AD-A129 501 COMPUTER PROGRAM FOR ESTIMATING STABILITY DERIVATIVES OF MISSILE CONFIGUR..(U) ARMY MISSILE COMMAND REDSTONE ARSENAL AL SYSTEMS SIMULATION A.. G A SANDERS ET AL. 1/2

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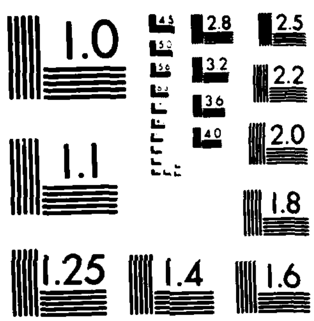

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TECHNICAL REPORT RD-83-2

COMPUTER PROGRAM FOR ESTIMATING STABILITY DERIVATIVES OF MISSILE CONFIGURATIONS - USERS MANUAL

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is intended to be a users manual for a computer program called AERODSN, which estimates the stability coefficients of typical missile configurations with wings or tail fins or both. The Mach range is from zero to approximately 4.0. The roll orientation is zero (plus configuration). Wings and tails must be in line. Control deflections are allowed. A limited amount of body alone experimental data is included (ogive cylinder or cone cylinder); however, body alone tables can be input if desired. A conical boattail segment

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) can be added. This program does not predict drag. Static stability and damping derivatives at zero angle of attack are predicted.

CONTENTS

I. INTRODUCTION

The purpose of this report is to provide a users manual and make comparative runs to verify a computer program called AERODSN. This report includes a step by step procedure for input and run instructions, a description of each output section and comparative plots to verify normal force and pitching moment coefficients. The program is a design tool for preliminary design phase of missile development programs. The current version is an update of AERODSN described in Reference 1. Changes in the program include referencing all coefficients to the reference area (input by the user), and changing the input format to free field read for convenience. The major portion of this program is concerned with the aerodynamics associated with adding wings and tails or both to a body of revolution. A limited amount of experimental body alone data is included for simple configurations (ogive cylinder or cone cylinder); however, body alone tabular data (CNA,Xcp) can be input. A conical boattail segment can be included if desired. Runs from AERODSN were compared with experimental data to establish a range of applicability. Data base configurations such as ADVINT, HIALFA, DCATFL and COPHED were used for comparison.

II. PROGRAM DESCRIPTION

The program was written to be used in preliminary design of typical missile shapes. Its primary function is to calculate the aerodynamics of wings or tails or both added to a cylindrical-shaped body using a combination of theoretical and imperical data. A limited amount of body alone data (cone cylinder and ogive cylinder) are included as an option; however, the body alone data can be input if desired. The roll orientation is assumed to be a plus configuration or zero roll. Wings and tails must be inline. Dynamic stability derivatives (damping) are calculated at zero angle of attack and zero control deflection. Angle of attack data is output corresponding to the values of alpha input. Table 1 summarizes the applicable ranges of independent variables. A description of each subroutine can be found in Reference 1. A listing of the program is presented in Appendix A.

III. INPUT

The following tables describe each record input. Table 2 is the general input format. Table 3 is a sample input file for a specific missile configuration.

IV. RUN INSTRUCTIONS

Two steps are required to run AERODSN on the MICOM Interdata 8/32 Computer. These steps are: (1) Develop and input file and, (2) Run the program using the CSS procedure AERODSN (already established on the system).

A. STEP 1 - Referring to the Input section, develop an input file using the edit mode. Inputs are separated by blanks or commas (free field read). Save the file by typing "SAVE filename". Exit the edit mode by typing "END".

TABLE 1. APPLICABLE RANGE OF INDEPENDENT VARIABLES

MACH NUMBER	0.0 TO 4.0
ANGLE OF ATTACK	0 TO 20 DEG.
ROLL ANGLE	0.0 DEG.
CONFIGURATIONS	BODY,BODY TAIL
	BODY WING,BODY WING TAIL
SWEEP ANGLE	NO FORWARD SWEPT WINGS.
FIN TAPER RATIO	0-1.
ASPECT RATIO	CONSISTANT WITH SLENDER BODY THEORY

TABLE 2. GENERAL INPUT FORMAT AND DEFINITION OF INPUTS

ALL GEOMETERIC VARIABLES MUST HAVE THE SAME SYSTEM OF UNITS.
I.E., CALIBERS, INCHES, ETC. ALL ARE DIVIDED BY DREF WITHIN
THE PROGRAM. THE PROGRAM WORKS IN CALIBERS.
A CALIBER IS DEFINED AS 1 REFERENCE DIAMETER.
INPUT BODY CENTER OF PRESSURE (POSITIVE AFT OF NOSE) - (CAL)
PROGRAM USES BRITISH DATA SHEETS FOR BASIC WING LIFT AND XCP.
PROGRAM USES SLENDER BODY THEORY (NACA 1307) FOR WING-BODY
AND WING-TAIL INTERFERENCE.

....

ALL INPUTS ARE FREE FIELD. INPUTS CAN BE SEPARATED BY A COMMA,
ONE OR MORE BLANKS, OR BY A SLASH (/).
ALL VARIABLES IN AN INPUT LINE MUST HAVE A VALUE TO READ,
I.E., 0. FREE FIELD READ WILL NOT INTERPRET BLANKS AS ZERO'S.

.... INPUT 1

TITLE CARD (1-80 CHARACTERS)

.... INPUT 2

NWPOS	=	1	INPUT XWING AS STATION OF WING LEADING EDGE
"	=	2	PROGRAM WILL MOVE WING 1/4 CHORD TO WING HINGE LINE
"	=	3	PROGRAM WILL MOVE WING 1/2 CHORD TO WING HINGE LINE
"	=	4	INPUT XWING AS STATION OF WING TRAILING EDGE
NTPOS	=	1	INPUT XTAIL AS STATION OF TAIL LEADING EDGE
"	=	2	PROGRAM WILL MOVE TAIL 1/4 CHORD TO TAIL HINGE LINE
"	=	3	PROGRAM WILL MOVE TAIL 1/2 CHORD TO TAIL HINGE LINE
"	=	4	INPUT XTAIL AS STATION OF TAIL TRAILING EDGE

TABLE 2. GENERAL INPUT FORMAT AND DEFINITION OF INPUTS (Cont'd).

MCDVT	= 1	NO EFFECT.
"	= 2	USE NACA REPT. 1253 (MCDEVITT) FOR FIN ALONE CLA.
		GOOD FOR RECTANGULAR FINS ONLY.
		GOOD FOR MACH NUMBERS BELOW 1.1 ONLY.
NOUT	= 1	TRIM OUTPUT ONLY.
	= 2	ALPHA OUTPUT ONLY.
	= 3	TRIM AND ALPHA OUTPUT.
NRUN	=	INITIAL RUN NUMBER. - 1 TO 4 DIGITS.
NDBASE	= 1	NO EFFECT.
	= 2	OUTPUT DATA BASE FILE.

.... INPUT 3

NOSE	= 1	OGIVE NOSE
"	= 2	CONICAL NOSE
XLN	=	NOSE LENGTH
XL	=	TOTAL LENGTH

.... INPUT 4

RBW	= RADIUS OF BODY AT WING
RBT	= RADIUS OF BODY AT TAIL
DREF	= REFERENCE LENGTH
AREF	= REFERENCE AREA
DREFFT	= REFERENCE LENGTH - FT.
AREFFT	= REFERENCE AREA IN SQ. FT.
YIY	= TRANSVERSE MOMENT OF INERTIA - SLUG-FT2.

TABLE 2. GENERAL INPUT FORMAT AND DEFINITION OF INPUTS (Cont'd).

.... INPUT 5

NBODY = NUMBER OF POINTS FOR BODY ALONE CNACY AND XCPCY

(IF NBODY=0, OMIT IMPUTS 6. PROGRAM WILL COMPUTE SLOPE DATA.)

.... INPUTS 6

TMACH = TABLE OF MACH NUMBERS FOR CNACY AND XCPCY

TCNACY = TABLE OF BODY ALONE NORMAL FORCE COEFF SLOPES (BASED ON BODY CROSS SECTIONAL REFERENCE AREA) - 1/RAD

TXCPCY = TABLE OF BODY ALONE CENTER OF PRESSURE - CAL FROM NOSE

.... INPUT 7

NBTL=0 PROGRAM WILL NOT ADD BOATTAIL CNA AND XCP.

" =1 PROGRAM USES BOATTAL CARDS TO CALCULATE BOATTAIL EFECTS

DBOD = DIAMETER RATIO (BOATTAIL/CYLINDER)

XLBOD = RATIO (BOATTAIL LENGTH/CYLINDER DIAMETER)

.... INPUT 8

NMF = NUMBER OF POINTS FOR XCG VS MACH NUMBER

.... INPUTS 9

TMF = TABLE OF MACH NUMBERS FOR XCG

TXCG = TABLE OF CENTER OF GRAVITY - CALIBERS FROM NOSE.

TWEIGH = TABLE OF WEIGHT - LBS.

.... INPUT 10

TABLE 2. GENERAL INPUT FORMAT AND DEFINITION OF INPUTS (Concluded).

NFMA = NUMBER OF FREE STREAM MACH NUMBERS

.... INPUTS 11

TFMA = TABLE OF FREE STREAM MACH NUMBERS

TALT = ALTITUDE FOR EACH MACH NO. - FT ABOVE SEA LEVEL

TRE = REYNOLDS NUMBER FOR EACH MACH NO. - MILLIONS/FT.

NOTE: PROGRAM MULTIPLIES TRE BY 1 MILLION TO GET RE.

.... INPUTS 12-26

TBOW = TABLE OF WING EXPOSED SEMI-SPANS(LOAD 0. IF NO WING)

TCRW = TABLE OF WING ROOT CHORDS

TTRW = TABLE OF WING TAPER RATIOS(CT/CR)

TSWTEW = TABLE OF WING TRAILING EDGE SWEEP ANGLES(DEG)

TXWING = TABLE OF WING STATIONS (MEASURED FROM NOSE) (SEE NWPOS)

THINGW = TABLE OF WING HINGE LINES

TBOT = TABLE OF TAIL EXPOSED SEMI-SPANS(LOAD 0. IF NO TAIL)

TCRT = TABLE OF TAIL ROOT CHORDS

TTRT = TABLE OF TAIL TAPER RATIOS (CT/CR)

TSWTET = TABLE OF TAIL TRAILING EDGE SWEEP ANGLES (DEG)

TXTAIL = TABLE OF TAIL POSITIONS (MEASURED FROM NOSE)

THINGT = TABLE OF TAIL HINGE LINES

" = 0. (PROGRAM SETS HINGT=1/4 MEAN AERODYNAMIC CHORD)

TDELT = TABLE OF TAIL DEFLECTIONS - DEG.

TDELW = TABLE OF WING DEFLECTIONS - DEG.

TALP = TABLE OF ANGLES OF ATTACK - DEG.

TABLE 3. SAMPLE INPUT FILE FOR AERODSN

```
SAMPLE INPUT FILE: BODY-WING-TAIL.
1 1 1 3 1 1
1 7.470 47.000
3. 3. 6.0 28.27 .50 .1963 1
6
.5 3.197 3.014
.8 3.059 3.154
.95 3.248 3.317
1.2 3.151 2.431
1.5 3.145 1.978
1.8 3.008 1.742
0 1.0 0.0
2
0.0 4.544 1.0
1.0 4.544 1.0
2
.5 0.0 3.592
1.8 0.0 12.933
7.149
3.051
1.0
20.0
32.32
0.0
5.974
3.051
1.0
20.0
41.226
42.582
0.
0.0
-5 -2 0.0 2 4 6 8 10 12 14 16 18 20
```

B. STEP 2 - To run the program type "AERODSN" and press "RETURN". Wait for instructions to appear and enter the name of the data file. When the program has finished running an "*" will appear on the screen.

V. OUTPUT

The output consists of five major groups:

- GEOMETRIC VARIABLES
- FLIGHT CONDITIONS
- ZERO ANGLE OF ATTACK DATA (SLOPES)
- TRIM POINT
- ANGLE OF ATTACK SWEEP

Presented in Table 4 are definitions of each output variable calculated within each output group. Table 5 illustrates a sample output.

The group GEOMETRIC VARIABLES is divided into three components which are body, wing and tail. The corresponding geometric values are listed in column form with the appropriate symbol and definition. Printed under FLIGHT CONDITIONS are Mach number, center of gravity location (calibers from the nose), altitude (ASL) in feet and Reynolds number (per ft.). These values are taken directly from the input file. The ZERO ANGLE OF ATTACK DATA (SLOPES) group is divided into body, wing, tail and total configuration values. Each aerodynamic coefficient slope is evaluated at zero angle of attack and is listed in column form corresponding to the missile component. Aerodynamic coefficients are calculated for individual angles of attack in the ANGLE OF ATTACK SWEEP group.

VI. PROGRAM VALIDATION

Comparisons are made to establish the range of validity. Configurations taken from the AERODYNAMIC DATA BASE such as ADVINT, HIALFA, DCATFL, and COPHED were used. Normal force and pitching moment coefficients were generated by AERODSN and plotted against wind tunnel data for comparison.

Detailed geometric description of each missile configuration tested is included with the plots. The Mach numbers range from 0.2 to 4.0. Angle of attack ranges from -5 to 25 degrees. Angles of attack greater than 25 degrees are included in this report; however, user discretion is advised. Missile configurations include body, body-tail, body-wing and body-wing-tail.

Figures 1 and 2 describe the geometry of ADVINT. Figures 3-26 show comparison between ADVINT wind tunnel data and AERODSN. Normal force and pitching moment coefficients are shown at Mach numbers of 1.95, 3.01 and 4.02. Body, body-tail, body-wing and body-wing-tail configurations are compared. Run numbers beginning with A are ADVINT wind tunnel data and runs beginning with G are AERODSN runs.

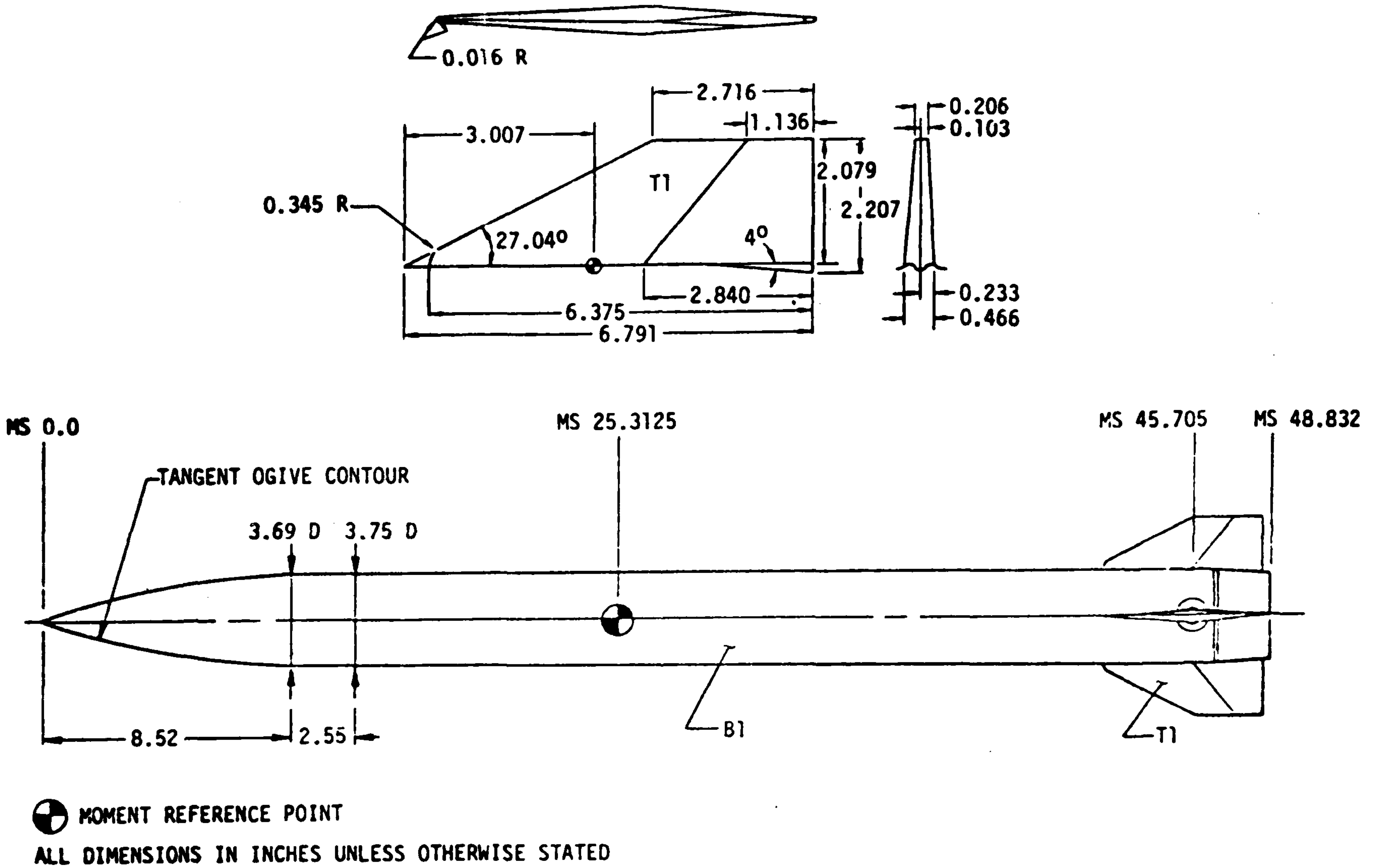
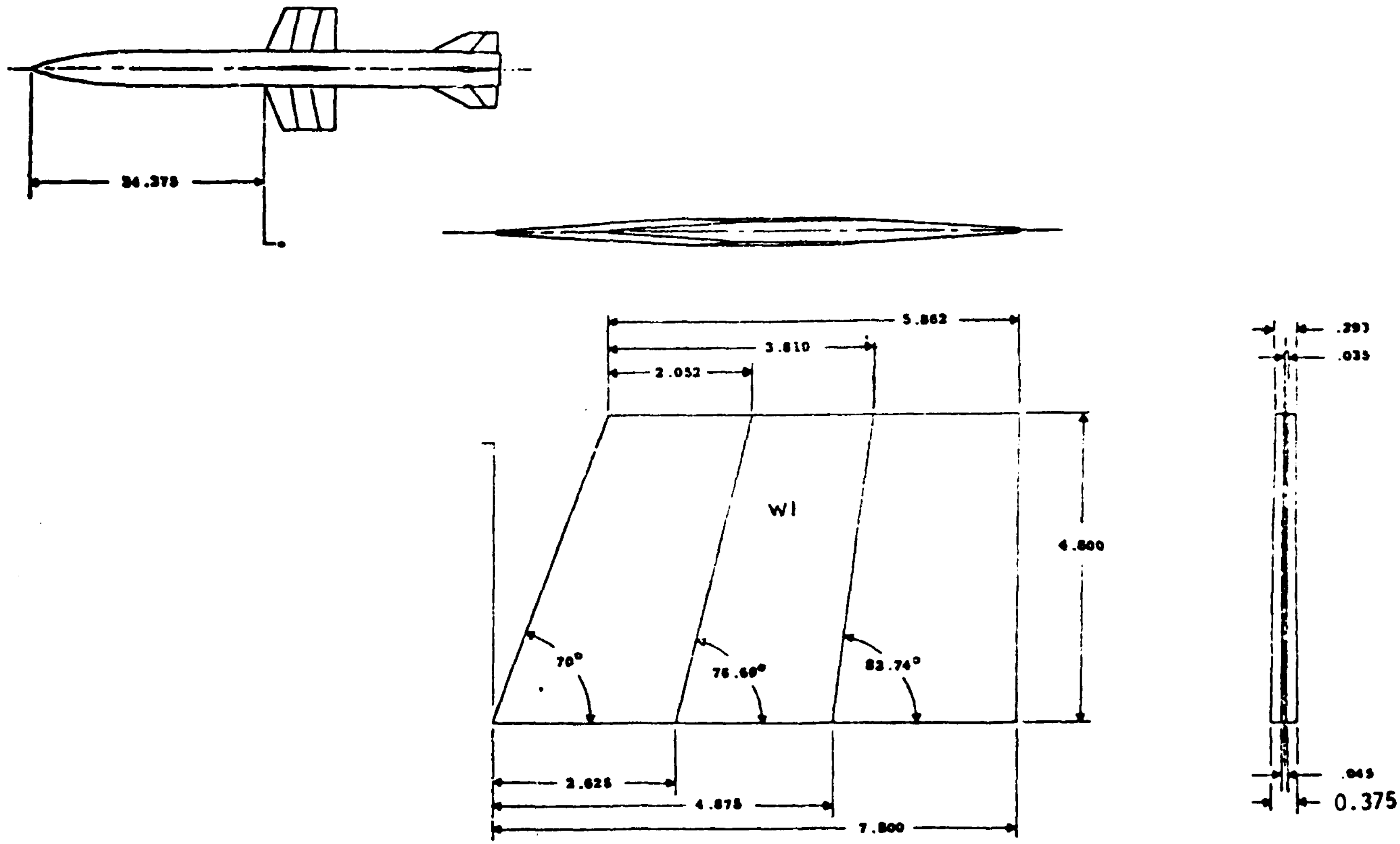


Figure 1. Body-tail details.



ALL DIMENSIONS IN INCHES UNLESS OTHERWISE STATED

SOURCE: Ref. 1

Figure 2. Straight wing (W1) details.

TABLE 4. DEFINITION OF OUTPUT

FLIGHT CONDITIONS

FMACH	FREE STREAM MACH NUMBER.
XCG	LOCATION OF CENTER OF GRAVITY (CALIBERS FROM NOSE).
WEIGHT	WEIGHT (LBS.).
ALT	ALTITUDE ABOVE SEALEVEL (FT.).
RE	REYNOLDS NUMBER X 10E6. (PER FT)

ZERO ANGLE OF ATTACK DATA (SLOPES)

BKUP	UPWASH; RATIO OF LIFT ON WINGS IN PRESENCE OF BODY TO LIFT OF WING ALONE.
BKCC	CARRYOVER; RATIO OF LIFT ON BODY DUE TO WING TO LIFT OF WING ALONE.
CLA	LIFT COEFFICIENT OF TAIL OR WING,BASED ON RESPECTIVE FIN AREAS. (1/RAD).
CPF	CENTER OF PRESSURE OF WING OR TAIL MEASURED FROM ROOT CHORD LEADING EDGE.
CNA	LIFT COEFFICIENT SLOPE OF COMPONENTS BASED ON AREF (1/RAD).
XCP	COMPONENT CENTER OF PRESSURE DIVIDED BY DREF. MEASURED FROM NOSE.
CMACG	PITCHING MOMENT COEFFICIENT ABOUT CG BASED ON AREF AND DREF.
CMQ	PITCH DAMPING COEFFICIENT SLOPE (ABOUT C.G.) DUE TO PITCH RATE, BASED ON AREF AND DREF (1/RAD).

TABLE 4. DEFINITION OF OUTPUT (Cont'd)

CLP	ROLL DAMPING COEFFICIENT SLOPE BASED ON AREF AND DREF. (1/RAD).
CLD	ROLL MOMENT COEFFICIENT SLOPE (4 FINS OR 4 WINGS DEFLECTED), BASED ON AREF AND DREF (1/RAD).
CHA	HINGE MOMENT COEFFICIENT SLOPE DUE TO ANGLE OF ATTACK, BASED ON AREF AND DREF (1/RAD).
CHD	HINGE MOMENT COEFFICIENT SLOPE DUE TO CONTROL DEFLECTION, (FOR ALL MOVEABLE FINS),BASED ON AREF AND DREF (1/RAD).
CND	NORMAL FORCE COEFFICIENT SLOPE DUE TO CONTROL DEFLECTION, BASED ON AREF (1/RAD).
CMDCG	PITCHING MOMENT COEFFICIENT SLOPE ABOUT CG DUE TO CONTROL DEFLECTIONS (1/RAD).
SIGMA	PITCH OSCILLATION NATURAL FREQUENCY (CYCLES/SEC).

TRIM POINT

ALPHA	TRIM ANGLE OF ATTACK (DEG).
DELW	WING DEFLECTION (DEG).
DELT	TAIL DEFLECTION (DEG).
CN	TOTAL NORMAL FORCE COEFFICIENT (NF/Q AREF).
XCP	LOCATION OF CENTER OF PRESSURE (FROM NOSE) XCP/DREF.
CMCG	TOTAL PITCHING MOMENT COEFFICIENT ABOUT C.G. (PM/Q*AREF*DREF)
HMW	HINGE MOMENT COEFFICIENT OF WING HMW/(Q*AREF*DREF).
HMT	HINGE MOMENT COEFFICIENT OF TAIL HMT(/Q*AREF*DREF).
GLOAD	LATERAL MANEUVERABILITY (G'S)

TABLE 4. DEFINITION OF OUTPUT (Concluded)

ANGLE OF ATTACK SWEEP

ALPHA	ANGLE OF ATTACK (DEG).
CN	TOTAL NORMAL FORCE COEFFICIENT NF/(Q*AREF).
XCP	LOCATION OF XCP (FORM NOSE) XCP/DREF
CMCG	TOTAL PITCHING MOMENT COEFFICIENT ABOUT C.G. PM/(Q*AREF*DREF)
CHW	HINGE MOMENT COEFFICIENT OF WING HMW/(Q*AREF*DREF).
CHT	HINGE MOMENT COEFFICIENT OF TAIL HMT/(Q*AREF*DREF).
CNB	BODY NORMAL FORCE COEFFICIENT NFB/(Q*AREF)
XCPB	LOCATION OF BODY XCP (FROM NOSE,XCPB/DREF).
CNW	NORMAL FORCE COEFFICIENT OF WING PLUS-BODY INTERFERENCE NFW/(Q*AREF).
XCPW	LOCATION OF WING XCP (FROM NOSE) XCPW/DREF.
CNT	NORMAL FORCE COEFFICIENT OF TAIL PLUS BODY TAIL INTERFERENCE NFT/(Q*DREF).
XCPT	LOCATION OF TAIL XCP (FROM NOSE) XCPT/DREF.
CNTV	NORMAL FORCE COEFFICIENT ON TAIL DUE TO WING VORTICES.

Figure 27 describes the Copperhead geometry. Figures 28-33 show normal force and pitching moment coefficient generated by AERODSN compared to that of Copperhead wind tunnel data. The Mach numbers tested are 0.5, 0.8 and 0.95 for the body-wing-tail configuration. Runs beginning with C are Copperhead wind tunnel data and runs beginning with T are AERODSN runs.

Figures 34-36 describe the geometry of the missile shape used for high angle of attack comparison. Nose 1, afterbody 1 and tail 11 were used. Alpha ranges from 25-45 degrees at Mach numbers of 2.0, 2.5 and 3.01. Runs beginning with "B" are HIALFA wind tunnel data and runs beginning with "O" are AERODSN runs. Figures 37-42 show normal force and pitching moment coefficient comparison.

Figures 43-44 describe the geometry for the body tail configuration used in this comparison. Figures 46-56 show normal force and pitching moment comparison at Mach numbers of 0.2 to 1.0. Angle of attack ranges from -6.0 to 6.0. Runs beginning with "A" are DCATFL wind tunnel data and runs beginning with "E" are AERODSN runs.

VII. SUMMARY AND CONCLUSIONS

The preliminary design computer program "AERODSN" has been evaluated for accuracy and range of applicability. A description of the inputs and outputs, as well as run instructions for running the program on MICOM's Interdata 8/32 computer, is included. "AERODSN" was tested at Mach numbers from 0.0 to 4.0. All configurations were tested with an angle of attack range from 0.0 to 20.0 degrees with the exception of one tested from 25.0 to 45.0 degrees. Roll orientations are zero for all cases. Body, body-wing, body-tail and body-wing-tail configurations were tested through the alpha and Mach ranges indicated based on the comparative analysis. The following conclusions are drawn:

A. The applicable Mach range is from 0 to 4.

B. In general, good results were obtained in CN and CM at angles of attack up to 20 deg alpha. In some cases, where configurations depart from the missile shapes applicable for this program, comparisons are not good for angles of attack greater than 5 deg.

C. "AERODSN" is applicable for configurations with roll orientations of zero only.

D. "AERODSN" is an acceptable preliminary design tool for obtaining a quick aerodynamic profile for missile shapes described in this report.

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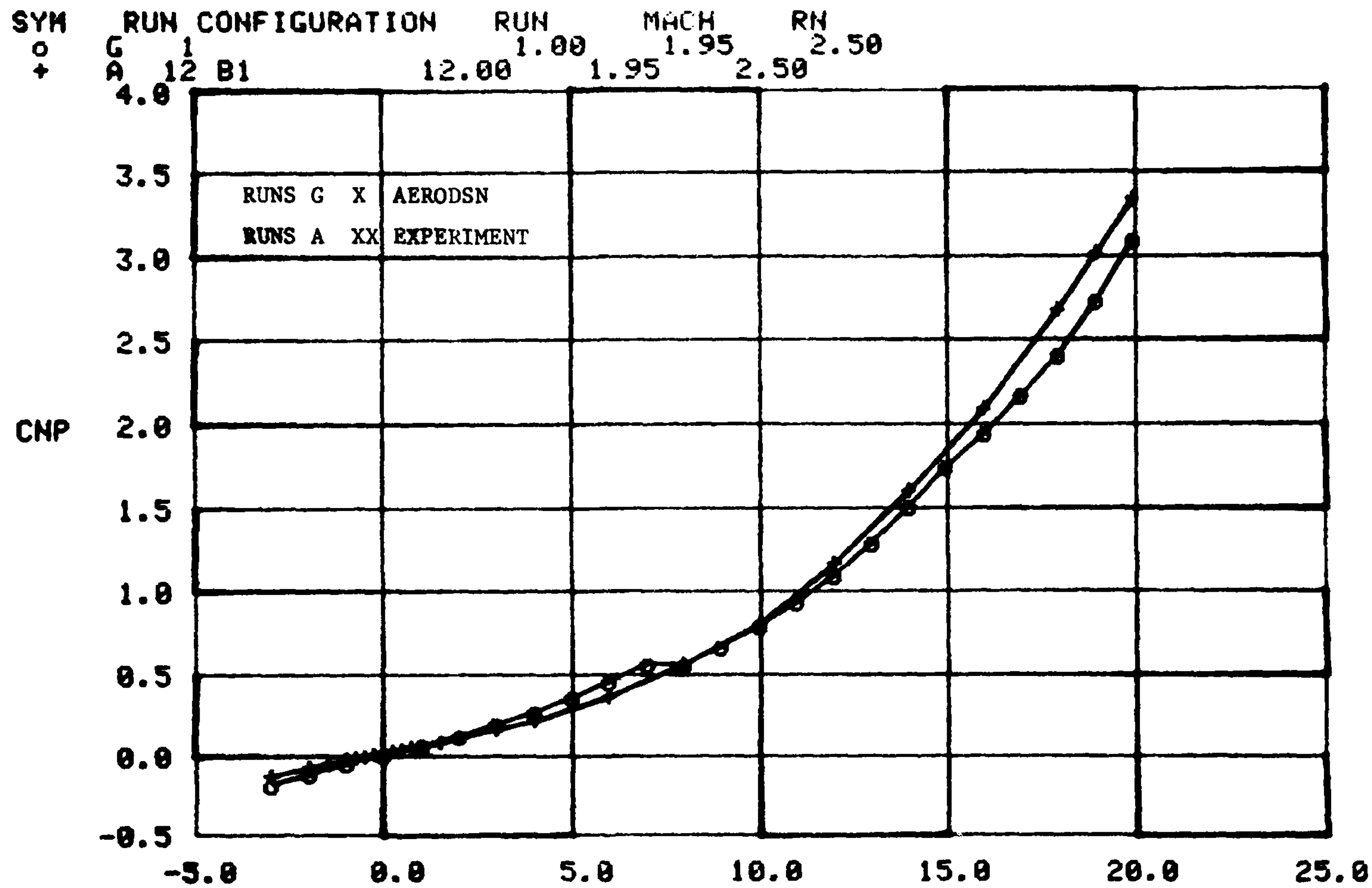


Figure 3. Body alone normal foile vs angle of attack at M = 1.95.

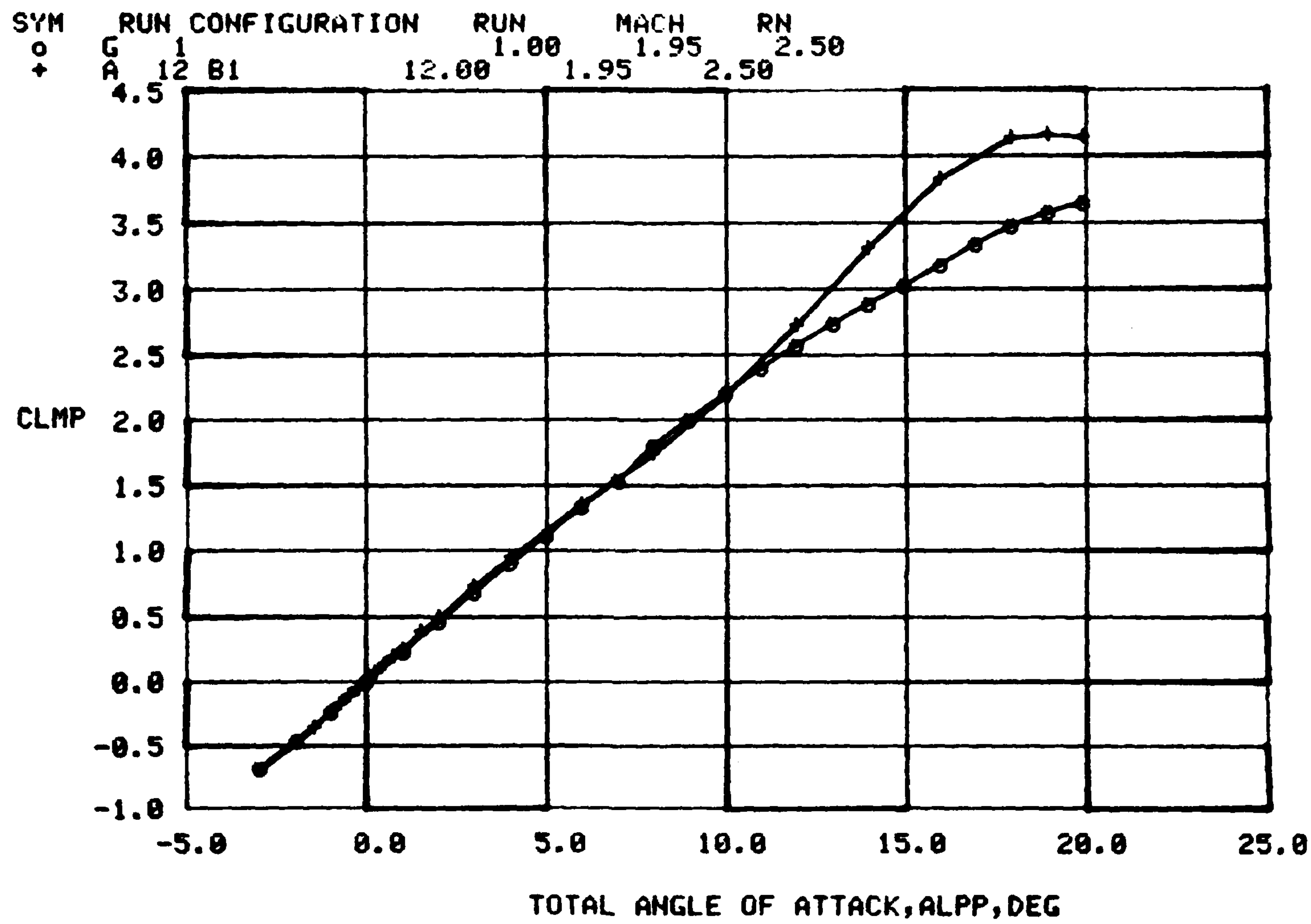


Figure 4. Body alone pitching moment vs angle of attack at M = 1.95.

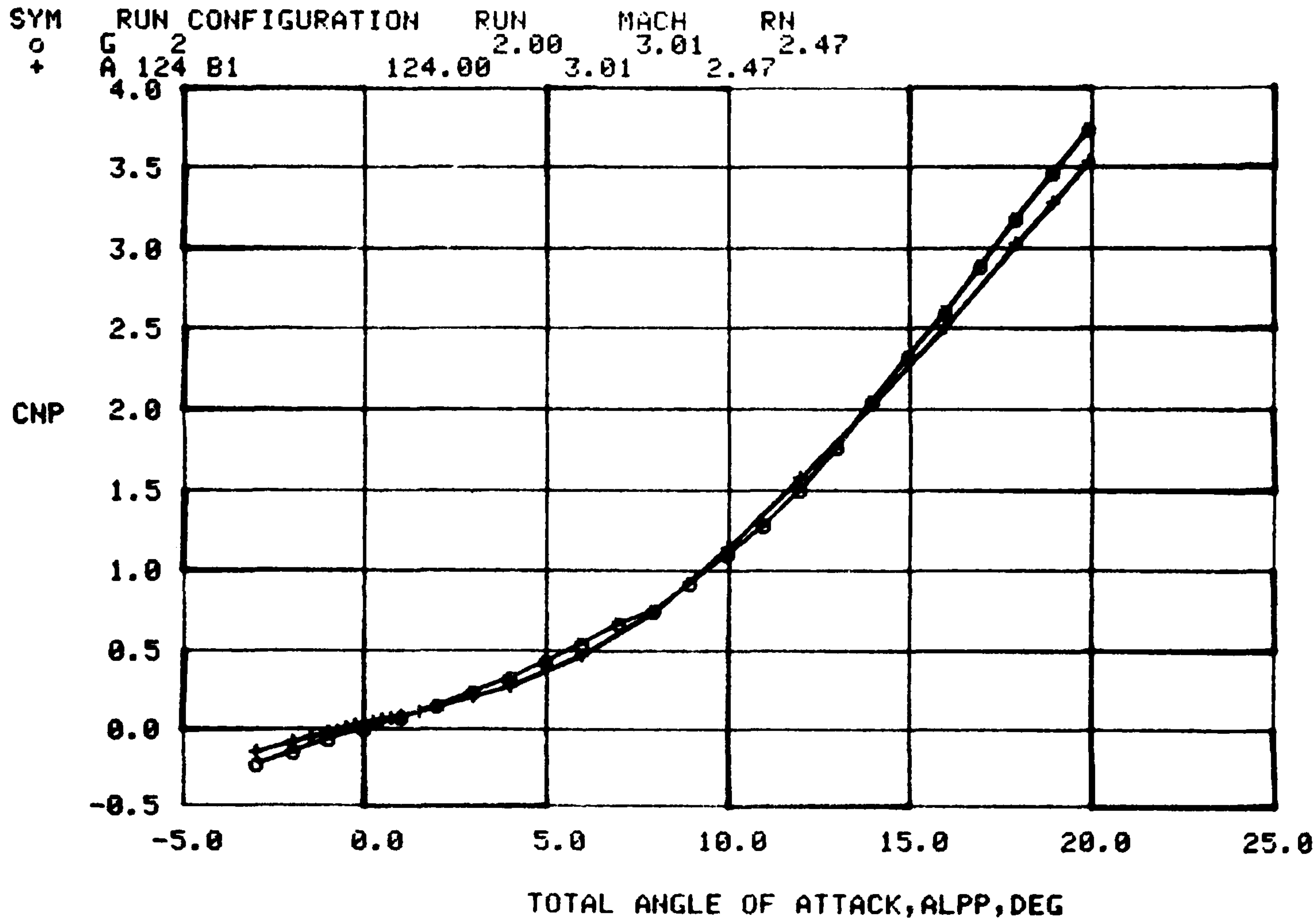


Figure 5. Body alone normal force vs angle of attack at M = 3.01.

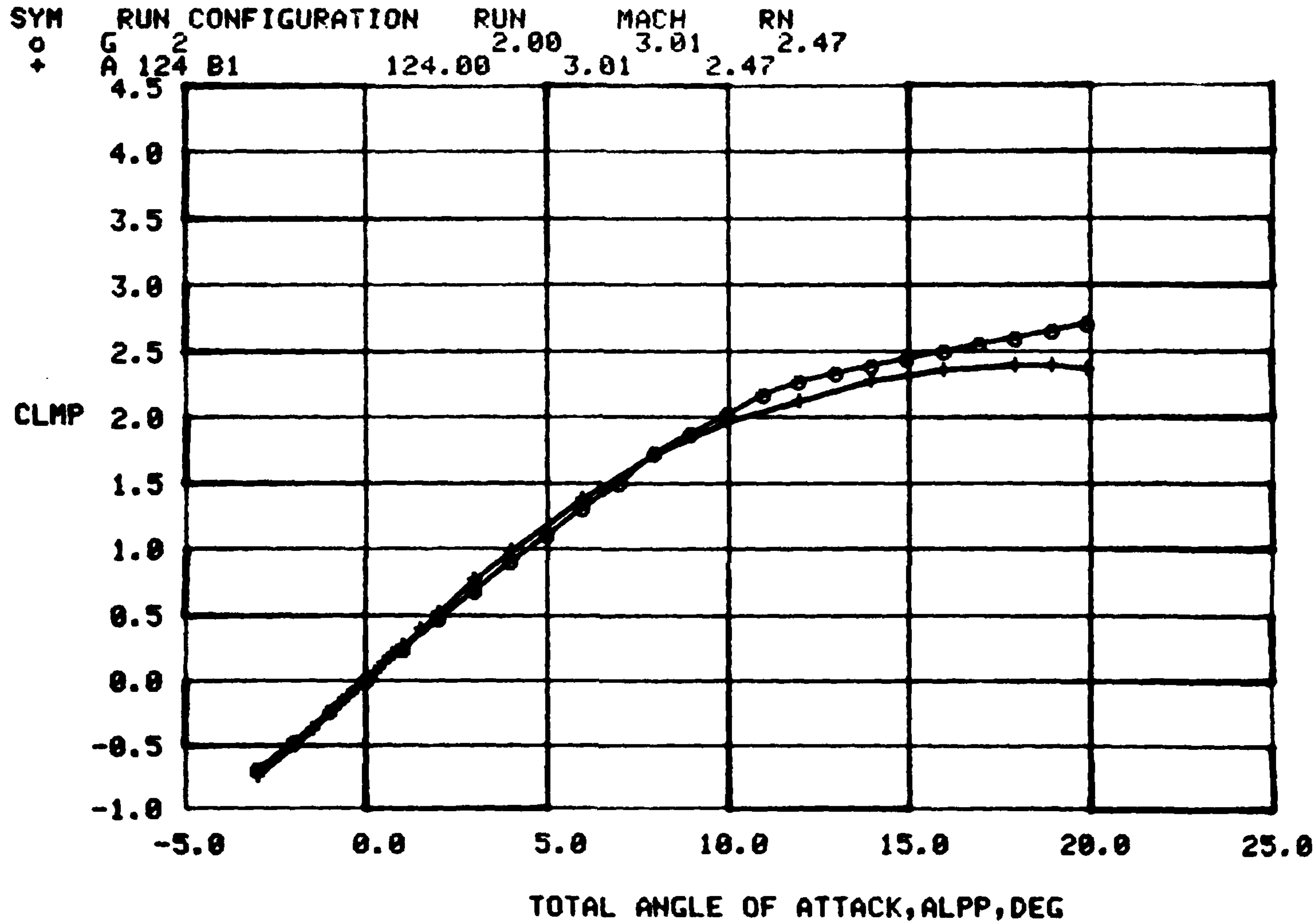


Figure 6. Body alone pitching moment vs angle of attack at M = 3.01.

