

(NASA-TM-78627) COMPUTER PROGRAM TO PREPARE
AIRFOIL CHARACTERISTIC DATA FOR USE IN
HELICOPTER PERFORMANCE CALCULATIONS (NASA)
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Computer Program To Prepare
Airfoil Characteristic Data
for Use in Helicopter
Performance Calculations

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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

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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 table 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.

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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 programming 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

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1      PROGRAM DECKPL(INPUT,OUTPUT,TAPES=INPUT,TAPE6=OUTPUT,PUNCH)      K001
1      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CD(30,30)PLTAERO
1      1,CPH(30,30),XTEMP(65),YTEMP(65),X(65),Y(65),YP(65),YPP(65)NCD1
1      2,XNA(30),XNMN(30),HEAD(30),BOTDM(30),XNAT(30),XNMNT(30)      PLTAERO
1      3,NMAX,NMMAX
1      COMMON/HLM/TENR,XINT,ST
1      DIMENSION XX(5)
1      CALL PSEUDO
1      CALL LEROY
1      CALL CALPLT(0.,0.,-3);
1      ST=10.
1      TENR=ST
1      WRITE(6,900)
1      900 FORMAT(29X,2ZH INPUT DATA CARD IMAGES)
1      READ(5,107)NAMAX,NMMAX
1      WRITE(6,107)NAMAX,NMMAX
1      READ(5,107)KA,KB,KC
1      WRITE(6,107)KA,KB,KC
1      READ(5,107)LA,LB,LC
1      WRITE(6,107)LA,LB,LC
1      READ(5,107)MA,MB,MC
1      WRITE(6,107)MA,MB,MC
1      READ(5,100) (XNMN(I),I=1,NMAX)
1      WRITE(6,207)(XNMN(I),I=1,NMAX)
1      READ(5,100)(XNA(I),I=1,NMMAX)
1      WRITE(6,207)(XNA(I),I=1,NMMAX)
1      READ(5,100)(XNAT(I),I=1,NMMAX)
1      WRITE(6,207)(XNAT(I),I=1,NMMAX)
1      READ(5,100)(XMN(I),I=1,NMMAX)
1      WRITE(6,207)(XMN(I),I=1,NMMAX)
1      READ(5,100)(PMN(I),I=1,NMMAX)
1      WRITE(6,207)(PMN(I),I=1,NMMAX)
1      READ(5,100)(PAA(I),I=1,NMAX)
1      WRITE(6,207)(PAA(I),I=1,NMAX)
1      DO 200 I=1,NMMAX
1      N=XNAT(I)
1      READ(5,100)(AA(I,J),J=1,M)
1      WRITE(6,207)(AA(I,J),J=1,M)
1      READ(5,100)(CL(I,J),J=1,M)
1      WRITE(6,207)(CL(I,J),J=1,M)
1      READ(5,100)(CD(I,J),J=1,M)
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1      25
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1      40
2      1,6    7    8    9    10   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32
2      2,6    7    8    9    10   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32
2      3,6    7    8    9    10   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32
2      4,6    7    8    9    10   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32
2      5,6    7    8    9    10   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32

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33 WRITE(6,207)ICD(I,J),J=1,M)
34 READ(5,100)(CPM(I,J),J=1,M)
35 WRITE(6,207)(CPM(I,J),J=1,M)
36
37 CONTINUE
38 READ(5,103)(HEAD(J),J=1,3)
39 WRITE(6,103)(HEAD(J),J=1,3)
40 READ(5,103)(BOTTOM(J),J=1,3)
41 WRITE(6,103)(BOTTOM(J),J=1,3)
42
43 CALL BOUND1(CL)
44 CALL BOUND1(CD)
45 CALL BOUND1(CPM)
46 CALL ADJUST1(CL)
47 CALL ADJUST1(CD)
48 CALL ADJUST1(CPM)
49 CALL BOUND2(CL)
50 CALL ADJUST2(CL)
51 CALL BOUND2(CD)
52 CALL ADJUST2(CD)
53 CALL BOUND2(CPM)
54 CALL ADJUST2(CPM)
55 IF(KA.EQ.0)GO TO 400
56 CALL P1(CL,.6,.24,.6,.1,16HLIFT COEFFICIENT,16,2.,1.,5.,125.,23.,)
57 14.,5.,24.,5.,625.,23.,5.,4.,875.,22.,5.,4.,875.,22.,9.,17.)
58
59 CONTINUE
60 IF(KB.EQ.0)IGO TO 500
61 CALL P1(CD,.0,.20,.0,.01,16HDRAg COEFFICIENT,16,2.,1.,5.,23.,5.,25PLTAERO
62 1.,24.,6.,23.,5.,5.,25.,22.,5.,5.,25.,22.,9.,19.)
63
64 CONTINUE
65
66 CONTINUE
67 IF(LC.EQ.0)IGO TO 700
68 CALL P1(CPM,.10.,.20.,.02,27HPITCHING MOMENT COEFFICIENT,27,1.,)
69 1.,5.,4.,875.,23.,4.,24.,5.,375.,23.,5.,4.,625.,22.,5.,4.,625.,22.,9.,17.)
70
71 CONTINUE
72 IF(LB.EQ.0)IGO TO 800
73 CALL P2(CD,.01,16HDRAg COEFFICIENT,16,0.,0.)
74
75 CONTINUE
76 IF(LC.EQ.0)IGO TO 1000
77 CALL P2(CPM,.02,27HPITCHING MOMENT COEFFICIENT,27,10.,-2.)
78
79 CONTINUE
80 WRITE(6,141)

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APPENDIX

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      85      WRITE(6,142)(PMN(I),I=1,NMMAX)
      DO 143 J = 1,NAMAX
      NMNN=XNMNN(J)
      WRITE(6,144)PAA(J),(CL(I,J),I=1,NMNN)
      143 CONTINUE
      WRITE(6,145)
      WRITE(6,142)(PMN(I),I=1,NMMAX)
      DO 146 J = 1,NAMAX
      NMNN=XNMNN(J)
      WRITE(6,144)PAA(J),(CD(I,J),I=1,NMNN)
      146 CONTINUE
      WRITE(6,147)
      WRITE(6,142)(PMN(I),I=1,NMMAX)
      DO 148 J = 1,NAMAX
      NMNN=XNMNN(J)
      WRITE(6,144)PAA(J),(CPN(I,J),I=1,NMNN)
      148 CONTINUE
      IF(MA.EQ.0)GO TO 1100
      CALL C81(CL,-1)
      1100 CONTINUE
      IF("B.EQ.0)GO TO 1200
      CALL C81(CD,0)
      1200 CONTINUE
      IF(MC.EQ.0)GO TO 1300
      CALL C81(CPM,1)
      1300 CONTINUE
      CALL NFRAME(300.,0.)
      CALL CALPLT(0.,0.,999)
      100 FORMAT(8F10.0)
      103 FORMAT(3A10)
      142 FORMAT(9X,13F8.4)
      144 FORMAT(14F8.4)
      141 FORMAT(//,58X,16HLIFT COEFFICIENT)
      145 FORMAT(//,58X,16HDAIG COEFFICIENT)
      147 FORMAT(//,53X,27HPITCHING MIMENT COEFFICIENT)
      207 FORMAT(8F10.4)
      STOP
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APPENDIX

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1      SUBROUTINE BOUND1(CX)
2      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),CL(30,30),CD(30,30)PLAERO
3      CPM(30,30),XTEMP(65),YTEMP(65),B(65),YL(65),YP(65),YPP(65)MOD1
4      1,CPH(30,30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)
5      2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)
6      3,NMAX,NMMAX
7      COMMON/FHM/TEMP,XINT,ST
8      DIMENSION CX(30,30)
9      DO 100 I=1,NMMAX
10     N = XNA(I)
11     N2 = XNA(I)
12     DO 101 J=1,M
13     XTEMP(J) = AA(I,J)
14     YTEMP(J) = CX(I,J)
15     XI(J) = AA(I,J)
16     C  WRITE(6,200)XTEMP(J),YTEMP(J),XI(J)
17
18     101 CONTINUE
19     CALL TSPLINE(XTEMP,YTEMP,M,B,SI,L,M,XI,YI,YP,YPP,XINT)
20     CX(I,1) = (PAA(1) - AA(I,1))*YP(1) + CX(I,1)
21     CX(I,M) = (PAA(M) - AA(I,M))*YP(M) + CX(I,M)
22
23     100 CONTINUE
24     200 FORMAT(3F10.4)
25     RETURN
26     END

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APPENDIX

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1      SUBROUTINE ADJUST1(CX)
2      COMMON /ONE/ XMMN(30),PMN(30),AA(30,30),PAA(30),C1(30,30),CD(30,30)PLTAERO
3      1,CPM(30,30),XTEMP(65),YTEMP(65),X(65),Y(65),YPP(65),YPM(65)MC01
4      2,XND(30),XMMN(30),HEAD(30),BOTTIM(30),XMAT(30),XNMNT(30)
5      3,NMAX,NMMAX
6      COMMON/HLM/TENR,XINT,ST
7      DIMENSION CX(30,30)
8      DD 100 I=1,NMAX
9      N = XMAT(I)
10     M2 = XMA(I)
11     AA(I,1) = PAA(I)
12     AA(I,M) = PAA(M)
13     DO 101 J=1,N
14     XTEMP(I,J) = AA(I,J)
15     YTEMP(I,J) = CX(I,J)
16     WRITE(6,200) XTEMP(I,J),YTEMP(I,J)
17     C 101 CONTINUE
18     DD 103 K = 1,M2
19     XI(K) = PAA(K)
20     103 CONTINUE
21     CALL TSPLINF(XTEMP,YTEMP,M,0,ST,1,M2,XI,YI,YPP,XINT)
22     DD 102 J = 1,K
23     CX(I,J) = YI(J)
24     C  WRITE(6,200) XI(J),CX(I,J)
25     C 102 CONTINUE
26     100 CONTINUE
27     200 FORMAT(3F10.4)
28     RETURN
29     END
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APPENDIX

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1      SUBROUTINE PLICK,YMS,LCS,VQCS,SFX,BCO,NC,TMAJ,TMIN,X1,Y1,X2,Y2,X3,PLTAERO
1      LY3,X4,Y5,Y5,YX1)
2      COMMON /ONE/ XMM(30),PMN(30),AA(30,30),PA(30),CL(30,30),CD(30,30)PLTAERO
3      CPK(30,30),XTEMP(65),YTEMP(65),X(65),Y(65),YL(65),YP(65),YPP(65)MOD1
4      2,XHA(30),XHMM(30),HEAD(30),BDYDM(30),XHAT(30),XNMHT(30)
5      3,NMAX,NMAX
6      COMMON/HLM/TENR,XINT,ST
7      DIMENSION CX(30,30),BCD(30),XX(5)
8      CALL AXES(0.,YMS,0.,10.,0.,0.,1.,0.,11)MACH NUMBER,=25,-11)
9      CALL AXES(0.,0.,90.,LCS,VQCS,SFX,TMAJ,TMIN,BCD(1),.25,NC)
10     CALL NOTATE(X1,Y1,.125,11MACH NUMBER,0.,11)
11     CALL NOTATE(Y2,Y2,.125,ACD(1),0.,NC)
12     CALL NOTATE(X3,Y3,.125,3HVS.,0.,3)
13     CALL NOTATE(X4,Y4,.125,HEAD(1),0.,30)
14     CALL NOTATE(X5,Y5,.125,BOTTOM(1),0.,30)
15     CALL NOTATE(X4,21.5,.125,24HINTERPOLATED TO SELECTED MACH,0.,29)
16     CALL NOTATE(X4,21.,.125,28HNUMBERS AND ANGLES OF ATTACK,0.,26)
17     NO=1
18     CALL CALPLT(0.,YMS,-3)
19     YX=YX1
20     CALL NOTATE(10.,YX,.125,28,0.,-1)
21     CALL NOTATE(11.5,YX,.125,4HSYM.,0.,4)
22     DO 100 J = 1,MAMAX
23       YX = YX -.25
24       NHMH=XMMH(J)
25       DO 200 I=1,NNNN
26         XTEMP(I)=10.*PNM(I)
27         YTEMP(I) = CX(I,J)/SFX
28         WRITE(6,300) YTEMP(I),YTEMP(I)
29         CONTINUE
30         CALL CURPLT(XTEMP,YTEMP,NNMH,NO,1,2,J)
31         CALL NUMBER(10.,YX,.125,PA(J),0.,2)
32         XY = YX -.0625
33         CALL PNTPLT(11.,XY,NO,1)
34         NO = NO + 1
35         100 CONTINUE
36         200 FORMAT(2F10.4)
37         CALL INFRAE(25.,0.)
38         RETURN
39         END
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APPENDIX

