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Computer Program To Prepare Airfoil Characteristic Data for Use in Helicopter Performance Calculations

Henry E. Jones
Structures Laboratory
U.S. Army R&T Laboratories (AVRADCOM)
Langley Research Center
Hampton, Virginia

NASA
National Aeronautics
and Space Administration

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SUMMARY

A computer program has been developed to prepare wind-tunnel-generated airfoil data for input into helicopter performance prediction programs. The program provides for numerically cross-plotting the data, plotting the data, and then tabulating and punching the tabulated result into computer cards for use in the government's rotorcraft flight simulation model.

INTRODUCTION

During the process of design and evaluation of rotors and rotor airfoils, it frequently becomes necessary to use experimentally derived airfoil characteristic data to predict helicopter performance. Performance predictions are usually accomplished through the use of helicopter performance programs such as the rotorcraft flight simulation model to calculate forward flight performance and the prescribed wake hover performance program to compute hover performance. (See refs. 1 and 2.) Generally, helicopter performance programs require airfoil characteristic data in a tabular format with angle of attack varying with Mach number. These programs generally require a uniform distribution of the coefficients at specified values of angle of attack and Mach number. This uniformity in distribution of data is rarely achievable in wind-tunnel testing; it is more efficient to test through a range of Mach number and angle of attack and then interpret the data at selected Mach numbers and angles of attack. This approach can result in a process of manually cross-plotting the data to prepare them for use in the performance programs.

The purpose of the current effort is to facilitate the preparation of the airfoil data from wind-tunnel experiments and to provide both plots of the data and punch card output for use in the performance programs. This purpose has been accomplished through the development of a computer program, entitled "PLTAERO," which is described in this report and is presented in the appendix.

SYMBOLS

c_d	blade-element drag coefficient
c_l	blade-element lift coefficient
c_m	blade-element pitching-moment coefficient
c_n	blade-element normal-force coefficient
M	Mach number
R	Reynolds number

α angle of attack, degrees

α_c angle of attack corrected for lift interference effects, degrees

ANALYSIS

The PLTAERO computer program provides for three functions: (1) numerically "cross-plotting" the wind-tunnel data to obtain values of c_l, c_d, and c_m at specified values of angle of attack and Mach number, (2) plotting the data as a function of both Mach number and angle of attack, and (3) tabulating and punching the data into computer cards for use in the performance programs. In accomplishing these functions, the computer program makes use of cubic-spline-under-tension subroutines for both the numerical cross-plotting and the data plots. References 3 and 4 give the theoretical background for these subroutines; the subroutines are unpublished but were written as part of the data-reduction computing package for the Langley V/STOL tunnel.

Numerical Cross-Plotting

The numerical cross-plotting is accomplished by four subroutines, each of which make use of the previously mentioned cubic-spline-under-tension technique to interpolate and extrapolate the input wind-tunnel data. The process requires three steps. The first step is to determine whether the wind-tunnel data fall within the minimum and maximum values of angle of attack and Mach number specified by PLTAERO and its input. The minimum angle of attack is required by the program to be -4°, and the maximum angle of attack is a function of Mach number and is specified by input. The second step in the numerical cross-plotting is to calculate the values of the airfoil characteristic data at the specified minimum and maximum angles of attack or Mach numbers. If the minimums and maximums fall within the range of the wind-tunnel data, a simple interpolation (using cubic splines under tension) is performed. If the minimums or the maximums fall outside the range of wind-tunnel data, then the cubic-spline-under-tension technique is used to calculate the slopes at the minimum and maximum points. After the slopes are calculated, a linear extrapolation of the curves is used to obtain values of the airfoil characteristic data at the specified "end" points. The third step in the process is an interpolation (using cubic splines under tension) to obtain the data at the specified angles of attack and Mach numbers.

The four subroutines applied are entitled "BOUND1," "BOUND2," "ADJUST1," and "ADJUST2." Subroutine BOUND1 calculates the airfoil characteristic data at the minimum and maximum angle of attack for each Mach number. Subroutine BOUND2 calculates the airfoil characteristic data at the minimum and maximum Mach numbers for each angle of attack. Subroutine ADJUST1 interpolates the data at specified angles of attack for each Mach number and subroutine ADJUST2 interpolates the data at specified Mach numbers for each angle of attack. The first and second steps of the cross-plotting take place in subroutines BOUND1 and BOUND2; the third step of the process takes place in subroutines ADJUST1 and ADJUST2.

Plotting of Data

The plotting of the coefficients takes place in two subroutines (P1 and P2). Plots are presented in two formats. The first format (produced by subroutine P1) presents the curves for c_l, c_d, and c_m as a function of Mach number for constant angle of attack as derived by BOUND1 and ADJUST1. Figures 1 to 4 are sample figures to illustrate the plotting formats of the computer program. They are all for a Wortmann FX69-H-098 airfoil with the data taken in the Langley 6- by 28-inch transonic tunnel. All the angles of attack are presented in one figure, as indicated by the example shown in figure 1. The second plotting format (produced by subroutine P2) presents the curves for c_l, c_d, and c_m as a function of angle of attack for constant Mach number. A separate curve for each Mach number is presented for the blade-element lift, drag, and pitching-moment coefficients as shown by the examples in figures 2, 3, and 4. Both subroutines make use of cubic splines under tension to fair the data. The data presented in figures 1, 2, 3, and 4 are based on the wind-tunnel data of reference 5.

Tabulating and Punching the Data

After the data have been plotted, they are presented in the format illustrated in table I. The information from table I is then "faired" into the internal table for an NACA 0012 airfoil of the rotorcraft flight simulation model (ref. 1). The table for the 0012 airfoil is included internal to PLTAERO. This inclusion is necessary because wind-tunnel tests do not generally include measurements at angles of attack from -180° to 180° (i.e., the range of values that might be experienced by a helicopter rotor blade as it travels around the hub).

The fairing is accomplished in the following manner: (1) Because values of c_l, c_d, and c_m at angles of attack less than -4° generally have little impact on performance, the coefficients in the reference tables at angles of attack less than -4° are left unchanged; (2) the values of c_l, c_d, and c_m for angles ranging from -4° to α_{max} (the maximum specified angle of attack at each specified Mach number) are replaced with corresponding values from table I; (3) values of c_l, c_d, and c_m for angles ranging from α_{max} to 21° are interpolated using TSPLINE; and (4) values of c_l, c_d, and c_m in the reference tables for angles of attack ranging from 21° to 180° are left unchanged. The resulting tables may be printed and punched in a format suitable for use with the rotorcraft flight simulation program. It is important to note that the plots generated by the PLTAERO program can be used to verify that the appropriate values have been inserted in the table. Any adjustments desired in the tabular data can be easily rectified by comparison with the plots.

RESULTS

Figure 5 is taken from reference 5 and shows the variation of c_n with angle of attack corrected for lift interference effects and c_d as a function of c_n. The blade-element lift coefficients used in the present report were calculated by using these normal-force coefficients with the corresponding drag coefficients of reference 5 to perform an axis rotation to define the lift coefficient. Comparison between these lift coefficients and the results of PLTAERO is presented in figure 6 as an example of program output. The card input guide is presented in table II.

CONCLUDING REMARKS

A computer program has been developed to facilitate the preparation of airfoil data for input into helicopter performance prediction programs. The program provides for numerically cross-plotting the data, plotting the data, and then tabulating and punching the tabulated results into computer cards for use in the government's rotorcraft flight simulation model.

Langley Research Center
National Aeronautics and Space Administration
Hampton, VA 23665
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APPENDIX

COMPUTER PROGRAM TO PREPARE AIRFOIL DATA FOR USE IN HELICOPTER PERFORMANCE PROGRAMS

The computer program PLTAERO is written in the Langley FORTRAN Extended Version 4, or FTN 4, and has been used on the Control Data series 6000 and CYBER 175 computer systems under the NOS system. The subroutines and their uses are presented in table III. Figure 7 is a diagram of the program structure. Basic plotting subroutines, such as those for drawing axes and annotation, are supplied from the Langley graphics output system; similar routines are assumed to be available to the general programing community. PLTAERO requires 77400 octal storage locations and takes about 4 seconds to compile. Each case takes about 20 seconds to execute on the CYBER 175 computer.

Subroutine TSPLINE

Subroutine TSPLINE performs two functions in PLTAERO; it interpolates curves at specified values and it calculates the first derivatives of curves at specified values. Inputs to TSPLINE include the x- and y-coordinates of the curve (x must be strictly increasing), the number of input points, a tension parameter (set to 10 in PLTAERO), a computing option, the number of points to be interpolated, and the x values at which interpolated values are desired. Outputs from TSPLINE include the interpolated values along with their first and second derivatives and the area under the curve defined by the input x- and y-coordinates.

Computer Program

The computer program PLTAERO used to prepare airfoil data for use in helicopter performance programs is presented as follows.

APPENDIX

```
      PROGRAM DECKPL(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,PUNCH)           MOD1        1
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO     2
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1        2
     2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)          PLTAERO     4
     3,NAMAX,NMMAX                                                      MOD2        1
      COMMON/HLM/TENR,XINT,ST                                           PLTAERO     6
      DIMENSION XX(5)                                                   PLTAERO     7
      CALL PSEUDO                                                       PLTAERO     8
      CALL LEROY                                                        PLTAERO     9
      CALL CALPLT(0.,0.,-3)                                             PLTAERO    10
      ST=10.                                                            PLTAERO    14
      TENR=ST                                                           PLTAERO    15
      WRITE(6,900)                                                      MOD1        3
  900 FORMAT(29X,22HINPUT DATA CARD IMAGES)                             MOD1        4
      READ(5,107)NAMAX,NMMAX                                            MOD2        2
      WRITE(6,107)NAMAX,NMMAX                                           MOD2        3
      READ(5,107) KA,KB,KC                                              MOD2        4
      WRITE(6,107)KA,KB,KC                                              MOD2        5
      READ(5,107) LA,LB,LC                                              MOD2        6
      WRITE(6,107) LA,LB,LC                                             MOD2        7
      READ(5,107) MA,MB,MC                                              MOD2        8
      WRITE(6,107)MA,MB,MC                                              MOD2        9
  107 FORMAT(3I5)                                                       MOD2       10
      READ(5,100) (XNMN(I),I=1,NAMAX)                                   PLTAERO    18
      WRITE(6,207)(XNMN(I),I=1,NAMAX)                                   PLTAERO    19
      READ(5,100)(XNA(I),I=1,NMMAX)                                     MOD2       11
      WRITE(6,207)(XNA(I),I=1,NMMAX)                                    MOD2       12
      READ(5,100)(XNAT(I),I=1,NMMAX)                                    MOD2       13
      WRITE(6,207)(XNAT(I),I=1,NMMAX)                                   MOD2       14
      READ(5,100)(XMN(I),I=1,NMMAX)                                     MOD2       15
      WRITE(6,207)(XMN(I),I=1,NMMAX)                                    MOD2       16
      READ(5,100) (PMN(I),I=1,NMMAX)                                    MOD2       17
      WRITE(6,207)(PMN(I),I=1,NMMAX)                                    MOD2       18
      READ(5,100) (PAA(I),I=1,NAMAX)                                    MOD2       19
      WRITE(6,207)(PAA(I),I=1,NAMAX)                                    MOD2       20
      DO 200 I=1,NMMAX                                                  MOD2       21
      M=XNAT(I)                                                         PLTAERO    27
      READ(5,100)(AA(I,J),J=1,M)                                        PLTAERO    28
      WRITE(6,207)(AA(I,J),J=1,M)                                       PLTAERO    29
      READ(5,100)(CL(I,J),J=1,M)                                        PLTAERO    30
      WRITE(6,207)(CL(I,J),J=1,M)                                       PLTAERO    31
      READ(5,100)(CD(I,J),J=1,M)                                        PLTAERO    32
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      WRITE(6,207)(CD(I,J),J=1,M)                                PLTAERO   33
      READ(5,100)(CPM(I,J),J=1,M)                                PLTAERO   34
      WRITE(6,207)(CPM(I,J),J=1,M)                               PLTAERO   35
  200 CONTINUE                                                   PLTAERO   36
      READ(5,103)(HEAD(J),J=1,3)                                 PLTAERO   37
      WRITE(6,103)(HEAD(J),J=1,3)                                PLTAERO   38
      READ(5,103)(BOTTOM(J),J=1,3)                               PLTAERO   39
      WRITE(6,103)(BOTTOM(J),J=1,3)                              PLTAERO   40
      CALL BOUND1(CL)                                            *******    1
      CALL BOUND1(CD)                                            *******    2
      CALL BOUND1(CPM)                                           *******    3
      CALL ADJUST1(CL)                                           *******    4
      CALL ADJUST1(CD)                                           *******    5
      CALL ADJUST1(CPM)                                          *******    6
      CALL BOUND2(CL)                                            *******    7
      CALL ADJUST2(CL)                                           *******    8
      CALL BOUND2(CD)                                            *******    9
      CALL ADJUST2(CD)                                           *******   10
      CALL BOUND2(CPM)                                           *******   11
      CALL ADJUST2(CPM)                                          *******   12
      IF(KA.EQ.0)GO TO 400                                       MOD2      22
      CALL P1(CL,6.,24.,-.6,.1,16HLIFT COEFFICIENT,16,2.,1.,5.125,23.,  PLTAERO   53
     14.5,24.,5.625,23.5,4.875,22.5,4.875,22.,17.)               PLTAERO   54
  400 CONTINUE                                                   MOD2      23
      IF(KB.EQ.0)GO TO 500                                       MOD2      24
      CALL P1(CD,0.,20.,0.,.01,16HDRAG COEFFICIENT,16,2.,1.,5.5,23.,5.25PLTAERO   55
     1,24.,6.,23.5,5.25,22.5,5.25,22.,19.)                       PLTAERO   56
  500 CONTINUE                                                   MOD2      25
      IF(KC.EQ.0)GO TO 600                                       MOD2      26
      CALL P1(CPM,10.,20.,-.2,.02,27HPITCHING MOMENT COEFFICIENT,27,1., PLTAERO   57
     1.5,4.875,23.,4.,24.,5.375,23.5,4.625,22.5,4.625,22.,9.)    PLTAERO   58
  600 CONTINUE                                                   MOD2      27
      IF(LA.EQ.0)GO TO 700                                       MOD2      28
      CALL P2(CL,.1,16HLIFT COEFFICIENT,16,0.,0.)                PLTAERO   59
  700 CONTINUE                                                   MOD2      29
      IF(LB.EQ.0)GO TO 800                                       MOD2      30
      CALL P2(CD,.01,16HDRAG COEFFICIENT,16,0.,0.)               PLTAERO   60
  800 CONTINUE                                                   MOD2      31
      IF(LC.EQ.0)GO TO 1000                                      MOD2      32
      CALL P2(CPM,.02,27HPITCHING MOMENT COEFFICIENT,27,10.,-.2) PLTAERO   61
 1000 CONTINUE                                                   MOD2      33
      WRITE(6,141)                                               PLTAERO   62
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      WRITE(6,142)(PMN(I),I=1,NMMAX)                              MOD2      34
      DO 143 J = 1,NAMAX                                          PLTAERO   64
      NNMN=XNMN(J)                                                PLTAERO   65
      WRITE(6,144)PAA(J),(CL(I,J),I=1,NNMN)                       PLTAERO   66
  143 CONTINUE                                                    PLTAERO   67
      WRITE(6,145)                                                PLTAERO   68
      WRITE(6,142)(PMN(I),I=1,NMMAX)                              MOD2      35
      DO 146 J = 1,NAMAX                                          PLTAERO   70
      NNMN=XNMN(J)                                                PLTAERO   71
      WRITE(6,144)PAA(J),(CD(I,J),I=1,NNMN)                       PLTAERO   72
  146 CONTINUE                                                    PLTAERO   73
      WRITE(6,147)                                                PLTAERO   74
      WRITE(6,142)(PMN(I),I=1,NMMAX)                              MOD2      36
      DO 148 J = 1,NAMAX                                          PLTAERO   76
      NNMN=XNMN(J)                                                PLTAERO   77
      WRITE(6,144)PAA(J),(CPM(I,J),I=1,NNMN)                      PLTAERO   78
  148 CONTINUE                                                    PLTAERO   79
      IF(MA.EQ.0)GO TO 1100                                       MOD2      37
      CALL C81(CL,-1)                                             PLTAERO   80
 1100 CONTINUE                                                    MOD2      38
      IF(MB.EQ.0)GO TO 1200                                       MOD2      39
      CALL C81(CD,0)                                              PLTAERO   81
 1200 CONTINUE                                                    MOD2      40
      IF(MC.EQ.0)GO TO 1300                                       MOD2      41
      CALL C81(CPM,1)                                             PLTAERO   82
 1300 CONTINUE                                                    MOD2      42
      CALL NFRAME(300.,0.)                                        PLTAERO   83
      CALL CALPLT(0.,0.,999)                                      PLTAERO   84
  100 FORMAT(8F10.0)                                              PLTAERO   85
  103 FORMAT(3A10)                                                PLTAERO   86
  142 FORMAT(9X,13F8.4)                                           PLTAERO   87
  144 FORMAT(14F8.4)                                              PLTAERO   88
  141 FORMAT(//,58X,16HLIFT COEFFICIENT)                          PLTAERO   89
  145 FORMAT(//,58X,16HDRAG COEFFICIENT)                          PLTAERO   90
  147 FORMAT(//,53X,27HPITCHING MOMENT COEFFICIENT)               PLTAERO   91
  207 FORMAT(8F10.4)                                              PLTAERO   92
      STOP                                                        PLTAERO   93
      END                                                         PLTAERO   94
```

```
      SUBROUTINE BOUND1(CX)                                             ********    13
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO     96
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1         8
     2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XMMNT(30)         PLTAERO      98
     3,NAMAX,NMMAX                                                     MOD2         43
      COMMON/HLM/TENR,XINT,ST                                          PLTAERO     100
      DIMENSION CX(30,30)                                              PLTAERO     101
      DO 100 I=1,NMMAX                                                 MOD2         44
      M = XNAT(I)                                                      PLTAERO     103
      M2 = XNA(I)                                                      PLTAERO     104
      DO 101 J=1,M                                                     PLTAERO     105
      XTEMP(J) = AA(I,J)                                               PLTAERO     106
      YTEMP(J) = CX(I,J)                                               PLTAERO     107
      XI(J) = AA(I,J)                                                  PLTAERG     108
C     WRITE(6,200)XTEMP(J),YTEMP(J),XI(J)                              PLTAERO     109
  101 CONTINUE                                                         PLTAERO     110
      CALL TSPLINE(XTEMP,YTEMP,M,B,ST,1,M,XI,YI,YP,YPP,XINT)           PLTAERO     111
      CX(I,1) = (PAA(1) - AA(I,1))*YP(1) + CX(I,1)                     PLTAERO     112
      CX(I,M) = (PAA(M2) - AA(I,M))*YP(M) + CX(I,M)                    PLTAERO     113
  100 CONTINUE                                                         PLTAERO     114
  200 FORMAT(3F10.4)                                                   PLTAERO     115
      RETURN                                                           PLTAERO     116
      END                                                              PLTAERO     117
```

```
      SUBROUTINE ADJUST1(CX)                                            *******       14
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO      119
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1           9
     2,XNA(30),XNMN(30),HEAD(30),BOTTIM(30),XMAT(30),XNMNT(30)          PLTAERO      121
     3,NAMAX,NMMAX                                                      MOD2          45
      COMMON/HLM/TENR,XINT,ST                                           PLTAERO      123
      DIMENSION CX(30,30)                                               PLTAERO      124
      DO 100 I=1,NMMAX                                                  MOD2          46
      M = XNAT(I)                                                       PLTAERO      126
      M2 = XNA(I)                                                       PLTAERO      127
      AA(I,1) = PAA(1)                                                  PLTAERO      128
      AA(I,M) = PAA(M2)                                                 PLTAERO      129
      DO 101 J=1,M                                                      PLTAERO      130
      XTEMP(J) = AA(I,J)                                                PLTAERO      131
      YTEMP(J) = CX(I,J)                                                PLTAERO      132
C     WRITE(6,200) XTEMP(J),YTEMP(J)                                    PLTAERO      133
  101 CONTINUE                                                          PLTAERO      134
      DO 103 K = 1,M2                                                   PLTAERO      135
      XI(K) = PAA(K)                                                    PLTAERO      136
  103 CONTINUE                                                          PLTAERO      137
      CALL TSPLINF(XTEMP,YTEMP,M,B,ST,1,M2,XI,YI,YP,YPP,XINT)           PLTAERO      138
      DO 102 J = 1,M2                                                   PLTAERO      139
      CX(I,J) = YI(J)                                                   PLTAERO      140
C     WRITE(6,200) XI(J),CX(I,J)                                        PLTAERO      141
  102 CONTINUE                                                          PLTAERO      142
  100 CONTINUE                                                          PLTAERO      143
  200 FORMAT(3F10.4)                                                    PLTAERO      144
      RETURN                                                            PLTAERO      145
      END                                                               PLTAERO      146
```

```
      SUBROUTINE P1(CX,YMS,LCS,VOCS,SFX,BCD,NC,TMAJ,TMIN,X1,Y1,X2,Y2,X3,PLTAERO  147
     1Y3,X4,Y4,X5,Y5,YXI)                                              PLTAERO  148
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO  149
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1      10
     2,XMA(30),XMMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)          PLTAERO  151
     3,NAMAX,NMMAX                                                      MOD2      47
      COMMON/HLM/TENR,XINT,ST                                           PLTAERO  153
      DIMENSION CX(30,30),BCD(30),XX(5)                                 PLTAERO  154
      CALL AXES(0.,YMS,0.,10.,0.,.1,1.,0.,11HMACH NUMBER,.25,-11)       PLTAERO  155
      CALL AXES(0.,0.,90.,LCS,VOCS,SFX,TMAJ,TMIN,BCD(1),.25,NC)         PLTAERO  156
      CALL NOTATE(X1,Y1,.125,11HMACH NUMBER,0.,11)                      PLTAERO  157
      CALL NOTATE(X2,Y2,.125,BCD(1),0.,NC)                              PLTAERO  158
      CALL NOTATE(X3,Y3,.125,3HVS.,0.,3)                                PLTAERO  159
      CALL NOTATE(X4,Y4,.125,HEAD(1),0.,30)                             PLTAERO  160
      CALL NOTATE(X5,Y5,.125,BOTTOM(1),0.,30)                           PLTAERO  161
      CALL NOTATE(X4,21.5,.125,29HINTERPOLATED TO SELECTED MACH,0.,29)  PLTAERO  162
      CALL NOTATE(X4,21.,.125,28HNUMBERS AND ANGLES OF ATTACK,0.,28)    PLTAERO  163
      NO=1                                                              PLTAERO  164
      CALL CALPLT(0.,YMS,-3)                                            PLTAERO  165
      YX= YXI                                                           PLTAERO  166
      CALL NOTATE(10.,YX,.125,28,0.,-1)                                 PLTAERO  167
      CALL NOTATE(11.5,YX,.125,4HSYM.,0.,4)                             PLTAERO  168
      DO 100 J = 1,NAMAX                                                PLTAERO  169
      YX = YX -.25                                                      PLTAERO  170
      NMMN=XMMN(J)                                                      PLTAERO  171
      DO 200 I=1,NMMN                                                   PLTAERO  172
      XTEMP(I)=10.*PMN(I)                                               PLTAERO  173
      YTEMP(I) = CX(I,J)/SFX                                            PLTAERO  174
C     WRITE(6,300) XTEMP(I),YTEMP(I)                                    PLTAERO  175
  200 CONTINUE                                                          PLTAERO  176
      CALL CURPLT(XTEMP,YTEMP,NMMN,NO,1,2,J)                            PLTAERO  177
      CALL NUMBER(10.,YX,.125,PAA(J),0.,2)                              PLTAERO  178
      XY= YX-.0625                                                      PLTAERO  179
      CALL PNTPLT(11.5,YX,NO,1)                                         PLTAERO  180
      NO = NO + 1                                                       PLTAERO  181
  100 CONTINUE                                                          PLTAERO  182
  300 FORMAT(2F10.4)                                                    PLTAERO  183
      CALL NFRAME(25.,0.)                                               PLTAERO  184
      RETURN                                                            PLTAERO  185
      END                                                               PLTAERO  186
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      SUBROUTINE BOUND2(CX)                                                *******     15
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO   188
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1       11
     2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)             PLTAERO   190
     3,NAMAX,NMMAX                                                         MOD2       48
      COMMON/HLM/TENP,XINT,ST                                              PLTAERO   192
      DIMENSION CX(30,30),XX(5)                                            PLTAERO   193
      DO 100 J = 1,NAMAX                                                   PLTAERO   194
      NNMN = XNMN(J)                                                       PLTAERO   195
      DO 200 I=1,NNMN                                                      PLTAERO   196
      XTEMP(I) = XMN(I)                                                    PLTAERO   197
      YTEMP(I) = CX(I,J)                                                   PLTAERO   198
      XI(I) = XMN(I)                                                       PLTAERO   199
C     WRITE(6,300) XTEMP(I),YTEMP(I),XI(I)                                 PLTAERO   200
  200 CONTINUE                                                             PLTAERO   201
      CALL TSPLINE(XTEMP,YTEMP,NNMN,B,ST,1,NNMN,XI,YI,YP,YPP,XINT)         PLTAERO   202
      CX(1,J) = (PMN(1) - XMN(1))*YP(1) + CX(1,J)                          PLTAERO   203
      CX(NNMN,J) =(PMN(NNMN) - XMN(NNMN))*YP(NNMN) + CX(NNMN,J)            PLTAERO   204
      XMN(1) = PMN(1)                                                      PLTAERO   205
      XMN(NNMN)= PMN(NNMN)                                                 PLTAERO   206
  100 CONTINUE                                                             PLTAERO   207
  300 FORMAT(3F10.4)                                                       PLTAERO   208
      RETURN                                                               PLTAERO   209
      END                                                                  PLTAERO   210
```

