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THE STATIC STABILITY CHARACTERISTICS OF SEVERAL CONE-CYLINDER-FLARE-CYLINDER CONFIGURATIONS AT MACH NUMBERS 0.4 TO 4.5

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THE STATIC STABILITY CHARACTERISTICS OF SEVERAL CONE-CYLINDER-FLARE-CYLINDER CONFIGURATIONS AT MACH NUMBERS 0.4 TO 4.5

By

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DA Project No. 1-B-2-22901-D-209

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ABSTRACT

The aerodynamic characteristics of various cone-cylinder-flare-skirt configurations were investigated between Mach Numbers 0.4 to 4.5. The Reynolds number range for the tests was from 0.5 to 6.0 million per foot. Data are presented in basic form, along with cross plots, to show the effect of changing various body component shapes.

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LIST OF SYMBOLS

A_b	Respective base area, $\pi D_b^2/4$, in.^{2}
$C_{A,T}$	Measured axial-force coefficient, axial force/$q_\infty S$
$C_{A,F}$	Forebody axial-force coefficient, $C_{A,T} - C_{A,b}$
$C_{A,b}$	Base axial-force coefficient, $\left(\frac{P_\infty - P_b}{q_\infty}\right)\frac{A_b}{S}$
$C_{m,N}$	Pitching-moment coefficient about model nose, positive-moment tending to lower model base, pitching moment/$q_\infty SD$
C_N	Normal force coefficient, normal force/$q_\infty S$
D	Reference diameter, inches
D_b	Base diameter, inches
L	Overall length, calibers
L_c	Centerbody length, calibers
L_f	Flare length, calibers
L_s	Afterbody skirt length, calibers
M_∞	Free-stream Mach number
p_∞	Free-stream static pressure, psi
p_b	Static pressure at model base, psi
q_∞	Free-stream dynamic pressure, $0.7p_\infty M_\infty^2$, psi
S	Reference cross-sectional area, $\pi D^2/4$, in.^{2}
X_{np}	Neutral-point location measured in calibers from model nose, positive aft
α	Model angle of attack, positive nose up, degrees
θ_N	Nose cone half angle, degrees

I. INTRODUCTION

A research project has been initiated by the Advanced Systems Laboratory to investigate the use of high-speed missiles as field anti-tank weapons. Typically, existing low-speed missiles are subject to errors in range due to the inability of the human operator to estimate the target range accurately. The proposed concept would use the high-speed missile to reduce the time to target, thereby reducing the errors caused by inaccurate estimations of the target range.

In support of this project, a series of wind tunnel tests was conducted to investigate the static aerodynamic characteristics of various configurations of a cone-cylinder-flare-skirt missile. These tests were conducted at NASA's 7- by 10-foot high speed tunnel at Langley Field, Virginia; the 1-foot transonic tunnel at the Arnold Engineering Development Center; and the Ballistics Research Laboratories No. 1 tunnel at the Aberdeen Proving Ground, Maryland. The Reynolds number range for the three tunnels was 0.5 to 6.0 million per foot.

Eighteen configurations were tested throughout the Mach number range of 0.4 to 4.5. In addition, nine "body alone" configurations were tested from 0.8 to 4.5. The data are presented in basic plots along with summary plots for a more detailed analysis. It is possible, through proper usage of the summary plots, to either determine a configuration shape to maintain a specified set of aerodynamic coefficients, or to determine the aerodynamic characteristics of a specified configuration.

II. APPARATUS

The 7- by 10-foot high speed tunnel is a closed, single-return wind tunnel which operates with atmospheric stagnation pressure and Mach numbers to 0.9. Further information on this tunnel can be found in Reference 1.

The 1-foot transonic tunnel is a continuous-flow, open-circuit wind tunnel capable of operation at Mach number throughout the transonic range (0.8 to 1.5). The test section is 1 foot square and 37.5 inches in length with four parallel, perforated walls. Further information on this tunnel is available in Reference 2.

The BRL supersonic tunnel No. 1 is a continuous-flow, closed-circuit, variable density wind tunnel capable of operation from 1.5 to 4.5. The test section is 13 inches wide, 18 inches high, and 40 inches long with four parallel, solid walls. Details of the tunnel can be found in Reference 3.

III. TEST ARTICLES

The models used during the test were capable of varying nose cone angle, centerbody, flare angle, flare length, afterbody length, and overall length. This allowed numerous variations, resulting in the 27 model configurations tested. A list of pertinent model dimensions is shown in Figure 1, along with a sketch of a typical configuration. The model used during the paremetric variation of the flares, and the skirts had a constant nose angle and overall length. In the cone-cylinger portion of the program (body alone), both cone angle and overall length were varied.

The model used for the transonic and supersonic phases was constructed with a centerbody diameter of 1.008 inches due to the test section geometry. The subsonic phase used a model with a centerbody diameter of 2.016 inches due to limitations in the balance capacities.

IV. INSTRUMENTATION

Two three-component, internal strain gage balances were used during the entire investigation. The first balance had the rated capacities of ±20 pounds normal force, ±60 inch pounds pitching moment, and ±25 pounds axial force. This balance was used for the majority of the test. The second balance had rated capacities of ±8 pounds normal force, ±5.78 inch pounds pitching moment, and ±8 pounds axial force. It was used to take advantage of the low capacity during the body alone portion of the test.

V. TEST PROCEDURE

Data were obtained for each configuration by setting the desired Mach number and then varying the model angle of attack.

VI. ACCURACY OF MEASUREMENT

The estimated uncertainties in the data were calculated using statistical theory based on an assumed normal error distribution and a probability of 20 to 1.

C_N	= ±0.014	$C_{A,T}$	= ±0.017
C_m	= ±0.022	X_{np}	= ±0.08 cal
$C_{A,F}$	= ±0.051	α	= ±0.10 deg
$C_{A,b}$	= ±0.047		

VII. CORRECTIONS

The data were corrected to account for tunnel wall interference at the subsonic Mach numbers. Corrections were applied to the angle of attack for sting and strut deflections due to aerodynamic loads.

