FORTRAN IV PROGRAMS TO DEVELOP CONTOUR MAPS OF 3-DIMENSIONAL DATA

MAY 1968
NO. 6

by
A K TURNER

Joint Highway Research Project
PURDUE UNIVERSITY
LAFAYETTE INDIANA
Progress Report

FORTRAN IV PROGRAMS TO DEVELOP CONTOUR MAPS OF 3-DIMENSIONAL DATA

To: G. A. Lechner, Director
Joint Highway Research Project

From: E. L. Michael, Associate Director
Joint Highway Research Project

May 9, 1968

File No.: 1-6-1
Project No.: C-36-72A

The attached Progress Report "Fortran IV Programs to Develop Contour Maps of 3-Dimensional Data" has been prepared by Mr. A. Keith Turner, Graduate Instructor in Research, under the direction of Professor R. D. Miles.

The material in the report was developed from the current HR-1 (5) research on "Evaluation of Numerical Surface Techniques Applied to Highway Location Analysis." This research is concerned with the graphical representation of various conceptual surfaces so that man-machine information interchanges between design engineers and electronic computers may be developed.

The need for graphical display of 3-Dimensional data exists for a wide variety of highway engineering applications, yet this capability has not been available at Purdue until the current research. It is anticipated that further refinement of these programs will become desirable, in the light of experience with their application. Further routines are still under development. Thus it is anticipated that additional reports in this area will be made.

The report is presented to the Board for the record and for review and comment. It will also be presented to the ISRC and the EPR for their review, comment and approval as partial fulfillment of the objectives of the research.

Respectfully submitted,

[Signature]

Harold L. Michael
Associate Director

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Progress Report

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by

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Graduate Instructor in Research

Joint Highway Research Project

Project No. C-36-72A
File No. 1-6-1

Prepared as Part of an Investigation

Conducted by

Joint Highway Research Project
Engineering Experiment Station
Purdue University

in cooperation with

Indiana State Highway Commission

and the

U.S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

Purdue University
Lafayette, Indiana
May 9, 1968
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Progress Report

FORTRAN IV PROGRAMS TO DEVELOP CONTOUR MAPS OF 3-DIMENSIONAL DATA

This report describes a series of FORTRAN-IV subroutines used to prepare graphical displays of three-dimensional data.

Considerable work has been expended to make these programs as flexible as possible. Many are based on routines obtained from the University of Michigan Department of Geography or the Harvard University Laboratory for Computer Graphics, and are believed to be among the best routines available.

It is hoped to produce a revised version of this report during the summer of 1968 which will contain additional programs now in the developmental stage. Comments from users regarding corrections or modifications to the routines are welcome.

A. Keith Turner
Airphoto Interpretation
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FORTRAN IV PROGRAMS TO DEVELOP CONTOUR
MAPS OF 3-DIMENSIONAL DATA

Joint Highway Research Project
Progress Report

PART I

INTRODUCTION
INTRODUCTION

The graphical display of three-dimensional data is important in many scientific and engineering studies. Such data form surfaces which may be of many types ranging from real surfaces such as the surface of the earth to various mathematical and functional relationships.

This manual describes an integrated series of routines which can be combined to produce various types of graphical displays of three-dimensional surfaces using either the printer or the CALCOMP plotter. Use of the printer has several advantages over the CALCOMP plotter, particularly in the early stages of a project, since the output is produced as part of the regular job output, the printer is cheap and fast (allowing many more plots to be produced), and its use does not require extra tape mounts. Due to the limited resolution of the printer which is controlled by the line and character spacing, printer displays may be distorted, although under favorable conditions distortion can be eliminated. Since the CALCOMP routines are designed to be easily compatible with the printer routines, the plotter can be used for final drafting of selected displays.

PROGRAM LANGUAGE

These routines are written in FORTRAN-IV. Most of these routines can be run on either the IBM 7094 or the CDC 6500 with only minor changes to accommodate the different word lengths on the two machines.

PROGRAM AVAILABILITY

FORTRAN-IV source decks are available for copying in the Airphoto Interpretation and Photogrammetry Laboratory, Room B-24, Civil Engineering Building and in Room G-150, Math. Sciences Building.

METHODS OF SURFACE REPRESENTATION

The three most common methods of graphically displaying three-dimensional data are:

1. perspective or isometric views of the surface
2. three-dimensional histograms
3. contour maps.

Routines presently under development will provide the capability of preparing perspective and isometric views, and three-dimensional histograms. It is hoped that these new routines will be available this summer.
This first edition of the manual describes a series of main programs and associated subroutines to perform the following functions:

a) Production of contour maps utilizing polynomial equations.
b) Interpolation of irregularly spaced to gridded data.
c) Production of contour maps of the printer.
d) Production of contour maps on the Calcomp plotter.

**BENEFITS AND LIMITATIONS OF MACHINE-COMPUTED CONTOUR MAPS**

Contouring can be extremely literal, extremely interpretative, or a compromise between the two. The routines developed here give literal contours. As such, the maps produced are not "unbiased," as is often claimed, but are in fact strongly and consistently biased toward literal interpretation of the data.

As a consequence, computer-generated contour maps developed by these routines may not be equally suitable for all applications. They are extremely useful as "quick-look" maps to give the user a general idea of his data, or to check the general validity of the data.

Furthermore, since all maps are made consistently, they can also be used for comparison purposes. Contouring several data sets by humans inevitably involves some learning processes which introduce an uncertain and subtle bias into the results rendering comparison of maps difficult. In contrast, the computer will not "learn" from one problem to the other, but will handle each data set uniformly.

**PROCEDURE**

Computer contouring of data involves two steps:

1) determination of regularly spaced (gridded) values of the dependent variable (elevation)
2) linear interpolation to locate contour lines within the grid squares.

(Obviously, if data is already in grid form, step 1 may be omitted.)

**Determination of Gridded Values**

1) **By Regression Analysis**

The determination of regularly spaced values can be accomplished by first developing an analytic equation to describe the data, and then evaluating this equation at a series of grid coordinates. Least squares regression procedures based on the polynomial expansion are commonly used, although double Fourier series expansion procedures have also been
developed (2). Statistical procedures allow the research to determine the ability of the various surfaces to conform to his data (1, 3). These techniques, termed Trend Surface Analysis, have long been used by geologists and geographers (3, 4, 5, 7). They have found residual maps, contour maps showing the lack of fit to the regression equations, useful in locating anomalous areas (6).

Program POLYFIT and its associated subroutines will fit polynomials up to the fifth power and produce trend surface maps. Program RESMAP will produce residual maps.

2) **By Weighted Moving-Average Procedures**

Weighted moving-averages or the fitting of local polynomials are two other techniques for interpolating irregularly spaced data to a uniform grid. Weighted moving averages are generally computationally easier, and therefore faster, than the fitting of local polynomials.

Subroutine GRID, based on an algorithm developed by Professor W. R. Tobler at the University of Michigan, uses a weighted moving average to determine grid values. As in all interpolation procedures some smoothing of the data results from its use. A limited amount of testing suggests that the smoothing is normally less than 2% of the data range, rising to nearly 10% of the range with extremely erratic data.

**Linear Interpolation Within Grid Squares**

Subroutines FICKON1 and FICKON2 perform this step on the printer; program CONUR, performs a similar operation on the CALCOMP plotter.

FICKON1 and FICKON2 differ only in the type of output produced. FICKON1 produces maps with various characters representing different contour intervals. Options allow for the printing of contour lines only, alternate contour bands, or all print positions within the map. FICKON2 produces maps with contour intervals delineated by combinations of overprinted characters to give a graded density from light (low areas) to dark (high areas). Since the overprint carriage control is only available on the CDC 6500, this program is restricted to that machine.

The CALCOMP plotting routines are much more efficient on the IBM 7094; plotting speeds are at least twice as great, and plot tapes are written at a higher density. Under these circumstances program CONUR has not been converted to run on the CDC 6500, although no unusual difficulties are anticipated for such a conversion.

**SUMMARY**

A series of integrated routines are available to perform machine contouring of three-dimensional data on either the printer or the CALCOMP plotter.
REFERENCES


NOTE - Program POLYFIT (and associated subroutines) should be used if polynomial regression surfaces are to be fitted to regularly or irregularly spaced data.

Program RESMAP (and associated subroutines) should be used in conjunction with program POLYFIT to analyze residual and original data.

CONTENTS OF THIS SECTION

1) Program POLYFIT - including subroutines READ1, INVER, INVCK, POLY, EVALU, and PLOT

2) Program RESMAP
PURPOSE

TO PERFORM TREND SURFACE ANALYSIS USING POWER SERIES EXPANSION, POLYNOMIALS UP TO FIFTH DEGREE CAN BE REQUESTED. THIS PROGRAM HAS EVOLVED FROM AN EARLIER PROGRAM OBTAINED FROM PROFESSOR R.B. JOHNSON, FORMERLY HEAD OF THE DEPARTMENT OF GEOSCIENCES, PURDUE UNIVERSITY.

PURDUE UNIVERSITY VERSION 4.2 A KEITH TURNER, CIVIL ENGINEERING, FEBRUARY, 1968.

THIS VERSION CAN FIT A SURFACE TO 1000 DATA POINTS, UP TO FOUR DIFFERENT VARIABLES CAN BE ANALYZED AT EACH POINT. DATA CARDS (ONE PER POINT) SHOULD INCLUDE IDENTIFICATION, X-COORDINATE, Y-COORDINATE, AND VARIABLES 1-4 (Z1 Z2 Z3 Z4). AN UNLIMITED NUMBER OF DATA SETS, EACH CONTAINING UP TO 1000 POINTS, CAN BE PROCESSED.

THE PROGRAM WILL (1) FIT THOSE POLYNOMIAL SURFACES REQUESTED, (2) LIST THE MATRICES USED TO DETERMINE THE COEFFICIENTS, (3) LIST THE COEFFICIENTS, (4) ESTIMATE THE ERROR IN EACH COEFFICIENT, (5) PERFORM ANALYSIS OF VARIANCE, AND (6) LIST THE ORIGINAL DATA, COMPUTED VALUES AND RESIDUALS FOR ALL POINTS.

SUBROUTINES EVALU AND PLOT GENERATE AND MACHINE-PUNCH GRIDDED VALUES FOR SELECTED TREND SURFACES AND PRODUCE PRINTER-CONTOUR MAPS OF THESE SURFACES. A VARIETY OF CONTOUR MAPS CAN BE SPECIFIED. MULTIPLE MAPS OF ANY SURFACE MAY BE PRODUCED. THE GRIDDED VALUES MAY PRODUCE CALCOMP CONTOUR MAPS USING PROGRAM CONTUR.

ALL ORIGINAL AND COMPUTED VALUES AND RESIDUALS, FOR THE DATA CAN BE STORED ON A USER-DESIGNATED TAPE (TAPES) FOR LATER ANALYSIS.

TAPE REQUIREMENTS

TAPE1 IS A SCRATCH TAPE USED TO STORE AND REGENERATE DATA DESTROYED DURING THE OPERATION OF SUBROUTINES EVALU AND PLOT. NO REQUEST CARD IS NECESSARY SINCE A DISK FILE WILL AUTOMATICALLY BE GENERATED.

TAPE2 IS USED TO STORE THE ORIGINAL INPUT VALUES, COMPUTED VALUES AND RESIDUALS FOR ALL POINTS. THE TAPE SHOULD BE WRITTEN IN BINARY AT 556 BPI. THE REQUEST CARD FORM IS --

REQUEST (TAPE2, HI) PLEASE MOUNT USERTAPENAME, FILE XXX

THE FIRST TAPE RECORD WILL CONTAIN THE NUMBER OF DATA POINTS (N) BEING ANALYZED. THEN FOLLOW N RECORDS CONTAINING THE DATA ID, X, Y, Z, 1ST DEGREE ESTIMATE, 1ST DEGREE RESIDUAL, 5TH DEGREE RESIDUAL.

THIS SEQUENCE WILL BE REPEATED FOR EACH VARIABLE (ONE UP TO FOUR TIMES) FOR EACH DATA SET OF 1000 POINTS OR LESS. AN END-OF-FILE IS WRITTEN AFTER THE LAST DATA SET.

IF IT IS DESIRED TO IMMEDIATELY ANALYZE THE RESIDUALS, PROGRAM RESMAP MAY BE INCLUDED UNDER THE SAME JOB CARD. IN THIS CASE NO TAPE REQUEST CARD IS REQUIRED.
Routines Required --

A) Main Program (POLYFIT)

1) Subroutines
   1) READ1 - Reads the data cards.
   2) INVER - Determines inverse matrix.
   3) INVCH - Prints out X-prime-X matrix.
   4) POLY - Determines (estimated values and) residuals.
   5) EVALU - Evaluates surfaces at grid points.
   6) PLOT - Produces printer contour maps.
   7) STATS - Calculates statistical measures.

Description of Control Cards -- Refeat all cards for each data set.

1) Large Card - POLYFT (cols 1-6) Code word indicating start of data

2) Master Control Card - POLYFT (cols 1-6)
   LIMIT(1-5) (cols 11-15) If LIMIT(K) = 1, surface of degree K fitted.
   ISURF(1-5) (cols 16-20) If ISURF(K) = 1, grid values for surface K are calculated (these will be punched if specified on card 9), however no map will be printed.
   INCY (col 25) If INCY = 1, X-prime-X matrices printed.
   NLINES (col 31) Number of general title cards to follow, maximum = 5
   NZ(1-4) (cols 537-540) If NZ(K) = 1, variable K will be analyzed.
   NRES (col 50) If NRES = 1, residual values listed.
   IOUT1 (col 60) If IOUT1 = 1, data written on tape.

3) General Title Card(s) - Each card contains any alphanumeric title in cols 1-72

4) Variable Identification Card - Four sets of alphanumeric titles (cols 1-25) which will identify variables Z1-Z4.
   Note: if no further identification required, insert blank card

5) Format Card - Format of data (cols 7-78) should be in form (A10.5 floating point fields (X', Y', Z1', Z2', Z3', Z4'))

6) Data Cards - One card for each point.

7) Blank Card - Blank card used to distinguish end of data set.
IF THE GRIDDING OR GRIDDING AND "ARPING" OPTIONS ARE REQUESTED
(IF ISURF(K)=1 OR 2) THE FOLLOWING CARDS MUST BE REPEATED FOR EACH REQUEST:

8) AREA DEFINITION CARD -
Maximum and minimum values of x and y coordinates (XMAX, XMIN, YMAX, YMIN) with decimals punched (Cols 1-10, 11-20, 21-30, 31-40).

9) GRID SPECIFICATION CARD -
ROWS (Cols 1-3) integer number of rows in grid (maximum=100).
COLS (Cols 4-6) integer number of columns in grid (maximum=100).
NMAP (Cols 7-9) number of different maps of this surface to be printed.
IPUN (Col 10) if IPUN=1, grid values punched (each surface identified by punched title cards).

NOTE:
A) FOR 1 INCH GRID COLS=MAP WIDTH (INCHES) + 1
ROWS=MAP LENGTH (INCHES) + 1
B) IF COLS>42, production of printer maps is impossible due to limited width of paper (however Calcomp plots allow up to 100X100 arrays).

REPEAT THE FOLLOWING CARD(S) FOR EACH MAP REQUESTED BY NMAP:

10) PLOT CONTROL CARD -
CON (Cols 1-2) number of contour intervals, maximum = 19
IF CON = 0, CON SET TO 6.
TOUR (Col 3) if TOUR=0, MAX AND MIN data elevations used as contour limits.
IF TOUR=1, desired top and bottom contours read in from special card (see below).
IF TOUR=2, variable contours read in (low to high). In this case set CON equal to the number of values to be read in.
IF TOUR=3, contour interval becomes 1/2 standard deviation increments. (MAX=+3 SIGMA, MIN=-3 SIGMA)

LINES (Cols 4) if LINES=0, contour lines are printed.
IF LINES=1, alternate (even-valued) bands are printed.
IF LINES=2, complete bands are printed.
INCHES (Cols 5-9) width of map in inches, maximum = 12.7

11) SPECIAL CARD(S) (required only if TOUR = 1 OR 2)
IF TOUR=1, this card specifies minimum and maximum elevation values: ZMIN (Cols 1-10), ZMAX (Cols 11-20) decimals punched.
IF TOUR=2, this card specifies a format (INCON) used in reading a series of irregularly spaced contour values. The values are arranged from lowest to highest on subsequent cards. SET CON = number of LINES.
PROGRAM POLYFIT MAIN PROGRAM

PROGRAM POLYFIT(INPUT,OUTPUT,PUNCH,TAPE1,TAPE8, TAPE5=INPUT,TAPE6= OUTPUT)

DIMENSION XX(21,21), P(21), A(21,5), XINV(21,21,5), PAR(21), ZR(1:1), SSR(5), EB(21,4), SSQZ(4), X(1000), Y(1000), Z(1000,4), ID(1000)
DIMENSION LIMIT(5), Nz(4), ERR(21), SSF(5), DFR(5)
DIMENSION ISURF(5), TITL(8,5), ORDIN(4,2)
DIMENSION DUM(3000)
COMMON X,Y,Z, ID, DUM, XINV, A, KSOB
DATA ND0G/6HPOLYFT/
XD=0.0
YD=0.0
ZD=0.0

SEARCH THE INPUT TAPE FOR THE PARAMETER CARD WITH THE CODE POLYFT

READ (5,370) LABEL
IF (EOF,5) 510,10
IF (LABEL=ND0G) 5,15,5
READ (5,375) LABEL,LIMIT,ISURF,INCK,NLINES,NZ,NRES,IOUT1

WRITE OUT HEADING

WRITE (6,455)
DO 20 I=1,NLINES
   READ (5,325) (TITL(I,I),I=1,8)
20   WRITE (6,460) (TITL(I,I),I=1,8)
WRITE (6,380)
READ (5,465) (ORDIN(I,1),ORDIN(I,2),I=1,4)
SS0Z(1)=0.0
SS0Z(2)=0.0
SS0Z(3)=0.0
SS0Z(4)=0.0
DO 30 I=1,N
   J=6-I
   IF (.LIMIT(J)) 25,30,25
   N=((J+1)*(J+2))/2
   JUMP=I
   GO TO 35
25 CONTINUE
GO TO 305

