THE GCARS SYSTEM
FORTRAN IV PROGRAMMERS MANUAL
PART A - PROGRAMS FOR DATA COLLECTION AND
EVALUATION

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BY

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JHRP

JOINT HIGHWAY RESEARCH PROJECT
PURDUE UNIVERSITY AND
INDIANA STATE HIGHWAY COMMISSION

Final Report (Part III-A)

THE GCARS SYSTEM FORTRAN IV PROGRAMMERS
MANUAL PART A - PROGRAMS FOR DATA COLLECTION
AND EVALUATION

To: J. F. McLaughlin, Director
Joint Highway Research Project

September 1969

File: 1-6-1

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

Project: C-36-72A

Attached is Part III-A of the Final Report on the research project "Evaluation of Numerical Surface Techniques Applied to Highway Location Analysis" which was approved on July 1, 1967. This report has been authored by Dr. A. Keith Turner of our staff.

This report describes in detail and documents the FORTRAN computer programs used by the GCARS System during the data collection and evaluation phases of an analysis. Any analysis is only as good as the data supplied, thus it is imperative that all data used in the GCARS System be checked for accuracy and lack of bias before the analysis proceeds. These programs are designed to accomplish this function. The report is one of a series of four reports documenting the various phases of the GCARS System.

This report is presented to the Board for review and comment and for the record.

Respectfully submitted,

Harold L. Michael/RDM

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Final Report (Part III - A)

THE GCARS SYSTEM FORTRAN IV PROGRAMMERS MANUAL

PART A - PROGRAMS FOR DATA COLLECTION AND EVALUATION

by

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Post-Doctoral Research Instructor

Joint Highway Research Project

Project: C-36-72A

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N O T I C E

These programs have been tested and are believed to be free of errors. If errors are located, the Joint Highway Research Project would appreciate notification.

Send comments to:-

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Professor Robert D. Miles, P. E., directed the research project and reviewed the manuscript. His assistance is gratefully acknowledged.

THE GCARS SYSTEM
FORTRAN IV PROGRAMMERS MANUAL
PART A - PROGRAMS FOR DATA COLLECTION AND
EVALUATION

by

A. Keith Turner

INTRODUCTION

The Generalized Computer-Aided Route Selection (GCARS) System has been developed to assist engineers in defining optimal highway alternatives in terms of many conflicting highway location factors (5, 10)*. The use of the computer dictates that information, or "measures", of the various factors which are considered pertinent to the particular analysis be reduced to numerical models. This generally involves sampling of areal data. The entire subsequent analysis depends on the quality of the information collected; thus the development of simple, logical, and reproducible sampling procedures is an important prerequisite to the successful application of the GCARS System. In addition, procedures for testing the sampled data for accuracy and for lack of bias in depicting the actual conditions form a necessary part of the GCARS System.

This part of the Programmers Manual describes the computer routines developed to (1) assist in the design of sampling procedures for topographic data (Program VECTOR), (2) convert card data to standard GCARS System tapes (Programs LOADS and LOADG), and (3) test sampled data for accuracy and lack of bias (Programs TREND and RESMAP). Parts B and C of this manual document the programs for other phases in the GCARS System (7, 8). Overall System design concepts and standards are summarized in the GCARS Users Manual (6).

* Numbers in parenthesis refer to references.

METHOD OF OPERATION

During development and testing of the prototype GCARS System, large volumes of data describing the various highway location factors had to be reduced to numerical form. Many factors were shown in graphical form on various types of maps. Figure 1 shows the LARR-V digital coordinatograph used to "digitize" the map data. This machine punches the data onto cards through the attached card punch.

Figure 2 shows the interconnections and flow of operations through the various programs and subroutines described in this manual. Program LOADS was developed to allow the conversion of large unwieldy card data decks produced by the LARR-V to more convenient tapes. Program LOADG performs similar functions for girded data arrays produced later in the analysis.

The remaining Programs perform various statistical and display functions which are designed to assist the engineer in evaluating his data.

PRESENT CAPACITIES, OPTIONS, AND RESTRICTIONS

a) Size of Matrices

The GCARS System, as presently developed, has been standardized to work with 50 x 50 matrices. Neither dimension can exceed these limits without correcting the DIMENSION statements in the programs. Changes in shape, for instance to 100 x 25, can be accomplished without increasing the overall storage requirements.

Program Vector, involved with the quantification of small land form units, is dimensioned to accept only a 20 x 20 array of elevations; larger arrays were not believed necessary.

b) Irregularly-Spaced Data

Program TREND performs regression analysis on large numbers of irregularly-spaced data-points. The maximum number of such observation that can be processed

LEGEND

A THE READING TABLE

- 1 X-axis arm
- 2 Y-axis arm
- 3 keyboard arm
- 4 keypack
- 5 cursor carriage
- 6 readout button
- 7 X-axis encoder
- 8 Y-axis encoder
- 9 magnetic hold-down strips
- 10 roller for long charts

B TELECORDEX UNIT

- 11 X-axis telepack
- 12 Y-axis telepack
- 13 event counter
- 14 memory and control unit
- 15 power switches
- 16 constant data switches
- 17 patch panel

C IBM MODEL 029 CARD PUNCH

FIGURE 1. THE LARR-V DIGITAL COORDINATOGRAPH

FIGURE 2. INTER-RELATIONSHIPS AMONG THE GCARS SYSTEM DATA COLLECTION PROGRAM.

at once is very large; over 10,000 observations have been successfully analyzed by this program. In other programs, 1000 irregularly spaced observations is generally the maximum number that can be handled.

c) Input Options

Both Programs TREND and RESMAP can accept data on either cards or tape. For purposes of consistency the various types of tapes are given different but consistent names (and numbers) with all these programs. They are as follows:

TAPE1 - any temporary "scratch" tape

TAPE2 - a tape containing irregularly spaced observations.

These tapes are blocked into 1000 observation
(3000 word) logical records.

TAPE3 - a tape containing gridded data matrices.

TAPE4 - a tape containing original values, computed values,
and residuals for all observation points. It may
be generated on request by Program TREND.

TAPE5 (SYSIN) - is the computer system input file from the
card recorder.

TAPE6 (SYSOT) - is the computer system output file to the printer.

PUNCH - is the output file to the card punch.

d) Output Options

Programs TREND and RESMAP allow many output options including different forms of printer display, punched cards, and tape.

METHOD OF COMPUTATIONa) Program VECTOR

The terrain through which a highway may pass is often an important location factor. In extremely rugged areas it may be the dominant factor. Topographic maps are one type of graphical measure of the earth's surface. This surface is not uniformly easy to sample however. Closely adjacent points can have a great variety of spatial relationships which collectively form the "topography" of an area. Topography is classifiable into any number of categories which are frequently given names such as "smooth", "rolling", "hilly", "crested", etc. Topographic maps show these differences by contour patterns of different types. It is possible to study topographic maps and subdivide them into areas containing different types of topography. Now each subarea has an associated degree of difficulty of sampling; obviously the more difficult areas should have a greater sampling density than the easier areas so that all portions of the map are sampled with a similar reliability. Some quantitative measure of this sampling difficulty is required.

The development of a suitable quantitative measure of terrain roughness utilized vector analysis procedures. Program VECTOR, a modified version of a computer program of the same name developed by Hobson, performs the calculations (3). The computations are quite simple. Within a rectangular array of elevation readings, a set of intersecting triangular planar surfaces is defined by groups of three adjacent values, as shown in Figure 3-A and 3-B. Normals to these planar elements are represented by unit vectors. A statistic, known as Fisher's dispersion factor (K) indicates the spread of these unit vectors (2, 3, 9). It takes on small values for highly dispersed distributions characteristic of "rough" areas (Figure 3-D) and large values for low dispersions characteristic of "smooth" areas (Figure 3-C).

A

DEFINITION OF TRIANGULAR PLANES FROM ELEVATION MATRIX

B

TYPE 1 TRIANGLES

TYPE 2 TRIANGLES

C

"SMOOTH" TERRAIN

LOW VECTOR DISPERSION

D

"ROUGH" TERRAIN

HIGH VECTOR DISPERSION

(adapted from Hobson)

FIGURE 3. PROGRAM VECTOR ANALYSIS PROCEDURES.

The technique was tested on 25 terrain types (9). As a result, Fisher's dispersion factor (K) was found to be an excellent descriptor of terrain roughness. The log K transformation was found useful and could be correlated with other topographic measures such as log (variance of dips) and log (maximum dip).

However the roughness does not completely measure the sampling difficulty. A perfectly smooth, planar, horizontal surface can be described by a single elevation value; any planar inclined surface requires three elevation values, and associated X and Y coordinates, to describe it. Gently curved surfaces require still more data points to satisfactorily describe their overall orientation. The overall orientation of subareas might be described in a number of ways. The range of the elevations is the simplest value to obtain, requiring no prior sampling procedure. Accordingly a terrain variability factor, which includes both roughness and range of elevations, is defined as follows:

$$\text{terrain variability factor} = \frac{\text{Range in elevation}}{\text{Log (roughness)}}$$

Values of this factor are large in "rough" areas and small in "smooth" areas. The terrain variability factor is used in designing a sampling procedure for a topographic map. The technique is described fully by Turner (5).

Program VECTOR computes the terrain roughness and the terrain variability factor for any elevation matrix submitted to it. Its associated subroutines TILIS, WULFF and HISTO are designed to give additional statistical descriptors of the terrain which may be used in more carefully analyzing terrain (9).

b) Program LOADS

Program LOADS reads X, Y, and Z-coordinate data from punched cards and writes the data onto tape. The tape is developed according to GCARS standards - one record containing title information followed by a series of logical records each containing 1000 sets of observation data. Since each set of data contains X, Y, and Z coordinates, the records are 3000 words long. Since the number of observations is unlikely to be an exact multiple of 1000, the last record contains any remainder and is therefore of variable length. All data is in relocatable binary. An end-of-file mark is placed at the end.

Program LOADS can accept two types of data, integer or floating point Z-coordinates. Integer Z-values occur when data such as soil conditions have been sampled with an integer code identifying each soil type. LOADS converts such integer codes to the corresponding floating point value (FAC) supplied as control data. These may represent one of several evaluation schemes. Thus Program LOADS allows for the simultaneous conversion of measures to values during the transfer of data from cards to tape. When floating point Z-values are indicated no conversion is attempted. Card formats can be varied, and more than one set of observations can be included on a card (the maximum is ten).

Program LOADS can also accept any number of data subsets, separated from each other by end-of-record cards, and combine them into one large data set. The identities of the individual subsets are lost in this process. A particular 1000-set record may contain values from several subsets.

Data in each subset may be referenced to its own origin, with the following restrictions: (1) all X-coordinates are assumed to increase toward the right

- (2) all Y-coordinates are assumed to increase upward.
- (3) all coordinate systems are assumed to have a common orientation.

Each subset includes one control card giving the X and Y coordinates of its origin in the master coordinate system and a scale factor used to convert the subset coordinates to a consistent scale (Thus different subsets may have different scales). Figure 4 shows how the coordinate conversions are specified. This option allows data to be collected from a number of adjacent maps then combined to produce a single data set covering a larger area.

c) Program TREND

Trend surface analysis, a variety of regression analysis, is used in the GCARS System to test value surfaces for adequacy and lack of bias. Trend surface analysis is widely used in the earth sciences to separate regional from local effects for any type of spatial phenomenon. The technique involves the fitting of comparatively simple trend surfaces to data, according to the least-squares criterion. Statistical measures, such as partial and total F-tests (1, 5) and the simple correlation coefficient, are used to estimate the significance of the surfaces. One or more of these surfaces are selected to represent the regional effects. The residuals to the surfaces, representing the lack of fit of the surface to the data, are plotted as contour maps and are studied for information concerning local anomalies. This technique is described in detail by Turner (5), and in the geological literature.

Trend surface analysis is also used to convert topographic data to earthwork cost values. Estimation of probable earthwork costs throughout an area requires:

FIGURE 4. PROGRAM LOADS COORDINATE DEFINITIONS.

- 1) development of topographic data by sampling topographic maps,
- 2) approximation of grade lines for all possible highway routes.

Trend surface analysis develops a series of smoothed surfaces of varying complexity. These trend surfaces are assumed to approximate all possible grade lines in the area while the residuals, measuring the lack of fit of these surfaces to the elevation data, represent the magnitudes of cut or fill required to build a highway having a grade-line following the trend surfaces. The residuals define those areas lying far above or far below the local mean elevation. Thus, topographic residuals are a suitable value of the earthwork cost factor (5, 10).

In cases where the topography is too complex to be satisfactorily explained by a single trend surface, it is possible to fit trend surfaces to overlapping sections of the area. After such "piece-wise" fitting of trend surfaces, a trend mosaic can be assembled from the various parts, much as a mosaic is assembled from individual aerial photographs.

Program TREND is used in the GCARS System to fit trend surfaces for the above purposes. Trends up to the fifth degree can be fitted. The current program represents the latest version in an evolving series of programs that were previously called "POLYFIT" (4).

The computation of the trend surface coefficients is accomplished by the matrix algebra procedures, as described in Chapter 2 of Draper and Smith (1). The procedure involves the construction of several matrices, resulting in the construction of:

- (1) an $(XY)'(XY)$ matrix.
- (2) an $(XY)'Z$ matrix.
- (3) the inverse of the $(XY)'(XY)$ matrix = $((XY)'(XY))^{-1}$

The matrix of coefficients = A is computed by matrix multiplication as follows:

$$A = ((XY)'(XY))^{-1}(XY)'Z$$

(XY) is a matrix of independent variables

$(XY)'$ is the transpose of the (XY) matrix.

Z is a matrix of the dependent variable

$(XY)'(XY)$ matrix contains the sums of all

the powers and products of the independent variables

(i.e. X, Y, X^2 , Y^2 , XY, etc).

Figure 5 is a generalized flow chart of Program TREND and its associated subroutines to show the sequence of operations. The matrix inversion process performed by Subroutine INVER is crucial to the accuracy of the method. One way of checking on the accuracy of the computed inverse is to multiply the inverse by the original matrix. The result should be an identity matrix. If it is not the computed coefficients should be suspected as being erroneous. This check may be requested as an option.

Program TREND has been developed so that all input functions are contained within Subroutine IREAD while most of the output functions are within Subroutine RITER. Subroutine POLY evaluates the coefficients of any surface at any X and Y coordinates to compute the value of the surface. It is used to compute values of the surfaces on a grid network to prepare for the production of contour maps of the surfaces.

Subroutine ANOVA computes the various analysis of variance statistics and displays them. Methods of utilizing these statistics are described by Turner (5).

FIGURE 5. FLOWCHART FOR PROGRAM TREND.

Program TREND utilizes Subroutines PRTCON⁴ and STATS to produce contour maps of the surfaces on the printer. These subroutines are described in Part C of this manual (8).

A large number of input and output options are available during the use of Program TREND. These may be requested through the use of appropriate control cards as described in the documentation of Subroutine IREAD which utilizes them (see pages A-59 to A-67). An example of a job submission deck is shown in Figure 8, sample input data is shown on page A-85, and the resulting sample output on pages A-86 to A-96.

d) Program RESMAP

Program RESMAP constructs residual maps showing the lack of fit of the various degrees of trend surface to the original data. Gridded value arrays for the original data and for each of the trend surfaces are supplied. Since the original data normally consists of a series of irregularly spaced X, Y, and Z-coordinate observations, these must be converted to a set of grid values. This is accomplished by the use of Program MAPPER and Subroutine GRID as described in Part C of this Manual (8). Gridded value arrays for each trend surface are supplied from Program TREND.

RESMAP takes each trend surface array in turn and computes the residual value for each point in the array as follows:

$$\text{Residual (I,J)} = \text{Interpolated "Original" Value (K,J)} - \text{Trend Surface Value (I,J)}$$

where I and J are the row and column coordinates.

These residual values are then contoured by PRTCON⁴. An option allows these residual arrays to be punched on cards or stored on tape.

e) Program LOADG

This program will load gridded data arrays onto tape in a standard GCARS format.

Each array will appear on the tape as a series of binary records. The first record contains identification information, as follows:

FACTOR - 40 characters identifying the factor.
 AREA - 30 characters identifying the area.
 NCOL - an integer giving the number of columns
 ITYPE - an integer identifying the type of array data.

Each row in the array forms a subsequent record. The array is thus stored row wise from the top down.

A single array, or a group of several arrays, separated from subsequent arrays by an End-of-Record card, will form a single binary file on the tape (i.e. when an End-of-Record card is encountered an End-of-File is written on the tape).

Such binary files can contain factor combinations which are often analyzed together by Program NETSUM (see Part B of this Manual).

LOADG can load any number of binary files onto tape at any one time.

PROGRAM OPERATING CHARACTERISTICS

a) Program VECTOR

Program VECTOR will load, compile, and execute in approximately 60K (octal) central memory locations.* Each analysis requires about 7 seconds. Figure 6 shows the sequence of control cards required to perform an analysis. Examples of typical input and output are shown on pages A-39 to A-41.

* On the CDC 6500.

FIGURE 6. PROGRAM VECTOR - TYPICAL DECK SETUP

b) Program LOADS

Program LOADS requires 40K (octal) central memory locations to load, compile, and execute. Execution requires 23.5K locations. It loaded approximately 2500 observations onto tape in just under 13 seconds. Figure 7 shows a typical deck setup.

c) Program TREND

Program TREND requires 60K (octal) central memory locations to load, compile and execute. Execution requires 47.5K locations. Running times depend on the number of observations, the number of trend surfaces filled, and the requested options. Program TREND computed all five degrees of trend surfaces for just over 2500 observations in 45 seconds (including load and compile times). This included the production of printer maps for all surfaces.

Figure 8 shows a typical deck setup for card data. If data is supplied from tape, the setup is similar except that the data cards are omitted. There are many options which are described in detail in the documentation of Subroutine IREAD, pages A-59 to A-66. A sample of input data and the resulting output is shown on pages A-85 to A-96.

d) Program RESMAP

Program RESMAP will load, compile, and execute in 50K (octal) central memory locations. Running times are dependent on the size of the arrays and the number of maps produced. The time can be estimated by allowing approximately 3 seconds for each copy of each map produced and adding another 3 seconds for load and compile times. Figure 9 shows a typical deck setup.

FIGURE 7. PROGRAM LOADS- TYPICAL DECK SETUP.

FIGURE 8. PROGRAM TREND-TYPICAL DECK SETUP.

FIGURE 9. PROGRAM RESMAP - TYPICAL DECK SETUP

e) Program LOADG

Program LOADG requires 40K (octal) central memory locations to load, compile and execute. Running times are dependent on the number of arrays being loaded and their sizes. An allowance of 5 seconds for each array should be adequate. Figure 10 shows a typical deck setup.

PROGRAM LISTINGS AND DOCUMENTATION

The following pages contain listings of the various routines in order. All are written in basic FORTRAN IV. Each routine is documented through the use of appropriate comment cards at the beginning and throughout the program.

Each program has been analyzed by Program TIDY, available as a library program at Purdue, which resequences all statement numbers, removes extraneous numbers, and generally makes the program neater. For this reason the statement numbers in each routine increase progressively in increments of five, and all FORMATS (if any) are collected at the end. The cards are each given a sequence number which appears at the far right.

a) The Use of FORSTAT Data

Each routine was next analyzed by another program, FORSTAT. This checks the syntax of source (FORTRAN) programs and produces cross-reference listings of all variables and statement numbers found within the routine. The cross-reference listings utilize a series of "FORSTAT Numbers" which are found at the far left of the listing. A vertical ink margin line has been added to separate these numbers from the rest of the listing. The cross-reference listings are found at the end of each routine.

FIGURE 10. PROGRAM LOADG - TYPICAL DECK SETUP.

All symbols defined in the routine are listed alphabetically and are identified according to type, definition and references (where referenced).

The following symbols are utilized in the cross-reference listings:-

Types

I = INTEGER

R = REAL

D = DOUBLE PRECISION

C = COMPLEX

L = LOGICAL

N = NAME LIST

ASF = ARITHMETIC

Definition

C = COMMON

D = DIMENSION

E = EQUIVALENCE

All other terms are believed self-explanatory. These cross-reference listings will be most useful should any reader desire to make changes to these routines.

PROGRAM
LISTINGS
FOR
CDC 6500

b) LISTING OF PROGRAM VECTOR

1.	PROGRAM VECTOR(INPUT,OUTPUT,PUNCH,IAFFE=INPUT,TAPE=OUTPUT)	VEC 2
C	-----	VEC 4
C	SUBROUTINE VECTOR	VEC 6
C	-----	VEC 8
C	PURPOSE --	VEC 10
C	TO ANALYZE TERRAIN TO DETERMINE SURFACE ROUGHNESS STATISTICS.	VEC 12
C	TWO TECHNIQUES ARE USED--1) ELEVATIONS ARE ANALYZED FOR MEAN RANGE	VEC 14
C	VARIANCE, STANDARD DEVIATION, ETC. 2) GROUPS OF THREE POINTS ARE USED	VEC 16
C	TO DEFINE PLANES WHOSE ORIENTATION IS DETERMINED. MEASURES OF VECTOR	VEC 18
C	STRENGTH AND DISPERSION ARE USED TO ESTIMATE ROUGHNESS. TYPE 1	VEC 20
C	AND TYPE 2 TRIANGLES CAN BE FITTED. A VARIABILITY FACTOR, V, IS	VEC 22
C	CALCULATED FROM THE RANGE OF ELEVATIONS/THE ROUGHNESS MEASURE, K.	VEC 24
C	-----	VEC 26
C	THE PROGRAM IS PARTLY BASED ON A PROGRAM DESCRIBED BY -	VEC 28
C	W. D. WILSON, 1961.	VEC 30
C	FORTRAN IV PROGRAMS TO DETERMINE SURFACE ROUGHNESS IN	VEC 32
C	TOPOGRAPHY FOR THE CDC 3400 COMPUTER.	VEC 34
C	COMPILED CONTRIBUTION 14, KANSAS GEOLOGICAL SURVEY,	VEC 36
C	LAWRENCE, KANSAS.	VEC 38
C	-----	VEC 40
C	THE GRAHS SYSTEM	VEC 42
C	PURDUE UNIVERSITY	VEC 44
C	-----	VEC 46
C	A. K. TURNER,	VEC 48
C	CIVIL ENGINEERING,	VEC 50
C	JUNE 1964.	VEC 52
C	-----	VEC 54
C	CARD ORDER IS -----	VEC 56
C	A) CARDS WHICH APPEAR ONCE. ---	VEC 58
C	1) END OF RECORD (7-H=9)	VEC 60
C	2) TITLE CARD (TITLE) --(COLS 1-80)	VEC 62
C	A GENERAL TITLE WHICH WILL APPEAR AS A HEADING AT THE BEGINNING	VEC 64
C	OF EACH DATA SET.	VEC 66
C	B) CARDS WHICH ARE REQUIRED AS PART OF EACH DATA SET. ---	VEC 68
C	1) SIZE/SCALE CARD (M,N,XSTEP,YSTEP,DTRN)	VEC 70
C	M=(COLS1-3), IS THE NUMBER OF ROWS.	VEC 72
C	N=(COLS4-6), IS THE NUMBER OF COLUMNS.	VEC 74
C	XSTEP=(COLS 11-20), IS THE SIZE OF COLUMN SPACING IN ELEVATION UNITS	VEC 76
C	YSTEP=(COLS 21-30), IS THE SIZE OF ROW SPACING IN ELEVATION UNITS	VEC 78
C	DTRN=(COLS 31-40), IS AZIMUTH IN DEGREES OF Y AXIS.	VEC 80
C	2) OUTPUT OPTION CARD (IPLOT,ISKIP,THIST(1),THIST(2),ITYPE)	VEC 82
C	IPLOT=(COL 1), IF IPLOT=1, STEREOGRAM OF NORMAL VECTORS IS PRODUCED	VEC 84
C	ISKIP=(COL 5), IF ISKIP=1, A LISTING OF TRIANGLE STRIKES AND DIPS	VEC 86
C	IS SUPPRESSED.	VEC 88
C	THIST=(COLS 10-11) IF THIST(1)=1, A HISTOGRAM OF DIPS IS PLOTTED.	VEC 90
C	IF THIST(2)=1, A HISTOGRAM OF STRIKES IS PLOTTED.	VEC 92
C	ITYPE=(COL 12), IF ITYPE=1, TYPE 1 TRIANGLES ARE FITTED.	VEC 94
C	IF ITYPE=2, TYPE 2 TRIANGLES ARE FITTED.	VEC 96
C	IF ITYPE=3, TYPES 1 AND 2 TRIANGLES ARE FITTED.	VEC 98
C	(IF THIS CARD IS BLANK STANDARD OUTPUT IS PRODUCED.---TYPE 1 TRI	VEC 100
C	ANGLES, A LISTING OF ALL TRIANGLE STRIKES AND DIPS, AND NO	VEC 102
C	STEREOGRAM OR HISTOGRAMS.)	VEC 104
C	3) FORMAT CARD (FMT) --(COLS 1-80)	VEC 106
C	SPECIFIES FORMAT OF DATA SET WHICH FOLLOWS	VEC 108
C	4) PROBLEM CARD (PROB) --(COLS 1-80)	VEC 110
C	A TITLE WHICH WILL SERVE TO IDENTIFY THE DATA SET.	VEC 112
C	5) SERIES OF DATA CARDS GIVING ELEVATION MATRIX.	VEC 114
C	-----	VEC 116
C	REQUIRED SUBROUTINES --	VEC 118
C	TITLE -- WHICH CALCULATES STRIKES AND DIPS FROM VECTOR COORDINATES.	VEC 120
C	STATS -- WHICH CALCULATES STATISTICAL MEASURES.	VEC 122
C	WULFE -- WHICH GENERATES WULFE NET STEREOGRAMS FROM VECTORS.	VEC 124
C	HISTO -- WHICH GENERATES HISTOGRAMS OF STRIKE AND DIP DISTRIBUTION	VEC 126
C	OPTIONAL SUBROUTINES --	VEC 128
C	NONE.	VEC 130
C	-----	VEC 132

