DESCRIPTION OF COMPUTED QUANTITIES

The following data are used to calculate altitude, standard deviation, probable error for all the roving and base stations:

1) measurements of elevation differences between roving stations and base stations, and their spreads (see below),

2) altitude and spread of a few known points, such as sea level or geodetic points

The term "spread" is here defined to be the standard deviation of the elevation difference measurements between a base station and a roving station. The standard deviation is generally not used because of lack of a sufficient number of measurements; instead two measurements of elevation difference are normally available from the two pairs of altimeters used in standard surveying practice. The spread is then just one half the absolute value of the base station-to-roving station elevation difference determined by one altimeter pair minus that determined by the other.

A loop is defined by one base station and all the roving stations measured from that base station. It may be made up of measurements made on different dates.

The altitude of a base station is calculated either from the altitudes of known points (first step), or from already calculated altitudes of roving stations to which the base station is tied (next steps). The measurements of altitude differences between known points (or stations) and the base station are called A_1, A_2, ... A_n, with the spreads E_1, E_2, ... E_n. The altitudes of known points (or stations) are called F_1, F_2, ... F_n, with spreads G_1, G_2, ... G_n. The altitude, standard deviation, and probable error of the base station are defined as follows:

$$F(B) = \frac{\sum_{i=1}^{n} (A_i - F_i)(E_i^2 + G_i^2)^{-\frac{1}{2}}}{\sum_{i=1}^{n} (E_i^2 + G_i^2)^{-\frac{1}{2}}} \qquad (1)$$

$$G(B) = \frac{n}{\sum_{i=1}^{n} (E_i^2 + G_i^2)^{-\frac{1}{2}}} \qquad (2)$$

$$D(B) = 0.674\, G(B) \qquad (3)$$

If only one point (or station) is known, the maximum spread is defined as $C = E + G$.

To calculate the altitude of a roving station from the altitude of the base station, analogous formulae are used. If there are n measurements of the same roving station in the same loop, the altitude differences between the roving and base stations are called A_1, A_2, ... A_n, with the spreads E_1, E_2, ... E_n. The altitude, standard deviation, and probable error of the roving station are defined as follows:

$$F(S) = \frac{\sum_{i=1}^{n} (A_i + F(B))\,(E_i^2 + G(B)^2)^{-\frac{1}{2}}}{\sum_{i=1}^{n} (E_i^2 + G(B)^2)^{-\frac{1}{2}}} \qquad (4)$$

$$G(S) = \frac{n}{\sum_{i=1}^{n} (E_i^2 + G(B)^2)^{-\frac{1}{2}}} \qquad (5)$$

$$D(S) = 0.674\ G(S) \qquad (6)$$

If there is only one measurement, the maximum spread is defined as $C = E_1 + G\ (B)$

When all the altitudes have been calculated, the following values are computed:

1) mean of probable errors of all base and roving stations

2) standard deviation of these probable errors

3) probable error of these probable errors, that is, 0.674 times the standard deviation calculated in 2)

DESCRIPTION OF THE PROGRAM

The general program flow-chart is shown in figure 1, and the "Calculation of Stations" subprogram flow-chart in figure 2. The basic tasks in order are:

1) Enter data from the keyboard or a cassette file. For each measurement the base station number, roving station number, elevation difference between roving and base stations, and spread are required. At this time, the data may be corrected if necessary.

2) Search for knots. A "knot" is added to the data for each measurement, and is defined by the numbers Ø through 3:

   Knot = 1 if the station is a known point.

   Knot = 2 if the roving station is a base station in another loop.

   Knot = 3 if the roving station is also a roving station in the same or another loop.

   Knot = Ø to all other measurements.

   This step is optional because the knot values are not used by the program; however, this step has been preserved for future modification of the program.

3) The altitudes of base stations in loops that contain a known point as a roving station are calculated. If several points are known in the same loop, the altitude of the base station is determined through use of all the values. Altitudes of roving stations other than known points in the same loops are calculated. If there are several measurements of the elevation difference between a roving station and base station in the same loop, the altitude of the roving station is determined through use of all these measurements

4) When the altitude of a base station is unknown, the program searches to determine if the altitude of any roving station of the loop is already known. If this is the case, the altitude of the base station is calculated with the same procedure as above. Then the altitudes of the remaining roving stations of the loop are calculated. Task 4) is performed as many times as necessary until the altitudes of all the roving and base stations have been calculated.

The number of "stations + known points" is limited to 255. If M_1 is the smallest station number, M_2 the largest station number, and M_0 the number of known points, then the number $L_1 = M_2 - M_1 + M_0 + 1$ must be less than 255. The known points must be given numbers preceding the smallest station number, that is, from M_1-M_0 to M_1-1.

The data read or stored on a cassette file with this program are in a COMMON statement containing:

1) LØ number of lines

2) BI(255) base station numbers (integer precision array)

3) SI(255) roving station numbers (integer precision array)

4) AS(255) altitude difference measurements (split precision array)

5) ES(255) spreads (split precision array)

Control and execution of the program is interactive through the HP983Ø keyboard and display and output is via the system printer. All printout is set up for 80 characters maximum printer width. The "string variables" option is utilized to provide titling and "yes" or "no" answers to questions controlling the flow of the program.

The program requires 3700 words of storage in the HP983Ø. No external routines are required other than the standard ones provided with the calculator. Execution time to calculate and print the altitudes of 28 base stations and 222 roving stations is 7 minutes 9 seconds, that is 1.7 seconds per station.

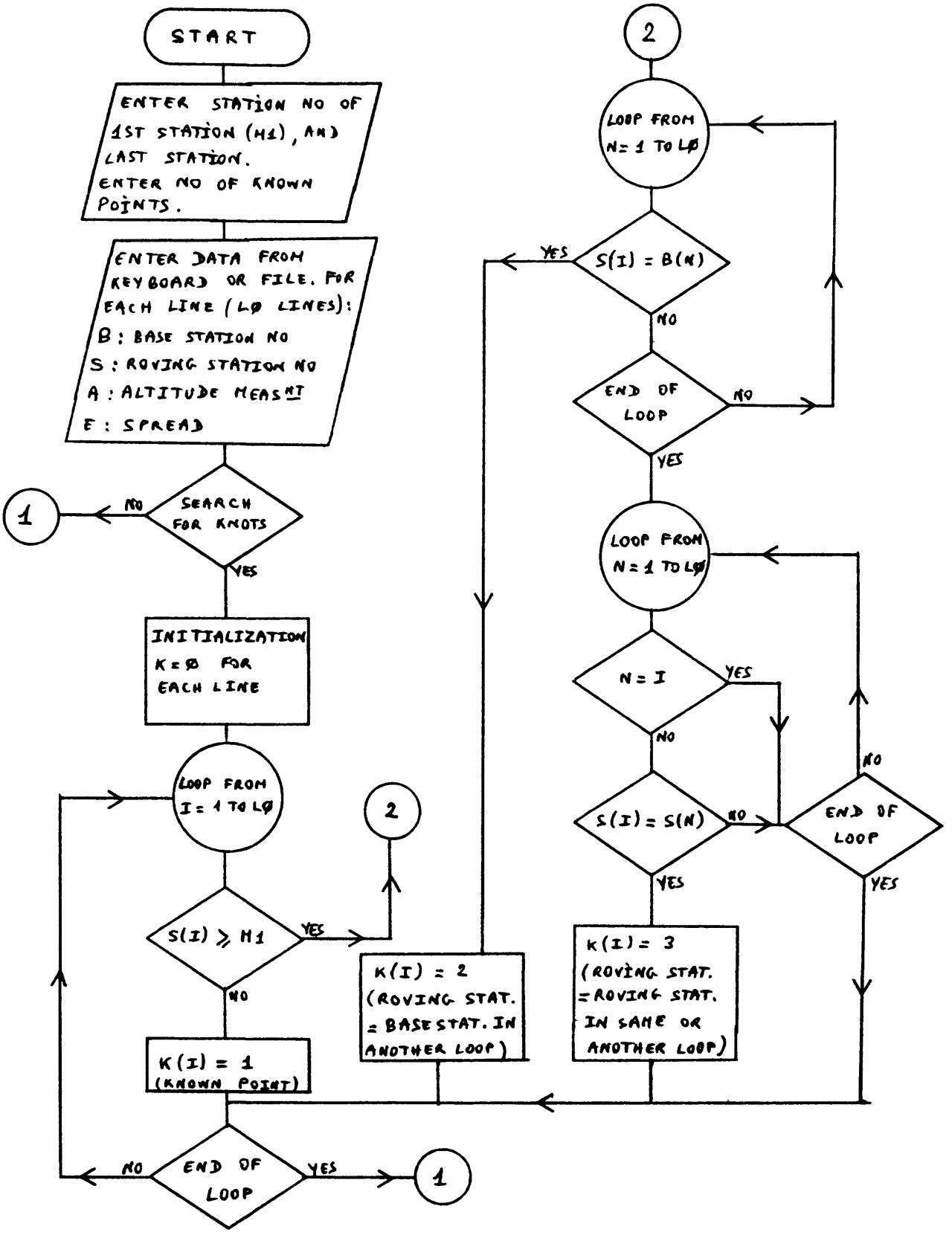

Figure 1.--Altimetric elevation calculation program flow chart.

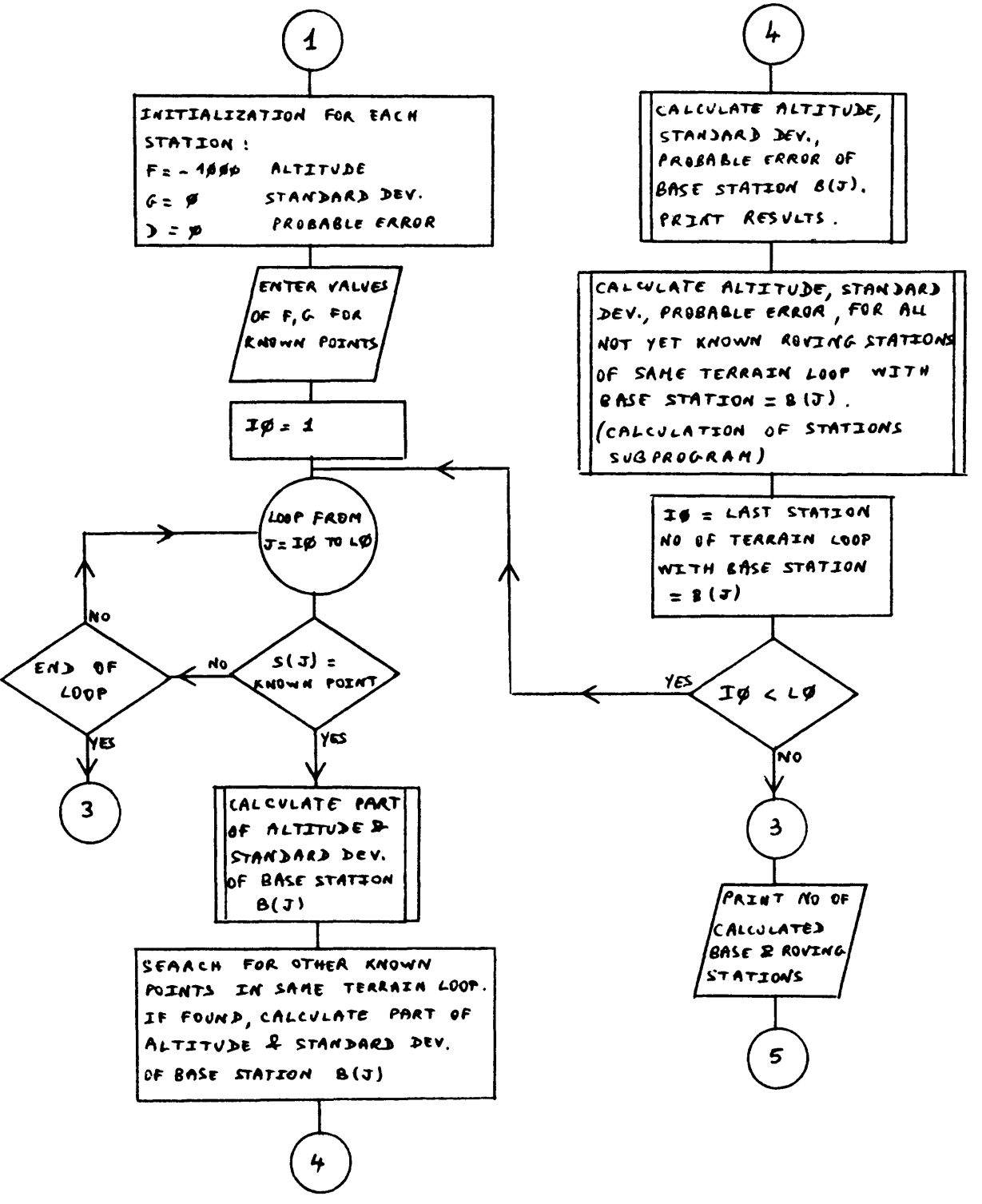

Figure 1.--Altimetric elevation calculation program flow chart (continued).

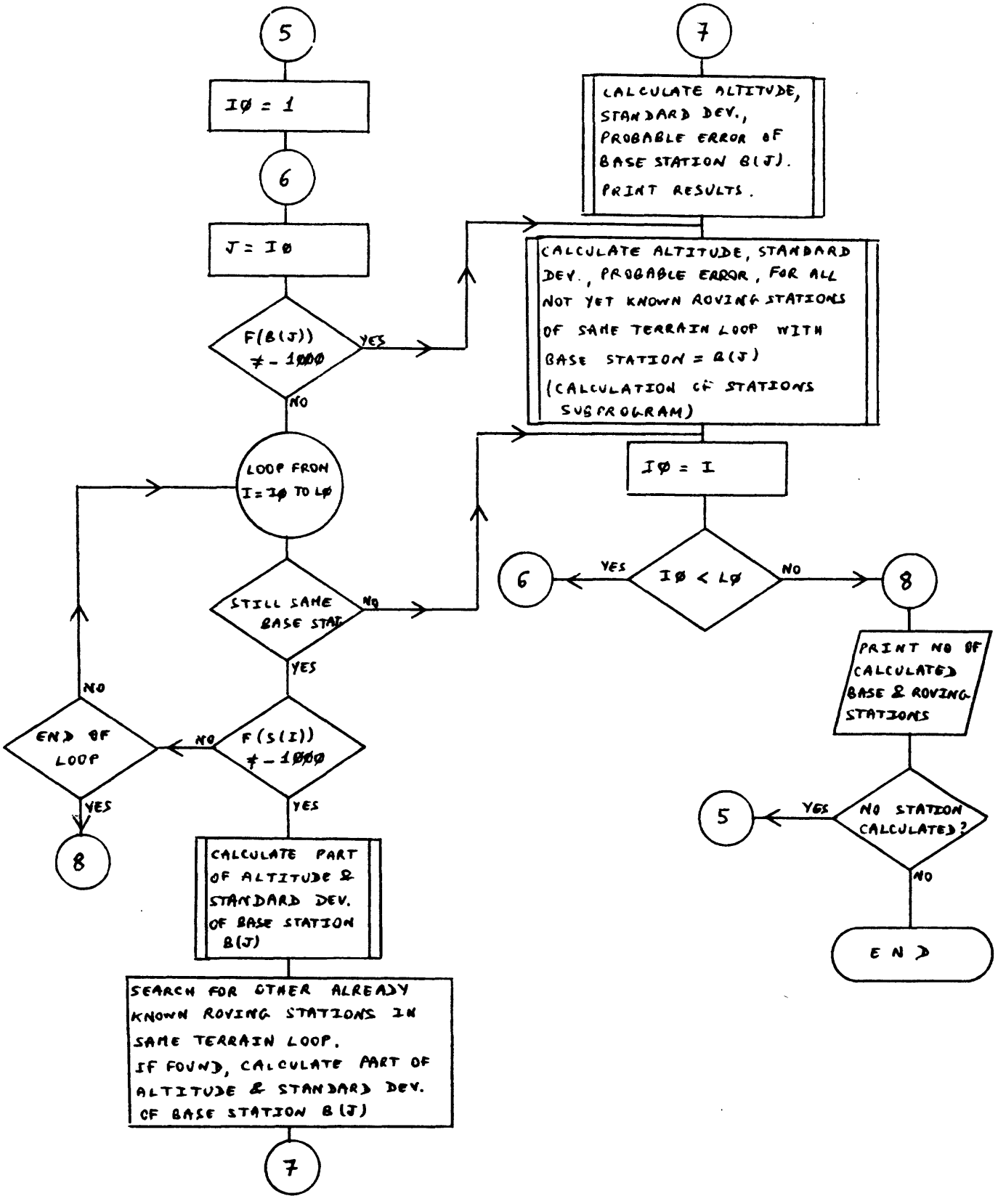

Figure 1.--Altimetric elevation program flow chart (continued).