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      SUBROUTINE ADJUST2(CX)                                             *******      16
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO      212
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1          12
     2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)           PLTAERO      214
     3,NAMAX,NMMAX                                                       MOD2          49
      COMMON/HLM/TENR,XINT,ST                                            PLTAERO      216
      DIMENSION CX(30,30),XX(5)                                          PLTAERO      217
      DO 100 J = 1,NAMAX                                                 PLTAERO      218
      NNMN = XNMN(J)                                                     PLTAERO      219
      XMN(1) = PMN(1)                                                    PLTAERO      220
      XMN(NNMN) = PMN(NNMN)                                              PLTAERO      221
      DO 200 I=1,NNMN                                                    PLTAERO      222
      XTEMP(I) = XMN(I)                                                  PLTAERO      223
      YTEMP(I) = CX(I,J)                                                 PLTAERO      224
C     WRITE(6,300) XTEMP(I),YTEMP(I)                                     PLTAERO      225
  200 CONTINUE                                                           PLTAERO      226
      DO 203 I = 1,NNMN                                                  PLTAERO      227
      XI(I) = PMN(I)                                                     PLTAERO      223
C     WRITE(6,300) XI(I)                                                 PLTAERO      229
  203 CONTINUE                                                           PLTAERO      230
      CALL TSPLINE(XTEMP,YTEMP,NNMN,B,ST,1,NNMN,XI,YI,YP,YPP,XINT)       PLTAERO      231
      DO 400 I = 1,NNMN                                                  PLTAERO      232
      CX(I,J) = YI(I)                                                    PLTAERO      233
  400 CONTINUE                                                           PLTAERO      234
  100 CONTINUE                                                           PLTAERO      235
  300 FORMAT(3F10.4)                                                     PLTAERO      236
      RETURN                                                             PLTAERO      237
      END                                                                PLTAERO      238
```

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      SUBROUTINE P2(CX,SFX,BCD,NC,YHS,VO)                                PLTAERO   239
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO   240
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1       13
     2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)          PLTAERO   242
     3,NAMAX,NMMAX                                                      MOD2       50
      COMMON/HLM/TENR,XINT,ST                                           PLTAERO   244
      DIMENSION CX(30,30),BCD(NC)                                       PLTAERO   245
      NO = 1                                                            PLTAERO   246
      DO 100 I=1,NMMAX                                                  MOD2       51
      M = XNA(I)                                                        PLTAERO   248
      CALL NFRAME(25.,0.)                                               PLTAERO   249
      CALL AXES(4.,0.,90.,20.,VO,SFX,2.,1.,BCD(1),.25,NC)               PLTAERO   250
      CALL AXES(0.,YHS,0.,20.,-4.,1.,2.,1.,15HANGLE OF ATTACK,.25,-15)  PLTAERO   251
      CALL NOTATE(7.75,24.,.125,BCD(1),0.,NC)                           PLTAERO   252
      CALL NOTATE(8.25,23.5,.125,3HVS.,0.,3)                            PLTAERO   253
      CALL NOTATE(7.625,23.,.125,15HANGLE OF ATTACK,0.,15)              PLTAERO   254
      CALL NOTATE(7.825,22.5,.125,HEAD(1),0.,30)                        PLTAERO   255
      CALL NOTATE(7.825,22.,.125,BOTTOM(1),0.,30)                       PLTAERO   256
      CALL NOTATE(7.825,20.5,.125,29HINTERPOLATED TO SELECTED MACH,0.,29PLTAERO   257
     1)                                                                 PLTAERO   258
      CALL NOTATE(7.825,20.,.125,28HNUMBERS AND ANGLES OF ATTACK,0.,28) PLTAERO   259
      CALL NOTATE(7.825,19.5,.125,13HMACH NUMBER =,0.,13)               PLTAERO   260
      CALL NUMBER(9.625,19.0,.125,PMN(I),0.,3)                          PLTAERO   261
      DO 200 J=1,M                                                      PLTAERO   262
      XTEMP(J) = PAA(J) + 4.                                            PLTAERO   263
      YTEMP(J) = (CX(I,J)/SFX) + YHS                                    PLTAERO   264
C     WRITE(6,300) XTEMP(J),YTEMP(J)                                    PLTAERO   265
  200 CONTINUE                                                          PLTAERO   266
      CALL CURPLT(XTEMP,YTEMP,M,NO,1,2,I)                               PLTAERO   267
      NO = NO + 1                                                       PLTAERO   268
  100 CONTINUE                                                          PLTAERO   269
  300 FORMAT(2F10.4)                                                    PLTAERO   270
      PAA(1) = -4.                                                      PLTAERO   271
      RETURN                                                            PLTAERO   272
      END                                                               PLTAERO   273
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      SUBROUTINE C81(CX,JXP)                                            PLTAERO  274
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO  275
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1      14
     2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMT(30)           PLTAERO  277
     3,NAMAX,NMMAX                                                      MOD2      52
      DIMENSION  CX(30,30),CXL(11,39),CXD(11,65),CXP(9,47) ,ALL(39),ALD(PLTAERO  279
     165),ALP(47),XML(11),XMD(11),XMP(9),DUM(65)                        PLTAERO  280
      DATA ALL/-180.,-172.5,-161.,-147.,-129.,-49.,-39.,-21.,-16.5,-15.,PLTAERO  281
     1-14.,-13.,-12.,-11.,-10.,-8.,-6.,-4.,-2.,0.,2.,4.,6.,8.,10.,11.,12PLTAERO  282
     2.,13.,14.,15.,16.5,21.,39.,49.,129.,147.,161.,172.5,180./         PLTAERO  283
      DATA ALD/-180.,-175.,-170.,-165.,-160.,-140.,-120.,-110.,-100.,-90PLTAERO  284
     1.,-80.,-70.,-60.,-50.,-30.,-21.,-16.,-15.,-14.,-13.,-12.,-11.,-10.PLTAERO  285
     2,-9.,-8.,-7.,-6.,-5.,-4.,-3.,-2.,-1.,0.,1.,2.,3.,4.,5.,6.,7.,8.,9.PLTAERO  286
     3,10.,11.,12.,13.,14.,15.,16.,21.,30.,50.,60.,70.,80.,90.,100.,110.PLTAERO  287
     4,120.,140.,160.,165.,170.,175.,180./                              PLTAERO  288
      DATA ALP/-180.,-170.,-165.,-160.,-135.,-90.,-30.,23.,-16.,-15.,-14PLTAERO  289
     1.,-13.,-12.,-11.,-10.,-9.,-8.,-7.,-6.,-4.,-3.,-2.,-1.,0.,1.,2.,3.,PLTAERO  290
     24.,6.,7.,8.,9.,10.,11.,12.,13.,14.,15.,16.,23.,30.,90.,135.,160., PLTAERO  291
     3165.,170.,180./                                                   PLTAERO  292
      DATA XML/0.,.2,.3,.4,.5,.6,.7,.75,.8,.9,1./                       PLTAERO  293
      DATA XMD/0.,.2,.3,.4,.5,.6,.7,.75,.8,.9,1./                       PLTAERO  294
      DATA XMP/.2,.3,.4,.5,.6,.7,.75,.8,.9/                             PLTAERO  295
      DATA((CXL(I,J),J=1,39),I=1,6)/0.,.78,.62,1.,1.,-1.18,-1.18,-.8,   MOD1      15
     S-1.007,-1.19,-1.333,                                              PLTAERO  297
     1-1.334,-1.225,-1.161,-1.055,-.844,-.633,-.422,-.211,0.,.211,.422, PLTAERO  298
     2.633,.844,1.055,1.161,1.255,1.334,1.333,1.19,1.007,.8,1.18,1.18,  PLTAERO  299
     3-1.,-1.,-.62,-.78,0.,0.,.78,.62,1.,1.,-1.18,-1.18,-.8,-1.007,-1.19PLTAERO  300
     4,-1.333,-1.334,-1.255,-1.161,-1.055,-.844,-.633,-.422,-.211,0.,   PLTAERO  301
     5.211,.422,.633,.844,1.055,1.161,1.255,1.334,1.333,1.19,1.007,.8,  PLTAERO  302
     61.18,1.18,-1.,-1.,-.62,-.78,0.,0.,.78,.62,1.,1.,-1.18,-1.18,-.81, PLTAERO  303
     7-.944,-1.09,-1.22,-1.28,-1.26,-1.19,-1.01,-.88,-.66,-.44,-.22,0., PLTAERO  304
     8.22,.44,.66,.88,1.1,1.19,1.26,1.28,1.22,1.09,.944,.81,1.18,1.18,  PLTAERO  305
     9-1.,-1.,-.62,-.78,0.,0.,.78,.62,1.,1.,-1.18,-1.18,-.83,-.93,      PLTAERO  306
     S-1.055,                                                           PLTAERO  307
     A-1.096,-1.12,-1.13,-1.12,-1.082,-.907,-.684,-.456,-.228,0.,.228,  PLTAERO  308
     B.456,.684,.907,1.082,1.12,1.13,1.12,1.096,1.055,.96,.83,1.18,1.18,PLTAERO  309
     C-1.,-1.,-.62,-.78,0.,0.,.78,.62,1.,1.,-1.18,-1.18,-.85,-.965,-.99,PLTAERO  310
     D-1.,-1.,-1.,-.994,-.985,-.922,-.741,-.494,-.247,0.,.247,.494,.741,PLTAERO  311
     E.922,.985,.994,1.,1.,1.,.99,.965,.85,1.18,1.18,-1.,-1.,-.62,-.78, PLTAERO  312
     F0.,0.,.78,.62,1.,1.,-1.18,-1.18,-.85,-.965,-.98,-.97,-.96,-.947,  PLTAERO  313
     G-.93,-.91,-.87,-.77,-.544,-.272,0.,.272,.544,.77,.87,.91,.93,.947,PLTAERO  314
     H.96,.97,.98,.965,.85,1.18,1.18,-1.,-1.,-.62,-.78,0./              PLTAERO  315
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 DATA((CXL(I,J),J=1,39),I=7,11)/0.,.78,.62,1.,                         MOD1       16
I1.,-1.18,-1.18,-.85,-.965,-.98,-.97,-.96,-.94,-.923,-.9,-.84,-.75,PLTAERO    317
J-.578,-.313,0.,.313,.578,.75,.84,.9,.923,.94,.96,.97,.98,.965,.85,PLTAERO    318
K1.18,1.18,-1.,-1.,-.62,-.78,0.,0.,.78,.62,1.,1.,-1.18,-1.18,-.71, PLTAERO    319
L-.795,-.83,-.84,-.85,-.85,-.85,-.845,-.82,-.77,-.627,-.35,0.,.35, PLTAERO    320
M.627,.77,.82,.845,.85,.85,.85,.84,.83,.795,.71,1.18,1.18,-1.,-1., PLTAERO    321
N-.62,-.78,0.,0.,.78,.62,1.,1.,-1.18,-1.18,-.68,-.76,-.79,-.805,   PLTAERO    322
O-.815,-.82,-.81,-.805,-.77,-.72,-.603,-.395,0.,.395,.603,.72,.77, PLTAERO    323
P.805,.81,.82,.815,.805,.79,.76,.68,1.18,1.18,-1.,-1.,-.62,-.78,0.,PLTAERO    324
Q0.,.78,.62,1.,1.,-1.18,-1.18,-.64,-.7,-.72,-.73,-.735,-.74,-.74,  PLTAERO    325
R-.73,-.695,-.593,-.396,-.2,0.,.2,.396,.593,.695,.73,.74,.74,.735, PLTAERO    326
S.73,.72,.7,.64,1.18,1.18,-1.,-1.,-.62,-.78,0.,0.,.78,.62,1.,1.,   PLTAERO    327
T-1.18,-1.18,-.64,-.7,-.72,-.73,-.735,-.74,-.74,-.73,-.695,-.593,  PLTAERO    328
U-.396,-.2,0.,.2,.396,.593,.695,.73,.74,.74,.735,.73,.72,.7,.64,   PLTAERO    329
V1.18,1.18,-1.,-1.,-.62,-.78,0./                                   PLTAERO    330
 DATA((CXD(I,J),J=1,65),I=1,3)/.022,.062,.132,.242,.302,1.042,      MOD1       17
S1.652,1.852,2.022,2.022,                                          PLTAERO    332
11.962,1.842,1.662,1.392,.562,.332,.155,.102,.038,.0264,.022,.0196,PLTAERO    333
2.0174,.0154,.0138,.0122,.011,.01,.0093,.0088,.0085,.0083,.008,    PLTAERO    334
3.0083,.0085,.0088,.0093,.01,.011,.0122,.0138,.0154,.0174,.0196,   PLTAERO    335
4.022,.0264,.038,.102,.155,.332,.562,1.392,1.662,1.842,1.962,2.022,PLTAERO    336
52.022,1.852,1.652,1.042,.302,.242,.132,.062,.022,.022,.062,.132,  PLTAERO    337
6.242,.302,1.042,1.652,1.852,2.022,2.022,1.962,1.842,1.662,1.392,  PLTAERO    338
7.562,.332,.155,.102,.038,.0264,.022,.0196,.0174,.0154,.0138,.0122,PLTAERO    339
8.011,.01,.0093,.0088,.0085,.0083,.008,.0083,.0085,.0088,.0093,.01,PLTAERO    340
9.011,.0122,.0138,.0154,.0174,.0196,.022,.0264,.038,.102,.155,.332,PLTAERO    341
1.562,1.392,1.662,1.842,1.962,2.002,2.002,1.852,1.652,1.042,.302,  PLTAERO    342
A.242,.132,.062,.022,.022,.062,.132,.242,.302,1.042,1.652,1.852,   PLTAERO    343
B2.022,2.022,1.962,1.842,1.662,1.392,.562,.332,.181,.148,.099,.0455PLTAERO    344
C,.03,.0232,.0189,.0159,.0138,.0122,.011,.01,.0093,.0088,.0085,    PLTAERO    345
D.0083,.008,.0083,.0085,.0088,.0093,.01,.011,.0122,.0138,.0159,    PLTAERO    346
E.0189,.0232,.03,.0455,.099,.148,.181,.332,.562,1.392,1.662,1.842, PLTAERO    347
F1.962,2.022,2.022,1.852,1.652,1.042,.302,.242,.132,.062,.022/     PLTAERO    348
 DATA((CXD(I,J),J=1,65),I=4,6)/.022,                                MOD1       18
G.062,.132,.242,.302,1.042,1.652,1.852,2.022,2.022,1.962,1.842,    PLTAERO    350
H1.662,1.392,.562,.332,.207,.181,.146,.094,.06,.038,.0259,.0187,   PLTAERO    351
I.0147,.0123,.011,.01,.0093,.0088,.0085,.0083,.008,.0083,.0085,    PLTAERO    352
J.0088,.0093,.01,.011,.0123,.0147,.0187,.0259,.038,.06,.094,.146,  PLTAERO    353
K .181,.207,.332,.562,1.392,1.662,1.842,1.962,2.022,2.022,1.852,   PLTAERO    354
L1.652,1.042,.302,.242,.132,.062,.022,.022,.062,.132,.242,.302,    PLTAERO    355
M1.042,1.652,1.852,2.022,2.022,1.962,1.842,1.662,1.392,.562,.332,  PLTAERO    356
N.235,.209,.18,.148,.111,.078,.053,.0351,.022,.0141,.011,.01,.0093,PLTAERO    357
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R,.022,.062,.132,.242,.302,1.042,1.652,1.852,2.022,2.022,1.962,    PLTAERO    361
S1.842,1.662,1.392,.562,.332,.257,.233,.212,.191,.164,.135,.105,   PLTAERO    362
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U.009,.01,.0132,.0212,.035,.053,.077,.105,.135,.164,.191,.212,.233,PLTAERO    364
V.257,.332,.562,1.392,1.662,1.842,1.962,2.022,2.022,1.852,1.652,   PLTAERO    365
W1.042,.302,.242,.132,.062,.022/                                   PLTAERO    366
 DATA((CXD(I,J),J=1,65),I=7,9)/.022,.062,.132,.242,.302,1.042,     MOD1        19
X1.652,1.852,2.022,2.022,1.962,1.842,1.662,1.392,.562,.332,.274,   PLTAERO    368
Y.252,.233,.216,.198,.17,.145,.122,.101,.082,.0615,.038,.0167,.0102PLTAERO    369
Z,.0086,.0083,.008,.0083,.0086,.0102,.0167,.038,.0615,.082,.101,   PLTAERO    370
1.122,.145,.17,.198,.216,.233,.252,.274,.332,.562,1.392,1.662,1.842PLTAERO    371
2,1.962,2.022,2.022,1.852,1.652,1.042,.302,.242,.132,.062,.022,.022PLTAERO    372
3,.062,.132,.242,.302,1.042,1.652,1.852,2.022,2.022,1.962,1.842,   PLTAERO    373
41.662,1.392,.562,.332,.292,.271,.249,.231,.211,.192,.176,.159,.14,PLTAERO    374
5.111,.082,.054,.030,.0175,.0117,.0091,.008,.0091,.0117,.0175,.03, PLTAERO    375
6.054,.082,.111,.14,.159,.176,.192,.211,.231,.249,.271,.292,.332,  PLTAERO    376
7.562,1.392,1.662,1.842,1.962,2.022,2.022,1.852,1.652,1.042,.302,  PLTAERO    377
8.242,.132,.062,.022,.022,.062,.132,.242,.302,1.042,1.652,1.852,   PLTAERO    378
92.022,2.022,1.962,1.842,1.662,1.392,.562,.332,.305,.282,.26,.239, PLTAERO    379
A.22,.202,.186,.172,.155,.139,.12,.048,.0575,.0355,.024,.0175,.0137PLTAERO    380
B,.0175,.024,.0355,.0575,.048,.12,.139,.155,.172,.186,.202,.22,.239PLTAERO    381
C,.26,.282,.305,.332,.562,1.392,1.662,1.842,1.962,2.022,2.022,1.852PLTAERO    382
D,1.652,1.042,.302,.242,.132,.062,.022/                            PLTAERO    383
 DATA((CXD(I,J),J=1,65),I=10,11)/.022,.062,.132,.242,.302,         MOD1        20
E1.042,1.652,1.852,2.022,2.022,1.962,1.842,1.662,1.392,.562,.332,  PLTAERO    385
F.342,.298,.293,.272,.252,.232,.213,.199,.183,.169,.14,.111,.095,  PLTAERO    386
G.086,.081,.078,.078,.078,.081,.086,.095,.111,.14,.169,.183,.199,  PLTAERO    387
H.213,.232,.252,.272,.293,.298,.342,.332,.562,1.392,1.662,1.842,   PLTAERO    388
I1.962,2.022,2.022,1.852,1.652,1.042,.302,.242,.132,.062,.022,.022,PLTAERO    389
J.062,.132,.242,.302,1.042,1.652,1.852,2.022,2.022,1.962,1.842,    PLTAERO    390
K1.662,1.392,.562,.332,.342,.298,.293,.292,.291,.275,.254,.232,.214PLTAERO    391
L,.192,.17,.14,.112,.102,.098,.096,.095,.096,.098,.102,.112,.14,.17PLTAERO    392
M,.192,.214,.232,.254,.275,.291,.292,.293,.298,.342,.332,.562,1.392PLTAERO    393
N,1.662,1.842,1.962,2.022,2.022,1.852,1.652,1.042, 302,.242,.132,  PLTAERO    394
O.062,.022/                                                        PLTAERO    395
 DATA((CXP(I,J),J=1,47),I=1,6)/0.,.4,.3,.3,.5,.5,.174,.112,.073,   MOD1        21
S.054,0.,0.,0.,0.,0.,0.,                                           PLTAERO    397
10.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,      PLTAERO    398
2-.054,-.073,-.112,-.174,-.5,-.5,-.3,-.3,-.4,0.,0.,.4,.3,.3,.5,.5, PLTAERO    399
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     3.184,.118,.078,.065,.027,.0015,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.PLTAERO    400
     4,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,-.0015,-.027,-.065,-.078,-.118, PLTAERO    401
     5-.184,-.5,-.5,-.3,-.3,-.4,0.,0.,.4,.3,.3,.5,.5,.196,.128,.086,.073PLTAERO    402
     6,.054,.025,.002,-.003,-.0015,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0., PLTAERO    403
     70.,0.,0.,0.,0.,.0015,.003,-.002,-.025,-.054,-.073,-.086,-.128,    PLTAERO    404
     8-.196,-.5,-.5,-.3,-.3,-.4,0.,0.,.4,.3,.3,.5,.5,.214,.144,.097,.084PLTAERO    405
     9,.068,.05,.03,.014,.002,-.003,-.004,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,PLTAERO    406
     A0.,0.,0.,.004,.003,-.002,-.014,-.03,-.05,-.068,-.084,-.097,-.144, PLTAERO    407
     B-.214,-.5,-.5,-.3,-.3,-.4,0.,0.,.4,.3,.3,.5,.5,.235,.157,.108,.097PLTAERO    408
     C,.086,.074,.06,.046,.032,.016,.005,-.004,-.063,0.,0.,0.,0.,0.,0.,0PLTAERO    409
     D.,0.,0.,.003,.004,-.005,-.016,-.032,-.046,-.06,-.074,-.086,-.097, PLTAERO    410
     E-.108,-.157,-.235,-.5,-.5,-.3,-.3,-.4,0.,0.,.4,.3,.3,.5,.5,.25,.17PLTAERO    411
     F1,.113,.111,.103,.093,.083,.074,.065,.054,.041,.0275,.016,.005,.00PLTAERO    412
     G25,0.,0.,0.,0.,0.,.0025,-.005,-.016,-.0275,-.041,-.054,-.065,-.074PLTAERO    413
     H,-.0183,-.093,-.103,-.111,-.117,-.171,-.25,-.5,-.5,-.3,-.3,-.4,0./PLTAERO    414
      DATA((CXP(I,J),J=1,47),I=7,9)/0.,.4,.3,.3,.5,.5,.264,.183,.137,   MOD1        22
     S.133,.127,.122,.116,.108,.1,.089,                                 PLTAERO    415
     J.082,.072,.0625,.04,.026,.013,.0035,0.,-.0035,-.013,-.026,-.04,   PLTAERO    417
     K-.0625,-.072,-.082,-.089,-.1,-.108,-.116,-.122,-.127,-.133,-.137, PLTAERO    418
     L-.183,-.264,-.5,-.5,-.3,-.3,-.4,0.,0.,.4,.3,.3,.5,.5,.277,.206,   PLTAERO    419
     M.176,.173,.167,.163,.157,.149,.142,.132,.123,.1125,.1,.076,.0665, PLTAERO    420
     N.053,.033,0.,-.033,-.053,-.0665,-.076,-.1,-.1125,-.123,-.132,-.142PLTAERO    421
     O,-.149,-.157,-.163,-.167,-.173,-.176,-.206,-.277,-.5,-.5,-.3,-.3, PLTAERO    422
     P-.4,0.,0.,.4,.3,.3,.5,.5,.298,.232,.2,.195,.189,.184,.176,.17,.163PLTAERO    423
     Q,.154,.145,.136,.125,.102,.087,.07,.045,0.,-.045,-.07,-.087,-.102,PLTAERO    424
     R-.125,-.136,-.145,-.154,-.163,-.17,-.176,-.184,-.189,-.195,-.2,   PLTAERO    425
     S-.232,-.298,-.5,-.5,-.3,-.3,-.4,0./                               PLTAERO    426
      IF(JXP) 107,108,109                                               MOD1        23
  107 WRITE(6,110)                                                      MOD1        24
      GO TO 113                                                         MOD1        25
  108 WRITE(6,111)                                                      MOD1        26
      GO TO 113                                                         MOD1        27
  109 WRITE(6,112)                                                      MOD1        28
  113 CONTINUE                                                          MOD1        29
  110 FORMAT(33X,14HC81 LIFT TABLE)                                     MOD1        30
  111 FORMAT(33X,14HC81 DRAG TABLE)                                     MOD1        31
  112 FORMAT(31X,16HC81 MOMENT TABLE)                                   MOD1        32
  977 FORMAT(////)                                                      MOD1        33
      IF(JXP)100,200,300                                                MOD1        34
  100 CONTINUE                                                          PLTAERO    428
      CALL C82(3,11,39,2,17,8,32,ALL,XML,CXL,CX,JXP)                    MOD1        35
      WRITE(6,120)                                                      MOD1        36
```

```
  120 FORMAT(32X,16HDATA CARD IMAGES)                          MOD1       37
      NXL = 11                                                 PLTAERO   459
      NZL = 39                                                 PLTAERO   460
      NXD = 11                                                 PLTAERO   461
      NZD = 65                                                 PLTAERO   462
      NXM = 9                                                  PLTAERO   463
      NZM = 47                                                 PLTAERO   464
      WRITE(6,905)(HEAD(J),J=1,3)                              MOD1       38
      PUNCH 905,(HEAD(J),J=1,3)                                MOD1       39
  905 FORMAT(1X,3A10)                                          MOD1       40
      WRITE(6,906)(BOTTOM(J),J=1,3),NXL,NZL,NXD,NZD,NXM,NZM    MOD1       41
      PUNCH 906,(BOTTOM(J),J=1,3),NXL,NZL,NXD,NZD,NXM,NZM      MOD1       42
  906 FORMAT(3A10,6I2)                                         PLTAERO   470
      WRITE(6,910) (XML(I),I=1,9)                              MOD1       43
      PUNCH910, (XML(I),I=1,9)                                 MOD1       44
      WRITE(6,911) (XML(I),I=10,11)                            MOD1       45
      PUNCH 911, (XML(I),I=10,11)                              MOD1       46
  907 FORMAT(F7.0,9F7.4)                                       MOD1       47
  908 FORMAT(7X,2F7.4)                                         MOD1       48
  910 FORMAT(7X,9F7.4)                                         MOD1       49
  911 FORMAT(7X,2F7.4)                                         MOD1       50
      DO 1000 J=1,39                                           PLTAERO   474
      WRITE(6,907) ALL(J),(CXL(I,J),I=1,9)                     MOD1       51
      WRITE(6,908) (CXL(I,J),I=10,11)                          MOD1       52
      PUNCH 907, ALL(J),(CXL(I,J),I=1,9)                       MOD1       53
      PUNCH 909, (CXL(I,J),I=10,11)                            MOD1       54
 1000 CONTINUE                                                 PLTAERO   477
      WRITE(6,977)                                             MOD1       55
      RETURN                                                   PLTAERO   478
  200 CONTINUE                                                 PLTAERO   479
      CALL C82(3,11,65,2,28,16,50,ALD,XMD,CXD,CX,JXP)          MOD1       56
      WRITE(6,120)                                             MOD1       57
      WRITE(6,910) (XMD(I),I=1,9)                              MOD1       58
      PUNCH910, (XMD(I),I=1,9)                                 MOD1       59
      WRITE(6,911) (XMD(I),I=10,11)                            MOD1       60
      PUNCH 911, (XMD(I),I=10,11)                              MOD1       61
      DJ 1400 J=1,65                                           PLTAERO   512
      WRITE(6,907) ALD(J),(CXD(I,J),I=1,9)                     MOD1       62
      WRITE(6,908) (CXD(I,J),I=10,11)                          MOD1       63
      PUNCH 907, ALD(J),(CXD(I,J),I=1,9)                       MOD1       64
      PUNCH 908, (CXD(I,J),I=10,11)                            MOD1       65
 1400 CONTINUE                                                 PLTAERO   515
```

```
      WRITE(6,977)                                               MOD1        66
      RETURN                                                     PLTAERO    516
  300 CONTINUE                                                   PLTAERO    517
      CALL C82(2,9,47,1,19,8,40,ALP,XMP,CXP,CX,JXP)              MOD1        67
      WRITE(6,120)                                               MOD1        68
      DO 1800 J=1,47                                             PLTAERO    549
      WRITE(6,910) (XMP(I),I=1,9)                                MOD1        69
      PUNCH910, (XMP(I),I=1,9)                                   MOD1        70
      WRITE(6,907) ALP(J),(CXP(I,J),I=1,9)                       MOD1        71
      PUNCH 907, ALP(J),(CXP(I,J),I=1,9)                         MOD1        72
 1800 CONTINUE                                                   PLTAERO    552
      WRITE(6,977)                                               MOD1        73
      RETURN                                                     PLTAERO    553
      END                                                        PLTAERO    554
```