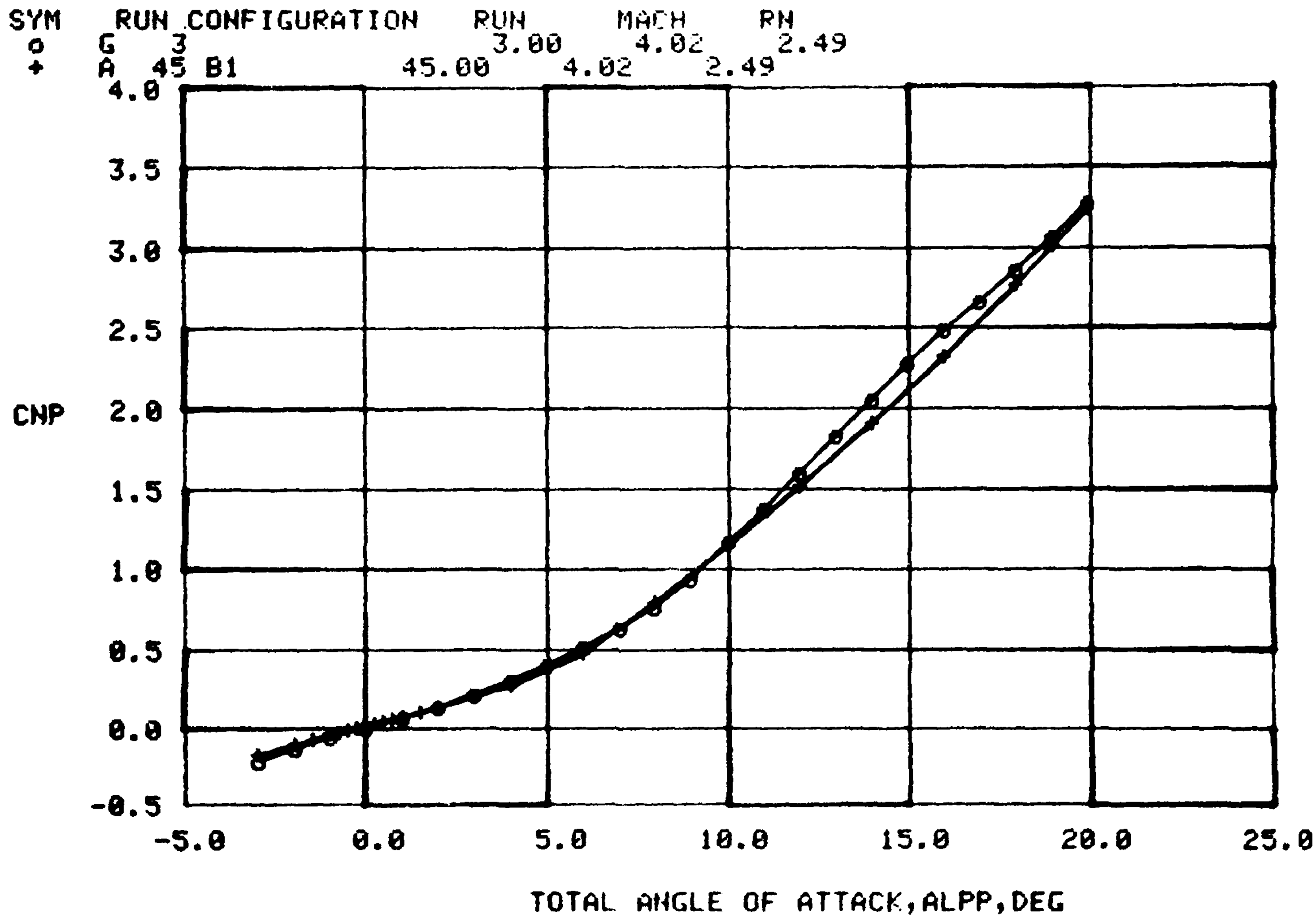


Figure 7. Body alone normal voile vs angle of attack at M = 4.02.

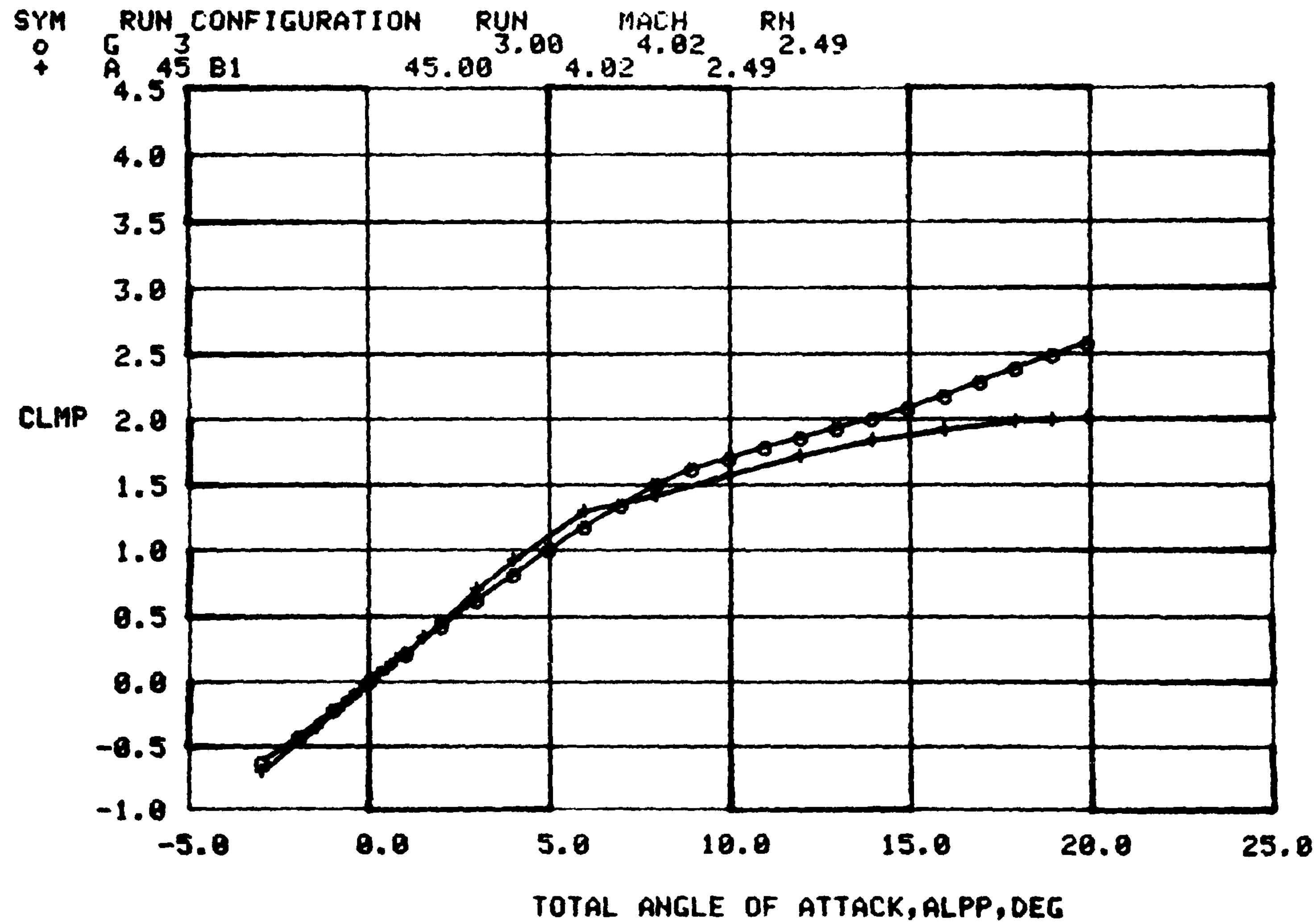


Figure 8. Body alone pitching moment vs angle of attack at M = 4.02.

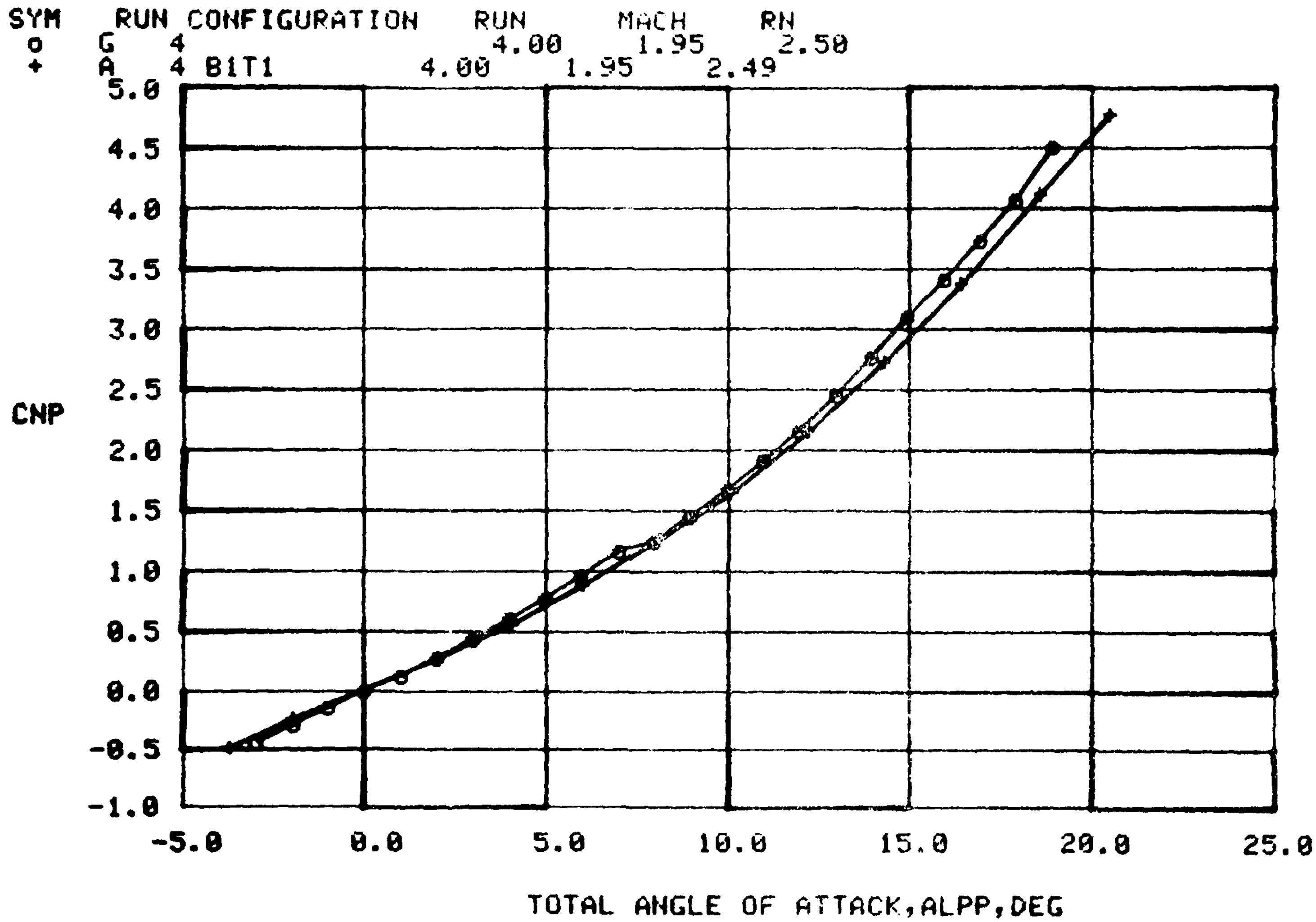


Figure 9. Body tail normal force vs angle of attack at M = 1.95.

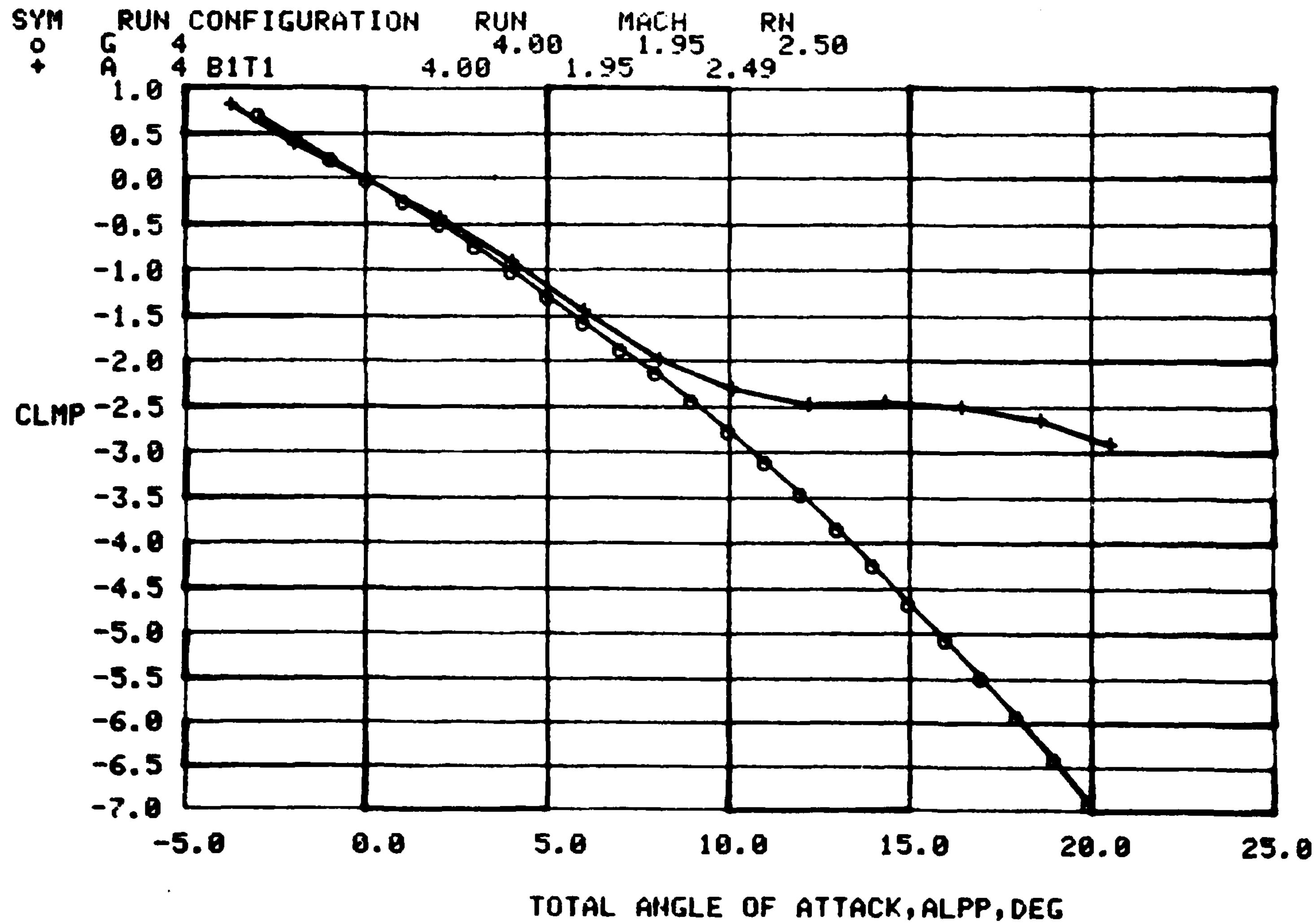


Figure 10. Body tail pitching moment vs angle of attack at M = 1.95.

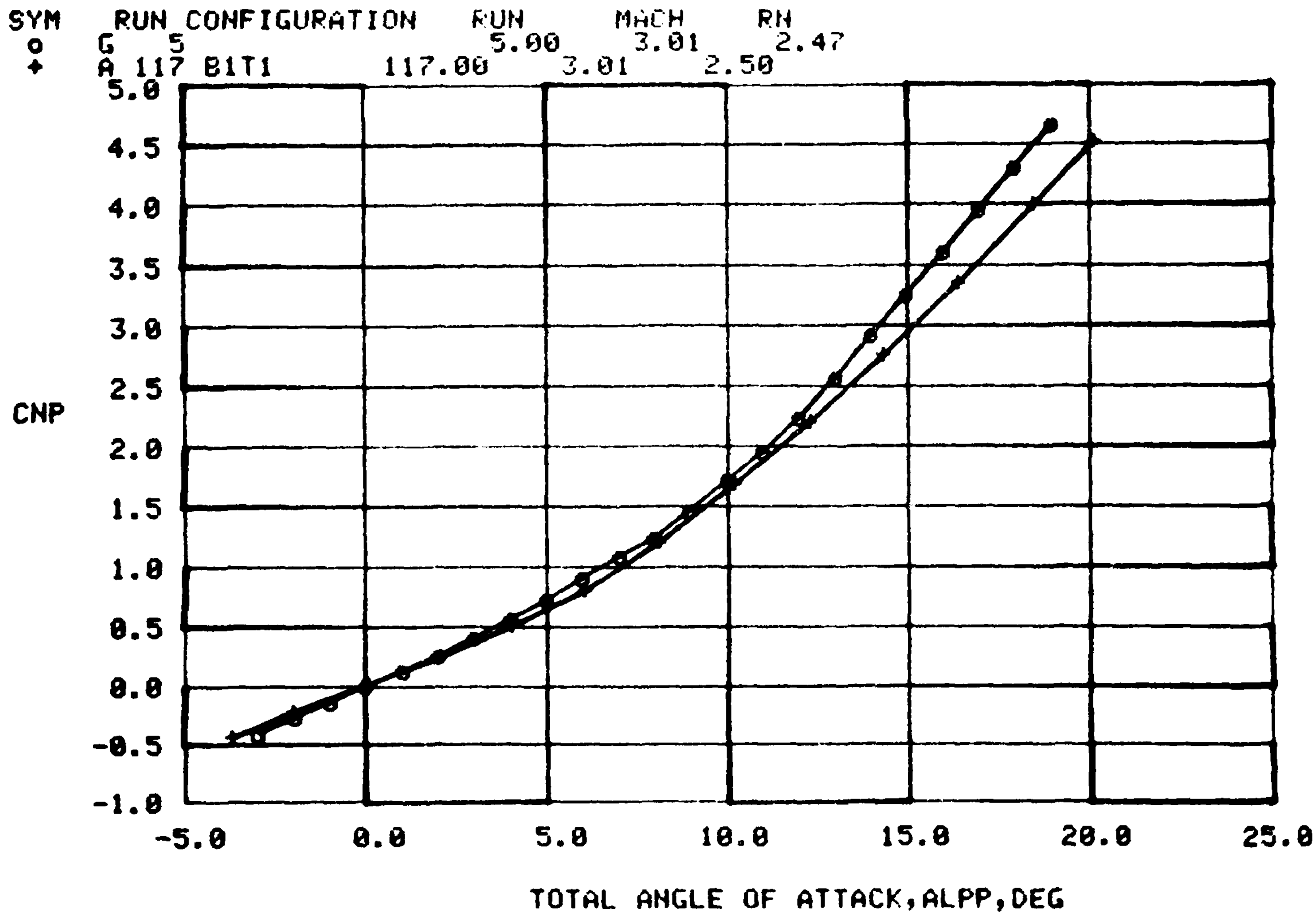


Figure 11. Body tail normal force vs angle of attack at M = 3.01.

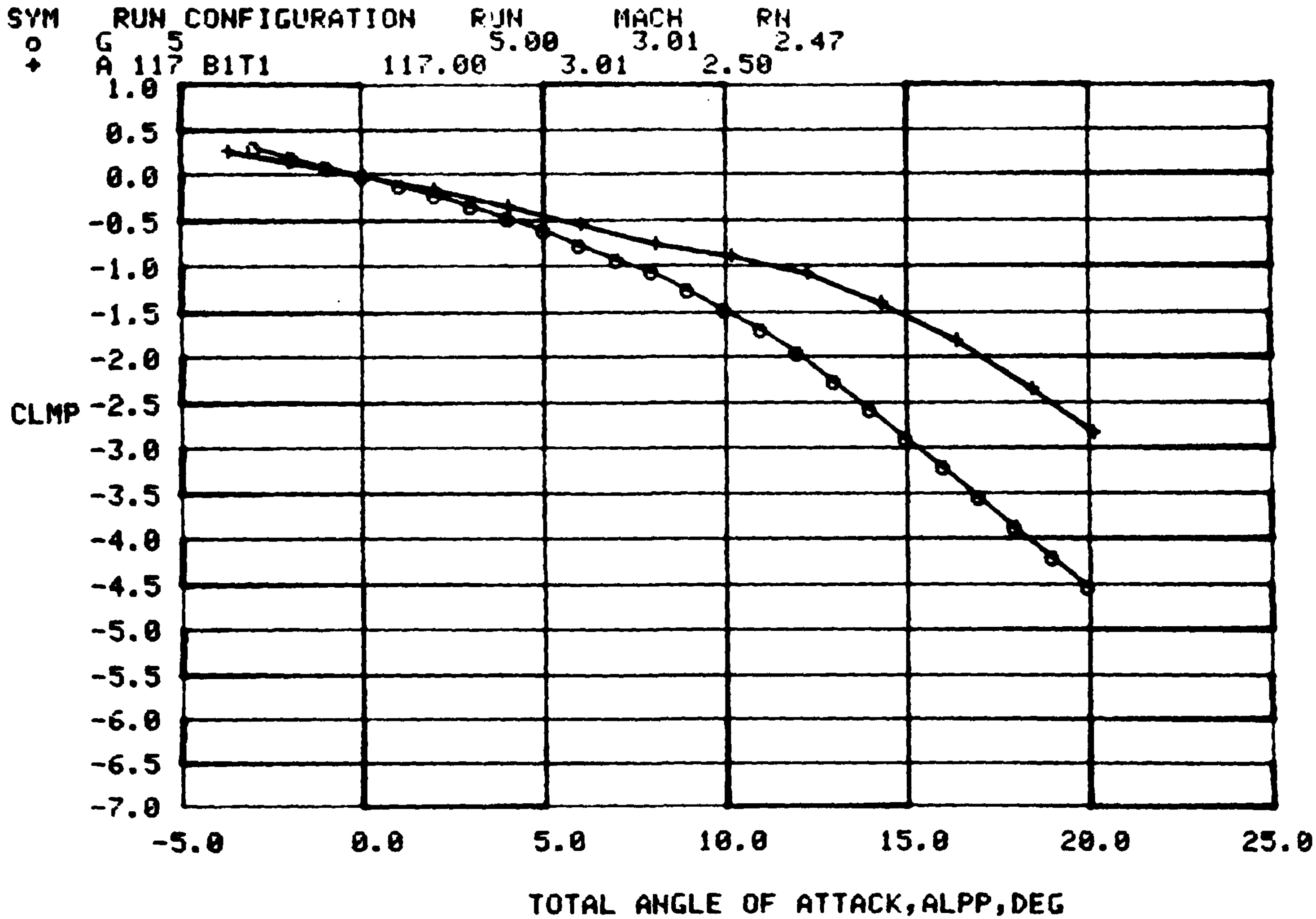


Figure 12. Body tail pitching moment vs angle of attack at M = 3.01.

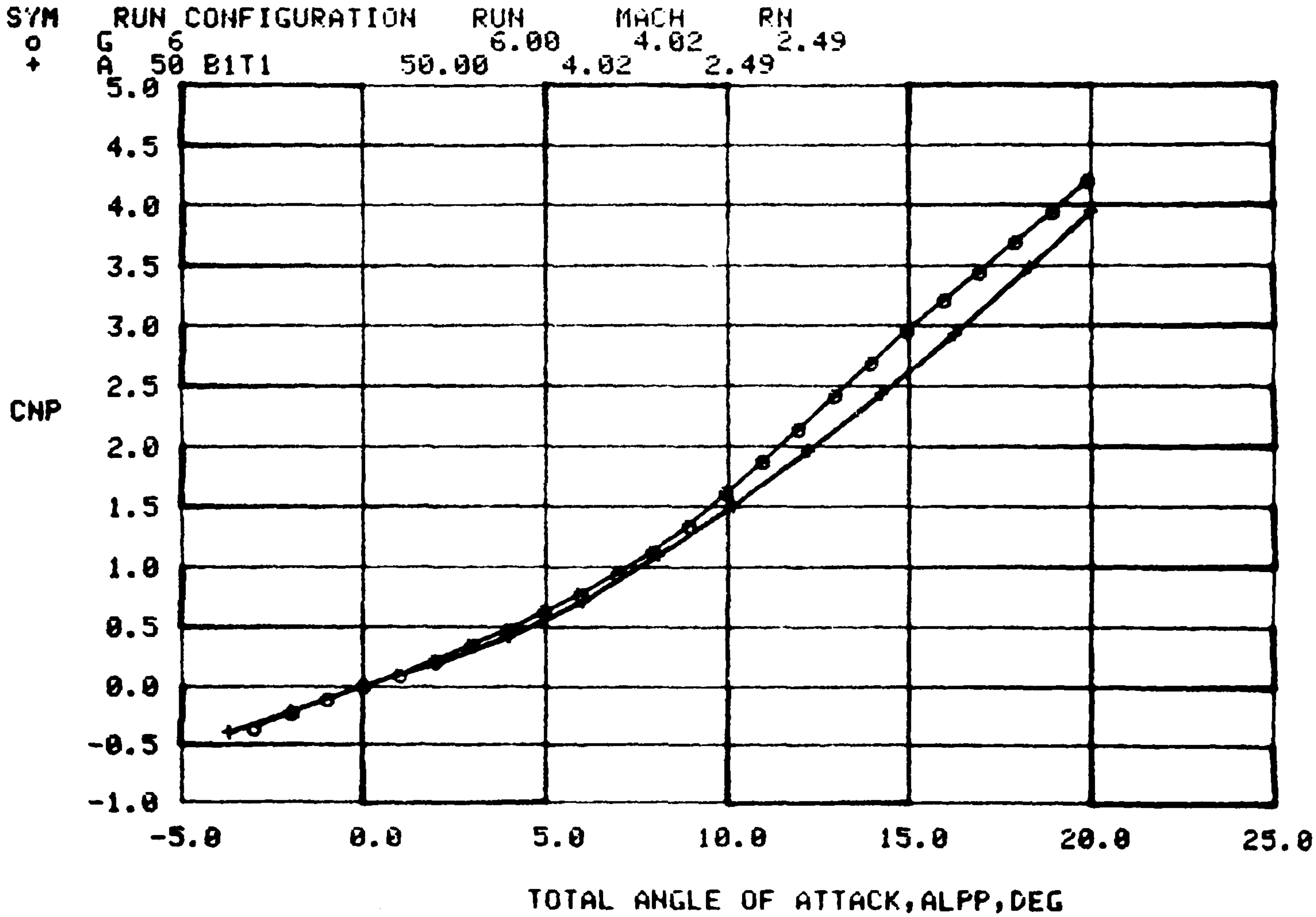


Figure 13. Body tail normal force vs angle of attack at M = 4.02.

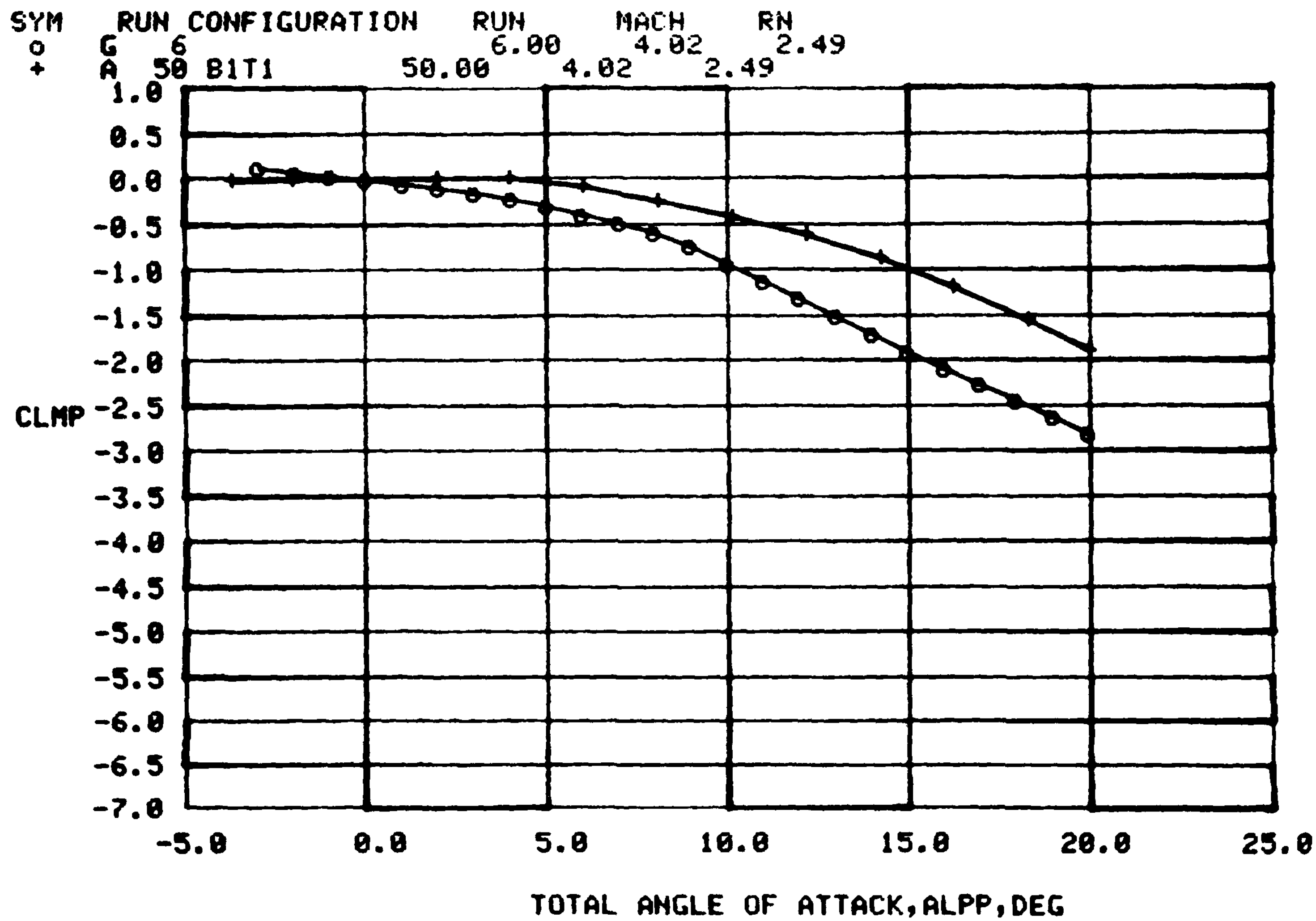


Figure 14. Body tail normal force vs angle of attack at M = 4.02.

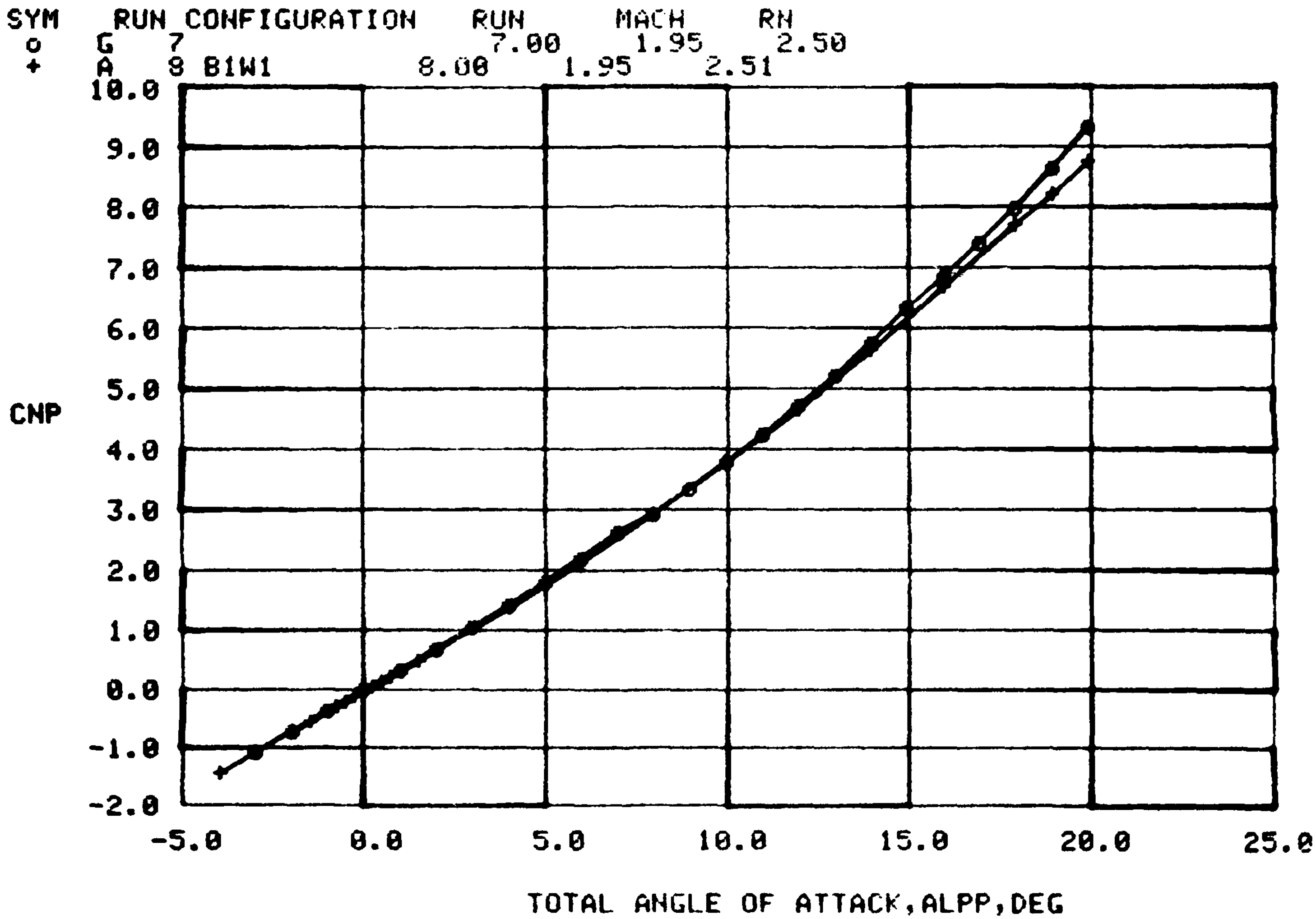


Figure 15. Body wing normal force vs angle of attack at M = 1.95.

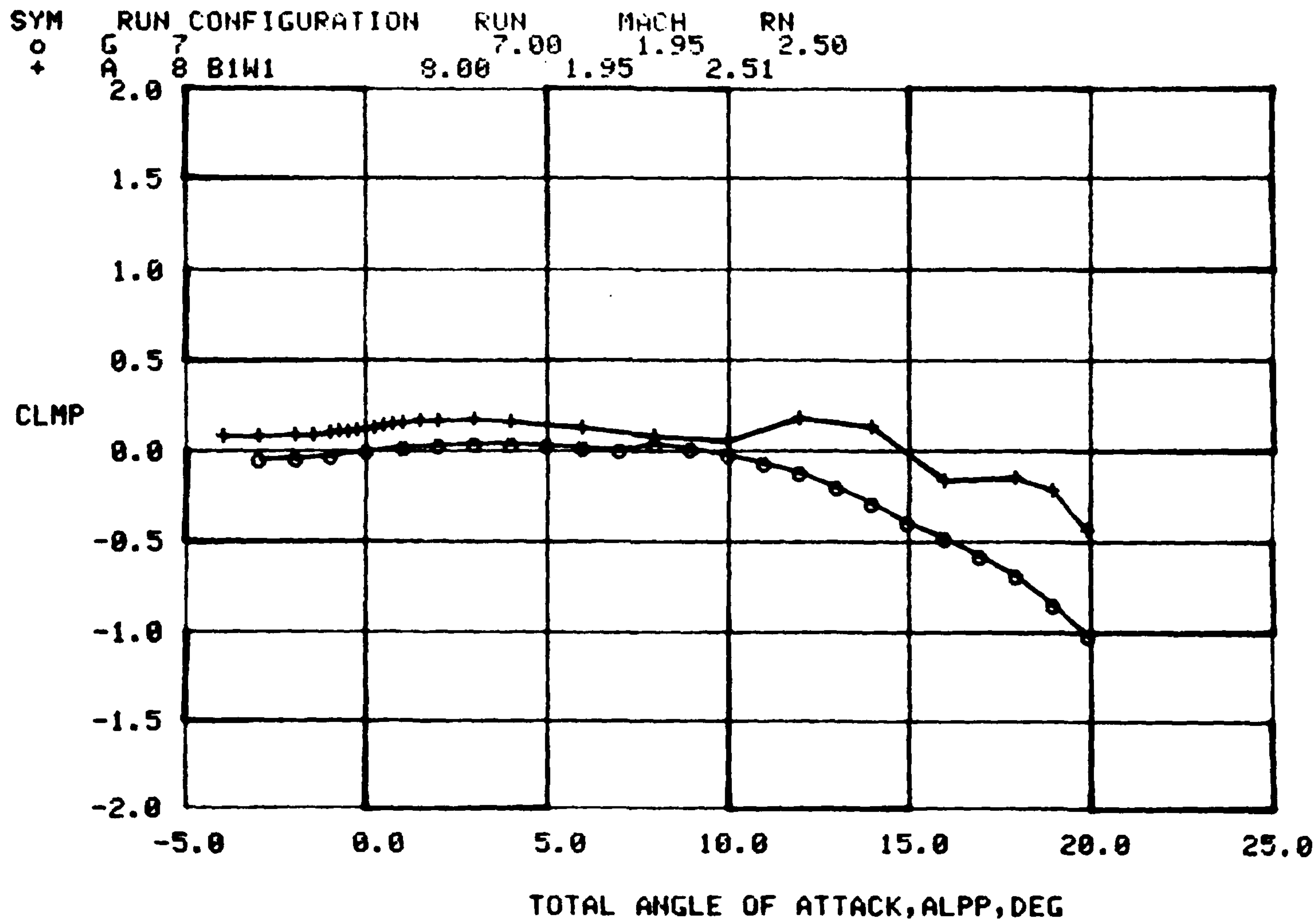


Figure 16. Body wing pitching moment vs angle of attack at M = 1.95.

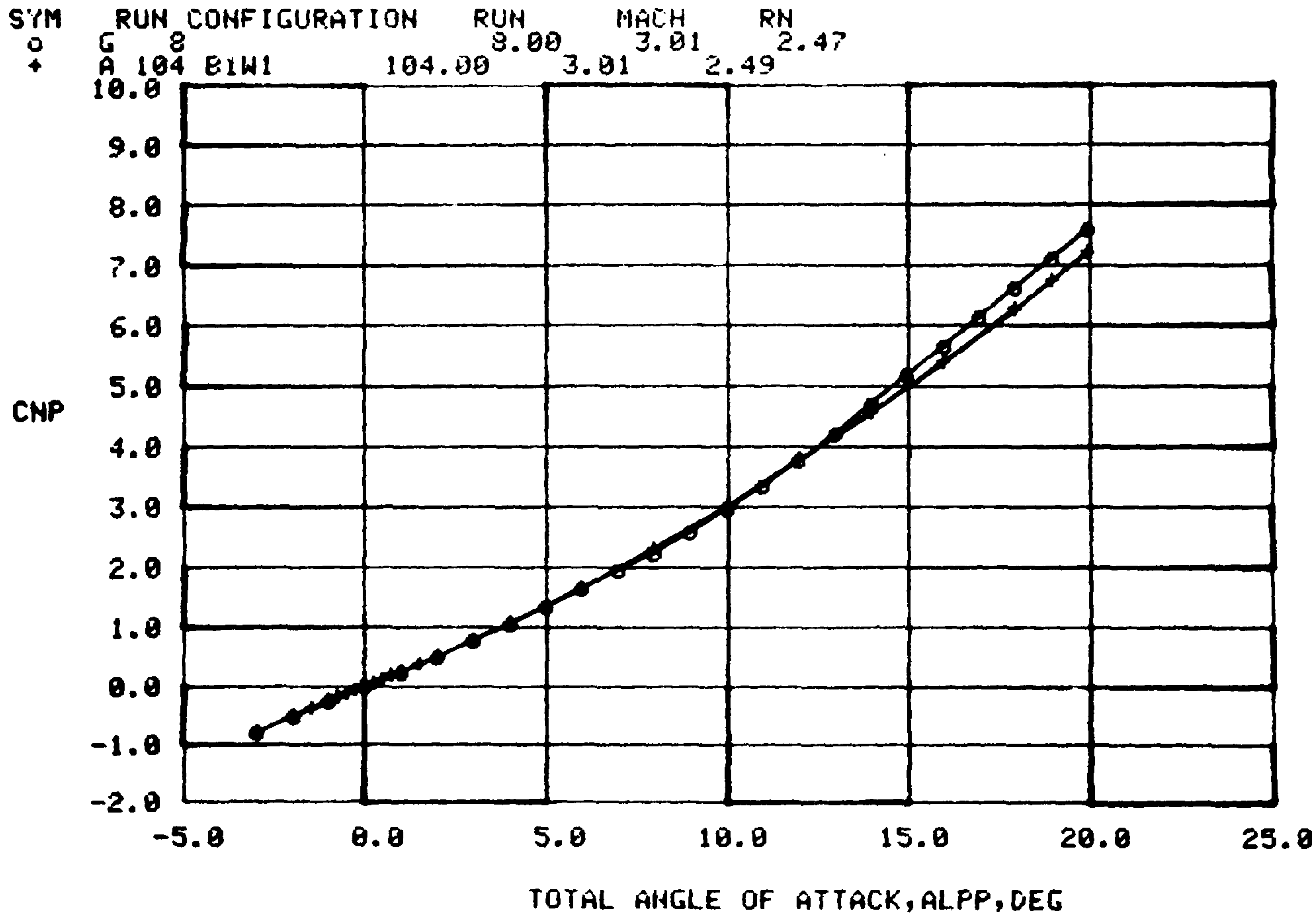


Figure 17. Body wing normal force vs angle of attack at M = 3.01.

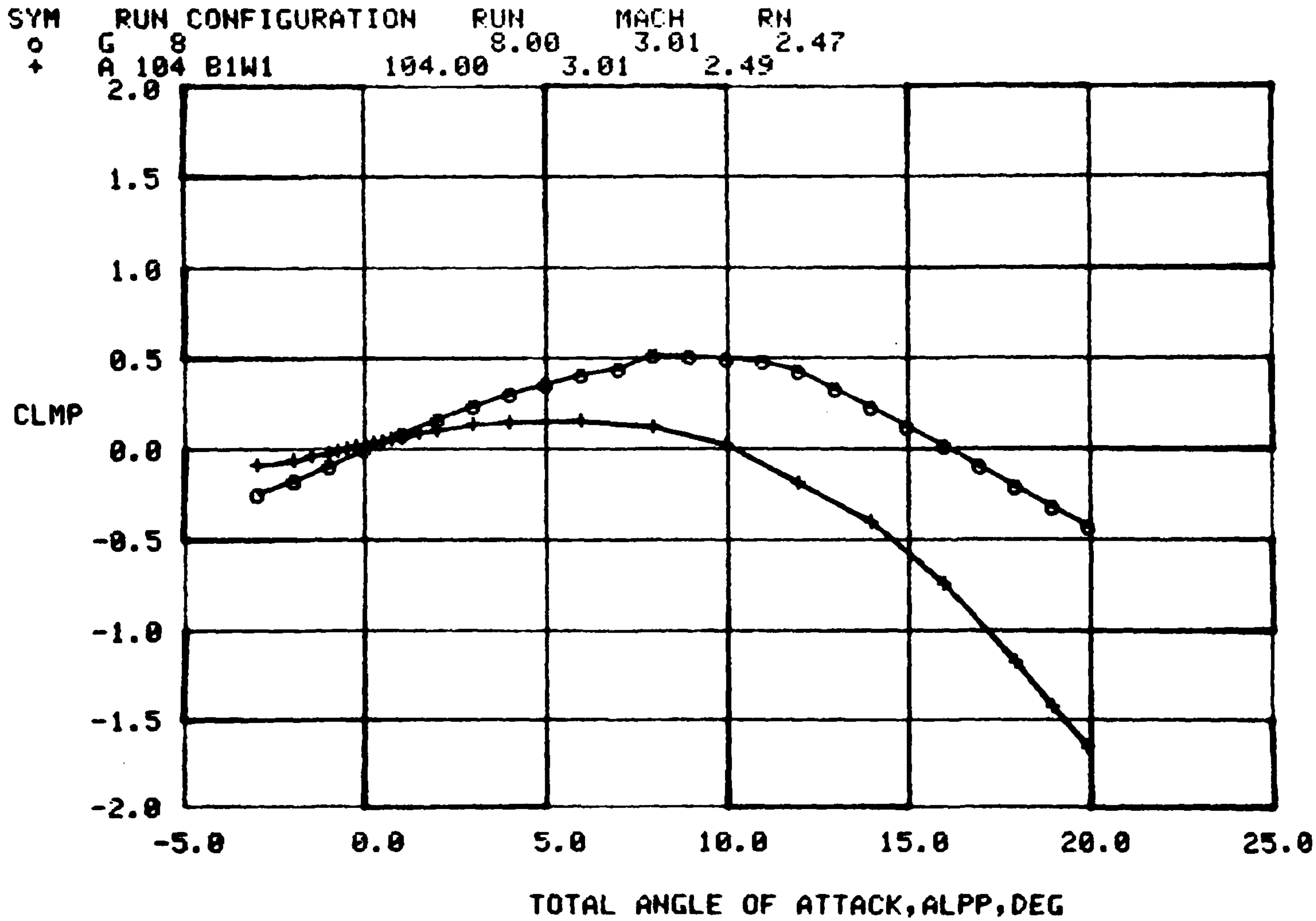


Figure 18. Body wing pitching moment vs angle of attack at M = 3.01.

