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PROGRAM PDP004: CONTUR

by

M. M. Donzeau, L. D. North, M. E. Gettings

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Program Documentation Manual

Program Number	:	PDP004
Program Name	:	CONTUR
Programmer	:	M. M. Donzeau
Language	:	FORTRAN IV PLUS
Computer/System	:	PDP-11/45
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ABSTRACT

The CONTUR program was modified from a program initially designed by CALCOMP to generate contour maps from any data set for any CALCOMP digital plotting systems.

A contour map can be drawn from data entered as an array of Z-values, corresponding to regularly spaced data in X and Y. Also a grid can be created from irregularly spaced data points, and then the contour map can be drawn.

The grid is calculated by using a least-square bivariate polynomial determined from a few neighbors for each grid mesh point, or determined as a trend surface from all the data points.

The program has been updated in several steps by the U.S. Geological Survey (USGS) and the Bureau de Recherche Geologique et Mineries (BRGM) programmers, so that the size of the program was greatly reduced, a few more input parameters were added, and a few errors occurring during the plot was suppressed.

It is advised to read the CALCOMP Manual (Calcomp, 1973) to fully understand how CONTUR works, and the documentation of the program CTRL2D which was designed by USGS programmers to prepare the input files for CONTUR.

SOURCE DECK LOCATION AND UPDATE STATUS

The FORTRAN source program is scattered into eight overlays: CONT00.FTN, CONT10.FTN, CONT20.FTN, CONT30.FTN, CONT40.FTN, CONT50.FTN, CONT60.FTN, CONT70.FTN. These overlays and the task image CONTUR.TSK are on the system disk of the DGMR PDP-11/45 computer under the UIC of [22,50].

This report recapitulates all the updates which have been made to the program.

DESCRIPTION OF COMPUTED QUANTITIES

The computed quantities are the same as in the original program designed by CALCOMP (1974).

DESCRIPTION OF THE PROGRAM

Main modifications

The following is a list of the main modifications from the CALCOMP version.

1) The size of the grid to be plotted is increased from 2000 to 2500 points.

2) If the size of the grid to be plotted is bigger than 2500, use the program CTRL2D before running CONTUR. It will divide the map in several parts and calculate the new parameters of the control cards. Thus, there is no limit to the size of the grid, except the time used for running CONTUR, considering that a crash may occur during a long run when using the DGMR PDP-11/45 computer.

3) The size of the grid to be calculated is increased from 2000 to about 32000 x 32000, with a number of input data points limited to about 32000. If the grid is bigger than 2500, it will be calculated but not plotted. If a plot is desired, see section 2.

4) To calculate the grid, the search for neighbors can be made either in a square of variable size (CALCOMP version), or in a circle of constant radius.

5) The program does not plot areas with blank values.

6) For the plot, the program takes care of the multi-crosses in the same sub-cell of the same track, thus avoiding track looping.

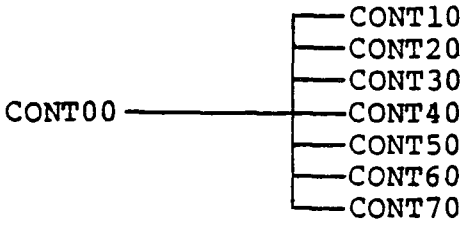
7) The contour levels can be equidistant (CALCOMP version), or chosen level by level. In the latter case, the number of levels is limited to 200, and the labels written on the curves may be different from the values of the contour levels.

8) The number of overlays is reduced from 19 to 7.

9) The scratch files are opened and closed in the overlays where they are needed, thus reducing the number of files open at the same time. There is now a maximum of five (no gridding) or six (gridding) files open simultaneously, instead of eight (CALCOMP version).

Overlays

The overlay structure is as follows:



The following is a brief description of the routines.

CONT00: Main program

CONT10: Initialization and termination routines
- INITA: initialize parameters and plot
- FINI: terminate CONTUR program activity

CONT20: Routines for reading and decoding control cards
- CONTL: read control cards
- CRDS1: decode LEVL, POST, RDGD, TREN control cards, and read Z-values of pre-gridded data
- CRDS2: decode MESH, NAOR, NDEC, PNCH, PRNT, REGN, TICK, TITL control cards
- DRWCD: decode DRAW control card

CONT30: Routines for reading (X, Y, Z) input data points and sorting them into segments
- GRDCD: decode GRID control card
- GTPTS: read and print (X, Y, Z) input data values, find min/max of X, Y, Z values
- SEGS1: prepare scratch file to store (X, Y, Z) input data points into segments
- SEGS2: separate (X, Y, Z) input data points into segments, sort, and store into scratch file
- SRTPT: sort (X, Y, Z) values with increasing X-value

CONT40: Routines for calculating the grid
- GRID: main routine to calculate the grid
- EVAL: calculate least-square polynomial and Z-value for one grid intersection
- GRDST: calculate X, Y range of neighborhood
- GTSEG: locate segment of (X, Y, Z) input data points corresponding to point to calculate
- INVRT: invert matrix of coefficients of least-square polynomial

NABOR: find neighbors surrounding point to calculate
NORMS: calculate coefficients of least-square polynomial
RANGE: find range of (X, Y, Z) values of neighbors
VALUE: calculate Z-value from least-square polynomial coefficients
WATES: calculate weight for each neighbor
XTRMS: find min/max of (X, Y, Z) values of neighbors

CONT50: Routines for calculating the grid for a trend surface
TREND: main routine to calculate the grid
EVALT: calculate least-square polymonial and Z-value for all grid intersections
GRDS2: initialization for calculation of the trend surface
INVR2: invert matrix of coefficients of least-square polymonial
NORM2: calculate coefficients of least-square polynomial
RANG2: find range of (X, Y, Z) values of all input data points
VALU2: calculate Z-value from least-square polynomial coefficients

CONT60: Routines for plotting Z-values, print and/or punch grid values
SETUP: plot map title and boundaries, read Z-values of the grid
PNCHR: punch Z-values of the grid
PRNTR: print Z-values of the grid
SET2: plot Z-values of (X, Y, Z) input data points, plot Z-values at each grid intersection
TICKS: plot a tick mark at each grid intersection

CONT70: Routines for plotting the contour lines
DRAW: main routine to plot the contour lines
AJOIN: find sub-cell next to origin of track, to prepare for second part of track
CLNUM: select label of the contour level and calculate the number of characters of label
CSUB: find if sub-cell has already been crossed by current contour level, and check for blank values in current grid cell

GRCK:	determine if contour level crosses any border of current grid cell
GTINT:	find coordinates of the point where track goes through sub-cell
LABEL:	plot label on track
SLOPE:	calculate angle parameters for labeling
MATGT:	get 4 x 4 matrix of grid values surrounding current grid cell
FLAG3:	calculate missing value for edge of map
CBLANK:	check for blank values in first/last row/column of 4 x 4 matrix, and replace by the mean of surrounding Z-values.
SERCH:	find cross-over of track on grid cell borders
SUBGD:	divide grid cell into sub-grid, and calculate Z-values of sub-grid using third order Lagrangian interpolation technique
FLAGR:	interpolate using Lagrangian floating three point technique
TRAK:	draw contour line through current sub-cell, find next sub-cell

Table 1 indicates the relations between all the routines of the program CONTUR, by specifying the calls needed by each routine.

Table 1.-- *Calls needed by each routine.*

Overlay	Routine	Calls	Called by
CONT00	MAIN	CONTL, DRAW, FINI, GRDCD, GRID, INITA, SETUP, SET2, TREND	
CONT10	INITA	(XYLIBF4P)	MAIN
	FINI	(XYLIBF4P)	MAIN
CONT20	CONTL	CRDS1, CRDS2, DRWCD	MAIN
	CRDS1		CONTL
	CRDS2		CONTL
	DRWCD	(XYLIBF4P)	CONTL
CONT30	GRDCD	GTPTS, SEGS1, SEGS2	MAIN
	GTPTS		GRDCD
	SEGS1		GRDCD, SEGS2
	SEGS2	SEGS1, SRTPT	GRDCD
	SRTPT		SEGS2
CONT40	GRID	EVAL, GRDST, GTSEG, NABOR, WATES, XTRMS	MAIN
	EVAL	INVERT, NABOR, NORMS, RANGE, VALUE, WATES	GRID
	GRDST		GRID
	GTSEG		GRID
	INVRT		EVAL
	NABOR		GRID, EVAL
	NORMS		EVAL
	RANGE		EVAL
	VALUE		EVAL
	WATES		GRID, EVAL
	XTRMS		GRID
CONT50	TREND	EVALT, GRDS2, RANG2	MAIN
	EVALT	INVR2, NORM2, VALU2	TREND
	GRDS2		TREND
	INVR2		EVALT
	NORM2		EVALT
	RANG2		TREND
	VALU2		EVALT
CONT60	SETUP	PNCHR, PRNTR, (XYLIBF4P)	MAIN
	PNCHR		SETUP
	PRNTR		SETUP
	SET2	TICKS, (XYLIBF4P)	MAIN
	TICKS	(XYLIBF4P)	SET2
CONT70	DRAW	AJOIN, CLNUM, CSUB, GRCK, GTINT, LABEL, MATGT, SERCH, SUBGD, TRAK, (XYLIBF4P)	MAIN
	AJOIN	CSUB	DRAW
	CLNUM		DRAW
	CSUB		DRAW, AJOIN, SERCH, TRAK
	GRCK		DRAW
	GTINT		DRAW
	LABEL	SLOPE, (XYLIBF4P)	DRAW
	SLOPE		LABEL
	MATGT	CBLANK, FLAG3	DRAW
	CBLANK		MATGT
	FLAG3		MATGT
	SERCH	CSUB	DRAW
	SUBGD	FLAGR	DRAW
	FLAGR		SUBGD
	TRAK	CSUB, (XYLIBF4P)	DRAW

Modifications routine by routine

1) Main program (CONT00)
The main program contains the calls of the main routines only.