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1      SUBROUTINE BOUND2(CX)
2      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PA(30),CL(30,30),CD(30,30)PLTAERO 15
3      COMMON /CPM/ (30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65)MOD1 188
4      COMMON /XNA/ (30),XMPN(30),HEAD(30),BOTTDH(30),XNAT(30),XNMNT(30) 1.1
5      COMMON /NMAX, NMMAX 100
6      COMMON /FLK/TENP,XINT,ST 100
7      DIMENSION CX(30,30),XX(5) 192
8      DO 100 J = 1,NMAX 193
9      NNMN = XMN(J) 194
10     DO 200 I=1,NNMN 195
11     XTEMP(I) = XMN(I) 196
12     YTEMP(I) = CX(I,J) 197
13     XI(I) = XMN(I) 198
14     WRITE(6,300) XTEMP(I),YTEMP(I),XI(I) 199
15     CONTINUE 200
16     CALL TSPLINE(XTEMP,YTEMP,NNMN,B,ST,l,NNMN,XI,YI,YP,YPP,XINT) 200
17     CX(I,J) = (PMN(I) - XMN(I))*YP(I) + CX(I,J) 201
18     CX(NNMN,J) = (PMN(NNMN) - XMN(NNMN))*YP(NNMN) + CX(NNMN,J) 202
19     XMN(I) = PMN(I) 203
20     XMN(NNMN) = PMN(NNMN) 204
21     CONTINUE 205
22     300 FORMAT(3F10.4) 206
23     RETURN 207
24     END 208
25     PLTAERO 209
26     PLTAERO 210

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APPENDIX

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1          SUBROUTINE ADJUST2(CX)
2          COMMON /ONE/ XMN(30),PMN(30),AA(30,30),PA(30),CL(30,30),CD(30,30)
3          CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YI(65),YP(65),YPP(65)M0D1
4          2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XHAT(30),XHANT(30)
5          3,NMAX,N:MAX
6          COMMON/HLM/TENR,XINT,ST
7          DIMENSION CX(30,30),XX(5)
8          DO 100 J = 1,NMAX
9          NMN = XMN(J)
10         XMN(1) = PMN(1)
11         XMN(NMN) = PMN(NMN)
12         DO 200 I=1,NMN
13         XTEMP(I) = XMN(I)
14         YTEMP(I) = CX(I,J)
15         C        WRITE(6,300) XTEMP(I),YTEMP(I)
16
16         200 CONTINUE
17         DO 203 I = 1,NMN
18         XI(I) = PMN(I)
19         C        WRITE(6,300) XI(I)
20
20         203 CONTINUE
21         CALL TSPLINE(XTEMP,YTEMP,NMN,B,ST,1,NMN,XI,YI,YP,YPP,XINT)
22
22         DO 400 I = 1,NMN
23         CX(I,J) = YI(I)
24
24         400 CONTINUE
25         1C0 CONTINUE
26         300 FORMAT(3F10.4)
27
28         RETURN
29
29         END

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APPENDIX

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1      SUBROUTINE P21CX,SFX,BCD,NC,YHS,V01
2      COMMON /DNE/ XHN(30),PMN(30),AA(30,30),PAA(30),CL(30,30),CO(30,30)
3      ,CPM(30,30),XTEMP(165),YTEMP(65),XI(65),YI(65),YP(65),YPP(65)MOD1
4      ,2,XNA(30),XNMN(30),HEAD(30),BOTTOM(30),XNAT(30),XNMNT(30)
5      ,3,NAMAX,NMMAX
6      COMMON/SHUM/TENR,XINT,ST
7      DIMENSION CX(30,30),BCD(NC)
8
9      NJ = 1
10     DO 100 I=1,NMMAX
11        N = XNAT(I)
12        CALL NFRAME(125.,0.)
13        CALL AXES(14.,0.,90.,20.,V0,SFX,2.,1.,BCD(1),.25,NC)
14        CALL AXES(0.,YHS,0.,20.,-4.,1.,2.,1.,15HANGLE OF ATTACK,.25,-15)
15        CALL NOTATE(17.75,24.,.125,BCD(1),0.,NC)
16        CALL NOTATE(18.25,23.5,.125,3HVS,.0.,3)
17        CALL NOTATE(17.625,23.,.125,15HANGLE OF ATTACK,0.,15)
18        CALL NOTATE(17.825,22.5,.125,HEAD(1),0.,30)
19        CALL NOTATE(17.825,22.,.125,BOTTOM(1),0.,30)
20        CALL NOTATE(17.825,20.5,.125,29HINTERPOLATED TO SELECTED MACH,0.,.29)
21        CALL NOTATE(17.825,.20.,.125,28HNUMBERS AND ANGLES OF ATTACK,0.,28)
22        CALL NUMBER(19.625,19.0,.125,13HMACH NUMBER ,0.,13)
23        DO 200 J=1,M
24          XTEMP(J) = PAA(J) + 4.
25          YTEMP(J) = (CX(1,J)/SFX) + YHS
26          WRITE(6,300) XTEMP(J),YTEMP(J)
27
28      C   200 CONTINUE
29      CALL CURPLT(XTEMP,YTEMP,N,NO,1,2,I)
30
31      NO = NO + 1
32      100 CONTINUE
33      300 FORMAT(2F10.4)
34      PAA(1) = -4.
35      RETURN
36
37      END

```

APPENDIX

APPENDIX

ORIGINAL PAGE IS
IF POOR QUALITY

APPENDIX

85
 P., • 0.0068, • 0.0083, • 0.008, • 0.0083, • 0.0085, • 0.0093, • 0.01, • 0.011, • 0.0141, • 0.022PLTAERO
 Qi. • 0.0351, • 0.053, • 0.078, • 0.111, • 0.148, • 0.18, • 0.209, • 0.235, • 0.332, • 0.562, • 0.662,
 R., • 0.022, • 0.062, • 0.132, • 0.242, • 0.302, • 1.042, • 1.652, • 1.852, • 1.652, • 1.042, • 0.302,
 S1. • 0.042, • 1.652, • 1.392, • 0.562, • 0.332, • 0.257, • 0.233, • 0.212, • 0.191, • 0.164, • 0.135, • 0.105,
 T. • 0.077, • 0.053, • 0.035, • 0.0212, • 0.0132, • 0.01, • 0.009, • 0.0085, • 0.0083, • 0.0085,
 U. • 0.009, • 0.01, • 0.0132, • 0.0212, • 0.035, • 0.053, • 0.077, • 0.105, • 0.135, • 0.164, • 0.191,
 V. • 2.57, • 3.32, • 5.62, • 1.392, • 1.662, • 1.842, • 1.662, • 2.022, • 2.022, • 1.852, • 1.652,
 W1. • 0.442, • 0.302, • 0.242, • 0.132, • 0.062, • 0.022 /
 DATA((CXD(I,J),J=1,651,I=7,91 /, 0.022, 0.062, 0.132, 0.242, 0.302, 0.1, C42,
 X1. • 0.652, • 1.852, • 2.022, • 2.022, • 1.962, • 1.842, • 1.662, • 1.392, • 0.562, • 0.332, • 0.274,
 Y. • 2.52, • 2.33, • 2.16, • 1.98, • 1.17, • 1.45, • 1.12, • 1.01, • 0.92, • 0.615, • 0.38, • 0.167,
 Z., • 0.0086, • 0.0083, • 0.0083, • 0.0083, • 0.0085, • 0.0085, • 0.0085, • 0.0085, • 0.0085,
 1. • 1.22, • 1.45, • 1.17, • 1.98, • 2.16, • 2.33, • 2.52, • 2.74, • 3.32, • 5.62, • 1.392, • 0.615,
 2. • 1.962, • 2.022, • 2.022, • 1.852, • 1.652, • 1.042, • 0.302, • 0.242, • 0.132, • 0.062,
 3., • 0.62, • 1.32, • 2.42, • 3.02, • 1.042, • 1.652, • 1.852, • 2.022, • 2.022, • 1.962, • 1.842,
 41. • 6.62, • 1.392, • 5.62, • 3.32, • 0.292, • 0.271, • 0.249, • 0.231, • 0.211, • 0.192, • 0.176,
 5. • 1.11, • 0.682, • 0.54, • 0.30, • 0.175, • 0.0117, • 0.0091, • 0.008, • 0.0091, • 0.0117,
 6. • 0.54, • 0.82, • 1.11, • 1.14, • 1.159, • 1.176, • 1.192, • 2.11, • 2.31, • 2.49, • 2.71, • 2.92, • 3.32,
 7. • 5.62, • 1.392, • 1.662, • 1.842, • 1.962, • 2.022, • 2.022, • 1.852, • 1.652, • 1.042,
 8. • 2.42, • 1.32, • 0.62, • 0.022, • 0.022, • 0.062, • 1.32, • 0.242, • 0.302, • 1.042, • 1.652,
 92. • 0.022, • 2.022, • 1.962, • 1.842, • 1.662, • 1.392, • 0.562, • 0.332, • 0.305, • 0.282,
 A. • 22, • 0.202, • 0.186, • 0.172, • 0.155, • 0.139, • 0.12, • 0.068, • 0.0575, • 0.0355, • 0.024,
 B., • 0.0175, • 0.024, • 0.0355, • 0.0575, • 0.043, • 0.12, • 0.139, • 0.155, • 0.172, • 0.186,
 C., • 0.26, • 0.282, • 0.305, • 0.332, • 0.562, • 1.392, • 1.662, • 1.042, • 0.202, • 0.022,
 D., • 1.652, • 1.042, • 0.302, • 0.242, • 0.132, • 0.062, • 0.022 /
 DATA((CXD(I,J),J=1,651,I=10,11) /, 0.022, • 0.062, • 0.132, • 0.242, • 0.302,
 E1. • 0.042, • 1.652, • 1.042, • 0.302, • 0.242, • 0.132, • 0.062, • 0.022, • 0.006, • 0.0095,
 F. • 3.42, • 2.98, • 2.93, • 2.72, • 2.52, • 2.232, • 2.13, • 1.99, • 1.83, • 1.69, • 1.4, • 1.11,
 G. • 0.81, • 0.78, • 0.78, • 0.78, • 0.78, • 0.78, • 0.78, • 0.78, • 0.78, • 0.78, • 0.78, • 0.78,
 H. • 2.13, • 2.32, • 2.52, • 2.72, • 2.93, • 2.98, • 3.42, • 3.32, • 5.62, • 1.392, • 1.662, • 1.042,
 I1. • 9.62, • 2.022, • 2.022, • 1.852, • 1.652, • 1.042, • 0.302, • 0.242, • 0.132, • 0.062,
 J. • 0.62, • 1.32, • 2.42, • 3.02, • 1.042, • 1.652, • 1.852, • 2.022, • 2.022, • 1.962, • 1.842,
 K1. • 6.62, • 1.392, • 5.62, • 3.32, • 0.342, • 0.298, • 0.293, • 0.292, • 0.275, • 0.254, • 0.232,
 L., • 1.92, • 1.17, • 1.14, • 1.12, • 1.02, • 0.98, • 0.96, • 0.95, • 0.96, • 1.02, • 1.12, • 1.14,
 M., • 1.92, • 2.14, • 2.32, • 2.54, • 2.75, • 2.91, • 2.92, • 2.93, • 2.98, • 3.42, • 3.32, • 3.62,
 N. • 1.662, • 1.842, • 1.962, • 2.022, • 2.022, • 1.852, • 1.652, • 1.042, • 0.202, • 0.242, • 0.132,
 O. • 0.62, • 0.22 /
 DATA((CXPL(I,J),J=1,47),I=1,61 /0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
 S. • 0.54, • 0.,
 10. • 0.,
 2-• 0.054, -• 0.073, -• 0.112, -• 0.174, -• 0.5, -• 0.5, -• 0.3, -• 0.4, -• 0.4, -• 0.3, -• 0.5, -• 0.5,
 115
 120
 355

APPENDIX

APPENDIX

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120 FORMAT(32X,16HDATA CARD IMAGES)
170      NXL = 11
      NZL = 39
      NXD = 11
      NZD = 65
      NXM = 9
      NZM = 47
      WRITE(6,905) (HEAD(J),J=1,3)
      PUNCH 905, (HEAD(J),J=1,3)
      MOD1 37
      PLTAERO 459
175      FORMAT(1X,3A1C)
      WRITE(6,906) (BOTTOM(J),J=1,3),NXL,NZL,NXD,NZD,NXM,NZM
      PUNCH 906, (BOTTOM(J),J=1,3),NXL,NZL,NXD,NZD,NXM,NZM
      MOD1 38
      PLTAERO 450
      MOD1 39
      MOD1 40
      MOD1 41
      MOD1 42
      PLTAERO 463
      MOD1 43
      MOD1 44
      MOD1 45
      MOD1 46
      MOD1 47
      MOD1 48
      MOD1 49
      MOD1 50
      PLTAERO 470
      MOD1 43
      MOD1 44
      MOD1 45
      MOD1 46
      MOD1 47
      MOD1 48
      MOD1 49
      MOD1 50
      PLTAERO 474
      MOD1 51
      MOD1 52
      MOD1 53
      MOD1 54
      PLTAERO 477
      MOD1 55
      PLTAERO 478
      MOD1 479
      MOD1 56
      MOD1 57
      MOD1 58
      MOD1 59
      MOD1 60
      MOD1 61
      PLTAERO 512
      MOD1 62
      MOD1 63
      MOD1 64
      MOD1 65
      PLTAERO 515
180      FORMAT(3A10,6I2)
      WRITE(6,910) (XML(I),I=1,9)
      PUNCH 910, (XML(I),I=1,9)
      WRITE(6,911) (XML(I),I=10,11)
      PUNCH 911, (XML(I),I=10,11)
      MOD1 43
      MOD1 44
      MOD1 45
      MOD1 46
      MOD1 47
      MOD1 48
      MOD1 49
      MOD1 50
      PLTAERO 470
      MOD1 43
      MOD1 44
      MOD1 45
      MOD1 46
      MOD1 47
      MOD1 48
      MOD1 49
      MOD1 50
      PLTAERO 474
      MOD1 51
      MOD1 52
      MOD1 53
      MOD1 54
      PLTAERO 477
      MOD1 55
      PLTAERO 478
      MOD1 479
      MOD1 56
      MOD1 57
      MOD1 58
      MOD1 59
      MOD1 60
      MOD1 61
      PLTAERO 512
      MOD1 62
      MOD1 63
      MOD1 64
      MOD1 65
      PLTAERO 515
185      FORMAT(F7.0,9F7.4)
      907 FORMAT(F7.0,9F7.4)
      908 FORMAT(7X,2F7.4)
      910 FORMAT(7X,9F7.4)
      911 FORMAT(7X,2F7.4)
      DO 1000 J=1,39
      WRITE(6,907) ALL(J),(CXL(I,J),I=1,9)
      WRITE(6,908) (CXL(I,J),I=10,11)
      PUNCH 907, ALL(J),(CXL(I,J),I=1,9)
      PUNCH 908, (CXL(I,J),I=10,11)
      1000 CONTINUE
      WRITE(6,977)
      RETURN
190      200 CONTINUE
      CALL C82(3,11,65,2,26,16,50,ALD,XMD,CXD,CX,JXP)
      WRITE(6,120)
      WRITE(6,910) (XMD(I),I=1,9)
      PUNCH 910, (XMD(I),I=1,9)
      WRITE(6,911) (XMD(I),I=10,11)
      PUNCH 911, (XMD(I),I=10,11)
      DO 1400 J=1,65
      WRITE(6,907) ALD(J),(CXD(I,J),I=1,9)
      WRITE(6,908) (CXD(I,J),I=10,11)
      PUNCH 907, ALD(J),(CXD(I,J),I=1,9)
      PUNCH 908, (CXD(I,J),I=10,11)
      1400 CONTINUE
200      210

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APPENDIX

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      MOD1          66
      PLTAERO      516
      PLTAERO      517
      MOD1          67
      MOD1          68
      PLTAERO      549
      MOD1          69
      MOD1          70
      MOD1          71
      MOD1          72
      PLTAERO      552
      MOD1          73
      PLTAERO      553
      PLTAERO      554

      WRITE(6,977)
      RETURN
      300 CONTINUE
      CALL C82(2,9,47,1,19,8,40,ALP,XMP,CXP,CX,JXP)
      WRITE(6,120)
      215      WRITE(6,910) (XMP(I),I=1,9)
      DO 1800 J=1,47
      WRITE(6,910) (XMP(I),I=1,9)
      PUNCH910, (XMP(I),I=1,9)
      WRITE(6,907) ALP(J),(CXP(I,J),I=1,9)
      PUNCH 907, ALP(J),(CXP(I,J),I=1,9)
      220      1600 CONTINUE
      WRITE(6,977)
      RETURN
      END

