PIT SLOPE MANUAL

supplement 2-2

DOMAIN ANALYSIS PROGRAMS

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PIT SLOPE PROJECT

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THE PIT SLOPE MANUAL

The Pit Slope Manual consists of ten chapters, published separately. Most chapters have supplements, also published separately. The ten chapters are:

1. Summary
2. Structural Geology
3. Mechanical Properties
4. Groundwater
5. Design
6. Mechanical Support
7. Perimeter Blasting
8. Monitoring
9. Waste Embankments
10. Environmental Planning

The chapters and supplements can be obtained from the Publications Distribution Office, CANMET, Energy, Mines and Resources Canada, 555 Booth Street, Ottawa, Ontario, K1A 0G1, Canada.

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FIGURES

SUMMARY

This report documents a User's Manual for the domain analysis of structural data. Card decks are supplied separately. Documentation of the computer programs that comprise the system has been carried out to ASCE standards (ASCE Proceedings 99, SM3, 1973, pp 249-266).

Domain analysis proceeds in four stages and the computer programs documented are grouped in these four stages. In stage 1, four programs - DTFX, TRVL2, INPT1 and MAP3 - prepare files and define groups of observations. In stage 2, four further programs are introduced - WNST5, GRPK1, INPK1 and GRPS - which assist in the computation of group means and dispersions. Stage 3 requires three programs - DSPD, NNPL1 and WNDPLT3 - for the display of group means and dispersions. Stage 4 uses two further programs - HOMO and DDKY.

INTRODUCTION

1. This analysis defines the orientation domains of a particular discontinuity. The discontinuity type (fabric element) to be analyzed must first be identified and retrieved from the master data file before the domain-analysis procedure can begin. Observations of orientation of the discontinuity type within the study area are then divided into groups and each group is characterized by a mean and dispersion. Statistical tests are used to define the largest possible areas within which the means and dispersions of the groups are similar. These areas are subfabric domains. Since the statistical tests are based on Fisher's model, the distribution of poles to the fabric element within each group should be unimodal and axially symmetric.

2. The procedure may be conveniently divided into four stages which are described as: File Preparation and Definition of Groups, Computation of Group Means and Dispersions, Display of Group Means and Dispersions, and Definition of Domains and Characterization of Domain Subfabrics.

3. The following four Sections describe each of these four stages in detail.

FILE PREPARATION AND DEFINITION OF GROUPS

4. Stage 1 is illustrated by the flow diagram in Fig 1, and consists of four steps.

5. Stage 1a. The file containing data for the fabric element, shown as uncorrected data file in Fig 1, is processed by the program DTFX. This produces a new data file in which every observation is associated with a distance from the traverse origin and observations on each traverse appear in order of increasing distance. This makes it possible to split traverses in the definition of groups.

6. Stage 1b. One of the requirements of the statistical tests for homogeneity of group means and dispersions is that groups contain not less than five observations. To satisfy this requirement, a map is produced that shows traverses and the number of observations on each traverse. This in turn requires that program TRVL2 uses the master traverse file and the data file produced by DTFX to produce a new corresponding traverse file.

7. Stage 1c. Program INPT1 reads the new traverse file and stores the data for program MAP3, which produces the map.

8. Stage 1d. The groups are outlined on the traverse map, and the group specifications tabulated in terms of traverse and observation numbers on each traverse.

9. Note that in all subsequent stages, references to the data files are taken to mean the new or adjusted data file, and all references to the traverse file are taken to mean the new traverse file.

PROGRAM DTFX

10. The program makes adjustments to a data file so that it is in a suitable form for areal analysis. The fabric data are examined one traverse at a time. Observations without corresponding distances are assumed to be uniformly distributed along the traverse. All observations on the traverse are then ordered by increasing distance. A flow diagram is given in Fig 2(a) and 2(b).

Solution

11. The fabric data are examined one traverse at a time. Those observations that have no corresponding distances associated with them are distributed uniformly along the traverse. The algorithm for doing this is as follows:

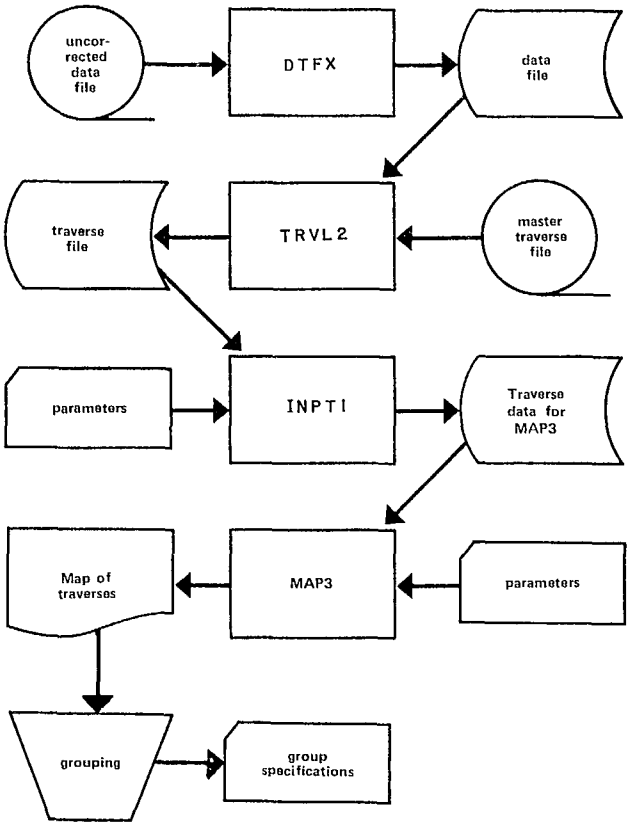

Fig 1 - Stage 1 - File preparation and definitions of groups

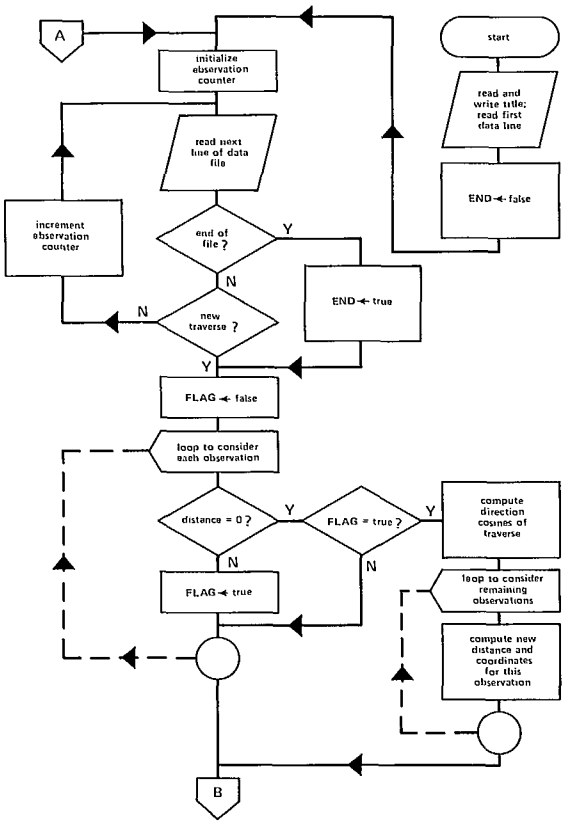

Fig 2(a) - Flow diagram for program DTFX - Part 1

l = length of traverse
n = number of observations without recorded distance
x(i) = distance assigned to the i-th observation without distance
a = l/n
b = a/2
x(i) = (i*a)-b :i=1,2,...n

All observations on the traverse are then ordered by increasing distance, and all the data for that traverse are written on the output file. The next traverse is then read from the input file and the process repeated. The first observation with zero distance following at least one observation with-zero distance is taken as the first observation for which distance is not recorded. This observation and all those that follow it in the traverse are assumed to have no distance recorded.

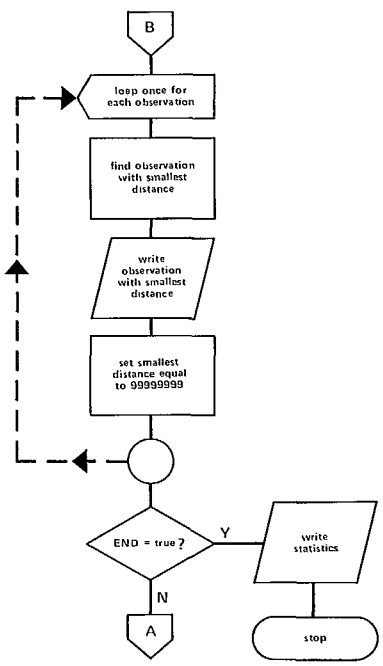

Fig 2(b) - Flow diagram for program DTFX - Part 2

Capabilities

12. Maximum number of observations in one traverse is 100. Those observations without distance must follow those with distance in each traverse.

Input

13. Unit 1 - tape or disk - input data file. Record length is 112 bytes. The records must all have the same length and format. Twenty-eight variables are read in each record with the format (A4, I4, 3A4, 2I3, I4, A4, A1, I4, 2I6, I5, 14A4). This file is created by CONVRT.

Variable no.	Columns	Specifications
2	005-008	integer, traverse number
6	021-023	integer, trend of traverse
7	024-026	integer, plunge of traverse
8	027-030	integer, length of traverse
11	036-039	integer, distance along traverse
12	040-045	integer, easting
13	046-051	integer, northing
14	052-056	integer, elevation

Output

14. Unit 6 - printer - statistics. Record length is 37 bytes. Prints number of traverses processed and the number of observations that were without distance.

Unit 2 - tape or disk - output data file. Record length is 112 bytes. Same as input data file (TAPE 1).

Variables

END	end-of-traverse flag
FLAG	flag to indicate non-zero distance has been found
K	array to contain input lines
TITLE	array to contain title
DTR	degrees-to-radians conversion factor
NTOT	counter of observations in file without distance
NTRAV	counter of traverses
I	index
J	index
NO	number of observations on traverse
TR	trend of traverse
PL	plunge of traverse
CP	cosine of plunge of traverse
DNORTH	first direction cosine of traverse
DEAST	second direction cosine of traverse
DELEV	third direction cosine of traverse
NFIRST	number of first observations on traverse without distance
NZ	number of observations on traverse without distance
A	see "method"
B	see "method"
X	see "method"
L	index
MIN	smallest distance
M	index

External References: FORTRAN functions SIN, COS, FLOAT.

Storage Requirements

15. Input and output file formats described elsewhere.

Code	bytes	words
DTFX	5724	302B
	10205(buffers)	4229
	15929	7257

PROGRAM TRVL2

16. The program reads traverse data from a traverse file. By simultaneously reading the data file, the program obtains the range of line numbers in the data file that corresponds to observations on each traverse. A new traverse file is produced containing this information. A flow diagram is presented in Fig 3.

Input

17. Unit 1 - tape or disk - traverse identification from data file. Record length 808 bytes

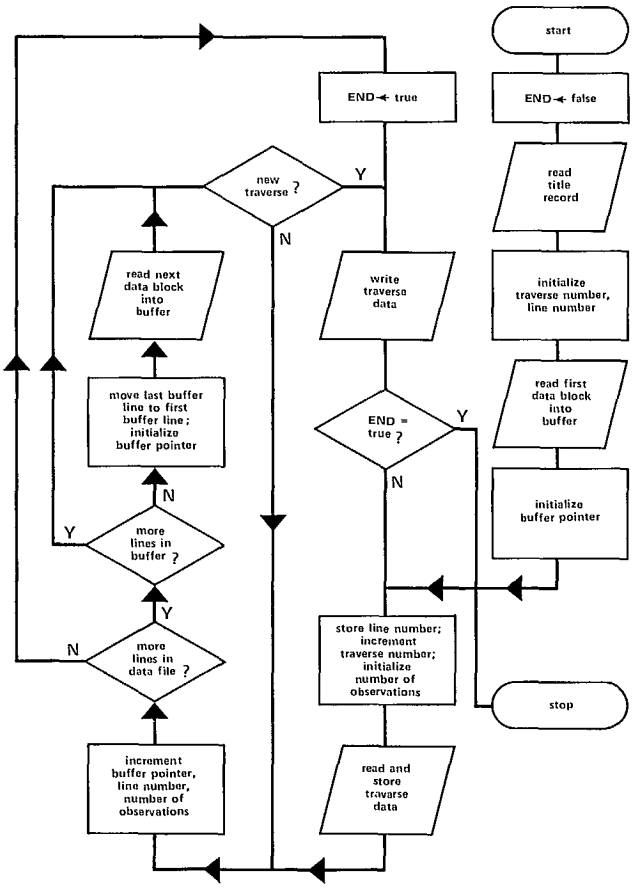

Fig 3 - Flow diagram for program TRVL2

unformatted. This is usually the output of INPT1 or INPK1.

Unit 4 - tape or disk - traverse list. Record length defined by format. Identical records, one for each traverse. Records are composed of:

a. double-word variable containing one to eight character identification of the traverse followed by
b. single word variables that may contain other information about the traverse

Unit 5 - card reader - formats for reading and writing the traverse data files. There are two records, one format on each (one for reading, one for writing). The formats are in columns 3-102. See Sample input.

Output

Unit 6,8 - tape, disk or card punch - printed output. Record length defined by format. Title of the traverse. New traverse file. Same variables as read on input unit 4, preceded by 4 full word integer variables containing:

a. sequence number of traverse in input file 4.
b. data file line number of first observation of this traverse
c. data file line number of last observation on this traverse
d. number of observations of this traverse.

Run Time

18. The program required 1.3 seconds of CPU time to process a data file containing 297 observations on 43 traverses.

PROGRAM INPT1

19. The program reads specified variables from an input file and writes the data in a convenient form for use by other programs in the areal analysis package. A flow diagram is shown in Fig 4(a) and 4(b).

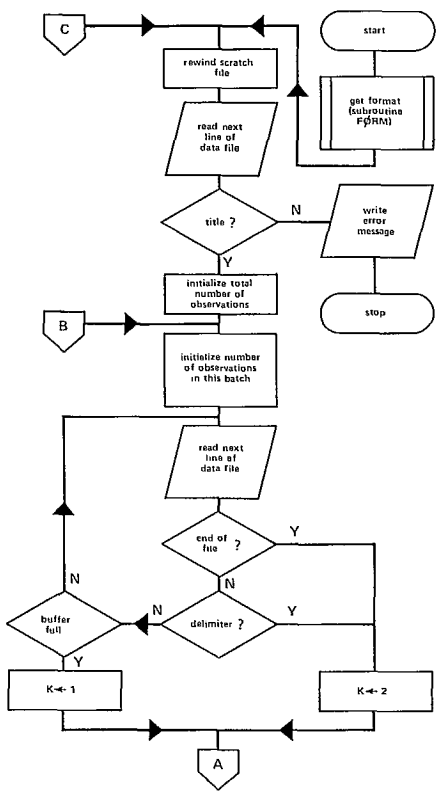

Fig 4(a) - Flow diagram for program INPT1 - Part 1

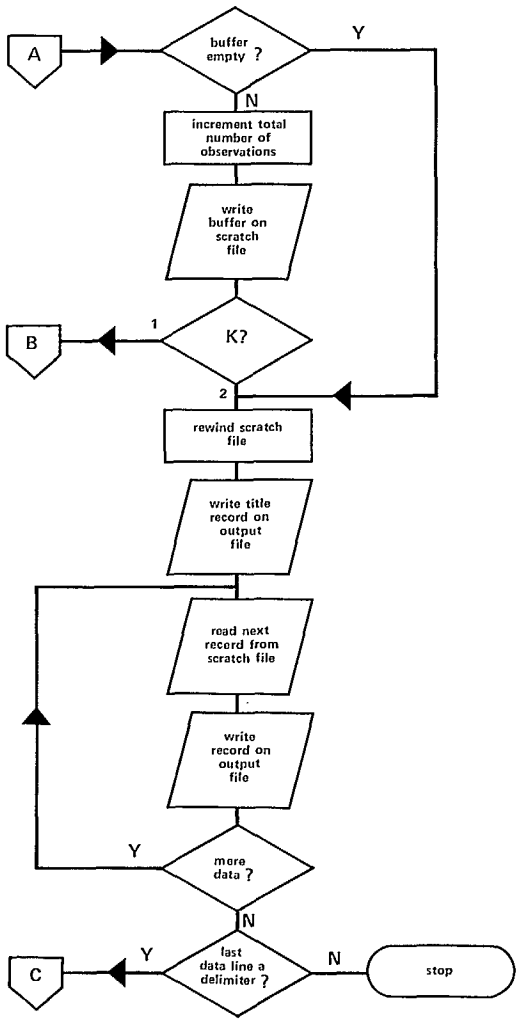

Fig 4(b) - Flow diagram for program INPT1 - Part 2

20. INPT1 accepts as parameters the number of variables to be read from each record of the input file and the format for reading those variables. The first field in the format specification must refer to a line-type character and must be specified as A1. The given number of variables must include the line-type character. Since the data array is declared as integer, and some FORTRAN input routines will not allow data to be read into an integer variable with an F format code, ie, as a real number, all input data must be in integer form and all fields must be specified with an I format code. If it is desired to convert integers to real numbers before they are placed in the output file, an additional set of parameters may be added to the parameter card containing the input format. These parameters specifiy which input variables are to be converted to real numbers and how many decimal places each should have.

21. At each data record in the input file, the program reads the specified number of one-word variables using the specified format. The data are written unformatted onto the output file as a header record followed by data records. Each output data record except the last always contains the data from 100 input records.

Solution

22. The output data records are first written onto a scratch file. After all the input records have been read, the title record is written onto the output file, and the output data records are then copied from the scratch file to the output file.

23. After each set of input records, terminated by a delimiter record, has been processed, the program attempts to read another title record. If an end-of-file condition results, the program terminates normally. If another title record is read, the program continues as before. If the next record is not a title record, the program stops after writing an error message.

Capabilities

24. Maximum length of the given format is 60 characters. Maximum number of variables read from each input record is 10.

Input

Unit 1 - tape or disk - input data file. Record length defined by format. The file contains one or several sets of data records. Each set must be preceded by a title record and followed by a delimiter record. The title record must contain the letter T in column 1 (this is called the line type character).

Unit 5 - card reader - a single record up to 102 bytes long. Record length: 102 bytes formatted.

Col 1-2 contains the number of variables to be read, right-justified.

3-62 FORTRAN format for reading input data from

unit 1.

63-102 up to 20 2-digit numbers. These numbers are interpreted in pairs: the first number of each pair is the number of a variable to be converted to a real number; the second number of the pair is the number of decimal places.
Example: '43' asks for the fourth variable (do not count the line-type character) to be divided by 10^3. The result is placed in the output record as a real number.

Unit 7 - scratch tape or disk - scratch file. Record length: 8+400xNV bytes unformatted. Output data records are stored in this file until they are copied to the output file.

Output

Unit 6 - printer messages - record length: 35 bytes unformatted. The program writes the number of output records. Error messages are self-explanatory.

Unit 8 - tape or disk - output file. Record length: 8+400 x NV unformatted. Output is written unformatted on this file as a header record followed by data records. Each header record contains four full word integers followed by the 120-byte title. The four integers are:

a. the total number of words in this set of data
b. the number, NV, of variables read from each input record
c. the total number of input records read in this set of data
d. the number of output data records following the header record.

Each data record contains 2 full word integers followed by the data from up to 100 input records. The integers contain:

a. the number, N, of input records in this output record (100 max)
b. the number of words of data in this output record = N x NV

The data are the variables from the input records in the order in which they were read.

Variables

NVAR	number of variables
FMT	format
IC	conversion factors
LINTYP	line-type character
NTOT	total number of data records read
NPHR	number of output data records (after title record)
N	number of data records in batch
DATA	array to contain the data
IV	number of variable to be converted to real
RDATA	array to contain real values - same location as DATA
IE	number of data words in data record
NN	number of data words in entire sample

Storage Requirements

25. The arrays DATA and RDATA occupy the same storage.

Code	bytes	words
INPT1	2400	1280
	12246(buffers)	5286
	14646	6566

PROGRAM MAP3

26. The program draws a map with coordinate grid lines showing either (1) survey traverses, (2) strikes of discontinuities, or (3) three-dimensional orientations of discontinuities. Three-dimensional orientations are represented by a line whose azimuth and length are those of a line drawn on an equal-area projection from the centre of the projection to the point representing the given orientation. A flow diagram is given in Fig 5.

