Program for the Analysis of Non-Linear Response Surfaces

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C OPTIONS

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ERRATA SHEET

Program CRS3 (page 84)

Statement 100 is:

```
100 XCN=XCNT(LL5)**(1./A4(LL6))*NN1
```

Should be:

```
100 XCN=XCNT(LL6)**(1./A4(LL6))*NN1
```

PROGRAM FOR THE ANALYSIS OF NON-LINEAR RESPONSE SURFACES

1. Introduction

Response surface methodology involves the study of the effect of various combinations of a given number of factors on a response. Hill and Hunter (1966) give a good review of the available literature. As originally introduced by Box and Wilson (1951), the procedure was intended for use in determining the optimum response and not the form of the surface. The linear model provides only a limited amount of information about the shape of the surface in the region of the factor space under consideration. Power transformations were first introduced for the independent variables by Box and Tidwell (1962) and then for the dependent variables by Box and Cox (1964). These studies opened up the possibility of considering, in more detail, the surface as a whole.

Likelihood inference techniques (see Barnard et al., 1962) are applied here to the problem, when the transformations are considered as non-linear parameters in the model. The theory of these techniques is explained more fully in a paper by Lindsey, Alderdice and Pienaar (MS) which uses the appended programs.

2. The program

These programs were developed for the IBM 1130 computer using the 1130 FORTRAN compiler. A large number of links were found to be necessary, so that only a small segment of the program is actually in core at any given time. The programs will execute under Version I only (not Version II) at Level 6 of

1130 FØRTRAN in an 8K IBM 1130 computer. A number of links use all but five (or fewer) words of core. An IBM 1627 plotter is used for the graphical output on 12" paper.

BØX2 is the mainline program for analysis of the two factor response surface. All of the plotting links are on option by use of data switches. The model used is:

$$y^c = b_0 + b_1 x_1^{a_1} + b_2 x_2^{a_2} + b_3 x_1^{2a_1} + b_4 x_2^{2a_2} + b_5 x_1^{a_1} x_2^{a_2}$$

A complete analysis of the given data is done using the above non-linear model, as well as the corresponding linear model:

$$y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_1^2 + b_4 x_2^2 + b_5 x_1 x_2$$

After this complete analysis, various other values of the parameters may be tried, using the mainline program CRLF2, to determine their relative likelihoods and a complete analysis done on these, if desired.

BØX3 is the corresponding mainline program for the calculations in a three-factor surface. The non-linear model is:

$$y^c = b_0 + b_1 x_1^{a_1} + b_2 x_2^{a_2} + b_3 x_3^{a_3} + b_4 x_1^{2a_1} + b_5 x_2^{2a_2} + b_6 x_3^{2a_3} + b_7 x_1^{a_1} x_2^{a_2} + b_8 x_1^{a_1} x_3^{a_3} + b_9 x_2^{a_2} x_3^{a_3}$$

The analysis is analogous to that in the two-factor case. Since this is a four dimensional model, an additional mainline program, SRS3, has been added (to that of the two-factor analysis) which allows the experimenter to choose slices through the surface on various planes for contour plotting. The analyses using BØX3 and CRLF3 automatically choose slices through the centre of the surface parallel to the axes of the factor space.

Details of the function of each link, of the arrangement of data and control cards, and of the options are given in the listings on the comment cards preceding each mainline program. Output should be self-explanatory. All pages of output for the analysis of the linear model have only the title at the top, while all pages for the non-linear model have the power parameters listed as well. In the output of 40 loci for response contours plotted, the first, eleventh, twenty-first and thirty-first rows define loci on the principal axes of the surface.

Since an iterative technique is used in the calculation of the maximum likelihood estimates of the power parameters, there can be no assurance of convergence with a given number of iterations. Ten iterations have been sufficient in some cases but forty or more may be required. With the large number of options available, and the large number of possible results from data, no guarantee can be given that all of the errors have been removed from the program. Comments and suggestions would be appreciated.

3. Restrictions

(a) The program, because of core size restrictions, is limited to a maximum of twenty points in the factor space with a maximum of four observed responses at each of these points. The four responses are treated as within cell replicates in the analysis of variance.

(b) Without the use of any data switch options, execution time is less than twenty minutes. The options, especially options 8 and 9, increase the time drastically.

4. Acknowledgements

During the development of this program the availability of a program for linear response surface models, by Dr. K. J. Turnbull, and the assistance of Dr. L. V. Pienaar, were most helpful and are gratefully acknowledged.

5. References

(1) Barnard, G. A., G. M. Jenkins, and C. B. Winsten. 1962. Likelihood inference and time series. J. R. Statist. Soc. A., 125: 321-372.

(2) Box, G. E. P., and D. R. Cox. 1964. An analysis of transformation. J. R. Statist. Soc. B., 26: 211-243.

(3) Box, G. E. P., and P. W. Tidwell. 1962. Transformation of the independent variables. Technometrics, 4: 531-550.

(4) Box, G. E. P., and K. Wilson. 1951. On the experimental attainment of optimum conditions. J. R. Statist. Soc. B., 12(1): 1-38.

(5) Hill, W. J., and W. G. Hunter. 1966. A review of response surface methodology: a literature survey. Technometrics, 8(4): 571-590.

(6) Lindsey, J. K., D. F. Alderdice, and L. V. Pienaar. 1968. The analysis of non-linear models - The non-linear response surface. MS.

