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R290

Preliminary documentation for a FORTRAN program to compute gravity terrain corrections based on topography digitized on a geographic grid

by

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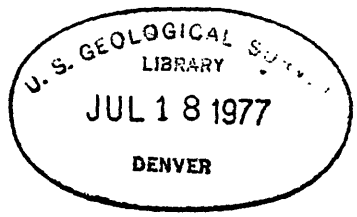
O P E N F I L E R E P O R T 77-535



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

JUL 22 1977

INTRODUCTION

The FORTRAN computer program listed in Table 1 has been used by the U.S. Geological Survey since 1972 to obtain terrain corrections to a distance as far as 167 km from gravity stations. This program evolved from earlier versions of the program that were first announced and distributed in 1966 (Plouff, 1966). The digitization for a previous terrain correction program of the U.S. Geological Survey (Kane, 1962) adopted the one-kilometer square grid of the Universal Transverse Mercator (UTM) coordinates that are marked on most topographic maps. J. H. Healy (oral communication, 1965) suggested to me that a system based on geographic latitude and longitude coordinates could be more general, more efficient (for storing digital elevations) and more flexible than the one-km UTM grid system. Healy suggested that only one quadrangle map of digitized average elevations needs to be retained in the computer memory at a given time.

I wrote a FORTRAN program in 1965 that implemented Healy's suggestions. That program and its later revisions primarily were used with 15-minute maps digitized in one-minute compartments and with one-by-two degree maps digitize in 3-minute compartments. The version of the program released as a preprint associated with the presentation at the 36th Annual Meeting of the Society of Exploration Geophysicists (Plouff, 1966) included all the basic improvements over previous terrain correction programs. These improvements are the digiti tion and gravity station locations in a latitude-longitude reference system, the assembly of digitization in quadrangle map units, a tie to an inner circular boundary that permits an exact join to conventional hand terrain corrections, a listing of maps needed but not found in the digital map-input, correction for the effect of the earth's curvature, and use of a gravity formula that is more accurate for those compartments that are closest to the location of the gravity station.

The last improvement was made because the formula used in the previous program was fairly accurate but was based on the assumption that the ground surface is horizontal within every compartment (fig. 1). To a first approximation, however, the ground surface near any point tends to slope through that point, in order to account for the observed difference of elevation

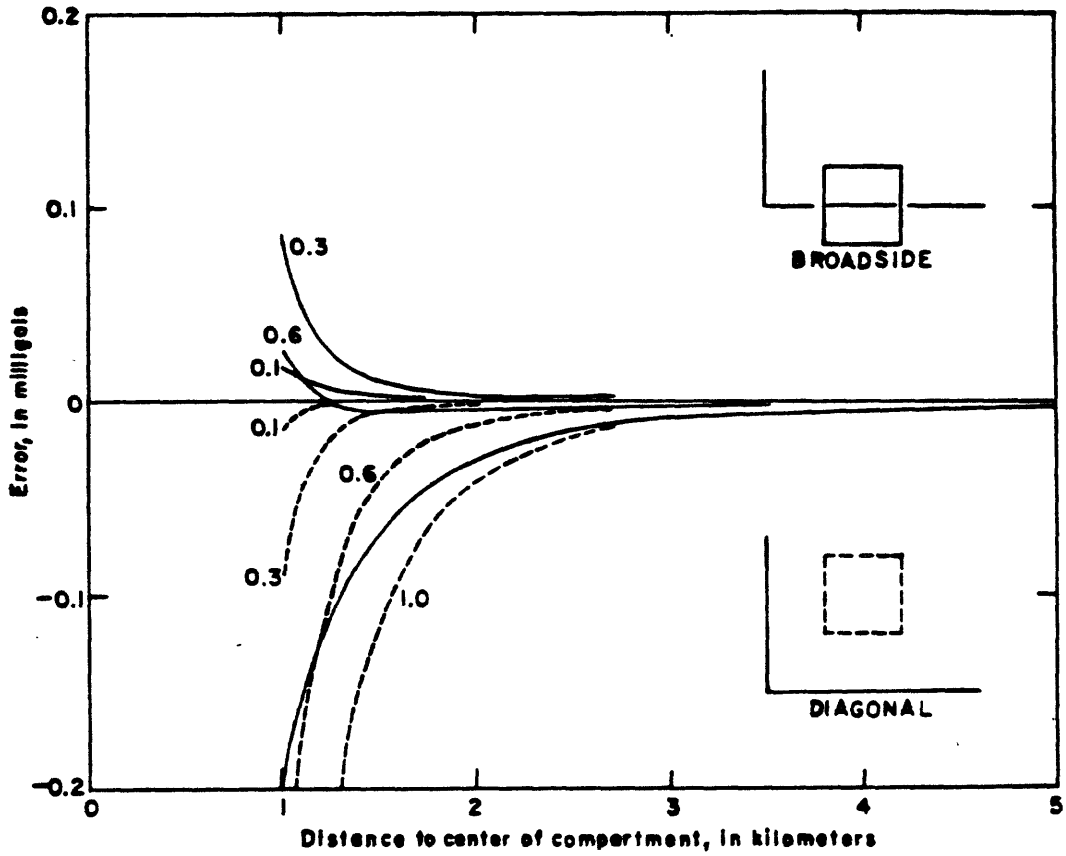


Figure 1.--Comparison of Kane's approximation to gravity effect of flat-topped rectangular prism. Solid lines indicate broadside orientation; dashed lines indicate diagonal orientation. Compartments are one-km squares. Constant height of compartment is distance to center of the compartment times number indicated near curve. Density is 2.67 gm/cm^3.

between that point and nearby locations. A simple formula, in which it is assumed that all the mass within a compartment is concentrated along a vertical line mass at the center of the compartment, was found to provide a close approximation to the gravity effect of a ground surface that slopes through a nearby station location (fig. 2). At farther distances from the gravity station-- distances that exceed about 4 compartment widths from the station--the gravity value calculated by using the two formulas are nearly identical.

Further modifications between the time of the 1966 program and the accompanying listed program improved the distance formulas, removed some minor discrepancies, protected the program user against making mistakes, and were in response to a need for a more self sufficient "final" program in terms of punch card and printer output. A program later was written to convert previous one-km digitization to one-minute (about 1.85 by 1.5 km) digitization, so that previous elevation digitization could be adopted for use with the present program. That program (Robbins, and others, 1973) enabled a substantial block of gridded topographic data in southern California to be absorbed into one-minute and three-minute digitization that entirely covers the state of California.

Though the program listed in Table 1 has been extensively tested, no surety should be implied concerning proper execution of the program. I would welcome receiving the results of independent tests. The program is by no means "final". Only positive values of latitude and longitude have been tested. The terrain corrections for land below sea level and for ocean compartments underlain by rock that does not have a density of 2.67 g/cc are incorrect in the accompanying program. There is no provision of the nearby terrain corrections for gravity observations at or below the surface of the ocean. The effect of water in large inland lakes or seas is not accounted for. An option for using the 1967 Geodetic Reference System for calculating the theoretical value of gravity at sea level has not been provided. None of the advantages of interactive computer usage, such as prompting and storage on disk or tape, are implemented. There is no option to reduce the bulk

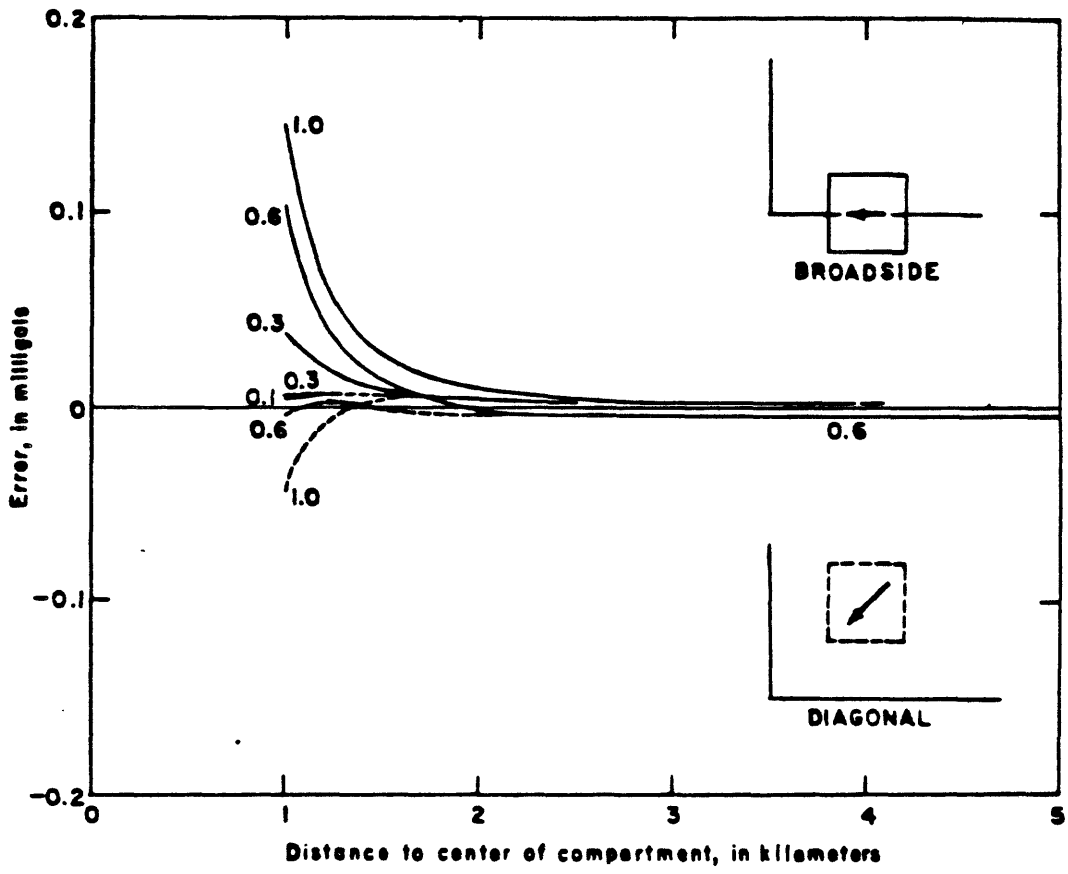


Figure 2.--Comparison of line element approximation to gravity effect of rectangular prism bounded on the top by an inclined plane that passes through the station. Solid lines indicate broadside orientation; dashed lines indicate diagonal orientation. Compartments are one-km squares. Direction of dip indicated by arrow. Numbers indicate slope of inclined plane. Density is 2.67 gm/cm^3.

of the printed output and the associated specialized input and output formats. The accompanying program, however, is useful for the majority of cases and can be adopted with little or no modification for use on most digital computers.

DIGITAL GRAVITY TERRAIN CORRECTION PROGRAM

General

A generalized program flow chart is shown in Figure 3. The arrangement of the card input to the gravity terrain correction program is shown in Figure 4. "Computer cards" on the illustration for example indicate positions for Job Control Language cards of the IBM system. The accompanying program (Table 1) was written in standard FORTRAN IV language and has been used on an IBM-370 computer system. The program designation, M0400, serves to distinguish this program from all other versions of the program. The "99-cards" shown on Figure 4 are cards with nines punched in all 80 columns. These cards serve as delimiters that indicate the end of the sets of station cards or map cards. The formats of other specific types of cards are described later. Examples of typical punch cards are shown in Figure 5 and punch cards for a test case are listed in Table 2.

Limitations

The total number of gravity stations may not exceed 500. The total number of "map sets" may not exceed 10, but 4 is the expected practical limit. The total number of digital maps within a set may not exceed 80. No more than 13 maps from a given map set can be used to provide the specified map coverage for any gravity station. Map parameter cards may not specify compartment and map sizes such that there are more than 30 compartments along the north-south dimension of a map and no more than 40 compartments along the east-west dimension of a map. There must be an integer number of compartments in a map. Similarly, there must be an integer number--not over 15 in either the north-south or east-west direction--of "blocks" in a map. A block is grouping of compartments that is intermediate in size

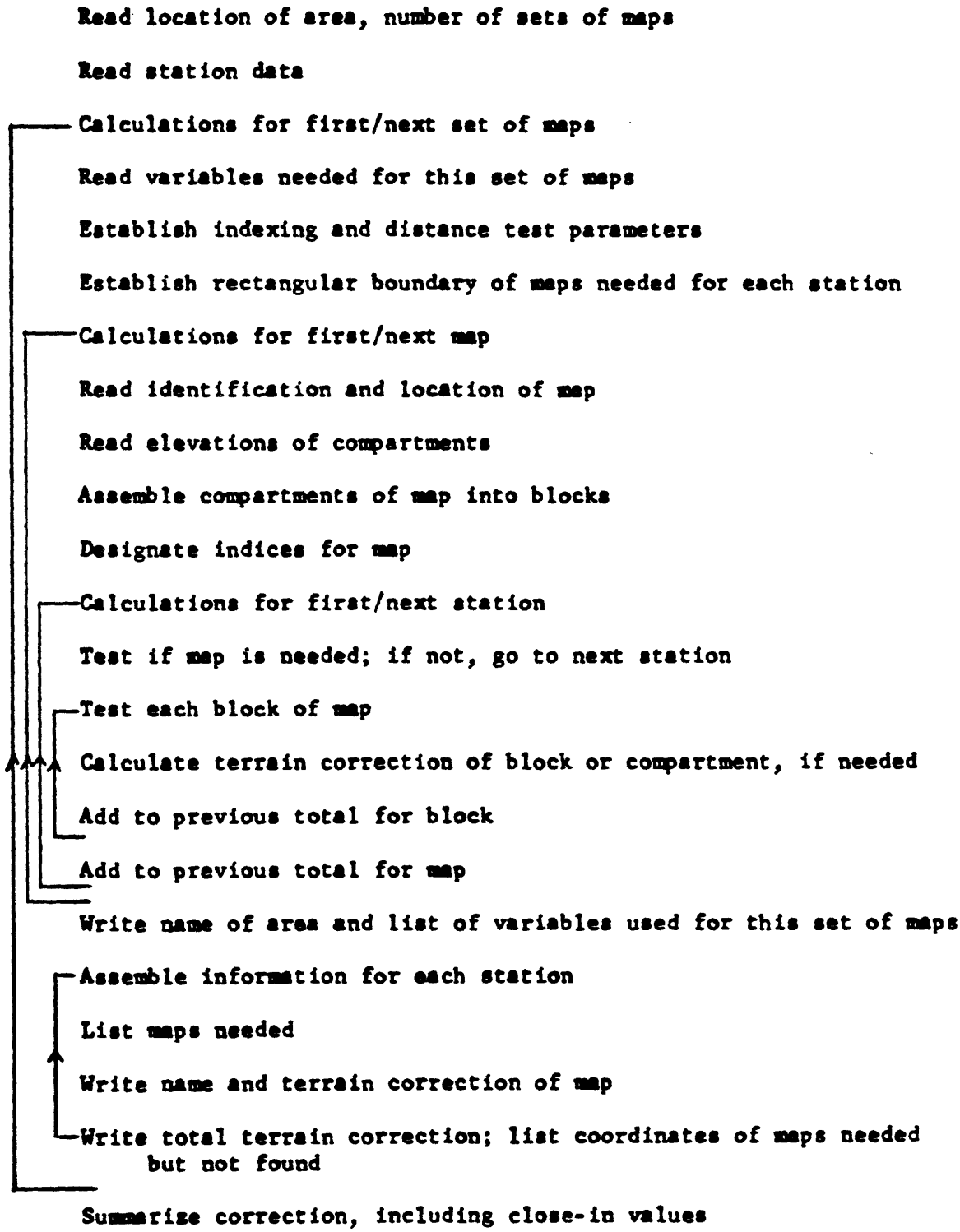


Figure 3.--Flow chart of program.

