DANIEL F. MERRIAM, Editor

FORTRAN IV AND MAP PROGRAM FOR COMPUTATION AND PLOTTING OF TREND SURFACES FOR DEGREES 1 THROUGH 6

By

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COMPUTER CONTRIBUTION 3
State Geological Survey
The University of Kansas, Lawrence
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Editor's Remarks

The application of computer techniques to solving problems in the earth sciences is now very important and becoming more so each day. Many applications were unthought of just a few years ago and indeed in some instances just a few months or even weeks ago.

....people who are thinking about what
they are doing are using computers....

Preston C. Hammer, April 17, 1966

Some of the applications involve statistical techniques - the primary objective of which is to predict. Or stated another way, these techniques can be used to (1) reduce complex situations to simple ones, (2) emphasize or isolate individual factors, or (3) interpolate or extrapolate from the data. Techniques presently being evaluated for problem solving in the earth sciences include: trend analysis, clustering techniques, factor analysis, and harmonic analysis.

Trend analysis attempts to isolate the fundamental, large-scale effects contained within the data which will explain a major portion of the variation. Clustering techniques are methods of grouping items based on the similarity and correlation of various characteristics of these items in n-dimensional space. Factor analysis is a method for finding common underlying factors in many interdependent variables. Harmonic analysis attempts to introduce order into irregular or erratic data and separate it into basic components, thus allowing meaningful interpretation.

Although some of these techniques were possible before the advent of the computer, many were not. Their execution is presently feasible only because of the ease and speed with which they can be accomplished.

....a computer is an intelligence amplifier....

Preston C. Hammer, April 17, 1966

Geologists are now confronted in the computer age with a multitude of methods about which they are completely unfamiliar. The Kansas Survey is studying these "new" methods by applying the various techniques to sample problems to ascertain their usefulness. Evaluating these methods is just another one of many important aspects in the study of the nature and genesis of rocks in the State of Kansas and the exploration and exploitation of their economic value.

The Kansas Survey is the only geological organization known to be actively distributing computer program decks as well as data decks. The programs are sold for a limited time at a nominal cost. The programs are for Burroughs B5500, Elliott 803C, IBM 1620, 7040, and 7090/1401 or 7094/1401 computer system. A list of available decks is given below.

	ALGOL	BALGOL	FORTRAN II	FORTRAN IV
Marine simulation (CC 1)		$20.00		
2D Regression (CC 2)	$10.00		$10.00	$10.00
Trend-6 (CC 3)				$25.00
Trend-3 (SDP 3)		$10.00		
Match-Coeff (SDP 4)			$ 2.00	
Correlation and distance Coeff (SDP 9)		$ 5.00(each)		
Time-trend (SDP 12)			$ 5.00	$ 5.00
Covap (SDP 13)			$15.00	
Trend-3 (SDP 14)			$25.00	$25.00
Cross-association (SDP 23)				$10.00
Single and		$ 5.00		
double Fourier (SDP 24)		$15.00		
Precambrian wells (SDP 25) List of about 2,600 Precambrian wells		$50.00		
Trend-4 (SDP 26)			$ 7.50	
Sediment analysis (SDP 28)			$10.00	
4D Trend (KGS B171)		$10.00		
Conversion of T&R to				
Cartesian coordinates (KGS B170-3)			$ 5.00	$ 5.00

The report presented here, as COMPUTER CONTRIBUTION 3, "FORTRAN IV and MAP program for computation and plotting of trend surfaces for degrees 1 through 6," by Mont O'Leary, R. H. Lippert, and O. T. Spitz, describes an operational computer program for trend analysis. The program is much improved over the versions previously published by the Survey (Special Distribution Publications 3 and 14).

Comments and suggestions concerning the COMPUTER CONTRIBUTIONS series are welcome and should be addressed to the editor.

FORTRAN IV AND MAP PROGRAM FOR COMPUTATION AND PLOTTING OF TREND SURFACES FOR DEGREES 1 THROUGH 6

By

MONT O'LEARY, R. H. LIPPERT, and OWEN T. SPITZ

INTRODUCTION

The original version of this program was published by John W. Harbaugh (1963) in BALGOL for the IBM 7090. In late 1963, Donald I. Good translated the program into FORTRAN II for the IBM 1620, but vast differences in language and hardware necessitated a complete rewriting. Good's program was published in 1964 as Kansas Geological Survey Special Distribution Publication 14. Shortly after publication of this program, The University of Kansas replaced the 1620 with a larger IBM 7040. In September, 1964, Owen T. Spitz converted the program to FORTRAN IV, revising it to its present two-link chain program form for adaptation to the IBM 7040 with 16 K.

The program described herein is a further modification of Good's program which exploits the speed and additional core storage of the IBM 7040. Polynomial surfaces (trend surfaces) are fitted up to sixth degree. Double precision arithmetic has been introduced into the program to reduce "roundoff error," and the capacity of the program has been expanded to a maximum of 500 data points.

Whereas the organization of the program has been greatly modified, the mathematical and computational structure of the program is essentially as described in Good (1964). Input and output are almost identical to those of the original program, and sizable portions of the documentation described herein are taken in their entirety from Good (1964).

A number of papers have appeared which deal with application of trend surfaces to geologic and geochemical data (Allen and Krumbein, 1962; Connor and Miesch, 1964; Krumbein, 1956, 1959; Miller, 1956; Whitten, 1959, 1961). Most of these papers deal with trend surfaces applied to petrologic data or facies data. However, Forgotson (1963), Merriam (1964), Merriam and Harbaugh (1964), and Wolfe (1962) suggest that trend surfaces fitted to structural data might aid in mineral exploration. Trend-surface computer programs available to the public have been written by Harbaugh (1963, 1964a, 1964b), McIntyre (1963), Peikert (1963), and Whitten (1963).

Card decks of the FORTRAN IV source programs, MAP subroutines, a sample data set with control cards, and a FORTRAN IV source program for determining numeric equivalents of plotting symbols may be obtained for a limited time from the Kansas Geological Survey for $25.00

Acknowledgments.- The authors express their appreciation to Donald I. Good for advice during the revision, to Fred Long for MAP subroutines OCV, LCV, DCV, and GCV, and to Gary Shilling of The University of Kansas Computation Center for providing the SHARE programs, IORED and modified POSTX, which were developed by the University of Utah Computation Center, Salt Lake City, Utah. The University of Kansas Computation Center, Dr. R. G. Hetherington, Director, provided computer time to develop the program.

PROGRAM DESCRIPTION

Flow of control through the chained program and the various subroutines is briefly illustrated in Figure 1. The main steps within each chain link are listed below in order of occurrence:

LINK 1

Plotting symbols are generated.
Data parameters are read into the program and checked.
xyz coordinates are read in.
Coefficient matrices are generated and solved.
Subroutine T2 is called.

Subroutine T2

Trend surface z values, residuals, error measures, and equations of surfaces are calculated and printed.
Link 1 control cards are read in and checked.
Map titles are printed.
Subroutine CONTUR is called.

Subroutine CONTUR

Trend surfaces are calculated and printed.

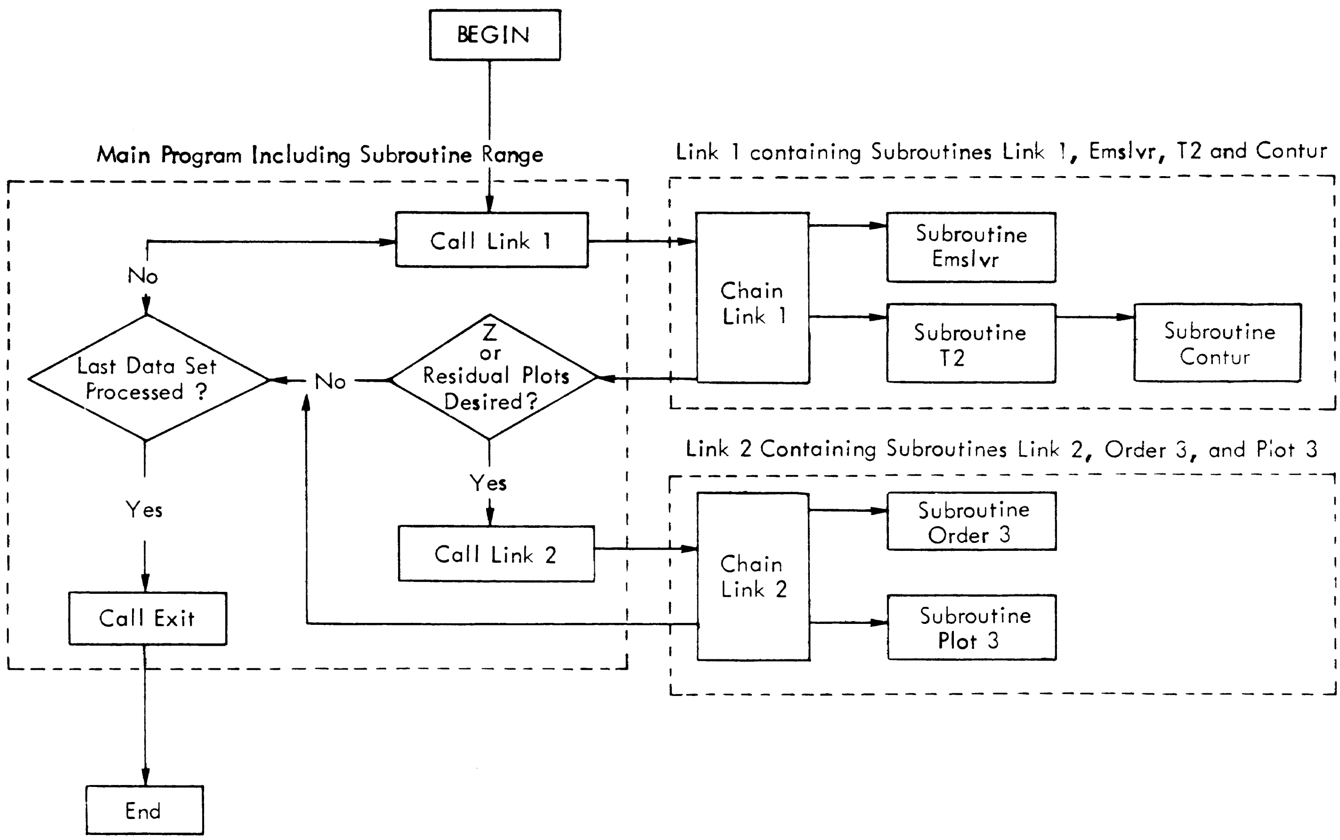

Figure 1. - Simplified chart of flow of control through mainline program, program links, and subroutines. Subroutine RANGE that is carried in mainline is called by Chain Link 1 and 2, and subroutines T2, CONTUR, and PLOT3. MAP subroutines are not involved in input, output, or computations and are not shown on flow chart.

(At this point, control of the program returns to mainline. Link 2 option is interrogated and Link 2 is called if so indicated by option.)

LINK 2

Link 2 control cards are read in and partially checked.
Map titles are printed.
Subroutine PLOT 3 is called.

Subroutine PLOT 3

Remainder of Link 2 control cards are checked.
Z and residual values are ordered and plotted.

Computation Time

On a test run, 23 minutes were required for computation, printing, and plotting of six trend surfaces, the original data, and six residual maps, each measuring 7 1/2 by 9 inches. Of this, 21 minutes were required for computation and printing of six trend surfaces.

The number of control points involved has little bearing on computation time. Major factors in computation time are (1) order of trend surface, (2) size (area) of plots, and (3) number of plots. On the test run, for example, solution and printing of the first-degree trend surface required 0.45 minutes whereas solution and printing of the sixth-degree trend surface required 4.3 minutes. If the test run had been output at 15 by 9 inches (thereby doubling the area) computation time would have doubled to approximately 45 minutes.

Core Space

Limited core space has been a critical problem in the development of this program. It has been overcome by (1) use of intermediate tape storage of matrices and data arrays, (2) overlaying of large arrays in COMMON, and (3) use of several MAP subroutines which conserve existing core space or provide additional core from the buffers.

Because all large data arrays are overlain in COMMON with matrices, reducing the dimensions of data points (xyz coordinates) will have little effect in saving core.

Included in the FORTRAN program are two sets of MAP subroutines. The first set, labeled CHEAT, consists of four subroutines - OCV, DCV, LCV, and GCV. A dummy entry point for octal, logical, double precision, and G conversions is defined by these subroutines, thus saving core space for input and output during loading of the variable format used in the program.

The second set consists of two subroutines - IORED and modified POSTX - which use the IOOP1 level of IOCS. These routines provide additional core space by giving access to core normally tied up in buffer. If IORED and POSTX are used, the $IBJOB card must carry the option IOOP1.

Adaptation to Other Installations

Because this program was developed for the compiler of the IBM 7040 at The University of Kansas Computation Center, minor modifications may be required for use at other installations. The following information may serve as a guide to two possible changes:

The FORTRAN equivalents of input-output devices for the KU compiler are as follows:

DEVICE	FORTRAN EQUIVALENT
S.SU00	0
S.SU01	1
S.SU02	2
S.SU03	3
S.SU04	4
S.SIN1	5
S.SOU1	6

Within the program, FORTRAN 1, 2, and 3 (S.SU01, S.SU02, and S.SU03) are used for intermediate storage of matrices and data arrays while FORTRAN 0 (S.SU00) is reserved as the chain tape.

Cards 12 through 73 in subroutine LINK 1 provide the numeric codes of the symbols used in plotting and contouring. The numeric codes of the symbols may differ among different compilers. Numeric codes may be tested for the machine on which the program is to be run by means of the following program:

```
      DIMENSION JARBO (52)
      READ (5, 1) (JARBO(I), I = 1, 52)
      IDENT = 11
      DO 2 I = 1, 52
    2 WRITE (6,3) I, JARBO(I), IDENT
    1 FORMAT (40A1, 12A2)
    3 FORMAT (6X, 6HJARBO(,I2,4H) = , I12, 42X,
     1 5HLINK1, I3)
      CALL EXIT
      END
```

The following symbol card (beginning in Column 1) is read into the above program:

ABCDEFGHIJKLMNOPQRSTUVWXYZ.0123456789*+-

Numbers appearing on cards 12 to 72 of LINK 1 must be changed to correspond to those output from the above program.