FORTRAN 1130 SOURCE DECK LISTING RESPONSE SURFACE - TWO FACTORS

```
//JOB
// DUP
*DELETE              BOX2
// FOR
*NAME BOX2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(1132 PRINTER,CARD)
C
C      THIS PROGRAM ANALYZES THE DATA FROM RESPONSE SURFACE EXPERIMENTS
C WHEN TWO FACTORS ARE MEASURED. OPTIONS ALLOW CALCULATION OF MAXIMUM
C LIKELIHOOD ESTIMATES OF POWER TRANSFORMATIONS OF BOTH INDEPENDENT AND
C DEPENDENT VARIABLES, AND THE PLOTTING OF THEIR RELATIVE MAXIMUM
C LIKELIHOOD GRAPHS, AS A MEASURE OF THE PRECISION OF THE ESTIMATES.
C THE DATA IS THEN SUBJECTED TO ANALYSIS OF VARIANCE, USING ORTHOGONAL
C POLYNOMIALS, AND PRINCIPAL COMPONENT ANALYSIS, AND SPECIFIED CONTOURS
C OF THE DEPENDENT VARIABLE ARE PLOTTED, BOTH WITHOUT AND WITH
C TRANSFORMATION.
C
C      OPTIONS ALLOW THE CALCULATION OF MAXIMUM RELATIVE LIKELIHOOD
C GRAPHS FOR THE B(J) COEFFICIENTS IN THE NON-LINEAR CASE, AND FOR THE
C X(I) COORDINATES OF THE CENTRE.
C
C      UP TO 20 POINTS IN THE FACTOR SPACE (TREATMENT COMBINATIONS) ARE
C ALLOWED, WITH UP TO 4 OBSERVATIONS AT EACH POINT (OBSERVATION SETS).
C
C     TO TRY OTHER VALUES OF THE POWER TRANSFORMATIONS THAN THE ML
C ESTIMATES, USE CRLF2.
C
C    LINKS CALLED
C
C   BOX2  - CALCULATES ML ESTIMATES AND POINTS FOR THE MLR GRAPHS
C   PMLR2 - PLOTS MLR GRAPHS OF THE POWER TRANSFORMATIONS
C   CPAR2 - CALCULATES POINTS FOR THE MLR GRAPHS OF B(J) IN THE
C NON-LINEAR CASE
C   PPAR2 - PLOTS MLR GRAPHS OF THE B(J) COEFFICIENTS
C   INFO2 - PERFORMS ANALYSIS OF VARIANCE
C   EIGN2 - PERFORMS CANONICAL ANALYSIS
C   CENT2 - CALCULATES POINTS FOR THE MLR GRAPHS OF THE CENTRE
C COORDINATES
C   PCNT2 - PLOTS MLR GRAPHS OF THE COORDINATES OF THE RESPONSE CENTRE
C   CRS2  - CALCULATES POINTS FOR THE RESPONSE SURFACE CONTOURS
C   PRS2  - PLOTS RESPONSE SURFACE CONTOURS
C
C    SUBROUTINES CALLED
C
C   CMLE2 - CALCULATES ML AND RML ESTIMATES
C   MATV7 - INVERTS MATRICES
C   ORTH2 - CALCULATES ORTHOGONAL POLYNOMIALS FOR ANOVA
C   CAN2  - DIAGONALIZES MATRICES
C   JACOB - CALCULATES EIGENVALUES AND VECTORS OF DIAGONAL MATRICES
C
C    OPTIONS
```

```
C
C SWITCH 10 UP - PLOT RESPONSE SURFACE CONTOURS
C SWITCH  9 UP - PLOT MAXIMUM LIKELIHOOD RATIOS OF POWER TRANSFORMATIONS
C  SWITCH  8 UP - PLOT MAXIMUM LIKELIHOOD RATIOS OF B(J) COEFFICIENTS
C SWITCH  7 UP -PLOT MAXIMUM LIKELIHOOD RATIOS OF THE CENTRE COORDINATES
C
C   MAKEUP OF DATA DECK
C
C 1.TITLE CARD FIRST - (12A6)
C 2.CONTROL CARD - (I1,2I2,4F5.3,I3,F5.3,I3)
C     I1 - OPTION  -  0 - POWER TRANS. FOR IND. AND DEP. VARIABLES
C                     1 - POWER TRANS. FOR IND. VARIABLE ONLY
C                     2 - POWER TRANS. FOR DEP. VARIABLE ONLY
C     I2 - NUMBER OF TREATMENT COMBINATIONS
C     I2 - NUMBER OF OBSERVATION SETS
C     F5.3 - CONSTANT ADDED TO DEPENDENT VARIABLE, Y
C     3F5.3 - INITIAL ESTIMATES OF PARAMETERS - A1,A2,C
C           0.0 YIELDS NATURAL LOG TRANSFORMATION
C           +100. YIELDS POSITIVE EXPONENTIAL TRANSFORMATION
C           -100. YIELDS NEGATIVE EXPONENTIAL TRANSFORMATION
C     I3 - MAXIMUM NUMBER OF ITERATIONS ALLOWED PER ESTIMATE
C    THE FOLLOWING REQUIRED ONLY WITH OPTION 10
C     F5.3 - HALF SIZE OF INTERVAL TO BE PLOTTED AROUND MAXIMUM -
C - SUGGEST 2.5
C     I3 - NUMBER OF POINTS TO BE PLOTTED (MAX= 75) - SUGGEST 51
C 3.TREATMENT COMBINATIONS IN PAIRS - (16F5.3)
C 4.DATA - SETS OF OBSERVATIONS FOR EACH TREATMENT COMBINATION
C     ONE SET PER CARD - (4F6.3)
C 5.99 IN COLS. 79-80 INDICATES END OF DATA, ANOTHER DECK TO FOLLOW
C   98 IN COLS. 79-80 INDICATES END OF JOB - CALL EXIT AFTER THIS DECK
C 6.IF OPTION  9 IS USED, CONTROL CARD - (12F6.2)
C   10F6.2 - 10 CONTOUR LEVELS IN UNITS OF THE DEPENDENT VARIABLE
C   2F6.2 - 2 FACTOR LIMITS FOR PLOTTING IN UNITS OF THE INDEPENDENT
C VARIABLES
C 7.REPEAT 1. TO 6. AS REQUIRED
C
C   STATION PLOTTER PEN EXACTLY 1.4 INCHES FROM THE RIGHT EDGE OF NARROW
C PAPER
C
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N5
     1,AN4,NNNN,D,R(75,3),Y1(4),AA(3)
   86 FORMAT('0CONSTANT ADDED     Y + 'F5.3/'0INITIAL ESTIMATES'//7X'A1'1
     13X'A2'13X'C'/3E15.7/)
   85 FORMAT('INCORRECT NUMBER OF OBSERVATION SETS - SKIPPING TO NEXT DA
     1TA DECK')
   84 FORMAT(16F5.3)
   83 FORMAT(I1,2I2,4F5.3,I3,F5.3,I3)
   82 FORMAT('1'12A6)
   81 FORMAT(4F6.3,54X,I2)
   80 FORMAT(12A6)
   79 FORMAT(5E15.5,I6)
   78 FORMAT('0MAXIMUM LIKELIHOOD ESTIMATES'//7X'A1'13X'A2'13X'C'14X'SSD
     1'10X'ITER   ALLOWED'/4E15.7,2I8/)
   77 FORMAT('0'6X'A1'13X'A2'13X'C'14X'SSD'13X'R'9X'ITER')
      V2=0.0
```

```
      J3=8
    5 READ(2,80)TITL
      WRITE(3,82)TITL
      READ(2,83)N5,N1,IREP,CONST,AA,NNNN,AN4,N4
      IF(N4-75)24,24,25
   25 N4=75
   24 WRITE(3,86)CONST,AA
      N5=N5+1
      READ(2,84)((X(I,J),J=1,2),I=1,N1)
      I=0
   22 I=I+1
      READ(2,81)Y1,ID
      IF(ID-98)9,23,23
    9 N2=N1+I
      N3=N1*2+I
      N6=N1*3+I
      Y(I)=Y1(1)+CONST
      Y(N2)=Y1(2)+CONST
      Y(N3)=Y1(3)+CONST
      Y(N6)=Y1(4)+CONST
      GO TO 22
   23 N2=I-1
      IF(N1-N2)2,4,2
    2 WRITE(3,85)
      IF(ID-98)5,6,5
    6 CALL EXIT
    4 N=N1*IREP
      DO 16 J=1,2
      IF(AA(J))26,17,26
   17 DO 18 I=1,N1
   18 X(I,J)=ALOG(X(I,J))
      GO TO 29
   26 IF(ABS(AA(J))-100.0)16,27,16
   27 DO 28 I=1,N1
   28 X(I,J)=EXP(AA(J)*X(I,J)/100.)
   29 AA(J)=1.0
   16 CONTINUE
      IF(AA(3))19,20,19
   20 DO 21 I=1,N
   21 Y(I)=ALOG(Y(I))
      GO TO 33
   19 IF(ABS(AA(3))-100.)31,30,31
   30 DO 32 I=1,N
   32 Y(I)=EXP(AA(3)*Y(I)/100.)
   33 AA(3)=1.0
   31 D=0.0
      DO 15 I=1,N
   15 D=D+ALOG(Y(I))
      DO 7 J=1,3
    7 A4(J)=AA(J)
      CALL CMLE2(4,ITER,V2,J3)
      WRITE(3,78)A4,SSY,ITER,NNNN
      DO 3 J=1,3
    3 A3(J)=A4(J)
      CALL DATSW(9,J9)
```

```
      GO TO (13,12),J9
   12 CALL DATSW(8,J8)
      GO TO (34,35),J8
   34 CALL LINK(CPAR2)
   35 N4=2
      CALL LINK(INFO2)
   13 SSY1=SSY
      AN5=N4-1
      DO 1 J=1,3
      GO TO (10,10,11),J
   10 GO TO (14,14,1),N5
   11 GO TO (14,1,14),N5
   14 WRITE(3,77)
      X4=A3(J)-AN4
      A=2.0*(A3(J)-X4)
      DO 8 JJ=1,3
    8 A4(JJ)=A3(JJ)
      DO 1 I=1,N4
      DO 36 K=1,3
      IF(ABS(A4(K))-5.0)36,36,37
   37 A4(K)=A3(K)
   36 CONTINUE
      A4(J)=I*A/AN5+X4-A/AN5
      CALL CMLE2(J,ITER,V2,J3)
      R(I,J)=N*ALOG(SSY1/SSY)/2.0
      R(I,J)=EXP(R(I,J))
      WRITE(3,79)A4,SSY,R(I,J),ITER
    1 CONTINUE
      CALL LINK(PMLR2)
      END
// DUP
*STORE       WS  UA  BOX2


// JOB
// DUP
*DELETE              CMLE2
// FOR
*NAME CMLE2
*EXTENDED PRECISION
*ONE WORD INTEGERS
      SUBROUTINE CMLE2(K4,ITER,V2,J3)
      DIMENSION SSXY(7),SSX(7,7),A5(3),X1(7),Y(20),YY2(20)
      COMMON Y1(80),W(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N
     15,AN5,NNNN,DDD,R(75,3),XX(7)
      N1=N/IREP
      K5=1
      D=EXP(DDD/FLOAT(N))
      ITER=0.0
      IF(J3-7)53,53,54
   54 MM=5
      GO TO 2
   53 MM=4
    2 ITER=ITER+1
      IF(ITER-NNNN)30,30,52
```

```
52 K5=2
30 DO 51 I=1,3
51 A5(I)=A4(I)
   DD=D**(A4(3)-1.)
   DO 8 J=1,N1
   Y(J)=0.0
   DO 8 I=1,IREP
   K=(I-1)*N1+J
 8 Y(J)=Y(J)+(Y1(K)**A4(3)-1.)/A4(3)/DD/IREP
   YY=0.0
   DO 32 I=1,N1
32 YY=YY+Y(I)/N1
   DO 24 J=1,7
24 XX(J)=0.0
   DO 1 I=1,N1
   DO 15 J=1,2
   X1(J)=W(I,J)**A4(J)
15 X1(J+2)=X1(J)*X1(J)
   X1(5)=X1(1)*X1(2)
   DO 1 J=1,5
 1 XX(J)=XX(J)+X1(J)/N1
   SSY=0.0
   DO 4 J=1,7
   SSXY(J)=0.0
   DO 4 K=1,7
 4 SSX(J,K)=0.0
   DO 5 I=1,N1
   DO 58 J=1,2
   X1(J)=W(I,J)**A4(J)
58 X1(J+2)=X1(J)*X1(J)
   X1(5)=X1(1)*X1(2)
   DO 7 J=1,IREP
   K=(J-1)*N1+I
   YY2(1)=(Y1(K)**A4(3)-1.)/A4(3)/DD-YY-V2*(X1(J3)-XX(J3))
 7 SSY=SSY+YY2(1)*YY2(1)
   DO 5 J=1,5
   IF(J-J3)60,5,61
60 JJ=J
   GO TO 62
61 JJ=J-1
62 SSXY(JJ)=SSXY(JJ)+(Y(I)-YY-V2*(X1(J3)-XX(J3)))*(X1(J)-XX(J))
   B(JJ)=SSXY(JJ)
   DO 5 K=1,5
   IF(K-J3)63,5,56
63 KK=K
   GO TO 55
56 KK=K-1
55 SSX(JJ,KK)=SSX(JJ,KK)+(X1(J)-XX(J))*(X1(K)-XX(K))
 5 CONTINUE
   CALL MATV7(SSX,MM,B,1,DET)
   DO 28 J=1,MM
28 SSY=SSY-R(J)*SSXY(J)*IREP
   DO 50 J=1,5
   JJ=6-J
   IF(JJ-J3)50,13,6
```

```
 6 B(JJ)=B(JJ-1)
   GO TO 50
13 B(JJ)=V2
50 CONTINUE
   GO TO (27,26),K5
26 ITER=ITER-1
   RETURN
27 GO TO (41,42,41),N5
41 GO TO (43,43,42,43),K4
43 DO 35 I=1,N1
   YY2(I)=YY
   DO 44 J=1,2
   X1(J)=W(I,J)**A4(J)
44 X1(J+2)=X1(J)*X1(J)
   X1(5)=X1(1)*X1(2)
   DO 35 J=1,5
35 YY2(I)=YY2(I)+B(J)*(X1(J)-XX(J))
42 GO TO (25,25,29,29),K4
29 GO TO (25,25,40),N5
40 GO TO (31,31,26,31),K4
25 DO 9 J=1,7
   SSXY(J)=0.0
   DO 9 K=1,7
 9 SSX(J,K)=0.0
   DO 3 I=1,N1
   DO 45 J=1,2
   X1(J)=W(I,J)**A4(J)
45 X1(J+2)=X1(J)*X1(J)
   X1(5)=X1(1)*X1(2)
   DO 46 J=1,2
46 X1(J+5)=(B(J)*X1(J)+2.0*B(J+2)*X1(J+2)+X1(5)*B(5))*ALOG(W(I,J))
   DO 3 J=6,7
 3 XX(J)=XX(J)+X1(J)/N1
   DO 10 I=1,N1
   DO 47 J=1,2
   X1(J)=W(I,J)**A4(J)
47 X1(J+2)=X1(J)*X1(J)
   X1(5)=X1(1)*X1(2)
   DO 48 J=1,2
48 X1(J+5)=(B(J)*X1(J)+2.0*B(J+2)*X1(J+2)+X1(5)*B(5))*ALOG(W(I,J))
   DO 10 J=1,7
   SSXY(J)=SSXY(J)+(Y(I)-YY)*(X1(J)-XX(J))
   DO 10 K=1,7
10 SSX(J,K)=SSX(J,K)+(X1(J)-XX(J))*(X1(K)-XX(K))
   DO 11 J=1,7
11 B(J)=SSXY(J)
   GO TO (17,18,19,19),K4
19 CALL MATV7(SSX,7,B,1,DET)
   DO 59 I=1,2
59 A4(I)=B(I+5)+A4(I)
   DO 49 I=1,2
   IF(ABS(B(I+5)/A4(I))-0.001)49,49,14
49 CONTINUE
   GO TO 16
17 SSXY(6)=SSXY(7)
```

```
      DO 20 J=1,6
      SSX(J,6)=SSX(J,7)
   20 SSX(6,J)=SSX(7,J)
      SSX(6,6)=SSX(7,7)
   18 CALL MATV7(SSX,6,SSXY,0,DET)
      DO 21 J=1,6
      B(J)=0.0
      DO 21 K=1,6
   21 B(J)=B(J)+SSX(J,K)*SSXY(K)
      GO TO (22,23),K4
   23 A4(1)=B(6)+A4(1)
      IF(ABS(B(6)/A4(1))-0.001)16,16,14
   22 A4(2)=B(6)+A4(2)
      IF(ABS(B(6)/A4(2))-0.001)16,16,14
   14 K5=1
      GO TO 33
   16 K5=2
   33 GO TO (34,2,34),N5
   34 GO TO (31,31,2,31),K4
   31 B(1)=0.0
      B(2)=0.0
      DO 36 I=1,N1
      DO 36 J=1,IREP
      K=(J-1)*N1+I
      B(4)=(Y1(K)**A4(3)-1.)/A4(3)/DD
      B(5)=Y1(K)**A4(3)*ALOG(Y1(K))/A4(3)/DD
      B(6)=B(5)-B(4)/A4(3)-B(4)*ALOG(D)
      B(1)=B(1)+B(6)*B(6)
   36 B(2)=B(2)+B(6)*(YY2(I)-B(4))
      A4(3)=A4(3)+B(2)/B(1)
      IF(ABS((A4(3)-A5(3))/A4(3))-0.001)37,37,38
   38 K5=1
      GO TO 2
   37 GO TO (2,2,39),N5
   39 K5=2
      GO TO 2
      END
// DUP
*STORE       WS  UA  CMLE2


// JOB
// DUP
*DELETE              MATV7
// FOR
* NAME MATV7
*EXTENDED PRECISION
*ONE WORD INTEGERS
      SUBROUTINE MATV7(A,N,B,M,DETM)
      DIMENSION IPVOT(7),A(7,7),B(7,1),INDEX(7,7),PIVOT(7)
      EQUIVALENCE (IROW,JROW),(ICLUM,JCLUM),(AMAX,T,SWAP)
      DETM=1.0
      DO 20 J=1,N
   20 IPVOT(J)=0
      DO 550 I=1,N
```

```
      AMAX=0.0
      DO 105 J=1,N
      IF(IPVOT(J)-1)60,105,60
   60 DO 100 K=1,N
      IF(IPVOT(K)-1)80,100,740
   80 IF(ABS(AMAX)-ABS(A(J,K)))85,100,100
   85 IROW=J
      ICLUM=K
      AMAX=A(J,K)
  100 CONTINUE
  105 CONTINUE
      IPVOT(ICLUM)=IPVOT(ICLUM)+1
      IF(IROW-ICLUM)140,260,140
  140 DETM=-DETM
      DO 200 L=1,N
      SWAP=A(IROW,L)
      A(IROW,L)=A(ICLUM,L)
  200 A(ICLUM,L)=SWAP
      IF(M)260,260,210
  210 DO 250 L=1,M
      SWAP=B(IROW,L)
      B(IROW,L)=B(ICLUM,L)
  250 B(ICLUM,L)=SWAP
  260 INDEX(I,1)=IROW
      INDEX(I,2)=ICLUM
      PIVOT(I)=A(ICLUM,ICLUM)
      DETM=DETM*PIVOT(I)
      A(ICLUM,ICLUM)=1.0
      DO 350 L=1,N
  350 A(ICLUM,L)=A(ICLUM,L)/PIVOT(I)
      IF(M)380,380,360
  360 DO 370 L=1,M
  370 B(ICLUM,L)=B(ICLUM,L)/PIVOT(I)
  380 DO 550 L1=1,N
      IF(L1-ICLUM)400,550,400
  400 T=A(L1,ICLUM)
      A(L1,ICLUM)=0.0
      DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICLUM,L)*T
      IF(M)550,550,460
  460 DO 500 L=1,M
  500 B(L1,L)=B(L1,L)-B(ICLUM,L)*T
  550 CONTINUE
      DO 710 I=1,N
      L=N+1-I
      IF(INDEX(L,1)-INDEX(L,2))630,710,630
  630 JROW=INDEX(L,1)
      JCLUM=INDEX(L,2)
      DO 705 K=1,N
      SWAP=A(K,JROW)
      A(K,JROW)=A(K,JCLUM)
      A(K,JCLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 IF(DETM-0.000001)750,750,760
```

```
  750 DETM=0.0
  760 RETURN
      END
// DUP
*STORE       WS  UA  MATV7


// JOB
// DUP
*DELETE              PMLR2
// FOR
*NAME PMLR2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER)
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N5
     1,AN4,NNNN,D,R(75,3)
   78 FORMAT(12A6)
   77 FORMAT('VALUE OF C   MAXIMUM AT C ='F8.4)
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF A'I1'   MAXIMUM AT A'I1' ='F8.4)
   74 FORMAT(F6.3)
   73 FORMAT('MAXIMUM LIKELIHOOD RATIO')
      AN5=N4-1
      DO 4 J=1,3
      GO TO (8,8,9),J
    8 GO TO (10,10,4),N5
    9 GO TO (10,4,10),N5
   10 X1=A3(J)
      X4=A3(J)-AN4
      A=2.0*AN4
      B1=A/20.
      C=X4-A/50.
      D=A/10.
      E=10./A
      F=X4-B1
      G=X4+D
      H=X4+A*1.3
      W=X4-A/15.
      Z=X4-D
      CALL SCALE(E,10.0,X4,0.0)
      CALL EGRID(0,X4,0.0,B1,20)
      CALL EGRID(1,X4,0.0,0.05,20)
      DO 2 I=1,11
      X1=G-D/10.0+D*FLOAT(I-2)
      XO=G+D*FLOAT(I-2)
      CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
    2 WRITE(7,74)XO
      DO 3 I=1,11
      X1=-0.1+0.1*FLOAT(I)
      CALL ECHAR(F,X1,0.1,0.1,0.0)
    3 WRITE(7,76)X1
      CALL ECHAR(G,-0.04,0.1,0.1,0.0)
      GO TO (5,5,6),J
    5 WRITE(7,75)J,J,A3(J)
```

```
      GO TO 7
    6 WRITE(7,77)A3(J)
    7 CALL ECHAR(W,0.1,0.1,0.1,1,.5709)
      WRITE(7,73)
      CALL ECHAR(Z,0.0,0.1,0.1,1,.5709)
      WRITE(7,78)TITL
      CALL EPLOT(-2,X4,0.0)
      DO 1 I=1,N4
      A4(J)=I*A/AN5+X4-A/AN5
      IF(R(I,J)-1.0)1,1,11
   11 R(I,J)=1.0
    1 CALL EPLOT(0,A4(J),R(I,J))
      CALL EPLOT(1,H,0.0)
    4 CONTINUE
      CALL DATSW(8,J8)
      GO TO (12,13),J8
   13 N4=2
      CALL LINK(INFO2)
   12 CALL LINK(CPAR2)
      END
// DUP
*STORE       WS  UA  PMLR2


// JOB
// DUP
*DELETE              CPAR2
// FOR
*NAME CPAR2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(1132 PRINTER)
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N5
     1,AN4,NNNN,D,R(35,5),BB(5),RR(52)
   80 FORMAT('1'12A6)
   79 FORMAT(10E11.3,I6)
   78 FORMAT('0POINTS PLOTTED FOR MLR GRAPH OF B('I1')'//5(5X'B('I1')'2X
     1)5X'A1'10X'A2'10X'C'9X'SSD'8X'R'7X'ITER')
      DO 14 I=1,3
   14 A4(I)=A3(I)
      V2=0.0
      J3=8
      D=0.0
      DO 11 I=1,N
   11 D=D+ALOG(Y(I))
      DD=EXP(D/FLOAT(N))
      CALL CMLE2(4,ITER,V2,J3)
      SS=SSY
      DO 5 I=1,5
    5 BB(I)=B(I)
      IF(N4-35)8,8,9
    8 AN5=N4-1
      GO TO 10
    9 N4=35
      AN5=34
```

```
   10 DO 1 J3=1,5
      IF(BB(J3))2,2,3
    2 X4=2.0*BB(J3)
      GO TO 13
    3 X4=0.0
   13 A=2.0*ABS(BB(J3))
      WRITE(3,80)TITL
      WRITE(3,78)J3,(I,I=1,5)
      DO 4 I=1,3
    4 A4(I)=A3(I)
      DO 1 KK=1,N4
      DO 15 I=1,3
      IF(ABS(A4(I))-5.0)15,15,16
   16 A4(I)=A3(I)
   15 CONTINUE
      V2=(KK-1)*A/AN5+X4
      CALL CMLE2(4,ITER,V2,J3)
      R(KK,J3)=N*ALOG(SS/SSY)/2.0
      R(KK,J3)=EXP(R(KK,J3))
      DO 6 J=1,5
    6 B(J)=A4(3)*DD**(A4(3)-1.0)*B(J)
      WRITE(3,79)(B(J),J=1,5),A4,SSY,R(KK,J3),ITER
    1 CONTINUE
      DO 12 I=1,3
   12 A4(I)=A3(I)
      V2=0.0
      J3=8
      CALL CMLE2(4,ITER,V2,J3)
      DO 7 J=1,5
    7 B(J)=A4(3)*DD**(A4(3)-1.0)*B(J)
      CALL LINK(PPAR2)
      END
// DUP
*STORE       WS  UA  CPAR2


// JOB
// DUP
*DELETE              PPAR2
// FOR
*NAME PPAR2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER)
      COMMON Y(80),X(20,2),BB(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N
     15,AN4,NNNN,D,R(35,5)
   78 FORMAT(12A6)
   77 FORMAT('MAXIMUM LIKELIHOOD RATIO')
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF B('I1')  -  MLE OF B('I1') ='E10.3)
   74 FORMAT(E10.3)
      IF(N4-35)8,8,9
    8 AN5=N4-1
      GO TO 10
    9 N4=35
```

```
      AN5=34
   10 DO 4 J3=1,5
      IF(BB(J3))5,5,6
    5 X4=2.0*BB(J3)
      GO TO 7
    6 X4=0.0
    7 A=2.0*ABS(BB(J3))
      B1=A/20.
      C=X4-A/50.
      D=A/10.
      E=10./A
      F=X4-B1
      G=X4+D
      H=X4+A*1.3
      W=X4-A/15.
      Z=X4-D
      CALL SCALE(E,10.0,X4,0.0)
      CALL EGRID(0,X4,0.0,B1,20)
      CALL EGRID(1,X4,0.0,0.05,20)
      DO 2 I=1,11
      X1=G+D*FLOAT(I-3)+D/2.5
      XO=G+D*FLOAT(I-2)
      CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
    2 WRITE(7,74)XO
      DO 3 I=1,11
      X1=-0.1+0.1*FLOAT(I)
      CALL ECHAR(F,X1,0.1,0.1,0.0)
    3 WRITE(7,76)X1
      CALL ECHAR(G,-0.04,0.1,0.1,0.0)
      WRITE(7,75)J3,J3,BB(J3)
      CALL ECHAR(W,0.1,0.1,0.1,1.5709)
      WRITE(7,77)
      CALL ECHAR(Z,0.0,0.1,0.1,1.5709)
      WRITE(7,78)TITL
      CALL EPLOT(-2,X4,0.0)
      DO 1 KK=1,N4
      V2=(KK-1)*A/AN5+X4
      IF(R(KK,J3)-1.0)1,1,11
   11 R(KK,J3)=1.0
    1 CALL EPLOT(0,V2,R(KK,J3))
      CALL EPLOT(1,H,0.0)
    4 CONTINUE
      N4=2
      CALL LINK(INFO2)
      END
// DUP
*STORE       WS  UA  PPAR2


// JOB
// DUP
*DELETE              INFO2
// FOR
*NAME INFO2
*EXTENDED PRECISION
```

```
*ONE WORD INTEGERS
*IOCS(1132 PRINTER)
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,K,
     1SSX2(7,7),XX(7),YY2(20),A5(3),SSXY(7),X4(2),YY,X1(7),SSX1(7,7),SS(
     25),YY1(4),SSY1(4),SSY5(5)
   92 FORMAT('ORELATIVE LIKELIHOOD OF NO TRANSFORMATION VS. ML ESTIMATES
     1 ='E14.5)
   90 FORMAT('0*** VARIABLES FITTED'//4X'X1'6X'X2'4X4(' OBS. SET'I2)'
     1 MEAN      VARIANCE    ST. DEV.')
   89 FORMAT(' STANDARD DEVIATIONS WITHIN OBSERVATION SETS'/17X,4F11.2)
   88 FORMAT(' VARIANCES WITHIN OBSERVATION SETS'/17X4F11.2)
   87 FORMAT(' MEANS WITHIN OBSERVATION SETS'/17X4F11.2)
   86 FORMAT('OVARIANCE-COVARIANCE MATRIX')
   85 FORMAT('OPOWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4/'OPOWER TRANSFORMATION OF DEPENDENT VARIABLE - C ='F
     28.4)
   84 FORMAT('OB(J) COEFFICIENTS'/'0'6E15.6)
   83 FORMAT('OINFORMATION MATRIX FOR PARAMETERS OF UNTRANSFORMED DATA')
   82 FORMAT('OINFORMATION MATRIX FOR PARAMETERS OF TRANSFORMED DATA')
   81 FORMAT('OANALYSIS OF VARIANCE TABLE - TRANSFORMED DATA'/'0   SOURC
     1E'11X'SS'6X'D.F.'5X'MSS'7X'APPROX. F'6X'MLR')
   80 FORMAT('1'12A6)
   79 FORMAT(' '5E15.6)
   78 FORMAT('OANALYSIS OF VARIANCE TABLE - UNTRANSFORMED DATA'/'0   SOU
     1RCE'11X'SS'6X'D.F.'5X'MSS'11X'F'9X'MLR')
   95 FORMAT(1X2F8.3,7F11.2)
   77 FORMAT(' TREATMENTS  'F12.2,I6,2F12.2,E16.6)
   76 FORMAT('  LINEAR     'F12.2,I6,2F12.2,E16.6)
   75 FORMAT('   X1 LINEAR 'F12.2,I6,2F12.2,E16.6)
   74 FORMAT('   X2 LINEAR 'F12.2,I6,2F12.2,E16.6)