APPENDIX

```
      SUBROUTINE C82(IA,IB,IC,ID,IE,IF,IG,ALPHA,XMACH,CXX,CX,JXP)        MOD1    74
      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)MOD1    75
     1,CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)MOD1    76
     2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)          MOD1    77
     3,NAMAX,NMMAX                                                      MOD2    53
      COMMON /HLM/ TENR,XINT,ST                                         MOD1    79
      DIMENSION CX(30,30),CXX(IB,IC),XMACH(IB),DUM(11,65),ALPHA(IC)     MOD1    80
      DO 499 I = 1,IB                                                   MOD1    81
      DO 498 J = 1,IC                                                   MOD1    82
      DUM(I,J) = CXX(I,J)                                               MOD1    83
  498 CONTINUE                                                          MOD1    84
  499 CONTINUE                                                          MOD1    85
  101 FORMAT(12F10.4)                                                   MOD1    86
  102 FORMAT(////)                                                      MOD1    87
      DO 500 I = IA,IB                                                  MOD1    88
      DO 501 J = 1,IC                                                   MOD1    89
      DO 502 II=1,NMMAX                                                 MOD2    54
      NAT = XNA(II)                                                     MOD1    91
      DO 503 JJ = 1,NAT                                                 MOD1    92
      IF(PAA(JJ).EQ.ALPHA(J).AND.PMN(II).EQ.XMACH(I)) CXX(I,J)=CX(II,JJ)MOD1    93
      IF(PAA(JJ).EQ.ALPHA(J).AND.PMN(II).EQ.XMACH(I)) GO TO 501         MOD1    94
  503 CONTINUE                                                          MOD1    95
  502 CONTINUE                                                          MOD1    96
  501 CONTINUE                                                          MOD1    97
  500 CONTINUE                                                          MOD1    98
      DO 510 I = 1,ID                                                   MOD1    99
      NAT = XNA(I)                                                      MOD1   100
      JJOP = IE + 1                                                     MOD1   101
      DO 511 J = JJOP,IC                                                MOD1   102
      IF(ALPHA(J).GT.PAA(NAT)) GO TO 511                                MOD1   103
      CXX(I,J) = CXX(IA,J)                                              MOD1   104
  511 CONTINUE                                                          MOD1   105
  510 CONTINUE                                                          MOD1   106
      IF(JXP.EQ.1) GO TO 513                                            MOD1   107
      IF(PMN(NMMAX).LE..9) GO TO 513                                    MOD2    55
      NAT = XNA(NMMAX)                                                  MOD2    56
      DO 512 J = JJOP,IC                                                MOD1   110
      IF(ALPHA(J).GT.PAA(NAT)) GO TO 512                                MOD1   111
      CXX(I,J) = CXX(10,J)                                              MOD1   112
  512 CONTINUE                                                          MOD1   113
  513 CONTINUE                                                          MOD1   114
      DO 600 I = 1,IB                                                   MOD1   115
```

```
      IJ = 0                                                  MOD1     116
      DO 601 J = 1,IC                                         MOD1     117
      IF(CXX(I,J).NE.DUM(I,J)) IJ = IJ+1                      MOD1     118
  601 CONTINUE                                                MOD1     119
      IJJ = IE + IJ                                           MOD1     120
      DO 602 J = 1,IJJ                                        MOD1     121
      XTEMP(J) = ALPHA(J)                                     MOD1     122
      YTEMP(J) = CXX(I,J)                                     MOD1     123
  602 CONTINUE                                                MOD1     124
      IJJP = IJJ + 1                                          MOD1     125
      IJJQ = IJJ + IF                                         MOD1     126
  107 FORMAT(11I5)                                            MOD1     127
      DO 603 J = IJJP,IJJQ                                    MOD1     128
      JXJ = (J-IJJP) + IG                                     MOD1     129
      XTEMP(J) = ALPHA(JXJ)                                   MOD1     130
      YTEMP(J) = CXX(I,JXJ)                                   MOD1     131
  603 CONTINUE                                                MOD1     132
      CALL TSPLINE(XTEMP,YTEMP,IJJQ,B,ST,1,IC,ALPHA,YI,YP,YPP,XINT)  MOD1     133
      DO 604 J = 1,IC                                         MOD1     134
      CXX(I,J) = YI(J)                                        MOD1     135
  604 CONTINUE                                                MOD1     136
  600 CONTINUE                                                MOD1     137
      DO 700 J = 1,IC                                         MOD1     138
      WRITE(6,101) ALPHA(J),(CXX(I,J),I=1,IB)                 MOD1     139
  100 FORMAT(11F10.4)                                         MOD1     140
  700 CONTINUE                                                MOD1     141
      WRITE(6,102)                                            MOD1     142
      RETURN                                                  MOD1     143
      END                                                     MOD1     144
```

```
      SUBROUTINE SYMBS(NO,IS,X,Y,T)                                     PLTAERO   555
C        NO  -  SYMBOL NUMBER                                           PLTAERO   556
C        IS  -  SYMBOL SIZE    1-SMALL    2-MEDIUM    3-LARGE           PLTAERO   557
C        X AND Y  -  INTERCEPT OF SYMBOL AND RADIAL DRAWN FROM SYMBOL   PLTAERO   558
C                    CENTER AT ANGLE T.                                 PLTAERO   559
      DIMENSION SCALE(3)                                                PLTAERO   560
      DATA RAD/57.2957795131/,PI/3.141592654/                           PLTAERO   561
      DATA DA/1.4142135624/,R/1.7320508076/,SCALE/.13,.16,.19/          PLTAERO   562
      DATA T1/213.6900675260/,T2/326.3099324740/,T3/116.5650511771/,T4/3PLTAERO   563
     133.4349488229/,T7/11.3099324740/,T8/168.6900675260/,T9/218.6598082PLTAERO   564
     2541/,S1/321.3401917459/,S2/185.7105931375/,S3/354.2894068625/,S4/1PLTAERO   565
     31.3099324740/,S5/168.6900675260/,S6/218.6598082541/,S7/321.3401917PLTAERO   566
     4459/                                                              PLTAERO   567
      IF ((NO.EQ.1).OR.(NO.EQ.11)) GO TO 1                              PLTAERO   568
      IF ((NO.EQ.2).OR.(NO.EQ.12)) GO TO 2                              PLTAERO   569
      IF ((NO.EQ.3).OR.(NO.EQ.13)) GO TO 8                              PLTAERO   570
      IF ((NO.EQ.4).OR.(NO.EQ.14)) GO TO 13                             PLTAERO   571
      IF ((NO.EQ.5).OR.(NO.EQ.15)) GO TO 17                             PLTAERO   572
      IF ((NO.EQ.6).OR.(NO.EQ.16)) GO TO 21                             PLTAERO   573
      IF ((NO.EQ.7).OR.(NO.EQ.17)) GO TO 26                             PLTAERO   574
      IF ((NO.EQ.8).OR.(NO.EQ.18)) GO TO 31                             PLTAERO   575
      IF ((NO.EQ.9).OR.(NO.EQ.19)) GO TO 35                             PLTAERO   576
      IF ((NO.EQ.10).OR.(NO.EQ.20)) GO TO 40                            PLTAERO   577
      IF ((NO.EQ.21).OR.(NO.EQ.22)) GO TO 45                            PLTAERO   578
      IF (NO.GT.22) RETURN                                              PLTAERO   579
C        SYMBOL NUMBER 1 OR 11                                          PLTAERO   580
1     X=SCALE(IS)*.5525*COS(T/RAD)                                      PLTAERO   581
      Y=SCALE(IS)*.5525*SIN(T/RAD)                                      PLTAERO   582
      RETURN                                                            PLTAERO   583
C        SYMBOL NUMBER 2 OR 12                                          PLTAERO   584
2     IF ((T.GE.0.).AND.(T.LT.45.)) GO TO 3                             PLTAERO   585
      IF ((T.GE.45.0).AND.(T.LT.135.)) GO TO 4                          PLTAERO   586
      IF ((T.GE.135.).AND.(T.LT.225.)) GO TO 5                          PLTAERO   587
      IF ((T.GE.225.).AND.(T.LT.315.)) GO TO 6                          PLTAERO   588
      IF ((T.GE.315.).AND.(T.LE.360.)) GO TO 7                          PLTAERO   589
3     X=SCALE(IS)/2.                                                    PLTAERO   590
      Y=X*TAN(T/RAD)                                                    PLTAERO   591
      RETURN                                                            PLTAERO   592
4     Y=SCALE(IS)/2.                                                    PLTAERO   593
      IF (T.EQ.90.) X=0.0                                               PLTAERO   594
      IF (T.NE.90.) X=Y/TAN(T/RAD)                                      PLTAERO   595
      RETURN                                                            PLTAERO   596
```

```
5     X=-SCALE(IS)/2.                                           PLTAERO  597
      Y=X*TAN(T/RAD)                                            PLTAERO  598
      RETURN                                                    PLTAERO  599
6     Y=-SCALE(IS)/2.                                           PLTAERO  600
      IF (T.EQ.270.) X=0.0                                      PLTAERO  601
      IF (T.NE.270.) X=Y/TAN(T/RAD)                             PLTAERO  602
      RETURN                                                    PLTAERO  603
7     X=SCALE(IS)/2.                                            PLTAERO  604
      Y=X*TAN(T/RAD)                                            PLTAERO  605
      RETURN                                                    PLTAERO  606
C        SYMBOL NUMBER 3 OR 13                                  PLTAERO  607
8     IF ((T.GE.0.).AND.(T.LT.90.)) GO TO 9                     PLTAERO  608
      IF ((T.GE.90.).AND.(T.LT.180.)) GO TO 10                  PLTAERO  609
      IF ((T.GE.180.).AND.(T.LT.270.)) GO TO 11                 PLTAERO  610
      IF ((T.GE.270.).AND.(T.LE.360.)) GO TO 12                 PLTAERO  611
9     X=SCALE(IS)*DA/2./(TAN(T/RAD)+1.)                         PLTAERO  612
      Y=-X+SCALE(IS)*DA/2.                                      PLTAERO  613
      RETURN                                                    PLTAERO  614
10    IF (T.EQ.90.) X=0.0                                       PLTAERO  615
      IF (T.NE.90.) X=SCALE(IS)*DA/2./(TAN(T/RAD)-1.)           PLTAERO  616
      Y=X+SCALE(IS)*DA/2.                                       PLTAERO  617
      RETURN                                                    PLTAERO  618
11    X=-SCALE(IS)*DA/2./(TAN(T/RAD)+1.)                        PLTAERO  619
      Y=-X-SCALE(IS)*DA/2.                                      PLTAERO  620
      RETURN                                                    PLTAERO  621
12    IF (T.EQ.270.) X=0.0                                      PLTAERO  622
      IF (T.NE.270.) X=-SCALE(IS)*DA/2./(TAN(T/RAD)-1.)         PLTAERO  623
      Y=X-SCALE(IS)*DA/2.                                       PLTAERO  624
      RETURN                                                    PLTAERO  625
C        SYMBOL NUMBER 4 OR 14                                  PLTAERO  626
13    IF ((T.GE.0.).AND.(T.LT.90.)) GO TO 14                    PLTAERO  627
      IF ((T.GE.90.).AND.(T.LT.T1)) GO TO 15                    PLTAERO  628
      IF ((T.GE.T1).AND.(T.LT.T2)) GO TO 16                     PLTAERO  629
      IF ((T.GE.T2).AND.(T.LE.360.)) GO TO 14                   PLTAERO  630
14    X=(2./3.)*SCALE(IS)*1.105/(TAN(T/RAD)+2.)                 PLTAERO  631
      Y=-2.*X+2.*SCALE(IS)*1.105/3.                             PLTAERO  632
      RETURN                                                    PLTAERO  633
15    IF (T.EQ.90.) X=0.0                                       PLTAERO  634
      IF (T.NE.90.) X=(2./3.)*SCALE(IS)*1.105/(TAN(T/RAD)-2.)   PLTAERO  635
      Y=2.*X+2.*SCALE(IS)*1.105/3.                              PLTAERO  636
      RETURN                                                    PLTAERO  637
16    Y=-SCALE(IS)*1.105/3.                                     PLTAERO  638
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          IF (T.NE.270.) X=0.0                                          PLTAERO  639
          IF (T.NE.270.) X=Y/TAN(T/RAD)                                 PLTAERO  640
          RETURN                                                        PLTAERO  641
C            SYMBOL NUMBER 5 OR 15                                      PLTAERO  642
17        IF ((T.GE.0.).AND.(T.LT.T3)) GO TO 18                         PLTAERO  643
          IF ((T.GE.T3).AND.(T.LT.225.)) GO TO 19                       PLTAERO  644
          IF ((T.GE.225.).AND.(T.LT.T4)) GO TO 20                       PLTAERO  645
          IF ((T.GE.T4).AND.(T.LE.360.)) GO TO 18                       PLTAERO  646
18        IF (T.EQ.90.) X=0.0                                           PLTAERO  647
          IF (T.NE.90.) X=SCALE(IS)*1.22222/3./(TAN(T/RAD)+1.)          PLTAERO  648
          Y=-X+SCALE(IS)*1.22222/3.                                     PLTAERO  649
          RETURN                                                        PLTAERO  650
19        X=-SCALE(IS)*1.22222/3.                                       PLTAERO  651
          Y=X*TAN(T/RAD)                                                PLTAERO  652
          RETURN                                                        PLTAERO  653
20        Y=-SCALE(IS)*1.22222/3.                                       PLTAERO  654
          IF (T.EQ.270.) X=0.0                                          PLTAERO  655
          IF (T.NE.270.) X=Y/TAN(T/RAD)                                 PLTAERO  656
          RETURN                                                        PLTAERO  657
C            SYMBOL NUMBER 6 OR 16                                      PLTAERO  658
21        A=4.*SCALE(IS)*1.22222/(3.*PI)                                PLTAERO  659
          B=SCALE(IS)*1.22222-A                                         PLTAERO  660
          T5=ATAN(A/B)*RAD                                              PLTAERO  661
          T6=360.-T5                                                    PLTAERO  662
          T5=90.+T5                                                     PLTAERO  663
          IF ((T.GE.0.).AND.(T.LT.T5)) GO TO 22                         PLTAERO  664
          IF ((T.GE.T5).AND.(T.LT.225.)) GO TO 24                       PLTAERO  665
          IF ((T.GE.225.).AND.(T.LT.T6)) GO TO 25                       PLTAERO  666
          IF ((T.GE.T6).AND.(T.LE.360.)) GO TO 22                       PLTAERO  667
22        IF (T.EQ.90.) GO TO 23                                        PLTAERO  668
          BB=-2.*A*(1.+TAN(T/RAD))                                      PLTAERO  669
          AA=TAN(T/RAD)**2+1.                                           PLTAERO  670
          CC=2.*A*A-(SCALE(IS)*1.22222)**2                              PLTAERO  671
          X=SQRT(BB*BB-4.*AA*CC)/(2.*AA)                                PLTAERO  672
          IF ((T.GE.0.).AND.(T.LT.90.)) X=X+BB/(2.*AA)                  PLTAERO  673
          IF ((T.GE.90.).AND.(T.LT.180.)) X=-X+BB/(2.*AA)               PLTAERO  674
          IF ((T.GE.270.).AND.(T.LE.360.)) X=X+BB/(2.*AA)               PLTAERO  675
          Y=X*TAN(T/RAD)                                                PLTAERO  676
          RETURN                                                        PLTAERO  677
23        X=0.0                                                         PLTAERO  678
          Y=-A+SQRT((SCALE(IS)*1.22222)**2-A*A)                         PLTAERO  679
          RETURN                                                        PLTAERO  680
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24    X=-A                                                            PLTAERO   681
      Y=X*TAN(T/RAD)                                                  PLTAERO   682
      RETURN                                                          PLTAERO   683
25    Y=-A                                                            PLTAERO   684
      IF (T.EQ.270.) X=0.0                                            PLTAERO   685
      IF (T.NE.270.) X=Y/TAN(T/RAD)                                   PLTAERO   686
      RETURN                                                          PLTAERO   687
C        SYMBOL NUMBER 7 OR 17                                        PLTAERO   688
26    IF ((T.GE.0.0).AND.(T.LT.T7)) GO TO 27                          PLTAERO   689
      IF ((T.GE.T7).AND.(T.LT.T8)) GO TO 28                           PLTAERO   690
      IF ((T.GE.T8).AND.(T.LT.T9)) GO TO 29                           PLTAERO   691
      IF ((T.GE.T9).AND.(T.LT.S1)) GO TO 30                           PLTAERO   692
      IF ((T.GE.S1).AND.(T.LE.360.)) GO TO 27                         PLTAERO   693
27    X=SCALE(IS)/2.                                                  PLTAERO   694
      Y=X*TAN(T/RAD)                                                  PLTAERO   695
      RETURN                                                          PLTAERO   696