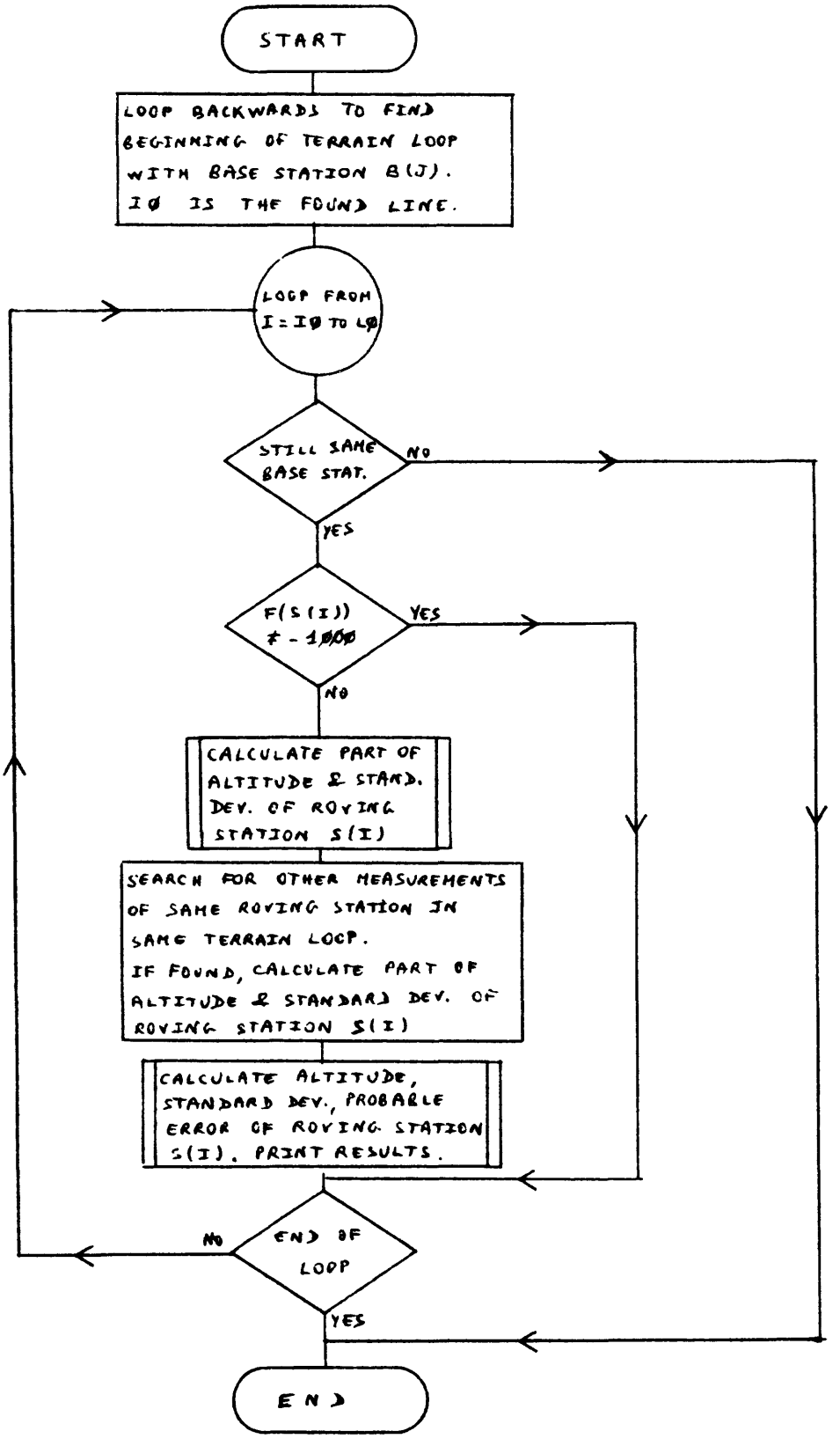

Figure 2.--Calculation of stations subprogram flow chart.

PROGRAM OPERATION

Operation of the program is largely self-explanatory. When the program has been loaded and execution started, requests for information appear on the 32-character calculator display. Questions requiring a "yes" or "no" answer are answered with "Y" or "N". When answering such a question, if one enters too many characters, for instance "YES" instead of "Y", an "ERROR 74" will occur. To recover, press "RECALL", delete line, and enter the correct response.

The data may be entered from the keyboard and then stored, or from a cassette file created either with the "Single Base Altimetry Data Reduction Program (HP9ØØ1)"* or with a previous run of the "Altimetric Elevation Calculation Program (HP9ØØ4)". Errors can be corrected, if necessary, by entering line number and field number, then the corrected data. To delete a line, enter the number Ø as a base station number.

Once the program has been run completely, a "CONT 264Ø" will repeat the altimetry calculation once more, without entering the data. A "GOSUB 82ØØ" will print the altitudes of all base stations and roving stations.

* Geetings, this open-file report, part 2.

EXAMPLE AND TEST DATA

The following is the resulting printout from a typical run.

The first example shows the printed results, and the execution times are as follows:

- total execution time : 7 minutes 9 seconds
- total execution time per base station or roving station : 1.7 seconds
- print data read from cassette file : 70 seconds
- reset arrays before calculation : 11 seconds
- step no. 1 : 80 seconds
- step no. 2 : 140 seconds
- step no. 3 : 40 seconds
- step no. 4 : 23 seconds
- print all altitudes : 65 seconds

The second example is similar to the first, except that the interactive queries and responses are included, and are underlined; only the parts of the printout holding queries and responses are shown here.

The third example shows the printed results of the "search for knots" procedure from the same data as the other examples. The execution time is 42 minutes; that is 10 seconds per line.

EXAMPLE NO. 1

SINGLE BASE ALTIMETRY CALCULATION

BISHAH-AD DARB GRAVITY, MD, USGS, 20 JULY 1977.

LOW.STAT NO: 47 BIG.STAT NO: 297 NO OF BASIC PTS: 3

GIVE NO 44 TO 46 TO THE BASIC POINTS.
THEN THE STATION NO OF THE FIRST STATION WILL BE : 47

	BASE STATION		ALTITUDE	SPREAD
1	47	44	-96.2	0.6
2	47	48	-52.2	1.3
3	47	49	-32.9	0.1
4	47	50	-5.7	0.3
5	47	51	61.3	1.0
6	47	52	38.1	1.3
7	47	53	21.7	0.7
8	47	54	-35.3	0.6
9	47	55	-74.5	0.3
10	56	57	-247.8	1.6
11	56	47	-350.1	1.6
⋮	⋮	⋮	⋮	⋮
253	286	297	-107.3	1.1

DATA READ FROM FILE 0

TO CORRECT ERRORS, ENTER LINE NO;
THEN, ENTER FIELD NO : 1 TO CHANGE BASE NO
2 TO CHANGE STATION NO
3 TO CHANGE ALTITUDE
4 TO CHANGE SPREAD

ENTER VALUES FOR POINTS OF KNOWN ALTITUDE :

POINT NO	ALTITUDE	SPREAD
44	0.0	0.1
45	135.6	0.1
46	47.0	0.1

STATION	ALTITUDE	MAX SPREAD	STANDARD DEV.	PROB. ERROR
STEP : 1				
47	96.2	0.7	0.6	0.4
48	44.0	1.9	1.4	1.0
49	63.3	0.7	0.6	0.4
50	90.5	0.9	0.7	0.5
51	157.5	1.6	1.2	0.8
52	134.3	1.9	1.4	1.0
53	117.9	1.3	0.9	0.6
54	60.9	1.2	0.9	0.6
55	21.7	0.9	0.7	0.5

117	352.0		0.2	0.1
116	664.3	1.5	1.3	0.9
118	761.3	3.3	3.1	2.1
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
285	196.1	3.6	2.6	1.7

CALCULATED : 9 BASES
77 STATIONS

STEP : 2

56	446.3	2.2	1.7	1.2
57	198.5	3.3	2.3	1.6
58	104.8	3.3	2.3	1.6
59	187.6	3.8	2.7	1.8
60	377.7	2.8	2.0	1.4
61	370.7	2.4	1.8	1.2
62	909.0	3.9	2.8	1.9
63	782.0	3.4	2.4	1.6
64	911.8	3.0	2.8	1.9
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
297	339.7	5.5	4.5	3.1

CALCULATED : 17 BASES
131 STATIONS

STEP : 3

157	769.7	5.4	4.5	3.0
158	768.7	6.3	4.8	3.3
159	1186.5	7.0	5.1	3.5
160	1172.2	5.7	4.6	3.1
161	1044.3	4.7	4.5	3.0
162	1299.3	5.3	4.6	3.1
163	638.3	5.9	4.7	3.2
164	376.3	6.5	4.9	3.3
195	457.0	5.4	3.9	2.6
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
203	276.0	5.0	4.0	2.7

CALCULATED : 2 BASES
14 STATIONS

STEP : 4

CALCULATED : 0 BASES
0 STATIONS

STATION	ALTITUDE	STANDARD DEV	PROB.ERROR
44	0.0	0.1	0.1
45	135.6	0.1	0.1
46	47.0	0.1	0.1
47	96.2	0.6	0.4
48	44.0	1.4	1.0
49	63.3	0.6	0.4
50	90.5	0.7	0.5
51	157.5	1.2	0.8
52	134.3	1.4	1.0
53	117.9	0.9	0.6
54	60.9	0.9	0.6
55	21.7	0.7	0.5
56	446.3	1.7	1.2
57	198.5	2.3	1.6
58	104.8	2.3	1.6
59	187.6	2.7	1.8
60	377.7	2.0	1.4
61	370.7	1.8	1.2
62	909.0	2.8	1.9
63	782.0	2.4	1.6
64	911.8	2.8	1.9
65	731.9	3.7	2.5
66	397.7	4.3	2.9
67	1581.0	2.8	1.9
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
297	339.7	4.5	3.1

MEAN OF PROB.ERRORS : 2.0
STANDARD DEVIATION : 0.9 PROBABLE ERROR : 0.6

CALCULATED : 28 BASES
222 STATIONS

END OF PROGRAM

EXAMPLE NO. 2

```
RUN
          SINGLE BASE ALTIMETRY CALCULATION

ENTER 70 CHARACTER TITLE ?BISHAH-AD DARB GRAVITY, MD, USGS, 20 JULY 1977.
BISHAH-AD DARB GRAVITY, MD, USGS, 20 JULY 1977.
-------------------------------------------------------------------------

ENTER LOWEST STAT NO ?47
ENTER BIGGEST STAT NO ?297
ENTER NO OF BASIC POINTS ?3
LOW.STAT NO:  47  BIG.STAT NO: 297  NO OF BASIC PTS:   3

GIVE NO  44  TO  46  TO THE BASIC POINTS.
THEN THE STATION NO OF THE FIRST STATION WILL BE : 47

FILE NO TO READ DATA, OR -1 ?0
PRINT DATA ?Y
          BASE STATION ALTITUDE  SPREAD

     1    47     44      -96.2      0.6
     2    47     48      -52.2      1.3
     3    47     49      -32.9      0.1
     4    47     50       -5.7      0.3
     5    47     51       61.3      1.0
     6    47     52       38.1      1.3
     7    47     53       21.7      0.7
     8    47     54      -35.3      0.6
     9    47     55      -74.5      0.3
    10    56     57     -247.8      1.6
    11    56     47     -350.1      1.6
    12    56     58     -341.5      1.6
    13    56     59     -258.7      2.1
    14    56     60      -68.6      1.1
    15    56     61      -75.6      0.7
    16    56     62      462.7      2.2
    17    56     63      335.7      1.7
    18    64     65     -179.9      2.5
    19    64     62       -2.8      0.2
    20    64     66     -514.1      3.3
    21    64     67      669.2      0.5
    22    64     68      166.8      0.4
    23    64     69      404.6      0.3
    24    64     70      353.5      1.5
    25    64     71      507.4      2.2
    26    72     64      217.3      2.2
    27    72     73     -313.1      0.7
    28    72     74      -73.9      0.6
    29    72     75     -177.6      0.7
    30    72     76     -353.4      4.9
    31    77     78      -42.2      1.4
    32    77     69      -43.1      2.1
    33    77     79      405.7      1.0
    34    77     80      423.9      1.3
    35    77     81      376.2      0.3
```

```
   244    286    288      315.8        2.9
   245    286    289       62.4        2.5
   246    286    290      159.2        1.2
   247    286    291      446.7        3.6
   248    286    292      585.8        3.4
   249    286    293      362.1        2.3
   250    286    294       61.5        1.8
   251    286    295      289.2        1.2
   252    286    296       15.8        0.6
   253    286    297     -107.3        1.1

CONT

DATA READ FROM FILE 0

ADD NEW DATA ?N

TO CORRECT ERRORS, ENTER LINE NO;
THEN, ENTER FIELD NO : 1 TO CHANGE BASE NO
                       2 TO CHANGE STATION NO
                       3 TO CHANGE ALTITUDE
                       4 TO CHANGE SPREAD
ANY ERROR ?N
FILE NO TO STORE DATA, OR -1 ?-1

WANT TO SEARCH FOR KNOTS ?N
WAIT... ARRAYS ARE ZEROED OUT
ENTER VALUES FOR POINTS OF KNOWN ALTITUDE :

POINT NO  ALTITUDE   SPREAD
ENTER ALTITUDE, SPREAD ?0,0.1
 0                0.1              OK ?Y
    44        0.0         0.1
ENTER ALTITUDE, SPREAD ?135.6,0.1
 135.6            0.1              OK ?Y
    45      135.6         0.1
ENTER ALTITUDE, SPREAD ?47,0.1
 47               0.1              OK ?Y
    46       47.0         0.1

  STATION    ALTITUDE      MAX       STANDARD    PROB.
                          SPREAD      DEV.       ERROR

 STEP : 1

      47        96.2         0.7         0.6         0.4
      48        44.0         1.9         1.4         1.0
      49        63.3         0.7         0.6         0.4
      50        90.5         0.9         0.7         0.5
      51       157.5         1.6         1.2         0.8
      52       134.3         1.9         1.4         1.0
      53       117.9         1.3         0.9         0.6
      54        60.9         1.2         0.9         0.6
      55        21.7         0.9         0.7         0.5
```

221	5.8	1.4	1.1	0.7
222	27.3	2.4	1.7	1.2
223	61.7	1.8	1.3	0.9
224	156.6	2.0	1.4	1.0
225	163.4	3.2	2.4	1.6
226	91.1	2.7	2.0	1.3
227	108.0	3.5	2.7	1.8
228	44.4	1.7	1.2	0.8
248	121.6	0.4	0.3	0.2
249	54.2	1.3	1.0	0.7
250	39.1	0.5	0.4	0.3
251	41.0	0.8	0.6	0.4
252	63.9	0.4	0.3	0.2
253	97.1	0.9	0.7	0.5
254	133.1	2.0	1.7	1.2
255	185.5	3.2	2.9	2.0
256	144.6	2.6	2.3	1.6
257	95.3	1.2	1.0	0.6
258	37.4	1.8	1.5	1.0
278	119.6	1.7	1.6	1.1
279	71.3	1.9	1.6	1.1
280	17.9	2.7	1.9	1.3
281	125.5	3.2	2.3	1.5
282	220.5	2.7	1.9	1.3
283	239.6	2.9	2.1	1.4
284	309.6	2.0	1.7	1.1
285	196.1	3.6	2.6	1.7

CALCULATED : 9 BASES
77 STATIONS

CONT
PRINT ALL ALTITUDES ?N

STEP : 2

56	446.3	2.2	1.7	1.2
57	198.5	3.3	2.3	1.6
58	104.8	3.3	2.3	1.6
59	187.6	3.8	2.7	1.8
60	377.7	2.8	2.0	1.4
61	370.7	2.4	1.6	1.2
62	909.0	3.9	2.8	1.9
63	782.0	3.4	2.4	1.6
64	911.8	3.0	2.8	1.9
65	731.9	5.3	3.7	2.5
66	397.7	6.1	4.3	2.9
67	1581.0	3.3	2.8	1.9
68	1078.6	3.2	2.8	1.9
69	1316.4	3.1	2.8	1.9
70	1265.3	4.3	3.2	2.1