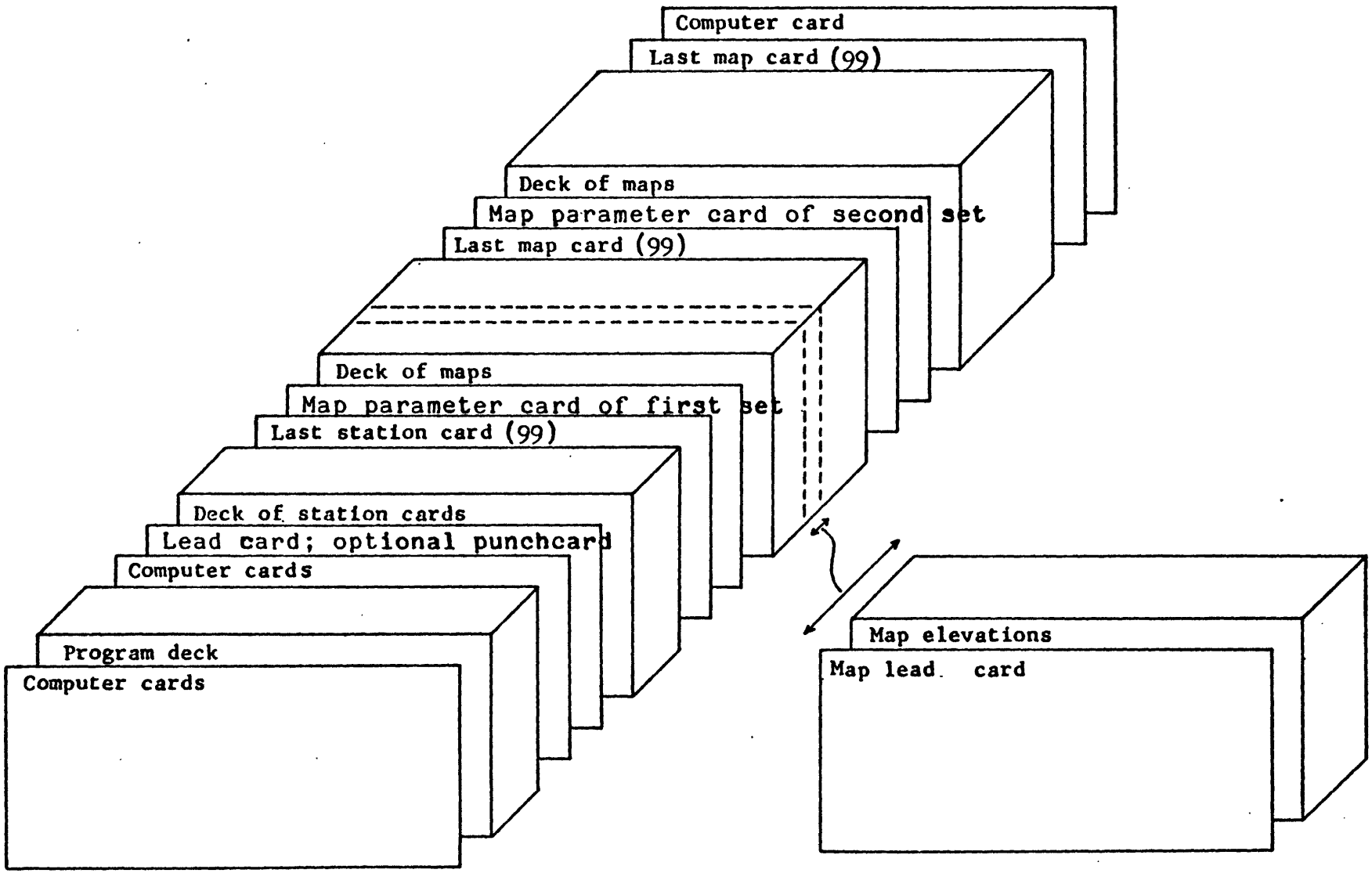


Figure 4.--Assembly of program for input to computer.

Lead card

```
SAN JUAN MTS., COLORADO -2 0 3  2.5
```

Special card

```
SJM
```

Station card

```
1857375508106504513718 1188UD5347884138                    KXFIS
```

Map parameter cards

```
 5  53030 60 60 4.1       0.8949  4.0     15.0                    160              5 MIN
15 15 1 1  3  3 21.        4.1     14.      14.                    0 1             15 MIN
60120 3 3 12 12 166.7      21.     60.      14.                    0 1             1-2 DEG
```

Map lead card

```
SJM VIIB7    37 20 107 50
```

Map elevation card

```
  9990   9200   9900  10200  10040   9200   8560   8300   7660   7050DURANGO
```

Output card

```
$JM 1857 375508 1065045137180788413 8D534 13357-33431 1188 1406U-32019-29130KXFI
```

Figure 5.-- Examples of punchcards.

between a "compartment" and a "map". The block size for one-minute digitization (one-by-one minute compartments), for example, usually is three-by-three minutes in anticipation of coarser three-minute digitization provided in another map set.

Definitions

The numbers near the left margin in the following paragraphs refer to inclusive card column numbers. The term "default" is the value or condition assumed if card columns for the specific parameter are left blank or are zero. The term "alpha" refers to any keyboard character. "Integer" is any right justified number without a decimal point. "Decimal" is a number in which a decimal point may be punched or the location of the decimal point is assumed to be located as indicated in the associated description.

Lead card

1-24	Alpha. Name of area or a title.
25-26	Integer. Indicates format of station cards. The code number minus-2 should be punched if punch card output is desired. The code numbers minus-1, zero, and one also are permitted. A detailed description is given in the next section.
27-28	Integer. The number zero indicates that the station elevations are expressed in feet. The number 3 indicates that station elevations are in meters.
29-30	Integer. The total number of digital map sets (or types) to follow the station data. The number 2 would indicate that 2 map sets will follow (for example, one-minute and three-minute digitization).
31-36	Decimal. Optional second density. The terrain corrections always are calculated for an assumed average rock density of 2.67 g/cm^3. The terrain correction and corresponding Bouguer anomaly also will be calculated for the optional second average density punched in these columns. The default is a density of 2.50 g/cm^3.

Station card formats for code numbers in columns 25-26 of the Lead Card

Minus-2 or minus-1 code (Burch format)

The present program produces punch card output only if this code is minus-2 (see description of "special card for punch output" for details of the format of the output card). If this code is minus-1, no output card is produced and alpha columns except 1-5 are ignored.

1-5	Alpha. Five-digit station name.

6-7	Integer. Latitude degrees (assumed North and positive). Negative numbers would give incorrect results.
8-11	Decimal. Latitude minutes with decimal point assumed between columns 9 and 10.
12-14	Integer. Longitude degrees (assumed West and positive). Negative numbers would give incorrect results.
15-18	Decimal. Longitude minutes with decimal point assumed between columns 16 and 17.
19-24	Decimal. Elevation with decimal point assumed between columns 23 and 24.
35-39	Decimal. Hand terrain correction in milligals or total terrain correction exclusive of that determined within this program. submittal. The assumed density is 2.67 g/ The decimal point is assumed between columns 37 and 38. The default implies a hand correction has not been done. Therefore, it is suggested that the number 1 punched in column 39 (0.01 milligal) rather than zero should be used to indicate that a hand correction has been determined for hand corrections that are less than 0.005 milligal.
40	Alpha. An optional code letter that indicates, for example, the distance to which the hand terrain calculation has been determined. The letter "F" may indicate that the hand correction has been done through Hayford's F-ring.
41-44	Alpha. An optional code grouping that indicates, for example, a 4-digit accuracy code.
45-51	Decimal. The observed gravity in milligals without the leading 9. The decimal point is assumed between columns 49 and 50; therefore, 0.01 milligal units are provided.
52-57	Decimal. The free-air an maly in milligals, with the assumed decimal point between columns 55 and 56. The default condition (or anomalies that are zero) signifies that the program will calculate the free-air anomaly using the International Formula of 1930 to calculate the theoretical value of gravity at sea level and the formula used by Swick (1942) to calculate the free-air correction.
69-73	Alpha, Optional information to be passed to the punch output card.

Zero or one codes

1-4 Alpha. Four-digit station name.

5-23 The same information related to location and elevation as appears in columns 6-24 of the Burch format.

24-29 Decimal. Relative observed gravity in milligals with the decimal point assumed between columns 27 and 28. The value is relative to 978,000 milligals if the code number is zero. If the code number is one, then the leading two digits (97 or 98, to cover the range of 975 to 985 gals) have been dropped from the absolute value of observed gravity.

71-74 Decimal. Hand terrain correction in milligals with the assumed decimal point between columns 72 and 73.

Special parameter card for punch output

This additional card must be placed between the Lead Card and the first Station Card if the format code is minus-2 in columns 25-26 on the Lead Card. The entire card may be blank or may provide the following supplementary data. The column structure of this card is identical to that of the punch output cards (see later section), but the card lacks numerical values.

1-3 Alpha. Three-digit prefix (area or project identifier) that is to precede the 5-digit station name on the output cards.

9 Alpha. Prefix, such as "N" or "+", that is to precede the latitude on output cards.

16 Alpha. Prefix, such as "W" or "-" or "+" that is to precede the longitude on output cards.

63 Alpha. Unless column 63 is left blank, this symbol will replace the symbol punched in column 40 of all station input cards. This symbol signifies the closest distance to which the computer terrain correction is carried.

76-80 Alpha. Unless left blank, this group of symbols will replace the data in columns 69-73 of the station input card. This option would rarely be used.

Map parameter card

One of these cards precedes each set of digital maps. The number of such cards therefore is prescribed in columns 29-30 of the Lead Card. See Figure 3 for the position of this type of card and see Figure 5 for an example of a combination of three of these cards.

1-3 Integer. North-south dimension of digital "map" in minutes. For example, 15 minutes is convenient for maps of one-minute digitization and 60 minutes for three-minute digitization.

4-6 Integer. East-west dimension of digital "map" in minutes. For example, 120 minutes is convenient for maps of three-minute digitization.

The geographic units of measurement (minutes or seconds) of the following four numbers are defined in columns 63-64 of this card. The program execution stops if there is not an integer number of "compartments" in a "block" or if there is not an integer number of "blocks" in a "map".

7-8 Integer. North-south dimension of the smallest cell--a "compartment"--of the gridded elevations.

9-10 Integer. East-width dimension of a compartment in minutes or seconds.

11-13 Integer. North-south dimension of a block of compartments. If the compartment size is one minute, for example, the block size would be three minutes, in order to make an exact join with three-minute gridded topography in another map set.

14-16 Integer. East-west dimension of a block in minutes or seconds.

17-24 Decimal. Maximum distance in kilometers to which a digital terrain correction is to be calculated by using this set of maps. The contribution to the terrain correction of all blocks of compartments whose centers occur at or beyond this distance are ignored.

25-32 Decimal. Minimum distance in kilometers to which a terrain correction is to be calculated by using this set of maps. Note that the minimum distance for the 3-minute set of digital maps should be identical to the maximum distance of the 1-minute set of digital maps, for example. This distance must exceed half the diagonal length of a compartment. The minimum distance selected for the map set with the smallest compartment size usually is equal to the farthest distance to which hand terrain corrections are carried. For example, 0.895 km (Hammer F-ring) is used for half-minute digitization and 2.29 km (Hayford F-ring) or 2.615 km (Hammer H-ring) are used for one-minute digitization.

33-40 Decimal. The distance in kilometers beyond which groups of compartments are lumped to form blocks for purposes of calculation of the terrain correction. This distance must be less than the value in columns 17-24 and probably should be greater than twice the maximum dimension of a block.

41-48 Decimal. Distance in kilometers beyond which a correction for the earth's curvature will be made. Values less than the default of 14 km produce a warning message, because the assumption of maximum slope upon which the curved-earth approximations are based would not necessarily be valid at shorter distances.

61-62 Integer. The number zero (or blank) signifies that the terrain corrections for only those compartments whose centers occur at or beyond the distance given in columns 25-32 are calculated. The number one signifies that an exact join to cylindrical rings of conventional hand terrain corrections will be made by excluding all parts of compartments that are closer to the station than the distance specified in columns 25-32 and including in the terrain

calculation all parts of compartments that are farther from the station than that distance. The latter option may be selected for only one Map Parameter Card of the terrain model.

63-64 Integer. The number 60 signifies that the units of compartment and block dimensions given in columns 7-16 are expressed in seconds. The units are expressed in minutes if this number is one.

Map Lead Card

1-12 Alpha. Name of map.

The following four numbers specify the geographic coordinates of the northwest corner of the map. Negative numbers should not be used. The purpose of the extra space in each field is to improve readability.

13-15 Integer. Latitude degrees.

16-18 Integer. Latitude minutes.

19-22 Integer. Longitude degrees.

23-25 Integer. Longitude minutes.

26-27 Integer. Number that defines the units of compartment elevations.

0 or 1.	All elevations are expressed in feet.
6	Positive elevations are in feet and negative elevations are in fathoms.
31	Positive elevations are in meters and negative elevations are in feet.
33	All elevations are expressed in meters.
36	Positive elevations are in meters and negative elevations are in fathoms.

Map elevation card

Ten average elevations are punched on each elevation card. Each elevation occupies 7 columns and the decimal point need not be punched if the elevation is a right-adjusted, integer number. In practice the elevations are estimated no closer than the nearest 10 elevation units, so that drum-card control is used to punch the final zero digits. Columns 71-80 often are used to indiate an abbreviated map name and a sequence number.

A blank or a zero elevation indicates that an elevation estimate has not been made and a terrain correction will not be calculated for that compartment. Therefore, a -1 or a +1 should be punched for compartments whose average elevation is near sea level. Negative compartment elevations refer to ocean bottom depths, so that water rather than rock beneath sea level is accounted for. Unfortunately, a small error occurs for land compartments that are beneath sea level, because sea water rather than air is assumed to be present.

The sequence of compartment numbering begins with the compartment in the northwest corner of the map and continues eastward along the northernmost row of compartments. Then, the compartments of the next row to the south and each successive row farther to the south similarly are arranged in west-to-east progression. A total of 23 elevation cards are needed, for example, to digitize 15-minute maps into one-minute compartments.

Format of output cards

1-3	Prefix from columns 1-3 on the "Special card".
4-8	Station name (from 1-5 of Station card).
9	From Special Card.
10-15	Latitude in degrees and minutes carried to hundredths, without a decimal point (from 6-11 of Station Card).
16	From Special Card.
17-23	Longitude in degrees and minutes carried to hundredths, without a decimal point (from 12-18 of Station card).
24-29	Elevation to nearest 0.1 foot or meter, without a decimal point from 19-24 of Station card.
30-36	Observed gravity in milligals to nearest hundredth without decimal point (from 45-51 of Station card). *No leading nine.*
37-40	Alpha data from 41-44 of Station card.
41-46	Free-air anomaly in 52-57 of Station card or as calculated during program execution.
47-52	Simple Bouguer anomaly at a reduction density of 2.67 g/cm^3.
53-57	Hand terrain correction in milligals in 71-74, expressed to 0.01 milligal.
58-62	Total terrain correction, including hand and digital computer correction at a density of 2.67 g/cm^3.
63	Single character from column 40 of the station input card or from the Special Card.
64-69	Complete Bouguer anomaly expressed to 0.01 milligal at a reduction density of 2.67 g/cm^3. It is the Simple Bouguer anomaly (47-52) plus the total terrain (58-62) plus a correction for the earth's curvature to 166.7 km.
70-75	Complete Bouguer anomaly expressed to 0.01 milligal at the reduction density specified in columns 31-36 of the Lead Card. That density is assumed instead of 2.67 g/cm^3 in making the mass, terrain, and curvature corrections. Note that a simple formula, ($T_2 = D_2 T_1 / 2.67$), is used to convert the total terrain correction (58-62), T_1, from a density of 2.67 g/cm^3 to the equivalent terrain correction, T_2, at the second density, D_2. The contribution of sea water compartments to the terrain correction is not correctly obtained for the second density when using this simple formula.
76-80	Optional data from 69-73 of the station input card or 76-80 of the Special Card.

Printout from terrain correction program (Table 3)

An example is attached. The first page includes a listing of the information about the punch card input and the calculated values of the theoretical gravity and free-air anomaly. When the free-air anomaly is provided on the station input card, the value 900,000 is printed for the theoretical gravity. Next, the names and location of maps of the first set are listed. A summary of the terrain corrections is printed, a station at a time. A similar list then is printed for each successive set of maps.

For each station the terrain correction of each map within the indicated range of distances is listed. Where maps are needed but not found in the set of maps, a list of the coordinates of the northwest corner of these maps is printed. Rarely, the coordinates of a map located near the maximum distance may be listed, though the map is included in the set, owing to a slightly abbreviated formula used for relating geographic to rectangular coordinates used in the map indexing part of the program. Later when the omitted maps are found or become available another computation can be made by using these maps and adding the terrain correction to the earlier printed total for each station.

The last pages of printout include a summary of the free-air anomaly and the simple and complete Bouguer anomalies at the two densities. The column labelled "(NEAR)" refers to that part of the computer terrain correction which represents the contribution of compartments that intersect the inner circular radius. If an exceptionally high value is printed, the average elevations in map compartments near the station should be checked. If no error is found, an outward shift of the selected inner circular radius may be considered.

The time of execution for a typical set of 60 stations using 4 sets of maps for terrain corrections in the distance interval 0.068 to 166.7 km is 48 seconds on the IBM-370 Computer. The maximum execution time for 2 sets of maps (1' and 3' digitization) that cover the distance interval 2.3 to 166.7 km is about 0.6 second per station and the length of printout is about 16 lines per station.

Input/output requirements

The program requires a region size of 160,000 bytes on the IBM-370 system. Logical unit 5 is used for reading data cards, unit 6 is used to print the results, and unit 8 is used for punch card output. The time of execution for a typical set of 60 stations using 4 sets of maps for terrain corrections in the distance interval 0.068 to 166.7 km is 48 seconds on the IBM-370 Computer. The maximum execution time for 2 sets of maps (1' and 3' digitization) that cover the distance interval 2.3 to 166.7 km is about 0.6 second per station and the length of printout is about 16 lines per station.

REFERENCES

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Plouff, Donald, 1966, Digital terrain corrections based on geographic coordinates [abs.]: Geophysics, v. 31, no. 6, p. 1208.

Robbins, S. L., Oliver, H. W., and Plouff, Donald, 1973, Description of magnetic tape containing average elevations of topography in California and adjacent regions for areas of 1x1 minute and 3x3 minutes in size: Nat'l. Tech. Inf. Service, No. PB-219-795 (magnetic tape is PB-219-794), U.S. Dept. Commerce, Springfield, Va., 31 p.

Swick, C.H., 1942, Pendulum gravity measurements and isostatic reductions: U.S. Coast and Geod. Survey, Spec. Publ. no. 232, 82 p.