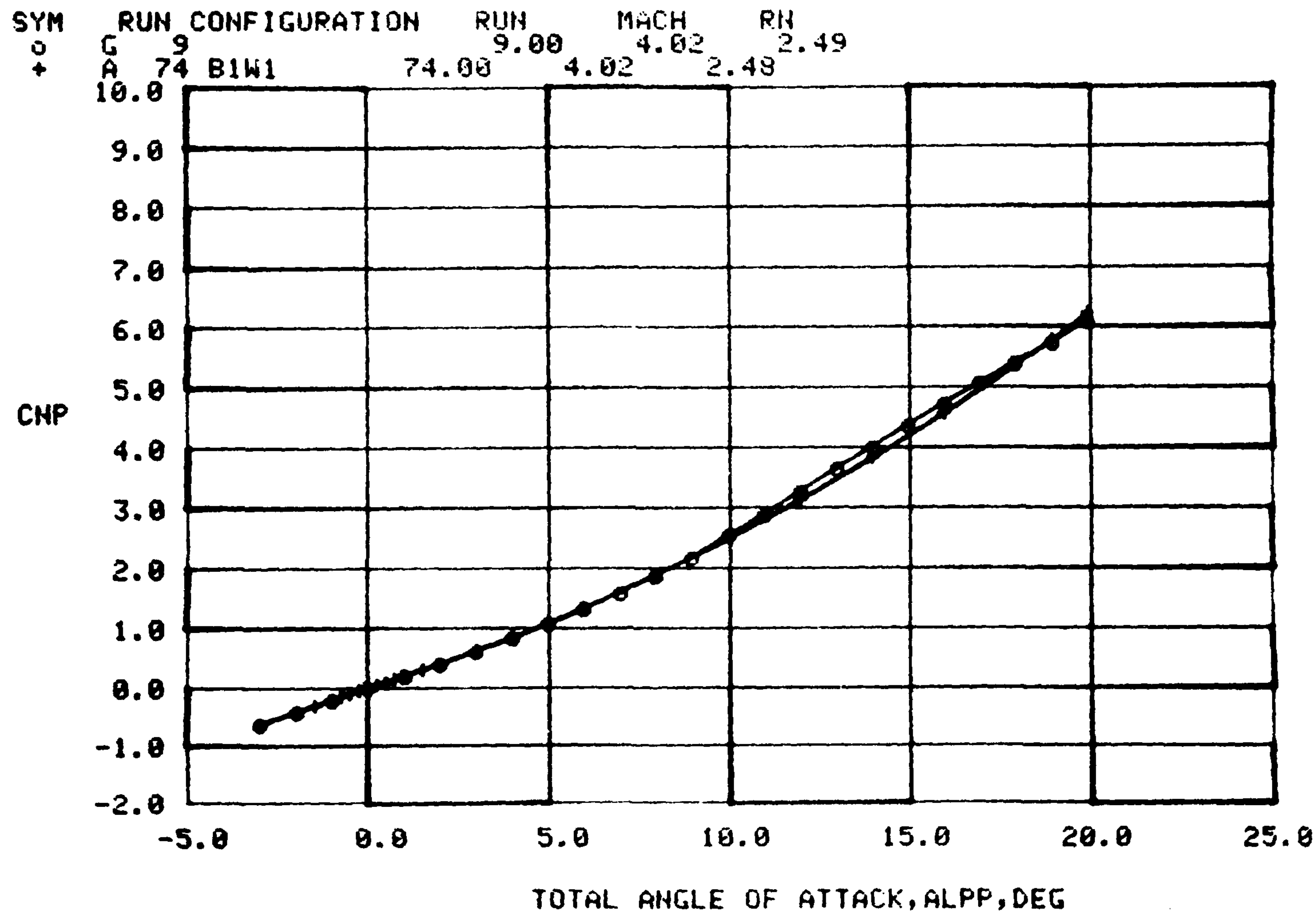


Figure 19. Body wing normal force coefficient vs angle of attack at M = 4.02.

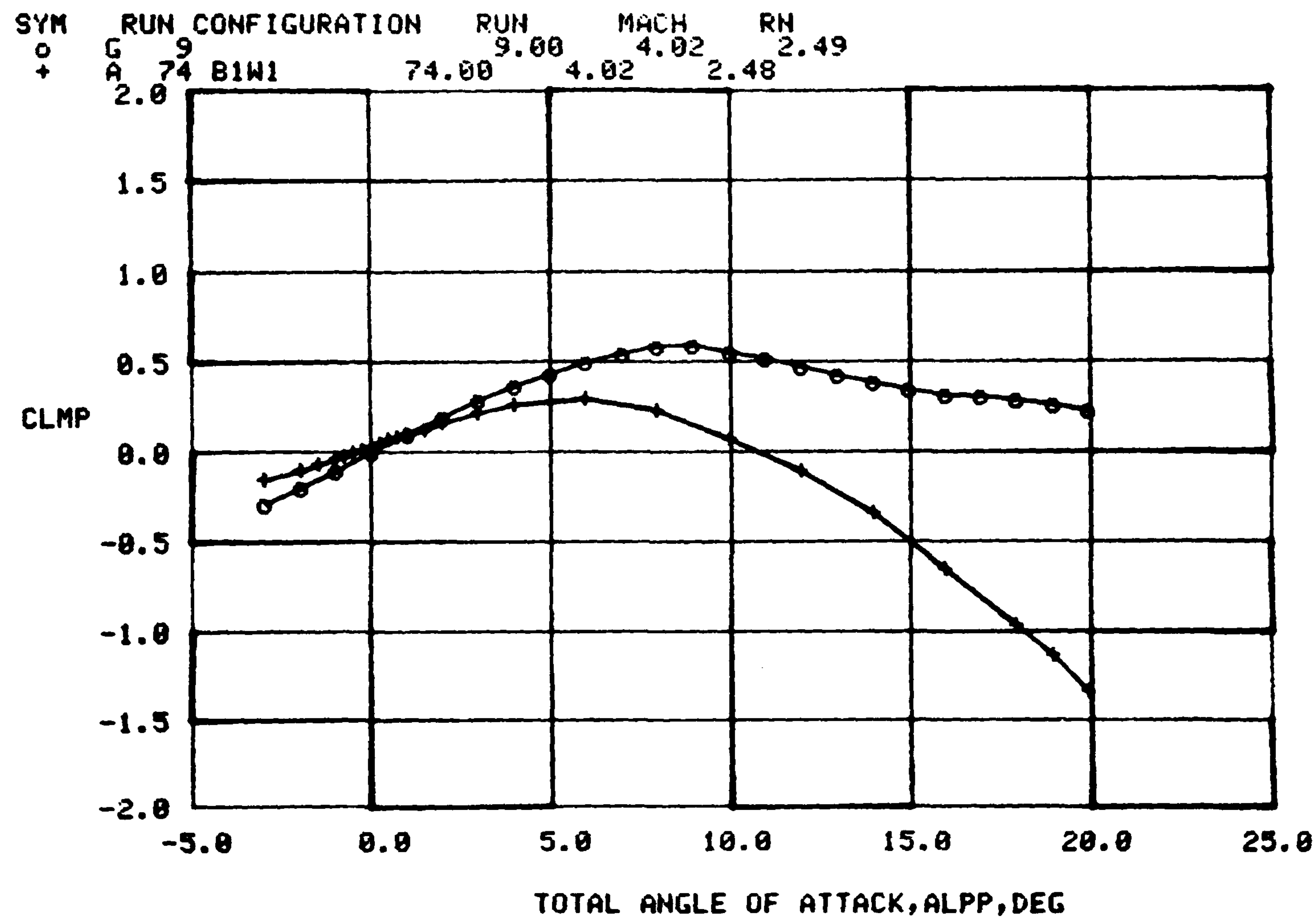


Figure 20. Body wing pitching moment coefficient vs angle of attack at M = 4.02.

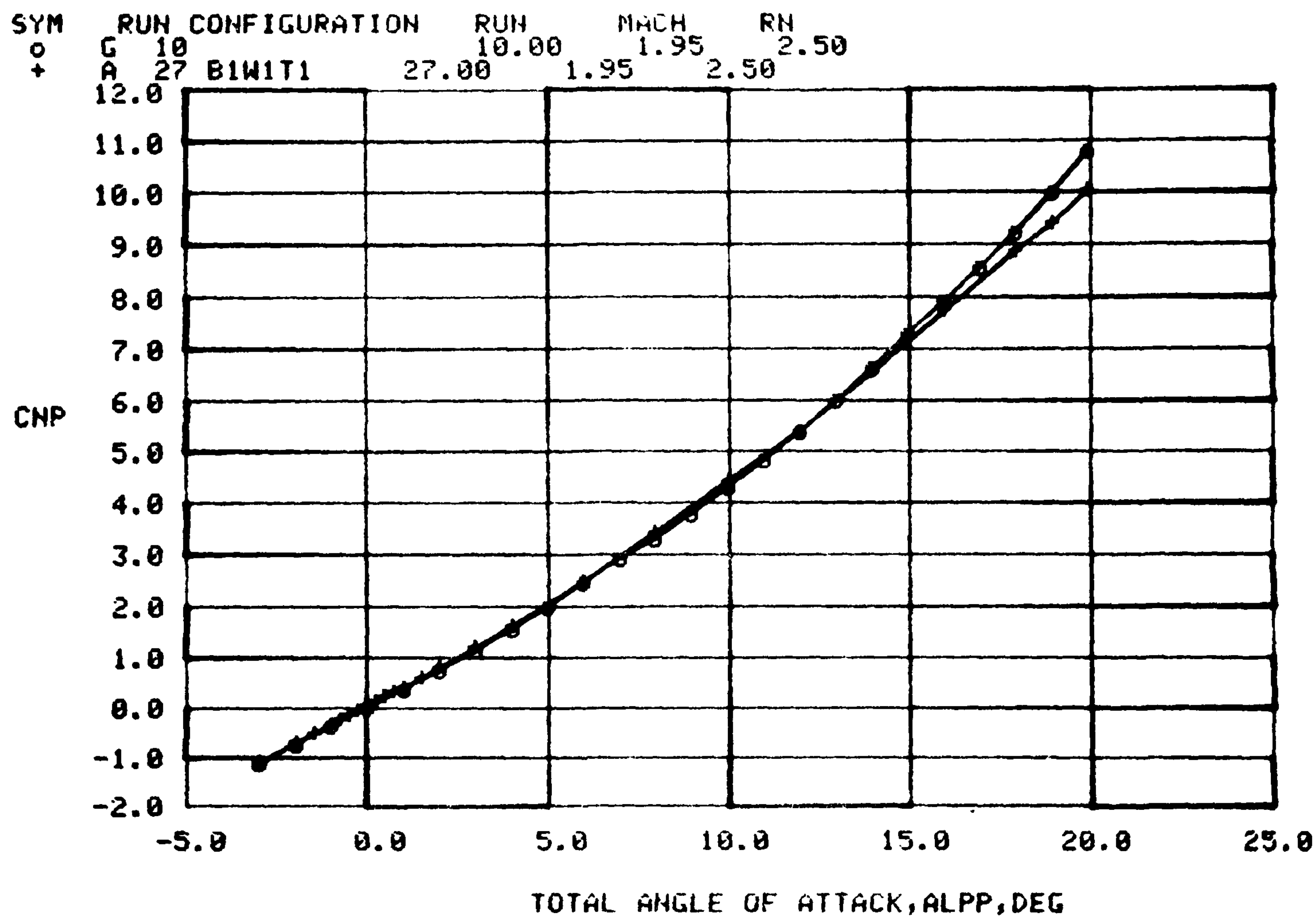


Figure 21. Body wing-tail normal force coefficient vs angle of attack at M = 1.95.

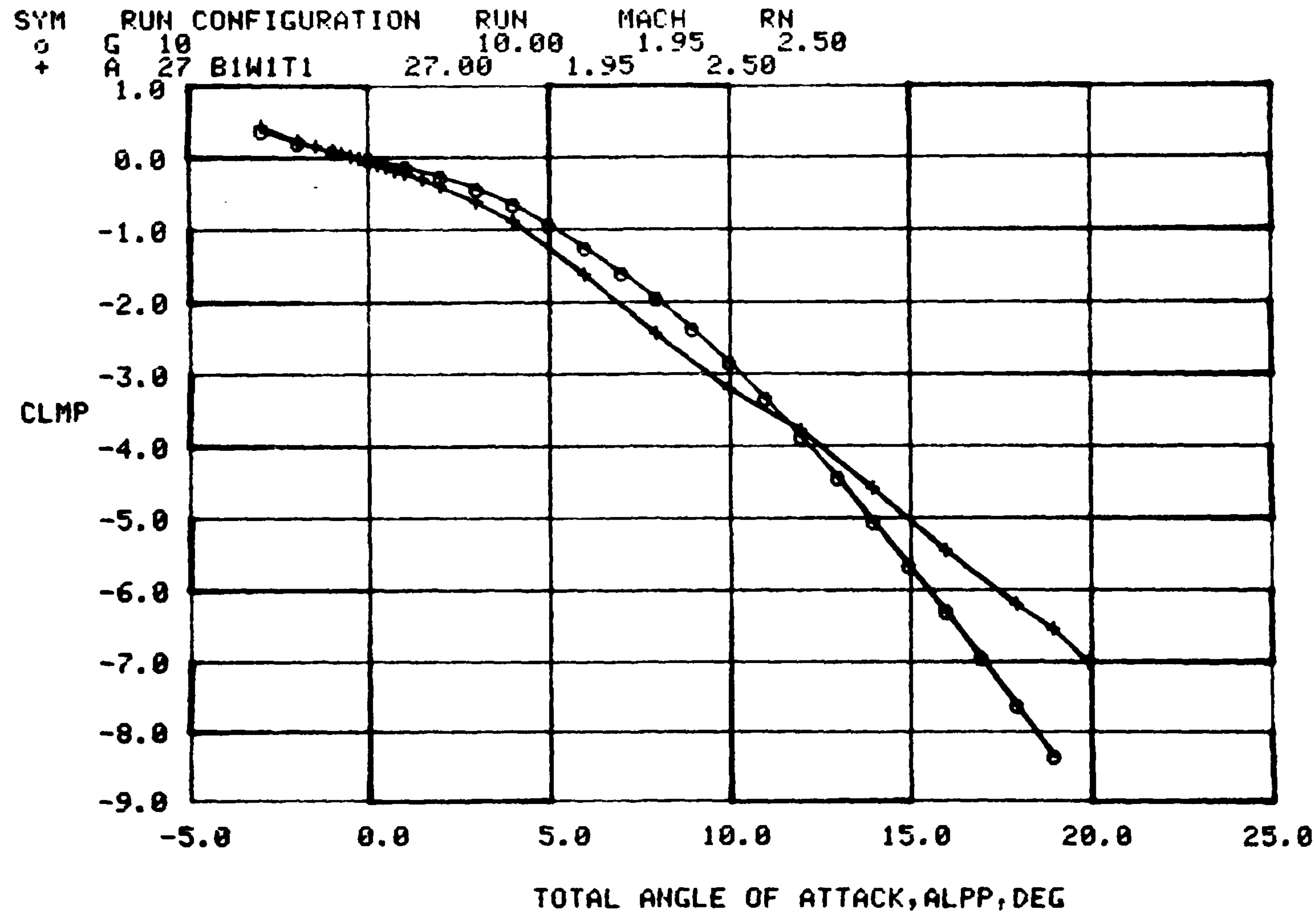


Figure 22. Body-wing-tail pitching moment coefficient vs angle of attack at M = 1.95.

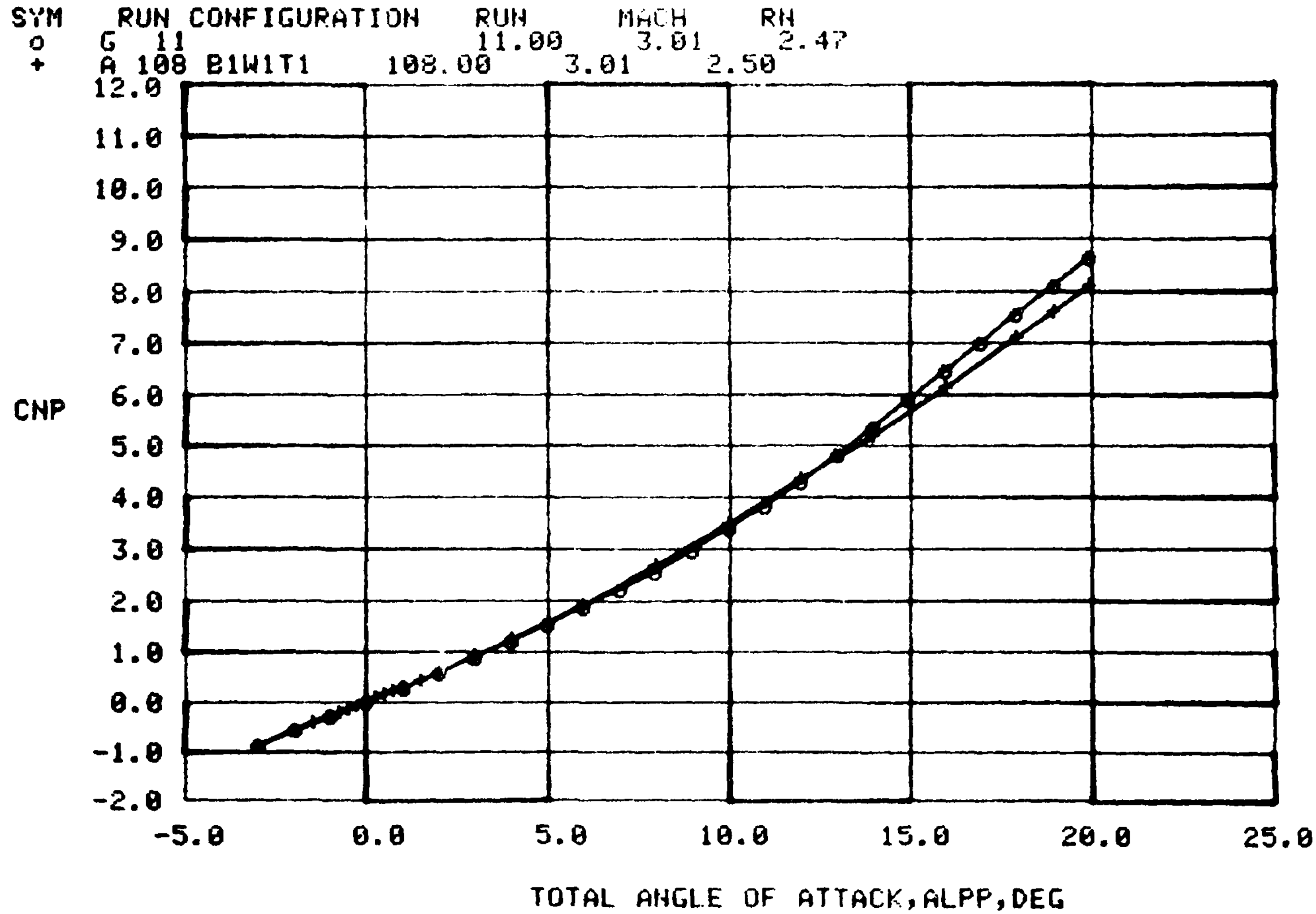


Figure 23. Body-wing-tail normal force coefficient vs angle of attack at M = 3.01.

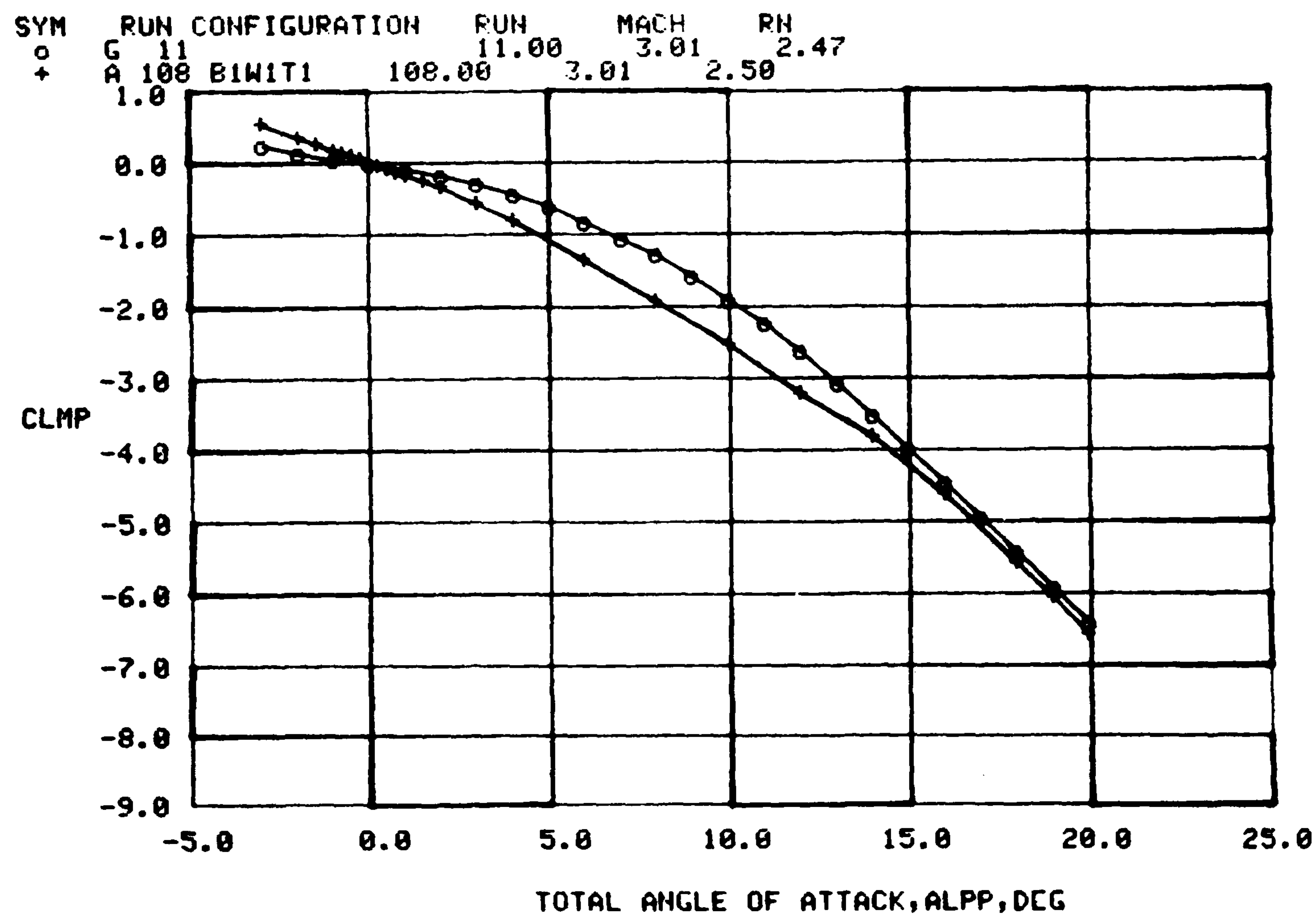


Figure 24. Body-wing-tail pitching moment coefficient vs angle of attack at M = 3.01.

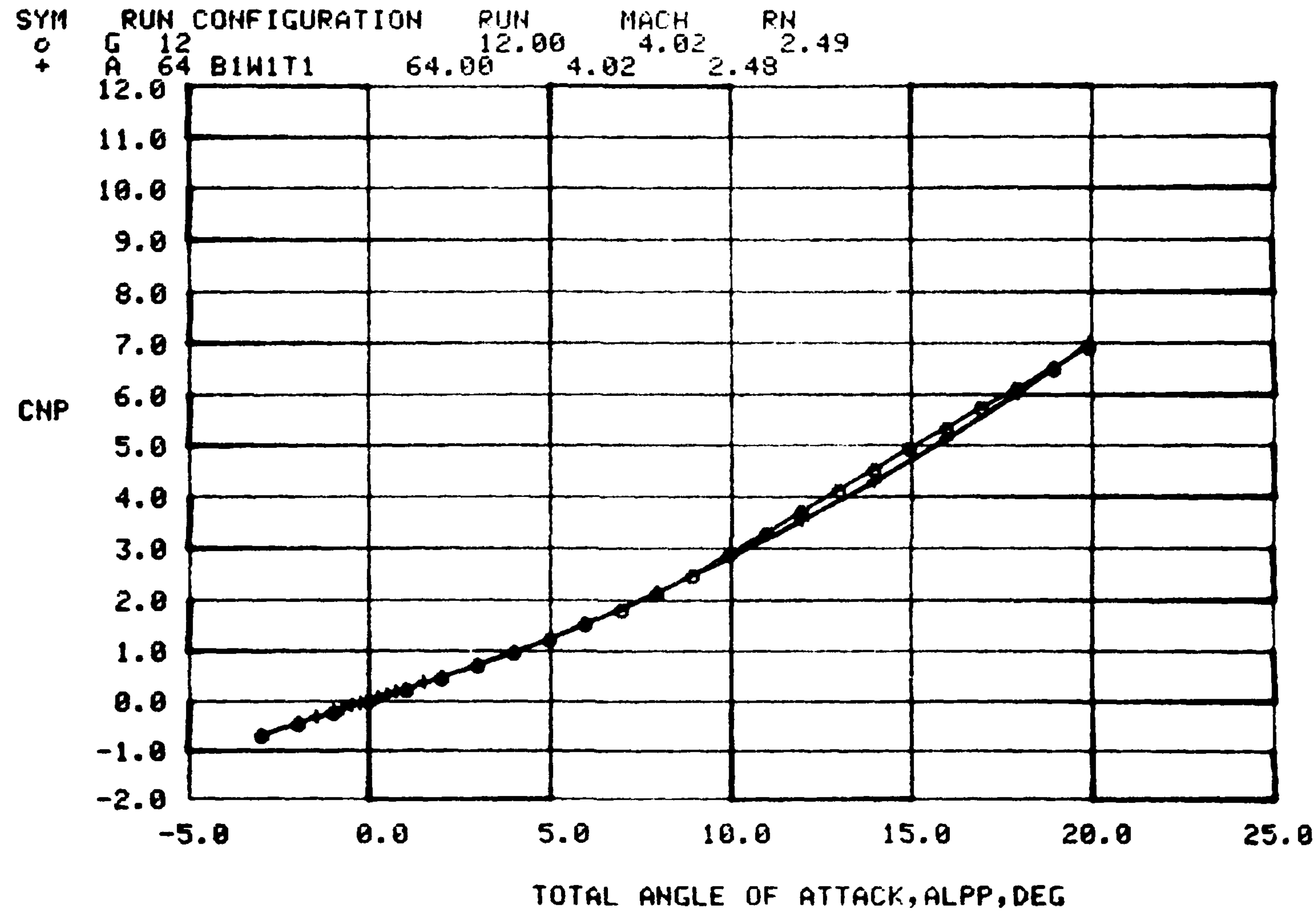


Figure 25. Body-wing-tail normal force coefficient vs angle of attack at M = 4.02.

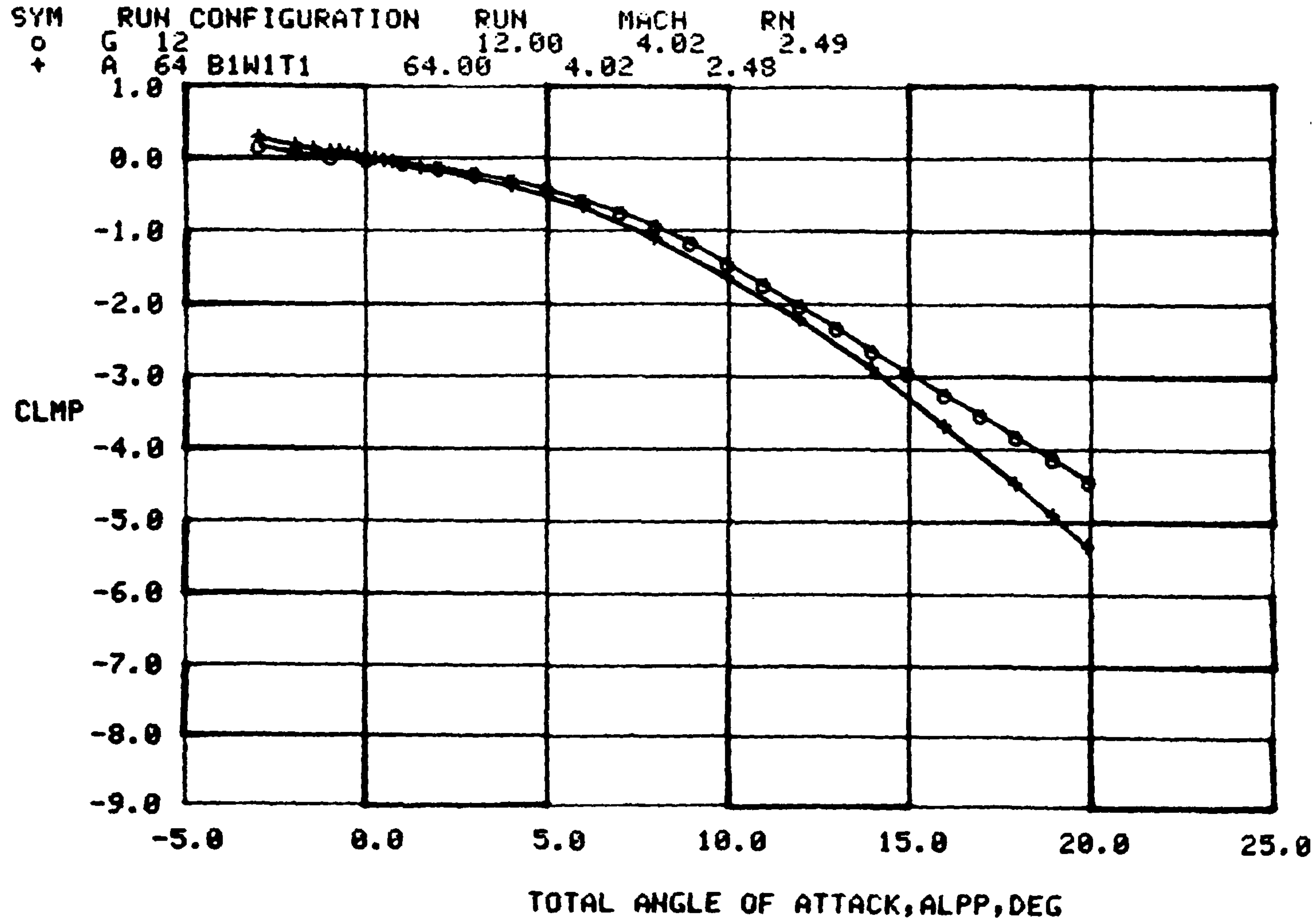
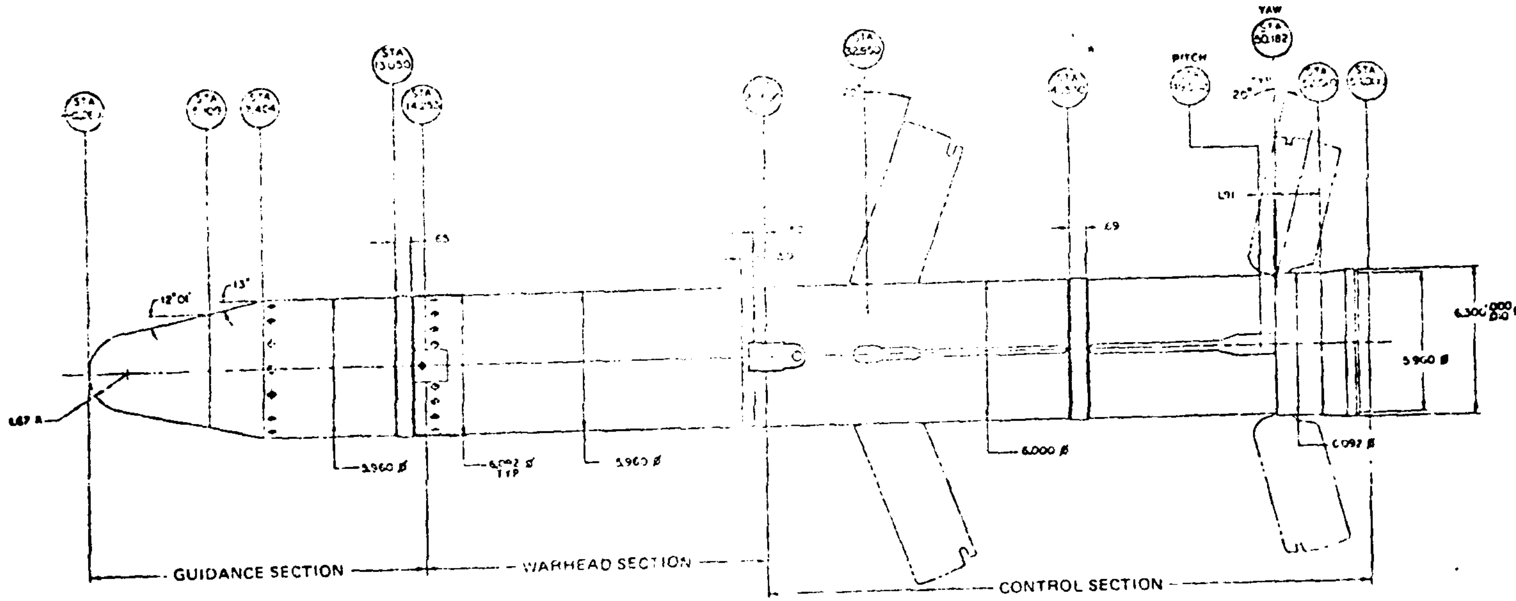


Figure 26. Body-wing-tail pitching moment coefficient vs angle of attack at M = 4.02.

MOMENT REFERENCE CENTER STATION 31.36



SOURCE: Ref. 1

Figure 27. Full-scale Copperhead model configuration.

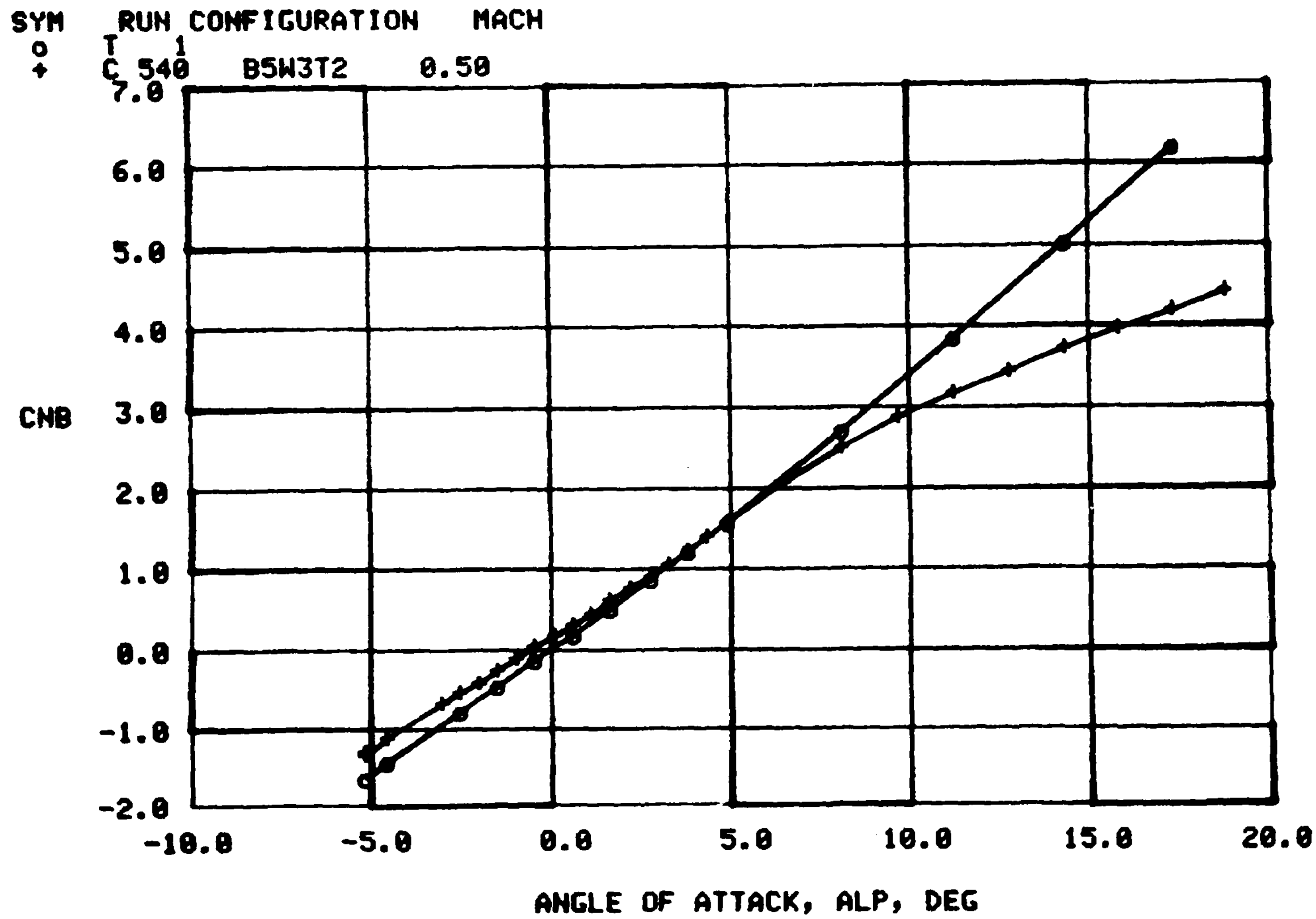


Figure 28. Normal force coefficient vs angle of attack at $M_\infty = 0.5$.

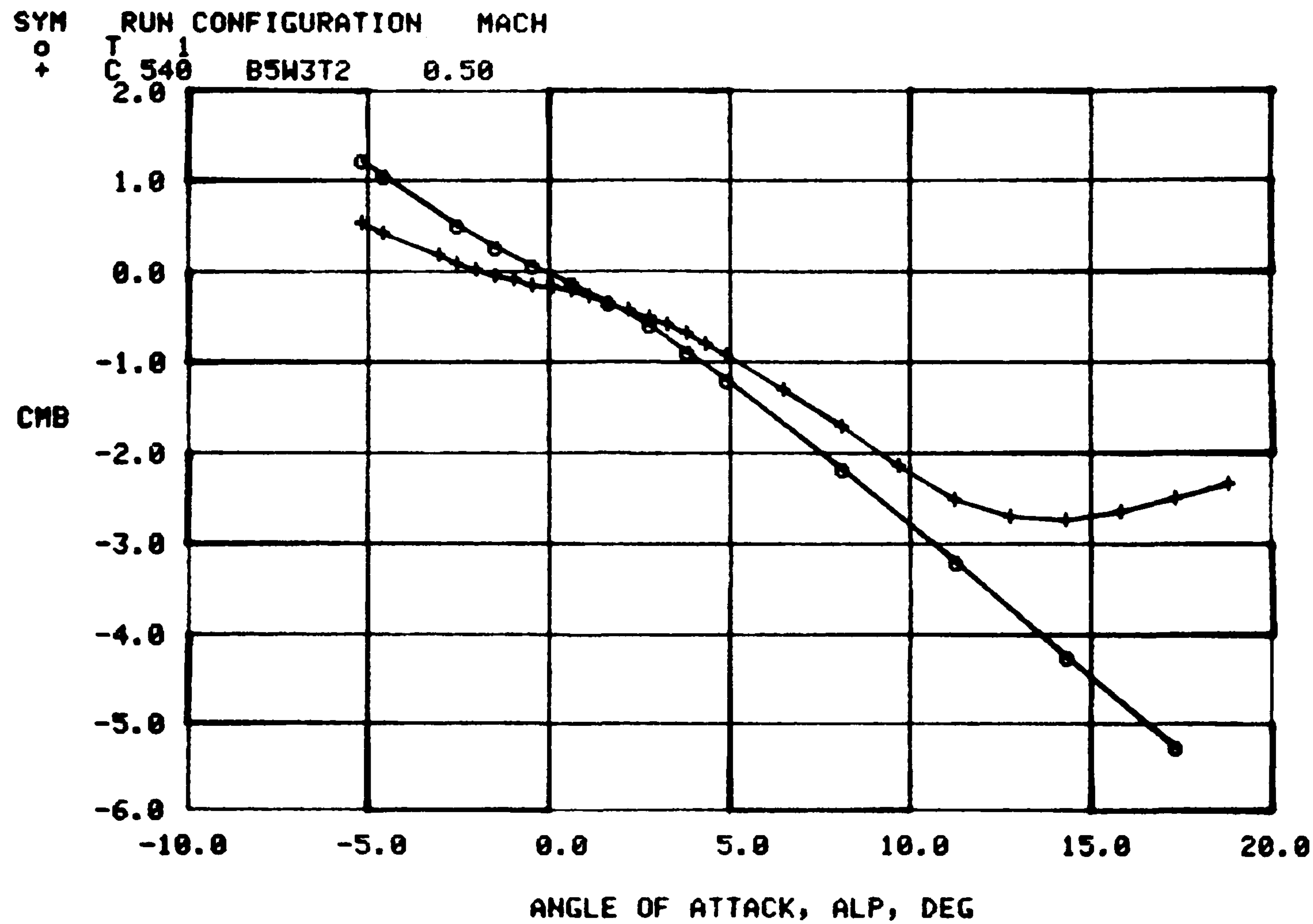


Figure 29. Pitching moment coefficient vs angle of attack at $M_\infty = 0.5$.