READ THE DATA POINTS

CALL READ1 (NCARDS)
C COMPUTE THE COEFFICIENT MATRIX

PAR(1) = .0
DO 45 I=1,N
    DO 40 J=1,N
40    XX(I,J) = 0.0
    BB(I,1) = 0.0
    BB(I,2) = 0.0
    BB(I,3) = 0.0
45    BB(I,4) = 0.0
DO 95 K=1,NCARDS
    XD = X(K)
    YD = Y(K)
    PAR(2) = XD
    PAR(3) = YD
    GO TO (50, 50, 50, 50, 70), JUMP
50    PAR(4) = XD*XD
    PAR(5) = XD*YD
    PAR(6) = YD*YD
    GO TO (55, 55, 55, 70, 70), JUMP
55    PAR(7) = PAR(4)*XD
    PAR(8) = PAR(4)*YD
    PAR(9) = PAR(6)*XD
    PAR(10) = PAR(6)*YD
    GO TO (60, 60, 70, 70, 70), JUMP
60    PAR(11) = PAR(7)*XD
    PAR(12) = PAR(7)*YD
    PAR(13) = PAR(4)*PAR(6)
    PAR(14) = PAR(10)*XD
    PAR(15) = PAR(10)*YD
    GO TO (65, 70, 70, 70, 70), JUMP
65    PAR(16) = PAR(11)*XD
    PAR(17) = PAR(11)*YD
    PAR(18) = PAR(7)*PAR(6)
    PAR(19) = PAR(10)*PAR(4)
    PAR(20) = PAR(15)*XD
    PAR(21) = PAR(15)*YD
70    DO 75 I=1,N
75    XX(I,J) = XX(I,J) + PAR(I)*PAR(J)
C
C COMPUTE THE P VECTORS FOR EACH Z TO BE FITTED.
C
DO 95 JIM=1,4
    IF (NZ(JIM)) 80, 90, 80
80    ZD = Z(K, JIM)
    DO 85 I=1,N
85    BB(I, JIM) = BB(I, JIM) + ZD*PAR(I)
    SSQZ(JIM) = SSQZ(JIM) + ZD*ZD
90    CONTINUE
95    CONTINUE
WRITE (6,325)
DO 100 I=1,N
  WRITE (6,330) I,(XX(I,J),J=1,N)
100  CONTINUE
WRITE (6,335)
DO 105 JIM=1,4
  IF (NZ(JIM).EQ.0) GO TO 105
DO 105 I=1,N
  WRITE (6,340) I,EB(I,JIM)
105  CONTINUE
NM1=N-1
DO 110 I=1,NM1
  IP1=I+1
DO 110 J=IP1,N
110  XX(J,I)=XX(I,J)
WRITE (6,345)
DO 115 I=1,N
  WRITE (6,330) I,(XX(I,J),J=1,N)
115  CONTINUE
DO 140 K=1,5
  IF (LIMIT(K)) 120,140,120
120  MTERMS=(K+1)*(K+2)/2
  KSOR=0
  CALL INVER (XX,XINV, MTERMS,K)
  IF (KSOR) 125,130,125
125  WRITE (6,385) K
  LIMIT(K)=0
130  CONTINUE
  IF (INCK) 135,140,135
135  CALL INVCK (XX,XINV,K)
140  CONTINUE
REWIND 1
C THE JIM DO LOOP RUNNING TO STATEMENT 300 CONTROLS WHICH Z IS BEING FITTED
C
DO 300 JIM=1,4
  IF (NZ(JIM)) 145,300,145
145  DO 150 I=1,NCARDS
150  READ (1) ID(I),X(I),Y(I),Z(I),Z(I,2)Z(I,3),Z(I,4)
  SSZ=SSQZ(JIM)
  DO 155 I=1,N
155  B(I)=BB(I,JIM)
C COMPUTE COEFFICIENTS
C
DO 160 K=1,5
  IF (LIMIT(K)) 165,170,160
160  NTERMS=(K+1)*(K+2)/2
DO 165 I=1,INTERMS
   A(I,K)=0.0
   DO 165 J=1,INTERMS
   A(I,K)=A(I,K)+XINV(I,J,K)*B(J)
165 CONTINUE
WRITE (6,455)
DO 175 I=1,NLINES
175 WRITE (6,460) (TITL(I,I),I=1,8)
WRITE (6,395) ORDIN(J1M1),ORDIN(J1M2)
WRITE (6,390) NCARDS
DO 185 K=1,5
   IF (LIMIT(K)) 180,185,180
180 NTERMS=((K+1)*K+2)/2
   rewrite 6,480) K,(A(I,K),I=1,INTERMS)
185 CONTINUE
C
C ANALYSIS OF VARIANCE
C
C ERROR ESTIMATES FOR COEFFICIENTS
C
ZSUM=0.0
DO 190 K=1,NCARDS
   ZSUM=ZSUM+Z(K,J1M)
ZBAR=ZSUM/FLOAT(NCARDS)
SSZBAR=ZSUM*ZBAR
SSZ=SSZ-SSZBAR
WRITE (6,405)
   DO 210 K=1,5
   IF (LIMIT(K)) 195,210,195
   NTERMS=((K+1)*K+2)/2
   SSR(K)=0.0
   DO 200 J=1,INTERMS
      SSR(K)=SSR(K)+A(J,K)/B(J)
      SSR(K)=SSR(K)-SSZBAR
      SSE(K)=SSZ-SSR(K)
      DFFER(K)=NCARDS-INTERMS-1
      SIGMAE=SQRT(SSE(K)/DFREE(K))
   DO 205 J=1,INTERMS
      ERR(J)=SIGMAE*SORT(XINV(J,J,K))
   WRITE (6,410) K,(ERR(J),J=1,INTERMS)
210 CONTINUE
C
C ANALYSIS OF VARIANCE
C
WRITE (6,455)
DO 215 I=1,NLINES
215 WRITE (6,460) (TITL(I,I),I=1,8)
WRITE (6,470) ORDIN(J1M1),ORDIN(J1M2)
WRITE (6,415)
NDF=NCARDS-1
WRITE (6,350) NDF,SSZBAR
DO 225 K=1,5
   IF (LIMIT(K)) 225,226,220
220 NTERMS=((K+1)*(K+2))/2
   XSE=SSE(K)/DFREE(K)
   XSR=SSR(K)/FLOAT(NTERMS)
   F=XSR/XSE
   NDF=DFREE(K)
   WRITE (6,420) K,NTERMS,NDF,SSR(K),XSR,SSE(K),XSF,F
225 CONTINUE
   JACK=6-JUMP
   WRITE (6,355) SSZ
   WRITE (6,360)
   DO 230 K=1,5
      IF (LIMIT(K)) 230,235,230
230 RR=SSR(K)/SSZ
   PCENT=PR*100.0
   R=SQRT(RR)
   WRITE (6,365) K,PCENT,RR,R
235 CONTINUE
   WRITE (6,425) JACK
   KSWT=1
   DO 255 K=1,5
      IF (LIMIT(K)) 240,255,240
240 NTERMS=((K+1)*(K+2))/2
      GO TO (245,250), KSWT
245 KSWT=2
   NTERMS=NTERMS-1
   XMSEQ=SSR(K)/FLOAT(NTERMS)
   F=XMSEQ/(SSR(JACK)/DFREE(JACK))
   WRITE (6,430) K,NTERMS,SSR(K),XMSEQ,F
   NTE=NTERMS+1
   J=K
   GO TO 255
C
C
250 DF=NTERMS-NTE
   SSQ=SSR(K)-SSR(J)
   XMSEQ=SSQ/DF
   F=XMSEQ/(SSR(JACK)/DFREE(JACK))
   NDF=DF
   WRITE (6,430) K,NDF,SSQ,XMSEQ,F
   J=K
   NTE=NTERMS
255 CONTINUE
   IF (NRES) 260,265,260
260 WRITE (6,455)
   DO 265 I=1,NLINES
265 WRITE (6,460) (TITL(I),I),18
   WRITE (6,435) ORDIN(JIM,1),ORDIN(JIM,2)
   WRITE (6,440)
DO 270 I=1,1C
    ZR(I)=0,0
    IF (IOUT1.NE.1) GO TO 275
    WRITE (8) NCARDS
  275    DO 285 I=1,NCARDS
      XD=X(I)
      YD=Y(I)
      ZD=Z(I,JIM)
      CALL POLY (ZR,LIMIT,XD,YD,ZD)
      WRITE (6,445) ID(I),X(I),Y(I),Z(I,JIM),(ZR(K),K=1,10)
      IF (IOUT1.NE.1) GO TO 280
      WRITE (8) ID(I),X(I),Y(I),Z(I,JIM),(ZR(K),K=1,10)
  280    CONTINUE
  285    CONTINUE
    DO 295 I=1,5
      IF (ISURF(I).NE.1.AND.ISURF(I).NE.2) GO TO 290
      CALL EVALU (A,I,ISURF,TITLE,NLINES,ORDIN,JIM)
  290    CONTINUE
    CONTINUE
  295    CONTINUE
  300    CONTINUE
    GO TO 5
C
C 305    WRITE (6,450)
    GO TO 5
C
C 310    CONTINUE
    IF (IOUT1.NE.1) GO TO 315
    END FILE 8
    REWIND 8
  315    CONTINUE
    STOP
C
C 320    FORMAT (8A10)
  325    FORMAT (1H1,13HTHE XX MATRIX///4H ROW)
  330    FORMAT (1H0,13,2X,11E1E3,6X,10E10.3)
  335    FORMAT (1H1,13HTHE BB MATRIX///4H ROW)
  340    FORMAT (1H0,13,2X,E16.4)
  345    FORMAT (1H1,21HTHE REVISED XX MATRIX///4H ROW)
  350    FORMAT (1H0,12H MEAN 1,4E17.8)
  355    FORMAT (///50X,47HCORRECTED TOTAL SS= TOTAL SS - SS DUE TO MEAN ///1F20.6)
  360    FORMAT (///1X,81HPERCENT SS EXPLAINED BY REGRESSION=MULTIPLE CORR 1ELATION COEFFICIENT ( R-SQUARED )///54H DEGREE PERCENT VARIAT! 2ON EXPLAINED R-SQUARED R)
  365    FORMAT (1H0,14,15X,F10.3,10X,F7.5,3X,F7.5)
FORMAT (A6)
FORMAT (A6,4X,5I1,5I1,4X,1I3X,12.6X,5I1,9X,1I,9X,1I)
FORMAT (1H0,///,5X,52HTREND SURFACE ANALYSIS USING POWER SERIES EXPANSIONS///5X,48H POLYNOMIALS UP TO FIFTH DEGREE CAN BE REQUESTED///2)
FORMAT (46H THE COEFFICIENT MATRIX FOR THE FIT OF DEGREE I1,70H IS MACHINE SINGULAR. THE PROGRAM WILL TRY THE OTHER FITS ASKED FOR 2.)
FORMAT (1H0,X15,39H THE NUMBER OF POINTS IN THIS GROUP IS I1,15///1)
FORMAT (1H0,25X,98HTREND SURFACE EQUATIONS FOR / 181HTHE COEFFICIENTS, WITH THE CONSTANT TERM LISTED FIRST. THE FOR 2M OF THE POLY IS //12H Z=A1+A2X+A3Y+A4X2+A5XY+A6Y2+A7X3+A8X2Y+3A9XY2+A10Y3+A11X4+A12X3Y+A13X2Y2+A14+XY3+A15Y4+A16X5+A17X4Y+A18X3Y+42+*** ETC.//1X7H DEGREE)
FORMAT (1H0,14,3X,7E16.7///E24.7,6E16.7///E24.7,6E16.7)
FORMAT ///51H ESTIMATE OF ERROR IN THE COEFFICIENTS OF THE POLYS/ 1/10H DEGREE)
FORMAT (1H0,16,1X,7F16.2///F24.7,F16.2///F24.2,F16.2)
FORMAT (56H0 ANALYSIS OF VARIANCES FOR ALL REGRESSION IS///1X99H SOURCE D F SS DUE REG MS DUE REG 2 SS ERROR MS F PROPF RATIO )
FORMAT (1H0,7H DEGREE I1,13///1H,14///E17.8,E16.8,E19.8,F18.5,F14.3)
FORMAT ///34H ANALYSIS OF VARIANCE FOR I1,12H DEGREE PO ILY///75H DEGREE OF SOURCE D F SUM OF SQUARES MEAN SQUARE 2RE F RATIO )
FORMAT (7X,11,12X,I2,F20.8,E20.8,F17.5)
FORMAT (1H0,18X,82HCORDINATES,ORIGINAL AND COMPUTED VALUES,AND RE SIDUALS FOR ALL SURFACES REQUESTED///40X,12H DATA IS FOR ,2A10, 2/)
FORMAT (1H0,8X,115HIC X Y Z Z LINEAR RES L 1 Z QUAD RES QUD Z CUBIC RES C Z QUAR RES QR Z QUINT RES 20T 1X)
FORMAT (1H ,A10,2F8.2,F9.3,5LF9.3,F9.3)
FORMAT (104HTHE LIMIT PARAMETER IS ZERO FOR THIS GROUP. THIS MEANS 1 NO FIT WAS ASKED FOR GOING ON TO NEXT GROUP. )
FORMAT (1H1)
FORMAT (1H ,2X,8A10)
FORMAT (8A10)
FORMAT (1H0,3X,9HDATA FOR ,2A10, )
END
SUBROUTINE READ1

PURPOSE -
TO READ ID,X,Y,Z1,Z2,Z3,Z4 DATA FROM THE DATA CARDS.

THE DATA CARDS SHOULD BE PRECEDED BY A FORMAT CARD (COLS 7-78)
AND BE FOLLOWED BY A BLANK CARD. THE SUBROUTINE DETERMINES THE NUM-
BER OF POINTS IN THE DATA SET BY SEARCHING FOR A CARD CONTAINING
BLANKS IN COLUMNS 1-10.

USAGE -
CALL READ1(NCARDS)

NCARDS - THE NUMBER OF DATA POINTS BEING ANALYZED. THIS IS DETER-
MINED BY READ1.

SUBROUTINE READ1 (NCARDS)
DIMENSION X(100), Y(100), Z(100), ID(100)
DIMENSION FMT(12)
COMMON X,Y,Z, ID
DATA NLANK/10H /
I=1
READ (5,20) FMT
5 READ (5,FMT) ID(I),X(I),Y(I),Z(I,1),Z(I,2),Z(I,3),Z(I,4)
WRITE (1) ID(I),X(I),Y(I),Z(I,1),Z(I,2),Z(I,3),Z(I,4)
IF (ID(I)-NLANK) 10,15,20
10 I=I+1
GO TO 5
15 NCARDS=I-1
RETURN
20 FORMAT (6X,12A6)
END
SUBROUTINE INVER(XX,XINV,K,NDEGRE)

XX = MATRIX FROM WHICH INVERSE IS REQUIRED.
XINV = THE CALCULATED INVERSE.
K = NUMBER OF TERMS IN EQUATION.
NDEGRE = DEGREE OF EQUATION.

DIMENSION XX(21*21),XINV(21*21),AM(21,22)
COMMON DUMMY,SOB

DO 5 I=1,K
DO 5 J=1,K
AM(I,J)=XX(I,J)
K=K+1
CONTINUE

DO 10 I=1,K
DO 10 J=1,K
NC(I)=0
CONTINUE

DO 15 J=1,K
DO 20 L=1,J
IF(NC(L))20,25,20
20 CONTINUE
IF(AM(I,L))25,35,35
25 AM(I,L)=AM(I,L)+1
IF(K-AM(I,L))30,15,15
30 CONTINUE
AM=ABS(AM)
CONTINUE

IF(AM(1))40,30,30
30 AM=AM(1)
GO TO 40

DO 40 I=1,K
DO 40 J=1,K
DO 45 L=1,J
IF(NC(L))45,40,40
40 CONTINUE
AMB=AM(1)
IF(AM(AMB))40,30,30
30 AM=AMB
GO TO 40

INITIALIZE THE ROW PERMUTATION CELLS TO ZERO.
TEST FOR MAXIMAL SIZE PIVOT ELEMENT.

Purpose:
To invert the XX matrices for all surfaces being fitted.
Usage:
CALL INVER(XX,XINV,K,NDEGRE)
N(J) = I

ADJOIN THE CORRECT IDENTITY COLUMN VECTOR.

DO 65 IZ=1,K
   AM(IZ, KK) = 0.0
   AM(I, KK) = 1.0
   DA = AM(I, 1)

NORMALIZE THE PIVOTAL ROW.

DO 70 IZ=2,KK
   AM(I, IZ-1) = AM(I, IZ) / DA
DO 85 IZ=1,K
   IF (IZ-I) .LE. 75,85,75
   DA = AM(IZ, 1)

ZERO OUT NON-PIVOTAL COLUMN ELEMENTS.

DO 90 JZ=2,KK
   AM(IZ, JZ-1) = AM(IZ, JZ) - AM(I, JZ-1) * DB
CONTINUE

DO 100 I=1,K
   DO 90 J=1,K
      IF (N(J)-I) .LE. 90,95,90
      CONTINUE

CONTINUE

DO 100 L=1,K
   LL = N+L
   XINV(L, NDEGRE) = AM(LL, J)
RETURN
END
SUBROUTINE INVCK

PURPOSE -
TO DETERMINE AND PRINT OUT THE PRODUCT OF THE XX AND XX INVERSE
MATRICES FOR ALL SURFACES BEING FITTED. THIS SUBROUTINE CALLED ONLY
WHEN INCK (COL 25, MASTER CONTROL CARD) IS SET EQUAL TO 1 (SEE DES-
CRIPTION OF CONTROL CARDS PAGE ).

THESE LISTINGS CAN BE EXAMINED TO DETERMINE IF STRONG DISCREP-
ANCIES FROM AN IDENTITY MATRIX OCCUR FOR ANY SURFACE. IF DISCREP-
ANCIES OCCUR, THE COEFFICIENTS SHOULD BE REGARDED WITH SUSPICION.

USAGE -
CALL INVCK(A, B, K)

A - ORIGINAL XX MATRIX.
B - INVERSE MATRICES FOR EACH DEGREE SURFACE.
K - NUMBER OF TERMS IN EQUATION OF EACH SURFACE = SIZE OF IDENTITY
AND OTHER MATRICES.

SUBROUTINE INVCK (A, B, K)
DIMENSION A(21,21), B(21,21,5), C(21)
N=((K+1)*(K+2))/2
WRITE (6,15) K
DO 10 I=1,N
   DO 5 J=1,N
      C(J)=0.0
   DO 5 L=1,N
      C(J)=A(I,L)*B(L,J,K)+C(J)
 5  WRITE (6,20) I, (C(J), J=1,N)
10  WRITE (6,15) K
RETURN

15  FORMAT (1H1, 77H THE PRODUCT OF THE COEFFICIENT MATRIX AND ITS INVE-
IRSE FOR THE FIT OF DFCREF */2/,//4H ROW)
20  FORMAT (1H0, 13, 2X, 11F10.7, 7X, 10F10.7)
END
SUBROUTINE POLY

PURPOSE --
TO EVALUATE THE EQUATIONS OF THE REQUESTED SURFACES AT EACH
OBSERVED DATA LOCATION IN ORDER TO DETERMINE THE ESTIMATED VALUES
AND THE RESIDUALS FOR EACH DATA POINT.

USAGE --
CALL POLY(ZR,LIMIT,XDD,YDD,ZDD)

ZR - UP TO TEN VALUES WHICH ARE THE CALCULATED AND RESIDUAL VALUES
FOR THIS DATA POINT FOR ALL SURFACES REQUESTED.
LIMIT - PARAMETER SPECIFYING WHICH SURFACES ARE BEING FITTED.
XDD - X COORDINATE OF THIS DATA POINT.
YDD - Y COORDINATE OF THIS DATA POINT.
ZDD - Z COORDINATE OF THIS DATA POINT.

SUBROUTINE POLY(ZR,LIMIT,XDD,YDD,ZDD)
DIMENSION A(21,5), ZR(10), XD(1), YD(1), ZD(1), PTU)
DIMENSION XDD(1), YDD(1), ZDD(1)
DIMENSION LIMIT(5), DUMMY(12205)
COMMON DUMMY,A
XD=XDD
YD=YDD
ZD=ZDD
DO 40 K=1,5
  IF (LIMIT(K)) 5,40,5
  GO TO (10,15,20,25,30), K
10  PT=A(1,K)+XD*A(2,K)+YD*A(3,K)
   GO TO 35
15  PT=A(1,2)+XD*A(2,2)+YD*A(3,2)+XD*XD*A(4,2)+XD*YD*A(5,2)+YD*YD*A(6,2)
   GO TO 35
20  XD2=XD*XD
   YD2=YD*YD
   PT=A(1,3)+XD*A(2,3)+YD*A(3,3)+XD2*A(4,3)+XD*YD*A(5,3)+YD2*A(6,3)
   +XD2*YD*A(7,3)+XD2*YD*A(8,3)+XD*YD2*A(9,3)+YD2*YD*A(10,3)
   GO TO 35
25  XD2=XD*XD
   XD3=XD2*XD
   YD2=YD*YD
   YD3=YPD2*YD
   PT=A(1,4)+XD*A(2,4)+YD*A(3,4)+XD2*A(4,4)+XD*YD*A(5,4)+YD2*A(6,4)
   +XD3*YD*A(7,4)+XD2*YD2*A(8,4)+XD*YD2*A(9,4)+YD3*A(10,4)+XD2*YD2*A(11,4)
   +XD3*YD2*A(12,4)+XD2*YD2*A(13,4)+XD*YD3*A(14,4)+YD2*YD2*A(15,4)
   GO TO 35
C

30  XD2=XD*XD
    XD3=D2*XD
    XD4=AD*XD
    YD2=YZ*YD
    YD3=YD2*YD
    YD4=YD3*YD

    PT=A(1,5)+XD*A(2,5)+YD*A(3,5)+XD2*A(4,5)+XD*YD*A(5,5)+YD2*A(6,5)
    +XD3*A(7,5)+XD2*YD*A(8,5)+XD*YD2*A(9,5)+YD3*A(10,5)

    PT=PT+XD4*A(11,5)+XD3*YD*A(12,5)+XD2*YD2*A(13,5)+XD*YD3*A(14,5)
    +YD4*A(15,5)+XD4*YD*A(16,5)+XD*YD4*A(17,5)+XD*YD2*A(18,5)+YD*YD

    ZR(2*K+1)=PT
    ZR(2*K)=ZD-PT

40  CONTINUE
RETURN
END
SUBROUTINE EVALU

PURPOSE -
TO EVALUATE THE EQUATIONS OF THE SURFACES AT A SERIES OF EQUALLY SPACED (GRIDDED) LOCATIONS SO THAT CONTOUR MAPS OF THE SURFACES CAN BE PREPARED.