   73 FORMAT('  QUADRATIC  'F12.2,I6,2F12.2,E16.6)
   72 FORMAT('   X1 QUAD.  'F12.2,I6,2F12.2,E16.6)
   98 FORMAT('   X2 QUAD.  'F12.2,I6,2F12.2,E16.6)
   97 FORMAT('  X1 * X2    'F12.2,I6,2F12.2,E16.6)
   91 FORMAT('  TRANSFORM  'F12.2,I6,2F12.2,E16.6)
   96 FORMAT('  LACK OF FIT'F12.2,I6,2F12.2,E16.6)
   94 FORMAT(' RESIDUAL    'F12.2,I6, F12.2)
   93 FORMAT(' TOTAL       'F12.2,I6)
      N1=N/IREP
      D=0.0
      DO 66 I=1,N
   66 D=D+ALOG(Y(I))
      DO 57 I=1,3
   57 A5(I)=A4(I)
      WRITE(3,80)TITL
      N2=N+1
      DO 55 I=N2,80
   55 Y(I)=0.0
      WRITE(3,90)(I,I=1,4)
      DO 54 I=1,N1
      YYY=0.0
      DO 8 J=1,IREP
      N2=(J-1)*N1+I
    8 YYY=YYY+Y(N2)/IREP
      SYY=0.0
```

```
      DO 9 J=1,IREP
      N2=(J-1)*N1+I
    9 SYY=SYY+(Y(N2)-YYY)*(Y(N2)-YYY)
      SSYY=SQRT(SYY)
      N6=N1+I
      N2=N1*2+I
      N3=N1*3+I
   54 WRITE(3,95)X(I,1),X(I,2),Y(I),Y(N6),Y(N2),Y(N3),YYY,SYY,SSYY
      DO 41 I=1,IREP
      YY1(I)=0.0
      DO 41 J=1,N1
      N2=(I-1)*N1+J
   41 YY1(I)=YY1(I)+Y(N2)/N1
      DO 44 I=1,IREP
      SSY1(I)=0.0
      DO 44 J=1,N1
      N2=(I-1)*N1+J
   44 SSY1(I)=SSY1(I)+(Y(N2)-YY1(I))*(Y(N2)-YY1(I))
      WRITE(3,87)(YY1(I),I=1,IREP)
      WRITE(3,88)(SSY1(I),I=1,IREP)
      DO 43 I=1,IREP
   43 SSY1(I)=SQRT(SSY1(I))
      WRITE(3,89)(SSY1(I),I=1,IREP)
      DO 58 I=1,3
   58 A4(I)=1.0
      DO 10 K=1,2
      YY=0.0
      DO 1 I=1,N
    1 YY=YY+Y(I)**A4(3)/N
      DO 40 I=1,N1
      YY2(I)=0.0
      DO 40 J=1,IREP
      N2=(J-1)*N1+I
   40 YY2(I)=YY2(I)+Y(N2)**A4(3)/IREP
      TOT=0.0
      DO 3 I=1,N
    3 TOT=TOT+(Y(I)**A4(3)-YY)*(Y(I)**A4(3)-YY)
      TREAT=0.0
      DO 4 I=1,N1
    4 TREAT=TREAT+(YY2(I)-YY)*(YY2(I)-YY)
      TREAT=TREAT*IREP
      DO 7 J=1,5
    7 XX(J)=0.0
      DO 6 I=1,N1
      DO 16 J=1,2
      X1(J)=X(I,J)**A4(J)
   16 X1(J+2)=X1(J)*X1(J)
      X1(5)=X1(1)*X1(2)
      DO 6 J=1,5
    6 XX(J)=XX(J)+X1(J)/N1
      DO 39 I=1,5
      SSXY(I)=0.0
      DO 39 J=1,5
   39 SSX2(I,J)=0.0
      DO 37 I=1,N1
```

```
      DO 21 J=1,2
      X1(J)=X(I,J)**A4(J)
   21 X1(J+2)=X1(J)*X1(J)
      X1(5)=X1(1)*X1(2)
      DO 37 J=1,5
      SSXY(J)=SSXY(J)+(YY2(I)-YY)*(X1(J)-XX(J))
      DO 37 J1=1,5
   37 SSX2(J,J1)=SSX2(J,J1)+(X1(J)-XX(J))*(X1(J1)-XX(J1))
      GO TO (27,28),K
   27 GO TO (68,28),N4
   28 WRITE(3,80)TITL
      GO TO (18,26),K
   18 WRITE(3,83)
      GO TO 19
   26 WRITE(3,85)A4
      WRITE(3,82)
   19 DO 30 I=1,5
   30 WRITE(3,79)(SSX2(I,J),J=1,5)
   68 DO 29 I=1,2
   29 X4(I)=SSX2(I,I)
      CALL MATV7(SSX2,5,SSXY,0,DET)
      GO TO (65,33),K
   65 GO TO (34,33),N4
   33 WRITE(3,86)
      DO 42 I=1,5
   42 WRITE(3,79)(SSX2(I,J),J=1,5)
   34 DO 11 J=1,5
      B(J)=0.0
      DO 11 I=1,5
   11 B(J)=B(J)+SSX2(I,J)*SSXY(I)
      AA=YY
      DO 38 J=1,5
   38 AA=AA-B(J)*XX(J)
      GO TO (35,36),K
   35 GO TO (45,36),N4
   36 WRITE(3,84)AA,(B(J),J=1,5)
   45 CALL ORTH2
      CALL MATV7(SSX2,5,SSXY,0,DET)
      DO 46 J=1,5
      B(J)=0.0
      DO 46 I=1,5
   46 B(J)=B(J)+SSX2(I,J)*SSXY(I)
      DEV=TREAT
      DO 17 I=1,5
   17 DEV=DEV-B(I)*SSXY(I)*IREP
      DO 12 J=1,2
      DO 12 J1=1,2
   12 SSX1(J,J1)=SSX2(J,J1)
      CALL MATV7(SSX1,2,SSXY,0,DET)
      SS1=0.0
      DO 14 I=1,2
      DO 14 J=1,2
   14 SS1=SS1+B(J)*SSX1(I,J)*B(I)*IREP
      DO 13 J=1,2
      DO 13 J1=1,2
```

```
13 SSX1(J,J1)=SSX2(J+2,J1+2)
   CALL MATV7(SSX1,2,SSXY,0,DET)
   SS2=0.0
   DO 15 I=1,2
   DO 15 J=1,2
15 SS2=SS2+B(J+2)*SSX1(I,J)*B(I+2)*IREP
   DO 31 I=1,5
31 SS(I)=B(I)*B(I)/SSX2(I,I)*IREP
   I1=1
   I2=2
   I3=N1-1
   I5=0
   DO 47 I=1,3
   IF(A4(I)-1.0)48,47,48
48 I5=I5+1
47 CONTINUE
   NN=N-I3-1
   NNN=N-1
   GO TO (20,22),K
20 SSY3=DEV
   I4=I3-5
   DEVM=DEV/I4
   GO TO 49
22 SSY3=SSY3-DEV
   SSY3M=SSY3/I5
   I4=I3-I5-5
   DEVM=DEV/I4
49 IF(IREP-1)50,50,51
51 RES=TOT-TREAT
   RESM=RES/NN
   RR=RES+DEV
   GO TO 52
50 RES=DEV
   RR=RES
   RESM=DEVM
52 SS1M=SS1/2.0
   SS2M=SS2/2.0
   TREAM=TREAT/I3
   F1=TREAM/RESM
   F2=SS1M/RESM
   F21=SS(1)/RESM
   F22=SS(2)/RESM
   F3=SS2M/RESM
   F31=SS(3)/RESM
   F32=SS(4)/RESM
   F33=SS(5)/RESM
   F6=SSY3M/RESM
   F4=DEVM/RESM
   DO 67 I=1,5
67 SSY5(I)=(RR/(RR+SS(I)))**(FLOAT(N)/2.0)
   SS3=(RR/(RR+TREAT))**(FLOAT(N)/2.0)
   SS4=(RR/(RR+SS1))**(FLOAT(N)/2.0)
   SS5=(RR/(RR+SS2))**(FLOAT(N)/2.0)
   SS6=(DEV/RR)**(FLOAT(N)/2.0)
   GO TO (53,56),K
```

```
   53 RRR=RR
      GO TO (60,25),N4
   56 WRITE(3,81)
      RRR=N*ALOG(RR/RRR)/2.0+(A3(3)-1.0)*D
      RRR=EXP(RRR)
      GO TO 32
   25 WRITE(3,78)
   32 WRITE(3,77)TREAT,I3,TREAM,F1,SS3
      WRITE(3,76)SS1,I2,SS1M,F2,SS4
      WRITE(3,75)SS(1),I1,SS(1),F21,SSY5(1)
      WRITE(3,74)SS(2),I1,SS(2),F22,SSY5(2)
      WRITE(3,73)SS2,I2,SS2M,F3,SS5
      WRITE(3,72)SS(3),I1,SS(3),F31,SSY5(3)
      WRITE(3,98)SS(4),I1,SS(4),F32,SSY5(4)
      WRITE(3,97)SS(5),I1,SS(5),F33,SSY5(5)
      GO TO (23,24),K
   24 IF(A3(3)-1.0)23,61,23
   61 WRITE(3,91)SSY3,I5,SSY3M,F6,RRR
   23 IF(IREP-1)62,62,63
   62 WRITE(3,96)DEV,I4,DEVM
      GO TO 64
   63 WRITE(3,96)DEV,I4,DEVM,F4,SS6
      WRITE(3,94)RES,NN,RESM
   64 WRITE(3,93)TOT,NNN
   60 DO 5 J=1,3
    5 A4(J)=A3(J)
   10 CONTINUE
      WRITE(3,92)RRR
      DO 59 I=1,3
   59 A4(I)=A5(I)
      GO TO (71,69),N4
   71 CALL DATSW(8,J8)
      GO TO (70,69),J8
   69 CALL LINK(EIGN2)
   70 CALL LINK(COEF2)
      END
// DUP
*STORE       WS  UA  INFO2


// JOB
// DUP
*DELETE              ORTH2
// FOR
*NAME ORTH2
*EXTENDED PRECISION
*ONE WORD INTEGERS
      SUBROUTINE ORTH2
      DIMENSION W(20,5)
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,K,
     1SSX2(7,7),XX(7),YY2(20),A5(3),SSXY(7),X4(2),YY,X3(2),X1(2),AA2
   85 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARIABLE - C ='F
     28.4)
   84 FORMAT(5F15.5)
```

```
   83 FORMAT('OCROSS PRODUCT MATRIX'/)
   82 FORMAT('ONORMAL ORTHOGONAL POLYNOMIALS'//10X'X1'13X'X2'11X'X1*X1'1
     10X'X2*X2'10X'X1*X2')
   81 FORMAT('1'12A6)
      N1=N/IREP
      DO 1 I=1,N1
      DO 1 J=1,2
    1 W(I,J)=(X(I,J)**A4(J)-XX(J))/SQRT(X4(J))
      DO 2 J=1,2
      X1(J)=0.0
      X3(J)=0.0
      AA2=A4(J)*2.0
      DO 2 I=1,N1
      X1(J)=X1(J)+X(I,J)**AA2
    2 X3(J)=X3(J)+X(I,J)**AA2*(X(I,J)**A4(J)-XX(J))
      DO 3 I=1,N1
      DO 3 J=1,2
    3 W(I,J+2)=(X(I,J)*X(I,J))**A4(J)-X1(J)/N1-(X(I,J)**A4(J)-XX(J))*X3(
     1J)/X4(J)
      DO 4 J=1,2
      X3(J)=0.0
      DO 4 I=1,N1
    4 X3(J)=X3(J)+W(I,J+2)*W(I,J+2)
      DO 5 I=1,N1
      DO 5 J=3,4
    5 W(I,J)=W(I,J)/SQRT(X3(J-2))
      DO 7 I=1,5
      SSXY(I)=0.0
      DO 7 J=1,5
    7 SSX2(I,J)=0.0
      DO 8 I=1,N1
      W(I,5)=W(I,1)*W(I,2)
      DO 8 J=1,5
      SSXY(J)=SSXY(J)+(YY2(I)-YY)*W(I,J)
      DO 8 J1=1,5
    8 SSX2(J,J1)=SSX2(J,J1)+W(I,J)*W(I,J1)
      GO TO (6,9),K
    6 GO TO (10,9),N4
    9 WRITE(3,81)TITL
      GO TO (11,12),K
   12 WRITE(3,85)A4
   11 WRITE(3,82)
      WRITE(3,84)((W(I,J),J=1,5),I=1,N1)
      WRITE(3,83)
      WRITE(3,84)((SSX2(I,J),J=1,5),I=1,5)
   10 RETURN
      END
// DUP
*STORE       WS  UA  ORTH2


// JOB
// DUP
*DELETE              COEF2
// FOR
```

```
*NAME COEF2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER,1132 PRINTER)
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N5
     1,X2(6),YY2(20),SSXY(7),SSX(7,7),BB(7),I5(4)
   82 FORMAT('POWER TRANSFORMATIONS  A1='F8.4'  A2='F8.4'  C='F8.4)
   81 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARIABLE - C ='F
     28.4)
   80 FORMAT('1'12A6)
   79 FORMAT(7E15.5)
   78 FORMAT(12A6)
   77 FORMAT('0POINTS PLOTTED FOR MLR GRAPH OF B('I1')'/5(7X'B('I1')'4X)
     19X'SSD'13X'R')
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF B('I1')  -  MLE OF B('I1') ='E10.3)
   74 FORMAT(E10.3)
   73 FORMAT('MAXIMUM LIKELIHOOD RATIO')
      N1=N/IREP
      SSY=0.0
      DO 16 I=1,N
   16 SSY=SSY+(Y(I)*Y(I))**A3(3)
      DO 14 I=1,N1
      YY2(I)=0.0
      DO 14 J=1,IREP
      K=(J-1)*N1+I
   14 YY2(I)=YY2(I)+Y(K)**A3(3)/IREP
      X2(1)=1.0
      DO 32 I=1,6
      BB(I)=0.0
      DO 32 J=1,6
   32 SSX(I,J)=0.0
      DO 33 I=1,N1
      DO 31 J=2,3
      X2(J)=X(I,J-1)**A3(J-1)
   31 X2(J+2)=X2(J)*X2(J)
      X2(6)=X2(2)*X2(3)
      DO 33 J=1,6
      BB(J)=BB(J)+YY2(I)*X2(J)
      SSXY(J)=BB(J)
      DO 33 K=1,6
   33 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
      CALL MATV7(SSX,6,BB,1,DET)
      SS=SSY
      DO 15 I=1,6
   15 SS=SS-SSXY(I)*BB(I)*IREP
      DO 21 JJ=2,6
      J3=JJ-1
      AN5=44
      IF(BB(JJ))25,25,26
   25 X4=2.0*BB(JJ)
      GO TO 27
   26 X4=0.0
   27 A=2.0*ABS(BB(JJ))
```

```
      B1=A/20.
      C=X4-A/50.
      D=A/10.
      E=10./A
      F=X4-B1
      G=X4+D
      H=X4+A*1.3
      W=X4-A/15.
      U=X4-A/7.5
      Z=X4-D
      CALL SCALE(E,10.0,X4,0.0)
      CALL EGRID(0,X4,0.0,B1,20)
      CALL EGRID(1,X4,0.0,0.05,20)
      DO 2 I=1,11
      X1=G+D*FLOAT(I-3)+D/2.5
      IF(X1)35,36,36
   35 NN1=-1
      GO TO 37
   36 NN1=1
   37 XO=G+D*FLOAT(I-2)*NN1
      CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
    2 WRITE(7,74)XO
      DO 3 I=1,11
      X1=-0.1+0.1*FLOAT(I)
      CALL ECHAR(F,X1,0.1,0.1,0.0)
    3 WRITE(7,76)X1
      CALL ECHAR(G,-0.04,0.1,0.1,0.0)
      WRITE(7,75)J3,J3,BB(JJ)
      CALL ECHAR(W,0.1,0.1,0.1,1.5709)
      WRITE(7,73)
      CALL ECHAR(Z,0.0,0.1,0.1,1.5709)
      WRITE(7,78)TITL
      CALL ECHAR(U,0.0,0.1,0.1,1.5709)
      WRITE(7,82)A3
      CALL EPLOT(-2,X4,0.0)
      WRITE(3,80)TITL
      WRITE(3,81)A3
      DO 4 I=2,6
      IF(I-JJ)7,4,5
    7 JJJ=I-1
      GO TO 6
    5 JJJ=I-2
    6 I5(JJJ)=I-1
    4 CONTINUE
      WRITE(3,77)J3,J3,I5
      DO 1 KK=1,45
      V2=(KK-1)*A/AN5+X4
      SSY1=0.0
      DO 17 I=1,5
      SSXY(I)=0.0
      DO 17 J=1,5
   17 SSX(I,J)=0.0
      DO 18 I=1,N1
      DO 28 J=2,3
      X2(J)=X(I,J-1)**A3(J-1)
```

```
    28 X2(J+2)=X2(J)*X2(J)
       X2(6)=X2(2)*X2(3)
       DO 34 J=1,IREP
       K=(J-1)*N1+I
    34 SSY1=SSY1+(Y(K)-V2*X2(JJ))**2
       DO 18 J=1,6
       IF(J-JJ)20,18,30
    20 JJJ=J
       GO TO 29
    30 JJJ=J-1
    29 SSXY(JJJ)=SSXY(JJJ)+(YY2(I)-V2*X2(JJ))*X2(J)
       B(JJJ)=SSXY(JJJ)
       DO 18 K=1,6
       IF(K-JJ)11,18,12
    11 KKK=K
       GO TO 13
    12 KKK=K-1
    13 SSX(JJJ,KKK)=SSX(JJJ,KKK)+X2(J)*X2(K)
    18 CONTINUE
       CALL MATV7(SSX,5,B,1,DET)
       DO 19 I=1,5
    19 SSY1=SSY1-SSXY(I)*B(I)*IREP
       R=(SS/SSY1)**(FLOAT(N)/2.0)
       WRITE(3,79)V2,(B(J),J=2,5),SSY1,R
     1 CALL EPLOT(0,V2,R)
       CALL EPLOT(1,H,0.0)
    21 CONTINUE
       CALL LINK(EIGN2)
       END
// DUP
*STORE       WS  UA  COEF2


// JOB
// DUP
*DELETE              EIGN2
// FOR
*NAME EIGN2
*IOCS(1132 PRINTER,TYPEWRITER,KEYBOARD)
*ONE WORD INTEGERS
*EXTENDED PRECISION
       DIMENSION ALAM1(2),ALAM2(2),PREP1(2,2),PREP2(2,2)
       COMMON Y(80),X(20,2),V(7),A4(3),SSY,NS,NREPS,TITL(12),ID,A3(3),N4,
      1I,YS(2),V1(2,2),ALAMD(2,2),PREP(2,2,2),COE(6),YDEV(20),BA(7,7),X1(
      26),Z(2),A5(3),XC(20,2),NNN(3)
       EQUIVALENCE (ALAMD(1,1),ALAM1(1)),(ALAMD(1,2),ALAM2(1))
       EQUIVALENCE (PREP1(1,1),PREP(1,1,1)),(PREP2(1,1),PREP(1,1,2))
    89 FORMAT(1HO,8X,'EIGEN VALUES',10X,'EIGEN VECTORS AS ROWS',/,)
    88 FORMAT('0'2(E11.4,'=YS'3X)'IN ORIGINAL UNITS'/)
    87 FORMAT(1HO,4(E11.4,'=X'I1'S'2X)' IN ORIGINAL UNITS')
    86 FORMAT(I4,3F9.3,4F15.3)
    85 FORMAT(1HO,1X,'TABLE OF RESIDUALS')
    84 FORMAT(I3)
    83 FORMAT('TYPE 1 TO CALL EXIT, EOF TO CONTINUE')
    82 FORMAT('1'12A6)
```

```
81 FORMAT(1H0,5X,3HY =,E15.6,3H + ,2(2H +,E15.6,2H Z,I1,3H SQ),/,)
80 FORMAT(1H0,7X,'Y EST',4X,'Y OBS',4X,'DEVN',12X,'VALUES OF Z',18X,'
  1FACTOR LEVELS'/)
79 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
  14'  A2 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARIABLE - C ='F
  28.4)
78 FORMAT( 52H0 CANONICAL REGRESSION   (Z ARE CANONICAL VARIABLES),/)
77 FORMAT(29H0  CENTRE OF RESPONSE SURFACE  ,/,)
   DO 27 I=1,3
27 A5(I)=A4(I)
   N1=NS/NREPS
   GO TO (11,10),N4
11 DO 12 I=1,3
12 A4(I)=A3(I)
   GO TO 13
10 DO 5 I=1,3
 5 A4(I)=1.0
13 DO 4 LL=1,N4
   WRITE(3,82)TITL
   GO TO (14,15),N4
15 GO TO (19,14),LL
14 WRITE(3,79)A3
19 DO 6 I=1,N1
   YDEV(I)=0.0
   DO 21 K=1,2
21 XC(I,K)=X(I,K)**A4(K)
   DO 6 K=1,NREPS
   KK=(K-1)*N1+I
 6 YDEV(I)=YDEV(I)+Y(KK)**A4(3)/NREPS
   DO 7 I=1,6
   V(I)=0.0
   DO 7 J=1,6
 7 BA(I,J)=0.0
   X1(1)=1.0
   DO 8 K=1,N1
   DO 3 J=2,3
 3 X1(J)=X(K,J-1)**A4(J-1)
   X1(4)=X1(2)*X1(2)
   X1(5)=X1(2)*X1(3)
   X1(6)=X1(3)*X1(3)
   DO 8 I=1,6
   V(I)=V(I)+YDEV(K)*X1(I)
   DO 8 J=1,6
 8 BA(I,J)=BA(I,J)+X1(I)*X1(J)
   CALL MATV7(BA,6,V,1,DET)
   DO 29 J=1,6
29 COE(J)=V(J)
   NFAK=2
   KP=NFAK+2
   DO 32 I=1,NFAK
   DO 32 J=1,I
   IF(I-J)31,30,31
30 PREP(I,J,LL)=V(KP)
   GO TO 32
31 PREP(I,J,LL)=V(KP)*0.5
```

```
      PREP(J,I,LL)=PREP(I,J,LL)
   32 KP=KP+1
      DO 33 I=1,NFAK
   33 V(I)=-V(I+1)*0.500
      DO 34 I=1,NFAK
      DO 34 J=1,NFAK
   34 BA(I,J)=PREP(I,J,LL)
      WRITE(3,77)
      CALL MATV7(BA,NFAK,V,1,DET)
      YS(LL)=COE(1)
      DO 44 I=1,NFAK
   44 YS(LL)=YS(LL)+0.5*V(I)*COE(I+1)
      GO TO (35,36),N4
   36 GO TO (37,35),LL
   35 I1=1
      I2=2
      DO 40 I=1,2
      IF(V(I))38,38,39
   38 NNN(I)=-1
      GO TO 40
   39 NNN(I)=1
   40 CONTINUE
      V4=V(2)**(1./A3(2))*NNN(2)
      V3=V(1)**(1./A3(1))*NNN(1)
      IF(YS(LL))41,41,42
   41 NNN(3)=-1
      GO TO 43
   42 NNN(3)=1
   43 YS1=YS(LL)**(1./A3(3))*NNN(3)
      WRITE(3,87)(V(I),I,I=1,NFAK),V3,I1,V4,I2
      WRITE(3,88)YS(LL),YS1
      GO TO 45
   37 WRITE(3,87)(V(I),I,I=1,NFAK)
      WRITE(3,88)YS(LL)
   45 WRITE(3,89)
      GO TO (22,23),LL
   22 CALL CAN2(PREP1,ALAM1,NFAK)
      GO TO 24
   23 CALL CAN2(PREP2,ALAM2,NFAK)
   24 WRITE(3,78)
      WRITE(3,81)YS(LL),(ALAMD(J,LL),J,J=1,NFAK)
      WRITE(3,85)
      WRITE(3,80)
      DO 18 J=1,N1
      YPRED=0.0
      DO 16 I=1,NFAK
      Z(I)=0.0
      DO 16 L=1,NFAK
   16 Z(I)=Z(I)+(XC(J,L)-V(L))*PREP(I,L,LL)
      DO 17 L1=1,NFAK
   17 YPRED=YPRED+(Z(L1)**2)*ALAMD(L1,LL)
      YPRED=YPRED+YS(LL)
      YDEV1=YDEV(J)-YPRED
   18 WRITE(3,86)J,YPRED,YDEV(J),YDEV1,(Z(I),I=1,NFAK),(XC(J,II),II=1,NF
     1AK)
```

```
      DO 25 I=1,3
   25 A4(I)=A3(I)
      DO 46 I=1,2
   46 V1(I,LL)=V(I)
    4 CONTINUE
      DO 28 I=1,3
   28 A4(I)=A5(I)
      CALL DATSW(7,J7)
      GO TO (50,49),J7
   50 CALL LINK(CENT2)
   49 CALL DATSW(10,J10)
      GO TO (48,47),J10
   48 CALL LINK(CRS2)
   47 GO TO (9,26),N4
    9 WRITE(1,83)
      READ(6,84)N5
      IF(N5)2,20,2
   26 IF(ID-98)1,2,1
    2 CALL EXIT
   20 CALL LINK(CRLF2)
    1 CALL LINK(BOX2)
      END
// DUP
*STORE       WS  UA  EIGN2


// JOB
// DUP
*DELETE                CAN2
// FOR
*NAME CAN2
*ONE WORD INTEGERS
*EXTENDED PRECISION
      SUBROUTINE CAN2(AA,AMBDA,N)
      DIMENSION AA(2,2),AMBDA(2),E(4),D(4)
   80 FORMAT(4X,I2,5X,E15.6,5X,2E15.6)
      NQ=+1
      K=1
      DO 1 I=1,N
      DO 1 J=1,I
      E(K)=AA(I,J)
    1 K=K+1
      CALL JACOB(E,D,AMBDA,N,NQ)
      K=1
      DO 2 I=1,N
      DO 2 J=1,N
      AA(I,J)=D(K)
    2 K=K+1
      DO 3 I=1,N
    3 WRITE(3,80)I,AMBDA(I),(AA(I,J),J=1,N)
      RETURN
      END
// DUP
*STORE       WS  UA  CAN2
```

```
// JOB
// DUP
*DELETE                JACOB
// FOR
*NAME JACOB
*ONE WORD INTEGERS
*EXTENDED PRECISION
      SUBROUTINE JACOB(A,B,C,NAA,NQ)
      DIMENSION A(1),B(1),C(1)
      LOOPC=0
      NA=NAA
      NN=(NA*(NA+1))/2
      IF (NQ) 120,100,100
  100 K=1
      DO 115 I=1,NA
      DO 115 J=1,NA
      IF(I-J)105,110,105
  105 B(K)=0.
      GO TO 115
  110 B(K)=1.
  115 K=K+1
  120 SUM=0.
      IF(NA-1)325,310,125
  125 K=1
      AMAX=0.
      DO 155 I=1,NA
      DO 150 J=1,I
      IF(I-J)135,145,135
  135 IF(ABS(A(K))-AMAX)145,145,140
  140 AMAX=ABS(A(K))
  145 TERM=A(K)*A(K)
      SUM=SUM+TERM+TERM
  150 K=K+1
  155 SUM=SUM-TERM
      SUM=SQRT(SUM)
      THRES=SUM/SQRT(FLOAT(NA))
      THRSH=THRES*1.0E-08
      IF(THRSH-AMAX)165,310,310
  165 THRES=AMAX/3.
      IF(THRES-THRSH)175,180,180
  175 THRES=THRSH
  180 K=2
      N=0
      JD=1
      DO 270 J=2,NA
      JD=JD+J
      JJ=J-1
      ID=0
      DO 265 I=1,JJ
      ID=ID+I
      IF(ABS(A(K))-THRES)265,265,195
  195 N=N+1
      ALPHA=(A(JD)-A(ID))/(2.*A(K))
      BETA=1./(1.+ALPHA*ALPHA)
```

```
      ROOT=1.0+ABS(ALPHA)*ESQRT(BETA)
      IF(ALPHA)205,200,200
  200 SSQ=0.5*BETA/ROOT
      CSQ=0.5*ROOT
      GO TO 210
  205 CSQ=0.5*BETA/ROOT
      SSQ=0.5*ROOT
  210 CC=SQRT(CSQ)
      S=-SQRT(SSQ)
      TWOSC=CC*S*2.
      TEMPA=CSQ*A(ID)+TWOSC*A(K)+SSQ*A(JD)
      A(JD)=CSQ*A(JD)-TWOSC*A(K)+SSQ*A(ID)
      A(ID)=TEMPA
      A(K)=0.
      KA=JD-J
      KB=ID-I
      KC=NA*(I-1)
      KD=NA*(J-1)
      DO 260 L=1,NA
      KC=KC+1
      KD=KD+1
      TEMPA=CC*B(KC)+S*B(KD)
      B(KD)=-S*B(KC)+CC*B(KD)
      B(KC)=TEMPA
      IF(I-L)230,220,245
  220 KB=KB+1
  225 KA=KA+1
      GO TO 260
  230 KB=KB+L-1
      IF(J-L)240,225,250
  240 KA=KA+L-1
      GO TO 255
  245 KB=KB+1
  250 KA=KA+1
  255 TEMPA=CC*A(KB)+S*A(KA)
      A(KA)=-S*A(KB)+CC*A(KA)
      A(KB)=TEMPA
  260 CONTINUE
  265 K=K+1
  270 K=K+1
      LOOPC=LOOPC+1
      IF(LOOPC-50)275,305,305
  275 IF(N-NN/8)280,280,180
  280 IF(THRES-THRSH)285,300,285
  285 THRES=THRSH/3.
      IF(THRES-THRSH)295,180,180
  295 THRES=THRSH
      GO TO 180
  300 IF(N)180,310,180
  305 WRITE(3,901)
  901 FORMAT(25H EIGENVALUE NOT CONVERGED  )
  310 LL=0
      DO 320 L=1,NA
      LL=LL+L
  320 C(L)=A(LL)
```

```
  325 RETURN
      END
// DUP
*STORE       WS  UA  JACOB


// JOB
// DUP
*DELETE              CENT2
// FOR
*NAME CENT2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(1132 PRINTER)
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N5
     1,YS(2),V1(2,2),ALAMD(2,2),PREP(2,2,2),R(45,2,2),X2(4),V2(2),YY2(20
     2),SSXY(7),A5(3),SSX(7,7),BB(7)
   81 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARIABLE - C ='F
     28.4)
   80 FORMAT('1'12A6)
   79 FORMAT(4E15.5)
   78 FORMAT('0POINTS PLOTTED FOR MLR GRAPH OF X'I1'S'/7X'X1S'12X'X2S'13
     1X'SSD'13X'R')
      N1=N/IREP
      DO 8 I=1,3
    8 A5(I)=A4(I)
      GO TO (9,10),N4
    9 DO 22 I=1,3
   22 A4(I)=A3(I)
      GO TO 23
   10 DO 24 I=1,3
   24 A4(I)=1.0
   23 DO 4 LL=1,N4
      SSY=0.0
      DO 16 I=1,N
   16 SSY=SSY+(Y(I)*Y(I))**A4(3)