Listing of FORTRAN IV statements in trend-surface program.

```
C                                              STATE GEOLOGICAL SURVEY
C                                              COMPUTER APPLICATIONS LABORATORY
C                                              OCT. 20, 1964
      COMMON /TAPE/NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      NTAPE1 = 1
      NTAPE2 = 2
      NTAPE3 = 3
      NTAPE4 = 4
      NTAPE5 = 5
      NTAPE6 = 0
      DOUBLE PRECISION A(28,6)
      COMMON A,DUMMY(1605),IPLOT
      N=5
      READ (N,102) J
  102 FORMAT(I2)
      DO 5 KIK=1,J
      CALL CHAIN (1)
      IF(IPLOT) 5,5,4
    4 CALL CHAIN (2)
    5 CONTINUE
      CALL EXIT
      CALL RANGE(0,0,N,N)
      END
```

```
$IBFTC RANGE
      SUBROUTINE RANGE(LL,LU,N,NER)
C
C     RANGE DETERMINES WHETHER OR NOT N FALLS IN THE CLOSED
C     INTERVAL (LL,LU)
C
      NER = 0
      IF(LL - N) 5, 15, 10
    5 IF (LU-N) 10, 15, 15
   10 NER = 1
   15 RETURN
      END
$ENTRY          MAIN
$LINK  LINK1
$IBFTC LINK1
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O-LEARY     LINK1  1
      COMMON /TAPE/NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      DOUBLE PRECISION T(28,29),A,U(28)                                  LINK1  2
      COMMON A(28,6),X(500),Y(500),Z(500),JARBO(52),ID(40),MTD(6),N,     LINK1  3
     1 SUMZ,FN,IP,DUMB(4)                                                LINK1  4
      EQUIVALENCE (MTD(1), M5), (MTD(2), M6), (MTD(3), M7)               LINK1  5
      EQUIVALENCE (MTD(4),M8),(MTD(5),M9)    ,(T,A)                      LINK1  6
C                                                                        LINK1  7
C     --------------------------                                         LINK1  8
C     CREATE PLOTTING CHARACTERS                                         LINK1  9
C     --------------------------                                         LINK1 10
      JARBO( 1) =  19071700016                                           LINK1 12
      JARBO( 2) =  20145441840                                           LINK1 13
      JARBO( 3) =  21219183664                                           LINK1 14
      JARBO( 4) =  22292925488                                           LINK1 15
      JARBO( 5) =  23366667312                                           LINK1 16
      JARBO( 6) =  24440409136                                           LINK1 17
      JARBO( 7) =  25514150960                                           LINK1 18
      JARBO( 8) =  26587892784                                           LINK1 19
      JARBO( 9) =  27661634608                                           LINK1 20
      JARBO(10) =  -1891830832                                           LINK1 21
      JARBO(11) =  -2965572656                                           LINK1 22
      JARBO(12) =  -4039314480                                           LINK1 23
      JARBO(13) =  -5113056304                                           LINK1 24
      JARBO(14) =  -6186798128                                           LINK1 25
      JARBO(15) =  -7260539952                                           LINK1 26
      JARBO(16) =  -8334281776                                           LINK1 27
      JARBO(17) =  -9408023600                                           LINK1 28
      JARBO(18) = -10481765424                                           LINK1 29
      JARBO(19) = -20145441840                                           LINK1 30
      JARBO(20) = -21219183664                                           LINK1 31
      JARBO(21) = -22292925488                                           LINK1 32
      JARBO(22) = -23366667312                                           LINK1 33
      JARBO(23) = -24440409136                                           LINK1 34
      JARBO(24) = -25514150960                                           LINK1 35
      JARBO(25) = -26587892784                                           LINK1 36
      JARBO(26) = -27661634608                                           LINK1 37
      JARBO(27) =  29809118256                                           LINK1 38
      JARBO(28) =    818089008                                           LINK1 39
      JARBO(29) =   1891830832                                           LINK1 40
      JARBO(30) =   2965572656                                           LINK1 41
      JARBO(31) =   4039314480                                           LINK1 42
      JARBO(32) =   5113056304                                           LINK1 43
      JARBO(33) =   6186798128                                           LINK1 44
      JARBO(34) =   7260539952                                           LINK1 45
      JARBO(35) =   8334281776                                           LINK1 46
      JARBO(36) =   9408023600                                           LINK1 47
```

```
      JARBO(37) =  10481765424
      JARBO(38) = -13702990896
      JARBO(39) =  17997958192
      JARBO(40) =    -818089008
      JARBO(41) = -17997958192
      JARBO(42) = -17997958192
      JARBO(43) = -17997958192
      JARBO(44) = -17997958192
      JARBO(45) = -17997958192
      JARBO(46) = -17997958192
      JARBO(47) = -17997958192
      JARBO(48) = -17997958192
      JARBO(49) = -17997958192
      JARBO(50) = -17997958192
      JARBO(51) = -17997958192
      JARBO(52) = -17997958192
C
C     ----------------------
C     READ IN DATA PARAMETERS
C     ----------------------
      READ 20, (ID(I),I=1,40)
   20 FORMAT (1X, 39A2, A1)
      READ 95, N, (MTD(I),I=1,6)
   95 FORMAT (1X, I3, 1X, 6I1)
C     ---------------------
C     CHECK DATA PARAMETERS
C     ---------------------
      NERR = 0
      CALL RANGE(1,500,N ,NKR)
      KAW=1
      IF(NKR) 600, 600, 700
C
  600 CALL RANGE(0,1,M5,NKR)
      KAW=2
      IF(NKR) 605, 605, 700
  605 CALL RANGE(0,1,M6,NKR)
      KAW=3
      IF(NKR) 610, 610, 700
C
  610 CALL RANGE(0,1,M7,NKR)
      KAW=4
      IF(NKR) 615, 615, 700
C
  615 CALL RANGE(0,1,M8,NKR)
      KAW=5
      IF(NKR)616,616,700
C
  616 CALL RANGE(0,1,M9,NKR)
      KAW=6
      IF(NKR)618,618,700
  618 CALL RANGE (0,1,MTD(6),NKR)
      KAW = 7
C
  620 IA = MTD(1) + MTD(2) + MTD(3)+MTD(4)+MTD(5) + MTD(6)
      KAW = 8
      IF (IA) 700, 700, 710
C
  700 PRINT 705, KAW
  705 FORMAT (1X, 13HPROGRAM ERROR I3)
      NERR = 1
      GO TO (600,605,610,615,616, 618,620,706),KAW
```

```
C
  710 IF(NERR) 100, 100, 706
  706 PRINT 707
  707 FORMAT(13H0INVALID DATA)
      CALL EXIT
C     ----------------------
C     READ IN XYZ-COORDINATES
C     ----------------------
      DIMENSION FMT(12)
  105 FORMAT (12A6)
  100 READ 105, FMT
      READ FMT, (X(I),Y(I),Z(I),I=1,N)
C     ----------------------------------------------
C     CALCULATE COEFFICIENT MATRIX AND COLUMN VECTOR
C     ----------------------------------------------
      I=7
  107 I = I - 1
      IF(MTD(I) - 1) 107, 108, 108
  108 L = I
C
C     SELECT ORDER OF LARGEST COEFFICIENT MATRIX TO BE GENERATED
C
      GO TO (121, 122, 123,125,126, 127),L
  121 MM = 3
      GO TO 124
  122 MM = 6
      GO TO 124
  123 MM = 10
      GO TO 124
  125 MM=15
      GO TO 124
  126 MM=21
      GO TO 124
  127 MM = 28
  124 MM1 = MM + 1
C
C     STASH COORDINATE DATA ON TAPE
C
      REWIND NTAPE2
      DO 9998 I=1,N
 9998 WRITE(NTAPE2) X(I), Y(I), Z(I)
      REWIND NTAPE2
      REWIND NTAPE3
C
C     ZERO COEFFICIENT MATRIX AND COLUMN VECTOR
C
      DO 10 I = 1,MM,1
      DO 10 J = 1,MM1,1
   10 T(I,J) = 0.0
C
      DO 185 I = 1,N,1
C
C     PICK UP X,Y,Z COORDINATES  ONE AT A TIME
C
      READ(NTAPE2) P,Q,R
      U(1) = 1.
      U(2) = P
      U(3) = Q
C
      IF (L - 2) 117, 115, 115
  115 U(4) = P*P
      U(5) = P*Q
```

```
      U(6) = Q*Q
C
      IF (L - 3) 117, 116, 116
  116 U(7) = U(4) * P
      U(8) = U(4) * Q
      U(9) = P    * U(6)
      U(10) = U(6) * Q
C
      IF(L-4)117,111,111
  111 U(11)=U(7)*P
      U(12)=U(7)*Q
      U(13)=U(4)*U(6)
      U(14)=U(2)*U(10)
      U(15)=U(10)*Q
      IF(L-5)117,112,112
  112 U(16)=U(11)*P
      U(17)=U(11)*Q
      U(18)=U(12)*Q
      U(19)=U(13)*Q
      U(20)=U(14)*Q
      U(21)=U(15)*Q
C
      IF(L-6) 117,110,110
  110 U(22) = U(16) * P
      U(23) = U(16) * Q
      U(24) = U(17) * Q
      U(25) = U(18) * Q
      U(26) = U(19) * Q
      U(27) = U(20) * Q
      U(28) = U(21) * Q
C
  117 DO 185 J = 1,MM,1
      T(J,MM1) = T(J,MM1) + U(J) * R
      DO 185 K=1,MM
  185 T(K,J)=T(K,J)+U(J)*U(K)
C
C
C
      SUMZ=T(1,MM1)
      FN=T(1,1)
C     --------------
C     SOLVE MATRICES
C     --------------
      IP = 0
  217 IF (IP - L) 218, 580, 580
  218 IP=IP+1
C
C
C
      GO TO (219,220,221,222,223, 224), IP
  219 M=3
      GO TO 234
  220 M=6
      GO TO 234
  221 M=10
      GO TO 234
  222 M=15
      GO TO 234
  223 M=21
      GO TO 234
  224 M = 28
  234 M1=M+1
```

```
C                                                                       LINK1233
C     SAVE COEFFICIENT MATRIX BEFORE ORDERING EMSLVR                    LINK1234
C                                                                       LINK1235
      REWIND NTAPE1
      WRITE(NTAPE1) T
C                                                                       LINK1238
      DO 250 J = 1,M,1                                                  LINK1239
  250 T(J,M1) = T(J,MM1)                                                LINK1240
      CALL EMSLVR(T,U,M,MAT)                                            LINK1241
C                                                                       LINK1242
C     REPLACE COEFFICIENT MATRIX IN CORE   CONTINUE CALCULATIONS.       LINK1243
C                                                                       LINK1244
      REWIND NTAPE1
      READ(NTAPE1)T
C                                                                       LINK1247
      MTD(IP) = MTD(IP) + MAT                                           LINK1248
C                                                                       LINK1249
C     STASH CALCULATED COEFFICIENTS ON TAPE 3                           LINK1250
C                                                                       LINK1251
      DO 260 J = 1,M,1                                                  LINK1252
  260 WRITE(NTAPE3) U(J)
      GO TO 217                                                         LINK1254
C     ***********************************                               LINK1255
C     REPLACE X,Y,Z COORDINATES IN COMMON                               LINK1256
C     ***********************************                               LINK1257
  580 REWIND NTAPE2
      DO 9999 I=1,N                                                     LINK1259
 9999 READ(NTAPE2)X(I),Y(I),Z(I)
C                                                                       LINK1261
      CALL T2                                                           LINK1262
      CALL CHNXIT                                                       LINK1263
      END                                                               LINK1264
$IBFTC EMSLVR
      SUBROUTINE EMSLVR (A,ACOE,N,NPQ)                                  EMSLV  1
C     WILL ORDER THE MATRIX BEFORE EACH ELIMINATION IF                  EMSLV  2
C     MORDER=+1                                                         EMSLV  3
C     N= ORDER OF MATRIX                                                EMSLV  4
C     WILL SOLVE AN (N)X(N+1) MATRIX                                    EMSLV  5
C     REQUIRES MATRICES OF THE FORM (A)X(COE)=(B)                       EMSLV  6
C     ACOE=VARIABLES TO BE SOLVED FOR                                   EMSLV  7
C     A(I,J)= MATRIX ENTRIES                                            EMSLV  8
C     COLUMN (I,N+1) OF THE A MATRIX CORRESPONDS TO                     EMSLV  9
C     COLUMN MATRIX B                                                   EMSLV 10
C     DIMENSIONED VARIABLES MUST BE AT LEAST OF ORDER N                  EMSLV 11
C     OR N+1 AS SHOWN BELOW                                             EMSLV 12
C     DIMENSION A(N,N+1), IC(N), COE(N+1), ACOE(N)                      EMSLV 13
C     ANSWERS TO SINGULAR MATRICES ARE ZERO(0)                          EMSLV 14
      DOUBLE PRECISION A(28,29),ACOE(28),COE(29),AB,AX,AY,SUM           EMSLV 15
      DIMENSION IC(28)                                                  EMSLV 16
      NPQ=1                                                             EMSLV 17
   12 NM=N                                                              EMSLV 18
      NN=0                                                              EMSLV 19
      KK=0                                                              EMSLV 20
      MM=0                                                              EMSLV 21
      NP1=N+1                                                           EMSLV 22
      NM1=N-1                                                           EMSLV 23
      DO 3 J=1,N                                                        EMSLV 24
    3 A(J,NP1)=-A(J,NP1)                                                EMSLV 25
C     INITIALIZE SUBSCRIPT COLUMN                                       EMSLV 26
  799 DO 800 J=1,N                                                      EMSLV 27
  800 IC(J)=J                                                           EMSLV 28
      KKK=0                                                             EMSLV 29
```

```
C     - - - - - - - - - - - - - - - - - - - - - - -
C     MATRIX ORDERING ROUTINE
C     - - - - - - - - - - - - - - - - - - - - - - -
  999 KKK=KKK+1
      AB=DABS(A(KKK,KKK))
      IBIG=KKK
      JBIG=KKK
      DO 901 I=KKK,N
      DO 901 J=KKK,N
      IF(AB-DABS(A(I,J)))900,901,901
  900 AB=DABS(A(I,J))
      IBIG=I
      JBIG=J
  901 CONTINUE
  910 DO 920 I=1, NP1
      AX=A(KKK,I)
      A(KKK,I)=A(IBIG,I)
  920 A(IBIG,I)=AX
      DO 930 J=1,N
      AY=A(J,KKK)
      A(J,KKK)=A(J,JBIG)
  930 A(J,JBIG)=AY
  940 IDUM=IC(KKK)
      IC(KKK)=IC(JBIG)
      IC(JBIG)=IDUM
      IF(NM1-KKK) 71,71,999
C     - - - - - - - - - - - - - - - - - - - - - - -
   71 CONTINUE
   75 NN=NN+1
      NNN=NN+1
      MM=MM+1
C     ---------------------------------
C     CHECK FOR SINGULAR MATRIX
C     ---------------------------------
      IF (A(NN,NN)) 77,1700,77
C     ---------------------------------
C     MATRIX SOLUTION ROUTINE
C     - - - - - - - - - - - - - - - - - - - - - - -
   77 DO 81 I=NN,N
      IF(A(I,NN))79,81,79
   79 DO 80 J=NNN,NP1
      A(I,J)=A(I,J)/A(I,NN)
   80 CONTINUE
   81 CONTINUE
      KK=KK+1
      IF(KK-NM1)85,85,100
   85 DO 95 I=NNN,N
      IF(A(I,NN))89,95,89
   89 DO 90 J=NNN,NP1
      A(I,J)=A(I,J)-A(NN,J)
   90 CONTINUE
   95 CONTINUE
      IF(MORDER)91,75,91
   91 IF(KK-NM1+1)92,92,75
   92 KKK=MM
      GO TO 999
C     ---------------------------------
C     BACK SOLVE UPPER TRIANGULAR MATRIX
C     ---------------------------------
  100 COE(NP1)=1.0
      DO 110 K=1,NM
      SUM=0.0
```

```
      J=NP1-K                                                           EMSLV 90
      L=J+1                                                             EMSLV 91
      DO 109 I=L,NP1                                                    EMSLV 92
  109 SUM=SUM-A(J,I)*COE(I)                                             EMSLV 93
  110 COE(J)=SUM                                                        EMSLV 94
C     -----------------------------------                               EMSLV 95
C     REORDER ANSWER MATRIX                                             EMSLV 96
C     -----------------------------------                               EMSLV 97
      DO 1005 I=1,NM                                                    EMSLV 98
      K1=IC(I)                                                          EMSLV 99
      ACOE(K1)=COE(I)                                                   EMSLV100
 1005 CONTINUE                                                          EMSLV101
      DO 1599 J=1,NM                                                    EMSLV103
 1599 PRINT 1, ACOE(J),J,IC(J)
 1600 RETURN                                                            EMSLV105
    1 FORMAT(1H E15.6,2I8)                                              EMSLV106
    2 FORMAT(1H037H VARIABLE          IDENT   ORDERED COL               EMSLV107
     14HUMNS)                                                           EMSLV108
 1700 PRINT 10
   10 FORMAT(1H0,16H SINGULAR MATRIX)                                   EMSLV110
      NPQ=-1                                                            EMSLV111
 1601 DO 1900 I=1,N                                                     EMSLV112
 1900 ACOE(I)=0.                                                        EMSLV113
      RETURN                                                            EMSLV114
      END                                                               EMSLV115
$IBFTC T2
      SUBROUTINE T2                                                     T2     1
      COMMON /TAPE/NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
C     PROGRAM - TREND SURFACE  LINK 2                                   T2     2
C     LANGUAGE - FORTRAN IV                                             T2     3
C     COMPUTER - IBM 7040    16 K CORE                                  T2     4
C     PROGRAMMER - DONALD I GOOD                                        T2     5
C     DATE COMPLETED - APRIL 1964                                       T2     6
C     REVISED SEPT 1964          OWEN T SPITZ                           T2     7
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O-LEARY    T2     8
C     FOR DOCUMENTATION SEE KANSAS GEOLOGICAL SURVEY SPECIAL            T2     9
C     DISTRIBUTION PUBLICATION 14 FOR 1620 VERSION                      T2    10
C                                                                       T2    11
C                                                                       T2    12
      DOUBLE PRECISION A(28,6)                                          T2    13
      COMMON A,X(500),Y(500),Z(500),JARBO(52),ID(40),MTD(6),N,SUMZ,     T2    14
     1FN,XMAX,XMIN,YMAX,YMIN,IPLOT                                      T2    15
      DIMENSION IREFU(11),IREFL(26),RL(500),RQ(500),RC(500),VAR(6),     T2    16
     1SQ(6),TVAR(6),SD(6),DET(6),COR(6),RQR(500),RQN(500),RSX(500)      T2    17
      EQUIVALENCE(JARBO(1),IREFL(1)),(JARBO(27),IREFU(1)) ,             T2    18
     1(X,RL,RQR),(Y,RQ,RQN),(Z,RC,RSX),(XMAX,IP)                        T2    19
C                                                                       T2    20
      DO 9997 K=1,6                                                     T2    21
      DO 9997 J=1,28                                                    T2    22
 9997 A(J,K)=0.0                                                        T2    23
      M=1                                                               T2    24
      REWIND NTAPE3
      DO 9998 K=1,IP                                                    T2    26
      M=M+K+1                                                           T2    27
      DO 9998 J=1,M                                                     T2    28
 9998 READ(NTAPE3) A(J,K)
      XMAX = X(1)                                                       T2    30
      XMIN = X(1)                                                       T2    31
      YMAX = Y(1)                                                       T2    32
      YMIN = Y(1)                                                       T2    33
```

```
C      ------------------------------------------
C      WRITE DATA ARRAYS ON INTERMEDIATE TAPE 1
C      ------------------------------------------
       REWIND NTAPE1
       WRITE(NTAPE1) Z
C      ----------------------------------------------------
C      DETERMINE MAXIMUM AND MINIMUM VALUES OF X AND Y ARRAYS
C      ----------------------------------------------------
       DO 870 I=2,N,1
       IF(XMAX-X(I))835,840,840
   835 XMAX  = X(I)
   840 IF (XMIN - X(I))850,850,845
   845 XMIN = X(I)
   850 IF (YMAX - Y(I))855,860,860
   855 YMAX = Y(I)
   860 IF (YMIN - Y(I))870,870,865
   865 YMIN = Y(I)
   870 CONTINUE
C      -------------------------------------------------------
C      CALCULATE AND PUNCH TREND SURFACE Z-VALUES, RESIDUALS, AND
C      ERROR TERMS
C      -------------------------------------------------------
       DO 321 I=1,6,1
   321 SQ(I)=0.0
       ZSQ=0.0
C
       PRINT 319
   317 FORMAT (1H1 39A2, A1)
   316 PRINT 317, (ID(I),I=1,40)
   319 FORMAT (1H0        11H    X-COORD 12H      Y-COORD 12H      Z-VALUE
   319112H     1ST-SURF  12H   1ST-RESID  12H    2ND-SURF
      212H   2ND-RESID 12H    3RD-SURF 12H    3RD-RESID)
C
       DO 465 I = 1,N,1
C
C
       AX = X(I)
       AY = Y(I)
       AZ=Z(I)
C
       IF(MTD(1)) 10,10,5
     5 Z1=A(1,1)+A(2,1)*AX+A(3,1)*AY
       GO TO 15
    10 Z1 = 0.0
C
    15 IF(MTD(2)) 17,17,16
    16 ZQ1 = AX * (A(2,2) + A(4,2) * AX + A(5,2) * AY)
       ZQ2=AY * (A(3,2) + A(6,2) * AY)
       Z2= A(1,2) + ZQ1 + ZQ2
       GO TO 18
    17 Z2 = 0.0
C
    18 IF (MTD(3)) 20,20,19
    19 ZC1 = AX * (A(2,3) + AX * (A(4,3) + A(7,3) * AX))
       ZC2=AY * (A(3,3) + AY * (A(6,3) + A(10,3) * AY))
       ZC3 = AX * AY * (A(5,3) + A(8,3) * AX + A(9,3) * AY)
       Z3= A(1,3)+ZC1 + ZC2 + ZC3
       GO TO 21
    20 Z3 = 0.0
C
    21 IF(MTD(1))334, 334, 330
```

```
  330 RL(I)=AZ-Z1
      GO TO 335
  334 RL(I) = 0.0
  335 IF (MTD(2)) 349, 349, 345
  345 RQ(I)=AZ-Z2
      GO TO 350
  349 RQ(I) = 0.0
  350 IF (MTD(3)) 364, 364, 360
  360 RC(I)=AZ-Z3
      GO TO 371
  364 RC(I) = 0.0
C
  371 SQ(1)=SQ(1)+RL(I)*RL(I)
      SQ(2)=SQ(2)+RQ(I)*RQ(I)
      SQ(3)=SQ(3)+RC(I)*RC(I)
      ZSQ=ZSQ+AZ*AZ
C
  465 PRINT 470,AX,AY,AZ,Z1,RL(I),Z2,RQ(I),Z3,RC(I)
  470 FORMAT(1X,F11.3,8F12.3)
C
C
C     WRITE RESIDUAL ARRAYS ON INTERMEDIATE TAPE 1
C
      WRITE(NTAPE1) RL
      WRITE(NTAPE1) RQ
      WRITE(NTAPE1) RC
C
      REWIND NTAPE2
      DO 9292I=1,N
 9292 READ(NTAPE2) X(I),Y(I),Z(I)
  416 PRINT 317, (ID(I),I=1,40)
      PRINT 419
  419 FORMAT (1H0         11H    X-COORD 12H      Y-COORD 12H      Z-VALUE
  419112H    4TH-SURF 12H   4TH-RESID12H    5TH-SURF    12H    5TH-RESID
     212H    6TH-SURF    12H    6TH-RESID    )
C
      DO 471 I = 1, N, 1
C
      AX = X(I)
      AY = Y(I)
      AZ=Z(I)
C
      IF (MTD(4)) 200,200,199
  199 ZQR1 = AX*(A(2,4) + AX * (A(4,4) + AY * (A(8,4) + AY * A(13,4))))
      ZQR2 = AY*(A(3,4)+AX*A(5,4)+AY*(A(6,4) + AX*A(9,4)))
      ZQR3 = AX*AX*AX*(A(7,4) + AX *A(11,4) + AY*A(12,4))
      ZQR4 = AY *AY*AY*(A(10,4) + AX * A(14,4) + AY * A(15,4))
      Z4   = A(1,4) + ZQR1 + ZQR2 + ZQR3 + ZQR4
      GO TO 201
  200 Z4 = 0.0
C
  201 IF(MTD(5)) 203,203,202
  202 ZQN1 = AX * (A(2,5)+AX*A(4,5)+AY*(A(5,5) + AX*A(8,5)))
      ZQN2 = AY * (A(3,5) + AY * (A(6,5) + AX * A(9,5)))
      ZQN3 = AX*AX*AY*AY*(A(13,5)+AX*A(18,5)+AY*A(19,5))
      ZQN4 = AX*AX*AX*(A(7,5)+AY*A(12,5)+AX*(A(11,5)+AX*A(16,5)+AY*A(17,
     15)))
      ZQN5=AY*AY*AY*(A(10,5)+AX*A(14,5)+AY*(A(15,5)+AX*A(20,5)+AY*A(21,5
     1)))
      Z5   = A(1,5) + ZQN1 + ZQN2 + ZQN3 + ZQN4 + ZQN5
      GO TO 382
```

```
  203 Z5 = 0.0
  382 IF(MTD(6)) 384,384,383
  383 Z61 = AX * (A(2,6) + AY * (A(5,6) + AX * A(8,6)) + AX * (A(4,6) +
     1 AX * A(7,6)))
      Z62 = AY * (A(3,6) + AY * (A(6,6) + AX * (A(9,6) + AX * A(13,6)) +
     1 AY * A(10,6)))
      Z63 = AY*AX*AX*AX*  (A(12,6) + AX * (A(17,6) + AY * A(24,6)) + AY
     1 * (A(18,6) + AY * A(25,6)))
      Z64 = AX*AY*AY*AY* (A(14,6) + AX * A(19,6))
      Z65 = AX*AX*AX*AX* (A(11,6) + AX * (A(16,6) + AY * A(23,6) + AX *
     1 A(22,6)))
      Z66 = AY*AY*AY*AY* (A(15,6) + AX * (A(20,6) + AX * A(26,6) + AY *
     1A(27,6)) + AY * (A(21,6) + AY * A(28,6)))
      Z6 = A(1,6)+ Z61 + Z62 + Z63 + Z64 + Z65 + Z66
      GO TO 365
  384 Z6 = 0.0
C
  365 IF(MTD(4))367,367,366
  366 RQR(I)=AZ-Z4
      GO TO 368
  367 RQR(I)=0.
  368 IF(MTD(5))370,370,369
  369 RQN(I)=AZ-Z5
      GO TO 385
  370 RQN(I)=0.0
  385 IF(MTD(6)) 387,387,386
  386 RSX(I) = AZ - Z6
      GO TO 381
  387 RSX(I) = 0.0
  381 SQ(4)=SQ(4)+RQR(I)*RQR(I)
      SQ(5)=SQ(5)+RQN(I)*RQN(I)
      SQ(6) = SQ(6) + RSX(I) * RSX(I)
C
  471 PRINT 472, AX,AY,AZ,Z4,RQR(I),Z5,RQN(I),Z6,RSX(I)
  472 FORMAT(1X,F11.3,8F12.3)
C
      WRITE(NTAPE1)RQR
      WRITE(NTAPE1)RQN
      WRITE(NTAPE1)RSX
C
C     ------------------------
C     CALCULATE ERROR MEASURES
C     ------------------------
      TVARI=ZSQ-(SUMZ*SUMZ)/FN
      SN=N-1
      RSN=1./SN
C
      DO 520 I=1,6,1
      IF(MTD(I))500,500,480
C
  480 SD(I)=SQRT (RSN*SQ(I))
      VAR(I)=TVARI-SQ(I)
      TVAR(I)=TVARI
      DET(I)=VAR(I)/TVARI
      IF(DET(I))485,490,490
C
  485 COR(I)=-SQRT (-DET(I))
      GO TO 520
  490 COR(I)=SQRT (DET(I))
      GO TO 520
C
```

```
  500 SD(I)=0.0
      VAR(I)=0.0
      TVAR(I)=0.0
      DET(I)=0.0
      COR(I)=0.0
C
  520 CONTINUE
C     --------------------------
C     PUNCH EQUATIONS OF SURFACES
C     --------------------------
      PRINT 317, (ID(I),I=1,40)
C
      IF(MTD(1))40,40,35
   35 PRINT 585
  585 FORMAT(1H0 39HCOEFFICIENTS OF FIRST-DEGREE EQUATION    )
      PRINT 595,(A(I,1),I=1,3)
  595 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 2H Y)
C
   40 IF(MTD(2))50,50,45
   45 PRINT 605
  605 FORMAT(1H0 39HCOEFFICIENTS OF SECOND-DEGREE EQUATION   )
      PRINT 615, (A(I,2),I=1,6)
  615 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 3H Y2)
C
   50 IF(MTD(3)) 56, 56,55
   55 PRINT 625
  625 FORMAT(1H0 39HCOEFFICIENTS OF THIRD-DEGREE EQUATION    )
      PRINT 635, (A(I,3),I=1,10)
  635 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 3H Y3)
C
   56 IF(MTD(4))58,58,57
   57 PRINT 626
  626 FORMAT(1H0 39HCOEFFICIENTS OF FOURTH-DEGREE EQUATION   )
      PRINT 627, (A(I,4),I=1,15)
  627 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 5H Y3 + F13.5, 5H X4 + F13.5,
     3 6H X3Y + /F13.5, 7H X2Y2 + F13.5, 7H XY3 + F13.5,3H Y4 )
C
   58 IF(MTD(5)) 60, 60, 59
   59 PRINT 628
  628 FORMAT(1H0 39HCOEFFICIENTS OF FIFTH-DEGREE EQUATION    )
      PRINT 629, (A(I,5),I=1,21)
  629 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 5H Y3 + F13.5, 5H X4 + F13.5,
     3 6H X3Y + /F13.5, 7H X2Y2 + F13.5, 7H XY3 + F13.5,7H Y4 +
     4F13.5,5H X5 + F13.5, 6H X4Y + F13.5, 7H X3Y2 + / F13.5,