2) INITA (CONT10)
Initialization of the constants is contained in DATA statements. The scratch files FOR001.DAT and FOR002.DAT are opened to be created, then closed. The control data file CONTUR.CTR is opened to read the names of the input data file, the printer file, the output grid file, the plotter file, and the general title. The input data file is opened; the printer file is opened; the output grid file is opened to be created, then closed; and the plotter file is initialized. The general title is plotted.

3) FINI (CONT10)
The pen is moved outside the previous map and the plotter file is closed. The control data file and the input data file are closed. The scratch files FOR001.DAT and FOR002.DAT are opened, then closed and deleted. The output grid file is opened, then closed if there are data in it, or closed and deleted if there are no data. The printer file is closed.

4) CONTL (CONT20)
No change.

5) CRDS1 (CONT20)
The scratch file FOR001.DAT is opened to store Z values of pre-gridded data, then closed. The equidistant or non-equidistant levels are read in.

6) CRDS2 (CONT20)
No change.

7) DRWCD (CONT20)
The second DRAW card, containing the parameters ZBLANK, XORIG, YORIG, is read in. The pen is moved from the last origin to the new origin.

8) GRDCD (CONT30)
The scratch file FOR002.DAT is opened to store (X, Y, Z) input data points, then closed.

9) GTPTS (CONT30)
No change.

10) SEGS1 (CONT30)
No change.

11) SEGS2 (CONT30)
If the number of points per segment is greater than 500, the number of segments is increased and the search is started again. The scratch file FOR004.DAT is opened to store the points by segment, then closed. The points are sorted with increasing X before being stored on file. The structure of the scratch file is as follows:
- record number 1: number of points in segment 1, location of first point of segment 1
- record number 2: number of points in segment 2, location of first point of segment 2

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- record number NSEGS: number of points in segment NSEGS, location of first point of segment NSEGS
- record number NSEGS+1: (X, Y, Z) coordinates of first point of segment 1
- record number NSEGS+2: (X, Y, Z) coordinates of second point of segment 1

and so forth.

12) SRTPT (CONT30)
This is a new routine from J.-P. Veyrier of BRGM.

13) GRID (CONT40)
The scratch file FOR001.DAT is opened to store the calculated grid, then closed. The scratch file FOR004.DAT is opened to read the segments, then closed and deleted. This routine prints the number of calculated points, the mean of the number of input points necessary for interpolation, the number of calculated points equal to the input data points, and the number of undefined points.

14) EVAL (CONT40)
The arrays RVEC, WD, XD, YD, ZD are reduced from 687 to 500. This was possible with an EQUIVALENCE statement with array Z, which is not used in this overlay.

15) GRDST (CONT40)
There are a few minor changes due to the new parameter RADIUS, which is the radius of the circle of neighborhood.

16) GTSEG (CONT40)
In the CALCOMP version, this routine was reading all the points of the segment around the point to calculate XG, YG. Now it reads the number of points and the location in the scratch file of the first point of the segment around XG, YG.

17) INVERT (CONT40)
No change.

18) NABOR (CONT40)
There are a few changes due to the new parameter RADIUS. In the case of the search for neighbors in a circle, if the number of neighbors is insufficient, the Z-value of the calculated point is set to the blank value of -1.E35. In the CALCOMP version, the search started from the first point of the segment; now the search starts from the first good point found by the previous search.

19) NORMS (CONT40)
No change.

20) RANGE (CONT40)
No change.

21) VALUE (CONT40)
No change.

22) WATES (CONT40)
No change.

23) XTRMS (CONT40)
No change.

24) TREND (CONT50)
The scratch file FOR001.DAT is opened to store the calculated grid, then closed. The scratch file FOR002.DAT is opened to read (X, Y, Z) input data points, then closed.

25) EVALT (CONT50)
The parameter EPS used in INVR2 is changed from 0.00001 to 0.0001.

26) GRDS2 (CONT50)
No change.

27) INVR2 (CONT50)
No change.

28) NORM2 (CONT50)
No change.

29) RANG2 (CONT50)
No change.

30) VALU2 (CONT50)
No change.

31) SETUP (CONT60)
The title is plotted with letters big enough to fill the width of the map, with a maximum character height of 0.4 inches. This routine can either plot the boundaries of the map, or put a '+' at each corner of the map, and(or) put a '+' at each internal corner in the case of a multipart map. The scratch file FOR001.DAT is opened to read Z-values, then closed. If the grid is too big it will not be plotted.

32) PNCHR (CONT60)
The output grid file is opened so that the Z-values are appended to the end, then the file is closed.

33) PRNTR (CONT60)
The Z-values are printed on the printer file, except when the Z-value is equal to the blank value of -1.E35.

34) SET2 (CONT60)
If plotting of the Z-values of the input data points was requested, the scratch file FOR002.DAT is opened to read and plot these Z-values, then closed. The new limits for multipart maps are calculated.

35) TICKS (CONT60)
The tick marks are plotted, taking into account the new limits for multipart maps.

36) DRAW (CONT70)
This routine takes care of equidistant or non-equidistant contour levels. The percentage of cells crossed by each contour level is given. There is no plot in a cell where one or more of the four points has a blank value. This routine keeps reference of the sub-cells where multicrosses of the same contour level occur; there is a maximum of ten such sub-cells. If the current track is looping inside a sub-cell, an error message is produced and the plot continues with the next track. When the plot is complete, the pen goes back to the local origin (down-left corner of the map).

37) AJOIN (CONT70)
This routine checks if there is a blank value in the chosen grid cell, and if the chosen sub-cell has already been crossed.

38) CLNUM (CONT70)
The number of statements was reduced by a factor of five by introducing an ENCODE statement.

39) CSUB (CONT70)
This is a new routine which checks if a sub-cell has already been crossed. If this is the case, it checks in the table to determine if it is a multicross sub-cell. The second option is used to find if there is a blank value in one of the four points of the grid cell.

40) GRCK (CONT70)
The grid cell is discarded if there is one blank value among the four points. The range of Z-value for the search of crossing of the track in the grid cell is reduced.

41) GTINT (CONT70)
No change.

42) LABEL (CONT70)
No change.

43) SLOPE (CONT70)
No change.

44) MATGT (CONT70)
There is a check for blank value in the 4 x 4 matrix surrounding the current grid cell.

45) FLAG3 (CONT70)
This routine takes account of the blank values to calculate the missing row/column at the edge of the map.

46) CBLANK (CONT70)
This is a new routine which checks for blank value in the 4 x 4 matrix surrounding the current grid cell. If a blank value is found, it is replaced by the mean of the Z-values of the two or three nearest points.

47) SERCH (CONT70)
This routine checks if the sub-cell has already been crossed.

48) SUBGD (CONT70)
No change.

49) FLAGR (CONT70)
No change.

50) TRAK (CONT70)
This routine checks for multicrosses in the same sub-cell and keeps references of them in a table. When the plot in the sub-cell is complete, the routine calculates the adjacent sub-cell, and for each case it checks if the new sub-cell is at cell edge or map edge. If it is at cell edge, it checks for blank value in the next grid cell.

Files used in the program

The nine files used in the program CONTUR are described in table 2. Table 3 indicates the opening and closing of files in each overlay.

Input cards

There are two kinds of input cards: control data cards, which are in the control data file, and input data cards (or records), which are in the input data file.

Table 4 indicates in which routines the control data cards are read in and decoded. The input data records are read in CRDS1 for pre-gridded data, and in GTPTS for ungridded data.

Size of the program

The source program is scattered into eight overlays: CONT00.FTN, CONT10.FTN, CONT20.FTN, CONT30.FTN, CONT40.FTN, CONT50.FTN, CONT60.FTN, and CONT70.FTN. It requires 247 blocks of disk space in the PDP-11/45 computer, and the task image CONTUR.TSK requires 208 blocks.

Table 2.--*Files used in the program CONTUR*

Logical unit number	Variable used as logical unit number	Name of file	Description
1	IGDFL	DB1:FOR001.DAT	scratch file, containing Z-input or calculated grid
2	IPTFL	DB1:FOR002.DAT	scratch file, containing X, Y, Z input data points.
3	JPTFL		plotter file
4	KSEGS	DB1:FOR004.DAT	scratch file, containing X, Y, Z points by segments
5	ICARD	DB0:CONTUR.CTR	control data file
6	JPNTR		printer file
7	JPNCH		output grid file
8	IUNIT		input data file
9	ITERM	TI:	terminal file

Table 3.--*Opening and closing of the files of the program CONTUR*

Logical unit number	CONT00	CONT10		CONT20	CONT30	CONT40	CONT50	CONT60	CONT70
		INITA	FINI						
1		O-C	O-D	O-C		O-C	O-C	O-C	
2		O-C	O-D		O-C		O-C	O-C	
3		O	C	X	X	X	X	X	X
4					O-C	O-D			
5		O	C	X	X	X	X	X	X
6		O	C	X	X	X	X	X	X
7		O-C	O-E					O-C	
8		O	C	X	X	X	X	X	X
9				O-C			O-C		O-C

O - open
C - close
D - close and delete
E - close and delete if empty
X - opened

Table 4.--*Reading and decoding of control data cards*

Card name	Read in routine	Decoded in routine
DRAW	CONTL, DRWCD	DRWCD
FMT	CONTL (card, format)	
GRID	CONTL	GRDCD, GTPTS
LEVL	CONTL, CRDS1	CRDS1
MESH	CONTL	CRDS2
NAOR	CONTL	CRDS2
NDEC	CONTL	CRDS2
PNCH	CONTL	CRDS2
POST	CONTL	CRDS1
PRNT	CONTL	CRDS2
RDGD	CONTL	CRDS1
REGN	CONTL	CRDS2
STOP	CONTL	
TICK	CONTL	CRDS2
TITL	CONTL (card), CRDS2 (title)	
TREN	CONTL	CRDS1

PROGRAM OPERATION

Input files

Two input files are necessary to run the program: the control data file and the input data file.