USAGE -
CALL EVALU(A,K,ISURF,TITL,NLINES,ORDIN,JIM)

A - MATRIX CONTAINING POLYNOMIAL COEFFICIENTS
K - COUNTER USED TO IDENTIFY SURFACES IN MAP TITLES.
ISURF - PARAMETER USED TO SPECIFY MAPPING OR GRIDDING OPTIONS.
TITL - GENERAL ALPHANUMERIC TITLE(S), NUMBER SPECIFIED BY NLINES
NLINES - NUMBER OF TITLE LINES (NUMBER OF CARDS), MAXIMUM = 5.
ORDIN - SPECIFIC ALPHANUMERIC TITLES USED TO IDENTIFY VARIABLES.
JIM - COUNTER USED TO IDENTIFY WHICH VARIABLE (1-4) BEING ANALYZED

INTEGER COLS, ROWS
DIMENSION ISURF(5)
DIMENSION A(21,5), C(100,100), DUMMY(2205)
DIMENSION TITL(8,5), ORDIN(4*2)
COMMON C,DUMMY,A
READ (5,9) XMAX,XMIN,YMAX,YMIN
READ (5,95) ROWS,COLS,NMAP,IPUN
XINC=(XMAX-XMIN)/FLOAT(COLS-1)
YINC=(YMAX-YMIN)/FLOAT(ROWS-1)

ZERO C ARRAY

DO 5 KK=1,95
DO 5 JJ=1,95
C(JJ,KK)=0.0

DEFINE STARTING X AND Y

XD=XMIN
YD=YMAX
DO 45 JJ=1,ROWS
   DO 44 KK=1,COLS
      GO TO (10,15,20,25,30), K
10    PT=A(1,1)+XD*A(2,1)+YD*A(3,1)
      GO TO 35

C

15    PT=A(1,2)+XD*A(2,2)+YD*A(3,2)+XD*XD*A(4,2)+XD*YD*A(5,2)+YD*Y
      D*A(6,2)
      GO TO 35

C
C
20

\[ XD2 = XD \times XD \]

\[ YD2 = YD \times YD \]

\[ PT = A(1,3) + XD \times A(2,3) + YD \times A(3,3) + XD2 \times A(4,3) + XD \times YD \times A(3,9) + YD2 \times A(6,3) + XD2 \times XD \times A(7,3) + XD2 \times YD \times A(8,3) + XD \times YD2 \times A(9,3) + YD2 \times YD \times A(10,3) \]

GO TO 33

C C
25

\[ XD2 = XD \times XD \]

\[ XD3 = XD2 \times XD \]

\[ YD2 = YD \times YD \]

\[ YD3 = YD2 \times YD \]

\[ PT = A(1,4) + XD \times A(2,4) + YD \times A(3,4) + XD2 \times A(4,4) + XD \times YD \times A(3,9) + YD2 \times A(6,4) + XD3 \times A(7,4) + XD2 \times YD \times A(8,4) + XD \times YD2 \times A(9,4) + YD2 \times YD \times A(10,4) \]

GO TO 35

C C
30

\[ XD2 = XD \times XD \]

\[ XD3 = XD2 \times XD \]

\[ XD4 = XD3 \times XD \]

\[ YD2 = YD \times YD \]

\[ YD3 = YD2 \times YD \]

\[ YD4 = YD3 \times YD \]

\[ PT = A(1,5) + XD \times A(2,5) + YD \times A(3,5) + XD2 \times A(4,5) + XD \times YD \times A(5,5) + YD2 \times A(6,5) + XD3 \times A(7,5) + XD2 \times YD \times A(8,5) + XD \times YD2 \times A(9,5) + YD2 \times YD \times A(10,5) \]

\[ PT = PT + XD4 \times A(11,5) + XD3 \times YD \times A(12,5) + XD2 \times YD2 \times A(13,5) + XD \times YD3 \times A(14,5) + YD4 \times A(15,5) \]

GO TO 35

C(JJ,KK) = PT
40

\[ XD = XD + XINC \]

\[ XD = XMIN \]

\[ YD = YD - YINC \]

WRITE (6,130)

DO 50 I=1,NLINES

WRITE (6,135) (TITL(I,I),II=1,8)

WRITE (6,145) ORDIN(JIM,1),ORDIN(JIM,2)

WRITE (6,150) K,COLS,ROWS

WRITE (6,160) XMAX,XMIN,YMAX,YMIN

DO 55 JJ=1,ROWS

WRITE (6,170) (C(JJ,KK),KK=1,COLS)

55

WRITE (6,180) IF (IPUN) 60,75,60

DO 65 I=1,NLINES

PUNCH 1,I (TITL(I,I),II=1,8)

PUNCH 1,I ORDIN(JIM,1),ORDIN(JIM,2)

PUNCH 15,I,K,COLS,ROWS

DO 70 J=1,ROWS

PUNCH 125,(C(JJ,KK),KK=1,COLS)

70

CONTINUE
CONTINUE
IF (ISURF(K) .NE. 2.0 OR COLS .GT. 42) GO TO 85
DO 80 I = 1, NMAP
80 CALL PLOT (C, ROWS, COLS, K, TITL, NLINE, ORDIN, JIM)
CONTINUE
RETURN
C C C
90 FORMAT (4F10.3)
95 FORMAT (3I3, I1)
100 FORMAT (1H0, 36HGRIDDED VALUES OF SURFACE OF DEGREE 11H9H GRID I 1I3, 12H COLUMNS BY 1I3, 6H ROWS)
105 FORMAT (3X, 36HGRIDDED VALUES OF SURFACE OF DEGREE 11H9H GRID IS 1I3, 12H COLUMNS BY 1I3, 6H ROWS)
110 FORMAT (1H0, 55H MAXIMUM AND MINIMUM COORDINATE VALUES READ IN ARE 1MAX=F10.3, 6H XMIN=F10.3, 6H YMAX=F10.3, 6H YMIN=F10.3//)
115 FORMAT (1H0, 12F10.3)
120 FORMAT (1H0)
125 FORMAT (8F10.3)
130 FORMAT (1H1)
135 FORMAT (1H0, 23X, 3A10)
140 FORMAT (8A10)
145 FORMAT (1H0, 1X, 13H ANALYSIS FOR 2A10;////)
150 FORMAT (2X, 2A10)
END
SUBROUTINE PLOT

DIMENSION SYMTAB(9), FSMT(13), ICON(10), DRANG(25), ZFROV(171)
SYM(121), 2(100,100), TILT(3,5), ORDIN(4,2)
INTEGER ROWS, COLS, CONTOUR, COLMAX, COL, SYM, PS, GRID, SYMBLANK, PLUS,
MINUS, STAR, SYMTAB, STOP, STOP
REAL MINZ, MAXZ
DATA (SYMTAB), 19=21, -100, 100, TIL(3,5), ORDIN(4,2)

READ (5,170) CONTOUR, LINES, INCHES
J1=0
MM=0
N=ROWS*COLS

WRITE (6,175)
100 10 I=1,LINES
WRITE (6,180) MM(11), I=1,8
WRITE (6,185) ORDIN(J1), I=1,2
WRITE (6,190) COLMAX, MM, ROWS
CALL STATS (ROWS, COLS, 10, 100, 7, ZBAR, XP, ZSIG, MAXZ, MINZ)
DETERMINE WHICH LINE PLACEMENTS
TOUR VALUE DETERMINES METHOD USED IN DEFINING CONTOURS

IF (TOUR GT 3 OR TOUR LE 0) GO TO 30
GO TO (15 20 25) + TOUR
WRITE (6, 195)
READ (5, 215) If *ZMAX
GO TO 35
READ (5, 215) IMCON
WRITE (6, 210)
READ (6,1 IMCON) (DRANG(I), I=1:CON)
ZMIN=DRANG(1)
ZMAX=DRANG(CON)
GO TO 35
ZMIN=Z3, R=Z0+ZSIG
ZMAX=Z3, R=Z0+ZSIG
CON=13
WRITE (6, 215)
GO TO 36
WRITE (6, 220)
ZMIN=MINZ
ZMAX=MAXZ
WRITE (6, 225) ROWS, COLS, ZBAR, ZSIG, MAXZ, MINZ

CALCULATE MAP WIDTH IN CHARACTERS (COL)

IF (INCHES LE 0.2) COL = 10
IF (INCHES GT 12.7) COL = 127
IF (INCHES GT 7.1 AND INCHES LE 12.7) COL = INCHES # 10.0
PS = (COL-COLS) / (COLS-1)
TEST GRID SIZE — IF GRID SMALLER THAN 2 CHARACTERS BETWEEN COLUMNS,
AN ERROR STATEMENT IS PRINTED AND PLOTTING ABORTED

IF (PS GT 1) GO TO 40
WRITE (6, 220)
GO TO 165

CALCULATE REQUIRED CONSTANTS

COLMAX = PS * (COLS - 1) + COLS
YINC=1.0/((FLOAT(PS+1))*0.6)
GRID=PS+1
XINC=1.0/FLOAT(GRID)
RANGZ=ZMAX-ZMIN
RHIGH=ZMAX+RANGZ
RLOW=ZMIN-RANGZ
IF (CON.EQ.0.OR.CON.GT.19) CON=5
FCON=CON
CI=RANGZ/FCON
IF (TOUR.EQ.2) GO TO 50
JJJ=CON+1
DO 45 I=1,JJJ
DRANG(I)=ZMIN+FLOAT(I-1)*CI
45 CONTINUE
WRITE (6,235)
WRITE (6,240) ZMIN,ZMAX,CI,GRID,XINC,YINC,CON,PS,COLMAX

C
C WRITE OUT CONTOUR SYMBOL TABLE
C
C
C WRITE (6,245)
IF (LINES.EQ.1) WRITE (6,250)
WRITE (6,255)
IF (LINES.NE.0) GO TO 55
WRITE (6,260)
WRITE (6,265) (SYMTAB(I),DRANG(I),I=1,CON)
WRITE (6,270) GO TO 60

55 WRITE (6,275)
WRITE (6,280) (SYMTAB(I),DRANG(I),DRANG(I+1),I=1,CON)
WRITE (6,285) DRANG(CON+1)
60 WRITE (6,175)
DO 65 I=1,NLINES
65 WRITE (6,180) (TITL(I),I=1,8)
WRITE (6,185) ORDIN(JIM+1),ORDIN(JIM+2)
WRITE (6,190) KOLD,N,CCLS,ROWS
XSTOP=GRID
GRID=COLS-1
COL=3
DO 75 J=1,GRID
   DO 70 I=2,XSTOP
      SYM(COL)=BLANK
70   COL=COL+1
      SYM(COL)=PLUS
75   COL=COL+1
M=COLMAX+2
SYM(2)=PLUS
SYM(1)=BLANK
SYM(N)=BLANK
WRITE (6,290) (SYM(I),I=1,N)
**ESTIMATE VALUE OF ALL PRINTING POSITIONS ON MAP**

**LOOP THROUGH MAP LENGTH, ROW BY ROW**

```plaintext
ITOP=1
IROW=IROWS+1
DO 160,1=M,2,IROW
   YSTOP=1./YINC+.5
   IF (MN.EQ.IROW) YSTOP=1
   M=M-1
   YP=0.
   PSYM(1)=PLUS
   PSYM(N)=PLUS
   DO 160 KJ=1,YSTOP
      COL=1
      ZL=YP*(Z(M,J)+Z(M+1,J)+Z(M,J+1))
      IF (ZL.GT.ZMAX) GO TO 85
      IF (ZL.LE.ZMIN) GO TO 80
      PSYM(COL)=MINUS
      ZPREV(COL)=ZEST
      ZLAST=ZEST
      GO TO 130
   80 IF (ZL.EQ.ZLOW) GO TO 90
      IF (ZL.LE.ZLOW) GO TO 85
      PSYM(COL)=BLANK
      ZPREV(COL)=ZEST
      ZLAST=ZEST
      GO TO 130
   160 IF (ZL.LE.ZLOW) GO TO 90
      IF (ZL.LE.ZLOW) GO TO 85
      PSYM(COL)=MINUS
      ZPREV(COL)=ZEST
      ZLAST=ZEST
      GO TO 130
```
IF (ZEST .GE. RHIGN) GO TO 90
PSYM(COL) = PLUS
ZPREV(COL) = ZEST
ZLAST = ZEST
GO TO 130

C
90
PSYM(COL) = STAP
ZPREV(COL) = ZEST
ZLAST = ZEST
GO TO 130

C
95
I = ((ZEST - ZMIN) / CI) + 1
LVAL = LINES + 1
IF (ITOP .EQ. 1 OR MM .EQ. ROW OR JLFT .EQ. 1) LVAL = 3
GO TO (100, 120, 125), LVAL

100
DO 105 I = 1, CON
  ZSTEP = DRANG(I)
  SW1 = 1
  SW2 = 1
  SW3 = 1
  SW4 = 1
  IF (ZSTEP .GE. ZLAST .OR. ZSTEP .GE. ZPREV(COL)) SW1 = 0
  IF (ZSTEP .LE. ZEST) SW2 = 0
  IF (ZSTEP .LT. ZLAST .OR. ZSTEP .LT. ZPREV(COL)) SW3 = 0
  IF (ZSTEP .GE. ZEST) SW4 = 0
  IF ((SW1 .EQ. 0 AND SW2 .EQ. 0) OR (SW3 .EQ. 0 AND SW4 .EQ. 0)) GO TO 110

105
CONTINUE
PSYM(COL) = BLANK
GO TO 115

C
110
PSYM(COL) = SYMTAB(I)
115
ZLAST = ZEST
ZPREV(COL) = ZEST
GO TO 130

C
120
K = I / 2
IF ((K * 2) .NE. I) PSYM(COL) = SYMTAB(I)
IF ((K * 2) .EQ. I) PSYM(COL) = BLANK
GO TO 130

C
125
PSYM(COL) = SYMTAB(I)
ZPREV(COL) = ZFST
130
XP = XP + XINC
71 = Z2
135
JLFT = 0
COL = COL + 1
IF (Z(M * COLS) .GE. ZMIN AND Z(M * COLS) .LE. ZMAX) GO TO 150
IF (Z(M * COLS) .GT. ZMAX) GO TO 140
IF (Z(M * COLS) .LE. RLOW) GO TO 145
PSYM(COL) = MINUS
GO TO 155
IF (Z(M,COLS) .GE. RHIGH) GO TO 145
PSYM(COL) = PLUS
GO TO 155

PSYM(COL) = STAR
GO TO 155

I = ((Z(M,COLS) - ZMIN) / CI) + 1
PSYM(COL) = SYMTAB(I)

WRITE (6,290) (PSYM(L), L = 1,N)
YP = YP + YINC
PSYM(I) = BLANK
PSYM(N) = BLANK

IT0P = U
WRITE (6,290) (SYM(L), L = 1,N)
CONTINUE
RETURN

FORMAT (12, 211, F4.0)
FORMAT (1H1)
FORMAT (1H0, 20X, 8A10)
FORMAT (1H0, 10X, 21H ANALYSIS OF DATA FOR /*2A10,///)
FORMAT (1H0, 33H CONTOUR MAP OF SURFACE OF DEGREE /*13,37H. THE EQUATION HAS BEEN EVALUATED AT /*14,21H LOCATIONS ON A GRID */13,12H COLUMN 2KNS BY */13,6H ROWS.///)
FORMAT (25H CONTOUR LEVELS SPECIFIED)
FORMAT (2F10.0)
FORMAT (10A6)
FORMAT (37H VARIABLE CONTOUR INTERVALS SPECIFIED)
FORMAT (39H CONTOUR INTERVAL = UI/2 SIGMA)
FORMAT (26H CONTOUR LEVELS CALCULATED)
FORMAT (14H GRIDDED DATA/*42H LINEAR INTERPOLATION WITHIN GRID SQUARES /// /*17H OBSERVED VALUES /// /*8H ROWS = */13,10H COLS = */13,8
2H ZBAR = */F10.3,10H ZSIG = */F10.3,10H MAXZ = */F10.3,10H MINZ = */F10.3)
FORMAT (25H TOO MANY COLUMNS IN GRID)
FORMAT (1H /*16H VALUES EMPLOYED)
FORMAT (8H ZMIN = */F10.3,10H ZMAX = */F10.3,8H CI = */F10.3,8H
1GRID = */I5,10H XINC = */F10.3,10H YINC = */F10.3,7H CON = I5,8
2H PS = */I5,12H COLMAX = */I5)
FORMAT (35H CONTOUR SYMBOL TABLE IS AS FOLLOWS)
FORMAT (43H (ONLY EVEN SYMBOLS PRINTED IN BODY OF MAP))
FORMAT (7H SYMBOLS, 11X, 5H VALUE)
FORMAT (5H 0 *,6X,7HMO DATA,/*5H */4X,10HBELOW LOW)
FORMAT (4X, A1, */2X, F12.4)
FORMAT (4X, 1H+, */4X, 10HABOVE HIGH)
FORMAT (5H *,25X,7HMO DATA,/*5H */23X,10HBELOW LOW)
FORMAT (4X, A1,2X, F12.4,6H TO */F12.4)
FORMAT (4X, 1H+, */2X, F12.4,1CH OR OVER)
FORMAT (1H9,129A1)
END
JOB CONTROL CARDS NECESSARY TO RUN POLYFIT AND RESMAP AS ONE JOB

COL 1

ACCT, NAME, T800, CM70:00, PRIORITY
RUN(S, ..., 77777)
REQUEST(TAPE8, HI)  USER TAPE IDENTIFICATION (THIS CARD OPTIONAL)
LGO
RFY7U...0U
REWIND(LGO)
RUN(S, ..., 77777)
LGO

7-8-9 CARD  PROGRAM POLYFIT SOURCE DECK
7-8-9 CARD  POLYFIT CONTROL AND DATA CARDS (SEE BELOW)
7-8-9 CARD  PROGRAM RESMAP SOURCE DECK
7-8-9 CARD  RESMAP CONTROL CARDS
6-7-8-9 CARD
### PROGRAM POLYFIT - SAMPLE DATA CARDS

**NOTE** - THESE CARDS WILL FIT TRENDS 1-4, PRODUCE PRINTER MAPS, AND STORE DATA FOR RESMAP. FOUR DIFFERENT VARIABLES WILL BE ANALYZED.

THE DATA REPRESENTS WATER WELL OBSERVATIONS DURING THE LAST FOUR MONTHS OF 1967 IN BARTHOLOMEW COUNTY, INDIANA.

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---|---|---|---
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**33 23 11** | **100111.2**
PROGRAM RESMAP SHOULD FOLLOW IMMEDIATELY
SAMPLE OUTPUT FROM PROGRAM POLYFIT

TREND 1

TREND 2

TREND 3

TREND 4
PURPOSE -  TO BE USED IN CONJUNCTION WITH PROGRAM POLYFIT. THIS PROGRAM ANALYZES THE ORIGINAL AND RESIDUAL VALUES STORED ON TAPE8 BY PROGRAM POLYFIT. GRIDDED VALUES AND PRINTER CONTOUR MAPS ARE PRODUCED BY SUBROUTINES GRID AND PLTCON1 OR PLTCON2. A VARIETY OF CONTOUR MAPS MAY BE SPECIFIED, MULTIPLE MAPS OF ANY DATA MAY BE PRODUCED. THE GRIDDED VALUES MAY PRODUCE CALCOP CONTOUR MAPS USING PROGRAM CONTUR.

PURDUE UNIVERSITY VERSION 2.0  A. KEITH TURNER, CIVIL ENGINEERING, FEBRUARY, 1968

TAPE REQUIREMENTS -  TAPE8 IS USED TO STORE DATA DEVELOPED BY PROGRAM POLYFIT.

SUBROUTINES REQUIRED -
1) GRID - TO GRID THE IRREGULARLY SPACED DATA
2) PRTCON1 - TO PRODUCE PRINTER CONTOUR MAPS
   OR
3) PRTCON2 - TO PRODUCE GRADED DENSITY PRINTER CONTOUR MAPS

NOTE 1 - GRID CONTROL CARDS ARE REQUIRED FOR EACH ANALYSIS REQUESTED. SEE SECTION III.