VIII. PRESENTATION OF RESULTS

Figures 3 through 83 present the basic data (C_N vs α; $C_{m,N}$ vs C_N; and $C_{A,F}$ vs α) obtained during the three tunnel entries. The changes in symbols on the plots are to delineate between the tunnels used for the tests. Figures 84 through 93 show the effects of various model configurations on the static stability parameter variations with Mach number. Additional analysis plots are shown in Figures 94 through 104 which depict the effect of model variation at a constant Mach number. Figure 105 presents a comparison for three typical configurations with second order shock theoretical predictions.

The model used during the parametric variations of the flares and skirts had a constant nose cone angle and overall length. For the cone-cylinder part of the program (body alone), both cone angles and overall length were varied.

IX. DISCUSSION

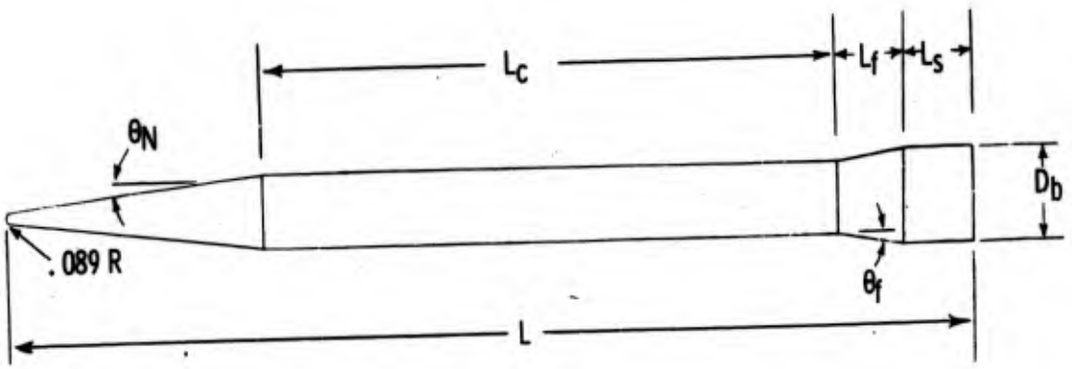
Increase in the parameters θ_f, L_f, and L yielded increases in the aerodynamic coefficient, primarily due to the increases in planform area. The neutral point showed a corresponding rearward shift. In contrast, the addition of longer afterbody skirts caused a decrease in C_{N_α}, a forward shift in neutral point and no noticeable change in $C_{A,F}$. This effect is caused by the loss of cylinder length when the skirt length is increased due to the overall length being held constant. It is interesting to note that the proper combination of flare angle and skirt length can yield a C_{N_α} and X_{np} that are invariant with Mach number (Figure 88). This type configuration could possibly be applied to simple type guided missiles to alleviate some control problems and to improve the overall accuracy of the missile.

Numerous cross plots (Figures 94 through 104) were made to show the effect of the parametric variations at constant Mach numbers and to present the data in a manner so that the curves could be used in later missile designs using the same type configurations. Although the

figures are purported to show the variation of only one parameter, the chosen testing techniques varied more than one parameter at a time. For example, when the flare lengths were varied, it resulted in a change in centerbody length to maintain the constant overall body length of 15.36 calibers.

The comparison of C_{N_α} and X_{np} with second order shock theory shows the maximum deviation between experiment and theory ranges from 4 to 14 percent for C_{N_α} and from 9 to 25 percent for X_{np}. This deviation appears large and is believed to be caused by the lack of an accurate prediction of the pressure distribution over the aft portion of the body for the flare and flare-skirt configurations, since the body alone characteristics are predicted satisfactorily.

Figures 88 and 89 show a marked nonlinearity in the transonic range for the 2.04 caliber flare length and the one-caliber skirt. No reason is apparent for this behavior especially when the other flare-skirt combinations are linear. Future tests will have a more comprehensive check of this effect to determine whether this behavior is a tunnel effect or a flow field effect.



CONFIG. NO.	L	D INCHES	θ_N	θ_f	L_c	L_f	L_s	D_b
1	15.357	1.008	5° 9'	0°	10.714	--	--	1.000
2	15.357	1.008	5° 9'	4°	8.672	2.043	--	1.286
3	15.357	1.008	5° 9'	4°	7.650	3.064	--	1.429
4	15.357	1.008	5° 9'	4°	6.650	3.064	1.000	1.429
5	15.357	1.008	5° 9'	4°	6.628	4.086	--	1.571
6	15.357	1.008	5° 9'	6°	9.355	1.359	--	1.286
7	15.357	1.008	5° 9'	6°	8.355	1.359	1.000	1.286
8	15.357	1.008	5° 9'	6°	8.676	2.039	--	1.429
9	15.357	1.008	5° 9'	6°	8.033	2.039	.643	1.429
10	15.357	1.008	5° 9'	6°	7.676	2.039	1.000	1.429
11	15.357	1.008	5° 9'	6°	7.318	2.039	1.357	1.429
12	15.357	1.008	5° 9'	6°	7.996	2.718	--	1.571
13	15.357	1.008	5° 9'	6°	6.996	2.718	1.000	1.571
14	15.357	1.008	5° 9'	8°	9.697	1.017	--	1.286
15	15.357	1.008	5° 9'	8°	9.189	1.525	--	1.429
16	15.357	1.008	5° 9'	8°	8.189	1.525	1.000	1.429
17	15.357	1.008	5° 9'	8°	8.682	2.033	--	1.571
18	13.580	1.008	8°23'	0°	10.714	--	--	1.000
19	15.357	1.000	5° 9'	0°	10.714	--	--	1.000
20	12.357	1.000	5° 9'	0°	7.714	--	--	1.000
21	10.357	1.000	5° 9'	0°	5.714	--	--	1.000
22	13.380	1.000	8°23'	0°	10.714	--	--	1.000
23	10.580	1.000	8°23'	0°	7.714	--	--	1.000
24	8.580	1.000	8°23'	0°	5.714	--	--	1.000
25	14.774	1.000	4°21'	0°	9.214	--	--	1.000
26	13.274	1.000	4°21'	0°	7.714	--	--	1.000
27	11.274	1.000	4°21'	0°	5.714	--	--	1.000