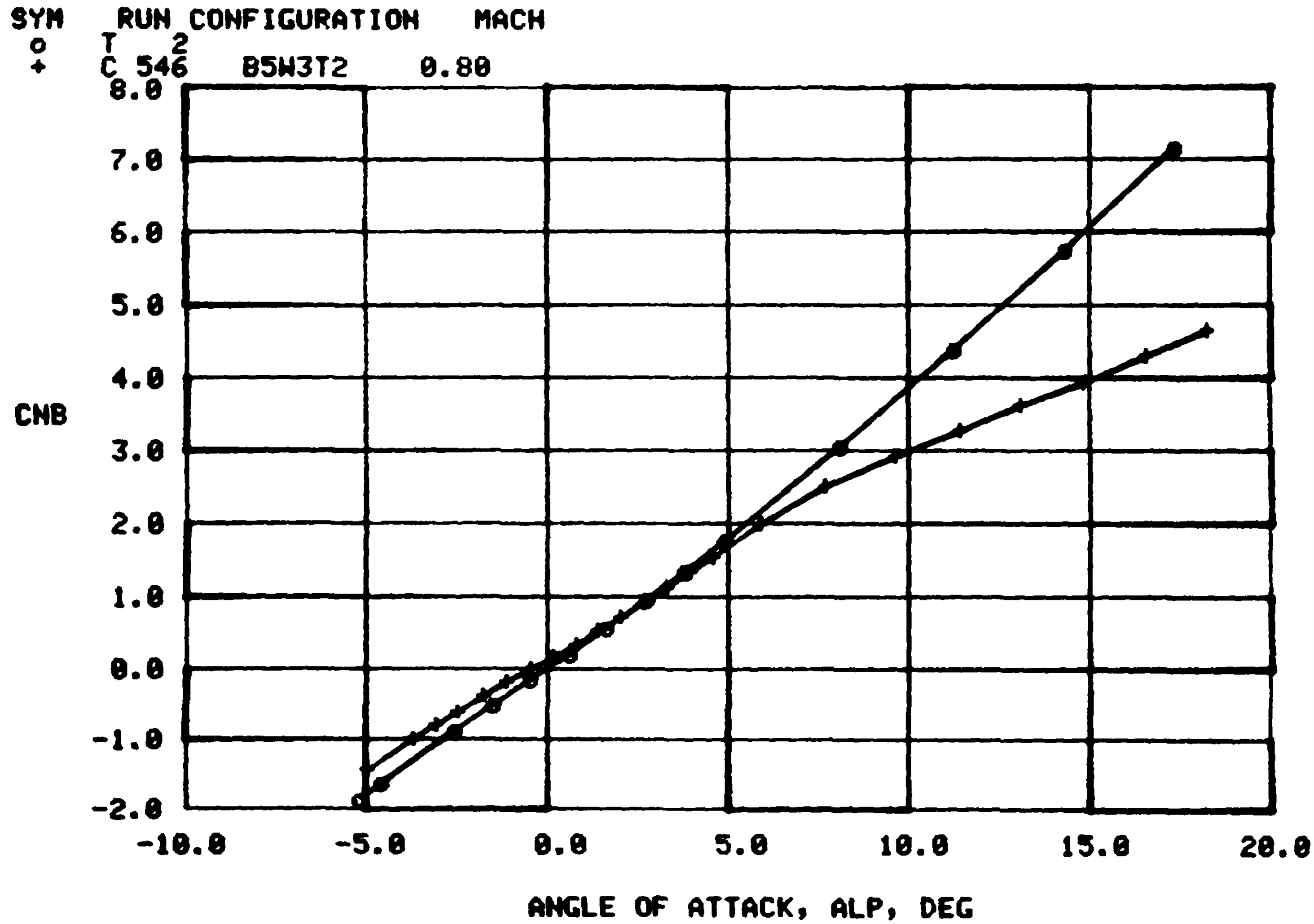


Figure 30. Normal force coefficient vs angle of attack at $M\infty = 0.8$.

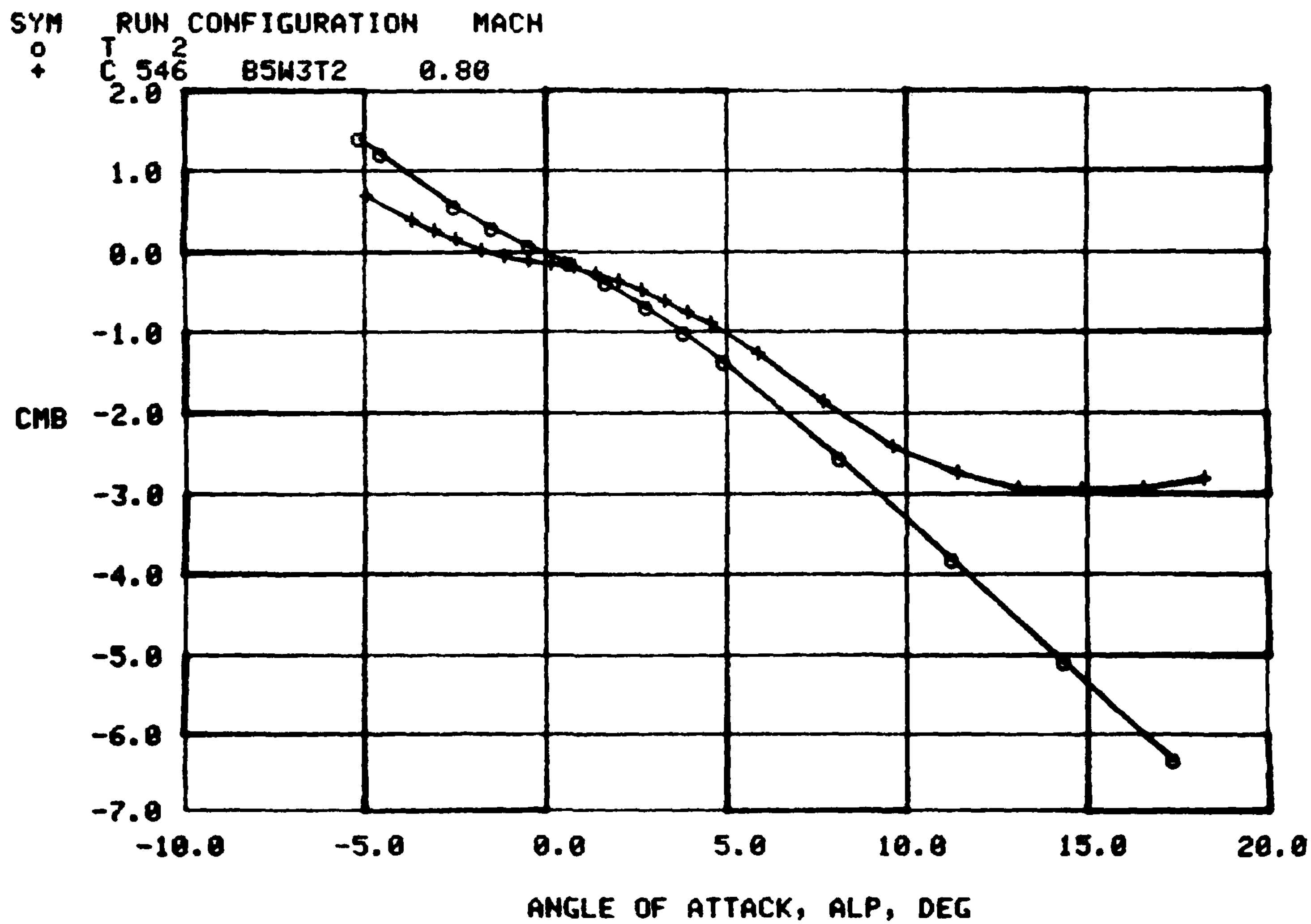


Figure 31. Pitching moment coefficient vs angle of attack at M_∞ = 0.8.

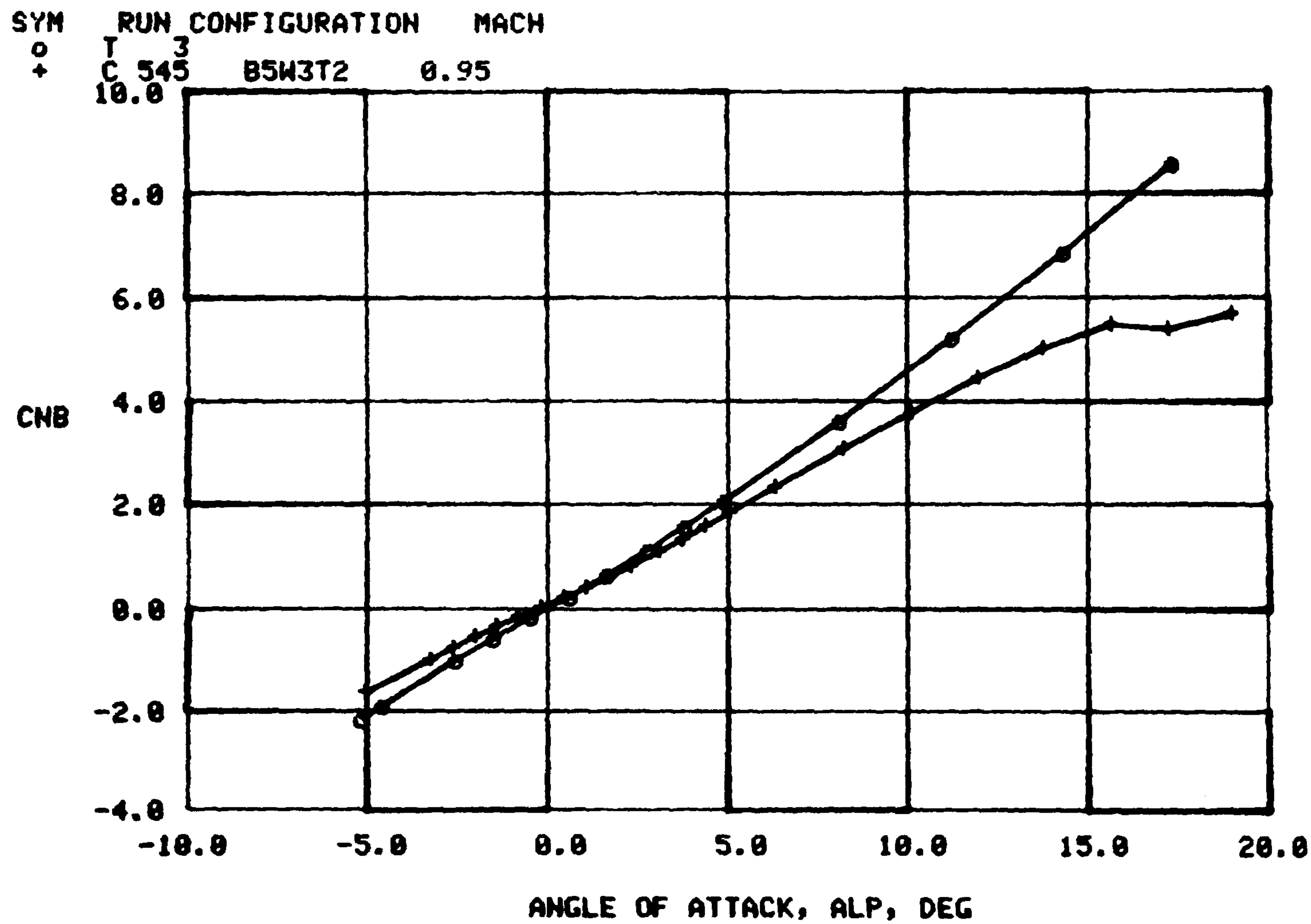


Figure 32. Normal force coefficient vs angle of attack at M_∞ = 0.95.

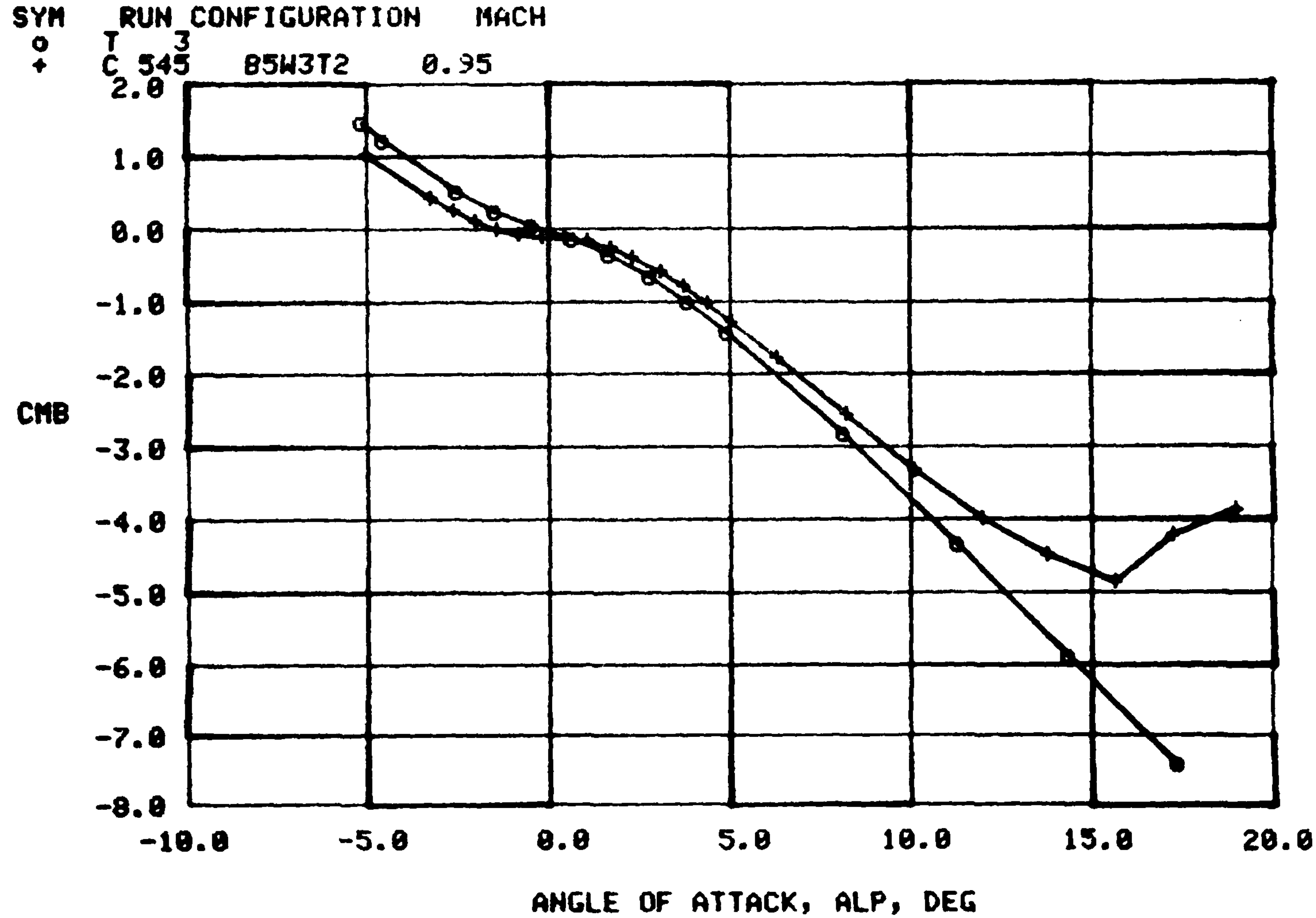
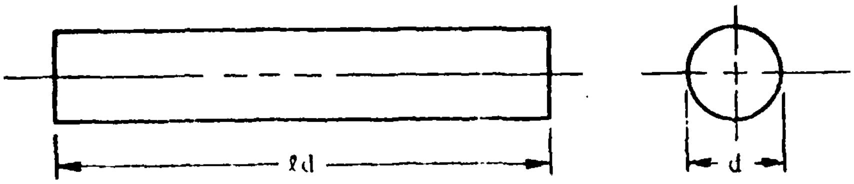
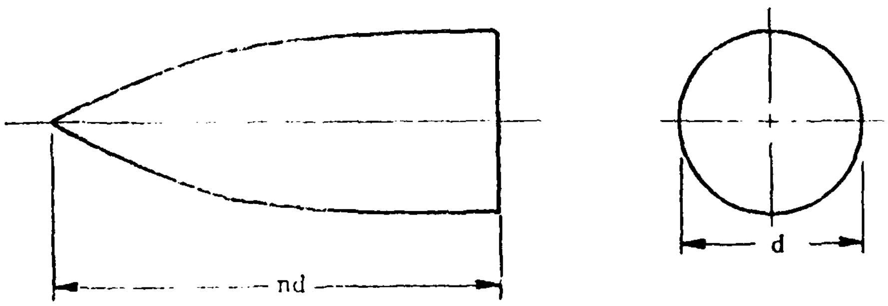


Figure 33. Pitching moment coefficient vs angle of attack at M_∞ = 0.95.



AFTERBODY CONFIGURATION	d (in.)	ℓ
A1	3.75	7.00
A2	3.75	7.50
A3	3.75	8.25
A4	3.75	9.50
A5	3.75	11.50
A6	4.00	7.00



NOSE CONFIGURATION	GEOMETRY	d (in.)	n
N1	TANGENT OGIVE	3.75	3.0
N2	TANGENT OGIVE	3.75	2.5
N3	CONE	3.75	3.0
N4	SECANT OGIVE	4.00	2.0

NOTE: ALL MOMENTS REFERENCED TO NOSE (STA. 0.0)

Figure 34. Nose-afterbody nomenclature.

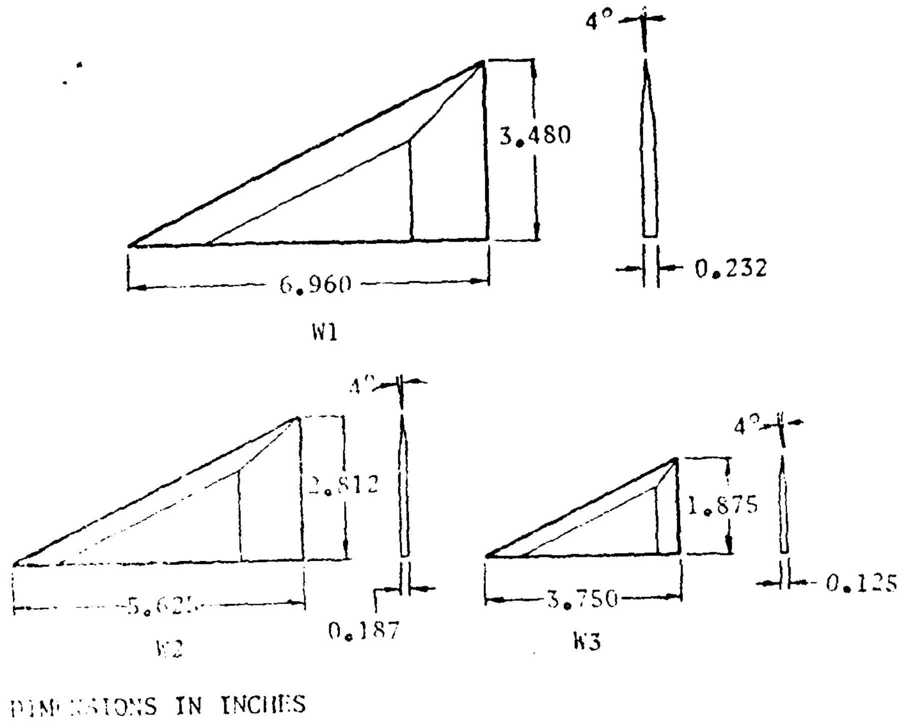
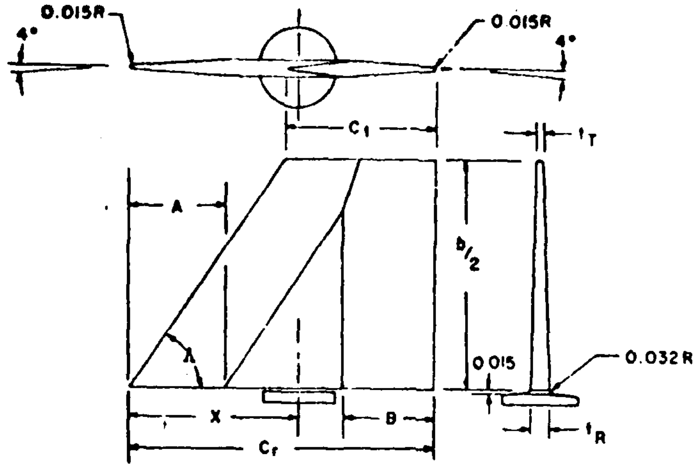


Figure 35. Wing configurations (Tests "F" and "I").



Tail Fin Config.	S_f, in.^{2}	AR	b/2, in.	[illegible]	[illegible]	A, in.	C_t, in.	B, in.	C_r, in.	X/C_r	t_r, in.	t_t
→ 11	7.028	1.0	1.875	1.0	90°	0.800	3.749	0.800	3.749	0.45	0.140	0.140
12	7.942	2.0	2.821	0	26°34'	1.172	0	1.140	5.625	0.62	0.187	0.187
13	7.916	2.0	2.821	0.5	56°19'	1.158	1.873	1.140	3.749	0.55	0.187	0.187
14	7.038	1.0	1.875	0	14°3'	1.195	0	1.140	7.499	0.62	0.187	0.187
15	7.024	1.0	1.875	0.5	36°51'	1.165	2.497	1.140	4.996	0.55	0.187	0.187
16	7.916	2.0	2.821	1.0	90°	0.800	2.813	0.800	2.813	0.45	0.140	0.140
21	3.513	2.0	1.875	1.0	90°	0.696	1.874	0.696	1.874	0.45	0.125	0.125
22	3.509	2.0	1.875	0	26°34'	0.728	0	0.694	3.749	0.62	0.125	0.125
23	3.605	2.0	1.875	0.5	55°38'	0.712	1.282	0.694	2.565	0.55	0.125	0.125
31	14.030	0.5	1.875	0.5	20°36'	1.626	4.990	1.587	9.980	0.55	0.250	0.125
32	14.036	0.5	1.875	1.0	90°	1.587	7.499	1.587	7.499	0.45	0.250	0.250
33	19.235	2.0	4.385	1.0	90°	1.587	4.395	1.587	4.395	0.45	0.250	0 250
34	18.373	2.0	4.385	0.5	57°35'	1.606	2.792	1.587	5.585	0.55	0.250	0.125
35	19.212	2.0	4.385	0	26°37'	1.619	0	1.587	8.771	0.55	0.250	0.250
36	14.056	0.5	1.875	0	7°8'	1.682	0	1.587	14.998	0.55	0.250	0.250

SOURCE: Ref. 4

Figure 36. Details of straight fin configurations.

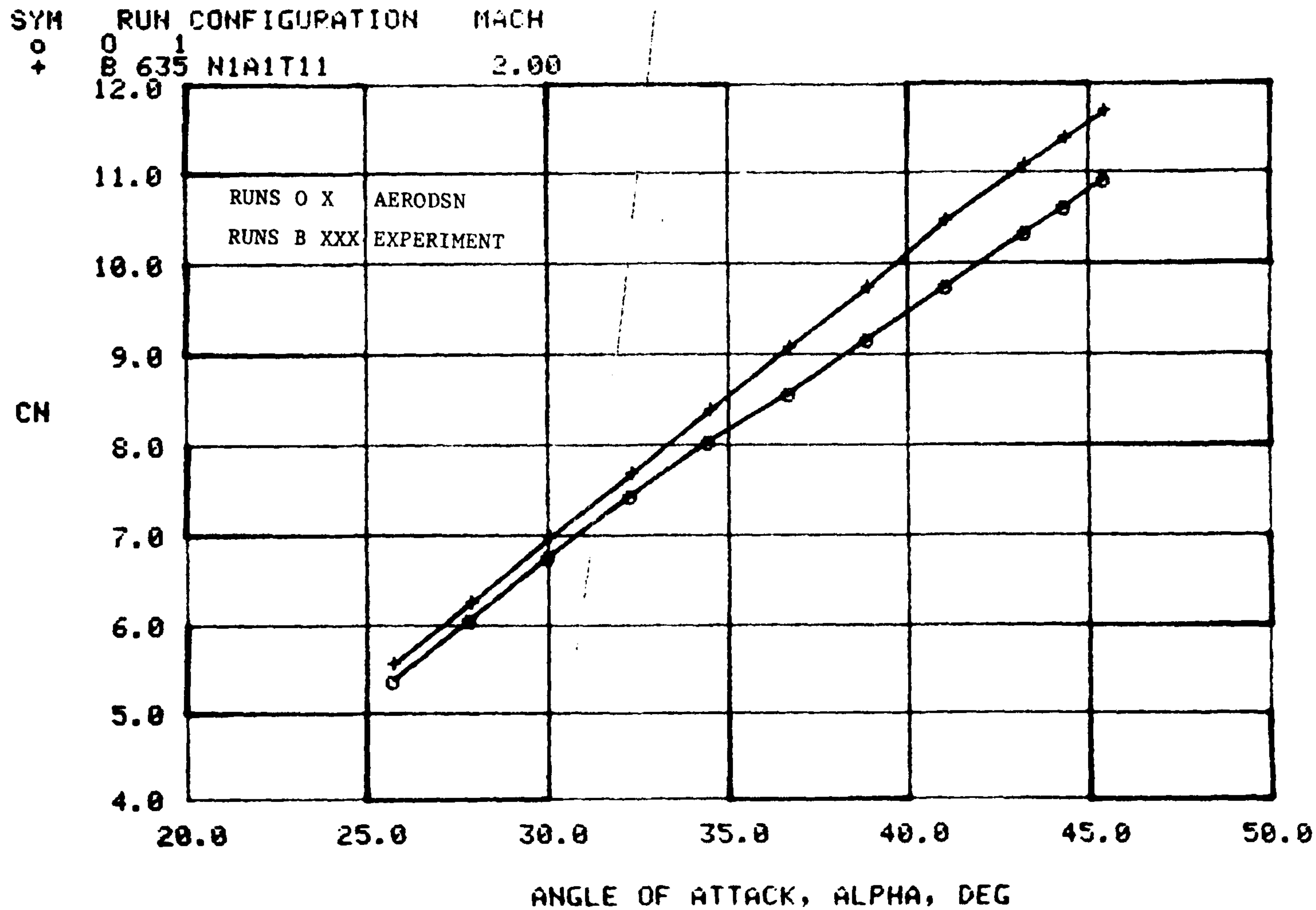


Figure 37. Normal force coefficient vs angle of attack at M_∞ = 2.0.

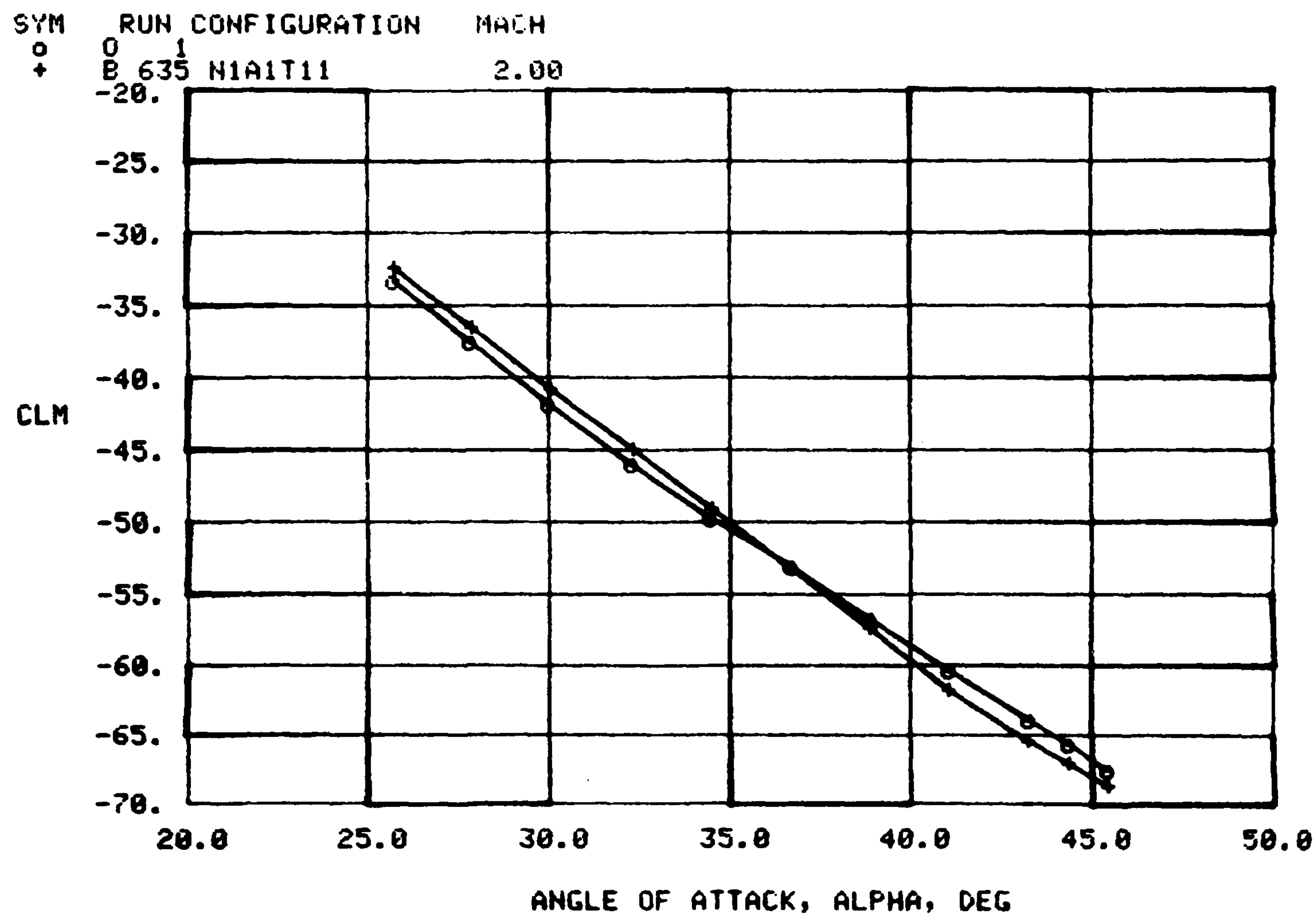


Figure 38. Pitching moment coefficient vs angle of attack at $M_\infty = 2.0$.

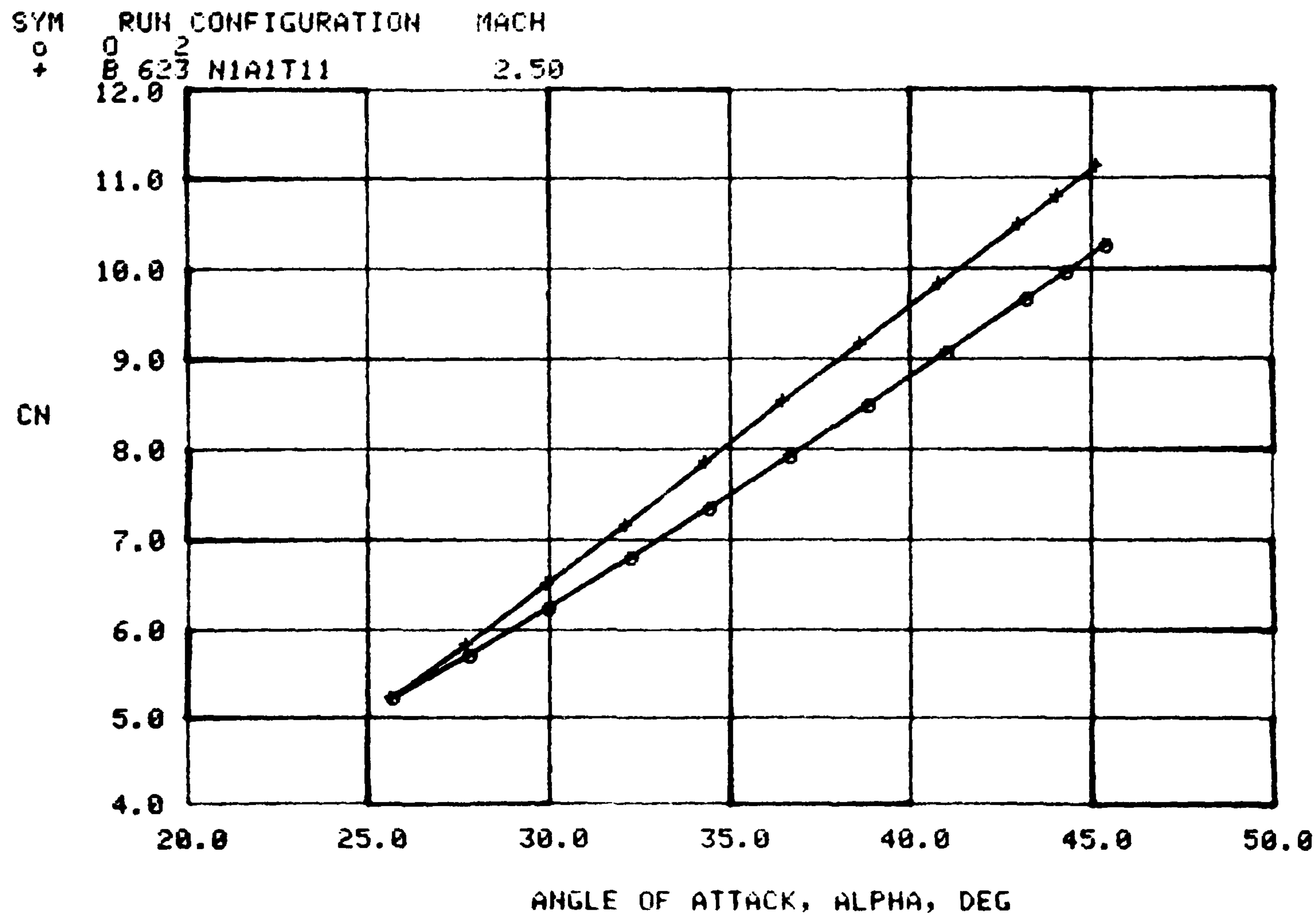


Figure 39. Normal force coefficient vs angle of attack at M∞ = 2.5.

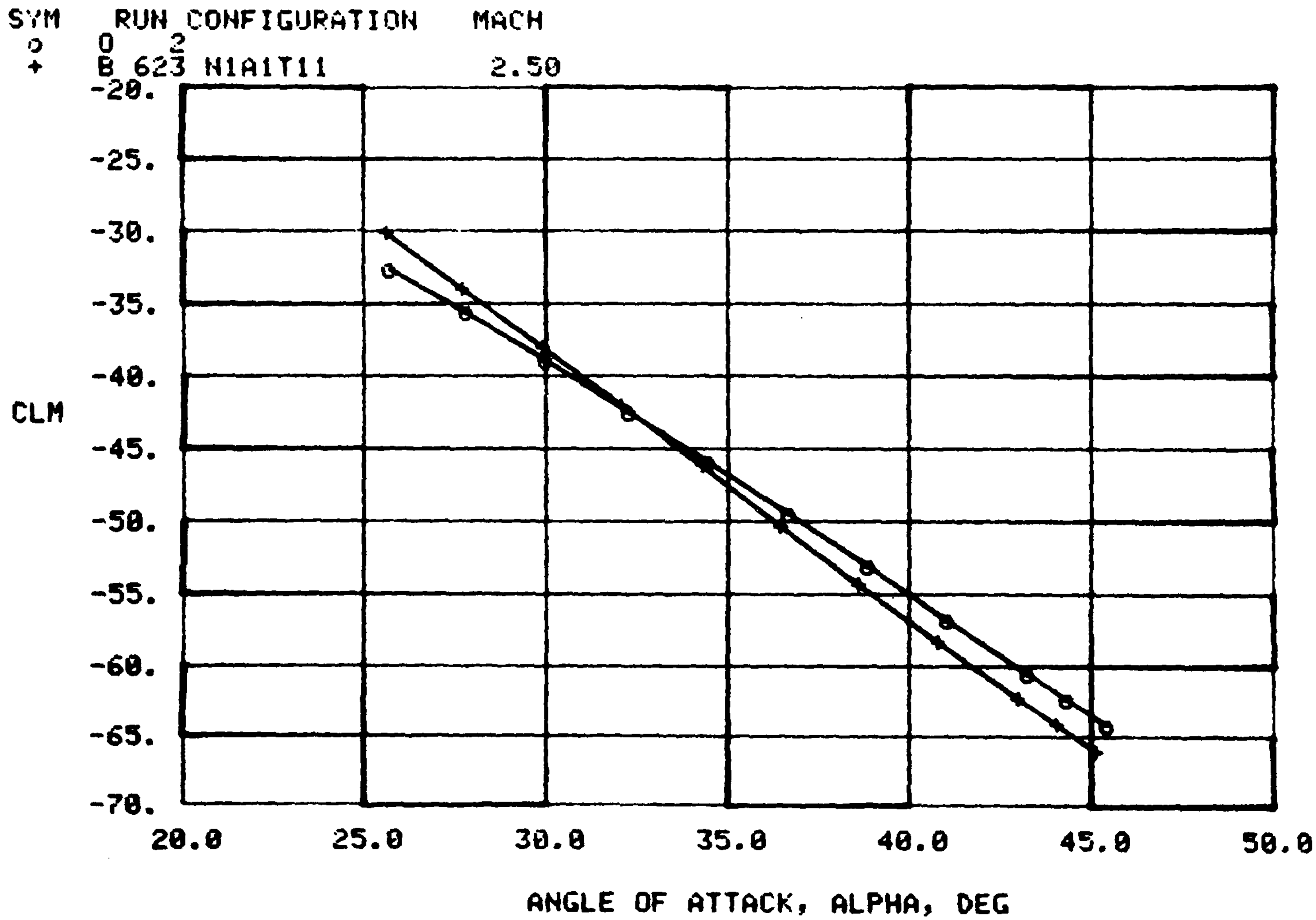


Figure 40. Pitching moment coefficient vs angle of attack at M_∞ = 2.5.

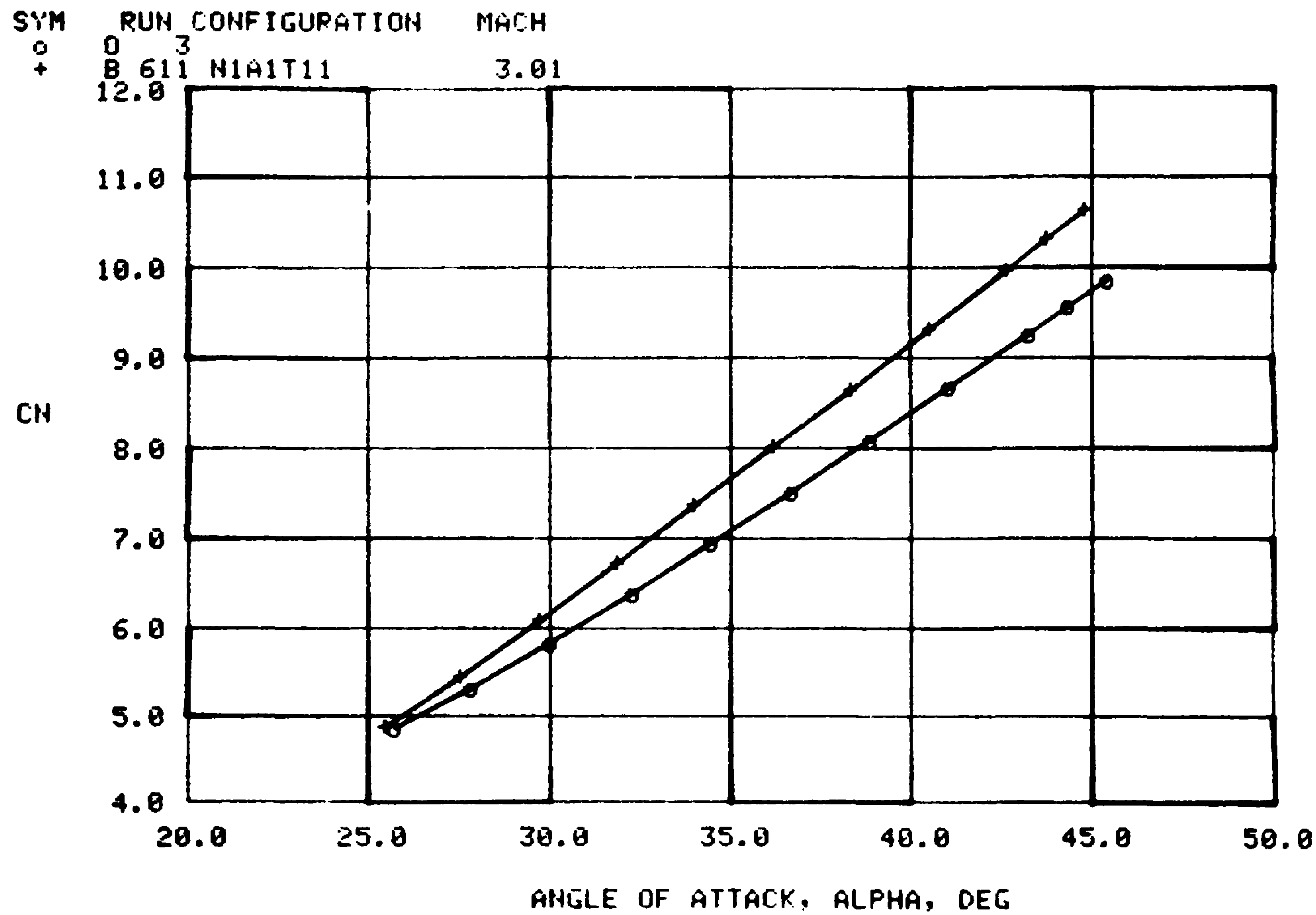


Figure 41. Normal force coefficient vs angle of attack at M_∞ = 3.01.