TABLE 1.--List of gravity terrain correction program (M0400)

```
      DOUBLE PRECISION DENTS,GOBS,THG,DENTST,DENTSK                          1
      DOUBLE PRECISION DATID,DATNM,BLANKN,OBSGR                              2
      INTEGER*2 NUMS                                                         3
      DIMENSION BREA(6),DENTS(500),SLATM(500),SLONM(500),ELS(500),           4
     1NUMS(500,13),GRAV(500,13),BOUG(500),TERH(500),AS(500),BS(500),
     2 GV(500),GCEN(500),LTM(500),LNM(500)
      DIMENSION ACCUR(501),ALPHA(501),DATID(501),OBSGR(501)                  5
      COMMON /STATN/ DENTS                                                   6
      COMMON RMIN,RMIN2,RMAX2,BL2K,BL2L,GB2B,GA2B,AGM,BGM,ST,SN,             7
     1 A,B,   GCEN,GRAV,GV,NUMS
      COMMON /BLK2/ SLATM,SLONM,AS,BS,ELS,BREA,LTM,LNM                       8
      DATA BLANK/'    '/                                                     9
      DATA BLANKN/'        '/                                               10
C 500 STATIONS. 80 MAPS. 1200 (30 NORTH BY 40 WEST) COMPARTMENTS
C PER MAP.  BREA-NAME OF AREA.
C LC=0 IS CARD OUTPUT FORMAT OF GRAVITY REDUCTION PROGRAM FIRST USED
C  ON WASHINGTON COMPUTER (EXCEPT HAND TERRAIN CORRECTION PUNCHED IN
C COLUMNS 71-74). OBSERVED GRAVITY IN COLUMNS 33-38. OBSERVED GRAVITY
C CARRIED TO 0.01 MGAL. 6 DIGITS RELATIVE TO 978,000. LC=1 FOR FIRST TWO
C SIGNIFICANT FIGURES DROPPED FROM OBSERVED GRAVITY. LC=-1 FOR 7 DIGITS
C           RELATIVE TO 900,000. LD=3 FOR STATION ELEVATIONS IN METERS.
C      LD=0 FOR FEET. D2-SECOND CHOICE OF DENSITY (FIRST IS 2.67).
C NTYPE-NUMBER OF DISTINCT MAP SETS TO FOLLOW STATION DATA (0 IS 1).
C       (PROBABLY FIRST RMAX=2ND RMIN, FIRST COMPOSITE BLOCK=2ND COMPART)
C LC=-2 SIMILAR TO LC=-1 FORMAT EXCEPT PROVIDES PUNCH OUTPUT WITH
C ADDITIONAL INFORMATION READ IN AND PUNCHED OUT.
      NCIRC=0                                                                11
      RAD1=10000.0                                                           12
      RAD2=0.0                                                               13
      ASMAX=0.0                                                              14
      READ  (5,100)BREA,LC,LD,NTYPE,D2                                       15
  100 FORMAT (6A4,3I2,F6.3)
C INFORMATION FOR CORRESPONDING COLUMNS OF OUTPUT CARD.
      ALFA=BLANK                                                             16
      DATNM=BLANKN                                                           17
      STDENT=BLANK                                                           18
      SIGNLT=BLANK                                                           19
      SIGNLN=BLANK                                                           20
      IF (LC .EQ. -2) READ (5,106) STDENT,SIGNLT,SIGNLN,ALFA,DATNM           21
  106 FORMAT (A3,5X,A1,6X,A1,46X,A1,12X,A5)
      IF (NTYPE .LE. 0) NTYPE=1                                              22
      DEGR=  1.7453292E-2                                                    23
      WRITE (6,206)BREA,NTYPE                                                24
  206 FORMAT ('1TERRAIN CORRECTION PROGRAM D. PLOUFF  9-1972',//,
     1         35HOSUMMARY OF PRELIMINARY VALUES FOR ,6A4,19H TERRAIN COR
     2RECTION/,18H WILL BE MADE FOR ,I2,13H SETS OF MAPS/,31HO STA  LATI
     3TUDE LONGITUDE  ELEV,4X,40HOBS GRAV  THEO GRAV  FREE AIR  HAND TER
     4 )
C READ IN STATION DATA
C DENTQ- IDENTIFICATION. LATSD,SLATM- LATITUDE IN DEGREES, MINUTES.
C LONSD,SLONM- LONGITUDE IN DEGREES, MINUTES.  ELS- ELEVATION IN FEET.
      DO 6  K=1,502                                                          25
      NS=K                                                                   26
      IF (NS-501) 77,76,91                                                   27
```

Read on unit 5
Print on unit 6
Punch on unit 8

TABLE 1--CONTINUED

```
   76 WRITE (6,216)DENTS(500)                                              28
  216 FORMAT (9H STATION , A5,20H IS CARD NUMBER 500.)
      GO TO 4                                                              29
   77 TMG=0.0                                                              30
      ALPHA(K)=BLANK                                                       31
      ACCUR(K)=BLANK                                                       32
      DATID(K)=BLANK                                                       33
      IF (LC .NE. -1 .AND. LC .NE. -2) GO TO 3                             34
C BURCH FORMAT. TC-TERRAIN CORRECTION DONE BY HAND (IN MGALS FOR 2.67).
C FA-PREVIOUSLY CALCULATED FREE AIR ANOMALY. 5-DIGIT STATION NAME.
      IF (LC .EQ. -1) GO TO 4                                              35
C LC=-2 OPTION (PUNCH OUTPUT)
      READ  (5,107)DENTST,LT,QT,LN,QN,ELSIS,TC,ALPHA(K),ACCUR(K),GOBS,     36
     1 FA,DATID(K)
  107 FORMAT (A5,I2,F4.2,I3,F4.2,F6.1,10X,F5.2,A1,A4,F7.2,F6.2,11X,A5)
      IF (ALFA .NE. BLANK) ALPHA(K)=ALFA                                   37
      IF (DATNM .NE. BLANKN) DATID(K)=DATNM                                38
      GO TO 52                                                             39
    4 READ  (5,102)DENTST,LT,QT,LN,QN,ELSIS,TC,GOBS,FA                     40
  102 FORMAT (A5,I2,F4.2,I3,F4.2,F6.1,10X,F5.2,5X,F7.2,F6.2)
   52 IF (LT-90) 5,7,7                                                     41
    5 DEGS=LT+QT/60.0                                                      42
      PNI=DEGR*DEGS                                                        43
      IF (LD .EQ. 0) GO TO 42                                              44
      IF (LD .EQ. 3) GO TO 41                                              45
      WRITE (6,201)                                                        46
  201 FORMAT (30H1STATION ELEVATION UNITS WRONG)
      STOP                                                                 47
   41 ELKM=ELSIS/1000.0                                                    48
      GO TO 43                                                             49
   42 ELKM=3.048006E-4*ELSIS                                               50
   43 IF (FA) 56,55,56                                                     51
C LONG USED FORMAT (EXCEPT TC PLACED IN COLUMNS 71-74)
    3 READ  (5,101)DENTST,LT,QT,LN,QN,ELSIS,GOBS,TC                        52
  101 FORMAT (A4,I2,F4.2,I3,F4.2,F6.1,F6.2,41X,F4.2)
      IF (LT-90) 8,7,7                                                     53
    8 IF (LD .EQ. 0) GO TO 70                                              54
      IF (LD .EQ. 3) GO TO 68                                              55
      WRITE (6,201)                                                        56
      STOP                                                                 57
   68 ELKM=ELSIS/1000.0                                                    58
      GO TO 75                                                             59
   70 ELKM=3.048006E-4*ELSIS                                               60
   75 IF (LC .EQ. 0) GO TO 58                                              61
      IF (LC .EQ. 1) GO TO 57                                              62
      WRITE (6,209)                                                        63
  209 FORMAT (39H1OBSERVED GRAVITY FORMAT NOT RECOGNIZED)
      STOP                                                                 64
   58 GOBS=GOBS+7.804                                                      65
      GO TO 59                                                             66
   57 KGB=GOBS/1000.000                                                    67
      IF (KGB-4) 60,60,61                                                  68
   60 GOBS=GOBS+8.004                                                      69
      GO TO 59                                                             70
   61 GOBS=GOBS+7.004                                                      71
```

TABLE 1--CONTINUED

```
   59 DEGS=LT+QT/60.0                                                    72
      PHI=DEGR*DEGS                                                      73
   55 S=SIN(PHI)                                                         74
      S2=S*S                                                             75
      E2=ELKM*ELKM                                                       76
C THG-THEORETICAL GRAVITY RELATIVE TO 900,000 MGALS
      THG=7.8049D4+S2*(5149.232+23.082*S2)                               77
C SWICK FORMULA
      FA=(GOBS-THG) +ELKM*(308.77  -0.44   *S2)-0.072 *E2                78
   56 BOUG(K)=FA                                                         79
C STATION LATITUDE AND LONGITUDE IN MINUTES
      JT=QT                                                              80
      JN=QN                                                              81
      SLATM(K)=QT-JT                                                     82
      SLONM(K)=QN-JN                                                     83
      LTM(K)=60*LT+JT                                                    84
      LNM(K)=60*LN+JN                                                    85
      ELS(K)=ELKM                                                        86
C AS,BS -EW AND NS CONSTANTS FOR CONVERSION BETWEEN GEOGRAPHIC AND
C RECTANGULAR COORDINATES (UNITS ARE KM/MINUTE).
      C=COS(PHI)                                                         87
      C2=C*C                                                             88
      AS(K)=C*(1.861656-0.006343*C2)                                     89
      BS(K)= 1.861656+C2*(0.000160*C2-0.019028)                          90
      IF (AS(K) .LT. ASMAX) GO TO 83                                     91
      ASMAX=AS(K)                                                        92
      BSMAX=BS(K)                                                        93
   83 GV(K)=0.0                                                          94
      GCEN(K)=0.0                                                        95
      DENTS(K)=DENTST                                                    96
      OBSGR(K)=GOBS                                                      97
      GOBS=GOBS+9.0D5                                                    98
      THG=THG+9.0D5                                                      99
      WRITE (6,214)DENTST, LT,QT,LN,QN,ELSIS,GOBS,THG, FA,TC            100
  214 FORMAT (1X,A5,I3,F6.2,I4,F6.2,F7.0,2F11.2,2F10.2)
    6 TERM(K)=TC                                                        101
C TOTAL NUMBER OF STATIONS, NS. CARD WITH 99 IN LOCATION FOR LATITUDE
C DEGREES PLACED BEHIND LAST STATION CARD.
    7 NS=NS-1                                                           102
      CALL ARRNG(NTYPE,RAD1,RAD2,NCIRC,ASMAX,BSMAX,NS)                  103
      IF (NCIRC) 63,62,63                                               104
   62 WRITE (6,215)NS,BREA,RAD1                                         105
  215 FORMAT (13H1SUMMARY FOR , I4,13H STATIONS IN , 6A4/,73H  COMPUTER
     1TERRAIN CORRECTIONS CARRIED FROM NON-CIRCULAR INNER RADIUS OF  ,
     2F8.3)
      GO TO 69                                                          106
   63 WRITE (6,218)NS,BREA,RAD1                                         107
  218 FORMAT (13H1SUMMARY FOR , I4,13H STATIONS IN , 6A4/,73H  COMPUTER
     1TERRAIN CORRECTIONS CARRIED FROM     CIRCULAR INNER RADIUS OF  ,
     2F8.3)
   69 WRITE (6,219)      RAD2,D2                                        108
  219 FORMAT (4H  TO,F8.3,37H KILOMETERS.  DENSITIES ARE 2.67 AND ,F5.2,
     1 30H   DENSITY OF 2.67 IS USED FOR/,     ' VALUES IN COLUMNS LABEL
     2LED CC, TC, TER, (NEAR), AND TOT. TC-HAND CORRECTION'/,' TER-TOTA
     3L COMPUTER CORRECTION. (NEAR)-PART OF TOTAL THAT REPRESENTS CONTRI
```

TABLE 1--CONTINUED

```
     4BUTION'/, '   OF COMPARTMENTS THAT INTERSECT INNER CIRCULAR RADIUS
     5. TOT-HAND PLUS COMPUTER TERRAIN.'/,  'O STATION LATITUDE LONGITUD
     6E    ELEV    OBS GRAV',  4X,'F.A.',5X,'S.B.1    S.B.2    CC    TC',
     7 4X,'TER (NEAR)  TOT',4X,'C.B.1    C.B.2  ACC    STA')
      D2B=B2/2.67                                                        109
      D2P=0.012774*B2                                                    110
      DO 53 KS=1,NS                                                      111
      ELSIS=3280.833*ELS(KS)                                             112
      JT=LTM(KS)                                                         113
      JN=LNM(KS)                                                         114
      LT=JT/60                                                           115
      LN=JN/60                                                           116
      JT=JT-60*LT                                                        117
      JN=JN-60*LN                                                        118
      BT=JT+SLATM(KS)                                                    119
      BN=JN+SLONM(KS)                                                    120
      FA=BOUG(KS)                                                        121
      SBA1=FA-3.410658E-2*ELSIS                                          122
      SBA2=FA-B2P*ELSIS                                                  123
      E2=ELSIS*ELSIS                                                     124
      TC=TERH(KS)                                                        125
      TER=GV(KS)                                                         126
      CC=ELSIS*(446200.0-32.82*ELSIS+1.27E-6*E2)*1.0E-9                  127
      TERCOR=TC+TER                                                      128
      A=TERCOR-CC                                                        129
      CBA1=SBA1+A                                                        130
      CBA2=SBA2+A+B2B                                                    131
      GOBS=OBSGR(KS)+9.085                                               132
      IF (LB .EQ. 0) GO TO 67                                            133
   66 ELSIS=0.3048006*ELSIS                                              134
   67 DENTSK=DENTS(KS)                                                   135
      IF (LC .NE. -2) GO TO 53                                           136
      JT=100.0*BT+0.5                                                    137
      JN=100.0*BN+0.5                                                    138
      LEL=10.0*ELSIS+0.5                                                 139
      IFA=100.0*FA+0.5                                                   140
      ISB=100.0*SBA1+0.5                                                 141
      ITC=100.0*TC+0.5                                                   142
      ITER=100.0*TERCOR+0.5                                              143
      ICB1=100.0*CBA1+0.5                                                144
      ICB2=100.0*CBA2+0.5                                                145
      LOBGR=1.0B2*OBSGR(KS)+5.0D-1                                       146
      IF (IFA .LT. 0) IFA=IFA-1                                          147
      IF (ISB .LT. 0) ISB=ISB-1                                          148
      IF (ICB1 .LT. 0) ICB1=ICB1-1                                       149
      IF (ICB2 .LT. 0) ICB2=ICB2-1                                       150
      WRITE (8,400) STDENT,DENTSK,SIGNLT,LT,JT,SIGNLN,LN,JN,LEL,LOBGR,   151
     1 ACCUR(KS),IFA,ISB,ITC,ITER,ALPHA(KS),ICB1,ICB2,DATID(KS)
  400 FORMAT (A3,A5,A1,I2,I4,A1,I3,I4,I6,I7,A4,2I6,2I5,A1,2I6,A5)
   53 WRITE (6,211) STDENT,DENTSK, LT,BT,LN,BN,ELSIS,GOBS, FA,SBA1,       152
     1 SBA2,CC, TC,TER,GCEN(KS),TERCOR,CBA1,CBA2,ACCUR(KS),DENTSK
  211 FORMAT (1X,A3,A5, I3,F6.2,I4,F6.2,F8.1,F10.2,3F9.2,F5.2,4F6.2,
     1 2F8.2,1X,A4,1X,A5)
  799 CONTINUE                                                           153
   91 STOP                                                               154
```