28    X=SCALE(IS)*.1*SIN(T/RAD)*COS(T/RAD)+SCALE(IS)*COS(T/RAD)*SQRT(.25PLTAERO   697
     1-(.1*COS(T/RAD))**2)                                            PLTAERO   698
      Y=X*TAN(T/RAD)                                                  PLTAERO   699
      RETURN                                                          PLTAERO   700
29    X=-SCALE(IS)/2.                                                 PLTAERO   701
      Y=X*TAN(T/RAD)                                                  PLTAERO   702
      RETURN                                                          PLTAERO   703
30    Y=-SCALE(IS)*.4                                                 PLTAERO   704
      IF (T.EQ.270.) X=0.0                                            PLTAERO   705
      IF (T.NE.270.) X=Y/TAN(T/RAD)                                   PLTAERO   706
      RETURN                                                          PLTAERO   707
C        SYMBOL NUMBER 8 OR 18                                        PLTAERO   708
31    IF ((T.GE.0.0).AND.(T.LT.S2)) GO TO 32                          PLTAERO   709
      IF ((T.GE.S2).AND.(T.LE.270.)) GO TO 33                         PLTAERO   710
      IF ((T.GT.270.).AND.(T.LE.S3)) GO TO 34                         PLTAERO   711
      IF ((T.GT.S3).AND.(T.LE.360.)) GO TO 32                         PLTAERO   712
32    X=-.05*SCALE(IS)*SIN(T/RAD)*COS(T/RAD)+SCALE(IS)*COS(T/RAD)*SQRT(.PLTAERO   713
     125-(.05*COS(T/RAD))**2)                                         PLTAERO   714
      Y=X*TAN(T/RAD)                                                  PLTAERO   715
      RETURN                                                          PLTAERO   716
33    IF (T.EQ.270.) X=0.0                                            PLTAERO   717
      IF (T.EQ.270.) Y=-SCALE(IS)*.55                                 PLTAERO   718
      IF (T.NE.270.) X=-SCALE(IS)*.55/(TAN(T/RAD)+1.)                 PLTAERO   719
      IF (T.NE.270.) Y=X*TAN(T/RAD)                                   PLTAERO   720
      RETURN                                                          PLTAERO   721
34    X=-SCALE(IS)*.55/(TAN(T/RAD)-1.)                                PLTAERO   722
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      Y=X*TAN(T/RAD)                                          PLTAERO 723
      RETURN                                                  PLTAERO 724
C        SYMBOL NUMBER 9 OR 19                                PLTAERO 725
35    IF ((T.GE.0.0).AND.(T.LT.90.)) GO TO 36                 PLTAERO 726
      IF ((T.GE.90.).AND.(T.LT.180.)) GO TO 37                PLTAERO 727
      IF ((T.GE.180.).AND.(T.LT.270.)) GO TO 38               PLTAERO 728
      IF ((T.GE.270.).AND.(T.LE.360.)) GO TO 39               PLTAERO 729
36    X=SCALE(IS)*R/2./(TAN(T/RAD)+R)                         PLTAERO 730
      Y=X*TAN(T/RAD)                                          PLTAERO 731
      RETURN                                                  PLTAERO 732
37    IF (T.EQ.90.) X=0.0                                     PLTAERO 733
      IF (T.NE.90.) X=SCALE(IS)*R/2./(TAN(T/RAD)-R)           PLTAERO 734
      IF (T.EQ.90.) Y=SCALE(IS)*R/2.                          PLTAERO 735
      IF (T.NE.90.) Y=X*TAN(T/RAD)                            PLTAERO 736
      RETURN                                                  PLTAERO 737
38    X=-SCALE(IS)*R/2./(TAN(T/RAD)+R)                        PLTAERO 738
      Y=X*TAN(T/RAD)                                          PLTAERO 739
      RETURN                                                  PLTAERO 740
39    IF (T.EQ.270.) X=0.0                                    PLTAERO 741
      IF (T.EQ.270.) Y=-SCALE(IS)*R/2.                        PLTAERO 742
      IF (T.NE.270.) X=-SCALE(IS)*R/2./(TAN(T/RAD)-R)         PLTAERO 743
      IF (T.NE.270.) Y=X*TAN(T/RAD)                           PLTAERO 744
      RETURN                                                  PLTAERO 745
C        SYMBOL NUMBER 10 OR 20                               PLTAERO 746
40    IF ((T.GE.0.0).AND.(T.LT.S4)) GO TO 41                  PLTAERO 747
      IF ((T.GE.S4).AND.(T.LT.S5)) GO TO 42                   PLTAERO 748
      IF ((T.GE.S5).AND.(T.LT.S6)) GO TO 43                   PLTAERO 749
      IF ((T.GE.S6).AND.(T.LT.S7)) GO TO 44                   PLTAERO 750
      IF ((T.GE.S7).AND.(T.LE.360.)) GO TO 41                 PLTAERO 751
41    X=SCALE(IS)/2.                                          PLTAERO 752
      Y=X*TAN(T/RAD)                                          PLTAERO 753
      RETURN                                                  PLTAERO 754
42    IF (T.LT.90.) X=SCALE(IS)*.6/(TAN(T/RAD)+1.)            PLTAERO 755
      IF (T.EQ.90.) X=0.0                                     PLTAERO 756
      IF (T.GT.90.) X=SCALE(IS)*.6/(TAN(T/RAD)-1.)            PLTAERO 757
      IF (T.EQ.90.) Y=SCALE(IS)*.6                            PLTAERO 758
      IF (T.NE.90.) Y=X*TAN(T/RAD)                            PLTAERO 759
      RETURN                                                  PLTAERO 760
43    X=-SCALE(IS)/2.                                         PLTAERO 761
      Y=X*TAN(T/RAD)                                          PLTAERO 762
      RETURN                                                  PLTAERO 763
44    Y=-SCALE(IS)*.4                                         PLTAERO 764
```

```
                IF (T.EQ.270.) X=0.0                          PLTAERO    765
                IF (T.NE.270.) X=Y/TAN(T/RAD)                 PLTAERO    766
                RETUPN                                        PLTAERO    767
           C       SYMBOL NUMBER 21 OR 22                     PLTAERO    768
 215       45   X=.1*SCALE(IS)*COS(T/RAD)                     PLTAERO    769
                Y=.1*SCALE(IS)*SIN(T/RAD)                     PLTAERO    770
                RETURN                                        PLTAERO    771
                END                                           PLTAERO    772
```

```
      SUBROUTINE CURPLT (X,Y,N,NO,IS,IOP,IRUN)                           PLTAERO    773
C        X AND Y  ARE COORDINATES OF POINTS TO BE PLOTTED                PLTAERO    774
C        N  IS NUMBER OF POINTS                                          PLTAERO    775
C        NO   IS SYMBOL IDENTIFICATION NUMBER                            PLTAERO    776
C        IS   IS SYMBOL SIZE IDENTIFICATION                              PLTAERO    777
C        IOP   IS PLOT OPTION    IOP=1 PLOT SYMBOLS ONLY                 PLTAERO    778
C                                IOP=2 PLOT CURVE AND SYMBOL             PLTAERO    779
C                                                                        PLTAERO    780
      DIMENSION X(N), Y(N)                                               PLTAERO    781
      DIMENSION DS1(105), DS2(105), DUMX(105), DUMY(105), DELTH(3)       PLTAERO    782
      REAL M(50)                                                         PLTAERO    783
      DATA RAD/57.2957795131/,NH/101/,XNT/100./,DIFF/0.0001/,NTA/100/,DEPLTAERO    784
     1LTH/.02,.03,.04/                                                   PLTAERO    785
      IF (IOP.EQ.1) GO TO 1                                              PLTAERO    786
      IF (IOP.EQ.2) GO TO 3                                              PLTAERO    787
    1 DO 2 I=1,N                                                         PLTAERO    788
    2 CALL PNTPLT (X(I),Y(I),NO,IS)                                      PLTAERO    789
      RETURN                                                             PLTAERO    790
C        CHECK TO SEE IF X IS STRICTLY INCREASING                        PLTAERO    791
    3 DO 4 I=2,N                                                         PLTAERO    792
      IF (X(I).LT.X(I-1)) GO TO 5                                        PLTAERO    793
    4 CONTINUE                                                           PLTAERO    794
      GO TO 7                                                            PLTAERO    795
    5 PRINT 21, IRUN                                                     PLTAERO    796
      PRINT 22, (X(I),Y(I),I=1,N)                                        PLTAERO    797
      DO 6 I=1,N                                                         PLTAERO    798
    6 CALL PNTPLT (X(I),Y(I),NO,IS)                                      PLTAERO    799
      RETURN                                                             PLTAERO    800
    7 CALL CUBSPL (X,Y,N,M)                                              PLTAERO    801
C        PLOT FIRST POINT                                                PLTAERO    802
      CALL PNTPLT (X(1),Y(1),NO,IS)                                      PLTAERO    803
C        PLOT REMAINING POINTS                                           PLTAERO    804
      NN=N-1                                                             PLTAERO    805
      DO 20 I=1,NN                                                       PLTAERO    806
C        COMPUTE STRAIGHT LINE DISTANCE BETWEEN TWO POINTS. IF DISTANCE PLTAERO    807
C        LESS THAN SYMBOL DIAMETER, PLOT POINTS ONLY.                    PLTAERO    808
      X1=X(I+1)-X(I)                                                     PLTAERO    809
      Y1=Y(I+1)-Y(I)                                                     PLTAERO    810
      DS=SQRT(X1*X1+Y1*Y1)                                               PLTAERO    811
      T1=ATANH(Y1,X1)                                                    PLTAERO    812
      CALL SYMBS (NO,IS,XS1,YS1,T1)                                      PLTAERO    813
      DSS1=SQRT(XS1*XS1+YS1*YS1)                                         PLTAERO    814
```

```
      X1=-X1                                                            PLTAERO    815
      Y1=-Y1                                                            PLTAERO    816
      T1=ATANH(Y1,X1)                                                   PLTAERO    817
      CALL SYMBS (NO,IS,XS2,YS2,T1)                                     PLTAERO    818
      DSS2=SQRT(XS2*XS2+YS2*YS2)                                        PLTAERO    819
      IF ((DSS1+DSS2).GE.DS) GO TO 19                                   PLTAERO    820
C        COMPUTE DISTANCE ALONG CURVE AS A FUNCTION OF X BETWEEN POINT  PLTAERO    821
C        I AND I+1                                                      PLTAERO    822
      NT=IFIX(XNT*(X(I+1)-X(I)))+1                                      PLTAERO    823
      IF (NT.LT.3) NT=3                                                 PLTAERO    824
      IF (NT.GT.NH) NT=NH                                               PLTAERO    825
      DELTA=(X(I+1)-X(I))/FLOAT(NT-1)                                   PLTAERO    826
      DUMX(1)=X(I)                                                      PLTAERO    827
      DUMY(1)=Y(I)                                                      PLTAERO    828
      DS1(1)=0.0                                                        PLTAERO    829
      XA=X(I)                                                           PLTAERO    830
      DO 8 J=2,NT                                                       PLTAERO    831
      XA=XA+DELTA                                                       PLTAERO    832
      DUMX(J)=XA                                                        PLTAERO    833
      DUMY(J)=FUNC(XA,X(I),X(I+1),Y(I),Y(I+1),M(I),M(I+1))              PLTAERO    834
8     DS1(J)=SQRT((DUMX(J)-X(I))**2+(DUMY(J)-Y(I))**2)                  PLTAERO    835
      DO 9 J=1,NT                                                       PLTAERO    836
      K=NT+1-J                                                          PLTAERO    837
9     DS2(J)=SQRT((DUMX(K)-X(I+1))**2+(DUMY(K)-Y(I+1))**2)              PLTAERO    838
C        FIND X AND Y LOCATION WHERE SYMBOL AND CURVE INTERSECT         PLTAERO    839
      DELTA=DELTH(IS)                                                   PLTAERO    840
      XA=X(I)                                                           PLTAERO    841
      DO 11 J=2,NTA                                                     PLTAERO    842
      XA=XA+DELTA                                                       PLTAERO    843
      IF (XA.GE.X(I+1)) GO TO 12                                        PLTAERO    844
      X1=XA-X(I)                                                        PLTAERO    845
      Y1=FUNC(XA,X(I),X(I+1),Y(I),Y(I+1),M(I),M(I+1))-Y(I)              PLTAERO    846
      DS=SQRT(X1*X1+Y1*Y1)                                              PLTAERO    847
      T1=ATANH(Y1,X1)                                                   PLTAERO    848
      CALL SYMBS (NO,IS,XS1,YS1,T1)                                     PLTAERO    849
      DSS1=SQRT(XS1*XS1+YS1*YS1)                                        PLTAERO    850
      IF (ABS(DS-DSS1).LE.DIFF) GO TO 12                                PLTAERO    851
      IF (DS.GT.DSS1) GO TO 10                                          PLTAERO    852
      GO TO 11                                                          PLTAERO    853
10    XA=XA-DELTA                                                       PLTAERO    854
      DELTA=DELTA/2.                                                    PLTAERO    855
11    CONTINUE                                                          PLTAERO    856
```

```
   12  XS1=XS1+X(I)                                                  PLTAERO  857
       YS1=YS1+Y(I)                                                  PLTAERO  858
       DELTA=DELTH(IS)                                               PLTAERO  859
       XA=X(I+1)                                                     PLTAERO  860
       DO 14 J=2,NTA                                                 PLTAERO  861
       XA=XA-DELTA                                                   PLTAERO  862
       IF (XA.LE.X(I)) GO TO 15                                      PLTAERO  863
       X1=XA-X(I+1)                                                  PLTAERO  864
       Y1=FUNC(XA,X(I),X(I+1),Y(I),Y(I+1),M(I),M(I+1))-Y(I+1)        PLTAERO  865
       DS=SQRT(X1*X1+Y1*Y1)                                          PLTAERO  866
       T1=ATANH(Y1,X1)                                               PLTAERO  867
       CALL SYMBS (NO,IS,XS2,YS2,T1)                                 PLTAERO  868
       DSS2=SQRT(XS2*XS2+YS2*YS2)                                    PLTAERO  869
       IF (ABS(DS-DSS2).LE.DIFF) GO TO 15                            PLTAERO  870
       IF (DS.GT.DSS2) GO TO 13                                      PLTAERO  871
       GO TO 14                                                      PLTAERO  872
   13  XA=XA+DELTA                                                   PLTAERO  873
       DELTA=DELTA/2.                                                PLTAERO  874
   14  CONTINUE                                                      PLTAERO  875
   15  XS2=XS2+X(I+1)                                                PLTAERO  876
       YS2=YS2+Y(I+1)                                                PLTAERO  877
       NP=1                                                          PLTAERO  878
       NDS1=0                                                        PLTAERO  879
       DO 16 J=2,NT                                                  PLTAERO  880
       IF ((DS1(J).LT.DSS1).AND.(NDS1.EQ.0)) GO TO 16                PLTAERO  881
       IF ((DS1(J).GE.DSS1).AND.(NDS1.EQ.0)) NDS1=1                  PLTAERO  882
       NP=NP+1                                                       PLTAERO  883
       DUMX(NP)=DUMX(J)                                              PLTAERO  884
       DUMY(NP)=DUMY(J)                                              PLTAERO  885
   16  CONTINUE                                                      PLTAERO  886
       DUMX(1)=XS1                                                   PLTAERO  887
       DUMY(1)=YS1                                                   PLTAERO  888
       DO 17 J=1,NT                                                  PLTAERO  889
       IF (DS2(J).LE.DSS2) GO TO 17                                  PLTAERO  890
       GO TO 18                                                      PLTAERO  891
   17  NP=NP-1                                                       PLTAERO  892
   18  NP=NP+1                                                       PLTAERO  893
       DUMX(NP)=XS2                                                  PLTAERO  894
       DUMY(NP)=YS2                                                  PLTAERO  895
C         PLOT CURVE BETWEEN POINTS                                  PLTAERO  896
       DUMX(NP+1)=DUMY(NP+1)=0.0                                     PLTAERO  897
       DUMX(NP+2)=DUMY(NP+2)=1.0                                     PLTAERO  898
```

```
      CALL LINE (DUMX,DUMY,NP,1,0,0,0)                                  PLTAERO  899
19    CALL PNTPLT (X(I+1),Y(I+1),NO,IS)                                 PLTAERO  900
20    CONTINUE                                                          PLTAERO  901
      RETURN                                                            PLTAERO  902
C                                                                       PLTAERO  903
21    FORMAT (1H1//5X,36HX IS NOT STRICTLY INCREASING FOR RUN,I7/16X,1HXPLTAERO  904
     1,13X,1HY/)                                                        PLTAERO  905
22    FORMAT (5X,2F15.4)                                                PLTAERO  906
      END                                                               PLTAERO  907
```