```

APPENDIX

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1      SUBROUTINE C02(IA,IB,IC,ID,IE,IF,IG,ALPHA,XMACH,CXX,CX,JXP)      MOD1
2      COMMON /ONE/ XMN(30),PMN(30),AA(30,30),SA(30),CL(30,30),CD(30,30)      MOD1
3      CPM(30,30),XTEMP(65),YTEMP(65),B(65),XI(65),YT(65),YP(65),YPP(65)      MOD1
4      XNA(30),XMN(30),HEAD(30),BOTTON(30),XNAT(30),XNMNT(30)      MOD1
5      XNMAX,NMAX      MOD1
6      COMMON /HLL/ TERR,XINT,ST      MOD1
7      DIMENSION CX(30,30),CXX(18,IC),XNACH(18),DUM(11,65),ALPHA(IC)      MOD1
8      DUM(11,1) = CXX(1,1)      MOD1
9      DUM(11,18) = 1.18      MOD1
10     DUM(11,18) = 1.1C      MOD1
11
12     496 CONTINUE      MOD1
13     499 CONTINUE      MOD1
14     101 FORMATT(12F10.4)      MOD1
15     102 FORMATT(//)      MOD1
16     DO 500 I = 1,A,B      MOD1
17     DO 501 J = 1,C      MOD1
18     DO 502 K = 1,MMAX      MOD1
19     NAT = XNA(I,J)      MOD1
20     IF(DA(1,J).EQ.0.0) GO TO 501      MOD1
21     IF(DA(1,J).AND.PMN(I,J).AND.PMN(I,J).EQ.0.0) CXX(I,J)=CXX(I,J)      MOD1
22     IF(DA(1,J).EQ.0.0) ALPH(A(J)).AND.PMN(I,J).EQ.0.0) XMACH(I,J)      MOD1
23     IF(PMN(NMAX,I,EQ.1)) GO TO 513      MOD1
24     IF(PMN(NMAX,I,EQ.0.9)) GO TO 512      MOD1
25     503 CONTINUE      MOD1
26     502 CONTINUE      MOD1
27     501 CONTINUE      MOD1
28     500 CONTINUE      MOD1
29     500 CONTINUE      MOD1
30     510 CONTINUE      MOD1
31     NAT = XNA(I,J)      MOD1
32     JDP = 1E + 1      MOD1
33     DO 511 J = JDP,IC      MOD1
34     IF(ALPH(A(J)).GT.PAA(NAT)) GO TO 511      MOD1
35     IF(XNA(NMAX,I,EQ.1)) GO TO 513      MOD1
36     DO 512 J = JDP,IC      MOD1
37     IF(ALPH(A(J)).GT.PAA(NAT)) GO TO 512      MOD1
38     512 CONTINUE      MOD1
39     513 CONTINUE      MOD1
40     513 CONTINUE      MOD1
41     513 CONTINUE      MOD1
42     513 CONTINUE      MOD1
43     513 CONTINUE      MOD1
44     513 CONTINUE      MOD1
45
46     00 600 I = 1,18

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APPENDIX

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116
117      IJ = 0
118      DO 601 J = 1,IC
119      IF(CXX(I,J).NE.DUM(I,J)) IJ = IJ+1
120      CONTINUE
121      IJ = IJ + 1
122      DO 602 J = 1,IJ
123      XTEMP(IJ) = ALPHA(IJ)
124      YTEMP(IJ) = CXX(I,J)
125      IJJP = IJ + 1
126      IJJQ = IJ + IF
127      FORMAT(11115)
128      DO 603 J = IJJP, IJJQ
129      IXJ = (IJ-IJJP) + IC
130      XTEMP(IJ) = ALPHA(IXJ)
131      YTEMP(IJ) = CXX(I,JXJ)
132      CONTINUE
133      CALL TSPLINE(XTEMP,YTEMP,IXJQ,0,SI,l,IC,ALPHA,YI,YP,YPP,XINT)
134      DO 604 J = 1,IC
135      CX(I,J) = Y(I(J))
136      CONTINUE
137      DO 605 J = 1,IC
138      WRITE(6,101) ALPHA(IJ), (CXX(I,J), I=1,IB)
139      100 FORMAT(11F10.4)
140      700 CONTINUE
141      WRITE(6,162)
142      RETURN
143      END

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ORIGINAL PAINT IS
OF POOR QUALITY

APPENDIX

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1      SUBROUTINE SYMBOL(IND,IS,X,Y,T)
C      IND - SYMBOL NUMBER
C      IS  - SYMBOL SIZE 1-SMALL 2-MEDIUM 3-LARGE
C      X AND Y - INTERCEPT OF SYMBOL AND RADIAL DRAWN FROM SYMBOL
5      C      CENTER AT ANGLE T.
C      DIMENSION SCALE(3)
C      DATA RAD/57.2957765131/,PI/3.141592654/
C      DATA DA/1.4142135624/,R/1.7320509676/,SCALE/.13,.16,.19/
C      DATA TI/213.6900675260/,T2/326.3099326740/,T3/116.5650511771/,T4/3PLTAERO
10     133.4349488229/.17/11.3099324740/,TE/168.6900675260/,T9/218.6598062PLTAERO
2541/.S1/321.3401917459/.52/185.7105931375/.S3/354.2894068625/.S4/1PLTAERO
31.3099324740/.55/168.6903675260/.56/218.6598062541/.57/321.3401917PLTAERO
4459/ PLTAERO
15     IF ((IND.EQ.1).OR.(IND.EQ.11)) GO TO 1
IF ((IND.EQ.2).OR.(IND.EQ.12)) GO TO 2
IF ((IND.EQ.3).OR.(IND.EQ.13)) GO TO 8
IF ((IND.EQ.4).OR.(IND.EQ.14)) GO TO 13
IF ((IND.EQ.5).OR.(IND.EQ.15)) GO TO 17
IF ((IND.EQ.6).OR.(IND.EQ.16)) GO TO 21
IF ((IND.EQ.7).OR.(IND.EQ.17)) GO TO 26
IF ((IND.EQ.8).OR.(IND.EQ.18)) GO TO 31
IF ((IND.EQ.9).OR.(IND.EQ.19)) GO TO 37
IF ((IND.EQ.10).OR.(IND.EQ.20)) GO TO 40
IF ((IND.EQ.21).OR.(IND.EQ.22)) GO TO 45
IF ((IND.GT.22)) RETURN
20     SYMBOL NUMBER 1 OR 11
1      X=SCALE(L15)*.5525*COS(T/RAD)
Y=SCALE(L15)*.5525*SIN(T/RAD)
RETURN
25     SYMBOL NUMBER 2 OR 12
2      IF ((T.GE.0.).AND.(T.LT.-45.)) GO TO 3
IF ((T.GE.-45.0).AND.(T.LT.-135.)) GO TO 4
IF ((T.GE.-135.).AND.(T.LT.-225.)) GO TO 5
IF ((T.GE.-225.).AND.(T.LT.-315.)) GO TO 6
IF ((T.GE.-315.).AND.(T.LE.-360.)) GO TO 7
3      X=SCALE(L15)/2.
Y=X*TAN(T/RAD)
RETURN
4      Y=SCALE(L15)/2.
40     IF (T.EQ.90.) X=0.0
IF (T.NE.90.) X=Y*TAN(T/RAD)
RETURN

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APPENDIX

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      X=-SCALE(1$)/2.
      Y=X*TAN(1$/RAD)
      RETURN
  45   Y=-SCALE(1$)/2.
      IF (1$.EQ.270.) X=0.0
      IF (1$.NE.270.) X=Y/TAN(1$/RAD)
      RETURN
  50   X=SCALE(1$)/2.
      Y=X*TAN(1$/RAD)
      RETURN
  55   C   SYMBOL NUMBER 3 OR 13
      IF (1$.GE.0.) AND.(1$.LT.90.) GO TO 9
      IF (1$.GE.90.) AND.(1$.LT.180.) GO TO 10
      IF (1$.GE.180.) AND.(1$.LT.270.) GO TO 11
      IF (1$.GE.270.) AND.(1$.LE.360.) GO TO 12
      X=SCALE(1$)*DA/2./TAN(1$/RAD)+1.
      Y=-X+SCALE(1$)*DA/2.
      RETURN
  60   10  IF (1$.EQ.90.) X=0.0
      IF (1$.NE.90.) X=SCALE(1$)*DA/2./(TAN(1$/RAD)-1.)
      Y=X+SCALE(1$)*DA/2.
      RETURN
  65   11  X=-SCALE(1$)*DA/2./(TAN(1$/RAD)+1.)
      Y=-X-SCALE(1$)*DA/2.
      RETURN
  70   12  IF (1$.EQ.270.) X=0.0
      IF (1$.NE.270.) X=-SCALE(1$)*DA/2./(TAN(1$/RAD)-1.)
      Y=X-SCALE(1$)*DA/2.
      RETURN
  75   13  SYMBOL NUMBER 4 OR 14
      IF (1$.GE.0.) AND.(1$.LT.90.) GO TO 14
      IF (1$.GE.90.) AND.(1$.LT.180.) GO TO 15
      IF ((1$.GE.180.) AND.(1$.LT.T2)) GO TO 16
      IF ((1$.GE.T2) AND.(1$.LE.360.)) GO TO 14
      X=(2./3.*SCALE(1$)+1.105/(TAN(1$/RAD)+2.))
      Y=-2.*X+2.*SCALE(1$)+1.105/3.
      RETURN
  80   14  IF (1$.EQ.90.) X=0.0
      IF (1$.NE.90.) X=(2./3.*SCALE(1$)+1.105/(TAN(1$/RAD)-2.))
      Y=2.*X+2.*SCALE(1$)+1.105/3.
      RETURN
  85   15  Y=-SCALE(1$)+1.105/3.
      RETURN
  90   16

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APPENDIX

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85      IF (T.NE.270.) X=0.0
        IF (T.NE.270.) X=Y/TAN(T/RADI)
        RETURN