      DO 14 I=1,N1
      YY2(I)=0.0
      DO 14 J=1,IREP
      K=(J-1)*N1+I
   14 YY2(I)=YY2(I)+Y(K)**A4(3)/IREP
      X2(1)=1.0
      DO 27 I=1,6
      BB(I)=0.0
      DO 27 J=1,6
   27 SSX(I,J)=0.0
      DO 3 I=1,N1
      DO 26 J=2,3
      X2(J)=X(I,J-1)**A4(J-1)
   26 X2(J+2)=X2(J)*X2(J)
      X2(6)=X2(2)*X2(3)
      DO 3 J=1,6
      BB(J)=BB(J)+YY2(I)*X2(J)
      DO 3 K=1,6
```

```
 3 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
   CALL MATV7(SSX,6,BB,1,DET)
   DO 11 I=1,4
   SSXY(I)=0.0
   DO 11 J=1,4
11 SSX(I,J)=0.0
   DO 12 I=1,N1
   DO 13 J=2,3
13 X2(J)=(X(I,J-1)**A4(J-1)-2.0*V1(J-1,LL))*X(I,J-1)**A4(J-1)
   X2(4)=X(I,1)**A4(1)*X(I,2)**A4(2)-V1(1,LL)*X(I,2)**A4(2)-V1(2,LL)*
  1X(I,1)**A4(1)
   DO 12 J=1,4
   SSXY(J)=SSXY(J)+YY2(I)*X2(J)
   B(J)=SSXY(J)
   DO 12 K=1,4
12 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
   CALL MATV7(SSX,4,B,1,DET)
   SS=SSY
   DO 15 I=1,4
15 SS=SS-SSXY(I)*B(I)*IREP
   DO 2 JJ=1,2
   J3=3-JJ
   AN5=44
   X1=V1(JJ,LL)
   IF(X1)5,5,6
 5 X4=2.0*X1
   GO TO 7
 6 X4=0.0
 7 A=2.0*ABS(X1)
   WRITE(3,80)TITL
   GO TO (29,30),N4
30 GO TO (28,29),LL
29 WRITE(3,81)A3
28 WRITE(3,78)JJ
   DO 1 KK=1,45
   V2(JJ)=(KK-1)*A/AN5+X4
   V2(J3)=-(BB(J3+1)+BB(6)*V2(JJ))/2.0/BB(J3+3)
   DO 17 I=1,4
   SSXY(I)=0.0
   DO 17 J=1,4
17 SSX(I,J)=0.0
   DO 18 I=1,N1
   DO 25 J=2,3
25 X2(J)=(X(I,J-1)**A4(J-1)-2.0*V2(J-1))*X(I,J-1)**A4(J-1)
   X2(4)=X(I,1)**A4(1)*X(I,2)**A4(2)-V2(JJ)*X(I,J3)**A4(J3)-V2(J3)*X(
  1I,JJ)**A4(JJ)
   DO 18 J=1,4
   SSXY(J)=SSXY(J)+YY2(I)*X2(J)
   B(J)=SSXY(J)
   DO 18 K=1,4
18 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
   CALL MATV7(SSX,4,B,1,DET)
   SSY1=SSY
   DO 19 I=1,4
19 SSY1=SSY1-SSXY(I)*B(I)*IREP
```

```
      R(KK,JJ,LL)=(SS/SSY1)**(FLOAT(N)/2.0)
      DO 31 I=1,2
      IF(V2(I))32,33,33
   32 NN1=-1
      GO TO 31
   33 NN1=1
   31 V2(I)=V2(I)**(1.0/A4(I))*NN1
    1 WRITE(3,79)V2,SSY1,R(KK,JJ,LL)
    2 CONTINUE
      DO 20 I=1,3
   20 A4(I)=A3(I)
    4 CONTINUE
      DO 21 I=1,3
   21 A4(I)=A5(I)
      CALL LINK(PCNT2)
      END
// DUP
*STORE       WS  UA  CENT2


// JOB
// DUP
*DELETE              PCNT2
// FOR
*NAME PCNT2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER,TYPEWRITER,KEYBOARD)
      COMMON Y(80),X(20,2),B(7),A4(3),SSY,N,IREP,TITL(12),ID,A3(3),N4,N5
     1,YS(2),V1(2,2),ALAMD(2,2),PREP(2,2,2),R(45,2,2),A5(3)
   80 FORMAT('POWER TRANSFORMATIONS  A1='F8.4'  A2='F8.4'  C='F8.4)
   79 FORMAT(I3)
   78 FORMAT(12A6)
   77 FORMAT('TYPE 1 TO CALL EXIT, EOF TO CONTINUE')
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF X'I1'S  -  CENTRE AT X'I1'S ='F7.3)
   74 FORMAT(F7.3)
   73 FORMAT('MAXIMUM LIKELIHOOD RATIO')
      DO 24 I=1,3
   24 A5(I)=A4(I)
      GO TO (25,26),N4
   25 DO 27 I=1,3
   27 A4(I)=A3(I)
      GO TO 28
   26 DO 29 I=1,3
   29 A4(I)=1.0
   28 DO 30 LL=1,N4
      DO 4 JJ=1,2
      AN5=44
      X1=V1(JJ,LL)
      IF(X1)12,12,13
   12 X4=2.0*X1
      GO TO 14
   13 X4=0.0
   14 A=2.0*ABS(X1)
```

```
   B1=A/20.
   C=X4-A/50.
   D=A/10.
   E=10./A
   F=X4-B1
   G=X4+D
   H=X4+A*1.3
   W=X4-A/15.
   U=X4-A/7.5
   Z=X4-D
   CALL SCALE(E,10.0,X4,0.0)
   CALL EGRID(0,X4,0.0,B1,20)
   CALL EGRID(1,X4,0.0,0.05,20)
   DO 2 I=1,11
   X1=G-D/5.0+D*FLOAT(I-2)
   IF(X1)18,19,19
18 NN1=-1
   GO TO 20
19 NN1=1
20 XO=(G+D*FLOAT(I-2))**(1.0/A4(JJ))*NN1
   CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
 2 WRITE(7,74)XO
   DO 3 I=1,11
   X1=-0.1+0.1*FLOAT(I)
   CALL ECHAR(F,X1,0.1,0.1,0.0)
 3 WRITE(7,76)X1
   CALL ECHAR(G,-0.04,0.1,0.1,0.0)
   IF(V1(JJ,LL))21,22,22
21 NN1=-1
   GO TO 23
22 NN1=1
23 V3=V1(JJ,LL)**(1.0/A4(JJ))*NN1
   WRITE(7,75)JJ,JJ,V3
   CALL ECHAR(W,0.1,0.1,0.1,1.5709)
   WRITE(7,73)
   CALL ECHAR(Z,0.0,0.1,0.1,1.5709)
   WRITE(7,78)TITL
   GO TO (11,9),N4
 9 GO TO (10,11),LL
11 CALL ECHAR(U,0.0,0.1,0.1,1.5709)
   WRITE(7,80)A3
10 CALL EPLOT(-2,X4,0.0)
   DO 1 KK=1,45
   V2=(KK-1)*A/AN5+X4
 1 CALL EPLOT(0,V2,R(KK,JJ,LL))
   CALL EPLOT(1,H,0.0)
 4 CONTINUE
   DO 31 I=1,3
31 A4(I)=A3(I)
30 CONTINUE
   DO 32 I=1,3
32 A4(I)=A5(I)
   CALL DATSW(10,J10)
   GO TO (16,15),J10
16 CALL LINK(CRS2)
```

```
   15 GO TO (17,8),N4
   17 WRITE(1,77)
      READ(6,79)N5
      IF(N5)5,6,5
    8 IF(ID-98)7,5,7
    5 CALL EXIT
    6 CALL LINK(CRLF2)
    7 CALL LINK(BOX2)
      END
// DUP
*STORE       WS  UA  PCNT2


// JOB
// DUP
*DELETE              CRS2
// FOR
*NAME CRS2
*IOCS(TYPEWRITER,KEYBOARD,1132 PRINTER,CARD,DISK)
*ONE WORD INTEGERS
*EXTENDED PRECISION
      COMMON Y(80),X(20,2),V(7),A4(3),SSY,NS,NREPS,TITL(12),ID,A3(3),N4,
     1I,YS(2),XCNTR(2,2),ALAMD(2,2),AVECT(2,2,2),YCONT(10,2),NSAD(3),ZLI
     2M(2),XH(40),XV(40),A5(3),YP1(5),XP1(5),YCON1(10),YP(400),XP(400)
      DEFINE FILE 21(400,6,U,KK1),22(400,6,U,KK2)
   89 FORMAT('0SADDLE EXISTS  -  CONTOUR POINTS PLOTTED'//5(14X,F5.1,4X)
     1/5(10X'X1'9X'X2'))
   88 FORMAT('0SADDLE EXISTS  -  ABSOLUTE VALUES OF CONTOUR POINTS PLOTT
     1ED IN ORIGINAL UNITS'//5(14X,F5.1,4X)/5(10X'X1'9X'X2'))
   87 FORMAT('0DATA FOR PLOTTING 5 CONTOURS'//'0ABSOLUTE VALUES OF TRANS
     1FORMED FACTOR LEVELS IN ORIGINAL UNITS'//5X5(9X,F5.1,9X)/5(10X'X1'
     29X'X2'))
   86 FORMAT('ENTER 2 FACTOR LIMITS FOR PLOTTING')
   85 FORMAT('ENTER 10 CONTOUR LEVELS, 5 BELOW THE CENTRE, THEN 5 ABOVE'
     1)
   84 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARIABLE - C ='F
     28.4)
   83 FORMAT('1'12A6)
   82 FORMAT(12F6.2)
   81 FORMAT(2X,5(2X,F10.2,1X,F10.2))
   80 FORMAT(F10.0)
   79 FORMAT(1H0,10X,'DATA FOR PLOTTING OF 5 CONTOURS'//5X5(9X,F5.1,9X)/
     15(10X'X1'9X'X2'))
      NFAK=2
      DO 4 I=1,3
    4 A5(I)=A4(I)
      GO TO (12,74),N4
   12 DO 23 I=1,3
   23 A4(I)=A3(I)
      GO TO 24
   74 DO 28 I=1,3
   28 A4(I)=1.0
   24 DO 15 LL=1,N4
      GO TO (16,17),N4
```

```
16 WRITE(1,85)
   READ(6,80)YCON1
   WRITE(1,86)
   READ(6,80)ZLIM
   GO TO 18
17 GO TO (66,18),LL
66 READ(2,82)YCON1,ZLIM
18 DO 29 I=1,10
   IF(A4(3))77,75,75
77 J=11-I
   GO TO 29
75 J=I
29 YCONT(I,LL)=YCON1(J)
   DO 61 I=1,400
   XP(I)=0.0
61 YP(I)=0.0
   NSWCH=0
   NSAD(LL)=0
   KCY=0
   IH=1
   IV=2
   IF(ALAMD(IH,LL))5,5,6
 5 N1=-1
   GO TO 7
 6 N1=+1
 7 IF(ALAMD(IV,LL))8,8,9
 8 N2=-1
   GO TO 10
 9 N2=+1
10 NSIGN=N1*N2
   IF(NSIGN)11,11,30
11 NSAD(LL)=1
   IF(N1)13,13,14
14 IDUM=IH
   IH=IV
   IV=IDUM
   NSWCH=1
   GO TO 40
30 IF(N1)40,40,45
45 DO 46 I=1,5
   IF(A4(3))76,78,78
76 J=I
   GO TO 46
78 J=I+5
46 YCONT(I,LL)=YCON1(J)
40 CONTINUE
   KCY=KCY+1
   ZFRST=SQRT((YCONT(KCY,LL)**A4(3)-YS(LL))/ALAMD(IH,LL))
   ZEND=ZLIM(IH)**A4(IH)-ZFRST
   XH(1)=ZFRST
   XV(1)=0.0
   THETA=0.0
   DO 1 I=2,10
   THETA=THETA+0.15710
   IF(NSAD(LL))51,51,52
```

```
51 XH(I)=ZFRST*COS(THETA)
   GO TO 53
52 XH(I)=ZFRST+ZEND-ZEND*COS(THETA)
53 ARG=(YCONT(KCY,LL)**A4(3)-YS(LL)-ALAMD(IH,LL)*(XH(I)**2))/ALAMD(IV
  1,LL)
   XV(I)=SQRT(ARG)
   IL=42-I
   XH(IL)=XH(I)
   XV(IL)=-XV(I)
 1 CONTINUE
   IF(NSAD(LL))54,54,55
54 XH(11)=0.0
   ARGG=(YCONT(KCY,LL)**A4(3)-YS(LL))/ALAMD(IV,LL)
   XV(11)=SQRT(ARGG)
   GO TO 56
55 XH(11)=ZLIM(IH)**A4(IH)
   ARG=(YCONT(KCY,LL)**A4(3)-YS(LL)-ALAMD(IH,LL)*(XH(I)**2))/ALAMD(IV
  1,LL)
   XV(11)=SQRT(ARG)
56 DO 2 I=12,21
   LL1=22-I
   II=42-I
   XH(I)=-XH(LL1)
   XV(I)=XV(LL1)
   XH(II)=XH(I)
 2 XV(II)=-XV(I)
   XV(31)=-XV(11)
   XH(31)=XH(11)
   IF(NSWCH)31,31,32
32 I1=IV
   I2=IH
   DO 33 I=1,40
   XDUM=XH(I)
   XH(I)=XV(I)
33 XV(I)=XDUM
   GO TO 60
31 I1=IH
   I2=IV
60 DO 41 I=1,40
   L=(KCY-1)*40+I
   XP(L)=AVECT(I1,I1,LL)*XH(I)+AVECT(I2,I1,LL)*XV(I)+XCNTR(I1,LL)
41 YP(L)=AVECT(I1,I2,LL)*XH(I)+AVECT(I2,I2,LL)*XV(I)+XCNTR(I2,LL)
   IF(KCY-5)40,34,34
34 IF(NSAD(LL)-1)35,47,47
47 IF(KCY-10)48,35,35
48 IF(KCY-5)40,36,40
36 IF(NSWCH)38,38,39
38 NSWCH=1
   GO TO 37
39 NSWCH=0
37 IDUM=IH
   IH=IV
   IV=IDUM
   GO TO 40
35 WRITE(3,83)TITL
```

```
      GO TO (19,20),N4
   20 GO TO (21,19),LL
   19 WRITE(3,84)A3
   21 WRITE(3,79)(YCONT(I,LL),I=1,5)
      DO 3 I=1,40
      DO 49 J=1,5
      L1=(J-1)*40+I
      XP1(J)=XP(L1)
   49 YP1(J)=YP(L1)
    3 WRITE(3,81)(XP1(J),YP1(J),J=1,5)
      IF(NSAD(LL))43,43,44
   44 WRITE(3,83)TITL
      GO TO (50,57),N4
   57 GO TO (58,50),LL
   50 WRITE(3,84)A3
   58 WRITE(3,89)(YCONT(I,LL),I=6,10)
      DO 42 I=1,40
      DO 59 J=1,5
      L1=200+(J-1)*40+I
      XP1(J)=XP(L1)
   59 YP1(J)=YP(L1)
   42 WRITE(3,81)(XP1(J),YP1(J),J=1,5)
   43 GO TO (25,26),LL
   25 DO 22 I=1,400
   22 WRITE(21'I)XP(I),YP(I)
      GO TO 73
   26 DO 27 I=1,400
   27 WRITE(22'I)XP(I),YP(I)
   73 DO 62 I=1,3
   62 A4(I)=A3(I)
   15 CONTINUE
      DO 63 I=1,3
   63 A4(I)=A5(I)
      LL=LL-1
      WRITE(3,83)TITL
      WRITE(3,87)(YCONT(I,LL),I=1,5)
      DO 65 I=1,40
      DO 64 J=1,5
      L1=(J-1)*40+I
      XP1(J)=XP(L1)**(1.0/A3(1))
   64 YP1(J)=YP(L1)**(1.0/A3(2))
   65 WRITE(3,81)(XP1(J),YP1(J),J=1,5)
      IF(NSAD(LL))13,13,67
   67 WRITE(3,83)TITL
      GO TO (68,69),N4
   69 GO TO (70,68),LL
   68 WRITE(3,84)A3
   70 WRITE(3,88)(YCONT(I,LL),I=6,10)
      DO 71 I=1,40
      DO 72 J=1,5
      L1=200+(J-1)*40+I
      XP1(J)=XP(L1)**(1.0/A3(1))
   72 YP1(J)=YP(L1)**(1.0/A3(2))
   71 WRITE(3,81)(XP1(J),YP1(J),J=1,5)
   13 CALL LINK(PRS2)
```

```
      END
// DUP
*STORE       WS  UA  CRS2


// JOB
// DUP
*DELETE              PRS2
// FOR
*NAME PRS2
*IOCS(DISK,PLOTTER,TYPEWRITER,KEYBOARD)
*ONE WORD INTEGERS
*EXTENDED PRECISION
      COMMON A(80),B(20,2),V(7),A4(3),SSY,NS,NREPS,TITL(12),ID,A3(3),N4,
     1I,YS(2),XCNTR(2,2),ALAMD(2,2),AVECT(2,2,2),YCONT(10,2),NSAD(3),ZLI
     2M(2),XP(5),YP(5),XS(2),YA(2),UPI(2),A5(3),YB,L5(5)
      DEFINE FILE 21(400,6,U,KK1),22(400,6,U,KK2)
   86 FORMAT(3X'POWER TRANSFORMATIONS - A1='F8.4'  A2='F8.4'  C='F8.4)
   85 FORMAT(12A6)
   84 FORMAT(I3)
   83 FORMAT('TYPE 1 TO CALL EXIT, EOF TO CONTINUE')
   82 FORMAT(1X,'  X1 - X2 COORDINATES FOR RESPONSE CONTOURS',10F6.1)
   81 FORMAT(F7.2)
   80 FORMAT(F6.2)
      DO 25 I=1,3
   25 A5(I)=A4(I)
      GO TO (5,9),N4
    5 DO 20 I=1,3
   20 A4(I)=A3(I)
      GO TO 21
    9 DO 22 I=1,3
   22 A4(I)=1.0
   21 DO 6 LL=1,N4
      DO 24 I=1,2
      XS(I)=4.0/ZLIM(I)
      UPI(I)=1.0/XS(I)
   24 YA(I)=ZLIM(I)+UPI(I)
      CALL SCALE(XS(1),XS(2),-ZLIM(1),-ZLIM(2))
      CALL EPLOT(-2,-ZLIM(1),-ZLIM(2))
      X=ZLIM(1)
      Y=-ZLIM(2)
      DO 11 J=1,9
      CALL EPLOT(-1,X,Y)
      IF(J-9)4,11,11
    4 Y=Y+UPI(2)
      CALL EPLOT(-2,X,Y)
      X=-X
   11 CONTINUE
      CALL EPLOT(-2,X,Y)
      Y=-ZLIM(2)
      DO 13 J=1,9
      CALL EPLOT(-1,X,Y)
      X=X-UPI(1)
      IF(J-9)12,13,13
   12 CALL EPLOT(-2,X,Y)
```

```
      Y=-Y
   13 CONTINUE
      CALL EPLOT(1,X,Y)
      DO 27 J=1,9
      Y=-YA(2)+UPI(2)*FLOAT(J)
      CALL ECHAR(-YA(1),Y,0.1,0.1,0.0)
      IF(Y)49,27,27
   49 Y=Y-0.00501
   27 WRITE(7,81)Y
      CALL ECHAR(-ZLIM(1),YA(2),0.1,0.1,0.0)
      WRITE(7,85)TITL
      GO TO (46,47),N4
   47 GO TO (48,46),LL
   46 YB=ZLIM(2)+UPI(2)/3.0
      CALL ECHAR(-ZLIM(1),YB,0.1,0.1,0.0)
      WRITE(7,86)A3
   48 YC=ZLIM(2)+UPI(2)/1.5
      CALL ECHAR(-ZLIM(1),YC,0.1,0.1,0.0)
      IF(NSAD(LL))1,1,2
    1 NN5=5
      GO TO 3
    2 NN5=10
    3 WRITE(7,82)(YCONT(I,LL),I=1,NN5)
      DO 28 J=1,9
      X=-YA(1)-UPI(1)/2.5+UPI(1)*FLOAT(J)
      XA=-ZLIM(2)-UPI(2)/5.0
      XO=-YA(1)+UPI(1)*FLOAT(J)
      CALL ECHAR(X,XA,0.1,0.1,0.0)
      IF(XO)50,28,28
   50 XO=XO-0.00501
   28 WRITE(7,81)XO
      DO 44 I=1,NN5
      DO 43 J=1,40,2
      K=J+40*(I-1)
      GO TO (7,8),LL
    7 READ(21'K)X,Y
      GO TO 10
    8 READ(22'K)X,Y
   10 IF(X)32,33,33
   32 NN1=-1
      GO TO 34
   33 NN1=1
   34 IF(Y)35,36,36
   35 NN2=-1
      GO TO 37
   36 NN2=1
   37 X=X**(1./A4(1))*NN1
      Y=Y**(1./A4(2))*NN2
      IF(ABS(X)-ZLIM(1))29,29,30
   30 IF(X)31,31,38
   38 X=ZLIM(1)
      GO TO 29
   31 X=-ZLIM(1)
   29 IF(ABS(Y)-ZLIM(2))39,39,40
   40 IF(Y)41,41,42
```

```
   42 Y=ZLIM(2)
      GO TO 39
   41 Y=-ZLIM(2)
   39 IF(J-1)43,14,15
   14 CALL EPLOT(-2,X,Y)
      XA=X
      XO=Y
      GO TO 43
   15 CALL EPLOT(0,X,Y)
   43 CONTINUE
      CALL EPLOT(-1,XA,XO)
      CALL ECHAR(XA,XO,0.075,0.075,0.0)
      WRITE(7,80)YCONT(I,LL)
   44 CONTINUE
      XOR=ZLIM(1)+6.0*UPI(1)
      CALL EPLOT(1,XOR,-ZLIM(2))
      DO 23 I=1,3
   23 A4(I)=A3(I)
    6 CONTINUE
      DO 26 I=1,3
   26 A4(I)=A5(I)
      GO TO (18,19),N4
   18 WRITE(1,83)
      READ(6,84)N5
      IF(N5)17,45,17
   19 IF(ID-98)16,17,16
   17 CALL EXIT
   45 CALL LINK(CRLF2)
   16 CALL LINK(BOX2)
      END
// DUP
*STORE       WS  UA  PRS2


// JOB
// DUP
*DELETE              CRLF2
// FOR
*NAME CRLF2
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(CARD,1132 PRINTER,TYPEWRITER,KEYBOARD)
C
C      THIS PROGRAM IS DESIGNED FOR COMPLETE CONSOLE CONTROL.
C
C      THIS PROGRAM ANALYZES DATA IN THE SAME MANNER AS BOX2, BUT ONLY
C  FOR TEST VALUES OF THE POWER TRANSFORMATIONS WHICH ARE ENTERED ON THE
C  CONSOLE TYPEWRITER.  THE RELATIVE LIKELIHOOD OF THESE TEST VALUES, AS
C  COMPARED WITH THE MAXIMUM LIKELIHOOD ESTIMATES, IS CALCULATED.
C  VARIOUS TEST VALUES MAY BE ENTERED, AND THE COMPLETE ANALYSIS DONE ON
C  ANY LIKELY VALUES SELECTED FROM THESE.   SEE BOX2 FOR DETAILS OF THE
C  ANALYSIS.
C
C    LINKS CALLED
C
```

```
C  CRLF2 - CALCULATES RELATIVE LIKELIHOODS OF VARIOUS TEST VALUES OF
C TRANSFORMS
C  INFO2 - PERFORMS ANALYSIS OF VARIANCE
C  COEF2 - CALCULATES AND PLOTS POINTS FOR MLR GRAPHS OF THE B(J)
C COEFFICIENTS
C  EIGN2 - PERFORMS CANONICAL ANALYSIS
C  CENT2 -CALCULATES POINTS FOR THE MLR GRAPHS OF THE CENTRE COORDINATES
C  PCNT2 - PLOTS MLR GRAPHS OF THE COORDINATES OF THE RESPONSE CENTRE
C  CRS2  - CALCULATES POINTS FOR THE RESPONSE SURFACE CONTOURS
C  PRS2  - PLOTS RESPONSE SURFACE CONTOURS
C
C   SUBROUTINES CALLED
C
C  MATV7 - INVERTS MATRICES
C  ORTH2 - CALCULATES ORTHOGONAL POLYNOMIALS FOR ANOVA
C  CAN2  - DIAGONALIZES MATRICES
C  JACOB - CALCULATES EIGENVALUES AND VECTORS OF DIAGONAL MATRICES
C
C   OPTIONS
C
C SWITCH 10 UP - PLOT RESPONSE SURFACE CONTOURS
C SWITCH  8 UP - PLOT MAXIMUM LIKELIHOOD RATIOS OF B(J) COEFFICIENTS
C SWITCH  7 UP -PLOT MAXIMUM LIKELIHOOD RATIOS OF THE CENTRE COORDINATES
C
C   MAKEUP OF DATA DECK
C
C 1.TITLE CARD FIRST - (12A6)
C 2.CONTROL CARD - (1X,2I2,F5.3)
C      I2 - NUMBER OF TREATMENT COMBINATIONS
C      I2 - NUMBER OF OBSERVATION SETS
C      F5.3 - CONSTANT ADDED TO DEPENDENT VARIABLE, Y
C 3.TREATMENT COMBINATIONS IN PAIRS - (16F5.3)
C 4.DATA - SETS OF OBSERVATIONS FOR EACH TREATMENT COMBINATION
C      ONE SET PER CARD - (4F6.3)
C 5.98 OR 99 IN COLS. 79-80 INDICATES END OF DATA
C 6.REPEAT 1. TO 5. AS REQUIRED
C
C   STATION PLOTTER PEN EXACTLY 1.4 INCHES FROM THE RIGHT EDGE OF NARROW
C PAPER
C
      COMMON Y(80),X(20,2),B(7),A4(3),SSY1,N,IREP,TITL(12),ID,A3(3),N4,N
     15,X1(6),SSX(7,7),SSXY(6),Y1(4),YY1(20)
     88 FORMAT('0CONSTANT ADDED     Y + 'F5.3)
     87 FORMAT('INCORRECT NUMBER OF OBSERVATION SETS - SKIPPING TO NEXT DA
       1TA DECK')
     86 FORMAT(16F5.3)
     85 FORMAT('IF RELATIVE LIKELIHOOD IS SATISFACTORY, PRESS EOF'/ 'IF NO
       1T, TYPE 1 TO TRY NEW TEST VALUES, -1 TO READ MORE DATA OR CALL EXI
       2T')
     84 FORMAT('0TEST VALUES OF POWER TRANSFORMATIONS'/'0'6X'A1'13X'A2'13X
       1'C'14X'SSD'13X'R'/5E15.5)
     83 FORMAT('0MAXIMUM LIKELIHOOD ESTIMATES'//7X'A1'13X'A2'13X'C'14X'SSD
       1'/4E15.5)
     82 FORMAT('1'12A6)
     81 FORMAT(4F6.3,54X,I2)
```

```
80 FORMAT(12A6)
79 FORMAT('TYPE IN TWO MAXIMUM LIKELIHOOD ESTIMATES OF POWER TRANSFOR
  1MATIONS FOR INDEPENDENT VARIABLES'/'THEN, ONE ML ESTIMATE FOR DEPE
  2NDENT VARIABLE')
78 FORMAT(1X,2I2,F5.3)
77 FORMAT('TYPE 1 TO READ NEW DATA DECK, EOF TO READ NEW TEST VALUES
  1ON SAME DATA, -1 TO CALL EXIT')
76 FORMAT(I3)
75 FORMAT(F10.5)
74 FORMAT('TYPE IN TWO TEST VALUES OF POWER TRANSFORMATIONS FOR INDEP
  1ENDENT VARIABLES'/'THEN, ONE FOR DEPENDENT VARIABLE'/'TYPE 0.0 FOR
  2 LOG TRANSFORM, + OR - 100 FOR EXPONENTIAL TRANSFORM'/'DATA DECK M
  3UST BE REREAD TO REGAIN ORIGINAL VARIABLE VALUES WITH THESE 3')
73 FORMAT('RELATIVE LIKELIHOOD IS'F8.5)
72 FORMAT('SWITCH 10 UP TO PLOT RESPONSE CONTOURS'/'SWITCH  8 UP TO P
  1LOT MLR GRAPHS OF B(J) COEFFICIENTS'/'SWITCH  7 UP TO PLOT MLR GRA
  2PHS OF THE COORDINATES OF THE RESPONSE CENTRE')
   WRITE(1,72)
18 WRITE(1,77)
   READ(6,76)N5
   N6=1
   N4=1
   IF(N5)19,1,2
 2 READ(2,80)TITL
   WRITE(1,80)TITL
   READ(2,78)N1,IREP,CONST
   N=N1*IREP
   READ(2,86)((X(I,J),J=1,2),I=1,N1)
   I=0
10 I=I+1
   READ(2,81)Y1,ID
   IF(ID-98)21,11,11
21 N2=N1+I
   N3=N1*2+I
   N6=N1*3+I
   Y(I)=Y1(1)+CONST
   Y(N2)=Y1(2)+CONST
   Y(N3)=Y1(3)+CONST
   Y(N6)=Y1(4)+CONST
   GO TO 10
11 N2=I-1
   IF(N1-N2)22,1,22
22 WRITE(1,87)
   GO TO 18
 1 N1=N/IREP
   IF(N5)20,25,20
20 WRITE(1,79)
   READ(6,75)A3
 8 SSY2=0.0
   DO 24 K=1,N
24 SSY2=SSY2+(Y(K)*Y(K))**A3(3)
   DO 26 I=1,N1
   YY1(I)=0.0
   DO 26 J=1,IREP
   K=(J-1)*N1+I
```

```
26 YY1(I)=YY1(I)+Y(K)**A3(3)/IREP
   DO 3 I=1,6
   B(I)=0.0
   DO 3 J=1,6
 3 SSX(I,J)=0.0
   X1(1)=1.0
   DO 4 K=1,N1
   DO 5 J=2,3
   X1(J)=X(K,J-1)**A3(J-1)
 5 X1(J+2)=X1(J)*X1(J)
   X1(6)=X1(2)*X1(3)
   DO 4 I=1,6
   B(I)=B(I)+YY1(K)*X1(I)
   DO 4 J=1,6
 4 SSX(I,J)=SSX(I,J)+X1(I)*X1(J)
   DO 9 I=1,6
 9 SSXY(I)=B(I)
   CALL MATV7(SSX,6,B,1,DET)
   IF(N6)14,13,14
13 SSY=SSY2
   DO 15 I=1,6
15 SSY=SSY-B(I)*SSXY(I)*IREP
   GO TO 12
14 SSY1=SSY2
   DO 6 I=1,6
 6 SSY1=SSY1-B(I)*SSXY(I)*IREP
   DO 7 I=1,3
 7 A4(I)=A3(I)
25 WRITE(1,74)
   READ(6,75)A3
   DO 28 J=1,2
   IF(A3(J))32,23,32
23 DO 29 I=1,N1
29 X(I,J)=ALOG(X(I,J))
   GO TO 33
32 IF(ABS(A3(J))-100.)28,34,28
34 DO 35 I=1,N1
35 X(I,J)=EXP(A3(J)*X(I,J)/100.)
33 A3(J)=1.0
28 CONTINUE
   IF(A3(3))30,31,30
31 DO 16 I=1,N
16 Y(I)=ALOG(Y(I))
   GO TO 37
30 IF(ABS(A3(3))-100.)36,38,36
38 DO 39 I=1,N
39 Y(I)=EXP(A3(3)*Y(I)/100.)
37 A3(3)=1.0
36 N6=0
   GO TO 8
12 D=0.0
   DO 27 I=1,N
27 D=D+ALOG(Y(I))
   R1=N*ALOG(SSY1/SSY)/2.0+(A4(3)-A3(3))*D
   R1=EXP(R1)
```

```
      WRITE(1,73)R1
      WRITE(3,82)TITL
      WRITE(3,88)CONST
      WRITE(3,83)A4,SSY1
      WRITE(3,84)A3,SSY,R1
      WRITE(1,85)
      READ(6,76)N5
      IF(N5)18,17,25
   17 CALL LINK(INFO2)
   19 CALL EXIT
      END
// DUP
*STORE      WS  UA  CRLF2
```

