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DECUS NO.	8-324
TITLE	TSP - TREND SURFACE PLOTTING
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DATE	January 29, 1970
SOURCE LANGUAGE	FORTRAN D

TSP - TREND SURFACE PLOTTING

DECUS Program Library Write-up DECUS No. 8-324

ABSTRACT

This program consists of a group of segments for which the output of one segment is the input of the next. It enables the significance of linear, quadratic, and cubic trend surfaces to be determined for each of a number of variables on the co-ordinates of their distribution in two-dimensional space. The significance of the various surfaces having been determined, the fitted surface can be plotted by means of a contour map on the teletype.

TAPES REQUIRED

1. Form of program tapes - All program tapes are written in the PDP-8 FORTRAN-D language and are in the source language for ease of modification. There are seven segments in the complete trend surface plotting program, as follows:

(a) TSP2 - program to compute the regressor matrices from the original data tape of the grid co-ordinates;

(b) TSP3 - program to invert the regressor matrices computed by TSP2;

(c) TSP4 - program to compute sums of squares and products vectors for dependent variables;

(d) TSP5 - program to compute regressions of dependent variables on the linear, quadratic, and cubic expressions of the grid co-ordinates;

(e) TSP6 - program to compute the significance of the computed regressions;

(f) TSP7 - program to compute trend surface parameters. (N.B. this program will usually require to be modified to suit individual applications. For advice on how these modifications should be made, consult the author.)

(g) TSP8 - program to plot trend surfaces.

2. Form of data tapes - Three data tapes are required for this program:

(a) Data tape for TSP2 - This tape should consist of the number of sample points, followed by the grid co-ordinates for each point, e.g.

```
41
3.44    7.29
3.30    7.50
3.15    7.70
3.30    7.70    etc.
```

(b) Data tape for TSP4 - This tape should consist of the successive values of the dependent variable, with the sampling points in the same order as the data tape for TSP2. As many dependent variables as are required can be included on this data tape, eash as a single column vector.

(c) Data tape for TSP5 - A short data tape containing the means of the linear, quadratic, and cubic terms of the grid co-ordinates is required, and can be derived from the printed results of TSP2.

OPERATING INSTRUCTIONS

All of the program segments follow the usual operating procedures for the PDP-8 disk operating system. The sequence of the various calculations is given in Figure 1. Detailed instructions for the individual segments are as follows:

(a) TSP2 - The data tape for this segment is placed in the high-speed tape reader before continuing after the teletype has printed "READY." The high-speed punch should be switched on while a summary of the data is being typed. The output from this segment should be saved, and used as the input to TSP3.

(b) TSP3 - The output from TSP2 should be placed in the high-speed reader, and the high-speed punch switched on before continuing after "READY." The output from this segment should be saved and used as an input for TSP5.

(c) TSP4 - The data tape for TSP4 (see 2 (b) above) should be placed in the low-speed tape reader, and the data tape for TSP2 in the high-speed reader, and the high-speed punch switched on before continuing after "READY." The output from this segment should be saved and used as an input to TSP5.

(d) TSP5 - The data tape containing the means of the linear, quadratic, and cubic terms of the grid co-ordinates (see 2 (c) above) should be placed in the high-speed reader before continuing after "READY." The program will then pause for the insertion of the output from TSP4 in the slow-speed reader and the output from TSP3 in the high-speed reader, before continuing. After computing the regressions for the first dependent variable, the program will pause for the output from TSP3 to be replaced in the high-speed reader before continuing to read the next dependent variable.

(e) TSP6 - Before running the TSP6 segment, it is necessary to create a data tape from the printed results of TSP5. This is done by punching the number of sample points, followed by the total sum of squares, sum of squares due to regression, and coefficient of determination for the linear, quadratic and cubic regressions. This data tape should be placed in the high-speed reader before continuing after "READY."

(f) TSP7 - On continuing after "READY," the program will pause for the entry of the regression coefficients of the significant trend surface. Note that the values for all nine coefficients must be entered even if they are zero. The coefficients must then be followed by the appropriate constant term, and by the starting value for the contours to be drawn and the contour interval. As a rough guide, the starting value should be a little below the minimum value recorded in the dependent variable and the contour interval about one third of the standard deviation of the dependent variable. The output from TSP7 is stored directly on the disk, in preparation for the use of TSP8.