Solution

27. MAP3 determines the maximum and minimum X and Y values from the data. It then determines the position of the first grid line above the maximum X value, and the position of the first grid line below the minimum X value,, using the given interval between grid lines. This is repeated for the Y values. The four grid lines so

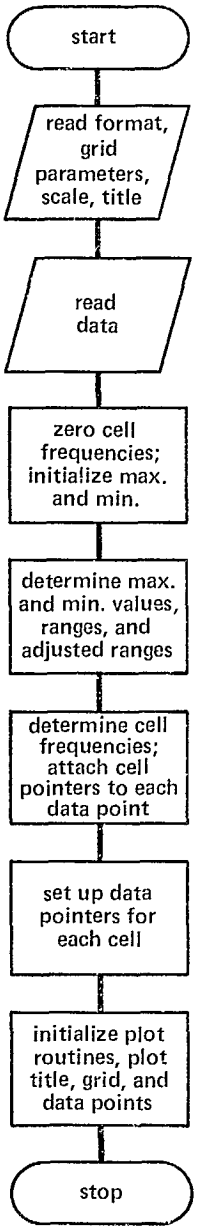

Fig 5 - Flow diagram for program MAP3

determined become the borders of the map. This border is drawn, as well as all intermediate grid lines, and a title is written below the lower border. The data points are then plotted. Optimization of plotting is achieved in the following way: Using the extreme X,Y values corresponding to the borders of the map, the program subdivides the whole rectangular region into a 60 by 60 grid, determines the number of observations within each grid square, and sets up pointers to locate all observations within each grid square. This enables the program to do a scan on the 60 by 60 matrix to optimize plotting.

28. The scale of the map is determined by a scale factor read from the parameter card. This scale factor specifies the number of data units that are to correspond to one inch on the map.

29. Beside each data point the program writes one number and one character string of up to four characters. If the number is zero, it is not plotted. From each data point a line is drawn with azimuth A and length, L. A and L are determined from the data items NUM1 and NUM2 associated with the data point, in a way determined by the parameter MODE.

Capabilities

30. Maximum number of data points in one map is 1500.

Program Options

31. If MODE= 1 (traverses) A=NUM1 and L=NUM2/SCALE (same scale as coordinates). If MODE=2 (strikes) A=NUM1 and L=0.5. If MODE=3 (three-dimensional directions) A=NUM1 and L=PROJARD(NUM2, DPI), where PROJARD(NUM2,DPI) is the distance on a Lambert equal-area projection with radius DPI from the centre of the projection to a point representing a plunge of NUM2 degrees. DPI is read from the parameter card.

32. Optional printout of the input and certain derived data are controlled by the LIST parameter.

Input

Unit 1 - tape or disk - data unformatted, as written by program INPT1, INPK1 or DSPD. Record length: 2408 bytes, unformatted.

Unit 5 - card reader - record length: 50 bytes formatted. One record containing:

Column	Content
10	A number specifying MODE for MODE= the plot is 1 traverses 2 strikes 3 3 dimensional directions such as poles to discontinuities.
11-20	Number of data units between grid lines. Right justified integer.
21-30	Number of data units per inch. Right-justified integer or with decimal point.
31-40	DPI. Radius of projection for plotting orientation. Right-justified integer or decimal value. If the field is left blank, or zero is specified, a default of 3.937 in. (20 cm) will be used.
50	A number specifying a LIST option for LIST= the point-out is 0 no data listing is produced. 1 input data are listed as they are read 2 input data plus a listing of the values of data points as they are plotted The values are for variables: NUM1, NUM2, TREND,PLUNGE,PROJX,PROJY (PROJEX and PROJY are the X and Y increments from the beginning to the end of the plotted line segment).

Output

Unit 6 - line printer. Record length: 112 bytes, formatted. Parameter list and messages. Input parameters.

Unit 7 - line printer. Record length: 120 bytes, formatted. Data listings. These listings are controlled by LIST parameter on I/O unit 5 parameter card.

Unspecified Plotter or plotter output tape. Record length: defined by plotting routines. This unit is selected by the plot routines which are not part of these programs.

Variables

KEY	control code
INTGR	grid interval (data units)
SCALE	scale (data units per inch)
DPI	radius of projection for plotting orientations
LIST	printout parameter
XSTART	x-coordinate of left-hand side of map
NN	number of data words in sample
NV	number of variables in input
NO	number of observations in input
NPHR	number of data records following title record
TITLE	array to contain title
N	number of observations in data record
IE	number of data words in record
IX,IY	x and y coordinates
IZ	number to be written beside data point
LABEL	character string to be written beside data point
NUM1	azimuth
NUM2	see "options"

External References: The following subroutines from the Calcomp plotting library:

PLOT(X,Y,J)

Moves the pen from its current position to the point (X,Y) with pen up (J=3) or down (J=2). Plot origin is reset to (X,Y) if J < 0.

WHERE(X,Y,F)

Returns in X,Y the current pen position, and in F the current scaling factor.

PLOTS

Initializes the plotting routines.

XLIMIT(X)

Resets the default limit of plotting in the

X-direction to X in.

NUMBER(X,Y,H,R,T,N)

Writes the real number, R, with N decimal places at the location X,Y with a character height of H, making an angle of T degrees with the positive x axis (counter-clockwise).

LINE(X,Y,N,I,J,K,)

Given N data points whose coordinates are in every i-th word of the vectors X and Y, either draws a line through the points (J=0), or draws the symbol number K at each point (J < 0) or both (J > 0).

SYMBOL(X,Y,H,IC,T,N)

Starting at the point X,Y and using a symbol height of H in., either draws N characters stored in EBCDIC in the array IC (N > 0) or draws symbol under IC (N=1) or draws symbol under IC with a line from the current pen position (N=-2). The symbols make an angle of T degrees with the positive x axis (counter-clockwise).

Storage Requirements:

Code		bytes		words
	MAP3	008144	2547	1383
			10205(buffers)	4229
	PGRID	001072	454	300
	PPTS2	001928	247	167
	TPXYEQ	000928	117	79
	PPTS	002112	353	235
	RJUST8	000560	41	33
	PPLOT	008680	43441	18209
	LEN1	000512	24	20
	PPTS3	002120	401	257
	LIMT		10	8
Labelled COMMON				
areas-	MAP1	042016	21453	9003
	MAP2	018416	21990	9208
	Total	86488	101283	55131

SAMPLE RUN - STAGE 1

Input Files
Uncorrected Data File
Unit 1 input to DTFX

```
TTEST DATA
 D2DM0051  3  126967   259 -5  21715D 3   53B053989391D069687BG  66  23-1589-3570  9205  33L   1        0   0   0MDSR2
 D2DM0051  3  126967   259 -5  217150 5   89B05363939D936969DBG  83  27 -553-45D6  891D  27L   2        0   0   0MDSR3
 D2DM0051  3  126967   259 -5  217150 6   92B05360939D9369690BG  83  27 -553-4506  8910  27L   2        0   0   DCMSR1
 D2DM0D51  3  126967   259 -5  21715010  1768D52789390776969 7BG  62  26-2058-3871  898B  29L   1        0   0   0MDSR3
 D2DM0051  3  126967   259 -5  21715014    0B0545093911069 6B2BG  46  17-2031-2103  9563  62 B             0   D   0MDSR2
 D2DM0051  3  126967   259 -5  21715015    D80545D9391106968 2BG  83  27 -553-4506  8910  27 B             0   0   0CMSR1
 O2DM0052  3  126967   262  5  28D220 1    0B0479093BB5069692BG  96  15  271-2574  9659  30L Z  2172FD-9255 3587 1215MDSR3
   ...     .  ....    .. .   ...           ...                   .   .   .   .   . .  . .    .    .    .    .   .
 D2HMDD89  3  116700   241-28  14023023    0B05360941610673 8BG  61  18-1498-27D3  9511  58 F             0   0   0COLS4
```

Master traverse file

Unit 4 input to TRVL2

```
*0101/2DM   2/59421/01/0R4/5920/  /78383 /96432 /222/-02/1001/ /68/312/
*0101/2DM   3/59538/01/0R4/5920/  /78314 /96363 /227/  0/ 211/ /24/317/
*0101/2DM   4/59425/01/0R4/5920/  /78237 /96226 /201/-02/ 998/ /41/291/
*0101/2DM   5/58837/01/0R4/5870/  /78202 /96299 /184/-03/ 289/ /12/274/
*0101/2DM   6/58808/01/0R4/5870/  /78186 /96242 /200/-02/ 898/ /42/290/
*0101/2DM   7/58881/01/0R4/5870/  /78147 /96071 /201/+02/ 278/ /29/291/
*0101/2DM   8/58880/01/0R4/5870/  /78118 /95961 /191/-01/ 185/ /11/281/
.........   ..................    ...... ...... ........  .... ........
*0101/2HM  90/64088/ 2/  4/    /  /79118 /94566 /162/-04/ 330/ / 4/172/
```

Output files

Data file

Unit 2 output from DTFX

Unit 1 input to INPT1

```
TTEST DATA
 D2DM  51  3  126967   259 -5 217150 3   538053989391O069687BG 66 23-1589-3570 9205 33L    1          0    D    OMOSR2
 D2OM  51  3  126967   259 -5 21715O14   548053979391O069687BG 46 17-2031-2103 9563 62 B             0    0    OMDSR2
 O2OM  51  3  126967   259 -5 217150 5   898053639390936969OBG 83 27 -553-4506 B910 27L    2          0    0    OMDSR3
 O2DM  51  3  126967   259 -5 217150 6   928053609390936969OBG 83 27 -553-4506 B910 27L    2          0    0    OCMSR1
 D2OM  51  3  126967   259 -5 21715O15  163B052919390796969GBG 83 27 -553-4506 8910 27 B             0    0    OCMSR1
 O2OM  51  3  126967   259 -5 21715O10  176805278939077696978G 62 26-2058-3871 8988 29L    1          0    0    OMDSR3
 O2DM  52  3  126967   262  5 280220 1    08047909388506969 2BG 96 15  271-2574 9659 30L Z  2172FO-9255 3587 1215MDSR2
 ....  ... ......  ... . .......  ..................... .. ..  ................   ..........  ....    ......
 O2HM  89  3  116700   241-28 14023023  123805265941558674O6BG 61 18-1498-2703 9511 58 F             0    0    OCOLS4
```

Traverse file

Unit 8 output from TRVL2

Unit 1 input to INPT1

```
TTEST DATA                                                                    TRAVERSES
  50    1   6   62DM   5169682  3  126967    80545  93911  259-05 217
  51    7  13   72DM   5269692  3  126967    80479  93885  262  5 280
  52   14  21   82DM   5469142  3  126900    80569  93962  258  0 472
  53   22  49  282DM   5569047  3  126900    80410  93953  252-02 294
  54   50  59  102DM   5668502  3  126833    80592  94086  247+01 333
  55   60  90  312DM   5768452  3  126833    80535  94062  228-14 435
  63   91  96   62DM   6568482  3  116833    80331  93992  259  7 375
  64   97 1DO   42DM   6767817  3  116767    807D5  94157  246+01 311
  ..   .. ...   ....   .......  .  ......    .....  .....  ...... ...
 163  291 297   72HM   8967348  3  116700    80536  94161  241-28 140
```

Input parameters (Unit 5, see Fig 6)

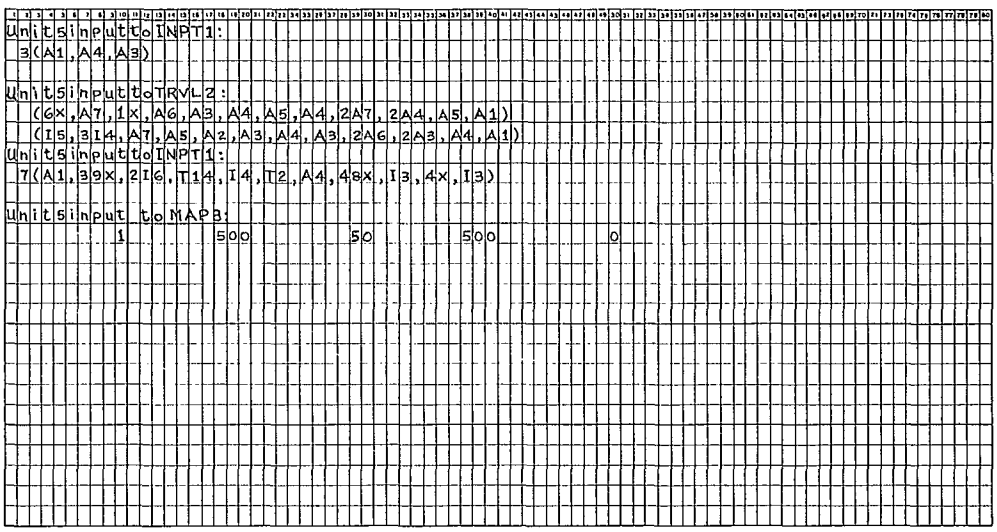

Fig 6 - Input parameters for Stage 1

Printed Output:

Unit 6 output from DTFX:

```
PROGRAM "PFIX" STATISTICS
NUMBER OF TRAVERSES:   43
OBSERVATIONS WITHOUT DISTANCE:   123
```

```
Unit 6 output from INPT1:
    3 VARIABLES
FORMAT=(A1,A4,A3)
TEST DATA
 297 DATA POINTS               3 PHYSICAL RECORDS
```

```
Unit 6 output from TRVL2:
TTEST DATA                                        TRAVERSES
```

```
Unit 6 output from INPT1:
     7 VARIABLES
FORMAT=(A1,39X,216,T14,14,T2,A4,4BX,13,4X,13)
TEST DATA                                  TRAVERSES
  43 DATA POINTS        1 PHYSICAL RECORDS
```

```
Unit 6 output from MAP3:
  MODE=1       DATA UNITS BETWEEN GRID LINES= 5000

DATA UNITS PER INCH=  500.0000      PROJECTION RADIUS=   3.937

INCHES PER DATA UNIT=   0.002000         PROJECTION RADIUS=   3.937
1
2
3
```

Plotted Output (Fig 7)

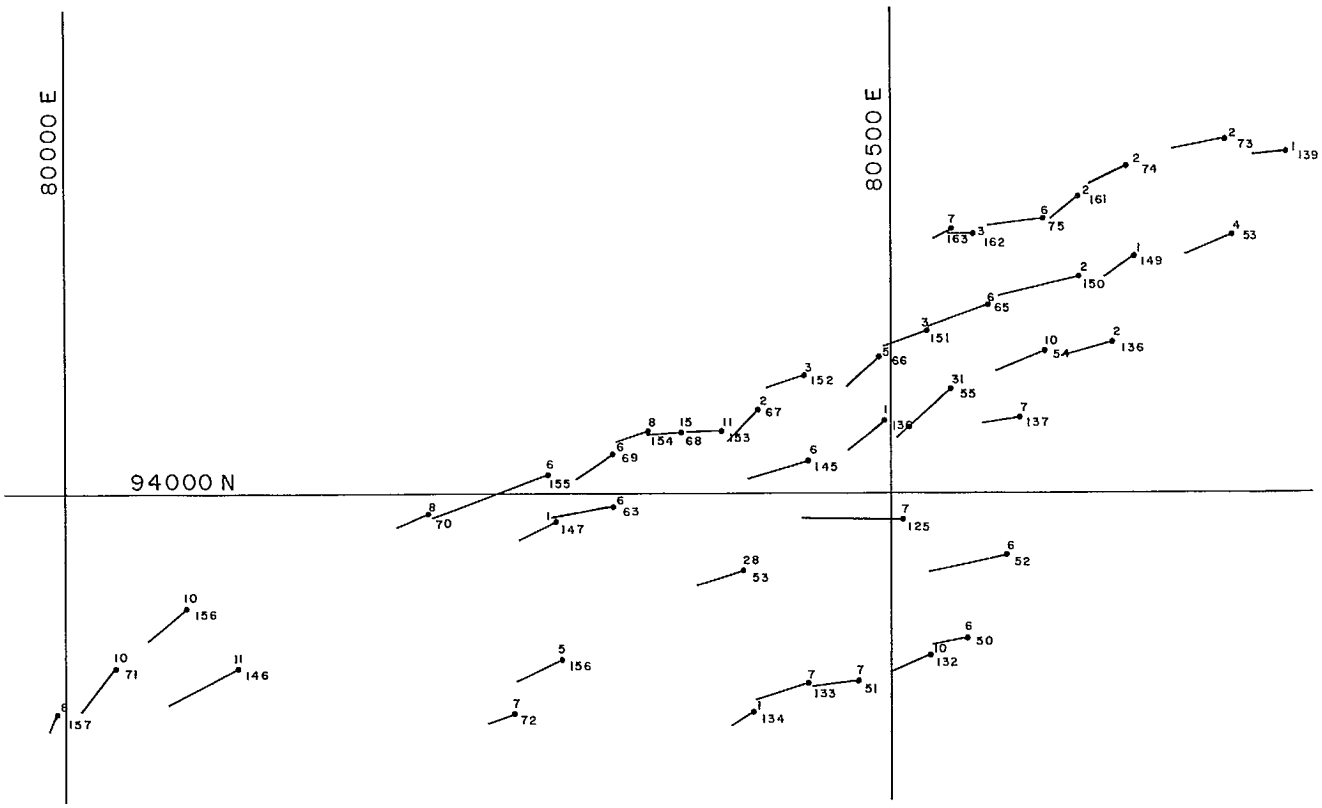

Fig 7 - Traverses with numbers of observations (above) and traverse numbers (below)

COMPUTATION OF GROUP MEANS AND DISPERSIONS

33. Stage 2 of domain analysis, is illustrated by the flow diagram in Fig 8 and consists of three steps.

34. Stage 2a. Program INPT1 reads the data file and stores the data required by program WNST5 which computes statistics for the whole data file. The eigenvectors for the whole data file are stored for use in Stage 2c and in Stage 3a.

35. Stage 2b. Using the group specifications and the traverse file, program GRPK1 computes the group keys, ie, the line-numbers in the data file corresponding to each group of observations outlined on the map.

36. Stage 2c. Program INPK1 reads the data file under control of the group keys and stores the data required by program GRPS, which computes the mean and dispersions of each group.

PROGRAM WNST5

37. The program computes axis statistics and vector statistics for weighted points on the hemisphere. A flow diagram is presented in Fig 9.

38. WNST5 calls the subroutines DCPM1 to compute the data cross-product matrix, then subroutine ESTAT1 to estimate population parameters using Bingham's model. This subroutine also tests

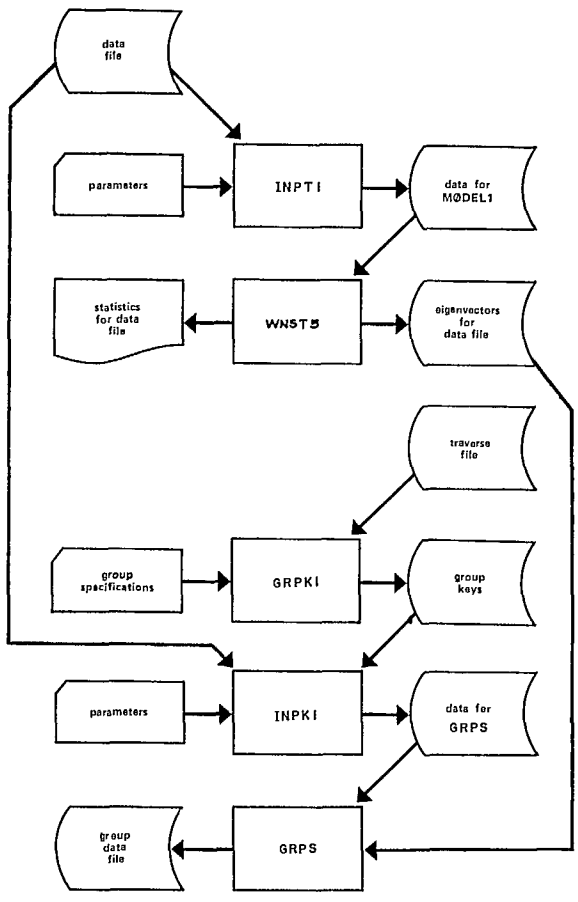

Fig 8 - Stage 2 - Computation of group means and dispersions

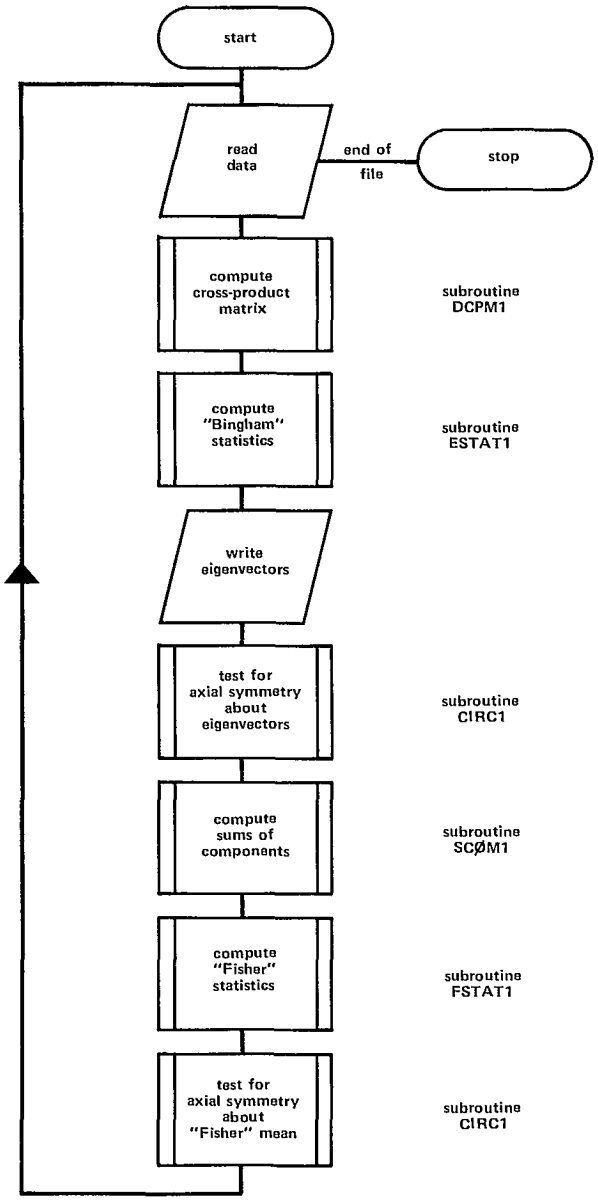

Fig 9 - Flow diagram for program WNST5

the hypotheses of uniformity and axial symmetry using the eigenvalues of the data cross-product matrix. Depending on the results of these tests, the program performs a more sensitive test for axial symmetry, using Kuiper's statistic, by calling the subroutine CIRC1.