NOTE: All Dimensions In Calibers
Except As Noted

FIGURE 1. PERTINENT MODEL DIMENSIONS

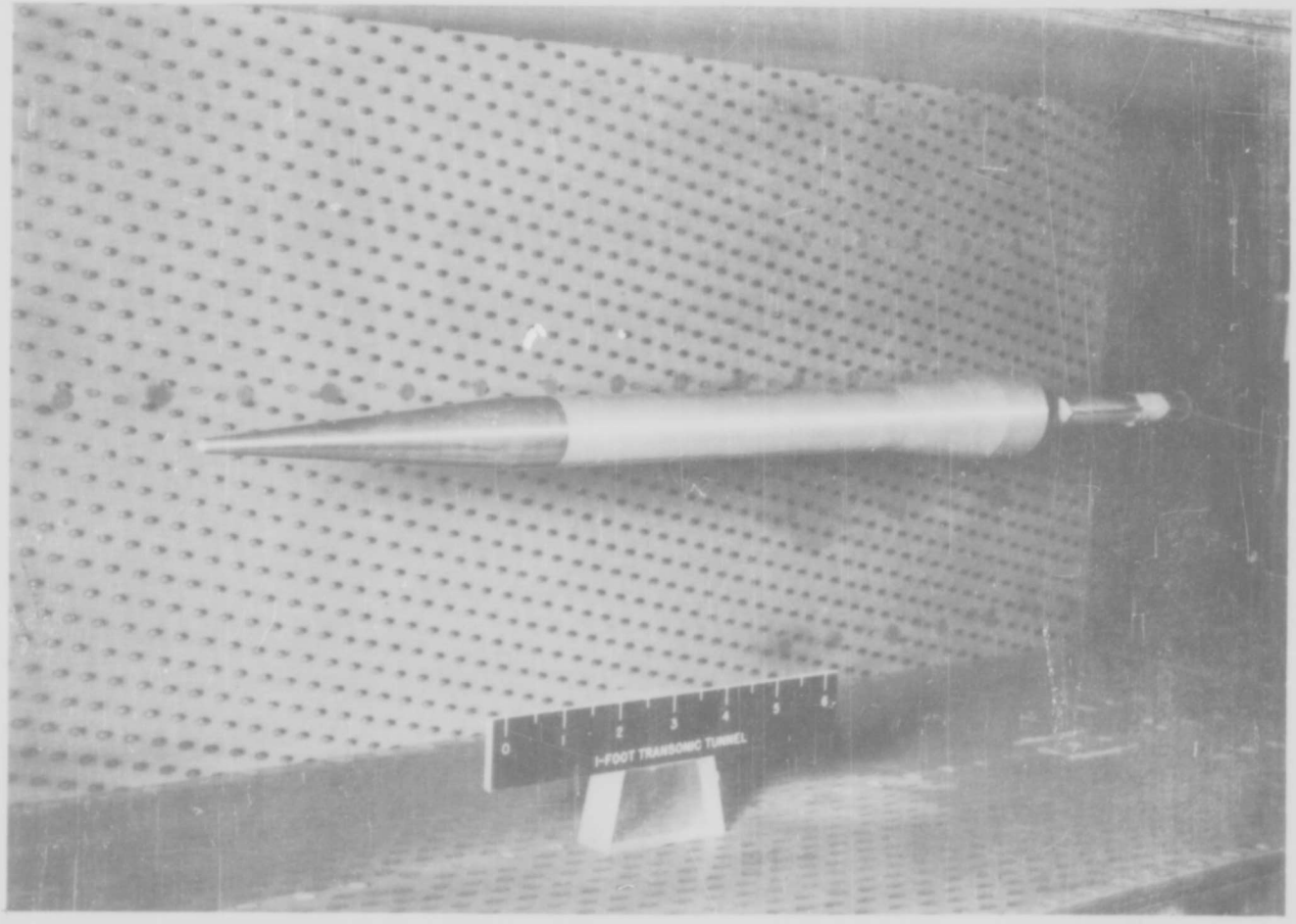
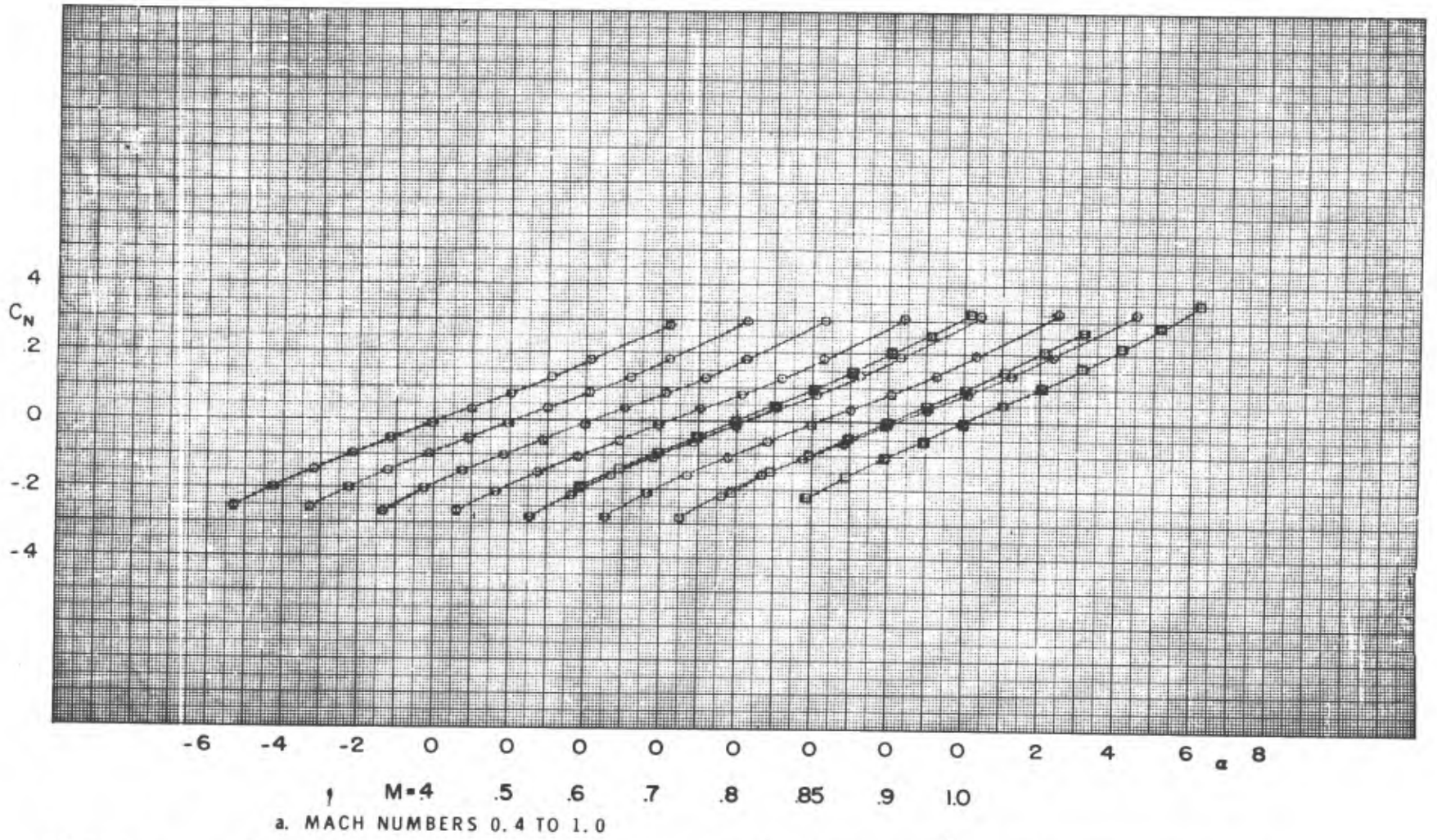
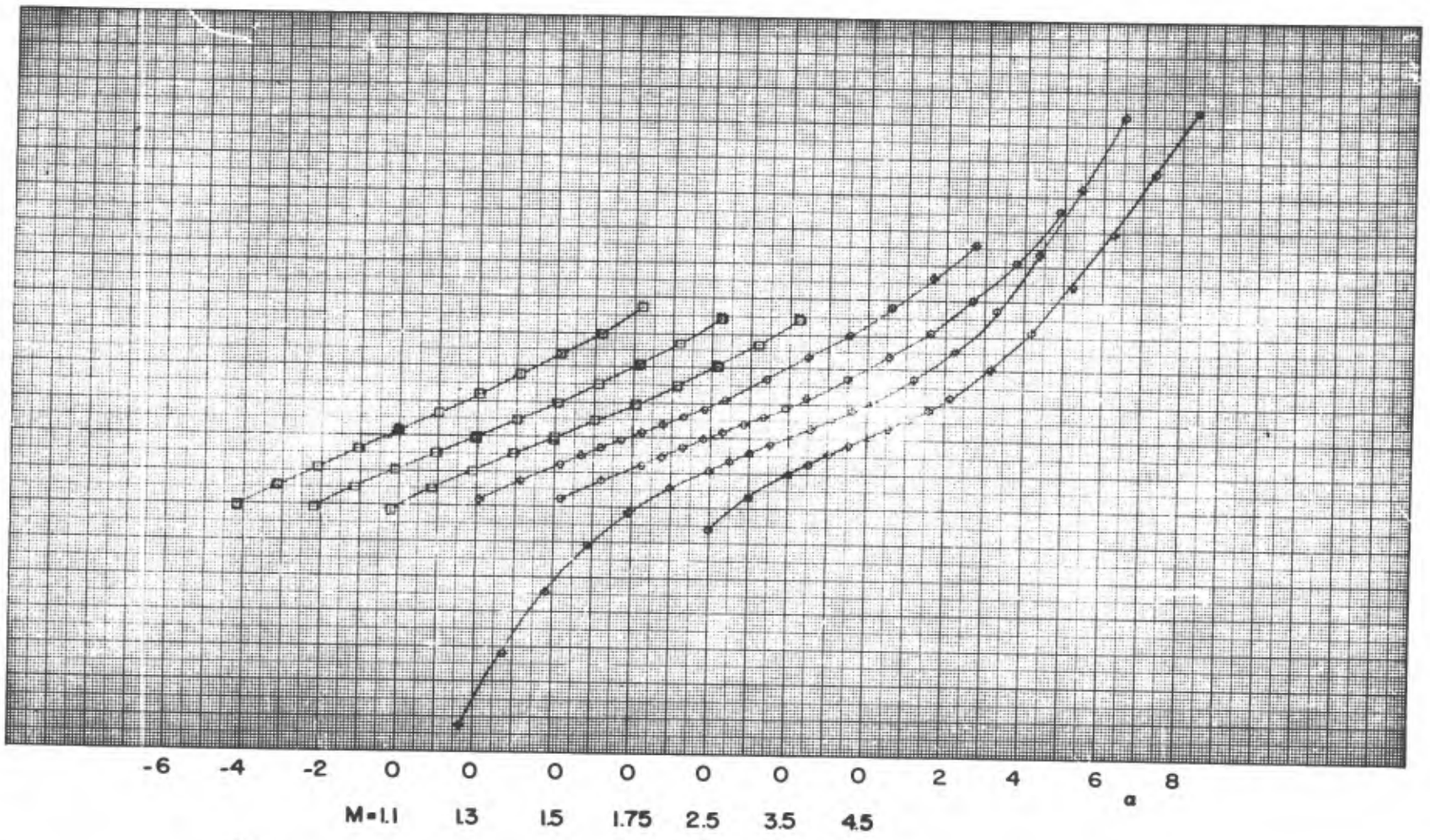