TABLE 1--CONTINUED

```
      END                                                                155


      SUBROUTINE ARRNG(NTYPE,RAD1,RAD2,NCIRC,ASMAX,BSMAX,NS)
      DOUBLE PRECISION DENTS,ASTER,RIF(10),RIL(10)                        1
      INTEGER*2 NUMS                                                      2
      DIMENSION BREA(6),DENTS(500),LATSD(500),SLATM(500),LONSD(500),      3
     1SLONM(500),ELS(500),LATNW(500),LONNW(500),LATSE(500),LONSE(500),
     2DENT@(3,81),NUMS(500,13),GRAV(500,13),E(30,40),
     3LAT@(81),LONG(81),BEL(15,15),GV(500),DY(4),AS(500),BS(500)
      DIMENSION GCEN(500),LTM(500),LNM(500),MSS(500),LCIRC(10)            4
      COMMON /STATN/ DENTS                                                5
      COMMON /MAP/ DENT@,LAT@,LONG                                        6
      COMMON RMIN,RMIN2,RMAX2,BL2K,BL2L,@B2B,@A2B,AGM,BGM,ST,SN,          7
     1 A,B,   GCEN,GRAV,GV,NUMS
      COMMON /BLK2/ SLATM,SLONM,AS,BS,ELS,BREA,LTM,LNM                    8
      DATA  ASTER/'********'/                                             9
      DEGM=  1.666667E-2                                                 10
      DEGR=  1.745329E-2                                                 11
      DEGR28=0.125*DEGR*DEGR                                             12
      DEGR24=0.25 *DEGR*DEGR                                             13
C CONSTANT IN TERRAIN CORRECTION FORMULA.  DISTANCES IN KM.  GRAVITY IN
C MGALS. DENSITY IS 2.67
      GP=2.67*6.670                                                      14
C LATM,LONM- TOTAL NUMBER OF MINUTES ALONG N-S AND E-W EDGES OF QUAD.
C KCLAT,LCLON- CORRESPONDING SHAPE OF SMALLEST COMPARTMENT IN MIN/SEC.
C MUST BE INTEGRAL NUMBER OF COMPARTMENTS AND BLOCKS ALONG EDGES OF QUAD
C AND EACH ELEMENT MUST DIVIDE BY AN INTEGRAL NUMBER INTO THE LARGER
C ELEMENTS.  KBLOK,LBLOK- CORRESPONDING SHAPE OF COMPOSITE BLOCK IN
C MIN/SEC (=KCLAT,LCLON IF COMPARTMENTS OF ONLY ONE SIZE ARE DESIRED).
C RMAX,RMIN-OUTER AND INNER RADII OF TERRAIN CORRECTION, IN KILOMETERS.
C RMED- INTERMEDIATE RADIUS, FOR CONVERSION TO LARGER BLOCKS, IN KM (=RM
C IF NOT USED).  RGR- DISTANCE FOR CONVERSION OF GRAVITY FORMULA (WITH
C AND WITHOUT CURVATURE CORRECTION).
C                       KCIRC=NON-ZERO, IF RMIN JOINS TRUE CIRCULAR BNDRY.
C SMALLEST PERMISSABLE QUAD IS 1 MINUTE, COMPARTMENT 1 SECOND.
C COMPARTMENT AND BLOCK SIZES EXPRESSED IN MINUTES (KSEC=1) OR SECONDS
C (KSEC=60). MAP EDGES ALWAYS IN MINUTES.
      DO 92 NMAP=1,NTYPE                                                 15
      READ  (5,103)LATM,LONM,KCLAT,LCLON,KBLOK,LBLOK,RMAX,RMIN,RMED,RGR,  16
     1           KCIRC,KSEC
  103 FORMAT (213,2I2,2I3,4F8.4,12X,2I2)
      IF (LATM .EQ. KBLOK .OR. LONM .EQ. LBLOK) GO TO 99                 17
      IF (KCLAT .EQ. KBLOK .OR. LCLON .EQ. LBLOK) GO TO 99               18
      IF ( RMIN .LT. RMED .AND. RMIN .LT. RMAX) GO TO 80                 19
      WRITE (6,221) RMIN,RMED,RMAX                                       20
  221 FORMAT (' INNER RADIUS',F8.2,' IS NOT LESS THAN INTERMEDIATE, OR OU
     1TER RADIUS',2F9.2)
   91 STOP                                                               21
   80 IF (RGR .EQ. 0.0) RGR=14.0                                         22
      IF (RGR .GT. 13.99) GO TO 81                                       23
      WRITE (6,222) RGR                                                  24
  222 FORMAT (///'0WARNING. EARTH CURVATURE EFFECT IS ASSUMED NEGLIGIBLE
     1 FOR DISTANCES LESS THAN 14 KM.'/, ' YOUR SELECTION OF',F9.2,
     2 ' KM MAY LEAD TO INACCURACY IN THE APPROXIMATION USED.')
```

TABLE 1--CONTINUED

```
   81 IF (NMAP .GT. 10) GO TO 2                                          25
      RIF(NMAP)=RMIN                                                     26
      RIL(NMAP)=RMAX                                                     27
      LCIRC(NMAP)=KCIRC                                                  28
    2 IF (RMIN-RAD1) 94,95,95                                            29
   94 RAD1=RMIN                                                          30
   95 IF (RMAX .LE. RAD2) GO TO 97                                       31
      RAD2=RMAX                                                          32
   97 NCIRC=NCIRC+KCIRC                                                  33
      IF (NCIRC .LE. 1) GO TO 96                                         34
      WRITE (6,210)                                                      35
  210 FORMAT (51H1MORE THAN ONE CIRCULAR INNER RADIUS CAN NOT BE RUN)
      STOP                                                               36
   96 RMAX2=RMAX*RMAX                                                    37
      RMED2=RMED*RMED                                                    38
      RMIN2=RMIN*RMIN                                                    39
      RGR2=RGR*RGR                                                       40
C ROWS (DIFFERING LATITUDE) AND COLUMNS OF SMALL COMPARTMENTSIN LARGE BL
      MCB=KBLOK/KCLAT                                                    41
      NCB=LBLOK/LCLON                                                    42
      LTES=LBLOK-LCLON*NCB                                               43
      KTES=KBLOK-KCLAT*MCB                                               44
      IF (LTES .NE. 0 .OR. KTES .NE.0) GO TO 99                          45
      CPNUM=MCB*NCB                                                      46
      MCB1=MCB-1                                                         47
      NCB1=NCB-1                                                         48
C NUMBER OF COMPARTMENTS AND  LARGE BLOCKS IN QUAD, BY ROWS AND COLUMNS
      NJN=(60*LONM)/LCLON                                                49
      NIT=(60*LATM)/KCLAT                                                50
      KBQ=(60*LATM)/KBLOK                                                51
      LBQ=(60*LONM)/LBLOK                                                52
C EDGES OF QUAD EXPRESSED IN MINUTES AND IN DEGREES
      BQM=LATM                                                           53
      AQM=LONM                                                           54
      BQD=BQM/60.0                                                       55
      AQD=AQM/60.0                                                       56
      KLCMP=KCLAT*LCLON                                                  57
      COMP2=KLCMP                                                        58
      COMP2=COMP2/3600.0                                                 59
C EDGES AND HALF-EDGES OF LARGE BLOCKS IN MINUTES
      BLOKK=KBLOK                                                        60
      BLOKL=LBLOK                                                        61
      BLOKK=BLOKK/60.0                                                   62
      BLOKL=BLOKL/60.0                                                   63
      BLOK2=BLOKK*BLOKL                                                  64
      BL2K=0.5*BLOKK                                                     65
      BL2L=0.5*BLOKL                                                     66
C HALF-EDGES OF LARGE BLOCKS IN INDEXING UNITS
      BLK2K=BL2K/BQM                                                     67
      BLK2L=BL2L/AQM                                                     68
      MLATM=0.5*BQM                                                      69
C EDGE OF QUAD MINUS HALF-BLOCK IN MINUTES, FOR TESTING RMAX
      QB2B=BQM-BL2K                                                      70
      QA2B=AQM-BL2L                                                      71
C EDGES AND HALF-EDGES OF COMPARTMENTS IN MINUTES OR SECONDS
```

TABLE 1--CONTINUED

```
      COMK=KCLAT                                                        72
      COML=LCLON                                                        73
      CMK2=COMK/120.0                                                   74
      CML2=COML/120.0                                                   75
      BC2K=BL2K-CMK2                                                    76
      BC2L=BL2L-CML2                                                    77
      ARCSB=COMP2/BLOK2                                                 78
      BQM60=60.0/BQM                                                    79
      AQM60=60.0/AQM                                                    80
      RM120=RMAX/120.0                                                  81
      RMXBQ=RMAX/BQM                                                    82
      RMXAQ=RMAX/AQM                                                    83
      IF (KSEC .EQ. 1) GO TO 44                                         84
      IF (KSEC .EQ. 60) GO TO 45                                        85
      WRITE (6,213)                                                     86
  213 FORMAT (49H1COMPARTMENT UNITS NOT SPECIFIED IN COLUMNS 63-64)
      STOP                                                              87
C MINUTES
   44 BLK2K=60.0*BLK2K                                                  88
      BLK2L=60.0*BLK2L                                                  89
      NJN=NJN/60                                                        90
      NIT=NIT/60                                                        91
      KTES=LONM-NJN*LCLON                                               92
      LTES=LATM-NIT*KCLAT                                               93
      IF (LTES .NE. 0 .OR. KTES .NE.0) GO TO 99                         94
      KBQ=KBQ/60                                                        95
      LBQ=LBQ/60                                                        96
      KTES=LATM-KBQ*KBLOK                                               97
      LTES=LONM-LBQ*LBLOK                                               98
      IF (LTES .NE. 0 .OR. KTES .NE.0) GO TO 99                         99
      COMP2=3600.0*COMP2                                               100
      BLOK2=3600.0*BLOK2                                               101
      BL2K=60.0*BL2K                                                   102
      BL2L=60.0*BL2L                                                   103
      BLOKK=KBLOK                                                      104
      BLOKL=LBLOK                                                      105
      BC2K=60.0*BC2K                                                   106
      BC2L=60.0*BC2L                                                   107
      BB2B=BQM-BL2K                                                    108
      BA2B=AQM-BL2L                                                    109
      GO TO 46                                                         110
C SECONDS
   45 COMK=COMK/60.0                                                   111
      COML=COML/60.0                                                   112
      KTES=60*LONM-NJN*LCLON                                           113
      LTES=60*LATM-NIT*KCLAT                                           114
      IF (LTES .NE. 0 .OR. KTES .NE.0) GO TO 99                        115
      KTES=60*LATM-KBQ*KBLOK                                           116
      LTES=60*LONM-LBQ*LBLOK                                           117
      IF (LTES .NE. 0 .OR. KTES .NE.0) GO TO 99                        118
   46 BL1=KBQ-1                                                        119
      AC10=0.5*COML*ASMAX                                              120
      BC10=0.5*COMK*BSMAX                                              121
      TEST=AC10*AC10+BC10*BC10                                         122
      IF (RMIN2 .GT. TEST) GO TO 82                                    123
```

TABLE 1--CONTINUED

```
      WRITE (6,223) RMIN                                                    124
  223 FORMAT (' PROGRAM NOT WRITTEN TO INCLUDE CASE WHERE HALF OF COMPAR
     1TMENT DIAGONAL-LENGTH IS GREATER THAN INNER RADIUS ', F6.2)
      STOP                                                                  125
   82 TEST=RMED-RMIN                                                        126
C HALF DIAGONAL OF LARGEST BLOCK
      ADEL=(AC10*NCB)**2+(BC10*MCB)**2                                      127
      ADEL=SQRT(ADEL)                                                       128
      IF (TEST .GT. ADEL) GO TO 84                                          129
      WRITE (6,224) RMIN,RMED                                               130
  224 FORMAT (' SELECTED RADII',2F8.2,' DO NOT LEAVE ROOM FOR BLOCKS')
      STOP                                                                  131
C ERROR OF 0.001 MINUTE
   84 AC10=ASMAX/1000.0                                                     132
      BC10=BSMAX/1000.0                                                     133
      DO 9 IS=1,NS                                                          134
C FLOATING POINT NOTATION FOR LOCATION OF STATION IN INDEX SYSTEM (QUAD
C INCREMENTS).
      DO 65 M=1,13                                                          135
      GRAV(IS,M)=0.0                                                        136
   65 NUMS(IS,M)=0                                                          137
      MSS(IS)=0                                                             138
      ST=(SLATM(IS)+LTM(IS))/60.0                                           139
      STIND=BQM60*ST                                                        140
      SNIND=(SLONM(IS)+LNM(IS))/AQM                                         141
C NW CORNER OF QUAD IN WHICH STATION IS LOCATED IN INDEX SYSTEM.
C STATIONS ALONG EAST AND SOUTH EDGES INCLUDED IN QUAD TO NORTHWEST.
      LATSD(IS)=STIND+1.0                                                   142
      LONSD(IS)=SNIND+1.0                                                   143
C MAX RADIUS IN DEGREES
      RQ2=RM120/BS(IS)                                                      144
      CN=COS(DEGR*(ST+RQ2))                                                 145
      CS=COS(DEGR*(ST-RQ2))                                                 146
      C2N=CN*CN                                                             147
      C2S=CS*CS                                                             148
      RBN=RMXBQ/(1.861656+C2N*(0.000160*C2N-0.019028))-BLK2K                149
      RBS=RMXBQ/(1.861656+C2S*(0.000160*C2S-0.019028))-BLK2K                150
      RAN=RMXAQ/(CN*(1.861656-0.006343*C2N))-BLK2L                          151
C NORTH BOUNDARY OF COVERAGE NEEDED, IN INDEX UNITS- REFERRED TO NW
C CORNER OF BOUNDING QUADS. NUMBERS INCREASE TO NW. THEN  S, E, AND W.
      LATNW(IS)=STIND+RBN +1.0                                              152
      LATSE(IS)=STIND-RBS +1.0                                              153
      LONSE(IS)=SNIND-RAN +1.0                                              154
    9 LONNW(IS)=SNIND+RAN +1.0                                              155
      WRITE (6,208)                                                         156
  208 FORMAT (1H1)
C CALCULATE TERRAIN CORRECTION, ONE QUAD AT A TIME
      DO 10 MQ=1,91                                                         157
C TOTAL NUMBER OF QUADS COUNTED
      NQ=MQ                                                                 158
C IDENTIFICATION OF QUAD. COORDINATES OF NW CORNER- DEGREES, MINUTES
C OF LATITUDE AND LONGITUDE IN INTEGERS. KFATH IS 6 IF DEPTHS (NEGATIVE
C ELEVATIONS) IN FATHOMS--FEET OTHERWISE.  33 IS FOR ALL DEPTHS IN
C METERS. 36 FOR ELEVATIONS IN METERS AND DEPTHS IN FATHOMS. 31--M, FT
      READ  (5,104)(DENTQ(ID,MQ),ID=1,3),LTDQ,LTMQ,LNDQ,LNMQ, KFATH        159
```

TABLE 1--CONTINUED

```
  104 FORMAT (3A4,2I3,I4,I3,I2)
      IF (LTDG-90) 74,12,12                                              160
   74 WRITE (6,212)(DENTG(ID,MG),ID=1,3),LTDG,LTMG,LNDG,LNMG             161
  212 FORMAT (1X,3A4,2I3,I4,I3)
      IF (NG-81) 11,73,73                                                162
   73 WRITE (6,217)(DENTG(ID,81),ID=1,3)                                 163
  217 FORMAT (24H 80 MAPS EXCEEDED.  MAP ,3A4,14H IS NUMBER 81.)
      STOP                                                               164
C ELEVATIONS OF COMPARTMENTS IN FEET.  ONE WEST-TO-EAST ROW AT A TIME,
C STARTING AT NORTHWEST CORNER.
C CARD WITH 99 IN LOCATION FOR LATITUDE DEGREES PLACED BEHIND ELEVATION
C CARDS OF LAST QUADRANGLE IN DATA--THE FINAL DATA CARD
   11 READ  (5,105)((E(I,J),J=1,NJN),I=1,NIT)                            165
  105 FORMAT ((10F7.0))
  801 DO 307 J=1,NJN                                                     166
      DO 307 I=1,NIT                                                     167
  307 E(I,J)=E(I,J)/1000.0                                               168
      IF (KFATH-31) 300,306,306                                          169
  300 DO 301 J=1,NJN                                                     170
      DO 301 I=1,NIT                                                     171
  301 E(I,J)=0.3048006*E(I,J)                                            172
      IF (KFATH-6) 305,302,305                                           173
  306 IF (KFATH-33) 308,305,309                                          174
  302 DO 304 J=1,NJN                                                     175
      DO 304 I=1,NIT                                                     176
      EIJ=E(I,J)                                                         177
      IF (EIJ) 303,304,304                                               178
  303 E(I,J)=6.0*EIJ                                                     179
  304 CONTINUE                                                           180
      GO TO 305                                                          181
  308 DO 310 J=1,NJN                                                     182
      DO 310 I=1,NIT                                                     183
      EIJ=E(I,J)                                                         184
      IF (EIJ) 312,310,310                                               185
  312 E(I,J)=0.3048006*EIJ                                               186
  310 CONTINUE                                                           187
      GO TO 305                                                          188
  309 DO 311 J=1,NJN                                                     189
      DO 311 I=1,NIT                                                     190
      EIJ=E(I,J)                                                         191
      IF (EIJ) 313,311,311                                               192
  313 E(I,J)=1.8288036*EIJ                                               193
  311 CONTINUE                                                           194
C AVERAGE ELEVATION OF COMPARTMENTS USED FOR ELEVATION OF BLOCKS.
  305 DO 86 K=1,KBG                                                      195
      KF=NCB*K                                                           196
      K1=KF-NCB1                                                         197
      DO 86 L=1,LBG                                                      198
      LF=NCB*L                                                           199
      L1=LF-NCB1                                                         200
      ELEV=0.0                                                           201
      CPDN1=CPNUM                                                        202
      DO 30 II=K1,KF                                                     203
      DO 30 JJ=L1,LF                                                     204
      EIJ=E(II,JJ)                                                       205
```