39. Fisher statistics are obtained by calling subroutine SCOM1 to compute sums of components, subroutine PSTAT1 to estimate population parameters using Fisher's model, and subroutine CIRC1 to test for axial symmetry about the Fisher mean.

Solution

See subroutine documentation in source listing.

Capabilities

Maximum number of data points in one sample is 2000.

Input

Unit 1 - tape or disk - record length: 1600 bytes unformatted. Input data. Unformatted records containing direction cosines and weights for up to 100 points. The sequence direction cosines, weight (four full word real numbers) is repeated for each data point. This file is written by program INPT1 or INPK1.

Output

Unit 6 - printer - record length: 76 bytes formatted. Statistics. All computed statistics are written on this I/O unit, with printer carriage control.

Unit 7 - disk or card punch - record length: 30 bytes formatted. Eigenvectors. The eigenvectors of the data cross-product matrix are written on this unit for later use by other programs. Three formatted records are written, each containing the direction cosines of one eigenvector in the normal sequence (north, east, down). The sequence of eigenvectors is such that the associated eigenvalues are in ascending order.

Subroutines

FSTAT1 Given the sums of components of a set of vectors, computes the length, direction cosines and angular co-ordinates of the resultant vector. FSTAT1 also computes the concentration parameter and confidence radius of the mean assuming Fisher's distribution. FSTAT1 calls RTSP and XKF. RTST computes the angular co-ordinates of the resultant, and XKF estimates the concentration parameter of the population.
Calling sequence: CALL FSTAT1(TITLE,N,SW, U,E,S,T,XK,CR,IPRINT)
TITLE = 120-byte title

N = number of data points
SW = sum of weights of the data points
U = vector of sums of components
E = vector of direction cosines returned
S = vector of angular co-ordinates returned. It contains trend and plunge, followed by dip direction and dip, of the perpendicular plane.
T = a rector returned containing 1. length of the resultant vector, and 2. length of the resultant divided by SW.
XK = estimated concentration parameter returned.
CR = confidence radii of mean returned.
IPRINT = print out parameter provided by calling routine IPRINT is less than zero if there is to be no print out. IPRINT is greater than or equal to zero for a printout, and the value of IPINT is the I/O unit.

KUIP2 See source
XK1 Function, See source
ROTMAT See CONVRT
XK3 Function, See source
BSTATC See source
RSTP See DSPD
ANDC Converts from spherical to rectangular co-ordinates for points on the unit sphere.
Calling sequence: CALL ANDC(T,P,J1,A,B,C, J3,N)
T = vector of horizontal angles
P = vector of vertical angles
J1 = first input code of spacing of input, in words, of vectors T and P.
J1 is greater than zero if the input units are in degrees. It is less than zero if the input units are radians.
J2 = second input code.
= 1 if input type is trend and plunge of line
= 2 if input type is dip direction and dip of plane.
= 3 if input type is strike and dip of plane.
In cases 2 and 3 the pole is the unit hemisphere and J2 is greater than zero if the domain of input is the unit sphere; J2 is less than zero if the domain of inputs is the unit hemisphere.
A = vector of first direction cosines returned
B = vector of second direction cosines
C = vector of third direction cosines
J3 = output code of spacing, in words, of vectors A, B, and C
N = number of data points input.

Variables

WEIGHT weighting code
NN number of data words in sample
NV number of variables
NO number of observations
NPHR number of data records following title record
TITLE array to contain title
N number of observations in data record
NE number of data words in data record
DC direction cosines
W weights
SW sum of weights of observations

External references:
Standard Fortran IV built-in functions.

Storage Requirements

Code		bytes	words
WNST5	58456	34052	14378
		10205(buffers)	4229
BSTATC	01768	326	214
KUIP2	00848	114	76
ANDC	01008	131	89
SYMM	01968	300	192
XKF	01344	332	218
EIGEN	02792	432	282
DCPM1	00656	103	67
TAB1	00704	43	35
FSTAT1	01848	304	196

RTSP	01496	206	134
GMPRD	00680	103	67
XK1	00904	223	147
GTPRD	00672	100	64
CIRC1	02424	713	459
ESTAT1	02144	445	293
BSTATG	01752	321	209
SCOM1	01032	142	98
VRM1	00880	71	57
ROTMAT1	00848	131	89
XK3	00944	203	131
TOTAL	85168 bytes	49000	21724

PROGRAM GRPK1

40. Using a list of the traverses in each domain and a list of the observations in each traverse, this program generates keys containing the numbers of the observations in each domain. A flow diagram is shown in Fig 10.

Solution

41. The program reads from the traverse file the range of data-file line numbers for each traverse. It then reads group definitions, one at a time. Each group is defined by traverse numbers and observation numbers on each traverse. Traverses specified for a group are processed in order of increasing traverse number, so that line numbers in the key will be in sequence. This traverse number is not the field traverse number, but one assigned by TRVL2 to place traverses sequentially in the data file. If the entire traverse is not to be included, the range of line numbers to be included in the key is computed. The line numbers in this range are added to the key.

42. The number of the traverse just processed is replaced by 10000 and the group definition again searched for the smallest traverse number. When all the traverses included in the group have been processed, the key is written out and the next group definition is read.

Capabilities

43. Maximum number of traverses in the traverse file is 999. Maximum number of traverses in one group is 10. Maximum number of line numbers in key is 20.

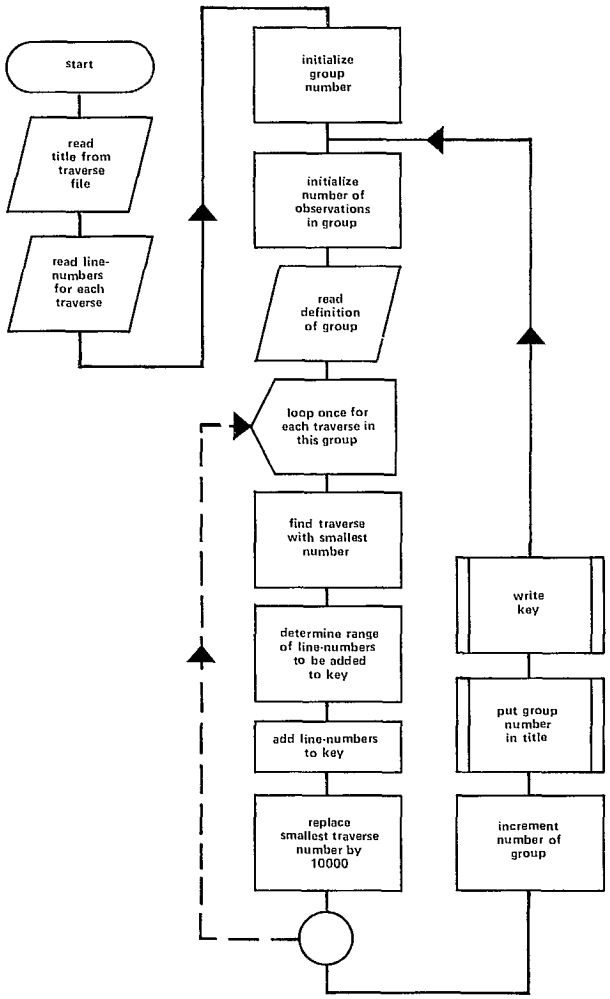

Fig 10 - Flow diagram for program GRPK1

Input

Unit 1 - tape or disk - record length: 121 bytes, formatted. Traverse numbers and line number ranges. One record for each traverse containing:

Column	Contents
2-5	traverse number
13-16	starting line number for traverse
17-20	ending line number for traverse

These data created by TRVL2.

Unit 2 - card reader - record length: 120 bytes formatted. Group definitions. One record for each group. Each record contains 120 characters, or 30 in each %, 4 character fields.

A group may have up to 10 traverses. Each traverse has 3, 4 character fields:

field 1 is the traverse number

field 2 is the number of the first observation to be included. If this field is blank or zero, the first observation of the traverse is assumed.

field 3 is the number of the last observation to be included. If this field is blank or zero, the last observation of the traverse is assumed.

Each field is right justified.

Output

Unit 6 - printer - record length: 121 bytes formatted. Error messages. If the number of observations indicated for inclusion in a traverse is greater than the number of observations taken for that traverse, an error message is produced. The program stops immediately.

Unit 7 - disk or card punch - record length: 80 bytes formatted. Key. Writes a single key for each group of traverses. These keys are used as input to the program INPK1.

Subroutines

WRITEK Writes a set of half-work integers in a special format: All records are 80 bytes long, sequenced in positions 78-80

Record 1: 1-72 = first 72 bytes of title

Record 2: 1-48 = last 48 bytes of title
53-56 = LENFIL
61-64 = LENKEY

Other records: 1-72 keys; usually 18

Calling sequence: CALL WRITEK(IOU,TITLE, LENFIL,LENKEY,KEY)

IOU = I/O Unit to be written on

TITLE = 120 bytes title

LENFIL = size of universe to which the set of data belongs.

LENKEY = size of set of the data

KEY = set of key data

Variables

FMT	format for reading traverse file
TITLE	title
M	number of first observation on traverse
N	number of last observation on traverse
LENFIL	number of observations in survey
IGROUP	counter for domains
LENKEY	number of observations in domain
L	array of traverse numbers in domain
NT	number of traverses in domain
MIN	smallest traverse number in domain
KEY	array of observation numbers in domain

Storage Requirements

Code		bytes	words
GRPK1	6016	5075	2621
		10205(buffers)	4229
WRITEK	0904	100	64
TOTAL	6920	15380	6914

PROGRAM INPK1

44. The program reads specified variables from an input file using a key and writes the data in a convenient form for use by other programs in the areal-analysis package. A flow diagram given in Fig 11(a) to (c).

45. INPK1 accepts as parameters the number of variables to be read from each record of the input file and the format for reading those variables. The first field in the format specification must refer to a line-type character and must be specified as A1. The specified number of variables must include this field. Because the data array is declared as integer, and some FORTRAN input routines will not allow data to be read into an integer variable with an F format code, ie, as a real number, all input data must be in integer form and all fields must be specified with an I format code. If it is desired to convert integers to real numbers before they are placed in the output file, an additional set of parameters may be added to the parameter card containing the input format. These parameters specify which input variables are to be converted to real

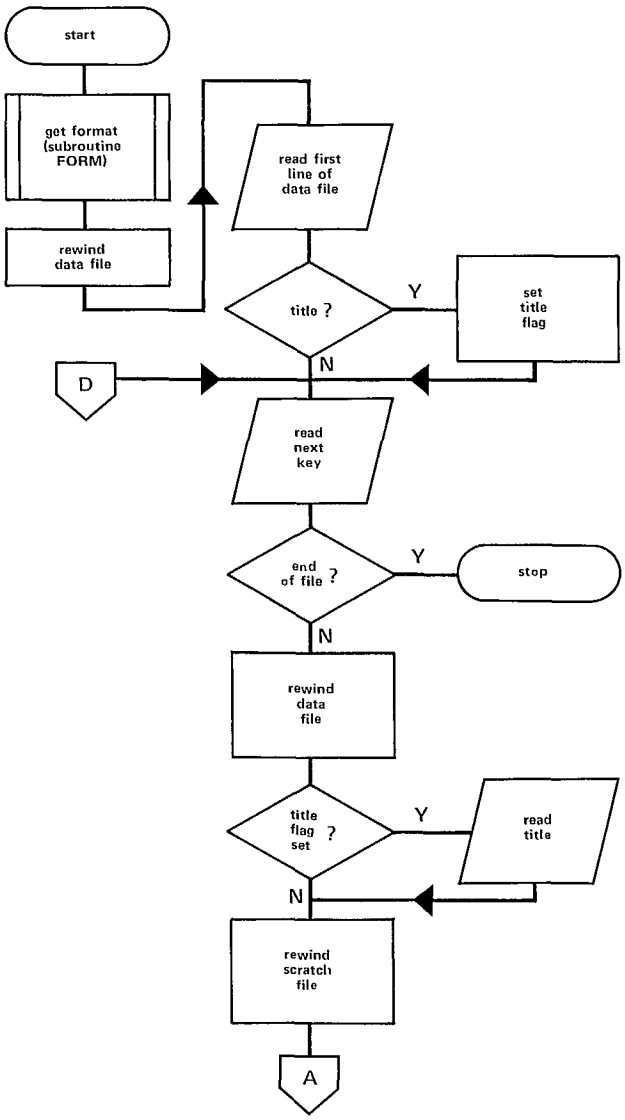

Fig 11(a) - Flow diagram for program INPK - Part 1

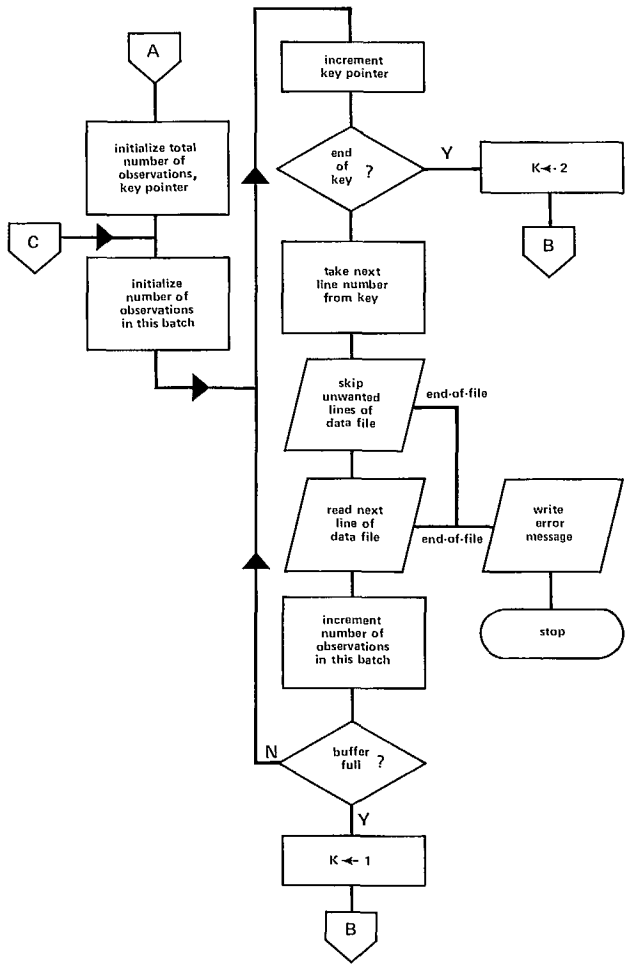

Fig 11(b) - Flow diagram for program INPK - Part 2

numbers and how many decimal places each should have.

46. Which records of the input file are read is determined by a key of record numbers. At each record of the input file whose number appears in the key, the program reads the specified number of full word variables using the specified format. The data are written unformatted into the output file as a header record followed by data records. Each output data record except the last always contains the data from 100 input records.

Solution

47. The output data records the first written onto a scratch file. After all the input records have been read, the header record is written onto the output file, and the output data records are then copied from the scratch file to the output file.

48. If the first byte of the first input record contains the letter T, this record is assumed to be a title record and counting of input records begins with record 2; otherwise counting

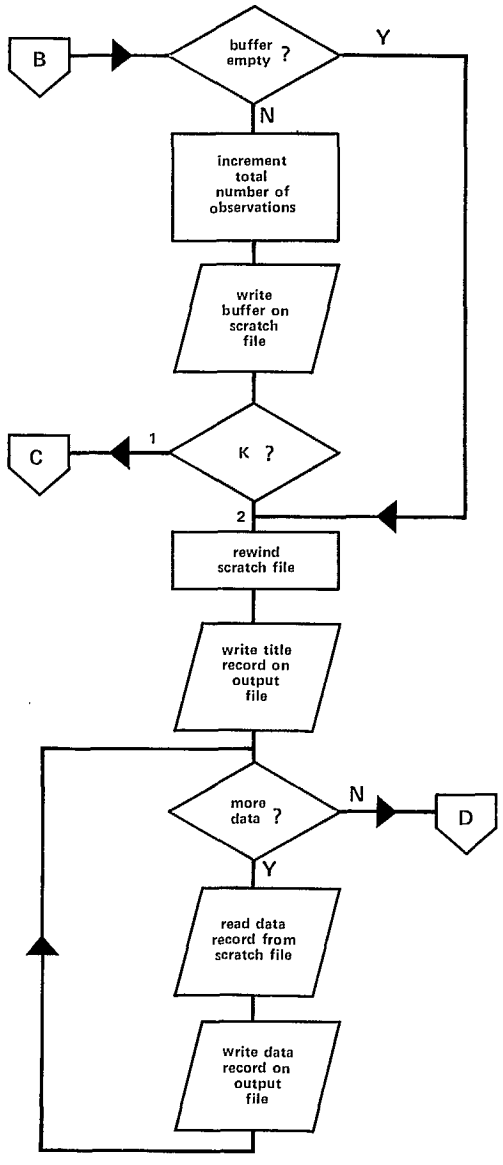

Fig 11(c) - Flow diagram for program INPK - Part 3

of the input records begins with record 1. Since only those input records are read whose numbers appear in the key, an end-of-file condition resulting from an attempt to read the input file always indicates an error, and the program stops after printing a message. After processing the input records as directed by a key, the program attempts to read another key. If an end-of-file conditions results, the program stops normally. If another key is read, the input file is rewound and the process repeated using the new key. In this way, any number of sets of data may be extracted from the input file and written sequentially on the output file.

Capabilities

49. Maximum length of the given format is 60 characters. Maximum number of variables read from each input record is 10. Maximum number of variables read from each input record is 10. Maximum number of input record numbers in one key is 5000.

Input

Unit 1 - tape or disk - record length: determined by format from unit 5. Output from DTFX. Input data file. All records have the same format unless the first record is a title record, in which case the first record contains the letter T in column 1 (This is the line type character) and a title in column 2-121.

Unit 2 - card reader - record length: 80 bytes formatted. Keys. This is the output file from GRPK1, unit 7.

Unit 5 - card reader - record length: 102 bytes, formatted. Parameters. One record containing:

Columns	Contents
1-2	number of variables to be read, right justified.
3-62	a FORTRAN format describing how to read data from unit 1.
63-102	up to 20, 2-digit numbers (right-justified). These numbers are interpreted in pairs: The first is the number of the variable to be converted to a real number; the second is the number of decimal places. Example: '43' asks that the fourth variable (not counting the first character, which is the line type character) divided by 10^3 and the result placed in the output record as a real number.

Output

Unit 6 - line printer - record length: 35 bytes, formatted. Messages. The program writes the number of output data records. Error messages are self-explanatory.

Unit 7 - tape or disk - record length: 8 + 400 x NV unformatted. Scratch file. Output data records are stored in this file until they are copied to the output file.

Unit 8 - tape or disk - record length 8 + 400 x NV, unformatted. NV = number of variables. Output file. Output is written unformatted on this file as a header record followed by data records. Each header record contains four full word integers followed by the 120 byte title. The four integers contain:

(1) total number of words in this set of data
(2) number, NV, of variables read from each input record
(3) total number of input records read in this set of data
(4) number of output data records following the header record.

Each data record contains two full word integers followed by the data from up to 100 input records.

Subroutines

READK reads a set of integers formatted by the subroutine WRITEK.
Calling sequence: CALL READK (IOU,TITLE, LENFIL,LENKEY,KEY)
IOU = I/O unit to be read
TITLE = title of the set of data to be read
LENFIL = size of the universe to which the set belongs
LENKEY = size of set
KEY = the set of data
double return from this routine
return 1 return taken if end-of-file is encountered at the first record
return 2 return is taken if end-of-file is encountered after the first record (set is not complete) of records is out of sequence.

Variables

NVAR	number of variables
FMT	format
IC	conversion factors
LINTYP	line-type character
TITLE	array to contain title
TITL	flag to indicate title present
NFILE	number of records in data file
LENK	number of records to be read
KEY	array of record numbers
NTOT	total number of data records read
NPHR	number of output data records (after title record)
N	number of data records in batch
DATA	array to contain the data
IV	number of variable to be converted to real
RDATA	array to contain real values - same locations as DATA
IE	number of data words in data record
NN	number of data words in entire sample

Storage Requirements

The arrays DATA and RDATA occupy the same storage.