NOTE 2 - PRTCON1 OR PRTCON2 CONTROL CARDS REQUIRED FOR EACH MAP REQUESTED (NUMBER OF MAPS = NUMBER OF MAPS PER REQUEST TIMES NUMBER OF ANALYSES REQUESTED). SEE SECTION IV.
C

PROGRAM RESMAP - MAIN PROGRAM

PROGRAM RESMAP(INPUT,OUTPUT,TAPE8,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT)
DIMENSION X(1000),Y(1000),Z(1000),IVAL(6),TITL(8)

5 READ(5,65) TITL
IF(EOF(5)) 55,6
6 READ(5,85) (IVAL(I),I=1,6)
DO 50 I=1,6
IF(IVAL(I).NE.1) GO TO 50
READ(8) NUM
IF(EOF(8)) 55,10
10 WRITE(6,60) NUM
WRITE(6,70) TITL
GO TO (20,21,22,23,24,25) I
20 DO 11 N=1,NUM
11 READ (8) ID,X(N),Y(N),Z(N),ZC1,ZR1,ZC2,ZR2,ZC3,ZR3,ZC4,ZR4,ZC5,ZR5
GO TO 45
21 DO 12 N=1,NUM
12 READ (8) ID,X(N),Y(N),ZC1,Z(N),ZC2,ZR2,ZC3,ZR3,ZC4,ZR4,ZC5,ZR5
GO TO 45
22 DO 13 N=1,NUM
13 READ (8) ID,X(N),Y(N),ZD,ZC1,ZR1,ZC2,Z(N),ZC3,ZR3,ZC4,ZR4,ZC5,ZR5
GO TO 45
23 DO 14 N=1,NUM
14 READ (8) ID,X(N),Y(N),ZD,ZC1,ZR1,ZC2,ZR2,ZC3,Z(N),ZC4,ZR4,ZC5,ZR5
GO TO 45
24 DO 15 N=1,NUM
15 READ (8) ID,X(N),Y(N),ZD,ZC1,ZR1,ZC2,ZR2,ZC3,ZR3,Z(N),ZC4,ZR4,ZC5,ZR5
GO TO 45
25 DO 16 N=1,NUM
16 READ (8) ID,X(N),Y(N),ZD,ZC1,ZR1,ZC2,ZR2,ZC3,ZR3,ZC4,ZR4,ZC5,Z(N)
45 REWIND 8
CALL GRID(NUM,X,Y,Z)
50 CONTINUE
GO TO 5
55 STOP
60 FORMAT(1H1,10X,32H NUMBER OF POINTS TO BE READ IN=,I4,///)
65 FORMAT(8A10)
70 FORMAT(1H1,5X,8A10)
85 FORMAT(6I1)
END
PROGRAM RESMAP - SAMPLE DATA CARDS

NOTE - THESE CARDS ARE DESIGNED TO ANALYZE DATA PRODUCED BY PROGRAM POLYFIT FROM THE SAMPLE DATA SHOWN THERE. THESE CARDS REQUEST THE PRODUCTION OF ORIGINAL AND FOUR DIFFERENT RESIDUAL MAPS FOR THE SAME FOUR MONTHS. PUNCHED CARD OUTPUT FOR THE GRIDDED VALUES WILL ALSO BE PRODUCED.

BARTHOLOMEW COUNTY WATER SURFACE ANALYSIS FOR SEPTEMBER 1967

11111
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - ORIGINAL WELL ELEV. DATA, SEPTEMBER 1967
11.0 0.0 16.0 0.0
100111.2
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - 1ST DEGREE RESIDUALS, SEPTEMBER 1967
11.0 0.0 16.0 0.0
100111.2
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - 2ND DEGREE RESIDUALS, SEPTEMBER 1967
11.0 0.0 16.0 0.0
100111.2
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - 3RD DEGREE RESIDUALS, SEPTEMBER 1967
11.0 0.0 16.0 0.0
100111.2
BARTHOLOMEW COUNTY WATER SURFACE ANALYSIS FOR OCTOBER 1967

11111
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - ORIGINAL WELL ELEV. DATA, OCTOBER 1967
11.0 0.0 16.0 0.0
100111.2
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - 1ST DEGREE RESIDUALS, OCTOBER 1967
11.0 0.0 16.0 0.0
100111.2
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - 2ND DEGREE RESIDUALS, OCTOBER 1967
11.0 0.0 16.0 0.0
100111.2
33 23 101 1
BARTHOLOMEW COUNTY GROUND WATER - 3RD DEGREE RESIDUALS, OCTOBER 1967
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100111.2
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<td>11.0 0.0 16.0 0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART III

PROCEDURES FOR ASSIGNING
IRREGULARLY SPACED (RANDOM) DATA
TO A SQUARE GRID

NOTE - This procedure must precede any attempt to machine-contour irregularly spaced data. Since potential users may wish to clearly understand the underlying principles used in subroutine GRID, a description of the algorithm is included.

CONTENTS OF THIS SECTION

1) Description of Interpolation Algorithm

2) SUBROUTINE GRID

3) SUBROUTINE STATS
AN INTERPOLATION ALGORITHM FOR GEOGRAPHICAL DATA

The documentation for this algorithm and a MAD language program were obtained from Professor W. R. Tobler, Geography Department, University of Michigan. The MAD language program formed the basis of the Subroutine GRID. The algorithm involves a weighted moving average procedure, and appears to give results which are comparable to those obtained by the fitting of local polynomials, but is computationally much simpler. Following considerable (empirical) testing, the main disadvantage appears to be a slight dampening (or smoothing) effect on the data. This approaches 10% of the data range for extremely erratic data, but for commonly encountered data distributions is much less. Competing schemes are described in the references cited.

The following discussion was obtained from Tobler:

Definitions:

An observation is recorded as \( X_i, Y_i, Z_i ; i = 1, \ldots, N \), where \( X, Y \) are locational coordinates and \( Z \) is a value at \( S, Y \).

Lattice points are labelled \( jk \) in standard matrix notation (\( j = \) row subscript, and \( K = \) column subscript). The problem is to estimate \( Z_{jk} \).

Procedure:

1. Calculate \( A \), the area of the rectangle bounded by the maximum and minimum of the coordinate values \( X \) and \( Y \).

2. Let the grid size, \( G \), equal the square root of the area divided by the number of observations,

\[
G = (A/N)^{1/2}
\]

3. The number of rows in the matrix is computed as the (truncated) integer part of

\[
R = (\Delta Y/G) + 1.5
\]
and the number of columns as the integer part of

\[ C = \lfloor \Delta X/G \rfloor + 1.5 \]

This yields a matrix which has approximately \( N \) entries.

\[(4)\] In general, because of truncation,

\[ (C - 1) \cdot G \neq \Delta X \]
\[ (R - 1) \cdot G \neq \Delta Y \]

Split the difference, letting

\[ \Delta^i X = (\Delta X - (C - 1) \cdot G)/2 \]
\[ \Delta^i Y = (\Delta Y - (R - 1) \cdot G)/2 \]

and assign \( X \) and \( Y \) coordinates to positions in the matrix. For example, the \( j^\text{th} \) row and the \( k^\text{th} \) column will have the coordinates

\[ X_k = X_{\text{min}} + \Delta^i X + (k - 1) \cdot G \]
\[ Y_j = Y_{\text{max}} - \Delta^i Y + (j - 1) \cdot G \]

\[(5)\] For each position in the matrix calculate the square of the distance to each observation using

\[ D_i^2 = (X_k - x_i^j)^2 + (Y_j - y_i^j)^2 \]

and rank the points in order of increasing distance from the \( jk^\text{th} \) lattice point as they are computed, saving the results for only the nearest six points, except if \( D_i^2 < \epsilon \) in which case set \( Z_{jk} = Z_i \) and proceed to the next position in the matrix since the assignment has been completed. (We have taken \( \epsilon = G/25 \), but this is arbitrary).
(6) Assign a value to the jkth position by using a weighted mean of the value at the nearest point with the weighted mean of the nearest six points. Symbolically, using the notation $D_{i\alpha}$ to denote the rank $\alpha$ of the distance from the jkth position to the point $i$ and $Z_{il}$ for the observed value at the nearest point, this can be written as

$$Z_{jk} = \frac{\sum_{\alpha=1}^{6}\frac{Z_{i\alpha}}{D_{i\alpha}} + \sum_{\alpha=1}^{2}\frac{1}{D_{i\alpha}}}{\sum_{\alpha=1}^{6} \frac{1}{D_{i\alpha}}}$$

References:


SUBROUTINE GRID

PURPOSE -
TO ASSIGN SCATTERED OBSERVATIONS TO A SQUARE GRID. THE PROGRAM INVOLVES A WEIGHTED MOVING AVERAGE TECHNIQUE AND LINEAR INTERPOLATION WITHIN GRID SQUARES.

PURDUE UNIVERSITY VERSION 2.0
A. KEITH TURNER
CIVIL ENGINEERING
FEBRUARY, 1968

USAGE -> CALL GRID (N, X, Y, W3)

DESCRIPTION OF PARAMETERS -
N - NUMBER OF SCATTERED OBSERVATIONS
X - X CO-ORDINATES OF SCATTERED OBSERVATIONS
Y - Y CO-ORDINATES OF SCATTERED OBSERVATIONS
W - ELEVATION (Z CO-ORDINATE) VALUES OF SCATTERED OBSERVATIONS

DESCRIPTION OF CONTROL CARDS -

1) GRID SPECIFICATION CARD -
ROWS (COLS 1-3) NUMBER OF ROWS IN GRID
COLS (COLS 4-6) NUMBER OF COLUMNS IN GRID
GSIZE(COLS 7-10) SIZE OF GRID IN X-Y INPUT DATA UNITS
BND (COL11) IF BND=0, GRID BOUNDARIES CALCULATED FROM DATA
IF BND=1, GRID BOUNDARIES SPECIFIED ON CARD 3
LIST(COL12) IF LIST=1, INPUT DATA IS LISTED
IF LIST=2, INTERPOLATED VALUES ARE LISTED
IF LIST=3, BOTH INPUT AND INTERPOLATED VALUES ARE LISTED
IPUN(COL13) IF IPUN=1, GRID VALUES ARE PUNCHED
NWAP(COL14-15) NWAP = NUMBER OF DIFFERENT MAPS DESIRED
IPL0T(COL16) IF IPL0T=1, GRID CALLS SUBROUTINE PRTC0L1
IF IPL0T=2, GRID CALLS SUBROUTINE PRTC0L2
NOTE -- IF ANY ONE OF ROWS, COLS, OR GSIZE SPECIFIED, PROGRAM WILL COMPUTE THE OTHERS. IF NONE ARE SPECIFIED, PROGRAM SELECTS A GRID SIZE.

2) TITLE CARD -
ANY ALPHANUMERIC TITLE IN COLS 1-72

3) BOUNDARY SPECIFICATION CARD (OPTIONAL - REQUIRED ONLY IF BND=1)
MAXIMUM AND MINIMUM X-Y COORDINATE VALUES (XMAX, XMIN, YMAX, YMIN) IN COLS 1-10, 11-20, 21-30, 31-40 WITH DECIMALS PUNCHED

REQUIRED SUBROUTINES -

1) SUBROUTINE STATS

2) MAPPING SUBROUTINES ( IF NWAP GREATER THAN ZERO )
IF IPL0T=1, SUBROUTINE PRTC0L1 (PRODUCES BANDS OR LINES)
IF IPL0T=2, SUBROUTINE PRTC0L2 (PRODUCES SHADOWED DENSITY MAPS)
SUBROUTINE GRID (N, X, Y, W)

DIMENSION X(1000), Y(1000), W(1000), Z(1000,100), D(20), N(20), FO

1RM(10), TITL(12), A(6), B(6), C(6)

REAL MAXX, MINX, MAXY, MINY, MAXW, MINW, MAXZ, MINZ

INTEGER TAPE, YES, BND, ROWS, COLS

READ (5,110) ROWS, COLS, GSIZE, BND, LIST, IPUN, NMAP, IPILOT

READ (5,115) (TITL(I), I=1,12)

IF (LIST LE 1 OR LIST LE 3) GO TO 5

IF (LIST NE 2) WRITE (6,120) (TITL(I), I=1,12)

DO 10 I=1,N

10 IF (LIST EQ 1 OR LIST EQ 3) WRITE (6,130) I, X(I), Y(I), W(I)

CALL STATS (N, 1, 1000, 1, X, XBAR, DUM, XSIG, MAXX, MINX)

CALL STATS (N, 1, 1000, 1, Y, YBAR, DUM, YSIG, MAXY, MINY)

CALL STATS (N, 1, 1000, 1, W, WBAR, DUM, WSIG, MAXW, MINW)

WRITE (6,135) (TITL(I), I=1,12), N

IF (BND NE 1) GO TO 15

WRITE (6,140)

READ (5,145) XMAX, XMIN, YMAX, YMIN

GO TO 20

15 WRITE (6,150)

XMAX=MAXX

XMIN=MINX

YMAX=MAXY

YMIN=MINY

20 FN=MAXW-MINW

WMAX=FN+MAXW

WMIN=MINW-FN

MAXZ=MAXW

MINZ=MINW

WRITE (6,155) NMAP, LIST, BND, TAPE

M=0

FN=M=0

DX=XMAX-XMIN

DY=YMAX-YMIN

AREA=DX*DY

BEST=SORT (AREA/FN)

AVEDIS=BEST*1.07346

WRITE (6,160) XBAR, XSIG, MAXX, MINX, YBAR, YSIG, MAXY, MINY, WBAR, WSIG, MAXW

IF (GSIZE LE 0) GO TO 25

COLS=(1.5+DX/GSIZE)

ROWS=(1.5+DY/GSIZE)

M=1

GO TO 45

25 IF (COLS LE 1) GO TO 35

30 GSIZE=DX/FLOAT(COLS-1)
ROWS=(1.5+DY/GSIZE)
M=1
GO TO 45
C
35 IF (ROWS.LE.1) GO TO 4C
GSIZE=DY/FLOAT(ROWS-1)
COLS=(1.5+DX/GSIZE)
M=1
GO TO 45
C
40 GSIZE=BEST
COLS=(1.5+DX/GSIZE)
ROWS=(1.5+DY/GSIZE)
45 CONTINUE
IF (COLS.LE.100) GO TO 50
COLS=100
GO TO 30
C
50 WRITE (6,165)
IF (M.EQ.1) WRITE (6,170)
IF (M.NE.1) WRITE (6,175)
WRITE (6,180) XM, XMIN, YMAX, YMIN, GSIZE, ROWS, COLS
IF (LIST.EQ.2 .OR. LIST.EQ.3) WRITE(6,185) (TITL(I),I=1,12)
DY=(DY-(ROWS-1.5)*GSIZE)/2.0
DX=(DX-(COLS-1.5)*GSIZE)/2.0
YMAX=YMAX-DY
XMIN=XMIN+DX
HGRID=GSIZE/25.0
FN=(XMAX-MINW)/2.0
MAXX=MAXW+FN
MINX=MINW-FN
DO 90 M=1,ROWS
YP=YMAX-(FLOAT(M-1))*GSIZE
DO 90 J=1,COL5
XP=XMIN+(FLOAT(J-1))*GSIZE
DO 55 I=1,N
55 D(I)=1.E10
N1(1)=1
N1(2)=1
DO 75 I=1,N
75 DIST=((XP-X(I))**2)+(YP-Y(I))**2)
IF (DIST.GE.HGRID) GO TO 50
Z(M,J)=W(I)
GO TO 85
C
60 YES=MINO(I,8)
DO 70 K=1,YES
70 IF (DIST.GE.D(K)) GO TO 70
DO 65 JJ=K,YES
65 K=K+JJ
MN=KK+1
D(MN)=D(KK)
N1(MN)=N1(KK)
D(K)=DIST  
N1(K)=I  
GO TO 75

70 CONTINUE
75 CONTINUE
DUM1=0.0  
PSUM=0.0  
DO 80 I=1,6  
YES=N1(I)  
MAXW=1.0/(SORT(D(I)))  
PSUM=PSUM+MAXW  
80 DUM1=DUM1+W(YES)*MAXW  
DUM6=DUM1/PSUM  
N11=N1(I)  
DUM2=W(N11)  
DUM=(DUM2+DUM6)/2.0  
IF (DUM.GT.MAXX.AND.DUM.LE.MINX) Z(M,J)=DUM  
IF (DUM.LE.MAXX.AND.DUM.GT.MINX) Z(M,J)=DUM  
CONTINUE

90 CONTINUE  
IF (LIST.EQ.2.OR.LIST.EQ.3) WRITE(6,190) (Z(M,I),I=1,COLS)  
IF (IPUN.EQ.1) PUNCH 195, (Z(M,I),I=1,COLS)  
95 CONTINUE
NEWTOT=ROWS*COLS  
CALL STATS (ROW*,COLS,10U,10U,Z,ZBAR,XP,ZSIG,ZMAX,ZMIN)  
YMIN=YP  
WRITE (6,200) NEWTOT,XMIN,YMIN,ZMAX,ZMIN,ZBAR,ZSIG  
WRITE (6,205)  
IF (NMAP.LT.1) GC TO 1C5  
DO 100 JNUM=1,NMAP  
IF (JNUM.EQ.1) CALL PRTCON1(Z,ROWS,COLS,TITLE)  
IF (JNUM.EQ.2) CALL PRTCON2(Z,ROWS,COLS,TITLE)  
100 CONTINUE  
105 CONTINUE  
RETURN

C

110 FORMAT (2I3,F4.0,31I3,J2,I1)  
115 FORMAT (12A6)  
120 FORMAT (1HI,12A6,/,3X,24H COORDINATE OBSERVATIONS)  
125 FORMAT (6X,12A6)  
130 FORMAT (5X,4H I =,I3,7H X(I) =,F10.3,7H Y(I) =,F10.3,7H W(I) =,F10 1.3)  
135 FORMAT (1HI,12A6,/,3X,15,13H OBSERVATIONS,/)  
140 FORMAT (3X,25H BOUNDARIES PREDETERMINED)  
145 FORMAT (4F10.0)  
150 FORMAT (3X,32H BOUNDARIES CALCULATED FROM DATA)  
155 FORMAT (3X,6HNMAP =,I3,7H LIST =,I3,6H 3ND =,I2,7H TAPE =,I3)  
160 FORMAT (3X,15H OBSERVED VALUES,/,3X,6H BAR =,F10.3,6H SIG =,F10 3.6,6H MAXX =,F10.3,6H MINX =,F10.3,6H MAXY =,F10.3,6H HIG =,F10.3,6 3MAXW =,F10.3,6MINW =,F10.3,6HDIST =,F10.3,6H AVID =,F10.3,6H HBAR =,F10.3,6H AVE =,F10.3,6H HWSIG =,F10.3,6H 4HBEST =,F10.3,/,3X,7H H SIZE =,F10.3,6H ROWS =,I4,6H COLS =,I4,/)
FORMAT (3X,2X,R8.5,52H, CALCULATED FROM DATA/F)
160 FORMAT (3X,16X, VALUES EMPLOYED FOR 3X,7H XMAX = F10.3,3X,7H YMAX = F10.3
YMIN = F10.3,3X,8H CSIZE = F10.3
2H RINT = 14,8X,7H COLS = 14)
185 FORMAT (1H1,12A6/73X,0H INTERPOLATED VALUES)
190 FORMAT (1HC,(10F10.3))
195 FORMAT (8F10.3)
200 FORMAT (1H1,3X,3HM = 13,6HWMIN = F10.3,3X,6HZMIN = F10.3
YMAX = F10.3,3X,6HZMAX = F10.3,3X,6HZSIG = F10.3)
205 FORMAT (13H1 END OF DATA)
END
PURPOSE -
TO CALCULATE STATISTICAL MEASURES OF ONE OR TWO DIMENSIONAL DATA
ARRAYS. MEASURES DETERMINED ARE 1) MEAN, 2) VARIANCE, 3) STANDARD DEVIATION,
4) MAXIMUM VALUE, 5) MINIMUM VALUE.

USAGE -
CALL STAT(ROWS,COLS,II,JJ,XBAR,XVAR,XMAX,XMIN)

ROWS - NUMBER OF ROWS IN ARRAY BEING ANALYZED
COLS - NUMBER OF COLUMNS IN ARRAY BEING ANALYZED.
II - MAXIMUM NUMBER OF ROWS ALLOWED FOR ARRAY BEING ANALYZED.
JJ - MAXIMUM NUMBER OF COLUMNS ALLOWED FOR ARRAY BEING ANALYZED.
X - DATA ARRAY BEING ANALYZED.
XBAR - MEAN OF ARRAY.
XVAR - VARIANCE OF ARRAY.
XSIG - STANDARD DEVIATION OF ARRAY.
XMAX - MAXIMUM VALUE OF ARRAY.
XMIN - MINIMUM VALUE OF ARRAY.