291	893.7	8.0	5.7	3.8
292	1032.8	7.8	5.6	3.8
293	809.1	6.7	5.0	3.4
294	508.5	6.2	4.8	3.2
295	736.2	5.6	4.6	3.1
296	462.8	5.0	4.5	3.0
297	339.7	5.5	4.5	3.1

CALCULATED : 17 BASES
131 STATIONS

CONT
PRINT ALL ALTITUDES ?N

STEP : 3

157	769.7	5.4	4.5	3.0
158	768.7	6.3	4.8	3.3
159	1186.5	7.0	5.1	3.5
160	1172.2	5.7	4.6	3.1
161	1044.3	4.7	4.5	3.0
162	1299.3	5.3	4.6	3.1
163	638.3	5.9	4.7	3.2
164	376.3	6.5	4.9	3.3
195	457.0	5.4	3.9	2.6
196	387.1	4.8	4.0	2.7
197	650.0	5.8	4.3	2.9
198	682.1	6.2	4.5	3.0
199	819.0	8.2	5.8	3.9
200	522.6	7.5	5.3	3.6
201	363.7	6.4	4.6	3.1
203	276.0	5.0	4.0	2.7

CALCULATED : 2 BASES
14 STATIONS

CONT
PRINT ALL ALTITUDES ?N

STEP : 4

CALCULATED : 0 BASES
0 STATIONS

CONT
PRINT ALL ALTITUDES ?Y

STATION	ALTITUDE	STANDARD DEV	PROB.ERROR
44	0.0	0.1	0.1
45	135.6	0.1	0.1
46	47.0	0.1	0.1
47	96.2	0.6	0.4
48	44.0	1.4	1.0
49	63.3	0.6	0.4

272	1037.3	3.5	2.4
273	901.6	3.5	2.4
274	831.7	3.5	2.4
275	847.6	3.8	2.5
276	589.1	3.7	2.5
277	604.5	3.7	2.5
278	119.6	1.6	1.1
279	71.3	1.6	1.1
280	17.9	1.9	1.3
281	125.5	2.3	1.5
282	220.5	1.9	1.3
283	239.6	2.1	1.4
284	309.6	1.7	1.1
285	196.1	2.6	1.7
286	447.0	4.4	3.0
287	464.9	4.7	3.2
288	762.8	5.3	3.6
289	509.4	5.1	3.4
290	606.2	4.6	3.1
291	893.7	5.7	3.8
292	1032.8	5.6	3.8
293	809.1	5.0	3.4
294	508.5	4.8	3.2
295	736.2	4.6	3.1
296	462.8	4.5	3.0
297	339.7	4.5	3.1

MEAN OF PROB.ERRORS : 2.0
STANDARD DEVIATION : 0.9 PROBABLE ERROR : 0.6

CALCULATED : 28 BASES
222 STATIONS

END OF PROGRAM

NOTE : THE WORD "CONT" DOES NOT USUALLY APPEAR
IT IS USED HERE TO PRODUCE A FEW PARTS OF THE COMPLETE
PRINTOUT.

EXAMPLE NO. 3

	BASE	STATION	ALTITUDE	SPREAD	KNOT
1	47	44	-96.2	0.6	1
2	47	48	-52.2	1.3	0
3	47	49	-32.9	0.1	0
4	47	50	-5.7	0.3	0
5	47	51	61.3	1.0	0
6	47	52	38.1	1.3	0
7	47	53	21.7	0.7	3
8	47	54	-35.3	0.6	0
9	47	55	-74.5	0.3	0
10	56	57	-247.8	1.6	0
11	56	47	-350.1	1.6	2
12	56	58	-341.5	1.6	0
13	56	59	-258.7	2.1	0
14	56	60	-68.6	1.1	0
15	56	61	-75.6	0.7	0
16	56	62	462.7	2.2	3
17	56	63	335.7	1.7	3
18	64	65	-179.9	2.5	0
19	64	62	-2.8	0.2	3
20	64	66	-514.1	3.3	0
21	64	67	669.2	0.5	0
22	64	68	166.8	0.4	0
23	64	69	404.6	0.3	3
24	64	70	353.5	1.5	0
25	64	71	507.4	2.2	0
26	72	64	217.3	2.2	2
27	72	73	-313.1	0.7	0
28	72	74	-73.9	0.6	0
29	72	75	-177.6	0.7	0
30	72	76	-353.4	4.9	0
31	77	78	-42.2	1.4	0
32	77	69	-43.1	2.1	3
33	77	79	405.7	1.0	0
34	77	80	423.9	1.3	0
35	77	81	376.2	0.3	0
36	77	82	362.9	1.5	0
37	77	83	-41.6	0.2	0
38	77	84	-223.9	0.5	0
39	77	85	-416.4	1.3	0
40	77	86	-367.9	1.3	0
41	87	88	-240.7	1.2	0
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
253	286	297	-107.3	1.1	0

SOURCE PROGRAM LISTING

```
1 COM L0,BI[255],SI[255],AS[255],ES[255]
20 REM---SINGLE BASE ALTIMETRY CALCULATION----------M.D. 20 JUL 77 -----
40 DIM T$[70],FS[255],GS[255],DS[255],KI[255]
60 PRINT "          SINGLE BASE ALTIMETRY CALCULATION"
80 PRINT
100 DISP "ENTER 70 CHARACTER TITLE ";
120 INPUT T$[1,70]
140 PRINT T$[1,70]
160 WRITE (15,162)
162 FORMAT 80"-"
164 DISP "ENTER LOWEST STAT NO ";
165 INPUT M1
166 DISP "ENTER BIGGEST STAT NO ";
167 INPUT M2
172 DISP "ENTER NO OF BASIC POINTS ";
174 INPUT M0
175 WRITE (15,176)M1,M2,M0
176 FORMAT "LOW.STAT NO:",F4.0,"  BIG.STAT NO:",F4.0,"  NO OF BASIC PTS:",F
177 L1=M2-M1+M0+1
178 IF L1 <= 255 THEN 184
180 PRINT "MORE THAN 255 STATIONS. SEPARATE STATIONS INTO 2 PARTS."
182 GOTO 164
184 M3=M1-M0
186 M4=M1-1
188 M5=M3-1
189 PRINT
190 WRITE (15,192)M3,M4
192 FORMAT "GIVE NO",F4.0,"  TO",F4.0,"  TO THE BASIC POINTS."
194 PRINT "THEN THE STATION NO OF THE FIRST STATION WILL BE :"M1
206 PRINT
208 FORMAT "          BASE STATION ALTITUDE  SPREAD"
220 DISP "FILE NO TO READ DATA, OR -1 ";
240 INPUT F1
260 IF F1=-1 THEN 620
280 REM-------------------ENTER DATA FROM TAPE----------------------
300 LOAD  DATA F1
302 DISP "PRINT DATA ";
304 INPUT Y$
306 IF Y$="N" THEN 440
308 WRITE (15,208)
310 PRINT
320 FOR I=1 TO L0
360 WRITE (15,380)I,B[I],S[I],A[I],E[I]
380 FORMAT 3F6.0,2F10.1
400 NEXT I
440 I=L0+1
450 PRINT
460 PRINT "DATA READ FROM FILE"F1
480 PRINT
```

```
500 DISP "ADD NEW DATA ";
520 INPUT Y$
540 IF Y$="N" THEN 980
560 GOTO 840
600 REM--------------------ENTER DATA FROM KEYBOARD----------------------
620 DISP "WAIT... ARRAYS ARE ZEROED OUT"
640 WAIT 2000
660 FOR I=1 TO 255
680 B[I]=0
700 S[I]=0
720 A[I]=0
740 E[I]=0
780 NEXT I
782 WRITE (15,208)
784 PRINT
800 I=0
820 I=I+1
822 IF I <= 255 THEN 840
824 PRINT "MORE THAN 255 LINES. ONLY 255 LINES ARE KEPT."
826 L0=255
828 GOTO 980
840 DISP "BASE, STAT, ALTITUDE, SPREAD";
860 INPUT B[I],S[I],A[I],E[I]
880 WRITE (15,380)I,B[I],S[I],A[I],E[I]
900 DISP "CONTINUE ";
920 INPUT Y$
940 IF Y$="Y" THEN 820
960 L0=I
980 PRINT
985 PRINT "TO CORRECT ERRORS, ENTER LINE NO;"
990 PRINT "THEN, ENTER FIELD NO : 1 TO CHANGE BASE NO"
992 PRINT "                       2 TO CHANGE STATION NO"
994 PRINT "                       3 TO CHANGE ALTITUDE"
996 PRINT "                       4 TO CHANGE SPREAD"
1000 DISP "ANY ERROR ";
1020 INPUT Y$
1040 IF Y$="N" THEN 1160
1060 DISP "ENTER LINE NO ";
1080 INPUT I
1090 WRITE (15,380)I,B[I],S[I],A[I],E[I]
1092 DISP "ENTER 1, 2, 3, OR 4 ";
1094 INPUT J
1096 IF J#1 THEN 1104
1098 DISP "ENTER BASE NO ";
1100 INPUT B[I]
1102 GOTO 1130
1104 IF J#2 THEN 1112
1106 DISP "ENTER STATION NO ";
1108 INPUT S[I]
1110 GOTO 1130
1112 IF J#3 THEN 1120
1114 DISP "ENTER ALTITUDE ";
1116 INPUT A[I]
```

```
1118 GOTO 1130
1120 DISP "ENTER SPREAD ";
1122 INPUT E[I]
1130 WRITE (15,380)I,B[I],S[I],A[I],E[I]
1140 GOTO 1000
1160 DISP "FILE NO TO STORE DATA, OR -1 ";
1180 INPUT F2
1200 IF F2=-1 THEN 1320
1220 STORE  DATA F2
1240 PRINT
1260 PRINT "DATA STORED ON FILE"F2
1320 PRINT
1321 REM
1960 DISP "WANT TO SEARCH FOR KNOTS ";
1980 INPUT Y$
2000 IF Y$="N" THEN 2640
2020 REM--------------------SEARCH FOR KNOTS
2030 PRINT
2040 WRITE (15,2050)
2050 FORMAT "          BASE STATION ALTITUDE  SPREAD   KNOT"
2060 PRINT
2062 FOR I=1 TO L0
2064 K[I]=0
2066 NEXT I
2080 B1=B[1]
2120 FOR I=1 TO L0
2140 IF B[I]=B1 THEN 2160
2150 PRINT
2155 B1=B[I]
2160 IF S[I] >= M1 THEN 2220
2180 K[I]=1
2200 GOTO 2460
2220 FOR N=1 TO L0
2240 IF S[I]=B[N] THEN 2300
2260 NEXT N
2280 GOTO 2340
2300 K[I]=2
2320 GOTO 2460
2340 FOR N=1 TO L0
2360 IF N=I THEN 2400
2380 IF S[I]=S[N] THEN 2440
2400 NEXT N
2420 GOTO 2460
2440 K[I]=3
2460 WRITE (15,2480)I,B[I],S[I],A[I],E[I],K[I]
2480 FORMAT 3F6.0,2F10.1,F6.0
2500 NEXT I
2520 PRINT
2630 REM--------------------1ST STEP : ALT OF BASE-STAT FROM SEALEVEL DIREC
2640 DISP "WAIT... ARRAYS ARE ZEROED OUT"
2645 WAIT 2000
2650 S0=0
2652 S1=0
```

```
2654 S8=0
2656 S9=0
2660 FOR I=1 TO L1
2680 F[I]=-1000
2700 G[I]=0
2715 D[I]=0
2720 NEXT I
2722 PRINT "ENTER VALUES FOR POINTS OF KNOWN ALTITUDE :"
2723 PRINT
2724 PRINT "POINT NO  ALTITUDE   SPREAD"
2726 FOR I=1 TO M0
2728 DISP "ENTER ALTITUDE, SPREAD ";
2730 INPUT F[I],G[I]
2732 DISP F[I],G[I],"OK ";
2734 INPUT Y$
2736 IF Y$="N" THEN 2728
2738 WRITE (15,2740)I+M5,F[I],G[I]
2740 FORMAT F6.0,2F10.1
2774 D[I]=G[I]
2776 NEXT I
2780 GOSUB 7800
2782 PRINT " STEP : 1"
2784 PRINT
2800 I0=1
2802 FOR J=I0 TO L0
2804 IF B[J]=0 THEN 2808
2806 IF S[J]<M1 THEN 2820
2808 NEXT J
2810 GOTO 3230
2815 REM--------------------CALCULATE BASE IF ONE STATION IS KNOWN
2820 K1=B[J]-M5
2822 K2=S[J]-M5
2824 F[K1]=0
2825 G[K1]=0
2826 L=J
2828 J1=1
2829 GOSUB 8020
2830 L2=J+1
2832 FOR L=L2 TO L0
2833 IF B[L]=0 THEN 2838
2834 IF B[J]#B[L] THEN 2860
2836 IF S[L]<M1 THEN 2842
2838 NEXT L
2839 GOTO 2860
2842 J1=J1+1
2844 K2=S[L]-M5
2850 GOSUB 8020
2854 L2=L+1
2856 GOTO 2832
2860 K3=K1
2870 S1=S1+1
2880 GOSUB 7020
2890 REM--------------------CALCULATE STATIONS OF TERRAIN LOOP
```

```
2900 I=J
2920 GOSUB 8500
3200 I0=I
3220 IF I0 <= L0 THEN 2802
3230 GOSUB 8380
3232 S8=S0
3234 S9=S1
3240 DISP "PRINT ALL ALTITUDES ";
3260 INPUT Y$
3280 IF Y$="N" THEN 3320
3300 GOSUB 8205
3320 REM--------------------OTHER STEPS--------------------------------
3340 L3=1
3360 L3=L3+1
3370 PRINT
3380 PRINT " STEP :"L3
3400 I0=0
3410 S0=0
3415 S1=0
3418 I0=I0+1
3420 J=I0
3430 IF B[J]=0 THEN 3418
3440 K1=B[J]-M5
3460 IF F[K1]=-1000 THEN 3640
3480 GOSUB 8600
3500 GOTO 4100
3620 REM--------------------CALCULATE BASE, IF ONE STATION IS KNOWN
3640 FOR I=I0 TO L0
3650 IF B[I]=0 THEN 3720
3660 IF B[J]#B[I] THEN 4100
3680 K2=S[I]-M5
3700 IF F[K2]#-1000 THEN 3724
3720 NEXT I
3722 GOTO 4160
3724 L=I
3726 J1=1
3728 F[K1]=0
3729 GOSUB 8020
3730 L2=I+1
3732 FOR L=L2 TO L0
3733 IF B[L]=0 THEN 3740
3734 IF B[I]#B[L] THEN 3796
3736 K2=S[L]-M5
3738 IF F[K2]#-1000 THEN 3744
3740 NEXT L
3742 GOTO 3796
3744 J1=J1+1
3746 GOSUB 8020
3756 L2=L+1
3758 GOTO 3732
3796 K3=K1
3798 GOSUB 7020
3800 S1=S1+1
```

```
3810 REM--------------------CALCULATE STATIONS OF TERRAIN LOOP
3820 GOSUB 8500
4100 I0=I
4120 IF I0 <= L0 THEN 3420
4160 GOSUB 8380
4170 S8=S8+S0
4175 S9=S9+S1
4180 DISP "PRINT ALL ALTITUDES ";
4200 INPUT Y$
4220 IF Y$="N" THEN 4260
4230 T0=S0
4232 T1=S1
4240 GOSUB 8205
4250 S0=T0
4252 S1=T1
4260 IF S0>0 THEN 3360
4280 PRINT "END OF PROGRAM"
4300 END
7000 REM--------------------FINAL CALCULATION OF STATION OR BASE---------
7020 F[K3]=F[K3]/G[K3]
7040 G[K3]=J1/G[K3]
7042 D[K3]=G[K3]*0.674
7045 IF K3#K1 THEN 7050
7048 PRINT
7050 IF J1#1 THEN 7100
7060 WRITE (15,7070)K3+M5,F[K3],C0,G[K3],D[K3]
7070 FORMAT F8.0,4F10.1
7080 RETURN
7100 WRITE (15,7110)K3+M5,F[K3],G[K3],D[K3]
7110 FORMAT F8.0,F10.1,10X,2F10.1
7120 RETURN
7800 REM--------------------TITLES---------------------------------------
7820 PRINT
7840 WRITE (15,7880)
7860 WRITE (15,7900)
7880 FORMAT "  STATION    ALTITUDE      MAX     STANDARD    PROB."
7900 FORMAT 24X,"SPREAD     DEV.      ERROR"
7920 PRINT
7940 RETURN
8000 REM--------------------ALTITUDE OF BASE-----------------------------
8020 F1=1/SQR(G[K2]^2+E[L]^2)
8030 G[K1]=G[K1]+F1
8040 F[K1]=F[K1]+(F[K2]-A[L])*F1
8042 C0=G[K2]+E[L]
8080 RETURN
8100 REM--------------------ALTITUDE OF STATION--------------------------
8120 F1=1/SQR(G[K1]^2+E[L]^2)
8130 G[K2]=G[K2]+F1
8140 F[K2]=F[K2]+(F[K1]+A[L])*F1
8142 C0=G[K1]+E[L]
8180 RETURN
8200 REM--------------------PRINT ALTITUDE-------------------------------
8205 PRINT
```

```
8210 WRITE (15,8220)
8220 FORMAT "  STATION    ALTITUDE  STANDARD DEV    PROB.ERROR"
8240 PRINT
8242 S2=0
8244 S3=0
8246 N1=0
8260 FOR I=1 TO L1
8280 WRITE (15,8300)I+M5,F[I],G[I],D[I]
8300 FORMAT F8.0,F10.1,F11.1,2X,F12.1
8302 IF I<M0+1 THEN 8310
8303 IF F[I]=-1000 THEN 8310
8304 S2=S2+D[I]
8306 S3=S3+D[I]^2
8308 N1=N1+1
8310 NEXT I
8321 S6=S2/N1
8322 S4=(N1*S3-S2^2)/(N1*(N1-1))
8324 S4=SQR(S4)
8326 S5=0.674*S4
8328 PRINT
8330 WRITE (15,8332)S6
8332 FORMAT "MEAN OF PROB.ERRORS :",F6.1
8334 WRITE (15,8336)S4,S5
8336 FORMAT "STANDARD DEVIATION  :",F6.1,"      PROBABLE ERROR :",F6.1
8338 PRINT
8340 S0=S8
8342 S1=S9
8346 GOSUB 8380
8348 RETURN
8360 REM--------------------PRINT BASE-STATION CALCULATED----------------
8380 PRINT
8400 WRITE (15,8420)S1
8420 FORMAT "CALCULATED :",F5.0,"  BASES"
8440 WRITE (15,8460)S0
8460 FORMAT "             ",F5.0,"  STATIONS"
8470 PRINT
8480 RETURN
8500 REM--------------------CALCULATION OF STATIONS OF SAME TERRAIN LOOP--
8505 REM                      TAKE VALUE WITH LOWEST ERROR
8510 FOR N0=I-1 TO 1 STEP -1
8515 IF B[N0]=0 THEN 8530
8520 IF B[J]#B[N0] THEN 8550
8530 NEXT N0
8540 N0=0
8550 I0=N0+1
8560 REM--------------------BEGIN WITH FIRST STATION OF TERRAIN LOOP
8600 FOR I=I0 TO L0
8605 IF B[I]=0 THEN 8640
8610 IF B[J]#B[I] THEN 8820
8620 K2=S[I]-M5
8630 IF F[K2]=-1000 THEN 8660
8640 NEXT I
8650 GOTO 8820
8660 L=I
```

```
8662 J1=1
8664 F[K2]=0
8668 GOSUB 8120
8670 L2=I+1
8680 FOR L=L2 TO L0
8685 IF B[L]=0 THEN 8710
8690 IF B[I]#B[L] THEN 8790
8700 IF S[I]=S[L] THEN 8730
8710 NEXT L
8720 GOTO 8790
8730 J1=J1+1
8740 GOSUB 8120
8770 L2=L+1
8780 GOTO 8680
8790 K3=K2
8800 GOSUB 7020
8805 S0=S0+1
8810 I0=I
8815 GOTO 8600
8820 RETURN
```