Code		bytes	words
INPK1	16512	14313	6347
		12246(buffers)	5286
READK	00952	120	80
TOTAL	17464	26679	11713

PROGRAM GRPS

50. This program computes statistics for each domain for areal analysis. A flow diagram is given in Fig 12.

51. GRPS accepts as parameters the format of the output and the pole of the hemisphere to be used for computing statistics. The data are read from a file written by program INPK. As the data for each group are read, statistics are computed by calling subroutines SCOM1 and FSTAT1. Since these are vector statistics, the pole read from the parameter card is used for assigning sense to the axes.

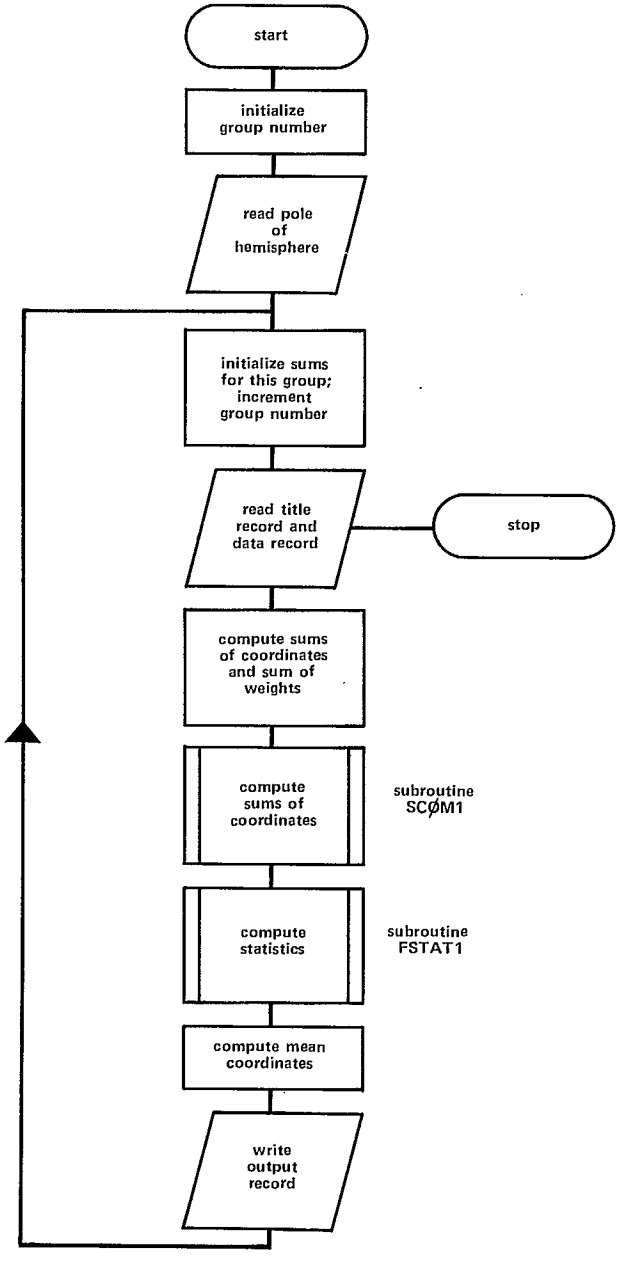

Fig 12 - Flow diagram for program GRPS

Solution

52. See subroutine documentation in source listing.

Capabilities

53. Maximum number of observations in any group is 100.

Input

Unit 1 - tape or disk - record length: 2408 bytes, unformatted. Input data file as written by INPK1.
Unit 3 - card reader - record length: 30 bytes, formatted. Pole of hemisphere. Three records containing in the usual sequence, direction cosines of pole, one direction cosine per record in columns 21-30 with decimal point.
Unit 5 - card reader - output format. Columns 3-102. See below.

Output

Unit 8 - tape or disk - record length: determined by format. Output data file. Format determined by given format specification on unit 5. Variables written are:

(1) number of group
(2) mean coordinate of group
(3) mean Y coordinate of group
(4) number of observations in group
(5) sum of weights times 10
(6) three sums of components in the usual sequence times 10
(7) three direction cosines of mean direction, in the usual sequence, times 10^6
(8) length of resultant divided by sum of weights times 10^6
(9) trend and plunge of mean direction as integers
(10) concentration parameter as integer.

Subroutines for GRPS

SCOM1:

Computes the sums of the components of a set of vectors. This subroutine calls ANDC.

Calling sequence:

```
CALL SCOM1(DC,W,N,V,JM,U)
DC = 3*N matrix of direction cosines
W  = vector of weights
N  = number of data points
V  = vector of length 2 or 3 - see JM
JM = 0 if directions used are given
   = 1 if directions are to be adjusted and V
     contains trend and plunge of center of
     hemisphere in degrees.
```

= 2 if directions are to be adjusted and V contains trend and plunge of centre of hemisphere in radians.

= 3 if directions are to be adjusted and V contains direction cosines of centre of hemisphere.

U = vector of length 3 that returns the sums of the components.

SRF:

Converts real numbers to integers, multiplying by a given power of 10 and rounding: Each real number is multiplied by 10**IF and then rounded. If the resulting integer is greater than MAX, it is set to MAX, if it is less than -MAX, it is set to MAX.

Calling sequence:

CALL SRF(RL,IN,N,IF,MAX)

RL = vector of real numbers. They may be in same location as IN, and may be positive or negative.

IN = vector of returned integers.

N = number of numbers to be processed.

IF = power of 10 by which the numbers are to be multiplied.

MAX = the maximum value to which resulting integers are truncated.

Function:

TAB1

Looks up and interpolates a one-dimensional table. If X is beyond the range of the table, the returned value is the extreme value of B in the table.

Calling sequence:

Y = TAB1(X,A,B,N)

X = given value with which to enter table

A = vector containing the column of the table in which X is to be found

B = vector containing the column of the table from which the returned value (TAB1) is to be obtained.

N = number of rows or entries in the table.

TAB1 = the value of the function is the value obtained from the table.

XKF See HOMO

RISP See DSPD

FSTAT1 See WNST5

ANDC See WNST5

Variables

IGRP	counter of domains
V	direction cosines of pole of hemisphere
ISX	sum of x-coordinates
ISY	sum of y-coordinates
SW	sum of weights
NN	number of numbers in input records
NV	number of variables in input records
NO	number of observations in input records
NPHR	number of input records following title record
TITLE	title
N	number of observations in data record
KE	number of numbers in data record
IX	x-coordinate
IY	y-coordinate
DC	direction cosines
W	weight
U	vector of sums of components
E	vector of direction cosines of resultant
S	vector of angular coordinates of resultant
T	length and fractional length of resultant
XK	estimated concentration parameter of population
R	confidence radii on mean: 95% and 99%
ITR	trend of resultant
IPL	plunge of resultant
IXAVG	average x-coordinate
IYAVG	average y-coordinate

External References: Standard Fortran IV built-in functions.

Storage Requirements

Code		bytes	words
GRPS	04632	1703	963
		10205(buffers)	4229
FSTAT1	0184B	304	196
SCOM1	01032	142	98

TAB1	00704	43	35
RTSP	01496	206	134
ANDC	01008	132	90
XKF	00640	41	33
Total	12704	13108	5996

SAMPLE RUN - STAGE 2

Input Files

Data File:

Unit 1 input to INPT1

Unit 1 input to INPK1

See TTEST DATA (STAGE 1)

Traverse File.

Unit 1 input to GRPK1.

TTEST DATA

TRAVERSES

50	1	6	62DM	516982	3	126967	B0545	93911	259-05	217
51	7	13	72DM	5269692	3	126967	B0479	93B85	262 5	280
52	14	21	82DM	5469142	3	126900	80569	93962	258 0	472
53	22	49	282DM	5569047	3	126900	B0410	93953	252-02	294
54	50	59	102DM	5668502	3	126833	B0592	94086	247+01	333
55	60	90	312DM	5768452	3	126833	B0535	94062	228-14	435
63	91	96	62DM	6568482	3	116833	80331	93992	259 7	375
64	97	100	42DM	6767817	3	116767	80705	94157	246+01	311
65	101	106	62DM	6867832	3	116767	80558	94114	250-02	400
66	107	111	52DM	6967857	3	116767	80492	94082	227-14	268
...	...	...	.....	.....	.	.....	.....	.....	... .	...
163	291	297	72HM	8967348	3	116700	80536	94161	241-2B	140

Group Specifications.

Unit 2 input to GRPK1.

```
159          73          74  161  0  0
 75
162          163
 64          149         150
 65          151
 66          152          67
153
 68
154
 69
155
 70
136          54
137
 55  1  10
 55  11 20
 55  21 29
 55  30 31  13B          145
 63          147
135
 53  1  10
 53  11 19
 53  20 28
 52
158          72
 50          132  1  5
132  6  10   51  1  5
 51  6  7   133          134
156
 71
157
148
```

Output files

Group keys.
Unit 7 output from GRPK1.
Unit 2 input to INPK1.

```
TEST DATA                                       GROUP      1                              1
                                                                297         8             2
 160  161  162  163  164  285  286  287    0    0    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP      2                              1
                                                                297         8             2
 165  166  167  168  169  170  171  172    0    0    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP      3                              1
                                                                297        10             2
 288  289  290  291  292  293  294  295  296  297    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP      4                              1
                                                                297         7             2
  97   98   99  100  226  227  228    0    0    0    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP      5                              1
 101  102  103  104  105  106  229  230  231    0    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP      6                              1
                                                                297        10             2
 107  108  109  110  111  112  113  232  233  234    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP      7                              1
                                                                297        11             2
 235  236  237  238  239  240  241  242  243  244  245    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP      8                              1
                                                                297        15             2
 114  115  116  117  118  119  120  121  122  123  124  125  126  127  128    0    0    0    3
TEST DATA                                       GROUP      9                              1
                                                                297         8             2
 246  247  248  250  251  252  253    0    0    0    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP     10                              1
                                                                297         6             2
TEST DATA                                       GROUP     19                              1
                                                                297         7             2
  91   92   93   94   95   96  214    0    0    0    0    0    0    0    0    0    0    0    3
TEST DATA                                       GROUP     20                              1
```

Eigenvectors.
Unit 7 output from WNST5.
Unit 3 input to GRPS.

```
-0.569916  0.817640  -0.081612
 0.801487  0.531250  -0.274574
 0.181146  0.221895   0.958096
```

Group Data

Unit 8 output from GRPS.

TTEST DATA					GROUPS							
1806565941979	8	771	-117001	-103741	746239	-153454	-136064	978744	988907	222	78	68
2805748941650	8	326	- 63014	- 40096	316908	-193537	-123150	973333	998744	212	77	597
3805336941579	10	724	- 49212	-202889	682455	- 68956	-284288	956256	985738	256	73	56
4806601941425	7	284	- 40332	- 60184	273266	-142663	-212684	966606	995448	236	75	157
5805301941031	9	603	54374	-108352	560983	94740	-188788	977437	951797	297	78	16
6804515940645	10	644	-142256	-155611	606118	-221672	-242483	944491	996492	228	71	228
7803860940368	11	229	- 37460	- 73441	213261	-163838	-321205	932730	998439	243	69	524
8803612940354	15	451	62815	-161001	413149	140262	-359507	922541	992991	291	67	124
9803430940339	8	210	3960	- 75036	195880	18876	-357660	933661	999037	273	69	779
10803224940174	6	369	- 43438	- 95381	352669	-118066	-259248	958567	997054	246	73	226
.....	.	...	.....	.....	.....	.....	.....	.....	.....	...	..	...
31799914938586	8	712	- 43871	-253532	662314	- 61744	-356818	932131	997946	260	69	365
32800807938806	11	420	- 41477	-119483	394625	-100091	-288329	952286	986663	251	72	61

Input parameters (Unit 5, see Fig 13)

```
Unit5input to INPT 1:
  5(A1,63x,3I5,I3)                                                  1 4 2 4 3 4 4 1

Unit5input to GRPK 1:
    (I5,2I4)

Unit5input to INPT 1:
  7(A1,38x,2I6,I3x,3I5,I3)                                          3 4 4 4 5 4 6 1

Unit5input to GRPS :
    (1x,3I6,I3,I7,3I8,4I7,I4,I3,I4)
```

Fig 13 - Input to Stage 2

Printed Output:

Unit 6 output from program INPT1:

5VARIABLES
FORMAT=(A1,63X,3I5,I3)
TEST DATA
297 DATA POINTS 3 PHYSICAL RECORDS

Unit 9 output from program WNST5:
297 TEST DATA
Unit 6 output from program INPK1:

8 TEST DATA GROUP 1
1 PHYSICAL DATA RECDRDS
8 TEST DATA GROUP 2
1 PHYSICAL DATA RECORDS
10 TEST DATA GROUP 3
1 PHYSICAL DATA RECORDS
7 TEST DATA GROUP 4
1 PHYSICAL DATA RECORDS
9 TEST DATA GROUP 5
1 PHYSICAL DATA RECORDS
10 TEST DATA GROUP 6
1 PHYSICAL DATA RECORDS
11 TEST DATA GROUP 7
1 PHYSICAL DATA RECORDS
15 TEST DATA GROUP 8
1 PHYSICAL DATA RECORDS
8 TEST DATA GROUP 9
1 PHYSICAL DATA RECORDS
6 TEST DATA GROUP 10
1 PHYSICAL DATA RECORDS
. ...
11 TEST DATA GROUP 32
1 PHYSICAL DATA RECORDS

Statistics for Data File.
Unit 6 output from WNST5.

TEST DATA
297 POINTS WITH TOTAL WEIGHT OF 1568.1

"BINGHAM" STATISTICS

EIGENVAL	EVAL/SW	DIRECTION	COSINES	TR	PL	DD	DP
20.23	0.01290	-0.56992	0.80149	0.18115	125.4	10.4	3D5.4	79.6
24.10	0.01537	0.81764	0.53125	0.22190	33.0	12.8	213.0	77.2
1523.75	0.97173	-0.08161	-0.27457	0.95810	253.4	73.4	73.4	16.6

TEST OF HYPOTHESIS K1-K2-K3: TEST STATISTIC= 5243.8984 5% POINT=11.0705
TEST OF HYPOTHESIS K2-K3: TEST STATISTIC= 1702.3879 5% POINT=5.99147
TEST OF HYPTTHESIS K1-K2: TEST STATISTIC= 3.0383 5% POINT=5.99147
HYPOTHESIS K1=K2 ACCEPTED

K FOR CLUSTER	CONFIDENCE RADII 95%		99%	
35.377	8.4	8.4	10.5	10.5

TEST DF UNIFORMITY ABOUT EIGENVECTOR 3
KUIPER'S STATISTIC = 2.419 95% POINT = 1.747

TEST DATA
297 POINTS WITH TOTAL WEIGHT OF 1568.1
"FISHER" STATISTICS

R	R/SW	DIRECTION	COSINES	TR	PL	DD	DP
1545.26	0.98546	-0.08043	-0.27388	0.95839	253.6	73.4	73.6	16.6

FISHER K	CONFIDENCE 95%	RADII 99%
68.327	1.0	1.2

TEST OF UNIFORMITY ABOUT FISHER MEAN
KUIPER'S STATISTIC = 2.516 95% POINT = 1.747

DISPLAY OF GROUP MEANS AND DISPERSIONS

54. Generation of displays in the observations and/or the group means and dispersions, both on maps and as point diagrams and density diagrams, constitutes Stage 3 of the procedures as shown in Fig 14, Display of the group data is illustrated; if the group data file is replaced by the data file and the format on the parameter card changed appropriately, the flow diagram will illustrate display of the individual observations.

55. Stage 3a. Program INPT1 reads the group data file and stores the information required by program DSPD. This program prepares data for the display programs, including rotation of the data so that the overall mean is vertical using the eigenvectors for the whole data file produced in Stage 2a.

56. Stage 3b. Program NPPL1 produces point diagrams on the plotter, program WNDPLT3 produces density diagrams on the printer, and program MAP3 produces a plotted map. Each data point on this map is shown as a line that begins at the point of observation, ie, the centre of the group in the case of group means, whose azimuth is the trend of the pole of discontinuity, and whose length is the distance from the centre of an equal-area projection to the projected pole.

PROGRAM DSPD

57. To read a data file written by program INPT1 or INPK1 and output four data files suitable for input to programs WNDP3, NPPL1 and MAP3. A flow diagram is presented in Fig 15.

58. DSPD reads a rotation matrix and two parameters. Each block of data read from the input file is written onto output files 10D and IMA. The data is then rotated using the rotation matrix, and the rotated data written onto output files 10DR and IMAR. Files 10D and 10DR are suitable for input to programs WNDP3 and NPPL1; files IMA and IMAR are suitable for input to program MAP3.

Solution

See options.

Capabilities

No restrictions.

Options

59. If the input parameter has a value of 1, the input data are assumed to contain the direction cosines of lines and the trends and plunges of the lines. The data are output as read. If

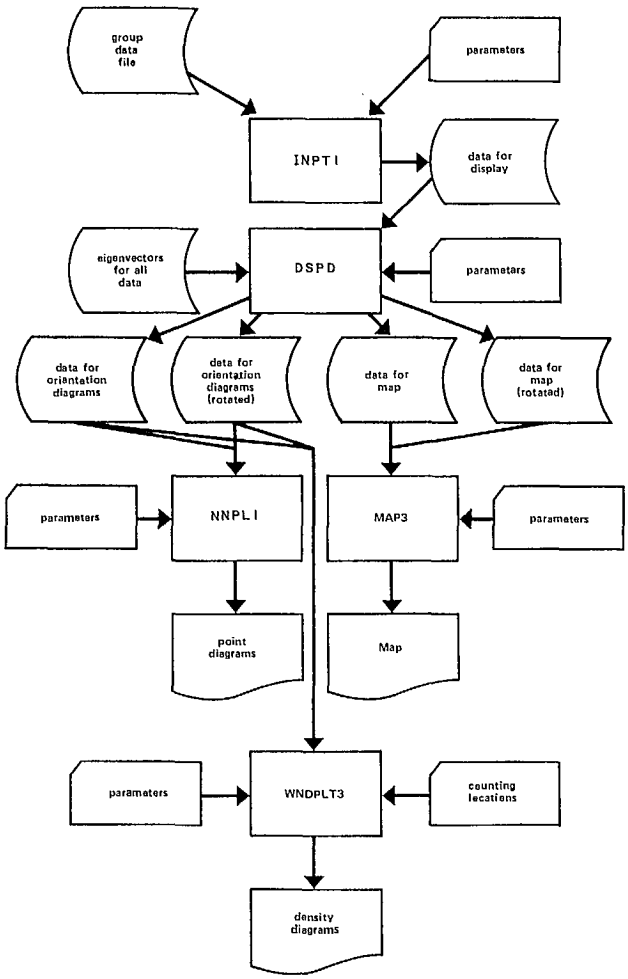

Fig 14 - Stage 3 - Display of group means and dispersions

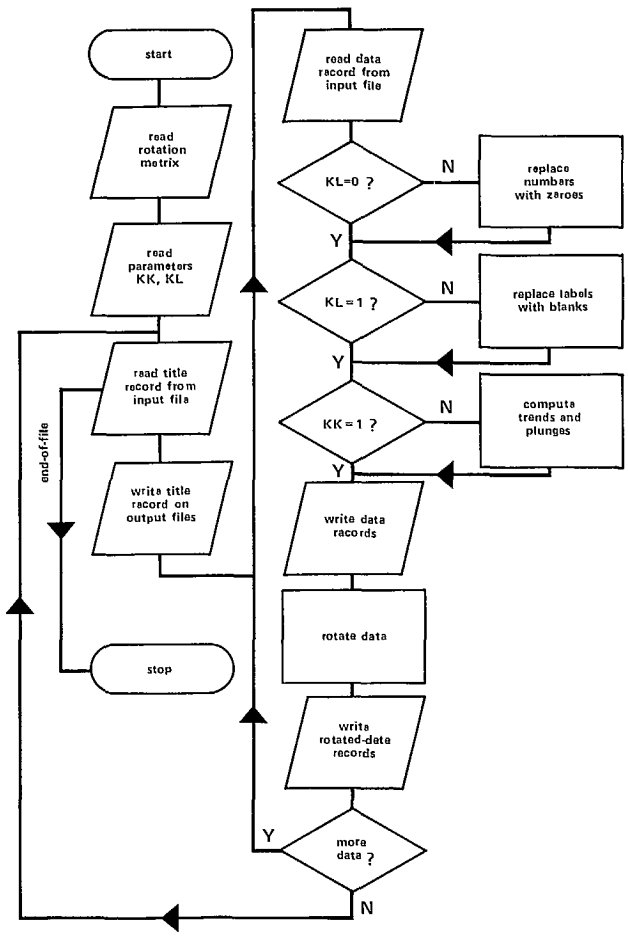

Fig 15 - Flow diagram for program DSPD

the input parameter has a value of 2, the input data are assumed to contain the direction cosines of the poles to planes and the dip directions and dips of the planes. The dip directions and dips are replaced by the trends and plunges of the poles to the planes before the data are written. After rotation, new trends and plunges are computed from the direction cosines. If the output parameter is not zero, all the numbers for display on the map are replaced by zeros. If the output parameter is neither zero nor 1, all the labels to be plotted on the map are replaced by blanks.