C      SYMBOL NUMBER 5 OR 15
17      IF ((T.GE.0.).AND.(T.LT.T3)) GO TO 16
        IF ((T.GE.T3).AND.(T.LT.225.)) GO TO 19
        IF ((T.GE.225.).AND.(T.LT.T4)) GO TO 20
        IF ((T.GE.T4).AND.(T.LE.360.)) GO TO 18
        IF (T.EQ.90.) X=0.0
        IF (T.NE.90.) X=SCALE((ISI)*1.22222/3.)/(TAN(T/RADI)*1.)
          Y=X+SCALE((ISI)*1.22222/3.
        RETURN
18      X=-SCALE((ISI)*1.22222/3.
          Y=X*TAN(T/RADI)
        RETURN
19      Y=-SCALE((ISI)*1.22222/3.
        IF (T.EQ.270.) X=0.0
        IF (T.NE.270.) X=Y/TAN(T/RADI)
        RETURN

C      SYMBOL NUMBER 6 OR 16
20      A=4.*SCALE((ISI)*1.22222/(3.*PI))
        B=SCALE((ISI)*1.22222-A
        TS=ATAN(A/B)*RAD
        T6=360.-TS
        TS=90.-TS
        IF ((T.GE.0.).AND.(T.LT.T5)) GO TO 22
        IF ((T.GE.T5).AND.(T.LT.225.)) GO TO 24
        IF ((T.GE.225.).AND.(T.LT.T6)) GO TO 25
        IF ((T.GE.T6).AND.(T.LE.360.)) GO TO 22
        IF (T.EQ.90.) GO TO 23
        BB=-2.*A*(1.+TAN(T/RADI))
        AA=TAN(T/RADI)*2+1.
        CC=2.*A-(SCALE((ISI)*1.22222)*2
        X=SQR(BB*B*-4.*AA*CC)/(2.*AA)
        IF ((T.GE.0.).AND.(T.LT.90.)) X=X*BB/(2.*AA)
        IF ((T.GE.90.).AND.(T.LT.180.)) X=-X*BB/(2.*AA)
        IF ((T.GE.270.).AND.(T.LE.360.)) X=X*BB/(2.*AA)
        Y=X*TAN(T/RADI)
        RETURN
22      X=0.0
        Y=-ASORT((SCALE((ISI)*1.22222)*2-AA))
        RETURN

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24      X=-A          681
       Y=X*TAN(IT/RADI)    PLTAERO
       RETURN           682
       Y=-A          683
       IF IT.EQ.0.270.) X=0.0    PLTAERO
       IF IT.NE.270.) X=Y/TAN(IT/RADI)    PLTAERO
       RETURN           685
       SYMBOL NUMBER 7 OR 17    PLTAERO
       135     IF ((T.GE.0.0).AND.(T.LT.T7)) GO TO 27    PLTAERO
       IF ((T.GE.T7).AND.(T.LT.T8)) GO TO 28    PLTAERO
       IF ((T.GE.T8).AND.(T.LT.T9)) GO TO 29    PLTAERO
       IF ((T.GE.T9).AND.(T.LT.S1)) GO TO 30    PLTAERO
       IF ((T.GE.S1).AND.(T.LE.360.)) GO TO 27    PLTAERO
       X=SCALE((ISI)/2.    PLTAERO
       Y=X*TAN(.1/RADI)    PLTAERO
       RETURN           694
       140     X=SCALE((ISI)*1.4SIN(1T/RADI)*COS(1T/RADI)+SCALE((ISI)*COS(1T/RADI)*SIN(1T/RADI))*.25    PLTAERO
       RETURN           695
       145     X=-(.1*COS(1T/RADI))**2    PLTAERO
       Y=X*TAN(1T/RADI)    PLTAERO
       RETURN           696
       150     X=-SCALE((ISI)/2.    PLTAERO
       Y=X*TAN(1T/RADI)    PLTAERO
       RETURN           697
       155     Y=-SCALE((ISI)**4    PLTAERO
       IF (T.EQ.270.) X=D.0    PLTAERO
       IF (T.NE.270.) X=Y/TAN(1T/RADI)    PLTAERO
       RETURN           698
       160     SYMBOL NUMBER 8 OR 18    PLTAERO
       165     IF ((T.GE.0.0).AND.(T.LT.S2)) GO TO 32    PLTAERO
       IF ((T.GE.S2).AND.(T.LE.270.)) GO TO 33    PLTAERO
       IF ((T.GT.270.).AND.(T.LE.S3)) GO TO 34    PLTAERO
       IF ((T.GT.S3).AND.(T.LE.360.)) GO TO 32    PLTAERO
       X=-.05*SCALE((ISI)*SIN(1T/RADI)*COS(1T/RADI)+SCALE((ISI)*COS(1T/RADI)*SIN(1T/RADI))*.25    PLTAERO
       Y=X*TAN(1T/RADI)    PLTAERO
       RETURN           703
       170     IF (T.EQ.270.) X=0.0    PLTAERO
       IF (T.EQ.270.) Y=-SCALE((ISI)**.55    PLTAERO
       IF (T.NE.270.) X=-SCALE((ISI)**.55/(TAN(1T/RADI)+1.0)    PLTAERO
       IF (T.NE.270.) Y=X*TAN(1T/RADI)    PLTAERO
       RETURN           719
       175     X=-SCALE((ISI)**.55/(TAN(1T/RADI)-1.0)    PLTAERO
       RETURN           720
       180     X=-SCALE((ISI)**.55/(TAN(1T/RADI)-1.0)    PLTAERO
       RETURN           721
  
```

APPENDIX

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170          Y=X*TAN(T/RAD)
            RETURN
175      C   SYMBOL NUMBER 9 OR 19
35       IF ((T.GE.0.0).AND.(T.LT.90.1)) GO TO 36
           IF ((T.GE.90.1).AND.(T.LT.180.1)) GO TO 37
           IF ((T.GE.180.1).AND.(T.LT.270.1)) GO TO 38
           IF ((T.GE.270.1).AND.(T.LE.360.1)) GO TO 39
           X=SCALE((IS)*R/2./(TAN(T/RAD)+R)
           Y=X*TAN(T/RAD)
           RETURN
37       IF (T.EQ.90.1) X=0.0
           IF (T.NE.90.) X=SCALE((IS)*R/2./(TAN(T/RAD)-R)
           IF (T.EQ.90.1) Y=SCALE((IS)*R/2.
           IF (T.NE.90.) Y=X*TAN(T/RAD)
           RETURN
38       X=-SCALE((IS)*R/2./(TAN(T/RAD)+R)
           Y=X*TAN(T/RAD)
           RETURN
39       IF (T.EQ.270.) X=0.0
           IF (T.EQ.270.) Y=-SCALE((IS)*R/2.
           IF (T.NE.270.) X=-SCALE((IS)*R/2./(TAN(T/RAD)-R)
           IF (T.NE.270.) Y=X*TAN(T/RAD)
           RETURN
180      C   SYMBOL NUMBER 10 OR 20
40       IF ((T.GE.0.0).AND.(T.LT.S4)) GO TO 41
           IF ((T.GE.S4).AND.(T.LT.S5)) GO TO 42
           IF ((T.GE.S5).AND.(T.LT.S6)) GO TO 43
           IF ((T.GE.S6).AND.(T.LT.S7)) GO TO 44
           IF ((T.GE.S7).AND.(T.LE.360.1)) GO TO 41
           X=SCALE((IS)/2.
           Y=X*TAN(T/RAD)
           RETURN
42       IF ((T.LT.90.1) X=SCALE((IS)*.6/(TAN(T/RAD)+1.))
           IF ((T.EQ.90.1) X=0.0
           IF ((T.GT.90.1) X=SCALE((IS)*.6/(TAN(T/RAD)-1.))
           IF ((T.EQ.90.1) Y=SCALE((IS)*.6
           IF (T.NE.90.1) Y=X*TAN(T/RAD)
           RETURN
43       X=-SCALE((IS)/2.
           Y=X*TAN(T/RAD)
           RETURN
44       Y=-SCALE((IS)*.4

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APPENDIX

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IF (TT.EQ.270.) X=0.0          755
IF (TT.NE.270.) X=Y/TAN(T/RAD)
RETURN
PLTAERO 756
FLYAERO 757
PLTAERO 758
PLTAERO 759
PLTAERO 760
PLTAERO 761
PLTAERO 762
PLTAERO 763
PLTAERO 764
PLTAERO 765
PLTAERO 766
PLTAERO 767
PLTAERO 768
PLTAERO 769
PLTAERO 770
PLTAERO 771
PLTAERO 772

SYMBOL NUMBER 21 OR 22
X=.1*SCALE(IIS)*COS(T/RAD)
Y=.1*SCALE(IIS)*SIN(T/RAD)
RETURN
END

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C 45

215

APPENDIX

APPENDIX

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X1=-X1          PLTAERO 815
Y1=-Y1          PLTAERO 815
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
COMPUTE DISTANCE ALONG CURVE AS A FUNCTION OF X BETWEEN POINT PLTAERO 821
I AND I+1 PLTAERO 822
NT=IFIX(XNT+(X(I+1)-X(I))+1 PLTAERO 823
IF (INT.LT.3) NT=3 PLTAERO 824
IF (INT.GT.NH) NT=NH PLTAERO 825
DELTA=(X(I+1)-X(I))/FLOAT(NT-1) PLTAERO 826
PLTAERD 827
DUMX(I)=X(I)
DUMY(I)=Y(I)
DS1(I)=0.0
XA=X(I)
DO 8 J=2,NT
XA=XA+DELTA
DUMX(J)=XA
DUMY(J)=FUNC(XA,X(I)),X(I+1),Y(I),Y(I+1),M(I),M(I+1))
DS1(J)=SORT((DUMX(J)-X(I))*2+(DUMY(J)-Y(I))*2)
DO 9 J=1,NT
K=NT+1-J
DS2(J)=SORT((DUMX(K)-X(I+1))*2+(DUMY(K)-Y(I+1))*2)
9 FIND X AND Y LOCATION WHERE SYMBOL AND CURVE INTERSECT
C   DELTA=DELT(IIS)
XA=X(I)
DO 11 J=2,NTA
XA=XA+DELTA
IF (XA.GE.X(I+1)) GO TO 12
X1=XA-X(I)
Y1=FUNC(XA,X(I)),X(I+1),Y(I),Y(I+1),M(I),M(I+1))-Y(I)
DS=SORT(X1*X1+Y1*Y1)
T1=ATANH(Y1,X1)
CALL SYMBS (NO,IS,XS1,YS1,T1)
DSS1=SORT(XS1*XS1+YS1*YS1)
IF (ABS(DS-DSS1).LE.DIFF) GO TO 12
IF (DS.GT.DSS1) GO TO 10
10 GO TO 11
XA=XA-DELTA
DELTA=DELTA/2.
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APPENDIX

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85      12    XS1=XS1+X(I)
          YS1=YS1+Y(I)
          DELTA=DELTH(I$)
          XA=X(I+1)
          DO 14 J=2,NT
          XA=XA-DELTA
          IF (XA.LE.X(I)) GO TO 15
          X1=XA-X(I+1)
          Y1=FUNC(XA,X(I),X(I+1),Y(I),Y(I+1),M(I),M(I+1))-Y(I+1)
          DS=SORT(X1+Y1+Y1)
          T1=ATANH(Y1,X1)
          CALL SYMB5 (NO,IS,XS2,YS2,T1)
          DSS2=SORT(XS2*X52+YS2*YS2)
          IF (ABS(DS-DSS2).LE.DIFF) GO TO 15
          IF (DS.GT.DSS2) GO TO 13
          GO TO 14
100     13    XA=XA+DELTA
          DELTA=DELTA/2.
          CONTINUE
          14
          15    XS2=XS2+X(I+1)
          YS2=YS2+Y(I+1)
          NP=1
          NDS1=0
          DO 16 J=2,NT
          IF ((DSS1(J).LT.DSS1).AND.(NDS1.EQ.0)) GO TO 16
          IF ((DSS1(J).GE.DSS1).AND.(NDS1.EQ.0)) NDS1=1
          NP=NP+1
          DUMX(NP)=DUMX(J)
          DUMY(NP)=DUMY(J)
          CONTINUE
          16    DUMX(1)=XS1
          DUMY(1)=YS1
          DO 17 J=1,NT
          IF (DSS2(J).LE.DSS2) GO TO 17
          GO TO 18
          17    NP=NP-1
          NP=NP+1
          DUMX(NP)=XS2
          DUMY(NP)=YS2
          C      PLOT CURVE BETWEEN POINTS
          DUMX(NP+1)=DUMY(NP+1)=0.0
          DUMX(NP+2)=DUMY(NP+2)=1.0
          PLTAERO   857
          PLTAERO   858
          PLTAERO   859
          PLTAERO   860
          PLTAERO   861
          PLTAERO   862
          PLTAERO   863
          PLTAERO   864
          PLTAERO   865
          PLTAERO   866
          PLTAERO   867
          PLTAERU   868
          PLTAERO   869
          PLTAERO   870
          PLTAERO   871
          PLTAERO   872
          PLTAERO   873
          PLTAERO   874
          PLTAERO   875
          PLTAERO   876
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          PLTAERO   879
          PLTAERO   880
          PLTAERO   881
          PLTAERO   882
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          PLTAERO   887
          PLTAERO   888
          PLTAERO   889
          PLTAERO   890
          PLTAERO   891
          PLTAERO   892
          PLTAERO   893
          PLTAERO   894
          PLTAERO   895
          PLTAERO   896
          PLTAERO   897
          PLTAERO   898