U. S. GEOLOGICAL SURVEY

SAUDI ARABIAN PROJECT

MISCELLANEOUS DOCUMENT 3

(INTERAGENCY REPORT 281)

PROGRAM HP9001:

SINGLE BASE ALTIMETRY DATA REDUCTION

by

M. E. Gettings

U.S. Geological Survey
Open-File Report 80-1275

U.S. Geological Survey
Jiddah, Saudi Arabia

1980

Part 2 of 3

The work on which this report is based was performed in accordance with a cooperative agreement between the U. S. Geological Survey and the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia.

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

Program Documentation Manual

Program Number	:	HP9001
Program Name	:	Single Base Altimetry Data Reduction
Programmer	:	M. E. Gettings
Language	:	BASIC
Computer/System	:	HP* 9830A programmable calculator with string variables ROM
Date	:	20 March 1977
Institution	:	U. S. Geological Survey/Saudi Arabian Project
Location	:	Jiddah, Saudi Arabia

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* Hewlett-Packard. Any trade names in this report are used for descriptive purposes only and do not constitute endorsement by the U.S. Geological Survey.

CONTENTS

ILLUSTRATION

PROGRAM HP9001:

SINGLE BASE ALTIMETRY DATA REDUCTION

by

M. E. Gettings

ABSTRACT

Program HP9001 is designed to reduce single base station altimetry data for one or two pairs of altimeters where one altimeter of each pair is at the base station and the other at the roving station. The program calculates the elevation difference between the base and roving altimeters, and makes temperature and humidity corrections and a barometric closure adjustment. Input is interactive via the HP9830A keyboard and display. The output is a printed tabulation of the reductions and a cassette tape file suitable for processing by program HP9004 (Altimetric Elevation Calculation)*.

*Donzeau, this open-file report, part 1.

SOURCE DECK LOCATION AND UPDATE STATUS

The source program HP9001 is on cassettes USGS-HP-101, file 2 on file in the offices of the geophysics section, USGS/SAP in Jiddah, Saudi Arabia.

No updates have been made to the program at this time.

DESCRIPTION OF COMPUTED QUANTITIES

The computations are outlined in the altimetry manual by Wallace and Tiernan (undated) for the determination of elevation differences between a base station and surrounding field stations whose elevation is to be determined. It is assumed that an altimeter is recording barometric variations at the base station while another, the "roving" altimeter, is read at the various field stations. At each roving altimeter station, the time, wet and dry bulb (psychrometric) temperatures, and altimeter reading are measured and recorded. The same information is measured and recorded at the base each time the base station altimeter is read. The survey data is assumed to be organized into loops on each base station, with each loop initiated and terminated by simultaneous readings of the base and roving altimeters at the base station.

From these data, calculations proceed in the following manner. First the "index difference" (I) is determined from the initial readings of the base (B) and roving (R) altimeters at the base, as shown in the following equation (eq.):

$$I = B_1 - R_1 \qquad (1)$$

Next, using the final readings (B_n and R_n) of the base and roving altimeters at the base and the psychrometric readings, the total "closure adjustment" to be distributed linearly timewise throughout the loop is calculated. The calculation of the temperature and humidity correction factor (c) is explained below. The total closure adjustment A is given by:

$$A = c\ (R_n + I - B_n) \qquad (2)$$

The elevation difference between a field station and the base is calculated according to the following scheme. For a roving altimeter reading R_i at time t_i with wet and dry bulb temperatures T^r_{wi} and T^r_{di}, one interpolates the corresponding base station readings B_i, T^b_{wi} and T^b_{di} at t_i linearly from the nearest bracketing pair of readings in the base station records, that is:

$$B_i\ (t_i) = B_j(t_j) + (t_i - t_j)\ \frac{(B_{j+1} - B_j)}{(t_{j+1} - t_j)} \qquad (3)$$

where the times of base observations t_j and t_{j+1} satisfy

$$t_j \leq t_i \text{ and } t_i < t_{j+1} \qquad (4)$$

Two formulas analogous to (3) are used for interpolation of the wet- and dry-bulb temperatures.

The relative humidity is calculated at the base and roving stations from (Handbook of Chemistry and Physics):

$$H=100\ (E_w - (T_D - T_w)\ (0.273 + 1.8E\text{-}4\ T_w))/E_D \qquad (5)$$

where E_w and E_D are the vapor tensions of water at T_w and T_D respectively. All formulae are for temperatures in degrees fahrenheit. The vapor tension of water E is calculated from:

$$E=10^{(9.2316-4215.6/(459.6+T))} \qquad (6)$$

which was obtained by empirical fitting of a curve to vapor tension tables in the Handbook of Chemistry and Physics (1975). Formulas (5) and (6) reproduce wet and dry bulb tables of relative humidity to within 0.5°F which is normally

at least as accurate as the temperature readings. Once the humidity at the roving (using T^r_{wi} and T^r_{di} in (5) and (6)) and base (using T^b_{wi} and T^b_{di}) stations has been calculated, the temperature and humidity correction factor is calculated as follows from the average humidity $\bar{H}$ and dry bulb temperatures $\bar{T}_d$ between the base and roving stations.

$$f_T = 0.900833 + 0.001983\ \bar{T}_d \qquad (7)$$

$$f_H = 1.0 + m\ \bar{H} \qquad (8)$$

$$m = 1.2E\text{-}5\ 10^{(0.012667\ \bar{T}_d)} \qquad (9)$$

Finally $c = f_T f_H$ (10)

is the correction factor.

These formulas were obtained empirically by curve fitting and reproduce the correction factor nomogram given by Wallace and Tiernan to within the accuracy to which it can be read.

The "indicated difference" is computed from

$$h_i = R_i + I - B_i \qquad (11)$$

The "corrected difference" is given by

$$h'_i = c\ h_i \qquad (12)$$

The "closure adjustment" is calculated by linear interpolation of A from eq. (2) timewise across the duration of the loop

$$A_i = A\ (t_i - t_o)/(t_f - t_o) \qquad (13)$$

where t_o and t_f are the times of the initial and final readings of the base and roving altimeters at the base.

Then the "final difference" is given by

$$h_i'' = h_i' + A_i \qquad (14)$$

Formulae (3) through (14) are applied successively to all roving stations in the loop.

DESCRIPTION OF THE PROGRAM

The general program flow is shown in figure 1. The basic tasks in order are: 1) enter titling and labeling information; 2) input the matrix of base station times, wet and dry temperatures, and altimeter readings for a loop; 3) calculate index differences eq. (1) and closure adjustments eq. (2); 4) enter, reduce (eqs. (3)-(14)), and printout roving altimeter observations a station at a time for all stations in the loop. Up to 50 base station observations during a loop may be accommodated. The program is set up to reduce data from two pairs of altimeters simultaneously since ordinarily one uses two altimeters at the base and roving stations as a matter of good field practice. Each of the base altimeters is paired with the roving altimeter that is experimentally determined to match it best. For each roving station all computed quantities are printed for each base-roving pair. In addition, the average final elevation difference for the two pairs and one half their difference is printed for each roving station.

Control and execution of the program are interactive through the 9830 keyboard and display and output are via the system printer. All printout is set up for an 80-character maximum printer width. The "string variables" option is utilized to provide titling and "yes" and "no" answers to questions controlling the flow of the program.

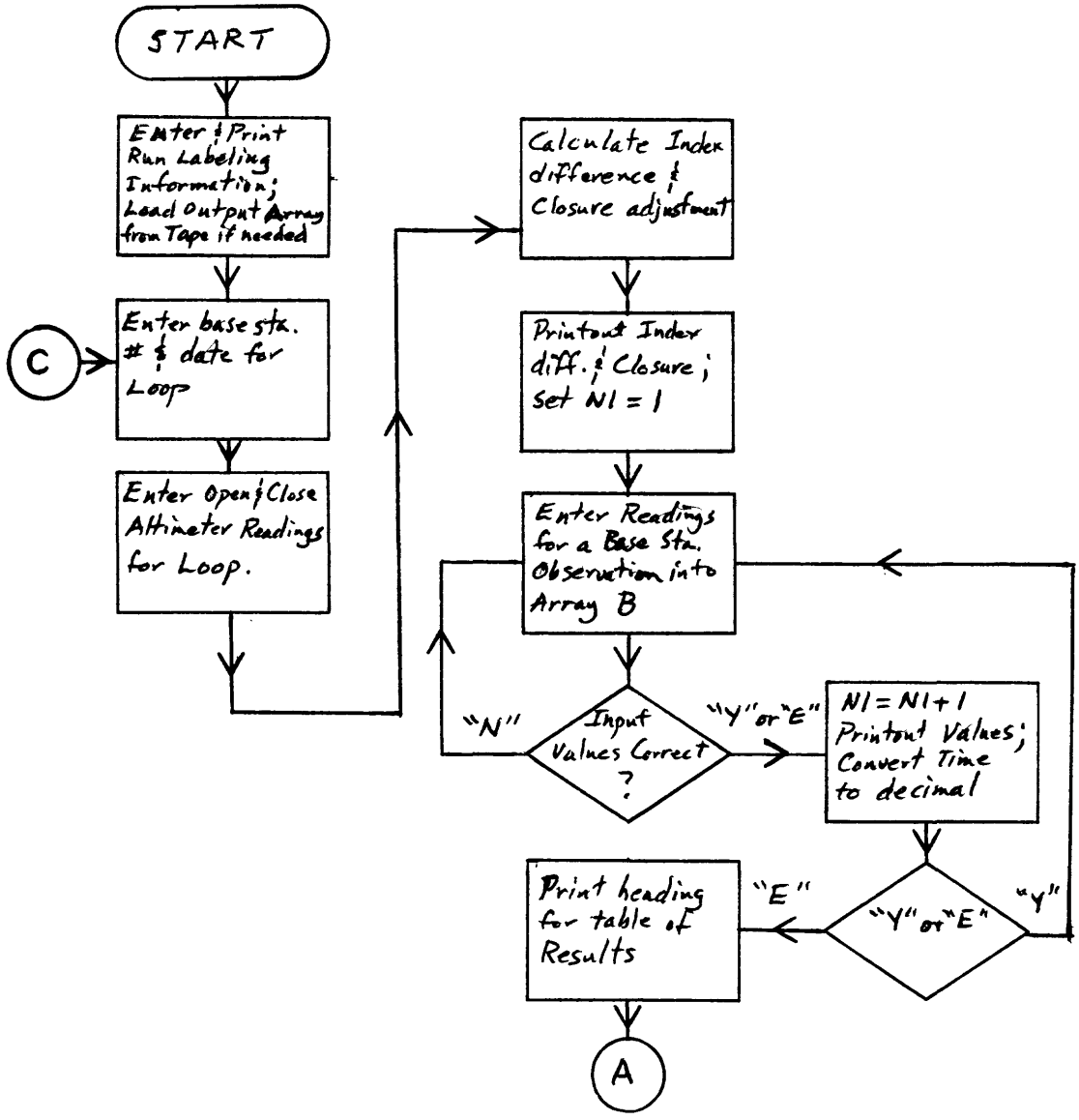

Figure 1. Altimetry data reduction program flow-chart.