Input

Unit 2 - card reader - record length: 30 bytes, formatted. Rotation matrix. Three records, each containing the corresponding column (1, 2, or 3) of the matrix as three real numbers:

Card column	Contents
1-10	row 1, column (1, 2 or 3)
11-20	row 2, column (1, 2 or 3)
21-30	row 3, column (1, 2 or 3)

Unit 5 - card reader - record length: 3 bytes, formatted. Parameters. One containing:

Column	Contents
1	input parameter 1-input is direction cosines of lines and the trends and plunges of the lines. 2-input is direction cosines of the poles to planes and the dip directions and dips of the planes. for more information see program options.
3	output parameters. ≠ 0 all numbers on the map are replaced by zeroes. ≠ 0 and ≠ all the labels to be plotted are replaced by blanks. See program options.

Unit 7 - tape or disk - record length: 4008, unformatted. Input data file. This file is created by INPT1 and INPK1. Variables for each observation are:

(1) three direction cosines
(2) weight
(3) easting
(4) northing
(5) number to appear on map
(6) label to appear on map
(7) trend or dip direction (depending on input parameter)
(8) plunge or dip (depending on input parameter)

Output

Unit 6 - line printer - record length: 62 bytes, formatted. Messages. If the number of variables in the input data file is not 10, an error message is written and the program stops immediately.

Unit 3 - tape or disk - record length: 1608 bytes, unformatted. Data file for orientation diagrams. Variables for each observation are: three direction cosines, weight.

Unit 4 - tape or disk - data file for orientation diagrams rotated. Same as unit 3 output except rotated direction cosines are used.

Unit 8 - tape or disk - record length: 2408, unformatted. Data file for map. Variables for each observation are: easting, northing, number to appear on map, label to appear on map, trend, plunge.

Unit 9 - tape or disk - data for map, rotated. Same as unit 8 output, except rotated trend and plunge are used.

Subroutines

RTSP

Converts from rectangular to spherical co-ordinates.

Calling sequence:

CALL TRSP(A,B,G,J1,T,P,R,J2,J3,N)

A = vector of X components.
B = vector of Y components.
G = vector of Z components.
J1 = input description parameter of the spacing in words of components.
in vectors A, B and G.
T = vector of horizontal angles.
P = vector of vertical angles.
R = vector of distances from origin.
J2 = first output description parameter of spacing of output words in vectors T and P. J2 is greater than zero if the output units are to be in degrees. J2 is less than zero if the output units are to be in radians.
J3 = second output description parameter.
= 1 if output type is to be trend and plunge.
= 2 if output type is to be dip direction and dip.
= 3 if output type is to be strike and dip.
J3 will be greater than zero if the domain is the sphere, and less than zero if the domain is the hemisphere.
N = number of data points.

SRF See GRPS.

GMPRD See CONVRT.

Variables

RM	rotation matrix
KK	first input parameter
KL	second input parameter
NN	number of numbers in input record
NV	number of variables in input
NO	number of observations in input
NPHR	number of input records following title record
TITLE	array to contain title
NTOT	total number of points in sample
NVOD	number of variables in output for orientation diagrams
NNOD	number of numbers in output for orientation diagrams
NVMA	number of variables in output for maps
NNMA	number of numbers in output for maps
NR	number of variables in record
IE	number of numbers in record
DC	direction cosines
W	weights
DATA	other variables
T	trends
P	plunges
DCR	rotated direction cosines

External References: Standard Fortran IV built-in functions.

Storage Requirements

Code		bytes	words
DSPD	10480	3665	1973
		16350(buffers)	7400
RTSP	01496	205	133
SRF	00640	41	33
GMPRD	00680	103	67
TOTAL	13296	53364	9606

PROGRAM NPPL1

60. The program generates commands for a digital incremental plotter to produce a point diagram on non-polar orientations on Lambert's equal-area projection. A flow diagram is shown in Fig 16(a) and (b).

Solution

61. The orientations must be given as direction cosines. These are converted into X,Y coordinates on the projection by the subroutine RTXYEQ. The projection is horizontal unless defined otherwise by a parameter card. If a non-horizontal projection is requested, the data are rotated before the subroutine RTXYEQ is called.

Capabilities

62. Maximum number of points in any plot is 1000.

Input

Unit 1 - tape or disk - record length: 1608 bytes, unformatted. Data. As written by programs INPT1, INPK or DSPD. As many samples as desired may follow sequentially. One plot will be produced for each sample.

Unit 4 - card reader - record length: determined by format from unit 5. Normal to projection plane. Used only if a P or Q parameter card is supplied with a non-position number in the fourth numeric field of parameter unit 5.

Format given on parameter card.

formatted. Parameters. One or more cards of format:

Column	Contents
1*	"P"
2-11	trend or first direction cosine
12-21	plunge or second direction cosine
22-31	blank of third direction cosine
32-40	Code: ± 1.0 if trend and plunge given in degrees. ± 2.0 if trend and plunge given in radians. ± 3.0 if direction cosines given code 0 if information is on parameter card. code 0 if information to be read on unit 4.
41-80	format for reading unit 4, if required.

* If this parameter card is supplied with a Q in

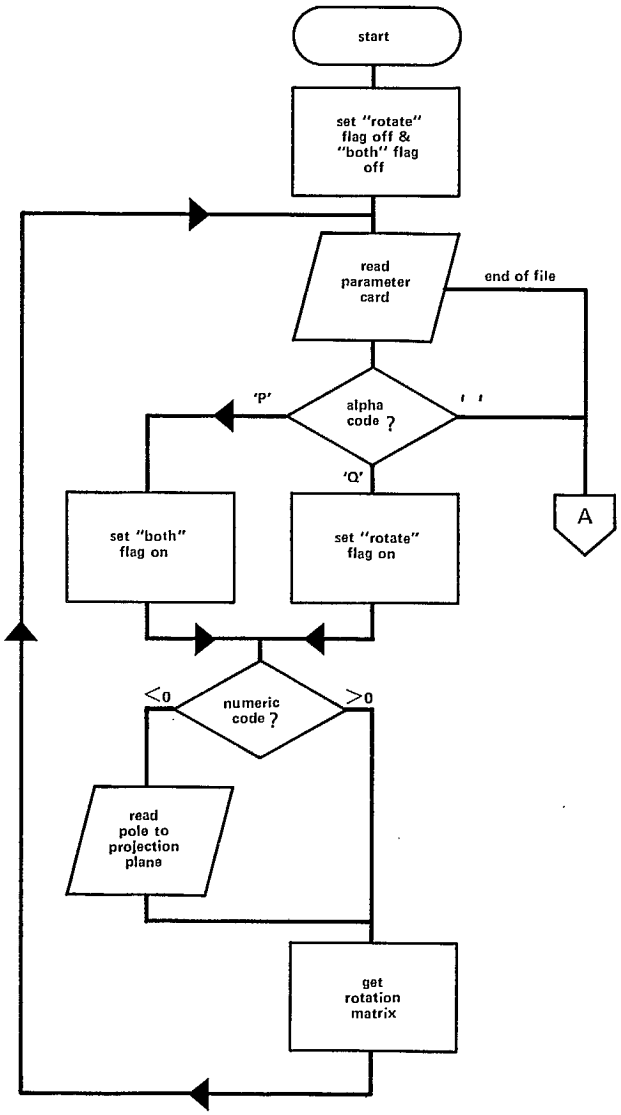

Fig 16(a) - Flow diagram for program NPPL1 - Part 1

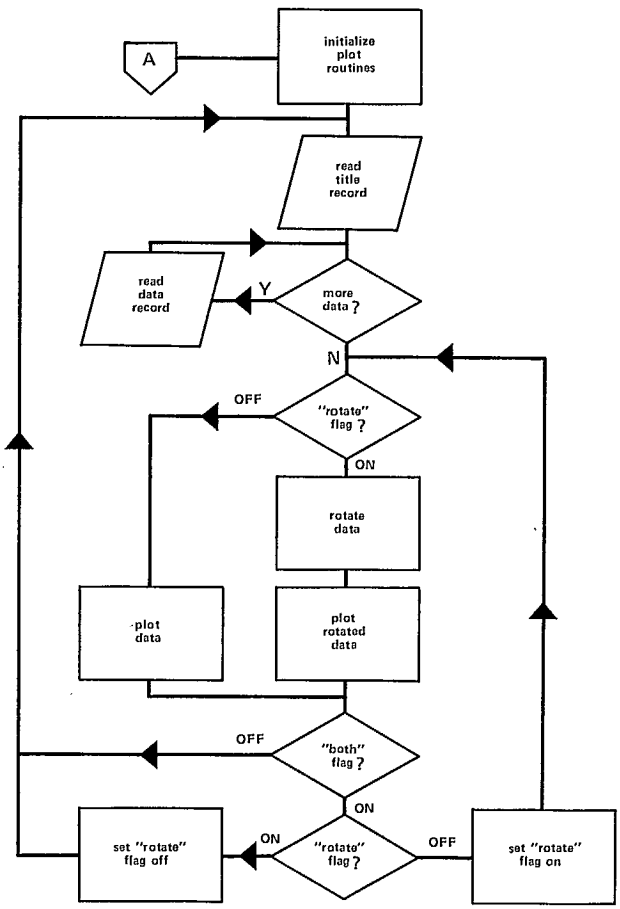

Fig 16(b) - Flow diagram for program NPPL1 - Part 2

column 1, two plots will be produced, one using the horizontal projection plane and one the specified projection plane.

Output

Unit 6 - printer - record length: 81 bytes, formatted. Error messages.

other - plotter or plot tapes - output from plotting subroutines. Unit number and device requirements depending on the plotting subroutines.

Variables

A	parameter code
X	parameters
ALPHA	alphanumeric parameter
BOTH	flag to indicate two plots required
ROTAT	flag to indicate rotation required

RM rotation matrix
IPLOT counter of plots
NN number of data words in sample
NV number of variables in output
NO number of observations in sample
TITLE array to contain title
DC direction cosines of data points
W weights of data points
N number of observations in sample
XP,YP coordinates of center of projection
DCR rotated direction cosines

External References: The following subroutines from the plot library:

PLOT(X,Y,J).

Moves the pen from its current position to the point (X,Y) with pen up (J=3) or down (J=2). Plot origin is reset to (X,Y) if J < 0.

NUMBER(X,Y,H,R,T,N).

Writes the real number R with N decimal places at the location X,Y with a character height H making an angle of T degrees with the positive x axis (counter-clockwise).

SYMBOL(X,Y,H,IC,T,N).

Starting at the point X,Y and using a symbol height, H in., either draws N characters stored in EBDIC in the array IC (N > 0) or draws symbol number IC (N=-1) or draws symbol number IC with a line from the current pen position (N=-2). The symbols make an angle of T degrees with the positive x axis (counter-clockwise).

CIRCLE(X,Y,A,B,C,D,E).

Draws a circular or spiral arc (solid if E = 0.0, dashed if E = 0.5) starting at the point (X,Y). A and B are the angles measured counter-clockwise from the positive x axis to the radius at the start of the arc and the radius at the end of the arc respectively. C and D are the corresponding radii in inches.

Subroutines

ROTMAT

See CONVRT.

RTXYEQ

See source listing.

VRM1

Returns the rotation matrix that will rotate a given direction to the vertical. The trend and plunge of the axis of rotation and the angle of rotation are computed, and the subroutines ROTMAT and RTSP are called.

Calling sequence: CALL VRM1(V,M,J)

V = vector of length 2 or 3. See J.
M = returns rotation matrix
J = 1 if V(1),V(2) contain trend and plunge in degrees
= 2 if V(1),V(2) contain trend and plunge in radians
= 3 if V(1),V(2),V(3) contain direction cosines

GMPRD

See CONVRT.

Storage Requirements

Code		bytes	words
NPPL1	30160	20265	8373
		10205(buffers)	4229
RTXYEQ	00992	132	90
GMPRD	00680	103	67
RTSP	01496	206	134
CC1	09968	4447	2343
VRM1	00880	73	59
GRPRD	00672	100	64
ROTMAT	00848	131	89
CIRCLE	13024	32	26
TOTAL	58720	35694	15474

PROGRAM WNDPLT3

63. For weighted, non-directed orientations, the program produces on the line printer equal-area projections of point density having a high density of counting locations. A flow diagram is presented in Fig 17(a) to (c).

64. The plane of the projection is horizontal, unless a parameter card is given redefining the projection plane. In this case the directions are rotated before being plotted. The program uses by default a 1 per cent counting circle, a contour

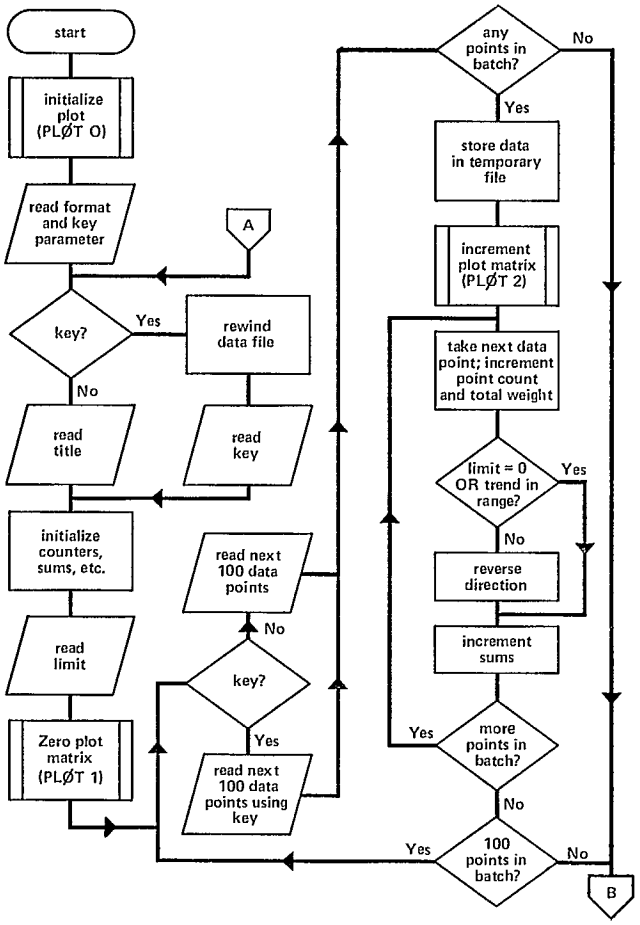

Fig 17(a) - Flow diagram for program WNDPLT3 - Part 1

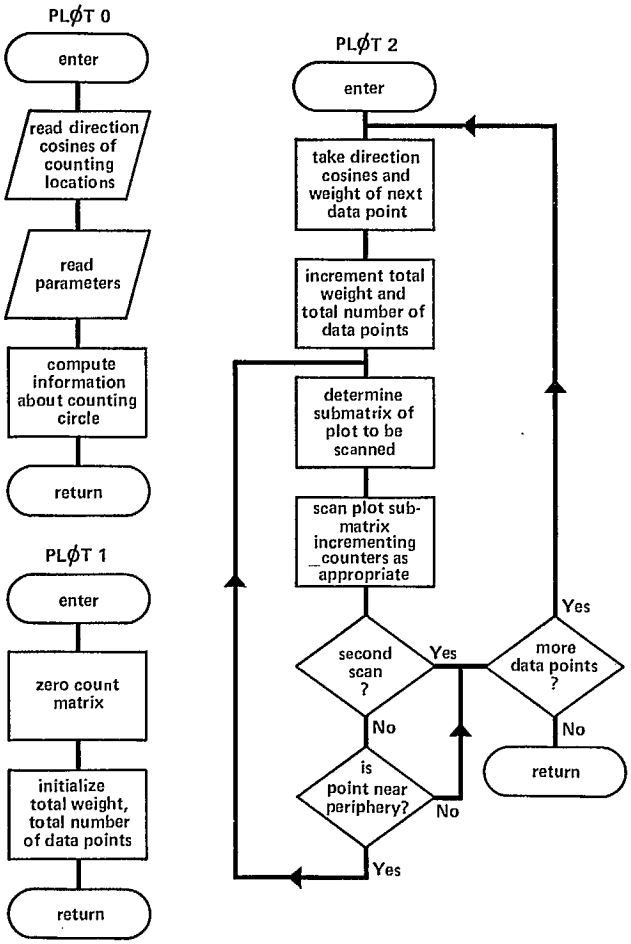

Fig 17(b) - Flow diagram for program WNDPLT3 - Part 2

interval of 1 per cent, and the following characters to represent successive contour intervals 0-1 per cent, 1-2 per cent, and so on: "1234567890abc defghijklmnopqrstuvwxyz****". Any of these defaults may be overridden by appropriate parameter cards.

65. The input data must include weights. Unless otherwise directed, the program uses these weights in the computations. A parameter card may be used to indicate that the weights are to be truncated at some specified upper limit, or that the weights are to be set equal to 1.

Solution

66. To map the density of points on the sphere, a density estimate is computed at each of a number of pre-determined counting locations. For unweighted points, the density estimate at a particular location would be obtained by counting the points falling inside a pre-determined area, the counting circle, surrounding the location. The density estimate is usually obtained by expressing this count as a percentage of the total number of points. This program obtains a density estimate for weighted points by summing the

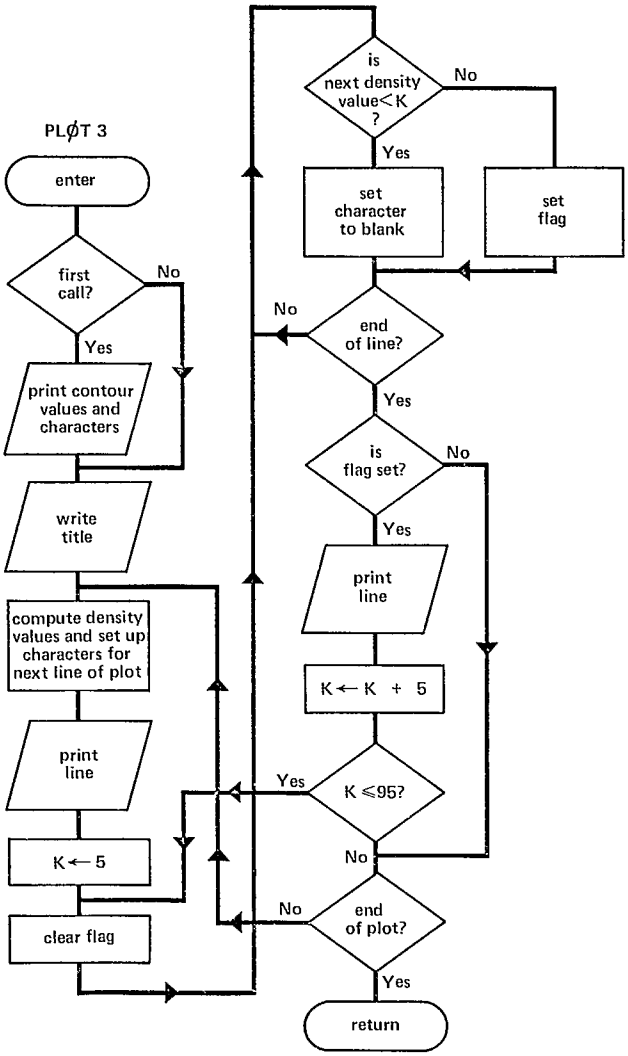

Fig 17(c) - Flow diagram for program WNDPLT3 - Part 3

weights of the points falling inside the area and expressing this sum as a percentage of the total of the weights of all the data points. The density estimates are printed in the form of an equal-area projection.

67. This program employs a print matrix consisting of 3713 print positions: 47 lines with 79 print positions on each. Printed six lines to the inch, the matrix is approximately eight inches square. The equal-area projection is a circle with a 10 cm radius centred on the print matrix. Every print position whose centre lies within the circle represents a counting location of which there are 2933. The counting locations are defined by direction cosines, which are read in by the program at the start of each run.

68. With such a large number of counting locations it is inefficient to compare every counting location with every data point in the counting process. The number of comparisons is thus reduced. For a particular data point, those counting locations that are to be incremented lie within a circle on the sphere whose projection approximates an ellipse that has its greatest size when the data point lies in the plane of projection. Before beginning the counting procedure, the program computes the maximum dimension, m, for the ellipse in this case. For each data point, the program computes XP, YP, the x and y coordinates on the print matrix of the projection of the data point, then determines the submatrix of the print matrix that lies inside the square bounded by X=XP+M, X=XP-M, Y=YP+M, Y=YP-M. This square wholly contains the projection of the counting circle centred on the data point. Each counting location represented in this submatrix is then tested by computing its angular distance from the data point and comparing this with the radius of the counting circle. This process is repeated in a slightly different form if the data point is close enough to the horizontal to affect counting locations on the diametrically opposite part of the projection.