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C ----- VFC 158
C DIMENSION F(20,20), XNORM(400), YNORM(400), ZNORM(400), DPS(400), VFC 160
C 1STH(400), TITL(R), FMT(R), PROH(R) VFC 162
2. DIMENSION THIST(2) VFC 164
3. C ----- VFC 166
C READ TITLE,MASTER,AND DATA FORMAT CARDS VFC 168
C ----- VFC 170
C READ (5,40) TITL VFC 172
4. READ (5,45) M,N,XSTEP,YSTEP,DIGN VFC 174
5. READ (5,100) 1PLOT,1SKIP,(THIST(I),I=1,2),1TYPE VFC 176
6. READ (5,40) FMT VFC 178
7. C ----- VFC 180
C WRITE OUT HEADINGS VFC 182
C ----- VFC 184
8. WRITE (6,105) VFC 186
9. WRITE (6,110) VFC 188
10. WRITE (6,115) TITL VFC 190
11. WRITE (6,110) VFC 192
12. WRITE (6,120) M,N,XSTEP,YSTEP,DIGN,FMT VFC 194
13. READ (5,115) PDATA VFC 196
14. WRITE (6,110) VFC 198
15. WRITE (6,125) PROH VFC 200
16. WRITE (6,110) VFC 202
C ----- VFC 204
C READ AND WRITE ELEVATION MAINTA VFC 206
C ----- VFC 208
17. DO 10 J=1,M VFC 210
18. 10 READ (5,FMT) (F(I,J),J=1,N) VFC 212
19. WRITE (6,130) VFC 214
20. DO 15 J=1,M VFC 216
21. 15 WRITE (6,135) (F(I,J),J=1,N) VFC 218
22. WRITE (6,140) VFC 220
23. CALL STALS (M,N,20,20,F,EHAR,EVAR,ESTG,FMAX,FMIN) VFC 222
24. WRITE (6,110) VFC 224
25. WRITE (6,145) VFC 226
26. WRITE (6,140) VFC 228
27. WRITE (6,175) EHAR,EVAR,ESTG,FMAX,FMIN VFC 230
28. WRITE (6,110) VFC 232
C ----- VFC 234
C GENERATE NORMALS TO TRIANGLES VFC 236
C TYPE DETERMINES TYPE OF TRIANGLE BEING FITTED VFC 238
C ----- VFC 240
29. NNM=M-1 VFC 242
30. NNN=N-1 VFC 244
31. IF (1TYPE,11,1,0R,1TYPE,61,3) 1TYPE=1 VFC 246
32. GO TO (20,30,20), 1TYPE VFC 248
33. 20 K=1 VFC 250
C ----- VFC 252
C FIT TYPE 1 TRIANGLES VFC 254
C (FIRST TRIANGLE IS DEFINED BY POSITIONS (1,1),(1,2),(2,1)) VFC 256
C ----- VFC 258
34. NNN=1 VFC 260
35. WRITE (6,150) NNN VFC 262
36. WRITE (6,110) VFC 264
37. DO 25 I=1,MM VFC 266
38. 25 I=1+1 VFC 268
39. DO 25 J=1,NN VFC 270
40. 25 J=1+1 VFC 272
41. A=(F(I,JJ)-F(I,J))*YSTEP VFC 274
42. B=(F(I,JJ)-F(II,J))*XSTEP VFC 276
43. C=XSTEP*YSTEP VFC 278
44. DIV=SQRT(A**2+B**2+C**2) VFC 280
45. XNORM(K)=A/DIV VFC 282
46. YNORM(K)=B/DIV VFC 284
47. ZNORM(K)=C/DIV VFC 286
48. K=K+1 VFC 288
49. A=(F(II,JJ)-F(II,J))*YSTEP VFC 290
50. B=(F(II,JJ)-F(I,JJ))*XSTEP VFC 292
51. C=XSTEP*YSTEP VFC 294
52. DIV=SQRT(A**2+B**2+C**2) VFC 296
53. XNORM(K)=A/DIV VFC 298
54. YNORM(K)=B/DIV VFC 300
55. ZNORM(K)=C/DIV VFC 302
56. K=K+1 VFC 304
57. KK=M-1 VFC 306
58. GO TO 40 VFC 308

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59. 30 K=1
C -----
C FILL TYPE 2 TRIANGLES
C (FIRST TRIANGLE IS DEFINED BY POSITIONS (1,1)+(2,1)+(2,2))
C -----
60. NNK=2
61. WRITE (A,160) NNK
62. WRITE (A,110)
63. DO 35 T=1,MM
64. II=T+1
65. DO 35 J=1,NN
66. JJ=J+1
67. A=(F(II,J)-F(II,JJ))*YSTEP
68. B=(F(I,J)-F(II,J))*XSTEP
69. C=XSTEP*YSTEP
70. UIV=SQRT(A**2+B**2+C**2)
71. XNORM(K)=A/UIV
72. YNORM(K)=B/UIV
73. ZNORM(K)=C/UIV
74. KK=K+1
75. A=(F(I,J)-F(I,JJ))*YSTEP
76. B=(F(II,JJ)-F(I,JJ))*XSTEP
77. C=XSTEP*YSTEP
78. UIV=SQRT(A**2+B**2+C**2)
79. XNORM(K)=A/UIV
80. YNORM(K)=B/UIV
81. ZNORM(K)=C/UIV
82. 35 KK=K+1
83. NK=K+1
84. 40 IF (ISKIP=1) 45,50,45
C -----
C CALCULATE STRIKE AND DIP OF ALL TRIANGLES
C BUT IF ISKIP=1 DO NOT LIST VALUES
C -----
85. 45 WRITE (A,155)
86. WRITE (A,160)
87. 50 CONTINUE
88. DO 55 K=1,NK
89. ALPHA=XNORM(K)
90. BETA=YNORM(K)
91. GAMMA=ZNORM(K)
92. CALL TITS (ALPHA,BETA,GAMMA,STRIKE,DIP,UIRN)
93. DPS(K)=DIP
94. STR(K)=STRIKE
95. 55 CONTINUE
96. IF (ISKIP=1) 60,65,60
97. 60 WRITE (A,165) (K,STRI(K),DPS(K),K=1,NK)
98. WRITE (A,110)
99. 65 CONTINUE
C -----
C COMPUTE MEAN AND STANDARD DEVIATIONS OF STRIKES AND DIPS
C -----
100. CALL STATS (1,NK,1,H00,SIH,SIRHAR,STRVAR,STHSIG,STRMAX,STRMIN)
101. CALL STATS (1,NK,1,H00,DPS,UPSHAR,DPSVAR,DPSIG,DPSMAX,DPSMIN)
102. WRITE (A,170)
103. WRITE (A,175) STRBAR,STRVAR,STPSIG,STRMAX,STRMIN
104. WRITE (A,180)
105. WRITE (A,175) DPSBAR,DPSVAR,DPSIG,DPSMAX,DPSMIN
106. WRITE (A,110)
107. I=1
C -----
C CALL HISTO FOR HISTOGRAMS OF STRIKES AND DIPS
C -----
108. IF (IHIS(1),NF,1) GO TO 70
109. CALL HISTO (NK,DPSMAX,0,0,DPS,PHOM,I,NNK)
110. I=I+1
111. IF (IHIS(1),NF,1) GO TO 75
112. CALL HISTO (NK,STRMAX,STRMIN,STR,PHOM,I,NNK)
113. 75 CONTINUE
C -----
C COMPUTE VECTOR STRENGTH
C -----
114. TOIX=0.0
115. TOIY=0.0
116. TOIZ=0.0

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117.      DO 80 K=1,NK                      VFC 464
118.          TOTX=TOTX+XNORM(K)           VFC 466
119.          TOTY=TOTY+YNORM(K)           VFC 468
120.      80  TOTZ=TOTZ+ZNORM(K)           VFC 470
121.          ZH=TOTX*TOTX+TOTY*TOTY+TOTZ*TOTZ VFC 472
          C ----- VFC 474
          C VECTOR STRENGTH SHOWN BY FISHER K1 OR R, DISPERSION BY ESTK VFC 476
          C ----- VFC 478
122.          R1=SQRT(ZR)                   VFC 480
123.          FNK=NK                        VFC 482
124.          R=R1/FNK                      VFC 484
125.          FSTK=(FNK-1.0)/(FNK-R1)       VFC 486
126.          WRITE (6,195)                 VFC 488
127.          WRITE (6,110)                 VFC 490
128.          WRITE (6,190) R1,R           VFC 492
129.          WRITE (6,195) FSTK            VFC 494
130.          V=(FMAX-FMIN)/ALOG10(FSTK)    VFC 496
131.          WRITE (6,200) V               VFC 498
          C ----- VFC 500
          C COMPUTE VECTOR MEAN AND MEAN PLANE ORIENTATION VFC 502
          C DIRECTION COSINES OF MEAN VECTOR VFC 504
          C ----- VFC 506
132.          ALPHA=TOTX/R1                 VFC 508
133.          BETA=TOTY/R1                  VFC 510
134.          GAMMA=TOTZ/R1                 VFC 512
135.          WRITE (6,205) ALPHA,BETA,GAMMA VFC 514
136.          CALL FILIS (ALPHA,BETA,GAMMA,STRIKE,DIP,DIPN) VFC 516
137.          WRITE (6,210) STRIKE,DIP      VFC 518
138.          WRITE (6,110)                 VFC 520
          C ----- VFC 522
          C WHEN IPLOT=1, CALL WULFF TO PLOT A STRENOGRAM OF THE TRIANGLES VFC 524
          C ----- VFC 526
139.          IF (IPLOT.NE.1) GO TO 85      VFC 528
140.          CALL WULFF (NK,XNORM,YNORM,ZNORM,PROB,FNK) VFC 530
141.      85  IF (ITYPE.EQ.3.AND.NNK.EQ.1) GO TO 30 VFC 532
142.          GO TO 5                        VFC 534
          C ----- VFC 536
          C ----- VFC 538
143.      90  FORMAT (A10)                  VFC 540
144.      95  FORMAT (2I3,4X,3F10.0)        VFC 542
145.      100  FORMAT (11,3X,11,4X,211,11)  VFC 544
146.      105  FORMAT (1H1,10X,30HCOMPUTATIONS BY PROGRAM VECTOR) VFC 546
147.      110  FORMAT (1H0,49H-----//VEC 548
          11 VFC 550
148.      115  FORMAT (1H ,A10)             VFC 552
149.      120  FORMAT (1H0,14HVALUES READ IN//,12H NO OF ROWS=,13,12H NO OF COLS=VEC 554
          1,13,7H XSTEP=,F4,2,7H YSTEP=,F4,2,11H Y-AXIS DIRECTION=,F4,2,13HVEC 556
          2 DATA FORMAT=,12A0) VFC 558
150.      125  FORMAT (1H0,32HCOMPUTATION RESULTS FOR SUBAREA ,A10) VFC 560
151.      130  FORMAT (1H0,23HORIGINAL ELEVATION DATA//) VFC 562
152.      135  FORMAT (1H ,12F10.2)         VFC 564
153.      140  FORMAT (1H0)                 VFC 566
154.      145  FORMAT (1H0,38HSTATISTICAL MEASURES OF ELEVATION DATA) VFC 568
155.      150  FORMAT (1H1,32HTHE PROGRAM IS NOW FITTING TYPE ,11,11H TRIANGLES.) VFC 570
156.      155  FORMAT (1H0,31HSTRIKE AND DIP OF ALL TRIANGLES//) VFC 572
157.      160  FORMAT (1H0,1X,35HTRIANGLE NUMBER STRIKE DIP) VFC 574
158.      165  FORMAT (1H ,3(7X,13,11X,F4,4,2X,F4,4)) VFC 576
159.      170  FORMAT (1H0,44HSTATISTICAL MEASURES OF STRIKES OF TRIANGLES) VFC 578
160.      175  FORMAT (1H ,5HMEAN=,F10.4,12H VARIANCE=,F10.4,22H STANDARD DEVEVC 580
          1TATION=,F10.4,11H MAXIMUM=,F10.4,11H MINIMUM=,F10.4) VFC 582
161.      180  FORMAT (1H0,41HSTATISTICAL MEASURES OF DIPS OF TRIANGLES) VFC 584
162.      185  FORMAT (1H1)                 VFC 586
163.      190  FORMAT (1H0,35HMEASURES OF VECTOR STRENGTH ARE D1=,F12.4,7H, REVEC 588
          1,F4,6,74H, WHERE K=1/NUMBER OF TRIANGLES.) VFC 590
164.      195  FORMAT (1H ,5HVECTOR DISPERSION MEASURED BY FISHERS DISPERSION FAVEC 592
          1CTOR,IS=,F12.4,40H, LOW VALUES INDICATE VARIABLE THERMATE) VFC 594
165.      200  FORMAT (1H0,60HTHE VARIABILITY FACTOR, V = ELEVATION RANGE/LOG(FSTVEVC 596
          1K) , IS ,F10.3) VFC 598
166.      205  FORMAT (1H0,51HTHE DIRECTION COSINES OF THE MEAN VECTOR ARE ALPHA=VEC 600
          1,F10.5,7H BETA=,F10.5,11H GAMMA=,F10.5) VFC 602
167.      210  FORMAT (1H0,59HTHE ORIENTATION OF THE MEAN PLANE IS AS FOLLOWS=-- VFC 604
          1 STRIKE=,F4,4AH, DIP=,F4,4) VFC 606
168.          ENJ VFC 608

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c) FORSTAT CROSS-REFERENCE LISTINGS FOR PROGRAM VECTOR

PROGRAM	VECTOR	STATEMENT NUMBER	DEFINITION	REFERENCES
		5	5.	142.
		10	18.	17.
		15	22.	20.
		20	23.	32.
		25	56.	37.
		30	59.	39.
		35	62.	141.
		40	65.	65.
		45	84.	58.
		50	85.	84.
		55	87.	84.
		60	95.	88.
		65	97.	96.
		70	99.	96.
		75	110.	104.
		80	113.	111.
		85	120.	117.
		90	141.	139.
		95	143.	4.
		100	144.	7.
		105	145.	5.
		110	146.	6.
		115	147.	8.
		120	148.	9.
		125	149.	10.
		130	150.	12.
		135	151.	15.
		140	152.	19.
		145	153.	21.
		150	154.	22.
		155	155.	24.
		160	156.	25.
		165	157.	35.
		170	158.	61.
		175	159.	86.
		180	160.	97.
		185	161.	102.
		190	162.	27.
		195	163.	103.
		200	164.	105.
		205	165.	104.
		210	166.	126.
			167.	128.
				129.
				131.
				135.
				137.
				138.
				139.
				140.
				141.
				142.
				143.
				144.
				145.
				146.
				147.
				148.
				149.
				150.
				151.
				152.
				153.
				154.
				155.
				156.
				157.
				158.
				159.
				160.
				161.
				162.
				163.
				164.
				165.
				166.
				167.

42 STATEMENT NUMBERS DEFINED
 12 MAXIMUM NUMBER OF REFERENCES
 62 TOTAL NUMBER OF REFERENCES
 1.5 AVERAGE NUMBER OF REFERENCES

PROGRAM	VECTING	DEFINITION	REFERENCE
LABEL	TYPE	FUNCTION	CFS
A	R	41.	
ALOG10	R	130.	
ALPHA	R	49.	
B	P	42.	
BETA	P	43.	
C	P	44.	
DIP	P	45.	
DIRN	P	46.	
DIV	P	47.	
DPS	R	48.	
DPSR	R	49.	
DPSMAX	R	50.	
DPSMIN	R	51.	
DPSIG	R	52.	
DPSVAR	R	53.	
F	P	54.	
FBAR	R	55.	
FWAX	R	56.	
FWIN	P	57.	
FSIG	P	58.	
ESTK	P	59.	
EVAR	P	60.	
FMT	R	61.	
FNK	R	62.	
GAMMA	R	63.	
HISTO	R	64.	
I	P	65.	
INIST	I	66.	
II	I	67.	
IPLOT	I	68.	
ISKIP	I	69.	
IITYPE	I	70.	
J	P	71.	
JJ	P	72.	
JK	P	73.	
K	P	74.	
M	P	75.	
MM	P	76.	
NN	P	77.	
NK	P	78.	
NNN	P	79.	
NKK	P	80.	

PAGE	P	2.	13.	15.	109.	112.	140.	
R	R	124.	124.	125.	128.	132.	133.	134.
RI	R	44.	52.	70.	78.	122.		
SOPT	R	23.	100.	101.	100.	112.		
STATS	R	100.	94.	97.	100.	112.		
STR	R	100.	103.	136.	137.			
STRAR	R	92.	94.	136.	137.			
STRKE	R	100.	103.	112.				
STRMAX	R	100.	103.	112.				
STRMIN	R	100.	103.	112.				
STOSIG	R	100.	103.	112.				
STVAR	R	100.	103.	112.				
TITL	R	92.	136.					
TITL	R	2.	4.	10.				
TOTX	R	114.	114.	121.	132.			
TOTY	R	115.	119.	121.	133.			
TOTZ	R	116.	120.	121.	134.			
V	R	130.	131.					
WJLFF	R	140.						
XNORM	P	2.	45.	53.	71.	79.	89.	118.
XSTEP	P	5.	12.	42.	43.	50.	51.	68.
YNORM	R	2.	46.	54.	72.	80.	90.	119.
YSTEP	R	5.	12.	41.	43.	49.	51.	67.
ZNORM	R	2.	47.	55.	73.	81.	91.	120.
ZR	R	121.	122.					

64 SYMBOLS DEFINED
30 MAXIMUM NUMBER OF REFERENCES
302 TOTAL NUMBER OF REFERENCES
4.6 AVERAGE NUMBER OF REFERENCES

d) LISTING OF SUBROUTINE TILTS

```

1. SUBROUTINE TILTS (ALPHA,BETA,GAMMA,STRIKE,DIP,DIRN)
2. SUBROUTINE TILTS
C
C PURPOSE--
C TO DETERMINE STRIKE AND DIP OF PLANES
C
C THE GCHS SYSTEM
C PHOENIX UNIVERSITY
C
C R. K. LOHMEYER
C CIVIL ENGINEERING
C JUNE 1969
C
C
C USAGE
C CALL TILTS(ALPHA,BETA,GAMMA,STRIKE,DIP,DIRN)
C WHERE - ALPHA = DIRECTION COSINE OF NORMAL VECTOR TO X-AXIS
C BETA = DIRECTION COSINE OF NORMAL VECTOR TO Y-AXIS
C GAMMA = DIRECTION COSINE OF NORMAL VECTOR TO Z-AXIS
C STRIKE = STRIKE OF PLANE (AZIMUTH) IN DEGREES
C DIP = DIP OF PLANE IN DEGREES
C DIRN = AZIMUTH (IN DEGREES) OF Y-AXIS OF ELEVATION GRID
C
C DESCRIPTION OF CONTROL CARDS-
C NONE REQUIRED
C
C REQUIRED SUBROUTINES-
C NONE
C
C OPTIONAL SUBROUTINES-
C NONE
C
3. ANGG=ARCOS(GAMMA)
4. AC=SQRT((ALPHA**2+(BETA**2)*SIGN(1.0,ALPHA)*SIGN(1.0,BETA)
5. COSTH=BETA/AC IF (AC.EQ.0.) GO TO 10
6. STRIKE=(1.5708-ARCOS(COSTH))*57.2957+DIRN
7. DIP=ANGG*57.2957
8. RETURN
9. END

```

Handwritten notes in red ink:

- IF (AC.EQ.0.) GO TO 10
- GO TO 15
- 10 STRIKE = 0.0
- 77
- 74
- 73
- 78 A
- 80
- 82

e) FORSTAT CROSS-REFERENCE LISTINGS FOR SUBROUTINE TILTS

SUBROUTINE TILTS

LABEL	TYPE	DEFINITION	REFERENCES
AC	R	4.	5.
ALPHA	R	1.	4.
ANGG	R	3.	7.
ARCOS	R	3.	6.
BETA	R	1.	4.
COSTH	R	5.	6.
DIP	R	1.	7.
DIRN	R	1.	6.
GAMMA	R	1.	3.
SIGN	R	4.	FUNCTION
SQRT	R	4.	FUNCTION
STRIKE	R	1.	6.
SUBROUT	R	2.	

13 SYMBOLS DEFINED

2 MAXIMUM NUMBER OF REFERENCES

11 TOTAL NUMBER OF REFERENCES

.8 AVERAGE NUMBER OF REFERENCES

f) LISTING OF SUBROUTINE WULFF

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1. SUBROUTINE WULFF (KOUNT2,IX,TY,TZ,PROB,ITYPE)
C -----
C SUBROUTINE WULFF
C -----
C PURPOSE--
C
C TO PLOT A SCATTER DIAGRAM OF A GROUP OF VECTORS DEFINED BY
C DIRECTION COSINES. THE DIAGRAMS MAY BE USED AS OVERLAYS ON A 20-
C CENTIMETER DIAMETER WULFF NET. THE DIP ANGLES HAVE BEEN DOUBLED TO
C INCREASE THE DISPERSION. THE NUMBER IN EACH RECTANGLE INDICATES THE
C NUMBER OF POINTS FALLING IN THAT RECTANGLE.
C REFERENCE-- SUBROUTINE WULFF IN--
C T. V. LOHMAN, 1964,
C COMPUTER ANALYSIS OF ORIENTATION DATA
C IN STRUCTURAL GEOLOGY,
C OFFICE OF NAVAL RESEARCH, GEOG. BRANCH
C TECHNICAL REPORT 13, ONR TASK NO. 3P9-135,
C 129 PAGES.
C -----
C THE GCMS SYSTEM
C PURDUE UNIVERSITY
C
C A. K. TURNER,
C CIVIL ENGINEERING,
C JUNE 1969.
C -----
C USAGE--
C CALL WULFF (KOUNT2,IX,TY,TZ,PROB,ITYPE)
C WHERE-KOUNT2 = NUMBER OF TRIANGULAR PLANES
C TX = DIRECTION COSINES OF NORMAL VECTORS TO X-AXIS
C TY = DIRECTION COSINES OF NORMAL VECTORS TO Y-AXIS
C TZ = DIRECTION COSINES OF NORMAL VECTORS TO Z-AXIS
C PROB = DATA SET TITLE (UP TO 80 ALPHANUMERIC CHARACTERS)
C ITYPE = TYPE OF TRIANGLES BEING ANALYZED
C -----
C DESCRIPTION OF CONTROL CARDS--
C NONE REQUIRED
C -----
C REQUIRED SUBROUTINES--
C NONE
C -----
C OPTIONAL SUBROUTINES--
C NONE
C -----
2. DIMENSION IROW(48,40), TX(400), TY(400), TZ(400)
3. DIMENSION PROB(8)
C -----
C INITIALIZE, PUTTING -9 IN THE AREA OUTSIDE THE STEREOGRAM.
C
4. WRITE (6,80)
C -----
C SEE COMMENT ON CONSTANTS BELOW
C -----
5. P=1.0/(3.937*6.0)
6. Q=1.0/(3.937*5.0)
C -----
C FOR POINTS ON THE CIRCUMFERENCE OF THE PRIMITIVE CIRCLE,
C  $(MP/2)**2 + (NQ/2)**2 = 1$ , BY THE THEOREM OF PYTHAGORAS
C -----
7. DO 15 M=1,48
8. R=M
9. R=ABS(R-24.0)
10. DO 5 N=1,40
11. IROW(M,N)=0
12. N2=SQRT((1.05-(R*P)**2)/(Q**2)+0.5)
13. N3=20-N2
14. N2=20+N2
15. DO 10 N=1,N3
16. IROW(M,N)=-9
17. DO 15 N=N2,40
18. IROW(M,N)=-9

```

```

C -----
C COMPUTE THE NUMBER OF POINTS IN EACH RECTANGLE OF THE STEREOGRAM.
C -----
19. 00 40 I=1,KOUNT2
20.    UP=IZ(I)
21.    IF (UP) 20,25,25
22.    TX(I)=-TX(I)
23.    TY(I)=-TY(I)
C -----
C IN THE NEXT TWO EXPRESSIONS, 3.937 IS THE RADIUS OF THE NET IN INCH
C 6.0 IS THE NUMBER OF LINE OF OUTPUT PER INCH, 5.0 IS THE NUMBER OF
C TWO-DIGIT CHARACTERS PER INCH, 0.5 IS A ROUNDING FACTOR.
C -----
24. M=((TY(I)/(1.0*ABS(TZ(I)))))*3.937*(-6.0)+1.0+3.937*6.0
25. N=((TX(I)/(1.0*ABS(TZ(I)))))*3.937*(-5.0)+1.0+3.937*5.0
C -----
C DOUBLE THE DISPERSION
C -----
26. IF (M.GF.25) GO TO 30
27. M=2*M-24
28. IF (N.LF.20) N=2*N-20
29. IF (N.GF.21) N=2*N-21
30. GO TO 35
C -----
31. 30 M=2*M-25
32. IF (N.LF.20) N=2*N-20
33. IF (N.GF.21) N=2*N-21
34. 35 IF (M.LF.1) M=1
35. IF (M.GF.48) M=48
36. IF (N.LF.1) N=1
37. IF (N.GF.40) N=40
38. IROW(M,N)=IROW(M,N)+1
C -----
C CONVERT THE NUMBER OF POINTS/RECTANGLE TO PERCENT
C -----
39. DO 45 M=1,48
40. DO 45 N=1,40
41. 45 IROW(M,N)=(100.*FLOAT(IROW(M,N))/FLOAT(KOUNT2))*0.5
C -----
C PRINT THE RESULTS
C -----
42. DO 50 M=1,24
43. 50 WRITE (6,60) (IROW(M,N),N=1*20),(IROW(M,N),N=21,40)
44. WRITE (6,75)
45. DO 55 M=25,48
46. 55 WRITE (6,60) (IROW(M,N),N=1*20),(IROW(M,N),N=21,40)
47. WRITE (6,85)
48. WRITE (6,100) PROB,ITYPE
49. WRITE (6,65) KOUNT2
50. WRITE (6,70)
51. WRITE (6,95)
52. WRITE (6,90)
C -----
C RETURN
C -----
53. RETURN
C -----
54. 60 FORMAT (1H,20X,20I2,1H,20I2)
55. 65 FORMAT (1H0,14,13H MEASUREMENTS)
56. 70 FORMAT (1H0,11HSTEREOGRAM SHOWING DISTRIBUTION OF POINTS, IN PERC
57. 75 FORMAT (19X,15HWEST.....(3).....
1.....EAST(2))
58. 80 FORMAT (1H1,57X,5HNORTH)
59. 85 FORMAT (56X,8HNSOUTH(1))
60. 90 FORMAT (1H0,36X,45H-----)
61. 95 FORMAT (1H0,9HNDISTRIBUTION HAS BEEN EXAGGERATED BY FOURLING EAST-
WEST AND NORTH-SOUTH DISTANCES FROM THE CENTER.)
62. 100 FORMAT (1H0,11HSUBAREA IS, 6A10,17H TRIANGLE TYPE =,1I)
63. EN()

```

9) FORSTAT CROSS-REFERENCE LISTINGS FOR SUBROUTINE WULFF

SUBROUTINE WULFF

STATEMENT NUMBER DEFINITION

REFERENCES

5	10.
10	15.
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20 STATEMENT NUMBERS DEFINED

2 MAXIMUM NUMBER OF REFERENCES

23 TOTAL NUMBER OF REFERENCES

1.1 AVERAGE NUMBER OF REFERENCES

SUBROUTINE WULFF

LAFEL TYPE DEFINITION

REFERENCES

ABC	R	9.	FUNCTION	24.	25.
FLCAT	R	41.	FUNCTION	20.	22.
I	I	19.		11.	16.
ITROW	I	2.		48.	43.
ITYPE	I	1.		49.	46.
KOUNT2	I	1.		41.	41.
M	I	7.		11.	16.
		8.		43.	45.
		11.		11.	15.
		10.		41.	43.
		12.		13.	14.
N2	I	12.		15.	17.
N3	I	13.		12.	
P	R	5.		48.	
PROR	R	1.		12.	
C	R	6.		9.	
R	R	5.			
ROUT	R	12.			
TX	R	1.	FUNCTION	22.	25.
TY	R	1.		2.	23.
TZ	R	1.		2.	24.
UP	R	20.		21.	25.

14 SYMBOLS DEFINED

17 MAXIMUM NUMBER OF REFERENCES

74 TOTAL NUMBER OF REFERENCES

3.9 AVERAGE NUMBER OF REFERENCES

h) LISTING OF SUBROUTINE HISTO