(g) TSP8 - Before continuing after "READY," it is advisable to title the trend surface plot with the teletype switched to "local," followed by five or six line feeds. If an output tape is required, switch on the low-speed printer before continuing.

OUTPUT

The output from the various program segments is as follows:

(a) TSP2 - The means and standard deviations of the linear, quadratic, and cubic terms are typed, and the corrected sums of squares and products for the linear, quadratic, and cubic regressions are output on the high-speed punch in a form suitable for direct re-input to TSP3.

(b) TSP3 - The inverse regressor matrices are output on the high-speed punch in a form suitable for direct re-input to TSP5.

(c) TSP4 - This program outputs a vector of sums of squares and products for each dependent variable, in a form suitable for direct input to TSP5.

(d) TSP5 - This program prints the number of sampling points, the partial regression coefficients and constant, the total sum of squares and the sum of squares due to regression and the proportion of the total variability accounted for by the regression for the linear, quadratic, and cubic trend surfaces.

(e) TSP6 - The program prints the degrees of freedom and variance ratio testing the significance of the linear, quadratic, and cubic components of the trend surface.

(f) TSP7 - The parameters for the printing of a contour map of the trend surface are stored directly on the disk.

(g) TSP8 - The contour map of the fitted trend surface is typed. An example of a typical map is given in Figure 2.

STORAGE AND LIMITATIONS

Normal for FORTRAN-D

There are no limits on the number of points that can be used in the computation of the trend surfaces. The scale of the map that can be printed will usually be limited by the width of the printed line on the teletype.

METHOD

The method follows closely that described by the following papers:

J. W. Harbaugh, BALGOL program for trend-surface mapping, Special Distribution Publication, University of Kansas, 1963.

M. O'Leary, R. H. Lippert, and O. T. Spitz, FORTRAN IV and map program for computation and plotting of trend surfaces for degrees 1 through 6, Computer Contribution 3, State Geological Survey, University of Kansas, 1966.