Control data file

The control data file must be named CONTUR.CTR. It may have been created by the program CTRL2D, or by using the EDI utility program.

The structure of the control data file is shown in figure 1. The first five cards of the file are as follows:

1) input data filename (80 characters)
2) printer filename (80 characters)
3) output grid filename (80 characters)
4) plotter filename (80 characters)
5) general title: a 40-character title which will be plotted at 90° direction, before all other plots

Note that the last character of a filename must be a null character. It is automatically inserted when using the program CTRL2D. Note that only the first 32 characters of a filename are used by the computer.

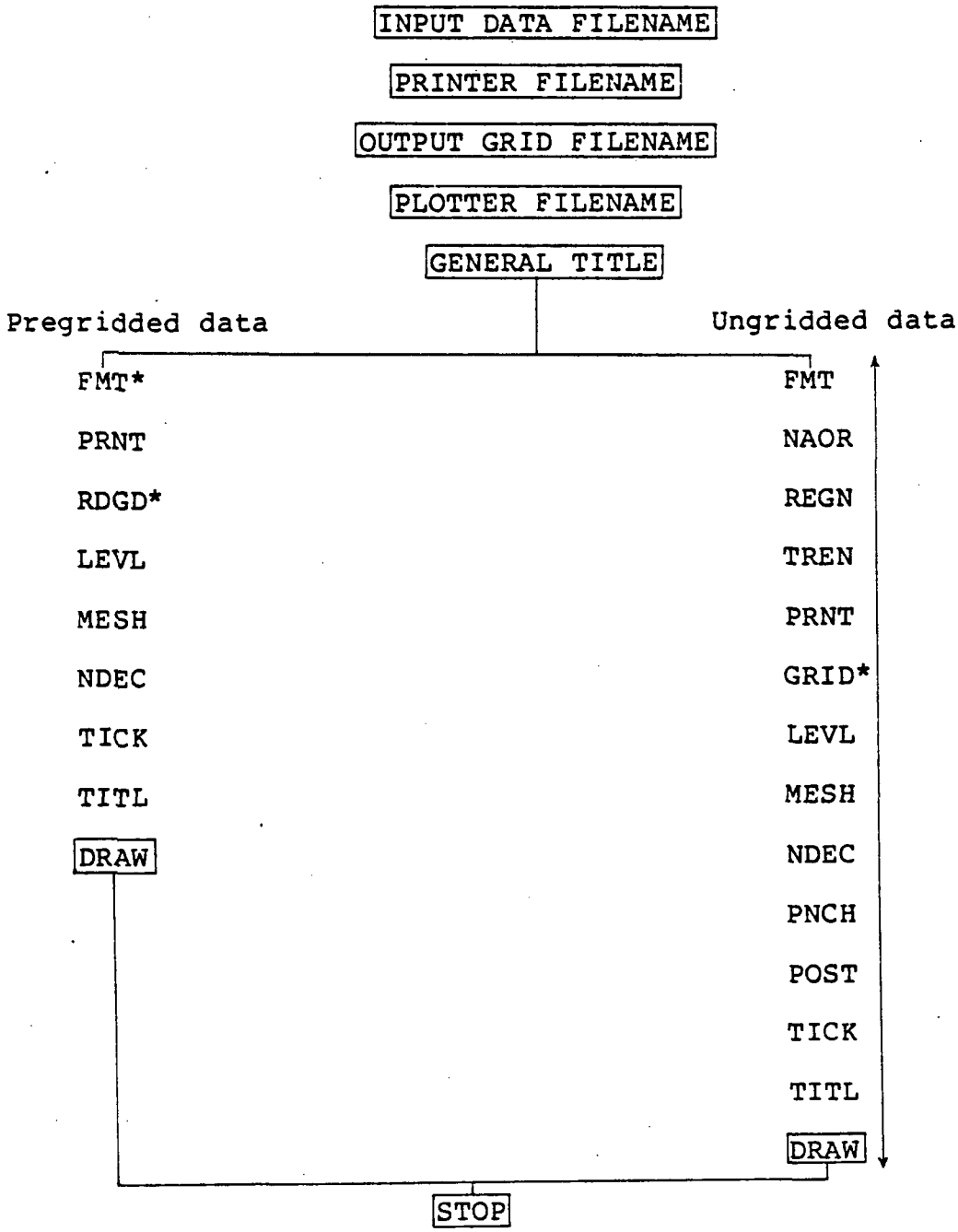
The following are descriptions of the other control cards. Most of them are identical to those described in the CALCOMP's CONTOUR Applications Software Manual (1974).

DRAW Card

It is made up of two cards and initiates the drawing of a map.

First DRAW Card

Columns	Parameter	
1-5	TYPE	DRAW1
6-10		blank
11-20	FMAPX	width of map to be drawn, in inches (default = 10)
21-30	FMAPY	height of map to be drawn, in inches (default = 10)



* This card must be present in the first control card set.

Figure 1. Structure of the control data file. Use as many control card sets of either type as the number of desired maps, boxed cards are essential.

Columns	Parameter	
31-40	SN	number of divisions in the X direction that each grid cell is to be divided into (default = 4, max = 10)
41-50	SM	number of divisions, in the Y direction, that each grid cell is to be divided into (default = 4, max = 10)
51-60	IBXOPT	boundary parameter = 0, draw box boundary = 1, put a '+' at each external corner, no boundary drawn = 2, draw box boundary, and put a '+' at each internal corner = 3, put a '+' at each internal and external corner, no boundary drawn (default = 0)

Second DRAW Card

1-5	TYPE	DRAW2
6-10		blank
11-20		ZBLANK Z-value given to blank areas (where there will be no contours). If there is no blank area, ZBLANK should be a Z-value different from all those of the data set. ZBLANK should be equal to -1.E35 for ungridded data. (default = 0)
21-30	XORIG	X-coordinate of down-left corner of boundary of map, in inches. (default = 0)
31-40	YORIG	Y-coordinate of down-left corner of boundary of map, in inches. (default = 0)

Note: an external corner is one of the corners of the area defined by the parameters FMAPX, FMAPY. An internal corner is inside this area, at a distance of one row and column from the corresponding external corner. It is used in the case of multipart maps (see the documentation of program CTRL2D for this kind of map).

FMT Card

It is made up of one card containing the TYPE parameter, and one card containing the format. It describes the format used to read the input data file. It remains in effect until changed by another FMT card.

First FMT Card

Columns	Parameter	
1-4	TYPE	FMT

Second FMT Card

1-80	FRMT	execution time format statement that describes data to be read in - for pre-gridded data, the FMT card must be supplied, at least for the first map. The format should uniquely describe one row or column of the grid - for ungridded data, the format should uniquely describe one data point by its alphanumeric field and its three coordinates. default = previous format, or (A4, 6X, 3F10.0)

GRID Card

This card initiates the creation of a grid and specifies if ungridded data points are to be read in or not. NX, NY remain in effect until changed. IXPOS, IYPOS, IZPOS remain in effect for only this GRID card.

1-4	TYPE	GRID
5-10		blank
11-20	NPT	number of data points used for gridding - if NPT is a positive number, the program tries to read that number of records on the input data file. The last record of the data set may be followed, if desired, by a record containing the word 'END' in the alphanumeric field with the format used to read the data. If less than NPT records are found, the number of data records will be kept as the NPT value

Columns	Parameter	
		- if NPT is a zero, the program will count the number of data records preceding the word 'END' in the alphanumeric field, or preceding the end of input data file - if NPT is a negative number, the program uses the NPT records of the previous data set. If there are no such records, the program prints an error message and stops. (default = 0, max = about 32000)
21-30	NX	number of grid divisions in the X-direction that the map is to be divided into. Note that the number of columns of the grid is NX+1. If NX$\leq$ 0, the NX value that was used for the previous grid is used. (default = 20)
31-40	NY	number of grid divisions in the Y-direction that the map is to be divided into. Note that the number of rows of the grid is NY+1. If NY$\leq$ 0, the NY value that was used for the previous grid is used. (default = 20)
41-50	IXPOS	relative position of X-coordinate in the data records
51-60	IYPOS	relative position of Y-coordinate in the data records
61-70	IZPOS	relative position of Z-coordinate in the data records. (if IXPOS< = 0, default values for IXPOS, IYPOS, IZPOS, are 1, 2, 3)

LEVL Card

This card defines the Z-values to be contoured. If the contour levels are defined one by one, there must be as many LEVL cards as the number of Z-values to be contoured. This card remains in effect for only one DRAW card. If this card is omitted for a data set, the program will attempt to calculate SLVL, DLVL, ELVL to give 10 satisfactory constant contour intervals (11 levels).