```

1. SUBROUTINE HISTO (N,XMAX,XMIN,X,PROB,KK,ITYPE)
C -----
C SUBROUTINE HISTO
C -----
C PURPOSE--
C TO PLOT HISTOGRAMS OF STRIKES AND/OR DIPS EACH HISTOGRAM HAS
C 40 INTERVALS AND THE HIGHEST CLASS IS SET EQUAL TO 100 ARBITRARY
C UNITS.
C -----
C THE GCARS SYSTEM
C PURDUE UNIVERSITY
C
C A. K. TURNER,
C CIVIL ENGINEERING,
C JUNE 1964.
C -----
C USAGE--
C CALL HISTO(N,XMAX,XMIN,X,PROB,KK,ITYPE)
C WHERE N = NUMBER OF TRIANGULAR PLANES
C XMAX = MAXIMUM VALUE OF X-ARRAY
C XMIN = MINIMUM VALUE OF X-ARRAY
C X = ARRAY OF OBSERVATIONS BEING GRAPHED (DIPS OR
C STRIKES)
C PROB = DATA SET TITLE
C KK = 1 OR 2 . IF KK = 1, HISTOGRAM IS OF DIPS.
C IF KK = 2, HISTOGRAM IS OF STRIKES.
C ITYPE = TYPE OF TRIANGLES BEING ANALYZED
C -----
C DESCRIPTION OF CONTROL CARDS-
C NONE REQUIRED
C -----
C REQUIRED SUBROUTINES-
C NONE
C OPTIONAL SUBROUTINES-
C NONE
C -----
2. DIMENSION K(40), X(N), IHIST(2), PROB(R)
3. DATA STAR/1H0/, (IHIST(KK), KK=1,2)/6H DIP ,6HSTRIKE/
C -----
C CALCULATE SIZE OF INTERVALS, SET NUMBER OF OBSERVATIONS PER INTERVAL
C TO 0
C -----
4. XTERVL=(XMAX+1.-XMIN)/40.
5. DO 5 I=1,40
6. K(I)=0
C -----
C PLACE EACH OBSERVATION IN APPROPRIATE INTERVAL
C -----
7. DO 10 I=1,N
8. M=((X(I)-XMIN)/XTERVL)+1.0
9. K(M)=K(M)+1
C -----
C FIND HEIGHT OF MAXIMUM INTERVAL = KMAX
C SET KMAX = 100 STARS, AND CALCULATE NUMBER OF OBSERVATIONS/STAR.
C -----
10. KMAX=K(1)
11. DO 15 I=1,40
12. IF (K(I).GT.KMAX) KMAX=K(I)
13. FACK=100./FLOAT(KMAX)
14. DO 20 M=1,40
15. K(M)=FACK*FLOAT(K(M))+0.5
16. FACK=1.0/FACK
C -----
C PRINT TITLES
C -----
17. WRITE (6,70) IHIST(KK),PROB
18. WRITE (6,75) ITYPE
19. WRITE (6,40) FACK

```

	C	-----	142
	C	PRINT OUT HISTOGRAM	144
20.		XBERN=XMIN	146
21.		DO 25 I=1,40	148
22.		XFVN=XREFGN+XTFVVL	150
23.		NN=K(1)	152
24.		WRITE (6,45) XBERN,XEND,(STAR,J=1,NN)	154
25.	25	XBERN=XEND	156
26.		RETURN	158
	C		160
27.	30	FORMAT (1H),13HHISTOGRAM OF ,A6,20H VALUES FOR SUBAREA ,PA10)	162
28.	35	FORMAT (1H0,19HTYPE OF TRIANGLE = ,I1)	164
29.	40	FORMAT (1H0,18H EACH * REPRESENTS ,F10,3,14H OBSERVATIONS,////)	166
30.	45	FORMAT (1H9,F12,6,1X,1H--,1X,F12,6,3X,100A1)	168
31.		END	170

i) FORSTAT CROSS-REFERENCE LISTINGS FOR SUBROUTINE HISTO

SUBROUTINE HISTO

STATEMENT NUMBER	DEFINITION	REFERENCES
5	6.	5.
10	9.	7.
15	12.	11.
20	15.	14.
25	25.	21.
30	27.	FORMAT 17.
35	28.	FORMAT 18.
40	29.	FORMAT 19.
45	30.	FORMAT 24.

9 STATEMENT NUMBERS DEFINED

1 MAXIMUM NUMBER OF REFERENCES

9 TOTAL NUMBER OF REFERENCES

1.0 AVERAGE NUMBER OF REFERENCES

SUBROUTINE HISTO

LABEL	TYPE	DEFINITION	REFERENCES			
FACT	R	13.	15.	16.	19.	
FLOAT	R	13.	15.			
I	I	5.	6.	7.	8.	11.
IHIST	I	2.	3.	17.	12.	21.
ITYPE	I	1.	18.		23.	
J	I	24.				
K	I	2.	6.	9.	10.	12.
KK	I	1.	3.	17.	15.	23.
KMAX	I	10.	12.	17.		
M	I	8.	9.	14.	15.	
N	I	1.	2.	7.		
NN	I	23.	24.			
PROR	R	1.	2.	17.		
STAR	R	3.	24.			
X	R	1.	2.	8.		
XREFGN	R	20.	22.	24.	25.	
XEND	R	22.	24.	25.		
XMAX	R	1.	4.			
XMIN	R	1.	4.	9.	20.	
XTFVVL	R	4.	8.	22.		

20 SYMBOLS DEFINED

7 MAXIMUM NUMBER OF REFERENCES

46 TOTAL NUMBER OF REFERENCES

2.3 AVERAGE NUMBER OF REFERENCES

j) SAMPLE INPUT FOR PROGRAM VECTOR

```

A PROGRAM TO ANALYZE TERRAIN ROUGHNESS
1 2 2 2 500.0 500.0
1 1 113
-123456789
WEEDSPORT 1. DROWLIN FIELD NEW YORK STATE
460 430 457 448 435 432 437 460 445 495 524 500 520 522 468 470 459 480 566 490
460 474 455 455 457 459 437 465 455 489 515 531 520 511 494 480 458 520 530 490
450 488 540 460 468 525 435 500 485 480 479 514 582 584 569 474 458 535 475 466
451 458 515 463 471 551 439 490 510 472 475 464 574 557 526 452 458 485 448 447
451 450 474 458 456 470 441 458 501 475 460 440 465 510 486 442 480 494 445 447
459 476 438 475 439 439 437 438 452 462 441 438 457 467 460 441 450 490 445 444
454 476 448 470 479 438 435 435 437 435 447 450 461 445 451 438 440 481 444 444
441 476 444 447 501 449 452 436 437 438 460 462 473 460 440 430 437 451 442 442
470 476 477 517 470 462 519 511 460 474 503 479 503 452 438 438 447 450 448 446
444 470 459 542 444 455 536 535 489 512 484 472 438 438 443 464 501 458 463
449 449 429 517 456 490 495 523 475 482 458 450 442 446 454 457 489 563 473 501
416 422 426 503 447 452 449 481 455 445 455 432 428 461 457 482 465 540 503 503
462 415 427 429 429 445 515 465 449 473 455 428 428 460 495 544 478 515 530 450
525 418 439 442 420 446 463 479 463 562 510 450 448 444 540 518 475 467 532 466
509 419 445 432 510 439 570 520 485 552 530 471 432 429 529 460 501 452 485 458
455 417 435 428 510 470 550 545 499 527 471 463 431 426 476 509 480 444 448 450
412 434 445 445 463 474 488 512 492 471 444 444 448 444 439 472 447 445 437 453
423 421 500 429 440 464 443 485 466 442 418 418 453 488 425 462 437 437 454 471
421 455 463 425 465 474 479 436 438 418 417 417 456 511 459 438 431 446 479 484
421 455 463 419 419 419 32 433 420 418 417 417 438 503 460 418 446 460 495 493

```

C**** END OF TEST DATA *****

K) Typical output of program VECTOR

COMPUTATIONS BY PROGRAM VECTOR

A PROGRAM TO ANALYZE TERRAIN HEIGHTNESS

VALUES READ IN

NO OF RUNS= 20 NO OF CULS= 20 XSTEP= 500.00 YSTEP= 500.00 T-AXIS DIRECTION= 0.
 DATA FORMAT(120F4.1)

COMPUTATION RESULTS FOR SUBAREA HEADQUARTERS 1, URMULIN FIELD NEW YORK STATE

ORIGINAL ELEVATION DATA

400.	480.	497.	440.	435.	432.	427.	460.	448.	440.	384.	380.
520.	522.	480.	470.	459.	480.	522.	490.				
440.	474.	515.	490.	457.	450.	427.	405.	409.	480.	518.	531.
520.	511.	490.	400.	430.	550.	500.	490.				
450.	485.	540.	440.	400.	525.	438.	505.	409.	480.	479.	514.
562.	504.	509.	474.	458.	535.	473.	464.				
481.	458.	515.	463.	471.	551.	439.	400.	510.	470.	478.	464.
574.	557.	520.	452.	458.	405.	440.	467.				
483.	450.	494.	458.	408.	470.	441.	484.	501.	478.	480.	460.
485.	510.	480.	445.	440.	484.	465.	467.				
489.	478.	430.	475.	439.	439.	434.	434.	482.	462.	441.	430.
487.	467.	400.	441.	450.	490.	465.	444.				
484.	470.	440.	470.	474.	430.	425.	425.	437.	425.	447.	460.
401.	465.	451.	430.	440.	401.	444.	444.				
541.	478.	444.	449.	501.	434.	462.	428.	437.	438.	480.	460.
473.	400.	430.	430.	417.	451.	449.	448.				
470.	470.	477.	517.	470.	462.	519.	511.	460.	464.	463.	479.
503.	452.	430.	440.	440.	450.	466.	446.				
444.	470.	454.	442.	444.	455.	530.	505.	480.	512.	482.	480.
472.	434.	430.	443.	404.	501.	454.	463.				
419.	440.	424.	417.	450.	490.	445.	523.	478.	488.	468.	460.
442.	440.	454.	477.	494.	563.	473.	501.				
410.	443.	420.	403.	447.	452.	449.	481.	488.	448.	436.	434.
424.	441.	457.	442.	405.	540.	503.	503.				
462.	415.	427.	474.	479.	444.	516.	465.	440.	473.	488.	480.
520.	480.	493.	544.	478.	513.	530.	498.				
525.	419.	434.	442.	420.	440.	463.	479.	463.	568.	518.	460.
428.	444.	540.	510.	475.	467.	532.	460.				
509.	414.	445.	412.	510.	439.	570.	520.	480.	588.	530.	471.
432.	479.	524.	480.	501.	442.	405.	458.				
495.	417.	434.	424.	510.	470.	550.	549.	460.	527.	481.	463.
431.	420.	470.	504.	480.	444.	448.	480.				
412.	411.	445.	425.	493.	474.	488.	513.	498.	471.	440.	440.
440.	444.	434.	442.	440.	440.	437.	453.				
423.	441.	500.	424.	440.	444.	443.	465.	462.	422.	418.	418.
453.	404.	423.	442.	417.	437.	494.	471.				
421.	400.	403.	475.	465.	474.	424.	425.	438.	418.	417.	417.
450.	511.	434.	430.	431.	440.	479.	484.				
441.	430.	414.	414.	401.	474.	432.	433.	420.	418.	487.	417.
434.	505.	480.	410.	440.	460.	496.	453.				

STATISTICAL MEASURES OF ELEVATION DATA

MEANS 407.0220 VARIANCE 1851.1000 STANDARD DEVIATION 43.3769 MAXIMUM 550.0000 MINIMUM 412.0000

THE PROGRAM IS NOW FITTING TYPE P TRIANGLES.

STATISTICAL MEASURES OF STRINGS OF TRIANGLES

MEANS 4.0002 VARIANCE 211.6907 STANDARD DEVIATION 14.5470 MAXIMUM 90.0000 MINIMUM -80.0700

STATISTICAL MEASURES OF HIPS OF TRIANGLES

MEANS 4.4722 VARIANCE 4.4070 STANDARD DEVIATION 2.1010 MAXIMUM 17.2200 MINIMUM -8.

STEREOPGRAM SHOWING DISTRIBUTION OF POINTS, IN PERCENT, PROJECTED ON LOWER HEMISPHERE OF 20-CENTIMETER WULF NET
DISTRIBUTION HAS BEEN EXAGGERATED BY DOUBLING EAST-WEST AND NORTH-SOUTH DISTANCES FROM THE CENTER.

1) LISTING OF PROGRAM LOADS

1.

```

PROGRAM LOADS (INPUT, OUTPUT, TAPE2, TAPES=INPUT, TAPE6=OUTPUT)
-----
PROGRAM LOADS
-----
PURPOSE--
  TO LOAD X,Y,Z COORDINATE DATA FROM CARDS TO TAPE.
  DATA TAPE IS TAPE2.
-----
THE UCARS SYSTEM
PURDUE UNIVERSITY
-----
A. KEITH TURNER,
CIVIL ENGINEERING,
JUNF, 1969.
-----
GENERAL INFORMATION
-----
THE PROGRAM CAN HANDLE TWO TYPES OF Z-DATA, FLOATING-POINT AND
INTEGER. FLOATING-POINT Z-VALUES (FOR EXAMPLE TOPOGRAPHIC
ELEVATIONS) ARE READ AND PLACED ON TAPE WITHOUT MODIFICATION.
INTEGER Z-VALUES (FOR EXAMPLE SOIL TYPE CODES) ARE CONVERTED TO THE
CORRESPONDING FLOATING-POINT COST OR BENEFIT VALUE SUPPLIED AS A
CONTROL PARAMETER. THE X AND Y COORDINATES AND THESE VALUES ARE
PLACED ON THE TAPE, AND THE CODE NUMBERS ARE DISCARDED.
-----
TAPE2 CONTAINS A TITLE CARD FOLLOWED BY A SERIES OF RECORDS,
EACH CONTAINING 1000 - OBSERVATIONS (3000 WORDS) IN RELOCATABLE
BINARY FORMAT. THE LAST RECORD WILL BE OF VARIABLE LENGTH
DEPENDENT ON THE NUMBER OF OBSERVATIONS.
-----
THE PROGRAM CAN COMBINE SEVERAL SETS OF SURFACE DATA, EACH
MEASURED IN ITS OWN COORDINATE SYSTEM, INTO A SINGLE LARGE DATA SET
HAVING A UNIFORM COORDINATE SYSTEM. ALL DATA MUST HOWEVER BE
REFERENCED TO AXES OF CONSISTENT DIRECTIONS, WITH X POSITIVE TO THE
RIGHT AND Y POSITIVE UPWARD. SURFACES MAY HAVE DIFFERENT SCALES.
DATA SUBSETS ARE SEPARATED BY END-OF-RECORD CARDS.
-----
TAPE REQUIREMENTS -
  TAPE2 - THE OUTPUT DATA TAPE ON WHICH THE CARD DATA IS LOADED.
-----
DESCRIPTION OF CONTROL CARDS -
(1) *ZYDATA CARD -
  *VALUES (COLS 1-7) - INDICATES THE Z-VALUES ARE FLOATING
                        POINT.
  *CODES (COLS 1-6) - INDICATES THE Z-VALUES ARE INTEGER.
(2) TITLE CARD -
  FACTOR-(COLS 1-30) ALPHANUMERIC FACTOR IDENTIFICATION.
  AREA -(COLS 41-70) ALPHANUMERIC AREA IDENTIFICATION.
  ITYPE -(COL 78) IF DATA MEASURES COSTS, ITYPE = 2.
                  IF DATA MEASURES BENEFITS, ITYPE = 3.
-----
THE FOLLOWING CARDS SHOULD BE REPEATED FOR EACH DATA SUBSET -
(3) SUBTITLE CARD -
  SUBTIT(COLS 1-70) SURFACE IDENTIFICATION (ALPHANUMERIC).
(4) ORIGIN/SCALE CARD -
  XORG -(COLS 1-10) X-COORDINATE OF SURFACE ORIGIN IN
                   OVER-ALL COORDINATE SYSTEM.
  YORG -(COLS 11-20) Y-COORDINATE OF SURFACE ORIGIN IN
                   OVER-ALL COORDINATE SYSTEM.
  SCALE-(COLS 21-30) RELATIVE SCALE OF SURFACE (IF BLANK,
                    SCALE IS SET EQUAL TO ONE).
-----
THE FOLLOWING CARDS ARE USED WITH FLOATING-POINT Z-VALUES -
(5A) FORMAT CARD-
  NPT -(COLS 1-2) NUMBER OF OBSERVATION SETS/DATA CARD.
  FORM -(COLS 71-76) FORMAT OF DATA CARDS.
(6A) DATA CARDS-
  CONTAIN NPT SETS OF X,Y, AND Z-COORDINATES.

```

C	(7A) END-OF-RECORD CARD -	A 158
C	THIS SIGNIFIES THE END OF ONE SUBSET OF DATA.	A 160
C		A 162
C	THE FOLLOWING CARDS ARE USED WITH INTEGER Z-VALUES -	A 164
C	-----	A 166
C	(54) FORMAT CARD-	A 168
C		A 170
C	NPT =(COLS 1-2) NUMBER OF OBSERVATION SETS/DATA CARD.	A 172
C	NFAC =(COLS 3-4) NUMBER OF ASSIGNED Z-CODES.	A 174
C	FORM =(COLS 7-76) FORMAT OF DATA CARDS.	A 176
C		A 178
C	(6B) VALUE ASSIGNMENT CARD(S) -	A 180
C	THESE CARDS CONTAIN A SEQUENCE OF VALUES TO BE ASSIGNED	A 182
C	TO THE INTEGER Z-VALUES (CODES). EACH Z WILL BE ASSIGNED	A 184
C	THE #FAC# VALUE AT THE POSITION IN THE SEQUENCE CORRESPOND	A 186
C	-ING TO ITS CODED Z-VALUE. (I.E. IF Z=5, Z BECOMES FAC(5))	A 188
C		A 190
C	THE VALUES ARE READ FROM 5-COLUMN FIELDS (1-5,6-10,11-15,	A 192
C	16-20,ETC), THERE BEING A MAXIMUM OF 16 VALUES PER CARD.	A 194
C	THE TOTAL NUMBER OF VALUES SHOULD NOT EXCEED FIFTY.	A 196
C		A 198
C	(7B) DATA CARDS-	A 200
C	CONTAIN NPT SETS OF X,Y, AND Z-COORDINATES.	A 202
C		A 204
C	(8B) END-OF-RECORD CARD -	A 206
C	THIS SIGNIFIES THE END OF ONE SUBSET OF DATA.	A 208
C		A 210
C	THE FOLLOWING CARD MUST BE ADDED AFTER THE LAST DATA SUBSET -	A 212
C	-----	A 214
C	(9) END-OF-RECORD CARD -	A 216
C	THIS SIGNIFIES THE END OF ALL DATA.	A 218
C		A 220
C	-----	A 222
C	SPECIAL NOTE -	A 224
C	-----	A 226
C	WHEN MULTIPLE OBSERVATION SETS PER CARD ARE USED AND THE LAST	A 228
C	CARD IS NOT COMPLETELY FILLED ONE ADDITIONAL DUMMY OBSERVATION MUST	A 230
C	BE ADDED TO INDICATE THIS SITUATION.	A 232
C	THIS OBSERVATION SHOULD BE -	A 234
C	(A) X = 0.0, Y = 0.0, Z = -999.0 FOR FLOATING-POINT Z-DATA	A 236
C	(B) A BLANK RECORD FOR INTEGER Z-DATA	A 238
C		A 240
C	-----	A 242
C		A 244
C	REQUIRED SUBROUTINES -	A 246
C	NONE.	A 248
C		A 250
C	OPTIONAL SUBROUTINES -	A 252
C	NONE.	A 254
C		A 256
C	-----	A 258
C		A 260
2.	DIMENSION NVAL(10), FACTOR(3), AREA(3), SURFIT(7), FORM(7), X(1000	A 262
	1), Y(1000), Z(1000), XT(10), YT(10), ZT(10), FAC(50), IDATA(2)	A 264
3.	INTEGER FORM	A 266
4.	INTEGER SYSOT, SYSIN, SDF2	A 268
5.	DATA SYSOT, SYSIN, SDF2/6,5,7/	A 270
6.	DATA (1DATA(1), I=1,2)/6#VALUE,6#CODES/	A 272
C		A 274
7.	REWIND SDF2	A 276
8.	KUHF=3	A 278
9.	KOUNT=1	A 280
10.	KT=0	A 282
11.	KNUM=0	A 284
C	-----	A 286
C	READ MYDATA CARD	A 288
C	-----	A 290
12.	READ (SYSIN,110) MYDATA	A 292
13.	IF (MYDATA.EQ.IDATA(1)) KODE=1	A 294
14.	IF (MYDATA.EQ.IDATA(2)) KODE=2	A 296
15.	IF (KODE.FQ.3) GO TO 100	A 298
C	-----	A 300
C	READ TITLE CARD	A 302
C	-----	A 304
16.	READ (SYSIN,115) FACTOR,AREA,ITYPE	A 306
C		A 308
C	OUTPUT TITLE CARD AS FIRST RECORD ON TAPE2	A 310
C	-----	A 312
17.	WRITE (SDF2) FACTOR,AREA,ITYPE	A 314

	C	-----	A 316
	C	SET UP PAGE HEADING FOR START OF OUTPUT	A 318
	C	-----	A 320
18.		WRITE (SYSOT,120) FACTOR,AREA,ITYPE	A 322
19.		WRITE (SYSOT,125)	A 324
	C	-----	A 326
	C	WORK WITH EACH SUBAREA IN TURN	A 328
	C	-----	A 330
	C	READ SUBTITLE CARD	A 332
	C	-----	A 334
20.	5	READ (SYSIN,130) SUBTIT	A 336
21.		IF (EOF,SYSIN) 70,10	A 338
	C	-----	A 340
	C	READ ORIGIN/SCALE CARD	A 342
	C	-----	A 344
22.	10	READ (SYSIN,135) XORG,YORG,SCALE	A 346
23.		IF (SCALE,FO,0.0) SCALE=1.0	A 348
24.		WRITE (SYSOT,140) SUBTIT,XORG,YORG,SCALE	A 350
25.		GO TO (15,40), KODE	A 352
	C	-----	A 354
	C	READ DATA WITH Z AS FLOATING POINT VALUES	A 356
	C	-----	A 358
	C	READ FORMAT CARD	A 360
	C	-----	A 362
26.	15	READ (SYSIN,145) NPT,FORM	A 364
	C	-----	A 366
	C	READ DATA CARDS	A 368
	C	-----	A 370
27.	20	READ (SYSIN,FORM) (X(I),Y(I),Z(I),I=1,NPT)	A 372
28.		IF (FOF,SYSIN) 35,25	A 374
29.	25	DO 30 N=1,NPT	A 376
30.		IF (Z(I),EQ,-999.) GO TO 30	A 378
	C	-----	A 380
	C	FIX UP THE COORDINATES	A 382
	C	-----	A 384
31.		X(KOUNT)=X(I)*SCALE+XORG	A 386
32.		Y(KOUNT)=Y(I)*SCALE+YORG	A 388
33.		Z(KOUNT)=Z(I)	A 390
34.		KOUNT=KOUNT+1	A 392
35.		IF (KOUNT,GT,1000) GO TO 65	A 394
36.	30	CONTINUE	A 396
37.		GO TO 20	A 398
	C	-----	A 400
38.	35	GO TO 5	A 402
	C	-----	A 404
	C	READ Z AS INTEGER CODES AND CONVERT TO VALUES	A 406
	C	-----	A 408
	C	READ FORMAT CARD	A 410
	C	-----	A 412
39.	40	READ (SYSIN,150) NPT,NFAC,FORM	A 414
	C	-----	A 416
	C	READ CODES=VALUES TRANSFORMATIONS	A 418
	C	-----	A 420
40.		READ (SYSIN,155) (FAC(I),I=1,NFAC)	A 422
	C	-----	A 424
	C	READ DATA CARDS	A 426
	C	-----	A 428
41.	45	READ (SYSIN,FORM) (X(I),Y(I),NVAL(I),I=1,NPT)	A 430
42.		IF (FOF,SYSIN) 60,50	A 432
43.	50	DO 55 N=1,NPT	A 434
44.		IF (NVAL(N),FO,0) GO (0) 55	A 436
	C	-----	A 438
	C	FIX UP THE COORDINATES	A 440
	C	-----	A 442
45.		N=NVAL(N)	A 444
46.		X(KOUNT)=X(N)*SCALE+XORG	A 446
47.		Y(KOUNT)=Y(N)*SCALE+YORG	A 448
48.		Z(KOUNT)=FAC(N)	A 450
49.		KOUNT=KOUNT+1	A 452
50.		IF (KOUNT,GT,1000) GO TO 65	A 454
51.	55	CONTINUE	A 456
52.		GO TO 45	A 458
	C	-----	A 460
53.	60	GO TO 5	A 462
	C	-----	A 464
54.	65	FORM=XFORM+1	A 466
			A 468