     5 7H X2Y3 + F13.5, 6H XY4 + F13.5, 3H Y5 )
C
   60 IF(MTD(6)) 640,640,61
   61 PRINT 630
  630 FORMAT(1H0 39HCOEFFICIENTS OF SIXTH-DEGREE EQUATION    )
      PRINT 631, (A(I,6),I=1,28)
  631 FORMAT (4H0Z = F15.5, 2H + F14.5, 4H X + F13.5, 4H Y + F13.5,
     1 5H X2 + , F13.5, 5H XY + F13.5, 5H Y2 +/F13.5, 5H X3 + F13.5,
     2 6H X2Y + , F13.5, 6H XY2 + F13.5, 5H Y3 + F13.5, 5H X4 + F13.5,
     3 6H X3Y + /F13.5, 7H X2Y2 + F13.5, 7H XY3 + F13.5,7H Y4 +
     4F13.5,5H X5 + F13.5, 6H X4Y + F13.5, 7H X3Y2 + / F13.5,
```

```
     5 7H X2Y3 + F13.5, 6H XY4 + F13.5, 5H Y5 + F13.5, 5H X6 + F13.5,
     66H X5Y + F13.5, 7H X4Y2 + / F13.5,7HX3Y3 + F13.5, 7H X2Y4 +
     7F13.5,6H XY5 + F13.5, 5H Y6  )
C
C      --------------------
C      PUNCH ERROR MEASURES
C      --------------------
  640 PRINT 644
  644 FORMAT(1H0,/1H0,/1H0,/1H0,/1H0)
      PRINT 645, (SD(I),I=1,6),(VAR(I),I=1,6),(SQ(I),I=1,6)
  645 FORMAT (1H0 29X, 14HERROR MEASURES / 1H0 7HSURFACE 25X, 12HFIRST-D
     1EGREE 2X, 13HSECOND-DEGREE,3X,12HTHIRD-DEGREE, 2X,13HFOURTH-DEGREE
     23X,12HFIFTH-DEGREE,2X,12HSIXTH-DEGREE/
     3 1H0 18HSTANDARD DEVIATION 11X, 6F15.2 /
     4/ 1H0 19HVARIATION EXPLAINED / 1X, 10HBY SURFACE 19X, 6E15.8 / 1H0
     523HVARIATION NOT EXPLAINED / 1X,10HBY SURFACE 19X, 6E15.8)
C
      PRINT 655, (TVAR(I),I=1,6),(DET(I),I=1,6),(COR(I),I=1,6)
  655 FORMAT (1H0 15HTOTAL VARIATION 14X, 6E15.8 / 1H0 14HCOEFFICIENT OF
     1/ 1X, 13HDETERMINATION 16X, 6F15.8 / 1H0 14HCOEFFICIENT OF / 1X,
     211HCORRELATION 18X, 6F15.8)
C      ----------------------------------------
C      O-LEARY,S LEFT THUMB IS ON BACKWARDS.
C      ----------------------------------------
C      -----------------------------------------------------------
C      READ IN NUMBER OF CONTOUR MAPS AND RESIDUAL INDICATOR
C      -----------------------------------------------------------
       IK=0
  116 READ 117, NUMB,IPLOT
  117 FORMAT (I5, 1X, I1)
      CALL RANGE(0, 1, IPLOT, I)
      IF(I)118,118,741
  741 KAW = 11
      PRINT 710,KAW
      GO TO 720
C      ----------------------
C      READ CONTOUR PARAMETERS
C      ----------------------
  118 IK=IK+1
      IF(NUMB-IK)300,119,119
  119 READ 125, MP,IOR,M3,MT,NCOL,CON,REF
  125 FORMAT (1X, 4I1, I4, 2F10.2)
C
C      CHECK PLOTTING PARAMETERS FOR VALIDITY
C
      NERR=0
      CALL RANGE (1,6,MP,NKR)
      KAW=13
      IF(NKR)700,700,705
  700 CALL RANGE(0,1,M3,NKR)
      KAW=14
      IF(NKR)715,715,705
  705 PRINT 710, KAW
  710 FORMAT(1X, 13HPROGRAM ERROR I3)
      NERR=1
      IF(KAW-8)700,720,720
C
  715 IF(NERR)730,730,720
  720 PRINT 725
  725 FORMAT (13H0INVALID DATA)
      CALL EXIT
C
```

```
  730 IF(M3)30,126,30                                              T2    341
  126 READ 127, XPMAX,XPMIN,YPMAX,YPMIN
  127 FORMAT (1X, 4F15.6)                                          T2    343
      GO TO 107                                                    T2    344
C                                                                  T2    345
   30 XPMAX = XMAX                                                 T2    346
      XPMIN = XMIN                                                 T2    347
      YPMAX = YMAX                                                 T2    348
      YPMIN = YMIN                                                 T2    349
C                                                                  T2    350
  107 IF(MTD(MP)) 118, 118, 108                                    T2    351
C     ------------------------------------------                   T2    352
C     PUNCH MAP TITLES AND CALL SUBROUTINE CONTUR                  T2    353
C     ------------------------------------------                   T2    354
  108 PRINT 317, (ID(I),I=1,40)
C                                                                  T2    356
      GO TO (245, 255, 266, 299, 301, 302), MP                     T2    357
C                                                                  T2    358
  245 PRINT 251
  251 FORMAT (1H0 32HCONTOURED FIRST-DEGREE SURFACE    )           T2    360
      GO TO 275                                                    T2    361
  255 PRINT 261
  261 FORMAT (1H0 32HCONTOURED SECOND-DEGREE SURFACE    )          T2    363
      GO TO 275                                                    T2    364
  266 PRINT 271
  271 FORMAT (1H0 32HCONTOURED THIRD-DEGREE SURFACE     )          T2    366
      GO TO 275                                                    T2    367
  299 PRINT 281
  281 FORMAT (1H0 32HCONTOURED FOURTH DEGREE SURFACE    )          T2    369
      GO TO 275                                                    T2    370
  301 PRINT 291
  291 FORMAT (1H0 32HCONTOURED FIFTH-DEGREE SURFACE     )          T2    372
      GO TO 275                                                    T2    373
  302 PRINT 303
  303 FORMAT (1H0 31HCONTOURED SIXTH-DEGREE SURFACE     )          T2    375
C                                                                  T2    376
  275 CALL CONTUR (MP,IOR,MT,NCOL,CON,REF,XPMAX,XPMIN,YPMAX,       T2    377
     1 YPMIN,  IREFU,IREFL,JKR)                                    T2    378
      GO TO 118                                                    T2    379
C                                                                  T2    380
  300 REWIND NTAPE2
      DO 9324 I=1,N                                                T2    382
 9324 READ(NTAPE2) X(I),Y(I),Z(I)
      RETURN                                                       T2    384
      END                                                          T2    385
$IBFTC CONTUR
      SUBROUTINE CONTUR (LM,M2,MT,NCOL,R1,R2,XPMAX,XPMIN,YPMAX,    CNTUR  1
     1 YPMIN,    IREFU,IREFL,KERR)                                 CNTUR  2
      COMMON /TAPE/NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
C                                                                  CNTUR  3
C     PROGRAM - SUBROUTINE CONTUR                                  CNTUR  4
C     LANGUAGE - FORTRAN II                                        CNTUR  5
C     PROGRAMMER - DONALD I GOOD                                   CNTUR  6
C     DATE COMPLETED - APRIL 1964                                  CNTUR  7
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O-LEARY CNTUR  8
C                                                                  CNTUR  9
C                                                                  CNTUR 10
      DOUBLE PRECISION A(28,6)                                     CNTUR 11
      COMMON A,MAP(110),DUMMY(1496)                                CNTUR 12
      DIMENSION          IREFU(11), IREFL(26)                      CNTUR 13
C     ------------------------------------                         CNTUR 14
C     CALCULATE X AND Y PLOTTING DIMENSIONS                        CNTUR 15
C     ------------------------------------                         CNTUR 16
```

```
      DX = XPMAX - XPMIN
      DY = YPMAX - YPMIN
      NC = NCOL - 11
      FNC = NC
      NC = NC + 1
C     ---------------
C     CHECK ARGUMENTS
C     ---------------
      KERR=0
C
      CALL RANGE(1,6,LM,NKR)
      KEW=1
      IF(NKR)5,5,50
C
    5 CALL RANGE(1,4,M2,NKR)
      KEW=2
      IF(NKR)10,10,50
C
   10 CALL RANGE(0,1,MT,NKR)
      KEW=3
      IF(NKR)15,15,50
C
   15 CALL RANGE(12,120,NCOL,NKR)
      KEW=4
      IF(NKR)20,20,50
C
   20 IF(R1)25,25,30
   25 KEW=5
      GO TO 50
C
   30 IF(DX)35,35,40
   35 KEW=6
      GO TO 50
C
   40 IF(DY)45,45,125
   45 KEW=7
C
   50 PRINT 55, KEW
   55 FORMAT (1X, 23HSUBROUTINE CONTUR ERROR I2,  49H,  YOUR CONTROL CAR
     1DS ARE PROBABLY ALL ////ED UP.)
      KERR=1
      GO TO (5,10,15,20,30,40,574),KEW
C
  125 IF(KERR)130,130,574
C     ---------------------
C     PUNCH PLOTTING LIMITS
C     ---------------------
  130 PRINT 60, XPMAX,XPMIN,YPMAX,YPMIN
   60 FORMAT (1H0 15HPLOTTING LIMITS / 1X, 11HMAXIMUM X = F15.6, 5X,
     1  11HMINIMUM X = F15.6/ 1X, 11HMAXIMUM Y = F15.6, 5X,
     2 11HMINIMUM Y = F15.6)
C     ------------------
C     CHOOSE ORIENTATION
C     ------------------
      GO TO (135, 165, 195, 196), M2
C
  135 EXL = XPMIN
      EXR = XPMAX
      EXT = YPMAX
      EXB = YPMIN
      M6 = 0
      GO TO 200
C
```

```
  165 EXL = YPMIN                                                         CNTUR 80
      EXR = YPMAX                                                         CNTUR 81
      EXT = XPMIN                                                         CNTUR 82
      EXB = XPMAX                                                         CNTUR 83
      M6 = 1                                                              CNTUR 84
      GO TO 200                                                           CNTUR 85
C                                                                         CNTUR 86
  195 IF (DX - DY) 135, 135, 165                                          CNTUR 87
  196 IF (DX - DY) 165, 135, 135                                          CNTUR 88
C     -----------------------------------------------------               CNTUR 89
C     CALCULATE VERTICAL AND HORIZONTAL PLOTTING INCREMENTS               CNTUR 90
C     -----------------------------------------------------               CNTUR 91
  200 HINC = (EXR - EXL) / FNC                                            CNTUR 92
C                                                                         CNTUR 93
      IF (MT) 201, 202, 201                                               CNTUR 94
  201 VINC = HINC * 1.6666667                                             CNTUR 95
      GO TO 214                                                           CNTUR 96
  202 VINC = HINC                                                         CNTUR 97
C                                                                         CNTUR 98
  214 IF (M6) 220, 215, 220                                               CNTUR 99
  215 VINC = - VINC                                                       CNTUR100
C     -------------------------------                                     CNTUR101
C     PUNCH MAP PARAMETERS AND SCALES                                     CNTUR102
C     -------------------------------                                     CNTUR103
  220 IF (M6) 300, 280, 300                                               CNTUR104
  280 PRINT 285, EXL,HINC
  285 FORMAT (1H0 21HX-SCALE IS HORIZONTAL / 1X, 9HX-VALUE = F8.2,        CNTUR106
     1 2H + F8.4, 16H X (SCALE VALUE))                                    CNTUR107
      PRINT 295
  295 FORMAT (1H0 19HY-SCALE IS VERTICAL)                                 CNTUR109
      GO TO 320                                                           CNTUR110
  300 PRINT 305, EXL, HINC
  305 FORMAT (1H0 21HY-SCALE IS HORIZONTAL / 1X, 9HY-VALUE = F8.2,        CNTUR112
     1 2H + F8.4, 16H X (SCALE VALUE))                                    CNTUR113
      PRINT 315
  315 FORMAT (1H0 19HX-SCALE IS VERTICAL)                                 CNTUR115
  320 PRINT 325, R1,R2
  325 FORMAT (1H0 18HCONTOUR INTERVAL = F29.2/ 1X, 17HREFERENCE CONTOUR   CNTUR117
     1 10H (.....) = F20.2)                                               CNTUR118
C                                                                         CNTUR119
      IF (NCOL - 80) 340, 340, 330                                        CNTUR120
C                                                                         CNTUR121
  330 PRINT 335
  335 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789           CNTUR123
 3351 10H 123456789 10H 123456789 10H 123456789 2H 1                      CNTUR124
     2 8H23456789 10H 123456789 10H 123456789 10H 123456789               CNTUR125
     3 10H 123456789 /)                                                   CNTUR126
      GO TO 344                                                           CNTUR127
C                                                                         CNTUR128
  340 PRINT 341
  341 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789           CNTUR130
     2 10H 123456789 10H 123456789 10H 123456789 10H 123456789 /)         CNTUR131
C     ----------------------------------------                            CNTUR132
C     CHOOSE CHARACTERS FOR LINE BY LINE PLOTTING                         CNTUR133
C     ----------------------------------------                            CNTUR134
  344 VERT = EXT - VINC                                                   CNTUR135
C                                                                         CNTUR136
C     INCREMENT VERTICAL INDEX BY ONE LINE                                CNTUR137
C                                                                         CNTUR138
  345 VERT = VERT + VINC                                                  CNTUR139
C                                                                         CNTUR140
C     ZERO PLOTTING ARRAY, MAP                                            CNTUR141
```

```
C
      DO 347 I = 1,NC,1
  347 MAP(I)=IREFU(26)
C
      HOR = EXL - HINC
      I = 0
C
C     INCREMENT HORIZONTAL INDEX BY ONE
C
  352 I = I + 1
      HOR = HOR + HINC
C
C     DETERMINE X AND Y VALUES OF THE PLOTTING POSITION
C
      IF (M6) 380, 365, 380
  365 AX = HOR
      AY = VERT
      GO TO 390
  380 AX = VERT
      AY = HOR
C
C     SELECT PLOTTING FUNCTION AND CALCULATE VALUE OF SURFACE AT THE
C     PLOTTING POSITION
C
  390 GO TO (395, 405, 415, 416, 417, 418),LM
C
  395 C =A(1,1)+A(2,1)*AX+A(3,1)*AY
      GO TO 420
C
  405 ZQ1 = AX * (A(2,2) + A(4,2) * AX + A(5,2) * AY)
      ZQ2=AY * (A(3,2) + A(6,2) * AY)
      C = A(1,2) + ZQ1 + ZQ2
      GO TO 420
C
  415 ZC1 = AX * (A(2,3) + AX * (A(4,3) + A(7,3) * AX))
      ZC2=AY * (A(3,3) + AY * (A(6,3) + A(10,3) * AY))
      ZC3 = AX * AY * (A(5,3) + A(8,3) * AX + A(9,3) * AY)
      C = A(1,3)+ZC1 + ZC2 + ZC3
      GO TO 420
C
  416 ZQR1 = AX*(A(2,4) + AX * (A(4,4) + AY * (A(8,4) + AY * A(13,4))))
      ZQR2 = AY*(A(3,4)+AX*A(5,4)+AY*(A(6,4) + AX*A(9,4)))
      ZQR3 = AX*AX*AX*(A(7,4) + AX *A(11,4) + AY*A(12,4))
      ZQR4 = AY *AY*AY*(A(10,4) + AX * A(14,4) + AY * A(15,4))
      C    = A(1,4) + ZQR1 + ZQR2 + ZQR3 + ZQR4
      GO TO 420
C
  417 ZQN1 = AX * (A(2,5)+AX*A(4,5)+AY*(A(5,5) + AX*A(8,5)))
      ZQN2 = AY * (A(3,5) + AY * (A(6,5) + AX * A(9,5)))
      ZQN3 = AX*AX*AY*AY*(A(13,5)+AX*A(18,5)+AY*A(19,5))
      ZQN4 = AX*AX*AX*(A(7,5)+AY*A(12,5)+AX*(A(11,5)+AX*A(16,5)+AY*A(17,
     15)))
      ZQN5=AY*AY*AY*(A(10,5)+AX*A(14,5)+AY*(A(15,5)+AX*A(20,5)+AY*A(21,5
     1)))
      C    = A(1,5) + ZQN1 + ZQN2 + ZQN3 + ZQN4 + ZQN5
C
      GO TO 420
C
  418 Z61 = AX * (A(2,6) + AY * (A(5,6) + AX * A(8,6)) + AX * (A(4,6) +
     1 AX * A(7,6)))
      Z62 = AY * (A(3,6) + AY * (A(6,6) + AX * (A(9,6) + AX * A(13,6)) +
     1 AY * A(10,6)))
```

```
      Z63 = AY*AX*AX*AX*  (A(12,6) + AX * (A(17,6) + AY * A(24,6)) + AY
     1 * (A(18,6) + AY * A(25,6)))
      Z64 = AX*AY*AY*AY* (A(14,6) + AX * A(19,6))
      Z65 = AX*AX*AX*AX* (A(11,6) + AX * (A(16,6) + AY * A(23,6) + AX *
     1 A(22,6)))
      Z66 = AY*AY*AY*AY* (A(15,6) + AX * (A(20,6) + AX * A(26,6) + AY *
     1A(27,6)) + AY * (A(21,6) + AY * A(28,6)))
      C  = A(1,6)+ Z61 + Z62 + Z63 + Z64 + Z65 + Z66
C
C     DETERMINE OF SURFACE VALUE LIES ABOVE OR BELOW REFERENCE CONTOUR
C     (DELZ IS + OR -)
C
  420 DELZ = C - R2
      IF (DELZ) 480, 421, 421
C
C     DETERMINE IF SURFACE VALUE LIES IN REFERENCE BAND
C
  421 IF (DELZ - R1) 425, 430, 430
  425 MAP(I) = IREFU(1)
      GO TO 535
C
C     SCALE DELZ SO THAT IT FALLS IN RANGE OF PLOTTING SYMBOLS(IREFU)
C
  430 DELZ = DELZ - R1
  431 IF (DELZ - 20. * R1) 445, 435, 435
  435 DELZ = DELZ - 20. * R1
      GO TO 431
C
C     CHOOSE PLOTTING SYMBOL
C
  445 NOD = DELZ / R1
      J = -1
      K = 1
  460 J = J + 2
      K = K + 1
      IF (NOD - J) 535, 475, 460
  475 MAP(I) = IREFU(K)
      GO TO 535
C
C     SCALE DELZ SO THAT IT FALLS IN RANGE OF PLOTTING SYMBOLS(IREFL)
C
  480 DELZ = - DELZ
  485 IF (DELZ - 52. * R1) 500, 490, 490
  490 DELZ = DELZ - 52. * R1
      GO TO 485
C
C     CHOOSE PLOTTING SYMBOL
C
  500 NOD = DELZ / R1
      J = -1
      K = 0
  515 J = J + 2
      K = K + 1
      IF (NOD - J) 535, 530, 515
  530 MAP(I) = IREFL(K)
C
C     DETERMINE IF LAST HORIZONTAL POSITION HAS BEEN PROCESSED
C
  535 IF (I - NC) 352, 540, 540
C
C     PUNCH PLOTTING ARRAY
C
```

```
  540 PRINT 545, VERT, (MAP(I),I=1,NC)
  545 FORMAT(1X,F8.2,1X,62A1,48A1)
C
C      DETERMINE IF LAST LINE HAS BEEN PROCESSED
C
      IF (M6) 565, 560, 565
  560 IF (VERT - EXB) 570, 570, 345
  565 IF (VERT - EXB) 345, 570, 570
C
C      PUNCH FINAL SCALES
C
  570 IF (NCOL - 80) 571, 571, 572
C
  571 PRINT 341
      GO TO 574
  572 PRINT 335
C
  574 RETURN
      END
$ENTRY          LINK1
$LINK  LINK2
$IBFTC LINK2
C      PROGRAM - TREND SURFACE  LINK 2
C      LANGUAGE - FORTRAN IV
C      COMPUTER - IBM 7040     16 K CORE
C      PROGRAMMER - DONALD I GOOD
C      DATE COMPLETED - APRIL 1964
C      REVISED SEPT 1964        OWEN T SPITZ
C      MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O-LEARY
C      FOR DOCUMENTATION SEE KANSAS GEOLOGICAL SURVEY SPECIAL
C      DISTRIBUTION PUBLICATION 14 FOR 1620 VERSION
C
C
      COMMON /TAPE/NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      DOUBLE PRECISION A(28,6)
      DIMENSION           JREF(12)
      COMMON A,X(500),Y(500),R(500),JARBO(52),ID(40),MTD(6),N,SUMZ,FN,
     1XMAX,XMIN,YMAX,YMIN,IPLOT
      EQUIVALENCE(JARBO(28),JREF(3))
C
C      CHECK LINK 2   INDICATOR
C
      REWIND NTAPE1
      IF (IPLOT - 1) 4, 5, 4
    4 KAW = 12
      PRINT 120, KAW
      GO TO 105
C
    5 KN = N + 1
      IP = 0
C
C      CALCULATE PLOTTING SYMBOLS FOR SUBROUTINE PLOT3
      NOP=37
      JARBO(1)=JARBO(26)
      JARBO(27)=JARBO(40)
      JARBO(26)=JARBO(39)
C      ---------------------------
C      READ IN PLOTTING PARAMETERS
C      ---------------------------
      READ 10, NUMB
   10 FORMAT (I5)
C
```

```
   15 IP = IP + 1
      IF (NUMB - IP) 105, 19, 19
   19 READ 20, MP,IOR,M3,MT,NCOL
   20 FORMAT (1X, 4I1, I4)
C     -----------------------------
C     CHECK PARAMETERS FOR VALIDITY
C     -----------------------------
      NERR=0
      CALL RANGE(0,6,MP,NKR)
      KAW=9
      IF(NKR)110,110,115
  110 CALL RANGE(0,1,M3,NKR)
      KAW=10
      IF(NKR)125,125,115
  115 PRINT 120, KAW
  120 FORMAT (1X, 13HPROGRAM ERROR I3)
      NERR=1
      IF(KAW-10)110,125,125
  125 IF(NERR)25,25,130
  130 PRINT 135
  135 FORMAT(13H0INVALID DATA)
      CALL EXIT
C
   25 IF(M3)40,30,40
   30 READ 35, XPMAX,XPMIN,YPMAX,YPMIN
   35 FORMAT (1X, 4F15.6)
      IF(NOP.EQ.MP) GO TO 165
      GO TO 50
C
   40 XPMAX=XMAX
      XPMIN=XMIN
      YPMAX=YMAX
      YPMIN=YMIN
C
   50 IF (MP) 51, 52, 51
   51 IF(MTD(MP).LE.0) READ (NTAPE1) R
      IF(MTD(MP))15,15,52
   52 DX = XMAX - XMIN
      DY = YMAX - YMIN
C     ***********************************
C     REPLACE X,Y,Z COORDINATES IN COMMON
C     ***********************************
      REWIND NTAPE2
      DO 740 I=1,N
  740 READ (NTAPE2) X(I),Y(I),R(I)
C     ---------------------------------------------
C     PLACE RESIDUAL ARRAY FROM TAPE 1 INTO R ARRAY
C     ---------------------------------------------
      NRD=MP+1
      DO 9976 ISQU=1,NRD
 9976 READ(NTAPE1) R
      REWIND NTAPE1
      READ(NTAPE1) R
      GO TO (140, 145, 150, 155), IOR
  140 CALL ORDER3(Y,X,R  ,1,N,1)
      K = 0
      GO TO 165
  145 CALL ORDER3(X,Y,R  ,1,N,0)
      K = 2
      GO TO 165
  150 IF (DX - DY) 140, 140, 145
  155 IF (DX - DY) 145, 140, 140
```

```
C     ----------------------------------------------------              LINK2 95
C     PUNCH MAP TITLES AND CALL PLOTTING SUBROUTINE PLOT3               LINK2 96
C     ----------------------------------------------------              LINK2 97
  165 PRINT 55, (ID(I),I=1,40)
   55 FORMAT (1H1 39A2, A1)                                             LINK2 99
C                                                                       LINK2100
      IF (MP) 59, 60, 59                                                LINK2101
   59 GO TO (70, 80, 90, 301, 303,305),MP                               LINK2102
C                                                                       LINK2103
   60 PRINT 65
   65 FORMAT (1H0 37HPLOT OF ORIGINAL DATA (Z-COORDINATES))             LINK2105
      GO TO 160                                                         LINK2106
C                                                                       LINK2107
   70 PRINT 75
   75 FORMAT (1H0 32HPLOT OF FIRST-DEGREE RESIDUALS    )                LINK2109
      GO TO 160                                                         LINK2110
C                                                                       LINK2111
   80 PRINT 85
   85 FORMAT (1H0 32HPLOT OF SECOND-DEGREE RESIDUALS  )                 LINK2113
      GO TO 160                                                         LINK2114
C                                                                       LINK2115
   90 PRINT 95
   95 FORMAT (1H0 32HPLOT OF THIRD-DEGREE RESIDUALS    )                LINK2117
      GO TO 160                                                         LINK2118
C                                                                       LINK2119
  301 PRINT 302
  302 FORMAT (1H0 32HPLOT OF FOURTH-DEGREE RESIDUALS  )                 LINK2121
      GO TO 160                                                         LINK2122
C                                                                       LINK2123
  303 PRINT 304
  304 FORMAT (1H0 32HPLOT OF FIFTH-DEGREE RESIDUALS    )                LINK2125
C                                                                       LINK2126
      GO TO 160                                                         LINK2127
  305 PRINT 306
  306 FORMAT (1H0 32HPLOT OF SIXTH-DEGREE RESIDUALS    )                LINK2129
  160 CALL PLOT3(X,Y,R,N,IOR,XPMAX,XPMIN,YPMAX,YPMIN,NCOL,MT,K,J,JREF,MELINK2130
     1R,JARBO)                                                          LINK2131
      NOP=MP
      GO TO 15                                                          LINK2132
C                                                                       LINK2133
  105 CONTINUE                                                          LINK2134
      CALL CHNXIT                                                       LINK2135
      END                                                               LINK2136
$IBFTC ORDER3
      SUBROUTINE ORDER3(A,B,C,NF,NL,KD)                                 ORDR3   1
      COMMON /TAPE/NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
C     PROGRAM - SUBROUTINE ORDER3                                       ORDR3   2
C     LANGUAGE - FORTRAN II                                             ORDR3   3
C     NECESSARY SUBROUTINES - RANGE                                     ORDR3   4
C     COMPUTER - IBM 1620      60K CORE                                 ORDR3   5
C     PROGRAMMER - DONALD I GOOD                                        ORDR3   6
C     DATE COMPLETED - APRIL 1964                                       ORDR3   7
C     MODIFIED FOR ORDERS 4,5 AND 6  5/65  R.H. LIPPERT, M.T.O-LEARY    ORDR3   8
C                                                                       ORDR3   9
C                                                                       ORDR3  10
      DIMENSION A(500), B(500), C(500)                                  ORDR3  11
C                                                                       ORDR3  12
C     CALCULATE ORDERING PARAMETERS                                     ORDR3  13
C                                                                       ORDR3  14
      ND=NL-NF                                                          ORDR3  15
   15 NP = NF + 1                                                       ORDR3  16
      NE = NL + 1                                                       ORDR3  17
```

```
C     -----------------------------------
C     ORDER ARRAYS IN ASCENDING ORDER ON A
C     -----------------------------------
      DO 90 K = 1,ND,1
C
   30 NE = NE - 1
      AMAX = A(NF)
      J = NF
      DO 50 I = NP,NE,1
      IF(AMAX - A(I)) 40, 50, 50
   40 AMAX = A(I)
      J = I
   50 CONTINUE
C
      BAMAX=B(J)
      CAMAX = C(J)
C
      A(J)=A(NE)
      B(J)=B(NE)
      C(J)=C(NE)
C
      A(NE) = AMAX
      B(NE) = BAMAX
      C(NE) = CAMAX
C
   90 CONTINUE
C
C     INVERT ARRAYS IF DESCENDING ORDER IS DESIRED
C
      IF(KD) 110, 110, 100
  100 NS2 = (NL - NF + 1) / 2 + NF - 1
      NT = NL + NF
      DO 105 I = NF, NS2, 1
      AMAX = A(I)
      BAMAX = B(I)
      CAMAX = C(I)
      K = NT - I
      A(I) = A(K)
      B(I) = B(K)
      C(I) = C(K)
      A(K) = AMAX
      B(K) = BAMAX
  105 C(K) = CAMAX
  110 RETURN
      END
$IBFTC PLOT3
C     PROGRAM - SUBROUTINE PLOT3
C     LANGUAGE - FORTRAN IV
C     NECESSARY SUBROUTINES - RANGE, ORDER3.
C     COMPUTER - IBM 1620     60K CORE
C     PROGRAMMER - DONALD I GOOD
C     DATE COMPLETED - APRIL 1964
C     REVISED SEPT 1964      OWEN T SPITZ
C
C
      SUBROUTINE PLOT3(X,Y,Z,N,IOR,XMAX,XMIN,YMAX,YMIN,NCOL,MT,M1,M2,JRE
     1F,NKR,JARBO)
C
      COMMON /TAPE/NTAPE1,NTAPE2,NTAPE3,NTAPE4,NTAPE5,NTAPE6
      DIMENSION X(500),Y(500),Z(500), JREF(12),IER(150),ITAB(150),MAP(11
     10),IZD(5),KTAB(150)
      DIMENSION JARBO(52)
```

```
C
C     DETERMINE NUMBER OF CHARACTERS, NCC, IN PLOTTING ARRAY
C
      NZ=150
      NCD=NCOL-10
      NCC=NCD-5
      FNC=NCC
C
C     CALCULATE PLOTTING DIMENSIONS
C
      DX=XMAX-XMIN
      DY=YMAX-YMIN
C     ----------------------------
C     CHECK ARGUMENTS FOR VALIDITY
C     ----------------------------
      NKR=0
      CALL RANGE(1,500,N,NAR)
      KAR=1
      IF(NAR)720,720,759
C
  720 CALL RANGE(1,4,IOR,NAR)
      KAR=2
      IF(NAR)725,725,759
C
  725 CALL RANGE(16,120,NCOL,NAR)
      KAR=3
      IF(NAR)730,730,759
C
  730 CALL RANGE(0,1,MT,NAR)
      KAR=4
      IF(NAR)735,735,759
C
  735 CALL RANGE(0,2,M1,NAR)
      KAR=5
      IF(NAR)740,740,759
C
  740 IF(DX)745,745,750
  745 KAR=6
      GO TO 759
C
  750 IF(DY)755,755,765
  755 KAR=7
  759 PRINT 760, KAR
  760 FORMAT(1X, 22HSUBROUTINE PLOT3 ERROR I2)
      NKR=1