FIGURE 2. TYPICAL TUNNEL INSTALLATION



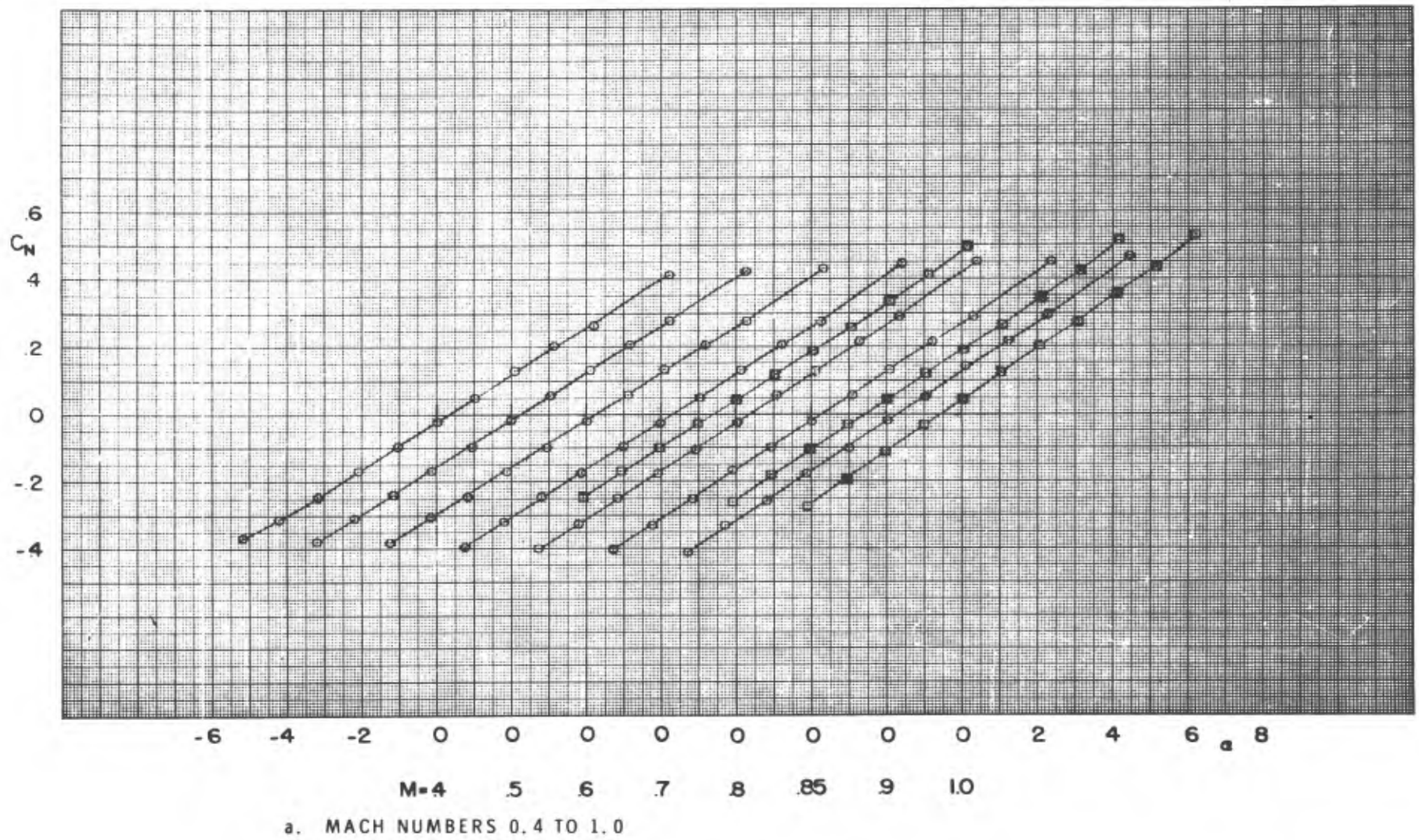
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 3. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 1