```

C -----
C WRITE BLOCK OF 1000 OBSERVATIONS ON TAPE 2
C -----
55.      KOUNT=1
56.      WRITE (SDF2) (X(I),Y(I),Z(I),I=1,1000)
57.      GO TO (20,45), KOUNT
58.      KOUNT=KOUNT+1
C -----
C WRITE FINAL RECORD ON TAPE2 AND THEN AN END-OF-FILE
C -----
59.      WRITE (SDF2) (X(I),Y(I),Z(I),I=1,KOUNT)
60.      END FILE SDF2
61.      REWIND SDF2
C -----
C CHECK DATA ON TAPE BY LISTING IT
C -----
62.      READ (SDF2) FACTOR,AREA,IITYPE
63.      WRITE (SYSOT,120) FACTOR,AREA,IITYPE
64.      NTOT=KOUNT*1000+KOUNT
65.      WRITE (SYSOT,160) NTOT
66.      IF (KOUNT.LT.1) GO TO 90
67.      DO 85 KK=1,KOUNT
68.          READ (SDF2) (X(I),Y(I),Z(I),I=1,1000)
69.          IKT=250
70.          IREG=1
71.          DO 40 II=1,IKT
72.              IEND=IREG+3
73.              WRITE (SYSOT,165) (X(I),Y(I),Z(I),I=IREG,IEND)
74.              IREG=IREG+4
75.          CONTINUE
76.          IF (KT.EQ.1) GO TO 45
77.          KT=1
78.          READ (SDF2) (X(I),Y(I),Z(I),I=1,KOUNT)
79.          IKT=KOUNT/4
80.          GO TO 75
C -----
81.      ILFT=KOUNT-IKT*4
82.      IF (ILFT.NE.0) WRITE (SYSOT,165) (X(I),Y(I),Z(I),I=IREG,KOUNT)
83.      REWIND SDF2
84.      GO TO 105
C -----
85.      100 WRITE (SYSOT,170) MYDATA
86.      105 STOP
C -----
87.      110 FORMAT (A6)
88.      115 FORMAT (3A10,10X,3A10,6X,I2)
89.      120 FORMAT (1H1,55X,29H-----,/,56X,29HI T
11E GCARS SYSTEM I,/,56X,29HI PURDUE UNIVERSITY VERSION I,/,56X
2,29H-----,/,32X,56HDATA PREPARATION ACTIV
3IITY = LOAD DATA FROM CARDS TO TAPE,/,/,40X,30HTHIS TAPE CONTAINS D
4ATA FOR --,/,/,40X,4HFACTOR = ,3A10,/,/,40X,9HAREA = ,3A10,/,/,40X,
58HIIITYPE = ,I2,36H IITYPE = 2 WHEN DATA MEASURES COSTS,/,/,50X,39H IT
6YPE = 2 WHEN DATA MEASURES BENEFITS,.,/////
90.      125 FORMAT (1H0,10X,69HTHE TAPE IS BEING LOADED WITH CARD DATA FROM TH
1E FOLLOWING SURFACES--,/,/,36X,12H$URFAREA NAME,33X,2,HORIGINCOORDINATE
2TESCALE,/,86X,1HX,10X,1HY,/)
91.      130 FORMAT (7A10)
92.      135 FORMAT (3F10,0)
93.      140 FORMAT (1H0,10X,77X10,5X,3F10,3)
94.      145 FORMAT (12,4X,7A10)
95.      150 FORMAT (2I2,2X,7A10)
96.      155 FORMAT (16F5,0)
97.      160 FORMAT (1H ,55HTOTAL NUMBER OF POINTS FOR THIS FACTOR IN THIS AREA
1 IS ,I5,/,/,39H LISTING OF DATA PLACED ON TAPE FOLLOWS,/,/,1H ,46
2X,25HI ( READ ACROSS THE LINES ),/,/,1H ,4(30H X-COORD. Y-COORD.
3Z=VALUE ),/)
98.      165 FORMAT (1H ,12F10,3)
99.      170 FORMAT (1H0,69H***ERROR*** CONTROL CARD ERROR,MYDATA CARD DOES NO
1T CHECK. MYDATA= ,A6)
100.      EN)

```

m) FORSTAT CROSS-REFERENCE LISTINGS FOR PROGRAM LOADS

PROGRAM	LOADS	STATEMENT NUMBER	DEFINITION	REFERENCES
		5	20.	38.
		10	22.	21.
		15	26.	25.
		20	27.	37.
		25	29.	57.
		30	36.	28.
		35	38.	29.
		40	39.	30.
		45	41.	28.
		50	43.	25.
		55	51.	52.
		60	53.	42.
		65	54.	42.
		70	56.	35.
		75	70.	21.
		80	74.	80.
		85	75.	71.
		90	77.	67.
		95	81.	66.
		100	85.	70.
		105	86.	15.
		110	87.	44.
		115	88.	12.
		120	89.	16.
		125	90.	18.
		130	91.	FOR-AT
		135	92.	FOR-AT
		140	93.	FOR-AT
		145	94.	FOR-AT
		150	95.	FOR-AT
		155	96.	FOR-AT
		160	97.	FOR-AT
		165	98.	FOR-AT
		170	99.	FOR-AT
				43.
				42.
				44.
				50.
				57.
				62.

34 STATEMENT NUMBERS DEFINED

2 MAXIMUM NUMBER OF REFERENCES

42 TOTAL NUMBER OF REFERENCES

1.2 AVERAGE NUMBER OF REFERENCES

n) SAMPLE OUTPUT FROM PROGRAM LOADS

```

-----
I      THE GCARS SYSTEM      I
I  PURDUE UNIVERSITY VERSION I
-----

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DATA PREPARATION ACTIVITY - LOAD DATA FROM CARDS TO TAPE

THIS TAPE CONTAINS DATA FOR --

FACTOR - TOPOGRAPHY 1724,000 QUADRANGLE

AREA - LAFAYETTE INDIANA (NORTHERN)

 ITYPE - 2 ITYPE = 2 WHEN DATA MEASURES COSTS.
 ITYPE = 3 WHEN DATA MEASURES BENEFITS.

THE TAPE IS BEING LOADED WITH CARD DATA FROM THE FOLLOWING SUBAREAS--

SUBAREA NAME	ORIGIN COORDINATES		SCALE
	X	Y	
BROOKSTON SOUTHWEST QUADRANGLE	0.000	36.150	1.000
BROOKSTON QUADRANGLE	17.400	36.150	1.000
STOCKMELL QUADRANGLE	17.400	-9.350	1.000
RODNEY QUADRANGLE	0.000	-9.350	1.000

PROGRAM	LOADS	DEFINITION		REFERENCES	
LAFL	TYPE	TYPE	DEFINITION	TYPE	DEFINITION
AREA	R	2.	D	16.	17.
EOF	R	21.		28.	42.
FAC	F	2.		40.	48.
FACTOR	R	2.		16.	17.
FORM	I	2.		27.	34.
	I	4.		41.	41.
DATA	I	70.		64.	73.
DATA	I	2.		82.	82.
DATA	I	72.		56.	59.
DATA	I	73.		82.	82.
DATA	I	13.		14.	14.
DATA	I	73.		17.	79.
DATA	I	71.		81.	81.
DATA	I	82.		17.	17.
DATA	I	16.		62.	63.
DATA	I	67.		66.	67.
DATA	I	11.		13.	15.
DATA	I	9.		31.	32.
DATA	I	9.		78.	81.
DATA	I	10.		76.	77.
DATA	I	12.		13.	14.
DATA	I	29.		30.	31.
DATA	I	30.		32.	33.
DATA	I	26.		27.	29.
DATA	I	64.		39.	41.
DATA	I	2.		44.	45.
DATA	I	45.		48.	48.
DATA	I	22.		23.	24.
DATA	I	4.		31.	32.
DATA	I	4.		50.	51.
DATA	I	4.		16.	20.
DATA	I	4.		19.	24.
DATA	I	2.		31.	46.
DATA	I	22.		24.	31.
DATA	I	2.		27.	41.
DATA	I	2.		32.	47.
DATA	I	22.		24.	32.
DATA	I	2.		32.	41.
DATA	I	2.		33.	45.
DATA	I	2.		45.	50.
DATA	I	2.		30.	33.

3R SYMBOLS DEFINED

1R MAXIMUM NUMBER OF REFERENCES

178 TOTAL NUMBER OF REFERENCES

4.7 AVERAGE NUMBER OF REFERENCES

IMPORTANT NOTICE

Program TREND involves matrix inversion procedures. The CDC 6500 has a 60-bit word. Due to this long word-length single precision gives sufficiently accurate results.

However on other computers with shorter word lengths (including all IBM 360's and 7094's and similar machines) double precision must be used.

The following variables need to be declared double precision:-

PAR, XX, A, B, BB, XINV, SSZ, SSQZ, SSR.

BBB in Subroutine RITER

AM in Subroutine INVER

o) LISTING OF PROGRAM TREND

1.	PROGRAM TREND(INPUT,OUTPUT,PUNCH,TAPE1,TAPE2,TAPE4,TAPES=INPUT,TAP 1E6=OUTPUT)	2
C	-----	4
C	PROGRAM TREND	6
C	-----	8
C	PURPOSE --	10
C	-----	12
C	TO PERFORM TREND SURFACE ANALYSIS USING POWER SERIES EXPANSION. POLYNOMIALS UP TO THE FIFTH DEGREE CAN BE REQUESTED. THE PROGRAM HAS EVOLVED FROM AN EARLIER SERIES OF PROGRAMS CALLED # POLYFIT # . THE PROGRAM IS USED WITHIN THE GCARS SYSTEM TO CHECK DATA FOR GENERAL VALIDITY , AND TO CONVERT TOPOGRAPHIC MEASURES TO EARTHWORK COST VALUES.	14 16 18 20 22 24 26 28
C	-----	30
C	THE GCARS SYSTEM	32
C	PURDUE UNIVERSITY	34
C		36
C		38
C	A. KEITH TURNER,	40
C	CIVIL ENGINEERING,	42
C	JUNE 1969.	44
C	-----	46
C	GENERAL INFORMATION	48
C	-----	50
C	THE PROGRAM CAN FIT A SURFACE TO AN ESSENTIALLY UNLIMITED NUM- BER OF OBSERVATIONS. APPROXIMATELY 11,000 OBSERVATIONS HAVE BEEN SUCCESSFULLY ANALYZED AT ONCE. HOWEVER, CARE SHOULD BE TAKEN TO SEE THAT VALUES REPRESENTING SUMS OF POWERS DO NOT EXCEED THE MAXIMUM SIZE THAT CAN BE HANDLED BY THE COMPUTER.	52 54 56 58 60 62 64
C	-----	66
C	OBSERVATIONS MUST BE DEFINED IN TERMS OF TWO INDEPENDENT VARI- ABLES (X AND Y COORDINATES) AND ONE DEPENDENT VARIABLE (Z). THE PROGRAM COMPUTES A SERIES OF LEAST SQUARES REGRESSION SURFACES (TREND SURFACES) TO THESE DATA. PROGRAM OPTIONS INCLUDE -	68 70 72 74
C	-----	76
C	(1) CALCULATION OF REQUESTED TREND SURFACES	78
C	(2) LISTING OF MATRICES USED IN DETERMINING THE COEFFICIENTS	80
C	(3) LIST OF COEFFICIENTS	82
C	(4) ESTIMATE OF ERROR IN EACH COEFFICIENT	84
C	(5) ANALYSIS OF VARIANCE STATISTICS	86
C	(6) LISTING OF ORIGINAL DATA, COMPUTED VALUES, AND RESIDUALS FOR ALL OBSERVATION POINTS	88 90
C	(7) GRIDDED VALUES OF SELECTED SURFACES ON A DESIGNATED SPACING	92
C	AND (8) CONTOUR MAPS OF THE TREND SURFACES ON THE PRINTER (THESE ARE PRODUCED BY SUBROUTINE PRCON4).	94 96
C	THE VARIOUS OPTIONS ARE REQUESTED BY APPROPRIATE CONTROL CARDS. THE CONTROL CARDS ARE READ BY A SPECIAL SUBROUTINE (IREAD) AND ARE THUS DESCRIBED IN DETAIL IN THAT SECTION.	98 100 102 104
C	-----	106
C	TAPE REQUIREMENTS --	108
C	THE PROGRAM UTILIZES UP TO THREE TAPE FILES IN ADDITION TO THE NORMAL INPUT, OUTPUT, AND PUNCH FILES. THE NUMBER REQUIRED DEPENDS ON THE OPTIONS REQUESTED. THE TAPES ARE -	110 112 114 116
C	A) TAPE1 - A SCRATCH TAPE USED TO STORE OBSERVATION DATA DURING THE ANALYSIS (USE REQUIRED).	118 120
C	B) TAPE2 - INPUT TAPE SUPPLYING OBSERVATION DATA (USE OPTIONAL).	122
C	C) TAPE4 - OUTPUT TAPE CONTAINING ORIGINAL AND COMPUTED VALUES FOR ALL OBSERVATIONS (USE OPTIONAL).	124 126 128
C	-----	130
C	THE PROGRAM ALSO CAN PRODUCE PUNCHED CARDS FOR THE GRIDDED VALUES OF THE TREND SURFACES. THESE CAN BE SUBMITTED AS DATA WITH PROGRAM CONTOUR TO PRODUCE CONTOUR MAPS ON THE CALCOMP PLOTTER.	132 134 136
C	-----	138
C	DESCRIPTION OF CONTROL CARDS --	140
C	-----	142
C	THE CONTROL CARDS ARE DESCRIBED IN SUBROUTINE IREAD , WHICH HEADS ALL DATA REQUIRED BY THIS PROGRAM FROM CARDS AND TAPE.	144 146 148 150

C	-----	152
C	REQUIRED SUBROUTINES =	154
C	- IREAD = READS IN DATA.	156
C	- RITER = WRITES MOST OF THE OUTPUT.	158
C	- ANOVA = COMPUTES AND WRITES STATISTICS.	160
C	- INVER = INVERTS MATRICES TO COMPUTE COEFFICIENTS.	162
C	- POLY = EVALUATES EQUATIONS AT GIVEN X-Y COORDINATES.	164
C	-----	166
C	OPTIONAL SUBROUTINES =	168
C	- PRTCON4 = PREPARES CONTOUR MAPS OF THE SURFACES.	170
C	- STATS = COMPUTES STATISTICS REQUIRED BY PRTCON4.	172
C	-----	174
C	-----	176
C	-----	178
C	-----	180
2.	DIMENSION ISURF(5), IPUN(5)	182
3.	DIMENSION TITL(8)	184
4.	DIMENSION C(50,50)	186
5.	DIMENSION X(1000), Y(1000), Z(1000)	188
6.	DIMENSION XX(21,21), A(21,5), XINV(21,21,5), PAR(21), BB(21), LIMIT(5)	190
7.	DIMENSION SYMTAB(21)	192
8.	DIMENSION AREA(3), FACTOR(3)	194
9.	DIMENSION CON(5), TOUR(5), LINES(5), INCHES(5), ZMIN(5), ZMAX(5)	196
10.	COMMON /INFO/ KNUM,JNUM,LIMIT,NCARDS,AREA,FACTOR,XMAX,XMIN,YMAX,YM	198
	1IN,ROWS,COLS,INCK,NHES,NNCARD,KTR,ISURF,IPUN,CON,TOUR,LINES,INCHES	200
	2,ZMIN,ZMAX,ITYPE,NTAPE,K	202
11.	COMMON /MATRIX/ X,Y,Z,A,XX,XINV,BB	204
12.	COMMON /MAPS/ KON,NTOUR,LINE,WIDTH,INHPSO,INCON(8),ORANG(25),ZMINI	206
	1,ZMAXI	208
13.	INTEGER SYSIN,SYSTOT,SDF1,SDF2,SDF4	210
14.	INTEGER TITL	212
15.	INTEGER SYMTAB	214
16.	INTEGER ROWS,COLS	216
17.	INTEGER CON,TOUR	218
18.	REAL INCHES	220
19.	DATA SYSIN,SYSTOT,SDF1,SDF2,SDF4/5,6,1,2,4/	222
20.	DATA TITL(1)/10HCONTOUR MA/,TITL(2)/10HP OF TREND/,TITL(3)/10H SUR	224
	1FACE F/,TITL(4)/10HOR DEGREE /,(TITL(5),J=5,8)/10H /	226
21.	DATA (SYMTAB(I),I=1,5)/10HONE ,10HTWO ,10HTHREE ,1	228
	10HFOUR ,10HFIVE /	230
22.	EQUIVALENCE (X,C)	232
	-----	234
23.	REWIND SDF2	236
24.	REWIND SDF4	238
25.	REWIND SDF1	240
	-----	242
C	-----	244
C	INITIALIZE ALL COUNTERS	246
C	-----	248
26.	INHPSO=0	250
27.	XD=0.0	252
28.	YD=0.0	254
29.	ZD=0.0	256
30.	ZSUM=0.0	258
31.	SSZ=0.0	260
C	-----	262
C	CALL SUBROUTINE IREAD TO OBTAIN CONTROL PARAMETERS	264
C	-----	266
32.	CALL IREAD (1)	268
C	-----	270
C	FIND LARGEST DEGREE FIT REQUESTED	272
C	-----	274
33.	DO 15 I=1,5	276
34.	J=6-I	278
35.	IF (LIMIT(J)) 10,15,10	280
36.	N=((J+1)*(J+2))/2	282
37.	JUMP=I	284
38.	JACK=6-JUMP	286
39.	GO TO 20	288
	-----	290
40.	15 CONTINUE	292
41.	GO TO 200	294
C	-----	296
	-----	298

	C	-----	300
	C	INITIALIZE PAR(1) AND ZERO XX AND BB ARRAYS	302
	C	-----	304
42.	20	PAR(1)=1.0	306
43.		DO 30 I=1,N	308
44.		DO 25 J=I,N	310
45.	25	XX(I,J)=0.0	312
46.	30	BB(I)=0.0	314
	C	-----	316
	C	PREPARE JOB TITLE PAGE	318
	C	-----	320
47.	C	CALL RITER (JACK,Y)	322
	C	-----	324
	C	READ DATA FROM TAPE3	326
	C	-----	328
48.		IF (NCARDS.GT.1000) GO TO 35	330
49.		KNUM=1	332
50.		KTR=NCARDS	334
51.		KTSW=1	336
52.		GO TO 40	338
	C	-----	340
53.	35	KNUM=NCARDS/1000	342
54.		JNUM=NCARDS-KNUM*1000	344
55.		KTR=1000	346
56.		KTSW=0	348
57.	40	NNCARD=NCARDS	350
58.		NCARDS=0	352
59.		DO 85 K=1,KNUM	354
60.	45	CALL IREAD (2)	356
	C	-----	358
	C	CHECK EACH DATA OBSERVATION TO SEE IF IT	360
	C	FALLS WITHIN LIMITS OF AREA OF INTEREST	362
	C	-----	364
61.		DO 85 IKT=1,KTR	366
62.		IF (X(IKT).GT.XMAX.OR.X(IKT).LT.XMIN) GO TO 85	368
63.		IF (Y(IKT).GT.YMAX.OR.Y(IKT).LT.YMIN) GO TO 85	370
64.		NCARDS=NCARDS*1	372
65.		XD=X(IKT)	374
66.		YD=Y(IKT)	376
67.		ZD=Z(IKT)	378
68.		PAR(2)=XD	380
69.		PAR(3)=YD	382
70.		GO TO (50,50,50,50,70); JUMP	384
71.	50	PAR(4)=XD*XD	386
72.		PAR(5)=XD*YD	388
73.		PAR(6)=YD*YD	390
74.		GO TO (55,55,55,70,70); JUMP	392
75.	55	PAR(7)=PAR(4)*XD	394
76.		PAR(8)=PAR(4)*YD	396
77.		PAR(9)=PAR(6)*XD	398
78.		PAR(10)=PAR(6)*YD	400
79.		GO TO (60,60,70,70,70); JUMP	402
80.	60	PAR(11)=PAR(7)*XD	404
81.		PAR(12)=PAR(7)*YD	406
82.		PAR(13)=PAR(4)*PAR(6)	408
83.		PAR(14)=PAR(10)*XD	410
84.		PAR(15)=PAR(10)*YD	412
85.		GO TO (65,70,70,70,70); JUMP	414
86.	65	PAR(16)=PAR(11)*XD	416
87.		PAR(17)=PAR(11)*YD	418
88.		PAR(18)=PAR(7)*PAR(6)	420
89.		PAR(19)=PAR(10)*PAR(4)	422
90.		PAR(20)=PAR(15)*XD	424
91.		PAR(21)=PAR(15)*YD	426
	C	-----	428
	C	DEVELOP XX MATRIX. --	430
	C	IT CONTAINS THE XY-TRANSPOSE,XY VALUES	432
	C	-----	434
92.	70	DO 75 I=1,N	436
93.		DO 75 J=I,N	438
94.	75	XX(I,J)=XX(I,J)+PAR(I)*PAR(J)	440

```

C -----
C DEVELOP BB MATRIX. --
C IT CONTAINS THE XY=TRANSPOSE,Z VALUES
C -----
95.      DO 80 I=1,N
96.      80  BB(I)=BB(I)+ZD*PAR(I)
97.      SSZ=SSZ+ZD*ZD
98.      ZSUM=ZSUM+ZD
99.      85  CONTINUE
100.     IF (KTSW.EQ.1) GO TO 90
101.     KTR=JNUM
102.     KTSW=1
103.     GO TO 45
C -----
104.     90  DO 100 II=1,5
105.         K=6-II
106.         IF (LIMIT(K)) 95,100,95
107.         95  GO TO 105
C -----
108.     100  CONTINUE
C -----
C CALL RITER TO PRINT UPPER RIGHT DIAGONAL OF THE XX ARRAY
C -----
109.     105  IF (INCK.EQ.2) CALL RITER (K,2)
C -----
C COMPLETE DEVELOPMENT OF SYMMETRIC XX ARRAY
C -----
110.     NMI=N-1
111.     DO 110 I=1,NMI
112.         IP1=I+1
113.         DO 110 J=IP1,N
114.         110  XX(J,I)=XX(I,J)
C -----
C CALL RITER TO PRINT ENTIRE SYMMETRIC XX ARRAY
C -----
115.     IF (INCK.EQ.2) CALL RITER (K,3)
116.     DO 125 K=1,5
117.         IF (LIMIT(K)) 115,125,115
118.         115  NTERMS=((K+1)*(K+2))/2
119.         KS08=0
120.         CALL INVER (NTERMS,K,KS08)
121.         IF (KS08) 120,125,120
122.         120  CALL RITER (K,6)
123.         LIMIT(K)=0
124.         125  CONTINUE
125.         IF (INCK) 130,140,130
C -----
C CALL RITER TO PRINT IDENTITY MATRICES
C -----
126.     130  CALL RITER (JACK,8)
127.     DO 140 K=1,5
128.         IF (LIMIT(K)) 135,140,135
129.         135  CALL RITER (K,1)
130.         140  CONTINUE
C -----
C COMPUTE COEFFICIENTS
C -----
131.     DO 155 K=1,5
132.         IF (LIMIT(K)) 145,155,145
133.         145  NTERMS=((K+1)*(K+2))/2
134.         DO 150 I=1,NTERMS
135.             A(I,K)=0.0
136.             DO 150 J=1,NTERMS
137.                 A(I,K)=A(I,K)+XINV(I,J,K)*BB(J)
138.             150  CONTINUE
C -----
C CALL SUBROUTINE ANOVA TO COMPUTE AND LIST STATISTICS
C -----
139.     CALL ANOVA (SSZ,ZSUM,JUMP)
140.     IF (NRES) 160,165,160

```


	C	-----	582
	C	OUTPUT RESIDUALS ON TAPE OR JUST PRINT THEM	584
	C	-----	586
141.	160	CALL RITER (JACK,R)	588
142.		CALL RITER (0,4)	590
143.	165	CONTINUE	592
144.		DO 195 K=1,5	594
145.		IF (ISURF(K).NE.1.AND.IPUN(K).NE.1) GO TO 190	596
146.		XINC=(XMAX-XMIN)/FLOAT(COLS-1)	598
147.		YINC=(YMAX-YMIN)/FLOAT(ROWS-1)	600
	C	-----	602
	C	DEFINE STARTING X AND Y	604
	C	-----	606
148.		XD=XMIN	608
149.		YD=YMAX	610
150.		DO 175 JJ=1,ROWS	612
151.		DO 170 KK=1,COLS	614
152.		CALL POLY (PT,XD,YD,K)	616
153.		C(JJ,KK)=PT	618
154.	170	XD=XD+XINC	620
155.		XD=XMIN	622
156.	175	YD=YD+YINC	624
157.		CALL RITER (JACK,B)	626
158.		CALL RITER (K,5)	628
159.		IF (ISURF(K).NE.1.OR.COLS.GT.64) GO TO 185	630
160.		TITL(5)=SYMTAB(K)	632
161.		DO 180 I=1,NMAP	634
162.		KON=CON(I)	636
163.		NTOUR=TOUR(I)	638
164.		LINE=LINES(I)	640
165.		WIDTH=INCHES(I)	642
166.		ZMINI=ZMIN(I)	644
167.		ZMAXI=ZMAX(I)	646
168.	180	CALL PRITCON4 (C,TITL,ROWS,COLS,50,50)	648
169.	185	CONTINUE	650
170.	190	CONTINUE	652
171.	195	CONTINUE	654
172.		GO TO 5	656
	C	-----	658
	C	-----	660
	C	NO FITS ASKED FOR. CALL RITER TO PRINT STATEMENT.	662
	C	-----	664
173.	200	CALL RITER (0,7)	666
174.		GO TO 5	668
	C	-----	670
175.		END	672-

p) FORSTAT CROSS-REFERENCE LISTING FOR PROGRAM TREND

PROGRAM	TREND			
STATEMENT NUMBER	DEFINITION		REFERENCES	
5	25.	172.	174.	
10	36.	35.		
15	40.	33.	35.	
20	42.	39.		
25	45.	44.		
30	46.	43.		
35	53.	48.		
40	57.	52.		
45	60.	103.		
50	71.	70.		
55	75.	74.		
60	80.	79.		
65	86.	85.		
70	92.	70.	74.	79.
75	94.	92.	93.	85.
80	96.	95.		
85	99.	59.	61.	62.
90	104.	100.	63.	
95	107.	106.		
100	108.	104.	106.	
105	109.	107.		
110	114.	111.	113.	
115	118.	117.		
120	122.	121.		
125	124.	116.	117.	121.
130	126.	125.		
135	129.	128.		
140	130.	125.	127.	128.
145	133.	132.		
150	137.	134.	136.	
155	138.	131.	132.	
160	141.	140.		
165	143.	140.		
170	154.	151.		
175	156.	150.		
180	168.	161.		
185	169.	159.		
190	170.	145.		
195	171.	144.		
200	173.	41.		