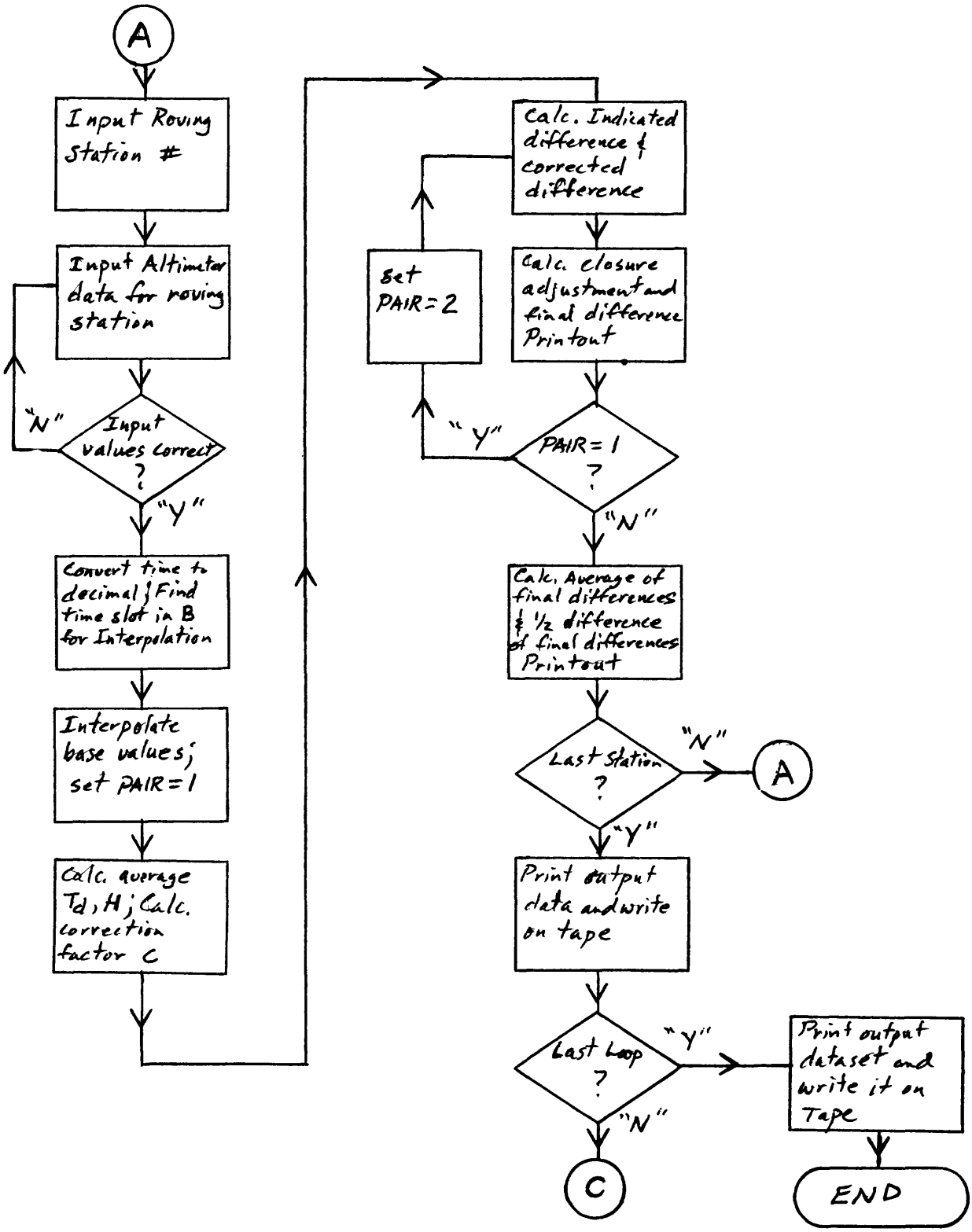

Figure 1.,continued.

The program requires 2500 words of storage in the HP9830. The only large array is the matrix B(50,5) that holds the base station observations. No external routines are required other than the standard ones (absolute value, etc.) provided with the calculator. Execution time to reduce a pair of roving altimeter observations is about 3 seconds.

The results of the altimetry reduction can be stored on a magnetic cassette tape file so that they can be processed by program HP9004 "Altimetric Elevation Calculation" (Domzeau, 1980) to calculate the altitudes in a network.

The data are stored with a COMMON statement holding:

1) L0 number of lines
2) BI(255) base numbers; integer precision array
3) SI(255) station numbers; integer precision array
4) AS(255) altitude difference measurements; split precision array
5) ES(255) difference between pair 1 and pair 2 final altitude difference; split precision array

Base and station numbers must follow the conventions given below. With each run, the program adds the output data to the end of the data previously stored on the same tape file, that is starting with line number L0 + 1. This allows one to interrupt and restart the data reduction, i.e. all data does not have to be reduced in one execution of the program.

The total number of measurements is limited to 255, that is, the number of "bases + stations + known points" must be less than 256. (A known point is defined as a point of known altitude, such as sea level, a geodetic point, etc.) If M_1 is the lowest station (or base) number, M_2 the highest station (or base) number, M_0 the number of known points, the number $L_1 = M_2 - M_1 + M_0 + 1$ must be less than 255. The known points must be given numbers preceding the lowest station number, that is from M_1-M_0 to M_1-1.

PROGRAM OPERATION

Operation of the program is largely self-explanatory. When the program has been loaded and execution started, requests for information appear on the 32 character calculator display. Questions requiring "yes" or "no" answer are answered with "Y" or "N". In entering base station data, the calculator echoes the entered numbers for an observation followed by "OK?". If all the numbers are correct and this is not the last base station observation, answer "Y"; if they are correct and this is the last base observation, answer "E"; if incorrect, answer "N" and reenter upon prompt. The same procedure is used in entering roving altimeter data except that the response "E" is not available.

When answering such a question, if one enters too many characters, for example, "YES" instead of "Y", an "ERROR 74" will occur. To recover, press "RECALL", delete line, and enter the correct response.

After completing all stations in a loop, a new loop can be initiated or program execution terminated.

Station identification names must be integer numbers.

When exercising the option of storing the results of the data reduction on cassette tape, note that the station numbering convention described in the last section must be used. If tape cassette output is not desired, one specifies a tape file number of -1 whenever prompted to do so by the program.

EXAMPLE

The following is the resulting printout from a typical run. In the first listing, the interactive queries and responses are included with the resulting printout and are underlined. The second listing shows just the resulting printed results for the same run. Note that an example of recovery from "ERROR 74" is included in the first listing. The example begins after the user has turned on the calculator, loaded the cassette containing the program (in this case, cassette USGS-HP-101), typed "LOAD 2", and pressed the key "EXECUTE". After the cassette file has been read, the prompt symbol is displayed by the calculator and execution is begun by typing "RUN" and pressing the "EXECUTE" key.

```
RUN
ENTER 70 CHAR SURVEY TITLE?SAMPLE RUN, 20 MAR 1978, MEG, USGS/SAP.

 * * * ALTIMETRY REDUCTIONS-SINGLE BASE, 2 PAIRS OF ALTIMETERS * * *

SURVEY TITLE:  SAMPLE RUN, 20 MAR 1978, MEG, USGS/SAP.

-------------------------------------------------------------------------

WARNING : GIVE NUMBERS TO BASE AND STATIONS, AS DESCRIBED IN
-------   PROGRAM DOCUMENTATION.

FILE NO TO READ DATA, OR -1 ?-1
WAIT... ARRAYS ARE ZEROED OUT.
FILE NO TO STORE DATA, OR -1 ?-1

-------------------------------------------------------------------------

ENTER BASE NO?3
ENTER DATE OF LOOP?14 APR 1975
BASE STATION FOR LOOP:          3          DATE OF LOOP:  14 APR 1975

BASE STATION READINGS
 TIME T(WET) T(DRY) ALT#1   ALT#2
ENTER BASE STATION READINGS
TIME,TW,TD,B1,B2?637,62,67,805,780
 637    62     67     805    780  OK?Y
  637    62     67      805     780
TIME,TW,TD,B1,B2?700,62,67,800,775
 700    62     67     800    775  OK?Y
  700    62     67      800     775
TIME,TW,TD,B1,B2?730,62,66,800,775
 730    62     66     800    775  OK?Y
  730    62     66      800     775
TIME,TW,TD,B1,B2?800,62,68,795,770
 800    62     68     795    770  OK?Y
  800    62     68      795     770
TIME,TW,TD,B1,B2?831,64,69,795,765
 831    64     69     795    765  OK?Y
  831    64     69      795     765
TIME,TW,TD,B1,B2?900,64,69,790,765
 900    64     69     790    765  OK?Y
  900    64     69      790     765
TIME,TW,TD,B1,B2?
```

```
                    930,65,70,785,765
 930    65     70     785    765  OK?Y
  930    65     70      785      765
TIME,TW,TD,B1,B2?1000,66,72,790,765
 1000      66     72     790    765  OK?Y
 1000    66     72      790      765
TIME,TW,TD,B1,B2?1030,67,73,785,760
 1030      67     73     785    760  OK?Y
 1030    67     73      785      760
TIME,TW,TD,B1,B2?1115,61,69,785,760
 1115      61     69     785    760  OK?N
TIME,TW,TD,B1,B2?1111,61,69,785,760
 1111      61     69     785    760  OK?E
 1111    61     69      785      760
ENTER LOOP OPEN READINGS B1,R1?802,805
ENTER LOOP OPEN READINGS B2,R2?776,776


LOOP OPEN READINGS

   B1=  802      B2=  776      R1=  805      R2=  776

INDEX DIFFERENCES
   I1=   -3      I2=    0

OK?Y
ENTER LOOP CLOSE B1,R1?785,792
ENTER LOOP CLOSE B2,R2?760,768
ENTER LOOP CLOSE WET&DRY TEMPS?61,69
LOOP CLOSE READINGS
   T(WET)=   61      T(DRY)=   69
   B1=  785      B2=  760      R1=  792      R2=  768
OK?Y

TEMP & HUMIDITY CORRECTION FACTOR AT CLOSE= 1.044

TOTAL CORRECTED CLOSURE ADJUSTMENTS

 PAIR B1,R1= -4.2      PAIR B2,R2= -8.3

ROVING ALTIMETER REDUCTIONS

  STA    PR TIME TW TD TA HA C FTR  BASE   ROVE  IN DIF CO DIF CLOSURE FIN DIF

STATION NO?260
ENTER TIME,TW,TD,R1,R2?820,62,68,830,800
 820   62     68     830    800  OK?Y
  260     1  820 62 68 68 73 1.043  795.0    830    32.0    33.4    -1.6     31.8
          2                         766.8    800    33.2    34.7    -3.1     31.5
                                                HALF SPREAD=    0.1 AVERAGE=    31.7

IS THIS THE LAST STATION?
```

```
ERROR 74 IN LINE 1320
?N
STATION NO?261
ENTER TIME,TW,TD,R1,R2?855,65,70,797,771
 855   65    70    797   771  OK?Y
 261     1  855 65 70 70 76 1.046  790.9   797    3.1    3.3   -2.1     1.2
         2                         765.0   771    6.0    6.3   -4.2     2.1
                                           HALF SPREAD=    0.4 AVERAGE=    1.6

IS THIS THE LAST STATION?N
STATION NO?250
ENTER TIME,TW,TD,R1,R2?937,62,70,818,789
 937   62    70    818   789  OK?Y
 250     1  937 62 70 70 69 1.047  786.2   818   28.8   30.2   -2.7    27.4
         2                         765.0   789   24.0   25.1   -5.5    19.6
                                           HALF SPREAD=    3.9 AVERAGE=   23.5

IS THIS THE LAST STATION?Y

LINE NO   BASE  STATION  ALTITUDE   SPREAD

    1       3     260      31.7       0.1
    2       3     261       1.6       0.4
    3       3     250      23.5       3.9
IS THIS THE LAST LOOP?Y
```

```
PRINT STORED DATA ?Y

LINE NO   BASE  STATION  ALTITUDE   SPREAD

    1       3     260      31.7       0.1
    2       3     261       1.6       0.4
    3       3     250      23.5       3.9
END OF RUN
```

```
 * * * ALTIMETRY REDUCTIONS-SINGLE BASE, 2 PAIRS OF ALTIMETERS * * *

SURVEY TITLE:  SAMPLE RUN, 20 MAR 1978, MEG, USGS/SAP.

-------------------------------------------------------------------------------

WARNING : GIVE NUMBERS TO BASE AND STATIONS, AS DESCRIBED IN
-------   PROGRAM DOCUMENTATION.

-------------------------------------------------------------------------------

BASE STATION FOR LOOP:          3              DATE OF LOOP:  14 APR 1975

BASE STATION READINGS
 TIME T(WET) T(DRY) ALT#1   ALT#2
  637    62     67     805     780
  700    62     67     800     775
  730    62     66     800     775
  800    62     68     795     770
  831    64     69     795     765
  900    64     69     790     765
  930    65     70     785     765
 1000    66     72     790     765
 1030    67     73     785     760
 1111    61     69     785     760


LOOP OPEN READINGS

   B1=  802      B2=  776      R1=  805      R2=  776

INDEX DIFFERENCES
   I1=   -3      I2=    0

LOOP CLOSE READINGS
   T(WET)=   61      T(DRY)=   69
   B1=  785      B2=  760      R1=  792      R2=  768

TEMP & HUMIDITY CORRECTION FACTOR AT CLOSE= 1.044

TOTAL CORRECTED CLOSURE ADJUSTMENTS

 PAIR B1,R1= -4.2      PAIR B2,R2= -8.3

ROVING ALTIMETER REDUCTIONS
```

STA	PR	TIME	TW	TD	TA	HA	C	FTR	BASE	ROVE	IN DIF	CO DIF	CLOSURE	FIN DIF
260	1	820	62	68	68	73	1.043		795.0	830	32.0	33.4	-1.6	31.8
	2								766.8	800	33.2	34.7	-3.1	31.5
										HALF SPREAD=		0.1	AVERAGE=	31.7
261	1	855	65	70	70	76	1.046		790.9	797	3.1	3.3	-2.1	1.2
	2								765.0	771	6.0	6.3	-4.2	2.1
										HALF SPREAD=		0.4	AVERAGE=	1.6
250	1	937	62	70	70	69	1.047		786.2	818	28.8	30.2	-2.7	27.4
	2								765.0	789	24.0	25.1	-5.5	19.6
										HALF SPREAD=		3.9	AVERAGE=	23.5