SUBROUTINE STATE (FOR) COLS = 1 TO JJ XBAR,XVAR,XSIG,XMAX,XMIN

PROGRAM TO FIND STATISTICAL MEASURES

INTEGER ROWS,COLS
DIMENSION X(II,JJ)
PRO=ROWS,COLS
XBAR,=0.0
XSUM=0.0
XMAX=X(1,1)
XMIN=X(1,1)
DO 5 I=1,ROWS
5 0 5 J=1,COLs
1  IF X(I,J)GT XMAX XMAX=X(I,J)
1  IF X(I,J)LT XMIN XMIN=X(I,J)
XSUM=XSUM+X(I,J)
FOR=FOR+X(I,J)*X(I,J)
XVAR=FOR/ROWS
XSIG=SQR(FOR/ROWS)
RETURN
END
PART IV

PRODUCTION OF CONTOUR MAPS

ON THE PRINTER

CONTENTS OF THIS SECTION

1) Subroutine   PRICON 1
2) Subroutine   PRICON 2
3) Subroutine   XYPSSO
4) Program      MAPPER
5) SAMPLE DATA
SUBROUTINES PRTCON1 AND PRTCON2 - GENERAL INSTRUCTIONS

THESE PROGRAMS ARE BASED ON A MAD LANGUAGE PROGRAM OBTAINED FROM PROFESSOR W. R. TOBLER, DEPT. OF GEOGRAPHY, UNIVERSITY OF MICHIGAN, ANN ARBOR. BOTH SUBROUTINES PRODUCE CONTOUR MAPS OF GRIDDED DATA ON THE PRINTER USING LINEAR INTERPOLATION WITHIN THE GRID SQUARES. HOWEVER PRTCON1 ASSIGN A SINGLE CHARACTER TO EACH CONTOUR INTERVAL (ALLOWING A MAXIMUM OF 19 INTERVALS) WHILE PRTCON2 USES THE OVERPRINT OPTION TO PRODUCED PATTERNS FOR EACH INTERVAL THAT ARE LIGHT FOR LOW AREAS AND DARK FOR HIGH AREAS (A MAXIMUM OF 10 CONTOUR INTERVALS IS POSSIBLE). PRTCON1 HAS THREE OPTIONS — CONTOUR LINES MAY BE PRINTED, ALTERNATE CONTOUR BANDS MAY BE PRINTED, OR ALL PRINT POSITIONS ON THE MAP MAY BE PRINTED. PRTCON2 HAS TWO OPTIONS — THE MAPS MAY BE PRINTED WITH OR WITHOUT WHITE BORDERS SEPARATING THE CONTOUR INTERVALS.

BOTH SUBROUTINES CAN CONTOUR IRREGULARLY SHAPED AREAS IF THE GRID POINTS FALLING OUTSIDE THE AREA OF INTEREST ARE GIVEN ARBITRARILY VERY HIGH OR LOW VALUES (VALUES MUST BE ONE DATA ELEVATION RANGE BELOW LOW OR ABOVE HIGH).

THE SUBROUTINES PREPARE A FREQUENCY TABLE SHOWING THE PERCENT MAP AREA (OR PERCENT AREA OF INTEREST FOR IRREGULAR AREAS) BY NUMERICAL INTEGRATION. THE VALUES MAY BE FURTHER ANALYZED BY SUBROUTINE HYPSO WHICH PERFORMS HYPSOMETRIC (AREA-ALTITUDE) ANALYSIS.

SPECIAL NOTE --

THE MAXIMUM MAP WIDTH IS 12.7 INCHES. THE WIDTH OF THE PAPER. THE MAXIMUM NUMBER OF COLUMNS OF INPUT DATA IS A FUNCTION OF THE SPECIFIED MAP WIDTH. IF PS=(COL-COLS)/(COLS-1) (SEE DEFINITIONS BELOW) IS LESS THAN 2, FEWER THAN 2 PRINTING POSITIONS WOULD BE ASSIGNED TO EACH COLUMN SPACE AND SO AN UNSATISFACTORY MAP WOULD RESULT. THUS THE PROGRAM WILL NOT PLOT A MAP IF PS IS LESS THAN 2, AND ACCORDINGLY THE MAXIMUM NUMBER OF COLUMNS FOR A MAP OF MAXIMUM WIDTH IS 42. IF MORE COLUMNS ARE REQUIRED THE MAP MUST BE MADE IN SECTIONS BY USING ONLY PART OF THE DATA IN EACH PASS. THE NUMBER OF COLUMNS SHOULD BE THE SAME IN EACH PASS FOR THE MAPS TO BE AT THE SAME SCALE. TO DO THIS IT MAY BE NECESSARY, AND IS ADVISABLE, TO REPEAT SOME COLUMNS.
SUBROUTINE PPTCON1

PURPOSE -
TO PRODUCE CONTOUR MAPS ON THE PRINTER.

USAGE -
CALL PPTCON1(Z,ROWS,COLS,TITL)
Z - ARRAY OF GRIDDED ELEVATION VALUES (MAXIMUM = 100 X 100).
ROWS - NUMBER OF ROWS IN Z ARRAY.
COLS - NUMBER OF COLUMNS IN Z ARRAY.
TITL - ALPHANUMERIC TITLE 1-72 CHARACTERS.

Purdue University Version 2.0
A. Keith Turner,
Civil Engineering,
February 1968.

CONTROL CARD ORDER -

1) MAST R CONTROL CARD -
CON (COLS 1-2) THE NUMBER OF CONTOUR INTERVALS (MAXIMUM = 19).
( CON = DATA RANGE / DESIRED CONTOUR INTERVAL).
TOUR (COL 3) IF TOUR=0, PROGRAM USES MAXIMUM AND MINIMUM FROM DATA FOR UPPER AND LOWER CONTOUR LIMITS.
IF TOUR=1, DESIRED TOP AND BOTTOM CONTOURS READ IN FROM SPECIAL PROGRAM CARD (SEE BELOW).
IF TOUR=2, VARIABLE CONTOURS READ IN (LOW TO HIGH). IN THIS CASE SET CON EQUAL TO THE NUMBER OF VALUES TO BE READ IN.
IF TOUR=3, CONTOUR INTERVAL BECOMES 1/2 STANDARD DEVIATION (MAX=+3 SIGMA, MIN=-3 SIGMA).
LINES (COL 4) IF LINES=0, CONTOUR LINES ARE PRINTED.
IF LINES=1, ALTERNATE (EVEN VALUED) CONTOUR BANDS ARE PRINTED.
IF LINES=2, ALL BANDS PRINTED (ALL PRINT POSNS).
INCHES (COLS 5-8) INCHES IS MAP WIDTH IN INCHES. IF GREATER THAN 12.7 OR BLANK, SET TO 10.0
(COL=MAP WIDTH IN CHARACTERS=INCHES*10.0).
IHYPSO (COL 10) IF IHYPSO=1, SUBROUTINE IHYPSO CALLED.

2) SPECIAL CAR DS -
REQUIRED ONLY WHEN TOUR = 1 OR 2
IF TOUR=1, THIS CARD SPECIFIES MINIMUM AND MAXIMUM ELEVATION VALUES -- ZMIN (COLS 1-10) AND ZMAX (COLS 11-20).
IF TOUR=2, THIS CARD SPECIFIES A FORMAT (INCON) TO BE USED IN READING IN A SERIES OF IRREGULARLY SPACED CONTOUR LINES. THE VALUES ARE ARRANGED FROM LOWEST TO HIGHEST ON SUBSEQUENT CARDS.
SUBROUTINE PRCTAB1 (Z, ROWS, COLS, TITL)
DIMENSION FORM (113), TITLE (12), SYMTAB (21), SYM (131), Z (100, 100)
1 INCON (10), GRANG (25), TABE (25), ZPREV (131), SYM (131)
DIMENSION CUMH (27)
INTEGER ROWS, COLS, CON, TOU, COLMAX, COL, PSYM, PS, GRID, TOUT, TLOW,
1 SYM, LNANK, PLUS, MINUS, STAR, SYMTAB
INTEGER XSTOP, YSTOP
REAL ZMIN, ZMAX, INCHES, INCON
DATA CSYMTABC (1) = 1
1 I = 1 * 21
2 I = 1 + H1, L1H1, L2H1, L1H2, L1H3, L1H4, L1H5, L1H6, L1H7, L1H8, L1H9,
1 L1HA, L1HB, L1HC, L1HD, L1HF, L1HG, L1HH, L1HJ, L1HK, PLANK, L1H1, L1H2, L1H3,
2 MINUS / L1H1, STAR / L1H2
1 READ (5, 1000) CON, TOU, INCHES, INCON
1000 FORMAT (12, 21, F4.0, 2, 11)
C ZERO COUNTERS AND ARRAYS USED IN FREQUENCY TABLE
C
JJ = 0
MM = 0
SUM = 0
TLOW = 0
TOUT = 0
DO 5 I = 1, 25
5 TAVE (I) = 0
N = ROWS * COLS
C
C N = NUMBER OF DATA POINTS
C
WRITE (6, 1030) TITL, N, COLS, ROWS
1030 FORMAT (1H12, 12A6//, 22H MAP IS DEVELOPED FROM IF 30H GRIDDED VALUES
1, CONSISTING OF 13, 12H COLUMNS BY 13, 6H ROWS, /)
CALL STATS (ROWS, COLS, 1, 100, Z, ZBAR, XP, ZSIG, MAXZ, MINZ)
C
C DETERMINE CONTOUR LINE ELEVATIONS
C
IF (TOU .GT. 3 .OR. TOUR .LE. 0) GO TO 60
GO TO (30, 40, 50), TOU
30 WRITE (6, 1060)
1060 FORMAT (25H CONTOUR LEVELS SPECIFIED)
READ (5, 1070) ZMIN, ZMAX
1070 FORMAT (2F10.0)
GO TO 70
40 READ (5, 1020) INCON
1020 FORMAT (1U6)
WRITE (6, 1080)
1080 FORMAT (37H VARIABLE CONTOUR INTERVALS SPECIFIED)
READ (5, INCON) (DRANG (I), I = 1, CON)
ZMIN = DRANG (1)
ZMAX = DRANG (CON)
GO TO 70
50 ZMIN = ZBAR - 3.0 * ZSIG
ZMAX = ZBAR + 3.0 * ZSIG
CON = 13
WRITE (6,1090)
1090 FORMAT (36H CONTOUR INTERVAL = U1/2 SIGMA)
GO TO 7
60 WRITE (6,1100)
1100 FORMAT (26H CONTOUR LEVELS CALCULATED)
ZMIN=MINZ
ZMAX=MAXZ
70 WRITE(6,1110) ROWS,COLS,ZBAR,ZSIG,ZMAX,ZMIN
1110 FORMAT (13H GRIDDED DATA/42H LINEAR INTERPOLATION WITHIN GRID SQU
IARES /17H OBSERVED VALUES / 8H ROWS = ,13,10H COLS = 
213,/,8H ZBAR = ,F10.3,10H ZSIG = ,F10.3,10H MAXZ = ,F10.3,10H 
3 MINZ = ,F10.3)
C **************************************************************************
C CALCULATE MAP WIDTH IN CHARACTERS (COL)
C **************************************************************************
C IF (INCHES*LE.0*O) COL=100
IF (INCHES*GT.12.7) COL=127
IF (INCHES*GT.0*O AND INCHFS*LE.12.7) COL=INCHES*10.0
PS=(COL-COLS)/(COLS-1)
C **************************************************************************
C TEST GRID SIZE—IF GRID SMALLER THAN 2 CHARACTERS BETWEEN COLUMNS, 
C AN ERROR STATEMENT IS PRINTED AND PLOT ABORTED
C **************************************************************************
C IF (PS*GT.1) GO TO 80
WRITE (6,1120)
1120 FORMAT (25H TOO MANY COLUMNS IN GRID)
GO TO 999
C CALCULATE REQUIRED CONSTANTS
C 80 COLMAX=PS*(COLS-1)+COLS
YINC=1.0/((FLOAT(PH+1))*0.6)
GRID=PS+1
XINC=1.0/FLOAT(GRID)
RANGZ=ZMAX-ZMIN
RHIGH=ZMAX+RANGZ
RLOW=ZMIN-RANGZ
IF (CON-EQ.0.0 OR CON*GT.19) CON=5
FCON=CON
CI=RANGZ/FCON
IF (TOUR*EQ.2) GO TO 100
JJJ=CON+1
DO 90 T=1,JJJ
90 DRANG(T)=ZMIN+FLOAT(T-1)*CI
CONTINUE
WRITE (6,1130)
1130 FORMAT (1H /16H VALUES EMPLOYED)
WRITE (6,1140) ZMIN,ZMAX,CI,GRID,XINC,YINC,CON,PS,COLMAX
1140 FORMAT (8H ZMIN = ,F10.3,10H ZMAX = ,F10.3,PH CI = ,F10.3/8H 
1GRID = ,15,10H XINC = ,F10.3,10H YINC = ,F10.3/7H CON = 15,
2 BH PS = ,15,12H COLMAX = ,15)
**WRITE OUT CONTOUR SYMBOL TABLE**

WRITEF (6,1150)

1150 FORMAT (35H4CONTOUR SYMBOL TABLE IS AS FOLLOWS)

IF (LINES.EQ.1) WRITE (6,1160)

1160 FORMAT (43H0ONLY EVEN SYMBOLS PRINTED IN BODY OF MAP)

WRITE (6,1170)

1170 FORMAT (7H0SYMBOLS 11X 3HVALUE)

IF (LINES.NE.0) GO TO 110

WRITE (6,1180)

1180 FORMAT (5HO 6X 7HNO DATA 5X 5H 9X 1OHBELOW LOW)

WRITE (6,1190) (SYMTAB(I),DRANG(I),I=1,CON)

1190 FORMAT (4X,A1,2X,F12.4)

WRITE (6,1200)

1200 FORMAM (4X,1H+,4X,10HABOVE HIGH)

GO TO 120

110 WRITE (6,1210)

1210 FORMAT (5HO 25X 7HNO DATA 5X 5H 23X 10HBELOW LOW)

WRITE (6,1220) (SYMTAB(I),DRANG(I),I=1,CON)

1220 FORMAT (4X,A1,2X,F12.4*6H TO *F12.4)

WRITE (6,1230) DRANG(CON+1)

1230 FORMAT (4X,1H+,2X,F12.4,10H OR OVER)

120 WRITE (6,1030) TITL,N,COLS,ROWS

XSTOP = GRID

GRID=COLS-1

C

COL=3

DO 140 J=1,GRID

DO 130 I = 2*XSTOP

SYM(COL)=BLANK

130 COL=COL+1

SYM(COL)=PLUS

140 COL=COL+1

N=COLMAX+2

SYM(2)=PLUS

SYM(1)=BLANK

SYM(N)=BLANK

WRITE (6,1240) (SYM(I),I=1,N)

1240 FORMAT (1H9,129A1)

C

C **ESTIMATE VALUE OF ALL PRINTING POSITIONS ON MAP**

C

C **LOOP THROUGH MAP LENGTH, ROW BY ROW**

C

ITER=1

IROW = ROWS + 1

DO 340 MM = 2*IROW

YSTOP = 1/YINC + .5

IF (MM.EQ.IROW) YSTOP=1

M=MM-1
145   \text{YP} = 0. J \\
PSYM(1) = \text{PLUS} \\
PSYM(N) = \text{PLUS} \\
\text{DO } 340 \text{ KJ} = 1 \text{ TO } \text{YSTOP} \\
150   \text{COL} = 1 \\
Z1 = \text{YP} \times (Z(M,1) - Z(M,1)) + Z(M,1) \\
C   \\
C   \text{LOOP THROUGH MAP WIDTH, COLUMN BY COLUMN} \\
C   \\
190   \text{II} = \text{COLS} - 1 \\
JLFT = 2 \\
\text{DO } 330 \text{ J} = 1 \text{ TO } \text{II} \\
JJ = J + 1 \\
Z2 = \text{YP} \times (Z(M, JJ) - Z(M, JJ)) + Z(M, JJ) \\
ZDELT = Z2 - Z1 \\
XP = 0.0 \\
\text{DO } 480 \text{ KK} = 1 \text{ TO } \text{XSTOP} \\
JLFT = JLFT - 1. \\
195   \text{COL} = \text{COL} + 1 \\
200   \text{ZEST} = \text{XP} \times \text{ZDELT} + Z1 \\
\text{IF( ZEST \geq ZMIN AND ZEST \leq ZMAX ) GO TO 325} \\
\text{IF( ZEST \leq ZMAX ) GO TO 203} \\
\text{IF( ZEST > ZMIN ) GO TO 206} \\
\text{IF( ITOP EQ \text{EQ} 1 \text{ OR } M \text{EQ} 1 \text{ ROW OR } JLFT = \text{EQ} 1 ) GO TO 201} \\
PSYM(COL) = \text{BLANK} \\
\text{GO TO 202} \\
201   PSYM(COL) = \text{MINUS} \\
202   TLOW = TLOW + 1 \\
ZPREV(COL) = \text{ZEST} \\
ZLAST = \text{ZEST} \\
\text{GO TO 124} \\
203   \text{IF( ZEST \geq ZHIGH ) GO TO 206} \\
\text{IF( ITOP EQ \text{EQ} 1 \text{ OR } M \text{EQ} 1 \text{ ROW OR } JLFT = \text{EQ} 1 ) GO TO 204} \\
PSYM(COL) = \text{BLANK} \\
\text{GO TO 205} \\
204   PSYM(COL) = \text{PLUS} \\
205   \text{TABLE(CON+1) = TABLE(CON+1) + 1.0} \\
ZPREV(COL) = \text{ZEST} \\
ZLAST = \text{ZEST} \\
\text{GO TO 124} \\
206   \text{IF( ITOP EQ \text{EQ} 1 \text{ OR } M \text{EQ} 1 \text{ ROW OR } JLFT = \text{EQ} 1 ) GO TO 207} \\
PSYM(COL) = \text{BLANK} \\
\text{GO TO 208} \\
207   PSYM(COL) = \text{STAR} \\
208   \text{TOUT = TOUT + 1} \\
ZPREV(COL) = \text{ZEST} \\
ZLAST = \text{ZEST} \\
\text{GO TO 480} \\
325   \text{I = ( (ZEST - ZMIN) / CI ) + 1.0 } \\
\text{TABLE(I) = TABLE(I) + 1.0} \\
LVAL = \text{LINES + 1
IF (ITOP.EQ.1 OR ITM.EQ.1 ROW OR JLFT.EQ.1) LVAL=3
GO TO (326,327,328), LVAL
326 DO 309 I=1,CON
  ZSTEP=DRANG(I)
  SW1=1.
  SW2=1.
  SW3=1.
  SW4=1.
  IF (ZSTEP.GF.ZLAST.OR.ZSTEP.GF.ZPRFV(COL)) SW1=0.
  IF (ZSTEP.LE.ZEST) SW2=0.
  IF (ZSTEP.LT.ZLAST.OR.ZSTEP.LT.ZPREV(COL)) SW3=0.
  IF (ZSTEP.GE.ZEST) SW4=0.
  IF((SW1.EQ.0 .AND. SW2.EQ.0 ) OR (SW3.EQ.0 .AND. SW4.EQ.0 )) GO TO 310
309 CONTINUE
  PSYM(COL)=BLANK
  GO TO 320
310 PSYM(COL)=SYMTAB(I)
320 ZLAST=ZEST
  ZPREV(COL)=ZEST
  ZLFT=ZEST
  Zlast=ZEST
  ZPREV(COL)=ZEST
  GO TO 124
327 K=I/2
  IF((K*2).NE.I) PSYM(COL)=SYMtab(I)
  IF((K*2).EQ.I) PSYM(COL)=BLANK
  GO TO 124
328 PSYM(COL)=SYMtab(I)
  ZPREV(COL)=ZEST
124 SUM=SUM+1.0
480 XP=XP+XINC
  Z1=Z2
330 J=COL+1
  IF((Z(M,COLS).GE.ZMIN.AND.Z(M,COLS).LE.ZMAX)) GO TO 333
  IF((Z(M,COLS).LT.ZMAX)) GO TO 335
  IF((Z(M,COLS).GT.ZLOW)) GO TO 336
  PSYM(COL)=MINUS
  TLOW=TLOW+1
  GO TO 334
335 IF((Z(M,COLS).GT.ZHIGH)) GO TO 336
  PSYM(COL)=PLUS
  TABE(CON+1)=TABE(CON+1)+1.0
  GO TO 334
336 PSYM(COL)=STAR
  TOUT=TOUT+1
  GO TO 332
333 I=((Z(M,COLS)-ZMIN)/CI)+1.
  TABE(I)=TABE(I)+1.0
  PSYM(COL)=SYMtab(I)
334 SUM=SUM+1.0
332 WRITE (6,1240) (PSYM(L),L=1,N)
  YP=YP+YINC
  PSYM(1)=BLANK
  PSYM(N)=BLANK
340 ITOP=0
  WRITE (6,1240) (SYM(L),L=1,N)
CALCULATE AND PRINT FREQUENCY TABLE

WRITE (6,1250) TOUT
1250 FORMAT (16H1FREQUENCY TABLE,12X,8HINTERVAL,16X,5HUNITS,6X,10HPERCENTAGE,4X,10HCUMULATIVE,16X,7IGNO DATA,11X,18)
PTAB=(FLOAT(TLOW)/SUM)*100.0
CTAB=PTAB
WRITE (6,1260) TLOW,PTAB,CTAB
1260 FORMAT (16X,9HBELOW LOV,11X,18$$2(3X,F12.4))
DO 350 I=1,CON
  VALUE=DRANG(I)
  VAL1=DRANG(I+1)
  VAL2=DRANG(I+1)
  PTAB=(TAVE(I)/SUM)*100.0
  CTAB=CTAB+PTAB
350 WRITE (6,1270) VALUE,VAL1,TAVE(I),PTAB,CTAB
1270 FORMAT (1X,F12.4,F6H TO ,F12.4)$$2(3X,F12.4)
  I=I+1
  PTAB=(TAVE(I)/SUM)*100.0
  CTAB=PTAB+CTAB
WRITE (6,1280) VAL1,TAVE(I),PTAB,CTAB,SUM,CTAB
1280 FORMAT (1X,F12.4,10H OR OVER ,11X,F8.0)$$2(3X,F12.4)
C IF IHYPSO = 1 , PERFORM HYPSOMETRIC ANALYSIS
C IF (IHYPSO) 450,999,450
450 CALL HYPSO(DRANG,ZMAX,ZMIN,CON,CUM,H,TITL)
999 CONTINUE
RETURN
END
SUBROUTINE PRTCON2

PURPOSE -
TO PRODUCE GRADED DENSITY CONTOUR MAPS ON THE PRINTER

USAGE -
CALL PRTCON2(Z,ROWS,COLS,TITL)
Z - ARRAY OF GRIDDED ELEVATION VALUES (MAXIMUM = 100 X 100 ).
ROWS - NUMBER OF ROWS IN Z ARR 8.
COLS - NUMBER OF COLUMNS IN Z ARRAY.
TITL - ALPHANUMERIC TITLE 1-72 CHARACTERS.