40 STATEMENT NUMBERS DEFINED

4 MAXIMUM NUMBER OF REFERENCES

57 TOTAL NUMBER OF REFERENCES

1.4 AVERAGE NUMBER OF REFERENCES

PROGRAM

TREND

LABEL	TYPE	DEFINITION	REFERENCES
ANOVA	R	6. CD	11. 135. 137. 152.
AREA	R	139.	
BB	R	8. CD	10.
C	R	6. CD	11. 46. 96. 137.
COLS	I	4. DE	22. 153. 168.
CON	I	10. C	16. 146. 151. 159. 168.
DRANG	I	9. CD	10. 17. 162.
FACTOR	R	12. CD	
FLOAT	R	8. CD	10.
I	I	FUNCTION	147.
		DATA	33. 34. 37. 43. 44. 45. 46. 92. 93. 94. 95. 96. 111. 112.
			114. 134. 135. 137. 161. 162. 163. 164. 165. 166. 167.
IMYPSO	I	12. C	26.
II	I	104.	105.
IKT	I	61.	62.
INCHES	R	8. CD	63. 65. 66. 67.
INCK	I	10. C	10. 18. 165.
INCON	I	12. CD	109. 115. 125.
INFO	I	10. C	
INVER	I	120.	
IPUN	I	2. CD	10. 145.
IP1	I	113.	
IREAD	I	32.	
ISURF	I	SUBROUTINE	60.
ITYPE	I	10. CD	10. 145. 159.
J	I	10. C	
JACK	I	20.	34. 35. 36. 44. 45. 93. 94. 113. 114. 136. 137.
JJ	I	38.	47. 126. 141. 157.
JNUM	I	150.	153.
JUMP	I	10. C	54. 101.
K	I	37.	38. 70. 74. 79. 85. 139.
		10. C	59. 105. 106. 109. 115. 116. 117. 118. 120. 122. 123. 127. 128. 129.
		10. C	131. 132. 133. 135. 137. 144. 145. 152. 158. 159. 160.
KK	I	151.	153.
KNUM	I	10. C	49. 53. 54. 59.
KON	I	12. C	162.
KSOB	I	119.	120. 121.
KTR	I	10. C	50. 55. 61. 101.
KTSW	I	51.	56. 100. 102.
LIMIT	I	6. CD	10. 35. 106. 117. 123. 128. 132.
LINE	I	12. C	164.
LINES	I	8. CD	10. 164.
MAPS	I	12. C	
MATRIX	I	11. C	

N	36.	43.	44.	92.	93.	95.	110.	113.	
NCAHDS	10. C	48.	50.	53.	54.	57.	58.	64.	
NMAP	161.								
NM1	110.	111.							
NMCARD	10. C	57.							
NRES	10. C	140.							
NTAPE	10. C								
NTERMS	118.	120.	133.	134.	136.				
NTOUR	12. C	163.	68.	69.	71.	72.	73.	75.	76.
PAR	8. D	42.	84.	86.	87.	88.	89.	90.	91.
		84.	86.	87.	88.	89.	90.	91.	94.
									96.
POLY	152.								
PRICONA	152.								
PT	47.	153.							
ROMS	10. C	109.	115.	122.	126.	129.	141.	142.	157.
SDF1	13.	16.	147.	150.	168.				173.
SDF2	13.	19.	25.						
SDF4	13.	19.	23.						
SSZ	31.	13.	19.	24.					
SYMTAB	7. D	97.	139.						
SYSDIN	13.	15.	21.	160.					
SYSGT	13.	19.							
TITL	3. D	14.	20.	160.	168.				
TOUR	9. CD	10.	17.	163.					
WIDTH	12. C	165.							
X	27.	11.	22.	62.	65.				
XD	146.	65.	64.	71.	72.	75.	77.	80.	83.
XINC	6. CD	154.							86.
XINV	10. C	11.	120.	137.					90.
XMAX	10. C	62.	146.						148.
XMIN	6. CD	11.	45.	94.	114.	120.			152.
XX	5. CD	11.	63.	66.					154.
Y	28.	66.	69.	72.	73.	76.	78.	81.	84.
YD	147.	156.							87.
YINC	10. C	63.	147.	149.					91.
YMAX	10. C	63.	147.						149.
YMIN	5. CD	11.	67.						152.
Z	23.	67.	96.	97.	98.				154.
ZD	9. CD	10.	167.						155.
ZMAX	12. C	167.							
ZMAXI	12. C	166.							
ZMIN	12. C	166.							
ZMINI	30.	98.	139.						
ZSUM									

85 SYMBOLS DEFINED
25 MAXIMUM NUMBER OF REFERENCES
291 TOTAL NUMBER OF REFERENCES
3.4 AVERAGE NUMBER OF REFERENCES

q) LISTING OF SUBROUTINE IREAD

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SUBROUTINE IREAD (KODE)
-----
SUBROUTINE IREAD
-----
PURPOSE--
TO READ IN DATA AND CONTROL OPTIONS FROM CARDS AND TAPE AS DE-
SIRED.
-----
THE GCARS SYSTEM
PURDUE UNIVERSITY
-----
A. K. TURNER,
CIVIL ENGINEERING,
JUNE 1969.
-----
USAGE--
CALL IREAD(KODE)
WHERE KODE = A POINTER TO CORRECT ENTRY POINT.
IF KODE = 1, CONTROL CARDS AND DATA TO BE READ IN.
DATA TO BE PLACED ON TEMPORARY STORAGE
TAPE (TAPE 1)
IF KODE = 2, READ DATA OFF TEMPORARY STORAGE TAPE
(TAPE 1)
NOTE-- THIS SUBROUTINE UTILIZES THE FOLLOWING LABELLED COMMON
/ MATHIA /
/ INFO /
-----
DESCRIPTIONS OF CONTROL CARDS--
(1) LABEL CARD -
THE WORD *TRENDS* MUST APPEAR IN COLUMNS 1-6. THIS CARD
INDICATES THE START OF A DATA SET.
(2) MASTER CONTROL CARD -
THIS CARD MUST HAVE THE WORD *TRENDS* IN COLUMNS 5-10.
THE CARD CAN HAVE EITHER OF TWO FORMATS -
(A) ALL TRENDS
OR (B) TRENDS 1,2,3,4,5 WHERE ANY OF THESE NUMBERS MAY BE
OMITTED.
IN CASE (A) *ALL TRENDS* REQUESTS A SET OF STANDARD OUTPUT
OPTIONS AND THE FITTING OF ALL FIVE TREND SURFACES (SEE
NEXT SECTION FOR DETAILS). IN CASE (B) FIVE TRENDS WOULD
BE FITTED, BUT NO OPTIONS HAVE BEEN SPECIFIED. CASE (B)
CAN ALSO BE USED TO REQUEST ONLY CERTAIN SURFACES.
(3) OPTION CARD(S) -
THESE ALL HAVE A STAR IN COLUMN 1, FOLLOWED BY A NAME.
THE PROGRAM ONLY CHECKS THE FIRST SIX COLUMNS OF THE CARD.
THE REMAINDER CAN HAVE COMMENTS DESCRIBING THE REQUEST.
THE FOLLOWING OPTION CARDS CAN BE USED IN ANY COMBINATION-
*MAPS - PRINT MAPS OF FITTED TREND SURFACES.
*PUNCH - PUNCH CARDS CONTAINING GRID VALUES FOR EACH OF
THE FITTED TREND SURFACES.
*TAPE2 - INPUT (OBSERVATION) DATA SUPPLIED ON A TAPE
(TAPE2). THE PROGRAM EXPECTS 3000-WORD LOGICAL
RECORDS WITH THE DATA SIGNED X1,Y1,Z1,X2,Y2,Z2
UP TO X1000,Y1000,Z1000. ONE LEAD RECORD
CONTAINS IDENTIFICATION INFORMATION.
*TAPE4 - STORE ORIGINAL VALUES, COMPUTED VALUES, AND
RESIDUALS FOR ALL OBSERVED DATA POINTS ON TAPE
(TAPE4). THE DATA IS IN THE SAME SEQUENCE AS
DISPLAYED BY THE *RESIDUALS* OPTION.
*IDENTITY - PRINT IDENTITY MATRICES. THIS IS A USEFUL
CHECK ON THE ACCURACY OF THE MATRIX INVERSION.
*DEBUG - PRINT ALL MATRICES USED IN THE COMPUTATION.
*RESIDUALS - PRINT ORIGINAL VALUES, COMPUTED VALUES, AND
RESIDUALS FOR ALL OBSERVED DATA POINTS.
THESE OPTION CARDS CAN BE USED TO INCREASE THE OPTIONS
SPECIFIED BY THE USE OF AN *ALL TRENDS* MASTER CARD.
WITHOUT MODIFICATION, THE USE OF *ALL TRENDS* IMPLIES THE
USE OF *MAPS* AND *IDENTITY* OPTION CARDS.
(4) *END CARD -
THE OPTION CARDS MUST BE TERMINATED WITH A *END CARD. *END*
IS PLACED IN COLUMNS 1-4. IF NO OPTION CARDS FOLLOW THE
MASTER CONTROL CARD, THE *END CARD* FOLLOWS IMMEDIATELY.
IN OTHER WORDS, AT LEAST TWO CARDS ARE REQUIRED,
FOR EXAMPLE -
ALL TRENDS
*PUNCH

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C (5) AREA DEFINITION CARD - R 162
 C N - (COLS 1-5) - NUMBER OF DATA POINTS BEING SUPPLIED. R 164
 C XMAX - (COLS 11-20) - MAXIMUM X-COORDINATE OF ANALYSIS AREA. R 166
 C XMIN - (COLS 21-30) - MINIMUM X-COORDINATE OF ANALYSIS AREA. R 168
 C YMAX - (COLS 31-40) - MAXIMUM Y-COORDINATE OF ANALYSIS AREA. R 170
 C YMIN - (COLS 41-50) - MINIMUM Y-COORDINATE OF ANALYSIS AREA. R 172
 C R 174
 C R 176
 C R 178
 C R 180
 C THE FOLLOWING CARDS ARE REQUIRED ONLY IF THE *MAPS OR *PUNCH OPTIONS R 182
 C HAVE BEEN SPECIFIED (THEY ARE REQUIRED WHENEVER THE #ALL TRENDS# R 184
 C MASTER CONTROL CARD IS USED). R 186
 C R 188
 C R 190
 C (6) GRID SPECIFICATION CARD - R 192
 C ROWS - (COLS 1-3) - DESIRED NUMBER OF ROWS IN GRID OF COM- R 194
 C PUTED TREND SURFACE VALUES. R 196
 C COLS - (COLS 4-6) - DESIRED NUMBER OF COLUMNS IN GRID OF R 198
 C COMPUTED TREND SURFACE VALUES. R 200
 C NMAP - (COLS 7-9) - NUMBER OF COPIES OF MAPS OF EACH SUR- R 202
 C FACE (MAXIMUM=5). THE MAXIMUM NUMBER OF MAPS R 204
 C THAT CAN BE PRODUCED BY ONE ANALYSIS IS R 206
 C 25 (5 TRENDS X 5 MAPS FOR EACH TREND). R 208
 C NOTE - ROWS, COLS , AND NMAP ARE INTEGERS. R 210
 C R 212
 C (7) PLOT CONTROL CARD(S) - R 214
 C NMAP SETS OF THESE CARDS ARE REQUIRED. EACH SET CONTAINS - R 216
 C R 218
 C (A) ONE CARD WITH - R 220
 C CON (COLS 1-2) - NUMBER OF CONTOUR INTERVALS (MAXIMUM =19) R 222
 C (CON = DATA RANGE/DESIRED CONTOUR INTERVAL) R 224
 C TOUR (COL 3) - IF TOUR=0, PROGRAM USES MAXIMUM AND MINIMUM R 226
 C OF SURFACE FOR UPPER AND LOWER CONTOUR R 228
 C LIMITS. R 230
 C IF TOUR=1, DESIRED TOP AND BOTTOM CONTOURS R 232
 C READ IN FROM NEXT CARD (SEE BELOW). R 234
 C IF TOUR=3, CONTOUR INTERVAL BECOMES 1/2 R 236
 C STANDARD DEVIATION (MAX = +3 SIGMA, R 238
 C MIN = -3 SIGMA). R 240
 C NOTE - TOUR = 2 (IRREGULAR CONTOUR INTERVALS OPTION) R 242
 C CANNOT BE REQUESTED BY TREND. R 244
 C LINES-(COL 4) -IF LINES = 0, CONTOUR LINES ARE PRINTED. R 246
 C IF LINES = 1, ALTERNATE (EVEN VALUED) R 248
 C CONTOUR HANDS ARE PRINTED. R 250
 C IF LINES = 2, ALL HANDS PRINTED (ALL PRINT R 252
 C POSITIONS). R 254
 C INCHES-(COL 5-8) INCHES IS WIDTH OF MAP IN INCHES. IF GREATER R 256
 C THAN 12.7 OR BLANK, SET TO 10.0) R 258
 C R 260
 C (B) ADDITIONAL CARD - REQUIRED ONLY IF TOUR = 1 R 262
 C THIS CARD SPECIFIES THE MINIMUM AND MAXIMUM CONTOUR R 264
 C ELEVATIONS. ZMIN (COLS 1-10) MINIMUM ELEVATION. R 266
 C ZMAX (COLS 11-20) MAXIMUM ELEVATION. R 268
 C NOTE - DECIMAL POINTS SHOULD BE PUNCHED. R 270
 C R 272
 C R 274
 C THE FOLLOWING CARDS ARE REQUIRED ONLY WHEN THE DATA IS BEING R 276
 C SUPPLIED FROM CARDS. THEY MUST BE OMITTED IF A *TAPE2 OPTION CARD R 278
 C IS USED. R 280
 C R 282
 C (8) FORMAT CARD - R 284
 C NPT - (COLS 1-5) - NUMBER OF OBSERVATION SETS / CARD. R 286
 C FORM - (COLS 7-55) - FORMAT OF DATA CARDS. R 288
 C R 290
 C R 292
 C (9) TITLE CARD - R 294
 C FACTOR - (COLS 1-30) - ALPHANUMERIC IDENTIFICATION OF FACTOR R 296
 C AREA - (COLS 31-70) - ALPHANUMERIC IDENTIFICATION OF AREA. R 298
 C ITYPE - (COL 71) - IF DATA MEASURES COSTS , ITYPE = 2 R 300
 C - IF DATA MEASURES BENEFITS, ITYPE = 3 R 302
 C R 304
 C (10) DATA CARDS - R 306
 C A SERIES OF CARDS R 308
 C A SERIES OF CARDS CONTAINING X,Y, AND Z-COORDINATES FOR R 310
 C ALL OBSERVATIONS. R 312

	C	-----	H 314
	C	REQUIRED SUBROUTINES=	H 316
	C	NONE	H 318
	C	OPTIONAL SUBROUTINES=	H 320
	C	NONE	H 322
	C	-----	H 324
2.		DIMENSION FORM(N)	H 326
3.		DIMENSION P(YOPT(10), IPUN(5), NDEGR(5), ISURF(5), LIMIT(5), AREA(3	H 328
		J), FACTOR(3), CON(5), TOUR(5), LINES(5), INCHES(5), ZMIN(5), /MAX(	H 330
		25)	H 332
4.		DIMENSION X(1000), Y(1000), Z(1000)	H 334
5.		INTEGER CON, TOUR	H 336
6.		INTEGER ROWS, CULS	H 338
7.		INTEGER SYSIN, SYSOI, SDF1, SDF2, SDF4	H 340
8.		REAL INCHES	H 342
9.		COMMON /MATRIX/ X,Y,Z,AX,AY,ALNV,BB	H 344
10.		COMMON /INFO/ KNUM, JNUM, LIMIT, NCARDS, AREA, FACTOR, AMAX, YMIN, YMAX, YH	H 346
		J(N, KNUM, CULS, INCHES, NCARD, KTR, ISURF, IPUN, CON, TOUR, LINES, INCHES	H 348
		2, ZMIN, ZMAX, ITYPE, NTAPE, K	H 350
11.		DATA SYSIR, SYSOI, SDF1, SDF2, SDF4/5,6,1,2,4/	H 352
12.		DATA NARENZ/6HIRENDS/, (NTOPT(1), I=1,9)/6H*MAPS, 6H*PUNCH, 6H*TAPE2, 6	H 354
		H*TAPE4, 6H*IDENTI, 6H*DEGRUS, 6H*RESIU, 6H*END, 3HALL/	H 356
13.		GO TO (5,115), KODE	H 358
	C	-----	H 360
	C	READ INPUT DATA TO FIND CARD WITH TRENDS ON IT	H 362
	C	-----	H 364
14.	B	READ (SYSIN,190) NAM	H 366
15.		IF (EOF, SYSIN) 155,10	H 368
16.	10	IF (NAM-NAREN) 5,15,5	H 370
	C	-----	H 372
	C	READ MASTER CONTROL CARD	H 374
	C	-----	H 376
17.	15	READ (SYSIN,170) KVAL, NAR, (NDEGR(1), I=1,5)	H 378
18.		IF (NAM, NE, NAREN) GO TO 150	H 380
19.		IF (KVAL, NF, MYOPT(9)) GO TO 25	H 382
	C	-----	H 384
	C	STANDARD OPTIONS REQUESTED BY #ALL TRENDS# CARD	H 386
	C	-----	H 388
20.		DO 20 I=1,5	H 390
21.	20	NDEGR(I)=1	H 392
22.		ISW=0	H 394
23.		ISW2=1	H 396
24.		INCR=1	H 398
25.		NRES=0	H 400
	C	-----	H 402
	C	READ OPTION CARD(5)	H 404
	C	-----	H 406
26.	25	READ (SYSIN,190) MYJOB	H 408
27.		DO 30 I=1,8	H 410
28.		IF (MYJOB, EQ, MYOPT(I)) GO TO 35	H 412
29.	30	CONTINUE	H 414
30.		GO TO 150	H 416
31.	35	GO TO (40,45,50,55,60,65,70,75), I	H 418
	C	-----	H 420
	C	MAPS OPTION REQUESTED	H 422
32.	40	ISW2=1	H 424
33.		GO TO 25	H 426
	C	-----	H 428
	C	-----	H 430
	C	-----	H 432
	C	PUNCH OPTION REQUESTED	H 434
34.	45	ISW=1	H 436
35.		GO TO 25	H 438
	C	-----	H 440
	C	-----	H 442
	C	TAPE2 OPTION REQUESTED	H 444
36.	50	NTAPE=1	H 446
37.		GO TO 25	H 448
	C	-----	H 450
	C	-----	H 452
	C	TAPE4 OPTION REQUESTED	H 454
38.	55	NTAPE=2	H 456
39.		GO TO 25	H 458
	C	-----	H 460
	C	-----	H 462
	C	IDENTITY OPTION REQUESTED	H 464
40.	60	INCR=1	H 466
41.		GO TO 25	H 468
	C	-----	H 470

	C	-----	B 472
	C	DEBUG OPTION REQUESTED	B 474
42.	07	INCR=2	B 476
43.		GO TO 25	B 478
	C	-----	B 480
	C	RESIDUALS OPTION REQUESTED	B 482
44.	70	NRES=1	B 484
45.		GO TO 25	B 486
	C	-----	B 490
	C	END CARD REACHED	B 492
	C	-----	B 494
	C	-----	B 496
46.	75	DO 80 K=1,5	B 498
47.		KK=NDIGR(K)	B 500
48.		IF (KK.EQ.0) GO TO 80	B 502
49.		LIMIT(KK)=1	B 504
50.		IPRIN(KK)=ISW	B 506
51.		ISWR(KK)=ISW2	B 508
52.	80	CONTINUE	B 510
	C	-----	B 512
	C	READ AREA DEFINITION CARD	B 514
	C	-----	B 516
53.		READ (SYSIN,180) NCARDS,XMAX,AMIN,YMAX,YMIN	B 518
54.		IF (ISW.NE.1.AND.ISW2.NE.1) GO TO 85	B 520
	C	-----	B 522
	C	READ GRID SPECIFICATION CARD	B 524
	C	-----	B 526
55.		READ (SYSIN,185) ROWS,COLS,NMAP	B 528
56.		IF (NMAP.LT.1.OR.NMAP.GT.5) NMAP=1	B 530
	C	-----	B 532
	C	READ PLOT CONTROL CARD(S)	B 534
	C	NUMBER OF THESE CARD SPIS = NMAP, MAXIMUM IS 5	B 536
	C	-----	B 538
57.		DO 85 I=1,NMAP	B 540
58.		READ (SYSIN,195) COM(I),FOUR(I),LINES(I),INCHES(I)	B 542
59.		IF (FOUR(I).NE.1) GO TO 85	B 544
60.		READ (SYSIN,200) ZMIN(I),ZMAX(I)	B 546
61.	85	CONTINUE	B 548
	C	-----	B 550
	C	READ DATA	B 552
	C	-----	B 554
62.		IF (NIAPE.EQ.1) GO TO 120	B 556
	C	-----	B 558
	C	READ DATA FROM CARDS TO TAPE1	B 560
	C	-----	B 562
	C	READ FORMAT CARD	B 564
	C	-----	B 566
63.		READ (SYSIN,205) NPT,FORM	B 568
	C	-----	B 570
	C	READ TITLE CARD	B 572
	C	-----	B 574
64.		READ (SYSIN,175) FACTOR,AREA,ITYPE	B 576
65.		IF (NCARDS.GT.1000) GO TO 90	B 578
66.		JNUM=NCARDS	B 580
67.		GO TO 105	B 582
	C	-----	B 584
68.	90	KNUM=NCARDS/1000	B 586
69.		JNUM=NCARDS-KNUM*1000	B 588
70.		NSTEP=1000/NPT	B 590
71.		DO 100 K=1,KNUM	B 592
72.		IMEG=1	B 594
73.		DO 95 N=1,NSTEP	B 596
74.		IFEND=IMEG+NPT-1	B 598
75.		READ (SYSIN,FORM) (X(I),Y(I),Z(I),I=IMEG,IFEND)	B 600
76.	95	IMEG=IMEG+NPT	B 602
77.	100	WRITE (SDP1) (X(I),Y(I),Z(I),I=1,1000)	B 604
78.	105	NSTEP=JNUM/NPT	B 606
79.		NCHK=NSTEP/NPT	B 608
80.		NVAL=ABS(NSTEP-NCHK)	B 610
81.		IF (NVAL.GT..1) NSTEP=NSTEP+1	B 612
82.		IMEG=1	B 614
83.		DO 110 N=1,NSTEP	B 616
84.		IFEND=IMEG+NPT-1	B 618
85.		READ (SYSIN,FORM) (X(I),Y(I),Z(I),I=IMEG,IFEND)	B 620
86.	110	IMEG=IMEG+NPT	B 622
87.		WRITE (SDP1) (X(I),Y(I),Z(I),I=1,JNUM)	B 624
88.		REWIND SDP1	B 626
89.		RETURN	B 628

	C	-----		
	C	READ DATA OFF TAPE1		R 630
	C	-----		R 632
90.	115	READ (SUP1) (X(I),Y(I),Z(I),I=1,KTR)		R 634
91.		RETURN		R 636
	C	-----		R 638
	C	READ DATA POINTS FROM INPUT TAPE (TAPE2)		R 640
	C	TO A SEARCH TAPE (TAPE1)		R 642
	C	-----		R 644
	C	READ TITLE RECORD FIRST		R 646
	C	-----		R 648
92.	120	READ (SUP2) FACTOR,AREA,IITYPE		R 650
93.		IF (NCARDS.GT.1000) GO TO 125		R 652
94.		KNUM=1		R 654
95.		KTR=NCARDS		R 656
96.		KIS=1		R 658
97.		GO TO 130		R 660
	C	-----		R 662
98.	125	KNUM=NCARDS/1000		R 664
99.		JNU=NCARDS-KNUM*1000		R 666
100.		KTR=1000		R 668
101.		KIS=0		R 670
102.	130	DO 140 K=1,KNUM		R 672
103.	135	READ (SUP2) (X(I),Y(I),Z(I),I=1,KTR)		R 674
104.	140	WRITE (SUP1) (X(I),Y(I),Z(I),I=1,KTR)		R 676
105.		IF (KIS.EQ.1) GO TO 145		R 678
106.		KTR=JNU		R 680
107.		KIS=1		R 682
108.		GO TO 135		R 684
	C	-----		R 686
109.	145	REWIND SUP1		R 688
110.		RETURN		R 690
111.	150	WRITE (SYSOUT,165)		R 692
112.	155	IF (NRES.NE.2) GO TO 160		R 694
113.		END FILE SUP4		R 696
114.		REWIND SUP4		R 698
115.	160	REWIND SUP2		R 700
116.		STOP		R 702
	C	-----		R 704
	C	-----		R 706
117.	165	FORMAT (1H1,24H***CONTROL CARD ERROR***)		R 708
118.	170	FORMAT (A3,1A,A6,5(1A,11))		R 710
119.	175	FORMAT (3A10,10A,3A10,4A,12)		R 712
120.	180	FORMAT (15,5A,4F10,0)		R 714
121.	185	FORMAT (313)		R 716
122.	190	FORMAT (A6)		R 718
123.	195	FORMAT (12,211,F4.0)		R 720
124.	200	FORMAT (2F10,0)		R 722
125.	205	FORMAT (15,1A,8A6)		R 724
126.		END		R 726

*** OF ***

r) FORSTAT CROSS-REFERENCE LISTINGS FOR SUBROUTINE IREAD

SUBROUTINE IREAD		REFERENCES	
STATEMENT NUMBER	DEFINITION		
5	10.	13.	14.
10	16.	15.	15.
15	17.	16.	
20	21.	20.	
25	25.	19.	33.
30	27.	35.	37.
35	31.	27.	41.
40	32.	28.	43.
45	34.	31.	45.
50	36.	31.	
55	38.	31.	
60	40.	31.	
65	42.	31.	
70	44.	31.	
75	46.	31.	
80	52.	46.	48.
85	61.	54.	57.
90	66.	57.	59.
95	76.	65.	
100	77.	73.	
105	78.	71.	
110	85.	67.	
115	90.	83.	
120	92.	13.	
125	98.	62.	
130	102.	93.	
135	103.	97.	
140	106.	106.	
145	109.	102.	
150	111.	105.	
155	112.	15.	30.
160	115.	15.	
165	117.	112.	
170	118.	111.	
175	119.	17.	
180	120.	64.	
185	121.	53.	
190	122.	55.	
195	123.	14.	24.
200	124.	58.	
205	125.	60.	
		63.	