      GO TO (720,725,730,735,740,750,710),KAR
  765 IF(NKR)5,5,710
C     ---------------------
C     PUNCH PLOTTING LIMITS
C     ---------------------
    5 PRINT 770, XMAX,XMIN,YMAX,YMIN
  770 FORMAT (1H0 15HPLOTTING LIMITS / 1X, 11HMAXIMUM X = F15.6, 5X,
     1  11HMINIMUM X = F15.6/ 1X, 11HMAXIMUM Y = F15.6, 5X,
     2 11HMINIMUM Y = F15.6)
C
C     ZERO CARRIAGE CONTROL ARRAY FOR OVERPRINT VALUES
C
      DO 10 I=1,NZ,1
      KTAB(I)=JARBO(52)
   10 ITAB(I)=JARBO(52)
```

```
C     ---------------------------------------                          PLOT3 76
C     SCALE PLOTTED VALUES TO 4-DIGIT MAXIMUM                          PLOT3 77
C     ---------------------------------------                          PLOT3 78
      AZMAX=ABS(Z(1))                                                  PLOT3 79
      DO 20 I=2,N,1                                                    PLOT3 80
      IF(AZMAX-ABS(Z(I))) 15,20,20                                     PLOT3 81
   15 AZMAX=ABS(Z(I))                                                  PLOT3 82
   20 CONTINUE                                                         PLOT3 83
C                                                                      PLOT3 84
      IF (AZMAX) 21, 66, 21                                            PLOT3 85
   21 M=(ALOG(9999.0/AZMAX))/ALOG(10.0)                                PLOT3 86
      IF(M)30,66,40                                                    PLOT3 87
C                                                                      PLOT3 88
   30 ND=-M                                                            PLOT3 89
      CON=0.1                                                          PLOT3 90
      GO TO 50                                                         PLOT3 91
C                                                                      PLOT3 92
   40 ND=M                                                             PLOT3 93
      CON=10.0                                                         PLOT3 94
C                                                                      PLOT3 95
   50 DO 60 I=1,ND,1                                                   PLOT3 96
      DO 60 J=1,N,1                                                    PLOT3 97
   60 Z(J)=Z(J)*CON                                                    PLOT3 98
C                                                                      PLOT3 99
C     PUNCH SCALE FACTOR                                               PLOT3100
C                                                                      PLOT3101
   61 PRINT 65, M
   65 FORMAT (1H0 40HPLOTTED VALUES HAVE BEEN MULTIPLIED BY A 20H FACTORPLOT3103
     1 OF 10 TO THE I5, 6H POWER)                                      PLOT3104
C     ---------------------------------------------------------------- PLOT3105
C     SELECT MAP ORIENTATION, CALCULATE HORIZONTAL PLOTTING INCREMENTS. PLOT3106
C     PUNCH PLOTTING PARAMETERS                                        PLOT3107
C     ---------------------------------------------------------------- PLOT3108
   66 GO TO (70,80,90,100),IOR                                         PLOT3109
C                                                                      PLOT3110
   70 EXT=YMAX                                                         PLOT3111
      M3=0                                                             PLOT3112
      HINC = DX / FNC                                                  PLOT3113
      PRINT 75, XMIN,HINC
   75 FORMAT (1H0 21HX-SCALE IS HORIZONTAL / 1X, 9HX-VALUE = F8.2, 2H + PLOT3115
     1 F8.4, 16H X (SCALE VALUE) / 1H0 19HY-SCALE IS VERTICAL)         PLOT3116
      GO TO 110                                                        PLOT3117
C                                                                      PLOT3118
   80 EXT=XMIN                                                         PLOT3119
      M3=1                                                             PLOT3120
      HINC = DY / FNC                                                  PLOT3121
      PRINT 85, YMIN,HINC
   85 FORMAT (1H0 21HY-SCALE IS HORIZONTAL / 1X, 9HY-VALUE = F8.2, 2H + PLOT3123
     1 F8.4, 16H X (SCALE VALUE) / 1H0 19HX-SCALE IS VERTICAL)         PLOT3124
      GO TO 110                                                        PLOT3125
C                                                                      PLOT3126
   90 IF(DX-DY)70,70,80                                                PLOT3127
  100 IF(DX-DY)80,70,70                                                PLOT3128
C                                                                      PLOT3129
C     PUNCH HORIZONTAL SCALE                                           PLOT3130
C                                                                      PLOT3131
  110 IF(NCOL-80)120,120,130                                           PLOT3132
C                                                                      PLOT3133
  120 PRINT 125
  125 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789 10H 1234PLOT3135
     156789 10H 123456789 10H 123456789 10H 123456789 /)               PLOT3136
      GO TO 140                                                        PLOT3137
```

```
C                                                                       PLOT3138
  130 PRINT 135
  135 FORMAT (1H0 9X, 10H0123456789 10H 123456789 10H 123456789 10H 1234PLOT3140
     156789 10H 123456789 10H 123456789 2H 1          8H23456789 10H 12PLOT3141
     23456789 10H 123456789 10H 123456789 10H 123456789 /)              PLOT3142
C                                                                       PLOT3143
C     CALCULATE VERTICAL PLOTTING INCREMENT                             PLOT3144
C                                                                       PLOT3145
  140 IF(MT)160,150,160                                                 PLOT3146
  150 V'NC=HINC                                                         PLOT3147
      GO TO 170                                                         PLOT3148
  160 VINC=HINC*1.6666667                                               PLOT3149
C     ----------------                                                  PLOT3150
C     PLOTTING ROUTINE                                                  PLOT3151
C     ----------------                                                  PLOT3152
C                                                                       PLOT3153
C     ORDER X, Y, AND Z ARRAYS ON ARRAY CORRESPONDING TO VERTICAL SCALE PLOT3154
C                                                                       PLOT3155
  170 IF(M3)200,180,200                                                 PLOT3156
C                                                                       PLOT3157
  180 VINC=-VINC                                                        PLOT3158
      IF(M1-1)220,190,190                                               PLOT3159
  190 CALL ORDER3(Y,X,Z,1,N,1)                                          PLOT3161
      M2=0                                                              PLOT3160
      GO TO 220                                                         PLOT3162
C                                                                       PLOT3163
  200 IF(M1-1)210,210,220                                               PLOT3164
  210 CALL ORDER3(X,Y,Z,1,N,0)                                          PLOT3165
      M2=2                                                              PLOT3166
C                                                                       PLOT3167
C     INITIALIZATION STEPS FOR PLOTTING                                 PLOT3168
C                                                                       PLOT3169
  220 PLIM=EXT                                                          PLOT3170
      KER=0                                                             PLOT3171
C                                                                       PLOT3172
C     DETERMINE INDEX OF FIRST DATA POINT THAT FALLS IN VERTICAL        PLOT3173
C     PLOTTING RANGE                                                    PLOT3174
C                                                                       PLOT3175
      IF (M3) 805, 800, 805                                             PLOT3176
  800 IF (YMIN - Y(1)) 221, 221, 226                                    PLOT3177
  221 DO 222 I = 1,N,1                                                  PLOT3178
      IF (YMAX - Y(I)) 222, 228, 228                                    PLOT3179
  222 CONTINUE                                                          PLOT3180
      GO TO 226                                                         PLOT3181
  805 IF (X(1) - XMAX) 223, 223, 226                                    PLOT3182
  223 DO 224 I = 1,N,1                                                  PLOT3183
      IF (XMIN - X(I)) 228, 228, 224                                    PLOT3184
  224 CONTINUE                                                          PLOT3185
  226 PRINT 227
  227 FORMAT (1X, 27HNO POINTS IN VERTICAL RANGE)                       PLOT3187
      GO TO 650                                                         PLOT3188
  228 NL = I - 1                                                        PLOT3189
C                                                                       PLOT3190
C     CALCULATE UPPER (TOWARD TOP OF PAGE) BOUND OF VERTICAL PLOTTING   PLOT3191
C     INTERVAL                                                          PLOT3192
C                                                                       PLOT3193
  225 VERT=PLIM                                                         PLOT3194
C                                                                       PLOT3195
C     INCREMENT OVERPRINT INDEX. BLANK PLOTTING ARRAY                   PLOT3196
C                                                                       PLOT3197
      KERF=KER+1                                                        PLOT3198
```

```
      DO 230 I=1,NCD,1                                                  PLOT3199
  230 MAP(I)=JARBO(52)                                                  PLOT3200
C                                                                       PLOT3201
C     CALCULATE LOWER (TOWARD BOTTOM OF PAGE) BOUND OF VERTICAL PLOTTINGPLOT3202
C     INTERVAL                                                          PLOT3203
C                                                                       PLOT3204
      PLIM=VERT+VINC                                                    PLOT3205
C                                                                       PLOT3206
C     DETERMINE INDEX OF NEXT DATA POINT, NF                            PLOT3207
C                                                                       PLOT3208
      NF=NL+1                                                           PLOT3209
      I=NL                                                              PLOT3210
C                                                                       PLOT3211
C     SET UP VALUES FOR VERTICAL INTERVAL                               PLOT3212
C                                                                       PLOT3213
      IF(M3)270,240,270                                                 PLOT3214
C                                                                       PLOT3215
C     COUNT NO. OF DATA POINTS IN VERTICAL PLOTTING INTERVAL            PLOT3216
C                                                                       PLOT3217
  240 I=I+1                                                             PLOT3218
      IF (I - N) 245, 245, 250                                          PLOT3219
  245 IF(Y(I)-PLIM)250,240,240                                          PLOT3220
C                                                                       PLOT3221
C     DETERMINE INDEX OF LAST DATA POINT IN VERTICAL PLOTTING INTERVAL, PLOT3222
C     NL. ORDER DATA POINTS IN VERTICAL PLOTTING INTERVAL               PLOT3223
C                                                                       PLOT3224
  250 NL=I-1                                                            PLOT3225
      IF(NL-NF)590,300,260                                              PLOT3226
  260 CALL ORDER3(X,Y,Z,NF,NL,1)                                        PLOT3227
      GO TO 300                                                         PLOT3228
C                                                                       PLOT3229
C     COUNT NO. OF DATA POINTS IN VERTICAL PLOTTING INTERVAL            PLOT3230
C                                                                       PLOT3231
  270 I=I+1                                                             PLOT3232
      IF (I - N) 275, 275, 280                                          PLOT3233
  275 IF(X(I)-PLIM)270,270,280                                          PLOT3234
C                                                                       PLOT3235
C     DETERMINE INDEX OF LAST DATA POINT IN VERTICAL PLOTTING INVERVAL, PLOT3236
C     NL. ORDER DATA POINTS IN VERTICAL PLOTTING INTERVAL               PLOT3237
C                                                                       PLOT3238
  280 NL=I-1                                                            PLOT3239
      IF(NL-NF)590,300,290                                              PLOT3240
  290 CALL ORDER3(Y,X,Z,NF,NL,1)                                        PLOT3241
C                                                                       PLOT3242
C     PLACE Z-VALUES FOR VERTICAL INTERVAL IN PLOTTING ARRAY FROM       PLOT3243
C     RIGHT TO LEFT                                                     PLOT3244
C                                                                       PLOT3245
  300 I = NF - 1                                                        PLOT3246
  305 I = I + 1                                                         PLOT3247
C                                                                       PLOT3248
C     DETERMINE POSITION, IDX, IN PLOTTING ARRAY TO PLACE SIGN OF       PLOT3249
C     PLOTTED VALUE                                                     PLOT3250
C                                                                       PLOT3251
      IF(M3)320,310,320                                                 PLOT3252
  310 IDX=(X(I)-XMIN)/HINC + 1.0                                        PLOT3253
      GO TO 330                                                         PLOT3254
  320 IDX=(Y(I)-YMIN)/HINC + 1.0                                        PLOT3255
C                                                                       PLOT3256
C                                                                       PLOT3257
C     DETERMINE IF PLOTTED VALUE LIES IN HORIZONTAL PLOTTING RANGE      PLOT3258
C                                                                       PLOT3259
  330 IF(IDX) 580, 580, 334                                             PLOT3260
```

```
  334 IF (IDX - NCC - 1) 335, 335, 580                                  PLOT3261
C                                                                       PLOT3262
C     DETERMINE IF THIS POSITION IN THE PLOTTING ARRAY IS ALREADY       PLOT3263
C     OCCUPIED                                                          PLOT3264
C                                                                       PLOT3265
  335 IF(MAP(IDX)-JARBO(52)) 470,340,470                                PLOT3266
C                                                                       PLOT3267
C     BREAK PLOTTED VALUE INTO 4 SEPARATE DIGITS AND CODE THESE DIGITS  PLOT3268
C     IN THE DOUBLE DIGIT CODE                                          PLOT3269
C                                                                       PLOT3270
  340 LAZ=ABS(Z(I))                                                     PLOT3271
      DVD=LAZ                                                           PLOT3272
      DSR=10000.0                                                       PLOT3273
      J=1                                                               PLOT3274
C                                                                       PLOT3275
  350 J=J+1                                                             PLOT3276
      DSR=DSR*0.1                                                       PLOT3277
      K=DVD/DSR                                                         PLOT3278
      IZD(J)=JREF(K+3)                                                  PLOT3279
      FK=K                                                              PLOT3280
      REM=DVD-FK*DSR                                                    PLOT3281
      IF(J-4)360,370,370                                                PLOT3282
  360 DVD=REM                                                           PLOT3283
      GO TO 350                                                         PLOT3284
  370 K = REM                                                           PLOT3285
      IZD(5) = JREF(K+3)                                                PLOT3286
C                                                                       PLOT3287
C     DETERMINE LEFT-MOST NON-ZERO DIGIT OF PLOTTED VALUE (EXCEPT ZERO) PLOT3288
C                                                                       PLOT3289
      J=1                                                               PLOT3290
  380 J=J+1                                                             PLOT3291
      IF (J - 5) 385, 390, 390                                          PLOT3292
  385 IF(IZD(J).NE.JARBO(28)) GO TO 390                                 PLOT3293
  386 IZD(J)=JARBO(52)                                                  PLOT3294
      GO TO 380                                                         PLOT3295
  390 K=J-1                                                             PLOT3296
C                                                                       PLOT3297
C     PLACE SIGN OF PLOTTED VALUE                                       PLOT3298
C                                                                       PLOT3299
      IF(Z(I))400,410,410                                               PLOT3300
  400 IZD(K)=JREF(2)                                                    PLOT3301
      GO TO 420                                                         PLOT3302
  410 IZD(K)=JREF(1)                                                    PLOT3303
C                                                                       PLOT3304
C     PLACE DIGITIZED VALUE IN PLOTTING ARRAY                           PLOT3305
C                                                                       PLOT3306
  420 IMP=IDX-1                                                         PLOT3307
      J = K - 1                                                         PLOT3308
  430 J = J + 1                                                         PLOT3309
      IF (J - 5) 435, 435, 580                                          PLOT3310
  435 IMP = IMP + 1                                                     PLOT3311
      IF(MAP(IMP)-JARBO(52)) 450,440,450                                PLOT3312
  440 MAP(IMP)=IZD(J)                                                   PLOT3313
      GO TO 430                                                         PLOT3314
C                                                                       PLOT3315
C     ERROR ROUTINE FOR OVERLAP PLOTTING                                PLOT3316
C                                                                       PLOT3317
  450 MAP(IDX)=JARBO(38)                                                PLOT3318
      L=IDX+1                                                           PLOT3319
      IMP = IMP - 1                                                     PLOT3320
      J = IDX                                                           PLOT3321
  455 J = J + 1                                                         PLOT3322
```

```
      IF(J - IMP) 460, 460, 465
  460 MAP(J)=JARBO(52)
      GO TO 455
C
  465 KER=KER+1
      IER(KER)=Z(I)
      ITAB(KER)=JARBO(38)
      GO TO 580
C
C     ERROR ROUTINES FOR MULTIPLE PLOTTING
C
C     CHECK FOR ASTERISK
  470 IF(MAP(IDX).EQ.JARBO(38))GO TO 510
  471 DO 472 ICU=1,12
      IF(MAP(IDX).NE.JREF(ICU)) GO TO 472
  473 IF(ICU-3) 490,530,530
  472 CONTINUE
      IF(MAP(IDX).NE.JARBO(52)) GO TO 530
C
C     IF 2 VALUES ARE TO OCCUPY MAP(IDX)
C
  490 KER=KER+2
      IER(KER-1)=Z(I-1)
      IER(KER) = Z(I)
      JAR=2
      ITAB(KER)=JARBO(JAR)
      JAM=2
      MAP(IDX)=JARBO(JAM)
      IMP=IDX
  495 IMP=IMP+1
      IF(MAP(IMP).EQ.JARBO(52)) GO TO 580
  501 MAP(IMP)=JARBO(52)
      GO TO 495
C
C     IF MAP(IDX) IS OCCUPIED BY AN *
C
  510 KER=KER+1
  520 IER(KER)=Z(I)
      ITAB(KER-1)=JARBO(52)
      JAR=2
      ITAB(KER)=JARBO(JAR)
      JAM=2
      MAP(IDX)=JARBO(JAM)
      GO TO 580
C
C     IF 3-9 VALUES ARE TO OCCUPY MAP(IDX)
C
  530 DO 531 ICU=2,9
      IF(MAP(IDX).EQ.JARBO(ICU)) GO TO 532
  531 CONTINUE
      GO TO 550
  532 JAR=ICU
      JAM=ICU
  540 JAM=JAM+1
      MAP(IDX)=JARBO(JAM)
      KER = KER + 1
      JAR=JAR+1
      ITAB(KER)=JARBO(JAR)
      ITAB(KER-1)=JARBO(52)
      IER(KER) = Z(I)
      GO TO 580
C
C     IF MORE THAN 9 VALUES ARE TO OCCUPY MAP(IDX)
C
```

```
  550 MAP(IDX)=JARBO(1)                                                  PLOT3387
  560 KER=KER+1                                                          PLOT3388
      IER(KER)=Z(I)                                                      PLOT3389
      ITAB(KER-1)=JARBO(52)                                              PLOT3390
      ITAB(KER)=JARBO(1)                                                 PLOT3391
C                                                                        PLOT3392
C     DETERMINE IF FINAL VALUE FOR THIS VERTICAL PLOTTING INTERVAL       PLOT3393
C     IS PROCESSED                                                       PLOT3394
C                                                                        PLOT3395
  580 IF(KER.GT.NZ) GO TO 920                                            PLOT3396
      IF(I-NL) 305,590,590                                               PLOT3397
C                                                                        PLOT3398
C     PUNCH PLOTTING ARRAY                                               PLOT3399
C                                                                        PLOT3400
  590 PRINT 595, VERT,(MAP(I),I=1,NCD)
  595 FORMAT(1X,F8.2,1X,62A1,48A1)                                       PLOT3402
C                                                                        PLOT3403
C     INVERT LIST OF OVERPRINT AND CARRIAGE CONTROL VALUES IN LAST       PLOT3404
C     VERTICAL PLOTTING INTERVAL                                         PLOT3405
C                                                                        PLOT3406
      IF (KER - KERF) 620, 601, 600                                      PLOT3407
  601 KTAB(KER)=JARBO(28)                                                PLOT3408
      GO TO 620                                                          PLOT3409
  600 KTAB(KERF)=JARBO(28)                                               PLOT3410
      KF=(KER-KERF+1)/2+KERF-1                                           PLOT3411
      J=KER+KERF                                                         PLOT3412
      DO 610 I=KERF,KF,1                                                 PLOT3413
      IED=IER(I)                                                         PLOT3414
      ITB=ITAB(I)                                                        PLOT3415
      K=J-I                                                              PLOT3416
      IER(I)=IER(K)                                                      PLOT3417
      ITAB(I)=ITAB(K)                                                    PLOT3418
      IER(K)=IED                                                         PLOT3419
  610 ITAB(K)=ITB                                                        PLOT3420
C                                                                        PLOT3421
C     DETERMINE IF LAST VERTICAL PLOTTING INTERVAL IS PLOTTED            PLOT3422
C                                                                        PLOT3423
  620 IF(M3)640,630,640                                                  PLOT3424
  630 IF(PLIM-YMIN)650,225,225                                           PLOT3425
  640 IF(PLIM-XMAX)225,225,650                                           PLOT3426
C                                                                        PLOT3427
C     PUNCH FINAL SCALE                                                  PLOT3428
C                                                                        PLOT3429
  650 IF(NCOL-80)660,660,670                                             PLOT3430
  660 PRINT 125
      GO TO 680                                                          PLOT3432
  670 PRINT 135
C                                                                        PLOT3434
C     PUNCH OVERPRINT VALUES                                             PLOT3435
C                                                                        PLOT3436
  680 IF(KER)710,710,690                                                 PLOT3437
  690 PRINT 695
  695 FORMAT (1H0 16HOVERPRINT VALUES)                                   PLOT3439
      PRINT 700, (KTAB(I),ITAB(I),IER(I),I=1,KER)
  700 FORMAT( 2A1, I6)                                                   PLOT3441
  710 RETURN                                                             PLOT3442
  920 PRINT 925
  925 FORMAT(1H0, 36HOVERPRINT VALUES HAVE EXCEEDED ARRAY,/              PLOT3444
     11H0, 29HPLOT OF THIS MAP DISCONTINUED)                             PLOT3445
      RETURN                                                             PLOT3446
      END                                                                PLOT3447
$ENTRY           LINK2
$ENDCH
```