Purdue University Version 1.0
A. Keith Turner,
Civil Engineering,
February 1968.

CONTROL CARD ORDER -

1) MASTER CONTROL CARD -
CON (COLS 1-2) THE NUMBER OF CONTOUR INTERVALS (MAXIMUM=10).
( CON = DATA RANGE / DESIRED CONTOUR INTERVAL).
TOUR (COL 3) IF TOUR=0, PROGRAM USES MAXIMUM AND MINIMUM FROM
DATA FOR UPPER AND LOWER CONTOUR LIMITS.
IF TOUR=1, DESIRED TOP AND BOTTOM CONTOURS READ IN FROM SPECIAL PROGRAM CARD (SEE BELOW).
IF TOUR=2, VARIABLE CONTOURS READ IN (LOW TO
HIGH). IN THIS CASE SET CON EQUAL TO THE NUMBER
OF VALUES TO BE READ IN.
LINES (COL 4) IF LINES=0, BLANK BORDERS ARE PLACED BETWEEN
CONTOUR INTERVALS.
IF LINES=1, BLANK BORDERS NOT DEVELOPED.
INCHES(COLS5-8) INCHES IS MAP WIDTH IN INCHES. IF GREATER THAN
12.87 OR BLANK, SET TO 10.0.
( COL = MAP WIDTH IN CHARACTERS=INCHESX10.0).
IHYPSO (COL10) IF IHYPSO=1, SUBROUTINE HYPSO CALLED.

2) SPECIAL CARD(S) -
REQUIRED ONLY WHEN TOUR = 1 OR 2.
IF TOUR=1, THIS CARD SPECIFIES MINIMUM AND MAXIMUM ELEVATION
VALUES. -- ZMIN (COLS 1-10) AND ZMAX (COLS11-20).
IF TOUR=2, THIS CARD SPECIFIES A FORMAT (INCON) TO BE USED IN
READING IN A SERIES OF IRREGULARLY SPACED CONTOUR LINES. THE
VALUES ARE ARRANGED FROM LOWEST TO HIGHEST ON SUBSEQUENT CARDS.
SUBROUTINE(PRTC0N2(Z,ROWS,COLS,TITL)
DIMENSION FORM(10),TITL(12),Z(100,100),DRANG(25),SYM(131)
DIMENSION ZPREV(131),INCON(10),TABE(25),CUMH(27)
INTEGER ROWS,COLS,CON,COLMAX,COL,SYM,PS,GRID,SYM,BLANK,PLUS,
1SYMTAB,YSTOP,YSTOP
INTEGER TOUR,STAR
INTEGER MINUS,DOT,OWF,EYE,LPAR,RPAR,SLASH,EGGS,EQUAL
REAL INCHES,MINZ,MAXZ,INCON
DATA BLANK/'1H+/',PLUS/'1H+/',MINUS/'1H-/',DOT/'1H*/',OWF/'1H0/',EYE/'1H/',
1EGGS/'1H/',EQUAL/'1H=',/SLASH/'1H//,LPAR/'1H(/,RPAR/'1H/,*STAR/'1H*/
SYMTAB(ls)=DOT
SYMTAB(1,2)=BLANK
SYMTAB(2,1)=LPAR
SYMTAB(2,2)=BLANK
SYMTAB(3,1)=OWE
SYMTAB(3,2)=OWE
SYMTAB(4,1)=EGGS
SYMTAB(4,2)=EGGS
SYMTAB(5,1)=LPAR
SYMTAB(5,2)=RPAR
SYMTAB(5,1)=OWE
SYMTAB(5,2)=MINUS
SYMTAB(7,1)=EYE
SYMTAB(7,2)=EQUAL
SYMTAB(8,1)=EGGS
SYMTAB(9,1)=OWE
SYMTAB(9,2)=SLASH
SYMTAB(10,1)=OWE
SYMTAB(10,2)=STAR
1
READ(5,1000) CON,TOUR,LINES,INCHES,1HYPSO
1000 FORMAT(12,21,F4.0,2X,F1)
C *************************************************************************
C ZERO COUNTERS AND ARRAYS USED IN FREQUENCY TABLE
C *************************************************************************
JJ=0
MM=0
SUM=0.0
TLOW=0
TOUT=0
DO 5 1=1,25
5 TABLE(1)=0.0
N=ROWS*COLS
C *************************************************************************
C N = NUMBER OF DATA POINTS
C *************************************************************************
WRITE(6,1030) TITL,N,ROWS
1030 FORMAT(1HI,12A6,12H MAP IS DEVELOPED FROM 15,30H GRIDDED VALUES
1,CON SISTING OF 15,12H COLUMNS BY 13,6H ROWS)
CALL STATS(ROWS,COLS,1.0,100,Z,ZBAR,XP,ZSIG,MAXZ,MINZ)
**DETERMINE CONTOUR LINE ELEVATIONS**

TOUR VALUE DETERMINES METHOD USED IN DEFINING CONTOURS

**IF (TOUR.GT.2.0 .OR. TOUR.LE.0) GO TO 60**

**GO TO (30+40), TOUR**

**WRITE (6,1060)**

**FORMAT (25H CONTOUR LEVELS SPECIFIED)**

**READ (5,1U70) ZMIN,ZMAX**

**TOUR**

**GO TO 70**

**WRITE (6,1080)**

**FORMAT (26H CONTOUR LEVELS CALCULATED)**

**ZMIN=MINZ**

**ZMAX=MAXZ**

**WRITE(6,1110) ROWS,COLS,ZBAR,ZSIG,MAXZ,MINZ**

**FORMAT (13H GRIDDED DATA/942H LINEAR INTERPOLATION WITHIN GRID SCN)**

1ARES /17H OBSERVED VALUES /8 8H ROWS = 213,10H COLS = ,
213,8H ZBAR = F10.3,10H ZSIG = F10.3,10H MAXZ = F10.3,10H
3 MINZ = F10.3)

**CALCULATE MAP WIDTH IN CHARACTERS (COL)**

**IF (INCHES.LE.0.0) COL=100**

**IF (INCHES.GT.12.7) COL=127**

**IF (INCHES.GT.0.0 .AND. INCHES.LE.12.7) COL=INCHES#10.0**

**PS=(COL-COLS)/(COLS-1)**

**CALCULATE REQUIRED CONSTANTS**

**IF (PS.GT.1) GO TO 80**

**WRITE (6,1120)**

**FORMAT (25H TOO MANY COLUMNS IN GRID)**

**GO TO 999**

**CALCULATE Required constants**

**COLMAX=PS*(COLS-1)+COL3**

**YINC=1.0/((FLOAT(PS+1))#0.6)**

**GRID=PS+1**

**XINC=1.0/FLOAT(GRID)**

**RANGZ=ZMAX-ZMIN**
RHIGH=ZMAX+RANGZ
RLOW=ZMIN-RANGZ
IF (CON.EQ.0.OR.CON.GT.10) CON=5
FCON=CON
CI=RANGZ/FCON
IF (TOUR.EQ.2) GO TO 100
JJJ=CON+1
DO 90 I=1,JJJ
90 DRANG(I)=ZMIN+FLOAT(I-1)*CI
100 CONTINUE
WRITE (6,1130)
1130 FORMAT (1H /*,16H VALUES EMPLOYED)
WRITE (6,1140) ZMIN,ZMAX,CI,GRID,XINC,YINC,CON,PS,COLMAX
1140 FORMAT (8H ZMIN = F10.3,10H ZMAX = F10.3,8H CI = F10.3,8H
GRID = I5,10H XINC = F10.3,10H YINC = F10.3,7H CON = I5,
2 8H PS = I5,12H COLMAX = I5)
C ****************************
C WRITE OUT CONTOUR SYMBOL TABLE
C ****************************
WRITE (6,1150)
1150 FORMAT (35H CONTOUR SYMBOL TABLE IS AS FOLLOWS)
WRITE (6,1170)
1170 FORMAT (7H SYMBOL,5H VALUE)
110 WRITE (6,1210)
1210 FORMAT (5H *,25X,7H DATA,5H = ,23X,10HE BELOW LOW)
DO 450 I=1,CON
WRITE (6,1221) SYMTAB(I,2)
450 CONTINUE
WRITE (6,1230) DRANG(CON+1)
1230 FORMAT (4X,1H+,2X,F12.4,*10H OR OVER)
120 WRITE (6,1030) TITL,N,COLS,ROWS
XSTOP = GRID
GRID=COLS-1
COL=3
DO 140 J=1,GRID
DO 13 I = 2,XSTOP
SYM(COL) = BLANK
130 COL=COL+1
SYM(COL) = PLUS
140 COL=COL+1
N=COLMAX+2
SYM(2) = PLUS
SYM(1) = BLANK
SYM(N) = BLANK
WRITE (6,1240) {SYM(I) = I=1,N}
ESTIMATE VALUE OF ALL PRINTING POSITIONS ON MAP

LOOP THROUGH MAP LENGTH, ROW BY ROW

ITOP=1
IROW = ROWS + 1
DO 340 MM = 2: IROW
YSTOP = 1: YINC = .5
IF (MM = EQ: IROW) YSTOP = 1
M = MM - 1
YP = 0.0
PSYM(1,1) = PLUS
PSYM(1,2) = BLANK
PSYM(N,1) = PLUS
PSYM(N,2) = BLANK
DO 340 K = 1: YSTOP

150 COL = 1
Z1 = YP*(Z(M,1)-Z(M,1))+Z(M,1)

LOOP THROUGH MAP WIDTH, COLUMN BY COLUMN

190 II = COL.*S-1
JLFT = !
DO 330 J = 1, II
JJ = J+1
Z2 = YP*(Z(M, JJ)-Z(M, JJ))+Z(M, JJ)
ZDELT = Z2 - Z1
XP = 0.0
DO 480 KK = 1: XSTOP

195 COL = COL+1
ZEST = XP*ZDELT+Z1
IF (ZEST .GE. ZMIN .AND. ZEST .LE. ZMAX) GO TO 325
IF (ZEST .GT. ZMAX) GO TO 203
IF (ZEST .LE. ZLOW) GO TO 203
IF (ITOP .EQ. 1 OR MM .EQ. IROW OR JLFT .EQ. 1) GO TO 201
PSYM(COL,1) = BLANK
GO TO 202

200 PSYM(COL,2) = BLANK
TLOW = TLOW + 1
ZPREV(COL) = ZEST
ZLAST = ZEST
GO TO 124

203 IF (ZEST .GE. ZHIGH) GO TO 205
IF(ITOP.EQ.1.OR.MM.EQ.IROW.OR.JLFT.EQ.1) GO TO 204
PSYM(COL,1)=BLANK
GO TO 205
204 PSYM(COL,1)=PLUS
205 PSYM(COL,2)=BLANK
TABF(CON+1)=TABF(CON+1)+1.0
ZPREV(COL)=ZEST
ZLAST=ZEST
GO TO 124
206 IF(ITOP.EQ.1.OR.MM.EQ.IROW.OR.JLFT.EQ.1) GO TO 207
PSYM(COL,1)=BLANK
GO TO 208
207 PSYM(COL,1)=STAR
208 PSYM(COL,2)=BLANK
TOUT=TOUT+1
ZPREV(COL)=ZEST
ZLAST=ZEST
GO TO 480
325 CONTINUE
LVAL=LINES+1
IF(ITOP.EQ.1.OR.MM.EQ.IROW.OR.JLFT.EQ.1) LVAL=2
GO TO (326*327),LVAL
326 DO 309 I=1,CON
ZSTEP=DRANG(I)
SW1=1.
SW2=1.
SW3=1.
SW4=1.
IF(ZSTEP.GE.ZLAST.OR.ZSTEP.GE.ZPREV(COL)) SW1=0.
IF(ZSTEP.LE.ZEST) SW2=0.
IF(ZSTEP.LT.ZLAST.OR.ZSTEP.LT.ZPREV(COL)) SW3=0.
IF(ZSTEP.GE.ZEST) SW4=0.
IF((SW1.EQ.0.AND.SW2.EQ.0).OR.(SW3.EQ.0.AND.SW4.EQ.0)) GO TO 310
327 CONTINUE
328 I=(ZEST-ZMIN)/CI+1.
PSYM(COL,1)=SYMTAB(I,1)
PSYM(COL,2)=SYMTAB(I,2)
TABF(I)=TABF(I)+1.0
GO TO 920
310 PSYM(COL,1)=BLANK
PSYM(COL,2)=BLANK
TABF(I)=TABF(I)+1.0
320 ZLAST=ZEST
ZPREV(COL)=ZEST
124 SUM=SUM+1.0
480 XP=XP+XINC
Z1=Z2
330 JLFT=)
COL = COL + 1
IF(Z(M,COLS).GE.ZMIN.AND.Z(M,COLS).LE.ZMAX) GO TO 333
IF(Z(M,COLS).GT.ZMAX) GO TO 335
IF(Z(M,COLS).LE.ZLOW) GO TO 336
PSYM(COL,1)=MINUS
PSYM(COL,2)=BLANK
TLow=TLow+1
GO TO 332
335 IF(2(M, COLS) .GE. RHIGH) GO TO 336
PSYM(COL, 1) = PLUS
PSYM(COL, 2) = BLANK
TABE(CON + 1) = TABE(CON + 1) + 1.0
GO TO 332
336 PSYM(COL, 1) = STAR
PSYM(COL, 2) = BLANK
TOUT = TOUT + 1
GO TO 334
333 I = ((Z(M, COLS) - ZMIN) / CI) + 1.
PSYM(COL, 1) = SYMTAB(I, 1)
PSYM(COL, 2) = SYMTAB(I, 2)
332 SUM = SUM + 1.0
334 WRITE(6, 1241) (PSYM(L, 2), L = 1, N)
1241 FOPMAT(1H+, 129A1)
WRITE(6, 1240) (PSYM(L, 1), L = 1, N)
YP = YP + YINC
PSYM(1, 1) = BLANK
PSYM(1, 2) = BLANK
PSYM(N, 1) = BLANK
PSYM(N, 2) = BLANK
332 ITOP = 0
WRITE(6, 1240) (SYM(L), L = 1, N)
C **********************************************************************
C CALCULATE AND PRINT FREQUENCY TABLE
C **********************************************************************
WRITE(6, 1250) TOUT
1250 FORMAT (16H1FREQUENCY TABLE/, 12X, 8HINTERVAL/, 16X, 5HUNIT'S/, 6X, 10HP
1ERCENTAGE/, 4X, 10HCUMULATIVE/, 16X, 7HNO DATA/, 11X, I8)
PTAB = (FLOAT(TLOW)/SUM) * 100.0
CTAB = PTAB
WRITE(6, 1260) TLOW, PTAB, CTAB
1260 FORMAT (14X, 9HBELOW LOW/, 11X, I8, 2(3X, F12.4))
DO 35 J = 1, CON
VALUE = DRANG(J)
VAL1 = DRANG(J + 1)
VAL1 = DRANG(J + 1)
PTAB = (TABE(J) / SUM) * 100.0
CTAB = PTAB + CTAB
35 WRITE(6, 127) VALUE, VAL1, TABF(I), PTAB, CTAB
127 FORMAT (1X, F12.4, 6H TO/, F12.4, 3X, F8.0, 2(3X, F12.4))
I = I + 1
PTAB = (TABE(I) / SUM) * 100.0
CTAB = PTAB + CTAB
WRITE(6, 1280) VAL1, TABE(I), PTAB, CTAB, SUM, CTAB, CTAB
128 FORMAT (1X, F12.4, 4H OR OVER/, 11X, F8.0, 2(3X, F12.4),/, 18X, 5HTOTAL
1, 11X, F8.0, 2(3X, F12.4))
C **********************************************************************
C IF HYPSO = 1, PERFORM HYPSOMETRIC ANALYSIS
C **********************************************************************
IF (HYPSO) 450, 999, 450
450 CALL HYPSO(DRANG, ZMAX, ZMIN, CON, CUMH, TITL)
999 CONTINUE
RETURN
END
SUBROUTINE HYPSO

PURPOSE:
TO PERFORM HYPSOMETRIC (AREA-ALTITUDE) ANALYSIS.

REFERENCE:
A. N. STRAHLER-1952-HYPSOMETRIC (AREA-ALTITUDE) ANALYSIS
OF EROSIONAL TOPOGRAPHY-GEOL. SOC. AMERICA BULL. VOL.63
PAGES 1117-1142.

USAGE:
CALL HYPSO(DRANG,ZMAX,ZMIN,CON,CUMH,TIL).

DRANG-ARRAY CONTAINING CONTOUR LEVELS.
ZMAX-MAXIMUM ELEVATION VALUE.
ZMIN-MINIMUM ELEVATION VALUE.
CON-NUMBER OF CONTOUR INTERVALS.
CUMH-ARRAY CONTAINING CUMULATIVE PCT AREAS BELOW EACH CONTOUR.
TIL ALPHANUMERIC TITLE (1-72 CHARACTERS).

DIMENSION IROW(49,81),RELH(25),RELH(25)
DIMENSION TIL(12),CUMH(27),DRANG(27)
DATA DOT, BLANK, STAR/1H.,1H.,1H. /1H.*/
REAL IROW
INTEGER CON

INTEGER CON

MAKE PLOT ALL BLANKS, DRAW BORDERS WITH DOTS, AND PLOT A STAR AT TOP LEFT AND BOTTOM RIGHT CORNERS.

DO 2 M=1,49
   DO 2 N=1,81
  2 IROW(M,N)=BLANK
   IROW(1,1)=STAR
   DO 3 N=2,81
  3 IROW(1,N)=DOT
   IROW(49,N)=STAR
   DO 4 N=1,80
  4 IROW(49,N)=DOT
   DO 5 M=2,48
  5 IROW(M,1)=DOT
   IROW(M,81)=DOT

DETERMINE POSITIONS OF STARS WITHIN THE PLOT.