```

APPENDIX

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CALL LINE (DUMX,DUMY,NP,1,0,0,0)
19 CALL PNTPLT (X(I+1),Y(I+1),NO,IS)
CONTINUE
RETURN
130
C
FORMAT (1H1//5X,36HX IS NOT STRICTLY INCREASING FOR RUN,I7/16X,1HXP)
1,13X,1HY/
22 FORMAT (5X,2F15.4)
END
135
      PLTAERO 899
      PLTAERO 900
      PLTAERO 901
      PLTAERO 902
      PLTAERO 903
      PLTAERO 904
      PLTAERO 905
      PLTAERO 906
      PLTAERO 907

```

APPENDIX

```

1      SUBROUTINE CUBSPL (X,Y,N,B)
2      DIMENSION X(N), Y(N), B(N)
3      DIMENSION A(10*N)
4      COMMON/HLM/TENR,XINT,ST
5      COMMON/TENS/T
6      CUBIC SPLINE CURVE FIT PROGRAM
7      M=N-1
8      N1=N+1
9      N2=N1+N
10     N3=N2+N
11     N4=N3+N
12     N5=N4+N
13     N6=N5+N
14     N7=N6+N
15     N8=N7+N
16     N9=N8+N
17
18     C      LOAD MATRIX ROWS 2 THRU N-1
19     T=TENR+FLOAT(N-1)/(X(N)-X(1))
20     DO 1 I=1,M
21       H2=X(I+1)-X(I)
22       A(I)=(1./H2-T/SINH(T*H2))/(T*T)
23       K=2*N+I
24       A(K)=A(I)
25       IF(I.EQ.1) GO TO 1
26       K=K+N
27       H1=X(I)-X(I-1)
28       A(K)=T*COSH(T*M1)/SINH(T*M1)-1./W1*T*COSH(T*H2)/SINH(T*H2)-1./W2
29       1/(T*T)
30
31       K=K+N
32       A(K)=(Y(I+1)-Y(I))/((X(I+1)-X(I))-(Y(I)-Y(I-1))/((X(I)-X(I-1)))
33
34       1 CONTINUE
35       C      LOAD MATRIX ROWS 1 AND N
36       A(N3)=1.0
37       A(N4-1)=1.0
38       A(N2)=-.5
39       A(M)=-.5
40       A(N4)=0.0
41       A(N5-1)=0.0
42
43       C      SOLVE TRIDIAGONAL MATRIX
44       A(N7)=A(N3)
45       A(N8)=A(N4)/A(N3)
46
47       PLTAERO 914
48       PLTAERO 915
49       PLTAERO 916
50       PLTAERO 917
51       PLTAERO 918
52       PLTAERO 919
53       PLTAERO 920
54       PLTAERO 921
55       PLTAERO 922
56       PLTAERO 923
57       PLTAERO 924
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81       PLTAERO 948
82       PLTAERO 949

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APPENDIX

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      C   A(N9)=A(N2)/A(N3)
45    DO 4 I=2,N
          I1=I-1
          I2=I-2
          A(N7+I1)=A(N3+I1)-A(I1)*A(N9+I2)
          IF (I.EQ.N) GO TO 4
          A(N9+I1)=A(N2+I1)/A(N7+I1)
          A(N8+I1)=(A(N4+I1)-A(I1)*A(N8+I2))/A(N7+I1)

      C   A(N6-1)=A(N9-1)
55    DO 5 I=1,M
          I1=N6-I
          I2=N-I
          I3=I2-I
          A(Ii)=A(N8+I3)-A(N9+I3)*A(I1+I)

      C   K=0
60    DO 6 I=1,N
          I1=I-1
          A(N6+K)=A(N5+I1)
          K=K+1
          A(M)=A(N3-2)
          6   C   LOAD SOLUTION INTO B VECTOR
          DO 7 I=1,N
          I1=N6+I-1
          B(I)=A(I1)

      C   XINT=0.0
70    DO 11 I=2,N
          H = X(I) - X(I-1)
          11 XINT=XINT+(Y(I)+Y(I-1))*(X(I)-X(I-1))/2.
          1 - (B(I)+B(I-1))*(I1-COSH(T*H))/(T*SINH(T*H))+H/(2.*T*T)
          RETURN
          END

      C   PLTAERO 950
          PLTAERO 951
          PLTAERO 952
          PLTAERO 953
          PLTAERO 954
          PLTAERO 955
          PLTAERO 956
          PLTAERO 957
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          PLTAERU 959
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          PLTAERO 978
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          PLTAERO 980
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          PLTAERO 983
          PLTAERO 984

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APPENDIX

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1      FUNCTION FUNC(X,X1,X2,Y1,Y2,M1,M2)
2      COMMON/TENS/T
3      REAL M1,M2
4      SPLINE FUNCTION UNDER TENSION (T)
5          DX1=X-X1
6          DX2=X2-X
7          H=X2-X1
8          F1=M1/(T*T)
9          F2=M2/(T*T)
10         FUNC=(F1*SINH(T*DX2)+F2*SINH(T*DX1))/SINH(T+H)+((Y1-F1)*DX2+(Y2-F2*DX1)/H
11         RETURN
12         ENO

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APPENDIX

APPENDIX

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A(K)=A(I)
IF(I.EQ.1) GO TO 1
K=K+N
      45 H1=X(I)-X(I-1)
      IF(ST.EQ.0.0) A(K)=(H2+H1)/3.
      IF(ST.NE.0.0) A(K)=(T*COSH(T*H1))/SINH(T*H1)-1./H1+T*COSH(T*H2)/SINH(T*H2)
      1H(T*H2)-1./H2)/(T*T)
      K=K+N
      A(K)=(Y(I+1)-Y(I))/H2-(Y(I))-Y(I-1))/H1
      50 1 CONTINUE
      C LOAD MATRIX ROWS 1 AND N.
      A(M)--.5
      A(N2)--.5
      A(N3)=1.0
      A(N4-1)=1.0
      A(N4)=0.0
      A(N5-1)=0.0
      A(N5)=0.0
      55 1 CONTINUE
      C SOLVE TRIDIAGONAL MATRIX.
      A(N7)=A(N3)
      A(N8)=A(N4)/A(N3)
      A(N9)=A(N2)/A(N3)
      DO 4 I=2,N
      I1=I-1
      I2=I-2
      A(N7+I1)=A(N3+I1)-A(I1)*A(N9+I2)
      IF(I.EQ.N) GO TO 4
      A(N9+I1)=A(N2+I1)/A(N7+I1)
      4 A(N8+I1)=(A(N4+I1)-A(I1)*A(N8+I2))/A(N7+I1)
      A(N6-1)=A(N9-1)
      60 5 I=1,N
      I1=N6-1-I
      I2=N-I
      I3=I2-1
      5 A(I1)=A(N9+I3)-A(N9+I1)*A(I1+1)
      K=9
      60 6 I=1,N
      I1=I-1
      A(N6+K)=A(N5+I1)
      6 K=K+1
      A(M)=A(N3-2)
      C LOAD SOLUTION INTO VECTOR B.
      60 7 I=1,N
      PLTAERO 1052
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APPENDIX

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85      II=M6+I-1
      C      7 B(I)=A(I)
      C      COMPUTE Y,YP,YPP AT DESIRED X VALUES
      IF(INP.EQ.0) RETURN
      IF(IOP.EQ.0) GO TO 13
      GO TO 14
13      DELTAX=(X(IW)-X(1))/FLOAT(NP-1)
      XI(I)=X(1)
      DO 15 I=2,NP
15      XI(I)=XI(I-1)+DELTAX
16      CONTINUE
      DO 8 I=1,NP
8       XI(I)
      DO 9 K=2,N
9       XI-K-1
      IF((P.GE.X(K1)).AND.(P.LE.X(K))) GO TO 10
      GO TO 9
10      J1=K1
      J2=K
      9 CONTINUE
      H=X(J2)-X(J1)
      IF(IST.EQ.0.O) GO TO 11
      SINHT=SINH(T*H)
      Y(I)=B(J1)*(SINH(T*(X(J2)-P))/(T*T*SINHT)-(X(J2)-P)/(H*T*T))+B(J2PLTAERO
1) *(SINH(T*(P-X(J1)))/(T*T*SINHT)-(P-X(J1))/(H*T*T))+((Y(J1)*(X(J1)*
2P)+Y(J2)*(P-X(J1)))/H
      YP(I)=3*(J1)*(1.0/(H*T*T))-COSH(T*(X(J2)-P))/(T*SINHT)+B(J2)*(COSH(TPLTAERO
1*(P-X(J1)))/(T*SINHT)-1.0/(H*T*T))+((Y(J2)-Y(J1))/H
      YPP(I)=B(J1)*SINH(T*(X(J2)-P))/SINHT+B(J2)*SINH(T*(P-X(J1)))/SINHTPLTAERO
1122
      GO TO 6
11      Y(I)=B(J1)*(((X(J2)-P)*(X(J2)-P)+3/(6.*H)-(X(J2)-P)*H/6.)*B(J2)+(P-X(J1))*(P-X(J1))*PLTAERO
1123
      1*3/(6.*H)-(P-X(J1))*H/6.)*((X(J2)-P)+Y(J2)*(P-X(J1)))/H
      YP(I)=B(J1)*(H/6.-(X(J2)-P)*2/(2.*H))+B(J2)*((P-X(J1))*2/(2.*H))-PLTAERO
1125
      1H/6.)*((Y(J2)-Y(J1))/H
      YPP(I)=B(J1)*(X(J2)-P)/(H*B(J2)*(P-X(J1))/H
      GO TO 6
120     * CONTINUE
      C      COMPUTE INTEGRAL OF Y BETWEEN X(I) AND X(W).
      XINT=0.0
      DO 12 I=2,W
12      H=X(I)-X(I-1)
      XINT=XINT+(Y(I)+Y(I-1))*H/2.
      IF(IST.EQ.0.O)XINT=XINT-(B(I)+B(I-1))*H**3/24.