TABLE 1--CONTINUED

```
C PROTECTION AGAINST BLANK ELEVATIONS
      IF (EIJ) 54,31,54                                                  206
   31 CPDN1=CPDN1-1.0                                                    207
      GO TO 30                                                           208
   54 ELEV=ELEV+EIJ                                                      209
   30 CONTINUE                                                           210
      IF (CPDN1) 32,32,85                                                211
   32 BEL(K,L)=0.0                                                       212
      GO TO 86                                                           213
   85 BEL(K,L)=ELEV/CPDN1                                                214
   86 CONTINUE                                                           215
C NW CORNER OF QUAD, IN MINUTES
   88 LTNWQ=60*LTDQ+LTMQ                                                 216
      LNNWQ=60*LNDQ+LNMQ                                                 217
      QT=LTNWQ                                                           218
      QN=LNNWQ                                                           219
C IN INDEX UNITS OF ONE-PER-QUAD
      LATQ(MQ)=LTNWQ/LATM                                                220
      LONQ(MQ)=LNNWQ/LONM                                                221
      LTQ=LATQ(MQ)                                                       222
      LNQ=LONQ(MQ)                                                       223
      LTES=LTNWQ-LTQ*LATM                                                224
      KTES=LNNWQ-LNQ*LONM                                                225
      IF (LTES .NE. 0 .OR. KTES .NE.0) GO TO 99                          226
      IF (MQ .EQ. 1) GO TO 3                                             227
      MINUS=MQ-1                                                         228
      DO 4 K=1,MINUS                                                     229
      IF (LTQ .EQ. LATQ(K) .AND. LNQ .EQ. LONQ(K)) GO TO 5               230
    4 CONTINUE                                                           231
      GO TO 3                                                            232
    5 WRITE (6,206)                                                      233
  206 FORMAT (' THIS MAP WAS SKIPPED. IT ALREADY HAS BEEN USED.')
      GO TO 10                                                           234
C PARAMETERS FOR NORTH AND SOUTHMOST BLOCK ROWS OF MAP
    3 DEGTOP=DEGM*(QT-BL2K)                                              235
      CQS=COS(DEGR*DEGTOP)                                               236
      C2=CQS*CQS                                                         237
      BT=1.861656+C2*(0.000160*C2-0.019028)                              238
      AT=CQS*(1.861656-0.006343*C2)                                      239
      DEGBOT=DEGM*(QT-BQM+BL2K)                                          240
      CQS=COS(DEGR*DEGBOT)                                               241
      C2=CQS*CQS                                                         242
      BB=1.861656+C2*(0.000160*C2-0.019028)                              243
      AB=CQS*(1.861656-0.006343*C2)                                      244
      ADELR=(AB-AT)/BL1                                                  245
      BDELR=(BB-BT)/BL1                                                  246
C COMPUTATION OF TERRAIN CORRECTION FOR ONE QUAD, ONE STATION AT A TIME
      DO 13 IS=1,NS                                                      247
C DETERMINE IF QUAD IS TO BE USED. FIRST OMIT STATIONS WHERE QUAD OCCURS
C OUTSIDE BORDER OF RMAX-RECTANGLE.  SEQUENCE N, S, W, E.
      IF (  LTQ    -LATNW(IS)) 14,14,13                                  248
   14 IF (  LTQ    -LATSE(IS)) 13,15,15                                  249
   15 IF (  LNQ    -LONNW(IS)) 16,16,13                                  250
   16 IF (  LNQ    -LONSE(IS)) 13,17,17                                  251
C LATITUDE AND LONGITUDE OF STATION IN MINUTES
```

TABLE 1--CONTINUED

```
   17 ST=SLATM(IS)+LTM(IS)                                                  252
      SN=SLONM(IS)+LNM(IS)                                                  253
      DEGS=ST/60.0                                                          254
      DEGN=SN/60.0                                                          255
C DIFFERENCE IN LOCATION BETWEEN NW QUAD CORNER AND STATION, IN MINUTES
      QTST=(LTNWQ-LTM(IS))-SLATM(IS)                                        256
      QNSN=(LNNWQ-LNM(IS))-SLONM(IS)                                        257
      QTS2B=QTST-BL2K                                                       258
      QNS2B=QNSN-BL2L                                                       259
      QQNB=QNSN-QA2B                                                        260
      QQTB=QTST-QB2B                                                        261
C INDEX UNITS FOR CORNER OF QUAD IN WHICH STATION LOCATED
      LTS=LATSD(IS)                                                         262
      LNS=LONSD(IS)                                                         263
C TEST IF QUAD OUTSIDE RMAX RADIUS SQUARED
      IF (LTQ-LTS) 19,22,20                                                 264
   19 DPHI2=(DEGS-DEGTOP)**2                                                265
      AQ2=(0.5*(AT+AS(IS))*(1.0+DEGR2B*DPHI2))**2                           266
      BQ2=(0.5*(BT+BS(IS)))**2                                              267
      IF (LNQ-LNS) 21,22,23                                                 268
   20 DPHI2=(DEGS-DEGBOT)**2                                                269
      AQ2=(0.5*(AB+AS(IS))*(1.0+DEGR2B*DPHI2))**2                           270
      BQ2=(0.5*(BB+BS(IS)))**2                                              271
      IF (LNQ-LNS) 24,22,25                                                 272
C SOUTHEAST
   21 DISQ2=BQ2+QTS2B*QTS2B+AQ2+QNS2B+QNS2B                                 273
      GO TO 26                                                              274
C SOUTHWEST
   23 DISQ2=BQ2+QTS2B*QTS2B+AQ2+QQNB+QQNB                                   275
      GO TO 26                                                              276
C NORTHEAST
   24 DISQ2=BQ2+QQTB*QQTB+AQ2+QNS2B+QNS2B                                   277
      GO TO 26                                                              278
C NORTHWEST
   25 DISQ2=BQ2+QQTB*QQTB+AQ2+QQNB+QQNB                                     279
C TEST RMAX
   26 IF (DISQ2-RMAX2) 22,13,13                                             280
   22 BCOMK=BS(IS)*COMK                                                     281
      ACOML=AS(IS)*COML                                                     282
      ABC5=0.5*SQRT(BCOMK*BCOMK+ACOML*ACOML)                                283
      MS=MSS(IS)+1                                                          284
      IF (MS-14) 72,71,71                                                   285
   71 WRITE (6,220)DENTS(IS),DEGS,DEGN,(DENTQ(ID,MQ),ID=1,3)                286
  220 FORMAT (' STATION ',A5,2F8.3,' (RENAMED *****) NEEDS MORE THAN 13
     1MAPS'/,8X,' MAP ', 3A4,' NEEDED BUT NOT COMPUTED.')
      DENTS(IS)=ASTER                                                       287
      GO TO 13                                                              288
   72 MSS(IS)=MS                                                            289
      NUMS(IS,MS)=MQ                                                        290
      RC5=RMIN+ABC5                                                         291
      RC5=RC5*RC5                                                           292
      ELST=ELS(IS)                                                          293
      DPHI2=(DEGS-DEGTOP)**2                                                294
      ATOP=0.5*(AT+AS(IS) *(1.0+DEGR24*DPHI2))                              295
      BTOP=0.5*(BT+BS(IS))                                                  296
```

TABLE 1--CONTINUED

```
      DPHI2=(DEGS-DEGBOT)**2                                              297
      ABOT=0.5*(AB+AS(IS) *(1.0+DEGR24*DPHI2))                            298
      BBOT=0.5*(BB+BS(IS))                                                299
      ADEL =(ABOT-ATOP)/BL1                                               300
      BDEL =(BBOT-BTOP)/BL1                                               301
      A=ATOP-ADEL                                                         302
      B=BTOP-BDEL                                                         303
      AROW=AT-ADELR                                                       304
      BROW=BT-BDELR                                                       305
C START LOOP FOR TESTING BLOCKS OF COMPARTMENTS NORTH TO SOUTH
      DO 411 I=1,KBQ                                                      306
      KF=MCB*I                                                            307
      K1=KF-MCB1                                                          308
      FK1=I-1                                                             309
C FOR DISTANCES OF STATION TO BLOCK ROW
      B=B+BDEL                                                            310
      A=A+ADEL                                                            311
C FOR DISTANCES WITHIN BLOCK ROW
      AROW=AROW+ADELR                                                     312
      BROW=BROW+BDELR                                                     313
      DISTN=B*(QTS2B-FK1*BLOKK)                                           314
      IF (DISTN .GE. RMAX) GO TO 411                                      315
C BLOCK AREA IN SQUARE KILOMETERS
      AREAB=AROW*BROW*BLOK2                                               316
      BCOMK=BROW*COMK                                                     317
      ACOML=AROW*COML                                                     318
C CONSTANT IN TERRAIN CORRECTION FORMULA
      GPA=AREAB*GP                                                        319
      AC5=0.5*ACOML                                                       320
      BC5=0.5*BCOMK                                                       321
C EAST TO WEST
      DO 40 L=1,LBQ                                                       322
      LF=NCB*L                                                            323
      L1=LF-NCB1                                                          324
      FL1=L-1                                                             325
   79 DISTW=A*(QNS2B-FL1*BLOKL)                                           326
      R2B=DISTN*DISTN+DISTW*DISTW                                         327
      IF (R2B-RMAX2) 28,40,40                                             328
   28 IF (R2B-RMED2) 34,29,29                                             329
C USE LARGE BLOCKS. AVERAGE THE ELEVATIONS OF COMPARTMENTS.
   29 ELEV=BEL(I,L)                                                       330
      IF (ELEV .NE. 0.0) GO TO 87                                         331
      WRITE (6,211)  I, L,DENTS(IS)                                       332
  211 FORMAT (' WARNING. BLOCK',       I3,'S,',I3,'E HAS ZERO ELEVATION.'
     1,' TC NEEDED BUT NOT CALCULATED FOR STATION ',A5)
      GO TO 40                                                            333
   87 GB=G(ELEV,ELST,R2B,RGR2)                                            334
      GO TO 39                                                            335
C USE SMALL COMPARTMENTS.  DISTANCES RELATIVE TO CENTER OF COMPARTMENT
C IN NW CORNER OF BLOCK.
   34 DISNC=DISTN+BROW*BC2K                                               336
      DISWC=DISTW+AROW*BC2L                                               337
      FJI=0.0                                                             338
      GB=0.0                                                              339
      DO 35 II=K1,KF                                                      340
```

TABLE 1--CONTINUED

```
      FIJ=0.0                                                                  341
      YC=DISNC-FJI*BCOMK                                                       342
      YC2=YC*YC                                                                343
C DISTANCE, IN KM, FROM STATION  TO NORTH AND S EDGES OF COMPARTMENT
      DYN=YC+BC5                                                               344
      DYS=YC-BC5                                                               345
      IF (ABS(DYN) .LT. BC10) DYN=0.0                                          346
      IF (ABS(DYS) .LT. BC10) DYS=0.0                                          347
      YN=DYN*DYN                                                               348
      YS=DYS*DYS                                                               349
      DY(1)=DYN                                                                350
      DY(2)=DYN                                                                351
      DY(3)=DYS                                                                352
      DY(4)=DYS                                                                353
      DO 78 JJ=L1,LF                                                           354
      ELEV=E(II,JJ)                                                            355
      IF (ELEV .NE. 0.0) GO TO 38                                              356
      WRITE (6,214) II,JJ,DENTS(IS)                                            357
  214 FORMAT (' WARNING. COMPARTMENT',I3,'S,',I3,'E HAS ZERO ELEVATION.'
     1,' TC NEEDED BUT NOT CALCULATED FOR STATION ',A5)
      GO TO 78                                                                 358
   38 XC=DISWC-FIJ*ACOML                                                       359
      XC2=XC*XC                                                                360
      RC=XC2+YC2                                                               361
C RC5 IS RMIN PLUS 0.5* SLANT LENGTH OF COMPARTMENT
C TEST IF THIS MAP GROUP REQUIRES INNER TIE TO CIRCLE
      IF (KCIRC) 49,51,49                                                      362
   49 IF (RC-RC5) 64,51,51                                                     363
   51 IF (RC-RMIN2) 78,37,37                                                   364
   37 GC=G(ELEV,ELST,RC,RGR2)*ARCSB                                            365
      GB=GB+GC                                                                 366
      GO TO 78                                                                 367
   64 CALL GINNER(XC,YC,AC5,YS,YN,DY,   ELEV,ELST,RC,AREAB,GPA,GB,             368
     1    RGR2,ARCSB,IS,AC10)
   78 FIJ=FIJ+1.0                                                              369
      FJI=FJI+1.0                                                              370
   35 CONTINUE                                                                 371
   39 GRAV(IS,MS)=GRAV(IS,MS)+GB*AREAB                                         372
   40 CONTINUE                                                                 373
  411 CONTINUE                                                                 374
      GRAV(IS,MS)=GRAV(IS,MS)*GP                                               375
C END STATION LOOP
   13 CONTINUE                                                                 376
C END MAP LOOP
   10 CONTINUE                                                                 377
      GO TO 12                                                                 378
   99 WRITE (6,229)KCLAT,LCLON,KBLOK,LBLOK,LATM,LONM,LTDG,LTMG,LNDG,LNMG      379
  229 FORMAT (1X,2I3,3X,2I4,3X,2I4,4X,2I3,I5,I3/, 4X, 'STOP. ABOVE LISTE
     1D COMPARTMENT, BLOCK, MAP SIZES OR NORTHWEST CORNER OF MAP DO NOT
     2PROGRESS BY INTEGER MULTIPLICATION (EXCLUDING 1).')
      STOP                                                                     380
   12 NG=NG-1                                                                  381
C PRINTOUT
      IF(KCIRC    .EQ. 0) GO TO 52                                             382
      WRITE (6,200)RMIN,RMAX,BREA                                              383
```

TABLE 1--CONTINUED

```
  200 FORMAT ('0MAP COVERAGE FOR ',F8.3,' TO ',F8.3,' KILOMETERS ',
     1 '(CIRCULAR INNER JOIN) OF ',6A4)
       GO TO 53                                                          384
   52 WRITE (6,209)RMIN,RMAX,BREA                                        385
  209 FORMAT ('0MAP COVERAGE FOR ',F8.3,' TO ',F8.3,' KILOMETERS ',
     1 '(PIECEMEAL INNER JOIN) OF ',6A4)
   53 IF (KSEC .EQ. 60) GO TO 48                                         386
   47 WRITE (6,204)KCLAT,LCLON,KBLOK,LBLOK                               387
  204 FORMAT (36H SMALLEST COMPARTMENT DIGITIZED ARE ,I2, 4H BY ,I2,
     1 33H AND LARGEST COMPOSITE BLOCKS ARE,I3,3H BY,I3,8H MINUTES)
       GO TO 50                                                          388
   48 WRITE (6,205)KCLAT,LCLON,KBLOK,LBLOK                               389
  205 FORMAT (36H SMALLEST COMPARTMENT DIGITIZED ARE ,I2, 4H BY ,I2,
     1 33H AND LARGEST COMPOSITE BLOCKS ARE,I3,3H BY,I3,8H SECONDS)
   50 WRITE (6,207)LATM,LONM,RMED,RGR                                    390
  207 FORMAT(49H IN LATITUDE AND LONGITUDE. QUADRANGLES USED ARE , I3,
     24H BY , I3,9H MINUTES.,26H  CONVERSION TO BLOCKS AT ,F7.2,4H KM./,
     3  25H CURVATURE CORRECTION AT ,F4.0,' KM.',///)
C BEGIN INDEXING LOOP FOR EACH STATION
       DO 90 IS=1,NS                                                     391
       ST=SLATM(IS)+LTM(IS)                                              392
       SN=SLONM(IS)+LNM(IS)                                              393
       DEGS=ST/60.0                                                      394
       DEGN=SN/60.0                                                      395
       WRITE (6,202)DENTS(IS),DEGS,DEGN                                  396
  202 FORMAT(9H STATION ,A5,' AT',F7.3,1H,,F8.3,' DEGREES')
       WRITE (6,203)                                                     397
  203 FORMAT (6X, 2(3HMAP,9X,'NW CORNER (D,M)',7X,'MGLS',11X))
       A=AS(IS)                                                          398
       B=BS(IS)                                                          399
       CALL DEXQD(IS,LATNW(IS),LONNW(IS),BQD,AQD,LATSE(IS),LONSE(IS),    400
     1 LATSD(IS),LONSD(IS),NQ,      MSS(IS),                  LATM,LONM)
   90 CONTINUE                                                           401
   92 CONTINUE                                                           402
       JN=NTYPE                                                          403
       IF (JN .GT. 10) JN=10                                             404
       WRITE (6,201)                                                     405
  201 FORMAT (////,'0LIST OF RADIAL COVERAGE FOR SUCCESSIVE MAP SETS',//,
     1 '  INNER BOUNDARY IS PIECEMEAL UNLESS CIRCULAR IS INDICATED. ',
     2 'ALL OUTER BOUNDARIES ARE PIECEMEAL')
       DO 6 J=1,JN                                                       406
       IF(LCIRC(J) .EQ. 0) GO TO 7                                       407
       WRITE (6,215)  RIF(J),RIL(J)                                      408
  215 FORMAT (1X,F10.5,' TO ',F10.5,' KM (CIRCULAR INNER JOIN)')
       GO TO 6                                                           409
    7 WRITE (6,216)  RIF(J),RIL(J)                                       410
  216 FORMAT (1X,F10.5,' TO ',F10.5,' KM')
    6 CONTINUE                                                           411
       RETURN                                                            412
       END                                                               413


       SUBROUTINE GINNER(XC,YC,AC5,YS,YN,DY,ELEV,ELST,RC,AREAB,GPA,GB,
     1 RGR2,ARCSB,IS,AC10)                    Circular inner join
       DOUBLE PRECISION DENTS                                             1
```