41	STATEMENT NUMBERS DEFINED
B	MAXIMUM NUMBER OF REFERENCES
55	TOTAL NUMBER OF REFERENCES
1.3	AVERAGE NUMBER OF REFERENCES

EOF

*DEL*EOF*

SOPHROUTIME TIME 611

DEFINITION			REFERENCES	
LABEL	TYPE	DEFINITION		
A		4. C		
ABS	F	4. C		
AREA	F	3. C D	10.	64. 92.
BE	F	4. C		
COLS	I	4. C	10.	55.
CON	I	3. C D	5.	10. 58.
EOP	F	15.		
FACTOR	F	3. C D	10.	64. 92.
FORM	F	2. D	63. 75. 85.	
I	I	12. Data	27. 28. 31. 57. 59. 60. 75. 77. 85. 87.	
IREG	I	72.	27. 28. 31. 57. 59. 60. 75. 77. 85. 87.	
IRCO	I	74.		
INCHES	F	3. C D	10.	64. 92.
INCK	I	10. C	75. 84. 85.	
INFO	I	10. C	24. 40. 42.	
IPUN	I	3. C D	10.	50.
ISURF	I	3. C D	10.	51.
ISRT	I	22.	34. 50. 54.	
ISRP	I	23.	32. 51. 54.	
ITYPE	I	10. C	64. 92.	
JNDM	I	10. C	66. 69. 76.	
K	I	10. C	46. 47. 71. 102.	
KK	I	47.	48. 49. 50. 51.	
KNOW	I	10. C	66. 69. 71. 94. 98. 99. 102.	
KOUE	I	1.	13.	
KIX	I	10. C	40. 95. 100. 103. 104. 106.	
KIS	I	46.	101. 105. 107.	
KVAL	I	17.	19.	
LIMIT	I	3. C D	10.	44.
LINES	I	3. C D	10.	54.
MATHIA	I	4. C		
MYJON	I	26.	28.	
MYOPT	I	3. D DATA	12. 19. 28.	
N	I	73.	63.	
NATI	I	14.	16. 17. 18.	
NATER	I	12.	16.	
NCHARS	I	10. C	53. 65. 66.	
NCHP	I	79.	80.	
NDEGR	I	3. D	17. 21. 47.	
NMAP	I	55.	56. 57.	
NMCARD	I	10. C		
NPI	I	43.	70. 74. 76.	
			78. 79. 84. 86.	

8) LISTING OF SUBROUTINE ANOVA

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SUBROUTINE ANOVA (SSZ,ZSUM,JUMP)
-----
C
C      SUBROUTINE ANOVA
C
C  PURPOSE--
C      TO PRINT TREND SURFACE EQUATION COEFFICIENTS AND TO COMPUTE AND
C      PRINT ANALYSIS OF VARIANCE STATISTICS. STATISTICS COMPUTED INCLUDE
C      (1) ERROR ESTIMATES FOR COEFFICIENTS
C      (2) TOTAL F-TESTS FOR ALL EQUATIONS
C      (3) PARTIAL F-TESTS FOR HIGHEST DEGREE EQUATION
C      (4) PERCENT VARIATION EXPLAINED (R-SQUARED)
C
C  USAGE--
C      CALL ANOVA(SSZ,ZSUM,JACK)
C      WHERE -SSZ = UNCORRECTED SUM OF SQUARES OF Z
C              ZSUM = SUM OF Z
C              JACK = HIGHEST DEGREE TREND SURFACE REQUESTED
C      NOTE- THIS SUBROUTINE UTILIZES THE FOLLOWING LABELLED COMMON
C              /INFO/
C              /MATRIX/
C
C  DESCRIPTION OF CONTROL CARDS--
C      NONE REQUIRED
C
C  REQUIRED SUBROUTINES--
C      NONE
C
C  OPTIONAL SUBROUTINES--
C      NONE
C
C
C 1.  DIMENSION AREA(3), FACTOR(4)
C 2.  DIMENSION ISURF(5), IPUN(5)
C 3.  DIMENSION DUM1(3000), DUM2(441)
C 4.  DIMENSION LIMIT(5), A(21,5), BH(21), SSR(5), SSF(5), DFREE(5), ERR
C      1(21), XINV(21,21,5)
C 5.  INTEGER SYSIN,YSOT,SDF1,SDF2,SDF4
C 6.  COMMON /INFO/ NCARD,UNUM,LIMIT,NCARDS,AREA,FACTOR,XMAX,XMIN,YMAX,YM
C      1IN,ROWS,COLS,INCH,NRES,NCARD,K1R,TSURF,IPUN,CON,TOUR,LINES,INCHES
C      2,ZMIN,YMAX,ITYPE,NTAPE,K
C 7.  COMMON /MATRIX/ DUM1,A,DUM2,XINV,BH
C 8.  DATA SYSIN,YSOT,SDF1,SDF2,SDF4/5,6,1,2,4/
C
C  CALCULATE CORRECTED SUM OF SQUARES
C
C 9.  ZBAR=ZSUM/FLOAT(NCARS)
C10.  SSZBAR=ZSUM*ZBAR
C11.  SSZ=SSZ-SSZBAR
C12.  JACK=6-JUMP
C
C  PRINT COEFFICIENTS
C
C13.  CALL RITER (JACK,0)
C14.  WRITE (YSOT,105) NCARDS
C15.  WRITE (YSOT,110)
C16.  DO 10 K=1,5
C17.  IF (LIMIT(K)) 5,10,5
C18. 5  NTERMS=((K+1)*(K+2))/2
C19.  WRITE (YSOT,135)
C20.  WRITE (YSOT,115) K,(A(I,K),I=1,NTERMS)
C21. 10  CONTINUE
C22.  WRITE (YSOT,135)
C
C  ERROR ESTIMATES FOR COEFFICIENTS
C
C23.  CALL RITER (JACK,0)
C24.  WRITE (YSOT,120)
C25.  DO 30 K=1,5
C26.  IF (LIMIT(K)) 15,30,15
C27. 15  NTERMS=((K+1)*(K+2))/2
C28.  SSR(K)=0.0
C29.  DO 20 J=1,NTERMS
C30. 20  SSR(K)=SSF(K)+A(J,K)*DB(J)
C31.  SSR(K)=SSR(K)-SSZBAR
C32.  SSF(K)=SSZ-SSR(K)
C33.  DFREE(K)=NCARDS-NTERMS-1
C34.  STGMF=SQRT(SSF(K)/DFREE(K))
C35.  DO 25 J=1,NTERMS
C36. 25  ERR(J)=STGMF*SQRT(XINV(J,K))
C37.  WRITE (YSOT,135)
C38.  WRITE (YSOT,125) K,(ERR(J),J=1,NTERMS)
C39. 30  CONTINUE

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40.      WRITE (SYSOT,135)
C -----
C      ANALYSIS OF VARIANCE
C -----
C      TOTAL F-TESTS
C -----
41.      CALL RITER (JACK,H)
42.      WRITE (SYSOT,130)
43.      WRITE (SYSOT,135)
44.      WRITE (SYSOT,140)
45.      WRITE (SYSOT,135)
46.      NDF=NCAHDS-1
47.      WRITE (SYSOT,75) NDF,SS/BAH
48.      WRITE (SYSOT,135)
49.      DO 40 K=1,5
50.          IF (LIMIT(K)) 35,40,35
51.          NTERMS=((K+1)*(K+2))/2
52.          XSE=SSE(K)/DFREE(K)
53.          XSH=SSR(K)/FLOAT(INTERMS)
54.          XSE=SSE(K)/DFREE(K)
55.          XSH=SSR(K)/FLOAT(INTERMS)
56.          F=XSH/XSE
57.          NDF=DFREE(K)
58.          WRITE (SYSOT,145) K,NTERMS,NDF,SSR(K),XSH,SSF(K),XSE,F
59.          WHILE (SYSOT,135)
60.      CONTINUE
61.      WRITE (SYSOT,80) SSZ
C -----
C      PARTIAL F-TESTS
C -----
62.      CALL RITER (JACK,H)
63.      WRITE (SYSOT,140) JACK
64.      WRITE (SYSOT,145)
65.      WRITE (SYSOT,140)
66.      WRITE (SYSOT,145)
67.      NDFJ=DFREE(JACK)
68.      KSWT=1
69.      DO 60 K=1,5
70.          IF (LIMIT(K)) 45,60,45
71.          NTERMS=((K+1)*(K+2))/2
72.          GO TO (50,55), KSWT
73.          KSWT=2
74.          NTERMS=NTERMS-1
75.          XMSQ=SSP(K)/FLOAT(NTERMS)
76.          F=XMSQ/(SSE(JACK)/DFREE(JACK))
77.          WRITE (SYSOT,165) K,NTERMS,NDFJ,SSR(K),XMSQ,F
78.          WRITE (SYSOT,155)
79.          NTE=NTERMS-1
80.          J=K
81.          GO TO 60
C -----
C      55
82.          NTE=NTERMS-NTE
83.          SSQ=SSR(K)-SSR(J)
84.          XMSQ=SSQ/NDF
85.          F=XMSQ/(SSE(JACK)/DFREE(JACK))
86.          NDF=NDF
87.          WRITE (SYSOT,165) K,NDF,NDFJ,SSQ,XMSQ,F
88.          WRITE (SYSOT,155)
89.          J=K
90.          NTE=NTERMS
91.      CONTINUE
C -----
C      PERCENT VARIATION EXPLAINED
C -----
92.      CALL RITER (JACK,H)
93.      WRITE (SYSOT,85)
94.      WRITE (SYSOT,90)
95.      WRITE (SYSOT,95)
96.      WRITE (SYSOT,90)
97.      DO 70 K=1,5
98.          IF (LIMIT(K)) 65,70,65
99.          RR=SSR(K)/SSZ
100.          PCENT=RR*100.0
101.          R=SQRT(RR)
102.          WRITE (SYSOT,100) K,PCENT,RR,R
103.          WRITE (SYSOT,90)
104.      CONTINUE
105.      RETURN
C 160
C 162
C 164
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C 314

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C
C
106. 75 FORMAT (1H,8X,2(1H1,10X),4(1H1,18X),1H1,12X,1HT,/,9X,10H1) HEAL. C 320
1 1 1,15,3H 1,E10.8,1X,3(1HT,18X),1H1,12X,1HT,/,9X,2(1H1,10X),4 C 322
2(1H1,18X),1H1,12X,1HT) C 324
107. 80 FORMAT (///30X,47HCOEFFICIENT TOTAL SS= TOTAL SS = SS DUE TO MEAN =, C 326
1F60.6) C 328
108. 85 FORMAT (1H0,54X,31HANALYSIS OF VARIANCE STATISTICS,/,23X,47HPERCE C 330
INT SUMS OF SQUARES EXPLAINED BY REGRESSION,/,22X,50H(THIS EQUALS C 332
2X-SQUARED, THE SQUARE OF THE MULTIPLE,/,22X,25HCOEFFICIENT COEFFIC C 334
3IENT),///) C 336
109. 90 FORMAT (1H,22X,47H----- C 338
1) C 340
110. 95 FORMAT (1H,22X,1H1,8X,1H1,13X,2(1H1,11X),1H1,/,23X,47H DEGREE I C 342
PERCENT SS, 1 R-SQUARED) I 1,/,23X,1H1,8X,15H1 EXPLAINED C 344
2 1,2(11X,1H1),/,23X,1H1,8X,1H1,13X,2(1H1,11X),1H1) C 346
111. 100 FORMAT (1H,22X,1H1,8X,1H1,13X,2(1H1,11X),1H1,/,23X,2H1,1X,5H I C 348
1,F10.3,2(5H 1,F7.5),3H 1,/,23X,1H1,8X,1H1,13X,2(1H1,11X),1H1) C 350
112. 105 FORMAT (1H0,40X,52H THE NUMBER OF OBSERVATIONS USED IN THIS ANALYSI C 352
IS IS,15) C 354
113. 110 FORMAT (1H0,37X,67H THE COMPUTED COEFFICIENTS FOR THE REQUESTED THE C 356
1ND SURFACE EQUATIONS,/,43X,30H THE EQUATIONS HAVE THE FORM --,/,4 C 358
25X,50H EST.7 = A1+A2(X)+A3(Y)+A4(X**2)+A5(X)(Y)+A6(Y**2)+/,53X,47H C 360
3A7(X**3)+A8(X**2)(Y)+A9(X)(Y**2)+A10(Y**3)+/,53X,47HA11(X**4) C 362
4+A12(X**3)(Y)+A13(X**2)(Y**2)+/,53X,47HA14(X)(Y**3)+A15(Y C 364
5**4)+A16(X**5)+A17(X**4)(Y)+/,53X,47HA18(X**3)(Y**2)+A19(X**2)(Y C 366
6**3)+A20(X)(Y**4)+/,53X,10HA21(Y**5),/,48H DEGREE) C 368
114. 115 FORMAT (1H0,14,3X,7E16,/,F24.7,6E16,/,F24.7,6F16,7) C 370
115. 120 FORMAT (1H0,54X,31HANALYSIS OF VARIANCE STATISTICS,/,46X,47H ESTIM C 372
1ATE OF ERROR IN THE POLYNOMIAL COEFFICIENTS,/,10H DEGREE) C 374
116. 125 FORMAT (1H0,16,1X,/,F16.2,/,F24.2,6F16,2,/,F24.2,6E16,2) C 376
117. 130 FORMAT (1H0,54X,31HANALYSIS OF VARIANCE STATISTICS,/,52X,36H TOTAL C 378
1 F-TESTS FOR ALL THREE SURFACES,/) C 380
118. 135 FORMAT (1H,8X,112H----- C 382
1) C 384
119. 140 FORMAT (1H,8X,2(1H1,10X),4(1H1,18X),1H1,12X,1HT,/,9X,112H1 SOURC C 386
1E I D.F. I SS DUE TO REG. I MS DUE TO REG. I SS DUE TO ER C 388
2ROM I MS DUE TO ERROR I F-RATIO I,/,9X,2(1H1,10X),4(1H1,18X), C 390
31H1,12X,1HT) C 392
120. 145 FORMAT (1H,8X,2(1H1,10X),4(1H1,18X),1H1,12X,1HT,/,9X,9H1 DEGREE C 394
111,3H 1,I2,1H1,15,3(3H 1,F16.8),3H 1,F16.5,3H 1,F13.2,3H 1,/,9 C 396
2X,2(1H1,10X),4(1H1,18X),1H1,12X,1HT) C 398
121. 150 FORMAT (1H0,54X,31HANALYSIS OF VARIANCE STATISTICS,/,20X,53H PARTI C 400
IAL F-TESTS FOR GROUPS OF COEFFICIENTS WITHIN THE,12X,23H DEGREE THEN C 402
2D EQUATION,/) C 404
122. 155 FORMAT (1H,20X,40H----- C 406
1) C 408
123. 160 FORMAT (1H,20X,1H1,16X,1H1,10X,2(1H1,18X),1H1,12X,1H1,/,21X,80H1 C 410
1GROUP OF TERMS I D.F. I SS DUE TO GROUP I MS DUE TO GROUP I C 412
2 F-RATIO I,/,21X,1H1 JUST ADDED I,10X,2(1H1,18X),1H1,12X,1H C 414
1I,/,21X,1H1,16X,1H1,10X,2(1H1,18X),1H1,12X,1H1) C 416
124. 165 FORMAT (1H,20X,1H1,16X,1H1,10X,2(1H1,18X),1H1,12X,1H1,/,21X,12H1 C 418
1) DEGREE I,14X,2H1,12,1H1,15,2(3H 1,F16.8),3H 1,F10.3,2H 1,/, C 420
221X,1H1,16X,1H1,10X,2(1H1,18X),1H1,12X,1H1) C 422
125. END C 424=

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†) FORSTAT CROSS-REFERENCE LISTING FOR SUBROUTINE ANOVA

PAGE 1

STATEMENT NUMBER DEFINITION REFERENCE

13.	17.	
14.	17.	
15.	26.	
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PROGRAM	LABEL	TYPE	DEFINITION	REFERENCES
	A	I	4. CD	7. 20. 30.
	AMEA	I	1. CD	6.
	AR	I	4. CD	7. 30.
	COLS	I	6. C	
	COIN	I	6. C	
	DF	I	42.	
	DEFREE	I	4. D	
	DUM1	I	3. CD	44. 34. 52. 54. 57. 67. 76. 85.
	DUM2	I	3. CD	7.
	ERR	I	36. 38.	
	F	I	56. 76.	
	FACTOR	I	6.	47.
	FLOAT	I	1. CD	
	I	I	53. 55. 75.	
	INCHES	I	20.	
	INCK	I	6. C	
	INFO	I	6. C	
	IPUN	I	6. C	
	ISURF	I	2. CD	6.
	ITYPE	I	6. C	
	J	I	29.	
	JACK	I	30. 35. 36. 34. 40. 43. 49. 76. 85. 92.	
	JNUM	I	13. 23. 41. 62. 63. 67.	
	JUMP	I	12.	
	K	I	6. C	
	KNUM	I	16. 17. 18. 20. 25. 26. 27. 28. 30. 31. 32. 33. 34. 36. 37. 70. 71. 75.	
	KSWT	I	72. 73.	
	KIG	I	6. 17. 26. 50. 70. 74.	
	LMIT	I	4. CD	
	LINES	I	6. C	
	MATRIX	I	7. C	
	MNCARDS	I	6. C	
	NDE	I	9. 14. 33. 46. 87.	
	NDEJ	I	47. 57. 58. 86. 87.	
	NDEJ	I	77.	
	NDCARD	I	6. C	
	NDFS	I	6. C	
	NDAPE	I	6. C	
	NTE	I	79.	
	NTERMS	I	18.	
	PCENT	R	100.	
	R	R	101.	
	RITER	R	13. C	
	ROWS	R	99.	
	RR	R	100. 101. 102.	
	SDF1	I	8. DATA	
	SDF2	I	5. DATA	
	SDF4	I	5. DATA	

u) LISTING OF SUBROUTINE RITER

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1. SUBROUTINE RITER (K,KODE)
C -----
C SUBROUTINE RITER
C -----
C PURPOSE--
C TO PRINT ANSWERS ACCORDING TO REQUESTED OPTIONS
C -----
C USAGE--
C CALL RITER(K,KODE)
C WHERE-K = DEGREE OF EQUATION FOR WHICH ANSWER IS BEING PRO-
C DUCED
C KODE = POINTER USED TO SELECT PROPER REQUEST ACCORDING TO
C CONTROL OPTIONS IN CALLING ROUTINES
C NOTE- THIS SUBROUTINE UTILIZES THE FOLLOWING LABELLED COMMON-
C /INFO/
C /MATRIX/
C -----
C DESCRIPTIONS OF CONTROL CARDS -
C NONE REQUIRED
C -----
C REQUIRED SUBROUTINES-
C POLY
C OPTIONAL SUBROUTINES-
C NONE
C -----
2. DIMENSION AREA(3), FACTOR(3)
3. DIMENSION ISURF(5), IPUN(5)
4. DIMENSION X(1000), Y(1000), Z(1000), A(21,5), XX(21,21), XINV(21,2
11,5)
5. DIMENSION RR(21), LIMIT(5), BBR(21), ZR(10), C(50,50)
6. EQUIVALENCE (X,C)
7. REAL INCHES
8. INTEGER SYSIN, SYSOT, SDF1, SDF2, SDF4
9. DATA SYSIN, SYSOT, SDF1, SDF2, SDF4/5, 6, 1, 2, 4/
10. INTEGER ROWS, COLS
11. COMMON /INFO/ KNUM, JNUM, LIMIT, NCARDS, AREA, FACTOR, XMAX, XMIN, YMAX, YM
IN, ROWS, COLS, INCK, NHES, INNCARD, KTR, ISURF, IPUN, CON, TOUR, LINES, INCHES
12. COMMON /MATRIX/ X, Y, Z, A, XX, XINV, BB
13. N=((K+1)*(K+2))/2
14. GO TO (5,20,35,45,120,145,150,155,160), KODE
C -----
C KODE = 1
C PRINT IDENTITY MATRICES
C -----
15. 5 WRITE (SYSOT,195) K
16. WRITE (SYSOT,190)
17. DO 15 I=1,N
18. DO 10 J=1,N
19. HBB(J)=0.0
20. DO 10 L=1,N
21. HHR(J)=XX(I,L)*XINV(L,J,K)+HBB(J)
22. 15 WRITE (SYSOT,200) I, (HBB(J), J=1,N)
23. RETURN
C -----
C KODE = 2
C PRINT UPPER TRIANGLE OF XX MATRIX
C PRINT THE HR MATRIX
C -----
24. 20 WRITE (SYSOT,255)
25. WRITE (SYSOT,275) AREA, FACTOR, K
26. WRITE (SYSOT,165)
27. DO 25 I=1,N
28. WRITE (SYSOT,170) I, (XX(I,J), J=1,N)
29. CONTINUE
30. WRITE (SYSOT,175)
31. DO 30 I=1,N
32. WRITE (SYSOT,180) I, BB(I)
33. 30 CONTINUE
34. RETURN
C -----
C KODE = 3
C PRINT THE COMPLETE XX MATRIX
C -----
35. 35 WRITE (SYSOT,185)
36. DO 40 I=1,N
37. WRITE (SYSOT,170) I, (XX(I,J), J=1,N)
38. CONTINUE
39. RETURN

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C -----
C KODE = 4
C PRINT ALL RESIDUALS FOR OBSERVATION LOCATIONS
C -----
40. 45 GO TO (50,60,50), NRES
41. 50 WRITE (SYSOT,240)
42. WRITE (SYSOT,245)
43. DO 55 I=1,10
44. 55 ZR(I)=0.0
45. 60 IF (NRES.EQ.1) GO TO 65
46. WRITE (SDF4) NCARDS
47. 65 REWIND SDF1
48. IF (NNCARD.GT.1000) GO TO 70
49. KNUM=1
50. KTR=NNCARD
51. KTSW=1
52. GO TO 75
C
53. 70 KTR=1000
54. KTSW=0
55. 75 KPT=1
56. DO 110 K=1,KNUM
57. 80 READ (SDF1) (X(I),Y(I),Z(I),I=1,KTR)
58. DO 110 I=1,KTR
59. IF (X(I).GT.XMAX.OR.X(I).LT.XMIN) GO TO 110
60. IF (Y(I).GT.YMAX.OR.Y(I).LT.YMIN) GO TO 110
61. XO=X(I)
62. YO=Y(I)
63. ZO=Z(I)
64. DO 90 KD=1,5
65. IF (LIMIT(KD)) 85,90,85
66. 85 CALL POLY (PT,XD,YD,KD)
67. ZR(2*KD-1)=PT
68. ZR(2*KD)=70.-PT
69. 90 CONTINUE
70. GO TO (95,100,95), NRES
71. 95 WRITE (SYSOT,250) KPT,X(I),Y(I),Z(I),(ZR(KK),KK=1,10)
72. 100 IF (NRES.EQ.1) GO TO 105
73. WRITE (SDF4) KPT,X(I),Y(I),Z(I),(ZR(KK),KK=1,10)
74. 105 KPT=KPT+1
75. 110 CONTINUE
76. IF (KTSW.EQ.1) GO TO 115
77. KTR=JNUM
78. KTSW=1
79. GO TO 80
C
80. 115 CONTINUE
81. RETURN
C -----
C KODE = 5
C PRINT AND PUNCH GRID VALUES
C -----
82. 120 WRITE (SYSOT,205) K,COLS,ROWS
83. WRITE (SYSOT,210) XMAX,XMIN,YMAX,YMIN
84. DO 125 JJ=1,ROWS
85. WRITE (SYSOT,215) (C(JJ,KK),KK=1,COLS)
86. 125 WRITE (SYSOT,220)
87. IF (IPUN(K)) 130,140,130
88. 130 WRITE (SYSOT,230)
89. PUNCH 235, FACTOR,K, AREA,ROWS,COLS,ITYPE
90. DO 135 J=1,ROWS
91. PUNCH 225, (C(J,KK),KK=1,COLS)
92. 135 CONTINUE
93. 140 CONTINUE
94. RETURN
C -----
C KODE = 6
C THIS MATRIX SINGULAR,PRINT STATEMENT
C -----
95. 145 WRITE (SYSOT,260) K
96. RETURN
C -----
C KODE = 7
C NO TRENDS REQUESTED,PRINT STATEMENT
C -----
97. 150 WRITE (SYSOT,265)
98. RETURN

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C -----
C      CODE = 9
C      PRINT GCARS PAGE HEADING
C -----
99. 155 WRITE (SYSOT,255)
100.   WHITE (SYSOT,275) AREA,FACTOR,K
101.   RETURN
C -----
C      CODE=9
C      PRINT JOB TITLE PAGE
C -----
102. 160 WRITE (SYSOT,255)
103.   WHITE (SYSOT,270)
104.   WHITE (SYSOT,275) AREA,FACTOR,K
105.   RETURN
C -----
C
106. 165 FORMAT (1H0,47X,35HPRINT=OUT OF ALL MATRICES REQUESTED,30X,58HTHE
      1 UPPER TRIANGULAR PORTION OF THE XY-TRANSPOSE,XY MATRIX,///,4H ROW)
107. 170 FORMAT (1H0,13,2X,11E10.3,6X,10E10.3)
108. 175 FORMAT (1H0,///,52X,25HTHE XY-TRANSPOSE,Z MATRIX,///,4H ROW)
109. 180 FORMAT (1H0,13,2X,E16.4)
110. 185 FORMAT (1H0,///,43X,45HTHE COMPLETE SYMMETRIC XY-TRANSPOSE,XY MAT
      1R IX,///,4H ROW)
111. 190 FORMAT (1H0,52HTHIS MATRIX SHOULD (IDEALLY) BE AN IDENTITY MATRIX.
      1 //,1H ,55HIF IT DEPARTS GREATLY FROM THIS IDEAL,THE CORRESPONDING
      2,/,1H ,44HDEGREE TREND SURFACE SHOULD BE HELD SUSPECT,.,///)
112. 195 FORMAT (1H0,81H THE PRODUCT OF THE XY-TRANSPOSE XY MATRIX AND ITS
      1INVERSE FOR THE FIT OF DEGREE ,12,///,4H ROW)
113. 200 FORMAT (1H0,13,2X,11F10.7,6X,10F10.7)
114. 205 FORMAT (1H0,36HGRIDDED VALUES OF SURFACE OF DEGREE ,11,9H. GRID IS
      1,13,12H COLUMNS BY ,13,6H ROWS.)
115. 210 FORMAT (1H0,55HMAXIMUM AND MINIMUM COORDINATE VALUES READ IN ARE X
      1MAX=,F10.3,6H XMIN=,F10.3,6H YMAX=,F10.3,6H YMIN=,F10.3,/)
116. 215 FORMAT (1H ,12F10.3)
117. 220 FORMAT (1H0)
118. 225 FORMAT (8F10.3)
119. 230 FORMAT (1H0,67H*** PUNCH OPTION REQUESTED *** THIS MATRIX BEING P
      1UNCHEDED ON CARDS.)
120. 235 FORMAT (3A10,3A10,8H DEGREE ,11,1X,2I3,I2)
121. 240 FORMAT (1H0,18X,82HCOORDINATES,ORIGINAL AND COMPUTED VALUES,AND RE
      1SIDUALS FOR ALL SURFACES REQUESTED.,///)
122. 245 FORMAT (121H0 ID X Y Z Z=LINEAR RES=L
      1Z=QUAD. RES=QD Z=CUBIC RES=C Z=QUAR. RES=QR Z=QUINT RES=Q
      2T/1X)
123. 250 FORMAT (1H ,16,2F8.2,F9.3,5(F9.3,F9.3))
124. 255 FORMAT (1H1,55X,29H-----,56X,29HI T
      1HE GCARS SYSTEM I,/,56X,29HI PURDUE UNIVERSITY VERSION I,/,56X
      2,29H-----,40X,62HSEARCH ACTIVITY = DAT
125. 260 3A ANALYSIS PHASE = TREND SURFACE ANALYSIS,/)
      FORMAT (46H THE COEFFICIENT MATRIX FOR THE FIT OF DEGREE ,11,70H I
      1S MACHINE SINGULAR. THE PROGRAM WILL TRY THE OTHER FITS ASKED FOR
      2. )
126. 265 FORMAT (104HTHE LIMIT PARAMETER IS ZERO FOR THIS GROUP. THIS MEANS
      1 NO FIT WAS ASKED FOR. GOING ON TO NEXT GROUP. )
127. 270 FORMAT (1H0,43X,30HTHE EQUATIONS HAVE THE FORM --,/,45X,50HTEST,Z
      1= A1*A2(X)+A3(Y)+A4(X**2)+A5(X)(Y)+A6(Y**2)+,/,53X,47HA7(X**3)+A8(
      2X**2)(Y)+A9(X)(Y**2)+A10(Y**3)+,/,53X,47HA11(X**4)+A12(X**3)(Y
      3)+A13(X**2)(Y**2)+,/,53X,47HA14(X)(Y**3)+A15(Y**4)+A16(X**
      45)+A17(X**4)(Y)+,/,53X,47HA18(X**3)(Y**2)+A19(X**2)+A20(X)(
      5Y**4)+,/,53X,10HA21(Y**5).)
128. 275 FORMAT (1H0,42X,22HIN THIS JOB REQUEST --,/,43X,27HTHE AREA BEING
      1 ANALYZED IS ,3A10,/,41X,29HTHE FACTOR BEING ANALYZED IS ,3A10,/,4
      21X,49HTHE HIGHEST DEGREE OF TREND SURFACE REQUESTED IS ,I2)
129.   END

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FOF

v) FORSTAT CROSS-REFERENCE LISTINGS FOR SUBROUTINE RITER

SUBROUTINE RITER

STATEMENT NUMBER	DEFINITION	REFERENCES		
5	15.	14.		
10	21.	18.	20.	
15	22.	17.		
20	24.	14.		
25	29.	27.		
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40	38.	36.		
45	40.	14.		
50	41.	40.		
55	44.	43.		
60	45.	40.		
65	47.	45.		
70	53.	48.		
75	55.	52.		
80	57.	79.		
85	66.	65.		
90	69.	64.	65.	
95	71.	70.		
100	72.	70.		
105	74.	72.		
110	75.	56.	58.	59. 60.
115	80.	76.		
120	82.	14.		
125	86.	84.		
130	88.	87.		
135	92.	90.		
140	93.	87.		
145	95.	14.		
150	97.	14.		
155	99.	14.		
160	102.	14.		
165	106.	26.		
170	107.	28.	37.	
175	108.	30.		
180	109.	32.		
185	110.	35.		
190	111.	16.		
195	112.	15.		
200	113.	22.		
205	114.	82.		
210	115.	83.		
215	116.	85.		
220	117.	86.		
225	118.	91.		
230	119.	88.		
235	120.	89.		
240	121.	41.		
245	122.	42.		
250	123.	71.		
255	124.	24.	99.	102.
260	125.	95.		
265	126.	97.		
270	127.	103.		
275	128.	25.	100.	104.