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APPENDIX

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IF(ST.ME=0.0)XINT=XINT-(S(I)+0(I-1))*(1.-COSH(T+H))/(T+3*SINH(T+PLTAERO)
1H)+H/(2.*T+T))
12 CONTINUE
      RETURN
      END
C
130

```

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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 Birgham, 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		DRAE COEFFICIENT
-3.0000	.3500	.4000	.4500
-2.0000	-.3137	-.3156	-.3267
-1.0000	-.1983	-.2056	-.2055
0.0000	-.0832	-.0848	-.0842
1.0000	-.0321	-.0323	-.0373
2.0000	-.0000	-.0000	-.0254
3.0000	-.4759	-.4755	-.4002
4.0000	.5848	.5944	.5799
5.0000	.7024	.7054	.7370
6.0000	.8394	.8401	.8150
7.0000	.9455	.9466	.9342
8.0000	1.0127	1.0115	1.0556
9.0000	1.0763	1.0758	1.0752
10.0000	1.1375	1.1297	1.0922
11.0000	1.1502	1.1515	1.1016
12.0000	1.1431	1.1438	1.1175
-4.0000	.3500	.4000	.4500
-3.0000	.0073	.0076	.0080
-2.0000	.0076	.0075	.0076
-1.0000	.0078	.0074	.0075
0.0000	.0074	.0070	.0077
1.0000	.0071	.0071	.0068
2.0000	.0077	.0077	.0072
3.0000	.0082	.0082	.0074
4.0000	.0084	.0084	.0073
5.0000	.0079	.0079	.0076
6.0000	.0089	.0089	.0090
7.0000	.0075	.0075	.0073
8.0000	.0072	.0072	.0072
9.0000	.0102	.0101	.0076
10.0000	.0116	.0118	.0146
11.0000	.0184	.0182	.0258
12.0000	.0269	.0255	.0417