TABLE 1--CONTINUED

```
      INTEGER*2 NUMS                                                          2
      DIMENSION DX(4),DY(4),R2(4),      GCEN(500),DENTS(500)                  3
      DIMENSION GRAV(500,13),NUMS(500,13),GV(500)                             4
      COMMON /STATN/ DENTS                                                    5
      COMMON RMIN,RMIN2,RMAX2,BL2K,BL2L,BB2B,BA2B,AGM,BGM,ST,SN,              6
     1 A,B,   GCEN,GRAV,GV,NUMS
   64 DXW=XC+AC5                                                              7
      DXE=XC-AC5                                                              8
      IF (ABS(DXW) .LT. AC10) DXW=0.0                                         9
      IF (ABS(DXE) .LT. AC10) DXE=0.0                                        10
      XW=DXW+DXW                                                             11
      XE=DXE+DXE                                                             12
      DX(1)=DXW                                                              13
      DX(2)=DXE                                                              14
      DX(3)=DXE                                                              15
      DX(4)=DXW                                                              16
      R2(1)=XW+YN                                                            17
      R2(2)=XE+YN                                                            18
      R2(3)=XE+YS                                                            19
      R2(4)=XW+YS                                                            20
      BIG=0.0                                                                21
C           NPT-NUMBER OF CORNERS OF COMPARTMENT THAT ARE LOCATED
C OUTSIDE RMIN CIRCLE
      NPT=0                                                                  22
      DO 320 K=1,4                                                           23
      IF (RMIN2 .GE. R2(K)) GO TO 320                                        24
      NPT=NPT+1                                                              25
      IF (BIG   .GE. R2(K)) GO TO 320                                        26
      KBIG=K                                                                 27
      BIG=R2(K)                                                              28
  320 CONTINUE                                                               29
      IF (NPT .EQ. 0) RETURN                                                 30
C ASSIGN COORDINATES (X2,Y2) TO CORNER FARTHEST FROM STATION
      Y2=DY(KBIG)                                                            31
      X2=DX(KBIG)                                                            32
      I1=1                                                                   33
      I2=1                                                                   34
      IF (X2 .LT. 0.0) I1=-1                                                 35
      IF (Y2 .LT. 0.0) I2=-1                                                 36
      KTEST=0                                                                37
      S1=DXW+DXE                                                             38
      IF (S1 .GE. 0.0) GO TO 337                                             39
      S1=DY(1)+DY(4)                                                         40
      IF (S1 .LT. 0.0) KTEST=1                                               41
  337 S1=I1                                                                  42
      S2=I2                                                                  43
C COORDINATES OF CORNER CLOSEST TO STATION (OPPOSITE FARTHEST CORNER)
      KSML=KBIG+2                                                            44
      IF (KSML .GT. 4) KSML=KBIG-2                                           45
      X1=DX(KSML)                                                            46
      Y1=DY(KSML)                                                            47
C CALCULATE ACCORDING TO HOW MANY CORNERS ARE OUTSIDE CIRCLE
      GO TO (322,323,324,325), NPT                                           48
C ONE CORNER OUTSIDE CIRCLE
  322 CALL CENTD(0.0,X2,0.0,Y2,S1, S2,AREA,YM,XM,1)                          49
```

TABLE 1--CONTINUED

```
C ASSUME 0.002-MINUTE LOCATION ACCURACY
      ABAR=ABS(AREA)                                                    50
      IF(ABAR .LT. 1.0E-5) RETURN                                       51
      RBAR2=(YM*YM+XM*XM)/(ABAR*ABAR)                                   52
      IF (RBAR2 .LT. R2(KBIG)) GO TO 406                                53
      RBAR2=R2(KBIG)                                                    54
      H=ELST+SQRT(RBAR2/RC)*(ELEV-ELST)                                 55
      GO TO 405                                                         56
C TWO POINTS OUTSIDE CIRCLE.
C FIND COORDINATES OF SECOND CORNER OUTSIDE CIRCLE-ADJACENT FARTHEST
  323 LBIG=KBIG+1                                                       57
      IF (LBIG .EQ. 5) LBIG=1                                           58
      IF (R2(LBIG) .GT. RMIN2) GO TO 65                                 59
      LBIG=KBIG-1                                                       60
      IF (LBIG .EQ. 0) LBIG=4                                           61
   65 IF (DY(KBIG) .EQ. DY(LBIG)) GO TO 342                             62
C REVERSED ROLES
      IF (Y1) 376,343,377                                               63
  376 LY1=-1                                                            64
      GO TO 367                                                         65
  377 LY1=1                                                             66
  367 L3=I2+LY1                                                         67
      IF (L3 .EQ. 0) GO TO 368                                          68
  343 CALL CENTD(Y1,Y2,0.0,X2,S2, S1,AREA,XM,YM,2)                      69
      GO TO 403                                                         70
  342 IF (X1) 346,344,347                                               71
  346 LX1=-1                                                            72
      GO TO 351                                                         73
  347 LX1=1                                                             74
  351 L4=I1+LX1                                                         75
      IF (L4 .EQ. 0) GO TO 349                                          76
  344 CALL CENTD(X1,X2,0.0,Y2,S1, S2,AREA,YM,XM,2)                      77
      GO TO 403                                                         78
C X1 AND X2 ARE OF OPPOSITE SIGN  (368 FOR OPP. Y1, Y2)
  349 IF (RMIN-ABS(Y2)) 344,344,330                                     79
  368 IF (RMIN-ABS(X2)) 343,343,330                                     80
C 3 CORNERS OUTSIDE CIRCLE
  324 IF (R2(KSML) .EQ. RMIN2) GO TO 37                                 81
      IF (Y1) 51,52,53                                                  82
   51 LY1=-1                                                            83
      GO TO 354                                                         84
   52 LY1= 0                                                            85
      GO TO 354                                                         86
   53 LY1= 1                                                            87
  354 L3=I2+LY1+3                                                       88
      IF (X1) 5,6,7                                                     89
    5 LX1=-1                                                            90
      GO TO 8                                                           91
    6 LX1= 0                                                            92
      GO TO 8                                                           93
    7 LX1= 1                                                            94
    8 L4=I1+LX1+3                                                       95
      GO TO (101,102,103,102,101), L3                                   96
  101 GO TO (355,121,104,121,355), L4                                   97
  355 CALL CENTD(X1,0.0,Y1,0.0,S1,S2,AREA,YM,XM,3)                      98
```

TABLE 1--CONTINUED

```
      GO TO 400                                                          99
  121 CALL CENTD(Y1,0.0,0.0,0.0,S2,S1,AREA,XM,YM,6)                     100
      GO TO 400                                                         101
  122 CALL CENTD(X1,0.0,0.0,0.0,S1,S2,AREA,YM,XM,6)                     102
      GO TO 400                                                         103
  104 IF (ABS(Y2) .GE. RMIN) GO TO 355                                  104
   15 LBIG=KBIG+1                                                       105
      IF (LBIG .EQ. 5) LBIG=1                                           106
      IF (DX(LBIG) .EQ. DX(KBIG)) GO TO 108                             107
      LBIG=KBIG-1                                                       108
      IF (LBIG .EQ. 0) LBIG=4                                           109
  108 CALL CENTD(Y1,Y2,0.0,X2,S2, S1,AREA,XM,YM,2)                      110
      GO TO 114                                                         111
  102 GO TO (122,105,106,105,122), L4                                   112
  105 AREA=0.7853982*RMIN2                                              113
      BIG=RMIN*RMIN2/3.0                                                114
      YM=S1*BIG                                                         115
      XM=S2*BIG                                                         116
      GO TO 400                                                         117
  106 IF (ABS(Y2) .LT. RMIN) GO TO 15                                   118
      GO TO 122                                                         119
  103 GO TO (111,112,113,112,111), L4                                   120
  111 IF (ABS(X2) .LT. RMIN) GO TO 12                                   121
  356 CALL CENTD(Y1,0.0,X1,0.0,S2,S1,AREA,XM,YM,3)                      122
      GO TO 400                                                         123
  112 IF (ABS(X2) .GE. RMIN) GO TO 121                                  124
   12 LBIG=KBIG+1                                                       125
      IF (LBIG .EQ. 5) LBIG=1                                           126
      IF (DY(LBIG) .EQ. DY(KBIG)) GO TO 109                             127
      LBIG=KBIG-1                                                       128
      IF (LBIG .EQ. 0) LBIG=4                                           129
  109 CALL CENTD(X1,X2,0.0,Y2,S1, S2,AREA,YM,XM,2)                      130
  114 LR=10-(KBIG+LBIG+KSML)                                            131
      CALL CENTD (0.0,DX(LR),0.0,DY(LR),0.0,0.0,AREAR,XE,XW,1)          132
      GO TO 115                                                         133
  113 IF (ABS(X2) .LT. RMIN) GO TO 107                                  134
      IF (ABS(Y2) .LT. RMIN) GO TO 15                                   135
      CALL CENTD(X1,X2,Y1,Y2,S1, S2,AREA,YM,XM,5)                       136
      AREAR=AREA                                                        137
      GO TO 115                                                         138
  107 IF (ABS(Y2) .GE. RMIN) GO TO 12                                   139
   14 LBIG=KBIG+1                                                       140
      IF (LBIG .EQ. 5) LBIG=1                                           141
      LR=10-(KBIG+LBIG+KSML)                                            142
      CALL CENTD (0.0,DX(LR),0.0,DY(LR),0.0,0.0,AREAR,XE,XW,1)          143
      GO TO 110                                                         144
  330 AREAR=0.0                                                         145
  110 CALL CENTD (0.0,DX(LBIG),0.0,DY(LBIG),0.0,0.0,AREA,XE,XW,1)       146
      AREAR=AREAR+AREA                                                  147
      CALL CENTD (0.0,X2,0.0,Y2,S1,S2,AREA,YM,XM,1)                     148
  115 AREAR=AREAR+AREA                                                  149
      ABAR=ABS(AREAR)                                                   150
      RBAR2=(XM*XM+YM*YM)/(AREA*AREA)                                   151
      H=ELEV                                                            152
      GO TO 405                                                         153
```

TABLE 1--CONTINUED

```
C 4 CORNERS OUTSIDE CIRCLE
  325 IF (X1) 54,37,55                                                  154
   54 LX1=-1                                                            155
      GO TO 56                                                          156
   55 LX1= 1                                                            157
   56 L3=I1+LX1                                                         158
      IF (L3 .NE. 0) GO TO 366                                          159
  360 IF (Y1) 57,37,58                                                  160
   57 LY1=-1                                                            161
      GO TO 59                                                          162
   58 LY1= 1                                                            163
   59 L4=I2+LY1                                                         164
      IF (L4 .EQ. 0) RETURN                                             165
  378 IF (ABS(Y1) .GE. RMIN) GO TO 37                                   166
  361 CALL CENTD(0.0,0.0,Y1,0.0,0.0,S2,AREA,YM,XM,4)                    167
      GO TO 400                                                         168
  366 IF (Y1) 16,37,17                                                  169
   16 LY1=-1                                                            170
      GO TO 18                                                          171
   17 LY1= 1                                                            172
   18 L4=I2+LY1                                                         173
      IF (L4 .NE. 0) GO TO 37                                           174
C REVERSED ROLES
   19 IF (ABS(X1) .GE. RMIN) GO TO 37                                   175
  373 CALL CENTD(0.0,0.0,X1,0.0,0.0,S1,AREA,XM,YM,4)                    176
C MOMENT OF RECTANGULAR COMPARTMENT.
  400 AREAR=ABS((X2-X1)*(Y2-Y1))                                       177
      AREA =AREAR-AREA                                                  178
C MOMENTS ABOUT Y- AND X-AXES FOR REMAINING AREA
      YM=XC*AREAR-YM                                                    179
      XM=YC*AREAR-XM                                                    180
  403 ABAR=ABS(AREA)                                                    181
      RBAR2=(YM*YM+XM*XM)/(ABAR*ABAR)                                   182
  406 RBAR=SQRT(RBAR2)                                                  183
      H=ELST+RBAR*(ELEV-ELST)/SQRT(RC)                                  184
  405 GC=ABAR*G(H,ELST,RBAR2,RGR2)/AREAB                                185
      BIG=GC*GPA                                                        186
      IF (KTEST .EQ. 1) WRITE (6,200) DENTS(IS),BIG                     187
  200 FORMAT (4X,'STATION ',A5,' IS INSIDE CALCULATED COMPARTMENT. ',
     1 'CORRECTION USED IS',F8.3,' MGAL.')
  404 GCEN(IS)=GCEN(IS)+BIG                                             188
      GB=GB+GC                                                          189
      RETURN                                                            190
   37 GB=GB+ G(ELEV,ELST,RC,RGR2)*ARCSB                                 191
   78 RETURN                                                            192
      END                                                               193


      SUBROUTINE CENTD(X1,X2,Y1,Y2,S1,S2,AREA,YM,XM,M)
      INTEGER*2 NUMS        Called by GINNER--circular inner join        1
      DIMENSION GRAV(500,13),NUMS(500,13),GV(500),GCEN(500)              2
      COMMON R,AA,       RMAX2,BL2K,BL2L,BB2B,BA2B,AQM,BQM,ST,SN,        3
     1 A,B,   GCEN,GRAV,GV,NUMS
C NOTE-COMMON STATEMENT NAMES ARE DIFFERENT THAN OTHER SUBROUTINES
C M-NUMBER OF CORNERS OUTSIDE COMPARTMENT (EXCEPT 5=3). ABSOLUTE VALUES
```

TABLE 1--CONTINUED

```
C GIVE PROTECTION AGAINST SQUARE ROOTS OF NEGATIVE NUMBERS MEANT TO BE 0
      GO TO (12,12,35,4,35,6), M                                          4
   12 AX2=ABS(X2)                                                         5
      AY2=ABS(Y2)                                                         6
      X22=X2*X2                                                           7
      Y22=Y2*Y2                                                           8
      AAX2=ABS(AA-X22)                                                    9
      AAY2=AA-Y22                                                        10
      SAX2=SQRT(AAX2)                                                    11
      IF (M .EQ. 2) GO TO 2                                              12
C 1 CORNER OUTSIDE
    1 AAY2=ABS(AAY2)                                                     13
      SAY2=SQRT(AAY2)                                                    14
C FACTOR TERMS TO MINIMIZE LOSS OF SIGNIFICANT FIGURES
      AREA=AX2*(AY2-0.5*SAX2)-0.5*(AY2*SAY2+AA*(ARSIN(AX2/R)-ARSIN(SAY2/ 15
     1 R)))
      YM=S1*(0.5*AY2*(Y22/3.0-AAX2)+AAX2*SAX2/3.0)                       16
      XM=S2*(0.5*AX2*(X22/3.0-AAY2)+AAY2*SAY2/3.0)                       17
      RETURN                                                             18
C 2 CORNERS OUTSIDE-CONNECTED AREA
    2 SX=S1*X1                                                           19
      X11=X1*X1                                                          20
      AAX1=ABS(AA-X11)                                                   21
      SAX1=SQRT(AAX1)                                                    22
      AREA=AY2*(AX2-SX)-0.5*(AX2*SAX2-SX*SAX1+AA*(ARSIN(AX2/R)           23
     1 -ARSIN(SX/R)))
      YM=S1*(0.5*AY2*(X22-X11)+(AAX2*SAX2-AAX1*SAX1)/3.0)                24
      XM=0.5*S2*(AX2*(X22/3.0-AAY2)-SX*(X11/3.0-AAY2))                   25
      RETURN                                                             26
C 4 CORNERS OUTSIDE-CONNECTED INSIDE AREA USED
    4 AAY1=ABS(AA-Y1*Y1)                                                 27
      SAY1=SQRT(AAY1)                                                    28
      AREA=AA*ARSIN(SAY1/R)-ABS(Y1)*SAY1                                 29
      YM=0.0                                                             30
      XM=0.6666667*S2*AAY1*SAY1                                          31
      RETURN                                                             32
   35 AY1=ABS(Y1)                                                        33
      X11=X1*X1                                                          34
      Y11=Y1*Y1                                                          35
      AAX1=ABS(AA-X11)                                                   36
      AAY1=ABS(AA-Y11)                                                   37
      SAX1=SQRT(AAX1)                                                    38
      SAY1=SQRT(AAY1)                                                    39
      IF (M .EQ. 5) GO TO 5                                              40
C 3 CORNERS OUTSIDE-1 CORNER INSIDE USED
    3 SX=S1*X1                                                           41
      IF (SAY1 .EQ. SX) GO TO 10                                         42
      AREA=SX*(AY1-0.5*SAX1)-0.5*(AY1*SAY1-AA*(ARSIN(SAY1/R)-ARSIN(SX/R) 43
     1 ))
      YM=S1*(AAX1*SAX1/3.0+0.5*AY1*(Y11/3.0-AAX1))                       44
      XM=S2*(AAY1*SAY1/3.0+0.5*SX*(X11/3.0-AAY1))                        45
      RETURN                                                             46
C CASE WHERE A CORNER IS ON CIRCLE AND WHOLE COMPARTMENT IS OUTSIDE
   10 AREA=0.0                                                           47
      YM=0.0                                                             48
```

TABLE 1--CONTINUED

```
      XM=0.0                                                                  49
      RETURN                                                                  50
C 3 CORNERS OUTSIDE-OCCUPIES 3 QUADRANTS (CLOSE-IN)
    5 AX1=ABS(X1)                                                             51
      AX2=ABS(X2)                                                             52
      AY2=ABS(Y2)                                                             53
      X22=X2*X2                                                               54
      Y22=Y2*Y2                                                               55
      AREA=AX2*(AY1+AY2)+AX1*AY2-0.5*(AX1*SAX1+AY1*SAY1                       56
     1 +AA*(1.570796+ARSIN(AX1/R)+ARSIN(AY1/R)))
      YM=S1*(0.5*(AY1*(Y11/3.0-AA+X22)+AY2*(X22-X11))-AAX1*SAX1/3.0)          57
      XM=S2*(0.5*(AX1*(X11/3.0-AA+Y22)+AX2*(Y22-Y11))-AAY1*SAY1/3.0)          58
      RETURN                                                                  59
C 3 CORNERS OUT, Y1=0.0
    6 SX=S1*X1                                                                60
      X11=X1*X1                                                               61
      AAX1=ABS(AA-X11)                                                        62
      SAX1=SQRT(AAX1)                                                         63
      AREA=0.5*(AA*(1.570796-ARSIN(SX/R))-SX*SAX1)                            64
      YM=S1*AAX1*SAX1/3.0                                                     65
      XM=S2*(AA*R/3.0+0.5*SX*(X11/3.0-AA))                                    66
      RETURN                                                                  67
      END                                                                     68


      SUBROUTINE DEXQD(IS,LT,LN,BQD,AQD,LTSE,LNSE,LTS,LNS,NQ,      MS,
     1                          LATM,LONM)
      INTEGER*2 NUMS                                                           1
      DIMENSION IQ(5,7),GCEN(500),GRAV(500,13),GV(500),DENTM(3,13),            2
     1 DENTQ(3,81),NUMS(500,13),          LATQ(81),LONQ(81),
     2 LTDQ(13),LTMQ(13),LNDQ(13),LNMQ(13)
      COMMON /MAP/ DENTQ,LATQ,LONQ                                             3
      COMMON RMIN,RMIN2,RMAX2,BL2K,BL2L,QB2B,QA2B,AQM,BQM,ST,SN,               4
     1 A,B,   GCEN,GRAV,GV,NUMS
C PREPARE LIST OF QUADRANGLES NEEDED  Indexing
      DO 41 K=1,5                                                              5
      DO 41 L=1,7                                                              6
   41 IQ(K,L)=0                                                                7
C NW CORNER OF INDEX MAP IN INDEX UNITS,DEGREES, AND MINUTES.
      QTNW=LT                                                                  8
      QNNW=LN                                                                  9
      QTNW=BQD*QTNW                                                           10
      QNNW=AQD*QNNW                                                           11
      QB=60.*QTNW                                                             12
      QA=60.*QNNW                                                             13
C FIND QUADS NEEDED.  FIRST BY N-S-W-E BOUNDARIES, THEN RADII.
C REFERENCE TO NW CORNER OF QUADS.
      KMAX=LT-LTSE+1                                                          14
      LMAX=LN-LNSE+1                                                          15
      KSM1=LT-LTS                                                             16
      LSM1=LN-LNS                                                             17
      KSP1=KSM1+2                                                             18
      LSP1=LSM1+2                                                             19
      DO 42 K=1,KMAX                                                          20
      DO 42 L=1,LMAX                                                          21
```