Figure 1. Flow diagram for segments of trend-surface plotting program

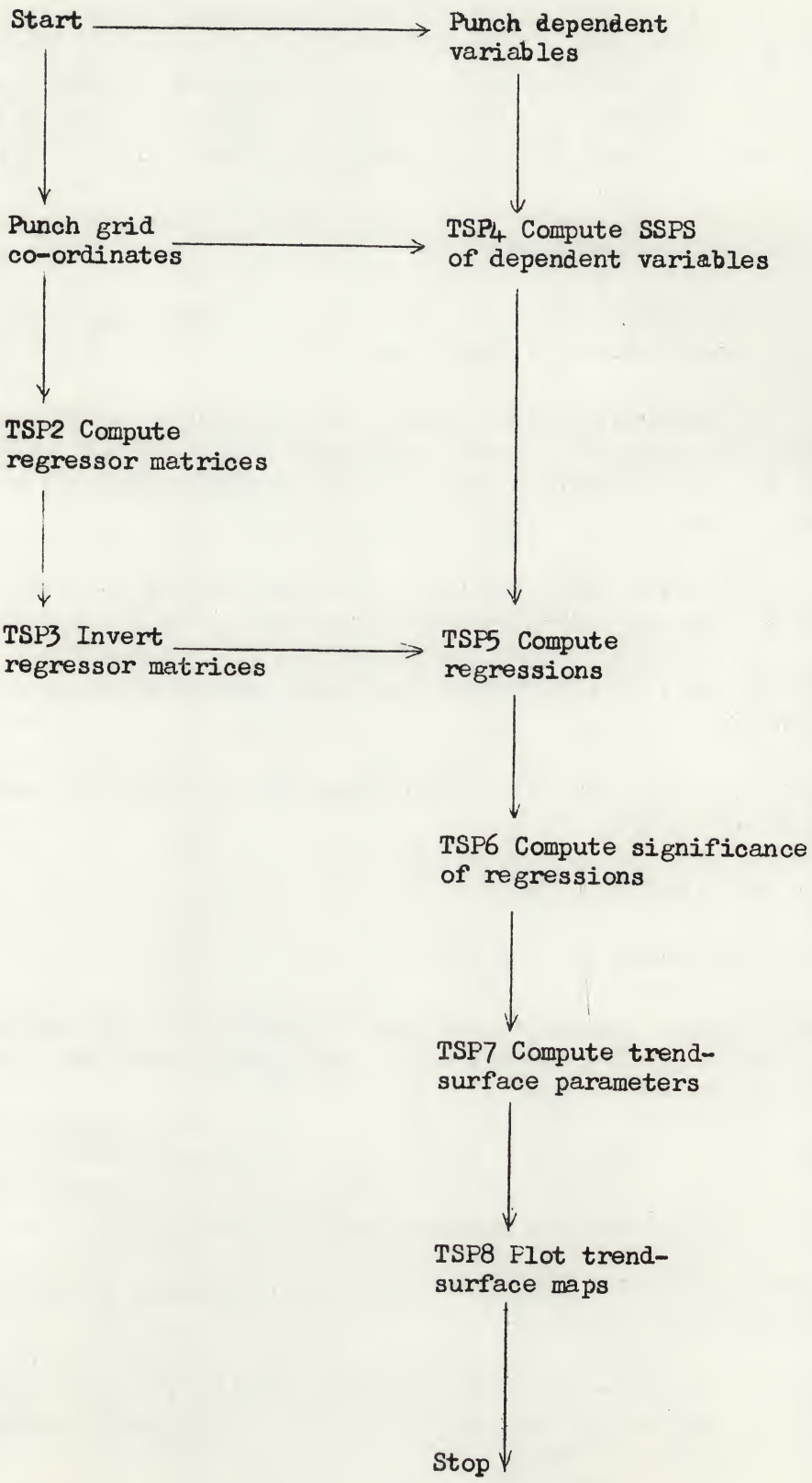
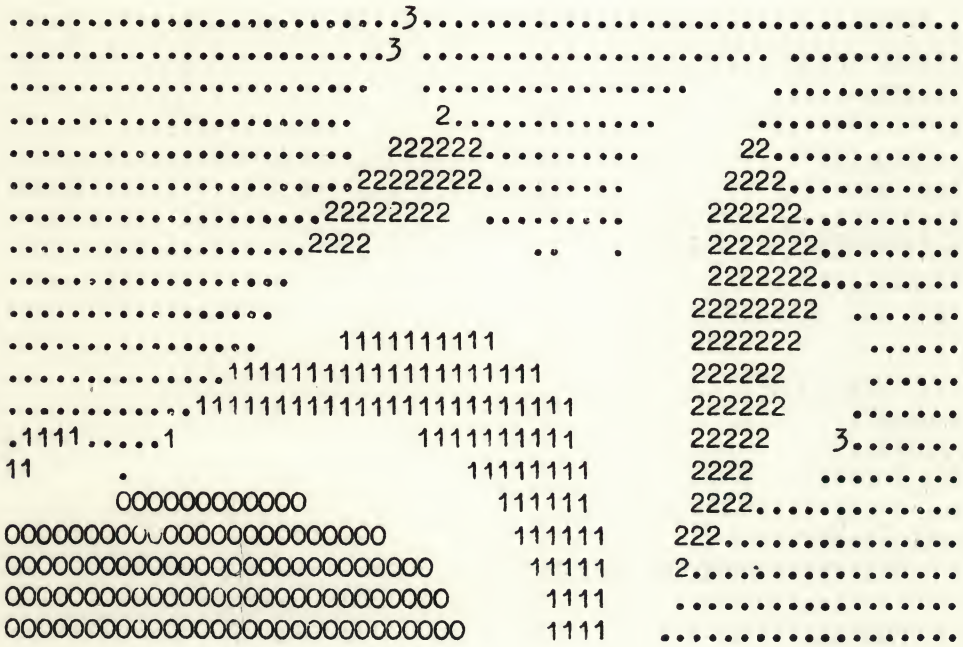