-4.0000	.3500	.4000	.4500
-3.0000	.0073	.0076	.0080
-2.0000	.0076	.0075	.0077
-1.0000	.0078	.0074	.0070
0.0000	.0071	.0071	.0074
1.0000	.0071	.0071	.0070
2.0000	.0077	.0077	.0076
3.0000	.0084	.0084	.0078
4.0000	.0079	.0079	.0076
5.0000	.0077	.0077	.0072
6.0000	.0089	.0089	.0090
7.0000	.0075	.0075	.0073
8.0000	.0072	.0072	.0072
9.0000	.0101	.0126	.0140
10.0000	.0116	.0118	.0168
11.0000	.0184	.0182	.0281
12.0000	.0269	.0255	.0367

TABLE I.— Concluded

	PITCHING-MOMENT COEFFICIENT						
	•3000	•3500	•4000	•4500	•5000	•5500	•6000
-4.0000	-•0155	-•0157	-•0195	-•0221	-•0252	-•0181	-•0398
-3.0000	-•0148	-•0162	-•0182	-•0202	-•0213	-•0163	-•0314
-2.0000	-•0141	-•0141	-•0157	-•0171	-•0184	-•0168	-•0243
-1.0000	-•0138	-•0138	-•0146	-•0150	-•0169	-•0173	-•0207
0.0000	-•C133	-•0133	-•0148	-•0149	-•0156	-•0160	-•0063
1.0000	-•0126	-•0124	-•0189	-•0135	-•0145	-•0144	-•0066
2.0000	-•0118	-•0115	-•0211	-•0124	-•0124	-•0133	-•0128
3.0000	-•0115	-•0114	-•0126	-•0115	-•0115	-•0117	-•0110
4.0000	-•0103	-•0103	-•0099	-•0100	-•0090	-•0080	-•0080
5.0000	-•0101	-•0101	-•0097	-•0079	-•0056	-•0041	-•0302
6.0000	-•0130	-•0131	-•0063	-•0049	-•0004	-•0008	-•0234
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	-•0365	-
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 calculation 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)