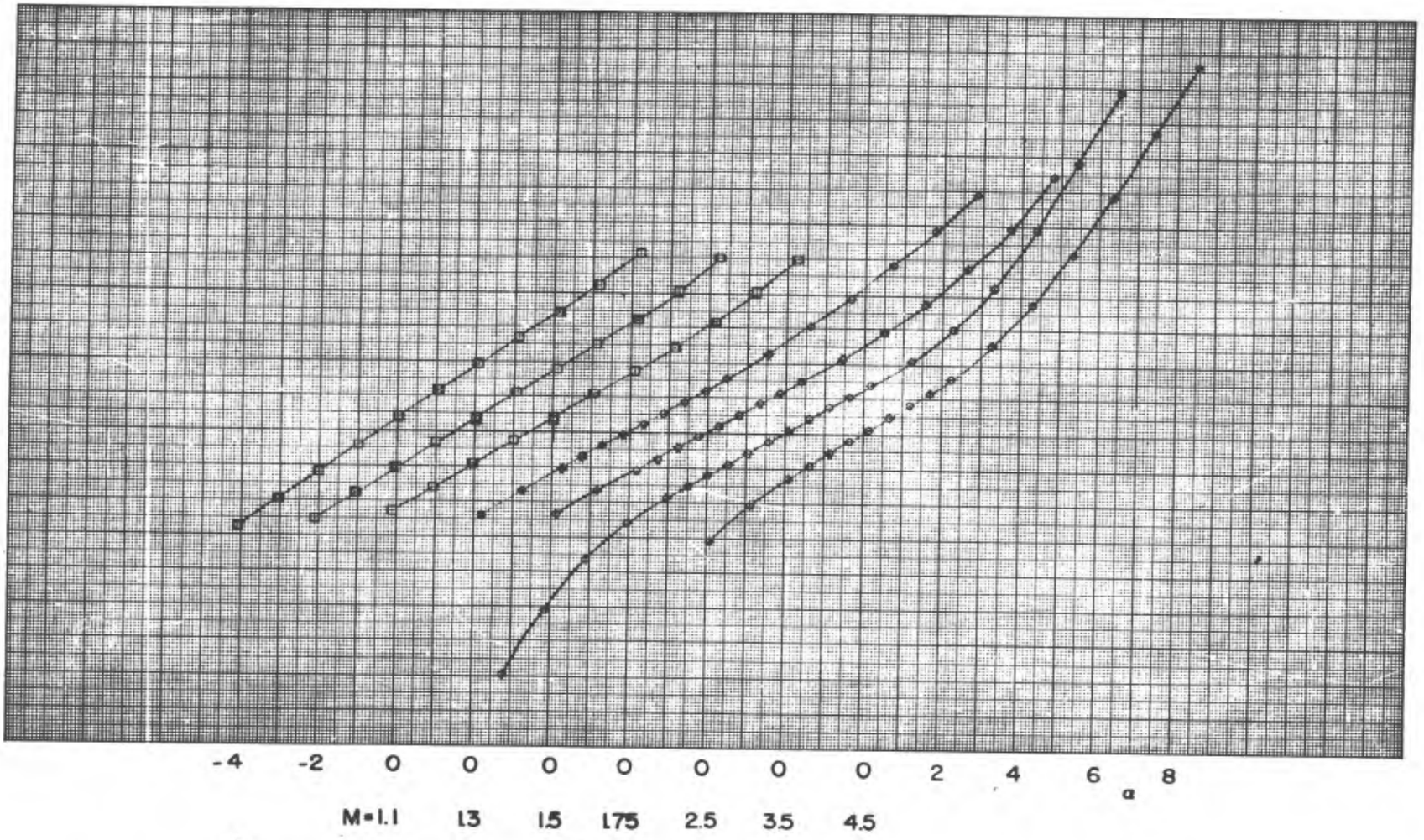
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 3. CONCLUDED



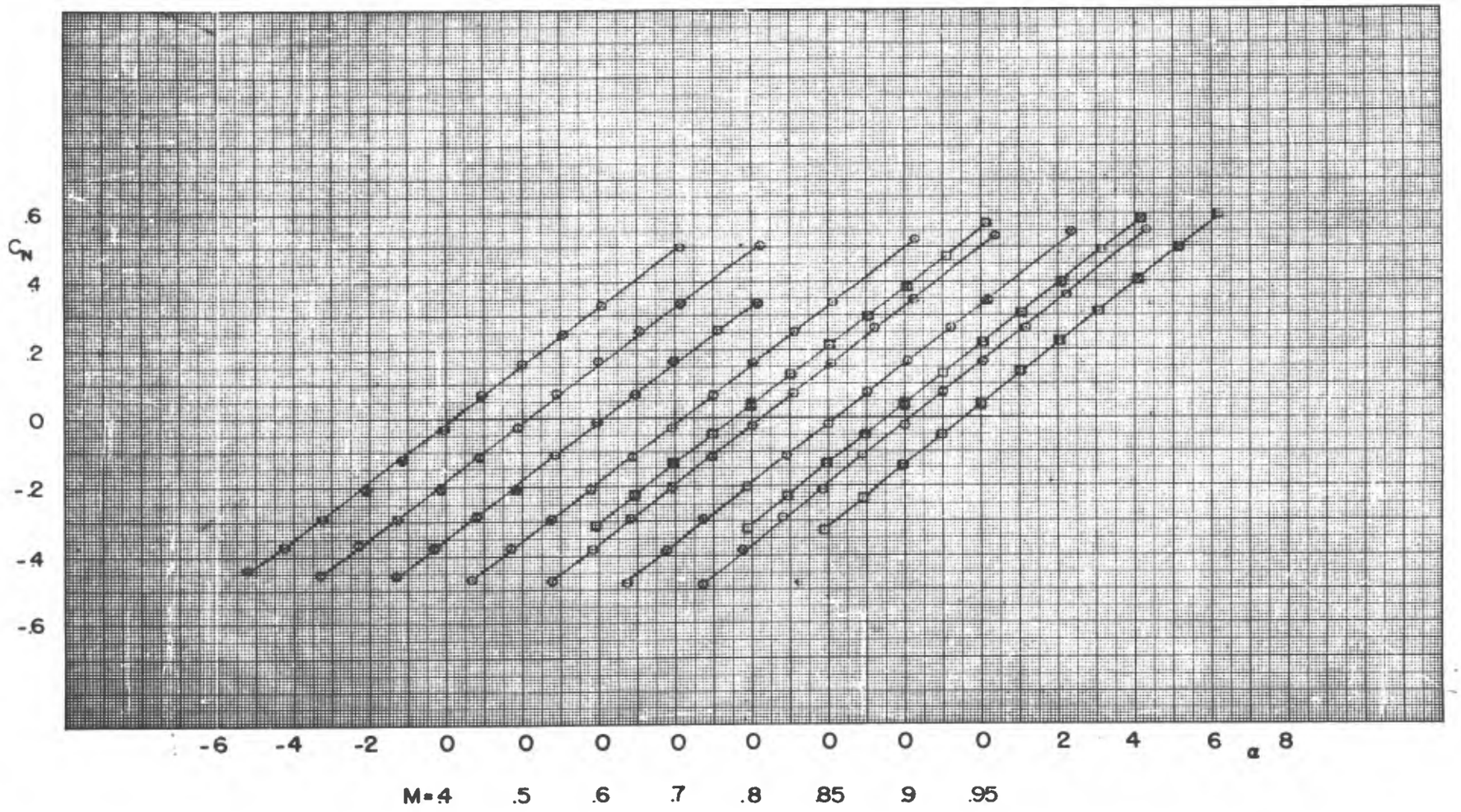
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 4. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 2