Figure 2.

```
.FOSL
*IN-S:TSP7
*
*OPT-S
*OUT-S:DATA
*
*IN-
*
*READY
↑
16.3551  12.4362  1.44363
0.205818  -3.70581  0
0  0  0
-60.3213
18.0  1.0
!
.FOSL
*IN-S:TSP8
*
*OPT-S
*OUT-
*
*IN-S:DATA
*
*READY
↑
```



```
L
C       PROGRAM TO COMPUTE REGRESSOR MATRICES   TSP2
        DIMENSION          SX(9),      SS(81),    X(9)
        READ 2,1Ø1,N
1Ø1     FORMAT (I)
        DO 1Ø I=1,9
        SX(I)=Ø.Ø
1Ø      CONTINUE
        DO 7Ø  J=1,81
        SS(J)=Ø.Ø
7Ø      CONTINUE
        DO 16 I=1,N
        READ 2,1Ø5,X(1),X(2)
1Ø5     FORMAT (E,E)
        X(3)=X(1)*X(1)
        X(4)=X(2)*X(2)
        X(5)=X(1)*X(2)
        X(6)=X(3)*X(1)
        X(7)=X(4)*X(2)
        X(8)=X(3)*X(2)
        X(9)=X(4)*X(1)
        EI=I
        DO 2Ø J=1,9
        DO 2Ø K=1,9
        KK=J+9*(K-1)
        SS(KK)=SS(KK)+(X(J)-SX(J) )*(X(K)-SX(K) )*(1.Ø-1.Ø/EI)
2Ø      CONTINUE
        DO 16 J=1,9
        SX(J)=SX(J)+(X(J)-SX(J) )/EI
61      CONTINUE
        EN=N
        DO 35 I=1,9
        K=I+9*(I-1)
        X(I)=SQTF(SS(K)/(EN-1.Ø) )
35      CONTINUE
        TYPE 1Ø1,N
        DO 1Ø3 I=1,9
        TYPE 1Ø4,SX(I),X(I)
1Ø3     CONTINUE
1Ø4     FORMAT (/,E,E)
        M=2
        WRITE 2,1Ø1,M
        WRITE 2,1Ø5,SS(1),SS(2),SS(1Ø),SS(11)
        M=5
        WRITE 2,1Ø1,M
        DO 4Ø I=1,37,9
        DO 4Ø J=1,5
        K=I+J-1
        WRITE 2,1Ø5,SS(K)
```

```
4Ø          CONTINUE
            M=9
            WRITE 2,1Ø1,M
            DO 6Ø I=1,81
            WRITE 2,1Ø5,SS(I)
6Ø          CONTINUE
            STOP
            END

*
```

```
L
AM TO INVERT MATRICES    TSP3
                DIMENSION A(156)
23Ø             READ 2, 3, N
3               FORMAT(I)
                LAST =N*N
                I1=1
                I2=LAST-N+1
                DO 1ØØ J=1,N
                DO 1Ø1  I=I1,I2,N
                READ 2,5,A(I)
5               FORMAT (E)
1Ø1             CONTINUE
                I1=I1+1
                I2=I2+1
1ØØ             CONTINUE
                WRITE 2,6,N
6               FORMAT (/,I)
149             DO 15Ø J=1,N
                DO 1Ø5 I=1,N
                A (LAST+I)=Ø.Ø
1Ø5             CONTINUE
                A(LAST+J)=1.Ø
                PVT=A(J)
                J3=LAST+J
                DO 1Ø6 KP=J,J3,N
                A(KP)=A(KP)/PVT
1Ø6             CONTINUE
                DO 11Ø KRT=1,N
                IF (KRT-J) 1Ø7,11Ø,1Ø7
1Ø7             KR1=KRT
                KR2=KR1+LAST
                KPR=J
                RWC=A(KR1)
                DO 1Ø9 KR=KR1,KR2,N
                A(KR)=A(KR)-RWC*A(KPR)
                KPR=KPR+N
1Ø9             CONTINUE
11Ø             CONTINUE
                DO 111 I=1,LAST
                A(I)=A(I+N)
111             CONTINUE
15Ø             CONTINUE
2ØØ             ILNE=4
                NR=NRC=1
                I1=1
                I2=LAST-N+1
                KONT =1
                DO 21Ø JP=1,N
```

```
              DO 213 I=I1,I2,N
              WRITE 2,212,A(I)
212           FORMAT(E)
              IF(N-NRC)216,216,215
216           IF(N-NR)213,213,217
217           NR=NR+1
              NRC=KONT=1
              ILNE=4
              GO TO 213
215           IF(KONT-ILNE)214,22Ø,214
22Ø           ILNE=ILNE+4
              WRITE 2,221
221           FORMAT (/,/)
214           KONT=KONT+1
              NRC=NRC+1
213           CONTINUE
              I1=I1+1
              I2=I2+1
21Ø           CONTINUE
              GO TO 23Ø
END