K=CON+1
   DO 20 I=1,K

20 CONTINUE
RELH(I) = (DRANG(I) - ZMIN) / (ZMAX - ZMIN)
RELH(I) = 1.0 - ((CUMH(I) - CUMH(I+1)) / (CUMH(I+1) - CUMH(I)))
M = (49.0 - (RELH(I) * 4.0)) + 0.5
N = (RELH(I) * 81.0) + 0.5

20 IROW(M, N) = START
C
PRINT OUT ALL THE PLOT SEQUENTIALLY
C
WRITE (6, 1000) TITL
1000 FORMAT (1H1, 22M1HYPSPOMETRIC CURVE FOR y12A6)
WRITE (6, 1001)
1001 FORMAT (1H, 8HREL. HT.)
WRITE (6, 1002)
1002 FORMAT (1H, 8X, 3H0, 0, 37Xs: H0, 5, 37Xs3H1, 0)
WRITE (6, 1003)
1003 FORMAT (1H, 9X, 1H+, 39X, 1H+, 39X, 1H+)
WRITE (6, 1004) (IROW(1: N), i = 1, 81)
1004 FORMAT (1H, 4X, 5H1, 0 + 81, 5H1, 0)
DO 100 M = 2, 24
100 WRITE (6, 1005) (IROW(M: N), i = 1, 81)
1005 FORMAT (1H, 9X, 81A1)
WRITE (6, 1006) (IROW(25: N), N = 1, 81)
1006 FORMAT (1H, 4X, 5H0, 5 + 81, 5H0, 5)
DO 101 M = 26, 48
101 WRITE (6, 1007) (IROW(M: N), i = 1, 81)
WRITE (6, 1008)
1008 FORMAT (1H, 4X, 13HRELATIVE AREA /)
C
CALCULATE AREA BELOW THE CURVE USING DECIMAL VALUES OF POINTS FOR
C
THE REST OBTAINABLE ACCURACY.
C
AREA = 0.0
DO 200 I = 1, CON
A = ((RELH(I) + RELH(I+1)) * (RELH(I) - RELH(I+1))) / 2.0
200 AREA = AREA + A
WRITE (6, 1010) AREA
1010 FORMAT (1H, 77H THE HYPSOMETRIC INTEGRAL FOR THE ABOVE CURVE ( THE AREA BELOW THE CURVE ) IS +/-4)
C
WRITE OUT COORDINATES OF HYPSOMETRIC CURVE
C
WRITE (6, 2001)
2001 FORMAT (1H1, 50H CALCULATED VALUES OF HYPSOMETRIC CURVE COORDINATES, 1//5X, 12H POINT NUMBER, 5X, G1-Axis, 10X, G2-H-axis)
DO 21 I = 1, CON
21 WRITE (6, 2000) I, RELA(I), RELH(I)
2000 FORMAT (1H1, 10X, I2, 10X, F8.4, 10X, F8.4)
RETURN
END
PROGRAM MAPPER

PURPOSE -
A SIMPLE PROGRAM TO READ IN GRIDDED DATA FOR CONTOURING.

CONTROL CARD ORDER -

1) SPECIFICATION CARD -
   ROWS(COLS1-3) NUMBER OF ROWS IN GRID. (MAX=100)
   COLS(COLS4-6) NUMBER OF COLS IN GRID. (MAX=100)
   LIST(COL 7) IF LIST=1, LIST INPUT DATA
   NMAP(COLS8-9) NUMBER OF MAPS REQUESTED FOR THIS DATA SET.

2) TITLE CARD -
   ANY ALPHANUMERIC TITLE IN COLUMNS 1-72.

3) FORMAT CARD -
   SPECIFIES FORMAT OF INPUT DATA (COLS 1-60)

4) DATA CARDS

PROGRAM MAPPER(INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT)
DIMENSION FORM(10), TITL(12), Z(100, 100)
INTEGER ROWS, COLS
READ (5, 1000) ROWS, COLS, LIST, NMAP
1000 FORMAT (2I3, I11, 12)
   IF (EOF, 5) 999, 2
2 IF (NMAP.LT.1) NMAP=1
   READ (5, 1010) TITL
1010 FORMAT (12A6)
   READ (5, 1020) FORM
1020 FORMAT (10A6)
   DO 7 1=1, ROWS
7 READ (5, FORM) (Z(I,J), J=1, COLS)
   IF LIST =1 LIST INPUT DATA, OTHERWISE GO TO 20
   IF (LIST.NE.1) GO TO 20
   WRITE (6, 1030) TITL
1030 FORMAT (1H1, 12A6//)
   WRITE (6, 1025)
1025 FORMAT (1HO, 25X, 22HListing of Input Data. )
   DO 10 I=1, ROWS
10 WRITE (6, 1040) (Z(I,J), J=1, COLS)
1040 FORMAT (1HO, 10F10.3, /(1X, 10F10.3))
   DO 25 I=1, NMAP
25 CALL PRTCON1(Z, ROWS, COLS, TITL)
   GO TO 1
999 STOP
END
SAMPLE DATA FOR PROGRAM MAPPER, SUBROUTINE PRCON1.

DRAINAGE BASIN, VERDUGO HILLS, CALIFORNIA.

(16F4.0)

999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999999
SAMPLE OUTPUT FROM SUBROUTINE PRTCON

320 OBSERVATIONS

CONTOUR LEVELS SPECIFIED

GRIDDED DATA
LINEAR INTERPOLATION WITHIN GRID SQUARES

OBSERVED VALUES

(16F4.0)
ROWS = 20 COLS = 16
ZBAR = 6145.009 ZSIG = 4262.532 MAXZ = 9999.000 MINZ = 1080.000

VALUES EMPLOYED

ZMIN = 1080.000 ZMAX = 1880.000 CI = 50.000

GRID = 16 XINC = 0.167 YINC = 0.278
CON = 16 PS = 5 COLMAX = 91

CONTOUR SYMBOL TABLE IS AS FOLLOWS

(ONLY EVEN SYMBOLS PRINTED IN BODY OF MAP)

SYMBOL VALUE

• NO DATA

- BELOW LOW

0 1080.0000 TO 1130.0000
1 1130.0000 TO 1180.0000
2 1180.0000 TO 1230.0000
3 1230.0000 TO 1280.0000
4 1280.0000 TO 1330.0000
5 1330.0000 TO 1380.0000
6 1380.0000 TO 1430.0000
7 1430.0000 TO 1480.0000
8 1480.0000 TO 1530.0000
9 1530.0000 TO 1580.0000
A 1580.0000 TO 1630.0000
B 1630.0000 TO 1680.0000
C 1680.0000 TO 1730.0000
D 1730.0000 TO 1780.0000
E 1780.0000 TO 1830.0000
F 1830.0000 TO 1880.0000

* 1880.0000 OR OVER

FREQUENCY TABLE

INTERVAL UNITS PERCENTAGE CUMULATIVE

NO DATA BELOW LOW 3081 0 0

1080.0000 TO 1130.0000 39 1.7751 1.7751
1130.0000 TO 1180.0000 98 4.4286 6.2038
1180.0000 TO 1230.0000 171 7.7833 14.0191
1230.0000 TO 1280.0000 184 8.3751 22.3942
1280.0000 TO 1330.0000 223 10.1502 32.5444
1330.0000 TO 1380.0000 230 10.4688 43.0132
1380.0000 TO 1430.0000 230 10.4688 53.4820
1430.0000 TO 1480.0000 213 9.6950 63.1771
1480.0000 TO 1530.0000 182 8.2840 71.4611
1530.0000 TO 1580.0000 146 6.6454 78.1065
1580.0000 TO 1630.0000 136 6.1903 84.2968
1630.0000 TO 1680.0000 88 4.0055 88.3022
1680.0000 TO 1730.0000 84 3.8234 92.1256
1730.0000 TO 1780.0000 67 3.0496 95.1752
1780.0000 TO 1830.0000 34 1.5476 96.7228
1830.0000 TO 1880.0000 17 0.7738 97.4966
1880.0000 OR OVER 55 2.5034 100.0000

TOTAL 2197 100.0000 100.0000

CONTOUR MAP OF DRAINAGE BASIN IN VERDUGO HILLS; STRAHLER FIG 15.

SAMPLE OUTPUT FROM SUBROUTINE PRTCON
Sample output from subroutines PRTCON I and HYPSO

Contour map of drainage basin in Verdugo Hills: Strahler Fig 15.
PROTECTION

OF GETOSIR

MS

SEE COOTJR

PROGRAM
PROGRAM CONTUR - GENERAL INSTRUCTIONS

PURPOSE -
TO PLOT CONTOUR MAPS OF GRIDDED DATA ON THE CALCOMP PLOTTING
THIS PROGRAM IS BASED ON A FORTRAN II PROGRAM WRITTEN BY FRANK J.
RENS, UNIVERSITY OF MICHIGAN DEPARTMENT OF GEOGRAPHY.

PURDUE UNIVERSITY VERSION 1.2
PROGRAMMED BY -- SANDRA L. TURNER, A. KEITH TURNER,
COMPUTER SCIENCE, CIVIL ENGINEERING, FEBRUARY 1968.

THIS PROGRAM CAN PRODUCE MAPS TO ANY SCALE WITHIN THE LIMITS
OF THE PLOTTER PAPER WIDTH (MAXIMUM = 28 INCHES).

MANY OPTIONS ARE AVAILABLE AND CAN BE SPECIFIED THROUGH THE USE
OF CONTROL CARDS. THE USER MAY SPECIFY CONTOURS AT REGULAR OR IRREG-
ULAR INTERVALS, AND MAY TRANSFORM MAP COORDINATES BY TRANSLATION OR
ROTATION ABOUT ANY OF THE THREE MAJOR AXES (X, Y, OR Z).

THE PROGRAM CAN PRODUCE ISOMETRIC BLOCK DIAGRAMS OF THE CONTOUR
MAPS BY ROTATING THE DATA ABOUT ALL THREE AXES BEFORE PLOTTING. THE
USF OF A PERSPECTIVE OPTION IN COMBINATION WITH TRANSLATION WILL
ALLOW THE PLOTTING OF LEFT AND RIGHT VIEWS FOR STEREOSCOPIC (3-D)
EFFECTS.

THE PROGRAM IS CAPABLE OF PLOTTING A NUMBER OF DIFFERENT MAPS
OF A SINGLE SET OF DATA, EACH INVOLVING DIFFERENT MAP SCALES, CONTOUR
INTERVALS, ROTATIONS OR TRANSLATIONS, WITHOUT REREADING THE DATA.
VALUES OF CONTOUR LINE COORDINATES ARE CALCULATED AND STORED ON A
SCRATCH TAPE. THESE VALUES ARE MODIFIED AND PLOTTED FOR EACH MAP
REQUESTED SO THAT THE CALCULATIONS ARE MINIMIZED AND THE PLOTTING
OF MULTIPLE MAPS IS EFFICIENT.

TAPE REQUIREMENTS -
1) A SCRATCH TAPE (TAPE 3) IS USED TO STORE CONTOUR COORDINATES
PRIOR TO PLOTTING.
2) A PLOT TAPE IS REQUIRED.
   SINCE TWO TAPES ARE USED, REASSIGNMENT OF TAPE UNITS IS REQUIRED
   THIS IS ACCOMPLISHED BY A MAP ROUTINE INCLUDED IN THE LISTING.

ROUTINES REQUIRED -
A) MAIN PROGRAM (CONTUR) PERFORMS OPERATIONS ACCORDING TO CONTROL
   CARD SPECIFICATIONS.
B) SUBROUTINES -
1) SCAN - SCANS DATA TO LOCATE CONTOURS.
2) TRACE - TRACES OUT CONTOUR LINE.
3) CALC - PERFORMS INTERPOLATION.
4) DRAFT - PERFORMS ROTATIONS AND TRANSLATIONS, WRITES PLOT TAPE.
5) PROJ - DUMMY SUBROUTINE TO ALLOW ADDITION OF USER-DEVELOPED
   MODIFICATIONS.
DESCRIPTION OF CONTROL CARDS AND THEIR OPERATIONS

Each control card contains a control integer (NCON) in columns 1-2. Some operations require input data in the form of variables and/or data on additional cards. Any variables required should be placed in columns 3-12, 13-22, 23-32, 33-42, etc., with decimal points punched. When the control integer indicates that additional cards are necessary for a complete operation, these cards should follow immediately.

NCON  REMARKS

01  OPERATION- READ AND CONTOUR DATA MATRIX
    VARIABLES-1) NUMBER OF ROWS
                 2) NUMBER OF COLUMNS
                 3) WIDTH OF MAP IN INCHES
                 4) SCALE FACTOR FOR Z VALUES (Z = Z/ZSCALE) (IF BLANK=1)
    ADDL CARDS- THE DATA MATRIX IS READ IN ROW BY ROW FROM TOP TO BOTTOM (EACH ROW IS SCANNED FROM LEFT TO RIGHT). THE MATRIX IS READ ACCORDING TO A PREVIOUSLY DEFINED FORMAT (SEE NCON=19). MAXIMUM SIZE IS 100X100.

02  OPERATION- ROTATE THE VIEWING POSITION OF THE SURFACE THETA
    DEGREES IN THE X DIRECTION.
    VARIABLES-1) THETA IN DEGREES.
    ADDL CARDS- NONE

03  OPERATION- ROTATE THE VIEWING POSITION OF THE SURFACE THETA
    DEGREES IN THE Y DIRECTION.
    VARIABLES-1) THETA IN DEGREES.
    ADDL CARDS- NONE

04  OPERATION- ROTATE THE VIEWING POSITION OF THE SURFACE THETA
    DEGREES IN THE Z DIRECTION.
    VARIABLES-1) THETA IN DEGREES.
    ADDL CARDS- NONE

05  OPERATION- CALL SUBROUTINE PROJ FOR USER-DEFINED MODIFICATIONS.
    VARIABLES- NONE
    ADDL CARDS- NONE

06  OPERATION- PLOT USERS NAME AND ACCOUNT NUMBER ON PLOT.
    VARIABLES- NONE
    ADDL CARDS- NAME AND ACCOUNT NUMBER

08  OPERATION- PLOT CONTOURS WITH PERSPECTIVE TRANSFORMATION TO PROD-
    UCE LEFT OR RIGHT STEREO MODELS.
    VARIABLES-1) DISTANCE TO PERSPECTIVE PLANE.
                 2) DISTANCE TO OBJECT PLANE.
    ADDL CARDS- NONE

10  OPERATION- TRANSLATION OF CONTOUR COORDINATES.
    VARIABLES-1) TRANSLATION OF X IN INCHES (NOT SCALED, TRUE MEASURE)
                 2) TRANSLATION OF Y IN INCHES (NOT SCALED, TRUE MEASURE)
                 3) TRANSLATION OF Z IN INCHES (NOT SCALED, TRUE MEASURE)
    ADDL CARDS- NONE
11 OPERATION- DEFINE PLOTTER TAPE AS OTHER THAN NORMAL NUMBER.
VARIABLES-1) PLOTTER TAPE NUMBER
ADDL CARDS- NONE

12 OPERATION- READ TITLE FOR PLOT (PLOTTED AT TOP OF MAP).
VARIABLES- NONE
ADDL CARDS- TITLE PUNCHED IN COLUMNS 1-48

13 OPERATION- TERMINATE PLOT TAPE
VARIABLES- NONE
ADDL CARDS- NONE

14 OPERATION- READ LABELS AND COORDINATES (MAX. PER PLOT = 10).
VARIABLES-1) X COORDINATE OF LABEL
  2) Y COORDINATE OF LABEL
  3) Z COORDINATE OF LABEL
  4) HEIGHT OF LABEL LETTERS.
ADDL CARDS- A LABEL PUNCHED IN COLUMNS 1-36

15 OPERATION- DEFINE REGULARLY SPACED CONTOURS.
VARIABLES-1) STARTING CONTOUR
  2) CONTOUR INTERVAL
  3) FINAL (HIGHEST) CONTOUR
ADDL CARDS- NONE

16 OPERATION- REDEFINE CONTOUR INTERVALS FOR SAME DATA.
VARIABLES- SAME AS FOR NCON=15

17 OPERATION- DEFINE IRREGULARLY SPACED CONTOURS.
VARIABLES-1) NCONT=NUMBER OF CONTOURS.
ADDL CARDS-1) FORMAT OF CONTOURS
  2) CONTOUR LEVELS AS DEFINED ABOVE.

18 OPERATION- SPECIFY WIDTH OF PAPER (11 OR 28 INCHES)
VARIABLES-1) WIDTH OF PAPER
ADDL CARDS- NONE

19 OPERATION- SPECIFY FORMAT OF DATA
VARIABLES- NONE
ADDL CARDS- FORMAT OF DATA MATRIX IN COLUMNS 1-72

20 OPERATION- PLOT MAP ACCORDING TO ALL CONTROLS GIVEN SINCE LAST CALL TO PLOT (LAST NCON=20)
VARIABLES- NONE
ADDL CARDS- NONE

21 OPERATION- CHANGE WIDTH OF PLOTTED MAP (CHANGE SCALE)
VARIABLES-1) NEW WIDTH IN INCHES
ADDL CARDS- NONE

COMMENTS AND RESTRICTIONS
PRIOR TO READING IN DATA MATRIX, THE FORMAT (NCON=19) AND CONTOUR INTERVALS (NCON=15 OR 17) MUST BE DEFINED.
BEFORE CALL TO PLOT (NCON=20) PAPER WIDTH (NCON=18) AND ACCOUNT CODE (NCON=06) MUST BE DEFINED.
PLOTTING THE MAP RESETS ALL CONTROLS TO PLOT A NEW SET OF DATA USE NCON=1 WITH OR WITHOUT A NEW FORMAT OR CONTOURING CONTROLS.
DIMENSION AM(100,100),REC(800),X(1500),Y(1500),IPT(3,3),INX(8),
1 INY(8),IOP(20),XL(10),YL(10),ZL(10),LAB(10,6),DX(2),DY(2),DZ(2),
2 HT(10),CTHETA(4),STHETA(4),TEMP(6),FMT(12),Z(1500),TIT(8),
3 CFMT(12),VCON(20),WORK(1024)

COMMON MT,NIT,NIX,ITY,ITX,IY,ITY,ITX,IX,ITY,ITX,NP,NJ,TV,RECC,VX,Y,IpT,
1 INX,INY,D L,A M,IOP,DP,LAB,XY,YZ,LAB,DX,DY,DZ,XMAX,HT,SCALE,
2 YMAX=CTHETA,STHETA,FM2,FNN,NN,MC,CL,DL,LINES,NCURV,Z,TIT,WORK

COMMON ZSCALE
REAL MAXX,MAXY,MINX,MINY
N PLOT=1
IOP (1)=0
NLINFS=0
ISTAP=5
D=0.

9999 ILAB=0
REWIND 3
DO 9981 I=2,20

9981 IOP(I)=0
NB OUND=0

100U READ (5,1U0) NCON,(TEMP(I),I=1,6)

100 FORMAT (I2,6F10.0)
WRITE (6,1001) NCON,(TEMP(I),I=1,6)

1001 FORMAT (3X,I5,6F10.3)
IF (NCON.LE.0 .OR. NCON.GT.21) GO TO 30
GO TO (1,2,2,2,5,6,30,8,8,10,11,12,13,14,15,16,17,18,19,20,21)
1 NCON

C
C NCON=1
1 M=TEMP(1)
NN=TEMP(2)
TEMP(1)=TEMP(2)-1.
SCALE=TEMP(1)/TEMP(3)
IF (TEMP(4).EQ.0.) TEMP(4)=1.
ZSCALE=TEMP(4)
FM2=FLOAT(M)/2.
FNN=FLOAT(NN)/2.
YMAX=(FM2/SCALE)+2.5
XMAX=(FNN/SCALE)+2.5
MAXX=0.
MAXY=0.
MINX=1.E15
MINY=1.E15
IF \((IOP(1) \cdot \text{EQ.} \ 0)\) GO TO 5027
\nIOP(15)=1
IOP(19)=1

5027 IOP(1)=1
IF(IOP(19) \cdot \text{EQ.} \ 0) \text{ GO TO 902}
DO 2026 I=1,M

2026 READ (ISTAP\_FMT) \((A_M(J,I),J=1,NN)\)
WRITE(6\_FMT) \(((A_M(J,I),J=1,NN),I=1,M)\)
IF(IOP(15) \cdot \text{EQ.} \ 0) \text{ GO TO 903}
IF (IOPV \cdot \text{EQ.} \ 0) \text{ GO TO 2065}

C
C VARIABLE CONTOURS

2027 DO 2069 I=1,NVCON
CL=VCON(I)
CV=CL
CALL SCAN

2069 CONTINUE
GO TO 200

C
C REGULAR CONTOURS

205 C=CBGN
NLINES=0

206 CL=CV
CALL SCAN
CV=CV+CINC
IF (CV \cdot \text{LE.} \ CEND) \text{ GO TO 2066}

200 END FILE 3

2068 REWIND 3
GO TO 1000

C
C NCON=2,3,4
C DEFINE THETA FOR ROTATION
2 IOP(NCON)=1
NBOUND=1
THETA=-TEMP(1)/57.295795
STHETA(NCON)=SIN(THETA)
CTHETA(NCON)=COS(THETA)
GO TO 1000