55 STATEMENT NUMBERS DEFINED

4 MAXIMUM NUMBER OF REFERENCES

65 TOTAL NUMBER OF REFERENCES

1.2 AVERAGE NUMBER OF REFERENCES

F0F

*DHL*F0F*

SUBROUTINE	RITER	LABEL	TYPE	DEFINITION	REFERENCES
A	R	A		4. CD	66.
AREA	R	2. CD		11. C	12.
B	R	5. CD		11. C	25.
B9	R	5. CD		12. B9	100. 104.
C	R	5. D		19. 21.	
D	R	888		6. DE	22.
E	R	5. DE		85. 91.	
COLS	I	10. C		11. A2.	89. 91.
CON	R	11. C		11. -5.	
CON	R	11. C		21. 22.	89. 100. 104.
FACTOR	R	2. CD		27. 28.	27. 31.
I	I	17.		61. 62.	32. 36. 37. 43. 44. 57. 58. 59. 60.
INCHES	R	7. C		11.	
INCK	I	11. C			
INFO	I	11. C			
IPUN	I	3. CD		11. A7.	
ISURF	I	3. CD		11.	
ITYPE	I	11. C		89.	
J	I	18.		19. 21.	90. 91.
JJ	I	84.		85.	
JJ	I	85.		77.	
JNUM	I	11. C		13. 15.	
K	I	1.		65. 66.	21. 25. 56.
KO	I	64.		71. 73.	82. 87. 89. 95. 100. 104.
KK	I	71.		85. 91.	
KNUM	I	11. C		49. 56.	
KODE	I	1.		14.	
KPT	I	55.		71. 73.	74.
KT	I	11. C			
KTR	I	11. C		50. 53.	
KTSW	I	51.		54. 76.	58. 77.
L	I	20.		21.	
LIMIT	I	5. CD		11.	65.
LINES	I	11. C			
MATRIX	I	12. C			
N	I	13.		17. 18.	20. 22. 27. 28. 31. 36. 37.
NCARDS	I	11. C		46.	
NNCARD	I	11. C		48. 50.	
NPRS	I	11. C		40. 45.	70. 72.

w) LISTING OF SUBROUTINE INVER

```

1. SUBROUTINE INVER (K,NDEGRE,KSOB)      B 2
C -----                        B 4
C SUBROUTINE INVER                      B 6
C -----                        B 8
C PURPOSE--                            B 10
C TO COMPUTE THE INVERSES OF ALL THE XY-TRANSPOSE, XY MATRICES B 12
C FOR ALL THE SURFACES BEING FITTED. B 14
C -----                        B 16
C THE GCMS SYSTEM                      B 18
C PURDUE UNIVERSITY                   B 20
C                                     B 22
C                                     A. K. TURNER, B 24
C                                     CIVIL ENGINEERING, B 26
C                                     JUNE 1969. B 28
C -----                        B 30
C USAGE--                              B 32
C CALL INVER (XX,XINV,K,NDEGRE,KSOB) B 34
C WHERE - XX = MATRIX FOR WHICH INVERSE IS REQUIRED B 36
C XINV = THE CALCULATED INVERSE B 38
C K = SIZE OF MATRIX (NO. OF COLS. AND ROWS) B 40
C NDEGRE = DEGREE OF SURFACE B 42
C KSOB = IF XX MATRIX IS SINGULAR KSOB SET EQUAL TO ONE B 44
C AND CONTROL RETURNED TO IEND. B 46
C NOTE- THIS SUBROUTINE UTILIZES THE LABELLED COMMON- B 48
C /MATRIX/ B 50
C -----                        B 52
C DESCRIPTION OF CONTROL CARDS- B 54
C NONE REQUIRED B 56
C -----                        B 58
C REQUIRED SUBROUTINES- B 60
C NONE B 62
C OPTIONAL SUBROUTINES- B 64
C NONE B 66
C -----                        B 68
2. DIMENSION XX(21,21), XINV(21,21,5), AM(21,22) B 70
3. DIMENSION N(21) B 72
4. DIMENSION DUM1(2643) B 74
5. COMMON /MATRIX/ AM,DUM1,XX,XINV B 76
6. DO 5 I=1,K B 78
7. DO 5 J=1,K B 80
8. 5 AM(I,J)=XX(I,J) B 82
9. KK=K+1 B 84
C -----                        B 86
C INITIALIZE THE ROW PERMUTATION CELLS TO ZERO. B 88
C -----                        B 90
10. DO 10 I=1,K B 92
11. 10 N(I)=0 B 94
12. DO 85 J=1,K B 96
13. I=1 B 98
14. JJ=J-1 B 100
15. DO 20 L=1,JJ B 102
16. IF (N(L)=I) 20,25,20 B 104
17. 20 CONTINUE B 106
18. IF (AM(I,1)) 35,25,35 B 108
19. I=I+1 B 110
20. IF (K=I) 30,15,15 B 112
21. 30 KSOB=1 B 114
22. RETURN B 116
23. 35 AMA=ABS(AM(I,1)) B 118
24. II=I B 120
25. II=II+1 B 122
26. IF (K=II) 60,45,45 B 124
27. 45 DO 50 IZ=1,J B 126
28. IF (N(IZ)=II) 50,40,50 B 128
29. 50 CONTINUE B 130
30. AMB=ABS(AM(II,1)) B 132
C -----                        B 134
C TEST FOR MAXIMAL SIZE PIVOTAL ELEMENT. B 136
C -----                        B 138
31. IF (AMA=AMB) 55,40,40 B 140
32. 55 AMA=AMB B 142
33. I=II B 144
34. GO TO 40 B 146
C -----                        B 148

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35. 60      N(J)=I                                B 150
      C -----
      C      ADJOIN THE CORRECT IDENTITY COLUMN VECTOR.
      C -----
36.      DO 65 IZ=1,K                            B 158
37.      AM(IZ,KK)=0.0                          B 160
38.      AM(I,KK)=1.0                            B 162
39.      DA=AM(I,1)                              B 164
      C -----
      C      NORMALIZE THE PIVOTAL ROW.
      C -----
40.      DO 70 IZ=2,KK                            B 172
41.      AM(I,IZ-1)=AM(I,IZ)/DA                  B 174
42.      DO 85 IZ=1,K                            B 176
43.      IF (IZ-I) 75,85,75                      B 178
44.      75   DB=AM(IZ,1)                        B 180
      C -----
      C      ZERO OUT NON-PIVOTAL COLUMN ELEMENTS.
      C -----
45.      DO 80 JZ=2,KK                            B 186
46.      AM(IZ,JZ-1)=AM(IZ,JZ)-AM(I,JZ-1)*DB     B 188
47.      80   CONTINUE                          B 190
48.      DO 100 I=1,K                             B 192
49.      DO 90 J=1,K                             B 194
50.      IF (N(J)-I) 90,95,90                    B 196
51.      90   CONTINUE                          B 198
52.      95   DO 100 L=1,K                       B 200
53.      LL=N(L)                                B 202
54.      100  XINV(L,I,NDEGRE)=AM(LL,J)          B 204
55.      RETURN                                  B 206
56.      END                                     B 208

```

x) FORSTAT CROSS-REFERENCE LISTING FOR SUBROUTINE INVER

SUBROUTINE INVER

STATEMENT NUMBER	DEFINITION	REFERENCES
5	8.	6. 7.
10	11.	10.
15	15.	20.
20	17.	15. 16.
25	19.	16. 18.
30	21.	20.
35	23.	18.
40	25.	28. 31. 34.
45	27.	26.
50	29.	27. 28.
55	32.	31.
60	35.	26.
65	37.	36.
70	41.	40.
75	44.	43.
80	46.	45.
85	47.	12. 42. 43.
90	51.	49. 50.
95	52.	50.
100	54.	48. 52.

20 STATEMENT NUMBERS DEFINED

3 MAXIMUM NUMBER OF REFERENCES

30 TOTAL NUMBER OF REFERENCES

1.5 AVERAGE NUMBER OF REFERENCES

SU-ROUTINE INVER

LABEL	TYPE	DEFINITION	REFERENCES																
			30.	8.	18.	23.	30.	37.	38.	39.	41.	44.	46.	54.	39.	38.	35.	33.	74.
ABS	R	23. CD	30.																
AM	R	23.	31.	32.															
AMA	R	30.	31.	32.															
AMH	R	30.	31.	32.															
DA	R	44.	46.																
DB	R	44.	46.																
DUM1	R	4. CD	5.																
I	I	6.	8.	10.	11.	13.	16.	18.	19.	20.	23.	74.	33.	35.	38.	39.			
I	I		41.	43.	46.	48.	50.	54.											
I	I	24.	25.	26.	28.	30.	33.												
I	I	27.	28.	34.	37.	40.	41.	42.	43.	44.	46.								
J	I	7.	8.	12.	14.	21.	35.	49.	50.	54.									
JJ	I	14.	15.																
JZ	I	45.	46.																
K	I	1.	6.																
KK	I	9.	37.	38.	40.	45.													
KS	I	1.	21.																
KS	I	15.	16.	52.	53.	54.													
L	I	53.	54.																
LL	I	54.																	
MATRIX	I	54.																	
N	I	3. D	11.	16.	28.	35.	50.	53.											
NDEGRE	I	1.	54.																
XINV	R	1. CD	2.	5.	54.														
XX	R	1. CD	2.	5.	8.														

23 SYMBOLS DEFINED

20 MAXIMUM NUMBER OF REFERENCES

99 TOTAL NUMBER OF REFERENCES

4.3 AVERAGE NUMBER OF REFERENCES

y) LISTING OF SUBROUTINE POLY

```

1. SUBROUTINE POLY (PT,XD,YD,K)
C -----
C SUBROUTINE POLY
C -----
C PURPOSE--
C TO EVALUATE ANY DESIRED TREND SURFACE EQUATION AT ANY REQUESTED
C X AND Y COORDINATES IN ORDER TO CALCULATE THE APPROPRIATE ESTIMATES
C OF Z.
C -----
C THE GCAHS SYSTEM
C PURDUE UNIVERSITY
C
C A. K. TURNER,
C CIVIL ENGINEERING,
C JUNE 1969.
C -----
C USAGE--
C CALL POLY(PT,XD,YD,K)
C WHERE - PT = THE DESIRED ESTIMATE OF Z
C XD = X-COORDINATE
C YD = Y-COORDINATE
C K = DEGREE OF EQUATION BEING EVALUATED
C NOTE- THIS SUBROUTINE UTILIZES LABELLED COMMON-
C /MATHIX/
C -----
C DESCRIPTION OF CONTROL CARDS-
C NONE REQUIRED
C -----
C REQUIRED SUBROUTINES-
C NONE
C OPTIONAL SUBROUTINES-
C NONE
C -----
2. DIMENSION A(21,5), DUMMY(3000)
3. COMMON /MATHIX/ DUMMY,A
4. 5 GO TO (10,15,20,25,30), K
C -----
C FIRST DEGREE COEFFICIENTS
C -----
5. 10 PT=A(1,K)+XD*A(2,K)+YD*A(3,K)
6. GO TO 35
C -----
C SECOND DEGREE COEFFICIENTS
C -----
7. 15 PT=A(1,2)+XD*A(2,2)+YD*A(3,2)+XD*XD*A(4,2)+XD*YD*A(5,2)+YD*YD*A(6,
8. 12)
GO TO 35
C -----
C THIRD DEGREE COEFFICIENTS
C -----
9. 20 XD2=XD*XD
10. YD2=YD*YD
11. PT=A(1,3)+XD*A(2,3)+YD*A(3,3)+XD2*A(4,3)+XD*YD*A(5,3)+YD2*A(6,3)+X
12. 12)XD3=XD*A(7,3)+XD2*YD*A(8,3)+XD*YD2*A(9,3)+YD2*YD*A(10,3)
GO TO 35
C -----
C FOURTH DEGREE COEFFICIENTS
C -----
13. 25 XD2=XD*XD
14. XD3=XD2*XD
15. YD2=YD*YD
16. YD3=YD2*YD
17. PT=A(1,4)+XD*A(2,4)+YD*A(3,4)+XD2*A(4,4)+XD*YD*A(5,4)+YD2*A(6,4)+X
18. 12)XD3*YD*A(12,4)+XD2*YD2*A(13,4)+XD*YD3*A(14,4)+YD2*YD2*A(15,4)
GO TO 35
C
C
C
C

```

	C	-----		C 142
	C	FIFTH DEGREE COEFFICIENTS		C 144
	C	-----		C 146
19.	30	X02=X0*X0		C 148
20.		X03=X02*X0		C 150
21.		X04=X03*X0		C 152
22.		Y02=Y0*Y0		C 154
23.		Y03=Y02*Y0		C 156
24.		Y04=Y03*Y0		C 158
25.		PT=A(1,5)+X0*A(2,5)+Y0*A(3,5)+X02*A(4,5)+X0*Y0*A(5,5)+Y02*A(6,5)+X03*A(7,5)+X02*Y0*A(8,5)+X0*Y02*A(9,5)+Y03*A(10,5)		C 160
26.		PT=PT+X04*A(11,5)+X03*Y0*A(12,5)+X02*Y02*A(13,5)+X0*Y03*A(14,5)+Y04*A(15,5)+X04*X0*A(16,5)+X04*Y0*A(17,5)+X03*Y02*A(18,5)+X02*Y03*A(19,5)+X0*Y04*A(20,5)+Y0*Y04*A(21,5)		C 162
27.	35	RETURN		C 164
28.		END		C 166
				C 168
				C 170
				C 172-

z) FORSTAT CROSS-REFERENCE LISTING FOR SUBROUTINE POLY

SUBROUTINE POLY

STATEMENT NUMBER	DEFINITION	REFERENCES
5	4.	
10	5.	4.
15	7.	4.
20	9.	4.
25	13.	4.
30	19.	4.
35	27.	6. 8. 12. 18.

7	STATEMENT NUMBERS DEFINED
4	MAXIMUM NUMBER OF REFERENCES
9	TOTAL NUMBER OF REFERENCES
1.3	AVERAGE NUMBER OF REFERENCES

SUBROUTINE POLY			REFERENCES																	
LABEL	TYPE	DEFINITION																		
A	R	1. CD	2.	3.	5.	7.	11.	17.	25.	26.										
DUMMY	R	2. CD	3.																	
K	I	1.	4.	5.																
MATRIX	I	3. C																		
PT	R	1.	5.	7.	11.	17.	25.	26.												
XD	R	1.	5.	7.	9.	11.	13.	14.	17.	19.	20.	21.	25.	26.	26.					
X02	R	9.	11.	13.	14.	17.	19.	20.	25.	26.										
X03	R	14.	17.	20.	21.	25.	26.													
X04	R	21.	26.																	
Y0	R	1.	5.	7.	10.	11.	15.	16.	17.	22.	23.	24.	25.	26.	26.					
Y02	R	10.	11.	15.	16.	17.	22.	23.	25.	26.										
Y03	R	16.	17.	23.	24.	25.	26.													
Y04	R	24.	26.																	

13 SYMBOLS DEFINED

12 MAXIMUM NUMBER OF REFERENCES

69 TOTAL NUMBER OF REFERENCES

5.3 AVERAGE NUMBER OF REFERENCES

aa) SAMPLE INPUT FOR PROGRAM TREND

```

TREND
  *maps
  *TRENDS 1,2,3,4
  *PUNCH
  *RESIDUALS
  *IDENTITY
  *END
  24      11.0      0.0      16.0      0.0
  33 23 1
  151111.2
  545.0
  560.0
  PROGRAM TREND TEST DATA ARRAY
  1 (10x2F10.2,F10.3)
  00485 00115
  00719 00134
  00826 00231
  00674 00253
  00414 00369
  00573 00327
  00684 00331
  00587 00385
  00727 00370
  00166 00739
  00414 00736
  00762 00666
  00467 00845
  00456 01049
  00759 01114
  00990 01229
  00476 01225
  00221 01163
  00410 01510
  00292 01420
  00414 01317
  00444 00556
  00706 01360
  00705 01513
  00634 00736
  00634 01167
  00517 00740
  00574 00934
  597100
  598100
  611400
  400400
  601700
  600500
  602000
  603600
  609100
  619100
  613700
  615200
  617100
  628600
  646800
  654100
  636700
  644500
  642700
  646600
  611900
  646300
  651400
  616100
  634600
  614600
  627100
  RA-THOLOMEY COUNTY

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2

bb) SAMPLE OUTPUT FROM PROGRAM TREND

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-----
THE ROCKS SYSTEM
I PUQUOT UNIVERSITY VERSION 1
-----

```

SEARCH ACTIVITY - DATA ANALYSIS PHASE - TREND SURFACE ANALYSIS

IN THIS JOB REQUEST --

THE AREA BEING ANALYZED IS BARTON-OLNEY COUNTY
 THE FACTOR BEING ANALYZED IS PROGRAM TREND TEST DATA ARRAY
 THE HIGHEST DEGREE OF TREND SURFACE REQUESTED IS 4

THE PRODUCT OF THE XY-TRANSPOSE XY MATRIX AND ITS INVERSE FOR THE FIT OF DEGREE 1

ROW

THIS MATRIX SHOULD (IDEALLY) BE AN IDENTITY MATRIX.
 IF IT DEPARTS GREATLY FROM THIS IDEAL, THE CORRESPONDING
 DEGREE TREND SURFACE SHOULD BE HELD SUSPECT.

```

1  1.0000000  -.0000000  0.0000000
2  -.0000000  1.0000000  .0000000
3  -.0000000  .0000000  1.0000000

```

THE PRODUCT OF THE XY-TRANSPOSE XY MATRIX AND ITS INVERSE FOR THE FIT OF DEGREE 2

ROW

THIS MATRIX SHOULD (IDEALLY) BE AN IDENTITY MATRIX.
 IF IT DEPARTS GREATLY FROM THIS IDEAL, THE CORRESPONDING
 DEGREE TREND SURFACE SHOULD BE HELD SUSPECT.

```

1  1.0000000  -.0000000  -.0000000  .0000000  .0000000  .0000000
2  -.0000000  1.0000000  .0000000  .0000000  .0000000  .0000000
3  .0000000  -.0000000  1.0000000  .0000000  -.0000000  0.0000000
4  .0000000  -.0000000  .0000000  1.0000000  -.0000000  .0000000

```



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-----
1  THE GCAMS SYSTEM
1  PURDUE UNIVERSITY VERSION 1
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SEARCH ACTIVITY - DATA ANALYSIS PHASE - TREND SURFACE ANALYSIS

IN THIS JOB REQUEST --

THE AREA BEING ANALYZED IS HASTHOLCHEN COUNTY
 THE FACTOR BEING ANALYZED IS PROGRAM TREND TEST DATA ARRAY
 THE HIGHEST DEGREE OF TREND SURFACE REQUESTED IS 4

THE NUMBER OF OBSERVATIONS USED IN THIS ANALYSIS IS 28

THE COMPUTED COEFFICIENTS FOR THE REQUESTED TREND SURFACE EQUATIONS

THE EQUATIONS HAVE THE FORM --

$$\begin{aligned}
 \text{EST} \cdot Z = & A1 \cdot A2(X1) + A3(Y1) + A4(X22) + A5(X1)(Y1) + A6(Y22) + \\
 & A7(X22) + A8(X22)(Y1) + A9(X1)(Y22) + A10(Y22) + \\
 & A11(X22) + A12(Y22)(Y1) + A13(X22)(Y22) + \\
 & A14(X1)(Y22) + A15(Y22) + A16(X22) + A17(X22)(Y1) + \\
 & A18(X22)(Y22) + A19(X22)(Y22) + A20(X1)(Y22) + \\
 & A21(Y22)
 \end{aligned}$$