*
```

```
L
C            PROGRAM TO COMPUTE DEPENDENT VECTOR    TSP 4
             DIMENSION X(1Ø),SS(1Ø), SX(1Ø)
1            READ 2,1Ø1,N
1Ø1          FORMAT (/,I)
             WRITE 2, 1Ø1, N
             DO 1Ø I=1, 1Ø
             X(I) = Ø.Ø
             SS(I) = Ø.Ø
             SX(I) = Ø.Ø
1Ø           CONTINUE
             DO 2Ø I=1,N
             READ 2,1Ø2,X(I),X(2)
1Ø2          FORMAT (E,E)
             X(3)=X(1)*X(1)
             X(4)=X(2)*X(2)
             X(5)=X(1)*X(2)
             X(6)=X(3)*X(1)
             X(7)=X(4)*X(2)
             X(8)=X(3)*X(2)
             X(9)=X(4)*X(1)
             EI=I
             READ 1,1Ø2,X(1Ø)
             DO 4Ø J=1,1Ø
             SS(J)=SS(J)+(X(J)-SX(J) )*(X(1Ø)-SX(1Ø) )*(1.Ø-1.Ø/EI)
             SX(J)=SX(J)+(X(J)-SX(J) )/EI
4Ø           CONTINUE
2Ø           CONTINUE
             EN=N
             DO 5Ø I=1,1Ø
             WRITE 2, 1Ø2,SS(I)
5Ø           CONTINUE
             WRITE 2, 1Ø2,SX(1Ø)
             PAUSE
             GO TO 1
             END

*
```

```
L
C               PROGRAM TO COMPUTE REGRESSION STATISTICS    TSP 5
                DIMENSION SXY(11),SX(81),B(1Ø),X(1Ø)
                DO 6Ø I=1,9
                READ 2, 1Ø2,X(I)
6Ø              CONTINUE
                PAUSE
4               READ 1,1Ø1,N
                TYPE 1Ø1,N
1Ø1             FORMAT (/,/,I)
                DO 1Ø I=1,11
                READ 1,1Ø2,SXY(I)
1Ø2             FORMAT (/,E)
1Ø              CONTINUE
3               READ 2,1Ø1,M
                MM=M*M
                DO 2Ø I=1,MM
                READ 2, 1Ø2,SX(I)
2Ø              CONTINUE
                RSS=Ø.Ø
                K=1
                DO 3Ø I=1,M
                B(I)=Ø.Ø
                DO 4Ø J=1,M
                B(I)=B(I)+SX(K)*SXY(J)
                K=K+1
Ø4              CONTINUE
3Ø              CONTINUE
                B(1Ø)=SXY(11)
                DO 5Ø I=1,M
                B(1Ø)=B(1Ø)-B(I)*X(I)
                TYPE 1Ø2,B(I)
                RSS=RSS+B(I)*SXY(I)
5Ø              CONTINUE
                TYPE 1Ø2,B(1Ø)
                RR=RSS/SXY(1Ø)
                TYPE 1Ø3,SXY(1Ø),RSS,RR
1Ø3             FORMAT (/,E,E,E)
                IF (M-9) 5,6,5
5               GO TO 3
6               PAUSE
                GO TO 4
                END

*
```

```
L
C       PROGRAM TO COMPUTE SIGNIFICANCE OF REGRESSIONS TSP 6
        DIMENSION SS(9)
        READ 2, 1Ø1, N
1Ø1     FORMAT (I)
1       DO 1Ø I=1,9
        READ 2,1Ø2,SS(I)
1Ø2     FORMAT (E)
1Ø      CONTINUE
        NR=2
        NDF=N-3
        EN=NDF
        RSD=(SS(1)-SS(2) )/EN
        FR=(SS(2)/2.Ø)/RSD
        TYPE 1Ø3, NR, NDF, FR
1Ø3     FORMAT (/,/,/,/,/,I,I,E)
        NR=3
        NDF=N-6
        EN=NDF
        RSD=(SS(4)-SS(5) )/EN
        FR=((SS(5)-SS(2) )/3.Ø)/RSD
        TYPE 1Ø4, NR, NDF, FR
1Ø4     FORMAT (/,I,I,E)
        NR=4
        NDF=N-1Ø
        EN=NDF
        RSD=(SS(7)-SS(8) )/EN
        FR=( (SS(8)-SS(5) )/4.Ø)/RSD
        TYPE 1Ø4, NR, NDF, FR
        GO TO 1
        END