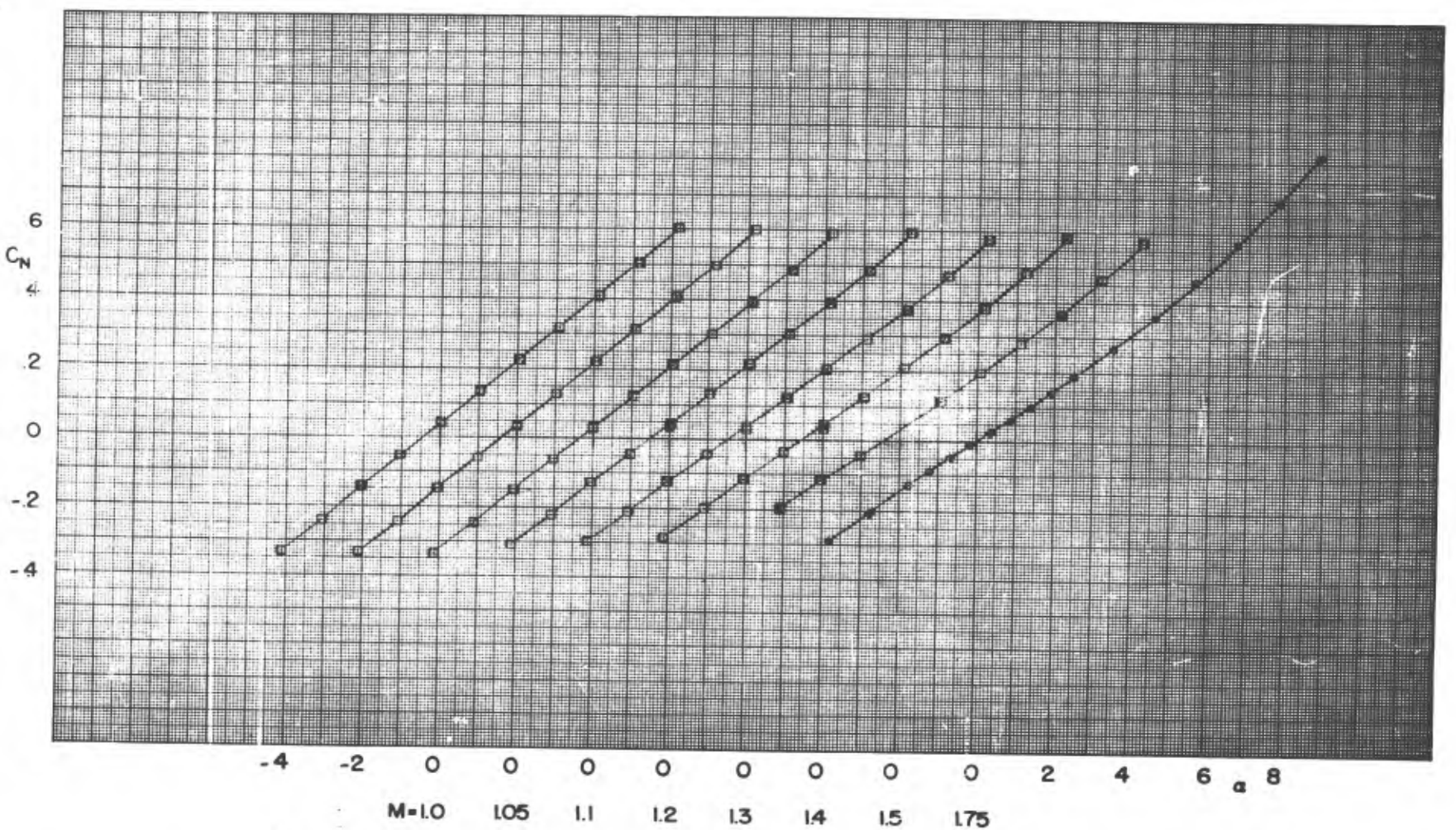
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 4 CONCLUDED