LINE NO	BASE	STATION	ALTITUDE	SPREAD
2	3	260	31.7	0.1
3	3	261	1.6	0.4
4	3	250	23.5	3.9

LINE NO	BASE	STATION	ALTITUDE	SPREAD
1	0	0	0.0	0.0
2	3	260	31.7	0.1
3	3	261	1.6	0.4
4	3	250	23.5	3.9

END OF RUN

SOURCE PROGRAM LISTING

```
1 COM L0,CI[255],SI[255],AS[255],ES[255]
10 REM SINGLE BASE ALTIMETRY REDUCTION - 2 PAIRS OF ALTS
20 REM GETTINGS,USGS,DEC 76.----- UPDATE MD, USGS, JUL 77.
30 DIM T$[70],B[50,5],B$[8],R$[8],D$[11]
40 DISP "ENTER 70 CHAR SURVEY TITLE";
50 INPUT T$
60 PRINT
70 PRINT
80 PRINT " * * * ALTIMETRY REDUCTIONS-SINGLE BASE, 2 PAIRS OF ALTIMETERS * *
90 PRINT
100 PRINT "SURVEY TITLE: ",T$
110 GOSUB 1400
112 GOSUB 1810
114 GOSUB 1400
120 DISP "ENTER BASE NO";
130 INPUT S1
140 DISP "ENTER DATE OF LOOP";
150 INPUT D$
160 PRINT "BASE STATION FOR LOOP: ",S1,"DATE OF LOOP: ",D$
170 PRINT
180 PRINT "BASE STATION READINGS"
190 PRINT " TIME T(WET) T(DRY) ALT#1   ALT#2"
200 DISP "ENTER BASE STATION READINGS"
210 WAIT 5000
220 N1=1
230 DISP "TIME,TW,TD,B1,B2";
240 INPUT B[N1,1],B[N1,2],B[N1,3],B[N1,4],B[N1,5]
250 DISP B[N1,1];B[N1,2];B[N1,3];B[N1,4];B[N1,5];"OK";
260 INPUT Q$
270 IF Q$="N" THEN 230
280 WRITE (15,290)B[N1,1],B[N1,2],B[N1,3],B[N1,4],B[N1,5]
290 FORMAT F5.0,2X,F3.0,3X,F3.0,3X,F5.0,3X,F5.0
300 B[N1,1]=FNT(B[N1,1])
310 N1=N1+1
320 IF Q$="E" THEN 340
330 GOTO 230
340 N1=N1-1
350 DISP "ENTER LOOP OPEN READINGS B1,R1";
360 INPUT B1,R1
370 DISP "ENTER LOOP OPEN READINGS B2,R2";
380 INPUT B2,R2
390 I3=B1-R1
400 I2=B2-R2
410 PRINT
420 PRINT
430 PRINT "LOOP OPEN READINGS"
440 PRINT
450 WRITE (15,460)B1,B2,R1,R2
```

```
460 FORMAT 3X,"B1=",F5.0,5X,"B2=",F5.0,5X,"R1=",F5.0,5X,"R2=",F5.0
470 PRINT
480 WRITE (15,490)I3,I2
490 FORMAT "INDEX DIFFERENCES",/,"   I1=",F5.0,5X,"I2=",F5.0
500 PRINT
505 DISP "OK";
506 INPUT Q$
507 IF Q$="N" THEN 350
510 REM
520 DISP "ENTER LOOP CLOSE B1,R1";
530 INPUT B1,R1
540 DISP "ENTER LOOP CLOSE B2,R2";
550 INPUT B2,R2
560 DISP "ENTER LOOP CLOSE WET&DRY TEMPS";
570 INPUT T7,T8
580 WRITE (15,590)T7,T8
590 FORMAT "LOOP CLOSE READINGS",/,3X,"T(WET)=",F5.0,5X,"T(DRY)=",F5.0
600 WRITE (15,460)B1,B2,R1,R2
605 DISP "OK";
606 INPUT Q$
607 IF Q$="N" THEN 520
610 GOSUB 1520
620 C9=T8
630 C8=E4
640 GOSUB 1600
650 PRINT
660 WRITE (15,670)C1
670 FORMAT "TEMP & HUMIDITY CORRECTION FACTOR AT CLOSE=",F6.3
680 A1=-C1*(R1+I3-B1)
690 A2=-C1*(R2+I2-B2)
700 PRINT
710 PRINT "TOTAL CORRECTED CLOSURE ADJUSTMENTS"
720 PRINT
730 WRITE (15,740)A1,A2
740 FORMAT " PAIR B1,R1=",F5.1,5X,"PAIR B2,R2=",F5.1
750 PRINT
760 PRINT "ROVING ALTIMETER REDUCTIONS"
770 PRINT
780 WRITE (15,790)"OSURE FIN DIF"
790 FORMAT "  STA   PR TIME TW TD TA HA C FTR  BASE  ROVE  IN DIF CO DIF CL
800 PRINT
810 REM INPUT ROVING ALT DATA AND REDUCE IT
812 L1=L0
815 L0=L0+1
820 DISP "STATION NO";
830 INPUT S[L0]
850 DISP "ENTER TIME,TW,TD,R1,R2";
860 INPUT T1,T3,T4,R1,R2
870 DISP T1;T3;T4;R1;R2;"OK";
880 INPUT Q$
890 IF Q$="N" THEN 850
900 T5=FNT(T1)
```

```
910 REM FIND SUBSCRIPT OF CELL IN COL 1 OF B WHERE T5 FITS
920 I1=FNS(T5)
930 P1=1
940 REM INTERPOLATE BASE VALUES
950 F1=FNI(2)
960 F2=FNI(3)
970 F3=FNI(4)
980 F4=FNI(5)
990 REM CALC AVERAGE TD,H
1000 C9=(F2+T4)/2
1010 T7=T3
1020 T8=T4
1030 GOSUB 1520
1040 C8=E4/2
1050 T7=F1
1060 T8=F2
1070 GOSUB 1520
1080 C8=C8+E4/2
1090 REM CALC CORRECTION FACTOR
1100 GOSUB 1600
1110 D1=R1+I3-F3
1120 D2=D1*C1
1130 A3=(T5-B[1,1])/(B[N1,1]-B[1,1])
1140 A4=A3*A1
1150 D3=D2+A4
1160 D4=D3
1170 WRITE (15,1180)S[L0],P1,T1,T3,T4,C9,C8,C1,F3,R1,D1,D2,A4,D3
1180 FORMAT F5.0,3X,F2.0,F5.0,4F3.0,F6.3,F7.1,F6.0,3F7.1,F8.1
1190 P1=2
1200 D1=R2+I2-F4
1210 D2=D1*C1
1220 A4=A3*A2
1230 D3=D2+A4
1240 WRITE (15,1250)P1,F4,R2,D1,D2,A4,D3
1250 FORMAT 8X,F2.0,23X,F7.1,F6.0,3F7.1,F8.1
1260 D5=ABS(D4-D3)/2
1270 D6=(D4+D3)/2
1280 WRITE (15,1290)D5,D6
1290 FORMAT 43X,"HALF SPREAD=",F6.1," AVERAGE=",F7.1
1292 A[L0]=D6
1294 E[L0]=D5
1296 C[L0]=S1
1300 PRINT
1310 DISP "IS THIS THE LAST STATION";
1320 INPUT Q$
1330 IF Q$="N" THEN 815
1332 L2=L1+1
1335 GOSUB 2050
1336 IF K1=-1 THEN 1340
1337 STORE  DATA K1
1338 FIND K1
1339 GOSUB 1860
```

```
1340 DISP "IS THIS THE LAST LOOP";
1350 INPUT Q$
1360 IF Q$="N" THEN 114
1370 GOSUB 1400
1371 GOSUB 1860
1372 IF K1=-1 THEN 1380
1374 STORE  DATA K1
1376 PRINT "DATA STORED ON FILE"K1
1378 PRINT
1380 PRINT "END OF RUN"
1390 STOP
1400 FOR I=1 TO 3
1410 PRINT
1420 NEXT I
1430 WRITE (15,1440)
1440 FORMAT 80"-"
1450 PRINT
1460 RETURN
1470 REM FNT CONVERTS 4 DIGIT TIME TO DECIMAL
1480 DEF FNT(X)
1490 Y=INT(X/100)
1500 T9=(X-Y*100)/60+Y
1510 RETURN T9
1520 REM CALCULATES RELATIVE HUMIDITY GIVEN TW(T7) & TD(T8)
1530 DEF FNE(X)=10^(9.2316-4215.6/(X+459.6))
1540 E1=FNE(T7)
1550 E2=FNE(T8)
1560 E3=(T8-T7)*(0.273+1.8E-04*T7)
1570 E4=100*(E1-E3)/E2
1580 RETURN
1590 REM CALCULATES CORRECTION FACTOR FROM TEMP & HUMIDITY
1600 C6=0.900833+0.001983*C9
1610 C5=1+1.2E-05*C8*10^(0.01267*C9)
1620 C1=C5*C6
1630 RETURN
1640 REM SEARCH FOR CORRECT TIME SLOT IN B(I,1)
1650 DEF FNS(X)
1660 FOR I=1 TO N1
1670 IF B[I,1] <= X AND B[I+1,1]>X THEN 1690
1680 NEXT I
1690 RETURN I
1700 REM LINEAR INTERPOLATION
1710 DEF FNI(J)
1720 F9=(B[I1+1,J]-B[I1,J])/(B[I1+1,1]-B[I1,1])
1730 F8=B[I1,J]+F9*(T5-B[I1,1])
1740 RETURN F8
1810 REM--------------------READING DATA OR BUILDING FILE---------------
1814 PRINT "WARNING : GIVE NUMBERS TO BASE AND STATIONS, AS DESCRIBED IN"
1816 PRINT "-------   PROGRAM DOCUMENTATION."
1818 PRINT
1820 DISP "FILE NO TO READ DATA, OR -1 ";
1830 INPUT K1
```

```
1840 IF K1=-1 THEN 1920
1850 LOAD  DATA K1
1855 FIND K1
1860 DISP "PRINT STORED DATA ";
1870 INPUT Y$
1880 IF Y$="N" THEN 2030
1890 L2=1
1900 GOSUB 2050
1910 RETURN
1920 L0=0
1922 DISP "WAIT... ARRAYS ARE ZEROED OUT."
1924 WAIT 2000
1930 FOR I=1 TO 255
1940 C[I]=0
1950 S[I]=0
1960 A[I]=0
1970 E[I]=0
1980 NEXT I
1990 DISP "FILE NO TO STORE DATA, OR -1 ";
2000 INPUT K1
2010 IF K1=-1 THEN 2030
2020 STORE  DATA K1
2025 FIND K1
2030 RETURN
2040 REM--------------------PRINT STORED DATA--------------------------
2050 PRINT
2060 PRINT "LINE NO   BASE  STATION  ALTITUDE   SPREAD"
2070 PRINT
2080 FOR I=L2 TO L0
2090 WRITE (15,2100)I,C[I],S[I],A[I],E[I]
2100 FORMAT F6.0,F7.0,F8.0,2F10.1
2110 NEXT I
2120 RETURN
```

ACKNOWLEDGMENTS

This work was carried out under the provisions of a work agreement between the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia, and the U. S. Geological Survey.

M.A.M. Donzeau implemented the cassette tape storage of output data option in the program and G.S. Pitts made several improvements to the logic of the program.

REFERENCES

Wallace and Tiernan, undated, Altimetry manual and operating instructions for Wallace and Tiernan surveying altimeters, Wallace and Tiernan, Inc., Belleville 9, New Jersey, 41 p.

Weast, R. C., ed., 1975, Handbook of Chemistry and Physics, 56th ed., CRC Press, Cleveland, Ohio, p. D-180 and E-45.

U. S. GEOLOGICAL SURVEY

SAUDI ARABIAN PROJECT

MISCELLANEOUS DOCUMENT 4

(INTERAGENCY REPORT 282)

PROGRAM PDPØØ6:

ALTRDN

by

M. A. M. Donzeau and M. E. Gettings

U.S. Geological Survey
Open-File Report 80 1275

U.S. Geological Survey
Jiddah, Saudi Arabia

1980

Part 3 of 3

The work on which this report is based was performed in accordance with a cooperative agreement between the U. S. Geological Survey and the Ministry of Petroleum and Mineral Resources, Kingdom of Saudi Arabia.

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

Program Documentation Manual

Program Number	:	PDP∅∅6
Program Name	:	ALTRDN
Programmer	:	M. A. M. Donzeau and M. E. Gettings
Language	:	FORTRAN IV PLUS
Computer/System	:	PDP-11/45
Date	:	18 December 1978
Institution	:	U. S. Geological Survey Saudi Arabian Project
Location	:	Jiddah, Saudi Arabia

CONTENTS

ILLUSTRATION

PROGRAM PDPØØ6: ALTRDN

by

M. A. M. Donzeau and M. E. Gettings

ABSTRACT

This program is designed to reduce simple base station altimetry data for two pairs of altimeters, where one altimeter of each pair is at the base station and the other roving. It has been adapted from the Single Base Altimetry Reduction Program HP9ØØ1* written for the HP983ØA** programmable calculator on 5 January 1977.

The Program calculates the elevation difference between the base and roving altimeters, and makes temperature and humidity corrections, and a barometric closure adjustment.

Base and station names, altitude differences, and half-spreads are stored on a data file. New data may be added to the file at each run. A tabulation of the reductions is output on a printer file, which can be spooled to the line printer afterwards.

* Gettings, this open-file report, part 2.

** Hewlett-Packard. Any trade names in this report are used for descriptive purposes only and do not constitute endorsement by the U.S. Geological Survey.

SOURCE DECK LOCATION AND UPDATE STATUS

The FORTRAN source program ALTRDN.FTN, the object module ALTRDN.OBJ, the task image ALTRDN.TSK are on the system disk of the DGMR PDP-11/45 computer under the UIC [22,1].

No updates have been made to the program at this time.

DESCRIPTION OF COMPUTED QUANTITIES

The computed quantities are described in the documentation of program HP9ØØ1. (Gettings, this open file report, part 2).

DESCRIPTION OF THE PROGRAM

The general program flow-chart is shown in figure 1. It follows the same pattern as in the program HP9ØØ1. The basic tasks are:

1) enter titling and labeling information.

2) read base station name, roving station name, altitude difference, and half-spread from the data file if file exists.

3) input the matrix of base station times, wet and dry temperatures, and altimeter readings for a loop.

4) calculate index differences and closure adjustments.

5) enter, reduce, and print roving altimeter observations a station at a time for all stations in the loop.

6) store base station name, roving station name, altitude differences, and half-spread on the data file.

As many as 50 base station observations during a loop may be accommodated, and as many as 300 altitude differences may be stored on the data file.

Control and execution of the program are accomplished interactively through the terminal display. Input is made via the system disk (data file), output is via the line printer (printer file), and the system disk (data file).

The source program ALTRDN.FTN requires 14 blocks of disk space in the PDP-11/45, the object module ALTRDN.OBJ requires 24 blocks, the task image ALTRDN.TSK 73 blocks. Execution time to reduce a pair of roving altimeter observations is less than 1 second.