INPUT DATA PREPARATION

The following section describes the preparation of control and data cards for processing by the program.

As shown diagrammatically in Figure 2, input to the program consists of an initial "N" card which specifies the number of data decks to follow, and one or more data decks. Each data deck is made up of:

1 - three lead control cards which contain information concerning the data cards to follow.

2 - data cards containing one xyz coordinate triplet per card.

3 - Link 1 and 2 control cards which specify contouring and plotting.

All numbers on control cards are integer (fixed point) unless mention is made of a decimal point.

Control and Data Cards:

"N" card: The first card immediately following the source deck specifies the number of data decks (from 1 to 99) which are to be processed. This number is punched in columns 1 and 2 of the N card and is right justified.

Lead control cards:

Card 1: This card is a 70 character title card used to identify the data being processed. This card is repeated in each different portion of the output. Column 1 is left blank and the title placed in columns 2-80.

Card 2: Column 1 Blank

Columns 2-4 contain the number of sets of xyz coordinates that are read in as data. This value may range from 1 to 500 and is right justified.

Column 5 Blank

Columns 6-11 contain the indicators for calculation of the first through sixth degree equations respectively. For each equation to be fitted to the data, a one (1) must be punched in the column assigned to that equation. Otherwise, that column must be punched zero or left blank.

Card 3: Columns 1-72 contain the format for reading the xyz coordinate values (in that order) from the data cards.

Data cards:

The data cards contain the xyz coordinates of each control point (normally, one control point or coordinate triplet per card).

As illustrated in Figure 3, the x and y values define the location or cartesian coordinates of each control point, while the z value refers to the numerical value of the point itself. The x and y values may be scaled in inches and tenths of an inch, centimeters, or any convenient unit. To keep all x and y values positive, origin must be taken as the lower left-hand corner of the map.

The number of points (cards) must agree with the number specified in columns 2-4 on card 2 of the lead control cards. The maximum number of points which may be handled by this program is 500. The minimum allowable number of points is determined by the highest order of trend surface to be computed. This minimum number may be computed by the formula

$$N = \frac{(P+1)(P+2)}{2}$$

where N is the minimum number of points allowable and P is the highest order of trend surface to be computed. Computation of a sixth-degree trend surface, for example, requires a minimum of 28 control points. Surfaces computed with a minimum number of control points are "trend" surfaces as the surface is not a best fit but an exact fit (i.e. the residuals are zero).

Location of the coordinate values on the data cards must agree with the format specified on card 3 of the lead control cards.

Link 1 and 2 control cards:

The control cards described in this section specify printing of the contour maps (Link 1) and plotting of z values and residuals (Link 2). An option is provided whereby Link 2 is not called if residual or data plots are not desired.