Columns	Parameter	
1-4	TYPE	LEVL
5-10		blank
11-20	SLVL	- lower Z-value on which contouring is to begin, if contour interval is constant - Z-value to be contoured, if contour levels are defined one by one. (no default)
21-30	DLVL	- contour interval (>0), if contour interval is constant - $\leq$ 0 if contour levels are defined one by one. (default = 0)
31-40	ELVL	- last (upper) contour level to be contoured, if contour interval is constant - label to be plotted on contour level defined by SLVL, if contour levels are defined one by one (= 0, if same value as SLVL) Note: to plot the label "0" on a contour level, ELVL must be a nonzero value such that it will be plotted as a zero value, taking into account the parameter NDEC of MESH or NDEC card (ELVL = 0.01 will be plotted as "0." if NDEC = 0, or as "0.0" if NDEC = 1). (default = 0)

MESH Card

The presence of this card instructs the program to make a tick mark at each grid intersection and to plot the Z-value at that location. HEIGT remains in effect for only one DRAW card, but NDEC remains in effect until changed by another MESH card or by a NDEC card.

1-4	TYPE	MESH
5-10		blank
11-20	HEIGT	height of numbers to be plotted showing the Z-value at each grid intersection. (default = 0.07 inches)

Columns	Parameters	
21-30	NDEC	number of digits to follow decimal point for numbers to be plotted at each grid intersection, for annotating individual contour lines, and for posting the values of (X, Y, Z) input data points. (default = 0)

NAOR Card

This card indicates how to determine the least-square polynomial used to calculate the grid. It remains in effect until changed by another NAOR card.

1-4	TYPE	NAOR
5-10		blank
11-20	NABRS	minimum number of (X, Y, Z) input data points used in the determination of each individual grid mesh point. default = the exact number of normal equations required for the order of the polynomial used to approximate the surface = (IORD**2+3*IORD+2)/2 (recommended = 12) If a trend surface is being generated, the program uses all the input data points in the determination of the equation describing the surface
21-30	IORD	order of bivariate polynomial used to approximate the surface when determining a grid mesh point. If the matrix of normal equations is nearly singular when a trend surface is being generated, the program reduces the order by one and tries again. (default = 1, max = 4)
31-40	RADIUS	radius of circle of neighborhood surrounding each individual grid mesh point. Each mesh point is determined by all (X, Y, Z) input data points which are inside the circle. If there are not enough data points inside the circle, the grid mesh

Columns	Parameter	
		point will have the value Z = -1.E35. If = 0, the program uses the number of input data points defined by NABRS. (default = 0)

NDEC Card

This card is necessary if a MESH card is not present and it is desired to assign NDEC a nonzero value for contour line annotation, and, if a POST card is present, for posting the values of the (X, Y, Z) input data points. NDEC remains in effect until changed by another NDEC card or by a MESH card.

1-4	TYPE	NDEC
5-10		blank
11-20	NDEC	number of digits to follow decimal points for annotating individual contour lines, and for posting the values of (X, Y, Z) input data points. (default = 0)

PNCH Card

The presence of this card instructs the program to punch out, on the output grid file (disk or magnetic tape), the array that has been created by the grid routine. The grid is punched by rows from left to right, five values per record in format 5E14.6. Columns 71-74 of each record contain the row number, and columns 75-80 a record sequence number. It remains in effect for only one DRAW card.

1-4	TYPE	PNCH

POST Card

The presence of this card instructs the program to plot the locations and values of the (X, Y, Z) input data points. It remains in effect for only one DRAW card.

1-4	TYPE	POST
5-10		blank

Columns	Parameter	
11-20	PSTHT	height of numbers to be plotted showing the Z-values of the (X, Y, Z) input data points, and height of the corresponding tick marks. (default = 0.07 inches)
21-30	NVALU	indicates if Z-values of the (X, Y, Z) input data points are to be plotted. = 0, plot tick marks only = 1, plot tick marks and Z-values (default = 0)

PRNT Card

The presence of this card instructs the program to print the Z-value array that is to be drawn, and optionally print the (X, Y, Z) input data points. It remains in effect for only one DRAW card.

1-4	TYPE	PRNT
5-10		blank
11-20	NPRNT	indicates if (X, Y, Z) input data points are to be printed. = 0, no print = 1, print (default = 0)

RDGD Card

This card instructs the program that a pre-gridded Z-value array is to be read in and gives the dimensions of the array. The Z-values read in remain in effect until changed by another RDGD card.

1-4	TYPE	RDGD
5-10		blank
11-20	NNX	number of columns in the data array to be read in. (no default)
21-30	NNY	number of rows in the data array to be read in. (no default)

Columns	Parameters	
31-40	MANNR	flag to indicate how data is to be read in. = 1, read data in by columns, top to bottom. = 2, read data in by rows, left to right. (default = 2) Note: first row read in is along top of map, first column is at left edge.

REGN Card

This card describes the (X, Y) limits of the grid that is to be produced. If this card is omitted, the limits used are those found by examining the data points. It remains in effect for only one GRID card.

1-4	TYPE	REGN
5-10		blank
11-20	XMPMN	minimum X-value of the grid to be produced, in data units. (no default)
21-30	XMPMX	maximum X-value of the grid to be produced, in data units. (no default)
31-40	YMPMN	minimum Y-value of the grid to be produced, in data units. (no default)
41-50	YMPMX	maximum Y-value of the grid to be produced, in data units. (no default)

STOP Card

This card terminates CONTUR program activity.

1-4	TYPE	STOP

TICK Card

The presence of this card instructs the program to make a tick mark at each grid intersection, even though it does not plot the grid mesh values. It remains in effect for only one DRAW card.

Columns	Parameter	
1-4	TYPE	TICK

TITL Card

This card is made up of one card containing the TYPE parameter and one card containing the title. The title is drawn just below the map in letters whose height is such that the title will fill the width of the map, without exceeding a height of 0.4 inches. It remains in effect until changed by another TITL card.

First TITL Card

1-4	TYPE	TITL

Second TITL Card

1-80	TITL	up to 80 characters of the desired title for the map.

TREN Card

The presence of this card tells the program that the grid to be produced should be a trend surface. It remains in effect for only one GRID card.

1-4	TYPE	TREN

Input data file

This file contains two kinds of data records.

1) The first type of record contains the (X, Y, Z) input data points from which a grid will be created. The first field of the record is an alphanumeric field; the word 'END' in this field tells the program that the last input point for the current data set was reached. The location of the (X, Y, Z) and alphanumeric fields is specified by the FMT control card. The order in which the (X, Y, Z) fields appear in the record is specified on the GRID control card.
2) The second type of record contains the Z-values of a rectangular array of pre-gridded data. The FMT and RDGD control cards control the reading of this kind of data.

Error messages

The error messages appear on the printer file. Some of them appear on the terminal as well, so that the user can abort the program if desired.

1) *** BAD OR MISPLACED CARD ***

Routine:	CONTL (CONT20)
Explanation:	the card was read, but did not contain correct information in the first four columns, or the card was not located correctly
Program action:	stop
User action:	correct the control card

2) *** NO MORE CONTROL CARDS FOLLOWING A 'LEVL' CARD ***

Routine:	CRDS1 (CONT20)
Explanation:	in case of contour levels entered one by one, the program finds no control card following such a LEVL card
Program action:	stop
User action:	add the next control cards in the control data file

3) *** NX OR NY BAD ***

Routine:	CRDS1 (CONT20)
Explanation:	parameter NX or NY of RDGD card is negative or null, or the grid is too big (over 2500)
Program action:	stop
User action:	correct RDGD card, or run CTRL2D to divide map in several parts

4) *** BAD REGION CARD ***

Routine:	CRDS2 (CONT20)
Explanation:	the maximum and minimum X or Y values in a REGN card are in disorder
Program action:	stop
User action:	reorder the parameters of REGN card

5) *** IORD OUT OF RANGE.REDUCED TO FIRST ORDER ***

Routine:	CRDS2 (CONT20)
Explanation:	parameter IORD of NAOR card is outside the range 1-4
Program action:	continue with IORD = 1
User action:	none
Note:	this message appears on the terminal, as well as on the printer file

6) *** SHOULD BE THE SECOND 'DRAW' CARD ***

Routine:	DRWCD (CONT20)
Explanation:	there is only one DRAW card instead of two
Program action:	stop
User action:	add the second DRAW card

7) *** END OF CONTROL FILE INSTEAD OF SECOND 'DRAW' CARD ***

Routine:	DRWCD (CONT20)
Explanation:	there is only one DRAW card instead of two, and there is no STOP card
Program action:	stop
User action:	add the second DRAW card and the STOP card

8) *** NOT ENOUGH INFO TO DRAW MAP ***

Routine:	DRWCD (CONT20)
Explanation:	a DRAW card has been encountered before a grid has been made available to the program
Program action:	stop
User action:	insert a RDGD or GRID card before the DRAW card

9) *** PLOT WILL BE IMPOSSIBLE: NX OR NY TOO BIG ***

Routine:	GRDCD (CONT30)
Explanation:	the grid to be calculated is too big to be plotted
Program action:	calculates the grid, eventually punches the grid, then prints error message number 15
User action:	none

10) *** NOT ENOUGH DATA TO GRID ***

Routine:	GRDCD (CONT30)
Explanation:	1) the program was told to produce a grid from points that were already either in core or on the program's point scratch file, but there are no such points, or 2) there are not enough points for the size of the neighborhood that has been requested or required by the order of the polynomial
Program action:	stop
User action:	modify the input data file, or the NAOR card in the control data file

11) *** IMPOSSIBLE TO GET SEGMENTS ***

Routine:	SEGS2 (CONT30)
Explanation:	(X, Y, Z) input points cannot be divided into segments, because the density of points is too big. It gives more than 500 points by segment
Program action:	stop
User action:	see programmer to modify the calculation of the number of segments in routine SEGS1 (CONT30)