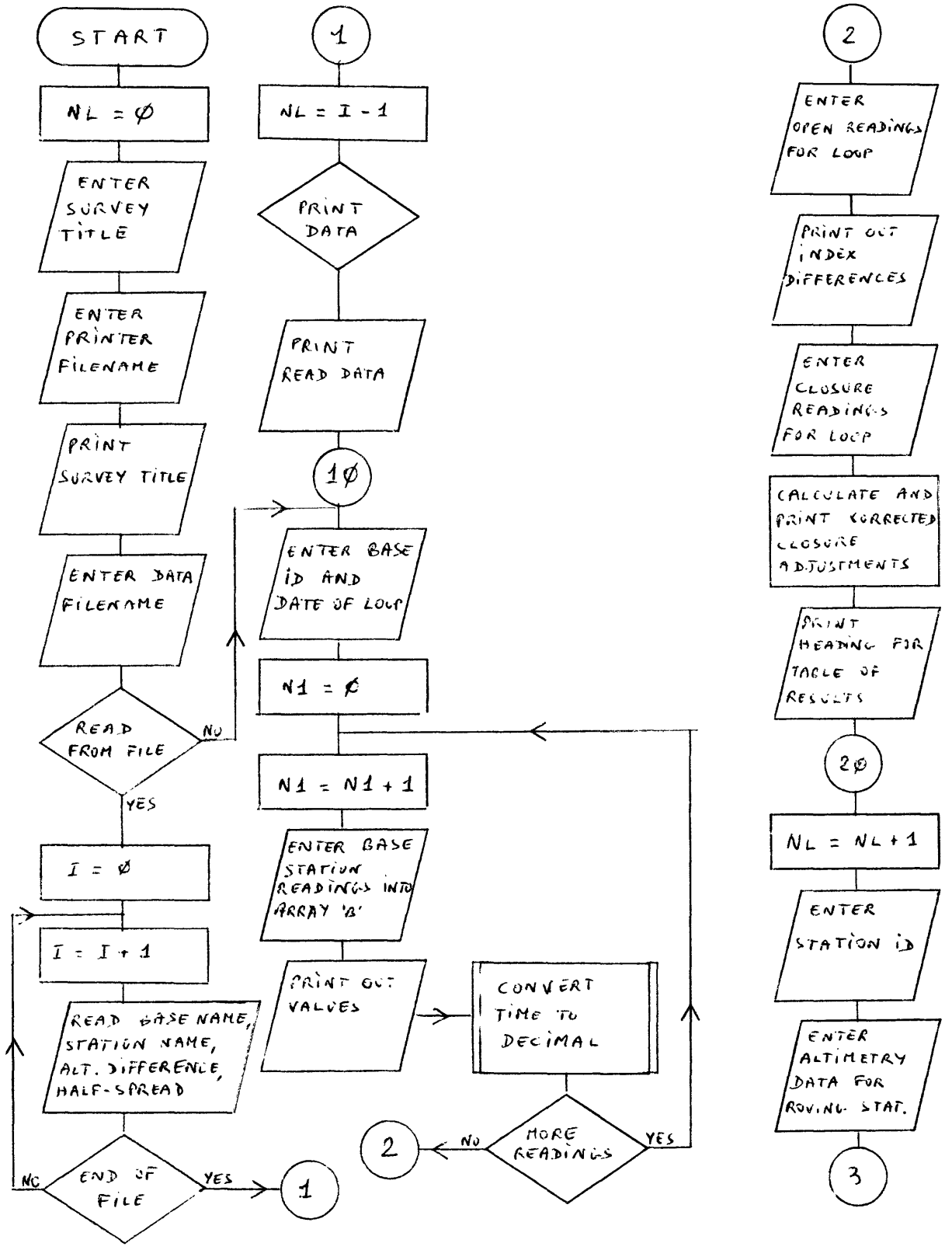

Figure 1.--ALTRDN program flow chart

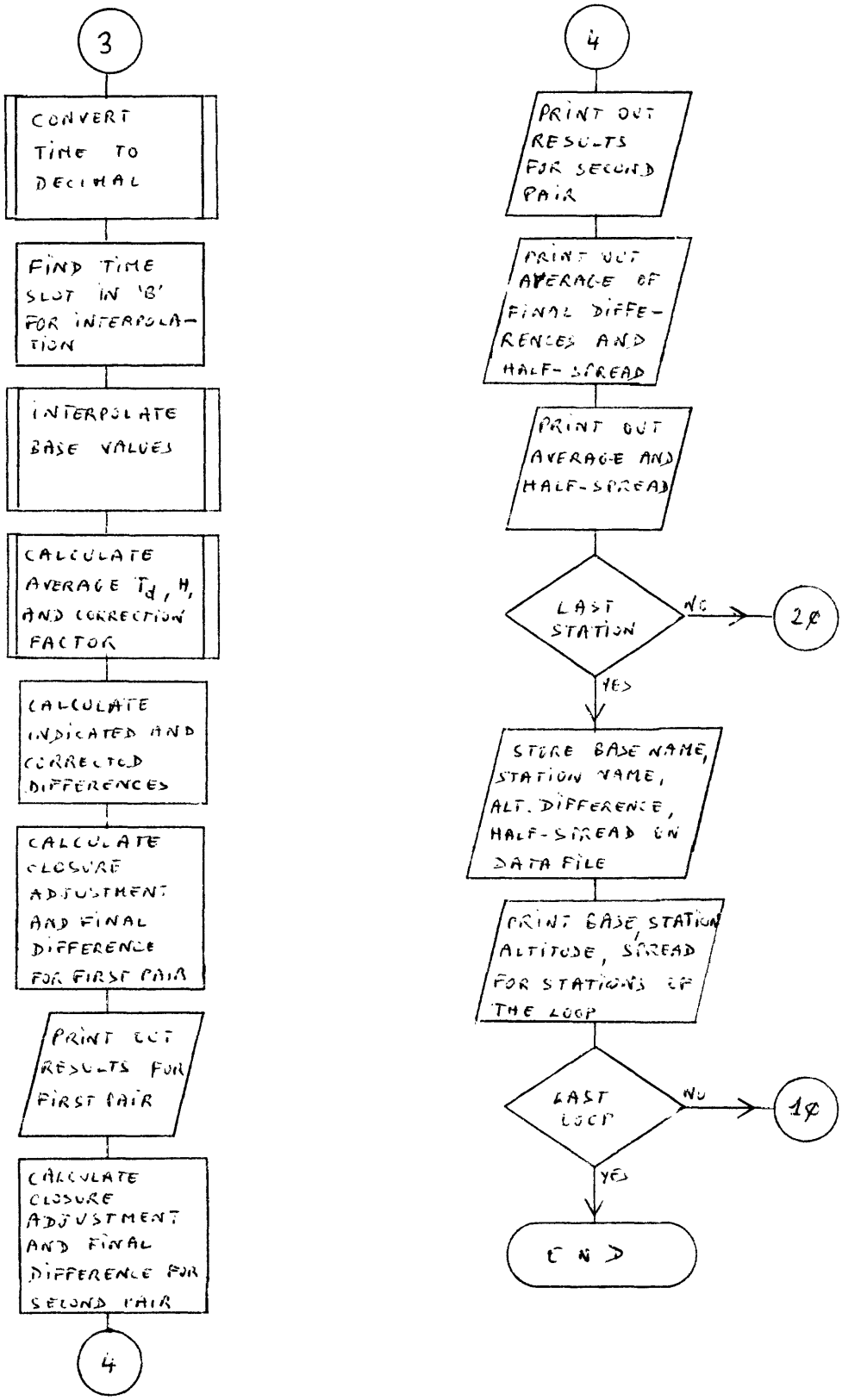

Figure 1.--ALTRDN program flow chart (continued).

PROGRAM OPERATION

Enter "RUN ALTRDN (ø)"[1/] to begin execution. Enter informations asked in questions appearing on the terminal display. Time is entered in hours and minutes, with a dot to separate the two numbers. Station identification names may be alphanumeric and as many as eight characters long. Questions requiring a "yes" and "no" answer are answered by "Y" and "N".

After all stations in a loop have been completed, a new loop can be initiated or program execution terminated. A tabulation of the reductions is written on the printer file during program execution. Use the PIP Utility Program to direct the printer file to the line printer.

Note that the word "spread" appearing in the printed tabulation is used for "half-spread".

1/ the symbol (ø) means ALT mode or ESC key

EXAMPLES

The following is the printout from two typical runs.

The first example shows the calculations for the stations of two loops, one with base BDØ47 and one with base BDØ56. The contents of the data file ALTRD1.DAT are shown just after the contents of the printer file. Two errors in station names have occurred: BØ57 instead of BDØ57, and BØ6Ø instead of BDØ6Ø. The errors were corrected with the EDI Utility Program, and the new version of the data file was called ALTRD2.DAT.

The second example uses the data file ALTRD2.DAT. The calculations for the stations of the loop with base BD1Ø7 are performed and the results stored on the data file. The contents of the data file ALTRD2.DAT after execution of the program are shown just after the contents of the printer file.

EXAMPLE NO. 1: CONTENTS OF PRINTER FILE

```
ALTIMETRY REDUCTIONS - SINGLE BASE, 2 PAIRS OF ALTIMETERS                14-OCT-78

SURVEY TITLE : BISHAH-AD DARB GRAVITY, PT 2, USGS, 14 OCT 1978,

********************************************************************************

BASE STATION FOR LOOP :     BD047     DATE OF LOOP :  12 DEC 1976

BASE STATION READINGS
  TIME  T(WET) T(DRY)   ALT#1    ALT#2
 12.30    74.    90.     59.      48.
 12.50    74.    91.     60.      48.
 13.10    74.    90.     61.      49.
 13.30    75.    90.     65.      50.
 13.50    76.    92.     68.      52.
 14.10    75.    91.     68.      50.
 14.30    74.    91.     69.      51.
 14.40    75.    92.     69.      51.


LOOP OPEN READINGS

  B1=  59.     B2=  48.     R1=  78.     R2=  65.

INDEX DIFFERENCES          I1=  -19     I2=  -17


LOOP CLOSE READINGS

  T(WET)=  75.     T(DRY)=  92.
  B1=  69.     B2=  51.     R1=  85.     R2=  71.


TEMP & HUMIDITY CORRECTION FACTOR AT CLOSE = 1.092

TOTAL CORRECTED CLOSURE ADJUSTMENTS
PAIR B1,R1 =  3.3      PAIR B2,R2 = -3.3

ROVING ALTIMETER REDUCTIONS
  STAT    PR TIME TW TD TA HA  C FTR  BASE  ROVE   IN DIF CO DIF CLOSURE FIN DIF


SEALEVEL  1 12.40 77,85,88,57, 1.084  59.5   -11.   -89.5  -97.1    2.3   -96.8
          2                           48.0   -23.   -88.0  -95.4   -0.3   -95.7
                                           HALF SPREAD=  0.6  AVERAGE=  -96.2

BD048     1 13.00 75,89,90,48, 1.087  60.5    32.   -47.5  -51.7    0.8   -50.9
          2                           48.5    17.   -48.5  -52.7   -0.8   -53.5
                                           HALF SPREAD=  1.3  AVERAGE=  -52.2

BD049     1 13.16 73,89,90,46, 1.086  62.2    50.   -31.2  -33.9    1.2   -32.7
          2                           49.3    37.   -29.3  -31.8   -1.2   -33.0
                                           HALF SPREAD=  0.1  AVERAGE=  -32.9

BD050     1 13.33 73,91,91,45, 1.089  55.5    78.    -6.5   -7.0    1.6    -5.4
          2                           50.0    63.    -4.0   -4.4   -1.6    -5.9
                                           HALF SPREAD=  0.3  AVERAGE=   -5.7

BD051     1 13.45 73,89,90,47, 1.088  67.3   140.    53.8   58.5    1.9    60.4
          2                           50.0   126.    59.0   64.2   -1.9    62.3
                                           HALF SPREAD=  1.0  AVERAGE=   61.3
```

```
BD052    1 13.50 73.90,91.45, 1.090  68.0   119.    32.0   34.9    2.0    36.9
         2                           50.0   105.    38.0   41.4   -2.0    39.4
                                          HALF SPREAD=  1.3  AVERAGE=   38.1

BD053    1 14.11 72.90,91.44, 1.088  68.0   104.    17.0   18.4    2.5    21.0
         2                           50.0    90.    23.0   25.0   -2.5    22.4
                                          HALF SPREAD=  0.7  AVERAGE=   21.7

BD054    1 14.16 76.93,92.46, 1.092  68.3    52.   -35.3  -38.5    2.7   -35.9
         2                           50.3    38.   -29.3  -32.0   -2.7   -34.7
                                          HALF SPREAD=  0.6  AVERAGE=  -35.3

BD055    1 14.28 76.90,91.48, 1.089  68.9    17.   -70.9  -77.2    3.0   -74.2
         2                           50.9     2.   -65.9  -71.8   -3.0   -74.7
                                          HALF SPREAD=  0.3  AVERAGE=  -74.5
```

LINE NO	BASE ID	STATION ID	MEASUREMENT (M)	SPREAD (M)
1	BD047	SEALEVEL	-96.2	0.6
2	BD047	BD048	-52.2	1.3
3	BD047	BD049	-32.9	0.1
4	BD047	BD050	-5.7	0.3
5	BD047	BD051	61.3	1.0
6	BD047	BD052	38.1	1.3
7	BD047	BD053	21.7	0.7
8	BD047	BD054	-35.3	0.6
9	BD047	BD055	-74.5	0.3

****

BASE STATION FOR LOOP : BD056 DATE OF LOOP : 13 DEC 1976

BASE STATION READINGS

TIME	T(WET)	T(DRY)	ALT#1	ALT#2
8.15	70.	76.	371.	359.
8.45	70.	76.	371.	359.
9.15	70.	77.	370.	358.
9.45	72.	81.	369.	355.
10.15	72.	83.	370.	358.

LOOP OPEN READINGS

B1= 371. B2= 359. R1= 382. R2= 373.

INDEX DIFFERENCES I1= -11 I2= -14

LOOP CLOSE READINGS

T(WET)= 72. T(DRY)= 83.
B1= 370. B2= 358. R1= 382. R2= 373.

TEMP & HUMIDITY CORRECTION FACTOR AT CLOSE = 1.074

TOTAL CORRECTED CLOSURE ADJUSTMENTS
PAIR B1,R1 = -1.1 PAIR B2,R2 = -1.1

ROVING ALTIMETER REDUCTIONS

STAT	PR	TIME	TW	TD	TA	HA	C FTR	BASE	ROVE	IN DIF	CO DIF	CLOSURE	FIN DIF

```
B057      1  8.23 73.81.79.71. 1.065 371.0   151.  -231.0 -246.1   -0.1  -246.2
          2                          359.0   139.  -234.0 -249.3   -0.1  -249.4
                                             HALF SPREAD=  1.6  AVERAGE= -247.8

BD047     1  8.35 72.81.79.69. 1.065 371.0    55.  -327.0 -348.3   -0.2  -348.5
          2                          359.0    43.  -330.0 -351.5   -0.2  -351.7
                                             HALF SPREAD=  1.6  AVERAGE= -350.1

BD058     1  8.51 72.81.79.69. 1.065 370.8    63.  -318.8 -339.6   -0.3  -340.0
          2                          358.8    51.  -321.8 -342.8   -0.3  -343.1
                                             HALF SPREAD=  1.6  AVERAGE= -341.5

BD059     1  9.02 71.81.79.66. 1.065 370.4   141.  -240.4 -256.2   -0.4  -256.6
          2                          358.4   128.  -244.4 -260.4   -0.4  -260.8
                                             HALF SPREAD=  2.1  AVERAGE= -258.7

B060      1  9.13 70.78.77.69. 1.063 370.1   318.   -63.1  -67.0   -0.5   -67.5
          2                          358.1   307.   -65.1  -69.2   -0.5   -69.7
                                             HALF SPREAD=  1.1  AVERAGE=  -68.6

BD061     1  9.25 70.80.79.64. 1.066 369.7   311.   -69.7  -74.3   -0.6   -74.9
          2                          357.0   300.   -71.0  -75.7   -0.6   -76.3
                                             HALF SPREAD=  0.7  AVERAGE=  -75.6

BD062     1  9.46 66.75.78.63. 1.063 369.0   818.   438.0  465.7   -0.8   464.9
          2                          355.1   803.   433.9  461.4   -0.8   460.6
                                             HALF SPREAD=  2.2  AVERAGE=  462.7

BD063     1 10.03 68.84.81.57. 1.069 369.6   697.   316.4  338.4   -1.0   337.4
          2                          356.8   684.   313.2  334.9   -1.0   334.0
                                             HALF SPREAD=  1.7  AVERAGE=  335.7
```

LINE NO	BASE ID	STATION ID	MEASUREMENT (M)	SPREAD (M)
10	BD056	B057	-247.8	1.6
11	BD056	BD047	-350.1	1.6
12	BD056	BD058	-341.5	1.6
13	BD056	BD059	-258.7	2.1
14	BD056	B060	-68.6	1.1
15	BD056	BD061	-75.6	0.7
16	BD056	BD062	462.7	2.2
17	BD056	BD063	335.7	1.7

```
**********************************************************************************

DATA STORED ON FILE : ALTRD1.DAT
```

CONTENTS OF DATA FILE ALTRD1.DAT

BD047	SEALEVEL	-96.24	0.56
BD047	BD048	-52.19	1.30
BD047	BD049	-32.87	0.13
BD047	BD050	-5.69	0.25
BD047	BD051	61.35	0.97
BD047	BD052	38.14	1.25
BD047	BD053	21.71	0.72
BD047	BD054	-35.27	0.61
BD047	BD055	-74.49	0.25
BD056	B057	-247.77	1.60
BD056	BD047	-352.08	1.60
BD056	BD058	-341.55	1.60
BD056	BD059	-258.72	2.13
BD056	B060	-68.61	1.06
BD056	BD061	-75.63	0.71
BD056	BD062	462.73	2.16
BD056	BD063	335.58	1.71

EXAMPLE NO. 2: CONTENTS OF PRINTER FILE

ALTIMETRY REDUCTIONS - SINGLE BASE, 2 PAIRS OF ALTIMETERS 14-OCT-78

SURVEY TITLE : BISHAH-AD DARB GRAVITY, MD, USGS, 14 OCT 1978.

****

DATA ARE READ FROM FILE : ALTRD2.DAT

LINE NO	BASE ID	STATION ID	MEASUREMENT (M)	SPREAD (M)
1	BD047	SEALEVEL	-96.2	0.6
2	BD047	BD048	-52.2	1.3
3	BD047	BD049	-32.9	0.1
4	BD047	BD050	-5.7	0.2
5	BD047	BD051	61.3	1.0
6	BD047	BD052	38.1	1.2
7	BD047	BD053	21.7	0.7
8	BD047	BD054	-35.3	0.6
9	BD047	BD055	-74.5	0.2
10	BD056	BD057	-247.8	1.6
11	BD056	BD047	-350.1	1.6
12	BD056	BD058	-341.5	1.6
13	BD056	BD059	-258.7	2.1
14	BD056	BD060	-68.6	1.1
15	BD056	BD061	-75.6	0.7
16	BD056	BD062	462.7	2.2
17	BD056	BD063	335.7	1.7

17 RECORDS ON FILE :ALTRD2.DAT

****

BASE STATION FOR LOOP : BD107 DATE OF LOOP : 16 DEC 1976

BASE STATION READINGS

TIME	T(WET)	T(DRY)	ALT#1	ALT#2
8.00	50.	64.	968.	956.
8.30	50.	65.	968.	956.
9.00	52.	68.	967.	957.
9.30	52.	70.	967.	957.
10.00	54.	74.	969.	959.
10.30	55.	77.	972.	961.
11.00	54.	77.	978.	966.
11.30	55.	79.	980.	970.
11.38	55.	80.	981.	970.

LOOP OPEN READINGS

B1= 968. B2= 956. R1= 987. R2= 972.

INDEX DIFFERENCES I1= -19 I2= -16

LOOP CLOSE READINGS

T(WET)= 55. T(DRY)= 80.
B1= 981. B2= 970. R1=1002. R2= 987.