FORTRAN 1130 SOURCE DECK LISTING RESPONSE SURFACE - THREE FACTORS

```
// JOB
// DUP
*DELETE              BOX3
// FOR
*NAME BOX3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(1132 PRINTER,CARD,DISK)
C
C     THIS PROGRAM ANALYZES THE DATA FROM RESPONSE SURFACE EXPERIMENTS
C WHEN THREE FACTORS ARE MEASURED. OPTIONS ALLOW CALCULATION OF MAXIMUM
C LIKELIHOOD ESTIMATES OF POWER TRANSFORMATIONS OF BOTH INDEPENDENT AND
C DEPENDENT VARIABLES AND THE PLOTTING OF THEIR RELATIVE MAXIMUM
C LIKELIHOOD GRAPHS, AS A MEASURE OF THE PRECISION OF THE ESTIMATES.
C THE DATA IS THEN SUBJECTED TO ANALYSIS OF VARIANCE, USING ORTHOGONAL
C POLYNOMIALS, AND PRINCIPAL COMPONENT ANALYSIS, AND SPECIFIED CONTOURS
C OF THE DEPENDENT VARIABLE ARE PLOTTED AS SLICES THROUGH THE CENTRE OF
C THE SURFACE, BOTH WITHOUT AND WITH TRANSFORMATION.
C
C     OPTIONS ALLOW THE CALCULATION OF MAXIMUM RELATIVE LIKELIHOOD
C GRAPHS FOR THE B(J) COEFFICIENTS IN THE NON-LINEAR CASE, AND FOR THE
C X(I) COORDINATES OF THE CENTRE.
C
C     UP TO 20 POINTS IN THE FACTOR SPACE (TREATMENT COMBINATIONS) ARE
C ALLOWED, WITH UP TO 4 OBSERVATIONS AT EACH POINT (OBSERVATION SETS).
C
C     TO TRY OTHER VALUES OF THE POWER TRANSFORMATIONS THAN THE ML
C ESTIMATES, USE CRLF3.
C
C     TO TRY OTHER SLICES THAN THROUGH THE RESPONSE SURFACE CENTRE, USE
C SRS3.
C
C    LINKS CALLED
C
C   BOX3  - CALCULATES ML ESTIMATES AND POINTS FOR THE MLR GRAPHS
C   PMLR3 - PLOTS MLR GRAPHS OF THE POWER TRANSFORMATIONS
C   CPAR3 - CALCULATES POINTS FOR THE MLR GRAPHS OF B(J) IN THE
C NON-LINEAR CASE
C   PPAR3 - PLOTS MLR GRAPHS OF THE B(J) COEFFICIENTS
C   INFO3 - CALULATES INFORMATION AND VARIANCE-COVARIANCE MATRICES
C   ANVA3 - PERFORMS ANALYSIS OF VARIANCE
C   EIGN3 - PERFORMS CANONICAL ANALYSIS
C   CENT3 -CALCULATES POINTS FOR THE MLR GRAPHS OF THE CENTRE COORDINATES
C   PCNT3 - PLOTS MLR GRAPHS OF THE COORDINATES OF THE RESPONSE CENTRE
C   SLIC3 - CALCULATES EIGENVALUES AND VECTORS FOR SLICES OF RESPONSE
C SURFACE
C   CRS3  - CALCULATES POINTS FOR THE RESPONSE SURFACE CONTOURS
C   PRS3  - PLOTS RESPONSE SURFACE CONTOURS
C
C    SUBROUTINES CALLED
C
C   CMLE3 - CALCULATES ML AND RML ESTIMATES
```

```
C  MATV  - INVERTS MATRICES
C  CAN3  - DIAGONALIZES MATRICES
C  JACOB - CALCULATES EIGENVALUES AND VECTORS OF DIAGONAL MATRICES
C
C   OPTIONS
C
C  SWITCH 10 UP - PLOT RESPONSE SURFACE CONTOURS
C SWITCH  9 UP - PLOT MAXIMUM LIKELIHOOD RATIOS OF POWER TRANSFORMATIONS
C SWITCH  8 UP - PLOT MAXIMUM LIKELIHOOD RATIOS OF B(J) COEFFICIENTS
C SWITCH  7 UP -PLOT MAXIMUM LIKELIHOOD RATIOS OF THE CENTRE COORDINATES
C
C   MAKEUP OF DATA DECK
C
C 1.TITLE CARD FIRST - (12A6)
C 2.CONTROL CARD - (I1,2I2,5F5.3,I3,F5.3,I3)
C     I1 - OPTION  -  0 - POWER TRANS. FOR IND. AND DEP. VARIABLES
C                     1 - POWER TRANS. FOR IND. VARIABLE ONLY
C                     2 - POWER TRANS. FOR DEP. VARIABLE ONLY
C     I2 - NUMBER OF TREATMENT COMBINATIONS
C     I2 - NUMBER OF OBSERVATION SETS
C     F5.3 - CONSTANT ADDED TO DEPENDENT VARIABLE, Y
C     4F5.3 - INITIAL ESTIMATES OF PARAMETERS - A1,A2,A3,C
C           0.0 YIELDS NATURAL LOG TRANSFORMATION
C           +100. YIELDS POSITIVE EXPONENTIAL TRANSFORMATION
C           -100. YIELDS NEGATIVE EXPONENTIAL TRANSFORMATION
C     I3 - MAXIMUM NUMBER OF ITERATIONS ALLOWED PER ESTIMATE
C    THE FOLLOWING REQUIRED ONLY WITH OPTION 10
C     F5.3 - HALF SIZE OF INTERVAL TO BE PLOTTED AROUND MAXIMUM -
C - SUGGEST 2.5
C     I3 - NUMBER OF POINTS TO BE PLOTTED (MAX= 75)
C 3.TREATMENT COMBINATIONS IN TRIPLETS - (16F5.3)
C 4.DATA - SETS OF OBSERVATIONS FOR EACH TREATMENT COMBINATION
C     ONE SET PER CARD - (4F6.3)
C 5.99 IN COLS. 79-80 INDICATES END OF DATA, ANOTHER DECK TO FOLLOW
C   98 IN COLS. 79-80 INDICATES END OF JOB - CALL EXIT AFTER THIS DECK
C 6.IF OPTION  9 IS USED, CONTROL CARD - (11F6.2)
C   8F6.2 - 8 CONTOUR LEVELS IN UNITS OF THE DEPENDENT VARIABLE
C   3F6.2 - 3 FACTOR LIMITS FOR PLOTTING IN UNITS OF THE INDEPENDENT
C VARIABLES
C 7.REPEAT 1. TO 6. AS REQUIRED
C
C   STATION PLOTTER PEN EXACTLY 1.4 INCHES FROM THE RIGHT EDGE OF NARROW
C PAPER
C
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,N
     15,AN4,NNNN,D,Y1(4),AA(4),CONST
      DEFINE FILE 21(320,6,U,KK1)
     86 FORMAT('0CONSTANT ADDED     Y + 'F5.3/'0INITIAL ESTIMATES'//7X'A1'1
       13X'A2'13X'A3'13X'C'/4E15.7/)
     85 FORMAT('INCORRECT NUMBER OF OBSERVATION SETS - SKIPPING TO NEXT DA
       1TA DECK')
     84 FORMAT(16F5.3)
     83 FORMAT(I1,2I2,5F5.3,I3,F5.3,I3)
     82 FORMAT('1'12A6)
     81 FORMAT(4F6.3,54X,I2)
```

```
   80 FORMAT(12A6)
   79 FORMAT(6E15.5,I6)
   78 FORMAT('0MAXIMUM LIKELIHOOD ESTIMATES'//7X'A1'13X'A2'13X'A3'13X'C'
     114X'SSD'10X'ITER    ALLOWED'/5E15.7,2I7/)
   77 FORMAT('0'6X'A1'13X'A2'13X'A3'13X'C'14X'SSD'13X'R'9X'ITER')
      V2=0.0
      J3=13
    5 READ(2,80)TITL
      WRITE(3,82)TITL
      READ(2,83)N5,N1,IREP,CONST,AA,NNNN,AN4,N4
      IF(N4-75)24,24,25
   25 N4=75
   24 WRITE(3,86)CONST,AA
      N5=N5+1
      READ(2,84)((X(I,J),J=1,3),I=1,N1)
      I=0
   22 I=I+1
      READ(2,81)Y1,ID
      IF(ID-98)9,23,23
    9 N2=N1+I
      N3=N1*2+I
      N6=N1*3+I
      Y(I)=Y1(1)+CONST
      Y(N2)=Y1(2)+CONST
      Y(N3)=Y1(3)+CONST
      Y(N6)=Y1(4)+CONST
      GO TO 22
   23 N2=I-1
      IF(N1-N2)2,4,2
    2 WRITE(3,85)
      IF(ID-98)5,6,5
    6 CALL EXIT
    4 N=N1*IREP
      DO 16 J=1,3
      IF(AA(J))26,17,26
   17 DO 18 I=1,N1
   18 X(I,J)=ALOG(X(I,J))
      GO TO 29
   26 IF(ABS(AA(J))-100.0)16,27,16
   27 DO 28 I=1,N1
   28 X(I,J)=EXP(AA(J)*X(I,J)/100.)
   29 AA(J)=1.0
   16 CONTINUE
      IF(AA(4))19,20,19
   20 DO 21 I=1,N
   21 Y(I)=ALOG(Y(I))
      GO TO 33
   19 IF(ABS(AA(4))-100.)31,30,31
   30 DO 32 I=1,N
   32 Y(I)=EXP(AA(4)*Y(I)/100.)
   33 AA(4)=1.0
   31 D=0.0
      DO 15 I=1,N
   15 D=D+ALOG(Y(I))
      DO 7 J=1,4
```

```
     7 A4(J)=AA(J)
       CALL CMLE3(5,ITER,V2,J3)
       WRITE(3,78)A4,SSY,ITER,NNNN
       DO 3 J=1,4
     3 A3(J)=A4(J)
       CALL DATSW(9,J9)
       GO TO (13,12),J9
    12 CALL DATSW(8,J8)
       GO TO (34,35),J8
    34 CALL LINK(CPAR3)
    35 N4=2
       CALL LINK(INFO3)
    13 SSY1=SSY
       AN5=N4-1
       DO 1 J=1,4
       GO TO (10,10,10,11),J
    10 GO TO (14,14,1),N5
    11 GO TO (14,1,14),N5
    14 WRITE(3,77)
       X4=A3(J)-AN4
       A=2.0*(A3(J)-X4)
       DO 8 JJ=1,4
     8 A4(JJ)=A3(JJ)
       DO 1 I=1,N4
       DO 36 K=1,4
       IF(ABS(A4(K))-5.0)36,36,37
    37 A4(K)=A3(K)
    36 CONTINUE
       A4(J)=I*A/AN5+X4-A/AN5
       CALL CMLE3(J,ITER,V2,J3)
       R=N*ALOG(SSY1/SSY)/2.0
       R=EXP(R)
       WRITE(3,79)A4,SSY,R,ITER
       K=(J-1)*N4+I
       WRITE(21'K)R
     1 CONTINUE
       CALL LINK(PMLR3)
       END
// DUP
*STORE       WS  UA  BOX3


// JOB
// DUP
*DELETE              CMLE3
// FOR
*NAME CMLE3
*EXTENDED PRECISION
*ONE WORD INTEGERS
      SUBROUTINE CMLE3(K4,ITER,V2,J3)
      DIMENSION X1(12),SSXY(12),SSX(12,12),XX(12),Y(20),YY2(20)
      COMMON Y1(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,
     1N5,AN5,NNNN,DDD,A5(4)
      N1=N/IREP
      K5=1
```

```
      D=EXP(DDD/FLOAT(N))
      ITER=0.0
      IF(J3-12)13,13,37
   37 MM=9
      GO TO 2
   13 MM=8
    2 ITER=ITER+1
      IF(ITER-NNNN)65,65,60
   60 K5=2
   65 DO 40 I=1,4
   40 A5(I)=A4(I)
      DD=D**(A4(4)-1.)
      DO 8 J=1,N1
      Y(J)=0.0
      DO 8 I=1,IREP
      K=(I-1)*N1+J
    8 Y(J)=Y(J)+(Y1(K)**A4(4)-1.)/A4(4)/DD/IREP
      YY=0.0
      DO 32 I=1,N1
   32 YY=YY+Y(I)/N1
      DO 24 J=1,12
   24 XX(J)=0.0
      DO 1 I=1,N1
      DO 15 J=1,3
      X1(J)=X(I,J)**A4(J)
   15 X1(J+3)=X1(J)*X1(J)
      X1(7)=X1(1)*X1(2)
      X1(8)=X1(1)*X1(3)
      X1(9)=X1(2)*X1(3)
      DO 1 J=1,9
    1 XX(J)=XX(J)+X1(J)/N1
      SSY=0.0
      DO 4 J=1,12
      SSXY(J)=0.0
      DO 4 K=1,12
    4 SSX(J,K)=0.0
      DO 5 I=1,N1
      DO 58 J=1,3
      X1(J)=X(I,J)**A4(J)
   58 X1(J+3)=X1(J)*X1(J)
      X1(7)=X1(1)*X1(2)
      X1(8)=X1(1)*X1(3)
      X1(9)=X1(2)*X1(3)
      DO 7 J=1,IREP
      K=(J-1)*N1+I
      YY2(1)=(Y1(K)**A4(4)-1.)/A4(4)/DD-YY-V2*(X1(J3)-XX(J3))
    7 SSY=SSY+YY2(1)*YY2(1)
      DO 5 J=1,9
      IF(J-J3)70,5,71
   70 JJ=J
      GO TO 52
   71 JJ=J-1
   52 SSXY(JJ)=SSXY(JJ)+(Y(I)-YY-V2*(X1(J3)/XX(J3)))*(X1(J)-XX(J))
      B(JJ)=SSXY(JJ)
      DO 5 K=1,9
```

```
   IF(K-J3)33,5,54
33 KK=K
   GO TO 50
54 KK=K-1
50 SSX(JJ,KK)=SSX(JJ,KK)+(X1(J)-XX(J))*(X1(K)-XX(K))
 5 CONTINUE
   CALL MATV(SSX,MM,B,1,DET)
   DO 28 J=1,MM
28 SSY=SSY-B(J)*SSXY(J)*IREP
   DO 38 J=1,9
   JJ=10-J
   IF(JJ-J3)38,29,6
 6 B(JJ)=B(JJ-1)
   GO TO 38
29 B(JJ)=V2
38 CONTINUE
   GO TO (57,26),K5
26 ITER=ITER-1
   RETURN
57 GO TO (41,42,41),N5
41 GO TO (43,43,43,42,43),K4
43 DO 55 I=1,N1
   YY2(I)=YY
   DO 44 J=1,3
   X1(J)=X(I,J)**A4(J)
44 X1(J+3)=X1(J)*X1(J)
   X1(7)=X1(1)*X1(2)
   X1(8)=X1(1)*X1(3)
   X1(9)=X1(2)*X1(3)
   DO 55 J=1,9
55 YY2(I)=YY2(I)+B(J)*(X1(J)-XX(J))
42 GO TO (25,25,25,59,59),K4
59 GO TO (25,25,62),N5
62 GO TO (61,61,61,26,61),K4
25 DO 9 J=1,12
   SSXY(J)=0.0
   DO 9 K=1,12
 9 SSX(J,K)=0.0
   DO 3 I=1,N1
   DO 45 J=1,3
   X1(J)=X(I,J)**A4(J)
45 X1(J+3)=X1(J)*X1(J)
   X1(7)=X1(1)*X1(2)
   X1(8)=X1(1)*X1(3)
   X1(9)=X1(2)*X1(3)
   DO 46 L1=1,2
   L2=L1+1
   DO 46 L3=L2,3
   L4=L1+L3-2
46 X1(L4+9)=(B(L4)*X1(L4)+2.0*B(L4+3)*X1(L4+3)+B(L1+6)*X1(L1+6)+B(L3+
  16)*X1(L3+6))*ALOG(X(I,L4))
   DO 3 J=10,12
 3 XX(J)=XX(J)+X1(J)/N1
   DO 10 I=1,N1
   DO 47 J=1,3
```

```
      X1(J)=X(I,J)**A4(J)
   47 X1(J+3)=X1(J)*X1(J)
      X1(7)=X1(1)*X1(2)
      X1(8)=X1(1)*X1(3)
      X1(9)=X1(2)*X1(3)
      DO 48 L1=1,2
      L2=L1+1
      DO 48 L3=L2,3
      L4=L1+L3-2
   48 X1(L4+9)=(B(L4)*X1(L4)+2.0*B(L4+3)*X1(L4+3)+B(L1+6)*X1(L1+6)+B(L3+
     16)*X1(L3+6))*ALOG(X(I,L4))
      DO 10 J=1,12
      SSXY(J)=SSXY(J)+(Y(I)-YY)*(X1(J)-XX(J))
      DO 10 K=1,12
   10 SSX(J,K)=SSX(J,K)+(X1(J)-XX(J))*(X1(K)-XX(K))
      DO 11 J=1,12
   11 B(J)=SSXY(J)
      GO TO (17,18,19,27,27),K4
   27 CALL MATV(SSX,12,B,1,DET)
      DO 66 I=1,3
   66 A4(I)=B(I+9)+A4(I)
      DO 49 I=1,3
      IF(ABS(B(I+9)/A4(I))-0.001)49,49,14
   49 CONTINUE
      GO TO 16
   17 SSXY(10)=SSXY(11)
      DO 20 J=1,10
      SSX(J,10)=SSX(J,11)
   20 SSX(10,J)=SSX(11,J)
      SSX(10,10)=SSX(11,11)
   18 SSXY(11)=SSXY(12)
      DO 31 J=1,11
      SSX(J,11)=SSX(J,12)
   31 SSX(11,J)=SSX(12,J)
      SSX(11,11)=SSX(12,12)
   19 CALL MATV(SSX,11,SSXY,0,DET)
      DO 21 J=1,11
      B(J)=0.0
      DO 21 K=1,11
   21 B(J)=B(J)+SSX(J,K)*SSXY(K)
      GO TO (22,23,30),K4
   22 DO 67 I=2,3
   67 A4(I)=B(I+8)+A4(I)
      DO 51 I=2,3
      IF(ABS(B(I+8)/A4(I))-0.001)51,51,14
   51 CONTINUE
      GO TO 16
   23 A4(1)=B(10)+A4(1)
      A4(3)=B(11)+A4(3)
      DO 35 I=1,3,2
      II=(I+1)/2
      IF(ABS(B(II+9)/A4(I))-0.001)35,35,14
   35 CONTINUE
      GO TO 16
   30 DO 68 I=1,2
```

```
    68 A4(I)=B(I+9)+A4(I)
       DO 53 I=1,2
       IF(ABS(B(I+9)/A4(I))-0.001)53,53,14
    53 CONTINUE
    16 K5=2
       GO TO 63
    14 K5=1
    63 GO TO (64,2,64),N5
    64 GO TO (61,61,61,2,61),K4
    61 B(1)=0.0
       B(2)=0.0
       DO 36 I=1,N1
       DO 36 J=1,IREP
       K=(J-1)*N1+I
       B(4)=(Y1(K)**A4(4)-1.)/A4(4)/DD
       B(5)=Y1(K)**A4(4)*ALOG(Y1(K))/A4(4)/DD
       B(6)=B(5)-B(4)/A4(4)-B(4)*ALOG(D)
       B(1)=B(1)+B(6)*B(6)
    36 B(2)=B(2)+B(6)*(YY2(I)-B(4))
       A4(4)=A4(4)+B(2)/B(1)
       IF(ABS((A4(4)-A5(4))/A4(4))-0.001)34,34,56
    56 K5=1
       GO TO 2
    34 GO TO (2,2,39),N5
    39 K5=2
       GO TO 2
       END
// DUP
*STORE       WS  UA  CMLE3


// JOB
// DUP
*DELETE              MATV
// FOR
* NAME MATV
*EXTENDED PRECISION
*ONE WORD INTEGERS
       SUBROUTINE MATV(A,N,B,M,DETM)
       DIMENSION IPVOT(12),A(12,12),B(12,1),INDEX(12,12),PIVOT(12)
       EQUIVALENCE (IROW,JROW),(ICLUM,JCLUM),(AMAX,T,SWAP)
       DETM=1.0
       DO 20 J=1,N
    20 IPVOT(J)=0
       DO 550 I=1,N
       AMAX=0.0
       DO 105 J=1,N
       IF(IPVOT(J)-1)60,105,60
    60 DO 100 K=1,N
       IF(IPVOT(K)-1)80,100,740
    80 IF(ABS(AMAX)-ABS(A(J,K)))85,100,100
    85 IROW=J
       ICLUM=K
       AMAX=A(J,K)
   100 CONTINUE
```

```
  105 CONTINUE
      IPVOT(ICLUM)=IPVOT(ICLUM)+1
      IF(IROW-ICLUM)140,260,140
  140 DETM=-DETM
      DO 200 L=1,N
      SWAP=A(IROW,L)
      A(IROW,L)=A(ICLUM,L)
  200 A(ICLUM,L)=SWAP
      IF(M)260,260,210
  210 DO 250 L=1,M
      SWAP=B(IROW,L)
      B(IROW,L)=B(ICLUM,L)
  250 B(ICLUM,L)=SWAP
  260 INDEX(I,1)=IROW
      INDEX(I,2)=ICLUM
      PIVOT(I)=A(ICLUM,ICLUM)
      DETM=DETM*PIVOT(I)
      A(ICLUM,ICLUM)=1.0
      DO 350 L=1,N
  350 A(ICLUM,L)=A(ICLUM,L)/PIVOT(I)
      IF(M)380,380,360
  360 DO 370 L=1,M
  370 B(ICLUM,L)=B(ICLUM,L)/PIVOT(I)
  380 DO 550 L1=1,N
      IF(L1-ICLUM)400,550,400
  400 T=A(L1,ICLUM)
      A(L1,ICLUM)=0.0
      DO 450 L=1,N
  450 A(L1,L)=A(L1,L)-A(ICLUM,L)*T
      IF(M)550,550,460
  460 DO 500 L=1,M
  500 B(L1,L)=B(L1,L)-B(ICLUM,L)*T
  550 CONTINUE
      DO 710 I=1,N
      L=N+1-I
      IF(INDEX(L,1)-INDEX(L,2))630,710,630
  630 JROW=INDEX(L,1)
      JCLUM=INDEX(L,2)
      DO 705 K=1,N
      SWAP=A(K,JROW)
      A(K,JROW)=A(K,JCLUM)
      A(K,JCLUM)=SWAP
  705 CONTINUE
  710 CONTINUE
  740 IF(DETM-0.000001)750,750,760
  750 DETM=0.0
  760 RETURN
      END
// DUP
*STORE       WS  UA  MATV


// JOB
// DUP
*DELETE              PMLR3
```

```
// FOR
*NAME PMLR3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER,DISK)
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,N
     15,AN4,NNNN
      DEFINE FILE 21(320,6,U,KK1)
   78 FORMAT(12A6)
   77 FORMAT('VALUE OF C   MAXIMUM AT C ='F8.4)
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF A'I1'   MAXIMUM AT A'I1' ='F7.3)
   74 FORMAT(F6.3)
   73 FORMAT('MAXIMUM LIKELIHOOD RATIO')
      AN5=N4-1
      DO 4 J=1,4
      GO TO (8,8,8,9),J
    8 GO TO (10,10,4),N5
    9 GO TO (10,4,10),N5
   10 X1=A3(J)
      X4=A3(J)-AN4
      A=2.0*AN4
      B1=A/20.
      C=X4-A/50.
      D=A/10.
      E=10./A
      F=X4-B1
      G=X4+D
      H=X4+A*1.3
      W=X4-A/15.
      Z=X4-D
      CALL SCALE(E,10.0,X4,0.0)
      CALL EGRID(0,X4,0.0,B1,20)
      CALL EGRID(1,X4,0.0,0.05,20)
      DO 2 I=1,11
      X1=G-D/10.0+D*FLOAT(I-2)
      XO=G+D*FLOAT(I-2)
      CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
    2 WRITE(7,74)XO
      DO 3 I=1,11
      X1=-0.1+0.1*FLOAT(I)
      CALL ECHAR(F,X1,0.1,0.1,0.0)
    3 WRITE(7,76)X1
      CALL ECHAR(G,-0.04,0.1,0.1,0.0)
      GO TO (5,5,5,6),J
    5 WRITE(7,75)J,J,A3(J)
      GO TO 7
    6 WRITE(7,77)A3(J)
    7 CALL ECHAR(W,0.1,0.1,0.1,1.5709)
      WRITE(7,73)
      CALL ECHAR(Z,0.0,0.1,0.1,1.5709)
      WRITE(7,78)TITL
      CALL EPLOT(-2,X4,0.0)
      DO 1 I=1,N4
      A4(J)=I*A/AN5+X4-A/AN5
```

```
      K=(J-1)*N4+I
      READ(21'K)R
      IF(R-1.0)1,1,11
   11 R=1.0
    1 CALL EPLOT(0,A4(J),R)
      CALL EPLOT(1,H,0.0)
    4 CONTINUE
      CALL DATSW(8,J8)
      GO TO (12,13),J8
   13 N4=2
      CALL LINK(INFO3)
   12 CALL LINK(CPAR3)
      END
// DUP
*STORE       WS  UA  PMLR3


// JOB
// DUP
*DELETE              CPAR3
// FOR
*NAME CPAR3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(1132 PRINTER,DISK)
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,N
     15,AN4,NNNN,D,RRR(4),BB(9)
      DEFINE FILE 21(320,6,U,KK1)
   80 FORMAT('1'12A6)
   79 FORMAT(9E13.5/26X6E13.5,I6)
   78 FORMAT('0POINTS PLOTTED FOR MLR GRAPH OF B('I1')'//9(6X'B('I1')'3X
     1)/6X'A1'11X'A2'11X'A3'11X'C'11X'SSD'12X'R'10X'ITER')
      DO 14 I=1,4
   14 A4(I)=A3(I)
      V2=0.0
      J3=13
      D=0.0
      DO 11 I=1,N
   11 D=D+ALOG(Y(I))
      DD=EXP(D/FLOAT(N))
      CALL CMLE3(5,ITER,V2,J3)
      SS=SSY
      DO 5 I=1,9
    5 BB(I)=B(I)
      IF(N4-35)8,8,9
    8 AN5=N4-1
      GO TO 10
    9 N4=35
      AN5=34
   10 DO 1 J3=1,9
      IF(BB(J3))2,2,3
    2 X4=2.0*BB(J3)
      GO TO 13
    3 X4=0.0
   13 A=2.0*ABS(BB(J3))
```

```
      WRITE(3,80)TITL
      WRITE(3,78)J3,(I,I=1,9)
      DO 4 I=1,4
    4 A4(I)=A3(I)
      DO 1 KK=1,N4
      DO 15 I=1,4
      IF(ABS(A4(I))-5.0)15,15,16
   16 A4(I)=A3(I)
   15 CONTINUE
      V2=(KK-1)*A/AN5+X4
      CALL CMLE3(5,ITER,V2,J3)
      R=N*ALOG(SS/SSY)/2.0
      R=EXP(R)
      LLL=(J3-1)*N4+KK
      WRITE(21'LLL)R
      DO 6 J=1,9
    6 B(J)=A4(4)*DD**(A4(4)-1.0)*B(J)
      WRITE(3,79)(B(J),J=1,9),A4,SSY,R,ITER
    1 CONTINUE
      DO 12 I=1,4
   12 A4(I)=A3(I)
      V2=0.0
      J3=13
      CALL CMLE3(5,ITER,V2,J3)
      DO 7 J=1,9
    7 B(J)=A4(4)*DD**(A4(4)-1.0)*B(J)
      CALL LINK(PPAR3)
      END
// DUP
*STORE       WS  UA  CPAR3


// JOB
// DUP
*DELETE              PPAR3
// FOR
*NAME PPAR3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER,DISK)
      COMMON Y(80),X(20,3),BB(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,
     1N5
      DEFINE FILE 21(320,6,U,KK1)
   78 FORMAT(12A6)
   77 FORMAT('MAXIMUM LIKELIHOOD RATIO')