12) *** ARRAY TOO LARGE FOR SRTPT ***

Routine:	SRTPT (CONT30)
Explanation:	the number of points to sort in one segment exceeds the limit fixed in SRTPT (10,000 points)
Program action:	stop
User action:	see programmer
Note:	this error should never occur, as the number of points per segment is fixed to 500 in routine SEGS2 (CONT30)

13) *** NORMAL EQUATIONS UNSTABLE AT ORDER XXXXX. REDUCED BY 1 ***

Routine:	TREND (CONT50)
Explanation:	the matrix of normal equations for a trend surface could not be inverted

Program action: if the order of polynomial is between 2 and 4, the program reduces the order by 1 and tries again to calculate the trend surface. If not, it prints error message number 14
User action: none
Note: this message appears on the terminal, as well as on the printer file

14) *** ABNORMAL TERMINATION.IORD OUT OF RANGE ***

Routine: TREND (CONT50)
Explanation: the matrix of normal equations for a trend surface could not be inverted for an order equal to 1
Program action: stop
User action: none

15) *** IMPOSSIBLE TO PLOT: ARRAY IS TOO BIG ***

Routine: SETUP (CONT60)
Explanation: the grid which was calculated is bigger than 2500, the maximum size for the plot
Program action: read next control card
User action: if the plot is desired with posting of (X, Y, Z) input data points, run CTRL2D before running CONTUR. If the plot is desired without posting the input data points, run CTRL2D with the grid created by this current run of CONTUR; then run CONTUR with the new control and input data files

16) *** ERROR NO. XXXXX FOR CONTOUR LEVEL XXXXX, followed by the description of grid cell and sub-cell.

Routine: DRAW (CONT70)
Explanation: the current track is stuck in a sub-cell
Program action: start the next track
User action: see programmer
Note: this message appears on the terminal, as well as on the printer file

17) *** MORE THAN XXXXX GRID CELLS USED FOR CONTOUR LEVEL XXXXX ***

Routine:	CSUB (CONT70)
Explanation:	there are too many grid cells used for one contour level
Program action:	start the next contour level
User action:	run CTRL2D with a lower maximum size of Z-value array; it will divide the map in several parts. Then run CONTUR with the new control and input data files
Note:	this message appears on the terminal, as well as on the printer file

18) *** ARRAY FOR MULTI-CROSSING IS TOO SMALL ***

Routine:	TRAK (CONT70)
Explanation:	there are too many grid cells which contain a multi-cross of the same contour level
Program action:	stop
User action:	see programmer to increase the size of array IDOUBL in overlay CONT70

After the program has stopped because of an error during the run, look at the printer file to find the error message, then delete the following files if they exist:

- DB1:FOR001.DAT
- DB1:FOR002.DAT
- DB1:FOR004.DAT
- plotter file
- printer file
- output grid file

If the program has been aborted during a run, the above files should be deleted, and the following files unlocked:

- CONTUR.CTR (control data file)
- input data file.

Errors in the plot

1) Unfinished contour levels.
The program prints error meassage number 17 for this type of error. If the user action advised for such an error is not desired, the arrays IJX, KLIN, KLOUT in overlay CONT70 may be increased but in such a way that the overlay is not too big.

2) Loop on a track.
This is usually due to error number 18. It could also be due to error number 16, but this kind of error has not occurred until now.

3) Very close contours at border of map.
These occur near the blank areas and seem to be due to the manner of interpolating values in the 4 x 4 matrix surrounding one grid cell, when one or more of the values of the extreme row or column are blank values. The routine CBLANK in overlay CONT70 may be modified to avoid this problem.

Directions for use of program

To run the program, enter RUN CONTUR($)[1]. When the program is finished, a message is printed on the terminal. If an error occurs, see the section on error messages.

There are two files needed to run CONTUR: the input data file, and the control data file. To create the input data file, follow the directions given in the description of the FMT, GRID, RDGD control cards. The control data file is named "CONTUR.CTR".

There are two ways to create the control data file: running the program CTRL2D, or using the EDI utility program. It is advised to use the program CTRL2D and to read the documentation of that program. Note that the input data file must exist before running the program CTRL2D. That program will create a control data file and a new input data file ready to be used by the program CONTUR.

It is necessary to run CTRL2D prior to CONTUR for plotting a contour map of a large array, as CTRL2D will divide the map into several adjacent parts. But in some cases, it could be of interest to use CONTUR directly; for example, to calculate a large grid without plotting the contour map.

[1] The symbol ($) means ALTmode or ESC key.

EXAMPLES

Following are two examples of runs of the program CONTUR. In the first one the grid is calculated, and in the second one the grid is entered as input data.

Example number one

The map to be produced is a contour map of the total intensity of the aeromagnetic field. The X and Y values are in kilometers, the Z-values in gammas.

The input data file "DB1:TEST5A.DAT" was output from another program, and contains the (X, Y, Z) values of the data points, with one point per record. The control data file "TEST5A.CTR" was created with the EDI utility program, its contents are shown on page 43.

The NAOR card indicates that the fitting polynomial is of the first order, and the search for neighbors is performed in a circle of 3.2 km of radius around each grid-mesh point. The X and Y limits of the grid are given in km in the REGN card. The size of the grid is given in the GRID card. The number of input data points and the place of the (X, Y, Z) values in the data records have the default values.

The Z-values to be contoured are given level by level from 5200 to 7000 gammas in the LEVL cards. The POST card instructs the program that tick marks are to be plotted at each (X, Y, Z) input data point, with a height of 0.04 inches, but with no indication of the Z-value.

The first DRAW card gives the size of the map in inches, instructs the program that there are 10 divisions for X and Y in each grid cell, and indicates to plot the box boundary. the second DRAW card gives -1.E35 as a Z-value for blank areas; this is the value given to grid-mesh points with not enough neighbors around them.

To run the program CONTUR, the control data file "CONTUR.CTR" was created by duplicating the file "TEST5A.CTR".

The printer file "DB1:TEST5A.PNT" resulting from the run is shown on page 44, and the plot appears in figure 2. The general title and the label ".....END OF PLOTS" are outside the figure.

Here are the sizes of the files used for this example.

Filename	No. of blocks of disk space
DB1:TEST5A.DAT	130
TEST5A.CTR	5
DB1:TEST5A.PNT	14
DB1:TEST5A.PLT	259

The time to run the program CONTUR was 15 minutes, and the time to plot was 30 minutes.

Example number two

The map to be produced is a topographic map, with the elevations in meters.

The input data file"DB1:TESTC1.DAT" was created with the EDI utility program, and its contents are shown on page 47. The control data file "TESTC1.CTR" was created with the program CTRL2D, and its contents are shown on page 48.

The RDGD card gives the number of columns and rows of the grid, and indicates that the data are to be read in by row. The FMT card specifies the format to read the Z-values. The Z-values to be contoured are equidistant, with an interval of two meters.

The first DRAW card gives the size of the map in inches, and instructs the program that there are five divisions for X and ten divisions for Y in each grid cell. The box boundary is not plotted, there will only be a '+' at each corner of the map. The second DRAW card gives -1. as a Z-value for blank areas.

After running the program CTRL2D, the new input data file "DB1:CONTUR.DAT" and the new control data file "CONTUR.CTR" were created; they are shown on page 49.

The printer file "DB1:TESTC1.PNT" resulting from the run of the program CONTUR is shown on page 50, and the plot appears in figure 3. The general title and the label "....END OF PLOTS" are outside the figure.

Here are the sizes of the files used for this example.

Filename	No. of blocks of disk space
DB1:TESTC1.DAT	3
TESTC1.CTR	3
DB1:CONTUR.DAT	5
CONTUR.CTR	2
DB1:TESTC1.PNT	15
DB1:TESTC1.PLT	177

The time to run the program CONTUR was 5 minutes, and the time to plot was 20 minutes.

FILE : TEST5A.CTR
****

```
DB1:TEST5A.DAT
DB1:TEST5A.PNT
DB1:BID.
DB1:TEST5A.PLT
TEST NO. 5A, 5 APR 80, M.DONZEAU
FMT
(A1,3E13.7)
NAOR                0          1  3.200000
REGN         744.8433  847.8560  702.5623  813.5297
GRID                0         40         40         0         0         0
LEVL         5200.000          0.0000E+00
LEVL         5600.000          0.0000E+00
LEVL         5700.000          0.0000E+00
LEVL         5800.000          0.0000E+00
LEVL         5900.000          0.0000E+00
LEVL         6000.000          0.0000E+00
LEVL         6100.000          0.0000E+00
LEVL         6200.000          0.0000E+00
LEVL         6600.000          0.0000E+00
LEVL         7000.000          0.0000E+00
POST           0.0400          0
TITL
AIRMAG N22.30-23.30/E41-42    SCALE 1:1000000
DRAW1        4.049338  4.366579        10.        10.         0
DRAW2     -.1000E+36
STOP
```