TABLE 1--CONTINUED

```
   42 IQ(K,L)=IQ(K,L)+2                                              22
      B2=B+B                                                         23
      A2=A+A                                                         24
C SOUTH CORNERS
      QTS2B=ST+BL2K                                                  25
C EAST CORNERS
      QNS2B=SN+BL2L                                                  26
C NORTH CORNERS
      QTST=ST+QB2B                                                   27
C WEST CORNERS
      QNSN=SN+QA2B                                                   28
C NW CORNER
      IF (KSM1) 152,152,156                                          29
  156 IF (LSM1) 158,158,157                                          30
  157 DO 44 K=1,KSM1                                                 31
      FK=K-1                                                         32
      QT=QB-FK*BQM-QTST                                              33
      DO 44 L=1,LSM1                                                 34
      FL=L-1                                                         35
      QN=QA-FL*AQM-QNSN                                              36
      DISQ2=B2*QT*QT+A2*QN*QN                                        37
      IF (DISQ2-RMAX2) 44,44,43                                      38
   43 IQ(K,L)=IQ(K,L)-2                                              39
   44 CONTINUE                                                       40
C NE CORNER
  158 IF (LMAX-LSP1) 152,151,151                                     41
  151 DO 46 K=1,KSM1                                                 42
      FK=K-1                                                         43
      QT=QB-FK*BQM-QTST                                              44
      DO 46 L=LSP1,LMAX                                              45
      FL=L-1                                                         46
      QN=QA-FL*AQM-QNS2B                                             47
      DISQ2=B2*QT*QT+A2*QN*QN                                        48
      IF (DISQ2-RMAX2) 46,46,45                                      49
   45 IQ(K,L)=IQ(K,L)-2                                              50
   46 CONTINUE                                                       51
C SW CORNER
  152 IF (KMAX-KSP1) 155,153,153                                     52
  153 IF (LSM1) 159,159,160                                          53
  160 DO 48 K=KSP1,KMAX                                              54
      FK=K-1                                                         55
      QT=QB-FK*BQM-QTS2B                                             56
      DO 48 L=1,LSM1                                                 57
      FL=L-1                                                         58
      QN=QA-FL*AQM-QNSN                                              59
      DISQ2=B2*QT*QT+A2*QN*QN                                        60
      IF (DISQ2-RMAX2) 48,48,47                                      61
   47 IQ(K,L)=IQ(K,L)-2                                              62
   48 CONTINUE                                                       63
C SE CORNER
  159 IF (LMAX-LSP1) 155,154,154                                     64
  154 DO 50 K=KSP1,KMAX                                              65
      FK=K-1                                                         66
      QT=QB-FK*BQM-QTS2B                                             67
      DO 50 L=LSP1,LMAX                                              68
```

TABLE 1--CONTINUED

```
      FL=L-1                                                              69
      GN=GA-FL*AGM-GNS2B                                                  70
      DISQ2=B2*QT*QT+A2*QN*QN                                             71
      IF (DISQ2-RMAX2) 50,50,149                                          72
  149 IQ(K,L)=IQ(K,L)-2                                                   73
   50 CONTINUE                                                            74
  155 CONTINUE                                                            75
C QUADS USED
   75 GB=0.                                                               76
      M=0                                                                 77
      IF (MS) 53,53,54                                                    78
   54 DO 132 MQ=1,MS                                                      79
      M  =NUMS(IS,MQ)                                                     80
   66 LTQ=LATQ(M)                                                         81
      LNQ=LONQ(M)                                                         82
      LTB=LATM*LTQ                                                        83
      LNA=LONM*LNQ                                                        84
      LTD=LTB/60                                                          85
      LND=LNA/60                                                          86
      LTDQ(MQ)=LTD                                                        87
      LTMQ(MQ)=LTB-60*LTD                                                 88
      LNDQ(MQ)=LND                                                        89
      LNMQ(MQ)=LNA-60*LND                                                 90
      LTS=LT-LTQ+1                                                        91
      LNS=LN-LNQ+1                                                        92
      IQ(LTS,LNS)=IQ(LTS,LNS)-1                                           93
      DENTM(1,MQ)=DENTQ(1,M)                                              94
      DENTM(2,MQ)=DENTQ(2,M)                                              95
      DENTM(3,MQ)=DENTQ(3,M)                                              96
  132 GB=GB+GRAV(IS,MQ)                                                   97
   68 GV(IS)=GV(IS)+GB                                                    98
      IF (MS-1) 53,134,52                                                 99
   52 MS5=MS/2                                                           100
      MS2=2*MS5                                                          101
      MSM=MS-MS2                                                         102
      DO 93 M=2,MS2,2                                                    103
      M1=M-1                                                             104
   93 WRITE (6,204)(DENTM(ID,M1),ID=1,3), LTDQ(M1),LTMQ(M1),LNDQ(M1),    105
     1 LNMQ(M1),GRAV(IS,M1), (DENTM(ID,M),ID=1,3),LTDQ(M),LTMQ(M),
     2 LNDQ(M),LNMQ(M),GRAV(IS,M)
  204 FORMAT (2X,2(3A4,I6,I3,I8,I3, F11.3,6X))
      IF (MSM) 134,133,134                                               106
  134 WRITE (6,207)(DENTM(ID,MS),ID=1,3),LTDQ(MS),LTMQ(MS),LNDQ(MS),     107
     1 LNMQ(MS),GRAV(IS,MS)
  207 FORMAT (2X,3A4,I6,I3,I8,I3,F11.3)
  133 WRITE (6,205)GB                                                    108
  205 FORMAT (35X,16HTOTAL CORRECTION,F7.3,10H MILLIGALS)
   53 LTB=LT*LATM                                                        109
      LNA=LN*LONM                                                        110
      DO 136 K=1,5                                                       111
      DO 136 L=1,7                                                       112
      IF (IQ(K,L)-2) 136,137,136                                         113
  137 LTMIN=LTB-LATM*(K-1)                                               114
      LNMIN=LNA-LONM*(L-1)                                               115
      LTDEG=LTMIN/60                                                     116
```

TABLE 1--CONTINUED

```
      LNDEG=LNMIN/60                                                    117
      LTMIN=LTMIN-60*LTDEG                                              118
      LNMIN=LNMIN-60*LNDEG                                              119
  138 WRITE (6,209)LTDEG,LTMIN,LNDEG,LNMIN                              120
  209 FORMAT (14H      NOT FOUND,I6,I3,I8,I3)
  136 CONTINUE                                                          121
      RETURN                                                            122
      END                                                               123


      FUNCTION G(H,E,R2,RGR2)
C DETERMINE TERRAIN CORRECTION FOR COMPARTMENT.   H,E- ELEVATION OF
C COMPARTMENT AND STATION IN KM.    R2- SQUARE OF DISTANCE IN KM.  RGR2-
C TEST RADIUS FOR USE OF CURVATURE CORRECTION.
      RP2=1.0/R2                                                         1
      RP=SQRT(RP2)                                                       2
      HKM=E-H                                                            3
      HE2=HKM*HKM                                                        4
      HR2=HE2*RP2                                                        5
      IF (H) 14,25,1                                                     6
    1 IF (RGR2-R2) 2,2,5                                                 7
C CURVATURE ACCOUNTED FOR.  MODIFIED LINE ELEMENT FORMULA.
    2 EARTH=6371.2                                                       8
      C2=R2/EARTH                                                        9
      G=0.5*HKM*RP*RP2                                                  10
      FG=HKM+C2                                                         11
      IF (HR2-0.013) 4,4,3                                              12
    3 FG=FG-0.75*HKM*HR2                                                13
    4 G=G*FG                                                            14
      RETURN                                                            15
C NO CURVATURE, LINE ELEMENT FORMULA.
    5 IF (HR2-0.47) 7,6,6                                               16
    6 G=RP*(1.0-1.0/SQRT(1.0+HR2))                                      17
      RETURN                                                            18
    7 G=0.5*RP*HR2                                                      19
      IF (HR2-0.013) 13,13,8                                            20
    8 FG=1.0-0.75*HR2                                                   21
      IF (HR2-0.12) 12,12,9                                             22
    9 HR4=HR2*HR2                                                       23
      FG=FG+0.625*HR4                                                   24
      IF (HR2-0.26) 12,12,10                                            25
   10 FG=FG-0.546875*HR2*HR4                                            26
      IF (HR2-0.37) 12,12,11                                            27
   11 FG=FG+0.4921875*HR4*HR4                                           28
   12 G=G*FG                                                            29
   13 RETURN                                                            30
C SEAWATER COMPARTMENTS (NEGATIVE ELEVATIONS)
   14 E2=E+E                                                            31
      IF (RGR2-R2) 15,15,18                                             32
C WITH CURVATURE
   15 EARTH=6371.2                                                      33
      C=0.5*R2/EARTH                                                    34
      C2=C+C                                                            35
      CE=C+E                                                            36
      CEH=C+HKM                                                         37
```

TABLE 1--CONTINUED

```
      CE2=CE*CE                                                          38
      CEH2=CEH*CEH                                                       39
      C4=C2*C2                                                           40
      CE4=CE2*CE2                                                        41
      CEH4=CEH2*CEH2                                                     42
      RP4=RP2*RP2                                                        43
      FG=-C2+0.3846*CE2+0.6154*CEH2                                      44
     1 -0.75*RP2*(-C4+0.3846*CE4+0.6154*CEH4)+0.625*RP4*(-C2*C4
     2 +0.3846*CE2*CE4+0.6154*CEH2*CEH4)
   17 G=0.5*RP*RP2*FG                                                    45
      RETURN                                                             46
C NO CURVATURE
   18 IF (HR2-0.42) 20,20,19                                             47
   19 G=RP*(1.0-0.3846/SQRT(1.0+E2/R2)-0.6154/SQRT(1.0+HE2/R2))          48
      RETURN                                                             49
   20 FG=0.3846*E2+0.6154*HE2                                            50
      IF (HR2-0.02) 24,24,21                                             51
   21 E4=E2*E2                                                           52
      HE4=HE2*HE2                                                        53
      FG=FG-0.75*RP2*(0.3846*E4+0.6154*HE4)                              54
      IF (HR2-0.16) 24,24,22                                             55
   22 RP4=RP2*RP2                                                        56
      FG=FG+0.625*RP4*(0.3846*E2*E4+0.6154*HE2*HE4)                      57
      IF (HR2-0.30) 24,24,23                                             58
   23 FG=FG-0.546875*RP2*RP4*(0.3846*E4*E4+0.6154*HE4*HE4)               59
   24 G=0.5*RP*RP2*FG                                                    60
   25 RETURN                                                             61
      END                                                                62
```

Table 2. List of punchcards for test case (See Table 3 for printout).

```
SAN JUAN MTS., COLORADO -2 0 3  2.5
SJM
 B21737164710752 67 65570                14      7928477
 185737550810650451 37180               1188UD5347884138                    KXFIS
99999999999999999999999999999999999999999999999999999999999999999999999999999999
  5  53030 60 60 4.1        0.8949  4.0     15.0             160            5 MIN
SJM VIIB7     37 20 107 50    Hanover F/G           SJ 30 SECOND
   8040   8350   8340   8310   8200   8080   7950   7780   7700   7540   VIIB7 01
   7700   7800   7800   7780   7750   7650   7600   7400   7340   7600   VIIB7 02
   7080   7310   7300   7360   7420   7380   7340   7300   7650   8050   VIIB7 03
   6920   7380   7290   7400   7460   7260   7230   7560   7680   7800   VIIB7 04
   7320   7640   7430   7280   7240   7250   7480   7640   7880   7880   VIIB7 05
   7480   7470   7490   7300   7100   7260   7680   7750   7700   7570   VIIB7 06
   7600   7680   7450   7260   7080   7260   7360   7400   7410   7320   VIIB7 07
   7500   7440   7250   7200   7140   7040   7120   7250   7220   7190   VIIB7 08
   7320   7160   7160   7180   7140   7080   7000   7070   7030   7060   VIIB7 09
   7130   7000   7030   7130   7070   7060   7010   6950   6970   7000   VIIB7 10
SJM VIIB8     37 20 107 55                          SJ 30 SECOND
   7500   7150   7000   6960   7250   7700   7520   6650   6550   6690   VIIB8 01
   7460   7320   6980   7070   7600   7840   7900   7020   6550   6570   VIIB8 02
   7380   7240   7040   6950   7360   7520   7260   6600   6560   6580   VIIB8 03
   7440   7140   6150   6880   6850   6720   6550   6540   6550   6740   VIIB8 04
   7480   7300   7120   6780   6620   6550   6600   6680   6880   6970   VIIB8 05
   7610   7110   6980   6740   6600   6540   6750   6860   6950   7320   VIIB8 06
   7270   6900   6850   6690   6570   6740   6860   6940   7260   7340   VIIB8 07
   6800   6720   6660   6550   6530   6640   6960   7040   7160   7620   VIIB8 08
   7360   7520   7320   7160   6480   6710   6900   6940   7320   7490   VIIB8 09
   7440   7300   7080   6940   6580   6640   6880   7080   7280   7250   VIIB8 10
SJM VIIC2     37 15 107 55                          SJ 30 SECOND
   7190   7050   6950   6840   6600   6480   6780   6980   7040   7000   VIIC2 01
   6880   6970   7160   7090   6760   6480   6650   6800   6870   6920   VIIC2 02
   6780   6900   7220   7400   7200   6750   6370   6760   6810   6720   VIIC2 03
   6750   6750   6850   6840   6880   6840   6480   6470   6660   6800   VIIC2 04
   7260   7280   7240   6860   6680   6720   6680   6410   6550   6750   VIIC2 05
   7160   7290   6920   6660   6580   6690   6530   6430   6370   6710   VIIC2 06
   6950   6900   6760   6600   6480   6430   6330   6360   6660   6670   VIIC2 07
   6720   6650   6650   6540   6320   6310   6460   6640   6640   6680   VIIC2 08
   6700   6640   6540   6380   6320   6460   6610   6610   6620   6700   VIIC2 09
   6540   6560   6500   6340   6320   6450   6590   6590   6620   6780   VIIC2 10
TRIAL MAP     37 15 107 55                          SJ 30 SECOND
                            } 10 blank cards (duplicate map location)
99999999999999999999999999999999999999999999999999999999999999999999999999999999
 15 15 1 1   3  3 21.     4.1     14.       14.                  0 1        15 MIN
IGNACIO 3     37 15 108 00                          SAN JUAN MTS
   7410   7300   7270   7160   7170   7020   7010   6580   6800   6960IGNACIO3 1
   6840   6970   7020   6960   6850   7280   7160   7030   6930   6840IGNACIO3 2
   6800   7080   6920   6520   6750   6830   6900   6950   6920   6820IGNACIO3 3
   7310   7400   7670   7560   7410   7250   6920   6670   6510   6600IGNACIO3 4
   6860   6870   6880   6870   6820   7770   7620   7400   7230   6970IGNACIO3 5
   6800   6640   6380   6450   6660   6830   6830   6820   6820   6750IGNACIO3 6
   7940   7410   7110   6920   6730   6610   6440   6390   6600   6680IGNACIO3 7
   6790   6780   6760   6770   6700   8020   7420   7160   6920   6770IGNACIO3 8
   6650   6370   6260   6550   6720   6730   6730   6680   6700   6580IGNACIO3 9
   7750   7080   6750   6660   6580   6460   6250   6250   6520   6670IGNACIO310
   6580   6550   6530   6480   6540   7180   7300   6780   6630   6470IGNACIO311
   6340   6180   6280   6480   6370   6430   6530   6460   6530   6580IGNACIO312
   6860   7460   7250   6560   6410   6310   6140   6250   6410   6400IGNACIO313
```