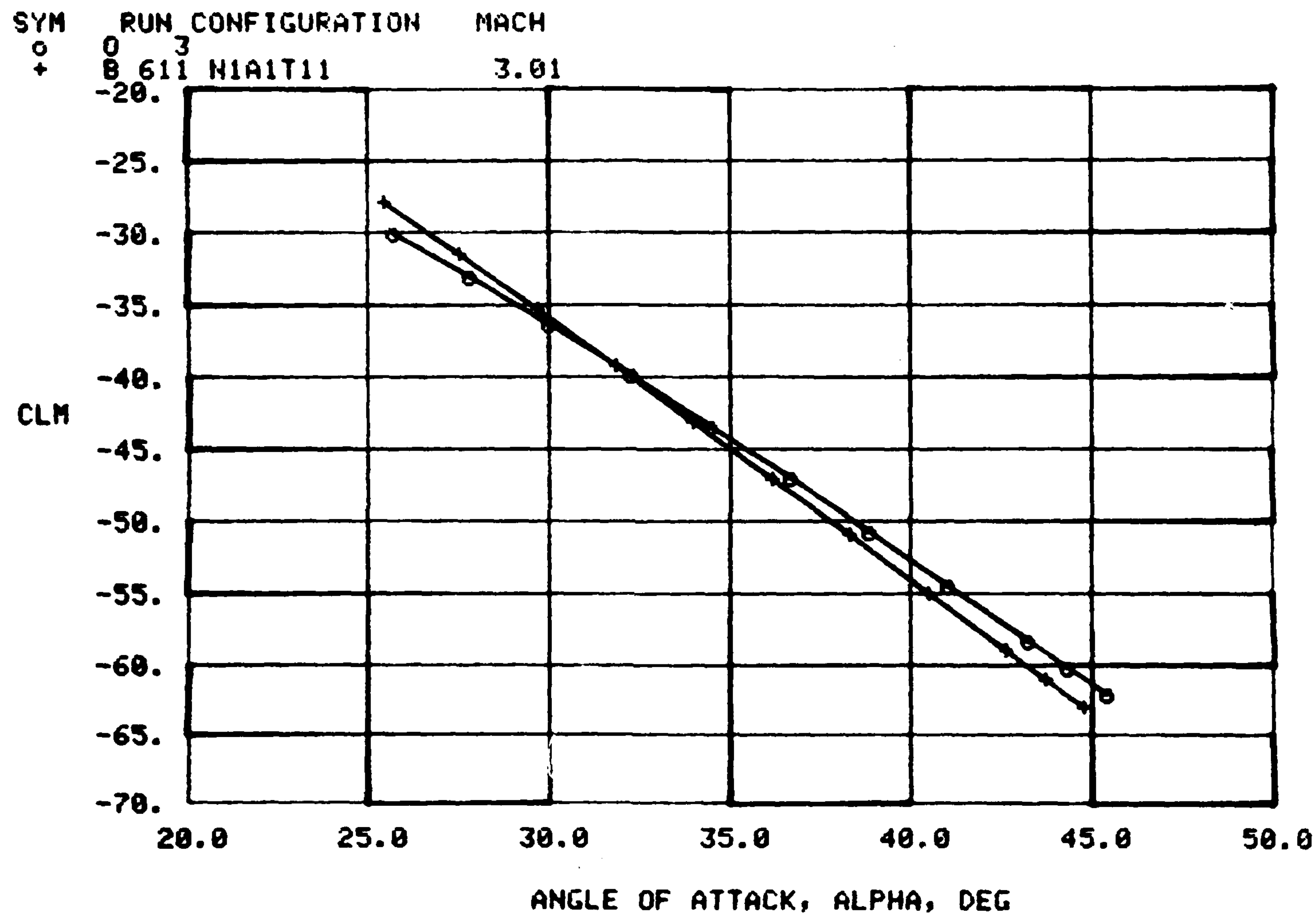
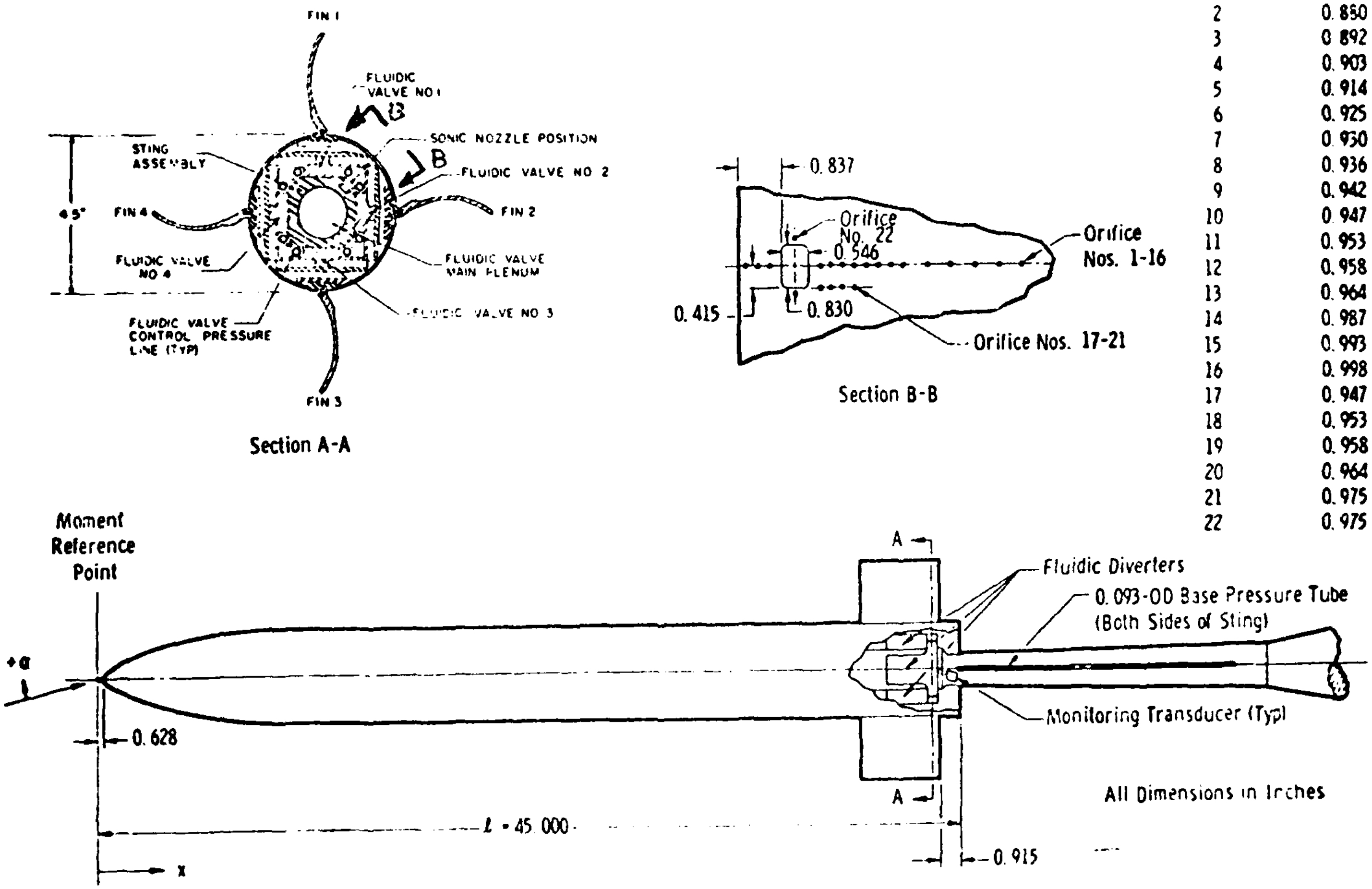


Figure 42. Pitching moment coefficient vs angle of attack at M∞ = 3.01.



Orifice No	Axial Location, x/ℓ
1	0.870
2	0.880
3	0.892
4	0.903
5	0.914
6	0.925
7	0.930
8	0.936
9	0.942
10	0.947
11	0.953
12	0.958
13	0.964
14	0.987
15	0.993
16	0.998
17	0.947
18	0.953
19	0.958
20	0.964
21	0.975
22	0.975

Figure 43. Configuration B1 model geometry.

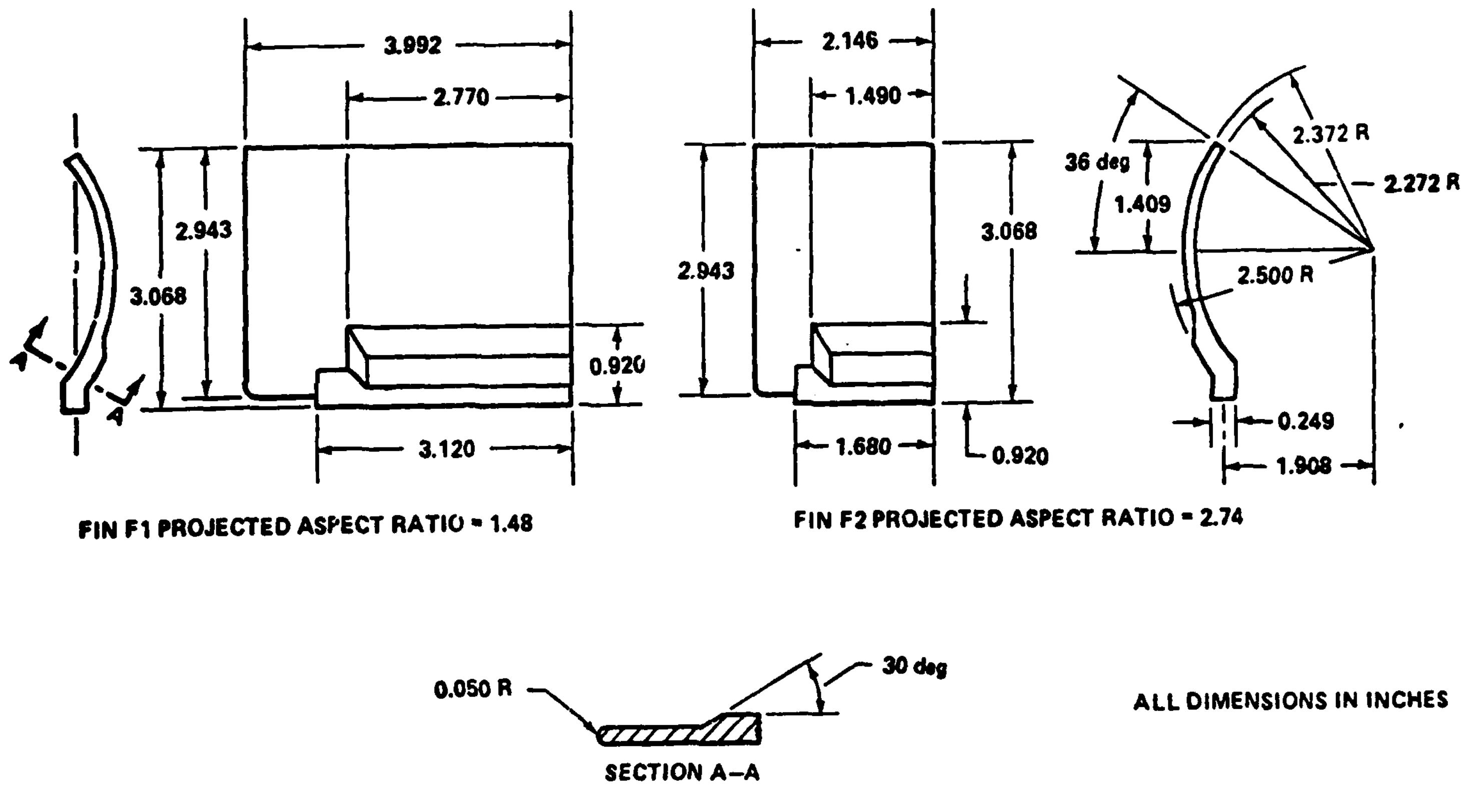


Figure 44. Fin details.

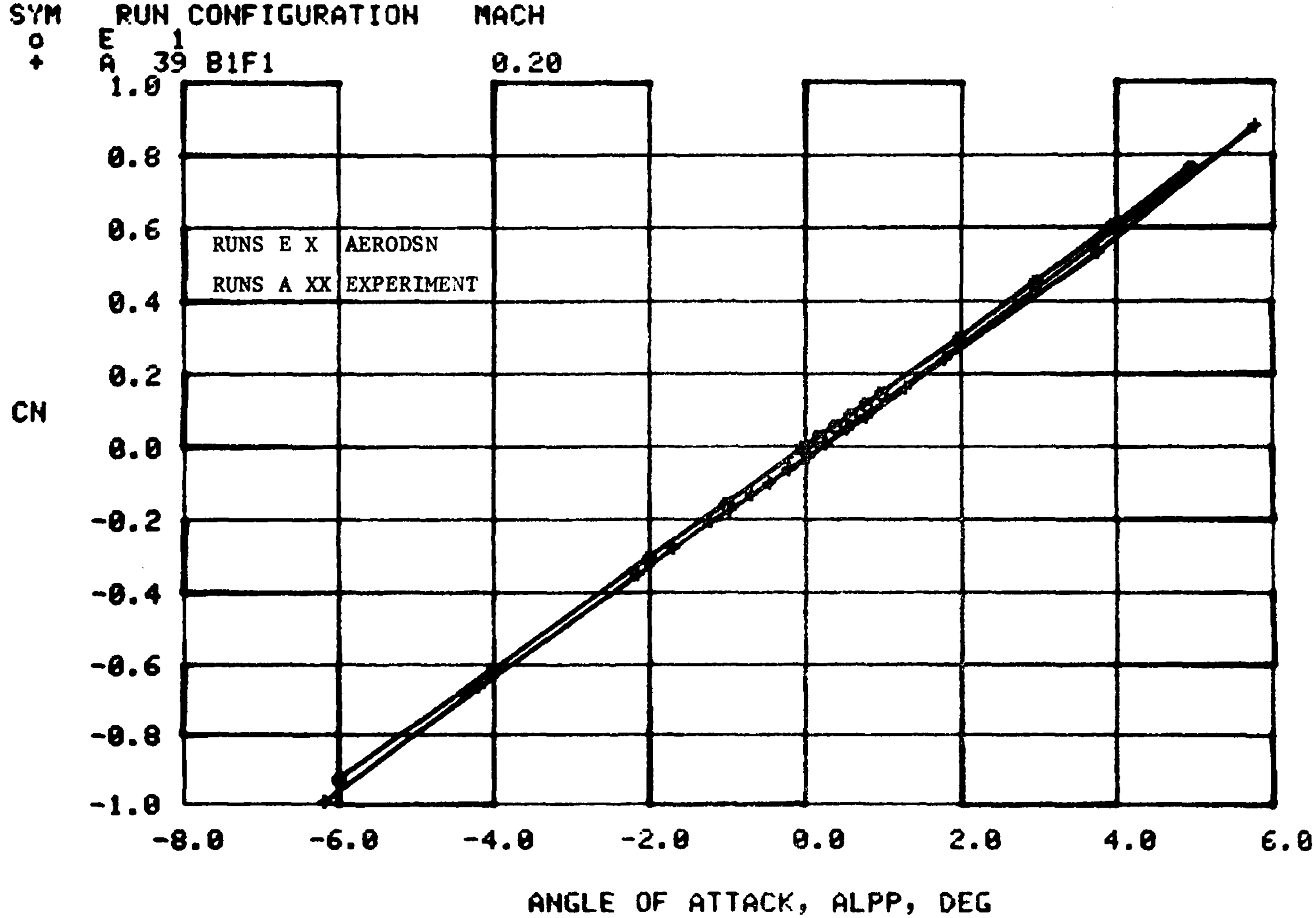


Figure 45. Normal force coefficient vs angle of attack at $M_\infty = 0.2$.

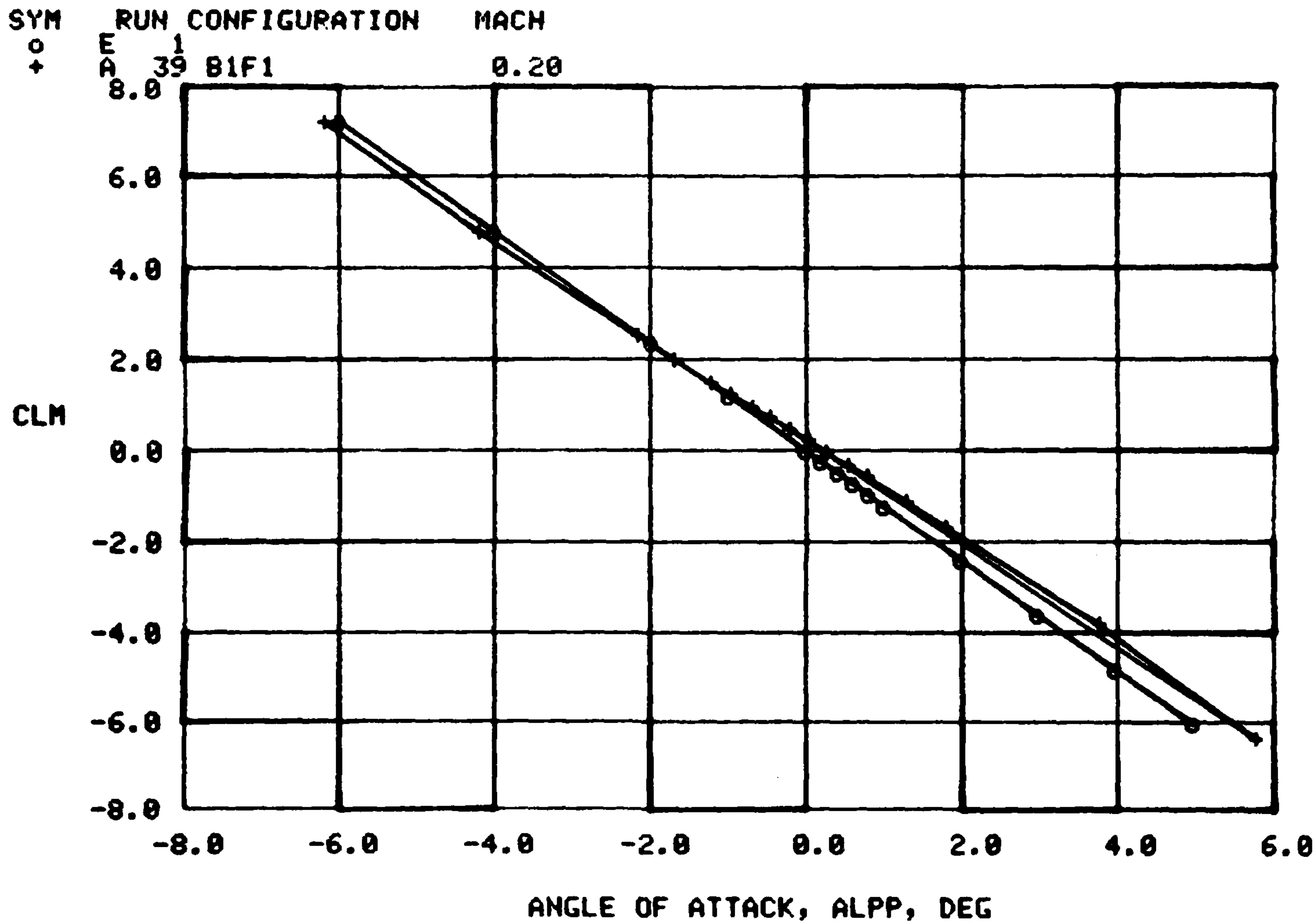


Figure 46. Pitching moment coefficient vs angle of attack at $M_\infty = 0.2$.

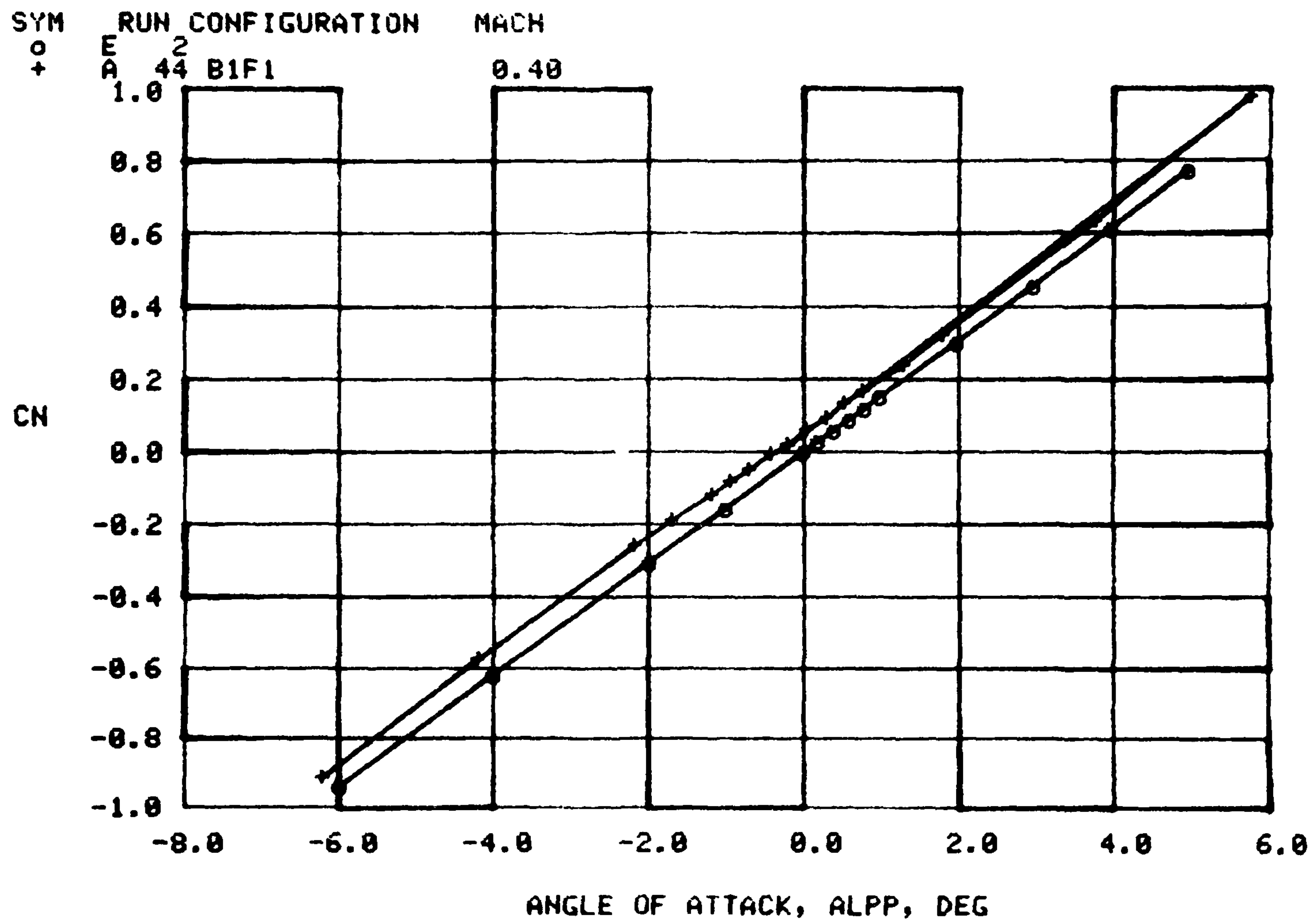


Figure 47. Normal force coefficient vs angle of attack at M_∞ = 0.4.

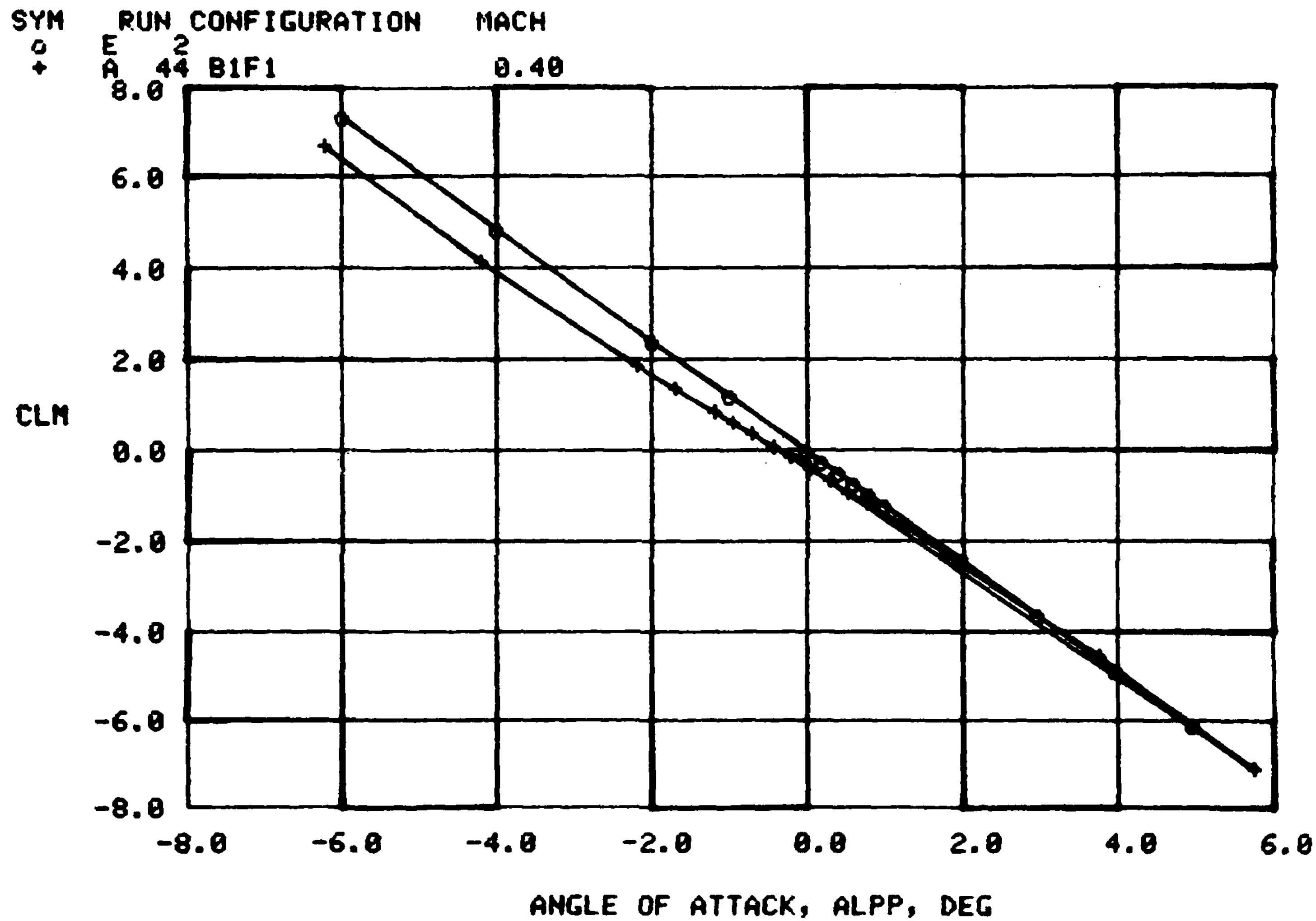


Figure 48. Pitching moment coefficient vs angle of attack at $M_\infty = 0.4$.

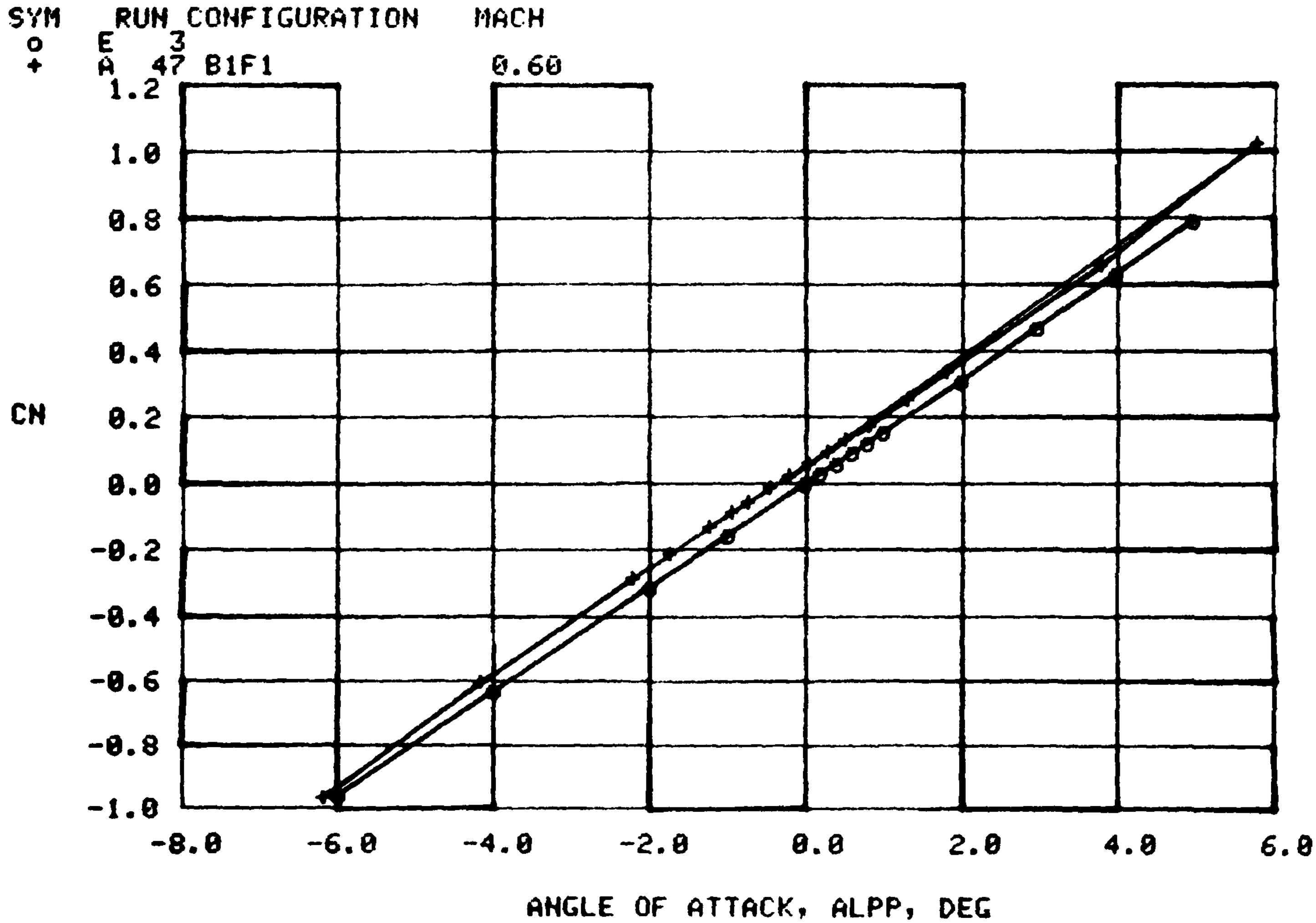


Figure 49. Normal force coefficient vs angle of attack at $M_\infty = 0.6$.

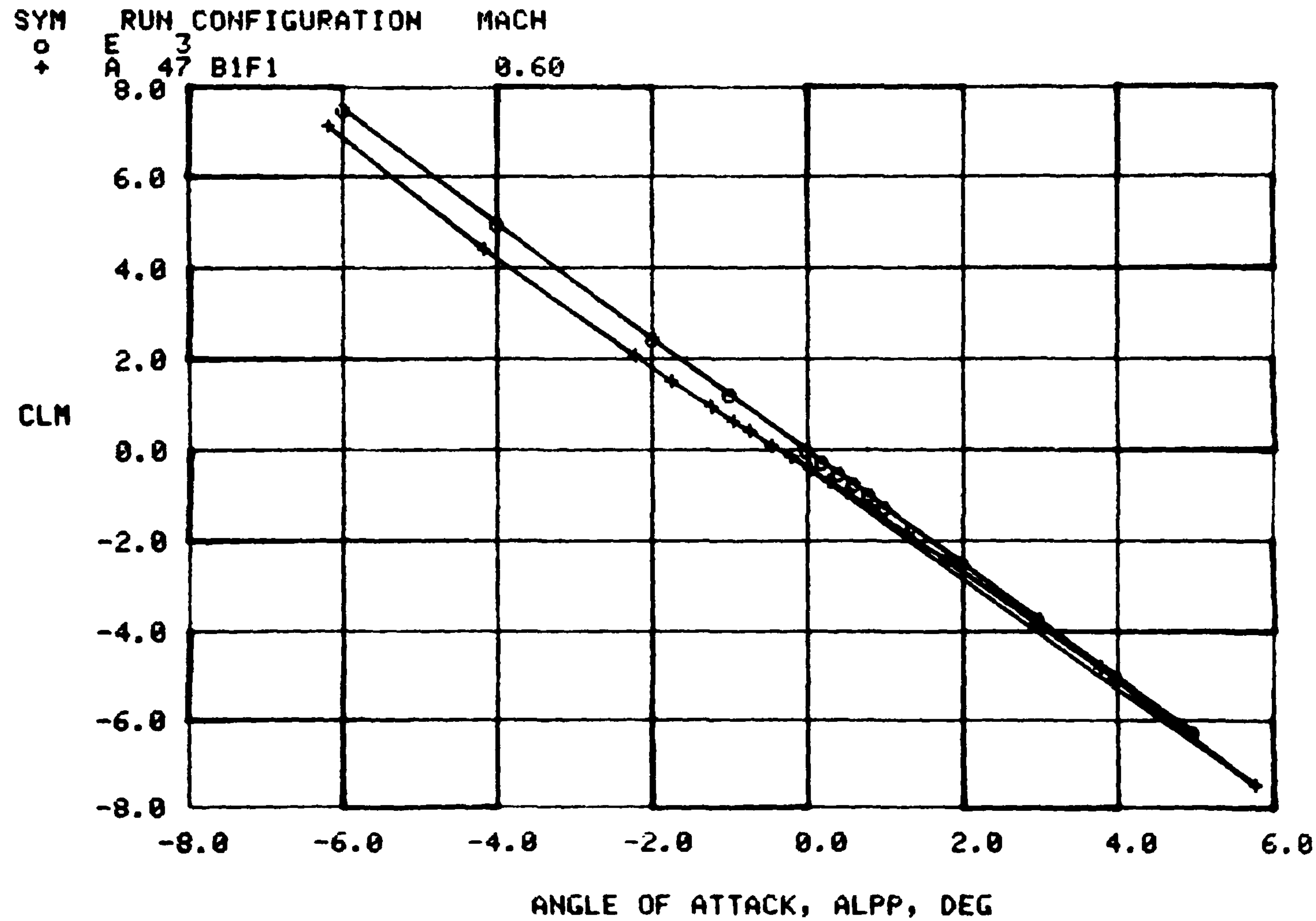


Figure 50. Pitching moment coefficient vs angle of attack at $M_\infty = 0.6$.

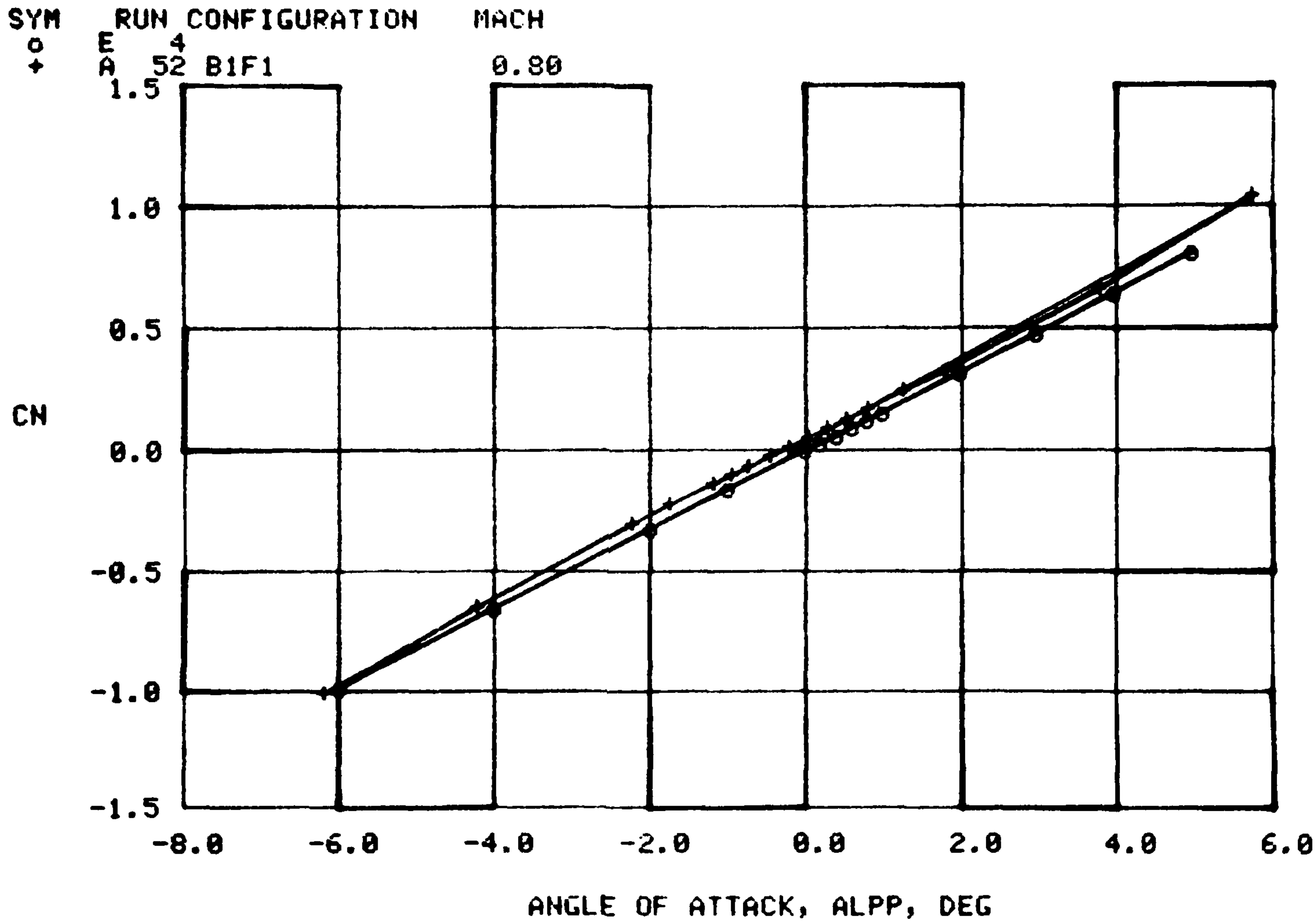


Figure 51. Normal force coefficient vs angle of attack at M_∞ = 0.8.

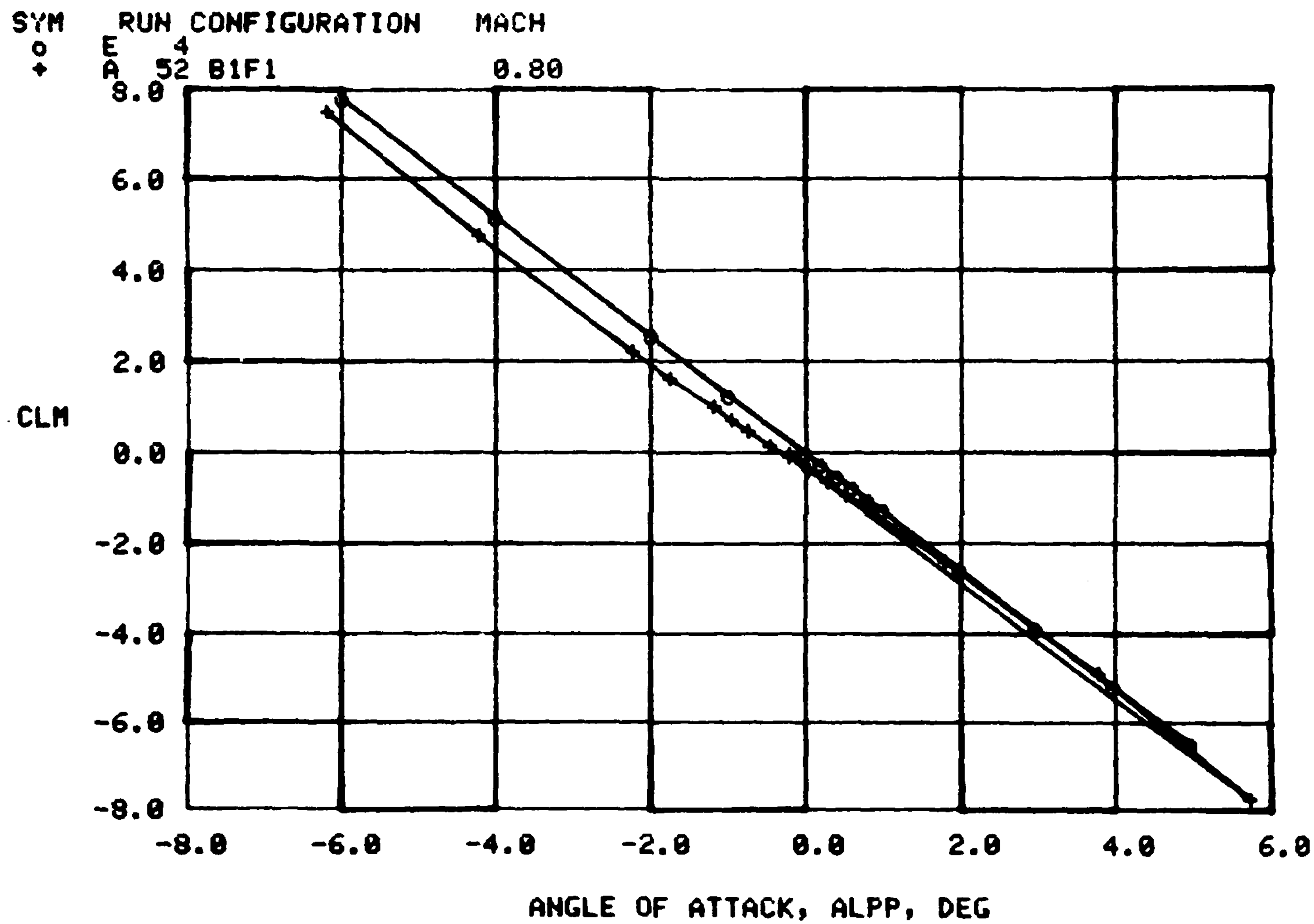


Figure 52. Pitching moment coefficient vs angle of attack at $M_\infty = 0.8$.

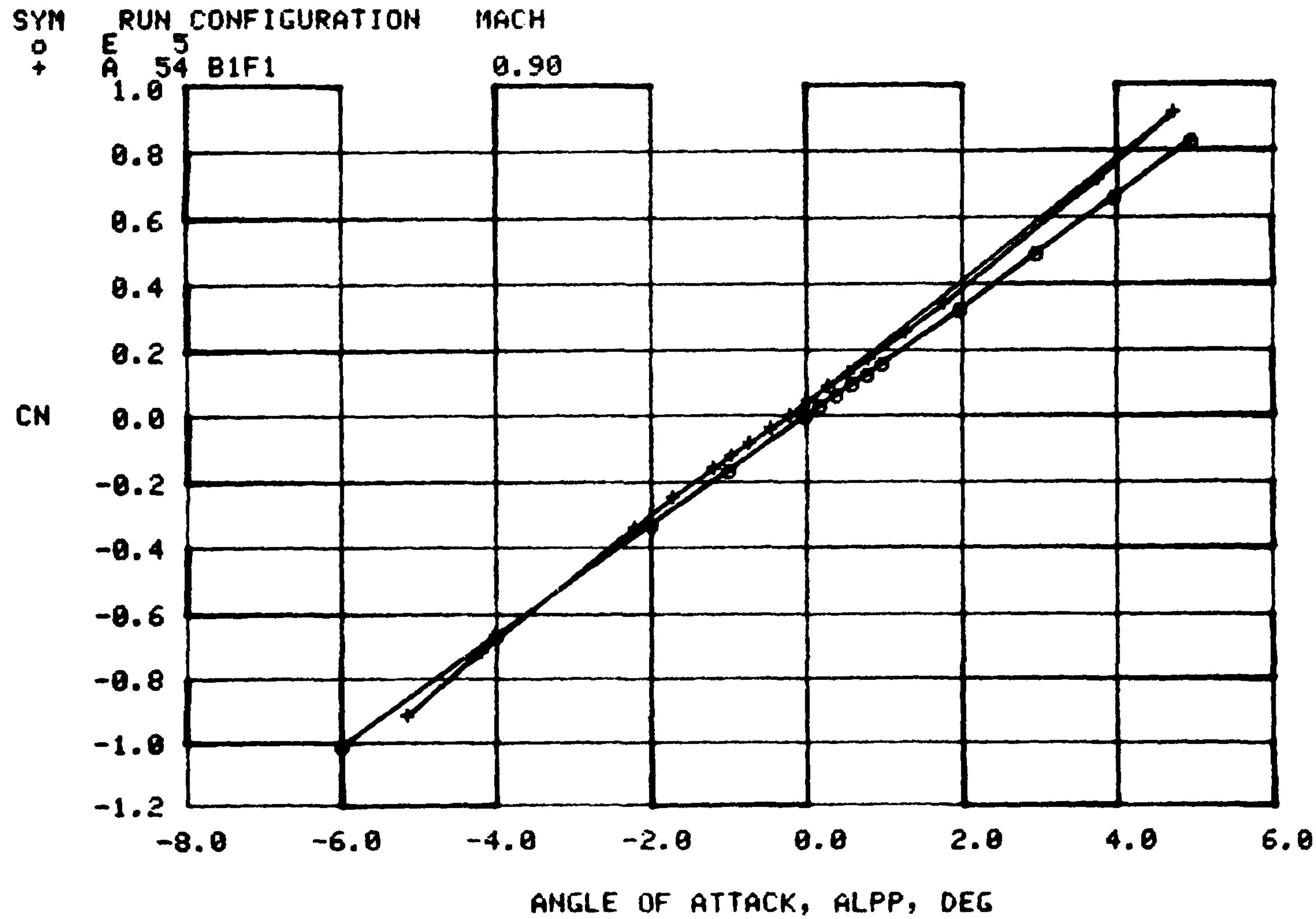


Figure 53. Normal force coefficient vs angle of attack at M_∞ = 0.9.