END OF FILE : TEST5A.CTR
****

```
CALCOMP CONTOURING SYSTEM, MODIFIED MAR,1979      27-APR-80  08:56:27


CONTROL CARD FILENAME :      CONTUR.CTR
INPUT DATA FILENAME :        DB1:TEST5A.DAT
PRINTER FILENAME :           DB1:TEST5A.PNT
OUTPUT GRID FILENAME :       DB1:GRID.
PLOTTER FILENAME :           DB1:TEST5A.PLT


TITLE FOR THE RUN :  TEST NO. 5A, 5 APR 80, W.DONZEAU


PMT          0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1
(A1,3E13.7)
XAXR         0.00000000      1.00000000      3.20000000      0.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1
REGN       744.84339       847.55691       782.66229       813.52972       0.00000000      0.00000000      PLOTTER BLOCK    1
GRID         0.00000000     40.00000000     40.00000000      2.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1

TOTAL NO OF INPUT DATA POINTS :       1580

NO OF SEGMENTS TO STORE INPUT DATA POINTS IN SCRATCH FILE =   36
NO OF HORIZONTAL SEGMENTS =    6          NO OF VERTICAL SEGMENTS =    6

SEGMENT NO=    1 HOR,VER=    1    1          NO OF INPUT POINTS=      132
SEGMENT NO=    2 HOR,VER=    2    1          NO OF INPUT POINTS=      131
SEGMENT NO=    3 HOR,VER=    3    1          NO OF INPUT POINTS=      124
SEGMENT NO=    4 HOR,VER=    4    1          NO OF INPUT POINTS=      136
SEGMENT NO=    5 HOR,VER=    5    1          NO OF INPUT POINTS=      144
SEGMENT NO=    6 HOR,VER=    6    1          NO OF INPUT POINTS=      132
SEGMENT NO=    7 HOR,VER=    1    2          NO OF INPUT POINTS=      141
SEGMENT NO=    8 HOR,VER=    2    2          NO OF INPUT POINTS=       96
SEGMENT NO=    9 HOR,VER=    3    2          NO OF INPUT POINTS=       58
SEGMENT NO=   10 HOR,VER=    4    2          NO OF INPUT POINTS=       87
SEGMENT NO=   11 HOR,VER=    5    2          NO OF INPUT POINTS=      130
SEGMENT NO=   12 HOR,VER=    6    2          NO OF INPUT POINTS=      123
SEGMENT NO=   13 HOR,VER=    1    3          NO OF INPUT POINTS=      124
SEGMENT NO=   14 HOR,VER=    2    3          NO OF INPUT POINTS=       40
SEGMENT NO=   15 HOR,VER=    3    3          NO OF INPUT POINTS=        0
SEGMENT NO=   16 HOR,VER=    4    3          NO OF INPUT POINTS=       51
SEGMENT NO=   17 HOR,VER=    5    3          NO OF INPUT POINTS=      142
SEGMENT NO=   18 HOR,VER=    6    3          NO OF INPUT POINTS=      132
SEGMENT NO=   19 HOR,VER=    1    4          NO OF INPUT POINTS=       97
SEGMENT NO=   20 HOR,VER=    2    4          NO OF INPUT POINTS=       17
SEGMENT NO=   21 HOR,VER=    3    4          NO OF INPUT POINTS=        2
SEGMENT NO=   22 HOR,VER=    4    4          NO OF INPUT POINTS=       76
SEGMENT NO=   23 HOR,VER=    5    4          NO OF INPUT POINTS=      141
SEGMENT NO=   24 HOR,VER=    6    4          NO OF INPUT POINTS=      138
SEGMENT NO=   25 HOR,VER=    1    5          NO OF INPUT POINTS=       63
SEGMENT NO=   26 HOR,VER=    2    5          NO OF INPUT POINTS=        9
SEGMENT NO=   27 HOR,VER=    3    5          NO OF INPUT POINTS=       29
SEGMENT NO=   28 HOR,VER=    4    5          NO OF INPUT POINTS=      106
SEGMENT NO=   29 HOR,VER=    5    5          NO OF INPUT POINTS=      134
SEGMENT NO=   30 HOR,VER=    6    5          NO OF INPUT POINTS=      144
SEGMENT NO=   31 HOR,VER=    1    6          NO OF INPUT POINTS=      141
SEGMENT NO=   32 HOR,VER=    2    6          NO OF INPUT POINTS=       90
SEGMENT NO=   33 HOR,VER=    3    6          NO OF INPUT POINTS=      109
SEGMENT NO=   34 HOR,VER=    4    6          NO OF INPUT POINTS=      136
SEGMENT NO=   35 HOR,VER=    5    6          NO OF INPUT POINTS=      124
SEGMENT NO=   36 HOR,VER=    6    6          NO OF INPUT POINTS=      132
```

```
TIME FOR WRITING SEGMENTS INTO SCRATCH FILE        3.16 MINUTES


  1681 GRID MESH POINTS ARE VALUED AS FOLLOWS :
          1039 ARE INTERPOLATED WITH A MEAN OF    4 INPUT DATA POINTS
           204 ARE EQUAL TO INPUT DATA POINTS
           438 ARE UNDEFINED BY RADIUS CHECKING

TIME FOR GRIDDING                                  4.13 MINUTES

LEVL        5200.0000     0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     PLOTTER BLOCK    1
LEVL        5000.000000                         0.000000
LEVL        4700.000000                         0.000000
LEVL        5800.000000                         0.000000
LEVL        5900.000000                         0.000000
LEVL        6000.000000                         0.000000
LEVL        6100.000000                         0.000000
LEVL        6200.000000                         0.000000
LEVL        6600.000000                         0.000000
LEVL        7000.000000                         0.000000
POST      0.3099999QE-31 0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     PLOTTER BLOCK    1
TITL        0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     PLOTTER BLOCK    1
AIRMAG N22.30-93.30/E41-42     SCALE 1:1000000
DRAW1       4.24933379     4.36657891     10.200000      10.200000      0.00000000     0.00000000     PLOTTER BLOCK    1
DRAW2      -0.12000000E+36 0.00000000     0.00000000                                                   PLOTTER BLOCK    1

TIME FOR PUNCHING AND PRINTING                     0.03 MINUTES


POSTING ON BLOCK         2

TIME FOR POSTING / MESH / TICKS                    0.56 MINUTES


CONTOURS ON BLOCK        3

CONTOUR LEVEL :        5200.000000   NO OF GRID CELLS :    0   POURCENTAGE :    0.00 %
CONTOUR LEVEL :        5500.000000   NO OF GRID CELLS :   10   POURCENTAGE :    0.59 %
CONTOUR LEVEL :        5700.000000   NO OF GRID CELLS :   48   POURCENTAGE :    2.86 %
CONTOUR LEVEL :        5900.000000   NO OF GRID CELLS :  260   POURCENTAGE :   15.47 %
CONTOUR LEVEL :        5900.000000   NO OF GRID CELLS :  508   POURCENTAGE :   30.22 %
CONTOUR LEVEL :        6200.000000   NO OF GRID CELLS :  270   POURCENTAGE :   16.06 %
CONTOUR LEVEL :        6100.000000   NO OF GRID CELLS :  113   POURCENTAGE :    6.72 %
CONTOUR LEVEL :        6200.000000   NO OF GRID CELLS :   53   POURCENTAGE :    3.15 %
CONTOUR LEVEL :        6500.000000   NO OF GRID CELLS :    0   POURCENTAGE :    0.00 %
CONTOUR LEVEL :        7000.000000   NO OF GRID CELLS :    0   POURCENTAGE :    0.00 %

TIME FOR CONTOURING                                7.00 MINUTES


STOP        0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     PLOTTER BLOCK    4
STOP TIME: 07-APR-80     09:11:16
```