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF B('I1') = MLE OF B('I1') ='E10.3)
   74 FORMAT(E10.3)
      IF(N4-35)8,8,9
    8 AN5=N4-1
      GO TO 10
    9 N4=35
      AN5=34
   10 DO 4 J3=1,9
      IF(BB(J3))5,5,6
```

```
    5 X4=2.0*BB(J3)
      GO TO 7
    6 X4=0.0
    7 A=2.0*ABS(BB(J3))
      B1=A/20.
      C=X4-A/50.
      D=A/10.
      E=10./A
      F=X4-B1
      G=X4+D
      H=X4+A*1.3
      W=X4-A/15.
      Z=X4-D
      CALL SCALE(E,10.0,X4,0.0)
      CALL EGRID(0,X4,0.0,B1,20)
      CALL EGRID(1,X4,0.0,0.05,20)
      DO 2 I=1,11
      X1=G+D*FLOAT(I-3)+D/2.5
      XO=G+D*FLOAT(I-2)
      CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
    2 WRITE(7,74)XO
      DO 3 I=1,11
      X1=-0.1+0.1*FLOAT(I)
      CALL ECHAR(F,X1,0.1,0.1,0.0)
    3 WRITE(7,76)X1
      CALL ECHAR(G,-0.04,0.1,0.1,0.0)
      WRITE(7,75)J3,J3,BB(J3)
      CALL ECHAR(W,0.1,0.1,0.1,1.5709)
      WRITE(7,77)
      CALL ECHAR(Z,0.0,0.1,0.1,1.5709)
      WRITE(7,78)TITL
      CALL EPLOT(-2,X4,0.0)
      DO 1 KK=1,N4
      V2=(KK-1)*A/AN5+X4
      LLL=(J3-2)*N4+KK
      READ(21'LLL)R
      IF(R-1.0)1,1,11
   11 R=1.0
    1 CALL EPLOT(0,V2,R)
      CALL EPLOT(1,H,0.0)
    4 CONTINUE
      N4=2
      CALL LINK(INFO3)
      END
// DUP
*STORE       WS  UA  PPAR3


// JOB
// DUP
*DELETE              INFO3
// FOR
*NAME INFO3
*EXTENDED PRECISION
*ONE WORD INTEGERS
```

```
*IOCS(1132 PRINTER)
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,X
     1X(12),YY2(20),A5(4),SSXY(12),YY,X1(12),YY1(4),SSY1(4),SSX2(12,12)
   89 FORMAT(' STANDARD DEVIATIONS WITHIN OBSERVATION SETS'/25X4F11.2)
   88 FORMAT(' VARIANCES WITHIN OBSERVATION SETS'/25X4F11.2)
   87 FORMAT(' MEANS WITHIN OBSERVATION SETS'/25X4F11.2)
   86 FORMAT('0VARIANCE-COVARIANCE MATRIX'/)
   85 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4'  A3 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARI
     2ABLE - C ='F8.4)
   84 FORMAT('0B(J) COEFFICIENTS'/'0'10E12.4)
   83 FORMAT('0INFORMATION MATRIX FOR PARAMETERS OF UNTRANSFORMED DATA'/
     1)
   82 FORMAT('0INFORMATION MATRIX FOR PARAMETERS OF TRANSFORMED DATA'/)
   81 FORMAT(1X3F8.3,7F11.2)
   80 FORMAT('1'12A6)
   79 FORMAT(' '9E13.4)
   78 FORMAT('0*** VARIABLES FITTED'//4X'X1'6X'X2'6X'X3'4X4(' OBS. SET'I
     12)'     MEAN       VARIANCE    ST. DEV.')
      N1=N/IREP
      DO 7 I=1,4
    7 A5(I)=A4(I)
      YY=0.0
      DO 1 I=1,N
    1 YY=YY+Y(I)/N
      WRITE(3,80)TITL
      N2=N+1
      DO 9 I=N2,80
    9 Y(I)=0.0
      WRITE(3,78)(I,I=1,4)
      DO 14 I=1,N1
      YYY=0.0
      DO 12 J=1,IREP
      N2=(J-1)*N1+I
   12 YYY=YYY+Y(N2)/IREP
      SYY=0.0
      DO 13 J=1,IREP
      N2=(J-1)*N1+I
   13 SYY=SYY+(Y(N2)-YYY)*(Y(N2)-YYY)
      SSYY=SQRT(SYY)
      N6=N1+I
      N2=N1*2+I
      N3=N1*3+I
   14 WRITE(3,81)(X(I,J),J=1,3),Y(I),Y(N6),Y(N2),Y(N3),YYY,SYY,SSYY
      DO 8 I=1,IREP
      YY1(I)=0.0
      DO 8 J=1,N1
      N2=(I-1)*N1+J
    8 YY1(I)=YY1(I)+Y(N2)/N1
      DO 15 I=1,IREP
      SSY1(I)=0.0
      DO 15 J=1,N1
      N2=(I-1)*N1+J
   15 SSY1(I)=SSY1(I)+(Y(N2)-YY1(I))*(Y(N2)-YY1(I))
      WRITE(3,87)(YY1(I),I=1,IREP)
```

```
   WRITE(3,88)(SSY1(I),I=1,IREP)
   DO 16 I=1,IREP
16 SSY1(I)=SQRT(SSY1(I))
   WRITE(3,89)(SSY1(I),I=1,IREP)
   DO 17 J=1,4
17 A4(J)=1.0
   DO 10 K=1,2
   GO TO (20,22),K
20 GO TO (23,22),N4
22 DO 36 J=1,9
36 XX(J)=0.0
   DO 6 I=1,N1
   DO 4 J1=1,3
   X1(J1)=X(I,J1)**A4(J1)
 4 X1(J1+3)=X1(J1)*X1(J1)
   X1(7)=X1(1)*X1(2)
   X1(8)=X1(1)*X1(3)
   X1(9)=X1(2)*X1(3)
   DO 6 J=1,9
 6 XX(J)=XX(J)+X1(J)/N1
   DO 24 I=1,N1
   YY2(I)=0.0
   DO 24 J=1,IREP
   N2=(J-1)*N1+I
24 YY2(I)=YY2(I)+Y(N2)**A4(4)/IREP
   DO 25 I=1,9
   SSXY(I)=0.0
   DO 25 J=1,9
25 SSX2(I,J)=0.0
   DO 27 I=1,N1
   DO 3 J=1,3
   X1(J)=X(I,J)**A4(J)
 3 X1(J+3)=X1(J)*X1(J)
   X1(7)=X1(1)*X1(2)
   X1(8)=X1(1)*X1(3)
   X1(9)=X1(2)*X1(3)
   DO 27 J=1,9
   SSXY(J)=SSXY(J)+(YY2(I)-YY)*(X1(J)-XX(J))
   DO 27 J1=1,9
27 SSX2(J,J1)=SSX2(J,J1)+(X1(J)-XX(J))*(X1(J1)-XX(J1))
   WRITE(3,80)TITL
   GO TO (18,26),K
18 WRITE(3,83)
   GO TO 19
26 WRITE(3,85)A4
   WRITE(3,82)
19 DO 30 I=1,9
30 WRITE(3,79)(SSX2(I,J),J=1,9)
   CALL MATV(SSX2,9,SSXY,0,DET)
   GO TO (28,29),K
28 GO TO (31,29),N4
29 WRITE(3,86)
   DO 5 I=1,9
 5 WRITE(3,79)(SSX2(I,J),J=1,9)
31 DO 11 J=1,9
```

```
      B(J)=0.0
      DO 11 I=1,9
   11 B(J)=B(J)+SSX2(I,J)*SSXY(I)
      AA=YY
      DO 32 J=1,9
   32 AA=AA-B(J)*XX(J)
      GO TO (33,34),K
   33 GO TO (23,34),N4
   34 WRITE(3,84)AA,(B(J),J=1,9)
   23 DO 21 I=1,4
   21 A4(I)=A3(I)
   10 CONTINUE
      DO 2 I=1,4
    2 A4(I)=A5(I)
      CALL LINK(ANVA3)
      END
// DUP
*STORE       WS  UA  INFO3


// JOB
// DUP
*DELETE                ANVA3
// FOR
*NAME ANVA3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(1132 PRINTER)
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,X
     1X(9),YY2(20),A5(4),SSXY(12),YY,X1(9),SS(9),YY1(4),SSY1(4),SSY5(9),
     2SSX3(12,12),SSX1(12,12),W(20,9)
   85 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4'  A3 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARI
     2ABLE - C ='F8.4)
   84 FORMAT(9F12.5)
   83 FORMAT('0CROSS PRODUCT MATRIX'/)
   82 FORMAT('0NORMAL ORTHOGONAL POLYNOMIALS'//7X'X1'10X'X2'10X'X3'8X'X1
     1*X1'7X'X2*X2'7X'X3*X3'7X'X1*X2'7X'X1*X3'7X'X2*X3')
   81 FORMAT('0ANALYSIS OF VARIANCE TABLE - TRANSFORMED DATA'/'0   SOURC
     1E'11X'SS'6X'D.F.'5X'MSS'7X'APPROX. F'6X'MLR')
   80 FORMAT('1'12A6)
   78 FORMAT('0ANALYSIS OF VARIANCE TABLE - UNTRANSFORMED DATA'/'0   SOU
     1RCE'11X'SS'6X'D.F.'5X'MSS'11X'F'9X'MLR')
   77 FORMAT(' TREATMENTS  'F12.2,I6,2F12.2,E16.6)
   76 FORMAT('  LINEAR     'F12.2,I6,2F12.2,E16.6)
   75 FORMAT('    X1 LINEAR 'F12.2,I6,2F12.2,E16.6)
   74 FORMAT('    X2 LINEAR 'F12.2,I6,2F12.2,E16.6)
   64 FORMAT('    X3 LINEAR 'F12.2,I6,2F12.2,E16.6)
   73 FORMAT('  QUADRATIC   'F12.2,I6,2F12.2,E16.6)
   72 FORMAT('    X1 QUAD.  'F12.2,I6,2F12.2,E16.6)
   71 FORMAT('    X2 QUAD.  'F12.2,I6,2F12.2,E16.6)
   63 FORMAT('    X3 QUAD.  'F12.2,I6,2F12.2,E16.6)
   62 FORMAT('  INTERACTION 'F12.2,I6,2F12.2,E16.6)
   70 FORMAT('    X1 * X2   'F12.2,I6,2F12.2,E16.6)
   68 FORMAT('    X1 * X3   'F12.2,I6,2F12.2,E16.6)
```

```
79 FORMAT('    X2 * X3    'F12.2,I6,2F12.2,E16.6)
65 FORMAT('  TRANSFORM    'F12.2,I6,2F12.2,E16.6)
69 FORMAT('  LACK OF FIT'F12.2,I6,2F12.2,E16.6)
67 FORMAT(' RESIDUAL      'F12.2,I6, F12.2)
66 FORMAT(' TOTAL         'F12.2,I6)
   N1=N/IREP
   D=0.0
   DO 52 I=1,N
52 D=D+ALOG(Y(I))
   DO 51 I=1,4
   A5(I)=A4(I)
51 A4(I)=1.0
   DO 10 K=1,2
   YY=0.0
   DO 1 I=1,N
 1 YY=YY+Y(I)**A4(4)/N
   DO 40 I=1,N1
   YY2(I)=0.0
   DO 40 J=1,IREP
   N2=(J-1)*N1+I
40 YY2(I)=YY2(I)+Y(N2)**A4(4)/IREP
   TOT=0.0
   DO 3 I=1,N
 3 TOT=TOT+(Y(I)**A4(4)-YY)*(Y(I)**A4(4)-YY)
   TREAT=0.0
   DO 4 I=1,N1
 4 TREAT=TREAT+(YY2(I)-YY)*(YY2(I)-YY)
   TREAT=TREAT*IREP
   DO 6 J=1,3
   XX(J)=0.0
   DO 6 I=1,N1
   X1(J)=X(I,J)**A4(J)
 6 XX(J)=XX(J)+X1(J)/N1
   DO 39 I=1,3
39 B(I)=0.0
   DO 37 I=1,N1
   DO 37 J=1,3
   X1(J)=X(I,J)**A4(J)
37 B(J)=B(J)+(X1(J)-XX(J))*(X1(J)-XX(J))
   DO 5 I=1,N1
   DO 5 J=1,3
 5 W(I,J)=(X(I,J)**A4(J)-XX(J))/SQRT(B(J))
   DO 7 J=1,3
   X1(J)=0.0
   SS(J)=0.0
   AA2=A4(J)*2.0
   DO 7 I=1,N1
   X1(J)=X1(J)+X(I,J)**AA2
 7 SS(J)=SS(J)+X(I,J)**AA2*(X(I,J)**A4(J)-XX(J))
   DO 8 I=1,N1
   DO 8 J=1,3
 8 W(I,J+3)=(X(I,J)*X(I,J))**A4(J)-X1(J)/N1-(X(I,J)**A4(J)-XX(J))*SS(
  1J)/B(J)
   DO 9 J=1,3
   SS(J)=0.0
```

```
      DO 9 I=1,N1
    9 SS(J)=SS(J)+W(I,J+3)*W(I,J+3)
      DO 11 I=1,N1
      DO 11 J=4,6
   11 W(I,J)=W(I,J)/SQRT(SS(J-3))
      DO 16 I=1,9
      SSXY(I)=0.0
      DO 16 J=1,9
   16 SSX1(I,J)=0.0
      DO 18 I=1,N1
      W(I,7)=W(I,1)*W(I,2)
      W(I,8)=W(I,1)*W(I,3)
      W(I,9)=W(I,2)*W(I,3)
      DO 18 J=1,9
      SSXY(J)=SSXY(J)+(YY2(I)-YY)*W(I,J)
      DO 18 J1=1,9
   18 SSX1(J,J1)=SSX1(J,J1)+W(I,J)*W(I,J1)
      GO TO (19,26),K
   19 GO TO (27,26),N4
   26 WRITE(3,80)TITL
      GO TO (28,29),K
   29 WRITE(3,85)A4
   28 WRITE(3,82)
      WRITE(3,84)((W(I,J),J=1,9),I=1,N1)
      WRITE(3,83)
      WRITE(3,84)((SSX1(I,J),J=1,9),I=1,9)
   27 CALL MATV(SSX1,9,SSXY,0,DET)
      DO 30 J=1,9
      B(J)=0.0
      DO 30 I=1,9
   30 B(J)=B(J)+SSX1(I,J)*SSXY(I)
      DEV=TREAT
      DO 17 J=1,9
   17 DEV=DEV-B(J)*SSXY(J)*IREP
      DO 12 J=1,3
      DO 12 J1=1,3
   12 SSX3(J,J1)=SSX1(J,J1)
      CALL MATV(SSX3,3,SSXY,0,DET)
      SS1=0.0
      DO 14 I=1,3
      DO 14 J=1,3
   14 SS1=SS1+B(J)*SSX3(I,J)*B(I)*IREP
      DO 13 J=1,3
      DO 13 J1=1,3
   13 SSX3(J,J1)=SSX1(J+3,J1+3)
      CALL MATV(SSX3,3,SSXY,0,DET)
      SS2=0.0
      DO 15 I=1,3
      DO 15 J=1,3
   15 SS2=SS2+B(J+3)*SSX3(I,J)*B(I+3)*IREP
      DO 41 J=1,3
      DO 41 J1=1,3
   41 SSX3(J,J1)=SSX1(J+6,J1+6)
      CALL MATV(SSX3,3,SSXY,0,DET)
      SS3=0.0
```

```
      DO 42 I=1,3
      DO 42 J=1,3
   42 SS3=SS3+B(J+6)*SSX3(I,J)*B(I+6)*IREP
      DO 31 I=1,9
   31 SS(I)=B(I)*B(I)/SSX1(I,I)*IREP
      I1=1
      I2=3
      I3=N1-1
      I5=0
      DO 33 I=1,4
      IF(A4(I)-1.0)34,33,34
   34 I5=I5+1
   33 CONTINUE
      NN=N-I3-1
      NNN=N-1
      GO TO (20,22),K
   20 SSY3=DEV
      I4=I3-9
      DEVM=DEV/I4
      GO TO 35
   22 SSY3=SSY3-DEV
      SSY3M=SSY3/I5
      I4=I3-I5-9
      DEVM=DEV/I4
   35 IF(IREP-1)36,36,38
   38 RES=TOT-TREAT
      RESM=RES/NN
      RR=RES+DEV
      GO TO 43
   36 RES=DEV
      RESM=DEVM
      RR=RES
   43 SS1M=SS1/3.0
      SS2M=SS2/3.0
      SS3M=SS3/3.0
      TREAM=TREAT/I3
      F1=TREAM/RESM
      F2=SS1M/RESM
      F21=SS(1)/RESM
      F22=SS(2)/RESM
      F23=SS(3)/RESM
      F3=SS2M/RESM
      F31=SS(4)/RESM
      F32=SS(5)/RESM
      F33=SS(6)/RESM
      F4=SS3M/RESM
      F41=SS(7)/RESM
      F42=SS(8)/RESM
      F43=SS(9)/RESM
      F6=SSY3M/RESM
      F4=DEVM/RESM
      DO 53 I=1,9
   53 SSY5(I)=(RR/(RR+SS(I)))**(FLOAT(N)/2.0)
      SS4=(RR/(RR+TREAT))**(FLOAT(N)/2.0)
      SS5=(RR/(RR+SS1))**(FLOAT(N)/2.0)
```

```
      SS6=(RR/(RR+SS2))**(FLOAT(N)/2.0)
      SS7=(RR/(RR+SS3))**(FLOAT(N)/2.0)
      SS8=(DEV/RR)**(FLOAT(N)/2.0)
      GO TO (44,45),K
   44 RRR=RR
      GO TO (50,25),N4
   45 WRITE(3,80)TITL
      WRITE(3,85)A4
      WRITE(3,81)
      RRR=N*ALOG(RR/RRR)/2.0+(A3(4)-1.0)*D
      RRR=EXP(RRR)
      GO TO 32
   25 WRITE(3,80)TITL
      WRITE(3,78)
   32 WRITE(3,77)TREAT,I3,TREAM,F1,SS4
      WRITE(3,76)SS1,I2,SS1M,F2,SS5
      WRITE(3,75)SS(1),I1,SS(1),F21,SSY5(1)
      WRITE(3,74)SS(2),I1,SS(2),F22,SSY5(2)
      WRITE(3,64)SS(3),I1,SS(3),F23,SSY5(3)
      WRITE(3,73)SS2,I2,SS2M,F3,SS6
      WRITE(3,72)SS(4),I1,SS(4),F31,SSY5(4)
      WRITE(3,71)SS(5),I1,SS(5),F32,SSY5(5)
      WRITE(3,63)SS(6),I1,SS(6),F33,SSY5(6)
      WRITE(3,62)SS3,I2,SS3M,F4,SS7
      WRITE(3,70)SS(7),I1,SS(7),F41,SSY5(7)
      WRITE(3,68)SS(8),I1,SS(8),F42,SSY5(8)
      WRITE(3,79)SS(9),I1,SS(9),F43,SSY5(9)
      GO TO (23,24),K
   24 IF(A3(4)-1.0)23,46,23
   46 WRITE(3,65)SSY3,I5,SSY3M,F6,RRR
   23 IF(IREP-1)47,47,48
   47 WRITE(3,69)DEV,I4,DEVM
      GO TO 49
   48 WRITE(3,69)DEV,I4,DEVM,F4,SS8
      WRITE(3,67)RES,NN,RESM
   49 WRITE(3,66)TOT,NNN
   50 DO 21 I=1,4
   21 A4(I)=A3(I)
   10 CONTINUE
      DO 2 I=1,4
    2 A4(I)=A5(I)
      GO TO (56,55),N4
   56 CALL DATSW(8,J8)
      GO TO (54,55),J8
   54 CALL LINK(COEF3)
   55 CALL LINK(EIGN3)
      END
// DUP
*STORE       WS  UA  ANVA3


// JOB
// DUP
*DELETE              COEF3
// FOR
```

```
*NAME COEF3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER,1132 PRINTER)
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,N
     15,X2(10),YY2(20),SSXY(12),BB(12),I5(8),SSX(12,12)
   82 FORMAT('POWER TRANSFORMATIONS  A1='F8.4'  A2='F8.4'  A3='F8.4'  C=
     1'F8.4)
   81 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4'  A3='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARIA
     2BLE - C ='F8.4)
   80 FORMAT('1'12A6)
   79 FORMAT(11E10.3)
   78 FORMAT(12A6)
   77 FORMAT('0POINTS PLOTTED FOR MLR GRAPH OF B('I1')'/9(4X'B('I1')'2X)
     14X'SSD'8X'R')
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF B('I1')  -  MLE OF B('I1') ='E10.3)
   74 FORMAT(E10.3)
   73 FORMAT('MAXIMUM LIKELIHOOD RATIO')
      N1=N/IREP
      SSY=0.0
      DO 16 I=1,N
   16 SSY=SSY+(Y(I)*Y(I))**A3(4)
      DO 14 I=1,N1
      YY2(I)=0.0
      DO 14 J=1,IREP
      K=(J-1)*N1+I
   14 YY2(I)=YY2(I)+Y(K)**A3(4)/IREP
      X2(1)=1.0
      DO 32 I=1,10
      BB(I)=0.0
      DO 32 J=1,10
   32 SSX(I,J)=0.0
      DO 33 I=1,N1
      DO 31 J=2,4
      X2(J)=X(I,J-1)**A3(J-1)
   31 X2(J+3)=X2(J)*X2(J)
      X2(8)=X2(2)*X2(3)
      X2(9)=X2(2)*X2(4)
      X2(10)=X2(3)*X2(4)
      DO 33 J=1,10
      BB(J)=BB(J)+YY2(I)*X2(J)
      SSXY(J)=BB(J)
      DO 33 K=1,10
   33 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
      CALL MATV(SSX,10,BB,1,DET)
      SS=SSY
      DO 15 I=1,10
   15 SS=SS-SSXY(I)*BB(I)*IREP
      DO 21 JJ=2,10
      J3=JJ-1
      AN5=44
      IF(BB(JJ))25,25,26
   25 X4=2.0*BB(JJ)
```

```
      GO TO 27
   26 X4=0.0
   27 A=2.0*ABS(BB(JJ))
      B1=A/20.
      C=X4-A/50.
      D=A/10.
      E=10./A
      F=X4-B1
      G=X4+D
      H=X4+A*1.3
      W=X4-A/15.
      U=X4-A/7.5
      Z=X4-D
      CALL SCALE(E,10.0,X4,0.0)
      CALL EGRID(0,X4,0.0,B1,20)
      CALL EGRID(1,X4,0.0,0.05,20)
      DO 2 I=1,11
      X1=G+D*FLOAT(I-3)+D/2.5
      IF(X1)35,36,36
   35 NN1=-1
      GO TO 37
   36 NN1=1
   37 XO=G+D*FLOAT(I-2)*NN1
      CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
    2 WRITE(7,74)XO
      DO 3 I=1,11
      X1=-0.1+0.1*FLOAT(I)
      CALL ECHAR(F,X1,0.1,0.1,0.0)
    3 WRITE(7,76)X1
      CALL ECHAR(G,-0.04,0.1,0.1,0.0)
      WRITE(7,75)J3,J3,BB(JJ)
      CALL ECHAR(W,0.1,0.1,0.1,1.5709)
      WRITE(7,73)
      CALL ECHAR(Z,0.0,0.1,0.1,1.5709)
      WRITE(7,78)TITL
      CALL ECHAR(U,0.0,0.1,0.1,1.5709)
      WRITE(7,82)A3
      CALL EPLOT(-2,X4,0.0)
      WRITE(3,80)TITL
      WRITE(3,81)A3
      DO 4 I=2,10
      IF(I-JJ)7,4,5
    7 JJJ=I-1
      GO TO 6
    5 JJJ=I-2
    6 I5(JJJ)=I-1
    4 CONTINUE
      WRITE(3,77)J3,J3,I5
      DO 1 KK=1,45
      V2=(KK-1)*A/AN5+X4
      SSY1=0.0
      DO 17 I=1,9
      SSXY(I)=0.0
      DO 17 J=1,9
   17 SSX(I,J)=0.0
```

```
      DO 18 I=1,N1
      DO 28 J=2,4
      X2(J)=X(I,J-1)**A3(J-1)
   28 X2(J+3)=X2(J)*X2(J)
      X2(8)=X2(2)*X2(3)
      X2(9)=X2(2)*X2(4)
      X2(10)=X2(3)*X2(4)
      DO 34 J=1,IREP
      K=(J-1)*N1+I
   34 SSY1=SSY1+(Y(K)-V2*X2(JJ))**2
      DO 18 J=1,10
      IF(J-JJ)20,18,30
   20 JJJ=J
      GO TO 29
   30 JJJ=J-1
   29 SSXY(JJJ)=SSXY(JJJ)+(YY2(I)-V2*X2(JJ))*X2(J)
      B(JJJ)=SSXY(JJJ)
      DO 18 K=1,10
      IF(K-JJ)11,18,12
   11 KKK=K
      GO TO 13
   12 KKK=K-1
   13 SSX(JJJ,KKK)=SSX(JJJ,KKK)+X2(J)*X2(K)
   18 CONTINUE
      CALL MATV(SSX,9,B,1,DET)
      DO 19 I=1,9
   19 SSY1=SSY1-SSXY(I)*B(I)*IREP
      R=(SS/SSY1)**(FLOAT(N)/2.0)
      WRITE(3,79)V2,(B(J),J=2,9),SSY1,R
    1 CALL EPLOT(0,V2,R)
      CALL EPLOT(1,H,0.0)
   21 CONTINUE
      CALL LINK(EIGN3)
      END
// DUP
*STORE       WS  UA  COEF3


// JOB
// DUP
*DELETE              EIGN3
// FOR
*NAME EIGN3
*IOCS(1132 PRINTER,TYPEWRITER,KEYBOARD)
*ONE WORD INTEGERS
*EXTENDED PRECISION
       DIMENSION ALAM1(3),ALAM2(3),PREP1(3,3),PREP2(3,3)
       COMMON Y(80),X(20,3),V(12),A4(4),SSY,NS,NREPS,TITL(12),ID,A3(4),N4
     1,N5,YS2(6),V1(3,2),ALAMD(3,2),PREP(3,3,2),X1(10),Z(3),YDEV(20),A5(
     24),COE(12),NNN(4),XC(20,3),BA(12,12)
       EQUIVALENCE (ALAMD(1,1),ALAM1(1)),(ALAMD(1,2),ALAM2(1)),(PREP(1,1,
     11),PREP1(1,1)),(PREP(1,1,2),PREP2(1,1))
    89 FORMAT(1HO,8X,'EIGEN VALUES',10X,'EIGEN VECTORS AS ROWS',/,)
    88 FORMAT('0'2(E11.4,'=YS'3X)'IN ORIGINAL UNITS'/)
    87 FORMAT(1HO,6(E11.4,'=X'I1'S'2X)' IN ORIGINAL UNITS')
```

```
 86 FORMAT(I4,3F9.3,6F15.3)
 85 FORMAT(1H0,1X,'TABLE OF RESIDUALS')
 84 FORMAT(I3)
 83 FORMAT('TYPE 1 TO CALL EXIT, EOF TO CONTINUE')
 82 FORMAT('1'12A6)
 81 FORMAT(1H0,5X,3HY =,E15.6,3H = ,3(2H +,E15.6,2H Z,I1,3H SQ),/,)
 80 FORMAT(1H0,7X,'Y EST',4X,'Y OBS',4X,'DEVN',12X,'VALUES OF Z',33X,'
   1FACTOR LEVELS'/)
 79 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
    14'  A2 ='F8.4'  A3 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARI
    2ABLE - C ='F8.4)
 78 FORMAT( 52H0 CANONICAL REGRESSION   (Z ARE CANONICAL VARIABLES),/)
 77 FORMAT(29H0  CENTRE OF RESPONSE SURFACE  ,/,)
    N5=1
    DO 27 I=1,4
 27 A5(I)=A4(I)
    N1=NS/NREPS
    GO TO (11,10),N4
 11 DO 12 I=1,4
 12 A4(I)=A3(I)
    GO TO 13
 10 DO 5 I=1,4
  5 A4(I)=1.0
 13 DO 4 LL=1,N4
    WRITE(3,82)TITL
    GO TO (14,15),N4
 15 GO TO (19,14),LL
 14 WRITE(3,79)A3
 19 DO 6 I=1,N1
    DO 20 K=1,3
 20 XC(I,K)=X(I,K)**A4(K)
    YDEV(I)=0.0
    DO 6 K=1,NREPS
    KK=(K-1)*N1+I
  6 YDEV(I)=YDEV(I)+Y(KK)**A4(4)/NREPS
    DO 7 I=1,10
    V(I)=0.0
    DO 7 J=1,10
  7 BA(I,J)=0.0
    X1(1)=1.0
    DO 8 K=1,N1
    DO 3 J=2,4
  3 X1(J)=X(K,J-1)**A4(J-1)
    X1(5)=X1(2)*X1(2)