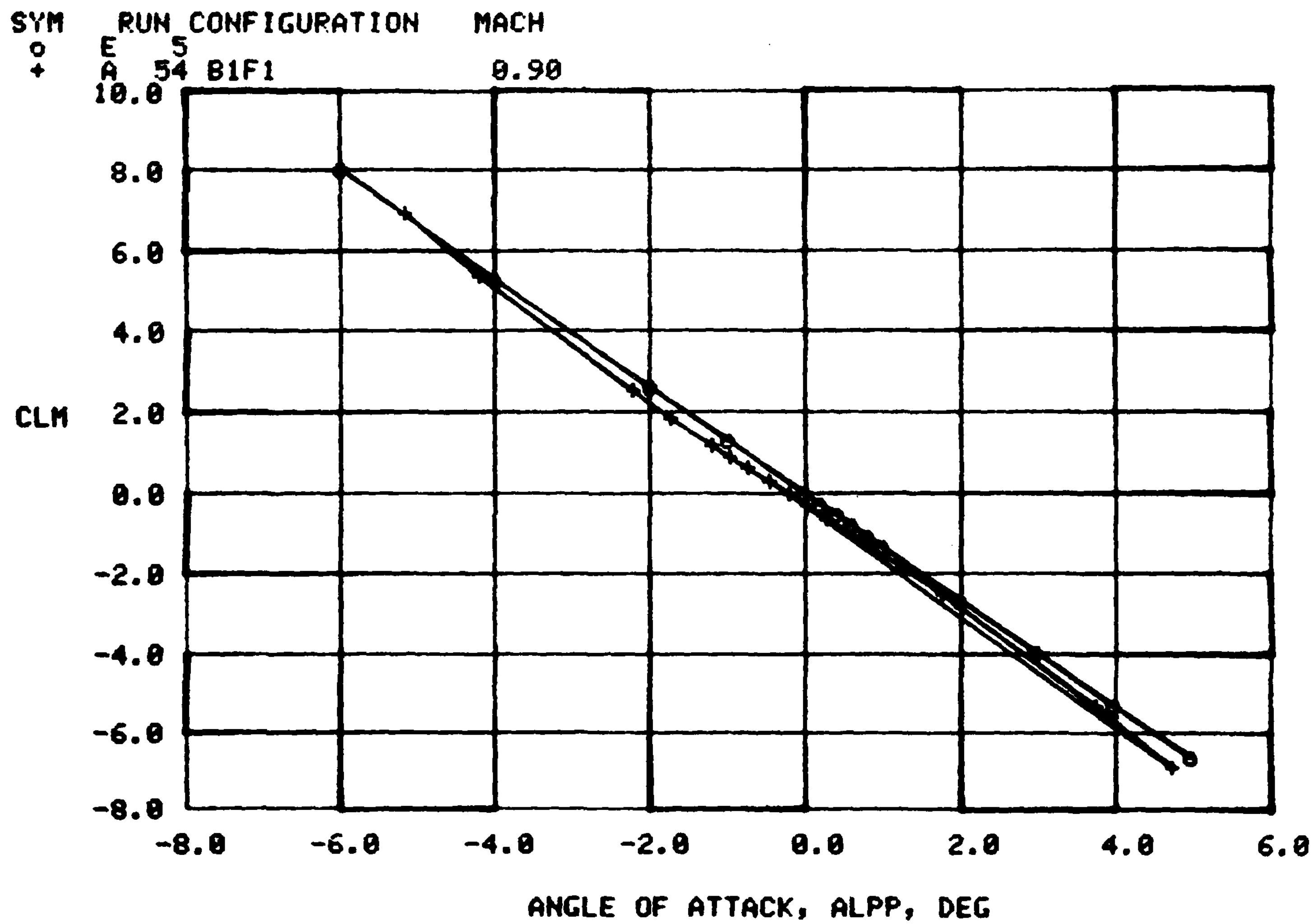


Figure 54. Pitching moment coefficient vs angle of attack at M_∞ = 0.9.

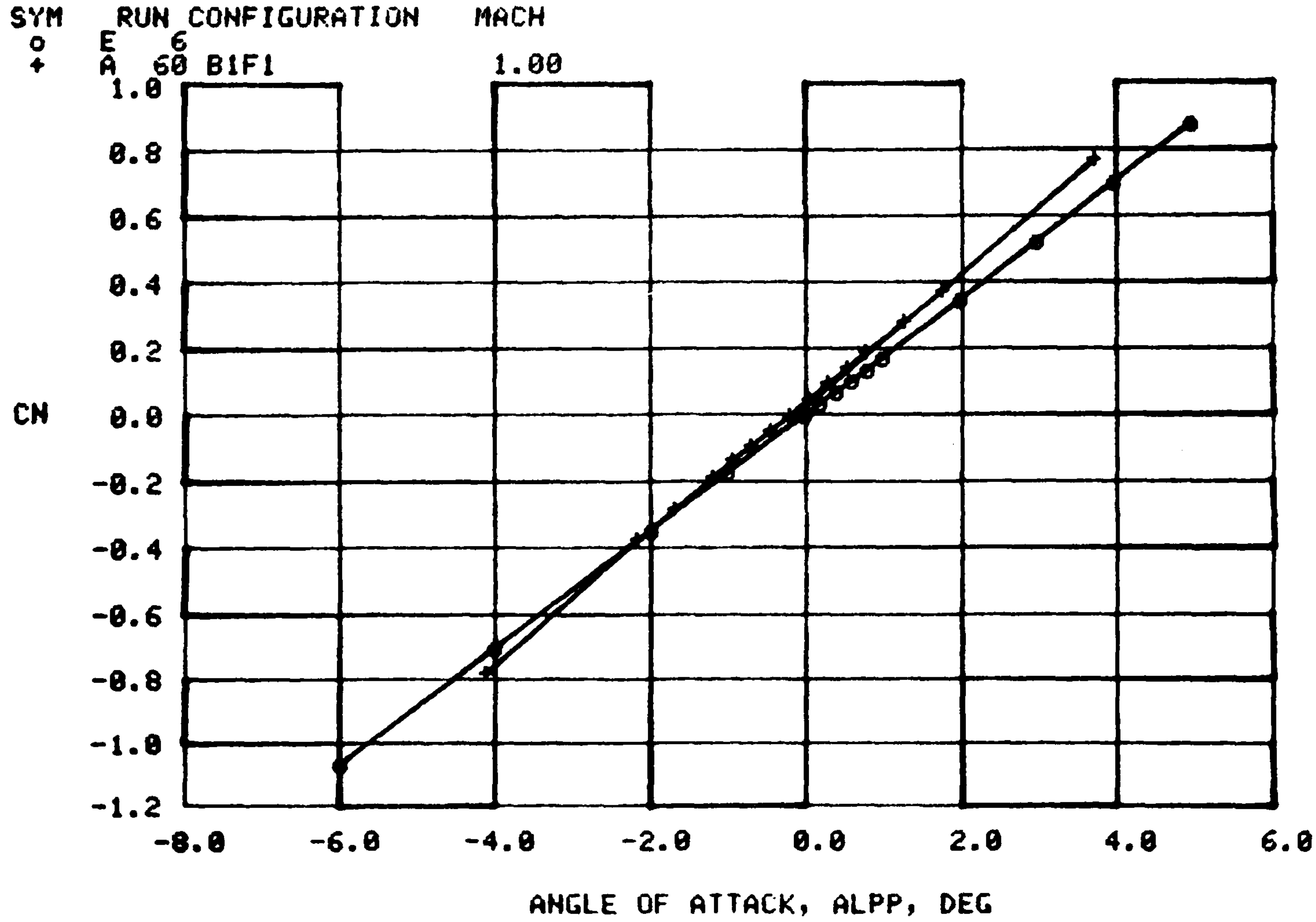


Figure 55. Normal force coefficient vs angle of attack at $M_\infty = 1.0$.

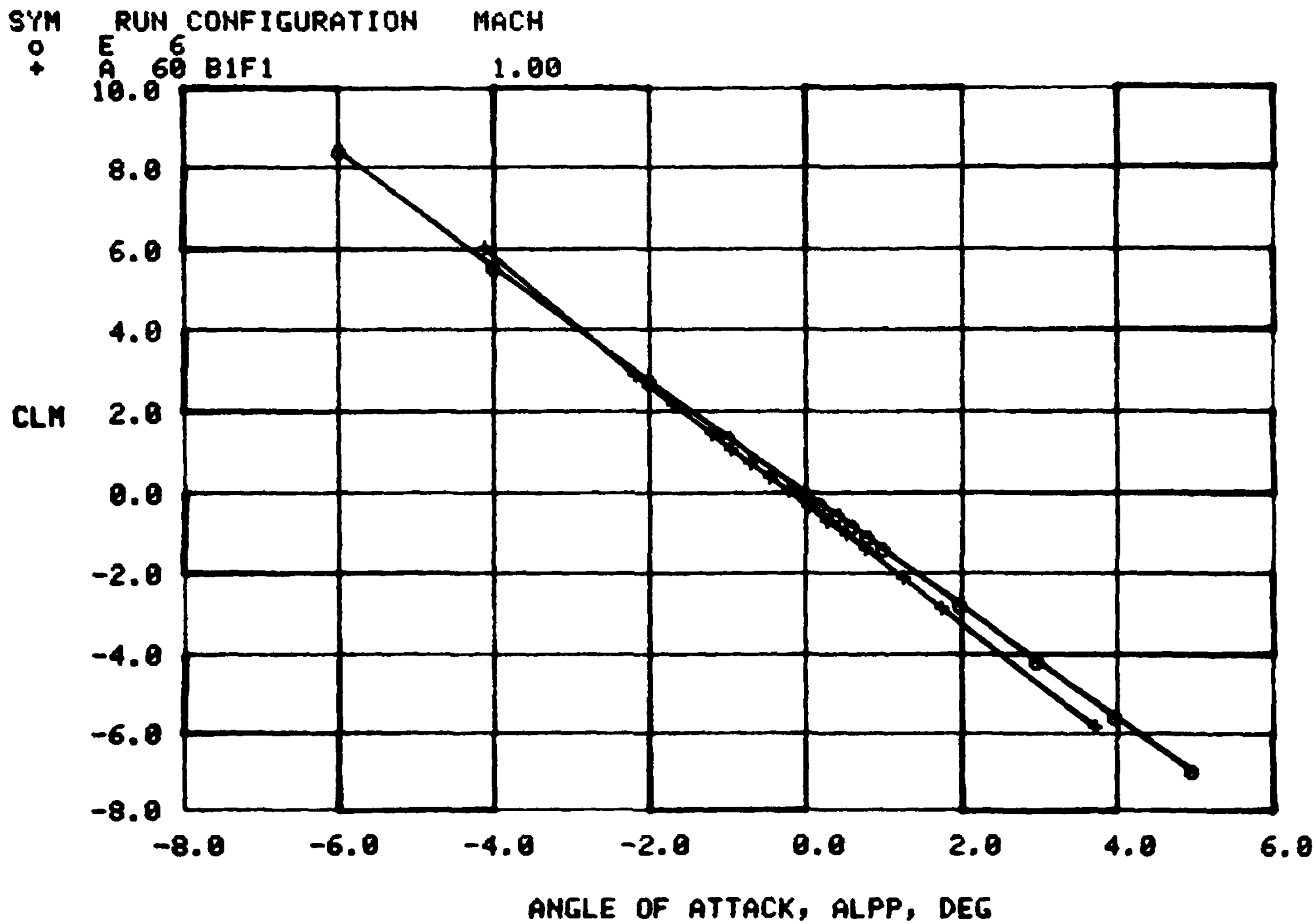


Figure 56. Pitching moment coefficient vs angle of attack at M_∞ = 1.0.

APPENDIX A

PROGRAM LISTING

```
$BATCH
PRELIMINARY DESIGN PROGRAM WITH PARAMETERIC VARIATION.
ALL GEOMETERIC VARIABLES MUST HAVE THE SAME SYSTEM OF UNITS.
I.E., CALIBERS, INCHES, ETC.  ALL ARE DIVIDED BY DREF WITHIN
THE PROGRAM.  THE PROGRAM WORKS IN CALIBERS.
A CALIBER IS DEFINED AS 1 REFERENCE DIAMETER.
INPUT BODY CENTER OF PRESSURE (POSITIVE AFT OF NOSE) - (CAL)
PROGRAM USES BRITISH DATA SHEETS FOR BASIC WING LIFT AND XCP.
PROGRAM USES SLENDER BODY THEORY (NACA 1307) FOR WING-BODY
AND WING-TAIL INTERFERENCE.
.............................................
ALL INPUTS ARE FREE FIELD.  INPUTS CAN BE SEPARATED BY A COMMA,
ONE OR MORE BLANKS, OR BY A SLASH (/).
ALL VARIABLES IN AN INPUT LINE MUST HAVE A VALUE TO READ,
I.E., 0.  FREE FIELD READ WILL NOT INTERPRET BLANKS AS ZERO'S.

........................................... INPUT 1

TITLE CARD (1-80 CHARACTERS)

.......................................... INPUT 2

NWPOS    =  1    INPUT XWING AS STATION OF WING LEADING EDGE
"        =  2    PROGRAM WILL MOVE WING 1/4 CHORD TO WING HINGE LINE
"        =  3    PROGRAM WILL MOVE WING 1/2 CHORD TO WING HINGE LINE
"        =  4    INPUT XWING AS STATION OF WING TRAILING EDGE.
NTPOS    =  1    INPUT XTAIL AS STATION OF TAIL LEADING EDGE
"        =  2    PROGRAM WILL MOVE TAIL 1/4 CHORD TO TAIL HINGE LINE
"        =  3    PROGRAM WILL MOVE TAIL 1/2 CHORD TO TAIL HINGE LINE
"        =  4    INPUT XTAIL AS STATION OF TAIL TRAILING EDGE.
MCDVT    = 1  NO EFFECT.
"        = 2  USE NACA REPT. 1253 (MCDEVITT) FOR FIN ALONE CLA.
           GOOD FOR RECTANGULAR FINS ONLY.
           GOOD FOR MACH NUMBERS BELOW 1.1 ONLY.
NOUT     = 1  TRIM OUTPUT ONLY.
    = 2  ALPHA OUTPUT ONLY.
    = 3  TRIM AND ALPHA OUTPUT.
NRUN     =     INITIAL RUN NUMBER, - 1 TO 4 DIGITS.
NDBASE   = 1  NO EFFECT.
    = 2  OUTPUT DATA BASE FILE.

........................................ INPUT 3

NOSE     = 1  OGIVE NOSE
"        = 2  CONICAL NOSE
XLN      =  NOSE LENGTH
XL       = TOTAL LENGTH

........................................ INPUT 4

RBW      = RADIUS OF BODY AT WING
RBT      = RADIUS OF BODY AT TAIL
DREF     = REFERENCE LENGTH
AREF     = REFERENCE AREA
DREFFT   = REFERENCE LENGTH - FT.
AREFFT   = REFERENCE AREA IN SQ. FT.
YIY      = TRANSVERSE MOMENT OF INERTIA - SLUG-FT2.

...................................... INPUT 5

NBODY    = NUMBER OF POINTS FOR BODY ALONE CNACY AND XCPCY
      (IF NBODY=0, OMIT INPUTS 6. PROGRAM WILL COMPUTE SLOPE DATA. )
```

.... INPUTS 6

IMACH = TABLE OF MACH NUMBERS FOR CNACY AND XCPCY
ICNACY = TABLE OF BODY ALONE NORMAL FORCE COEFF SLOPES (BASED ON BODY CROSS SECTIONAL REFERENCE AREA) - 1/RAD
IXCPCY = TABLE OF BODY ALONE CENTER OF PRESSURE - CAL FROM NOSE

.... INPUT 7

NBTL=0 PROGRAM WILL NOT ADD BOATTAIL CNA AND XCP.
" =1 PROGRAM USES BOATITAL CARDS TO CALCULATE BOATTAIL EFECTS
DBOD = DIAMETER RATIO (BOATTAIL/CYLINDER)
XLBOD = RATIO (BOATTAIL LENGTH/CYLINDER DIAMETER)

.... INPUT 8

NMF = NUMBER OF POINTS FOR XCG VS MACH NUMBER

.... INPUTS 9

TMF = TABLE OF MACH NUMBERS FOR XCG
TXCG = TABLE OF CENTER OF GRAVITY - CALIBERS FROM NOSE.
TWEIGH = TABLE OF WEIGHT - LBS.

.... INPUT 10

NFMA = NUMBER OF FREE STREAM MACH NUMBERS

.... INPUTS 11

TFMA = TABLE OF FREE STREAM MACH NUMBERS
TALT = ALTITUDE FOR EACH MACH NO. - FT ABOVE SEA LEVEL
TRE = REYNOLDS NUMBER FOR EACH MACH NO. - MILLIONS/FT.
NOTE: PROGRAM MULTIPLIES TRE BY 1 MILLION TO GET RE.

.... INPUTS 12-26

TBOW = TABLE OF WING EXPOSED SEMI-SPANS(LOAD 0. IF NO WING)
TCRW = TABLE OF WING ROOT CHORDS
TTRW = TABLE OF WING TAPER RATIOS(CT/CR)
TSWTEW = TABLE OF WING TRAILING EDGE SWEEP ANGLES(DEG)
TXWING = TABLE OF WING STATIONS (MEASURED FROM NOSE) (SEE NWPOS)
THINGW = TABLE OF WING HINGE LINES
TBOT = TABLE OF TAIL EXPOSED SEMI-SPANS(LOAD 0. IF NO TAIL)
TCRT = TABLE OF TAIL ROOT CHORDS
TTRT = TABLE OF TAIL TAPER RATIOS (CT/CR)
TSWTET = TABLE OF TAIL TRAILING EDGE SWEEP ANGLES (DEG)
TXTAIL = TABLE OF TAIL POSITIONS (MEASURED FROM NOSE)
THINGT = TABLE OF TAIL HINGE LINES
" = 0. (PROGRAM SETS HINGT=1/4 MEAN AERODYNAMIC CHORD)
TDELT = TABLE OF TAIL DEFLECTIONS - DEG.
TDELW = TABLE OF WING DEFLECTIONS - DEG.
TALP = TABLE OF ANGLES OF ATTACK - DEG.

.... INPUTS 27-29 (USED ONLY IF NOBASE=2)

IC(1) = FIRST PACKED WORD FOR COEFFICIENTS.
IC(2) = SECOND PACKED WORD FOR COEFFICIENTS.
IP = PACKED WORD FOR PARAMETERS.
(SEE DATA BASE INSTRUCTIONS FOR DEFINITION OF PACKED WORDS)

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***************************************************
DIMENSION TMF(15),TXCG(15),TMACH(15),TCNACY(15),TXCPCY(15)
DIMENSIONTFMA(16),TCRW(16),TTRW(16),TBOW(16),TSWTEW(16),TXWING(16)
DIMENSION          TCRT(16),TTRT(16),TBOT(16),TSWTET(16),TXTAIL(16)
DIMENSION THINGW(16),THINGT(16)
DIMENSION TRE(16),TALT(16),TDELT(10),TDELW(10),TALP(20),TWEIGH(15)
DIMENSION IFILE(3),TITLE(20),HOL(10)
DIMENSION ACON(3),H(32),Y(25,3)

COMMON /BODY/ XL,XLN,RE,DREFFT,DCY,ACY,AREF,NOSE,CNAB,XCPB
COMMON /WING/ BOW,RBW,CRW,XWING,XCENW,PHIW,HINGW,AWAR,ARW
COMMON /WING2/ CLAW,XCPW,BKWB,BKBW,SKWB,SKBW
COMMON /TAIL/ BOT,RBT,TRT,XTAIL,XCENT,PHIT,HINGT,ATAR,ART
COMMON /TAIL2/ CLAT,XCPT,BKTB,BKBT,SKTB,SKBT
COMMON /PARTS/ CNBY,XCPBY,CNW,XCPWN,CNT,XCPTL,CLTV

REAL  LABEL
102   FORMAT (2F10.4)
103   FORMAT (3F10.4)
108   FORMAT (8F10.4)
109   FORMAT (13I2)
110   FORMAT (I2,8X,3F10.4)
111  FORMAT (20A4)
112  FORMAT (2I2,6X,3F10.4)
198   FORMAT (1H )
199   FORMAT (1H1)
200   FORMAT (1H1,'INPUT TABLES'/)
202   FORMAT (1H ,2F10.4)
203   FORMAT (1H ,3F10.4)
209  FORMAT (1H0,20A4)
210   FORMAT (1H0,'GEOMETERIC VARIABLES'30X'BODY'6X'WING'6X,'TAIL'/)
211   FORMAT (1H ,'CR          ROOT CHORD'                       36X2F10.4)
212   FORMAT (1H ,'CT          TIP CHORD'                        37X2F10.4)
213   FORMAT (1H ,'BO          EXPOSED SEMI-SPAN'                29X2F10.4)
214   FORMAT (1H ,'AR          ASPECT RATIO'                     34X2F10.4)
215   FORMAT (1H ,'TR          TAPER RATIO'                      35X2F10.4)
216   FORMAT (1H ,'SWLE        LEADING EDGE SWEEP ANGLE (DEG)'   16X2F10.4)
217   FORMAT (1H ,'SWTE        TRAILING EDGE SWEEP ANGLE (DEG)'  15X2F10.4)
218   FORMAT (1H ,'CBAR/CR     MEAN GEOMETERIC CHORD/CR'         22X2F10.4)
219   FORMAT (1H ,'YBAR/BO     SPANWISE LOCATION OF CBAR'        21X2F10.4)
220   FORMAT (1H ,'XM/CR       CHORDWISE LOCATION OF CBAR'       20X2F10.4)
221   FORMAT (1H ,'CENT/CR     DIST. FROM L.E. CR TO CENTROID'   16X2F10.4)
222   FORMAT (1H ,'RB          RADIUS OF BODY AT FIN'            25X2F10.4)
223   FORMAT (1H ,'XFIN        DIST. FROM NOSE TO L.E. CR'       20X2F10.4)
224   FORMAT (1H ,'XCENT       DIST. FROM NOSE TO CENTROID'      19X2F10.4)
225   FORMAT (1H ,'A/AR        AREA RATIO (2 FINS/AREF)'         22X2F10.4)
226   FORMAT (1H ,'HINGE       DIST. FROM NOSE TO HINGE'         22X2F10.4)
227   FORMAT (1H ,'PHI         FIN ROLL ANGLE (DEG)'             26X2F10.4)
230  FORMAT (1H ,'XL          BODY LENGTH'                      24XF10.4)
231  FORMAT (1H ,'DREF        REFERENCE LENGTH   '              17XF10.4)
232  FORMAT (1H ,'AREF        REFERENCE AREA          '         10XF12.4)
2322  FORMAT (1H ,'DREFFT      REFERENCE LENGTH-FT.'             15XF10.4)
2323  FORMAT (1H ,'AREFFT      REFERENCE AREA FT**2'             15XF10.4)
233  FORMAT (1H ,'YIY         MOMENT OF INERTIA'                18XF10.4)
234  FORMAT (1H ,'DBOD        BOATTAIL DIA. (CAL.)'             15XF10.4)
235  FORMAT (1H ,'XLBOD       BOATTAIL LENGTH (CAL.)'           13XF10.4)
236  FORMAT (1H ,'DCYODR      RATIO (CYL. DIA/REF. DIA)'        10XF10.4)
301  FORMAT (1H0'PROBLEM WITH INPUT DATA FILE-(TAPE5),  STATUS='I4/)
302  FORMAT (1H0'WARNING: TAPE5 NOT CLOSED'/)
400   FORMAT (1H0,11X,'BKUP',5X,'BKCO',5X,'CLA',5X,'CP',8X,
+ 'CNA',6X,'XCP',5X,'CMACG',5X,'CMO',6X,'CLP',6X,'CLD',
+ 6X,'CHA',6X,'CHD',6X,'CNO',5X,'CMOCG')
401   FORMAT (1X,'BODY ',36X,4F9.3)
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```
402    FORMAT (1X,'WING ',14F9.3)
403    FORMAT (1X,'TAIL ',14F9.3)
404    FORMAT (1X,'TOTAL',36X,5F9.3)
4444   FORMAT (1X,'SIGMA ',F9.3)
4040   FORMAT (" ",T43,46("*"),/,T43,"*",T88,"*",/,
+  T43,"*",T58,"FLIGHT CONDITIONS",T88,"*",/,T43,"*",T88,"*"
+  ,/,T43,46("*"))
4041   FORMAT (1H0," ",T44,46("*"),/,T43,"*",T88,"*",/,
+  T43,"*",T52,"ANGLE OF ATTACK DATA (SLOPES)",T88,"*",/,T43,"*",T88,"*",/,
+  T43,"*",T88,"*",/,T43,46("*"))
4042   FORMAT (" ",T43,46("*"),/,T43,"*",T88,"*",/,T43,"*",T88,"*",/,
+  T43,"*",T61,"TRIM POINT",T88,"*",/,T43,"*",T88,"*",/,
+  T43,"*",T88,"*",/,T43,46("*"))
4043   FORMAT (1H0," ",T44,46("*"),/,T43,"*",T88,"*",/,T43,"*",T88,"*",/,
+  T43,"*",T55,"ANGLE OF ATTACK SWEEP",T88,"*",/,T43,"*",T88,"*",/,
+  T43,"*",T88,"*",/,T43,46("*"))
410    FORMAT (1H0,'FMACH=',F9.3,2X,'XCG=',F9.3,2X'WEIGHT=',F9.3,
+ 2X,'ALT=',F9.3,2X,'RE=',F10.0)
450    FORMAT (1H0,3X,'ALPHA',4X,'DELW',4X,'DELT',6X,'CN',6X,
+  'XCP',6X,'CMCG',5X,'HMW',6X,'HMT',5X,'FTRAT',3X,'GLOAD')
451    FORMAT (1H ,1F8.2,3F9.3,10F8.3)
452    FORMAT (1H0,'NO TRIM AFTER ',I3,2X,'ITERATIONS FOR DELW=',
+  F7.3,3X,'DELT=',F7.3)
453    FORMAT (1H0,3X,'ALPHA',6X,'CN',6X,
+  'XCP',6X,'CMCG',6X,'CHW',5X,'CHT',3X,'FTRAT',4X,
+  'CNB',4X,'XCPB',5X,'CNW',4X,'XCPW',5X,'CNT',4X,'XCPT',4X,'CNTV')
454    FORMAT (1H0,'TRIM POINT')
455    FORMAT (1H0,'NO TRIM BELOW ALP=',F7.3,2X,'FOR DELW=',F7.3,
+  2X,'AND DELT=',F7.3)
456    FORMAT (1H0,'RUN NUMBER',I4)
990   FORMAT (1H0,'TYPE INPUT FILE NAME - 1 TO 12 CHARACTERS')
991   FORMAT (3A4)
995    FORMAT (1H1,'CONFIGURATION'I4)
----------------------------------
1      WRITE (1,990)
READ (1,991) IFILE
CALL CLOSE (5,ISTA)
CALL OPENW (5,IFILE,1,0,0,ISTA)
IF (ISTA.EQ.0) GO TO 8
WRITE (1,301) ISTA
PAUSE
GO TO 1
8      NCONF=0
READ (5,111) TITLE
READ (5,*) NWPOS,NTPOS,MCDVT,NOUT,NRUN,NDBASE
READ (5,*) NOSE,XLN,XL
READ (5,*) RBW,RBT,DREF,AREF,DREFFT,AREFFT,YIY
READ (5,*) NBODY
IF (NBODY.EQ.0) GO TO 4
READ (5,*) (TMACH(I),TCNACY(I),TXCPCY(I), I=1,NBODY)
4      READ (5,*) NBTL,DBOD,XLBOD
READ (5,*) NMF
READ (5,*) (TMF(I),TXCG(I),TWEIGH(I), I=1,NMF)
READ (5,*) NFMA
READ (5,*) (TFMA(I),TALT(I),TRE(I), I=1,NFMA)
CALL READX (5,80,HOL,TBOW,NH,NBOW,EOFF)
CALL READX (5,80,HOL,TCRW,NH,NCRW,EOFF)
CALL READX (5,80,HOL,TTRW,NH,NTRW,EOFF)
CALL READX (5,80,HOL,TSWTEW,NH,NSWW,EOFF)
CALL READX (5,80,HOL,TXWING,NH,NXWING,EOFF)
CALL READX (5,80,HOL,THINGW,NH,NHINGW,EOFF)
CALL READX (5,80,HOL,TBOT,NH,NBOT,EOFF)
CALL READX (5,80,HOL,TCRT,NH,NCRT,EOFF)
```

```
CALL READX (5,80,HOL,TTRT,NH,NTRT,EOFF)
CALL READX (5,80,HOL,TSWTET,NH,NSWT,EOFF)
CALL READX (5,80,HOL,TXTAIL,NH,NXTAIL,EOFF)
CALL READX (5,80,HOL,THINGT,NH,NHINGT,EOFF)
CALL READX (5,80,HOL,TDELT,NH,NDELT,EOFF)
CALL READX (5,80,HOL,TDELW,NH,NDELW,EOFF)
CALL READX (5,80,HOL,TALP,NH,NALP,EOFF)

IF (NDBASE.EQ.2) CALL DATA1
CALL CLOSE (5,ISTA)
IF (ISTA.NE.0) WRITE (1,302)
................................   WRITE INPUT TABLES
WRITE (6,200)
IF(NBODY.EQ.0) GO TO 2
WRITE (6,203) (TMACH(I),TCNACY(I),TXCPCY(I), I=1,NBODY)
2     WRITE (6,198)
WRITE (6,203) (TMF(I),TXCG(I),TWEIGH(I), I=1,NMF)


PI=3.14159
RAD=57.29578
SMALL=1.E-30
PHIW=0.0
PHIT=0.0
DCY=2.*RBT
DCYODR=DCY/DREF
ACY=(PI/4)*DCY**2
.................................
DO 90 I2=1,NCRW
CRW=TCRW(I2)
DO 90 I3=1,NTRW
TRW=TTRW(I3)
DO 90 I4=1,NBOW
BOW=TBOW(I4)
DO 90 I5=1,NSWW
SWTEW=TSWTEW(I5)
DO 90 I6=1,NXWING
XWING=TXWING(I6)
DO 90 I12=1,NHINGW
HINGW=THINGW(I12)
.................................   CALCULATE WING GEOMETRY
CALL ROLL (BOW,CRW,TRW,RBW,DREF,AREF,CLPW1,CLDW1)
CALL FINGEOM (CRW,TRW,BOW,AREF,SWTEW,CTW,ARW,SWLEW,CBARW,YBARW,
+  XMW,CENTW,AFAR,TANLW,SWHAW)
AWAR=2.*AFAR
IF(NWPOS.EQ.2) XWING=HINGW-(.25*CBARW+XMW)*CRW
IF(NWPOS.EQ.3) XWING=HINGW-(.50*CBARW+XMW)*CRW
IF(NWPOS.EQ.4) XWING=XWING - CRW
XCENW=(CENTW*CRW+XWING)
.................................
DO 90 I7=1,NCRT
CRT=TCRT(I7)
DO 90 I8=1,NTRT
TRT=TTRT(I8)
DO 90 I9=1,NBOT
BOT=TBOT(I9)
DO 90 I10=1,NSWT
SWTET=TSWTET(I10)
DO 90 I11=1,NXTAIL
XTAIL=TXTAIL(I11)
DO 90 I13=1,NHINGT
HINGT=THINGT(I13)
.................................   CALCULATE TAIL GEOMETRY
```

```
CALL ROLL (BOT,CRT,TRT,RBT,DREF,AREF,CLPT1,CLDT1)
CALL FINGEOM (CRT,TRT,BOT,AREF,SWTET,CTT,ART,SWLET,CBART,YBART,
+  XMT,CENTT,AFAR,TANLT,SWHAT)
ATAR=2.*AFAR
IF(NTPOS.EQ.2) XTAIL=HINGT-(.25*CBART+XMT)*CRT
IF(NTPOS.EQ.3) XTAIL=HINGT-(.50*CBART+XMT)*CRT
IF(NTPOS.EQ.4) XTAIL=XTAIL - CRT
XCENT=(CENTT*CRT+XTAIL)
IF(HINGT.EQ.0.) HINGT=XTAIL + (XMT + .25*CBART)*CRT
................................    GEOMETRY OUTPUT
NCONF=NCONF + 1
WRITE (6,995) NCONF
WRITE (6,209) TITLE
WRITE (6,210)
WRITE (6,230) XL
WRITE (6,231) DREF
WRITE (6,232) AREF
WRITE (6,2322) DREFFT
WRITE (6,2323) AREFFT
WRITE (6,233) YIY
IF (NBTL.EQ.0) GO TO 5
WRITE (6,234) DBOD
WRITE (6,235) XLBOD
WRITE (6,236) DCYODR
5     WRITE (6,213) TBOW(14),TBOT(19)
WRITE (6,211) TCRW(12),TCRT(17)
WRITE (6,212) CTW,CTT
WRITE (6,215) TRW,TRT
WRITE (6,214) ARW,ART
WRITE (6,216) SWLEW,SWLET
WRITE (6,217) SWTEW,SWTET
WRITE (6,218) CBARW,CBART
WRITE (6,219) YBARW,YBART
WRITE (6,220) XMW,XMT
WRITE (6,221) CENTW,CENTT
WRITE (6,222) RBW,RBT
WRITE (6,223) XWING,XTAIL
WRITE (6,224) XCENW,XCENT
WRITE (6,225) AWAR,ATAR
WRITE (6,226) HINGW,HINGT
WRITE (6,227) PHIW,PHIT
................................    START MACH NUMBER LOOP
DO 91 I1=1,NFMA
FMACH=TFMA(I1)
ALT=TALT(I1)
RE=TRE(I1)*1.E6
CALL STAN62 (ALT,CS,RHO,PRESS,TEMP,2)
Q=(.7*PRESS*FMACH**2)
BETA=SQRT(ABS(FMACH**2-1.))
CALL INTERP (2,1,XCG,TXCG,FMACH,TMF,NMF,2,MIN,MAX)
CALL INTERP (2,1,WEIGHT,TWEIGH,FMACH,TMF,NMF,2,MIN,MAX)
XCG=XCG*DCY
IF (WEIGHT.EQ.0.) WEIGHT=1.
.............................................

     START ZERO ALPHA LOOP  -  SLOPES

................................    BODY FORCE COEFF.
IF (NBODY.NE.0) GO TO 7
XLA=XL - XLN
XLN2=XLN/DCY
XLA2=XLA/DCY
CALL BODY (NOSE,XLN2,XLA2,FMACH,CNACY,XCPCY)
```

```
GO TO 3
7     CALL INTERP (2,1,CNACY,TCNACY,FMACH,TMACH,NBODY,3,MIN,MAX)
CALL INTERP (2,1,XCPCY,TXCPCY,FMACH,TMACH,NBODY,3,MIN,MAX)
3     CONTINUE
XCPCY=XCPCY*DCY
CNACY=CNACY*ACY/AREF
CNABT=0.
XCPBT=0.
IF (NBTL.EQ.0) GO TO 6
CALL BOATL (FMACH,DBOD,XLBOD,CNABT,XCPBT)
XCPBT=XCPBT*DCYODR*DREF + XL - XLBOD*DCYODR*DREF
CNABT=CNABT*ACY/AREF
6     CNAB=CNACY + CNABT
CMAB=(CNACY*XCPCY + CNABT*XCPBT)/DREF
XCPB=CMAB*DREF/(CNAB + SMALL)
ARMCY=(XCG-XCPCY)/DREF
ARMBT=(XCG-XCPBT)/DREF
CMQB=-2.*(CNACY*ARMCY**2 + CNABT*ARMBT**2)
CMACGB=CNACY*ARMCY + CNABT*ARMBT
.................................     WING FORCE COEFF.
FW=0.
XCPW=0.
CMQW=0.
CMACGW=0.
CLPW=0.
IF(BOW.EQ.0.0) GO TO 561
CALL BRIT (FMACH,ARW,TRW,SWHAW,CLAW,CPCB)
CPW=CPCB*CBARW + XMW
IF((MCDVT.EQ.2).AND.(FMACH.LE.1.1)) CALL MCDEVT (FMACH,ARW,CLAW)
CLPW=CLPW1*CLAW/(PI*ARW/2.)
CLDW=CLDW1*CLAW/(PI*ARW/2.)
XCPW=(CPW*CRW + XWING)
BMW=99.9999E+30
IF(TANLW.GT.0.0) BMW=BETA/TANLW
CALL INTSLB (1,FMACH,BETA, BMW,RBW,CRW,TRW,BOW,ARW,CLAW,
1  BKWB,BKBW,SKWB,SKBW)
FW=(BKWB + BKBW)*CLAW*AWAR
ARMWH=(HINGW-XCPW)/DREF
CHAW=BKWB*CLAW*(AWAR/2.)*ARMWH
CHDW=SKWB*CLAW*(AWAR/2.)*ARMWH
CNDW=(SKWB+SKBW)*CLAW*AWAR
ARMW=(XCG-XCPW)/DREF
CMDWCG=CNDW*ARMW
CMQW=-2.*(FW *ARMW**2)
CMACGW=FW *ARMW
561   CONTINUE
.................................     TAIL FORCE COEFF.
FTI=0.
XCPT=0.
CMQT=0.
CMACGT=0.
CLPT=0.
IF(BOT.EQ.0.0) GO TO 651
CALL BRIT (FMACH,ART,TRT,SWHAT,CLAT,CPCB)
CPT=CPCB*CBART + XMT
IF((MCDVT.EQ.2).AND.(FMACH.LE.1.1)) CALL MCDEVT (FMACH,ART,CLAT)
CLPT=CLPT1*CLAT/(PI*ART/2.)
CLDT=CLDT1*CLAT/(PI*ART/2.)
XCPT=(CPT*CRT + XTAIL)
BMT=99.9999E+30
IF(TANLT.GT.0.0) BMT=BETA/TANLT
CALL INTSLB (1,FMACH,BETA, BMT,RBT,CRT,TRT,BOT,ART,CLAT,
1  BKTB,BKBT,SKTB,SKBT)
```

```
BTAIL=XL-XTAIL-CRT
XXLB=XLBOD*DREF
DDB=DBOD*DREF
CALL ARAT(FMACH,CRT,BTAIL,XXLB,DDB,DCY,A1A)
BKBT=BKBT*A1A
SKBT=SKBT*A1A
FT=(BKTB + BKBT)*CLAT*ATAR
CNDT=(SKTB+SKBT)*CLAT*ATAR
CMDTCG=CNDT*(XCG-XCPT)/DREF
................................    VORTEX CALCULATION
CLIA=0.0
XI=0.0
FWSW=0.0
ARMT=(XCG-XCPT)/DREF
ARMTH=(HINGT-XCPT)/DREF
IF(BOW.EQ.0.0) GO TO 655
XHW=+XCPW-XWING
XBART=+XCPT-XTAIL
ALP=.5
CALL FACTOR (BOW,RBW,CRW,XHW,XWING,0.,BOT,RBT,TRT,XTAIL,XBART,
1  ALP,XI,FWSW)
FWMRW = FWSW*BOW
CLIA=(CLAW*CLAT*BKWB*XI*BOT/(2.*PI*ART*FWMRW))*AWAR
CLIDW=(CLAW*CLAT*SKWB*XI*BOT/(2.*PI*ART*FWMRW))*AWAR
CMIDWC=CLIDW*ARMT
655   CONTINUE
FTI=FT + CLIA
FTRAT=FTI/(FT+SMALL)
CHAT=(BKTB*CLAT*ATAR + CLIA)*.5*ARMTH
CHDT=(SKTB*CLAT*ATAR + CLIA)*.5*ARMTH
CMQT=-2.*(FTI*ARMT**2)
CMACGT=FTI*ARMT
651   CONTINUE
IF((BOT.EQ.0.).OR.(BOW.EQ.0.)) GO TO 652
CNDW=CNDW+CLIDW
CMDWCG=CMDWCG+CMIDWC
652   CONTINUE


IF (NOUT.NE.1) WRITE (6,199)
WRITE (6,198)
WRITE (6,198)
WRITE (6,4040)
WRITE (6,410) FMACH,XCG,WEIGHT,ALT,RE
WRITE (6,4041)
WRITE (6,400)
WRITE (6,401) CNAB,XCPB,CMACGB,CMQB
IF (BOW.EQ.0) GO TO 653
WRITE (6,402) BKWB,BKBW,CLAW,CPW,FW,XCPW,CMACGW,CMQW,CLPW,
+CLDW,CHAW,CHDW,CNDW,CMDWCG
653   IF (BOT.EQ.0) GO TO 654
WRITE (6,403) BKTB,BKBT,CLAT,CPT,FTI,XCPT,CMACGT,CMQT,CLPT,
+CLDT,CHAT,CHDT,CNDT,CMDTCG
654   CONTINUE


COMPLETE CONFIGURATION

CNA=CNAB + FW + FTI
CMA=CMAB + FW*XCPW/DREF + FTI*XCPT/DREF
XCP=CMA*DREF/(CNA + SMALL)
CMQ=CMQB + CMQW + CMQT
CMACG=CMACGB + CMACGW + CMACGT
```

```
CLP=CLPW + CLPT
SIGMA=SQRT(ABS(CMACG)*Q*AREFFT*DREFFT/(YIY+SMALL))/(2.*PI)

WRITE (6,404) CNA,XCP,CMACG,CMO,CLP
WRITE (6,4444) SIGMA

......................................

   END ZERO ALPHA LOOP

......................................
DO 92 L1=1,NDELT
DELT=TDELT(L1)
DO 92 L2=1,NDELW
DELW=TDELW(L2)

....................          TRIM CONDITIONS

IF (NOUT.EQ.2) GO TO 94
ALP=-(CMDWCG*DELW + CMDTCG*DELT)/CMACG
NTRIM=100
DO 95 ITR=1,NTRIM
CALL HIGHALP (FMACH,XCG,ALP,DELW,DELT,CN,XCP,CMCG,CHW,CHT,
+  FTRAT,DREF)
DALPS=0.5
IF (ALP.LT.0) DALPS=-0.5
ALPS=ALP - DALPS
CALL HIGHALP (FMACH,XCG,ALPS,DELW,DELT,X1,X2,CMCG1,X3,X4,X5,DREF)
CMCGS=(CMCG-CMCG1)/DALPS
DALP=CMCG/(CMCGS + SMALL)
IF (ABS(DALP).LE.0.1) GO TO 96
ALP=ALP - DALP
95     CONTINUE
WRITE (6,452) NTRIM,DELW,DELT
GO TO 94
96     ALPMAX=40.
IF (ABS(ALP).LT.ALPMAX) GO TO 97
WRITE (6,455) ALPMAX,DELW,DELT
GO TO 94
97     GLOAD=(CN*COS(ALP/RAD))*Q*AREFFT/WEIGHT
HMW=CHW*Q*AREFFT*DREFFT
HMT=CHT*Q*AREFFT*DREFFT

WRITE (6,198)
WRITE (6,4042)
WRITE (6,454)
WRITE (6,450)
WRITE (6,451) ALP,DELW,DELT,CN,XCP,CMCG,HMW,HMT,FTRAT,GLOAD

....................          ALPHA CONDITIONS
94     IF (NOUT.EQ.1) GO TO 92
ACON(1)='     '
ACON(2)='     '
ACON(3)='     '
H(1)=NALP
H(2)=NRUN
H(3)=1
H(4)=PHIT
H(5)=FMACH
H(6)=RE/1.E6
WRITE (6,4043)
WRITE (6,456) NRUN
WRITE (6,453)
```

```
DO 93 L3=1,NALP
ALP=IALP(L3)
CALL HIGHALP (FMACH,XCG,ALP,DELW,DELT,CN,XCP,CMCG,CHW,CHT,
+  FTRAT,DREF)
WRITE (6,451) ALP,CN,XCP,CMCG,CHW,CHT,FTRAT,
+ CNBY,XCPBY,CNW,XCPWN,CNT,XCPTL,CLTV
Y(L3,1)=ALP
Y(L3,2)=CN
Y(L3,3)=CMCG
93    CONTINUE
IF (NOBASE.EQ.2) CALL DATA (ACON,H,Y)
NRUN = NRUN + 1
92    CONTINUE
91    CONTINUE
90    CONTINUE
STOP
END
SUBROUTINE HIGHALP (FMACH,XCG,ALPHA,DELW,DELT,CN,XCP,CMCG,
+  CHW,CHT,FTRAT,DREF)
HIGH ANGLE OF ATTACK AERO
ALL GEOMETRIC VARIABLES MUST HAVE SAME SYSTEM OF UNITS.
I.E.,  IN., FT., CAL., ETC.