Table 2.--Continued

```
   6650   6720   6670   6640   6660   6680   7340   6920   6690   6620IGNACIO314
   6310   6270   6160   6320   6290   6570   6640   6700   6800   6860IGNACIO315
   6540   6760   7280   6790   6660   6640   6260   6120   6270   6520IGNACIO316
   6550   6690   6980   7320   7370   6480   6660   7180   6760   6540IGNACIO317
   6370   6290   6050   6380   6570   6680   6960   7330   7270   7220IGNACIO318
   6420   6620   7120   6730   6480   6500   6300   6130   6560   6560IGNACIO319
   6850   6690   7100   7200   7070   6460   6640   6560   6550   6470IGNACIO320
   6630   6570   6140   6660   6530   6540   6650   7030   7140   7150IGNACIO321
   6560   6600   6600   6500   6330   6400   6660   6150   6410   6460IGNACIO322
   6680   6800   6950   6990   6900                                    IGNACIO323
DURANGO      37 30 108 00                        SAN JUAN MTS
   9480   8880   8930   8860   8830   8150   7950   8330   9190   9500DURANGO  1
   8700   7470   7400   8000   9050   9520   9420   9450   9000   8690DURANGO  2
   8500   8230   7750   8340   9000   8470   7300   7200   7800   8800DURANGO  3
  10820  10150   9590   9320   9040   9100   8900   8140   7630   8630DURANGO  4
   8640   7300   6870   7760   8720  10550   9820  10120  10320   9630DURANGO  5
   9130   8680   8340   7600   7990   8350   7010   6750   7600   8720DURANGO  6
   9990   9200   9900  10200  10040   9200   8560   8300   7660   7050DURANGO  7
   6980   6650   7040   8170   8930  10300   9260   9050   9300   9740DURANGO  8
   9550   9180   8400   7550   6680   6600   6860   7920   8750   9100DURANGO  9
  10490   9840   8880   8580   9460   9300   8990   8120   7250   6600DURANGO 10
   6840   7800   8480   8830   9250   9100   9200   8980   8200   8760DURANGO 11
   9350   8930   7900   7000   6600   7790   8400   9100   9340   9240DURANGO 12
   8600   8640   8830   8460   7960   8450   8650   8000   6850   6800DURANGO 13
   8100   8860   9460   9240   8800   8350   7950   7920   7730   7560DURANGO 14
   7600   7800   7540   6790   6880   8430   8970   8700   8660   8300DURANGO 15
   7650   7560   7640   7460   7630   7360   7000   7600   7270   6600DURANGO 16
   7970   8060   7900   7700   7520   7900   7420   7900   7380   8100DURANGO 17
   7300   6760   7110   6740   6600   7170   7340   7400   7360   7800DURANGO 18
   7960   7780   7460   7240   7670   7400   6900   6580   6700   7000DURANGO 19
   7480   7370   7200   7640   7760   7610   7400   7300   7310   7000DURANGO 20
   6900   6700   6620   6950   7350   7550   7290   7100   7280   7280DURANGO 21
   7500   7350   7400   7500   7220   7400   7100   6600   6950   7330DURANGO 22
   7150   7100   7100   7000   7000                                    DURANGO 23
99999999999999999999999999999999999999999999999999999999999999999999999999999999
 60120 3 3 12 12 166.7      21.     60.      14.                0 1          1-2 DEG
DURANGO   AMS 38     108
   8900   9400  10320  11360  12200  11280  10760  11370  12210  12140 38108  1
  11770  12480  11580  11080  10070  11440  10670  11710  12030  11480 38108  2
  11980  12390  12140  11990  10950  10670  10070  10650  11010  10430 38108  3
  10580   9940   9800  10070   8790   8170   7690   7590   7590   7570 38108  4
   9300   9010   9440  10000  11120  12280  11020  12260  11960  12480 38108  5
  11870  11870  10940  10070  11440  11490  10840  11900  12070  11620 38108  6
  11580  11470  12060  12070  11630  11150  10810  11760  11640  11120 38108  7
  10000   9420   9460   9310   8480   7890   7640   7580   7580   7560 38108  8
  11160  10030   9920  11490  12470  11480  11440  12210  11030  12450 38108  9
  12160  11880  11810  12160  11260  10810  10390  10990  11890  11170 38108 10
  10380  10170  11040  11050  11550  11640  11750  11740  10930  10680 38108 11
  10090   9510   9070   8820   8230   7780   7630   7600   7600   7560 38108 12
  11670  10950  10400  11920  11460  10680  10300  10910  11340  12400 38108 13
  12090  12470  11810  11440  10770  10760  10170   9900  11260  10840 38108 14
   9080   8880   9030   9410  10830  11010  11580  10780  10280   9780 38108 15
   9960   9400   8740   8350   7910   7730   7650   7620   7600   7580 38108 16
  10210  10540  11890  12070  11580  11740  10660  12200  12170  12040 38108 17
  11360  11910  10720  11130  10580  10210   9620   9240   9790   9850 38108 18
   9940  10290  10180   9170   9790  10710  10680  10720   9290   8680 38108 19
   9310   8740   8450   8160   7850   7720   7670   7650   7610   7600 38108 20
  10880  11190  11440  11100  11170  10790  10610  11070  11950  12240 38108 21
  11700  11570  11100  10640  10210  10190  10660  10730   9490   8920 38108 22
  10180  10990  10380   9200  10270   9030   9420   9410   9340   8400 38108 23
```

Table 2--Continued

8340	8200	8140	7920	7780	7740	7690	7660	7630	7600	38108	24
10920	10030	10980	10110	9990	11240	10200	11650	12410	11720	38108	25
11990	11480	12180	11030	11460	11320	11530	11640	10380	9640	38108	26
10680	11320	10150	10330	10990	9680	8720	8470	8490	8280	38108	27
8100	8020	8010	7870	7770	7750	7700	7660	7630	7600	38108	28
10110	9370	9990	9700	8970	10000	10060	12040	12470	10940	38108	29
12180	11800	11540	10820	11670	11630	11620	11090	10840	10770	38108	30
11460	11340	10800	11230	10650	9440	8860	9950	10050	9640	38108	31
8870	8380	8420	8360	7980	7750	7690	7660	7630	7600	38108	32
9460	9290	10100	9170	8760	11070	11920	12020	11920	10410	38108	33
11900	11170	10570	10600	9990	11040	10050	10980	11420	11480	38108	34
11920	11380	11640	10900	10020	9470	9650	10310	11280	10350	38108	35
9260	9490	9170	8600	8160	7850	7680	7640	7620	7600	38108	36
9430	8700	9380	8860	8440	10270	11040	11200	11450	9980	38108	37
11270	10090	10840	10770	8770	8760	9690	10210	11090	11650	38108	38
10970	10700	11520	10650	10020	10650	10060	10540	11310	10010	38108	39
10180	10890	10100	9030	8380	7980	7730	7630	7610	7600	38108	40
9580	8830	8270	8330	7960	10300	9680	11240	9640	9280	38108	41
9740	9980	10590	9500	9030	8260	8330	8800	10530	11480	38108	42
11050	9580	10370	10870	10510	10570	10580	11240	11510	11230	38108	43
11230	11910	10860	9710	9110	8400	7790	7650	7620	7600	38108	44
9800	9680	8250	7130	8110	9840	8960	9530	8800	8160	38108	45
9220	10040	9550	9200	8630	8140	7920	8670	10300	10040	38108	46
9600	9040	8840	9340	9260	10260	11310	11580	11450	10880	38108	47
10170	11120	10320	9690	9920	8820	7870	7720	7640	7600	38108	48
9170	8720	7960	7530	9080	8930	8450	8520	8020	8800	38108	49
9500	9200	8450	8280	8430	8500	8080	8280	8740	8400	38108	50
8380	8180	8500	8980	10170	10570	11850	11190	10730	10780	38108	51
11090	9970	9730	9410	8680	8410	8000	7840	7710	7620	38108	52
7810	7570	7180	7560	7930	7880	7990	7580	7950	8010	38108	53
8400	9320	8730	8100	9150	8850	8030	7890	7900	7620	38108	54
7690	7850	9230	10310	10940	11180	11520	11320	10740	10630	38108	55
10310	11260	10100	9860	8780	8390	8080	7910	7750	7630	38108	56
7530	7290	6790	7290	7260	7340	7540	7270	7290	7310	38108	57
7690	8090	8000	7940	8990	7850	7900	7670	7590	7340	38108	58
7310	7760	8420	9570	10170	9910	11680	11080	11870	11440	38108	59
10210	10760	9900	9730	8820	8340	7980	7880	7750	7640	38108	60
7310	7130	6780	6840	6880	6940	7060	6950	6930	7180	38108	61
8040	7650	7280	7090	7260	7090	7200	7490	7490	7220	38108	62
7340	7780	8000	8650	8460	9600	10980	11390	11120	10510	38108	63
9780	10200	9750	9690	9210	8600	8230	8120	7900	7680	38108	64
7540	6840	6450	6750	6720	6680	6710	6740	6760	7200	38108	65
8190	7700	6890	6680	6900	7400	7300	7870	7480	7240	38108	66
7440	7500	7930	8430	9490	10300	9510	11000	11770	11160	38108	67
10700	9900	10150	9760	9360	8770	8740	8250	7960	7760	38108	68
7140	6500	6300	6600	6610	6680	6590	6560	6610	7040	38108	69
8020	7290	6470	7130	7460	7830	7090	7280	7300	6950	38108	70
7280	7670	7840	8890	9930	9840	8730	11310	11100	11380	38108	71
11130	9810	9440	9630	9500	9180	8900	8370	8010	7860	38108	72
6890	6610	6220	6610	7140	7130	6680	6430	6460	6610	38108	73
7110	6720	7080	7470	7340	6880	6820	7000	6900	6980	38108	74
7540	7600	7790	7950	8600	8970	8820	10800	10150	10490	38108	75
11010	10670	10470	9710	9290	8660	9010	8410	8010	7910	38108	76
6620	6510	6450	6660	7110	6970	6920	6450	6390	6370	38108	77
6240	6190	6370	6570	6690	6600	6680	6720	7380	7830	38108	78
8380	7450	7780	7600	7750	8060	8970	10080	9420	9920	38108	79
10290	10000	10230	10150	9870	9100	8540	8400	8170	7960	38108	80
9999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999											

Table 3. Example of printout from terrain correction program HD400.

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 TERRAIN CORRECTION PROGRAM D. Plouff  9-1972

SUMMARY OF PRELIMINARY VALUES FOR SAN JUAN MTS., COLORADO  TERRAIN CORRECTION
WILL BE MADE FOR  3 SETS OF MAPS

 STA  LATITUDE LONGITUDE  ELEV    OBS GRAV  THEO GRAV  FREE AIR  HAMD TER
 8217 37 16.47 107 52.67  6557.  979284.77  979940.81    -39.55      0.14
 1857 37 55.08 106 50.45 13718.  978841.38  979996.90    133.57     11.88
                        ← page skipped
SJM VIID7     37 20 107 50
SJM VIID8     37 20 107 55
   STATION  8217 IS INSIDE CALCULATED COMPARTMENT. CORRECTION USED IS    0.000 MGAL.
SJM VIIC2     37 15 107 55
TRIAL MAP     37 15 107 55
THIS MAP WAS SKIPPED. IT ALREADY HAS BEEN USED.

MAP COVERAGE FOR    0.895 TO    4.100 KILOMETERS (CIRCULAR INNER JOIN) OF SAN JUAN MTS., COLORADO
SMALLEST COMPARTMENT DIGITIZED ARE 30 BY 30 AND LARGEST COMPOSITE BLOCKS ARE 60 BY 60 SECONDS
IN LATITUDE AND LONGITUDE. QUADRANGLES USED ARE   5 BY   5 MINUTES.  CONVERSION TO BLOCKS AT    4.00 KM.
CURVATURE CORRECTION AT  15. KM.

STATION  8217 AT 37.274, 107.878 DEGREES
     MAP          NW CORNER (D,M)       MGLS          MAP          NW CORNER (D,M)       MGLS
 SJM VIID8        37 20      107 55      0.478       SJM VIIC2       37 15      107 55      0.010
                                  TOTAL CORRECTION  0.488 MILLIGALS
STATION  1857 AT 37.918, 106.841 DEGREES
     MAP          NW CORNER (D,M)       MGLS          MAP          NW CORNER (D,M)       MGLS
    NOT FOUND     38  0      106 55
    NOT FOUND     38  0      106 50
    NOT FOUND     37 55      106 55
    NOT FOUND     37 55      106 50
                        ← page skipped
IGNACIO 3     37 15 108  0
DURANGO       37 30 108  0

MAP COVERAGE FOR    4.100 TO   21.000 KILOMETERS (PIECEMEAL INNER JOIN) OF SAN JUAN MTS., COLORADO
SMALLEST COMPARTMENT DIGITIZED ARE  1 BY  1 AND LARGEST COMPOSITE BLOCKS ARE  3 BY  3 MINUTES
IN LATITUDE AND LONGITUDE. QUADRANGLES USED ARE  15 BY  15 MINUTES.  CONVERSION TO BLOCKS AT   14.00 KM.
CURVATURE CORRECTION AT  14. KM.

STATION  8217 AT 37.274, 107.878 DEGREES
     MAP          NW CORNER (D,M)       MGLS          MAP          NW CORNER (D,M)       MGLS
 IGNACIO 3        37 15      108  0      0.060       DURANGO         37 30      108  0      0.693
                                  TOTAL CORRECTION  0.753 MILLIGALS
    NOT FOUND     37 30      108 15
    NOT FOUND     37 30      107 45
    NOT FOUND     37 15      108 15
    NOT FOUND     37 15      107 45
STATION  1857 AT 37.918, 106.841 DEGREES
     MAP          NW CORNER (D,M)       MGLS          MAP          NW CORNER (D,M)       MGLS
    NOT FOUND     38 15      107 15
    NOT FOUND     38 15      107  0
    NOT FOUND     38 15      106 45
    NOT FOUND     38  0      107 15
    NOT FOUND     38  0      107  0
    NOT FOUND     38  0      106 45
```

Table 3--continued

```
DURANGO  AMS 38  0 108  0

MAP COVERAGE FOR   21.000 TO  166.700 KILOMETERS (PIECEMEAL INNER JOIN) OF SAN JUAN MTS., COLORADO
SMALLEST COMPARTMENT DIGITIZED ARE  3 BY  3 AND LARGEST COMPOSITE BLOCKS ARE 12 BY 12 MINUTES
IN LATITUDE AND LONGITUDE. QUADRANGLES USED ARE  60 BY 120 MINUTES.  CONVERSION TO BLOCKS AT   60.00 KM.
CURVATURE CORRECTION AT  14. KM.


STATION  8217 AT 37.274, 107.875 DEGREES
      MAP          NW CORNER (D,M)        MGLS          MAP          NW CORNER (D,M)        MGLS
 DURANGO  AMS     38  0     108  0        0.371
                                    TOTAL CORRECTION  0.371 MILLIGALS
     NOT FOUND    39  0     110  0
     NOT FOUND    39  0     108  0
     NOT FOUND    38  0     110  0
     NOT FOUND    37  0     110  0
     NOT FOUND    37  0     108  0
     NOT FOUND    36  0     110  0
     NOT FOUND    36  0     108  0
STATION  1857 AT 37.918, 106.841 DEGREES
      MAP          NW CORNER (D,M)        MGLS          MAP          NW CORNER (D,M)        MGLS
 DURANGO  AMS     38  0     108  0        2.183
                                    TOTAL CORRECTION  2.183 MILLIGALS
     NOT FOUND    40  0     108  0
     NOT FOUND    40  0     106  0
     NOT FOUND    39  0     110  0
     NOT FOUND    39  0     108  0
     NOT FOUND    39  0     106  0
     NOT FOUND    38  0     110  0
     NOT FOUND    38  0     106  0
     NOT FOUND    37  0     110  0
     NOT FOUND    37  0     108  0
     NOT FOUND    37  0     106  0


LIST OF RADIAL COVERAGE FOR SUCCESSIVE MAP SETS
 INNER BOUNDARY IS PIECEMEAL UNLESS CIRCULAR IS INDICATED. ALL OUTER BOUNDARIES ARE PIECEMEAL
   0.89490 TO   4.10000 KM (CIRCULAR INNER JOIN)
   4.10000 TO  21.00000 KM
  21.00000 TO 166.70000 KM
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 SUMMARY FOR    2 STATIONS IN SAN JUAN MTS., COLORADO
 COMPUTER TERRAIN CORRECTIONS CARRIED FROM     CIRCULAR INNER RADIUS OF     0.895
 TO 166.700 KILOMETERS.  DENSITIES ARE 2.67 AND  2.58   DENSITY OF 2.67 IS USED FOR
 VALUES IN COLUMNS LABELLED CC, TC, TER, (MEAN), AND TOT. TC-HAND CORRECTION
 TER-TOTAL COMPUTED CORRECTION, (MEAN)-PART OF TOTAL THAT REPRESENTS CONTRIBUTION
  OF COMPARTMENTS THAT INTERSECT INNER CIRCULAR RADIUS. TOT-HAND PLUS COMPUTER TERRAIN.

 STATION LATITUDE LONGITUDE   ELEV    OBS GRAV    F.A.     S.B.1   S.B.2   CC    TC    TER (MEAN)  TOT     C.B.1   C.B.2  ACC   STA
SJM 8217 37 16.47 107 52.67  6357.0 979284.77   -39.55  -263.18  -248.96 1.52  8.14  1.61  0.02  1.75 -262.95 -248.72        8217
SJM 1857 37 55.08 106 50.45 13718.0 978841.38   133.57  -334.31  -304.52-0.85 11.88  2.18  0.00 14.06 -328.19 -291.38 0534  1857
```