    X1(6)=X1(2)*X1(3)
    X1(7)=X1(3)*X1(3)
    X1(8)=X1(2)*X1(4)
    X1(9)=X1(3)*X1(4)
    X1(10)=X1(4)*X1(4)
    DO 8 I=1,10
    V(I)=V(I)+YDEV(K)*X1(I)
    DO 8 J=1,10
  8 BA(I,J)=BA(I,J)+X1(I)*X1(J)
    CALL MATV(BA,10,V,1,DET)
    DO 29 J=1,10
```

```
29 COE(J)=V(J)
   NFAK=3
   KP=NFAK+2
   DO 32 I=1,NFAK
   DO 32 J=1,I
   IF(I-J)31,30,31
30 PREP(I,J,LL)=V(KP)
   GO TO 32
31 PREP(I,J,LL)=V(KP)*0.5
   PREP(J,I,LL)=PREP(I,J,LL)
32 KP=KP+1
   DO 33 I=1,NFAK
33 V(I)=-V(I+1)*0.500
   DO 34 I=1,NFAK
   DO 34 J=1,NFAK
34 BA(I,J)=PREP(I,J,LL)
   WRITE(3,77)
   CALL MATV(BA,NFAK,V,1,DET)
   YS=COE(1)
   DO 44 I=1,NFAK
44 YS=YS+0.500*V(I)*COE(I+1)
   GO TO (35,36),N4
36 GO TO (37,35),LL
35 I1=1
   I2=2
   I3=3
   DO 40 I=1,3
   IF(V(I))38,38,39
38 NNN(I)=-1
   GO TO 40
39 NNN(I)=1
40 CONTINUE
   V3=V(1)**(1./A3(1))*NNN(1)
   V4=V(2)**(1./A3(2))*NNN(2)
   V5=V(3)**(1./A3(3))*NNN(3)
   IF(YS)41,41,42
41 NNN(4)=-1
   GO TO 43
42 NNN(4)=1
43 YS1=YS**(1./A3(4))*NNN(4)
   WRITE(3,87)(V(I),I,I=1,NFAK),V3,I1,V4,I2,V5,I3
   WRITE(3,88)YS,YS1
   GO TO 45
37 WRITE(3,87)(V(I),I,I=1,NFAK)
   WRITE(3,88)YS
45 WRITE(3,89)
   GO TO (22,23),LL
22 CALL CAN3(PREP1,ALAM1,NFAK)
   GO TO 24
23 CALL CAN3(PREP2,ALAM2,NFAK)
24 WRITE(3,78)
   WRITE(3,81)YS,(ALAMD(J,LL),J,J=1,NFAK)
   WRITE(3,85)
   WRITE(3,80)
   DO 18 J=1,N1
```

```
      YPRED=YS
      DO 16 I=1,NFAK
      Z(I)=0.0
      DO 16 L=1,NFAK
   16 Z(I)=Z(I)+(XC(J,L)-V(L))*PREP(I,L,LL)
      DO 17 L1=1,NFAK
   17 YPRED=YPRED+(Z(L1)**2)*ALAMD(L1,LL)
      YDEV1=YDEV(J)-YPRED
   18 WRITE(3,86)J,YPRED,YDEV(J),YDEV1,(Z(I),I=1,NFAK),(XC(J,II),II=1,NF
     1AK)
      DO 25 I=1,4
   25 A4(I)=A3(I)
      DO 46 I=1,3
   46 V1(I,LL)=V(I)
    4 CONTINUE
      DO 28 I=1,4
   28 A4(I)=A5(I)
      CALL DATSW(7,J7)
      GO TO (49,50),J7
   49 CALL LINK(CENT3)
   50 CALL DATSW(10,J10)
      GO TO (48,47),J10
   48 CALL LINK(SLIC3)
   47 GO TO (9,26),N4
    9 WRITE(1,83)
      READ(6,84)N5
      IF(N5)2,21,2
   26 IF(ID-98)1,2,1
    2 CALL EXIT
   21 CALL LINK(CRLF3)
    1 CALL LINK(BOX3)
      END
// DUP
*STORE       WS  UA  EIGN3


// JOB
// DUP
*DELETE              CAN3
// FOR
*NAME CAN3
*ONE WORD INTEGERS
*EXTENDED PRECISION
      SUBROUTINE CAN3(AA,AMBDA,N)
      DIMENSION AA(3,3),AMBDA(3),E(9),D(9)
   80 FORMAT(4X,I2,5X,E15.6,5X,3E15.6)
      NQ=+1
      K=1
      DO 1 I=1,N
      DO 1 J=1,I
      E(K)=AA(I,J)
    1 K=K+1
      CALL JACOB(E,D,AMBDA,N,NQ)
      K=1
      DO 2 I=1,N
```

```
      DO 2 J=1,N
      AA(I,J)=D(K)
    2 K=K+1
      DO 3 I=1,N
    3 WRITE(3,80)I,AMBDA(I),(AA(I,J),J=1,N)
      RETURN
      END
// DUP
*STORE      WS  UA  CAN3


// JOB
// DUP
*DELETE              JACOB
// FOR
*NAME JACOB
*ONE WORD INTEGERS
*EXTENDED PRECISION
      SUBROUTINE JACOB(A,B,C,NAA,NQ)
      DIMENSION A(1),B(1),C(1)
      LOOPC=0
      NA=NAA
      NN=(NA*(NA+1))/2
      IF (NQ) 120,100,100
  100 K=1
      DO 115 I=1,NA
      DO 115 J=1,NA
      IF(I-J)105,110,105
  105 B(K)=0.
      GO TO 115
  110 B(K)=1.
  115 K=K+1
  120 SUM=0.
      IF(NA-1)325,310,125
  125 K=1
      AMAX=0.
      DO 155 I=1,NA
      DO 150 J=1,I
      IF(I-J)135,145,135
  135 IF(ABS(A(K))-AMAX)145,145,140
  140 AMAX=ABS(A(K))
  145 TERM=A(K)*A(K)
      SUM=SUM+TERM+TERM
  150 K=K+1
  155 SUM=SUM-TERM
      SUM=SQRT(SUM)
      THRES=SUM/SQRT(FLOAT(NA))
      THRSH=THRES*1.0E-08
      IF(THRSH-AMAX)165,310,310
  165 THRES=AMAX/3.
      IF(THRES-THRSH)175,180,180
  175 THRES=THRSH
  180 K=2
      N=0
      JD=1
```

```
      DO 270 J=2,NA
      JD=JD+J
      JJ=J-1
      ID=0
      DO 265 I=1,JJ
      ID=ID+I
      IF(ABS(A(K))-THRES)265,265,195
  195 N=N+1
      ALPHA=(A(JD)-A(ID))/(2.*A(K))
      BETA=1./(1.+ALPHA*ALPHA)
      ROOT=1.0+ABS(ALPHA)*ESQRT(BETA)
      IF(ALPHA)205,200,200
  200 SSQ=0.5*BETA/ROOT
      CSQ=0.5*ROOT
      GO TO 210
  205 CSQ=0.5*BETA/ROOT
      SSQ=0.5*ROOT
  210 CC=SQRT(CSQ)
      S=-SQRT(SSQ)
      TWOSC=CC*S*2.
      TEMPA=CSQ*A(ID)+TWOSC*A(K)+SSQ*A(JD)
      A(JD)=CSQ*A(JD)-TWOSC*A(K)+SSQ*A(ID)
      A(ID)=TEMPA
      A(K)=0.
      KA=JD-J
      KB=ID-I
      KC=NA*(I-1)
      KD=NA*(J-1)
      DO 260 L=1,NA
      KC=KC+1
      KD=KD+1
      TEMPA=CC*B(KC)+S*B(KD)
      B(KD)=-S*B(KC)+CC*B(KD)
      B(KC)=TEMPA
      IF(I-L)230,220,245
  220 KB=KB+1
  225 KA=KA+1
      GO TO 260
  230 KB=KB+L-1
      IF(J-L)240,225,250
  240 KA=KA+L-1
      GO TO 255
  245 KB=KB+1
  250 KA=KA+1
  255 TEMPA=CC*A(KB)+S*A(KA)
      A(KA)=-S*A(KB)+CC*A(KA)
      A(KB)=TEMPA
  260 CONTINUE
  265 K=K+1
  270 K=K+1
      LOOPC=LOOPC+1
      IF(LOOPC-50)275,305,305
  275 IF(N-NN/8)280,280,180
  280 IF(THRES-THRSH)285,300,285
  285 THRES=THRSH/3.
```

```
      IF(THRES-THRSH)295,180,180
  295 THRES=THRSH
      GO TO 180
  300 IF(N)180,310,180
  305 WRITE(3,901)
  901 FORMAT(25H EIGENVALUE NOT CONVERGED  )
  310 LL=0
      DO 320 L=1,NA
      LL=LL+L
  320 C(L)=A(LL)
  325 RETURN
      END
// DUP
*STORE       WS  UA  JACOB


// JOB
// DUP
*DELETE                CENT3
// FOR
*NAME CENT3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(1132 PRINTER)
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,N
     15,YS(6),V1(3,2),R(45,3,2),X2(7),V2(3),YY2(20),SSXY(10),A5(4),SSX(1
     22,12),BB(12)
   81 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4'  A3 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARI
     2ABLE - C ='F8.4)
   80 FORMAT('1'12A6)
   79 FORMAT(5E15.5)
   78 FORMAT('0POINTS PLOTTED FOR MLR GRAPH OF X'I1'S'/7X'X1S'12X'X2S'12
     1X'X3S'13X'SSD'13X'R')
      N1=N/IREP
      DO 8 I=1,4
    8 A5(I)=A4(I)
      GO TO (9,10),N4
    9 DO 22 I=1,4
   22 A4(I)=A3(I)
      GO TO 23
   10 DO 24 I=1,4
   24 A4(I)=1.0
   23 DO 4 LL=1,N4
      SSY=0.0
      DO 16 I=1,N
   16 SSY=SSY+(Y(I)*Y(I))**A4(4)
      DO 14 I=1,N1
      YY2(I)=0.0
      DO 14 J=1,IREP
      K=(J-1)*N1+I
   14 YY2(I)=YY2(I)+Y(K)**A4(4)/IREP
      X2(1)=1.0
      DO 27 I=1,10
      BB(I)=0.0
```

```
      DO 27 J=1,10
   27 SSX(I,J)=0.0
      DO 3 I=1,N1
      DO 26 J=2,4
      X2(J)=X(I,J-1)**A4(J-1)
   26 X2(J+3)=X2(J)*X2(J)
      X2(8)=X2(2)*X2(3)
      X2(9)=X2(2)*X2(4)
      X2(10)=X2(3)*X2(4)
      DO 3 J=1,10
      BB(J)=BB(J)+YY2(I)*X2(J)
      DO 3 K=1,10
    3 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
      CALL MATV(SSX,10,BB,1,DET)
      DO 11 I=1,7
      SSXY(I)=0.0
      DO 11 J=1,7
   11 SSX(I,J)=0.0
      DO 12 I=1,N1
      DO 13 J=1,2
      J1=J+1
      DO 13 J2=J1,3
      J3=J+J2-2
      X2(J3+1)=(X(I,J3)**A4(J3)-2.0*V1(J3,LL))*X(I,J3)**A4(J3)
   13 X2(J3+4)=X(I,J)**A4(J)*X(I,J2)**A4(J2)-V1(J,LL)*X(I,J2)**A4(J2)-V1
     1(J2,LL)*X(I,J)**A4(J)
      DO 12 J=1,7
      SSXY(J)=SSXY(J)+YY2(I)*X2(J)
      B(J)=SSXY(J)
      DO 12 K=1,7
   12 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
      CALL MATV(SSX,7,B,1,DET)
      SS=SSY
      DO 15 I=1,7
   15 SS=SS-SSXY(I)*B(I)*IREP
      DO 2 J1=1,2
      J2=J1+1
      DO 2 J3=J2,3
      JJ=J1+J3-2
      J4=4-J1
      J5=4-J3
      J6=4-JJ
      AN5=44
      X1=V1(JJ,LL)
      IF(X1)5,5,6
    5 X4=2.0*X1
      GO TO 7
    6 X4=0.0
    7 A=2.0*ABS(X1)
      WRITE(3,80)TITL
      GO TO (29,30),N4
   30 GO TO (28,29),LL
   29 WRITE(3,81)A3
   28 WRITE(3,78)JJ
      DO 1 KK=1,45
```

```
      V2(JJ)=(KK-1)*A/AN5+X4
      SSX(1,1)=BB(J4+4)
      SSX(2,2)=BB(J5+4)
      SSX(1,2)=BB(J6+7)/2.0
      SSX(2,1)=SSX(1,2)
      B(1)=-(BB(J4+1)+BB(J3+7)*V2(JJ))/2.0
      B(2)=-(BB(J5+1)+BB(J1+7)*V2(JJ))/2.0
      CALL MATV(SSX,2,B,1,DET)
      V2(J4)=B(1)
      V2(J5)=B(2)
      DO 17 I=1,7
      SSXY(I)=0.0
      DO 17 J=1,7
   17 SSX(I,J)=0.0
      DO 18 I=1,N1
      DO 25 J=1,2
      JJ1=J+1
      DO 25 JJ2=JJ1,3
      JJ3=J+JJ2-2
      X2(JJ3+1)=(X(I,JJ3)**A4(JJ3)-2.0*V2(JJ3))*X(I,JJ3)**A4(JJ3)
   25 X2(JJ3+4)=X(I,J)**A4(J)*X(I,JJ2)**A4(JJ2)-V2(J)*X(I,JJ2)**A4(JJ2)-
     1V2(JJ2)*X(I,J)**A4(J)
      DO 18 J=1,7
      SSXY(J)=SSXY(J)+YY2(I)*X2(J)
      B(J)=SSXY(J)
      DO 18 K=1,7
   18 SSX(J,K)=SSX(J,K)+X2(J)*X2(K)
      CALL MATV(SSX,7,B,1,DET)
      SSY1=SSY
      DO 19 I=1,7
   19 SSY1=SSY1-SSXY(I)*B(I)*IREP
      R(KK,JJ,LL)=(SS/SSY1)**(FLOAT(N)/2.0)
      DO 31 I=1,3
      IF(V2(I))32,33,33
   32 NN1=-1
      GO TO 31
   33 NN1=1
   31 V2(I)=V2(I)**(1.0/A4(I))*NN1
    1 WRITE(3,79)V2,SSY1,R(KK,JJ,LL)
    2 CONTINUE
      DO 20 I=1,4
   20 A4(I)=A3(I)
    4 CONTINUE
      DO 21 I=1,4
   21 A4(I)=A5(I)
      CALL LINK(PCNT3)
      END
// DUP
*STORE       WS  UA  CENT3


// JOB
// DUP
*DELETE              PCNT3
// FOR
```

```
*NAME PCNT3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(PLOTTER,TYPEWRITER,KEYBOARD)
      COMMON Y(80),X(20,3),B(12),A4(4),SSY,N,IREP,TITL(12),ID,A3(4),N4,N
     15,YS(6),V1(3,2),R(45,3,2),A5(4)
   80 FORMAT('POWER TRANSFORMATIONS  A1='F8.4'  A2='F8.4'  A3='F8.4'  C=
     1'F8.4)
   79 FORMAT(I3)
   78 FORMAT(12A6)
   77 FORMAT('TYPE 1 TO CALL EXIT, EOF TO CONTINUE')
   76 FORMAT(F3.1)
   75 FORMAT('VALUE OF X'I1'S  -  CENTRE AT X'I1'S ='F7.3)
   74 FORMAT(F7.3)
   73 FORMAT('MAXIMUM LIKELIHOOD RATIO')
      AN5=44
      DO 24 I=1,4
   24 A5(I)=A4(I)
      GO TO (25,26),N4
   25 DO 27 I=1,4
   27 A4(I)=A3(I)
      GO TO 28
   26 DO 29 I=1,4
   29 A4(I)=1.0
   28 DO 30 LL=1,N4
      DO 4 JJ=1,3
      X1=V1(JJ,LL)
      IF(X1)12,12,13
   12 X4=2.0*X1
      GO TO 14
   13 X4=0.0
   14 A=2.0*ABS(X1)
      B1=A/20.
      C=X4-A/50.
      D=A/10.
      E=10./A
      F=X4-B1
      G=X4+D
      H=X4+A*1.3
      W=X4-A/15.
      U=X4-A/7.5
      Z=X4-D
      CALL SCALE(E,10.0,X4,0.0)
      CALL EGRID(0,X4,0.0,B1,20)
      CALL EGRID(1,X4,0.0,0.05,20)
      DO 2 I=1,11
      X1=G-D/5.0+D*FLOAT(I-2)
      IF(X1)18,19,19
   18 NN1=-1
      GO TO 20
   19 NN1=1
   20 XO=(G+D*FLOAT(I-2))**(1.0/A4(JJ))*NN1
      CALL ECHAR(X1,-0.02,0.1,0.1,0.0)
    2 WRITE(7,74)XO
      DO 3 I=1,11
```

```
      X1=-0.1+0.1*FLOAT(I)
      CALL ECHAR(F,X1,0.1,0.1,0.0)
    3 WRITE(7,76)X1
      CALL ECHAR(G,-0.04,0.1,0.1,0.0)
      IF(V1(JJ,LL))21,22,22
   21 NN1=-1
      GO TO 23
   22 NN1=1
   23 V3=V1(JJ,LL)**(1.0/A4(JJ))*NN1
      WRITE(7,75)JJ,JJ,V3
      CALL ECHAR(W,0.1,0.1,0.1,1.5709)
      WRITE(7,73)
      CALL ECHAR(Z,0.0,0.1,0.1,1.5709)
      WRITE(7,78)TITL
      GO TO (11,9),N4
    9 GO TO (10,11),LL
   11 CALL ECHAR(U,0.0,0.1,0.1,1.5709)
      WRITE(7,80)A3
   10 CALL EPLOT(-2,X4,0.0)
      DO 1 KK=1,45
      V2=(KK-1)*A/AN5+X4
    1 CALL EPLOT(0,V2,R(KK,JJ,LL))
      CALL EPLOT(1,H,0.0)
    4 CONTINUE
      DO 31 I=1,4
   31 A4(I)=A3(I)
   30 CONTINUE
      DO 32 I=1,4
   32 A4(I)=A5(I)
      CALL DATSW(10,J10)
      GO TO (16,15),J10
   16 CALL LINK(SLIC3)
   15 GO TO (17,8),N4
   17 WRITE(1,77)
      READ(6,79)N5
      IF(N5)5,6,5
    8 IF(ID-98)7,5,7
    5 CALL EXIT
    6 CALL LINK(CRLF3)
    7 CALL LINK(BOX3)
      END
// DUP
*STORE       WS  UA  PCNT3


// JOB
// DUP
*DELETE              SLIC3
// FOR
*NAME SLIC3
*IOCS(1132 PRINTER)
*ONE WORD INTEGERS
*EXTENDED PRECISION
      COMMON Y(80),X(20,3),V(12),A4(4),SSY,NS,NREPS,TITL(12),ID,A3(4),N4
     1,N5,YS(6),VV1(3,2),V1(2,6),ALAMD(2,6),PREP(2,2,6),X1(10),YDEV(20),
```

```
     2A5(4),COE(6),ALAM1(3),PREP1(3,3),VV(10),BA(12,12),NNN(3)
   82 FORMAT('1'12A6)
   81 FORMAT(1H0,8X,'EIGEN VALUES',10X,'EIGEN VECTORS AS ROWS',/,)
   80 FORMAT(1H0,4(E11.4,'=X'I1'S'2X)' IN ORIGINAL UNITS')
   79 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4'  A3 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARI
     2ABLE - C ='F8.4)
   78 FORMAT('0'2(E11.4,'=YS'3X)'IN ORIGINAL UNITS')
   77 FORMAT(//'0  CENTRE OF RESPONSE SURFACE FOR THE PLANE X'I1'='F8.2)
      N1=NS/NREPS
      DO 2 I=1,4
    2 A5(I)=A4(I)
      GO TO (11,10),N4
   11 DO 12 I=1,4
   12 A4(I)=A3(I)
      GO TO 13
   10 DO 5 I=1,4
    5 A4(I)=1.0
   13 DO 4 LL=1,N4
      WRITE(3,82)TITL
      GO TO (21,22),N4
   22 GO TO (23,21),LL
   21 WRITE(3,79)A3
   23 DO 6 I=1,N1
      YDEV(I)=0.0
      DO 6 K=1,NREPS
      KK=(K-1)*N1+I
    6 YDEV(I)=YDEV(I)+Y(KK)**A4(4)/NREPS
      DO 7 I=1,10
      VV(I)=0.0
      DO 7 J=1,10
    7 BA(I,J)=0.0
      X1(1)=1.0
      DO 8 K=1,N1
      DO 3 J=2,4
      X1(J)=X(K,J-1)**A4(J-1)
    3 X1(J+3)=X1(J)*X1(J)
      X1(8)=X1(2)*X1(3)
      X1(9)=X1(2)*X1(4)
      X1(10)=X1(3)*X1(4)
      DO 8 I=1,10
      VV(I)=VV(I)+YDEV(K)*X1(I)
      DO 8 J=1,10
    8 BA(I,J)=BA(I,J)+X1(I)*X1(J)
      CALL MATV(BA,10,VV,1,DET)
      DO 1 LL1=2,3
      LL2=LL1+1
      DO 1 LL3=LL2,4
      LL4=LL1+LL3-4
      LL5=(LL-1)*3+LL4
      LL6=4-LL4
      LL7=12-LL1
      LL8=12-LL3
      L1=LL1-1
      L3=LL3-1
```

```
      V(1)=VV(1)+VV(LL6+1)*VV1(LL6,LL)+VV(LL6+4)*VV1(LL6,LL)*VV1(LL6,LL)
      V(2)=VV(LL1)+VV(LL8)*VV1(LL6,LL)
      V(3)=VV(LL3)+VV(LL7)*VV1(LL6,LL)
      V(4)=VV(LL1+3)
      V(5)=VV(LL4+7)
      V(6)=VV(LL3+3)
      DO 17 J=1,6
   17 COE(J)=V(J)
      NFAK=2
      KP=NFAK+2
      DO 14 I=1,NFAK
      DO 14 J=1,I
      IF(I-J)15,16,15
   16 PREP1(I,J)=V(KP)
      GO TO 14
   15 PREP1(I,J)=V(KP)*0.5
      PREP1(J,I)=PREP1(I,J)
   14 KP=KP+1
      DO 9 I=1,NFAK
    9 V(I)=-V(I+1)*0.500
      DO 34 I=1,NFAK
      DO 34 J=1,NFAK
   34 BA(I,J)=PREP1(I,J)
      CALL MATV(BA,NFAK,V,1,DET)
      IF(VV1(LL6,LL))36,37,37
   36 NN1=-1
      GO TO 38
   37 NN1=1
   38 VVV=VV1(LL6,LL)**(1./A4(LL6))*NN1
      WRITE(3,77)LL6,VVV
      YS(LL5)=COE(1)
      DO 24 I=1,NFAK
   24 YS(LL5)=YS(LL5)+0.5*V(I)*COE(I+1)
      GO TO (25,26),N4
   26 GO TO (27,25),LL
   25 DO 30 I=1,2
      IF(V(I))28,28,29
   28 NNN(I)=-1
      GO TO 30
   29 NNN(I)=1
   30 CONTINUE
      V3=V(1)**(1./A3(L1))*NNN(1)
      V4=V(2)**(1./A3(L3))*NNN(2)
      IF(YS(LL5))31,31,32
   31 NNN(3)=-1
      GO TO 33
   32 NNN(3)=1
   33 YS1=YS(LL5)**(1./A3(4))*NNN(3)
      WRITE(3,80)V(1),L1,V(2),L3,V3,L1,V4,L3
      WRITE(3,78)YS(LL5),YS1
      GO TO 35
   27 WRITE(3,80)V(1),L1,V(2),L3
      WRITE(3,78)YS(LL5)
   35 WRITE(3,81)
      CALL CAN3(PREP1,ALAM1,NFAK)
```

```
      DO 19 I=1,2
      V1(I,LL5)=V(I)
      ALAMD(I,LL5)=ALAM1(I)
      DO 19 J=1,2
   19 PREP(I,J,LL5)=PREP1(I,J)
    1 CONTINUE
      DO 20 I=1,4
   20 A4(I)=A3(I)
    4 CONTINUE
      DO 18 I=1,4
   18 A4(I)=A5(I)
      CALL LINK(CRS3)
      END
// DUP
*STORE       WS  UA  SLIC3


// JOB
// DUP
*DELETE                CRS3
// FOR
*NAME CRS3
*IOCS(TYPEWRITER,KEYBOARD,1132 PRINTER,CARD,DISK)
*ONE WORD INTEGERS
*EXTENDED PRECISION
      COMMON Y(80),X(20,3),XP1(4),YP1(4),A5(4),A4(4),SSY,NS,NREPS,TITL(1
     12),ID,A3(4),N4,N5,YS(6),XCNT(6),XCNTR(2,6),ALAMD(2,6),AVECT(2,2,6)
     2,YCONT(8,6),NSAD(6),ZLIM1(3),YP(320),XP(320),XH(40),XV(40),YCON1(8
     3),ZLIM(2)
      DEFINE FILE 21(320,6,U,KK1),22(320,6,U,KK2),23(320,6,U,KK3),24(320
     1,6,U,KK4),25(320,6,U,KK5),26(320,6,U,KK6)
   90 FORMAT(1H0,10X,'DATA FOR PLOTTING OF 4 CONTOURS (X'I1'='F6.2')'//5
     1X4(9X,F5.1,9X)/4(10X'X'I1,9X'X'I1))
   89 FORMAT('0SADDLE EXISTS  -  ABSOLUTE VALUES OF CONTOUR POINTS PLOTT
     1ED IN ORIGINAL UNITS (X'I1'='F6.2')'//4(14X,F5.1,4X)/4(10X'X'I1,9X
     2'X'I1))
   88 FORMAT('0SADDLE EXISTS  -  CONTOUR POINTS PLOTTED (X'I1'='F6.2')'/
     1/4(14X,F5.1,4X)/4(10X'X'I1,9X'X'I1))
   87 FORMAT('0DATA FOR PLOTTING 4 CONTOURS (X'I1'='F6.2')'//'0ABSOLUTE
     1VALUES OF TRANSFORMED FACTOR LEVELS IN ORIGINAL UNITS'//5X4(9X,F5.
     21,9X)/4(10X'X'I1,9X'X'I1))
   86 FORMAT('ENTER 3 FACTOR LIMITS FOR PLOTTING')
   85 FORMAT('ENTER 8 CONTOUR LEVELS, 4 BELOW THE CENTRE, THEN 4 ABOVE')
   84 FORMAT('0POWER TRANSFORMATIONS OF INDEPENDENT VARIABLES - A1 ='F8.
     14'  A2 ='F8.4'  A3 ='F8.4/'0POWER TRANSFORMATION OF DEPENDENT VARI
     2ABLE - C ='F8.4)
   83 FORMAT('1'12A6)
   82 FORMAT(12F6.2)
   81 FORMAT(2X,4(2X,F10.2,1X,F10.2))
   80 FORMAT(F10.0)
      NFAK=3
      DO 4 I=1,4
    4 A5(I)=A4(I)
      GO TO (12,97),N4
   12 DO 23 I=1,4
```

```
 23 A4(I)=A3(I)
    GO TO 24
 97 DO 28 I=1,4
 28 A4(I)=1.0
 24 DO 96 LL=1,N4
    GO TO (16,17),N4
 16 WRITE(1,85)
    READ(6,80)YCON1
    WRITE(1,86)
    READ(6,80)ZLIM1
    GO TO 18
 17 GO TO (66,18),LL
 66 READ(2,82)YCON1,ZLIM1
 18 DO 15 LL1=1,2
    LL3=LL1+1
    DO 15 LL2=LL3,3
    LL4=LL1+LL2-2
    LL5=(LL-1)*3+LL4
    LL6=4-LL4
    DO 29 I=1,8
    IF(A4(4))101,102,102
101 J=9-I
    GO TO 29
102 J=I
 29 YCONT(I,LL5)=YCON1(J)
    DO 61 I=1,320
    XP(I)=0.0
 61 YP(I)=0.0
    NSWCH=0
    NSAD(LL5)=0
    KCY=0
    IH=1
    IV=2
    LLH=LL1
    LLV=LL2
    ZLIM(1)=ZLIM1(LL1)
    ZLIM(2)=ZLIM1(LL2)
    IF(ALAMD(IH,LL5))5,5,6
  5 N1=-1
    GO TO 7
  6 N1=+1
  7 IF(ALAMD(IV,LL5))8,8,9
  8 N2=-1
    GO TO 10
  9 N2=+1
 10 NSIGN=N1*N2
    IF(NSIGN)11,11,30
 11 NSAD(LL5)=1
    IF(N1)13,13,14
 14 IDUM=IH
    IH=IV
    IV=IDUM
    IDUM=LLH
    LLH=LLV
    LLV=IDUM
```

```
      NSWCH=1
      GO TO 13
   30 IF(N1)13,13,45
   45 DO 46 I=1,4
      IF(A4(4))103,104,104
  103 J=I
      GO TO 46
  104 J=I+4