Link 1

Card 1 Columns 1-5 contain the total number of contour maps to be

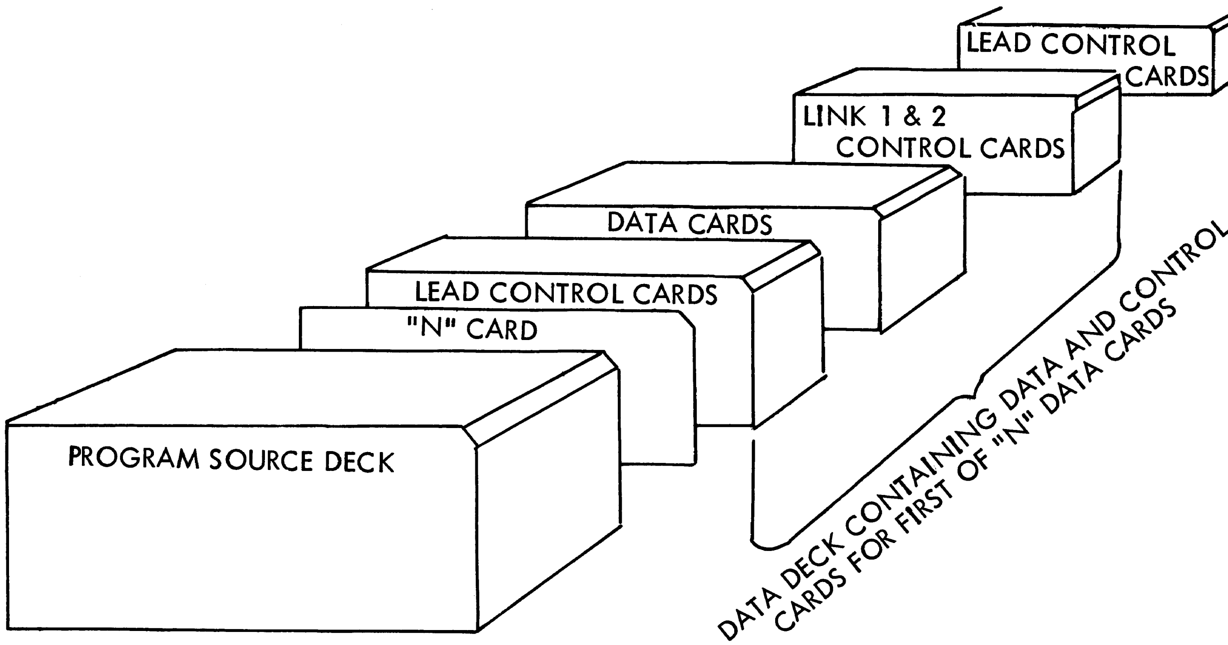

Figure 2. - Make-up of trend-surface program package with source deck, data, and control cards.

printed from this data deck. This value must be right justified.

Column 6 Blank

Column 7 contains the option for Link 2. If plots of the z values and/or the residual values are desired, this column contains a 1 (one); otherwise, it must be 0 (zero) or blank.

Card 2 This is the first of a set of M cards which contain the contouring parameters of each map to be contoured. (M is the number specified in columns 1-5 of card 1).

Column 1 Blank

Column 2 contains the contour map indicator, MP, which designates the degree of the equation of the map to be contoured. If MP is 1, the first-degree is contoured; if 2, the second-degree surface is contoured, etc. This number cannot be larger than 6.

Column 3 contains the orientation indicator, IOR. This variable controls the orientation of the printed map on the paper. If IOR is 1, the x axis is horizontal. If IOR is 2, the y axis is horizontal. If IOR is 3, the contoured map is oriented so that it occupies as much space as possible. For instance, if an interval of 10 units on the x axis and an interval of

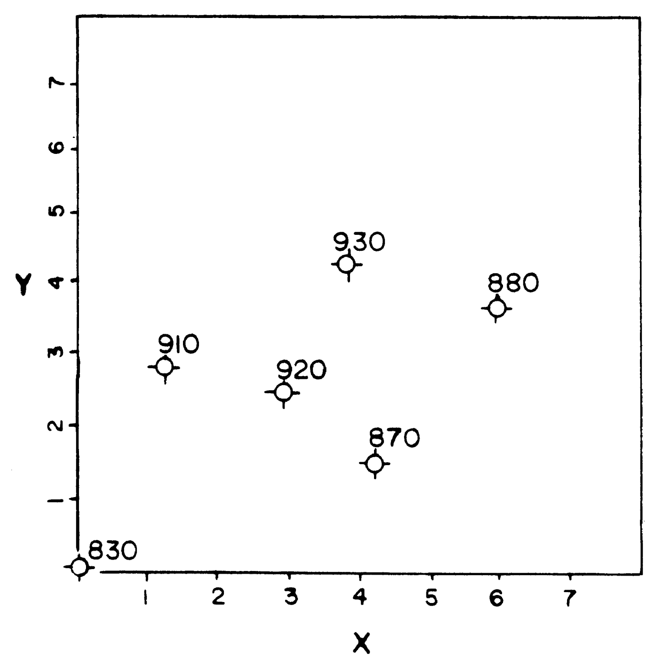

Figure 3. - Example of mapped data scaled for coding as xyz coordinates.

5 units on the y axis is to be contoured, the map is oriented with the x axis vertical. If IOR is 4, the contoured map is oriented so that it occupies as little space as possible.

Column 4 contains the plotting limit indicator, M3. If M3 is 1, the x-plotting interval is the interval between the maximum and minimum values of the X data array, and the y-plotting interval is the interval between the maximum and minimum values of the Y data array. If M3 is 0 (zero), the plotting limits are read in on a card that immediately follows this card (not this set of cards). These limits are on the card in the form:

Column 1 Blank

Columns 2-16 contain the maximum x-plotting limit. If no decimal is punched it is assumed to be between columns 10 and 11.

Columns 17-31 contain the minimum x-plotting limit. If no decimal point is punched, it is assumed to be between columns 25 and 26.

Columns 32-46 contain the maximum y-plotting limit. If no decimal point is punched, it is assumed to be between columns 40 and 41.

Columns 47-61 contain the minimum y-plotting limit. If no decimal point is punched, it is assumed to be between columns 55 and 56.

Column 5 contains the card tabulator indicator, MT. If MT is 1, the output is to be listed at six lines per inch. If MT is 0 (zero) the output is to be listed at ten lines per inch.

Columns 6-9 contain the program variable NCOL, which indicates the number of horizontal columns of output. The value of NCOL may range from 12-120 inclusive and must be right justified. The contour map occupies NCOL - 10 columns.

Columns 10-19 contain the program variable CON which is the contour interval of the contour map. This value must not be zero or negative. If no decimal point is punched, it is assumed to be between columns 17 and 18.

Columns 20-29 contain the program variable REF which is the reference contour. This value regulates the placement of the reference symbol (.....) on the contour map. If no decimal point is punched, it is assumed to be between columns 27 and 28.

The remaining cards control the plotting of the original data and the residuals. If this output is not desired, column 7 of card 1 in the previous section must be zero or blank, and the following control cards are omitted.

Link 2

Card 1 Columns 1-5 contain the total number of plots to be made. This value must be right justified.

Card 2 This is the first of a set of M cards that contain the plotting parameters for each set of values to be plotted. (M is the number specified on card 1).

Column 1 Blank

Column 2 contains the residual plot indicator, MP. If MP is 0 (zero), the original data are plotted. If MP is 1, the first-degree residuals are plotted; if 2, the second-degree residuals are plotted, etc. This indicator cannot be larger than 6.

Column 3 contains the orientation indicator, IOR. IOR has the same function here as described in Link 1, card 2, column 3.

Column 4 contains the plotting limit indicator, M3. M3 has the same function here as described in Link 1, card 2, column 4.

Column 5 contains the card tabulator indicator, MT. MT has the same function here as described in Link 1, card 2, column 5.

Columns 6–9 contain the value of the program variable NCOL. NCOL has the same function here as described in Link 1, card 2, columns 6–9 except that the value of NCOL in Link 2 may range from 16–120 inclusive and the plot occupies NCOL – 15 columns. (Note: For the contour maps and the residual plots to have the same scale, the value of NCOL for Link 2 should be four greater than NCOL for a corresponding contour map in Link 1).

SAMPLE INPUT DATA

Following is a sample data set with control cards to obtain contours of the six polynomial surfaces, a plot of the original (z) data, and plots of the residual values for each surface:

```
STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)
179 111111
    (1X,2F7.0,F8.0)
5    33.7  - 0.2 -2355.0
5    32.7  - 0.5 -2408.0
5    20.9  - 0.9 -2437.0
5    17.3  - 0.3 -2553.0
5    13.8  - 0.3 -2602.0
5    27.5  - 0.3 -2491.0
5    27.8  -13.3 -2636.0
5    29.4  -13.8 -2678.0
5    24.0  -19.2 -2686.0
5    27.3  -21.8 -2798.0
5    19.4  - 1.0 -2504.0
5    22.3  - 1.2 -2460.0
5    23.9  - 3.5 -2560.0
5    20.5  - 4.5 -2629.0
5    20.5  - 5.5 -2605.0
5    23.4  - 6.5 -2586.0
5    19.7  - 6.0 -2596.0
5    24.5  - 4.7 -2567.0
5    25.9  - 7.9 -2570.0
5    27.0  - 8.5 -2644.0
5    24.4  - 9.4 -2590.0
5    27.7  - 9.0 -2565.0
5    27.4  - 4.0 -2492.0
5    31.9  - 2.0 -2476.0
5    24.7  -11.8 -2586.0
5    23.5  -19.8 -2674.0
5    19.0  -21.9 -2699.0
5    18.6  -23.6 -2705.0
5    21.5  -23.5 -2690.0
5    22.4  -24.9 -2784.0
5    20.5  -24.5 -2686.0
5    18.5  -24.5 -2718.0
5    20.4  -27.0 -2758.0
5    19.7  -28.5 -2808.0
5    26.5  -22.5 -2799.0
5    29.5  -23.4 -2832.0
5    27.8  -24.9 -2817.0
5    26.6  -24.6 -2806.0
5    27.1  -25.3 -2816.0
5    28.9  -26.5 -2879.0
5    27.8  -26.8 -2846.0
5    28.4  -29.9 -2947.0
5    17.0  - 8.9 -2680.0
5    14.9  - 9.0 -2697.0
5    16.7  -11.9 -2702.0
5    17.4  -11.9 -2693.0
5    17.0  -13.5 -2682.0
5    16.9  -14.9 -2705.0
5    15.4  -15.5 -2752.0
5    19.9  - 7.0 -2625.0
5    23.3  - 8.7 -2632.0
5    23.8  -11.4 -2627.0
5    18.2  -12.0 -2693.0
5    21.5  -14.9 -2593.0
5    41.9  -26.0 -3039.0
5    38.0  -26.0 -3005.0
5    39.3  -27.4 -3003.0
5    38.5  -28.9 -3045.0
5    41.9  -29.0 -3127.0
5    23.9  -15.9 -2660.0
5    22.0  -16.0 -2678.0
5    18.4  -16.3 -2723.0
5    23.5  -17.9 -2638.0
5    22.0  -18.0 -2655.0
5    16.1  -15.3 -2726.0
5    17.5  -16.5 -2753.0
5    14.0  -17.0 -2868.0
5    15.5  -18.4 -2796.0
5    16.9  -21.0 -2805.0
5    13.4  -22.5 -2918.0
5    12.5  -23.5 -3087.0
5    13.5  -24.9 -2916.0
5    18.3  -29.6 -2882.0
5    16.5  - 1.4 -2478.0
5    13.4  - 2.5 -2600.0
5    16.9  - 4.9 -2635.0
5    14.4  - 4.0 -2623.0
5    12.9  - 6.0 -2727.0
5    15.4  - 7.5 -2643.0
5    30.0  -17.2 -2788.0
5    32.4  -17.5 -2710.0
5    32.0  -18.9 -2757.0
5    31.0  -21.0 -2802.0
5    32.0  -21.4 -2801.0
5    35.0  -22.0 -2829.0
5    35.8  -24.6 -2933.0
5    34.0  -25.5 -2860.0
5    33.0  -26.4 -2880.0
5    32.5  -26.9 -2900.0
5    37.0  - 0.4 -2441.0
5    41.5  - 0.4 -2587.0
5    31.9  -29.5 -2930.0
5    35.4  -29.5 -3073.0
5    27.9  - 2.4 -2454.0
5    26.9  - 2.0 -2557.0
5    28.4  - 4.0 -2412.0
5    28.4  -22.5 -2790.0
5     2.0  -12.4 -2904.0
5     5.9  -13.9 -2875.0
5     4.0  -14.4 -2917.0
5     4.1  -16.3 -2919.0
5     1.5  -16.0 -2903.0
5     1.0  -18.7 -3066.0
5     9.5  -23.0 -3027.0
5     8.0  -24.4 -3093.0
5     7.7  -26.7 -3136.0
5    10.2  -27.7 -3168.0
5     7.6  -29.3 -3320.0
5    11.6  -29.6 -3034.0
5     2.9  - 1.9 -2743.0
5     5.0  - 1.5 -2748.0
5     5.0  - 2.9 -2755.0
5     3.9  - 2.9 -2737.0
5    33.4  - 3.4 -2494.0
5    33.9  - 4.8 -2467.0
5    32.0  - 5.2 -2377.0
5    35.0  - 7.0 -2652.0
5    30.0  - 9.5 -2523.0
5    32.5  - 9.5 -2636.0
5    34.4  -11.4 -2704.0
5    35.9  -12.9 -2751.0
5    31.3  -12.0 -2704.0
5    30.4  -14.9 -2758.0
5    32.0  -16.0 -2687.0
5    39.5  -13.7 -2675.0
5    41.0  -16.9 -2882.0
5    39.5  -16.0 -2761.0
5    37.4  -16.9 -2753.0
5    39.5  -17.4 -2774.0
5    38.0  -18.9 -2792.0
5    36.5  -18.4 -2771.0
5    40.1  -19.6 -2893.0
5    39.8  -22.7 -2964.0
5    36.4  -22.4 -3261.0
5    38.9  -24.9 -3006.0
5     4.9  - 5.0 -2813.0
5     1.4  - 8.9 -2899.0
5    14.2  -25.0 -2871.0
5    15.4  -25.9 -2837.0
5    13.9  -26.5 -2945.0
5    14.4  -27.0 -2899.0
5     9.9  - 1.5 -2640.0
5    11.0  - 1.4 -2672.0
5    11.0  - 2.2 -2575.0
5    10.9  - 4.0 -2671.0
5     8.5  - 4.9 -2747.0
5     8.4  - 5.5 -2749.0
5     6.9  - 7.4 -2843.0
5    11.9  - 8.9 -2764.0
5     9.0  - 9.0 -2815.0
5    11.9  -13.9 -2852.0
5     7.7  -15.9 -2878.0
5     6.4  -17.4 -2875.0
5    10.0  -19.4 -2924.0
5    41.5  - 2.5 -2613.0
5    38.2  - 2.4 -2568.0
5    38.3  - 4.7 -2600.0
5    41.0  - 5.4 -2680.0
5    40.3  - 8.8 -2669.0
5    38.5  - 8.9 -2700.0
5    37.9  - 9.4 -2699.0
5    11.0  -10.4 -2811.0
5     8.0  -10.9 -2841.0
5    38.3  -10.0 -2722.0
5    28.2  -15.8 -2308.0
5    26.8  -16.5 -2560.0
5    24.4  -16.5 -2617.0
5    25.9  -17.4 -2619.0
5    38.5  - 9.3 -2710.0
5    29.3  -20.4 -2781.0
5    26.9  -10.0 -2594.0
5    20.5  -20.5 -2675.0
5    21.4  -10.0 -2646.0
5    15.4  -20.3 -2841.0
5    35.4  -20.5 -2810.0
5    34.4  -10.5 -2669.0
5    30.0  -10.5 -2520.0
5    37.4  -10.1 -2700.0
5    40.4  -20.0 -2882.0
```

SAMPLE PROGRAM OUTPUT

Output from the preceding sample data and control cards are listed below and on the following pages.

EXPLANATION OF OUTPUT

Error measures for the various surfaces are computed from the following formulas.

The "TOTAL VARIATION," V, is given by

$$V = \sum_{i=1}^{N} (z_i - \overline{z})^2$$

where z_i is the ith z data coordinate,

$$\overline{z} = \frac{\sum_{i=1}^{N} z_i}{N}$$

V is calculated entirely from the input data and hence is the same for each surface.

The "VARIATION NOT EXPLAINED BY SURFACE," S, is given by

$$S = \sum_{i=1}^{N} (z_{i\ \text{observed}} - z_{i\ \text{calculated}})^2 .$$

This value is obtained by squaring the appropriate order of residuals and summing. The "VARIATION EXPLAINED BY SURFACE," E, is given by

$$E = V - S.$$

The "COEFFICIENT OF DETERMINATION," T, is given by

$$T = \frac{E}{V} .$$

The value E, and hence T, may be negative if S is sufficiently large. The "COEFFICIENT OF CORRELATION," L, is given by

$$L = T^{1/2} .$$

If T is negative, L also is output as a negative number (Spiegel, 1961, p. 252-253). The "STANDARD DEVIATION," D, is given by

$$D = \left(\frac{S}{N}\right)^{1/2}$$

where N is the number of sets of data coordinates. Each of these quantities is calculated for each surface. If the equation of a particular surface is

Sample control cards

```
   6 1
1101 100        25.0   -2825.00
         33.5              0.0     0.0  -27.0
2101 100        25.0   -2825.00
         33.5              0.0     0.0  -27.0
3101 100        25.0   -2825.00
         33.5              0.0     0.0  -27.0
4101 100        25.0   -2825.00
         33.5              0.0     0.0  -27.0
5101 100        25.0   -2825.00
         33.5              0.0     0.0  -27.0
6101 100        25.0   -2825.00
         33.5              0.0     0.0  -27.0
   7
0101 104
         27.0              0.0     0.0  -24.0
1101 104
         27.0              0.0     0.0  -24.0
2101 104
         27.0              0.0     0.0  -24.0
3101 104
         27.0              0.0     0.0  -24.0
4101 104
         33.5              0.0     0.0  -27.0
5101 104
         33.5              0.0     0.0  -27.0
6101 104
         33.5              0.0     0.0  -27.0
```

not calculated, the corresponding error measures are printed as zeros.

The scale on the left edge of the contour map reads directly in terms of whichever scale is specified as vertical, but the horizontal scales do not read directly. On the horizontal scales, only the units digits of the scale values are shown; blanks in the scales represent increments of ten. For example, the leftmost blank represents ten and the next blank to the right represents 20. After the reading is made on the horizontal scale, the reading must be substituted for "SCALE VALUE" in the formula for the horizontal scale. The value given by this substitution corresponds directly to the original units of the horizontal axis (x or y). Scales are positioned on contour maps so that any character on the map is in direct line with the scales both vertically and horizontally. Any given character is selected from a calculation of the value of the surface of the center of the small region in which the character is plotted.

Contours are read in the following manner. The reference contour runs along the "letter-edge" of the band of dots. From this reference contour each edge of each band of characters represents an increment of one contour interval -- the letter bands proceeding downward (A,B,C,.....) from the reference contour and the number bands upward (0,1,2,.....). Both letter and number bands feature "wrap-around" character selection. For example, if a surface reaches a greater value above the reference contour than can be contoured by using 10 different bands of digits, the next higher band of digits is a band of 0's, the next a band of 1's, the next a band of 2's, etc. The same is true of letter bands. The next band lower than Z is A, the next lower is B, etc. The character selection may "wrap around" any number of times, but the reference band is printed only once. A result of this "wrap-around" feature is that unless the reference band is printed on the contour map, the specific values represented by the other band are not uniquely determined by the character in the band.

Contour maps are printed in the order in which they are encountered in the input data for Link 1. If it is specified that a surface be contoured but the equation of that surface has not been determined, the contouring of that surface is bypassed.

The next section of output is the plotting of the original data and the first through sixth-degree residuals on the xy plane. Again, if a certain order of residual is specified to be plotted but the equation of the corresponding surface has not been determined, the plotting of these residuals is bypassed.

Each residual plot is also preceded by the program title, name of the plot, plotting limits, and orientation of the scales. The plots may contain one additional preliminary statement. The plotting routine is designed so that the number of digits in the largest plotted value is always four. If values to be plotted do not have this property, the entire set of values is multiplied successively either by 10 or 0.1 until this property is attained. If the plotted values are scaled, the scale factor is printed.

The scales for axes residual plots are interpreted somewhat differently from the scales of the contour maps. Conversion of the horizontal scale reading, however, is the same. The position of the plotted number is indicated by the sign of the number. A zero is preceded by a plus sign. In addition, the horizontal scale should be shifted half a space to the left, and the vertical scale half a line upward while the plotted values remain stationary. Thus the scales establish horizontal and vertical limits on the location of the sign of the number rather than defining a unique central position. These limits may be made as small as possible by enlarging the printing area. (It should be noted that by proper manual selection of plotting limits, the total width of the plots and contour maps may be made to occupy more than one page by specifying identical plots with adjacent plotting limits).

Several symbols other than numbers may occur on the plots. These are the "overprint characters;" their meaning is explained below.