TEMP & HUMIDITY CORRECTION FACTOR AT CLOSE = 1.061

TOTAL CORRECTED CLOSURE ADJUSTMENTS
PAIR B1,R1 = -2.1 PAIR B2,R2 = -1.1

ROVING ALTIMETER REDUCTIONS

STAT	PR	TIME	TW	TD	TA	HA	C FTR	BASE	ROVE	IN DIF	CO DIF	CLOSURE	FIN DIF
BD108	1	8.22	38.	53.	59.	24.	1.019	968.0	2338.	1351.0	1376.9	-0.2	1376.7
	2							956.0	2326.	1354.0	1380.0	-0.1	1379.8
									HALF SPREAD=	1.6	AVERAGE=		1378.3
BD109	1	8.32	51.	74.	70.	22.	1.041	967.9	1019.	32.1	33.4	-0.3	33.1
	2							956.1	1004.	31.9	33.2	-0.2	33.1
									HALF SPREAD=	0.0	AVERAGE=		33.1
BD110	1	8.50	51.	70.	69.	26.	1.039	967.3	1056.	69.7	72.4	-0.5	71.9
	2							956.7	1041.	68.3	71.0	-0.2	70.8
									HALF SPREAD=	0.6	AVERAGE=		71.3
BD111	1	9.06	54.	75.	72.	25.	1.046	967.0	628.	-358.0	-374.3	-0.6	-375.0
	2							957.0	617.	-356.0	-372.2	-0.3	-372.5
									HALF SPREAD=	1.2	AVERAGE=		-373.7
BD112	1	9.19	58.	77.	73.	28.	1.049	967.0	451.	-535.0	-561.1	-0.8	-561.9
	2							957.0	444.	-529.0	-554.8	-0.4	-555.2
									HALF SPREAD=	3.3	AVERAGE=		-558.5
BD113	1	9.32	55.	76.	73.	23.	1.048	967.1	740.	-246.1	-258.0	-0.9	-258.9
	2							957.1	727.	-246.1	-258.0	-0.4	-258.5
									HALF SPREAD=	0.2	AVERAGE=		-258.7
BD114	1	9.45	54.	79.	76.	19.	1.053	968.0	644.	-343.0	-361.1	-1.0	-362.1
	2							958.0	634.	-340.0	-357.9	-0.5	-358.4
									HALF SPREAD=	1.8	AVERAGE=		-360.3
BD115	1	10.02	53.	77.	76.	18.	1.053	969.2	1095.	106.8	112.4	-1.2	111.3
	2							959.1	1081.	105.9	111.5	-0.6	110.9
									HALF SPREAD=	0.2	AVERAGE=		111.1
BD116	1	10.22	56.	84.	80.	16.	1.062	971.2	604.	-386.2	-410.1	-1.4	-411.4
	2							960.5	594.	-382.5	-406.1	-0.7	-406.8
									HALF SPREAD=	2.3	AVERAGE=		-409.1

LINE NO	BASE ID	STATION ID	MEASUREMENT (M)	SPREAD (M)
18	BD107	BD108	1378.3	1.6
19	BD107	BD109	33.1	0.0
20	BD107	BD110	71.3	0.6
21	BD107	BD111	-373.7	1.2
22	BD107	BD112	-558.5	3.3
23	BD107	BD113	-258.7	0.2
24	BD107	BD114	-360.3	1.8
25	BD107	BD115	111.1	0.2
26	BD107	BD116	-409.1	2.3

****

DATA STORED ON FILE : ALTRD2.DAT

CONTENTS OF DATA FILE ALTRD2.DAT

3D047	SEALEVEL	-96.24	0.56
3D047	BD048	-52.19	1.30
3D047	BD049	-32.87	0.13
3D047	BD050	-5.69	0.25
3D047	BD051	61.35	0.97
3D047	BD052	38.14	1.25
3D047	BD053	21.71	0.72
3D047	BD054	-35.27	0.61
3D047	BD055	-74.49	0.25
3D056	BD057	-247.77	1.60
3D056	BD047	-350.08	1.60
3D056	BD058	-341.55	1.60
3D056	BD059	-258.72	2.13
3D056	BD060	-68.61	1.06
3D056	BD061	-75.64	0.71
3D056	BD062	462.73	2.16
3D056	BD063	335.68	1.71
3D107	BD108	1378.26	1.58
3D107	BD109	33.08	0.01
3D107	BD110	71.33	0.57
3D107	BD111	-373.74	1.21
3D107	BD112	-558.55	3.34
3D107	BD113	-258.70	0.22
3D107	BD114	-362.27	1.83
3D107	BD115	111.06	0.19
3D107	BD116	-409.12	2.33

SOURCE PROGRAM LISTING

```
0001            PROGRAM ALTRDN
        C       --------------
        C          ALTIMETRY REDUCTION, FROM HP PROGRAM M.GETTINGS
        C   LIBRARY : [22,37]GENLBR
        C   M.D., 25 FEB 78.
        C
0002            LOGICAL*1 FILEN1(20),TITLE(80),FILEN4(20),DAT(10)
0003            DOUBLE PRECISION BASE(300),STAT(300),S1
0004            DIMENSION AMEAS(300),SPREAD(300),DOL(3)
0005            COMMON B(50,5)
0006            DATA NL/0/
0007            DATA IG1/1/,IO4/4/,ITT/5/
0008    1000    FORMAT(1X,2A8,2F10.2)
0009    2000    FORMAT(' ALTIMETRY REDUCTION PROGRAM.'/)
0010    2001    FORMAT(' ENTER BASE STATION READINGS : TIME, WET TEMP, DRY TEMP,
               1 ' ALT#1, ALT#2')
0011    2002    FORMAT(' TIME IS OUT OF TIME READINGS OF BASE STATION')
0012    2200    FORMAT(1H1,'ALTIMETRY REDUCTIONS - SINGLE BASE, 2 PAIRS OF',
               1 ' ALTIMETERS',T70,10A1//' SURVEY TITLE :',T17,64A1/T17,16A1)
0013    2201    FORMAT(' DATA ARE READ FROM FILE : ',20A1)
0014    2202    FORMAT(//T5,'LINE NO',T20,'BASE ID',T35,'STATION ID',T50,
               2 'MEASUREMENT (M)',T70,'SPREAD (M)'/)
0015    2203    FORMAT(I5,I5,T20,A8,T35,A8,T49,F10.1,T67,F10.1)
0016    2204    FORMAT(/I5,' RECORDS ON FILE :',20A1)
0017    2205    FORMAT(' BASE STATION FOR LOOP :',5X,A8,T40,'DATE OF LOOP :',2X,
               5 3A4//' BASE STATION READINGS'/
               6 '    TIME T(WET) T(DRY)   ALT#1    ALT#2')
0018    2206    FORMAT(F7.2,F6.0,F7.0,F8.0,F8.0)
0019    2207    FORMAT(//' LOOP OPEN READINGS'//3X,'B1=',F5.0,5X,'B2=',F5.0,5X,
               7 'R1=',F5.0,5X,'R2=',F5.0//
               8 ' INDEX DIFFERENCES',10X,'I1=',I5,5X,'I2=',I5//)
0020    2208    FORMAT(' LOOP CLOSE READINGS'//3X,'T(WET)=',F5.0,5X,'T(DRY)=',
               8 F5.0/3X,'B1=',F5.0,5X,'B2=',F5.0,5X,'R1=',F5.0,5X,'R2=',F5.0//)
0021    2209    FORMAT(' TEMP & HUMIDITY CORRECTION FACTOR AT CLOSE =',F6.3//
               9 ' TOTAL CORRECTED CLOSURE ADJUSTMENTS'/' PAIR B1,R1 =',F5.1,5X,
               1 ' PAIR B2,R2 =',F5.1//' ROVING ALTIMETER REDUCTIONS'/
               2 '    STAT    PR TIME TW TD TA HA   C FTR  BASE   ROVE    IN DIF CO',
               3 ' DIF CLOSURE FIN DIF'/)
0022    2211    FORMAT(/1X,A8,I2,F6.2,1X,4F3.0,F6.3,F6.1,F7.0,1X,3F7.1,F8.1)
0023    2212    FORMAT(9X,I2,25X,F6.1,F7.0,1X,3F7.1,F8.1)
0024    2213    FORMAT(43X,'HALF SPREAD=',F5.1,'  AVERAGE=',F7.1)
0025    2216    FORMAT(' DATA STORED ON FILE : ',20A1)
0026    2217    FORMAT(/1X,80(1H*)/)
        C
0027            WRITE(ITT,2000)
0028            CALL TTINAA ('80=CHAR SURVEY TITLE',20,TITLE,80,ITT)
0029            CALL TTINAA ('FILENAME OF PRINTER FILE',24,FILEN4,20,ITT)
0030            OPEN (UNIT=IO4,NAME=FILEN4,TYPE='UNKNOWN')
0031            CALL DATE(DAT)
0032            WRITE(IO4,2200) DAT,TITLE
0033            WRITE(IO4,2217)
0034            CALL TTINAA ('FILENAME OF INPUT/OUTPUT DATA FILE',34,FILEN1,20,
               1 ITT)
0035            OPEN (UNIT=IO1,NAME=FILEN1,TYPE='UNKNOWN')
        C------------------------------------ READING ----------------------
0036            CALL TTINAA ('READ DATA FROM FILE',19,IAN,2,ITT)
```

```
0037            IF (IAN.EQ.'N') GOTO 300
0038            WRITE(IO4,2201) FILEN1
0039            CALL TTINAA ('PRINT DATA',10,IAN,2,ITT)
0040            IF (IAN.NE.'N') WRITE(IO4,2202)
0041            I=0
0042    400     I=I+1
0043            READ (IO1,1000,END=402) BASE(I),STAT(I),AMEAS(I),SPREAD(I)
0044            GOTO 400
0045    402     NL=I-1
0046            IF (IAN.NE.'N') WRITE(IO4,2203) (I,BASE(I),STAT(I),AMEAS(I),SPREAD(I),
     1 I=1,NL)
0047            WRITE(IO4,2204) NL,FILEN1
0048            WRITE(IO4,2217)
      C------------------------------------ BASE READINGS ----------------
0049    300     CONTINUE
0050            CALL TTINAA ('ENTER BASE ID',13,S1,8,ITT)
0051            CALL TTINAA ('ENTER DATE OF LOOP',18,DOL,12,ITT)
0052            WRITE(IO4,2205) S1,DOL
0053            WRITE(ITT,2001)
0054            N1=0
0055    330     N1=N1+1
0056            CALL TTINSR ('TIME, IN HR.MN',14,B(N1,1),ITT)
0057            CALL TTINSR ('WET TEMP',8,B(N1,2),ITT)
0058            CALL TTINSR ('DRY TEMP',8,B(N1,3),ITT)
0059            CALL TTINSR ('ALT #1',6,B(N1,4),ITT)
0060            CALL TTINSR ('ALT #2',6,B(N1,5),ITT)
0061            WRITE(IO4,2206) (B(N1,I),I=1,5)
0062            B(N1,1)=DEGDMN(B(N1,1))
0063            CALL TTINAA ('MORE BASE STATION READINGS',26,IAN,2,ITT)
0064            IF (IAN.NE.'N') GOTO 330
0065            CALL TTINSR ('LOOP OPEN READINGS B1',21,B1,ITT)
0066            CALL TTINSR ('LOOP OPEN READINGS R1',21,R1,ITT)
0067            CALL TTINSR ('LOOP OPEN READINGS B2',21,B2,ITT)
0068            CALL TTINSR ('LOOP OPEN READINGS R2',21,R2,ITT)
0069            I3=B1-R1
0070            I2=B2-R2
0071            WRITE(IO4,2207) B1,B2,R1,R2,I3,I2
0072            CALL TTINSR ('LOOP CLOSE READINGS B1',22,B3,ITT)
0073            CALL TTINSR ('LOOP CLOSE READINGS R1',22,R1,ITT)
0074            CALL TTINSR ('LOOP CLOSE READINGS B2',22,B4,ITT)
0075            CALL TTINSR ('LOOP CLOSE READINGS R2',22,R2,ITT)
0076            WRITE(IO4,2208) B(N1,2),B(N1,3),B3,B4,R1,R2
0077            C9=B(N1,3)
0078            C8=RELHUM(B(N1,2),B(N1,3))
      C             ------
0079            CF=CORFAC(B(N1,3),C8)
      C             -'----
0080            A1=-CF*(R1+I3-B3)
0081            A2=-CF*(R2+I2-B4)
0082            WRITE(IO4,2209) CF,A1,A2
      C-----------*------------------------------ INPUT ROVING ALTIMETER DATA & REDUCE
0083            NL1=NL+1
0084    350     NL=NL+1
0085            BASE(NL)=S1
0086            CALL TTINAA ('STATION ID',10,STAT(NL),8,ITT)
0087    340     CALL TTINSR ('TIME, IN HR.MN',14,TM,ITT)
```

```
0088            CALL TTINSR ('WET TEMP',8,TWM,ITT)
0089            CALL TTINSR ('DRY TEMP',8,TDM,ITT)
0090            CALL TTINSR ('ALT #1',6,A1M,ITT)
0091            CALL TTINSR ('ALT #2',6,A2M,ITT)
0092            T=DEGOMN(TM)
      C------------------------------ FIND SUBSCRIPT OF ARRAY B, COL 1, WHERE T FITS
0093            DO 100 I=1,N1
0094            IF ((B(I,1).LE.T).AND.(B(I+1,1).GT.T)) GOTO 335
0095    100     CONTINUE
0096            WRITE(ITT,2002)
0097            GOTO 343
0098    335     TWI=BINTER(I,2,T)
      C              ------
0099            TDI=BINTER(I,3,T)
0100            A3I=BINTER(I,4,T)
0101            A4I=BINTER(I,5,T)
0102            J1=1
      C-----------------------------CALCULATE AVERAGE OF TD, H ---------------
0103            TD=(TDI+TDM)/2.
0104            RH=RELHUM(TWM,TDM)/2.+RELHUM(TWI,TDI)/2.
      C              ------
      C------------------------------ CALCULATE CORRECTION FACTOR, ALT #1 ----
0105            CF=CORFAC(TD,RH)
      C              ------
0106            D1=A1M+I3-A3I
0107            D2=D1*CF
0108            A3=(T-B(1,1))/(B(N1,1)-B(1,1))
0109            A4=A3*A1
0110            AMEAS1=D2+A4
0111            WRITE(IO4,2211) STAT(NL),J1,TM,TWM,TDM,TD,RH,CF,A3I,A1M,D1,D2,
           1 A4,AMEAS1
      C------------------------------ ALT #2 ----------------------------------
0112            J1=2
0113            D1=A2M+I2-A4I
0114            D2=D1*CF
0115            A4=A3*A2
0116            AMEAS2=D2+A4
0117            WRITE(IO4,2212) J1,A4I,A2M,D1,D2,A4,AMEAS2
0118            SPREAD(NL)=ABS(AMEAS1-AMEAS2)/2.
0119            AMEAS(NL)=(AMEAS1+AMEAS2)/2.
0120            WRITE(IO4,2213) SPREAD(NL),AMEAS(NL)
      C------------------------------ WRITE ON FILE ---------------------------
0121            CALL TTYNAA ('IS THIS THE LAST STATION',24,YAN,2,YTT)
0122            IF (IAN.EQ.'N') GOTO 350
0123            WRITE(IO4,2202)
0124            DO 110 I=NL1,NL
0125            WRITE(IO1,1000) BASE(I),STAT(I),AMEAS(I),SPREAD(I)
0126    110     WRITE(IO4,2203) I,BASE(I),STAT(I),AMEAS(I),SPREAD(I)
0127            WRITE(IO4,2217)
0128            CALL TTINAA ('IS THIS THE LAST LOOP',22,IAN,1,ITT)
0129            IF (IAN.EQ.'N') GOTO 300
0130            WRITE(IO4,2216) (FILEN1(I),I=1,20)
0131    8000    STOP ' *** END OF PROGRAM ***'
0132    9000    STOP ' *** ERROR WHILE READING FILE ***'
0133            END
```

ALTRDN.FTN /TR:BLOCKS/WR

```
0001            FUNCTION RELHUM (TW,TD)
        C       ---------------
        C   CALCULATE RELATIVE HUMIDITY, GIVEN TW & TD
        C
0002            FNE(X)=10.**(9.2316-4215.6/(X+459.6))
0003            E1=FNE(TW)
0004            E2=FNE(TD)
0005            E3=(TD-TW)*(0.273+1.8E-4*TW)
0006            RELHUM=100.*(E1-E3)/E2
0007            RETURN
        C
0008            ENTRY CORFAC (TD,RH)
        C       ------------
        C   CALCULATE CORRECTION FACTOR, FROM TEMP TD & RELATIVE HUMIDITY RH
        C
0009            C6=0.999833+0.001983*TD
0010            C5=1.+1.2E-5*RH*10.**(0.01267*TD)
0011            CORFAC=C5*C6
0012            RETURN
0013            END
```

```
ALTRUN.FTN      /TR:BLOCKS/WR

0001            FUNCTION BINTER (I,J,T)
                C     ---------------
                C    INTERPOLATE
0002            COMMON B(50,5)
0003            DO 100 I=1,50
0004            IF ((T.GE.B(I,1)).AND.(T.LT.B(I+1,1))) GOTO 200
0005    100     CONTINUE
0006    200     A=(B(I+1,J)-B(I,J))/(B(I+1,1)-B(I,1))
0007            BINTER=B(I,J)+A*(T-B(I,1))
0008            RETURN
0009            END
```