APPENDIX

```
      SUBROUTINE CUBSPL (X,Y,N,B)                                        PLTAERO  908
      DIMENSION X(N), Y(N), B(N)                                         PLTAERO  909
C        DIMENSION A(10*N)                                               PLTAERO  910
      DIMENSION A(500)                                                   PLTAERO  911
      COMMON/HLM/TENR,XINT,ST                                            PLTAERO  912
      COMMON/TENS/T                                                      PLTAERO  913
C        CUBIC SPLINE CURVE FIT PROGRAM                                  PLTAERO  914
      M=N-1                                                              PLTAERO  915
      N1=M+1                                                             PLTAERO  916
      N2=N1+N                                                            PLTAERO  917
      N3=N2+N                                                            PLTAERO  918
      N4=N3+N                                                            PLTAERO  919
      N5=N4+N                                                            PLTAERO  920
      N6=N5+N                                                            PLTAERO  921
      N7=N6+N                                                            PLTAERO  922
      N8=N7+N                                                            PLTAERO  923
      N9=N8+N                                                            PLTAERO  924
C        LOAD MATRIX ROWS 2 THRU N-1                                     PLTAERO  925
      T=TENR*FLOAT(N-1)/(X(N)-X(1))                                      PLTAERO  926
      DO 1 I=1,M                                                         PLTAERO  927
      H2=X(I+1)-X(I)                                                     PLTAERO  928
      A(I)=(1./H2-T/SINH(T*H2))/(T*T)                                    PLTAERO  929
      K=2*N+I                                                            PLTAERO  930
      A(K)=A(I)                                                          PLTAERO  931
      IF(I.EQ.1) GO TO 1                                                 PLTAERO  932
      K=K+N                                                              PLTAERO  933
      H1=X(I)-X(I-1)                                                     PLTAERO  934
      A(K)=(T*COSH(T*H1)/SINH(T*H1)-1./H1+T*COSH(T*H2)/SINH(T*H2)-1./H2)PLTAERO  935
     1/(T*T)                                                             PLTAERO  936
      K=K+N                                                              PLTAERO  937
      A(K)=(Y(I+1)-Y(I))/(X(I+1)-X(I))-(Y(I)-Y(I-1))/(X(I)-X(I-1))       PLTAERO  938
    1 CONTINUE                                                           PLTAERO  939
C        LOAD MATRIX ROWS 1 AND N                                        PLTAERO  940
      A(N3)=1.0                                                          PLTAERO  941
      A(N4-1)=1.0                                                        PLTAERO  942
      A(N2)=-.5                                                          PLTAERO  943
      A(M)=-.5                                                           PLTAERO  944
      A(N4)=0.0                                                          PLTAERO  945
      A(N5-1)=0.0                                                        PLTAERO  946
C        SOLVE TRIDIAGONAL MATRIX                                        PLTAERO  947
      A(N7)=A(N3)                                                        PLTAERO  948
      A(N8)=A(N4)/A(N3)                                                  PLTAERO  949
```

```
      A(N9)=A(N2)/A(N3)                                                PLTAERO  950
C                                                                      PLTAERO  951
      DO 4 I=2,N                                                       PLTAERO  952
      I1=I-1                                                           PLTAERO  953
      I2=I-2                                                           PLTAERO  954
      A(N7+I1)=A(N3+I1)-A(I1)*A(N9+I2)                                 PLTAERO  955
      IF (I.EQ.N) GO TO 4                                              PLTAERO  956
      A(N9+I1)=A(N2+I1)/A(N7+I1)                                       PLTAERO  957
    4 A(N8+I1)=(A(N4+I1)-A(I1)*A(N8+I2))/A(N7+I1)                      PLTAERO  958
C                                                                      PLTAERO  959
      A(N6-1)=A(N9-1)                                                  PLTAERO  960
      DO 5 I=1,M                                                       PLTAERO  961
      I1=N6-1-I                                                        PLTAERO  962
      I2=N-I                                                           PLTAERO  963
      I3=I2-1                                                          PLTAERO  964
    5 A(I1)=A(N8+I3)-A(N9+I3)*A(I1+1)                                  PLTAERO  965
C                                                                      PLTAERO  966
      K=0                                                              PLTAERO  967
      DO 6 I=1,N                                                       PLTAERO  968
      I1=I-1                                                           PLTAERO  969
      A(N6+K)=A(N5+I1)                                                 PLTAERO  970
    6 K=K+1                                                            PLTAERO  971
      A(M)=A(N3-2)                                                     PLTAERO  972
C        LOAD SOLUTION INTO B VECTOR                                   PLTAERO  973
      DO 7 I=1,N                                                       PLTAERO  974
      I1=N6+I-1                                                        PLTAERO  975
    7 B(I)=A(I1)                                                       PLTAERO  976
C                                                                      PLTAERO  977
      XINT=0.0                                                         PLTAERO  978
      DO 11 I=2,N                                                      PLTAERO  979
      H = X(I) - X(I-1)                                                PLTAERO  980
   11 XINT=XINT+(Y(I)+Y(I-1))*(X(I)-X(I-1))/2.                         PLTAERO  981
     1 - (B(I)+B(I-1))*((1.-COSH(T*H))/(T**3*SINH(T*H))+H/(2.*T*T))    PLTAERO  982
      RETURN                                                           PLTAERO  983
      END                                                              PLTAERO  984
```

```
      FUNCTION FUNC(X,X1,X2,Y1,Y2,M1,M2)                                PLTAERO  985
      COMMON/TENS/T                                                     PLTAERO  986
      REAL M1,M2                                                        PLTAERO  987
C        SPLINE FUNCTION UNDER TENSION (T)                              PLTAERO  988
      DX1=X-X1                                                          PLTAERO  989
      DX2=X2-X                                                          PLTAERO  990
      H=X2-X1                                                           PLTAERO  991
      F1=M1/(T*T)                                                       PLTAERO  992
      F2=M2/(T*T)                                                       PLTAERO  993
      FUNC=(F1*SINH(T*DX2)+F2*SINH(T*DX1))/SINH(T*H)+((Y1-F1)*DX2+(Y2-F2PLTAERO  994
     1)*DX1)/H                                                          PLTAERO  995
      RETURN                                                            PLTAERO  996
      END                                                               PLTAERO  997
```

```
      FUNCTION ATANH (DY,DX)                                            PLTAERO  998
      IF (DX.EQ.0.0) GO TO 1                                            PLTAERO  999
      ATANH=ABS(DY/DX)                                                  PLTAERO 1000
      ATANH=ATAN(ATANH)*57.2957795131                                   PLTAERO 1001
      IF ((DX.GT.0.0).AND.(DY.LT.0.0)) ATANH=360.-ATANH                 PLTAERO 1002
      IF ((DX.LT.0.0).AND.(DY.GT.0.0)) ATANH=180.-ATANH                 PLTAERO 1003
      IF ((DX.LT.0.0).AND.(DY.LT.0.0)) ATANH=180.+ATANH                 PLTAERO 1004
      RETURN                                                            PLTAERO 1005
    1 IF (DY.LT.0.0) ATANH=270.                                         PLTAERO 1006
      IF (DY.GE.0.0) ATANH=90.                                          PLTAERO 1007
      RETURN                                                            PLTAERO 1008
      END                                                               PLTAERO 1009
```

```
      SUBROUTINE TSPLINE(X,Y,N,B,ST,IOP,NP,XI,YI,YP,YPP,XINT)           PLTAERO   1010
C                                                                       PLTAERO   1011
C        TENSION AND CUBIC SPLINE CURVE FIT PROGRAM                     PLTAERO   1012
C                                                                       PLTAERO   1013
C        X AND Y - INPUT TABLE.                                         PLTAERO   1014
C        N       - NUMBER OF INPUT VALUES OF X AND Y.                   PLTAERO   1015
C        B       - SOLUTION VECTOR (SECOND DERIVATIVE AT INPUT VALUES OFPLTAERO   1016
C                  X AND Y.                                             PLTAERO   1017
C        ST      - TENSION PARAMETER.                                   PLTAERO   1018
C        IOP     - COMPUTING OPTION.                                    PLTAERO   1019
C                  =0  COMPUTE YI,YP,AND YPP AT NP EQUALLY SPACED VALUESPLTAERO   1020
C                      OF XI BETWEEN X(1) AND X(N)                      PLTAERO   1021
C                  =1  COMPUTE YI,YP,AND YPP AT NP INPUT VALUES OF XI   PLTAERO   1022
C        NP      - NUMBER OF INPUT VALUES OF XI.                        PLTAERO   1023
C        XI      - INPUT TABLE OF INTERPOLATION VALUES OF X BETWEEN X(1)PLTAERO   1024
C                  AND X(N).                                            PLTAERO   1025
C        YI      - INTERPOLATED TABLE OF Y VALUES.                      PLTAERO   1026
C        YP      - INTERPOLATED TABLE OF FIRST DERIVATIVE VALUES.       PLTAERO   1027
C        YPP     - INTERPOLATED TABLE OF SECOND DERIVATIVE VALUES.      PLTAERO   1028
C        XINT    - VALUE OF INTEGRAL OF Y BETWEEN X(1) AND X(N).        PLTAERO   1029
C                                                                       PLTAERO   1030
      DIMENSION X(N),Y(N),B(65),XI(65),YI(65),YP(65),YPP(65)            MOD1       145
C        A IS DUMMY STORAGE VECTOR. DIMENSION A(10*N).                  PLTAERO   1032
      DIMENSION A(650)                                                  MOD1       146
C                                                                       PLTAERO   1034
      M=N-1                                                             PLTAERO   1035
      N1=N+1                                                            PLTAERO   1036
      N2=N1+N                                                           PLTAERO   1037
      N3=N2+N                                                           PLTAERO   1038
      N4=N3+N                                                           PLTAERO   1039
      N5=N4+N                                                           PLTAERO   1040
      N6=N5+N                                                           PLTAERO   1041
      N7=N6+N                                                           PLTAERO   1042
      N8=N7+N                                                           PLTAERO   1043
      N9=N8+N                                                           PLTAERO   1044
      T=ST*FLOAT(N-1)/(X(N)-X(1))                                       PLTAERO   1045
C        LOAD MATRIX ROWS 2 THRU N-1.                                   PLTAERO   1046
      DO 1 I=1,M                                                        PLTAERO   1047
      H2=X(I+1)-X(I)                                                    PLTAERO   1048
      IF(ST.EQ.0.0) A(I)=H2/6.                                          PLTAERO   1049
      IF(ST.NE.0.0) A(I)=(1./H2-T/SINH(T*H2))/(T*T)                     PLTAERO   1050
      K=2*N+I                                                           PLTAERO   1051
```

```
      A(K)=A(I)                                                         PLTAERO  1052
      IF(I.EQ.1) GO TO 1                                                PLTAERO  1053
      K=K+N                                                             PLTAERO  1054
      H1=X(I)-X(I-1)                                                    PLTAERO  1055
      IF(ST.EQ.0.0) A(K)=(H2+H1)/3.                                     PLTAERO  1056
      IF(ST.NE.0.0) A(K)=(T*COSH(T*H1)/SINH(T*H1)-1./H1+T*COSH(T*H2)/SINPLTAERO  1057
     1H(T*H2)-1./H2)/(T*T)                                              PLTAERO  1058
      K=K+N                                                             PLTAERO  1059
      A(K)=(Y(I+1)-Y(I))/H2-(Y(I)-Y(I-1))/H1                            PLTAERO  1060
    1 CONTINUE                                                          PLTAERO  1061
C        LOAD MATRIX ROWS 1 AND N.                                      PLTAERO  1062
      A(M)=-.5                                                          PLTAERO  1063
      A(N2)=-.5                                                         PLTAERO  1064
      A(N3)=1.0                                                         PLTAERO  1065
      A(N4-1)=1.0                                                       PLTAERO  1066
      A(N4)=0.0                                                         PLTAERO  1067
      A(N5-1)=0.0                                                       PLTAERO  1068
C        SOLVE TRIDIAGONAL MATRIX.                                      PLTAERO  1069
      A(N7)=A(N3)                                                       PLTAERO  1070
      A(N8)=A(N4)/A(N3)                                                 PLTAERO  1071
      A(N9)=A(N2)/A(N3)                                                 PLTAERO  1072
      DO 4 I=2,N                                                        PLTAERO  1073
      I1=I-1                                                            PLTAERO  1074
      I2=I-2                                                            PLTAERO  1075
      A(N7+I1)=A(N3+I1)-A(I1)*A(N9+I2)                                  PLTAERO  1076
      IF(I.EQ.N) GO TO 4                                                PLTAERO  1077
      A(N9+I1)=A(N2+I1)/A(N7+I1)                                        PLTAERO  1078
    4 A(N8+I1)=(A(N4+I1)-A(I1)*A(N8+I2))/A(N7+I1)                       PLTAERO  1079
      A(N6-1)=A(N9-1)                                                   PLTAERO  1080
      DO 5 I=1,M                                                        PLTAERO  1081
      I1=N6-1-I                                                         PLTAERO  1082
      I2=N-I                                                            PLTAERO  1083
      I3=I2-1                                                           PLTAERO  1084
    5 A(I1)=A(N9+I3)-A(N9+I3)*A(I1+1)                                   PLTAERO  1085
      K=0                                                               PLTAERO  1086
      DO 6 I=1,N                                                        PLTAERO  1087
      I1=I-1                                                            PLTAERO  1088
      A(N6+K)=A(N5+I1)                                                  PLTAERO  1089
    6 K=K+1                                                             PLTAERO  1090
      A(M)=A(N3-2)                                                      PLTAERO  1091
C        LOAD SOLUTION INTO VECTOR B.                                   PLTAERO  1092
      DO 7 I=1,N                                                        PLTAERO  1093
```

```
      I1=N6+I-1                                                         PLTAERO 1094
    7 B(I)=A(I1)                                                        PLTAERO 1095
C        COMPUTE  Y,YP,YPP AT DESIRED X VALUES                          PLTAERO 1096
      IF(NP.LE.0) RETURN                                                PLTAERO 1097
      IF(IOP.EQ.0) GO TO 13                                             PLTAERO 1098
      GO TO 14                                                          PLTAERO 1099
   13 DELTAX=(X(N)-X(1))/FLOAT(NP-1)                                    PLTAERO 1100
      XI(1)=X(1)                                                        PLTAERO 1101
      DO 15 I=2,NP                                                      PLTAERO 1102
   15 XI(I)=XI(I-1)+DELTAX                                              PLTAERO 1103
   14 CONTINUE                                                          PLTAERO 1104
      DO 8 I=1,NP                                                       PLTAERO 1105
      P=XI(I)                                                           PLTAERO 1106
      DO 9 K=2,N                                                        PLTAERO 1107
      K1=K-1                                                            PLTAERO 1108
      IF((P.GE.X(K1)).AND.(P.LE.X(K))) GO TO 10                         PLTAERO 1109
      GO TO 9                                                           PLTAERO 1110
   10 J1=K1                                                             PLTAERO 1111
      J2=K                                                              PLTAERO 1112
    9 CONTINUE                                                          PLTAERO 1113
      H=X(J2)-X(J1)                                                     PLTAERO 1114
      IF(ST.EQ.0.0) GO TO 11                                            PLTAERO 1115
      SINHT=SINH(T*H)                                                   PLTAERO 1116
      YI(I)=B(J1)*(SINH(T*(X(J2)-P))/(T*T*SINHT)-(X(J2)-P)/(H*T*T))+B(J2PLTAERO 1117
     1)*(SINH(T*(P-X(J1)))/(T*T*SINHT)-(P-X(J1))/(H*T*T))+(Y(J1)*(X(J2)-PLTAERO 1118
     2P)+Y(J2)*(P-X(J1)))/H                                             PLTAERO 1119
      YP(I)=B(J1)*(1./(H*T*T)-COSH(T*(X(J2)-P))/(T*SINHT))+B(J2)*(COSH(TPLTAERO 1120
     1*(P-X(J1)))/(T*SINHT)-1./(H*T*T))+(Y(J2)-Y(J1))/H                 PLTAERO 1121
      YPP(I)=B(J1)*SINH(T*(X(J2)-P))/SINHT+B(J2)*SINH(T*(P-X(J1)))/SINHTPLTAERO 1122
      GO TO 8                                                           PLTAERO 1123
   11 YI(I)=B(J1)*((X(J2)-P)**3/(6.*H)-(X(J2)-P)*H/6.)+B(J2)*((P-X(J1))*PLTAERO 1124
     1*3/(6.*H)-(P-X(J1))*H/6.)+(Y(J1)*(X(J2)-P)+Y(J2)*(P-X(J1)))/H     PLTAERO 1125
      YP(I)=B(J1)*(H/6.-(X(J2)-P)**2/(2.*H))+B(J2)*((P-X(J1))**2/(2.*H)-PLTAERO 1126
     1H/6.)+(Y(J2)-Y(J1))/H                                             PLTAERO 1127
      YPP(I)=B(J1)*(X(J2)-P)/H+B(J2)*(P-X(J1))/H                        PLTAERO 1128
    8 CONTINUE                                                          PLTAERO 1129
C        COMPUTE INTEGRAL OF Y BETWEEN X(1) AND X(N).                   PLTAERO 1130
      XINT=0.0                                                          PLTAERO 1131
      DO 12 I=2,N                                                       PLTAERO 1132
      H=X(I)-X(I-1)                                                     PLTAERO 1133
      XINT=XINT+(Y(I)+Y(I-1))*H/2.                                      PLTAERO 1134
      IF(ST.EQ.0.0)XINT=XINT-(B(I)+B(I-1))*H**3/24.                     PLTAERO 1135
```