- * An attempt was made to write a number, but before it was completed another number to the right was encountered.
- B Two numbers fall within the limits of the region of this position.
- C Three numbers fall within the limits of the region of this position.
- D Four numbers fall within the limits of the region of this position.
- .
- .
- .
- I Nine numbers fall within the limits of the region of this position.
- Z Ten or more numbers fall within the limits of the region of this position.

The "overprint characters" are printed on the plot, and the "OVERPRINT VALUES" that they represent are listed in a single column following the plot. Each time a new line containing overprint values is encountered on the plot, a double space is made in the column of overprint values. Overprint values for this line are then read from left to right across the plot. The table of "OVERPRINT VALUES" is limited to 150 numbers. If control points are clustered or an unfortunate choice of SCALE VALUES results in more than 150 overprint values, the plot is discontinued, overprint values are suppressed, and a message is printed on the incomplete plot.

ERROR MESSAGES

Twenty-eight error messages have been built into the program to indicate that invalid data or control cards have been encountered in the program. These data or control card errors and the messages generated by the errors are listed below:

Program errors

1. Number of sets of data points outside allowable range (1-500).
2. Indicator for calculation of first-degree equation outside allowable range (0-1).
3. Indicator for calculation of second-degree equation outside allowable range (0-1).
4. Indicator for calculation of third degree equation outside allowable range (0-1).
5. Indicator for calculation of fourth-degree equation outside allowable range (0-1).
6. Indicator for calculation of fifth-degree equation outside allowable range (0-1).
7. Indicator for calculation of sixth-degree equation outside allowable range (0-1).
8. Indicators for calculation of first-, second-third-, fourth-, fifth-, and sixth-degree equations are all zero.
9. Residual plot indicator outside allowable range (0-6).
10. Plotting limit indicator for residual map outside allowable range (0-1).
11. Indicator for use of Link 2 outside allowable range (0-1).
12. Use of Link 2 attempted without proper specification in Link 1.
13. Contour map indicator outside allowable range (1-6).

14 Plotting limit indicator for contour map outside allowable range (0-1).

Subroutine CONTUR Errors

1 Indicator for evaluation subroutines outside allowable range (1-6).
2 Indicator for orientation outside allowable range (1-4).
3 Card tabulator indicator outside allowable range (0-1).
4 Number of columns of output outside allowable range (12-120).
5 Contour interval negative or zero.
6 Maximum x-plotting limit less than or equal to minimum x-plotting limit.
7 Maximum y-plotting limit less than or equal to minimum y-plotting limit.

Subroutine PLOT3 Errors

1 Number of points to be plotted outside allowable range (1-500).
2 Orientation indicator outside allowable range (1-4).
3 Number of columns of output outside allowable range (16-120).
4 Card tabulator indicator outside allowable range (0-1).
5 Indicator for previous ordering of elements outside allowable range (0-2).
6 Maximum x-plotting limit less than or equal to minimum x-plotting limit.
7 Maximum y-plotting limit less than or equal to minimum y-plotting limit.

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

X-COORD	Y-COORD	Z-VALUE	1ST-SURF	1ST-RESID	2ND-SURF	2ND-RESID	3RD-SURF	3RD-RESID
33.700	-0.200	-2355.000	-2485.524	130.524	-2480.129	125.129	-2426.780	71.780
32.700	-0.500	-2408.000	-2494.014	86.014	-2475.717	67.717	-2432.277	24.277
20.900	-0.900	-2437.000	-2546.461	109.461	-2481.640	44.640	-2499.856	62.856
17.300	-0.300	-2553.000	-2551.485	-1.515	-2511.603	-41.397	-2530.329	-22.671
13.800	-0.300	-2602.000	-2565.238	-36.762	-2563.819	-38.181	-2577.198	-24.802
27.500	-0.300	-2491.000	-2511.406	20.406	-2451.271	-39.729	-2434.834	-56.166
27.800	-13.300	-2636.000	-2707.858	71.858	-2633.591	-2.409	-2630.320	-5.680
29.400	-13.800	-2678.000	-2709.172	31.172	-2647.523	-30.477	-2640.676	-37.324
24.000	-19.200	-2686.000	-2812.483	126.483	-2727.733	41.733	-2697.455	11.455
27.300	-21.800	-2798.000	-2839.042	41.042	-2775.096	-22.904	-2730.474	-67.526
19.400	-1.000	-2504.000	-2553.875	49.875	-2495.996	-8.004	-2518.393	14.393
22.300	-1.200	-2460.000	-2545.521	85.521	-2475.539	15.539	-2491.740	31.740
23.900	-3.500	-2560.000	-2574.199	14.199	-2496.188	-63.812	-2519.906	-40.094
20.500	-4.500	-2629.000	-2602.761	-26.239	-2528.380	-100.620	-2564.435	-64.565
20.500	-5.500	-2605.000	-2617.964	12.964	-2541.074	-63.926	-2578.099	-26.901
23.400	-6.500	-2586.000	-2621.771	35.771	-2537.214	-48.786	-2566.945	-19.055
19.700	-6.000	-2596.000	-2628.708	32.708	-2554.149	-41.851	-2592.562	-3.438
24.500	-4.700	-2567.000	-2590.084	23.084	-2509.772	-57.228	-2534.952	-32.048
25.900	-7.900	-2570.000	-2633.231	63.231	-2551.036	-18.964	-2572.035	2.035
27.000	-8.500	-2644.000	-2638.030	-5.970	-2559.908	-84.092	-2576.895	-67.105
24;400	-9.400	-2590.000	-2661.928	71.928	-2574.340	-15.660	-2595.118	5.118
27.700	-9.000	-2565.000	-2642.880	77.880	-2568.229	3.229	-2582.456	17.456

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

X-COORD	Y-COORD	Z-VALUE	4TH-SURF	4TH-RESID	5TH-SURF	5TH-RESID	6TH-SURF	6TH-RESID
33.700	-0.200	-2355.000	-2420.957	65.957	-2407.717	52.717	-2412.734	57.734
32.700	-0.500	-2408.000	-2420.232	12.232	-2412.244	4.244	-2412.589	4.589
20.900	-0.900	-2437.000	-2461.068	24.068	-2490.997	53.997	-2501.314	64.314
17.300	-0.300	-2553.000	-2501.015	-51.985	-2516.390	-36.610	-2554.817	1.817
13.800	-0.300	-2602.000	-2571.123	-30.877	-2558.407	-43.593	-2588.763	-13.237
27.500	-0.300	-2491.000	-2384.228	-106.772	-2415.482	-75.518	-2445.971	-45.029
27.800	-13.300	-2636.000	-2627.170	-8.830	-2620.395	-15.605	-2606.248	-29.752
29.400	-13.800	-2678.000	-2643.307	-34.693	-2633.315	-44.685	-2623.944	-54.056
24.000	-19.200	-2686.000	-2686.914	0.914	-2676.901	-9.099	-2671.741	-14.259
27.300	-21.800	-2798.000	-2743.218	-54.782	-2733.344	-64.656	-2749.184	-48.816
19.400	-1.000	-2504.000	-2488.634	-15.366	-2510.680	6.680	-2517.358	13.358
22.300	-1.200	-2460.000	-2452.794	-7.206	-2483.400	23.400	-2483.222	23.222
23.900	-3.500	-2560.000	-2502.422	-57.578	-2518.528	-41.472	-2500.321	-59.679
20.500	-4.500	-2629.000	-2562.206	-66.794	-2573.002	-55.998	-2560.824	-68.176
20.500	-5.500	-2605.000	-2578.729	-26.271	-2588.954	-16.046	-2584.842	-20.158
23.400	-6.500	-2586.000	-2560.789	-25.211	-2571.328	-14.672	-2572.346	-13.654
19.700	-6.000	-2596.000	-2597.260	1.260	-2606.105	10.105	-2606.775	10.775
24.500	-4.700	-2567.000	-2523.391	-43.609	-2535.136	-31.864	-2526.149	-40.851
25.900	-7.900	-2570.000	-2565.747	-4.253	-2570.232	0.232	-2578.114	8.114
27.000	-8.500	-2644.000	-2571.916	-72.084	-2572.833	-71.167	-2583.050	-60.950
24.400	-9.400	-2590.000	-2587.264	-2.736	-2593.867	3.867	-2593.146	3.146
27.700	-9.000	-2565.000	-2578.657	13.657	-2577.143	12.143	-2588.087	23.087

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

COEFFICIENTS OF FIRST-DEGREE EQUATION

```
Z =    -2614.90258 +       3.92936 X +     15.20235 Y
```

COEFFICIENTS OF SECOND-DEGREE EQUATION

```
Z =    -2923.87688 +      35.39211 X +      9.03288 Y +     -0.65721 X2 +      0.11411 XY +     -0.13211 Y2
```

COEFFICIENTS OF THIRD-DEGREE EQUATION

```
Z =    -2750.70028 +       9.97256 X +     24.02224 Y +      0.37606 X2 +     -0.57420 XY +      0.72142 Y2 +
    -0.01133 X3 +       0.02128 X2Y +      0.01053 XY2 +     0.02448 Y3
```

COEFFICIENTS OF FOURTH-DEGREE EQUATION

```
Z =    -2535.09176 +     -44.19909 X +     49.15755 Y +      4.84141 X2 +     -1.50792 XY +      3.63627 Y2 +
    -0.14609 X3 +       0.09056 X2Y +      0.03222 XY2 +     0.17477 Y3 +       0.00132 X4 +     -0.00161 X3Y +
    -0.00160 X2Y2 +    -0.00113 XY3 +       0.00209 Y4
```

COEFFICIENTS OF FIFTH-DEGREE EQUATION

```
Z =    -2793.34892 +      30.01393 X +     12.16366 Y +     -1.57745 X2 +      4.87662 XY +      0.28134 Y2 +
     0.06422 X3 +      -0.40850 X2Y +      0.10596 XY2 +    -0.06898 Y3 +      -0.00111 X4 +      0.01287 X3Y +
    -0.00526 X2Y2 +    -0.00037 XY3 +     -0.00605 Y4 +      0.00000 X5 +     -0.00013 X4Y +      0.00008 X3Y2 +
     0.00004 X2Y3 +     0.00004 XY4 +     -0.00009 Y5
```

COEFFICIENTS OF SIXTH-DEGREE EQUATION

```
Z =    -3144.06072 +     144.59617 X +    -94.14483 Y +    -17.14740 X2 +     15.23939 XY +    -24.04299 Y2 +
     1.09350 X3 +      -1.36034 X2Y +      0.33502 XY2 +    -3.17811 Y3 +      -0.03741 X4 +      0.04646 X3Y +
    -0.03070 X2Y2 +    -0.00517 XY3 +     -0.20063 Y4 +      0.00066 X5 +     -0.00053 X4Y +      0.00120 X3Y2 +
     0.00055 X2Y3 +     0.00025 XY4 +     -0.00573 Y5 +     -0.00000 X6 +      0.00000 X5Y +     -0.00001 X4Y2 +
    -0.00000X3Y3 +      0.00001 X2Y4 +     0.00001 XY5 +     -0.00006 Y6
```

ERROR MEASURES

SURFACE	FIRST-DEGREE	SECOND-DEGREE	THIRD-DEGREE	FOURTH-DEGREE	FIFTH-DEGREE	SIXTH-DEGREE
STANDARD DEVIATION	109.07	72.56	65.76	59.67	57.28	54.56
VARIATION EXPLAINED BY SURFACE	0.32700842E 07	0.44503218E 07	0.46178647E 07	0.47539100E 07	0.48036234E 07	0.48577746E 07
VARIATION NOT EXPLAINED BY SURFACE	0.21174998E 07	0.93726217E 06	0.76971919E 06	0.63367397E 06	0.58396056E 06	0.52980935E 06
TOTAL VARIATION	0.53875840E 07	0.53875840E 07	0.53875840E 07	0.53875840E 07	0.53875840E 07	0.53875840E 07
COEFFICIENT OF DETERMINATION	0.60696671	0.82603292	0.85713090	0.88238252	0.89160993	0.90166104
COEFFICIENT OF CORRELATION	0.77906068	0.90886353	0.92581364	0.93935218	0.94425099	0.94955834

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

CONTOURED FIRST-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X = 33.500000 MINIMUM X = 0.000000
MAXIMUM Y = 0.000000 MINIMUM Y = -27.000000

X-SCALE IS HORIZONTAL
X-VALUE = 0.00 + 0.3764 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL = 25.00
REFERENCE CONTOUR (......) = -2825.00

```
       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

 -0.00 33333333333                44444444444444444                 55555555555555555
 -0.63 33333333333333333                 44444444444444444                 55555555555555555
 -1.25        3333333333333333                 44444444444444444                 5555555555555555
 -1.88              33333333333333333                 44444444444444444                 555555555
 -2.51 222                33333333333333333                 44444444444444444                 555
 -3.14 222222222                 33333333333333333                 44444444444444444
 -3.76 222222222222222                 33333333333333333                 44444444444444444
 -4.39      22222222222222222                 33333333333333333                 44444444444444444
 -5.02            22222222222222222                 33333333333333333                 44444444444
 -5.65 1                 22222222222222222                 33333333333333333                 4444
 -6.27 1111111                 22222222222222222                 33333333333333333
 -6.90 11111111111111                 22222222222222222                 33333333333333333
 -7.53    11111111111111111                 22222222222222222                 33333333333333333
 -8.16           11111111111111111                 22222222222222222                3333333333333
 -8.78                 11111111111111111                 22222222222222222                 333333
 -9.41 000000                 11111111111111111                 2222222222222222
-10.04 000000000000                 11111111111111111                 22222222222222222
-10.66   00000000000000000                 11111111111111111                22222222222222222
-11.29         00000000000000000                 11111111111111111                 22222222222222
-11.92                00000000000000000                 1111111111111111                 22222222
-12.55 ....                 00000000000000000                 11111111111111111                 2
-13.17 ...........                 00000000000000000                11111111111111111
-13.80 .................                 00000000000000000                 11111111111111111
-14.43        .................                 0000000000000000                 1111111111111111
-15.06              .................                 00000000000000000                 111111111
-15.68 AAA                 .................                00000000000000000                 111
-16.31 AAAAAAAAA                 .................                 00000000000000000
-16.94 AAAAAAAAAAAAAAAA                 ................                 00000000000000000
-17.57      AAAAAAAAAAAAAAAAA                 .................                 00000000000000000
-18.19             AAAAAAAAAAAAAAAAA                .................                 00000000000
-18.82 B                 AAAAAAAAAAAAAAAAA                 .................                 0000
-19.45 BBBBBBBB                 AAAAAAAAAAAAAAAA                 .................
-20.07 BBBBBBBBBBBBBB                 AAAAAAAAAAAAAAAAA                 .................
-20.70     BBBBBBBBBBBBBBBBB                AAAAAAAAAAAAAAAAA                 .................
-21.33           BBBBBBBBBBBBBBBBB                 AAAAAAAAAAAAAAAAA                 ............
-21.96                  BBBBBBBBBBBBBBBB                 AAAAAAAAAAAAAAAAA                 ......
-22.58 CCCCCC                 BBBBBBBBBBBBBBBBB                 AAAAAAAAAAAAAAAAA
-23.21 CCCCCCCCCCCCC                BBBBBBBBBBBBBBBBB                 AAAAAAAAAAAAAAAAA
-23.84   CCCCCCCCCCCCCCCCC                 BBBBBBBBBBBBBBBBB                 AAAAAAAAAAAAAAAAA
-24.47          CCCCCCCCCCCCCCCC                 BBBBBBBBBBBBBBBBB                 AAAAAAAAAAAAAA
-25.09                CCCCCCCCCCCCCCCCC                 BBBBBBBBBBBBBBBBB                 AAAAAAA
-25.72 DDDDD                CCCCCCCCCCCCCCCCC                 BBBBBBBBBBBBBBBBB                 A
-26.35 DDDDDDDDDDD                 CCCCCCCCCCCCCCCCC                 BBBBBBBBBBBBBBBBB
-26.98 DDDDDDDDDDDDDDDDD                 CCCCCCCCCCCCCCCCC                 BBBBBBBBBBBBBBBBB
-27.60        DDDDDDDDDDDDDDDDD                 CCCCCCCCCCCCCCCCC                 BBBBBBBBBBBBBBB

       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

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STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

CONTOURED FOURTH DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X =      33.500000     MINIMUM X =       0.000000
MAXIMUM Y =       0.000000     MINIMUM Y =     -27.000000

X-SCALE IS HORIZONTAL
X-VALUE =    0.00 +  0.3764 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL =                         25.00
REFERENCE CONTOUR (.....) =             -2825.00

       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

 -0.00  44  333      22222222       3333    444    555   6666     77777          888888888       777
 -0.63 4  33   2222            222222    3333   4444   555    6666     777777777        777777777
 -1.25  33  222      1111111        2222   3333    4444   5555    66666      77777777777          66
 -1.88 3  22   1111111111111111      2222   333    444    5555    6666666                  6666666
 -2.51  22   111                11111   2222   3333   4444    5555      666666666666666666
 -3.14 22  11      0000000000      1111     222   3333   4444      55555                          555
 -3.76   11    0000000000000000      1111    2222   3333    44444      5555555               55555555
 -4.39  11   0000            000000      111     222    333    44444      5555555555555555555555
 -5.02 11  000                 0000    1111    2222   3333    44444        555555555555           4
 -5.65   00      ..........      0000    1111    2222    3333    444444                         4444
 -6.27  000   ...............     0000    111    2222    3333     44444444               44444444
 -6.90 00    .......  ........    0000    1111    2222    3333    4444444444444444444444444
 -7.53 0   ....           .......   0000   1111    2222    33333    44444444444444444444
 -8.16    ...               .....    000    111    2222    33333      444444444444444        33
 -8.78  ...                 ....    0000    1111    222     333333                         3333
 -9.41 ...      AAAAAAAAA      ....   000    111    2222    333333                      3333333
-10.04 .    AAAAAAAAAAAAA      ....   0000    1111    2222    3333333                 33333333
-10.66    AAAAAAAAAAAAAAAAA      ....   000    111    22222    333333333       333333333
-11.29  AAAAA        AAAAAAA     ....   0000    1111    2222    3333333333333333333333333
-11.92 AAA             AAAAAA    ...    000    111    22222    333333333333333333333           22
-12.55 A                AAAAA    ....   0000    1111    22222    333333333333333333          22222
-13.17    BBBBBBBBBBB     AAAA    ...    000    111    22222      333333333333              222222
-13.80 BBBBBBBBBBBBBBBB    AAAA    ...   0000    1111    222222                          222222
-14.43 B          BBBBB    AAAA    ....   000    1111    222222                         2222222
-15.06                 BBBB    AAA    ...   0000    1111    2222222                  22222222    11
-15.68 CCCCCCCCCCCC    BBBB    AAA    ...   000    1111    22222222            222222222     1111
-16.31         CCCCC    BBB    AAA    ...   000    1111    222222222222222222222222       11111
-16.94 DDDDDD     CCCC   BBBB   AA    ...    000    1111    2222222222222222222        11111
-17.57    DDDDDDD    CCCC   BBB   AA    ...   0000    1111    222222222222222        11111
-18.19        DDDD    CCC   BBB   AA    ...   0000    11111        22222              111111   000
-18.82  EEEEEEE   DDD    CCC  BBB   AA    ...   0000    111111                     1111111   00000
-19.45 FF     EEEE   DDD  CCC    BB    AA   ...   0000    1111111                1111111    00000
-20.07   FFFFF   EEE    DD    CC    BB    AA   ...   0000    111111111      1111111111    00000
-20.70 GGG    FFF    EE    DD   CCC  BB    AAA  ...   0000     1111111111111111111       00000   ..
-21.33     GGG    FF    EE   DDD   CC   BBB   AAA  ....   0000     11111111111111       0000    ...
-21.96  HHH   GGG  FF   EEE   DD   CC    BB   AAA    ...   00000                     00000     ....
-22.58 II   HH    GG  FF   EE   DD   CCC  BB   AAA    ...   00000                 000000     ....  A
-23.21    II   HH   GG   FF   EE   DD   CC   BB    AA    ....   0000000         0000000    ....   AAA
-23.84  JJJ  II   HH   GG   F   EE   DD   CC   BB    AAA    ...   0000000000000000000       ....  AAA
-24.47 KKK   JJ   I   HH   G   FF   E   DD   CC   BBB   AAA    ....   000000000000000      ....   AAA
-25.09 LL   K   JJ   I   HH GG   F   EE   D   CC    BB   AAA    ....       0000000         ....   AAAA  B
-25.72 M   L   KK JJ   I   H   G   FF EE   DD   CC   BB    AAA    .....                .....   AAA   BBB
-26.35    MM LL KK JJ II HH GG FF   E   DD   CC   BB    AAA    ......             .......  AAAA   BBB
-26.98     N   M LL KK J   I   H   G   F   E   DD   CC   BBB   AAA    ........   .........   AAAA   BBB
-27.60  OO N   M LL K   J II HH G   F   EE DD   CC   BBB    AAA     ................    AAAA   BBB

       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
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STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

CONTOURED SIXTH-DEGREE SURFACE

PLOTTING LIMITS
MAXIMUM X =       33.500000      MINIMUM X =        0.000000
MAXIMUM Y =        0.000000      MINIMUM Y =      -27.000000

X-SCALE IS HORIZONTAL
X-VALUE =    0.00 +  0.3764 X (SCALE VALUE)

Y-SCALE IS VERTICAL

CONTOUR INTERVAL =                          25.00
REFERENCE CONTOUR (.....) =               -2825.00

        0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

  -0.00     DC  A . 00 111  2222       33333333       444444      555555      6666666       7777777
  -0.63    DCB A . 0  11  222      3333333       4444444      55555       666666       7777777777
  -1.25 EDC BA . 00 11   222      333333      444444      555555      6666666          7777777777
  -1.88    CB A . 00 111   222       333333      44444      55555      666666666
  -2.51 D  B A . 00  111    22222       333333      44444      55555       6666666666666       6666
  -3.14 DC B A .  00   111      222222      33333      44444     555555          66666666666666666
  -3.76  C B A ..  000    11111      22222     33333    44444     55555555
  -4.39  C B AA ..   0000     111111     2222     3333    44444     5555555555555555555555555
  -5.02  C B AA  ...   00000      111111    22222    3333    44444          555555555
  -5.65  C B   AA  ....      000000     1111    2222    33333     4444444                 444444
  -6.27 CC B   AAA    ...,..     00000    1111    2222    3333     44444444444444444444444444
  -6.90 C  B    AAA     ,.......     0000    1111    222    33333      44444444444444444
  -7.53 C BB    AAAA        .......    0000    1111    2222    33333        44444444           333
  -8.16 C BB    AAAAAA        ......    0000    1111    2222    333333                     333333
  -8.78   BB    AAAAAAAAA       .....    0000    1111    2222    333333                   33333333
  -9.41  BB     AAAAAAAAAAAA      ....    0000    111    2222    3333333                 33333333
 -10.04 BBB     AAAAAAAAAAAAA      ....    000    111    222    333333              33333333
 -10.66 BB      AAAAAAAAAAAAAA      .....   000    1111   222    333333            33333333
 -11.29 B       AAAAAAAAAAAAAAAA     ....   000    1111   222    333333           33333333
 -11.92 B      AAAAAAAAAAAAAAAAA     ....   0000    111    222    333333          33333333      22
 -12.55 B       AAAAAAAAAAAAAAAAA     ...    000    111    222    333333         33333333      222
 -13.17 B                AAAAAAAA     ....   000    111    222    3333333       33333333      2222
 -13.80 B                  AAAAAA    ...    000    111    222    333333333  3333333333      22222
 -14.43 BBB                  AAAAA   ....    00    111    2222    333333333333333333333     22222
 -15.06 BBBBBBBBBBBBBBB       AAAAA   ...    000    11     222     33333333333333333      22222
 -15.68      BBBBBBBBBBBBBBBBB     AAAA   ...    00    111    2222     3333333333333      22222     1
 -16.31 C                BBBBBBBB    AAAA   ...  000    111    2222        333333         22222    1111
 -16.94  CCCCCCC              BBBBB    AAA   ..   000    111   22222                22222    1111
 -17.57 D        CCCCCCCCCC       BBBB.  AAA   ..   000    111   222222           2222222   1111
 -18.19   DDDDD          CCCCCC     BBB   AAA   ..   000    111    2222222222222222222     1111    000
 -18.82 EEE      DDDDDD       CCCC    BBB    AA   ..   000    111        222222222222      1111    0000
 -19.45 FF  EEEEE      DDDDD    CCCC    BB    AA    ..   000   1111                   11111    000    .
 -20.07 G  FFF     EEEE     DDD     CC    BBB  AA    ..   000    11111              11111   0000   ....
 -20.70 H GG    FFF     EEE     DDD  CCC  BBB  AA    ..   000    111111111  111111111    0000   ....
 -21.33   HH  GG    FFF    EEE    DD    CC  BBB  AA    ..   0000    111111111111111      0000   ...    A
 -21.96   I  HH  GGG  FFF   EEE  DDD  CC  BBB  AA    ..   0000      11111111        0000   ....   AAA
 -22.58 K J  I   HH  GG    FF   EE    DD  CC  BB    AA   ...    0000                 0000    ...   AAA
 -23.21 L K JJ II  H  GG  FFF   EE  DD   CC  BB   AA   ...    00000             0000    ....   AAA
 -23.84 M L K  J II  H  GG  FF  EE  D  CC  BB    AA   ...    00000          00000    ...   AAA    B
 -24.47   M L K  J II HH  G  FF  E  DD   CC  BB   AA   ...    000000        000000    ...   AAA   BB
 -25.09  ON M L K JJ I  H  G  FF EE  DD CC   BB   AA   ...    0000000    0000000    ....   AAA   BBB
 -25.72 QP  N M L K J II HH G  F  EE DD  C  BB   AAA   ...    00000000000000000      ...   AAA   BBB
 -26.35 R  PO NM L K JJ I HH G  F  E  D  CC  B    AA   ...    00000000000000000     ...   AAA   BBB
 -26.98   RQP ON M L K J I HH G FF EE DD CC  BB   AA   ...    00000000000000     ....   AAA   BBB
 -27.60 UTS   PO NM L K J I HH G FF E  D  CC BB   AAA  ...     00000000000      ...   AAA   BBB

        0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

PLOT OF ORIGINAL DATA (Z-COORDINATES)

PLOTTING LIMITS
MAXIMUM X = 27.000000 MINIMUM X = 0.000000
MAXIMUM Y = 0.000000 MINIMUM Y = -24.000000

X-SCALE IS HORIZONTAL
X-VALUE = 0.00 + 0.3034 X (SCALE VALUE)

Y-SCALE IS VERTICAL