DFGPEF

```

-----
1  5.776231E+02  1.912473E+00  4.1524687E+00
-----
2  4.029140E+02  -5.530445E+00  2.5603577E+00  4.064000E-01  5.823915E-02  6.7539439E-02
-----
3  6.534419E+02  -1.4571499E+01  -5.2455247E+00  1.5099173E+00  1.8066327E+00  1.0571318E+00  1.1051130E-02
-----
-1.1494600E-01  -2.4679411E-02  -3.4350479E-02
-----
4  5.4946604E+02  3.0735832E+01  1.4994815E+01  -7.0533864E+00  -5.3703008E+00  -1.3048807E+00  5.9420365E-01
  4.9200497E-01  3.2634365E-01  8.0220511E-02  -1.0263939E-02  -3.4625179E-02  -1.0149423E-02  -5.2179844E-03
-----
-1.82444930E-03
-----

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 THE GCMS SYSTEM
 I PURDUE UNIVERSITY VERSION I

SEARCH ACTIVITY - DATA ANALYSIS PHASE - THERM SURFACE ANALYSIS

IN THIS JOB REQUEST --

THE AREA BEING ANALYZED IS WARTHOLOFTOWN COUNTY
 THE FACTOR BEING ANALYZED IS PROGRAM THERM TEST DATA ARRAY
 THE HIGHEST DEGREE OF THERM SURFACE REQUESTED IS 4

ANALYSIS OF VARIANCE STATISTICS

ESTIMATE OF ERROR IN THE POLYNOMIAL COEFFICIENTS

FIGURE

1	3.55E+00	4.84E-01	2.04E-01				
2	8.72E+00	1.80E+00	1.10E+00	1.57E-01	1.02E-01	4.44E-02	
3	2.61E+01	8.26E+00	4.64E+00	9.91E-01	9.46E-01	3.14E-01	6.05E-02
	5.74E-02	2.84E-02	9.92E-03				
4	1.77E+02	7.24E+01	4.09E+01	1.13E+01	1.44E+01	2.91E+00	1.30E+00
	1.64E+00	6.94E-01	1.14E-01	7.24E-02	6.07E-02	4.10E-02	1.13E-02
	3.06E-03						

 I THE GCAMS SYSTEM I
 I PURDUE UNIVERSITY VERSION I

SEARCH ACTIVITY - DATA ANALYSIS PHASE - TREND SURFACE ANALYSIS

IN THIS JOB REQUEST --

THE AREA BEING ANALYZED IS BARTHOLOMEW COUNTY
 THE FACTOR BEING ANALYZED IS PROGRAM TREND TEST DATA ARRAY
 THE HIGHEST DEGREE OF TREND SURFACE REQUESTED IS 4

ANALYSIS OF VARIANCE STATISTICS

TOTAL F-TESTS FOR ALL TREND SURFACES

SOURCE	D.F.	SS DUE TO REG.	MS DUE TO REG.	SS DUE TO ERROR	MS DUE TO ERROR	F-RATIO
MEAN	1	1.04526651E+07				
DEGREE 1	3	4.77627398E+03	2.92542465E+03	5.16623180E+02	21.52597	135.902
DEGREE 2	6	9.60431347E+03	1.56138558E+03	2.44583671E+02	13.55160	110.790
DEGREE 3	10	9.13490148E+03	9.13890196E+02	1.53995167E+02	9.05054	100.887
DEGREE 4	15	9.16515833E+03	6.11010554E+02	1.27738810E+02	10.64490	57.399

CORRECTED TOTAL SS = TOTAL SS - SS DUE TO MEAN = 9292.497143

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-----
I THE GCARS SYSTEM I
I PURDUE UNIVERSITY VERSION I
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SEARCH ACTIVITY - DATA ANALYSIS PHASE - TREND SURFACE ANALYSIS

IN THIS JOB REQUEST --

THE AREA BEING ANALYZED IS HARTHOLONEW COUNTY
 THE FACTOR BEING ANALYZED IS PROGRAM TREND TEST DATA ARRAY
 THE HIGHEST DEGREE OF TREND SURFACE REQUESTED IS 4

ANALYSIS OF VARIANCE STATISTICS

PARTIAL F-TESTS FOR GROUPS OF COEFFICIENTS WITHIN THE OVERALL TREND EQUATION**

GROUP OF TERMS JUST ADDED	D.F.	SS DUE TO GROUP	MS DUE TO GROUP	F-RATIO
DEGREE 1	1	8.77627396E+03	8.77627396E+03	412.229
DEGREE 2	1	2.32039509E+02	2.32039509E+02	7.266
DEGREE 3	1	1.30588504E+02	1.30588504E+02	3.067
DEGREE 4	1	2.6256975E+01	2.6256975E+01	.493

I THE GOALS SYSTEM I
I PURDUE UNIVERSITY VERSION I

SEARCH ACTIVITY - DATA ANALYSIS PHASE - TREND SURFACE ANALYSIS

-- THIS IS YOUR REQUEST --

THE AREA BEING ANALYZED IS RALSTON NEW COUNTY
THE FACTOR BEING ANALYZED IS PROGRAM TRFND TEST DATA ARRAY
THE HIGHEST DEGREE OF TRFND SURFACE REQUESTED IS 4

ANALYSIS OF VARIANCE STATISTICS

PERCENT SUMS OF SQUARES EXPLAINED BY REGRESSION.
(THIS EQUALS R-SQUARED, THE SQUARE OF THE MULTIPLE
CORRELATION COEFFICIENT.)

DEGREE	PERCENT SS. EXPAINED	R-SQUARED	K
1	94.44	.6464	.6718
2	96.34	.6634	.6857
3	96.34	.6634	.6716
4	96.625	.66625	.6931

 I THE GRAS SYSTEM I
 I PLOQUE UNIVERSITY VERSION I

SEARCH ACTIVITY - DATA ANALYSIS PHASE - THERM SURFACE ANALYSIS

IN THIS JOB REQUEST --

THE AREA BEING ANALYZED IS HARTHOLLEN COUNTY
 THE FACTOR BEING ANALYZED IS PROGRAM IDENT TEST DATA ARRAY
 THE HIGHEST DEGREE OF THERM SURFACE REQUESTED IS 4

COORDINATES, ORIGINAL AND COMPUTED VALUES, AND RESTORALS FOR ALL SURFACES REQUESTED.

IN	X	Y	Z	7-LINEAR	REF-L	Z-QUAD.	RES-ON	Z-CURVE	7-QUAD.	RES-OR	Z-CURVE	RES-OT
1	4.35	1.15	537.100	591.675	594.425	593.705	3.395	597.710	-6.10	596.646	.454	0.000
2	7.19	1.34	594.100	596.939	1.161	596.591	-4.91	600.664	-2.869	600.246	-2.166	0.000
3	4.28	2.31	611.400	603.052	5.344	606.057	5.343	609.622	2.774	609.959	1.441	0.000
4	6.74	2.53	600.400	601.060	-6.60	601.071	-6.71	599.646	.764	599.247	1.153	0.000
5	4.14	2.69	601.700	600.865	.825	601.662	.034	600.740	1.444	602.439	-1.139	0.000
6	5.73	3.47	609.500	602.582	-6.422	603.477	-1.477	599.056	.540	599.660	.820	0.000
7	6.44	3.31	602.000	604.451	-2.451	603.971	-1.971	601.614	.382	601.077	.923	0.000
8	5.87	4.65	604.600	604.591	-3.391	606.446	-3.396	603.653	-1.653	603.723	-1.123	0.000
9	7.27	6.70	604.100	615.199	-6.099	613.934	-6.834	612.209	-3.104	611.225	-2.125	0.000
10	1.66	7.39	614.100	611.444	1.612	616.724	.372	619.994	-1.54	614.741	.319	0.000
11	4.14	7.36	613.700	614.107	-2.407	616.662	-0.942	613.764	.196	614.583	-.883	0.000
12	7.82	6.66	615.200	615.655	-4.655	618.963	-3.763	614.569	-3.349	614.030	-2.430	0.000
13	4.67	4.45	617.100	620.647	-4.547	619.059	-1.959	619.320	-2.220	614.965	-1.865	0.000
14	4.68	1.49	624.600	620.947	-1.347	627.345	1.215	629.916	-1.316	626.912	-2.312	0.000
15	7.59	11.16	644.600	634.460	10.314	637.767	11.033	650.474	7.924	642.333	5.867	0.000
16	9.90	12.29	654.100	647.597	6.513	656.312	-2.212	655.066	-1.566	654.425	-1.325	0.000
17	4.78	12.25	634.700	637.639	1.061	635.234	3.466	633.461	.139	637.455	1.045	0.000
18	2.21	11.53	634.600	630.149	4.451	634.061	.539	633.865	.715	634.666	-0.064	0.000
19	4.10	11.10	644.500	642.174	-3.674	644.093	-1.559	646.245	-1.745	643.721	-1.221	0.000
20	2.92	14.20	646.700	642.140	5.620	644.323	-1.623	642.373	.317	643.343	-.693	0.000
21	4.14	14.17	646.600	644.368	2.212	643.663	2.923	644.379	2.271	643.644	2.956	0.000
22	4.64	13.60	641.900	613.358	-1.458	611.704	.196	609.942	1.554	611.010	.490	0.000
23	7.66	13.60	646.300	647.606	-1.306	646.079	-6.679	644.214	-1.616	649.656	-3.356	0.000
24	7.05	15.13	651.600	653.941	-2.141	654.456	-2.556	661.047	.753	650.351	1.449	0.000
25	6.34	7.36	614.100	620.314	-2.214	617.430	-6.70	616.644	1.611	615.672	2.424	0.000
26	4.39	11.67	634.600	634.263	-3.704	635.729	-1.129	634.299	-4.69	639.406	-5.506	0.000
27	5.17	7.40	614.600	614.263	-3.663	613.493	-.793	614.300	.360	614.073	.157	0.000
28	5.74	9.34	627.100	627.390	-.290	624.063	3.037	625.724	1.376	624.925	2.175	0.000

 1 THE GRASS SYNTAX
 1 PROGRAM UNIVERSITY VERSION 1

SEARCH ACTIVITY - DATA ANALYSIS PHASE - TREND SURFACE ANALYSIS

IN THIS JOB REQUEST --

THE AREA BEING ANALYZED IS HARTFORD, CT COUNTY
 THE FACTOR BEING ANALYZED IS PROGRAM TREND TEST DATA ARRAY
 THE HIGHEST DEGREE OF TREND SURFACE REQUESTED IS 4

GRATTIONED VALUES OF SURFACE OF DEGREE 1. GRID IS 23 COLUMNS BY 33 ROWS.

	MAXIMUM AND MINIMUM COORDINATE VALUES READ IN ARE			0.000 YMAX=			15.000 YMIN=			0.000		
	XMAX=			XMIN=			YMAX=			YMIN=		
644.071	645.027	645.983	646.939	647.896	648.852	649.808	650.764	651.721	652.677	653.633	654.589	
655.546	656.502	657.458	658.414	659.370	660.327	661.283	662.239	663.195	664.152	665.108		
641.994	642.950	643.907	644.863	645.819	646.775	647.732	648.688	649.644	650.600	651.557	652.513	
653.469	654.425	655.382	656.338	657.294	658.250	659.206	660.163	661.119	662.075	663.031		
639.912	640.874	641.830	642.786	643.743	644.699	645.655	646.611	647.568	648.524	649.480	650.436	
652.340	653.305	654.261	655.218	656.174	657.130	658.086	659.042	660.000	660.955			
585.929	586.885	587.841	588.797	589.753	590.709	591.665	592.621	593.577	594.533	595.489	596.445	
597.404	598.360	599.316	600.272	601.228	602.184	603.140	604.096	605.052	606.008	606.964	607.920	
583.853	584.809	585.765	586.721	587.678	588.634	589.590	590.546	591.502	592.458	593.414	594.370	
595.327	596.284	597.240	598.196	599.152	600.109	601.065	602.021	602.977	603.933	604.889	605.845	
581.774	582.732	583.689	584.645	585.601	586.557	587.514	588.470	589.426	590.382	591.339	592.295	
593.251	594.207	595.163	596.120	597.076	598.032	598.988	599.945	600.901	601.857	602.813		
579.700	580.656	581.612	582.568	583.525	584.481	585.437	586.393	587.350	588.306	589.262	590.218	
591.175	592.131	593.087	594.043	594.999	595.956	596.912	597.868	598.824	599.781	600.737		
577.623	578.579	579.536	580.492	581.448	582.404	583.361	584.317	585.273	586.229	587.186	588.142	
590.094	591.050	592.007	592.963	593.919	594.875	595.831	596.787	597.743	598.699	599.655	600.611	

INCOMPLETE ARRAY
 SHOWN HERE

*** PUNCH OPTION REQUESTED *** THIS MATRIX BEING PUNCHED ON CARDS.

CONTINUED FROM REAR SURFACE OF SHEET NO. 1

Map is Dated: 1964. The UNITED STATES GOVERNMENT OF THE DISTRICT OF COLUMBIA

CONTINUED FROM REAR SURFACE OF SHEET NO. 1

Map is Dated: 1964. The UNITED STATES GOVERNMENT OF THE DISTRICT OF COLUMBIA

CONTINUED FROM REAR SURFACE OF SHEET NO. 1

Map is Dated: 1964. The UNITED STATES GOVERNMENT OF THE DISTRICT OF COLUMBIA

CONTINUED FROM REAR SURFACE OF SHEET NO. 1

Map is Dated: 1964. The UNITED STATES GOVERNMENT OF THE DISTRICT OF COLUMBIA

cc) LISTING OF PROGRAM RESMAP

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1.  PROGRAM RESMAP (INPUT,OUTPUT,TAPE3,PUNCH,TAPE5=INPUT,TAPE6=OUTPUT)  A 2
C  -----  A 4
C  PROGRAM RESMAP  A 6
C  -----  A 8
C  PURPOSE =  A 10
C  TO PRODUCE RESIDUAL MAPS FROM TREND SURFACE GRID VALUES.  A 12
C  -----  A 14
C  THE GCARS SYSTEM  A 16
C  PURDUE UNIVERSITY  A 18
C  A. KEITH TURNER,  A 20
C  CIVIL ENGINEERING,  A 22
C  JUNE 1969.  A 24
C  -----  A 26
C  DESCRIPTION OF CONTROL CARDS -  A 28
C  1) TITLE CARD  A 30
C  A GENERAL TITLE IN COLUMNS 1-80.  A 32
C  2) OPTION CARD  A 34
C  NSURF = NUMBER OF TRENDS FOR WHICH RESIDUALS ARE TO BE  A 36
C  CALCULATED, ( COL 2 )  A 38
C  NTAPE = IF NTAPE=1, RESIDUALS WILL BE STORED ON TAPE3. (COL 4)  A 40
C  IPUN = IF IPUN=1, RESIDUALS PUNCHED ON CARDS (COL 6).  A 42
C  THE FOLLOWING CARDS ARE REQUIRED FOR THE ORIGINAL DATA ARRAY, AND FOR  A 44
C  EACH TREND SURFACE DATA ARRAY. THE ORIGINAL DATA ARRAY MUST BE THE  A 46
C  FIRST ARRAY, THE TREND SURFACE ARRAYS CAN THEN FOLLOW IN ANY ORDER.  A 48
C  A) FORMAT CARD  A 50
C  FORM ( COLS 1-80 ) -FORMAT FOR DATA ARRAY (NORMALLY (8F10.3)).  A 52
C  B) HEADER CARD  A 54
C  FACTOR (COLS 1-40)-ALPHANUMERIC IDENTIFICATION OF FACTOR.  A 56
C  AREA (COLS 41-70)-ALPHANUMERIC IDENTIFICATION OF AREA.  A 58
C  NCOL (COLS 71-73)-NUMBER OF COLUMNS IN THE ARRAY.  A 60
C  NROW (COLS 74-76)-NUMBER OF ROWS IN THE ARRAY.  A 62
C  ITYPE ( COLS 78 )-IF DATA IS TOPOGRAPHIC RESIDUALS, ITYPE=1.  A 64
C  IF DATA MEASURES COSTS, ITYPE=2.  A 66
C  IF DATA MEASURES BENEFITS, ITYPE=3.  A 68
C  C) DATA CARDS  A 70
C  -----  A 72
C  OPTIONAL TAPE =  A 74
C  TAPE3 MAY BE REQUIRED.  A 76
C  -----  A 78
C  REQUIRED SUBROUTINES =  A 80
C  = NONE  A 82
C  OPTIONAL SUBROUTINES --  A 84
C  = NONE  A 86
C  -----  A 88
2.  DIMENSION FORM(8), FACTOR(4), AREA(3), RES(3),ZOR(50,50),Z(50,50),  A 90
C  1 TITL(8)  A 92
3.  INTEGER SYSIN,SYSOT,SDF3,FORM  A 94
4.  DATA SYSIN,SYSOT,SDF3/5,6,3//RES(1)/10H RESIDUALS/  A 96
5.  READ (SYSIN,70) TITL  A 98
6.  IF (EOF,SYSIN) 60,10  A 100
7.  READ (SYSIN,65) NSURF,NTAPE,IPUN  A 102
8.  READ (SYSIN,70) FORM  A 104
9.  WRITE (SYSOT,75) TITL  A 106
10. READ (SYSIN,90) FACTOR,AREA,NCOL,NROW,ITYPE  A 108
11. WRITE (SYSOT,80)  A 110
12. DO 15 I=1,NROW  A 112
13. READ (SYSIN,FORM) (ZOR(I,J),J=1,NCOL)  A 114
14. 15 WRITE (SYSOT,85) (ZOR(I,J),J=1,NCOL)  A 116
15. DO 55 K=1,NSURF  A 118
16. READ (SYSIN,70) FORM  A 120
17. READ (SYSIN,90) FACTOR,AREA,NCOL,NROW,ITYPE  A 122
18. WRITE (SYSOT,95) FACTOR  A 124
19. DO 20 I=1,NROW  A 126
20. READ (SYSIN,FORM) (Z(I,J),J=1,NCOL)  A 128
21. 20 WRITE (SYSOT,85) (Z(I,J),J=1,NCOL)  A 130
22. WRITE (SYSOT,100)  A 132

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23.		DO 30 I=1,NROW	A 160
24.		DO 25 J=1,NCOL	A 162
25.	25	Z(I,J)=ZOR(I,J)/ (I,J)	A 164
26.	30	WRITE (SYSO1,M5) (Z(I,J),J=1,NCOL)	A 166
27.		IF (NTAPE,NE,1) GO TO 40	A 168
28.		WRITE (SDF3) FACTOR,HFS,NCOL,NROW,ITYPE	A 170
29.		DO 35 I=1,NROW	A 172
30.	35	WRITE (SDF3) (Z(I,J),J=1,NCOL)	A 174
31.	40	IF (IPUN,NE,1) GO TO 50	A 176
32.		PUNCH 90, FACTOR,RES,NCOL,NROW,ITYPE	A 178
33.		DO 45 I=1,NROW	A 180
34.	45	PUNCH FORM, (Z(I,J),J=1,NCOL)	A 182
35.	50	CONTINUE	A 184
36.	55	CONTINUE	A 186
37.		GO TO 5	A 188
		C	A 190
38.	60	STOP	A 192
		C	A 194
39.	65	FORMAT (3I2)	A 196
40.	70	FORMAT (8A10)	A 198
41.	75	FORMAT (1H1,8A10)	A 200
42.	80	FORMAT (1H0,27H THE ORIGINAL GRIDDED DATA)	A 202
43.	85	FORMAT (1H0,12F10.3,/(1X,12F10.3))	A 204
44.	90	FORMAT (4A10,3A10,213,I2)	A 206
45.	95	FORMAT (1H1,4A10)	A 208
46.	100	FORMAT (1H1,22H THE GRIDDED RESIDUALS)	A 210
47.		END	A 212-

***, IF ***

dd) FORSTAT CROSS-REFERENCE FOR PROGRAM RESMAP

PROGRAM RESMAP

STATEMENT NUMBER	DEFINITION	REFERENCES		
5	5.	37.		
10	7.	6.		
15	14.	12.		
20	21.	19.		
25	25.	24.		
30	26.	23.		
35	30.	29.		
40	31.	27.		
45	34.	33.		
50	35.	31.		
55	36.	15.		
60	38.	6.		
65	39.	7.		
70	40.	5.	8.	18.
75	41.	9.		
80	42.	11.		
85	43.	14.	21.	25.
90	44.	10.	17.	32.
95	45.	18.		
100	46.	22.		

20 STATEMENT NUMBERS DEFINED

3 MAXIMUM NUMBER OF REFERENCES

26 TOTAL NUMBER OF REFERENCES

1.3 AVERAGE NUMBER OF REFERENCES

OF

D 41 OF 04

PROGRAM RESMAP

LABEL TYPE		DEFINITION	REFERENCES									
AREA	H	2. D	10.	17.								
EOF	H	6.										
FACTOR	H	2. D	10.	17.	14.	24.	32.					
FORM	I	2. D	3.	4.	13.	10.	20.	34.				
I	I	12.	13.	14.	19.	20.	21.	23.	25.	24.	29.	30.
IPUN	I	7.	31.									33.
ITYPE	I	10.	17.	24.	32.							34.
J	I	13.	14.	20.	21.	24.	25.	26.	30.	34.		
K	I	15.										
NCUL	I	10.	13.	14.	17.	20.	21.	24.	26.	28.	30.	34.
NRGM	I	10.	12.	17.	19.	23.	24.	29.	32.	33.		
NSURE	I	7.	15.									
NTAPE	I	7.	27.									
RES	H	2. D DATA	4.	24.	32.							
SDEF3	I	3.	4.	24.	30.							
SYSIN	I	3.	4.	5.	6.	7.	8.	10.	13.	14.	17.	20.
SYSOT	I	3.	4.	9.	11.	14.	18.	21.	22.	24.		
TIIL	H	2. D	5.	9.								
Z	H	2. D	20.	21.	25.	26.	30.	34.				
ZOR	H	2. D	13.	14.	25.							

20 SYMBOLS DEFINED

12 MAXIMUM NUMBER OF REFERENCES

93 TOTAL NUMBER OF REFERENCES

4.6 AVERAGE NUMBER OF REFERENCES

ee)	LISTING OF PROGRAM LOADS	A	2
1.	PROGRAM LOADS (TAPE 1: INPUT, TAPE 3: TAPE SET INPUT, TAPE 5: OUTPUT)	A	4
C	-----	A	5
C	PROGRAM LOADS	A	5
C	-----	A	6
C	PURPOSE --	A	10
C	TO LOAD GRIDDED DATA ARRAYS ONTO TAPE IN STANDARD GCARS FORMATS	A	12
C	-----	A	14
C	THE GCARS SYSTEM	A	16
C	PURDUE UNIVERSITY	A	18
C	-----	A	20
C	A. KEITH TURNER,	A	22
C	CIVIL ENGINEERING,	A	24
C	JUNE 1969.	A	26
C	-----	A	28
C	GENERAL INFORMATION	A	30
C	-----	A	32
C	EACH ARRAY IS PLACED ON THE TAPE AS A SERIES OF BINARY RECORDS.	A	34
C	THE FIRST RECORD CONTAINS THE ARRAY IDENTIFICATION INFORMATION. EACH	A	36
C	ROW IN THE ARRAY FORMS A SUBSEQUENT RECORD.	A	38
C	-----	A	40
C	A SINGLE ARRAY OR A GROUP OF SEVERAL ARRAYS SEPARATED BY AN	A	42
C	END-OF-RECORD CARD IN THE CARD DECK WILL FORM A SINGLE BINARY FILE	A	44
C	ON THE TAPE. SEVERAL SUCH BINARY FILES, EACH CONTAINING ONE OR MORE	A	46
C	ARRAYS, CAN BE LOADED AT ONE TIME.	A	48
C	-----	A	50
C	BINARY FILES CONTAINING GROUPS OF ARRAYS ARE PARTICULARLY USEFUL	A	52
C	IN STORING DATA FOR SEVERAL FACTORS PRIOR TO MULTIPLE FACTOR	A	54
C	ANALYSES BY PROGRAM NEISUM.	A	56
C	-----	A	58
C	DESCRIPTION OF CONTROL CARDS -	A	60
C	-----	A	62
C	EACH DATA ARRAY SHOULD BE AS FOLLOWS	A	64
C	1) FORMAT CARD -	A	66
C	FORM (COLS 1-80) - FORMAT FOR DATA ARRAY (NORMALLY (BF10.3)).	A	68
C	2) HEADER CARD -	A	70
C	FACTOR (COLS 1-40) - ALPHANUMERIC IDENTIFICATION OF FACTOR.	A	72
C	AREA (COLS 41-70) - ALPHANUMERIC IDENTIFICATION OF AREA.	A	74
C	COCOL (COLS 71-73) - NUMBER OF COLUMNS IN THE ARRAY.	A	76
C	NRJ (COLS 74-76) - NUMBER OF ROWS IN THE ARRAY.	A	78
C	ITYPE (COLS 78) - IF DATA IS TOPOGRAPHIC RESIDUALS, ITYPE=1.	A	80
C	IF DATA MEASURES COSTS, ITYPE=2.	A	82
C	IF DATA MEASURES BENEFITS, ITYPE=3.	A	84
C	3) DATA CARDS --	A	86
C	NOTE -	A	88
C	AN END-OF-RECORD CARD (1-9 MULTIPUNCH IN COLUMN 1 ON COC0500)	A	90
C	SHOULD BE PLACED BETWEEN THOSE ARRAYS OR GROUPS OF ARRAYS WHICH ARE	A	92
C	TO FORM BINARY FILES ON THE TAPE. AN END-OF-FILE CARD WILL TERMINATE	A	94
C	THE PROGRAM.	A	96
C	-----	A	98
C	REQUIRED SUBROUTINES -	A	100
C	NONE	A	102
C	OPTIONAL SUBROUTINES -	A	104
C	NONE	A	106
C	-----	A	108
C	-----	A	110
C	-----	A	112
C	-----	A	114
C	-----	A	116
C	-----	A	118
C	-----	A	120
C	-----	A	122
C	-----	A	124
C	-----	A	126
C	-----	A	128
C	-----	A	130
C	-----	A	132

2.		DIAGONAL FORM(1), FACTOR(4), AREA(3), 7(S0)	A 144
3.		WRITE(1,SYSTIN,SYSTOUT,SUF3	A 146
4.		WRITE(1,SYSTIN,SYSTOUT,SUF3/10,4/	A 148
5.	5	READ(1,SYST,40) FORM	A 148
6.		IF (1) 30,SYSTIN) 20,10	A 142
7.	10	WRITE(1,SYSTOUT,35) FORM	A 144
8.		READ(1,SYST,40) FACTOR,AREA,NCOL,NROW,ITYPE	A 146
9.		WRITE(1,SYSTOUT,45) FACTOR,AREA,NCOL,NROW,ITYPE	A 148
10.		WRITE(1,SUF3) FACTOR,AREA,NCOL,NROW,ITYPE	A 150
11.		DO 15 J=1,NROW	A 152
12.		READ(1,SYSTIN,FORM) (/1) 1=1,NCOL	A 154
13.		WRITE(1,SYSTOUT,50) (2(1) 1=1,NCOL)	A 156
14.	15	WRITE(1,SUF3) (/1) 1=1,NCOL)	A 158
15.		GO TO 5	A 160
	C		A 162
16.	20	END FILE SUF3	A 164
17.		READ(1,SYSTIN,30) FORM	A 166
18.		IF (EOP,SYSTIN) 25,10	A 168
19.	25	READ(1,SUF3)	A 170
20.		STOP	A 172
	C		A 174
21.	30	FORMAT (A10)	A 176
22.	35	FORMAT (43H16R10DED DATA ARRAY BEING LOADED ONTO TAPE3,/,19H FORM	A 178
		1A1 FOR DATA = ,A10U//)	A 180
23.	40	FORMAT (4A10,3A10,2I3,12)	A 182
24.	45	FORMAT (1H0,4A10,3A10,2I3,12,//)	A 184
25.	50	FORMAT (1H0,12F10.3,/(1A,12F10.3))	A 186
26.		END	A 188

ff) FORSTAT CROSS-REFERENCE LISTING FOR PROGRAM LOADG

PROGRAM		LOADS									
LABEL	TYPE	DEFINITION		REFERENCES							
ARFA	R	2.	D	8.	9.	10.					
FOP	R	6.		18.							
FACTOR	R	2.	D	8.	9.	10.					
FORM	R	2.	D	5.	7.	12.	17.				
I	I	12.		13.	14.						
I TYPE	I	8.		9.	10.						
J	I	11.									
NCOL	I	8.		9.	10.	12.	13.	14.			
NROW	I	8.		9.	10.	11.					
SOF3	I	3.	FILE	4.	10.	14.	16.	19.			
SYSIN	I	3.	FILE	4.	5.	6.	8.	12.	17.	18.	
SYSUT	I	3.	FILE	4.	7.	9.	13.				
Z	R	2.	D	12.	13.	14.					

13 SYMBOLS DEFINED.

7 MAXIMUM NUMBER OF REFERENCES

42 TOTAL NUMBER OF REFERENCES

3.2 AVERAGE NUMBER OF REFERENCES

PROGRAM LOADS

STATEMENT NUMBER DEFINITION

REFERENCES

5	5.	15.	
10	7.	6.	18.
15	14.	11.	
20	16.	8.	
25	19.	18.	
30	21.	5.	17.
35	22.	7.	
40	23.	8.	
45	24.	9.	
50	25.	13.	

10 STATEMENT NUMBERS DEFINED

2 MAXIMUM NUMBER OF REFERENCES

12 TOTAL NUMBER OF REFERENCES

1.2 AVERAGE NUMBER OF REFERENCES

REFERENCES

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3. Hobson, R. D., 1967, "FORTRAN IV Programs to Determine Surface Roughness in Topography for the CDC 3400 Computer," Kansas Geological Survey Computer Contribution No. 14, University of Kansas, Lawrence, Kansas.
4. Turner, A.K., 1968, "FORTRAN IV Programs to Develop Contour Maps of Three-Dimensional Data," Joint Highway Research Project, Progress Report, May, No. 6, Purdue University, Lafayette, Indiana.
5. Turner, A. K., 1968, "Computer-Assisted Procedures to Generate and Evaluate Regional Highway Alternatives," Joint Highway Research Project, Final Report (Part I), December, No. 32, Purdue University, Lafayette, Indiana, 218 p.
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9. Turner, A. K. and Miles R. D., 1967, "Terrain Analysis By Computer" Joint Highway Research Project, Technical Paper, November, No. 31, Purdue University, Lafayette, Indiana.
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