COMMON /BODY/ XL,XN,RE,D,DCY,ACY,AREF,NOSE,CNAB,XCPB
COMMON /WING/ BOW,RBW,CRW,XWING,XCENW,PHIW,HINGW,AWAR,ARW
COMMON /WING2/ CLAW,XCW,BKWB,BKBW,SKWB,SKBW
COMMON /TAIL/ BOT,RBT,TRT,XTAIL,XCENT,PHIT,HINGT,ATAR,ART
COMMON /TAIL2/ CLAT,XCT,BKTB,BKBT,SKTB,SKBT
COMMON /PARTS/ CNBY,XCPBY,CNW,XCPW,CNT,XCPT,CLT

...................................   BODY FORCES

SMALL=1.0E-30
RAD=57.29578

ALP=ABS(ALPHA)
XL2=XL/DCY
XN2=XN/DCY
XCG2=XCG/DCY
CALL CROSFLO (FMACH,ALP,RE,D,XL2,XN2,NOSE,XCG2,CNV,CMV,X3)
CALL CROSFL1 (FMACH,ALP,1,1,XN2,XL2,XCG2,X1,X2,XCPV2)
XCPV=XCPV2*DCY
CNV=CNV*ACY/AREF

CNABD=CNAB/RAD
CNBY=CNABD*ALP + CNV
XCPBY=XCPB
IF(ALPHA.EQ.0.) GO TO 44
XCPBY=(XCPB*CNABD*ALP+XCPV*CNV)/(CNBY+SMALL)
IF(ALPHA.LT.0.) CNBY=-CNBY
...................................   WING FORCES
44    IF(BOW.NE.0.0) GO TO 750
CLW=0.0
XCPW=0.0
CHW=0.0
GO TO 751
750   CONTINUE
DI=ALPHA + DELW
CLAWD=CLAW/RAD
CLWA=CLAWD*ALPHA
CLWD=CLAWD*DELW
XCPW=XCW
ARMHW=(HINGW-XCPW)/DREF
```

```
CLW=(( BKWB+ BKBW)*CLWA + ( SKWB+ SKBW)*CLWD)*AWAR
CHW=(BKWB*CLWA + SKWB*CLWD)*ARMHW*AWAR/2.
CHW=CHW*(COS(D1/RAD) + SIN(D1/RAD)**2)
...............................   TAIL FORCES
751   IF(BOT.NE.0.0) GO TO 650
CLTI=0.0
XCPT=0.0
CHT=0.0
GO TO 651
650   CONTINUE
D2=ALPHA + DELT
CLATD=CLAT/RAD
CLTA=CLATD*ALPHA
CLTD=CLATD*DELT
XCPT=XCT
CLT=(( BKTB+ BKBT)*CLTA + ( SKTB+ SKBT)*CLTD)*ATAR
XHW=HINGW-XWING
XBART=+XCPT-XTAIL
CLI=0.
IF(BOW.EQ.0.) GO TO 68
CALL VORTEX (BOW,RBW,CRW,XHW,XWING,DELW,PHIW,AWAR,BOT,RBT,TRT,
C  XTAIL,XBART,PHIT,ART,ALPHA,CLAW,CLAT,BKWB,SKWB,CLI,FWSW)
68    CONTINUE
ARMHT=(HINGT-XCPT)/DREF
CHT=(BKTB*CLTA + SKTB*CLTD + CLI)*ARMHT*ATAR/2.
CHT=CHT*(COS(D2/RAD) + SIN(D2/RAD)**2)
CLTI=CLT+CLI
FTRAT=CLTI/(CLT + SMALL)
651   CONTINUE
..................................   COMPLETE CONFIGURATION
CNW=CLW
CNT=CLT
CNTI=CLTI
CN   =CNBY+CNW+CNTI
CM   =+CNBY*XCPBY+CNW*XCPW+CNTI*XCPT
XCP=CM/(CN + SMALL)
CMCG=(+CNBY*(XCG-XCPBY)+CNW*(XCG-XCPW)+CNTI*(XCG-XCPT))/DREF
RETURN
END
SUBROUTINE DATA1
INITIALIZE DATA BASE FILE INPUT.
N2       = NO. OF COEFFICIENTS.
N3       = NO. OF PARAMETERS.
CHARACTER*18 OFILE
COMMON /PACK/ IC(2),IP,N2,N3
200   FORMAT (1H0,'ENTER: IC(1) - 8 HEX. CHAR., I.E., ABCDEF12')
201   FORMAT (1H0,'ENTER: IC(2) - 8 HEX. CHAR., I.E., C0280000')
202   FORMAT (1H0,'ENTER: IP   - 8 HEX. CHAR., I.E.,  AF2E1000')
210   FORMAT (Z8)
300   FORMAT(1H0,'ENTER DATA BASE FILE NAME - I.E., DATA:ZCOPHED.DAT')
400   FORMAT(A18)
401   FORMAT (1H0,'PROBLEM WITH FILE=',A18,3X,'ISTAT=',I4)


13    WRITE(1,300)
READ(1,400)OFILE
OPEN(10,FILE=OFILE,FORM='BINARY',COUNTBY='RECORD'
*,RECL=32,BLOCKSIZE=32,IOSTAT=ISTAT,ACCESS='DIRECT'
*,STATUS='NEW')

IF (ISTAT .EQ. 0)GO TO 12
WRITE (1,401) OFILE,ISTAT
PAUSE 'CORRECT PROBLEM AND CONTINUE'
```

```
GO TO 13

12    CONTINUE
N2=3
N3=6

WRITE (1,200)
READ (5,210) IC(1)
WRITE (1,201)
READ (5,210) IC(2)
WRITE (1,202)
READ (5,210) IP

RETURN
END
SUBROUTINE DATA (ACON,H,Y)
DIMENSION Y(25,3), ACON(3), H(32), C(2,64)
COMMON /PACK/ IC(2),IP,N2,N3
H        = VALUE OF HEADING PARAMETERS.
Y        = COEFF. ARRAY AT EACH DATA POINT.
ACON     = CONFIGURATION NAME - 3 WORDS - 12 CHARACTERS.
C        = MAX AND MIN VALUES. (LOAD ZERO)
      CORFILE.FTN  PROGRAM DETERMINES MAX'S AND MIN'S.

DO 10 I=1,2
DO 10 J=1,64
10    C(I,J)=0.
WRITE (10) N2,N3,IC,IP,ACON
WRITE (10) (H(I), I=1,N3)
WRITE (10) (C(1,I),I=1,N2)
WRITE (10) (C(2,I),I=1,N2)
NPTS=H(1)
DO 50 I=1,NPTS
50    WRITE (10) (Y(I,J),J=1,N2)
RETURN
END
SUBROUTINE BODY(NOSE,XLN,XLA,FMACH,CNA,XCP)
INPUTS
NOSE = 1    OGIVE NOSE
NOSE = 2    CONICAL NOSE
XLN = NOSE LENGTH (CAL)
XLA = AFTERBODY LENGTH (CAL)
OUTPUT
CNA = NORMAL FORCE COEFF. (1/RAD)
XCP = CENTER OF PRESSURE (CAL FROM NOSE)
TABLE 1 = BODY DATA FOR TANGENT OGIVE NOSE WITH VARIOUS NOSE LENGTHS
TABLE 2 = BODY DATA FOR TANGENT OGIVE NOSE WITH VARIOUS AFTERBODY LENGTHS
TABLE 3 = BODY DATA FOR CONICAL NOSES OF VARIOUS ANGLES
TABLE 4 = BODY DATA FOR CONICAL NOSE WITH VARIOUS AFTERBODY LENGTHS
DIMENSION TMACH(15),TCNA1(15,3),TXCP1(15,3),TXLN(3),TCNA2(15,3)
$,TXCP2(15,3),TXLA(3),TANG(4),TALA(5),TCNA3(15,4),TXCP3(15,4),
$TCNA4(15,5),TXCP4(15,5)
DATA (TMACH(I),I=1,15)/.8,.9,1.,1.05,1.1,1.2,1.4,1.6,1.8,2.,2.5,
$3.,3.5,4.,4.5/
DATA (TXLN(I),I=1,3)/3.,4.,5./
DATA(TXLA(I),I=1,3)/4.,6.,8./
DATA(TANG(I),I=1,4)/6.,7.125,8.,10./
DATA(TALA(I),I=1,5)/4.,6.,8.,9.5,11./
DATA ((TCNA1(I,J),I=1,15),J=1,3)/.042,.043,.0465,.048,.0465,.0455,
$.0435,.0432,.044,.045,.05,.054,.055,.0575,.0575,.043,.044,.0465,
$.048,.0465,.044,.042,.0412,.0415,.0425,.047,.0518,.055,.055,.0545,
$.044,.045,.046,.048,.0465,.043,.042,.0405,.0408,.041,.0445,.05,.05
$2,.053,.054/
```

```
DATA((TXCP1(I,J),I=1,15),J=1,3)/.65,.55,.25,.17,.25,.65,.97,1.08,
$1.08,1.05,.88,.7,.5,.3,.08,1.17,1.05,.55,.45,.65,1.,1.4,1.57,1.6,
$1.58,1.46,1.3,1.1,.9, .65 ,1.6,1.35,.9,.77,.98,1.51,1.93,2.1,2.12,
$2.1,2.,1.9,1.69,1.47,1.2/
DATA((TCNA2(I,J),I=1,15),J=1,3)/0.0415,0.044,0.0465,0.048,0.0465,
$0.0445,0.042,0.0418,0.042,0.0425,0.0470,.0515,.054,.055,.056,.043,
$0.045,0.048,0.0505,0.0495,0.047,0.0448,0.044,0.0445,0.045,0.049,
$0.053,0.0545,0.056,0.0575,0.045,0.047,0.051,0.052,0.0515,0.0495,
$0.047,0.0462,0.046,0.0465,0.0495,0.053,0.0552,0.057,0.058/
DATA((TXCP2(I,J),I=1,15),J=1,3)/1.62,1.4,1.05,0.92,1.15,1.48,1.95,
$2.1,2.1,2.08,1.97,1.81,1.57,1.3,1.2,1.15,0.90,0.40,0.25,0.045,1.05
$,1.58,1.84,1.90,1.90,1.78,1.65,1.4,1.13,0.98,0.72,0.41,-0.10,-0.25
$,0.0,0.75,1.4,1.65,1.70,1.70,1.55,1.4,1.2,1.0,0.82/
DATA((TCNA3(I,J),I=1,15),J=1,4)/0.0405,0.042,0.046,0.0475,0.0455,
$0.044,0.042,0.041,0.041,0.042,0.044,0.048,0.052,0.0535,0.053,0.040
$5,.042,0.046,0.0475,0.0455,0.044,0.042,0.042,0.042,0.043,0.046,
$0.05,0.053,0.055,0.056,0.0405,0.042,0.046,0.0475,0.0455,0.044,0.04
$4,0.042,0.043,0.044,0.047,0.051,0.0545,0.057,0.058,0.0405,0.042,
$0.046,0.0475,0.0455,0.044,0.0438,0.0435,0.044,0.045,0.049,0.053,
$0.057,0.059,0.060/
DATA((TXCP3(I,J),I=1,15),J=1,4)/0.75,0.552,0.20,0.05,0.325,0.65,
$0.94,1.05,1.1,1.09,0.90,0.65,0.42,0.24,0.20,0.55,0.40,0.05,-0.10,
$0.15,0.47,0.70,0.85,0.85,0.83,0.60,0.37,0.15,-0.05,-0.11,0.37,0.20
$,-0.10,-0.20,0.0,0.30,0.57,0.70,0.70,0.65,0.45,0.22,-0.01,-0.20,
$-0.27,0.20,0.05,-0.30,-0.38,-0.25,0.05,0.30,0.45,0.47,0.43,0.242,
$-0.05,-0.30,-0.48,-0.50/
DATA((TCNA4(I,J),I=1,15),J=1,5)/0.039,0.041,0.0445,0.045,0.0435,
$0.043,0.041,0.040,0.0415,0.042,0.046,0.049,0.0515,0.053,0.054,
$0.0405,0.042,0.046,0.0475,0.0455,0.044,0.042,0.042,0.042,0.043,
$0.046,0.050,0.053,0.055,0.056,0.0435,0.045,0.0485,0.052,0.0515,
$0.049,.046,.045,.045,.046,.047,.051,.054,.055,.057,.044,.046,
$0.050,0.051,0.050,0.047,0.044,0.0435,0.044,0.045,0.047,0.050,0.054
$,0.056,0.057,0.045,0.047,0.051,0.053,0.051,0.048,0.043,0.042,0.042
$,0.0432,0.047,0.050,0.054,0.057,0.058/
DATA((TXCP4(I,J),I=1,15),J=1,5)/0.90,0.75,0.55,0.38,0.50,0.72,0.90
$,0.94,0.90,0.80,0.60,0.41,0.25,0.15,0.15,0.55,0.40,0.05,-0.10,0.15
$,.47,0.70,0.85,0.85,0.83,0.60,0.37,0.15,-0.05,-0.11,-0.11,-0.45,
$-0.75,-0.90,-0.65,-0.25,0.25,0.45,0.53,0.55,0.50,0.30,0.10,-0.15,
$-0.35,-0.30,-0.60,-1.20,-1.30,-1.05,-0.60,0.0,0.30,0.42,0.46,0.40,
$0.20,0.0,-0.24,-0.45,-0.55,-0.80,-1.45,-1.65,-1.50,-1.0,-0.30,0.13
$,0.28,0.39,0.30,0.10,-0.15,-0.35,-0.60/
RAD = 57.29578
IF (NOSE.EQ.2) GO TO 10
----------------------------------  OGIVE-CYLINDER
CALL TABLE2 (2,CNA1,TCNA1,FMACH,TMACH,15,3,XLN,TXLN,3,2)
CALL TABLE2 (2,CNA2,TCNA2,FMACH,TMACH,15,3,XLA,TXLA,3,2)
CALL TABLE2 (2,CNA3,TCNA2,FMACH,TMACH,15,3,6.0,TXLA,3,2)
CNA = (CNA1+CNA2-CNA3)*RAD
CALL TABLE2 (2,XCP1,TXCP1,FMACH,TMACH,15,3,XLN,TXLN,3,2)
CALL TABLE2 (2,XCP2,TXCP2,FMACH,TMACH,15,3,XLA,TXLA,3,2)
CALL TABLE2 (2,XCP3,TXCP2,FMACH,TMACH,15,3,6.0,TXLA,3,2)
XCP=XLN-(XCP1+XCP2-XCP3)
GO TO 11
----------------------------------  CONE-CYLINDER
10    ANG=ATAN (.5/XLN)
CALL TABLE2 (2,CNA4,TCNA3,FMACH,TMACH,15,3,ANG,TANG,4,2)
CALL TABLE2 (2,CNA5,TCNA4,FMACH,TMACH,15,3,XLA,TALA,5,2)
CALL TABLE2 (2,CNA6,TCNA4,FMACH,TMACH,15,3,6.0,TALA,5,2)
CNA=(CNA4+CNA5-CNA6)*RAD
CALL TABLE2 (2,XCP4,TXCP3,FMACH,TMACH,15,3,ANG,TANG,4,2)
CALL TABLE2 (2,XCP5,TXCP4,FMACH,TMACH,15,3,XLA,TALA,5,2)
CALL TABLE2 (2,XCP6,TXCP4,FMACH,TMACH,15,3,6.0,TALA,5,2)
XCP=XLN-(XCP4+XCP5-XCP6)
```

```
11     RETURN
END
SUBROUTINE BOATL (FMACH,DBOD,XLBOD,CNA,XCPOD)
COMPUTES (CNA) AND (XCP) FOR CONICAL BOATTAILS
REF.  MICOM REPORT NO. RD-TM-68-5
  BY.  W. D. WASHINGTON
INPUTS
FMACH = FREE STREAM MACH NUMBER
DBOD  = DIAMETER RATIO (BOATTAIL/CYLINDER)
XLBOD = BOATTAIL LENGTH/CYLINDER DIAMETER
OUTPUT
CNA   = BOATTAIL NORMAL FORCE COEFF., BASED ON CYLINDER AREA-1/RAD
XCPOD = BOATTAIL CENTER OF PRESSURE, CALIBERS FROM LEADING EDGE
DIMENSION TFMACH(11),TXCPLB(11),TBETLB(18),TCNPR(18)
DATA (TXCPLB(I), I=1,11) /.41,.41,.41,.415,.425,.45,.48,.52,.58,
+  .635,.7/
DATA (TFMACH(I), I=1,11) /.0,.5,1.,1.5,2.,2.5,3.,3.5,4.,4.5,5./
DATA (TBETLB(I), I=1,18) /-2.,-1.5,-1.,-.75,-.5,-.25,0.,.25,.5,
+  .75,1.,1.25,1.5,2.,3.,4.,5.,6./
DATA (TCNPR(I), I=1,18) /2.01,2.01,2.03,2.12,2.52,2.92,3.09,2.87,
+  2.35,1.66,1.15,1.,.93,.83,.69,.57,.5,.43/
BETLB=SQRT(ABS(FMACH**2-1.))/XLBOD
IF(FMACH.LT.1.) BETLB=-BETLB
IF(BETLB.LE.6.) GO TO 10
WRITE (6,500) BETLB
500  FORMAT (1H0,'BETLB='F10.2,5X,'OUTSIDE TABLE 5.0, LAST POINT USED')
BETLB=6.0
10   XMACH=FMACH
IF(FMACH.LE.5.) GO TO 11
WRITE (6,501) FMACH
501  FORMAT (1H0,'FMACH,'F10.2,5X,'OUTSIDE TABLE 5.0, LAST POINT USED')
XMACH=5.0
11   CALL INTERP (2,1,CNPR,TCNPR,BETLB,TBETLB,18,2,MINX,MAXX)
CALL INTERP (2,1,XCPLB,TXCPLB,XMACH,TFMACH,11,2,MINX,MAXX)
CNA=-CNPR*(1.-DBOD**2)
XCPOD=XCPLB*XLBOD
RETURN
END
SUBROUTINE CROSFLO(FMACH,ALP,RE,D,LODT,LODN,NOSE,XCG,CNV,CMV,XCPV)
CALCULATE VISCOUS COMPONENTS OF NORMAL FORCE AND PITCHING MOMENT
USING ALLEN'S METHOD WITH MODIFIED CDC CURVE.
INPUTS:
FMACH    = FREE STREAM MACH NUMBER.
ALP      = ANGLE OF ATTACK - DEG.
RE       = FREE STREAM REYNOLDS NO. - 1/FT.
D        = CYLINDER DIAMETER - FT.
LODT     = TOTAL BODY LENGTH - CALIBERS.
LODN     = NOSE LENGTH - CALIBERS.
NOSE     = 1  OGIVE
     = 2  CONE
XCG      = CENTER OF GRAVITY - CALIBERS FROM NOSE.
OUTPUTS:
CNV      = VISCOUS COMPONENT OF NORMAL FORCE
CMV      = VISCOUS COMPONENT OF PITCHING MOMENT, ABOUT XCG.
XCPV     = VISCOUS COMPONENT CENTER OF PRESSURE - CAL. FROM NOSE.
NOTES:
     1 CALIBER IS 1 CYLINDER DIAMETER (D).
     CNV AND CMV ARE BASED ON CYLINDER CROSS SECTIONAL AREA
     AND DIAMETER.

DIMENSION TLOD(7),TETAO(7),TMN(22),TCDC(22),TMN2(6),TCDC2(6)
REAL MN,LODN,LODA,LODT
DATA TLOD /0.,5.,10.,15.,20.,30.,40./
```

```
DATA TETAO /.53,.63,.69,.74,.76,.80,.82/
DATA TMN /.0,.1,.2,.3,.4,.5,.6,.7,.8,.85,.9,.94,
+  1.0,1.1,1.2,1.4,1.6,1.8,2.0,2.4,2.8,3.0/
DATA TCDC /1.2,1.18,1.18,1.2,1.23,1.28,1.37,
+  1.52,1.45,1.42,1.64,2.08,2.0,
+  1.67,1.80,1.82,1.85,1.85,1.85,
+  1.8,1.69,1.56,1.48,1.43,1.40,1.36,1.34,1.34/
DATA TMN2 /.0,.1,.2,.3,.4,.5/
DATA TCDC2 /.30,.37,.48,.72,.96,1.28/

DEG=57.29578
PI=3.14159
SMALL=1.E-30

IF (NOSE.EQ.1) GO TO 16
              CONE PLANFORM AREA AND CENTROID
AP1=(LODN/2.)*4./PI
XB1=.6667*LODN
GO TO 15
                OGIVE PLANFORM AREA AND CENTROID
16     BROD=LODN**2 + .25
XB1=.55*LODN
AP1=-2.*LODN*(BROD-.5) + LODN*SQRT(BROD**2-LODN**2)
+   +BROD**2*ASIN(LODN/BROD)
AP1=AP1*4./PI
            ADD CYLINDERICAL AFTERBODY
15     LODA=LODT - LODN
AP2=LODA*4./PI
XB2=.5*LODA
APOAR=AP1 + AP2
XCPV=(XB1*AP1 + (LODN + XB2)*AP2)/APOAR

MN=FMACH*SIN(ALP/DEG)
REN=RE*D*SIN(ALP/DEG)
CALL INTERP (2,1,ETAO,TETAO,LODT,TLOD,7,2,MIN,MAX)
RECRIT=1.E05

ETA=ETAO

IF (REN.LE.RECRIT) GO TO 10
IF (MN.GE.0.5) GO TO 10
CALL INTERP (2,1,CDC,TCDC2,MN,TMN2,6,2,MIN,MAX)
GO TO 11
10     CALL INTERP (2,1,CDC,TCDC,MN,TMN,22,2,MIN,MAX)
11     CNV=CDC*ETA*APOAR*SIN(ALP/DEG)**2
CMV=CNV*(XCG-XCPV)
RETURN
END
SUBROUTINE CROSFL1 (FMACH,ALP,LT,NOSE,XNOSE,XTOT,XCG,CNV,CMV,XCPV)
CALCULATE VISCOUS COMPONENTS OF NORMAL FORCE AND PITCHING MOMENT
USING CROSS FLOW DRAG METHOD OF PERKINS AND JORGENSEN.
INPUTS:
FMACH    = FREE STREAM MACH NO.
ALP      = ANGLE OF ATTACK - DEG.
LT       = 1  LAMINAR BOUNDARY LAYER.
    = 2  TURBULENT BOUNDARY LAYER.
NOSE     = 1  OGIVE NOSE.
    = 2  CONE NOSE.
XNOSE    = NOSE LENGTH - CALIBERS
XTOT     = TOTAL BODY LENGTH - CALIBERS
XCG      = CENTER OF GRAVITY - CALIBERS FROM NOSE
OUTPUTS:
CNV      = VISCOUS COMPONENT OF NORMAL FORCE
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CMV     = VISCOUS COMPONENT OF PITCHING MOMENT
NOTES:
    1 CALIBER IS 1 CYLINDER DIAMETER (D).
    CNV AND CMV ARE BASED ON CYLINDER CROSS SECTIONAL AREA
    AND DIAMETER.

DIMENSION TXOLM(21),TCDRL(21),TCDRT(21),TMC(21),TCDCP(21)
DIMENSION TBOXN(11),TLMO(11),TLMC(11)
REAL LM,LMOXN,MC

DATA TXOLM /.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0,1.1,1.2,
+  1.3,1.4,1.5,1.6,1.7,1.8,1.9,2.0/
DATA TCDRL /.0,.025,.085,.185,.35,.63,.93,1.20,1.38,1.49,
+  1.48,1.40,1.30,1.21,1.14,1.08,1.04,1.00,.97,.94,.92/
DATA TCDRT /.0,.01,.05,.10,.25,.50,.80,1.0,1.1,1.1,
+  1.03,.96,.90,.85,.82,.80,.80,.80,.80,.80,.80/
DATA TMC /.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0,1.1,1.2,
+  1.3,1.4,1.5,1.6,1.7,1.8,1.9,2.0/
DATA TCDCP /1.2,1.18,1.18,1.2,1.25,1.36,1.53,1.73,1.82,
+  1.82,1.79,1.74,1.67,1.60,1.53,1.46,1.40,1.37,1.33,1.30,1.28/
DATA TBOXN /.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0/
DATA TLMO /1.0,1.09,1.22,1.39,1.57,1.76,1.98,2.20,2.42,2.65,2.88/
DATA TLMC /1.0,1.21,1.42,1.63,1.84,2.05,2.27,2.47,2.67,2.89,3.09/

SMALL=1.E-30
DEG=57.29578
PI=3.14159
LMOXN=1.0
IF (FMACH.LE.1.0) GO TO 11
BOXN=SQRT(FMACH**2-1.)/XNOSE
IF (NOSE.EQ.2) GO TO 10
CALL INTERP (2,1,LMOXN,TLMO,BOXN,TBOXN,11,2,MIN,MAX)
GO TO 11
10     CALL INTERP (2,1,LMOXN,TLMC,BOXN,TBOXN,11,2,MIN,MAX)
11     LM=LMOXN*XNOSE
...................................  CALCULATE CDCP
MC=FMACH*SIN(ALP/DEG)
CALL INTERP (2,1,CDCP,TCDCP,MC,TMC,20,2,MIN,MAX)

SUMN=0.
SUMM=0.
FN1=0.
FM1=0.
X1=0.
I=2
56     X2=X1 + .1*LM
IF (X2.LE.XTOT) GO TO 54
X2=XTOT
XOLM=X2/LM
IF (LT.EQ.2) GO TO 55
CALL INTERP (2,1,CDR2,TCDRL,XOLM,TXOLM,21,2,MIN,MAX)
GO TO 51
55     CALL INTERP (2,1,CDR2,TCDRT,XOLM,TXOLM,21,2,MIN,MAX)
GO TO 51
54     IF (LT.EQ.2) GO TO 50
CDR2=TCDRL(I)
GO TO 51
50     CDR2=TCDRT(I)

51     K2=.5
IF(X2.GE.XNOSE) GO TO 53
IF (NOSE.EQ.2) GO TO 52
BIGR=.25 + XNOSE**2
```

```
R2=SQRT(BIGR**2-(XNOSE-X2)**2)-(BIGR-.5)
GO TO 53
52     R2=X2*(1./XNOSE)/2.

53     FN2=CDR2*R2
FM2=FN2*(XCG-X2)
DN=(FN2 + FN1)*(X2-X1)/2.
DM=(FM2 + FM1)*(X2-X1)/2.
SUMN=SUMN + DN
SUMM=SUMM + DM

X1=X2
FN1=FN2
FM1=FM2
I=I + 1
IF (I.GT.21) I=21
IF (X2.LT.XTOT) GO TO 56

CONST=(8./PI)*CDCP*SIN(ALP/DEG)**2
CNV=CONST*SUMN
CMV=CONST*SUMM
XCPV=XCG - CMV/(CNV + SMALL)
RETURN
END
SUBROUTINE ARAT(XM,CCR,XX1,XXLB,DDB,D,A1A)
THIS SUBROUTINE CALCULATES THE SHADED AREA RATIO
FOR MODIFING CARRYOVER WHEN FINS ARE CLOSE TO BASE OF BODY
FOR CYLINDER OR BOATTAIL
XM     = MACH NUMBER
CCR    = FIN ROOT CHORD
XX1    = DISTANCE FROM BASE OF MISSILE TO FIN TRAILING EDGE
XXLB   = LENGTH OF BOATTAIL
DDB    = DIAMETER OF BASE
D      = DIAMETER OF CYLINDER
A1A    = SHADED AREA RATIO
PROGRAM MODIFIED (9 DEC,71) TO INCLUDE FINS EXTENDED AFT BASE, TAS
A1A=1.0
IF(XM.LE.1.0) GO TO 7
CR=CCR/D
X1=XX1/D
XLB=XXLB/D
DB=DDB/D
A=CR

IF(X1.LT. 0.0) CR=CR+X1
IF(X1.LT. 0.0) X1=0.0

XLC=CR + X1 - XLB
BETA=SQRT(XM*XM - 1.0)
TANMU=1.0/BETA
TANTH=0.0
IF(XLB.NE.0.0) TANTH=.5*(1.0-DB)/XLB
TANTM=(TANTH + TANMU)/(1.0-TANTH*TANMU)
C1=SQRT(1.0 + XLC*XLC)
C2=SQRT(1.0 + ((XLC + XLB)/(.5*(1.0 + DB)))**2)
C3=SQRT(1.0 + (TANTH + X1*(1.0 + TANTH**2)/DB)**2)
IF((XM.GE.1.0).AND.(XM.LE.C1)) I=1
IF((XM.GT.C1).AND.(XM.LE.C2)) I=2
IF((XM.GT.C2).AND.(XM.LE.1.0E+25)) I=3
IF((XM.GT.C3).AND.(XM.LE.1.0E+25)) J=1
IF((XM.GE.1.0).AND.(XM.LE.C3)) J=2
GO TO (1,2,3), I
1      B=0.
```

```
H=BETA
C=0.
H1=0.
GO TO (4,5), J
2       B=1.0-XLC/BETA
H=XLC
C=0.
H1=B/(TANTH + TANMU)
GO TO (4,5), J
3       B=1.0-XLC/BETA
H=XLC
C=.5*(1.0+DB)-(XLC+XLB)/BETA
H1=XLB
GO TO (4,5), J
4       E=1.0-2.0*(XLB-X1)*TANTH
F=DB-X1*(TANTM-TANTH)
H2=X1
GO TO 6
5       E=1.0-2.0*(XLB-X1)*TANTH
F=0.
H2=E/(TANTH+TANTM)
GO TO 6
6       A1=.5*(2.0*XLC+(1.0+DB)*XLB-(1.0+B)*H-(B+C)*H1-(E+DB)*X1+(E+F)*H2)
A1A=A1/A
7       RETURN
END
SUBROUTINE READX (LU,LRECL,HOL,FLO,LH,LF,EOFF)

IMPROVED VERSION OF FFREAD
BY J.M. CHAFIN

DIMENSION FORM(6),IBUF(132),JBUF(33),HOL(1),FLO(1)
1060    FORMAT (132A1)
1260    FORMAT('(A',I2,')')
1270    FORMAT('(',I2,'XA',I2,')')
1280    FORMAT('(',I2,'A4,A',I2,')')
1290    FORMAT('(',I2,'X',I2,'A4,A',I2,')')
1360    FORMAT('(',I2,'XF',I2,'.1)')
1400    FORMAT('(F',I2,'.1)')
1460    FORMAT('(',I2,'XI',I2,')')
1500    FORMAT('(I',I2,')')
-------------------------------------------------------------

PURPOSE
-------

READS ONE CARD IN FREE FIELD FORMAT (UP TO 132 CHARS)
ANY COMMENT CARDS ENCOUNTERED IN THE DATA DECK ARE
SKIPPED AND NOT INTERPRETED

ARGUMENTS  I=INPUT
---------  O=OUTPUT

LU    -- I -- LOGICAL UNIT NUMBER OF INPUT DEVICE
LRECL-- I -- LOGICAL RECORD LENGTH IN CHARACTERS (132 MAX)
HOL   -- O -- WILL CONTAIN HOLLERITHS FOUND ON RECORD (33 MAX)
FLO   -- O -- WILL CONTAIN FLOATS FOUND ON RECORD
LH    -- O -- NUMBER OF HOLLERITHS ON RECORD
LF    -- O -- NUMBER OF FLOATS  ON RECORD
EOFF -- O -- 0 RETURNED IF NO END OF FILE ENCOUNTERED.
EOFF -- O -- 1 RETURNED IF END OF FILE ENCOUNTERED.

DEFINITIONS -- LIMITATIONS
```

```
------------------------
A *TRACAR* (TRANSPARENT CHARACTER) IS A BLANK, COMMA OR = SIGN
THE FOLLOWING ARE DELIMITERS
- BEGIN OF CARD
- END OF CARD
- A STRING CONSISTING OF ONE OR MORE TRACARS
AN ITEM CONSISTS OF ONE OR MORE NON-TRACARS PRECEDED AND FOLLOWED BY A
DELIMITER.
EACH ITEM WILL BE INTERPRETED AS EITHER INTEGER, FLOAT, OR HOLLERITH:
ANY ITEM STARTING WITH + - . OR DIGIT WILL BE INTERPRETED AS
- INTEGER IF IT CONTAINS NO .
- FLOAT IF IT CONTAINS ONE .
- HOLLERITH IF IT CONTAINS MORE THAN ONE .
ALL OTHER ITEMS WILL BE INTERPRETED AS HOLLERITHS

------------------------------------------------------------
INITIALIZE COUNTS AND READ CARD
------------------------------------------------------------
EOFF=0
1020 LH=0
LF=0
LI=0
1021   READ(LU,1060,END=999) (IBUF(I),I=1,LRECL)
IF(IBUF(1).EQ.'C'.AND.IBUF(2).EQ.' ') GO TO 1021
ENCODE(JBUF,1060) (IBUF(I),I=1,LRECL)
I2=0
------------------------------------------------------------
FIND I1 = FIRST COLUMN OF FIELD
------------------------------------------------------------
1100 I1=I2
1120 I1=I1+1
IF (I1.GT.LRECL) RETURN
IX=IBUF(I1)
IF (IX.EQ.' '.OR.IX.EQ.','.OR.IX.EQ.'=') GO TO 1120
------------------------------------------------------------
FIND I2 = LAST COLUMN OF FIELD
------------------------------------------------------------
I2=I1
1140 I2=I2+1
IF (I2.GT.LRECL) GO TO 1160
IX=IBUF(I2)
IF (IX.NE.' '.AND.IX.NE.','.AND.IX.NE.'=') GO TO 1140
I2=I2-1
GO TO 1180
1160 I2=LRECL
------------------------------------------------------------
IW = FIELD WIDTH
------------------------------------------------------------
1180 NX=I1-1
IW=I2-I1+1
DO 1190 I=1,6
1190 FORM(I) ='    '
IX=IBUF(I1)
IF(IX.EQ.'+'.OR.IX.EQ.'-'.OR.IX.EQ.'.') GO TO 1200
IF (IX.GE.'0'.AND.IX.LE.'9') GO TO 1200
GO TO 1240
------------------------------------------------------------
COUNT THE DOTS
------------------------------------------------------------
1200 NDOTS=0
DO 1220 I=I1,I2
IF (IBUF(I).EQ.'.') NDOTS=NDOTS+1
```

```
1220 CONTINUE
IF(NOUTS-1) 1440,1340,1240
-----------------------------------------------------------------
HOLLERITH
-----------------------------------------------------------------
1240   CONTINUE
NF=IW/4
NP=MAX0(1,MOD(IW,4))
IF(NF.EQ.0.AND.NX.EQ.0) ENCODE(FORM,1260) NP
IF(NF.EQ.0.AND.NX.GT.0) ENCODE(FORM,1270) NX,NP
IF(NF.GT.0.AND.NX.EQ.0) ENCODE(FORM,1280) NF,NP
IF(NF.GT.0.AND.NX.GT.0) ENCODE(FORM,1290) NX,NF,NP
IF(MOD(IW,4).GT.0) NF=NF+1
LH1=LH+1
LHN=LH+NF
DECODE(JBUF,FORM) (HOL(I),I=LH1,LHN)
LH=LH+NF
GO TO 1100
-----------------------------------------------------------------
FLOAT
-----------------------------------------------------------------
1340   CONTINUE
IF(NX.EQ.0) ENCODE(FORM,1400) IW
IF(NX.GT.0) ENCODE(FORM,1360) NX,IW
LF=LF+1
DECODE (JBUF,FORM)FLO(LF)
GO TO 1100
-----------------------------------------------------------------
INTEGER
-----------------------------------------------------------------
1440   CONTINUE
IF(NX.EQ.0) ENCODE(FORM,1500) IW
IF(NX.GT.0) ENCODE(FORM,1460) NX,IW
LF=LF+1
DECODE (JBUF,FORM) INT
FLO(LF)=FLOAT(INT)
GO TO 1100
----------------------------------------------------------------------
IF END OF FILE ENCOUNTERED, SET EOFF=1
----------------------------------------------------------------------
999   EOFF=1
RETURN
END
SUBROUTINE ROLL (BO,CR,TR,RBODY,DREF,AREF,CLP,CLD)

SUBROUTINE FOR CALCULATING ROLL DAMPING AND ROLL MOMENT EFFECTIVENESS.
THEORY FROM  NACA REPORT 1088.

ALL GEOMETRIC INPUTS MUST HAVE SAME SYSTEM OF UNITS.
I.E., FT., IN., CALIBERS, ETC.

BO   = FIN EXPOSED SEMI-SPAN
CR   = FIN ROOT CHORD
TR   = FIN TAPER RATIO
RBODY= RADIUS OF BODY AT FIN
DREF= REFERENCE LENGTH
AREF= REFERENCE AREA

OUTPUT

CLP = ROLL DAMPING COEFFICIENT (BASED ON DREF $ AREF)
CLD = ROLLING MOMENT EFFECTIVENESS COEFF (BASED ON DREF $ AREF)
  (FOUR FINS DEFLECTED)
```

```
DREF=REFERENCE DIAMETER
DIMENSION TLAMDA(11),TCLPAR(11),TCLDAR(11)
DATA TLAMDA/.0,.1,.2,.3,.4,.5,.6,.7,.8,.9,1.0/
DATA TCLPAR/.16,.159,.161,.164,.160,.1475,.120,.086,.043,.013,.0/
DATA TCLDAR/.252,.254,.256,.248,.230,.202,.158,.100,.048,.014,.0/
CLP=0.0
CLD=0.0
DBODY=2.*RBODY
IF(BO.EQ.0.0) RETURN
SPAN=2.*BO + DBODY
XLAMDA=DBODY/SPAN
S=CR*(BO+DBODY/2.)*(1.+TR+(1.-TR)*DBODY/(2.*BO))
AR=SPAN**2/S
CALL INTERP (2,1,CLPAR,TCLPAR,XLAMDA,TLAMDA,11,3,MIN,MAX)
CALL INTERP (2,1,CLDAR,TCLDAR,XLAMDA,TLAMDA,11,3,MIN,MAX)
CLP=-CLPAR*AR
CLD=CLDAR*AR
CLP=CLP*(SPAN/DREF)**2*S/AREF
CLD=CLD*(SPAN/DREF)*S/AREF
RETURN
END
SUBROUTINE FINGEOM (CR,TR,BO,AREF,SWTE,CT,AR,SWLE,CBAR,
+  YBAR,XM,CENT,AFAR,TANL,SWHA)

FIN PANEL GEOMETRY.

ALL GEOMETRIC INPUTS MUST HAVE SAME SYSTEM OF INPUTS.
I.E., FT., IN., CALIBERS, ETC.
OUTPUTS WILL HAVE CONSISIANT UNITS WITH INPUTS.

INPUTS:

CR       = ROOT CHORD
TR       = TAPER RATIO
BO       = EXPOSED SEMI-SPAN
AREF     = REFERENCE AREA
SWTE     = TRAILING EDGE SWEEPBACK ANGLE - DEG.

OUTPUTS:

CT       = TIP CHORD
AR       = ASPECT RATIO ( 1 FIN PANEL ).
    ( SAME FOR 2 FINS JOINED, WITHOUT BODY).
SWLE     = LEADING EDGE SWEEPBACK ANGLE - DEG.
CBAR     = MEAN AERODYNAMIC CHORD / ROOT CHORD.
YBAR     = SPANWISE LOCATION OF M.A.C. / EXPOSED SEMI-SPAN.
XM       = DISTANCE FROM L.E. CR TO L.E. MAC.
CENT     = DISTANCE FROM L.E. CR TO CENTROID.
AFAR     = AREA OF 1 FIN / AREF.
TANL     = TANGENT OF LEADING EDGE SWEEPBACK ANGEL
SWHA     = MID CHORD SWEEPBACK ANGLE - DEG.