69. After the counting procedure is completed, the program constructs the plot, line by line, by expressing each count as a percentage of the total weight and then placing the appropriate character in the corresponding print position. A contour interval and a string of characters are supplied to the program on parameter cards. As an enhancement to the visual impact of the plot, characters representing higher densities are overprinted, the number of overprintings increasing with the density value.

Capabilities

70. No restrictions.

Options

71. The parameters with their defaults are:

a. Normal to projection plane. Default: vertical. Card format:

Col	contents
1	"P"
2-11	trend or first direction cosine
12-21	plunge of second direction cosine
22-31	blank or third direction cosine
32-40	code: ± 1.0 if trend and plunge given in degrees ± 2.0 if trend and plunge given in radians ± 3.0 if direction cosines are given code > 0 if information is on parameter card code < 0 if information to be read on unit 4
41-80	format for reading unit 4 if required.

b. Size of counting circle. Default: 1%. Card format:

Col	Contents
1	"S"
2-11	per cent size of circle

c. Contour interval. Default: 1%. Card format:

Col	Contents
1	"I"
2-11	contour interval

d. Plot characters. Default: "1234567890ABCDEFGHIJKLMNOPQRSTUVWXYZ****". Card format:

Col	Contents
1	"C"
4180	plot characters

e. Weighting procedure. Default: weights are used as read. Card format:

Col	Contents
1	"W"
2-11	value

Action:

If value = 0	all weights will be set to 1.0 before data is processed.
If value > 0	weights greater than value will be set equal to value. Weights less than or equal to value will not be changed.
If value < 0	the default action will remain in effect.

f. Printout. Default: overprinting and list of character values. Card format:

Col	Contents
1	"O"

Action: Overprinting and list of character values suppressed.

Input

Unit 1 - tape or disk - record length: 1608 bytes, unformatted. Data. As written by program INPT1, INPK1, or DSPD, as many samples as desired. One plot will be produced for each sample.

Unit 3 - tape or disk - record length: 80 bytes, formatted. Direction cosines of counting locations. A file of direction cosines is supplied with this set of programs, filename: DIRECTIONCOSINE.

Unit 4 - card reader - record length: determined by format. Normal to projection plane. The contents and format of the single record are described under "P" option under program options.

Unit 5 - card reader - record length: 80 formatted. Parameters. All parameter cards are optional because all parameters have default values. The reading of parameter cards is determined by a

blank card or an end-of-file (7/8/9). One parameter record must be supplied for each parameter for which a value is to be specified. See Program Options.

Output

Unit 6 - printer - record length: 42 bytes, formatted. Messages. Error messages are selfexplanatory.

Unit 8 - printer - record length: 84 bytes, formatted. Plot. Preceding the plot, there are five records.

(1) first 80 characters of the title
(2) remainder of the title
(3) number of data points and total weight
(4) size of counting circle
(5) contour interval and characters.

The plot consists of 49 lines, each having 82 characters of which the first is carriage control.

Unit 9 - line printer - record length: 127 bytes, formatted. Title of each sample. On this unit the program writes the number of data points and the title for each sample as it is read.

Variables

ICODE1	overprinting flag
CHAR	array to contain plot characters
SIZE	per cent size of counting circle
CONTI	contour interval
WEIGHT	weighting code
A	parameter code
X	array to contain parameters
ALPHA	array to contain new plot characters
BOTH	flag for unrotated plot when ROTAT=.true.
ROTAT	flag for rotation of data
CRC	cosine of radius of counting circle
CRCC	test value
RC	radius of counting circle (radians)
MPLRC	maximum projected length of RC
NN	number of data words in sample
NV	number of variables in input
NO	number of observations in sample
NPHR	number of data records following title record
TITLE	array to contain title
NB	number of observations in record
NWD	number of data words in record
DC	direction cosines of data points
W	weights of data points
DCR	array to contain rotated direction cosines
RM	rotation matrix

External References: None.

Storage Requirements

Code		bytes	words
WNDPLT3	05336	2152	1130
		10205(buffers)	4229
PLOT1A	00360	13	11
PLOT1B	01440	224	148
GRID10	00496	61	49
PLOT1C	02224	721	465
BLNK	004BB	30	24
RANGEX	00912	76	62
VRM1	00880	73	59
ROTMAT	00848	131	89
GRMPRD	00680	103	67
GTPRD	00672	100	64
RTSP	01496	206	134
Labelled common:			
ONE	15000	9503	3779
TWO	22312	25612	11146
TOTAL	53912	49210	21456

SAMPLE RUN - STAGE 3

Input Files

Data File.

Unit 1 input to INPT1

```
TTEST DATA
D2Dm  51  3  126967   259 -5 217150 3   5380539893910069687BG 66 23-1589-3570 9205 33L    1          0    0    OMDSR2
D2DM  51  3  126967   259 -5 21715014   5480539793910069687BG 46 17-2031-21D3 9563 62 B             0    0    OMDSR2
D2DM  51  3  126967   259 -5 21715D 5   89BD536393909369690BG 83 27 -553-4506 891D 27L    2          0    0    OMDSR3
D2DM  51  3  126967   259 -5 21715D 6   9280536093909369690BG 83 27 -553-4506 B91D 27L    2          0    0    OCMSR1
D2DM  51  3  126967   259 -5 21715D15   1638052919390796996BG 83 27 -553-4506 8910 27 B             0    0    OCMSR1
D2DM  51  3  126967   259 -5 21715010   1768052789390769697BG 62 26-2058-3871 898B 29L    1          0    0    OMDSR3
D2DM  52  3  126967   262  5 28022D 1    0804790938850696928G 96 15  271-2574 9659 30L Z  2172FD-9255 3587 1215MDSR2
....  ..  .  ......   ...  . ........  ...................... .. ..  ................   .......... ....   .......
D2HM  89  3  116700   241-28 14D23D23   1238052659415586740BG 61 18-1498-2703 9511 58 F             0    0    OCOLS4
```

Eigenvectors

Unit 2 input to DSPD

```
-D.569916   0.817640   -0.D81612
 0.801487   0.53125D   -0.274574
 0.181146   0.228195    0.958096
```

Group data file

Unit 1 input to INPT1

(see Unit 8 output from GRPS Stage 2)

Input parameters (Unit 5, see Fig 18)

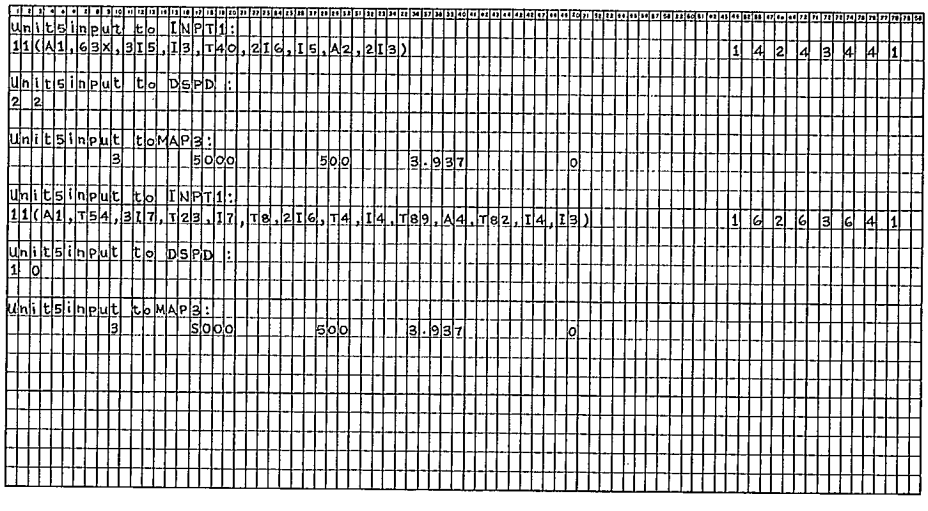

Fig 18 - Input to Stage 3

Printed outputs

Unit 6 output from INPT1

```
  11 VARIABLES
FORMAT=(A1,63X,3I5,I3,T40,2I6,I5,A2,2I3)
TEST DATA
 297 DATA POINTS          3 PHYSICAL RECORDS
```

Unit 6 output from DSPD:

TEST DATA
3 PHYSICAL RECORDS: 10 VARIABLES, 297 OBSERVATIONS

Unit 8 output from WNDPLT3:

CONTOUR VALUES AND CHARACTERS FOR THIS RUN ARE

>	0.0%	K >	20.0%
1 >	1.0%	L >	21.0%
2 >	2.0%	M >	22.0%
3 >	3.0%	N >	23.0%
4 >	4.0%	O >	24.0%
5 >	5.0%	P >	25.0%
6 >	6.0%	Q >	26.0%
7 >	7.0%	R >	27.0%
8 >	8.0%	S >	28.0%
9 >	9.0%	T >	29.0%
A >	10.0%	U >	30.0%
B >	11.0%	V >	31.0%
C >	12.0%	W >	32.0%
D >	13.0%	X >	33.0%
E >	14.0%	Y >	34.0%
F >	15.0%	Z >	35.0%
G >	16.0%	* >	36.0%
H >	17.0%	* >	37.0%
I >	18.0%	* >	38.0%
J >	19.0%	* >	39.0%

Printed Output (see Fig 19 and Fig 20)

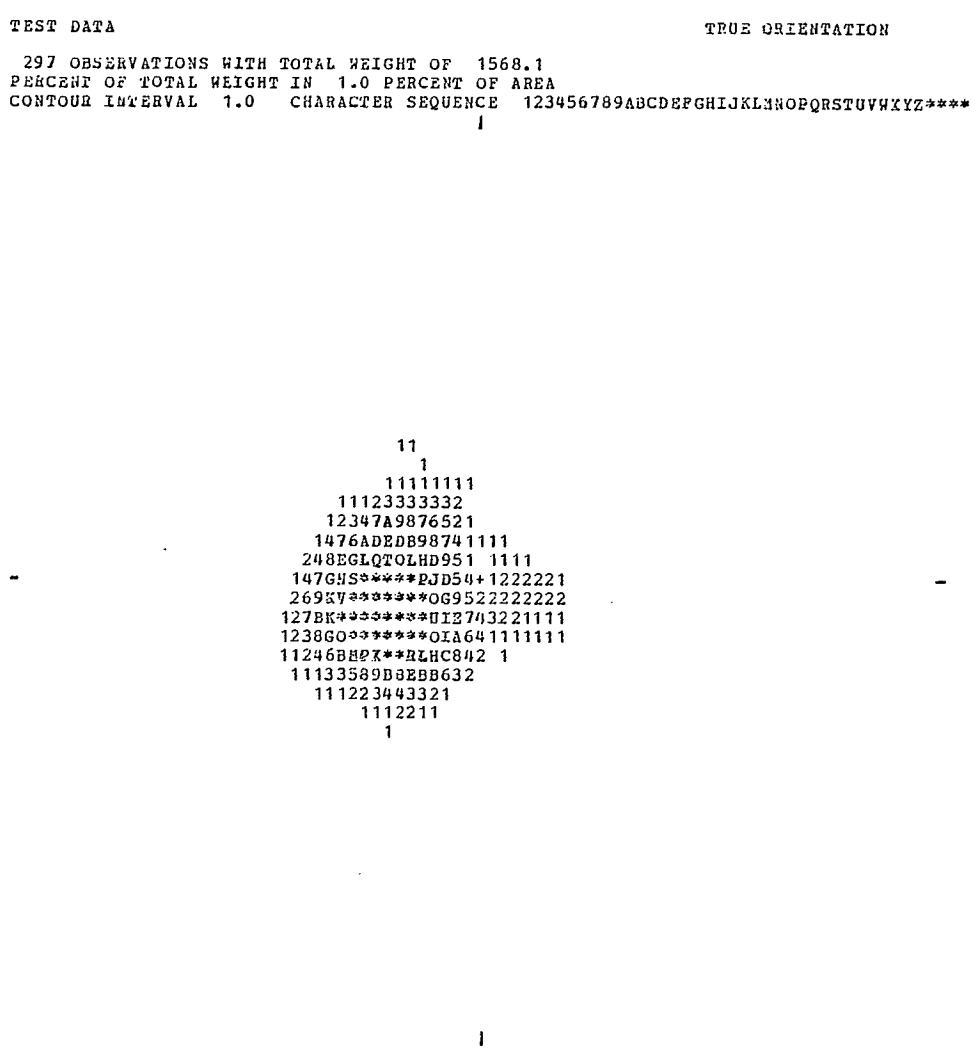

Fig 19 - Plot of true orientation

```
TEST DATA                                                    MEAN VERTICAL

 297 OBSERVATIONS WITH TOTAL WEIGHT OF  1568.1
PERCENT OF TOTAL WEIGHT IN  1.0 PERCENT OF AREA
CONTOUR INTERVAL  1.0   CHARACTER SEQUENCE  123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ****
                                I

                                  111
                                 1111221
                                111222221
                              12332222222222
                           3358ABD9854322211
                         11245CGJHKIGD552 1111
                         1246BQZ****RH984111
                         1359NZ******SJG9731
-                      1235EP********MHA964111                              -
                       1136BN*******XME98853111
                       11149FQW*****UPEDA86311
                       1122498DKLKHFA89633111
                         111256688875411 2 1   1
                              1221111211

                                I
```

Fig 20 - Plot with mean vector vertical

Unit 6 output from MAP3:

```
MODE=3       DATA UNITS BETWEEN GRID LINES= 5000

     DATA UNITS PER INCH=   500.0000      PROJECTION RADIUS=   3.937
INCHES PER DATA UNIT=  0.002000           PROJECTION RADIUS=   3.937
TTEST DATA                                                    TRUE ORIENTATION
1
2
3
TTEST DATA                                                    MEAN VERTICAL
1
2
3
```

Unit 6 output from INPT1:

```
  11 VARIABLES
FORMAT=(A1,T54,3I7,T23,I7,T8,2I6,T4,I4,T89,A4,T82,I4,I3)
TEST DATA                                GROUPS
  32 DATA POINTS        1 PHYSICAL RECORDS
```

Unit 6 output from DSPD:

```
TEST DATA                                GROUPS
     1 PHYSICAL RECORDS;   10 VARIABLES,    32 OBSERVATIONS
```

Unit 8 output from WNDPLT3:

CONTOUR VALUES AND CHARACTERS FOR THIS RUN ARE

>	0.0%	A >	10.0%	K >	20.0%	U >	30.0%
1 >	1.0%	B >	11.0%	L >	21.0%	V >	31.0%
2 >	2.0%	C >	12.0%	M >	22.0%	W >	32.0%
3 >	3.0%	D >	13.0%	N >	23.0%	X >	33.0%
4 >	4.0%	E >	14.0%	O >	24.0%	Y >	34.0%
5 >	5.0%	F >	15.0%	P >	25.0%	Z >	35.0%
6 >	6.0%	G >	16.0%	Q >	26.0%	* >	36.0%
7 >	7.0%	H >	17.0%	R >	27.0%	* >	37.0%
8 >	8.0%	I >	18.0%	S >	28.0%	* >	38.0%
9 >	9.0%	J >	19.0%	T >	29.0%	* >	39.0%

Printed Output (see SR-7 and SR-8)

```
TEST DATA                                         GROUPS               TRUE ORIENTATION

  32 OBSERVATIONS WITH TOTAL WEIGHT OF  1568.1
PERCENT OF TOTAL WEIGHT IN  1.0 PERCENT OF AREA
CONTOUR INTERVAL  1.0   CHARACTER SEQUENCE  123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ****
                                                  I



                            22222
                           22222BB8888
                          22444FFEBBB88
                           4ACHZTQECBD51111
                          28H******VRD11+111
                          4FW*******OE861111
                          4C********KEB8611
                          28U*******NC966
                           277PH*ZRFPD662
                              5554666222
                                 44

                                                  I
```

Fig 21 - Plot of groups in true orientation

```
TEST DATA                                GROUPS              MEAN VERTICAL

  32 OBSERVATIONS WITH TOTAL WEIGHT OF  1568.1
PERCENT OF TOTAL WEIGHT IN  1.0 PERCENT OF AREA
CONTOUR INTERVAL  1.0   CHARACTER SEQUENCE  123456789ABCDEFGHIJKLMNOPQRSTUVWXYZ****
                                  I

                                2222211111
                               6B9998811111
                             446FFGGCEB61111
                             457V****OHD1111
                              5D********FDD83
                              7P********KBB883
                            27B********FBD883
                             28LY*****IHEB88
                              449CCEC448772
                                 2344442222
                                   222222

                                  I
```

Fig 22 - Plot of groups with mean vertical

Unit 6 output from MAP3:

MODE=3 DATA UNITS BETWEEN GRID LINES= 5000

DATA UNITS PER INCH= 500.0000 PROJECTION RADIUS= 3.937

INCHES PER DATA UNIT= 0.002000 PROJECTION RADIUS= 3.937

TTEST DATA GROUPS TRUE ORIENTATION

1

2

3

TTEST DATA GROUPS MEAN VERTICAL

1

2

3

Plotted Output (see Fig 23 to 28)