*
```

```
L
C       PROGRAM TO COMPUTE TREND SURFACE PARAMETERS  TSP7
        DEFINE DISK
        DIMENSION K(74),B(1Ø),V(9)
        DO 1Ø I=1,74
        READ 2,1Ø1,K(I)
1Ø      CONTINUE
1Ø1     FORMAT (I)
1Ø2     FORMAT (E)
5       N5=1
        N1=Ø
        V24=8.Ø
        DO 2Ø I=1,9
        ACCEPT 1Ø2,B(I)
2Ø      CONTINUE
        ACCEPT 1Ø2,B(1Ø)
        ACCEPT 1Ø3,V21,V22
1Ø3     FORMAT (E,E)
4       V23=2.Ø5
3       IF (K(N5) ) 31,1,1
31      NØ=-K(N5)
        DO 3Ø I=1,NØ
        N1=N1+1
        V23=V23+Ø.Ø5
        WRITE 3,1Ø1,K(N5)
3Ø      CONTINUE
11      N5=N5+1
        IF (N1-6Ø) 3,32,3
32      V24=V24-Ø.1
        N1=Ø
        IF (N5-74) 4,4,33
33      STOP
        GO TO 5
1       N3=K(N5)
        N4=Ø
9       V(1)=V23
        V(2)=V24
        V(3)=V(1)*V(1)
        V(4)=V(2)*V(2)
        V(5)=V(1)*V(2)
        V(6)=V(3)*V(1)
        V(7)=V(4)*V(2)
        V(8)=V(3)*V(2)
        V(9)=V(4)*V(1)
        VØ=Ø.Ø
        DO 4Ø I=1,9
        VØ=V(I)*B(I)+VØ
```

```
4Ø          CONTINUE
            VØ=VØ+B(1Ø)
            N2=Ø
            V25=V21
7           V25=V25+V22
            N2=N2+1
            IF (V25-VØ) 34,34,35
34          IF (N2-19) 7,35,35
35          WRITE 3,1Ø1, N2
            N4=N4+1
            N1=N1+1
            V23=V23+Ø.Ø5
            IF (N4-N3) 9,11,9
            END

*
```

```
L
C       TREND SURFACE PLOTTING PROGRAM TSP 8
        DEFINE DISK
        DIMENSION K(6Ø)
32      DO 4Ø I=1,2Ø
        DO 2Ø J=1,6Ø
        READ 3,99,K(J)
2Ø      CONTINUE
99      FORMAT(I)
        DO 3Ø J=1,6Ø
        IF(K(J) ) 21,22,22
12      TYPE 1ØØ
ØØ1     FORMAT (".")
        GO TO 3Ø
1       TYPE 1Ø1
1Ø1     FORMAT ("Ø")
        GO TO 3Ø
2       TYPE 1Ø2
1Ø2     FORMAT (" ")
        GO TO 3Ø
3       TYPE 1Ø3
Ø3      FORMAT ("1")
        GO TO 3Ø
4       TYPE 1Ø2
        GO TO 3Ø
5       TYPE 1Ø4
1Ø4     FORMAT ("2")
        GO TO 3Ø
6       TYPE 1Ø2
        GO TO 3Ø
7       TYPE 1Ø5
1Ø5     FORMAT ("3")
        GO TO 3Ø
8       TYPE 1Ø2
        GO TO 3Ø
9       TYPE 1Ø6
1Ø6     FORMAT ("4")
        GO TO 3Ø
1Ø      TYPE 1Ø2
        GO TO 3Ø
11      TYPE 1Ø7
1Ø7     FORMAT ("5")
        GO TO 3Ø
21      TYPE 1Ø2
        GO TO 3Ø
13      TYPE 1Ø8
1Ø8     FORMAT ("6")
        GO TO 3Ø
```

```
14          TYPE 1Ø2
            GO TO 3Ø
15          TYPE 1Ø9
1Ø9         FORMAT ("7")
            GO TO 3Ø
61          TYPE 1Ø2
            GO TO 3Ø
17          TYPE 11Ø
11          FORMAT ("8")
            GO TO 3Ø
81          TYPE 1Ø2
            GO TO 3Ø
91          TYPE 111
111         FORMAT ("9")
            GO TO 3Ø
22          LIST=K(J)
            GO TO (1,2,3,4,5,6,7,8,9,1Ø,11,12,13,14,15,16,17,18,19),LIST
Ø3          CONTINUE
            TYPE 112
121         FORMAT(/)
Ø4          CONTINUE
            TYPE 113
131         FORMAT (/,/,/,/,/,/,/,/,/,/,/ )
            PAUSE
            GO TO 23
            END

*
```