```
       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

  0.00                                              -2602       -2553
 -0.51                                                                -2504-2437
 -1.01                 -2748           *   -2672             -2478              -2460
 -1.52          -2743                                                                        -2557
 -2.02                                     -2575   -2600
 -2.53             *   -2755
 -3.03                                                                               -2560
 -3.54                                    -2671       -2623
 -4.04                                                                    -2629
 -4.55                 -2813       -2747                      -2635                    -2567
 -5.06                            -2749                                   -2605
 -5.56                                           -2727                 -2596
 -6.07                                                                              -2586
 -6.57                                                                  -2625
 -7.08                       -2843                       -2643
 -7.58                                                                                      -2570
 -8.09                                                                                       -2644
 -8.60     -2899                    -2815     -2764     -2697  -2680               -2632
 -9.10                                                                                 -2590
 -9.61                                                                       -2646          -2594
-10.11                                     -2811
-10.62                               -2841
-11.12                                                                               -2627
-11.63                                                        * * -2693                 -2586
-12.13       -2904
-12.64
-13.15                                                               -2682
-13.65                    -2875               -2852
-14.16                    -2917
-14.66                                                        -2705          -2593
-15.17                                                       *  -2726
-15.67     -2903                -2878                                          -2678 -2660
-16.18                    -2919                                       *  -2723               -2617-2560
-16.69                                                     -2868
-17.19                      -2875                                                                   -2619
-17.70                                                                               -2655-2638
-18.20    -3066                                           -2796
-18.71                                                                                      -2686
-19.21                                       -2924
-19.72                                                                                    -2674
-20.22                                                     -2841            -2675
-20.73                                                              -2805
-21.24
-21.74                                                                     -2699                  -2798
-22.25                                                     -2918                                  -2799
-22.75                                      -3027
-23.26                                                -3087               -2705    -2690
-23.76

       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

```
                         * -2702
   OVERPRINT VALUES      * -2693

   * -2640               * -2752

   * -2737               * -2753
```

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

PLOT OF FIRST-DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X = 27.000000 MINIMUM X = 0.000000
MAXIMUM Y = 0.000000 MINIMUM Y = -24.000000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 1 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.00 + 0.3034 X (SCALE VALUE)

Y-SCALE IS VERTICAL

```
        0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

   0.00                                              -367        -15
  -0.51                                                                +498 +1094
  -1.01                 -1299           -411-790              +933               +855
  -1.52          -1106                                                                         -173
  -2.02                                     +301    +2
  -2.53             -933-1156
  -3.03                                                                               +141
  -3.54                                    -381        -38
  -4.04                                                                   -262
  -4.55                 -1413      -910                       -120                     +230
  -5.06                            -834                                   +129
  -5.56                                           -715                 +327
  -6.07                                                                              +357
  -6.57                                                                 +181
  -7.08                       -1427                      +254
  -7.58                                                                                     +632
  -8.09                                                                                       -59
  -8.60     -1542                    -986      -605      -38     +34                 +236
  -9.10                                                                                 +719
  -9.61                                                                       +368            +672
 -10.11                                     -812
 -10.62                               -918
 -11.12                                                                               +676
 -11.63                                                       * * +328                  +1112
 -12.13       -1084
 -12.64
 -13.15                                                         +713
 -13.65                    -719                -725
 -14.16              -989
 -14.66                                                       +700           +1639
 -15.17                                                  *  +582
 -15.67     -507                 -516                                           +936  +1027
 -16.18              -724                                        *  +674                +1528+2004
 -16.69                                                -496
 -17.19                     -207                                                            +1586
 -17.70                                                                         +1470+1566
 -18.20    -1707                                        +377
 -18.71                                                                                +1264
 -19.21                                 -534
 -19.72                                                                              +1495
 -20.22                                                  +219             +1709
 -20.73                                                       +627
 -21.24
 -21.74                                                              +1741                   +410
 -22.25                                            -136                                    +538
 -22.75                                -997
 -23.26                                         -1639              +1955    +1976
 -23.76

        0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
```

OVERPRINT VALUES

* 281
* 344
* 380
* 439

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

PLOT OF FOURTH-DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X =   33.500000   MINIMUM X =   0.000000
MAXIMUM Y =   0.000000   MINIMUM Y =   -27.000000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE   1 POWER

X-SCALE IS HORIZONTAL
X-VALUE =   0.00 + 0.3764 X (SCALE VALUE)

Y-SCALE IS VERTICAL

```
       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

  0.00                                     -308     -519                        -1067        *+659
 -0.63                                                    -153+240-72
 -1.25              -378         *  -104          +780
 -1.88        -427                  +1099 +490                                  *  +28       -129
 -2.51           +69-34
 -3.14                                                                -575                   +217
 -3.76                             +558      +389                              +60+864
 -4.39              -164     +292                  -60       -667       -436
 -5.02                       +371                            -262                           +1646
 -5.65                                  -68               +12
 -6.27                                                               -252
 -6.90                   -193                  +439        -187
 -7.53                                                                     -42
 -8.16                                                              -451      -720
 -8.78    -732                -19     -8      +98   -117               -27      +136
 -9.41                                                     -315           -50   +712   -218
-10.04                              -225                                              +867
-10.66                      +4
-11.29                                             * -143             * +222
-11.92      -106                                       -260                               -676
-12.55
-13.17                                              +118                        -88  -346
-13.80           +101 +246            -599
-14.43                                             -6           +564                   -909
-15.06                                       * -54
-15.68    +714   +446      +193                        -301      -220 -118       +3521      +149
-16.31                                             -456              +372   +1005
-16.94                  +733                -933                       +489       -909   +227
-17.57                                                           +214+328
-18.19   -5                                     -362
-18.82                           -239                                 +9                    -45
-19.45                                                               +208
-20.07                                         -553          +410                   -390
-20.70                                             -373                                  -251
-21.33                                                   +509                  -547         -2
-21.96                                  -510                               -515 -226
-22.58                          -338
-23.21                                  -1754           +755    +624                 -334
-23.84                      -72
-24.47                                  * +236        +781 +879 -137       *  -161
-25.09                                                                        -171
-25.72                                         +438
-26.35                     +405            -106                                 *  -369     *+384
-26.98                                           +307            +540

       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
                      * -1112             * -37
                                          * -234
 OVERPRINT VALUES     * -119
                      * -191              * -157
 *   122                                  * 165
                      * -175
 *   415
```

STRUCTURE ON TOP OF THE ARBUCKLE GROUP (CAMBRIAN-ORDOVICIAN)

PLOT OF SIXTH-DEGREE RESIDUALS

PLOTTING LIMITS
MAXIMUM X = 33.500000 MINIMUM X = 0.000000
MAXIMUM Y = 0.000000 MINIMUM Y = -27.000000

PLOTTED VALUES HAVE BEEN MULTIPLIED BY A FACTOR OF 10 TO THE 1 POWER

X-SCALE IS HORIZONTAL
X-VALUE = 0.00 + 0.3764 X (SCALE VALUE)

Y-SCALE IS VERTICAL

```
       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789

  0.00                                     -132     +18                         -450      +45+577
 -0.63                                                    +133+643+232
 -1.25              -413         *  -649          +716
 -1.88        +519                  +462  +27                                 *  -26       -414
 -2.51           *  -268
 -3.14                                                                -596                 -89
 -3.76                             +91       +120                              +31+816
 -4.39              -255     -83                  -108      -681      -408
 -5.02                       +105                           -201                        +1622
 -5.65                                 -82              +107
 -6.27                                                               -136
 -6.90                   -208                  +651        -35
 -7.53                                                                     +81
 -8.16                                                              -347      -609
 -8.78    -27                 +142    +257    +383  +125               +31      +230
 -9.41                                                         -247           -27     +803   -113
-10.04                              +52                                                 +894
-10.66                        +125
-11.29                                             * -22              * +91
-11.92      -272                                       -187                               -737
-12.55
-13.17                                              +186                        -297 -540
-13.80           -259 +86             -360
-14.43                                             +32           +335                   -1094
-15.06                                         * +32
-15.68    +250   +90        +230                       -358      -473 -414       +3280      +28
-16.31                                                 -449              +85     +745
-16.94                  +700                -701                           +251       -1027  +204
-17.57                                                           +26  +104
-18.19   -226                                   -156
-18.82                           +135                                 -142                  +38
-19.45                                                               +90
-20.07                                         -276          +389                   -297
-20.70                                             -185                                  -42
-21.33                                                   +565                  -488         +264
-21.96                                    -163                               -486 -103
-22.58                          +52
-23.21                                  -1451          +735    +526                 -168
-23.84                        +211
-24.47                                    * +263        +669 +707 -360       *  -181
-25.09                                                                        -262
-25.72                                         +263
-26.35                     +476            -304                                 *  -455     *+442
-26.98                                       +18              +96

       0123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789 123456789
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                          *    238          *     38
                                            *   -294
  OVERPRINT VALUES        *     37
                          *   -281          *   -317
  *   -205                                  *    183
                          *    -45
  *  -1084
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PROGRAM ABSTRACT

Title (If subroutine state in title): FORTRAN IV program for computation and plotting of trend surfaces and residuals for degrees 1 through 6

Computer: IBM 7040 and Printer

Date: May 31, 1966

Programming language: FORTRAN IV

Author, organization: Mont O'Leary, The University of Kansas; R. H. Lippert, Shell Oil Company; Owen T. Spitz, Kansas Geological Survey

Direct inquiries to: Operations Research Section, Kansas Geological Survey or

Name: Owen T. Spitz

Address: Kansas Geological Survey
University of Kansas, Lawrence, Kansas

Purpose/description: Determines any or all trend surfaces from first through sixth degree; the surfaces may be contoured and the residuals plotted.

Mathematical method: A polynomial surface is determined by least - squares criteria. The normal equations are reordered during solution to reduce round-off errors.

Restrictions, range: 500 or less data points

Storage requirements: 16K and 4 magnetic tapes

Equipment specifications:

Memory 20K____ 40K____ 60K____ K____

Automatic divide: Yes____ No____ Indirect addressing: Yes____ No____

Other special features required____

Additional remarks (include at author's discretion: fixed/float, relocatability; optional: running time, approximate number of times run successfully, programming hours) Normally 70 to 90 percent of total machine time used is required in contouring trend surfaces. Approximately 40 minutes are required for 200 data points for 7 1/2 x 9 inches trend-surface maps through sixth degree. MAP routine called XEM must be supplied by the operational installation or number of dimensioned data points reduced.

COMPUTER CONTRIBUTIONS
Kansas Geological Survey
University of Kansas
Lawrence, Kansas

Daniel F. Merriam, Editor

Computer Contribution

1. Mathematical simulation of marine sedimentation with IBM 7090/7094 computers, by J. W. Harbaugh, 1966 . . $1.00
2. A generalized two-dimensional regression procedure, by J. R. Dempsey, 1966 . . . . $0.50
3. FORTRAN IV and MAP program for computation and plotting of trend surfaces for degrees 1 through 6, by Mont O'Leary, R. H. Lippert, and O. T. Spitz, 1966. . . . . $0.75

Special Distribution Publication

3. BALGOL program for trend-surface mapping using an IBM 7090 computer, by J. W. Harbaugh, 1963. . . . . $0.50
4. FORTRAN II program for coefficient of association (Match-Coeff) using an IBM 1620 computer, by R. L. Kaesler, F. W. Preston, and D. I. Good, 1963 . . . . $0.25
9. BALGOL programs for calculation of distance coefficients and correlation coefficients using an IBM 7090 computer, by J. W. Harbaugh, 1964 . . . . $0.75
11. Trend-surface analysis of regional and residual components of geologic structure in Kansas, by D. F. Merriam and J. W. Harbaugh, 1964 . . . . $0.75
12. FORTRAN and FAP program for calculating and plotting time-trend curves using an IBM 7090 or 7094/1401 computer system, by W. T. Fox, 1964 . . . . $0.75
13. FORTRAN program for factor and vector analysis of geologic data using an IBM 7090 or 7094/1401 computer system, by Vincent Manson and John Imbrie, 1964 . . . . $1.00
14. FORTRAN II trend-surface program for the IBM 1620, by D. I. Good, 1964 . . . . $1.00
15. Application of factor analysis to petrologic variations of Americus Limestone (Lower Permian), Kansas and Oklahoma, by J. W. Harbaugh and Ferruh Demirmen, 1964 . . . . $1.00
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24. BALGOL program and geologic application for single and double Fourier series using IBM 7090/7094 computers, by F. W. Preston and J. W. Harbaugh, 1965 . . . . $1.00
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27. Application of factor analysis to a facies study of the Leavenworth Limestone (Pennsylvanian-Virgilian) of Kansas and environs, by D. F. Toomey, 1966 . . . . $0.75
28. FORTRAN II program for standard-size analysis of unconsolidated sediments, by J. W. Pierce and D. I. Good, 1966 $0.75

Reprints (available for limited time)

Mathematical conversion of section, township, and range notation to Cartesian Coordinates, by D. I. Good (Kansas Geological Survey Bulletin 170, pt. 3, 1964) $0.50

A computer method for four-variable trend analysis illustrated by a study of oil-gravity variations in southeastern Kansas, by J. W. Harbaugh (Kansas Geological Survey Bulletin 171, 1964) $1.00

Pattern recognition studies of geologic structure using trend-surface analysis, by D. F. Merriam and R. H. Lippert (reprinted from Colorado School Mines Quarterly, v. 59, no. 4, 1964) . . . . no charge

Finding the ideal cyclothem, by W. C. Pearn (reprinted from Symposium on cyclic sedimentation, D. F. Merriam, editor, Kansas Geological Survey Bulletin 169, v. 2, 1964) . . . . no charge

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