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      IF(ST.NE.0.0)XINT=XINT-(B(I)+B(I-1))*((1.-COSH(T*H))/(T**3*SINH(T*PLTAERO   1136
     1H))+H/(2.*T*T))                                                          PLTAERO   1137
130  12 CONTINUE                                                               PLTAERO   1138
C                                                                              PLTAERO   1139
      RETURN                                                                   PLTAERO   1140
      END                                                                      PLTAERO   1141
```

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1. Davis, John M.: Rotorcraft Flight Simulation With Aeroelastic Rotor and Improved Aerodynamic Representation. Volume II - User's Manual. USAAMRDL-TR-74-10B, U.S. Army, June 1974. (Available from DDC as AD 782 756.)

2. Landgrebe, Anton J.: An Analytical and Experimental Investigation of Helicopter Rotor Hover Performance and Wake Geometry Characteristics. USAAMRDL Tech. Rep. 71-24, U.S. Army, June 1971. (Available from DDC as AD 728 835.)

3. Cline, A. K.: Scalar- and Planar-Valued Curve Fitting Using Splines Under Tension. Commun. ACM, vol. 17, no. 4, Apr. 1974, pp. 218-220.

4. Cline, A. K.: Algorithm 476 - Six Subprograms for Curve Fitting Using Splines Under Tension [E2]. Commun. ACM, vol. 17, no. 4, Apr. 1974, pp. 220-223.

5. Noonan, Kevin W.; and Bingham, Gene J.: Two-Dimensional Aerodynamic Characteristics of Several Rotorcraft Airfoils at Mach Numbers From 0.35 to 0.90. NASA TM X-73990, 1977.

TABLE I.- COMPUTER PRINTOUT OF INTERPOLATED DATA

LIFT COEFFICIENT

	.3000	.3500	.4000	.4500	.5000	.5500	.6000	.6500	.7000	.7500	.8000	.8500	.9000
-4.0000	-.3137	-.3137	-.3156	-.3267	-.3409	-.3364	-.3392	-.3592	-.4059	-.4958	-.5654	-.5720	-.2865
-3.0000	-.1984	-.1983	-.2056	-.2055	-.2156	-.2105	-.2138	-.2302	-.2553	-.3028	-.3562	-.3801	-.2224
-2.0000	-.0832	-.0829	-.0948	-.0842	-.0904	-.0844	-.0873	-.1006	-.1043	-.1119	-.1478	-.1894	-.1657
-1.0000	.0321	.0323	.0254	.0373	.0347	.0429	.0487	.0446	.0493	.0567	.0535	.0017	-.1091
0.0000	.1463	.1463	.1457	.1563	.1607	.1704	.1827	.1898	.1986	.2184	.2381	.1939	-.0524
1.0000	.2574	.2575	.2568	.2698	.2895	.2982	.3079	.3255	.3375	.3786	.3926		
2.0000	.3683	.3683	.3693	.3834	.4122	.4242	.4365	.4620	.4849	.4859	.4599		
3.0000	.4759	.4765	.4902	.4971	.5301	.5484	.5675	.5930	.6371	.5676	.4750		
4.0000	.5848	.5844	.5990	.6148	.6535	.6720	.6934	.7166	.7048				
5.0000	.7024	.7024	.7054	.7370	.7658	.7925	.8040	.8217	.7614				
6.0000	.8394	.8401	.8150	.8664	.8465	.9067	.8891	.8706	.7904				
7.0000	.9465	.9468	.9342	.9776	.9224	.9769	.9437						
8.0000	1.0127	1.0115	1.0596	1.0719	.9940	1.0048	.9920						
9.0000	1.0763	1.0758	1.0952	1.0950	1.0334	1.0355							
10.0000	1.1375	1.1397	1.0922	1.0973	1.0468	1.0590							
11.0000	1.1502	1.1515	1.1016	1.0972	1.0621	1.0764							
12.0000	1.1431	1.1438	1.1175	1.0958	1.0789	1.0873							

DRAG COEFFICIENT

	.3000	.3500	.4000	.4500	.5000	.5500	.6000	.6500	.7000	.7500	.8000	.8500	.9000
-4.0000	.0073	.0073	.0076	.0080	.0078	.0089	.0114	.0137	.0178	.0274	.0470	.0240	.0406