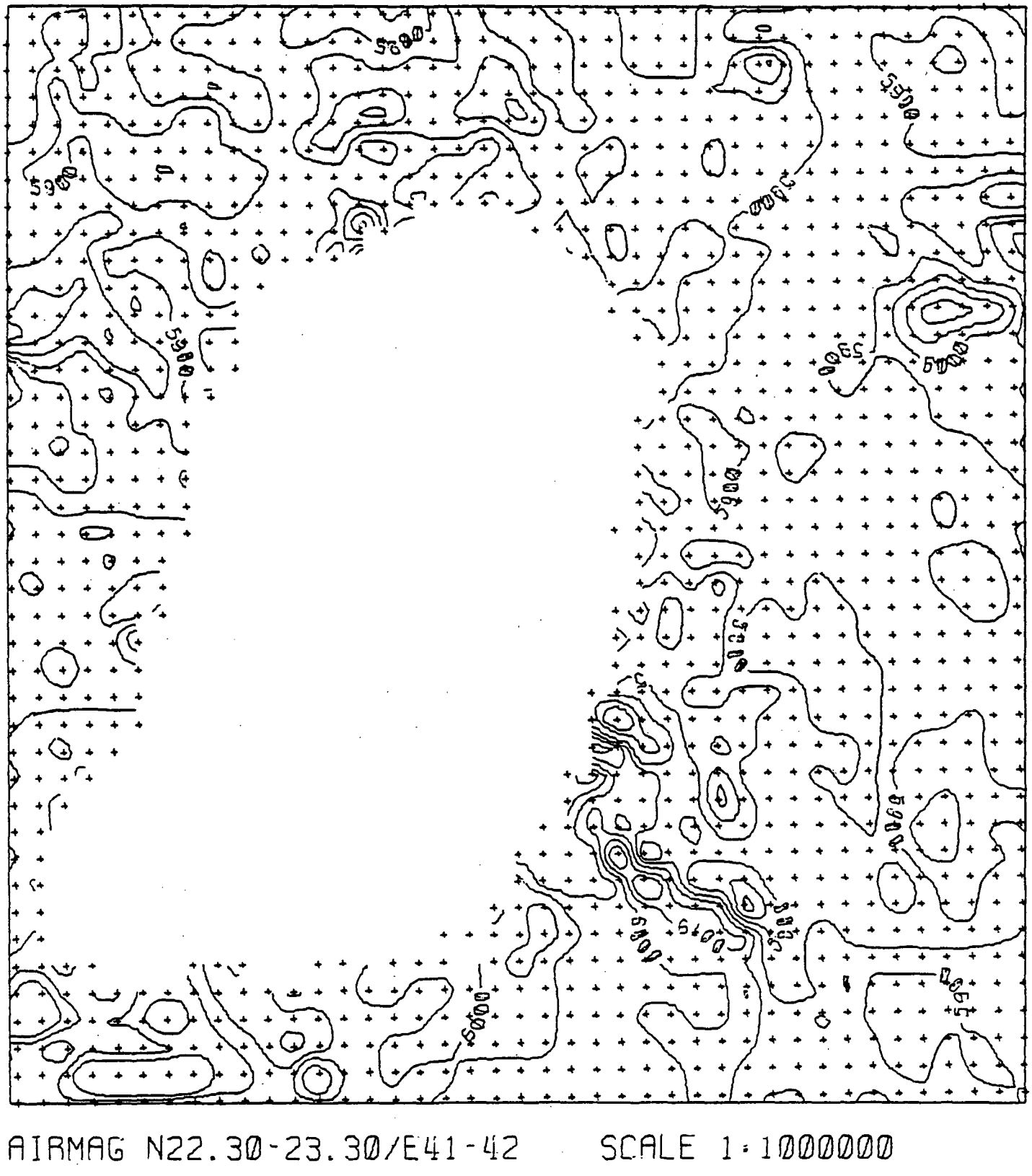


Figure 2.–Total intensity aeromagnetic map of the area around Harrat al Kishb, Kingdom of Saudi Arabia (values in gammas, contour interval 100 gammas).

FILE : DB1:TESTC1.DAT
****

144.70000 138.28999 139.78999 141.94000 140.81000 141.16000 145.45000 150.92999
146.12000 143.75999 149.21001 155.99001 152.60001 157.92999 161.59000 153.16000
151.34000 147.46001 139.17999 141.60001 145.21001 145.08000 148.20000 151.05000
145.55000 137.02000 147.78000 142.55000 150.11000 159.88000 174.59000 169.83000
148.19000 144.28999 145.16000 141.99001 133.84000 139.49001 144.63000 141.08000
138.73000 136.53000 135.63000 139.23000 143.53000 153.33000 154.92999 165.23000
147.95000 143.20000 141.91000 139.42999 138.23000 130.66000 132.03000 131.63000
132.23000 135.56000 134.56000 138.75999 145.36000 147.36000 150.56000 156.56000
133.53000 139.63000 135.52000 136.03999 133.64000 129.44000 134.84000 140.44000
149.14000 145.50000 142.08000 144.00000 151.00000 156.39999 157.30000 161.89999
133.81000 128.09000 127.61000 128.41000 128.61000 130.41000 134.71001 139.61000
148.50999 154.31000 149.98000 152.11000 150.00999 148.41000 145.50999 144.00999
127.46000 125.56000 126.56000 131.25999 133.86000 130.56000 135.86000 139.00999
140.71001 149.66000 158.82000 155.03999 149.24001 147.12000 147.83000 148.33000
124.77000 126.47000 136.57001 138.53000 133.61000 131.78999 132.74001 135.94000
137.34000 146.53999 156.14000 163.00999 154.89999 151.45000 147.67999 149.31000
130.92999 129.92999 137.33000 147.23000 142.89000 137.28000 142.82000 138.96001
135.84000 140.94000 145.14000 155.94000 161.66000 153.50000 149.30000 153.86000

END OF FILE : DB1:TESTC1.DAT
****

FILE : TESTC1.CTR
****

```
DB1:TESTC1.DAT
DB1:TESTC1.PNT
DB1:BID.
DB1:TESTC1.PLT
TEST NO. C1, 7 APR 88, M.DONZEAU
FMT
(8F10.0/8F10.0)
PRNT                 3
RDGD                16          9          2
LEVL         110.0000   2.000000   180.0000
TITL
TOPOGRAPHY,    SCALE 1:2000
DRAW1        5.905500   6.290111         5.        10.          1
DRAW2       -1.000000
STOP
```

FILE : DB1:CONTUR.DAT
****

```
0.1447000E+030,1382900E+030,1397900E+030,1419400E+030,1408100E+030,1411500E+03      1  1
0.1458500E+030,1539300E+030,1461200E+030,1437600E+030,1492100E+030,1859900E+03      1  2
0.1582600E+030,1579300E+030,1615900E+030,1631600E+03                                1  3
0.1513400E+030,1474600E+030,1391800E+030,1416000E+030,1452100E+030,1450800E+03      2  1
0.1482000E+030,1510500E+030,1455500E+030,1370200E+030,1477800E+030,1425500E+03      2  2
0.1501100E+030,1598500E+030,1745900E+030,1698300E+03                               2  3
0.1481900E+030,1442900E+030,1451600E+030,1419900E+030,1338400E+030,1394900E+03      3  1
0.1446300E+030,1412800E+030,1387300E+030,1365300E+030,1366300E+030,1392300E+03      3  2
0.1435300E+030,1533300E+030,1549300E+030,1652300E+03                               3  3
0.1479500E+030,1432000E+030,1419100E+030,1394300E+030,1382300E+030,1306600E+03      4  1
0.1320300E+030,1316300E+030,1322300E+030,1355600E+030,1348600E+030,1387600E+03      4  2
0.1453600E+030,1473600E+030,1505600E+030,1565600E+03                               4  3
0.1335300E+030,1396300E+030,1355200E+030,1367400E+030,1336400E+030,1294400E+03      5  1
0.1348400E+030,1404400E+030,1491400E+030,1455000E+030,1402800E+030,1440000E+03      5  2
0.1510000E+030,1564000E+030,1573000E+030,1619000E+03                               5  3
0.1334100E+030,1293900E+030,1276100E+030,1284100E+030,1286100E+030,1304100E+03      6  1
0.1347100E+030,1396100E+030,1465100E+030,1543100E+030,1499800E+030,1521100E+03      6  2
0.1500100E+030,1494100E+030,1455100E+030,1440100E+03                               6  3
0.1274500E+030,1295500E+030,1265600E+030,1312600E+030,1338600E+030,1305600E+03      7  1
0.1358600E+030,1390100E+030,1407100E+030,1496600E+030,1588000E+030,1550400E+03      7  2
0.1492400E+030,1471200E+030,1478300E+030,1483300E+03                               7  3
0.1247700E+030,1254700E+030,1365700E+030,1385300E+030,1336100E+030,1317900E+03      8  1
0.1327400E+030,1359400E+030,1373400E+030,1465400E+030,1561400E+030,1632100E+03      8  2
0.1549000E+030,1514500E+030,1476800E+030,1493100E+03                               8  3
0.1309300E+030,1299300E+030,1373300E+030,1472300E+030,1428900E+030,1372800E+03      9  1
0.1428000E+030,1389600E+030,1389400E+030,1409400E+030,1451400E+030,1559400E+03      9  2
0.1616600E+030,1535000E+030,1493000E+030,1538600E+03                               9  3
```

END OF FILE : DB1:CONTUR.DAT
****

FILE : CONTUR.CTR
****

```
DB1:CONTUR.DAT
DB1:TESTC1.PNT
DB1:BID.
DB1:TESTC1.PLT
TEST NO. C1, 7 APR 88, M.DONZEAU
FMT
(      2(6E13.7/),      4E13.7)
PRNT                 0
RDBD                16          9          2
LEVL         1180.0000  2.000000  180.0000
TITL
TOPOGRAPHY.   SCALE 1:2000
DRAW1        5.905500  6.299111         5.        10.         1
DRAW2       -1.0000000.0000E+000.0000E+00
STOP
```