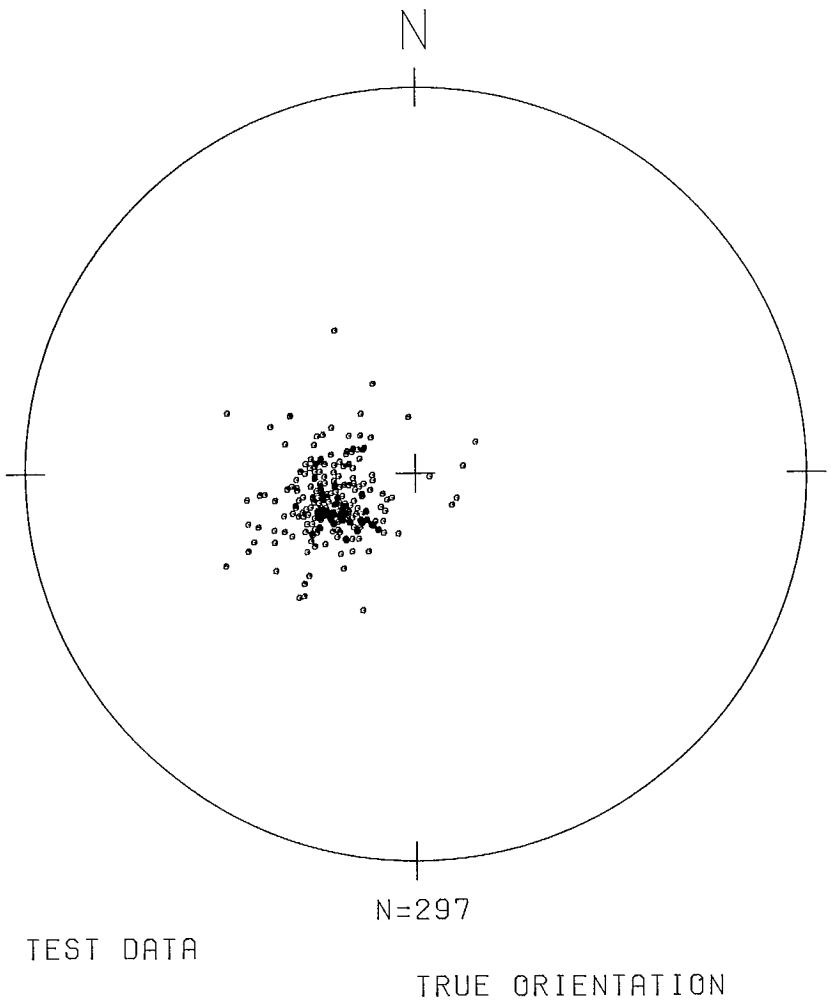

Fig 23 - Point diagram of 297 observations

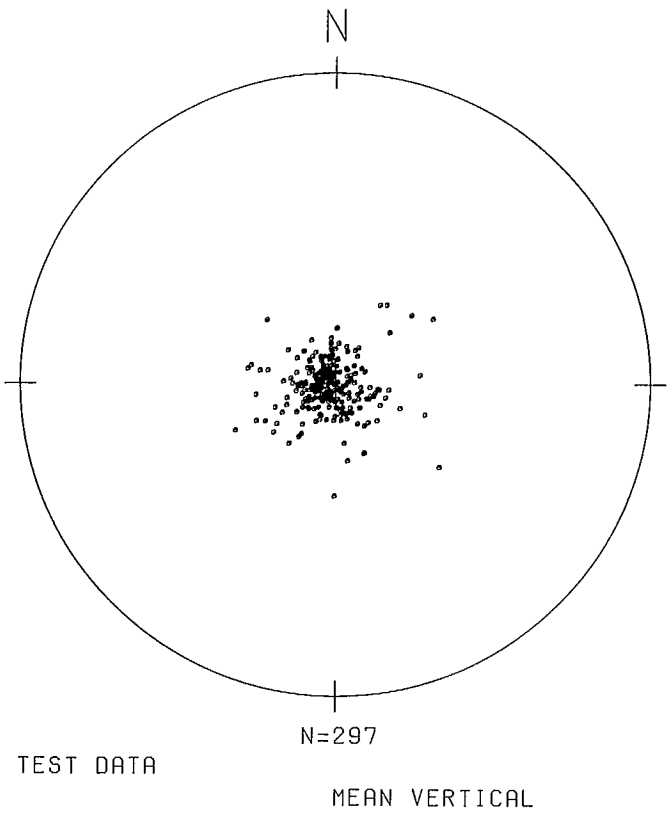

Fig 24 - Point diagram of 297 orientations with mean in vertical position

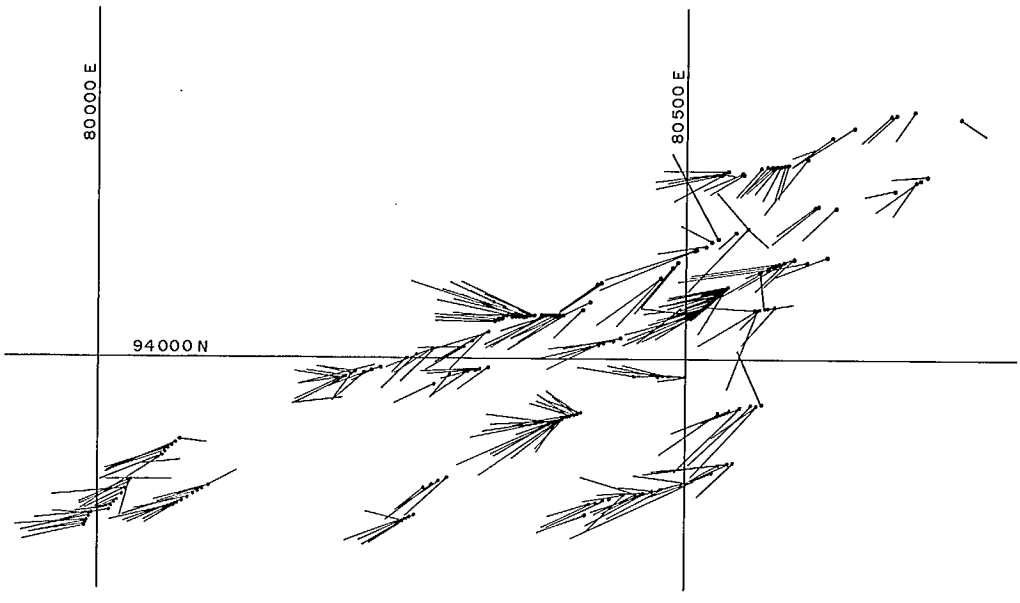

Fig 25 - Locations and orientations of observed discontinuities

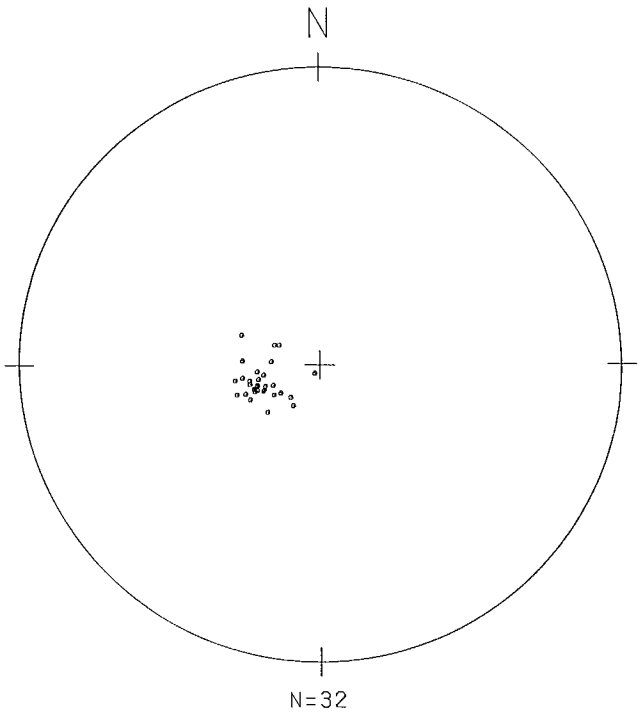

Fig 26 - Point diagram of 32 group means

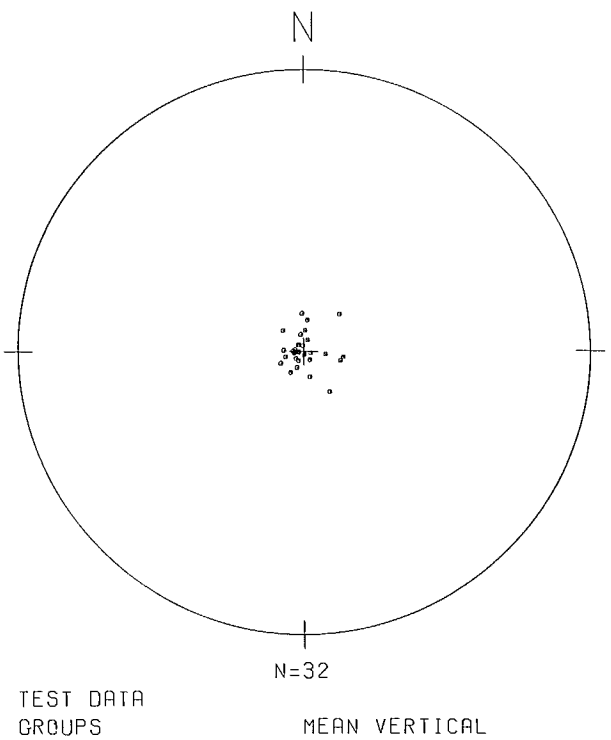

Fig 27 - Point diagram of 32 group means with mean vertical

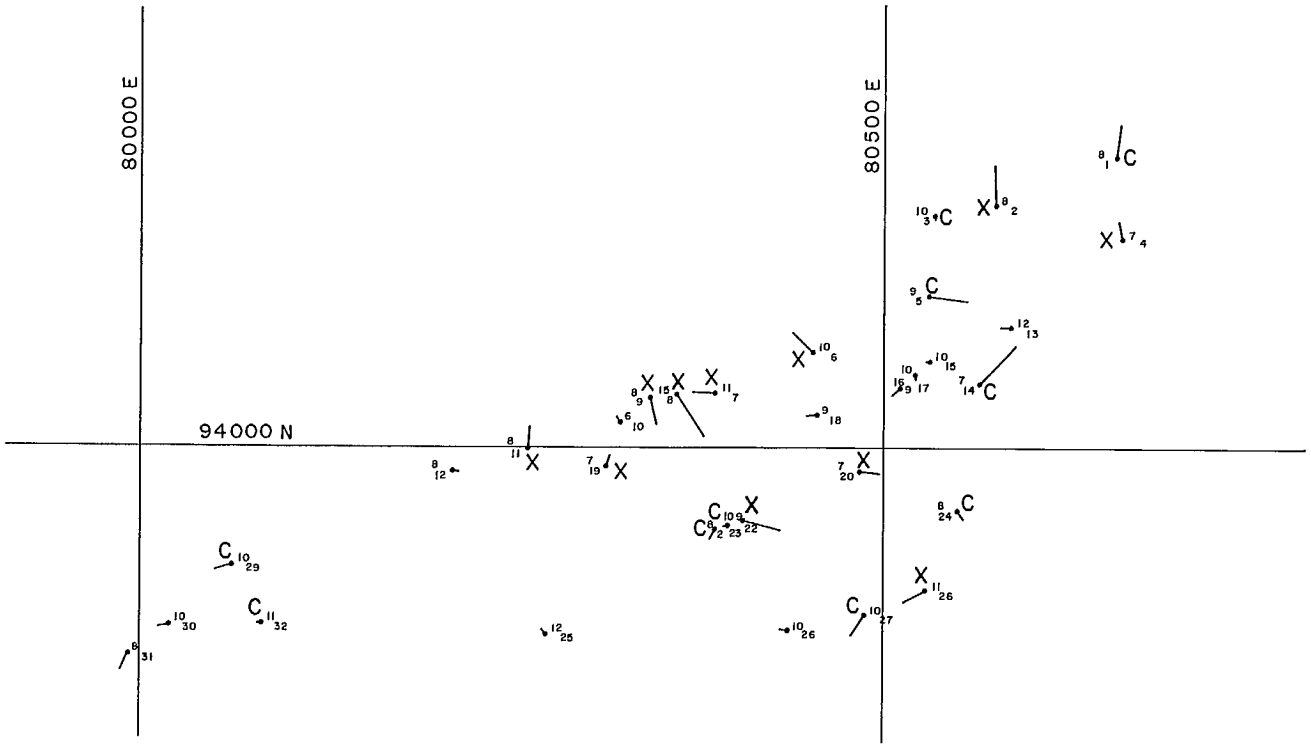

Fig 28 - Locations and orientations of deviations of group means from overall mean

DEFINITION OF DOMAINS AND CHARACTERIZATION OF DOMAIN SUBFABRICS

72. In the final stage, the geologist uses the map displays produced in Stage 3 to combine groups into tentative domains (Fig 29).

73. Stage 4a. The information in the group data file is read by program INPT1 and stored for input to program HOMO. This program may be instructed to perform tests for homogeneity of means and dispersions on any given set of adjacent groups. If the hypothesis of homogeneity is not rejected, the area is increased in size by including neighbouring groups and the tests repeated. The area is thus expanded to the point at which the inclusion of any more groups result in the rejection of homogeneity in either dispersions or means. The program is then instructed to output the numbers of the groups within the area, which is at this point a subfabric domain. The procedure is then repeated to define other domains.

74. Stage 4b. Program DDKY1 merges the datafile keys for the groups within each domain into a single key for the domain. This key is in turn used by program INPK1 to retrieve from the data file the observations in the domain. Program WNST5 characterizes the domain subfabric for the fabric element being analyzed.

75. If displays of the data within each domain are required, they can be produced by repeating

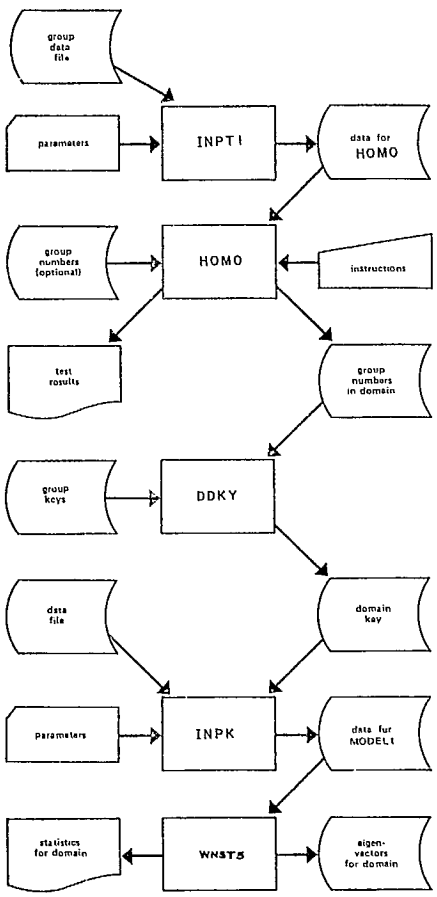

Fig 29 - Stage 4 - Defintion of domains and characterization of domain subfabrics

Stage 3 with the following changes. In Stage 3a (Fig 29) program INPT1 is replaced by program INPK1 and the eigenvectors for the whole data file are replaced by the eigenvectors for the domain produced by program WNST5 in Stage 4b. Then using the group data file with the group numbers in the domain as written by program HOMO, it will produce displays of the group means within the domain. Alternatively, using the data file and domain key created by program DDKY will produce displays of the individual observations within the domain.

PROGRAM HOMO

76. This is an interactive program for testing grouped orientation data for homogeneity of concentration parameters and group means. The program first reads the group data, then accepts commands from the input device attached to I/O unit 5, normally an interactive terminal but possibly a card reader. In response to these commands, the program will add groups to or delete groups from the set of currently included groups and test for homogeneity of concentration parameters or for homogeneity of mean directions among the currently included groups. A flow diagram is shown in Fig 30(a) to (e).

Solution

77. The tests for homogeneity of concentration parameters and homogeneity of group mean directions are taken from Mardia, K.V., 1972, Statistics of Directional Data, London & New York, Academic Press, pp 267-271, with the following change: The number of degrees of freedom for the Chi-square statistics used for testing the concentration parameters has been taken as n-1, where n is the number of groups tested, instead of 2n-2 as given by Mardia. Checks performed using data generated artificially from a Fisher distribution with k=50 indicate that the correct number of degrees of freedom is approximately n-1.

Capabilities

78. Maximum number of groups is 100.

Options

79. Details of the commands and their effects follow. These commands are entered on cards as unit 5 input.

Name: Delete.

Form: "D" followed by optional list of group numbers.

Effect: If group numbers are given, those group numbers are deleted from the list of currently included groups. If no group numbers are given, all groups are deleted from the list.

Name: Restore.

Form: "R" followed by optional list of group numbers.

Effect: If group numbers are given, those group numbers are added to the list of currently

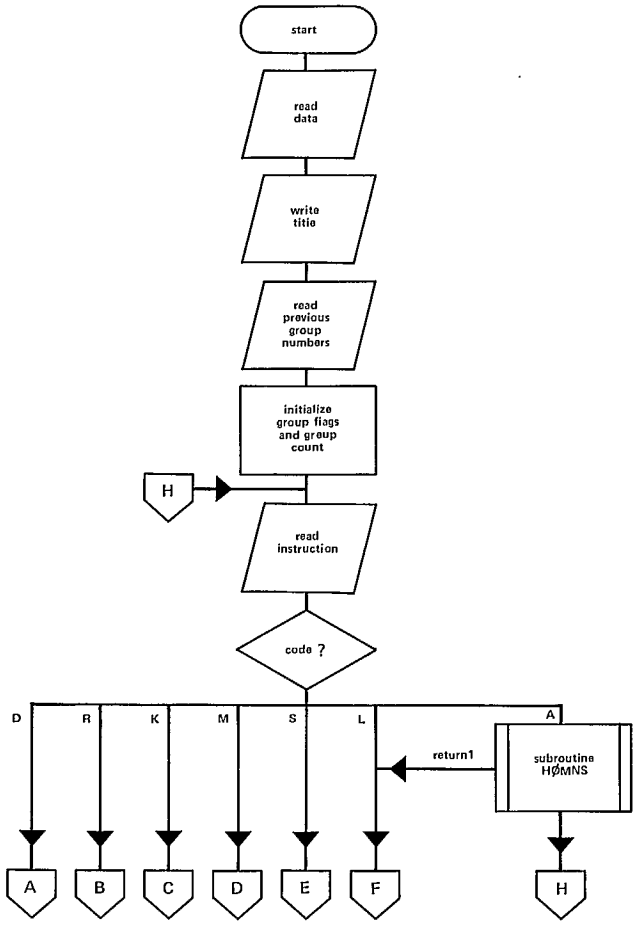

Fig 30(a) - Flow diagram for program HOMO - Part 1

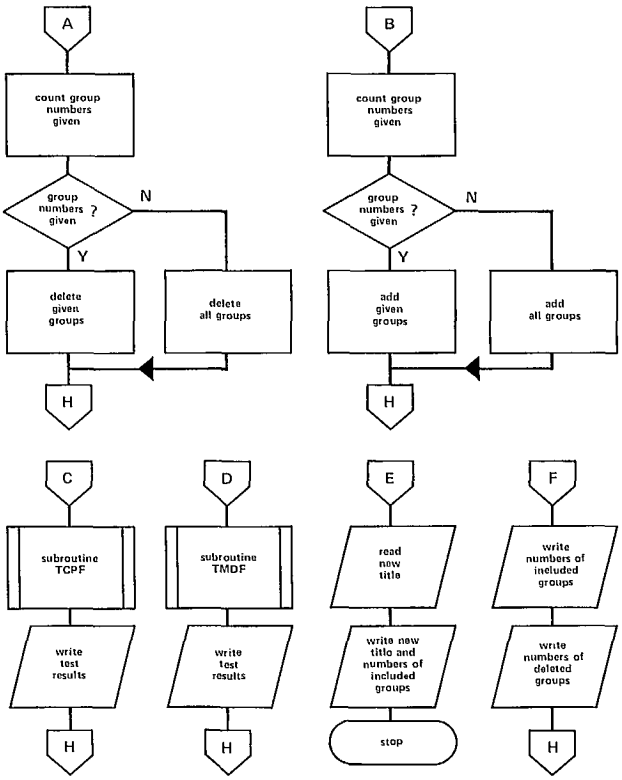

Fig 30(b) - Flow diagram for program HOMO - Part 2

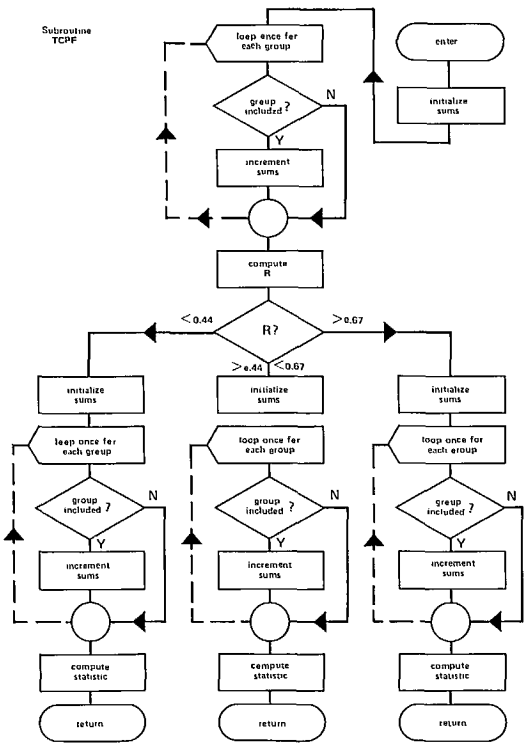

Fig 30(c) - Flow diagram for program HOMO - Part 3

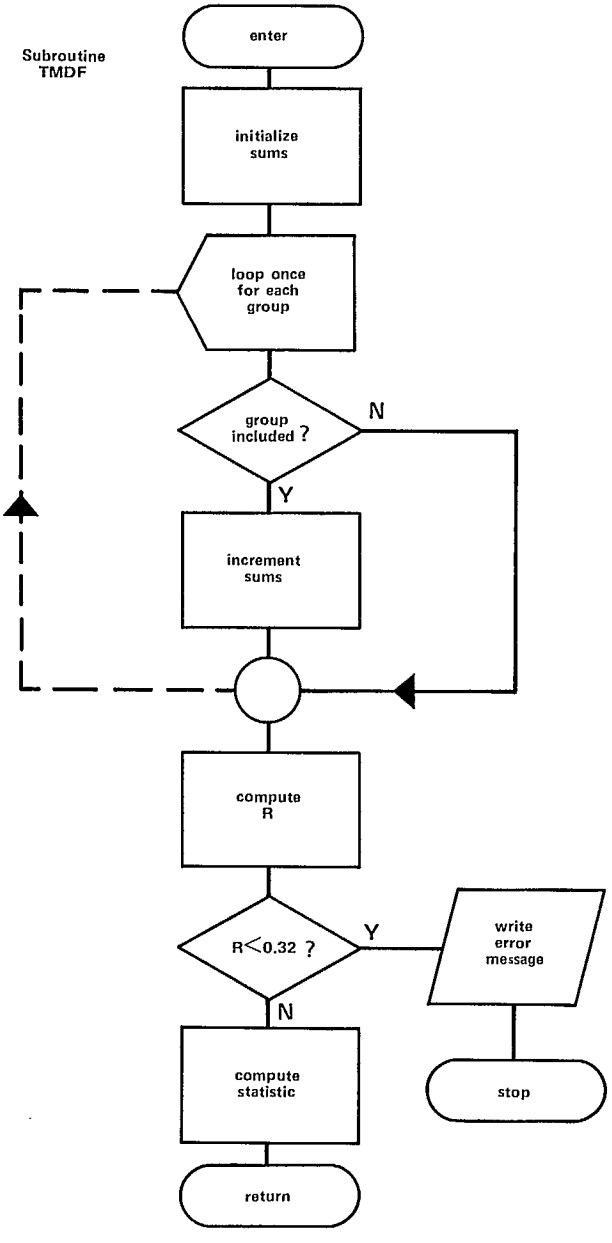

Fig 30(d) - Flow diagram for program HOMO - Part 4

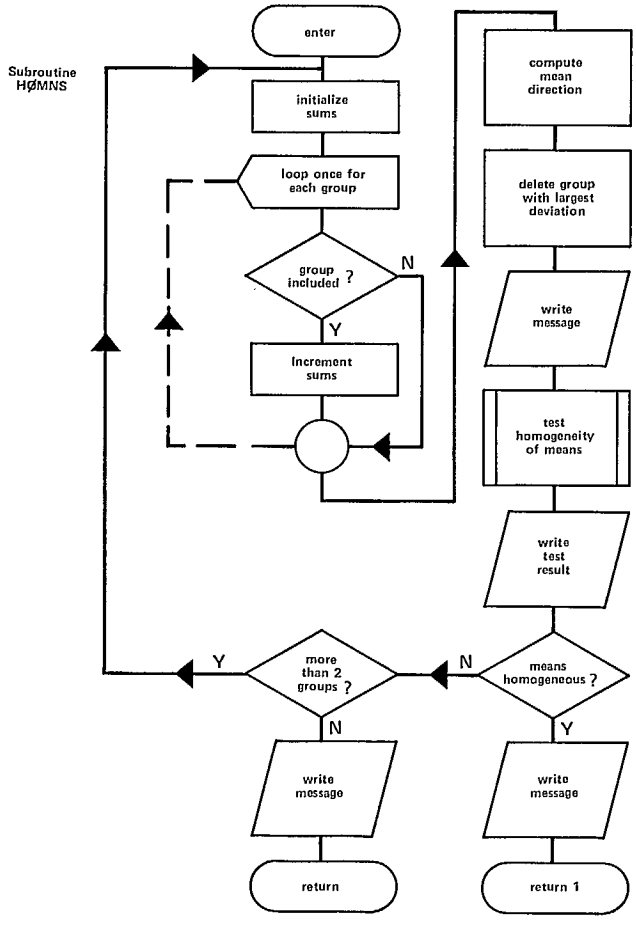

Fig 30(e) - Flow diagram for program HOMO - Part 5

included groups. If no group numbers are given, all groups are added to the list.