C
C NCON=5
5 IOP(NCON)=1
GO TO 1000

C
C NCON=6
6 IOP(NCON)=1
   READ (5*6000) (USER(I),I=1,8)
   6000 FORMAT (8A6)
   GO TO 1000
C
C NCON=6,9
C DEFINE PERSPECTIVE CONSTANTS
8 IOP(NCON)=1
   IF (NCON=8) 7083,7084,7083
7084 NBOUND=1
7083 CONTINUE
   DP=TEMP(1)
   DO=TEMP(2)
   GO TO 1000
C
C NCON=10
C DEFINE TRANSLATION
10 DX(1)=TEMP(1)
   DY(1)=TEMP(2)
   DZ(1)=TEMP(3)
   IOP(NCON)=1
   GO TO 1000
C
C NCON=11
11 ISTAP=TEMP(1)
   GO TO 1000
C
C NCON=12
12 IOP(12)=1
   READ (5*556) (TIT(I),I=1,8)
   WRITE (6*1008) (TIT(I),I=1,8)
   556 FORMAT (8A6)
   GO TO 1000
   1008 FORMAT (1H0,12A6)
C
C NCON=13
C END PLOT TAPE
13 CALL PLOT (0,0,999)
   STOP
C
C NCON=14
C READ LABELS, AND THEIR CORRESPONDING COORDINATES
14   IOP(14)=1
     ILAB=ILAB+1
     XL(ILAB)=TEMP(1)
     YL(ILAB)=TEMP(2)
     IF (ZSCALE) 92, 96, 92
96   ZL(ILAB)=TEMP(3)
     GO TO 94
94   ZL(J)=TEMP(3)/ZSCALE
     T(J,ILAB)=TEMP(4)
     READ (5,102) (LAB(I,ILAB),I=1,6)
102  FORMAT (6A6)
     GO TO 1000
C
C NCON=15
C DEFINE CONTOUR INCREMENTS
15   CBGN=TEMP(1)
     CINC=TEMP(2)
     CEND=TEMP(3)
     IOP(15)=1
     IOPV=0
     GO TO 1000
C
C NCON=16
16   CBGN=TEMP(1)
     CINC=TEMP(2)
     CEND=TEMP(3)
     IOPV=0
     RWIND 3
     GO TO 2065
C
C NCON=17
17   NVCON=TEMP(1)
     IOP(15)=1
     IOPV=1
     READ (5,1/5) (VFMT(I),I=1,12)
     READ (5,13) (VCON(I),I=1,NVCON)
     GO TO 1000
C
C NCON=18
18   IOP("J")=1
     SIZ=TEMP(1)
     GO TO 1000
C
C NCON=19
C READ FORMAT FOR MATRIX
19  READ (5,105) (FMT(I),I=1,12)
105  FORMAT (12A6)
       IOP(19)=1
       GO TO 1050
C
C NCON=20
C BEGIN PLOTTING
20  IF (IOP(2) .EQ. 1) GO TO 953
   IF (IOP(6) .EQ. 0) GO TO 6001
   CALL PLOTS (WORK(1),1024,0)
   CALL SYMBOL(0,0,2,USER,90,48)
   CALL PLOT(1,0,-3)
       IOP(20)=1
6001  IF (IOP(8) .EQ. 0) IOP(9)=1
   IF (IOP(18) .EQ. 0) GO TO 954
   XCEN=(MAXX+MINX)/2.
   YCEN=(MAXY+MINY)/2.
   YCEN1=YCEN
   XCEN1=XCEN
   IF (IOP(17) .EQ. 0) GO TO 955
   CBGN=VCN(1)
   CEND=VCN(NVCN)
955  IF (IOP(2) .EQ. 0) GO TO 956
   YCEN1=CTHETA(2)*YCEN-CBGN*STHETA(2)/ZSCALE
   YCEN=CTHETA(2)*YCEN-CEND*STHETA(2)/ZSCALE
956  IF (IOP(3) .EQ. 3) GO TO 957
   XCEN1=CTHETA(3)*XCEN+CBGN*STHETA(3)/ZSCALE
   XCEN=CTHETA(3)*XCEN+CEND*STHETA(3)/ZSCALE
957  IF (IOP(3) .EQ. 0) GO TO 958
   XCEN1=CTHETA(4)*XCN1-STHETA(4)*YCEN1
   XCEN=CTHETA(4)*XCEN-STHETA(4)*YCEN
958  XCEN=(XCEN1+XCEN)/2.
   XCFN=XCEN/SCALE+XMAX
   XMAX=XMAX-XCEN+SIZE/2.
954  IF (IOP(1) .EQ. 0) GO TO 904
C
C CALL DRAFT TO PLOT
   CBGN=-53139.E15
   NCURV=0
   NCOUNT=0
   NCMAX=0
   IF (NLINES) 23,23,25
25  READ(3) N,CV
       IF (CBGN .EQ. -53139.E15) CBGN=CV/ZSCALE-5
       READ (3) (X(I),Y(I),I=1,N)
       NCURV=NCURV+1
       NCOUNT=NCOUNT+N
IF (N-NCMAX) 7337, 7338, 7338
7338 NCMAX=N
CLMAX=CV
7337 CV=CV/ZSCALE
CALL DRAFT
IF (NCURV-NLINES) 25, 22, 22
23 CRGN=0.
22 N=5
CV=CRGN
X(1)=FNN
X(2)=X(1)+1.
X(3)=X(2)
X(4)=X(1)
X(5)=X(1)
Y(1)=FM2
Y(2)=Y(1)
Y(3)=-Y(2)+1.
Y(4)=Y(3)
Y(5)=Y(1)
CALL DRAFT
XNEW=YMAX*2,
28 CALL PLOT(XNEW, 0,.,-3)
GO TO 1000
C
C NCON=21
C CHANGE SCALE
21 SCALE = (FLOAT(M)-1.) / TEMP(1)
GO TO 1000
6001 WRITE (6*,6002)
6002 FORMAT (41H***PLOT USER IDENTIFICATION NOT DEFINED)
GO TO 920
902 WRITE (6*,402)
402 FORMAT (32H***FORMAT NOT DEFINED FOR DATA)
GO TO 920
903 WRITE (6*,403)
403 FORMAT (31H***CONTOUR LEVELS NOT DEFINED)
GO TO 920
904 WRITE (6*,404)
404 FORMAT (12H***NO DATA)
GO TO 920
30 WRITE (6*,531) NCON
531 FORMAT (27H***NCON NOT LEGAL, NCON =, I5)
920 WRITE (6*,6003)
6003 FORMAT (20H***PLOT TERMINATED)
STOP
END
$IBFTC SCANS DECK
SUBROUTINE SCAN
DIMENSION AM(100,100),REC(800),X(1500),Y(1500),INT(3,3),INX(8)
1 INX(8),IOP(20),XL(10),YL(10),LAB(10),DX(2),DY(2),DZ(2)
2 HT(10),CHOTTA(4),STHTA(4),Z(15,0),TIT(8),WORK(1024)
COMMON MT,NT,NX,NY,IDX,IDY,ISS,IT,IV,IP,T,JT,PY,REC,CV,XY,IP,T,
1 INX,INY,DL,AM,IOP,DP,DO,LAB,XL,YL,ZL,LAB,IDX,IDY,DY,DM,STXY,HT,SCALF,
2 YMAX,CHOTTA,STHTA,FM2,FNN,NN,CL,DLINES,NCURV,Z,TIT,WORK
IZX=1
NP=0
DL=D
MT=NN
MT=NN
IF (IZX) 3,3,1
1 IPT(1,1)=8
IPT(1,2)=1
IPT(1,3)=2
IPT(2,1)=7
IPT(2,3)=3
IPT(3,1)=6
IPT(3,2)=5
IPT(3,3)=4
INX(1)=-1
INX(2)=-1
INX(3)=U
INX(4)=1
INX(5)=1
INX(6)=1
INX(7)=U
INX(8)=-1
INY(1)=U
INY(2)=1
INY(3)=1
INY(4)=1
INY(5)=0
INY(6)=-1
INY(7)=-1
INY(8)=-1
IZX=0
3 XT=MT
DO 58 J=1,800
58 REC(J)=U
ISS=0
MT1=MT-1
DO 110 I=1,MT1
IF (AM(I,1)-CV) 55,110,110
55 IF (AM(I+1,1)-CV) 110,57,57
57 IX=I+1
IY=1
IDX=-1
IDY=0
CALL TRACE
10 CONTINUE
NT1=NT-1
DO 20 I=1,NT1
   IF (AM(MT,I)-CV) 15,20,20
15 IF (AM(MT,I+1)-CV) 20,17,17
17 IX=MT
   IY=I+1
   IDX=0
   IDY=-1
   CALL TRACE
20 CONTINUE
DO 30 I=1,MT1
   MT2=MT+1-I
   IF (AM(MT2,NT)-CV) 25,30,30
25 IF (AM(MT2-1,NT)-CV) 30,27,27
27 IX=MT2-1
   IY=NT
   IDX=1
   IDY=0
   CALL TRACE
30 CONTINUE
DO 40 I=1,NT1
   NT2=NT+1-I
   IF (AM(1,NT2)-CV) 35,40,40
35 IF (AM(1,NT2-1)-CV) 40,37,37
37 IX=1
   IY=NT2-1
   IDX=0
   IDY=1
   CALL TRACE
40 CONTINUE
ISS=1
NT1=NT-1
MT1=MT-1
DO 10 J=2,NT1
   DO 10 I=1,MT1
      IF (AM(I,J)-CV) 5,10,10
10 IF (AM(I+1,J)-CV) 10,7,7
5 COM=100*U(I+1)+J
   IF (NP) 12,11,12
12 DO 9 I=1,NP
      IF (REC(IDJ-COM)) 9,10,9
9 CONTINUE
11 IX=I+1
   IY=J
   IDX=-1
   IDY=0
   CALL TRACE
10 CONTINUE
RETURN
END
SUBROUTINE TRACE
DIMENSION AM(100,100), REC(20), X(1500), Y(1500), IPT(3,3), INX(8)
1 INY(8), IOP(20), XL(10), YL(10), ZL(10), LA3(10,6), DX(2), DY(2), DZ(2)
2 HT(10), CTHETA(4), STHETA(4), Z(1500), TIT(8), WORK(1024)
COMMON MT, NT, NI, IX, IY, IDX, IDY, ISS, IT, IV, NP, N, JT, PY, REC, CV, X, IPT
1 INX, INY, XL, AM, IOP, DP, DO, I, LAB, XL, YL, ZL, LAB, DX, DY, DZ, XMAX, HT, SCALE
2 YM, CTHETA, STHETA, FM2, FNN, MN, CL, DL, N, LINES, NCURV, Z, TIT, WORK
COMMON MAXX, MAXY, MINX, MINY, SIZE
REAL MAXX, MAXY, MINX, MINY, PY
PY=0.0

501 JT=0
N=0
IX0=IX
IY0=IY
ISX=IDX+2
ISY=IDY+2
IS=IPT(ISX, ISY)
JTB=0
ISO=IS
IF (ISO=8) 18, 18, 17
17 ISO=ISO-8
18 IT=0
5 CALL CALC
NZ=N
N=NZ
IF (IT+JT-1) 49, 49, 47
47 XS=X(N-1)
YS=Y(N-1)
X(N-1)=X(N)
Y(N-1)=Y(N)
X(N)=XS
Y(N)=YS
49 IS=IS+1
JT=IT
9 IF (IS=9) 8, 7, 7
7 IS=IS-8
8 IDX=INX(IS)
IDY=INY(IS)
IX2=IX+IDX
IY2=IY+IDY
JTP=JTP+1
IF (JTP=1500) 51, 51, 308
308 WRITE (6, 103) CV
103 FORMAT (21HO A CONTOUR AT LEVEL 5F6.2, 16H WAS TERMINATED.)
RETURN
51 IF (ISS) 10, 10, 20
20 IF (IX=IX0) 12, 21, 12
21 IF (IY=IY0) 12, 22, 12
22 IF (IS=ISO) 12, 23, 12
23 CALL CALC
GO TO 73
10 IF (IX2) 13,50,13
13 IF (IX2-MT) 19,19,50
19 IF (IY2) 11,50,11
11 IF (IY2-NT) 12,12,50
12 IF (CV-AM(IX2, IY2)) 206,206,5
206 IF (IDX**2+IDY**2-1) 213,6,213
213 DCP=(AM(IX, IY)+AM(IX2, IY)+AM(IX, IY2)+AM(IX2, IY2))/4.0
IF (DCP-CV) 5,217,217
217 IF (INX(IS-1)) 214,215,214
214 IX=IX+IDX
IDX=-IDX
PY=2.0
CALL CALC
IX=IX+IDX
GO TO 6
215 IY=IY+IDY
IDY=-IDY
PY=2.0
CALL CALC
IY=IY+IDY
6 IF (AM(IX-1,IY)-CV) 306,16,16
306 NP=NP+1
REC(NP)=100*IX+IY
16 IS=IS+5
IX=IX2
IY=IY2
GO TO 9
50 XT=MT
IF (AM(IX-1,IY)-CV) 307,73,73
307 NP=NP+1
REC(NP)=100*IX+IY
73 NLINES=NLINES+1
DO 135 K=1,N
X(K)=X(K)-FM2
Y(K)=Y(K)-FM2
135 CONTINUE
C
C STORE CURVE ON TAPE 3 (A4)
IF (N) 2072,2072,2071
2071 WRITE (3) N, CL
071 WRITE (3) (X(I), Y(I), I=1,N)
WRITE (6,104) CV
104 FORMAT (16HOCONTOUR LEVEL =,F6.2)
WRITE (6,105) (X(I), Y(I), I=1,N)
105 FORMAT (2X,5F10.3)
IF (IOPC18) .GT. 0 GO TO 2072
DO 72 I=1,N
IF (X(I) .GE. MAXX) MAXX=X(I)
IF (Y(I) .GT. MAXY) MAXY=Y(I)
IF (X(I) .LE. MINX) MINX=X(I)
72 IF (Y(I) .LE. MINY) MINY=Y(I)
2072 N=-1
RETURN
END
SUBROUTINE CALC

DIMENSION AM(100,100), REC(80), X(1500), Y(1500), IPT(3,3), INX(8),
1 INY(8), IOP(20), XL(10), YL(10), ZL(10), LAB(10,6), DX(2), DY(2), DZ(2),
2 HT(10), CTHETA(4), STHETA(4), Z(1500), TIT(8), WORK(1024)

COMMON MT, NT, NI, IX, IY, IDX, IDY, IS, IT, IV, N, JT, PY, REC, CV, X, Y, IPT,
1 INX, INY, DL, AM, IOP, DP, DO, ILAB, XL, YL, ZL, LAB, DX, DY, DZ, XMAX, HT, SCALE,
2 YMAX, CTHETA, STHETA, FMZ, FNN, NN, M, CL, D, NLIST, NCURV, Z,TIT, WORK

IT=0
N=N+1
IF (IDX**2+IDY**2-1) 20,1,20
1 IF (IDX) 10,2,10
2 X(N)=IX
Z=IY
IY2=IY+IDY
DY=IDY
41 Y(N)=((AM(IX,IY)-CV)/(AM(IX,IY)-AM(IX,IY2)))*DY+Z
RETURN
10 Y(N)=IY
W=IX
DX=IDX
IX2=IX+IDX
44 X(N)=((AM(IX,IY)-CV)/(AM(IX,IY)-AM(IX2,IY)))*DX+W
RETURN
20 IX2=IX+IDX
IY2=IY+IDY
W=IX
Z=IY
DX=IDX
DY=IDY
dcp=(AM(IX,IY)+AM(IX2,IY)+AM(IX,IY2)+AM(IX2,IY2))/4.0
IF (PY-2.0) 24,21,24
24 IF (DCP-CV) 21,21,25
21 AL=AM(TX2, TY?)-DCP
23 V=5*(AL+DCP-CV)/AL
27 X(N)=V*DX+W
Y(N)=V*DY+Z
PY=0.0
RETURN
25 IT=1
AL=AM(TX2, TY?)-DCP
33 V=5*(AL+DCP-CV)/AL
28 X(N)=-V*DX+W+DX
Y(N)=-V*DY+Z+DY
RETURN
END
$1BFTC DRAFTS DECK$

SUBROUTINE DRAFT

DIMENSION AM(100,100), REC(800), X(1500), Y(1500), IPT(3,3), INX(8),
1 INY(8), IOP(20), XL(10), YL(10), ZL(10), LAB(1C,6), DX(2), DY(2), DZ(2),
2 HT(1U), CTHTA(4), STHTA(4), Z(1500), TIT(8), WORK(1024)

DIMENSION PART1(2)

COMMON HT, NT, NI, IX, IY, IDX, IDY, ISSN, IT, IV, NP, N, JT, PY, REC, CV, X, Y, IPT,
1 INX, INY, DL, AM, IOP, DP, DO, I1AB, XL, YL, ZL, LAB, DX, DY, DZ, XMAX, HT, SCALE,
2 YMAX, CTHTA, STHTA, FM2, FN, NN, TM, CL, DNLINES, NCURV, Z, TIT, WORK

COMMON MAXX, MAXY, MINX, MINY, SIZE

COMMON ZSCALE

REAL MAXX, MAXY, MINX, MINY

363 KTYPE=3

DO 80 I=2, 14
IF (IOP(I)) 80, 80, 81
81 GO TO (101, 101, 102, 103, 80, 80, 80, 80, 80, 80, 80, 80, 80, 80, 14, 1)

C

C ROTATION ABOUT X

101 D1=1.0
D2=0.0
D3=0.0
D4=0.0
D5=CTHTA(2)
D8=STHTA(2)
D7=0.0
D6=-D8
D9=D5
GO TO 106

C

C ROTATION ABOUT Y

102 D1=CTHTA(3)
D2=0.0
D3=STHTA(3)
D4=0.0
D5=1.0
D6=0.0
D7=-D3
D8=0.0
D9=D1
GO TO 106

C

C ROTATION ABOUT Z

103 D1=CTHTA(4)
D4=STHTA(4)
D3=0.0
D2=-D4
D5=D1
D6=0.0
D7=0.0
D8=0.0
D9=1.0

C
C ROTATE
106 CVD3 = CV*D3
CVD6 = CV*D6
CVD9 = CV*D9
DO 20 J = 1, N
XX = D1*X(J) + D2*Y(J) + CVD3
YY = D4*X(J) + D5*Y(J) + CVD6
Z(J) = D7*X(J) + D8*Y(J) + CVD9
X(J) = XX
20 Y(J) = YY
GO TO 80

C PRINT HEADING INFORMATION
8 TITCOD = 9
IF (I-8) 401, 401, 301
401 NN1 = 2
WRITE (6, 1010) DP, DO
1010 FORMAT (24H0 DISTANCE TO PLANE = F9.2, 22H, DISTANCE TO OBJECT =
1, F9.2)
GO TO 86
301 NN1 = 1
86 IF (IOP(12)) 565, 566, 565
565 CALL SYMBOL (TITCOD, 3, 14, TIT, 90, 48)
566 IOP(8) = 0
IOP(9) = 0
GO TO 80

C PLOT LABEL ON GRAPH
14 DO 935 J = 1, ILAB
GO TO (751, 752)*NN1
751 C1 = XL(J)/SCALE + XMAX
C2 = YL(J)/SCALE + YMAX
F = SCALE
934 HT(J) = HT(J)/F
935 IOP(14) = 0
893 GO TO 80

C TRANSLATE DATA
10 DO 602 J = 1, N
X(J) = X(J) + DX(1)
Y(J) = Y(J) + DY(1)
602 Z(J) = Z(J) + DZ(1)
C PLOT PLANE OR PERSPECTIVE VIEW OF SURFACE
80 CONTINUE
   IOPC=IOP(2)+IOP(3)+IOP(4)
405 DO 300 J=1,N
   IF (IOPC) 894,894,892
894 Z(J)=CV
892 GO TO (402,403)•NN1
402 C1=X(J)/SCALE+XMAX
   C2=Y(J)/SCALE+YMAX
   GO TO 406
403 E=(DO-Z(J))/DP*SCALE
   C1=X(J)/E+XMAX
   C2=Y(J)/E+YMAX
406 IF (IOP(5)) 933,933,930
930 CALL PROJ(C1,C2)
933 IF (C1.GT.SIZE.OR.C1.LT.-1.) GO TO 936
   CALL PLOT (C2,C1,KTYPE)
   IF(KTYPE.EQ.2) GO TO 304
   CVV=CV*ZSCALE
   CALL NUMBER (C2,C1,.07,CVV,90.,2)
   CALL PLOT (C2,C1,3)
   CB1=C1
   CB2=C2
304 KTYPE=2
   GO TO 300
936 KTYPE=3
300 CONTINUE
   IF(CB2.EQ.C2.AND.CB1.EQ.C1) GO TO 305
   CALL NUMBER (C2,C1,.07,CVV,90.,2)
305 CONTINUE
RETURN
END
SUBROUTINE PROJ(X,Y)
X=1.
Y=1.
RETURN
END

SIBMAP INPUT
ENTRY 'UNU8.
*UNU8 PZF UNIT08
UNIT08 FILE 'A,READY,INPUT,BLK=22,HIGH,bCD
END
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**DEGREE TREND SURFACE, APRIL 1967**

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