SMALL=1.E-30
RAD=57.29578
AR=4.*BO/(CR*(1.+TR)+SMALL)
CT=CR*TR
AFAR=CR*BO*(1.+TR)/AREF/2.
TANL=(CR-CT)/(BO+SMALL)+TAN(SWTE/RAD)
SWLE=(ATAN(TANL))*57.3
TANH=TANL-.5*(CR-CT)/(BO+SMALL)
SWHA=(ATAN(TANH))*57.3
CBAR=1.0-(1.0-(2.0*TR**2)/(1.0+TR))/3.0
```

AD-A129 501 COMPUTER PROGRAM FOR ESTIMATING STABILITY DERIVATIVES OF MISSILE CONFIGUR..(U) ARMY MISSILE COMMAND REDSTONE ARSENAL AL SYSTEMS SIMULATION A.. G A SANDERS ET AL. 2/2

UNCLASSIFIED AUG 82 DRSMI/RD-83-2-TR SBI-AD-E950 390 F/G 16/4 NL

END
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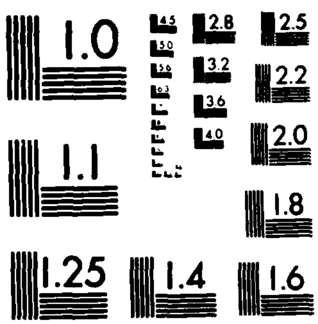

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
YBAR=(((1.0+2.0*TR)/(1.0+TR))/3.0)
XM=YBAR*TANL*BO/(CR+SMALL)
CENT=XM+.5*CBAR
RETURN
END
SUBROUTINE STAN62(HEIGHT,VSOUND,RHO,PRESS,TEMP,IUNITS)

THIS SUBROUTINE IS A U. S. STANDARD MODEL ATMOSPHERE, 1962
PREPARED BY AMSMI-RST, 21 JULY 1967

THIS ROUTINE IS VALID BELOW 700,000 METERS
EXTRAPOLATION IS PROVIDED ABOVE 700,000 METERS

   1 HEIGHT   ALTITUDE                    M          FT
   2 VSOUND   VELOCITY OF SOUND           M/SEC      FT/SEC
   3 RHO      DENSITY                     KG/M3      SLUG/FT3
   4 PRESS    PRESSURE                    KG/M2      LBS/FT2
   5 TEMP     TEMPERATURE                 K          R
   6 IUNITS   =1 FOR METRIC
              =2 FOR ENGLISH

DIMENSION ZZ(13),PB(13),RL(13),ZB(13),TB(13),XXX(13)
DIMENSION HH(8),PBH(8),RLH(8),HBH(8),TBH(8)
DATA HH/ 11.0, 20.0, 32.0, 47.0, 52.0, 61.0, 79.0, 88.743/
DATA PBH/ 10331.9076, 2307.7398, 558.2615, 88.50965, 11.30876,
1  6.016163, 1.85682, .105812/
DATA RLH/ -6.5, 0.0, 1.0, 2.8, 0.0, -2.0, -4.0, 0.0/
DATA HBH/ 0.0, 11.0, 20.0, 32.0, 47.0, 52.0, 61.0, 79.0/
DATA TBH/ 288.15, 216.65, 216.65, 228.65, 270.65, 270.65, 252.65,
1  180.65/
DATA ZZ/ 100.,110.,120.,150.,160.,170.,190.,230.,300.,400.,500.,
1  600.,700./
DATA PB/ .016762, .0030667, .7499E-3, .2571E-3, .516E-4,
1  .3767E-4, .28476E-4, .17184E-4, .709767E-5, .1921E-5, .41097E-6,
2  .1117E-6, .3518E-7/
DATA RL/ 3.0, 5.0, 10.0, 20.0, 15.0, 10.0, 7.0, 5.0, 4.0, 3.3,
1  2.6, 1.7, 1.1/
DATA ZB/ 90.0, 100.0, 110.0, 120.0, 150.0, 160.0, 170.0, 190.0,
1  230.0, 300.0, 400.0, 500.0, 600.0/
DATA TB/ 180.65, 210.65, 260.65, 360.65, 960.65, 1110.65, 1210.65,
1  1350.65, 1550.65, 1830.65, 2160.65, 2420.65, 2590.65/
DATA XXX/ 33.166119, 33.064396, 32.96512, 32.784318, 32.530427,
1  32.455229, 32.309443, 32.016142, 31.492584, 30.704189,
1  29.808321, 28.937691, 28.123252/
DATA AA,BB,CC,DD,EE/
1      1.5731262E-7,2.4656553E-14,3.8667054E-21,6.0621354E-28,
2      9.5013649E-35/

************************************          0 - 90,000.


IF (HEIGHT.LT.0.0001) HEIGHT=0.0
H = HEIGHT
IF(IUNITS .NE. 1)   H = H * .3048
Z=H*.001
IF(Z .GT. 90.0) GO TO 140
H = (H - AA*H**2 + BB*H**3 - CC*H**4 + DD*H**5 - EE*H**6) * .001

DO 550 I=1,8
IF(H - HH(I)) 551,551,550
550   CONTINUE
GO TO 140
551   IF((I.NE.2).AND.(I.NE.5).AND.(I.NE.8)) GO TO 120
```

```
110   TEMP=TBH(I)
PRESS=PBH(I)*EXP(-34.16479*(H-HBH(I))/TBH(I))
GO TO 130
120   TEMP=TBH(I) + (H-HBH(I))*RLH(I)
EP=34.16479/RLH(I)
PRESS=PBH(I)*(TBH(I)/TEMP)**EP
130 RHO = PRESS/(29.26945*TEMP)
VSOUND = 20.046333*TEMP**0.5
GO TO 460

************************************          90,000. - 700,000.

140 Z1 = HEIGHT
IF(Z1 .GT. 170000.0) GO TO 142
Z BETWEEN 90000. M AND 170000. M
XM = (((((0.14186509E-27*Z1 -0.11145834lE-21)*Z1
1   +0.359201416E-16) *Z1 -0.60665213E-11)*Z1
2 +0.565215163E-6) * Z1 -0.275300356E-1)*Z1
3 +5.76957191E+2
GO TO 150
Z GREATER THAN 170000. M
142 XM = (((((1.180554E-33*Z1 -3.429162E-27)
1   *Z1+3.8159669E-21)*Z1 -2.0402054E-15)
2   *Z1 +5.6422141E-10)*Z1 -1.0700489E-4)
3 *Z1 +3.5629995E+1
150   DO 500 I=1,13
IF(Z-ZZ(I)) 450,450,500
500   CONTINUE
WRITE (6,290)
290 FORMAT(30H0 ALT .GT. 700000.0 M..STANO2)
I=13
450   TM=TB(I) + (Z-ZB(I))*RL(I)
TEMP=TM*XM/28.964
EP=XXX(I)/RL(I)
PRESS=PB(I)*(TB(I)/TM)**EP
RHO = PRESS/(29.26945*TM)
VSOUND = (401.90467 * TM) ** 0.5
460 IF(IUNITS .EQ. 1)   GO TO 999
VSOUND = VSOUND * 3.2808333
RHO = RHO * .194032E-2
PRESS = PRESS * .20482
TEMP = TEMP * 1.8
999 RETURN
END
SUBROUTINE BRIT (XM,AR,TR,SWEEP,CLA,XCPCB)
TAKEN FROM THE BRITISH DATA SHEETS  S.01.03.06
                                    S.01.03.05
                                    S.01.03.04
                                    S.01.03.03
                                    S.08.01.02
XM     = FREE STREAM MACH NO.
AR     = ASPECT RATIO (TWO WINGS JOINED WITHOUT BODY)
TR     = TAPER RATIO
SWEEP = WING MID-CHORD SWEEPBACK ANGLE (DEG)
CLA    = LIFT COEFF. SLOPE, BASED ON EXPOSED WING AREA  1/RAD.
XCPCB = CENTER OF PRESSURE (PERCENT MEAN GEOMETERIC CHORD),
    MEASURED FROM LEADING EDGE MEAN GEOMETERIC CHORD.
DIMENSION XT1(15),YT1(7),ZT1(4),XT2(8),YT2(5),ZT2(4),YT4(7)
DIMENSION BAR1(15,7,4), BAR2(8,5,4),BAR3(15,7,4),BAR4(8,7,4)
DATA XT1/0.,.5,1.,1.5,2.,2.5,3.,3.5,4.,4.5,5.,5.5,6.,6.5,7./
DATA YT1/0.,1.,2.,3.,4.,5.,6./
DATA ZT1/0.,.25,.5,1./
DATA XT2/0.,1.,2.,3.,4.,5.,6.,7./
```

```
DATA YT2/0.,1.,2.,3.,4./
DATA Y14/0.,1.,2.,3.,4.,5.,6./
DATA ZT2/0.,.25,.5,1./
DATA (((BAR1(I,J,K),I=1,15),J=1,7),K=1,2) /
A                   1.56,1.52,1.41,1.30,1.20,1.11,1.03,.95,.89,.83,
1.78,.74,.70,.66,.63,1.56,1.52,1.40,1.27,1.17,1.08,1.00,.93,.87,
2.82,.77,.73,.69,.65,.62,1.56,1.47,1.30,1.17,1.08,1.01,.95,.89,.84,
3.79,.75,.71,.67,.64,.61,1.26,1.21,1.13,1.05,.99,.93,.88,.83,.79,
4.75,.71,.68,.65,.62,.59,1.05,1.01,.98,.94,.89,.85,.81,.77,.73,.7,
5.67,.64,.61,.59,.57,.90,.88,.86,.83,.80,.77,.74,.71,.68,.66,.63,
6.61,.59,.57,.55,.79,.78,.77,.75,.73,.70,.68,.65,.63,.61,.59,.57,
7.55,.53,.52,1.57,1.53,1.45,1.34,1.25,1.16,1.07,1.,.93,.875,.82,.78
8,.735,.695,.66,1.57,1.53,1.42,1.31,1.20,1.11,1.03,.97,.91,.86,.81,
9.765,.72,.685,.65,1.57,1.45,1.31,1.205,1.12,1.05,.98,.925,.87,.82,
1.78,.74,.70,.665,.63,1.26,1.19,1.12,1.06,1.00,.95,.90,.85,.81,.77,
2.74,.70,.67,.64,.61,1.05,1.00,.96,.92,.885,.86,.83,.79,.76,.725,
3.69,.665,.64,.61,.59,.90,.855,.82,.80,.78,.76,.74,.72,.70,.67,.64,
4.62,.60,.57,.55,.79,.75,.73,.71,.70,.68,.67,.65,.64,.62,.60,.58,
5.56,.55,.53/
DATA (((BAR1(I,J,K),I=1,15),J=1,7),K=3,4) /
A                   1.58,1.53,1.45,1.35,1.25,1.16,1.07,1.00,.93,.88,
1.82,.78,.73,.69,.66,1.58,1.52,1.42,1.31,1.21,1.12,1.04,.98,.915,
2.86,.805,.76,.72,.68,.64,1.58,1.44,1.32,1.20,1.12,1.05,.98,.92,
3.87,.82,.78,.74,,70,.66,.63,1.26,1.20,1.13,1.06,1.01,.96,.90,.85,
4.81,.77,.74,.70,.66,.63,.60,1.05,1.01,
5                        .97,.93,.89,.85,.82,.78,.75,.72,.68,.66,.63,
6.60,.58,.90,.87,.84,.81,.79,.76,.73,.71,.68,.66,.64,.62,.59,.57,
7.55,.79,.76,.74,.71,.69,.67,.66,.64,.62,.60,.59,.57,.55,.54,.52,
81.57,1.52,1.45,1.34,1.22,1.12,1.04,.97,.90,.84,.77,.74,.70,.67,
9.64,1.57,1.51,1.42,1.30,1.18,1.08,1.00,.94,.88,.82,.78,.73,.69,
1.65,.63,1.57,1.48,1.36,1.22,1.10,1.02,.95,.88,.82,.78,.73,.69,.66,
2.63,.61,1.27,1.17,1.10,1.025,.96,.91,.86,.81,.77,.73,.69,.66,.63,
3.60,.58,1.06,.99,.94,.89,.84,.81,.78,.74,.71,.68,.65,.62,.60,.58,
4.56,.91,.85,.80,.77,.74,.72,.70,.68,.65,.62,.60,.58,.56,.55,.54,
5.79,.74,.70,.67,.65,.63,.62,.61,.59,.58,.56,.54,.53,.52,.50/
DATA BAR2 /
A                   .265,.270,.273,.275,.274,.273,.270,.268,.380,
1.347,.327,.314,.303,.295,.290,.285,.500,.420,.378,.352,.335,.325,
2.318,.313,.505,.445,.405,.380,.365,.353,.345,.340,.505,.460,.432,
3.410,.395,.383,.375,.370,.145,.195,.225,.240,.247,.250,.250,.250,
4.262,.265,.267,.267,.267,.267,.267,.267,.380,.332,.305,.290,.283,
5.282,.282,.282,.395,.355,.330,.315,.305,.298,.295,.293,.405,.385,
6.365,.345,.325,.315,.307,.303,.070,.185,.225,.237,.243,.245,.247,
7.248,.177,.217,.235,.243,.245,.245,.245,.244,.285,.247,.243,.247,
8.250,.250,.248,.247,.305,.267,.257,.255,.255,.255,.255,.255,.317,
9.287,.275,.270,.270,.270,.270,.270,0.,.175,.225,.237,.243,.245,
1,245,.245,.085,.110,.165,.205,.220,.225,.227,.230,.165,.167,.170,
1,182,.197,.205,.210,.213,.193,.190,.189,.190,.193,.197,
2           .200,.203,.200,.197,.189,.190,.193,.195,.196,.198/
DATA (((BAR3(I,J,K),I=1,15),J=1,7),K=1,2) /
A                   1.56,1.70,1.76,1.75,1.70,1.43,1.22,1.06,.94,.85,
1.77,.71,.65,.60,.56,1.56,1.735,1.76,1.62,1.48,1.35,1.24,1.09,.96,
2.86,.78,.715,.66,.61,.565,1.56,1.535,1.47,1.395,1.31,1.22,1.14,
31.07,1.005,.90,.805,.73,.67,.62,.58,1.26,1.30,1.275,1.233,1.17,
41.11,1.05,1.00,.945,.90,.86,.775,.70,.645,.60,1.046,1.07,1.085,
51.085,1.06,1.023,.986,.95,.90,.86,.822,.79,.76,.682,.635,.895,
6.915,.93,.94,.94,.93,.91,.888,.855,.822,.788,.76,.73,.707,.682,
7.79,.795,.80,.80,.80,.802,.805,.81,.81,.78,.755,.73,.71,.68,.661,
81.57,1.56,1.85,1.82,1.64,1.41,1.21,1.06,.94,.845,.77,.71,.65,.60,
9.558,1.57,1.50,1.83,1.72,1.585,1.41,1.215,1.065,.955,.86,.78,.716,
1.66,.61,.562,1.57,1.13,1.46,1.46,1.40,1.305,1.22,1.11,.985,.89,
2.804,.73,.67,.62,.572,1.26,1.18,1.10,1.23,1.275,1.20,1.125,1.065,
31.015,.94,.85,.772,.71,.65,.60,1.05,1.05,1.05,1.05,1.05,1.05,1.04,
```

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41.01,.962,.92,.87,.815,.74,.68,.63,.90,.908,.915,.923,.93,.942,
5,.95,.935,.91,.875,.84,.815,.78,.73,.67,.79,.786,.78,.78,.779,.78,
6,.785,.80,.82,.83,.82,.785,.755,.73,.704/
DATA (((BAR3(I,J,K),I=1,15),J=1,7),K=3,4) /
A                 1.58,1.88,1.92,1.80,1.59,1.36,1.17,1.03,.92,.84,
1,.75,.69,.635,.59,.55,1.58,1.80,1.90,1.76,1.55,1.355,1.18,1.045,
2,.935,.847,.77,.705,.645,.60,.56,1.58,1.46,1.35,1.445,1.43,1.32,
31.23,1.08,.97,.87,.79,.72,.66,.61,.57,1.26,1.25,1.235,1.22,1.26,
41.21,1.145,1.08,.995,.91,.83,.756,.693,.64,.59,1.05,1.05,1.055,
51.055,1.055,1.07,1.05,1.015,.97,.925,.86,.80,.74,.68,.63,.90,.90,
6,.902,.903,.905,.907,.91,.91,.90,.88,.86,.83,.77,.71,.67,.79,.792,
7,.80,.80,.804,.81,.813,.816,.82,.822,.817,.798,.76,.74,.69,1.57,
81.79,2.0,1.8,1.52,1.29,1.12,.985,.88,.795,.72,.665,.62,.575,.535,
91.57,1.60,2.0,1.72,1.48,1.29,1.13,1.0,.90,.81,.74,.68,.63,.583,
1,.545,1.57,1.55,1.52,1.48,1.44,1.29,1.16,1.03,.93,.835,.76,.70,
2,.645,.60,.56,1.27,1.30,1.30,1.28,1.24,1.19,1.145,1.05,.96,.87,.80,
3,.735,.68,.625,.58,1.06,1.055,1.05,1.04,1.02,.995,.98,.97,.97,.90,
4,.83,.765,.70,.655,.61,.905,.90,.885,.875,.865,.86,.858,.855,.853,
5,.85,.84,.785,.735,.69,.65,.795,.783,.78,.77,.762,.76,.757,.75,.75,
6 .75,.758,.76,.77,.74,.72/
DATA BAR4 /        .250,.350,.450,.465,.475,.483,.486,.490,.380,
1,.472,.472,.472,.480,.487,.490,.495,.5,.5,.5,.5,.5,.5,.501,.501,
2,.505,.54,.54,.54,.54,.54,.525,.520,.505,.542,.580,.580,.580,.580,
3,.580,.558,.509,.548,.585,.625,.625,.625,.625,.625,.515,.555,.595,
4,.633,.673,.673,.673,.673,.145,.295,.450,.475,.485,.490,.495,.495,
5,.267,.350,.437,.473,.483,.487,.492,.493,.380,.445,.445,.445,.488,
6,.502,.502,.502,.395,.440,.481,.481,.481,.532,.530,.523,.405,.433,
7,.470,.525,.525,.525,.570,.560,.413,.457,.503,.550,.570,.570,.570,
8,.615,.425,.450,.477,.510,.560,.625,.625,.625,.070,.260,.450,.477,
9,.485,.490,.493,.493,.177,.270,.365,.457,.475,.482,.485,.485,.285,
1,.360,.385,.415,.480,.485,.485,.485,.305,.355,.400,.435,.465,.511,
2,.510,.505,.317,.323,.326,.460,.487,.501,.543,.537,.330,.320,.310,
3,.425,.505,.523,.550,.565,.337,.315,.300,.423,.500,.560,.580,.605,
40.00,.330,.445,.465,.475,.483,.485,.485,.085,.310,.400,.440,.455,
5,.465,.470,.470,.165,.290,.380,.425,.448,.458,.467,.475,.193,.300,
6,.390,.433,.457,.470,.477,.477,.200,.330,.423,.465,.485,.493,.496,
7,.495,.200,.330,.423,.465,.485,.493,.496,.495,.200,.330,.423,.465,
8,.485,.493,.496,.495/
X=AR*SQRT(ABS(1.-XM**2))
Y=AR*TAN(SWEEP/57.29578)
Z=TR
IF(X.GT.7.) WRITE (6,900) X
IF(Z.GT.1.) WRITE (6,902) Z
IF(XM.GT.1.0) GO TO 1
CALL TABLE3 (2,CLAR,BAR1,X,XT1,15,3,Y,YT1,7,3,Z,ZT1,4,3)
IF(Y.GT.4.) WRITE (6,901) Y
CALL TABLE3 (2,XCPCB,BAR2,X,XT2,8,3,Y,YT2,5,3,Z,ZT2,4,3)
CLA=CLAR*AR
RETURN
1     CALL TABLE3 (2,CLAR,BAR3,X,XT1,15,3,Y,YT1,7,3,Z,ZT1,4,3)
IF(Y.GT.6.) WRITE (6,901) Y
CALL TABLE3 (2,XCPCB,BAR4,X,XT2,8,3,Y,YT4,7,3,Z,ZT2,4,3)
CLA=CLAR*AR
RETURN
900   FORMAT (1X,'EXTRAPOLATION REQUIRED, '10HAR'BETA = F10.4)
901   FORMAT (1X,'EXTRAPOLATION REQUIRED, '11HAR'TANS= = F10.4)
902   FORMAT (1X,'EXTRAPOLATION REQUIRED, TAPER RATIO = 'F10.4)
END
SUBROUTINE MCDEVT (FMACH,AR,CLA)
FIN NORMAL FORCE FROM NACA REPT. 1253  (MCDEVITT)
RECTANGULAR ONLY
DIMENSION TFMACH(6),TAR(7),TCLA(7,6,1)
DATA (TFMACH(I), I=1,6) /.0,.5,.8,.9,1.,1.1/
```

```
DATA (TAR(I), I=1,7) /.0,.5,1.,1.5,2.,3.,4./
DATA TCLA /.0,.014,.029,.04,.049,.063,.075,
+ .0,.014,.029,.04,.049,.063,.075,.0,.014,.029,.041,.052,.067,.076,
+ .0,.016,.03,.043,.056,.081,.107,.0,.018,.034,.05,.064,.086,.099,
+ .0,.018,.034,.048,.06,.078,.089/
CALL TABLE2 (2,CLA,TCLA,AR,TAR,7,2,FMACH,TFMACH,6,2)
CLA=CLA*57.3
RETURN
END
SUBROUTINE FACTOR (BOW,RBW,CRW,XHW,XLW,DELTW,BOT,RBT,TRT,XLT,XCPT,
C  ALPHA,XI,FWSW)
DIMENSION TL(4)
DETERMINATION OF TAIL INTERFERENCE FACTOR (I) BY STRIP THEORY
AND SLENDER BODY THEORY  FROM NACA 1307 - APPENDIX B
USE THIS IN EQUATION  (55)  TO CALCULATE
LIFT ON TAIL SECTION DUE TO WING VORTICES
WING VORTEX LATERAL POSITION IS SET AT  .7854 (SEE EQUATION 39)
BOW    = EXPOSED SEMI-SPAN OF WING
RBW    = RADIUS OF BODY AT WING
CRW    = ROOT CHORD OF WING
XHW    = DISTANCE FROM WING LEADING EDGE TO WING HINGE LINE
XLW    = DISTANCE FROM NOSE OF BODY TO WING LEADING EDGE
DELTW = WING DEFLECTION ANGLE (SEE PAGE 11) - DEG
BOT    = EXPOSED SEMI-SPAN OF TAIL
RBT    = RADIUS OF BODY AT TAIL
TRT    = TAPER RATIO OF TAIL (CT/CR)
XLT    = DISTANCE FROM NOSE OF BODY TO TAIL LEADING EDGE
XCPT   = CENTER OF PRESSURE OF TAIL (MEASURED FROM LEADING EDGE OF
    ROOT CHORD)
ALPHA = ANGLE OF ATTACK - DEG
XI     = TAIL INTERFERENCE FACTOR
FWSW   = RATIO OF VORTEX LATERAL POSITION TO WING EXPOSED SEMI-SPAN
    (MEASURED FROM BODY SURFACE)
FW     = SPANWISE LOCATION OF WING VORTEX (FROM BODY CENTERLINE)
FT     = SPANWISE LOCATION OF WING VORTEX AT TAIL FIN STATION
HT     = HEIGHT OF WING VORTEX ABOVE TAIL FIN STATION
HT     = EQUATION 41, PAGE 13
RAD=57.29578
PI=3.14159
HT=-(CRW-XHW)*SIN(DELTW/RAD)+(XLT+XCPT-XLW-CRW)*SIN(ALPHA/RAD)
ROSW=RBW/(RBW+BOW)
C1=1.-ROSW
C2=1.+ROSW**2
C3=1.-ROSW**2
FWSW=((PI/4.)*C3-ROSW+(C2**2/(2.*C3))*ASIN(C3/C2))/(2.*C1)
FW=FWSW*BOW + RBW
FT=FW-RBW+RBT
S=BOT+RBT
RS=RBT/S
HS=HT/S
FS=FT/S
IF((FS.EQ.1.).AND.(HS.EQ.0.)) FS=.99
FSI=(FS*RS**2)/(FS**2 + HS**2)
HSI=(HS*RS**2)/(FS**2 + HS**2)
I=1
80    TL(I)=(((1.0-RS*TRT)-FS*(1.0-TRT))/(2.0*(1.0-RS)))
TL(I)=TL(I)*ALOG((HS**2 + (FS-1.0)**2)/(HS**2 + (FS-RS)**2))
TL(I)=TL(I)-(1.-TRT)
IF(HS.EQ.0.0) GO TO 81
TL(I)=TL(I)-((1.-TRT)/(1.-RS))*HS*(ATAN((FS-1.)/HS)
1   -ATAN((FS-RS)/HS))
81    I=I + 1
GO TO (82,82,83,84,85),I
```

```
82     FS=-FS
GO TO 80
83     FS=FSI
HS=HSI
GO TO 80
84     FS=-FSI
GO TO 80
85     XI=(2.0/(1.0 + TRT))*(TL(1)-TL(2)-TL(3)+TL(4))
RETURN
END
SUBROUTINE FNCROS (FMACH,AR,C1)
THIS SUBROUTINE CALCULATES THE COEFF. OF NON-LINEAR CONTRIBUTION
TO LIFT,  C1.
TAKEN FROM A PAPER PRESENTED AT THE SIXTH U. S. NAVAL SYMPOSUIM
ON AEROBALLISTICS, 1 NOV 1963.
AUTHOR,  A. F. LAMPROS

NOTE:  THIS THEORY IS VALID ONLY FOR SUBSONIC FLOW.
   (C1) IS REDUCED QUADRATICALLY WITH MACH NUMBER
   BEYOND MACH 1.0.  THIS IS AN ARBITRARY FIX TO SMOOTH
   THE TRANSITION INTO SUPERSONIC FLOW.

DIMENSION TC1(10),TAR1(10)
DATA (TC1(I),I=1,10)/9.8,8.95,6.65,5.3,4.45,3.75,3.3,2.55,2.,1.55/
DATA (TAR1(I), I=1,10) /.0,.5,1.,1.5,2.,2.5,3.,4.,5.,6./
CALL INTERP (2,1,C1,TC1,AR,TAR1,10,3,MIN,MAX)
C1=C1*.0001
IF (FMACH.GT.1.) C1=C1/FMACH**4
RETURN
END
SUBROUTINE VORTEX (BOW,RBW,CRW,XHW,XLW,DELTW,PHIW,AWAR,BOT,RBT,
1  TRT,XLT,XCPT,PHIT,ART,ALPHA,CLAW,CLAT,BKWB,SKWB,CLTV,FWSW)
THIS SUBROUTINE CALC. LIFT ON TAIL SECTION DUE TO WING VORTICES.
THE METHOD OUTLINED IN NACA 1307 IS USED.
APPENDIX  B  IS USED FOR THE TAIL INTERFERENCE FACTOR (I).
INDEPENDENT ROLL ANGLES OF WING AND TAIL ARE ALLOWED.
THE SUBROUTINE ACCOUNTS FOR ROLL ANGLES BY ADJUSTING THE GEOMETRY
AND TAKING COMPONENTS IN THE PITCH PLANE.
THE FINAL ANSWER (CLTV) IS VECTORED IN THE ANGLE OF ATTACK PLANE
(OR PITCH PLANE) REGARDLESS OF WING OR TAIL ROLL ANGLES.
BOW    = EXPOSED SEMI-SPAN OF WING
RBW    = RADIUS OF BODY AT WING
CRW    = ROOT CHORD OF WING
XHW    = DISTANCE FROM WING LEADING EDGE TO WING HINGE LINE
XLW    = DISTANCE FROM NOSE OF BODY TO WING LEADING EDGE
DELTW  = WING DELFECTION ANGLE (SEE PAGE 11) - DEG
PHIW   = ROLL ANGLE OF WING FROM VERTICAL (DEG).
AWAR   = RATIO OF WING AREA(TWO WINGS) TO REFERENCE AREA.
BOT    = EXPOSED SEMI-SPAN OF TAIL
RBT    = RADIUS OF BODY AT TAIL
TRT    = TAPER RATIO OF TAIL (CT/CR)
XLT    = DISTANCE FROM NOSE OF BODY TO TAIL LEADING EDGE
XCPT   = CENTER OF PRESSURE OF TAIL (MEASURED FROM LEADING EDGE OF
    ROOT CHORD)
PHIT   = ROLL ANGLE OF TAIL FROM VERTICAL (DEG).
ART    = ASPECT RATIO OF TAIL (TWO TAILS JOINED WITHOUT BODY).
ALPHA  = ANGLE OF ATTACK - DEG
CLAW   = LIFT COEFFICIENT SLOPE OF WING, BASED ON WING AREA (1/RAD)
CLAT   = LIFT COEFFICIENT SLOPE OF TAIL, BASED ON TAIL AREA (1/RAD)
BKWB   = UPWASH INTERFERENCE FACTOR FOR WING, DUE TO ALPHA.
SKWB   = UPWASH INTERFERENCE FACTOR FOR WING, DUE TO DELTW.
    SEE NACA 1307, PAGE 48, FOR  BKWB  AND  SKWB.
CLTV   = LIFT COEFFICIENT ON TAIL SECTION DUE TO WING VORTICES,
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```
    BASED ON REFERENCE AREA.
    RETURN WITH  (CLTV)  SUMMED FOR ALL CASES.  (EACH WING
    AFFECTING EACH TAIL).
XI     = TAIL INTERFERENCE FACTOR.  (ONE WING ACTING ON ONE TAIL)
FWSW   = RATIO OF VORTEX LATERAL POSITION TO WING EXPOSED SEMI-SPAN
    (MEASURED FROM BODY SURFACE)
DIMENSION PHWING(4),PHTAIL(4),HT(4),FT(4),PHIV(4),RV(4),IL(2)
OMMENT................................    NO. OF WING VORTEX AND TAILS
PI=3.14159265360
RAD=57.2957795128
IF(PHIW) 7,1,7
7      IF(PHIW-90.) 2,1,2
1      NVORT=2
PHWING(1)=PI/2.
PHWING(2)=3.*PI/2.
GO TO 3
2      NVORT=4
PHWING(1)=PHIW/RAD
PHWING(2)=(PHIW+90.)/RAD
PHWING(3)=(PHIW+180.)/RAD
PHWING(4)=(PHIW+270.)/RAD
3      IF(PHIT) 8,4,8
8      IF(PHIT-90.) 5,4,5
4      NTAIL=1
PHTAIL(1)=PI/2.
GO TO 6
5      NTAIL=2
PHTAIL(1)=PHIT/RAD
PHTAIL(2)=(PHIT+90.)/RAD
6      CONTINUE
OMMENT................................    WING VORTEX POSITION
ROSW=RBW/(RBW+BOW)
C1=1.-ROSW
C2=1.+ROSW**2
C3=1.-ROSW**2
FWSW=((PI/4.)*C3-ROSW+(C2**2/(2.*C3))*ASIN(C3/C2))/(2.*C1)
FW=FWSW*BOW+RBW
FW=FW-RBW+RBT
S=BOT+RBT
RS=RBT/S
DO 10 K=1,NVORT
SIPHW=SIN(PHWING(K))
COPHW=COS(PHWING(K))
SIDLW=SIN(DELTW/RAD)
SIALP=SIN(ALPHA/RAD)
HT(K)=-(CRW-XHW)*SIDLW*ABS(SIPHW)
C   +FW*COPHW+(XLT+XCPT-XLW-CRW)*SIALP
FT(K)=FW*SIPHW+(CRW-XHW)*SIDLW*COPHW*SIPHW/ABS(SIPHW)
PHI=ATAN(HT(K)/FT(K))
PHIV(K)=PI/2.-PHI
IF(FT(K)) 9,9,10
9      PHIV(K)=3.*PI/2.-PHI
10     RV(K)=SQRT(FT(K)**2 + HT(K)**2)
OMMENT................................    CALC. TAIL INTERFER. FACTOR
CLTV=0.0
DO 15 L=1,2
DO 11 J=1,NTAIL
DO 11 K=1,NVORT
F=RV(K)*COS(PHTAIL(J)-PHIV(K))
H=RV(K)*SIN(PHTAIL(J)-PHIV(K))
FS=F/S
HS=H/S
FSI=(FS*RS**2)/(FS**2 + HS**2)
```

```
HSI=(HS*RS**2)/(FS**2 + HS**2)
DO 12 I=1,2
TL(I)=(((1.0-RS*TRT)-FS*(1.0-TRT))/(2.0*(1.0-RS)))
TL(I)=TL(I)*ALOG((HS**2 + (FS-1.0)**2)/(HS**2 + (FS-RS)**2))
TL(I)=TL(I)-((1.0-TRT)/(1.0-RS))*((1.0-RS) + HS*(ATAN((FS-1.0)/HS)
C  -ATAN((FS-RS)/HS)))
FS=FSI
12     HS=HSI
XL    =TL(1)
XLIM    =TL(2)
XI=(2./(1.+TRT))*(XL-XLIM)*SIN(PHWING(K))/ABS(SIN(PHWING(K)))
OMMENT...............................     CALCULATE  CLTV
GAMOSV=(BKWB*(ALPHA/RAD )*ABS(SIN(PHWING(K)))+SKWB*DELTW/RAD )
C  *CLAW*AWAR*ABS(SIN(PHWING(K)))/(4.*FWSW*BOW)
CLPART=XI*CLAT*ABS(SIN(PHTAIL(J)))          *BOT*GAMOSV/(PI*ART)
CLTV=CLTV+CLPART
11     CONTINUE
DO 13 J=1,NTAIL
13     PHTAIL(J)=PI-PHTAIL(J)
DO 14 K=1,NVORT
PHWING(K)=2.*PI-PHWING(K)
14     PHIV(K)=2.*PI-PHIV(K)
15     CONTINUE
RETURN
END
SUBROUTINE INTSLB (N,FMACH,BETA, BM,RB,CR,TR,BO,AR,CLA,
1  BKWB,BKBW,SKWB,SKBW)
WING-BODY AND TAIL-BODY INTERFERENCE FACTORS FROM CHARTS 1,4,5
NACA 1307
N      = 1      AFTERBODY
N      = 2      NO AFTERBODY
FMACH = FREE STREAM MACH NUMBER
BETA  = SUBSONIC ON SUPERSONIC BETA
BM    = BETA * COTANGENT OF LEADING-EDGE SWEEP ANGLE
RB    = RADIUS OF BODY
CR    = ROOT CHORD
TR    = TAPER RATIO (CT/CR)
BO    = EXPOSED SEMI-SPAN
AR    = EXPOSED ASPECT RATIO
CLA   = LIFT COEFFICIENT SLOPE (PER RADIAN) - BASED ON WING OR
    TAIL EXPOSED AREA (2 PANELS)
BKWB  = BIG (K) WING-BODY INTERFERENCE (CHART 1)
BKBW  = BIG (K) BODY-WING INTERFERENCE (CHARTS 1, 4, 5)
SKWB  = SMALL (K) WING-BODY INTERFERENCE (CHART 1)
SKBW  = SMALL (K) BODY-WING INTERFERENCE (CHART 1)
DIMENSION TBKWB(11),TBKBW(11),TSKWB(11),TSKBW(11),TROS(11),
1  TBRC(7),TBRCN(7),TBM(18),TBMN(8),TKBWC(7,18),TKBWCN(7,8)
DATA (TBKWB(I), I=1,11)/
X 1.0,1.08,1.165,1.255,1.352,1.45,1.555,1.663,1.772,1.885,2.0/
DATA (TBKBW(I), I=1,11)/
X 0.0,0.13,0.28,0.44,0.61,0.80,1.0,1.22,1.45,1.70,2.0/
DATA (TSKWB(I), I=1,11)/
X 1.0,.963,.943,.935,.935,.938,.946,.958,.970,.985,1.0/
DATA (TSKBW(I), I=1,11)/
X 0.0,0.11,0.21,0.315,0.415,0.515,0.61,0.705,0.802,0.90,1.0/
DATA (TROS(I), I=1,11)/
X 0.0,0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.0/
DATA (TBRC(I), I=1,7)/ .1,.6,1.0,1.4,2.0,2.8,4.0/
DATA (TBRCN(I), I=1,7)/ .2,.6,1.0,1.4,2.2,2.8,4.0/
DATA (TBM(I), I=1,18)/  .1,.2,.3,.4,.5,.6,.7,.8,.9,
X  1.0,1.2,1.6,2.0,3.0,4.0,7.0,10.0,99.9999E+30/
DATA (TBMN(I), I=1,8)/ .2,.4,.6,.8,1.0,2.0,4.0,99.9999E+30/
DATA TKBWC/
```

```
X .6331, .3498, .2665, .2332, .2332, .1832, .1333,
X  1.25, .8163, .6664, .5998, .4989, .4332, .3998,
X  1.866, 1.25, 1.05, .933, .8163, .6831, .8331,
X  2.332, 1.666, 1.399, 1.25, 1.0099, .9496, .8497,
X  2.849, 2.016, 1.749, 1.549, 1.366, 1.199, 1.05,
X  3.249, 2.316, 2.016, 1.816, 1.633, 1.466, 1.233,
X  3.615, 2.632, 2.266, 2.066, 1.893, 1.633, 1.433,
X  3.898, 2.882, 2.499, 2.266, 2.0, 1.799, 1.566,
X  4.215, 3.149, 2.716, 2.466, 2.199, 1.966, 1.733,
X  4.415, 3.315, 2.882, 2.599, 2.332, 2.083, 1.832,
X  4.781, 3.615, 3.149, 2.866, 2.516, 2.249, 2.016,
X  5.181, 3.998, 3.515, 3.215, 2.849, 2.516, 2.232,
X  5.515, 4.248, 3.749, 3.432, 3.082, 2.732, 2.382,
X  5.914, 4.665, 4.132, 3.798, 3.399, 3.049, 2.682,
X  6.214, 4.915, 4.382, 4.015, 3.632, 3.232, 2.866,
X  6.647, 5.265, 4.681, 4.315, 3.898,  3.499, 3.082,
X  6.864, 5.431, 4.848, 4.465, 4.048, 3.632, 3.215,
X  7.23, 5.848, 5.231, 4.831, 4.365, 3.932, 3.482/
DATA TKBWCN/
X  .9653, .5442, .3685, .2632, .1755, .1229, .0877,
X  1.86, 1.14, .737, .526, .333, .246, .176,
X  2.597, 1.509, 1.017, .737,.456, .351, .281,
X  3.123, 1.772, 1.176, .84, .544, .439, .316,
X  3.65, 2.264, 1.457, 1.053, .684, .544, .368,
X  4.56, 2.861, 1.842, 1.316, .842, .666, .491,
X  5.247, 3.287, 2.088, 1.527, 1.000, .789, .544,
X  6.107, 3.879, 2.51, 1.772, 1.193, .912, .649/
ROS=RB/(RB + BO)
IF(FMACH.LE.1.0) GO TO 1
IF(BM.GT.99.9999E+30) BM=99.9999E+30
CON=BETA*AR*(1.0 + TR)*(1.0 + 1.0/ BM)
IF(CON.LE.4.0) GO TO 1
BRC=2.0*BETA*RB/CR
IF(BRC.GT.4.0) BRC=4.0
CON2=BETA*CLA*(TR + 1.0)*(1.0/ROS - 1.0)
IF(N.GT.1) GO TO 3
CALL TABLE2 (2,ANR,TKBWC,BRC,TBRC,7,3,BM,TBM,18,3)
BKBW=ANR/CON2
GO TO 4
3     CALL TABLE2 (2,ANR,TKBWCN,BRC,TBRCN,7,3,BM,TBMN,8,3)
BKBW=ANR/CON2
GO TO 4
1     CALL INTERP (2,1,BKBW,TBKBW,ROS,TROS,11,3,MIN,MAX)
4     CALL INTERP (2,1,BKWB,TBKWB,ROS,TROS,11,3,MIN,MAX)
CALL INTERP (2,1,SKBW,TSKBW,ROS,TROS,11,3,MIN,MAX)
CALL INTERP (2,1,SKWB,TSKWB,ROS,TROS,11,3,MIN,MAX)
RETURN
END
SUBROUTINE INTERP (IXTRP,LMT,Y,YT,X,XT,NX,NPX,MINX,MAXX)

TABLE LOOK-UP ROUTINE FOR 1 INDEPENDENT VARIABLE
WITH SIMPLE INTERPOLATION OR EXTRAPOLATION.

IXTRP = 1 EXTRAPOLATE IF NECESSARY.
IXTRP = 2 EXTRAPOLATION NOT ALLOWED. TAKE THE LAST(OR FIRST) POINT.
LMT = 1 PROGRAM WILL DETERMINE SUBSCRIPT RANGE (MINX TO MAXX).
LMT = 2 PROGRAM ASSUMS THAT MINX AND MAXX SUBSCRIPTS ARE KNOWN.
Y        ANSWER OR DEPENDENT VARIABLE CORRESPONDING TO INPUT (X).
YT       TABLE OF DEPENDENT VARIABLES CORRESPONDING TO XT.
X        ARGUMENT OR INDEPENDENT VARIABLE FOR WHICH ANSWER (Y) WILL
   BE DETERMINED.
XT       TABLE OF INDEPENDENT VARIABLES.
NX       NUMBER OF POINTS IN XT,YT
```

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NPX      NUMBER OF POINTS TO BE USED FOR INTERPOLATION.
MINX     MINIMUM XT SUBSCRIPT USED FOR INTERPOLATION.
MAXX     MAXIMUM XT SUBSCRIPT USED FOR INTERPOLATION.

DIMENSION XT(NX),YT(NX)
IF (IXTRP.EQ.1) GO TO 140
Y=YT(1)
IF(X.LE.XT(1)) RETURN
Y=YT(NX)
IF(X.GE.XT(NX)) RETURN
140   IF(LMT.EQ.2) GO TO 130
CALL LIMIT (X,XT,NX,NPX,MINX,MAXX)
130   Y=YT(MINX)
IF(MINX.EQ.MAXX) RETURN
Y=0.
DO 120 J=MINX,MAXX
P=1.
DO 110 I=MINX,MAXX
IF(I.EQ.J) GO TO 110
P=P*(X-XT(I))/(XT(J)-XT(I))
110   CONTINUE
120   Y=Y + YT(J)*P
RETURN
END
SUBROUTINE TABLE2 (IXTRP,W,WT,X,XT,NX,NPX,Y,YT,NY,NPY)

TABLE LOOK-UP ROUTINE FOR 2 INDEPENDENT VARIABLES.
IXTRP = 1 EXTRAPOLATE IF NECESSARY.
IXTRP = 2 EXTRAPOLATION NOT ALLOWED. TAKE THE LAST(OR FIRST) POINT.
W      = ANSWER,(DEPENDENT VARIABLE CORRESPONDING TO INPUTS  X,Y)
WT     = TABLE OF DEPENDENT VARIBALE CORRESPONDING TO XT,YT
    WT(I,J)     INCREMENT SUBSCRIPTS LEFT TO RIGHT WHEN LOADING
X      = THE ARGUMENT OR INDEPENDENT VARIABLE  X
XT     = TABLE OF INDEP.  X  VALUES (MUST BE IN INCREASING ORDER)
NX     = NUMBER OF POINTS IN  XT
NPX    = NUMBER OF POINTS TO USE FOR  X  INTERPOLATION
Y      = THE ARGUMENT OR INDEPENDENT VARIABLE  Y
YT     = TABLE OF INDEP.  Y  VALUES (MUST BE IN INCREASING ORDER)
NY     = NUMBER OF POINTS IN  YT
NPY    = NUMBER OF POINTS TO USE FOR  Y  INTERPOLATION

DIMENSION XT(NX),YT(NY),WT(NX,NY), B(20)
CALL LIMIT (Y,YT,NY,NPY,MINY,MAXY)
CALL LIMIT (X,XT,NX,NPX,MINX,MAXX)
DO 42 J=MINY,MAXY
CALL INTERP (IXTRP,2,B(J),WT(1,J),X,XT,NX,NPX,MINX,MAXX)
42    CONTINUE
CALL INTERP (IXTRP,2,W,B,Y,YT,NY,NPY,MINY,MAXY)
RETURN
END
SUBROUTINE TABLE3 (IXTRP,W,WT,X,XT,NX,NPX,Y,YT,NY,NPY,Z,ZT,NZ,NPZ)

TABLE LOOK-UP ROUTINE FOR 3 INDEPENDENT VARIABLES.
IXTRP = 1 EXTRAPOLATE IF NECESSARY.
IXTRP = 2 EXTRAPOLATION NOT ALLOWED. TAKE THE LAST(OR FIRST) POINT.
W      = ANSWER,(DEPENDENT VARIABLE CORRESPONDING TO INPUTS  X,Y,Z)
WT     = TABLE OF DEPENDENT VARIBALE CORRESPONDING TO XT,YT,ZT
    WT(I,J,K)  INCREMENT SUBSCRIPTS LEFT TO RIGHT WHEN LOADING
X      = THE ARGUMENT OR INDEPENDENT VARIABLE  X
XT     = TABLE OF INDEP   X  VALUES (MUST BE IN INCREASING ORDER)
NX     = NUMBER OF POINTS IN  XT
NPX    = NUMBER OF POINTS TO USE FOR  X  INTERPOLATION
Y      = THE ARGUMENT OR INDEPENDENT VARIABLE  Y
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YT     = TABLE OF INDEP.  Y  VALUES (MUST BE IN INCREASING ORDER)
NY     = NUMBER OF POINTS IN  YT
NPY    = NUMBER OF POINTS TO USE FOR  Y  INTERPOLATION
Z      = THE ARGUMENT OR INDEPENDENT VARIABLE  Z
ZT     = TABLE OF INDEP.  Z  VALUES (MUST BE IN INCREASING ORDER)
NZ     = NUMBER OF POINTS IN  ZT
NPZ    = NUMBER OF POINTS TO USE FOR  Z  INTERPOLATION

DIMENSION XT(NX),YT(NY),ZT(NZ),WT(NX,NY,NZ), B(20),A(10)
CALL LIMIT (Z,ZT,NZ,NPZ,MINZ,MAXZ)
CALL LIMIT (Y,YT,NY,NPY,MINY,MAXY)
CALL LIMIT (X,XT,NX,NPX,MINX,MAXX)
DO 41 K=MINZ,MAXZ
DO 42 J=MINY,MAXY
CALL INTERP (IXTRP,2,B(J),WT(1,J,K),X,XT,NX,NPX,MINX,MAXX)
42     CONTINUE
CALL INTERP (IXTRP,2,A(K),B,Y,YT,NY,NPY,MINY,MAXY)
41     CONTINUE
CALL INTERP (IXTRP,2,W,A,Z,ZT,NZ,NPZ,MINZ,MAXZ)
RETURN
END
SUBROUTINE LIMIT (X,XT,NX,NP ,MINX,MAXX)
THIS SUBROUTINE WILL FIND THE MINIMUM AND MAXIMUM SUBSCRIPTS
(OR RANGE) TO BE CONSIDERED FOR INTERPOLATION.
DIMENSION XT(NX)
NPX=NP
IF(NPX.GT.NX) NPX=NX
DO 25 I=1,NX
IF(XT(I)-X) 25,22,21
25     CONTINUE
.................................    GREATER THAN MAX SUBSCRIPT
24     MAXX=NX
MINX=NX-NPX+1
RETURN
.................................    WITHIN RANGE
21     MINX=I-NPX/2
MAXX=MINX+NPX-1
IF(MAXX.GT.NX) GO TO 24
IF(MINX.GE.1) RETURN
.................................    LESS THAN MIN SUBSCRIPT
MINX=1
MAXX=NPX
RETURN
.................................    NO INTERP NECESSARY
22     MINX=I
MAXX=I
RETURN
END
$BEND
```

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