-3.0000	.0076	.0076	.0075	.0077	.0079	.0081	.0094	.0104	.0124	.0183	.0283	.0222	.0383
-2.0000	.0078	.0078	.0074	.0075	.0080	.0074	.0077	.0073	.0077	.0098	.0112	.0208	.0363
-1.0000	.0074	.0074	.0070	.0077	.0082	.0071	.0074	.0070	.0069	.0081	.0098	.0225	.0374
0.0000	.0071	.0071	.0068	.0078	.0084	.0070	.0076	.0073	.0065	.0079	.0156	.0253	.0397
1.0000	.0077	.0077	.0072	.0079	.0081	.0072	.0078	.0077	.0063	.0149	.0281		
2.0000	.0082	.0082	.0074	.0077	.0078	.0076	.0078	.0085	.0101	.0252	.0329		
3.0000	.0084	.0084	.0071	.0073	.0078	.0082	.0079	.0098	.0218	.0371	.0330		
4.0000	.0079	.0079	.0076	.0071	.0084	.0085	.0093	.0150	.0340				
5.0000	.0077	.0077	.0083	.0072	.0091	.0097	.0117	.0230	.0480				
6.0000	.0089	.0089	.0090	.0076	.0101	.0129	.0157	.0378	.0659				
7.0000	.0095	.0095	.0099	.0092	.0108	.0146	.0203						
8.0000	.0092	.0092	.0111	.0115	.0113	.0149	.0251						
9.0000	.0102	.0101	.0126	.0140	.0133	.0152							
10.0000	.0118	.0118	.0146	.0168	.0165	.0158							
11.0000	.0184	.0182	.0258	.0281	.0248	.0265							
12.0000	.0269	.0265	.0417	.0440	.0367	.0441							

TABLE I.- Concluded

PITCHING-MOMENT COEFFICIENT

	.3000	.3500	.4000	.4500	.5000	.5500	.6000	.6500	.7000	.7500	.8000	.3500	.9000
-4.0000	-.0155	-.0155	-.0157	-.0195	-.0221	-.0252	-.0181	-.0388	-.0442	-.0492	-.0370	-.0291	-.0424
-3.0000	-.0148	-.0148	-.0162	-.0182	-.0202	-.0217	-.0163	-.0314	-.0352	-.0397	-.0365	-.0310	-.0350
-2.0000	-.0141	-.0141	-.0157	-.0171	-.0184	-.0188	-.0144	-.0243	-.0267	-.0304	-.0355	-.0330	-.0275
-1.0000	-.0138	-.0138	-.0146	-.0160	-.0169	-.0173	-.0120	-.0207	-.0219	-.0240	-.0299	-.0352	-.0200
0.0000	-.0133	-.0133	-.0148	-.0149	-.0156	-.0160	-.0063	-.0180	-.0176	-.0196	-.0269	-.0373	-.0126
1.0000	-.0126	-.0124	-.0189	-.0135	-.0145	-.0144	.0066	-.0158	-.0140	-.0177	-.0306		
2.0000	-.0118	-.0115	-.0211	-.0124	-.0133	-.0128	.0141	-.0132	-.0103	-.0201	-.0335		
3.0000	-.0115	-.0114	-.0126	-.0115	-.0117	-.0110	.0148	-.0087	-.0072	-.0244	-.0358		
4.0000	-.0103	-.0103	-.0099	-.0100	-.0090	-.0080	-.0132	-.0032	-.0083				
5.0000	-.0101	-.0101	-.0097	-.0079	-.0056	-.0041	-.0302	.0001	-.0130				
6.0000	-.0130	-.0131	-.0063	-.0049	-.0004	.0008	-.0234	-.0028	-.0254				
7.0000	-.0115	-.0117	-.0040	-.0013	.0045	.0037	-.0191						
8.0000	-.0041	-.0041	-.0017	.0029	.0093	.0047	-.0172						
9.0000	.0004	.0004	.0038	.0079	.0127	.0056							
10.0000	.0032	.0031	.0103	.0127	.0148	.0065							
11.0000	-.0048	-.0051	.0056	.0015	.0042	.0043							
12.0000	-.0173	-.0177	-.0048	-.0187	-.0151	.0002							

TABLE II.- CARD INPUT GUIDE

Card	Variable	Format	Description
1	NAMAX	I5	Maximum number of angles of attack
	NMMAX	I5	Maximum number of Mach numbers
2	KA, KB, KC	3I5	Control plotting of c_l, c_d, and c_m, respectively, in P1 subroutine; e.g., if KA = 0, c_l plots are suppressed, etc.
3	LA, LB, LC	3I5	Control plotting of c_l, c_d, and c_m, respectively, in P2 subroutine; e.g., if LA = 0, c_l plots are suppressed, etc.
4	MA, MB, MC	3I5	Control ılculation and punching of tables for performance program, e.g.; if MA = 0, c_l tables are suppressed, etc.
5	PMN(I)	8F10.0	Desired Mach numbers (extend lowest Mach number data back through 0.3, 0.2, to M = 0, NMMAX values required)