   46 YCONT(I,LL5)=YCON1(J)
   13 CONTINUE
      KCY=KCY+1
      ZFRST=SQRT((YCONT(KCY,LL5)**A4(4)-YS(LL5))/ALAMD(IH,LL5))
      ZEND=ZLIM(IH)**A4(LLH)-ZFRST
      XH(1)=ZFRST
      XV(1)=0.0
      THETA=0.0
      DO 1 I=2,10
      THETA=THETA+0.15710
      IF(NSAD(LL5))51,51,52
   51 XH(I)=ZFRST*COS(THETA)
      GO TO 53
   52 XH(I)=ZFRST+ZEND-ZEND*COS(THETA)
   53 ARG=(YCONT(KCY,LL5)**A4(4)-YS(LL5)-ALAMD(IH,LL5)*(XH(I)**2))/ALAMD
     1(IV,LL5)
      XV(I)=SQRT(ARG)
      IL=42-I
      XH(IL)=XH(I)
      XV(IL)=-XV(I)
    1 CONTINUE
      IF(NSAD(LL5))54,54,55
   54 XH(11)=0.0
      ARGG=(YCONT(KCY,LL5)**A4(4)-YS(LL5))/ALAMD(IV,LL5)
      XV(11)=SQRT(ARGG)
      GO TO 56
   55 XH(11)=ZLIM(IH)**A4(LLH)
      ARG=(YCONT(KCY,LL5)**A4(4)-YS(LL5)-ALAMD(IH,LL5)*(XH(I)**2))/ALAMD
     1(IV,LL5)
      XV(11)=SQRT(ARG)
   56 DO 2 I=12,21
      LLL5=22-I
      II=42-I
      XH(I)=-XH(LLL5)
      XV(I)=XV(LLL5)
      XH(II)=XH(I)
    2 XV(II)=-XV(I)
      XV(31)=-XV(11)
      XH(31)=XH(11)
      IF(NSWCH)31,31,32
   32 I1=IV
      I2=IH
      DO 33 I=1,40
      XDUM=XH(I)
      XH(I)=XV(I)
   33 XV(I)=XDUM
      GO TO 60
```

```
 31 I1=IH
    I2=IV
 60 DO 41 I=1,40
    L=(KCY-1)*40+I
    XP(L)=AVECT(I1,I1,LL5)*XH(I)+AVECT(I2,I1,LL5)*XV(I)+XCNTR(I1,LL5)
 41 YP(L)=AVECT(I1,I2,LL5)*XH(I)+AVECT(I2,I2,LL5)*XV(I)+XCNTR(I2,LL5)
    IF(KCY-4)13,34,34
 34 IF(NSAD(LL5)-1)35,47,47
 47 IF(KCY-8)48,35,35
 48 IF(KCY-4)13,36,13
 36 IF(NSWCH)38,38,39
 38 NSWCH=1
    GO TO 37
 39 NSWCH=0
 37 IDUM=IH
    IH=IV
    IV=IDUM
    IDUM=LLH
    LLH=LLV
    LLV=IDUM
    GO TO 13
 35 WRITE(3,83)TITL
    IF(XCNT(LL5))98,99,99
 98 NN1=-1
    GO TO 100
 99 NN1=1
100 XCN=XCNT(LL5)**(1./A4(LL6))*NN1
    GO TO (19,20),N4
 20 GO TO (21,19),LL
 19 WRITE(3,84)A3
 21 WRITE(3,90)LL6,XCN,(YCONT(I,LL5),I=1,4),(LL1,LL2,J=1,4)
    DO 3 I=1,40
    DO 49 J=1,4
    L1=(J-1)*40+I
    XP1(J)=XP(L1)
 49 YP1(J)=YP(L1)
  3 WRITE(3,81)(XP1(J),YP1(J),J=1,4)
    IF(NSAD(LL5))43,43,44
 44 WRITE(3,83)TITL
    GO TO (50,57),N4
 57 GO TO (58,50),LL
 50 WRITE(3,84)A3
 58 WRITE(3,88)LL6,XCN,(YCONT(I,LL5),I=5,8),(LL1,LL2,J=1,4)
    DO 42 I=1,40
    DO 59 J=1,4
    L1=200+(J-1)*40+I
    XP1(J)=XP(L1)
 59 YP1(J)=YP(L1)
 42 WRITE(3,81)(XP1(J),YP1(J),J=1,4)
 43 GO TO (25,26),LL
 25 GO TO (70,71,72),LL4
 70 DO 22 I=1,320
 22 WRITE(21'I)XP(I),YP(I)
    GO TO 92
 71 DO 73 I=1,320
```

```
    73 WRITE(23'I)XP(I),YP(I)
       GO TO 92
    72 DO 74 I=1,320
    74 WRITE(25'I)XP(I),YP(I)
       GO TO 92
    26 GO TO (75,76,77),LL4
    75 DO 27 I=1,320
    27 WRITE(22'I)XP(I),YP(I)
       GO TO 92
    76 DO 78 I=1,320
    78 WRITE(24'I)XP(I),YP(I)
       GO TO 92
    77 DO 79 I=1,320
    79 WRITE(26'I)XP(I),YP(I)
    92 GO TO (40,91),N4
    91 GO TO (15,40),LL
    40 WRITE(3,83)TITL
       WRITE(3,87)LL6,XCN,(YCONT(I,LL5),I=1,4),(LL1,LL2,J=1,4)
       DO 65 I=1,40
       DO 64 J=1,4
       L1=(J-1)*40+I
       XP1(J)=XP(L1)**(1.0/A3(LL1))
    64 YP1(J)=YP(L1)**(1.0/A3(LL2))
    65 WRITE(3,81)(XP1(J),YP1(J),J=1,4)
       IF(NSAD(LL5))15,15,67
    67 WRITE(3,83)TITL
       GO TO (68,69),N4
    69 GO TO (93,68),LL
    68 WRITE(3,84)A3
    93 WRITE(3,89)LL6,XCN,(YCONT(I,LL5),I=5,8),(LL1,LL2,J=1,4)
       DO 95 I=1,40
       DO 94 J=1,4
       L1=200+(J-1)*40+I
       XP1(J)=XP(L1)**(1.0/A3(LL1))
    94 YP1(J)=YP(L1)**(1.0/A3(LL2))
    95 WRITE(3,81)(XP1(J),YP1(J),J=1,4)
    15 CONTINUE
       DO 62 I=1,4
    62 A4(I)=A3(I)
    96 CONTINUE
       DO 63 I=1,4
    63 A4(I)=A5(I)
       CALL LINK(PRS3)
       END
// DUP
*STORE       WS  UA  CRS3


// JOB
// DUP
*DELETE              PRS3
// FOR
*NAME PRS3
*IOCS(DISK,PLOTTER,TYPEWRITER,KEYBOARD)
*ONE WORD INTEGERS
```

```
*EXTENDED PRECISION
      COMMON A(80),B(20,3),V(12),A4(4),SSY,NS,NREPS,TITL(12),ID,A3(4),N4
     1,N8,YS(6),XCNT(3,2),XCNT1(2,6),ALAM1(2,6),AVEC1(2,2,6),YCONT(8,3,2
     2),NSAD(3,2),ZLIM1(3),A5(4),ZLIM(2),XS(2),YA(2),UPI(2)
      DEFINE FILE 21(320,6,U,KK1),22(320,6,U,KK2),23(320,6,U,KK3),24(320
     1,6,U,KK4),25(320,6,U,KK5),26(320,6,U,KK6)
   86 FORMAT(3X'POWER TRANSFORMATIONS - A1='F8.4'  A2='F8.4'  A3='F8.4'
     1 C='F8.4)
   85 FORMAT(12A6)
   84 FORMAT(I3)
   83 FORMAT('TYPE 1 TO CALL EXIT, EOF TO CONTINUE')
   82 FORMAT(3X'X'I1' - X'I1' COORDINATES FOR RESPONSE CONTOURS (X'I1'='
     1F6.2')'8F6.1)
   81 FORMAT(F7.2)
   80 FORMAT(F6.2)
      DO 25 I=1,4
   25 A5(I)=A4(I)
      GO TO (5,9),N4
    5 DO 20 I=1,4
   20 A4(I)=A3(I)
      GO TO 21
    9 DO 22 I=1,4
   22 A4(I)=1.0
   21 DO 46 LL=1,N4
      DO 6 LL1=1,2
      LL3=LL1+1
      DO 6 LL2=LL3,3
      LL4=LL1+LL2-2
      LL6=4-LL4
      ZLIM(1)=ZLIM1(LL1)
      ZLIM(2)=ZLIM1(LL2)
      DO 24 I=1,2
      XS(I)=4.0/ZLIM(I)
      UPI(I)=1.0/XS(I)
   24 YA(I)=ZLIM(I)+UPI(I)
      CALL SCALE(XS(1),XS(2),-ZLIM(1),-ZLIM(2))
      CALL EPLOT(-2,-ZLIM(1),-ZLIM(2))
      X=ZLIM(1)
      Y=-ZLIM(2)
      DO 11 J=1,9
      CALL EPLOT(-1,X,Y)
      IF(J-9)4,11,11
    4 Y=Y+UPI(2)
      CALL EPLOT(-2,X,Y)
      X=-X
   11 CONTINUE
      CALL EPLOT(-2,X,Y)
      Y=-ZLIM(2)
      DO 13 J=1,9
      CALL EPLOT(-1,X,Y)
      X=X-UPI(1)
      IF(J-9)12,13,13
   12 CALL EPLOT(-2,X,Y)
      Y=-Y
   13 CONTINUE
```

```
      CALL EPLOT(1,X,Y)
      DO 27 J=1,9
      Y=-YA(2)+UPI(2)*FLOAT(J)
      CALL ECHAR(-YA(1),Y,0.1,0.1,0.0)
      IF(Y)56,27,27
   56 Y=Y-0.00501
   27 WRITE(7,81)Y
      CALL ECHAR(-ZLIM(1),YA(2),0.1,0.1,0.0)
      WRITE(7,85)TITL
      GO TO (50,51),N4
   51 GO TO (52,50),LL
   50 YB=ZLIM(2)+UPI(2)/3.0
      CALL ECHAR(-ZLIM(1),YB,0.1,0.1,0.0)
      WRITE(7,86)A3
   52 YC=ZLIM(2)+UPI(2)/1.5
      CALL ECHAR(-ZLIM(1),YC,0.1,0.1,0.0)
      IF(XCNT(LL6,LL))60,61,61
   60 NN1=-1
      GO TO 62
   61 NN1=1
   62 XCN=XCNT(LL6,LL)**(1./A4(LL6))*NN1
      IF(NSAD(LL4,LL))1,1,2
    1 NN5=4
      GO TO 3
    2 NN5=8
    3 WRITE(7,82)LL1,LL2,LL6,XCN,(YCONT(I,LL4,LL),I=1,NN5)
      DO 28 J=1,9
      X=-YA(1)-UPI(1)/2.5+UPI(1)*FLOAT(J)
      XA=-ZLIM(2)-UPI(2)/5.0
      XO=-YA(1)+UPI(1)*FLOAT(J)
      CALL ECHAR(X,XA,0.1,0.1,0.0)
      IF(XO)57,28,28
   57 XO=XO-0.00501
   28 WRITE(7,81)XO
      DO 44 I=1,NN5
      DO 43 J=1,40,2
      K=J+40*(I-1)
      GO TO (7,8),LL
    7 GO TO (47,48,49),LL4
   47 READ(21'K)X,Y
      GO TO 10
   48 READ(23'K)X,Y
      GO TO 10
   49 READ(25'K)X,Y
      GO TO 10
    8 GO TO (53,54,55),LL4
   53 READ(22'K)X,Y
      GO TO 10
   54 READ(24'K)X,Y
      GO TO 10
   55 READ(26'K)X,Y
   10 IF(X)32,33,33
   32 NN1=-1
      GO TO 34
```

```
   33 NN1=1
   34 IF(Y)35,36,36
   35 NN2=-1
      GO TO 37
   36 NN2=1
   37 X=X**(1./A4(LL1))*NN1
      Y=Y**(1./A4(LL2))*NN2
      IF(ABS(X)-ZLIM(1))29,29,30
   30 IF(X)31,31,38
   38 X=ZLIM(1)
      GO TO 29
   31 X=-ZLIM(1)
   29 IF(ABS(Y)-ZLIM(2))39,39,40
   40 IF(Y)41,41,42
   42 Y=ZLIM(2)
      GO TO 39
   41 Y=-ZLIM(2)
   39 IF(J-1)43,14,15
   14 CALL EPLOT(-2,X,Y)
      XA=X
      XO=Y
      GO TO 43
   15 CALL EPLOT(0,X,Y)
   43 CONTINUE
      CALL EPLOT(-1,XA,XO)
      CALL ECHAR(XA,XO,0.075,0.075,0.0)
      WRITE(7,80)YCONT(I,LL4,LL)
   44 CONTINUE
      XOR=ZLIM(1)+6.0*UPI(1)
      CALL EPLOT(1,XOR,-ZLIM(2))
    6 CONTINUE
      DO 23 I=1,4
   23 A4(I)=A3(I)
   46 CONTINUE
      DO 26 I=1,4
   26 A4(I)=A5(I)
      GO TO (18,19),N4
   18 WRITE(1,83)
      READ(6,84)N5
      IF(N5)17,45,17
   19 IF(ID-98)16,17,16
   17 CALL EXIT
   45 GO TO (58,59),N8
   58 CALL LINK(CRLF3)
   59 CALL LINK(SRS3)
   16 CALL LINK(BOX3)
      END
// DUP
*STORE       WS  UA  PRS3


// JOB
// DUP
*DELETE              CRLF3
// FOR
```

```
*NAME CRLF3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(CARD,1132 PRINTER,TYPEWRITER,KEYBOARD)
C
C      THIS PROGRAM IS DESIGNED FOR COMPLETE CONSOLE CONTROL.
C
C      THIS PROGRAM ANALYZES DATA IN THE SAME MANNER AS BOX3, BUT ONLY
C  FOR TEST VALUES OF THE POWER TRANSFORMATIONS WHICH ARE ENTERED ON THE
C  CONSOLE TYPEWRITER.  THE RELATIVE LIKELIHOOD OF THESE TEST VALUES, AS
C  COMPARED WITH THE MAXIMUM LIKELIHOOD ESTIMATES, IS CALCULATED.
C  VARIOUS TEST VALUES MAY BE ENTERED, AND THE COMPLETE ANALYSIS DONE ON
C  ANY LIKELY VALUES SELECTED FROM THESE.  SEE BOX3 FOR DETAILS OF THE
C  ANALYSIS.
C
C    LINKS CALLED
C
C   CRLF3 - CALCULATES RELATIVE LIKELIHOODS OF VARIOUS TEST VALUES OF
C  TRANSFORMS
C    INF03 - CALULATES INFORMATION AND VARIANCE-COVARIANCE MATRICES
C    ANVA3 - PERFORMS ANALYSIS OF VARIANCE
C    COEF3 - CALCULATES AND PLOTS POINTS FOR MLR GRAPHS OF THE B(J)
C  COEFFICIENTS
C    EIGN3 - PERFORMS CANONICAL ANALYSIS
C    CENT3 -CALCULATES POINTS FOR THE MLR GRAPHS OF THE CENTRE COORDINATES
C    PCNT3 - PLOTS MLR GRAPHS OF THE COORDINATES OF THE RESPONSE CENTRE
C    CRS3  - CALCULATES POINTS FOR THE RESPONSE SURFACE CONTOURS
C    PRS3  - PLOTS RESPONSE SURFACE CONTOURS
C
C    SUBROUTINES CALLED
C
C   MATV   - INVERTS MATRICES
C   CAN3   - DIAGONALIZES MATRICES
C   JACOB  - CALCULATES EIGENVALUES AND VECTORS OF DIAGONAL MATRICES
C
C    OPTIONS
C
C  SWITCH 10 UP - PLOT RESPONSE SURFACE CONTOURS
C  SWITCH  8 UP - PLOT MAXIMUM LIKELIHOOD RATIOS OF B(J) COEFFICIENTS
C  SWITCH  7 UP- PLOT MAXIMUM LIKELIHOOD RATIOS OF THE CENTRE COORDINATES
C
C    MAKEUP OF DATA DECK
C
C 1.TITLE CARD FIRST - (12A6)
C 2.CONTROL CARD - (1X,2I2,F5.3)
C       I2 - NUMBER OF TREATMENT COMBINATIONS
C       I2 - NUMBER OF OBSERVATION SETS
C       F5.3 - CONSTANT ADDED TO DEPENDENT VARIABLE, Y
C 3.TREATMENT COMBINATIONS IN TRIPLETS - (16F5.3)
C 4.DATA - SETS OF OBSERVATIONS FOR EACH TREATMENT COMBINATION
C       ONE SET PER CARD - (4F6.3)
C 5.98 OR 99 IN COLS. 79-80 INDICATES END OF DATA
C 6.REPEAT 1. TO 5. AS REQUIRED
C
C    STATION PLOTTER PEN EXACTLY 1.4 INCHES FROM THE RIGHT EDGE OF NARROW
```

```
C PAPER
C
      COMMON Y(80),X(20,3),B(12),A4(4),SSY1,N,IREP,TITL(12),ID,A3(4),N4,
     1X1(10),SSXY(10),Y1(4),YY1(20),SSX(12,12)
   88 FORMAT('0CONSTANT ADDED     Y + 'F5.3)
   87 FORMAT('INCORRECT NUMBER OF OBSERVATION SETS - SKIPPING TO NEXT DA
     1TA DECK')
   86 FORMAT(16F5.3)
   85 FORMAT('IF RELATIVE LIKELIHOOD IS SATISFACTORY, PRESS EOF'/ 'IF NO
     1T, TYPE 1 TO TRY NEW TEST VALUES, -1 TO READ MORE DATA OR CALL EXI
     2T')
   84 FORMAT('0TEST VALUES OF POWER TRANSFORMATIONS'/'0'6X'A1'13X'A2'13X
     1'A3'13X'C'14X'SSD'13X'R'/6E15.5)
   83 FORMAT('0MAXIMUM LIKELIHOOD ESTIMATES'//7X'A1'13X'A2'13X'A3'13X'C'
     114X'SSD'/5E15.5)
   82 FORMAT('1'12A6)
   81 FORMAT(4F6.3,54X,I2)
   80 FORMAT(12A6)
   79 FORMAT('TYPE IN THREE MAXIMUM LIKELIHOOD ESTIMATES OF POWER TRANSF
     1ORMATIONS FOR INDEPENDENT VARIABLES'/'THEN, ONE ML ESTIMATE FOR DE
     2PENDENT VARIABLE')
   78 FORMAT(1X,2I2,F5.3)
   77 FORMAT('TYPE 1 TO READ NEW DATA DECK, EOF TO READ NEW TEST VALUES
     1ON SAME DATA, -1 TO CALL EXIT')
   76 FORMAT(I3)
   75 FORMAT(F10.5)
   74 FORMAT('TYPE IN THREE TEST VALUES OF POWER TRANSFORMATIONS FOR IND
     1EPENDENT VARIABLES'/'THEN, ONE FOR DEPENDENT VARIABLE'/'TYPE 0.0 F
     2OR LOG TRANSFORM, + OR - 100 FOR EXPONENTIAL TRANSFORM'/'DATA DECK
     3 MUST BE REREAD TO REGAIN ORIGINAL VARIABLE VALUES WITH THESE 3')
   73 FORMAT('RELATIVE LIKELIHOOD IS'F8.5)
   72 FORMAT('SWITCH 10 UP TO PLOT RESPONSE CONTOURS'/'SWITCH  8 UP TO P
     1LOT MLR GRAPHS OF B(J) COEFFICIENTS'/'SWITCH  7 UP TO PLOT MLR GRA
     2PHS OF THE COORDINATES OF THE RESPONSE CENTRE')
      WRITE(1,72)
   18 WRITE(1,77)
      READ(6,76)N5
      N6=1
      N4=1
      IF(N5)19,1,2
    2 READ(2,80)TITL
      WRITE(1,80)TITL
      READ(2,78)N1,IREP,CONST
      N=N1*IREP
      READ(2,86)((X(I,J),J=1,3),I=1,N1)
      I=0
   10 I=I+1
      READ(2,81)Y1,ID
      IF(ID-98)21,11,11
   21 N2=N1+I
      N3=N1*2+I
      N6=N1*3+I
      Y(I)=Y1(1)+CONST
      Y(N2)=Y1(2)+CONST
      Y(N3)=Y1(3)+CONST
```

```
   Y(N6)=Y1(4)+CONST
   GO TO 10
11 N2=I-1
   IF(N1-N2)22,1,22
22 WRITE(1,87)
   GO TO 18
 1 N1=N/IREP
   IF(N5)20,25,20
20 WRITE(1,79)
   READ(6,75)A3
 8 SSY2=0.0
   DO 24 K=1,N
24 SSY2=SSY2+(Y(K)*Y(K))**A3(4)
   DO 26 I=1,N1
   YY1(I)=0.0
   DO 26 J=1,IREP
   K=(J-1)*N1+I
26 YY1(I)=YY1(I)+Y(K)**A3(4)/IREP
   DO 3 I=1,10
   B(I)=0.0
   DO 3 J=1,10
 3 SSX(I,J)=0.0
   X1(1)=1.0
   DO 4 K=1,N1
   DO 5 J=2,4
   X1(J)=X(K,J-1)**A3(J-1)
 5 X1(J+3)=X1(J)*X1(J)
   X1(8)=X1(2)*X1(3)
   X1(9)=X1(2)*X1(4)
   X1(10)=X1(3)*X1(4)
   DO 4 I=1,10
   B(I)=B(I)+YY1(K)*X1(I)
   DO 4 J=1,10
 4 SSX(I,J)=SSX(I,J)+X1(I)*X1(J)
   DO 9 I=1,10
 9 SSXY(I)=B(I)
   CALL MATV(SSX,10,B,1,DET)
   IF(N6)14,13,14
13 SSY=SSY2
   DO 15 I=1,10
15 SSY=SSY-B(I)*SSXY(I)*IREP
   GO TO 12
14 SSY1=SSY2
   DO 6 I=1,10
 6 SSY1=SSY1-B(I)*SSXY(I)*IREP
   DO 7 I=1,4
 7 A4(I)=A3(I)
25 WRITE(1,74)
   READ(6,75)A3
   DO 28 J=1,3
   IF(A3(J))32,23,32
23 DO 29 I=1,N1
29 X(I,J)=ALOG(X(I,J))
   GO TO 33
32 IF(ABS(A3(J))-100.)28,34,28
```

```
   34 DO 35 I=1,N1
   35 X(I,J)=EXP(A3(J)*X(I,J)/100.)
   33 A3(J)=1.0
   28 CONTINUE
      IF(A3(4))30,31,30
   31 DO 16 I=1,N
   16 Y(I)=ALOG(Y(I))
      GO TO 37
   30 IF(ABS(A3(4))-100.)36,38,36
   38 DO 39 I=1,N
   39 Y(I)=EXP(A3(3)*Y(I)/100.)
   37 A3(4)=1.0
   36 N6=0
      GO TO 8
   12 D=0.0
      DO 27 I=1,N
   27 D=D+ALOG(Y(I))
      R1=N*ALOG(SSY1/SSY)/2.0+(A4(4)-A3(4))*D
      R1=EXP(R1)
      WRITE(1,73)R1
      WRITE(3,82)TITL
      WRITE(3,88)CONST
      WRITE(3,83)A4,SSY1
      WRITE(3,84)A3,SSY,R1
      WRITE(1,85)
      READ(6,76)N5
      IF(N5)18,17,25
   17 CALL LINK(INFO3)
   19 CALL EXIT
      END
// DUP
*STORE       WS  UA  CRLF3


// JOB
// DUP
*DELETE                SRS3
// FOR
*NAME SRS3
*EXTENDED PRECISION
*ONE WORD INTEGERS
*IOCS(CARD,TYPEWRITER,KEYBOARD)
C
C      THIS PROGRAM PLOTS CONTOURS OF THE RESPONSE SURFACE FOR GIVEN
C  POWER TRANSFORMATIONS (ENTERED ON THE CONSOLE TYPEWRITER) ON GIVEN
C  PLANES PARALLEL TO THE AXES OF THE FACTOR SPACE, DEFINED BY X(I)=KI
C  (KI ENTERED ON THE CONSOLE TYPEWRITER).  FOR EACH PLOT, 3 PLANES ARE
C  USED, CORRESPONDING TO THE 3 FACTOR AXES.
C
C    LINKS CALLED
C
C   SLIC3 - CALCULATES EIGENVALUES AND VECTORS FOR SLICES OF RESPONSE
C  SURFACE
C    CRS3  - CALCULATES POINTS FOR THE RESPONSE SURFACE CONTOURS
C    PRS3  - PLOTS RESPONSE SURFACE CONTOURS
```

```
C
C    SUBROUTINES CALLED
C
C   MATV  - INVERTS MATRICES
C   CAN3  - DIAGONALIZES MATRICES
C   JACOB - CALCULATES EIGENVALUES AND VECTORS OF DIAGONAL MATRICES
C
C    MAKEUP OF DATA DECK
C
C 1.TITLE CARD FIRST - (12A6)
C 2.CONTROL CARD - (1X,2I2,F5.3)
C       I2 - NUMBER OF TREATMENT COMBINATIONS
C       I2 - NUMBER OF OBSERVATION SETS
C       F5.3 - CONSTANT ADDED TO DEPENDENT VARIABLE, Y
C 3.TREATMENT COMBINATIONS IN TRIPLETS - (16F5.3)
C 4.DATA - SETS OF OBSERVATIONS FOR EACH TREATMENT COMBINATION
C       ONE SET PER CARD - (4F6.3)
C 5.98 OR 99 IN COLS. 79-80 INDICATES END OF DATA
C 6.REPEAT 1. TO 5. AS REQUIRED
C
C    STATION PLOTTER PEN EXACTLY 1.4 INCHES FROM THE RIGHT EDGE OF NARROW
C PAPER
C
      COMMON Y(80),X(20,3),B(12),A4(4),SSY1,N,IREP,TITL(12),ID,A3(4),N4,
     1N5,YS(6),VV1(3,2),Y1(4)
   84 FORMAT('TYPE IN 3 FACTOR LEVELS FOR SLICES IN UNTRANSFORMED UNITS'
     1)
   83 FORMAT('TYPE IN 3 VALUES OF POWER TRANSFORMATIONS FOR INDEPENDENT
     1VARIABLES,'/'THEN, ONE FOR DEPENDENT VARIABLE'/'TYPE 0.0 FOR LOG T
     2RANSFORM, + OR - 100 FOR EXPONENTIAL TRANSFORM'/'DATA DECK MUST BE
     3 REREAD TO REGAIN ORIGINAL VARIABLE VALUES WITH THESE 3')
   82 FORMAT(16F5.3)
   81 FORMAT(4F6.3,54X,I2)
   80 FORMAT(12A6)
   79 FORMAT('INCORRECT NUMBER OF OBSERVATION SETS - SKIPPING TO NEXT DA
     1TA DECK')
   78 FORMAT(1X,2I2,F5.3)
   77 FORMAT('TYPE 1 TO READ NEW DATA DECK, 2 TO READ NEW FACTOR LEVELS
     1FOR SLICES'/'3 TO READ NEW TRANSFORMATION VALUES AND FACTOR LEVELS
     2')
   76 FORMAT(I1)
   75 FORMAT(F10.5)
      WRITE(1,77)
      N5=2
      N4=1
      READ(6,76)N6
      GO TO (2,3,1),N6
    2 READ(2,80)TITL
      WRITE(1,80)TITL
      READ(2,78)N1,IREP,CONST
      N=N1*IREP
      READ(2,82)((X(I,J),J=1,3),I=1,N1)
      I=0
   23 I=I+1
      READ(2,81)Y1,ID
```

```
      IF(ID-98)8,9,9
    8 N2=N1+I
      N3=N1*2+I
      N6=N1*3+I
      Y(I)=Y1(1)+CONST
      Y(N2)=Y1(2)+CONST
      Y(N3)=Y1(3)+CONST
      Y(N6)=Y1(4)+CONST
      GO TO 23
    9 N2=I-1
      IF(N1-N2)7,1,7
    7 WRITE(1,79)
    1 WRITE(1,83)
      READ(6,75)A3
      DO 10 J=1,3
      IF(A3(J))11,12,11
   12 DO 13 I=1,N1
   13 X(I,J)=ALOG(X(I,J))
      GO TO 16
   11 IF(ABS(A3(J))-100.)10,14,10
   14 DO 15 I=1,N1
   15 X(I,J)=EXP(A3(J)*X(I,J)/100.)
   16 A3(J)=1.0
   10 CONTINUE
      IF(A3(4))17,18,17
   18 DO 19 I=1,N
   19 Y(I)=ALOG(Y(I))
      GO TO 20
   17 IF(ABS(A3(4))-100.)3,21,3
   21 DO 22 I=1,N
   22 Y(I)=EXP(A3(3)*Y(I)/100.)
   20 A3(4)=1.0
    3 WRITE(1,84)
      READ(6,75)(VV1(I,1),I=1,3)
      DO 4 I=1,3
      IF(VV1(I,1))5,6,6
    5 NN1=-1
      GO TO 4
    6 NN1=1
    4 VV1(I,1)=VV1(I,1)**A3(I)*NN1
      CALL LINK(SLIC3)
      END
// DUP
*STORE       WS  UA  SRS3
```