END OF FILE : CONTUR.CTR
****

```
CALCOMP CONTOURING SYSTEM, MODIFIED MAR,1979      07-APR-80  11:54:22


CONTROL CARD FILENAME :      CONTUR.CTR
INPUT DATA FILENAME :        DB1:CONTUR.DAT
PRINTER FILENAME :           DB1:TESTC1.PNT
OUTPUT GRID FILENAME :       DB1:GRID.
PLOTTER FILENAME :           DB1:TESTC1.PLT


TITLE FOR THE RUN :  TEST NO. C1, 7 APR 80, M.DONZEAU


FMT          0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1
(     2(6E13.7/),     4E13.7)
PRNT         0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1
RDGD        16.000000        9.0000000       2.0000000       0.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1

TIME FOR READING PREGRIDDED DATA                    0.08 MINUTES

LEVL       110.00000        2.0000000      100.00000        0.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1
TITL         0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      0.00000000      PLOTTER BLOCK    1
TOPOGRAPHY,  SCALE 1:2000
DRAW1        5.9054999       6.2991199       5.0000000      10.000000        1.0000000       0.00000000      PLOTTER BLOCK    1
DRAW2       -1.0000000       0.00000000      0.00000000                                                      PLOTTER BLOCK    1


          1           2           3           4           5           6           7           8           9          10
  1  144.70000   138.29999   139.79999   141.94000   140.81000   141.16000   145.45000   150.92999   146.12000   143.75999
  2  151.34000   147.45001   139.17999   141.60001   145.21001   145.33000   148.20002   151.05000   145.55000   137.02000
  3  148.19000   144.29999   145.16000   141.99001   133.84000   139.49001   144.63000   141.48000   138.73000   136.53000
  4  147.95000   143.20000   141.91000   139.42999   138.23000   130.55000   132.03000   131.63000   132.23000   135.56000
  5  133.53000   139.63000   135.52000   136.03999   133.64000   129.44000   134.84000   140.44000   149.14000   145.52000
  6  133.81000   128.89000   127.61000   128.41000   128.61000   130.41000   134.71001   139.61000   146.56999   154.31000
  7  127.46000   125.55000   126.86000   131.25999   133.86000   136.55000   135.86000   139.00999   142.71001   149.56000
  8  124.77000   124.47000   135.57001   138.53000   133.61000   131.78999   132.74001   135.94000   137.34000   146.53999
  9  130.92999   129.92999   137.33000   147.23000   142.89000   137.29000   142.86000   138.96001   135.84000   142.94000

          11          12          13          14          15          16
  1  149.21001   154.99001   152.60001   157.92999   161.59000   163.15000
  2  147.78000   142.55000   152.11000   150.88000   174.59000   169.83000
  3  136.63000   139.23000   143.53000   153.33000   154.92999   155.23000
  4  134.56000   138.75999   145.36000   147.36000   150.56000   156.56000
  5  142.78000   148.03000   151.92000   156.39999   157.33000   161.89999
  6  149.98000   152.11000   158.20999   148.41000   145.56999   144.00999
  7  158.80000   155.23999   149.24001   147.12000   147.83000   148.33000
  8  156.14000   153.23999   154.89999   151.45000   147.67999   149.31000
  9  145.14000   156.94000   151.66000   153.53000   149.33000   153.85000

TIME FOR PUNCHING AND PRINTING                      0.14 MINUTES


TIME FOR POSTING / MESH / TICKS                     0.00 MINUTES
```

```
CONTOURS ON BLOCK        2

CONTOUR LEVEL :        110.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        112.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        114.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        116.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        118.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        120.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        122.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        124.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        126.000000   NO OF GRID CELLS :     8   POURCENTAGE :     5.56 %
CONTOUR LEVEL :        128.000000   NO OF GRID CELLS :     9   POURCENTAGE :     6.25 %
CONTOUR LEVEL :        130.000000   NO OF GRID CELLS :    17   POURCENTAGE :    11.81 %
CONTOUR LEVEL :        132.000000   NO OF GRID CELLS :    28   POURCENTAGE :    19.44 %
CONTOUR LEVEL :        134.000000   NO OF GRID CELLS :    32   POURCENTAGE :    22.22 %
CONTOUR LEVEL :        136.000000   NO OF GRID CELLS :    40   POURCENTAGE :    27.78 %
CONTOUR LEVEL :        138.000000   NO OF GRID CELLS :    43   POURCENTAGE :    29.86 %
CONTOUR LEVEL :        140.000000   NO OF GRID CELLS :    41   POURCENTAGE :    28.47 %
CONTOUR LEVEL :        142.000000   NO OF GRID CELLS :    45   POURCENTAGE :    31.25 %
CONTOUR LEVEL :        144.000000   NO OF GRID CELLS :    45   POURCENTAGE :    31.25 %
CONTOUR LEVEL :        146.000000   NO OF GRID CELLS :    42   POURCENTAGE :    29.17 %
CONTOUR LEVEL :        148.000000   NO OF GRID CELLS :    42   POURCENTAGE :    29.17 %
CONTOUR LEVEL :        150.000000   NO OF GRID CELLS :    36   POURCENTAGE :    25.00 %
CONTOUR LEVEL :        152.000000   NO OF GRID CELLS :    32   POURCENTAGE :    22.22 %
CONTOUR LEVEL :        154.000000   NO OF GRID CELLS :    26   POURCENTAGE :    18.06 %
CONTOUR LEVEL :        156.000000   NO OF GRID CELLS :    21   POURCENTAGE :    14.58 %
CONTOUR LEVEL :        158.000000   NO OF GRID CELLS :    18   POURCENTAGE :    12.50 %
CONTOUR LEVEL :        160.000000   NO OF GRID CELLS :    14   POURCENTAGE :     9.72 %
CONTOUR LEVEL :        162.000000   NO OF GRID CELLS :     9   POURCENTAGE :     6.25 %
CONTOUR LEVEL :        164.000000   NO OF GRID CELLS :     5   POURCENTAGE :     3.47 %
CONTOUR LEVEL :        166.000000   NO OF GRID CELLS :     4   POURCENTAGE :     2.78 %
CONTOUR LEVEL :        168.000000   NO OF GRID CELLS :     4   POURCENTAGE :     2.78 %
CONTOUR LEVEL :        170.000000   NO OF GRID CELLS :     4   POURCENTAGE :     2.78 %
CONTOUR LEVEL :        172.000000   NO OF GRID CELLS :     4   POURCENTAGE :     2.78 %
CONTOUR LEVEL :        174.000000   NO OF GRID CELLS :     4   POURCENTAGE :     2.78 %
CONTOUR LEVEL :        176.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        178.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %
CONTOUR LEVEL :        180.000000   NO OF GRID CELLS :     0   POURCENTAGE :     0.00 %

TIME FOR CONTOURING                          3.78 MINUTES


STOP       0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     0.00000000     PLOTTER BLOCK    3
STOP TIME: 07-APR-84      11:58:51
```

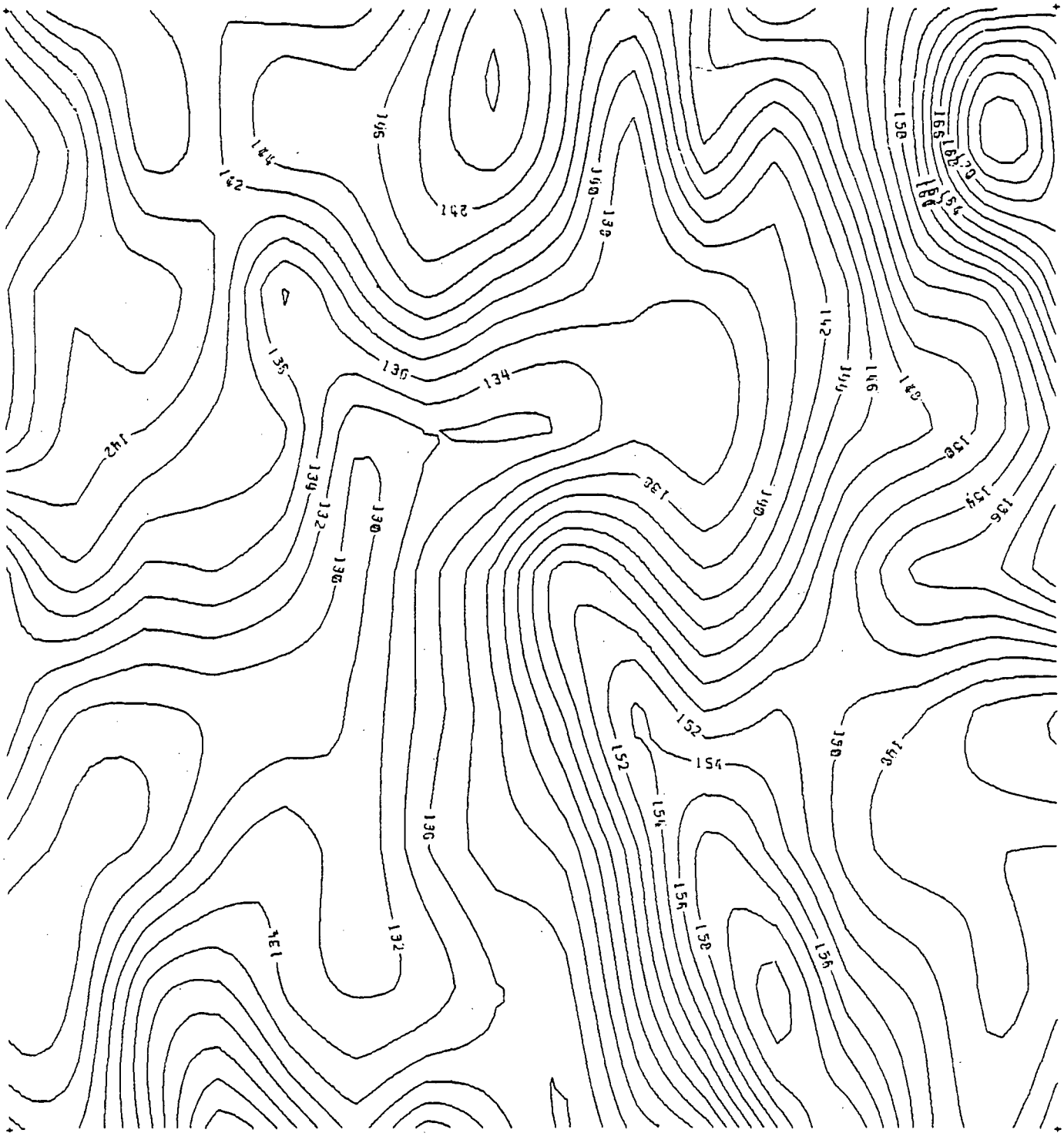


Figure 3.–Topographic map of Muzubiah area, Kingdom of Saudi Arabia (values in meters, contour interval 2 meters).

SOURCE PROGRAM LISTING

The source program listing is not reproduced here as it is quite big. It is stored in the Geophysics section of the U.S. Geological Survey office in Jiddah, and is at the disposal of the people interested in it.

ACKNOWLEDGEMENTS

All the modifications of the CALCOMP version of the program described in this report were made partly by J. Bobillier and J. -P. Veyrier from BRGM/Jiddah, and partly by B. Dixon, L. North, and M. Donzeau from USGS/Jiddah.

REFERENCES

California Computer Products, Inc., 1974, CONTOUR, a basic contouring program, by CALCOMP, Applications software, Anaheim, Calif.

_____, 1973, GPCP-a general purpose contouring program: User's manual, Anaheim, Calif.

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