6	XNMN(I)	8F10.0	Number of desired Mach numbers at each desired angle of attack (NAMAX values required)
7	PAA(I)	8F10.0	Desired angles of attack, using 1° intervals starting at -4° (NMMAX values required)
8	XNA(I)	8F10.0	Number of desired angles of attack at each desired Mach number (NMMAX values required)
9	XMN(I)	8F10.0	Measured Mach numbers (extend lowest Mach number data back through 0.3, 0.2, to M = 0, NMMAX values)
10	XNAT(I)	8F10.0	Number of measured angles of attack at each measured Mach number (NMMAX values required)
11	AA(I,J)	8F10.0	Measured angles of attack at Ith Mach number (XNAT(I) values)
12	CL(I,J)	8F10.0	Measured lift coefficients at Ith Mach number (XNAT(I) values)
13	CD(I,J)	8F10.0	Measured drag coefficients at Ith Mach number (XNAT(I) values)
14	CM(I,J)	8F10.0	Measured pitching-moment coefficients at Ith Mach number (XNAT(I) values)
(a)			
15	Title	3A10	Heading for plots (first line)
16	Title	3A10	Heading for plots (second line)

[a]Cards 11, 12, 13, and 14 should be repeated NMMAX times.

TABLE III.- SUBROUTINES USED IN PLTAERO

Subroutine	Use
DECKPL	Input/output and control
BOUND1	Numerical cross-plotting
ADJUST1	Numerical cross-plotting
P1	Plot control
BOUND2	Numerical cross-plotting
ADJUST2	Numerical cross-plotting
P2	Plot control
C81	Punch control
C82	Numerical fairing of performance tables
SYMBS	Draws standards, NASA symbol for cubic spline
CURPLT	Plots and fairs a cubic spline under tension through a set of points
CUBSPL	Calculates cubic spline for CURPLT
FUNC (function)	Auxiliary to CUBSPL
ATANH (function)	Auxiliary to CUBSPL
TSPLINE	Tension and cubic-spline interpolating subroutine

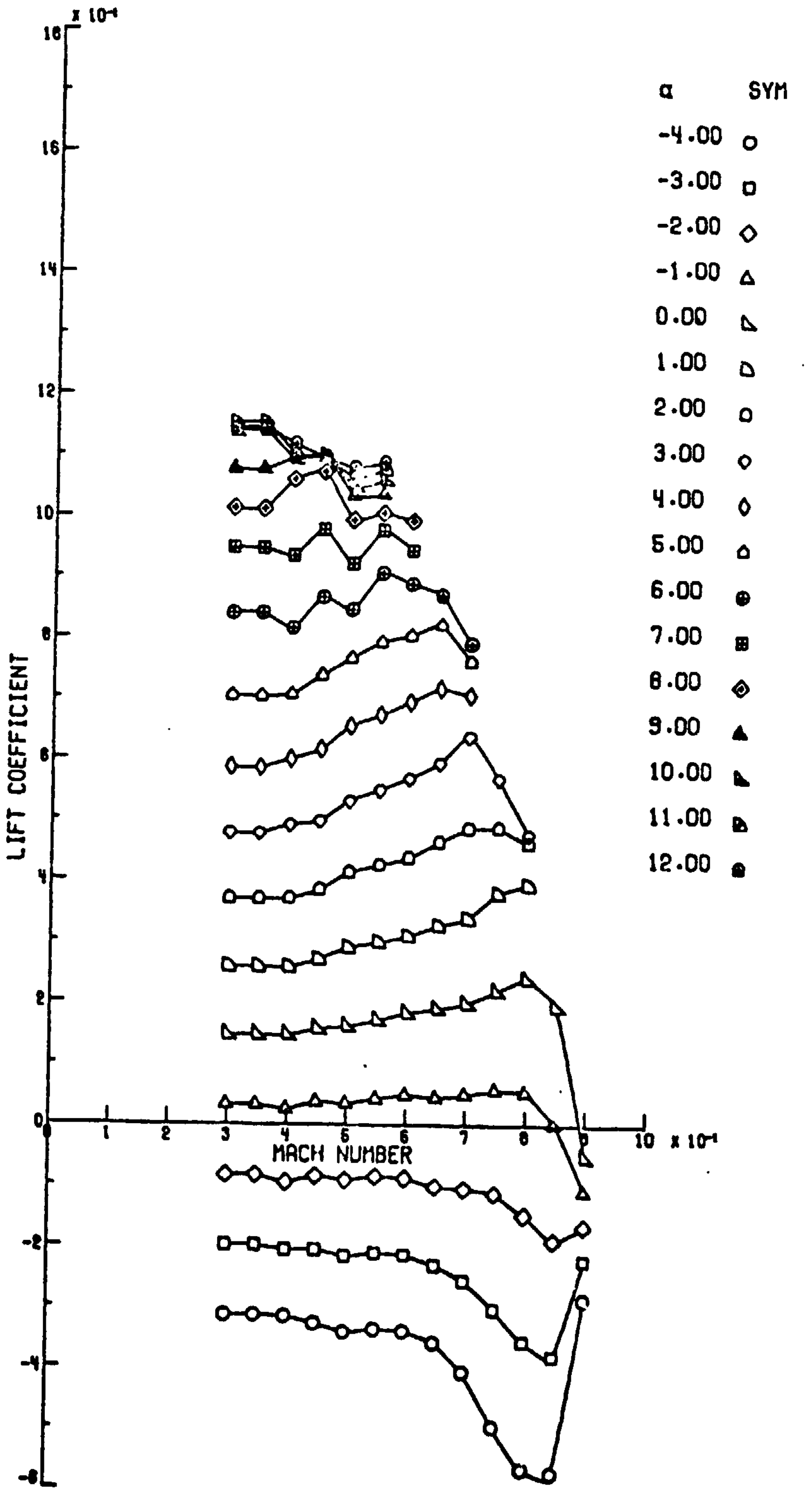


Figure 1.- Blade-element lift coefficient plotted against Mach number for FX69-H-098 airfoil, generated by subroutine P1.

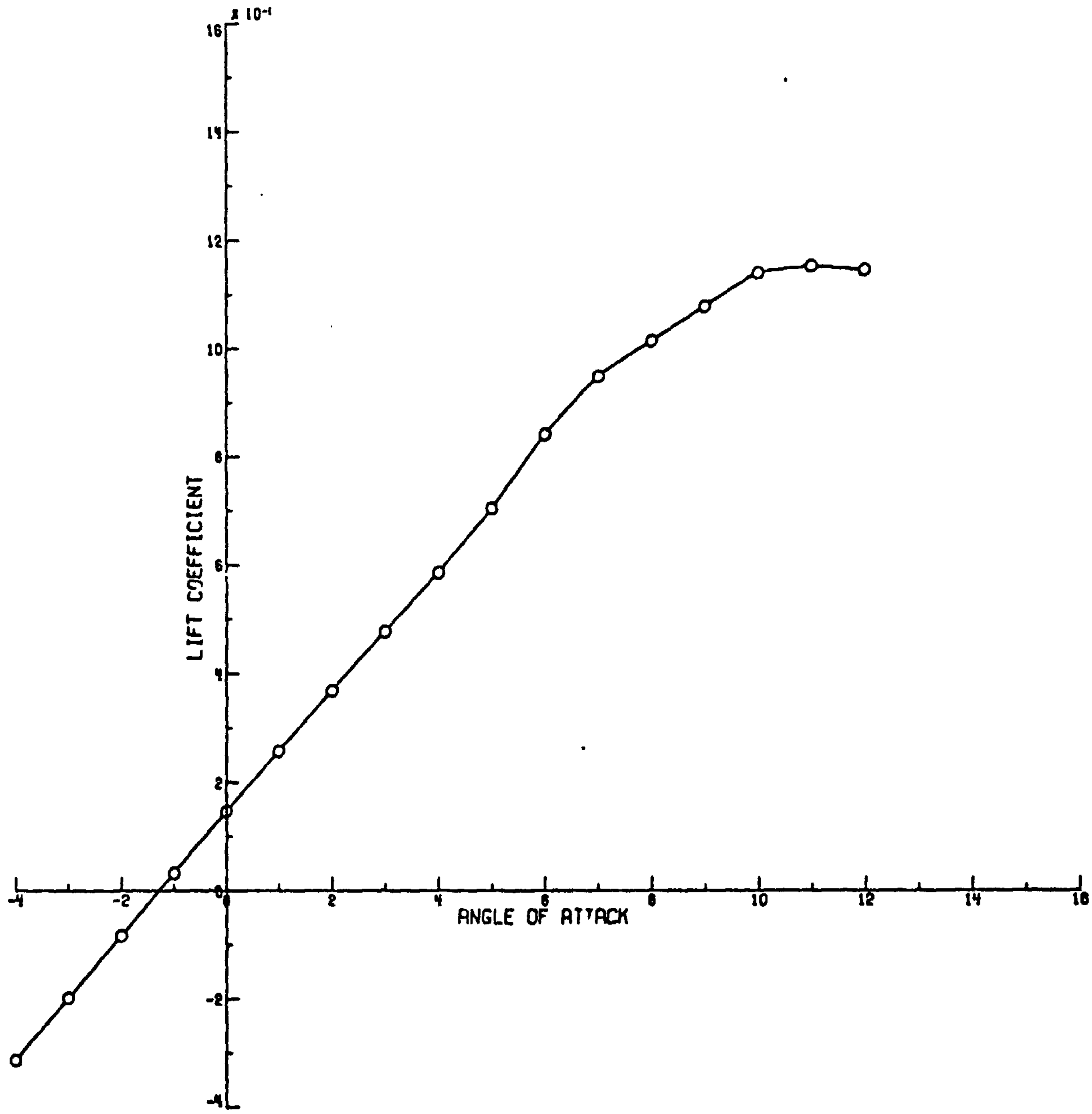


Figure 2.- Blade-element lift coefficient plotted against angle of attack at M = 0.30 for FX69-H-098 airfoil, generated by subroutine P2.

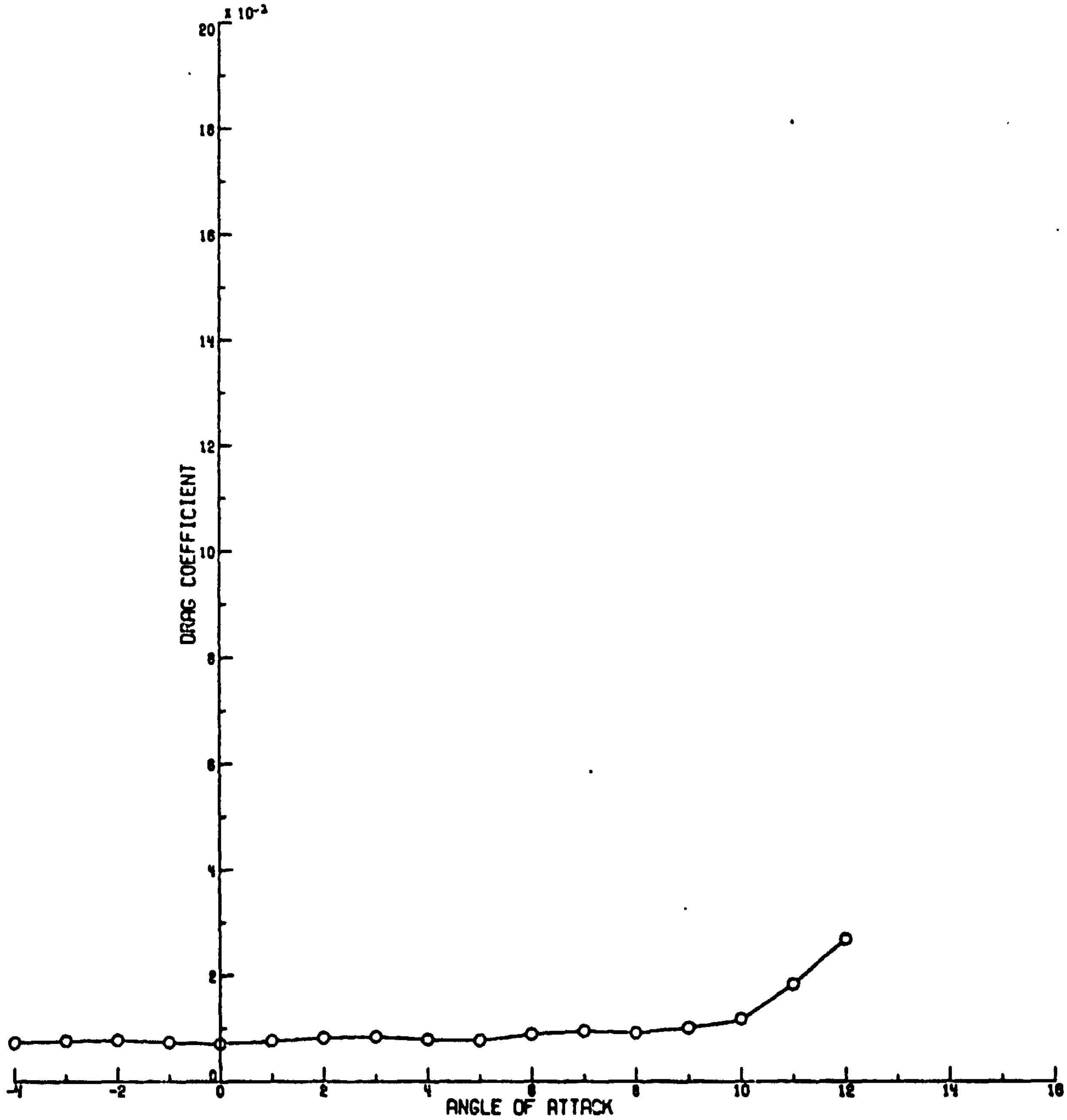


Figure 3.- Blade-element drag coefficient plotted against angle of attack at M = 0.30 for FX69-H-098 airfoil, generated by subroutine P2.

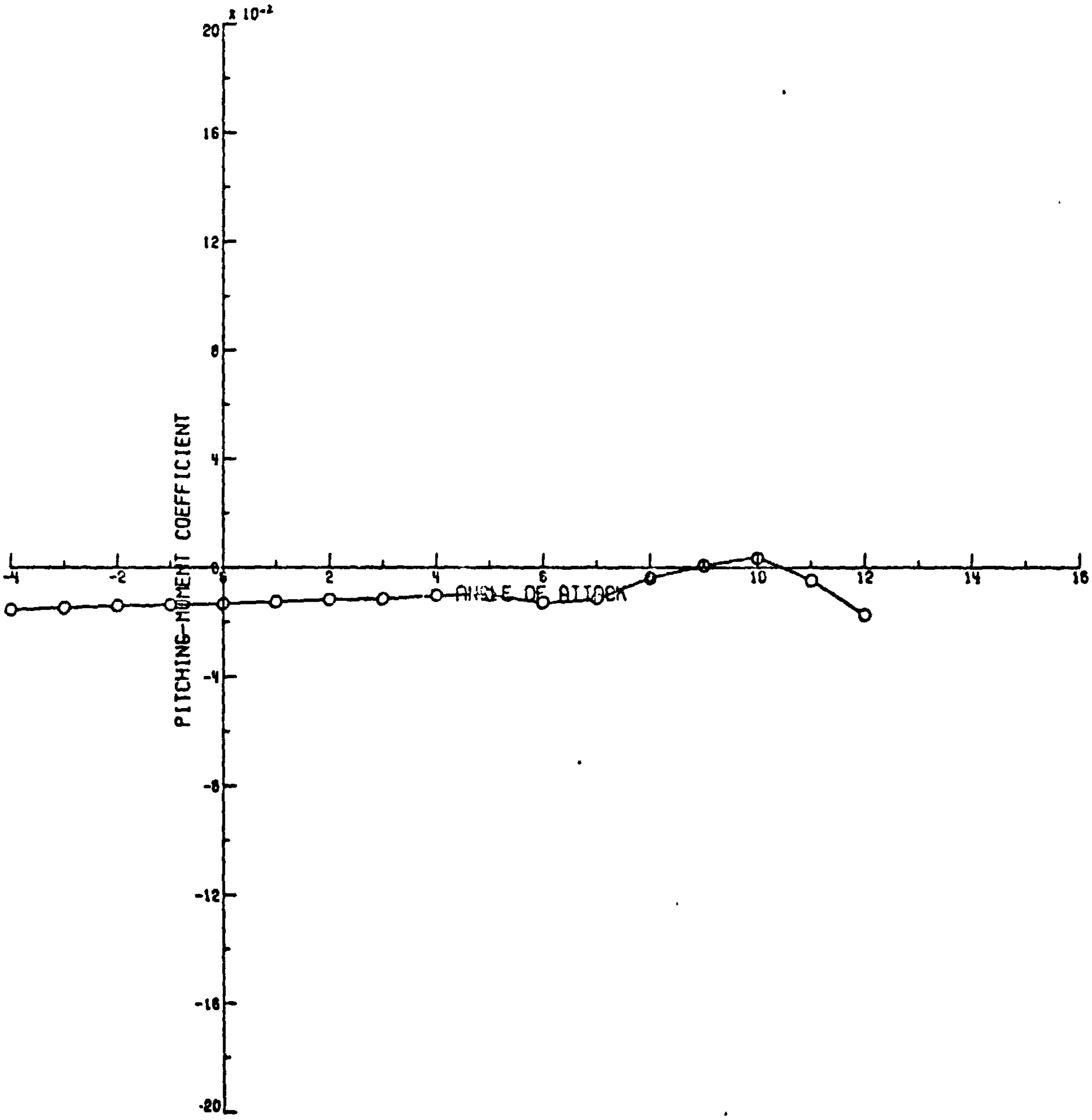
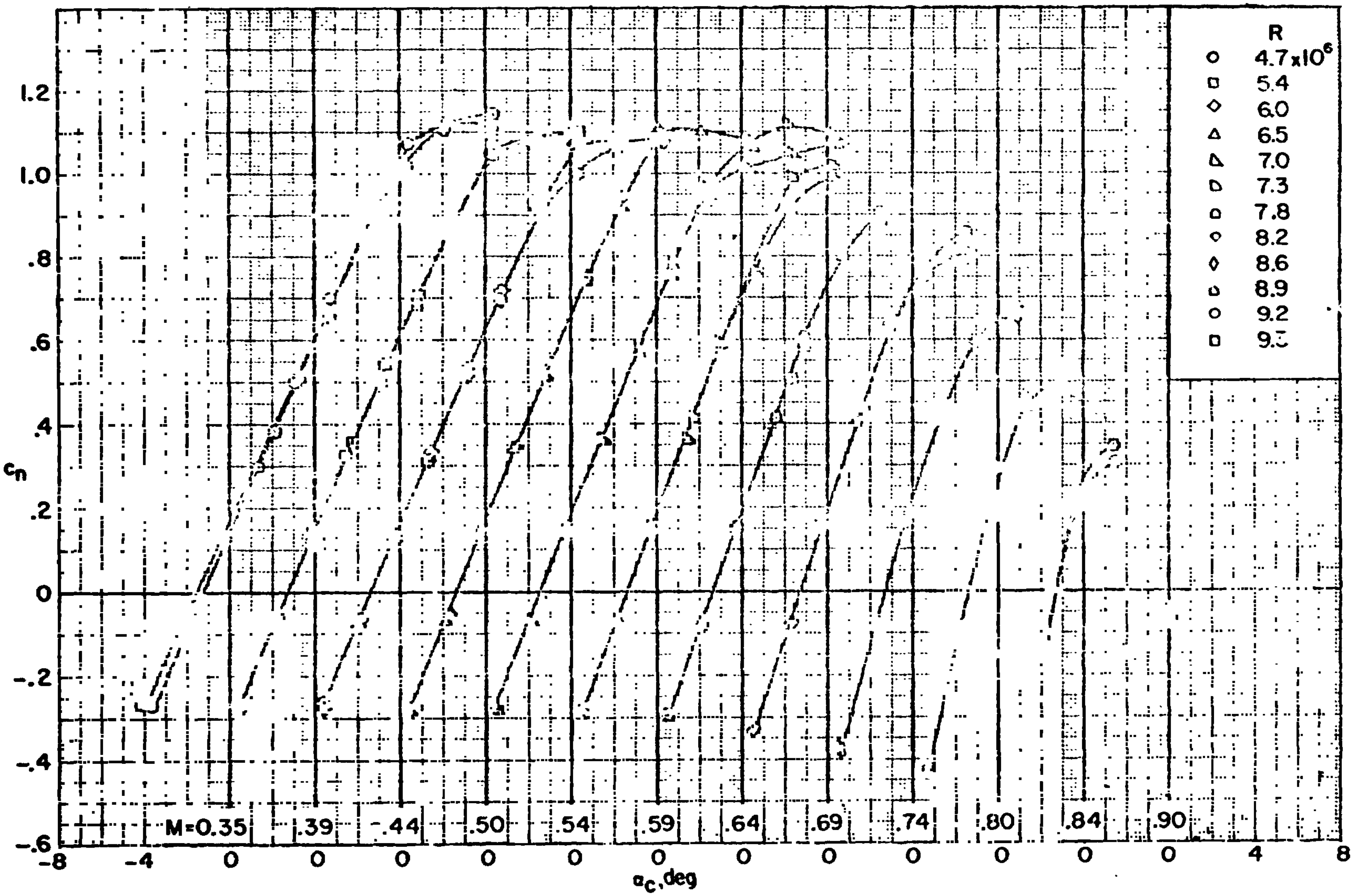
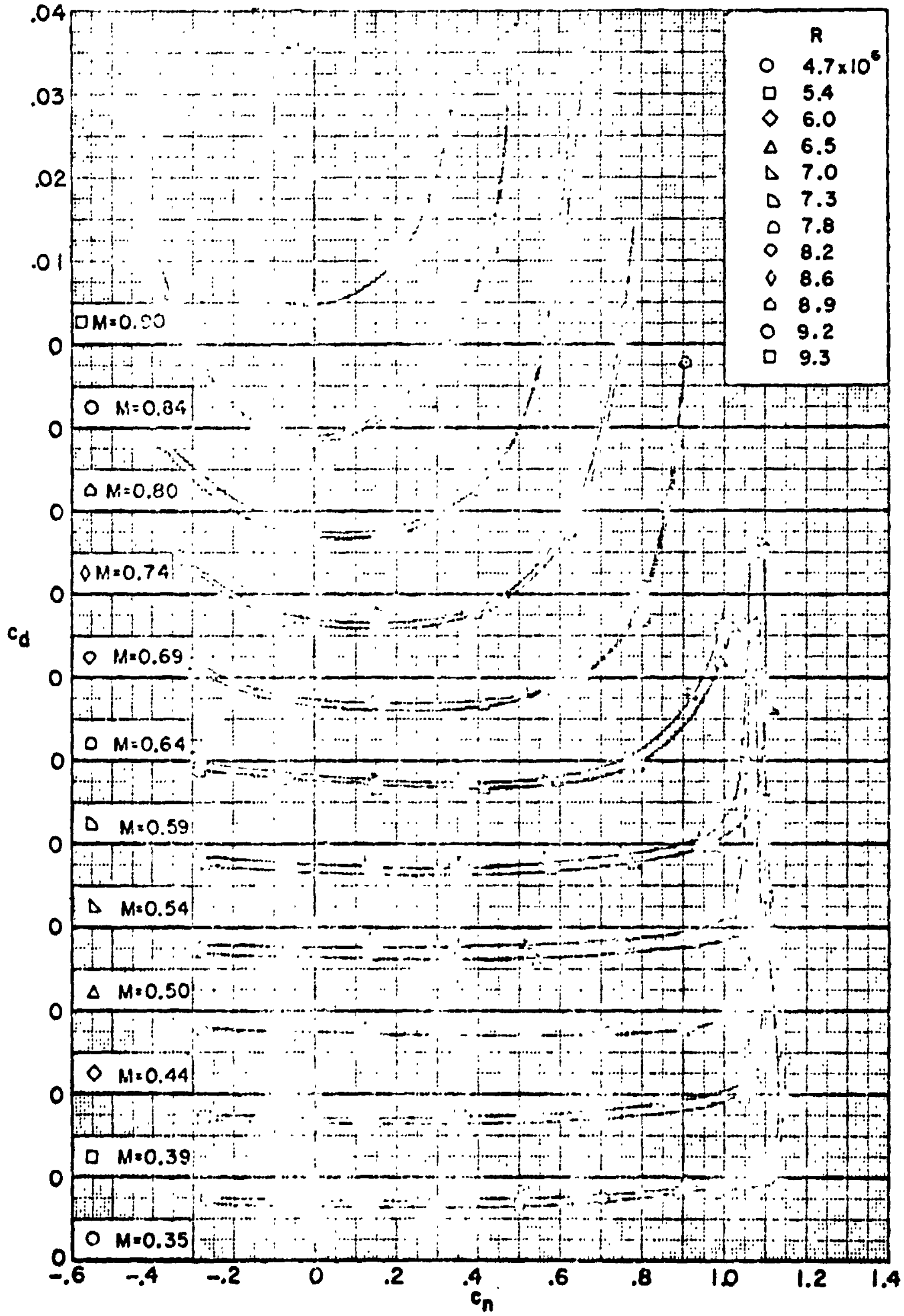


Figure 4.- Blade-element pitching-moment coefficient plotted against angle of attack at M = 0.30 for FX69-H-098 airfoil, generated by subroutine P2.



(a) Normal-force coefficients.

Figure 5.- Section coefficients for FX69-H-098 airfoil in the Langley 6- by 28-inch transonic tunnel. (From ref. 5.) Plain symbols indicate model smooth; symbols with +, transition fixed.



(b) Drag coefficients.

Figure 5.- Concluded.

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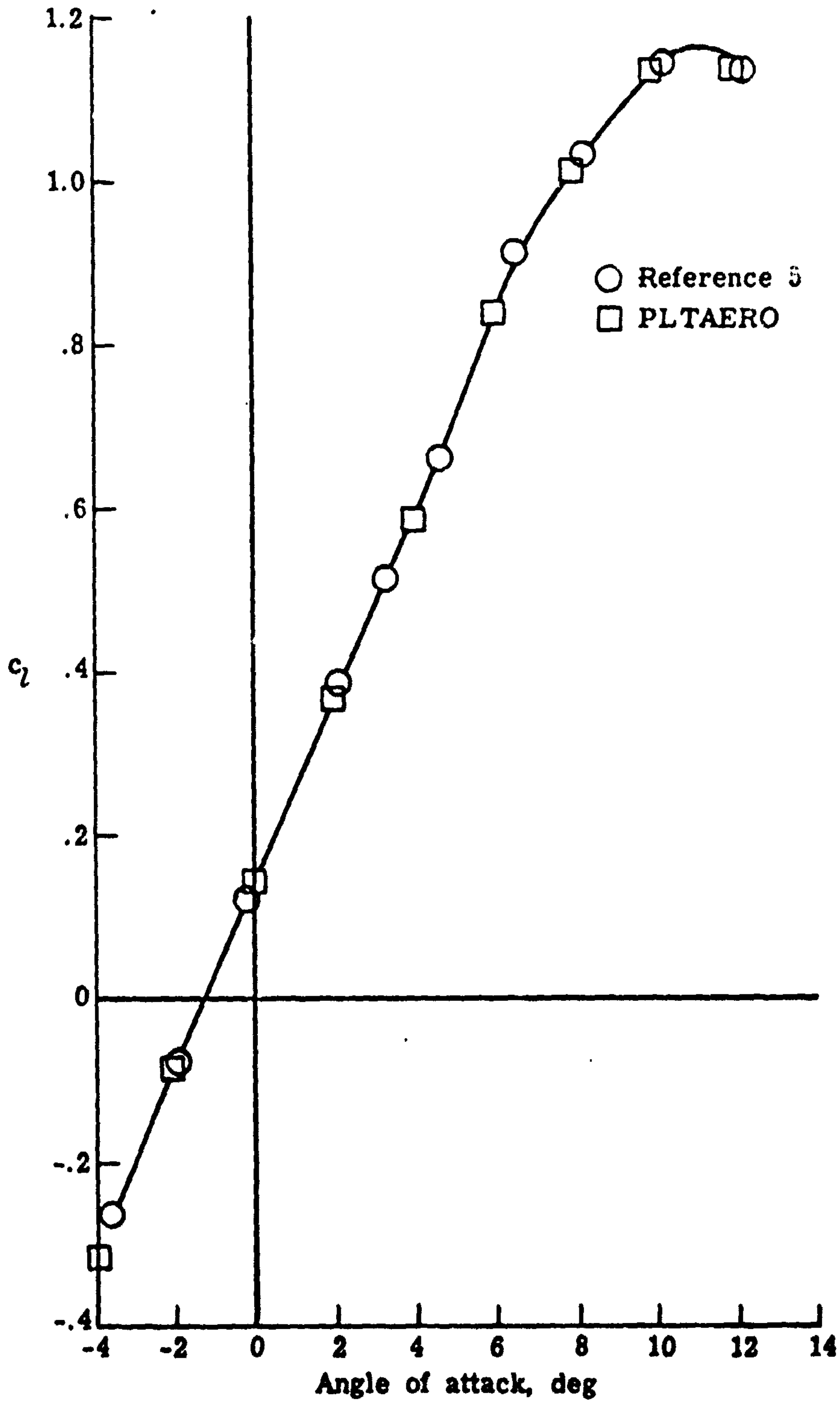
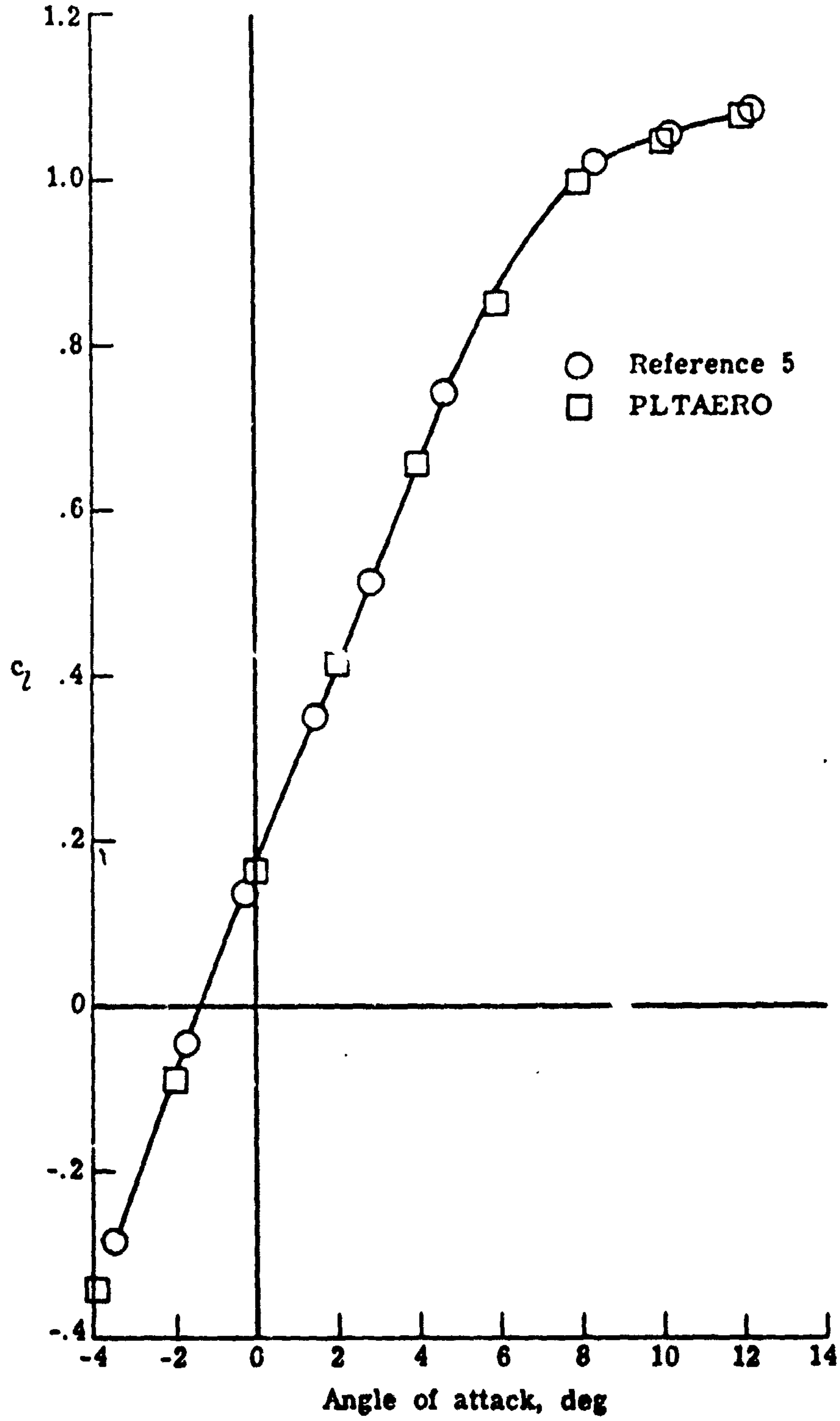


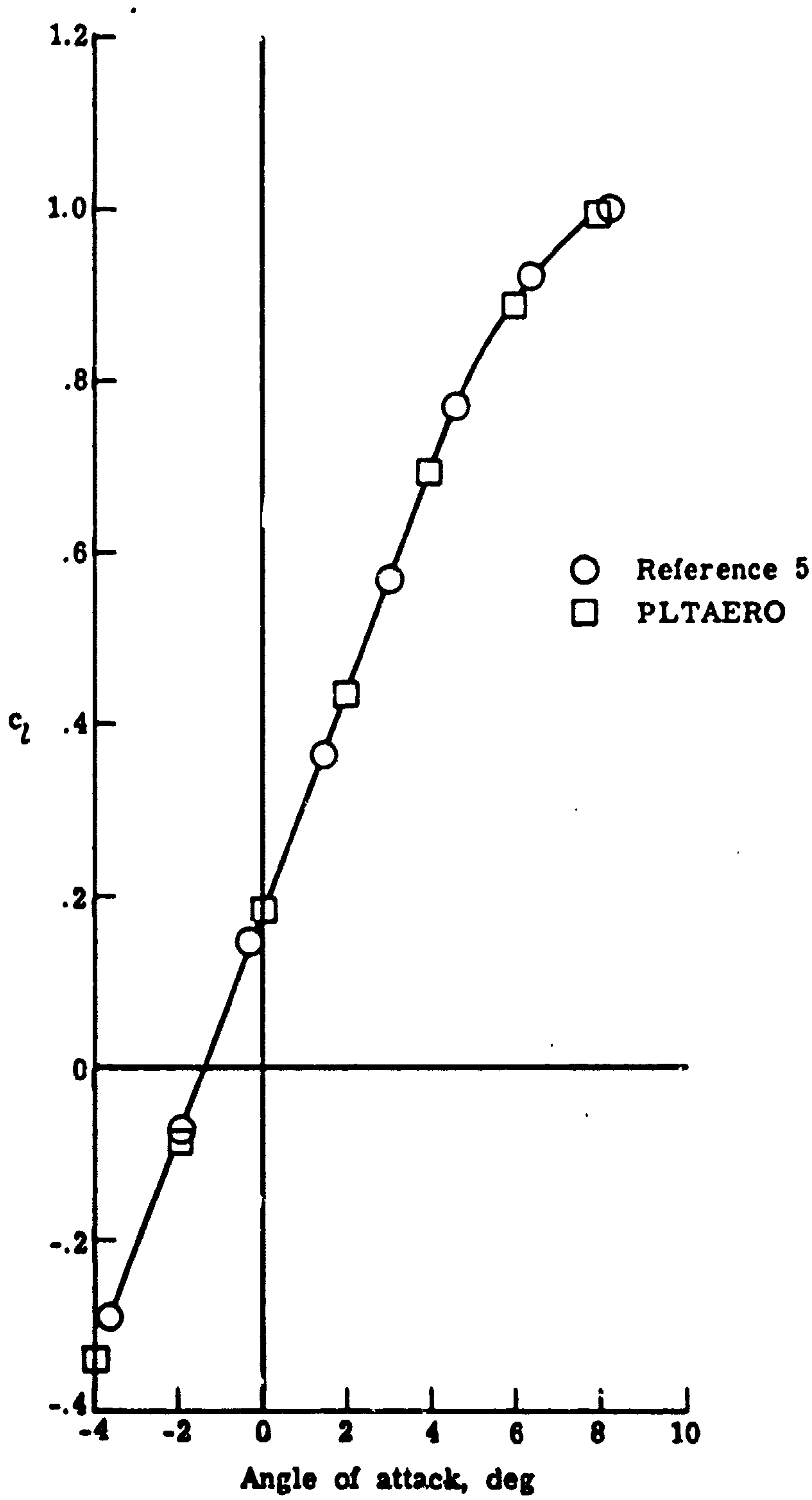
(a) M = 0.35.

Figure 6.- Comparison of section lift coefficients calculated by PLTAERO and section lift coefficients generated from reference 5 for FX69-H-098 airfoil.



(b) M = 0.5.

Figure 6.- Continued.



(c) M = 0.6.

Figure 6.- Concluded.

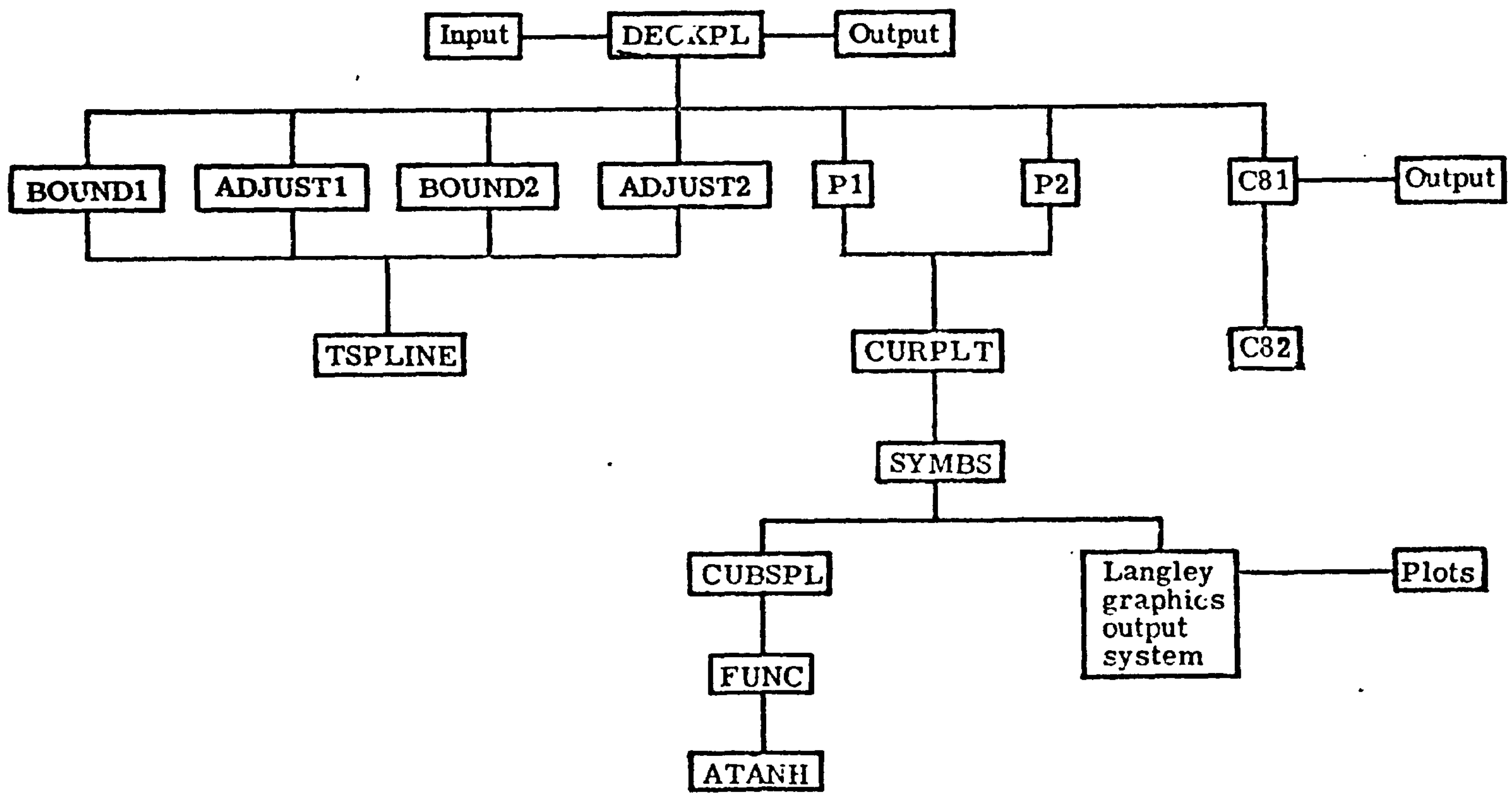


Figure 7.- Program structure.