Name: List.

Form: "L".

Effect: Those group numbers in the list of currently included groups are printed. Those group numbers not in the list are printed separately.

Name: Concentration Parameter Test.

Form: "K".

Effect: Concentration parameters of currently included groups are tested for homogeneity by the subroutine TCPF and the results of the test are printed.

Name: Mean Direction Test.

Form: "M".

Effect: Mean direction of currently included groups are tested for homogeneity by the subroutine TMDF and the results of the test are printed.

Name: Automatic Deletion of Groups until Means are Homogeneous.

Form: "A"

Effect: The group whose mean direction is farthest away from the overall mean direction is deleted from the list of currently included groups. The mean directions of the groups then remaining in the list are tested for homogeneity. If the test indicates that the means are homogeneous, a message to that effect is printed and the command list is executed before returning to command mode. If the test indicates that the means are not homogeneous, the procedure is repeated, a new overall mean direction being computed first. This iteration is continued until either the means become homogeneous or only two groups remain.

Name: Stop.

Form: "S".

Effect: The program requests and reads a name for the set of currently included groups. This set of group numbers is then written on I/O unit 7 and the group stops.

Input

Unit 1 - tape or disk - record length: 3608 bytes, unformatted. Group data. As written by program INPT1 or INPK1.

Unit 2 - card reader - record length: 80 bytes, formatted. Predefined set of group numbers (optional). If this input is supplied, the format must be written by GRPS. The group number is the first variable of the GRPS output. See GRPS. If this is not supplied, an end-of-file (7/8/9) should be placed in the file.

Unit 5 - card reader - record length: 61 bytes, formatted. Commands. The commands are described under program options. The general format of the commands is:

Columns	Contents
1	code letter
2-5	first group number
6-9	second group number
.	.
.	.
.	.
78-81	twentieth group number

Output

Unit 6 - printer - record length: 121 bytes, formatted. Messages and test results. These should be self-explanatory.

Unit 7 - card punch or disk - record length, 80 bytes, formatted. Final set of group numbers. Used as input by DDKY. These are in the same format as those produced by GRPS.

Subroutines

XKF

estimates the concentration parameter for Fisher's distribution, given as R = Q/S, where Q = length of the resultant of a set of vectors, and S = the sume of the lengths of the vectors. The table given by MARDIA (1972, p322) is used to obtain AK if R is less than 0.9. Otherwise the estimate (1-2/N) (1-R) is used. The function TAB1 is used.

Calling sequence: CALL XRF(R,N,AK,IE)

R = proportional length resultant = Q/S

N = number of vectors in the data

AK = estimated concentration parameter returned by this routine

IE = error code returned.

= 0 if there is no error

= 1 if R is the outside range of 0 to 1. AK is set to 0.0.

TAB1

See GRPS

MDCH

See source listing

MGAMMA

See source listing

MDFD

See source listing

MERF

See source listing

UERTST

See HIST2V

WRITEK

See GRPK1

READK

See INPK1

HOMNS

See source listing

TMDF

See source listing

TCPF

See source listing

Variables

NN	number of numbers in input data
NV	number of variables in input data
NO	number of observations in input data
NPHR	number of data records following the title record
TITLE	title of input data
IE	number of numbers in input data record
N	array of numbers of observations in group
T	sums of weights for groups
X,Y,Z	mean coordinates of groups
A,B,C	direction cosines of group means
R	lengths of resultants for groups
LENFIL	total number of groups
LENK	number of groups in predefined combination
KEY	numbers of groups in previously defined combination
IS	array of flags for 'included' groups
L	command code letter
IG	group numbers in command
U	test statistic
NDF	number of degrees of freedom
P	probability of test statistic < = U
F	test statistic
ND1	degrees of freedom
ND2	degrees of freedom

External References: Standard FORTRAN built-in functions.

Storage Requirements

Code		bytes	words
HOMO	07592	2205	1152
		10205(buffers)	4229
TCPF	01784	251	169
TMDF	01328	164	116
HOMNS	01536	063	179
READK	00952	125	85
WRITEK	00904	100	64
TAB1	00704	43	35
XKF	01344	332	218
MDCH	01736	371	249
UERTST	00776	104	68
MDFD	02960	320	208
MGMMA		400	256
MERF		254	176
Labelled common:			
HOMO	02808	1275	701
TOTAL		16412	7910

PROGRAM DDKY

80. The program reads sets of integers and constructs a new one containing all the integers in all sets read. Not all the sets in the input file are used. Which are used is determined by sequence numbers read from another I/O unit. A flow diagram is given in Fig 31.

Solution

81. The integers in the input sets are copied sequentially into the output set as they are read. After all the input sets have been copied, the integers in the output set are ordered by calling the subroutine ORDERH. The program does not check for duplicates. An integer will appear in the output set as many times as it appears in all of the input sets.

Capabilities

82. Maximum number of input sets to be included is 100. Maximum size of each input set is 20 integers. Maximum size of the output set is 1000 integers.

Input

Unit 1 - tape or disk or card reader - record length: 80 bytes, formatted. Input sets. This is the output from HOMO.

Unit 2 - card reader - record length: 80 bytes, formatted. Numbers of those input sets to be used. Same format as for unit 1, see format for

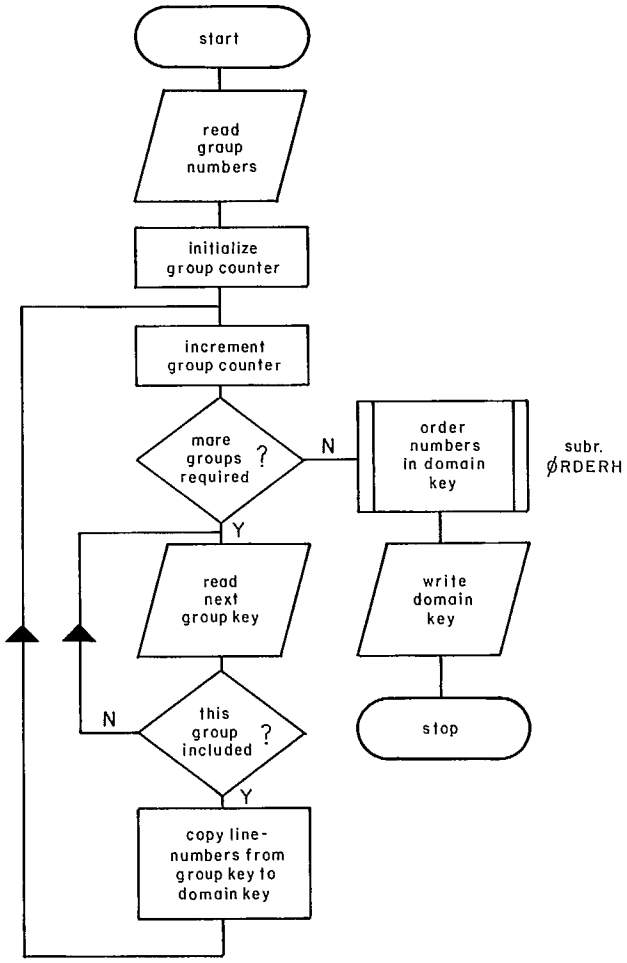

Fig 31 - Flow diagram for program DDKY

HOMO and GRPS.

Output

Unit 7 - tape, disk or card punch - record length: 80 bytes, formatted. Output set; used as input to INPK1. These output records are in the same format as the input.

Variables

KEY	list of numbers of sets to be merged
MKEY	array to contain output set
IGN	array to contain list of set numbers
TITLE	array to contain title
OV	array of blanks
TITLE2	array to contain title of output set
LEN	counter for size of output set
NG	number of sets to be merged
NGD	number of sets in the output file
I	index
IG	counter of sets to be read
IGF	counter of sets merged
LENFIL	size of set of which all input sets are subsets
LENK	size of input set
J	index

Storage Requirements

Code		bytes	words
DDKY	3312	2375	1277
		6144(buffers)	3172
ORDERH	536	40	32
READK	952	125	85
WRITEK	904	100	64
Total	5704	8784	4630

SAMPLE RUN - STAGE 4

Input Files

Group data file.

Unit 1 input to INPT1.

TTEST DATA GROUPS

1806565941979	8	771	-117001	-103741	746239	-153454	-136064	978744	988907	222	78	68
2805718941650	8	326	- 63014	- 40096	316908	-193537	-123150	973333	998744	212	77	597
3805336941579	10	724	- 49212	-202889	682455	- 68956	-284288	956256	985738	256	73	56
4806601941425	7	284	- 40332	- 60184	273266	-142663	-212884	966606	995448	236	75	157
5805301941031	9	603	54374	-108352	560983	94740	-188788	977437	951797	297	78	16
6804515940645	10	644	-142256	-155611	606118	-221672	-242483	944491	996492	228	71	228
7803860940368	11	229	- 37460	- 73441	213281	-163838	-321205	932730	998439	243	69	524
8803612940354	15	451	62815	-161001	413149	140262	-359507	922541	992991	291	67	124
9803430940339	8	210	3960	- 75036	195880	18876	-357660	933661	999037	273	60	779
10803224940174	6	369	-43438	- 95381	352669	-118066	-259248	958567	997054	246	73	226
.....	.	...	.....	.....	.....	.....	.....	.....	.....	...	..	...
32800807938806	11	420	-41477	-119483	394625	-100091	-288329	952286	986663	251	72	61

Group keys.
Unit 1 input to DDKY.

```
TEST DATA                                         GROUP        1                                1
                                                                    297       8                 2
 160  161  162  163  164  285  286  286    0    0    0    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP        2                                1
                                                                    297       8                 2
 165  166  167  168  169  170  171  172    0    0    0    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP        3                                1
                                                                    297      10                 2
 288  289  290  291  292  293  294  295  296  297    0    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP        4                                1
                                                                    297       7                 2
  97   98   99  100  226  227  228    0    0    0    0    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP        5                                1
                                                                    297       9                 2
 101  102  103  104  105  106  229  230  231    0    0    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP        6                                1
                                                                    297      10                 2
 107  108  109  110  111  112  113  232  233  234    0    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP        7                                1
                                                                    297      11                 2
 235  236  237  238  239  240  241  242  243  244  245    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP        8                                1
                                                                    297      15                 2
 114  115  116  117  118  119  120  121  122  123  124  125  126  127  128    0    0    0       3
TEST DATA                                         GROUP        9                                1
                                                                    297       8                 2
 246  247  248  249  250  251  252  253    0    0    0    0    0    0    0    0    0    0       3
TEST DATA                                         GROUP       10                                1
                                                                    297       6                 2
 129  130  131  132  133  134    0    0    0    0    0    0    0    0    0    0    0    0       3
 ...  ...  ...  ...  ...  ...    .    .    .    .    .    .    .    .    .    .    .    .       .
TEST DATA                                         GROUP       32                                1
                                                                    297      11                 2
  215  216  217  218  220  221  222    0    0    0    0    0    0    0    0    0    0    0      3
```

Data file

Unit 1 input to INPK1

TTEST DATA

```
D2Dm  51  3  126967   259 -5 217150 3   5380539893910069687BG 66 23-1589-3570 9205 33L    1          0    0    OMDSR2
D2DM  51  3  126967   259 -5 21715014   54B0539793910069687BG 46 17-2031-2103 9563 62 B               0    0    OMDSR2
D2DM  51  3  126967   259 -5 217150 5   8985363939093696990BG 83 27 -553-4506 8910 27L    2          0    0    OMDSR3
D2DM  51  3  126967   259 -5 217150 6   92B0546093909369690BG 83 27 -553-4506 8910 27L    2          0    0    OCMSR1
D2DM  51  3  126967   259 -5 21715015  16380529193907969696BG 83 27 -553-4506 8910 27 B               0    0    OCMSR1
D2DM  51  3  126967   259 -5 21715010  17380527893907769697BG 62 26-2058-3871 8988 29L    1          0    0    OMDSR3
D2DM  52  3  126967   262  5 280220 1    080479093884069692BG 96 15  271-2574 9659 30L Z  2172FD-9255 3587 1215MDSR2
....  ..  .  ......   ... .  ........  ..................... .. ..  .................    ........... .... .........
D2Hm  89  3  116700   241-28 14023023  12380526594155867406BG 61 18-1498-2703 9511 58 F               0    0    OCOLS4
```

Output files

Group numbers in domain
Unit 7 output from HOMO
Unit 2 input DDKY

```
TEST DATA                                      GROUPS                     DOMAIN1        1
                                                                 32          9           2
  4   5   6   7   8   9  10  11  12   0   0   0   0   0   0   0   0   0                  3
```

Data file key for domain
Unit 7 output from DDKY
Unit 2 input to INPK1

```
TEST DATA                                                             DOMAIN1          1
                                                            297        82              2
 97  98  99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114                3
115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132                4
133 134 135 136 137 138 139 140 141 142 226 227 228 229 230 231 232 233                5
234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251                6
252 253 254 255 256 257 258 259 260 261   0   0   0   0   0   0   0   0                7
```

Eigenvectors for domain.
Unit 7 output from WNST5.

```
0.199661   0.977697  -0.065149
0.943174  -0.209783  -0.257709
0.265628   0.009993   0.964024
```

Input parameters (Unit 5, see Fig 32)

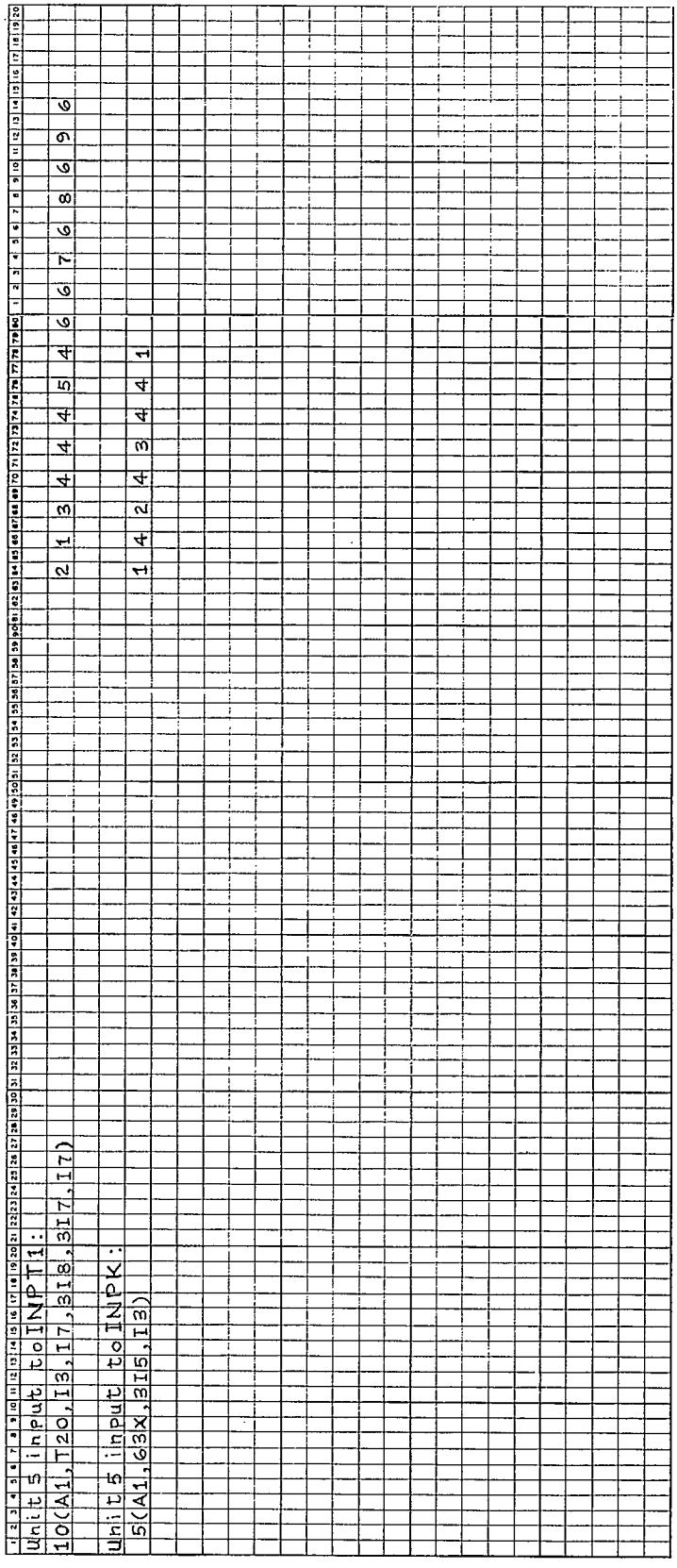

Fig 32 - Coding form for INPT1 and INPK1

Printed output

Unit 6 output from INPT1:

```
  10 VARIABLES
FORMAT=(A1,T20,I3,I7,3I8,3I7,I7)
TEST DATA                                   GROUPS
  32 DATA POINTS          1 PHYSICAL RECORDS
```

Unit 5 input and unit 6 output for HOMO

(→ indicates input):

```
TEST DATA                                   GROUPS
TEST FOR HOMOGENEITY OF FABRIC
ENTER
  D TO DELETE GROUPS
  R TO RESTORE GROUPS
  L TO LIST GROUPS INCLUDED AND DELETED
  K TO TEST CONCETNRATION PARAMETERS
  M TO TEST MEAN DIRECTIONS
  A FOR AUTOMATIC DELETION OF GROUPS UNTIL MEANS ARE HOMOGENEOUS
  S TO STOP

→ ? d
→ ? r 01 02 03 04 05 06 07 08 09 10 11 12
→ ? k
  CHI-SQUARE=  114.27     DF= 11
  TAIL PROBABILITY = 0.0

→ ? m
  F STATISTIC=  11.78     DF= 22, 192
  TAIL PROBABILITY = 0.0

→ ? d 01 02 03
→ ? k
  CHI-SQUARE=  96.78      DF=  8
  TAIL PROBABILITY = 0.000

→ ? m
  F STATISTIC=  14.66     DF=  16,146
  TAIL PROBABILITY = 0.0

→ ? s
  ENTER NAME OF DOMAIN
→ ? domain1
```

```
        Unit 6 output from INPT1:

82 TEST DATA                                                          DOMAIN1
1 PHYSICAL DATA RECORDS

        Unit 9 output from WNST5:

82 TEST DATA                                                          DOMAIN1

        Unit 6 output from WNST5:

         1
          TEST DATA                                                   DOMAIN1
             82 POINTS WITH TOTAL WEIGHT OF 330.5

          "BINGHAM" STATISTICS

          EIGENVAL    EVAL/SW    DIRECTION     COSINES         TR    PL    DD     DP
              4.14    0.01251   0.19966  0.94317  0.26563   78.0  15.4  258.0  74.6
             10.60    0.03207   0.97770 -0.20978  0.00999  347.9   0.6  167.9  89.4
            315.77    0.95542  -0.06515 -0.25771  0.96402  255.8  74.6   75.8  15.4

    TEST OF HYPOTHESIS K1=K2=K3:  TEST STATISTIC=  1186.5664    5%  POINT=11.0705
    TEST OF HYPOTHESIS K2=K3:  TEST STATISTIC=  314.9097    5% POINT=5.99147
    TEST OF HYPOTHESIS K1=K2:  TEST STATISTIC=   24.2093    5% POINT=5.99147
    ALL HYPOTHESES REJECTED


         TEST DATA                                                    DOMAIN1
            82 POINTS WITH TOTAL WEIGHT OF 330.5
         "FISHER" STATISTICS

             R        R/SW       DIRECTION     COSINES         TR     PL      DD      DP
           322.85    0.97687  -0.06154 -0.25837   0.96408    256.6  74.6    76.6    15.4

         FISHER        CONFIDENCE RADII
           K               95%    99%
         42.186            2.4    3.0

        TEST OF UNIFORMITY ABOUT FISHER MEAN
        KUIPER'S STATISTIC =    2.310     95% POINT = 1.747
```