*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

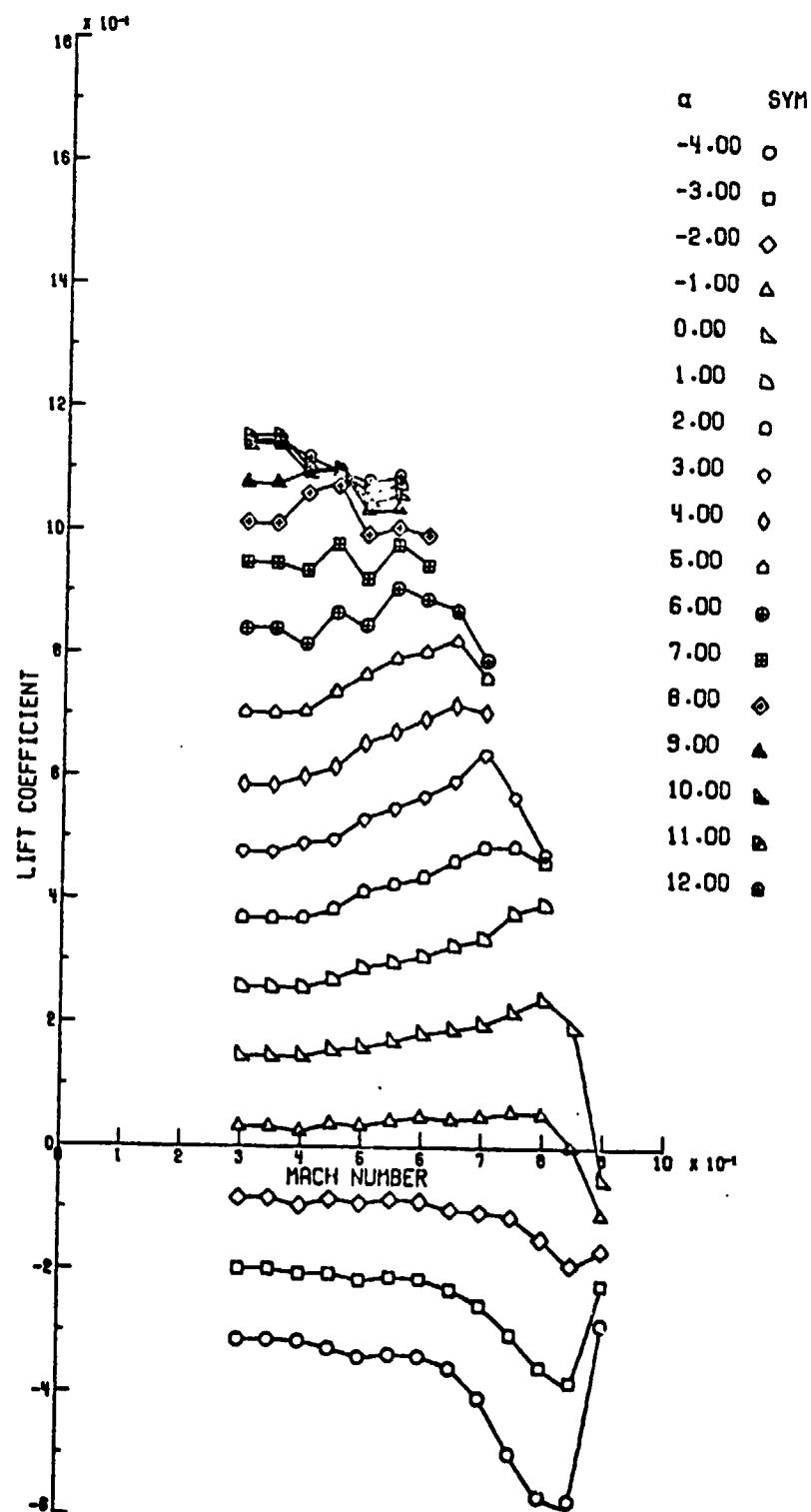


Figure 1.- Blade-element lift coefficient plotted against Mach number for FX69-H-098 airfoil, generated by subroutine P1.

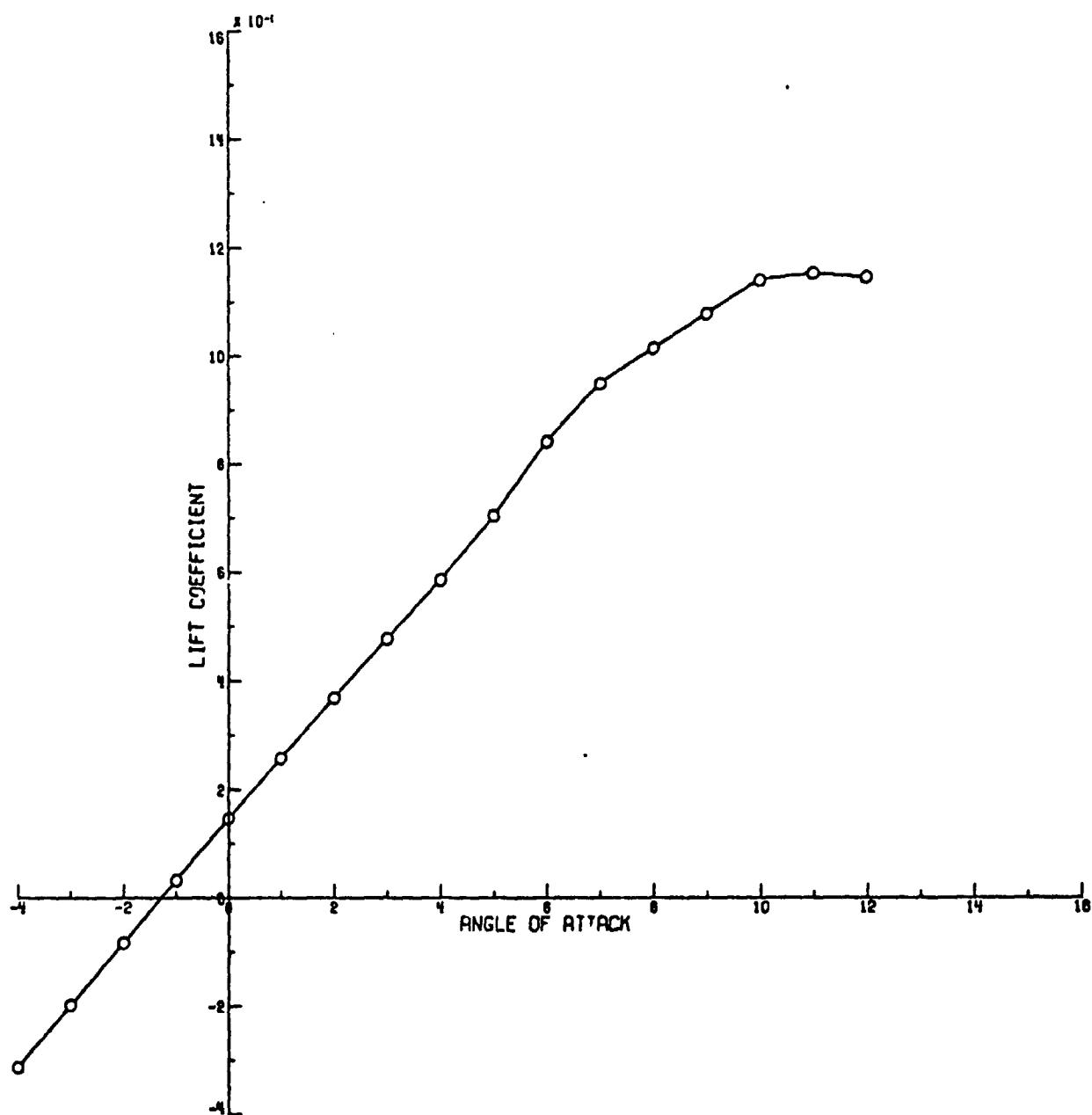


Figure 2.- Blade-element lift coefficient plotted against angle of attack at $M = 0.30$ for FX69-H-098 airfoil, generated by subroutine P2.

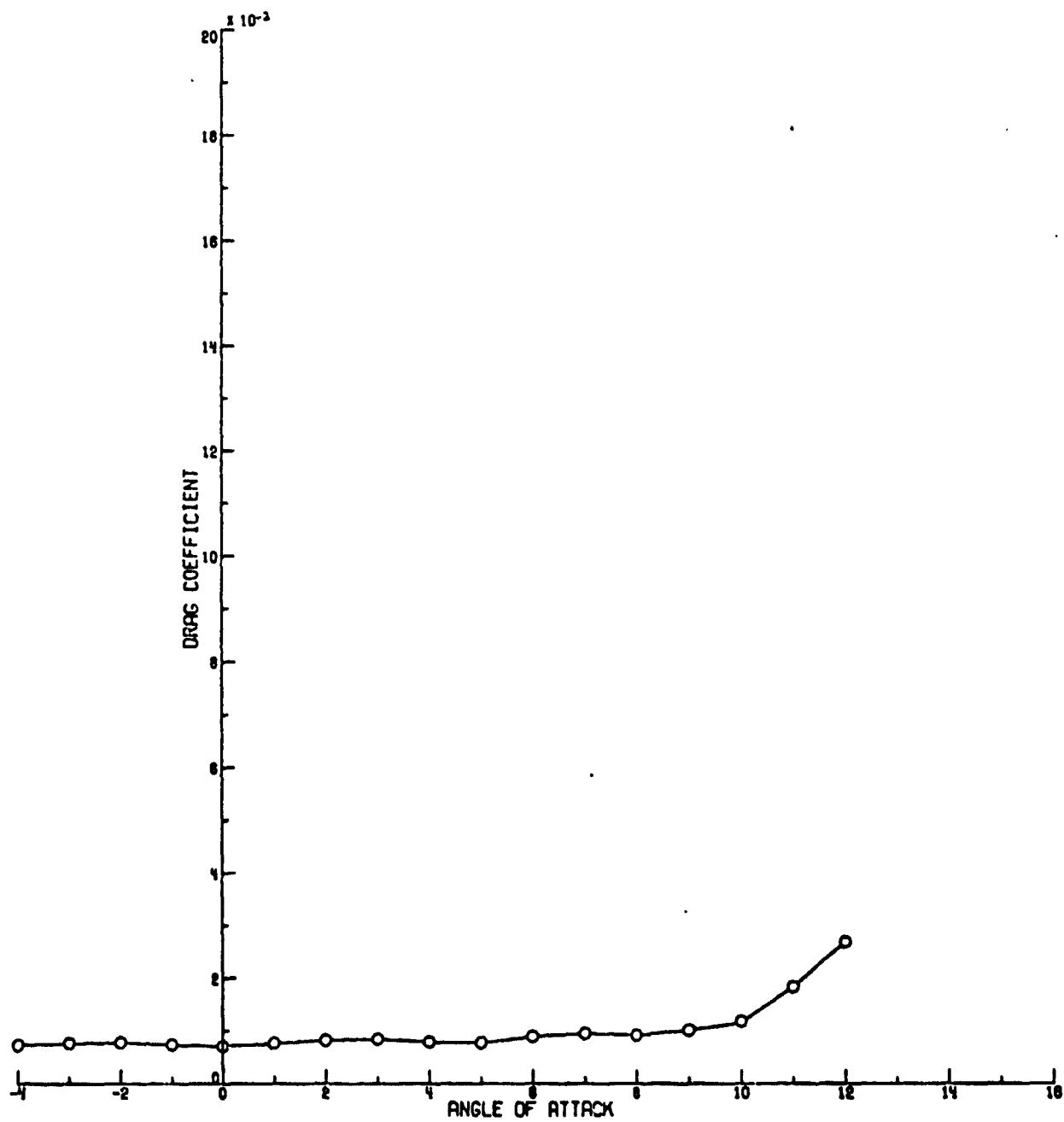


Figure 3.- Blade-element drag coefficient plotted against angle of attack at $M = 0.30$ for FX69-H-098 airfoil, generated by subroutine P2.

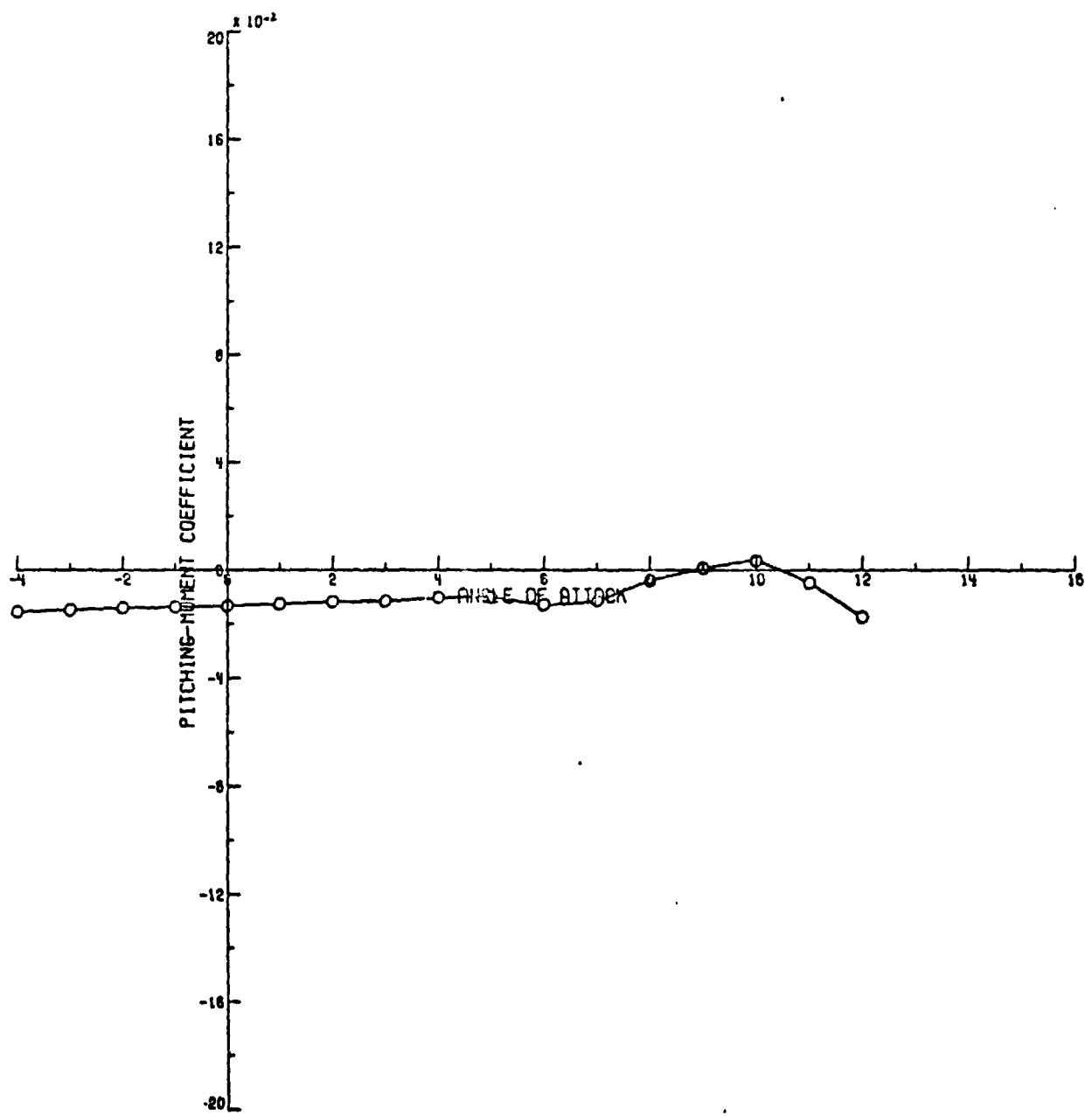
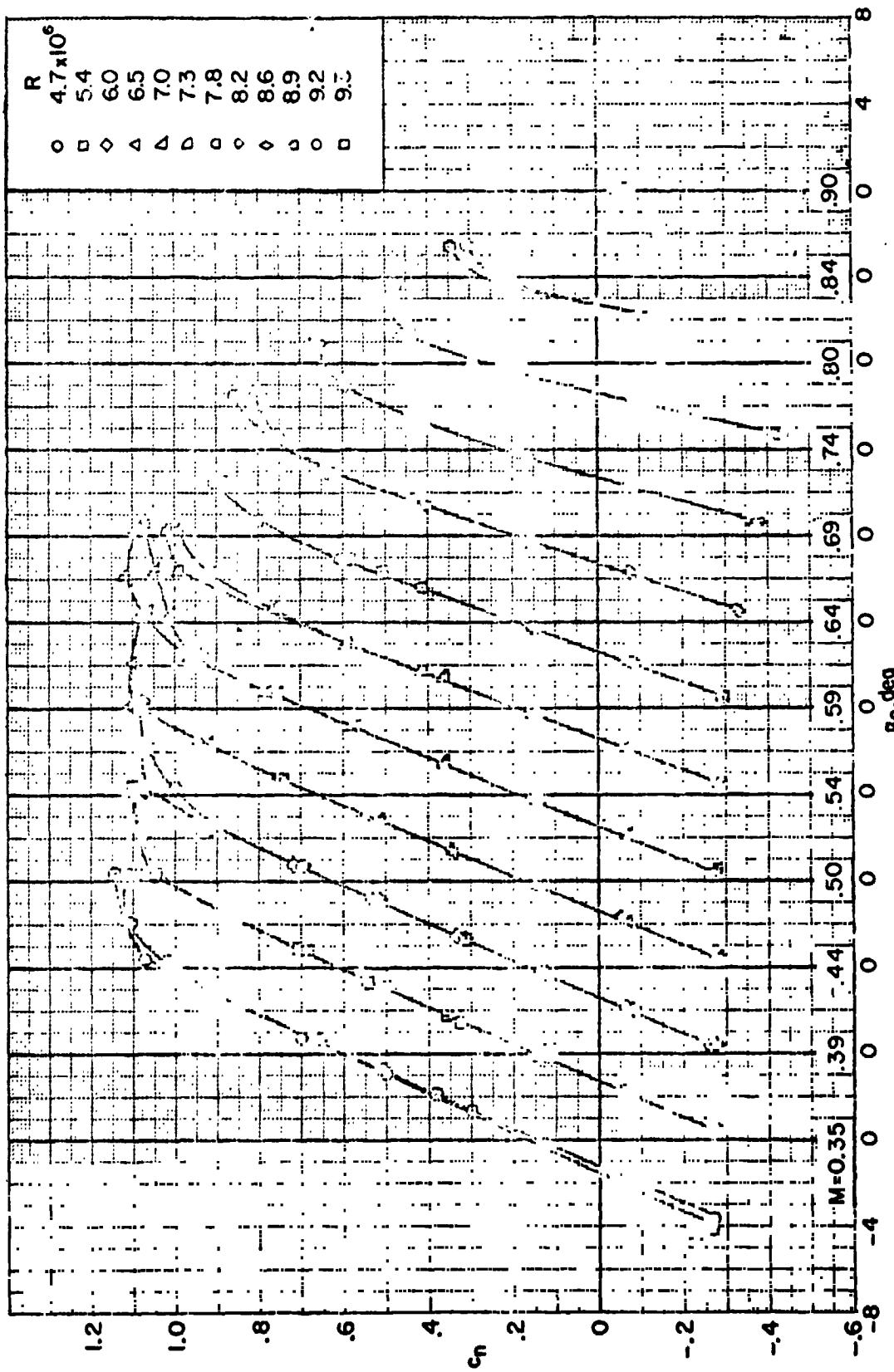
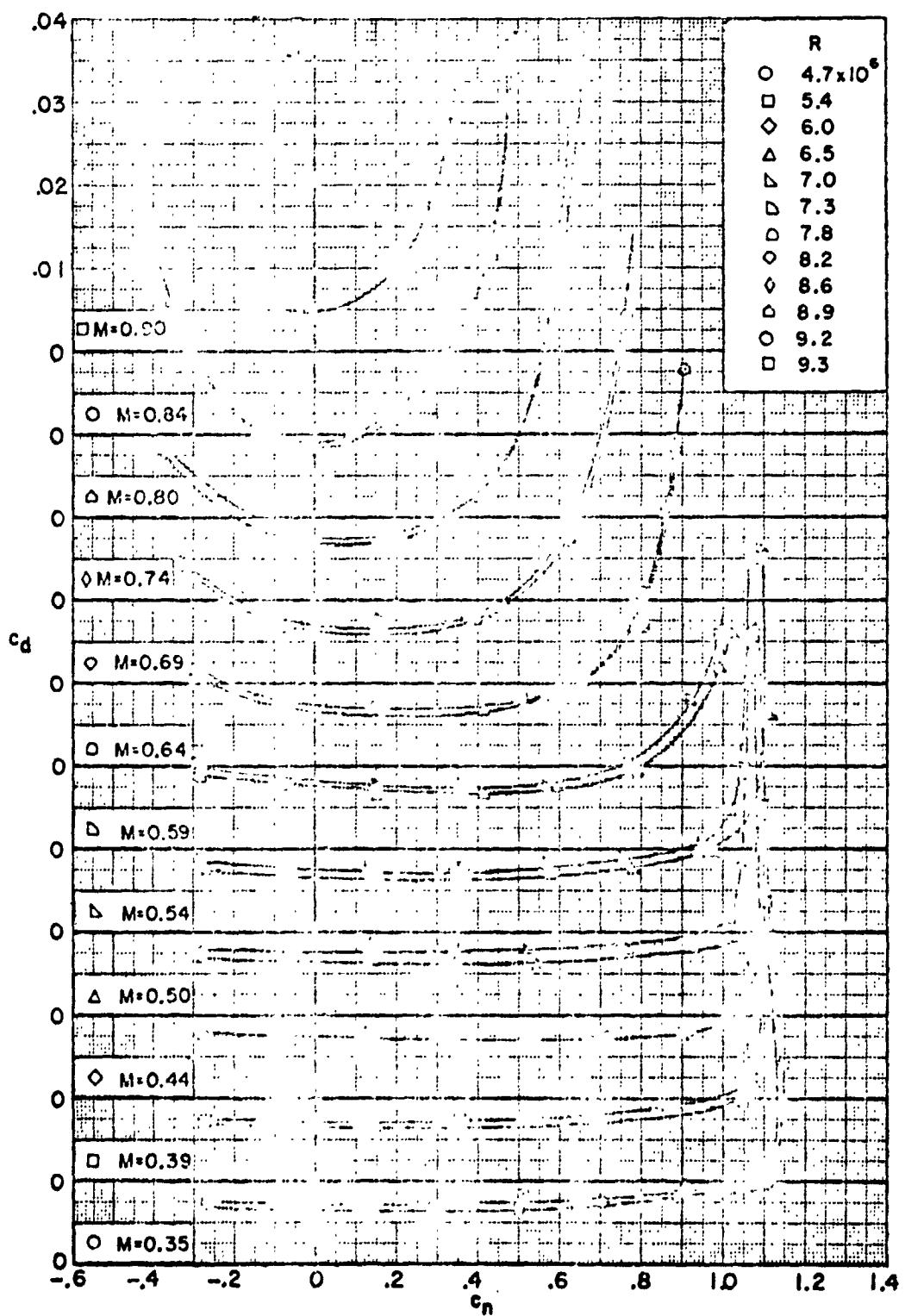


Figure 4.- Blade-element pitching-moment coefficient plotted against angle of attack at $M = 0.30$ for FX69-H-098 airfoil, generated by subroutine P2.



(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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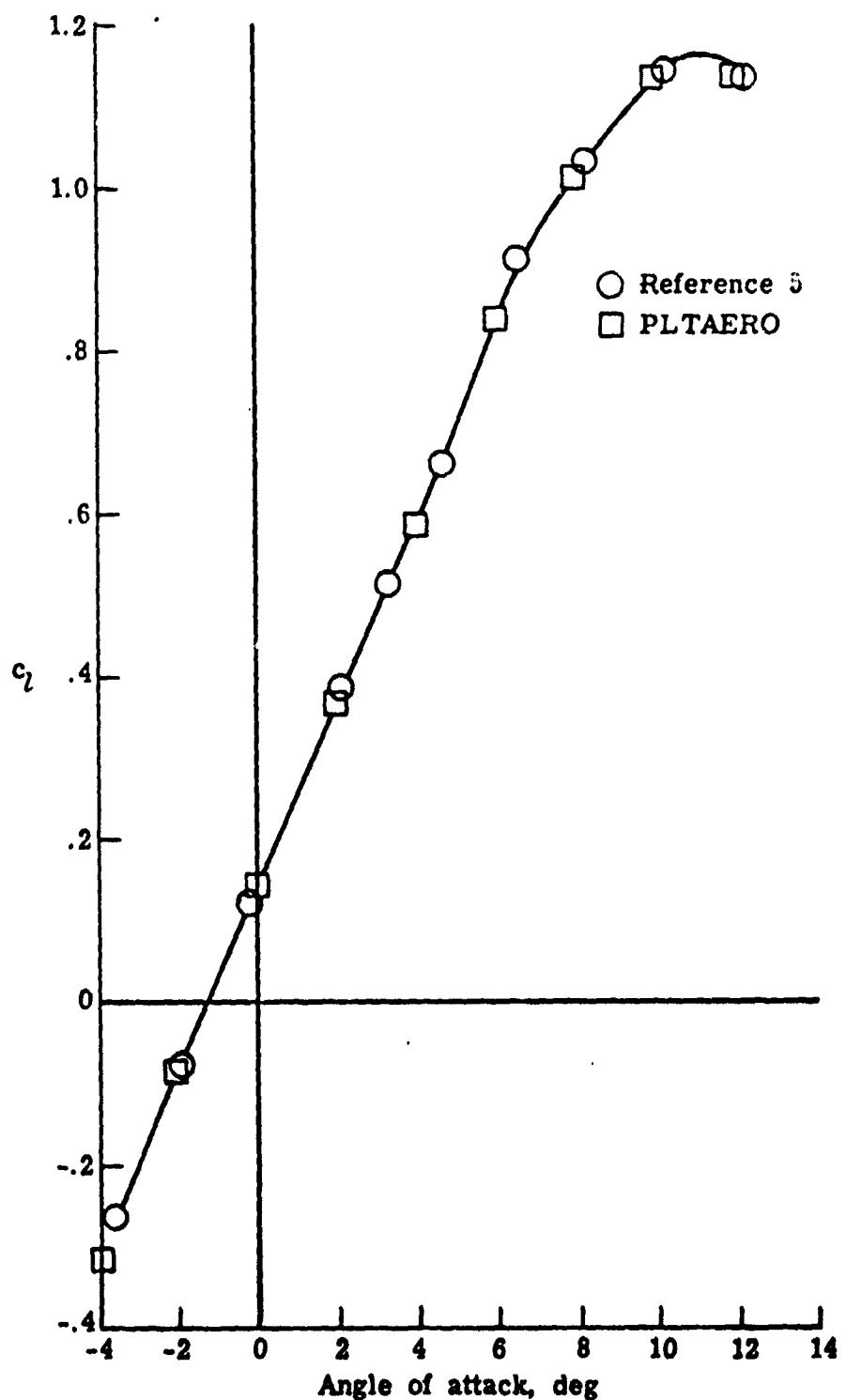
(a) $M = 0.35$.

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

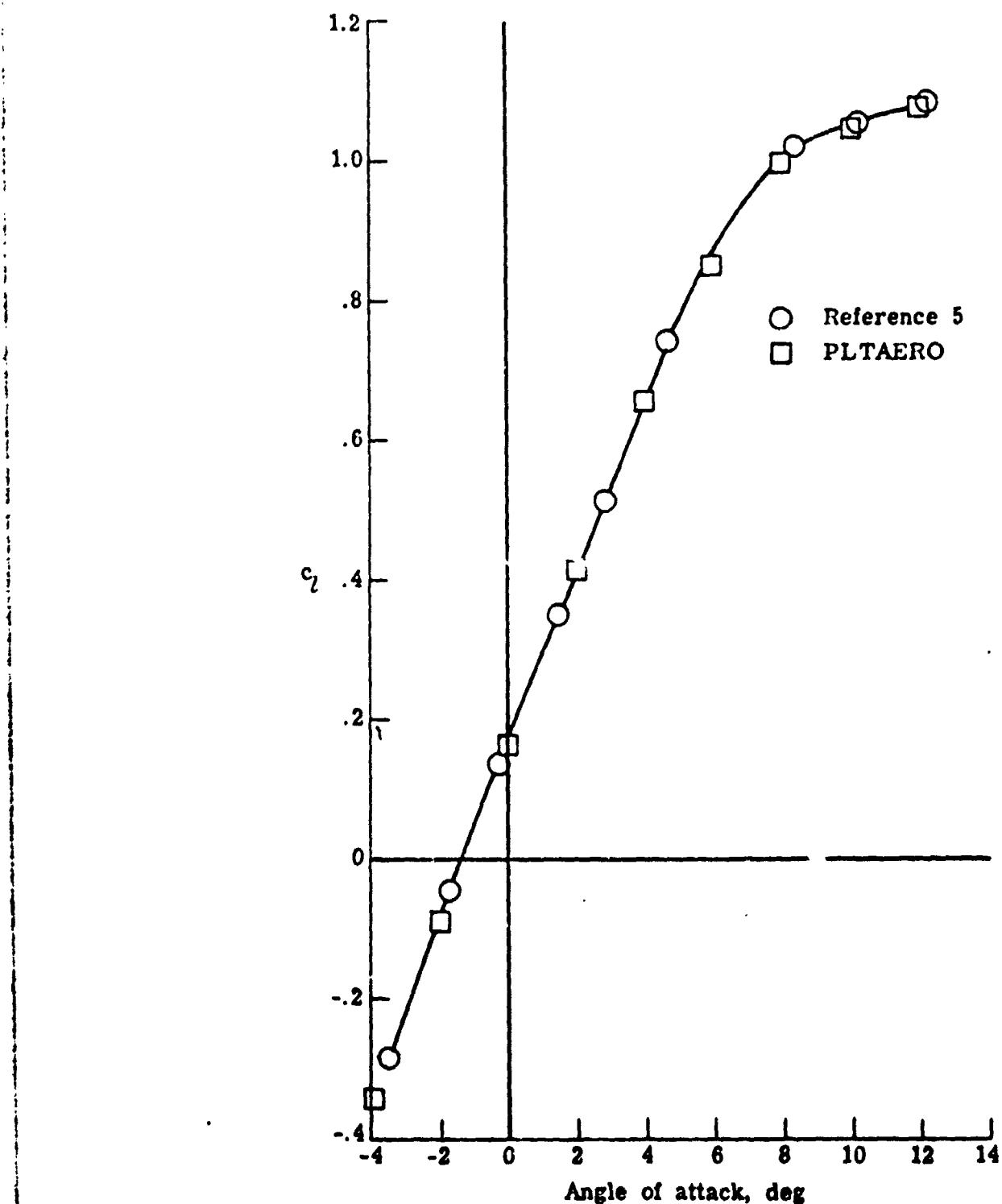
(b) $M = 0.5$.

Figure 6.- Continued.

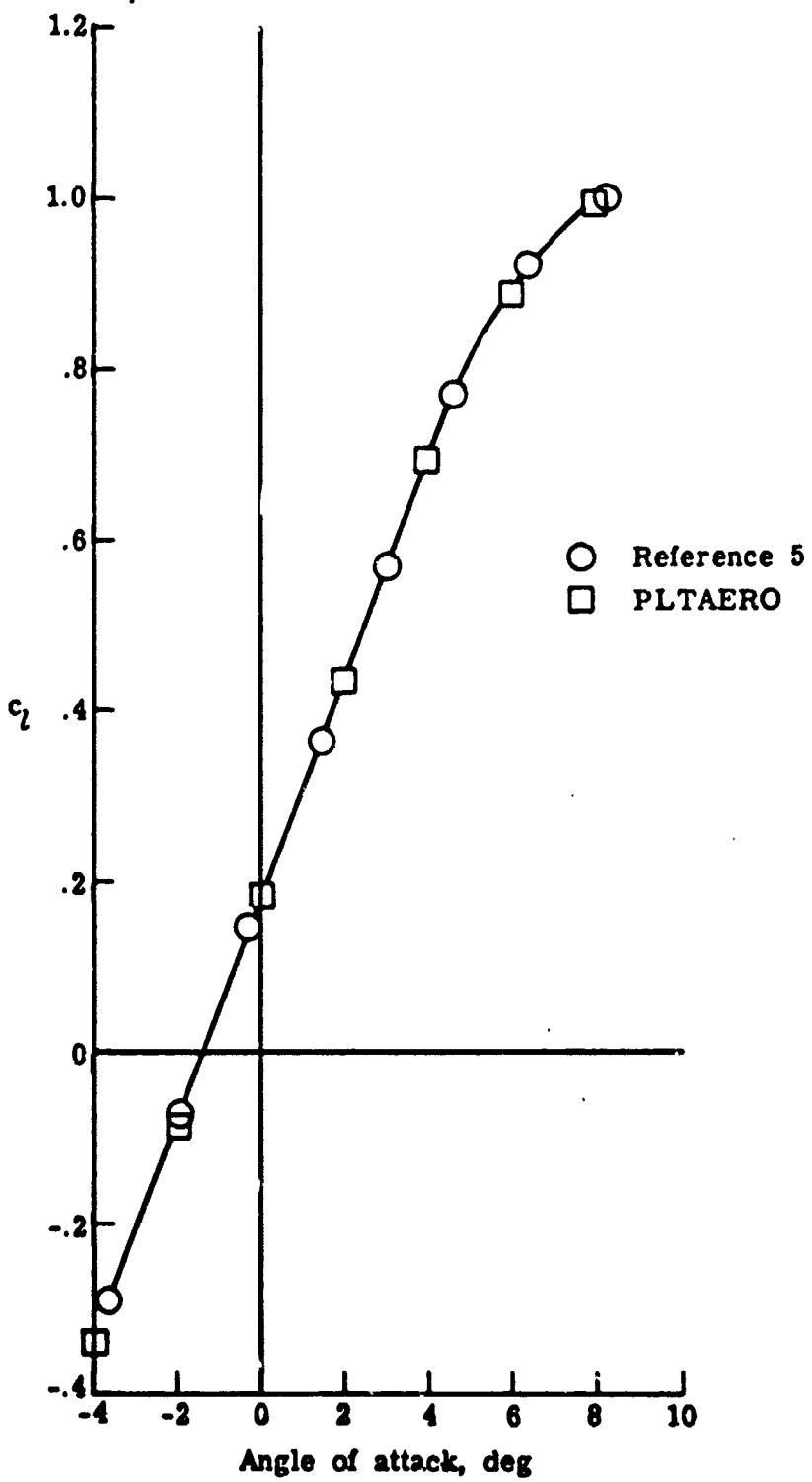
(c) $M = 0.6.$

Figure 6.- Concluded.

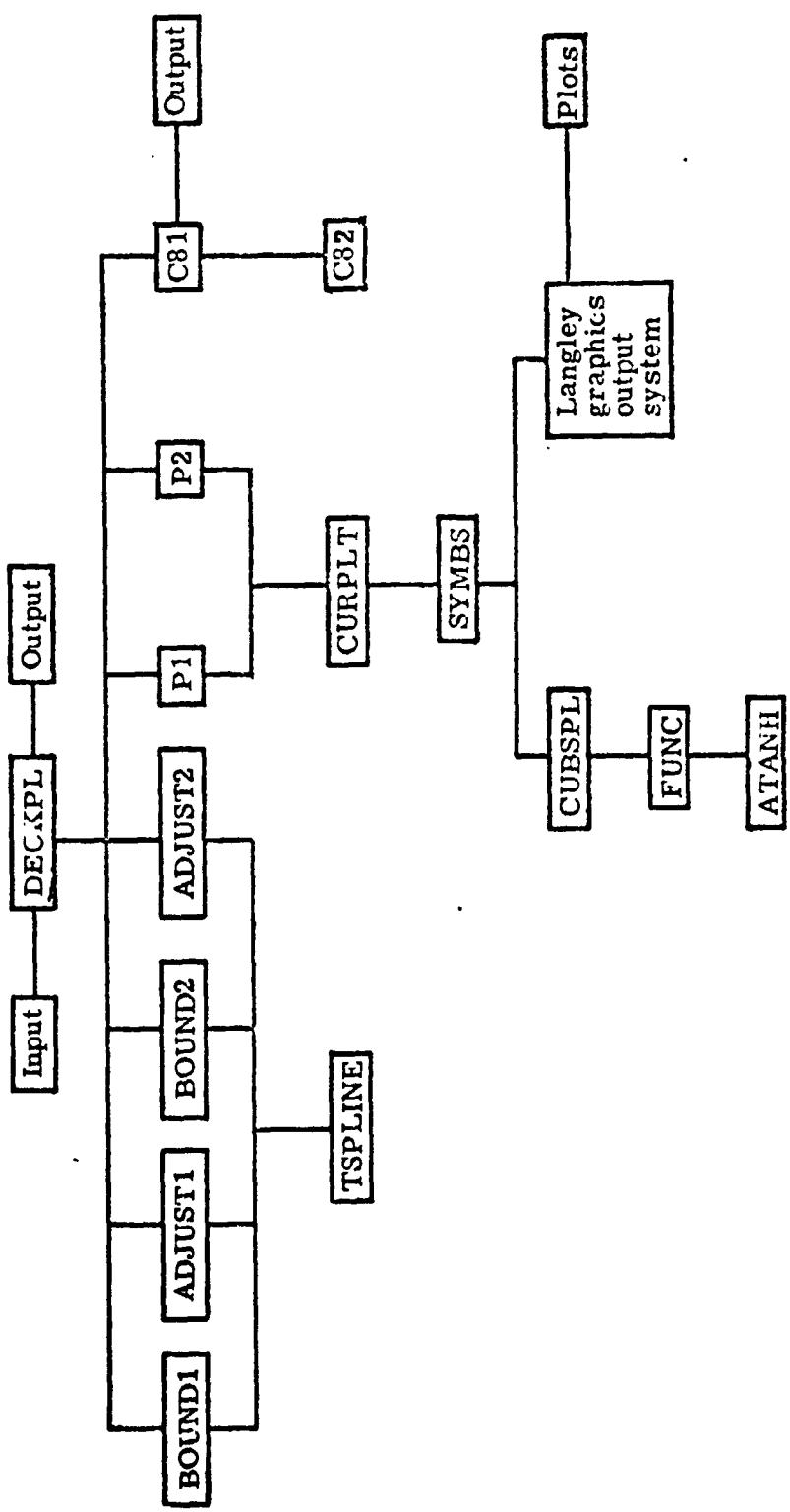


Figure 7.- Program structure.