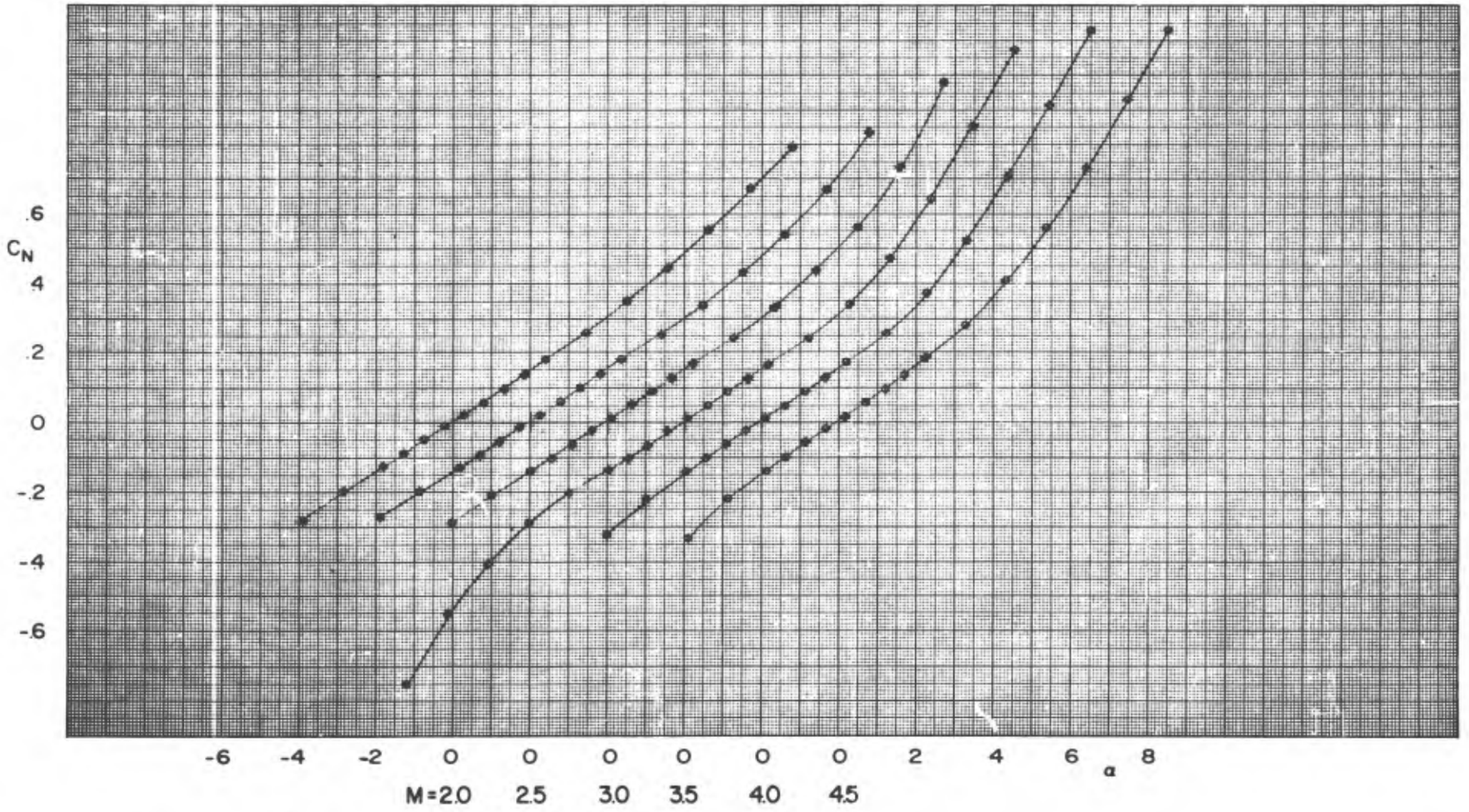
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 5. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 3



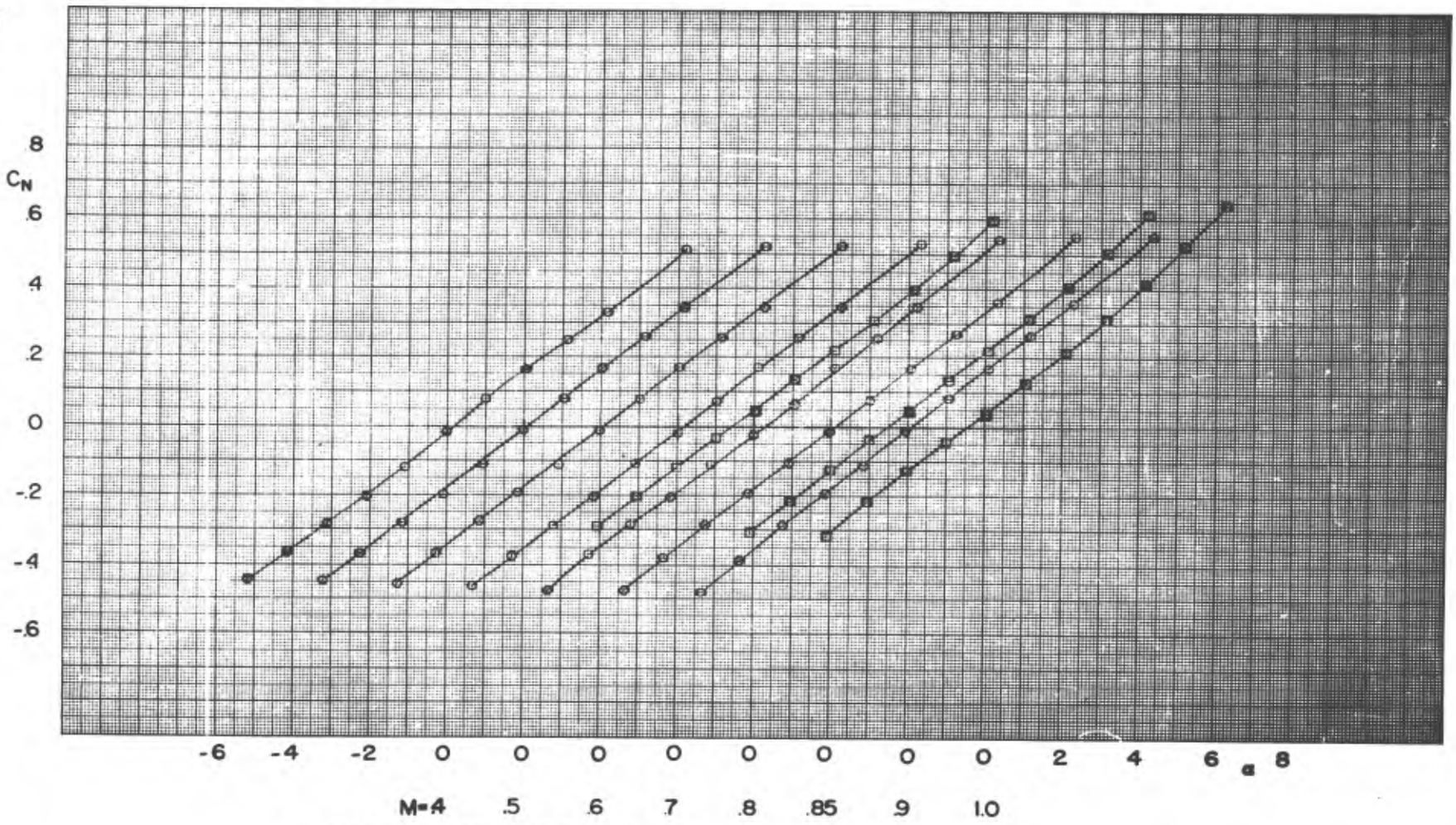
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 5. CONTINUED



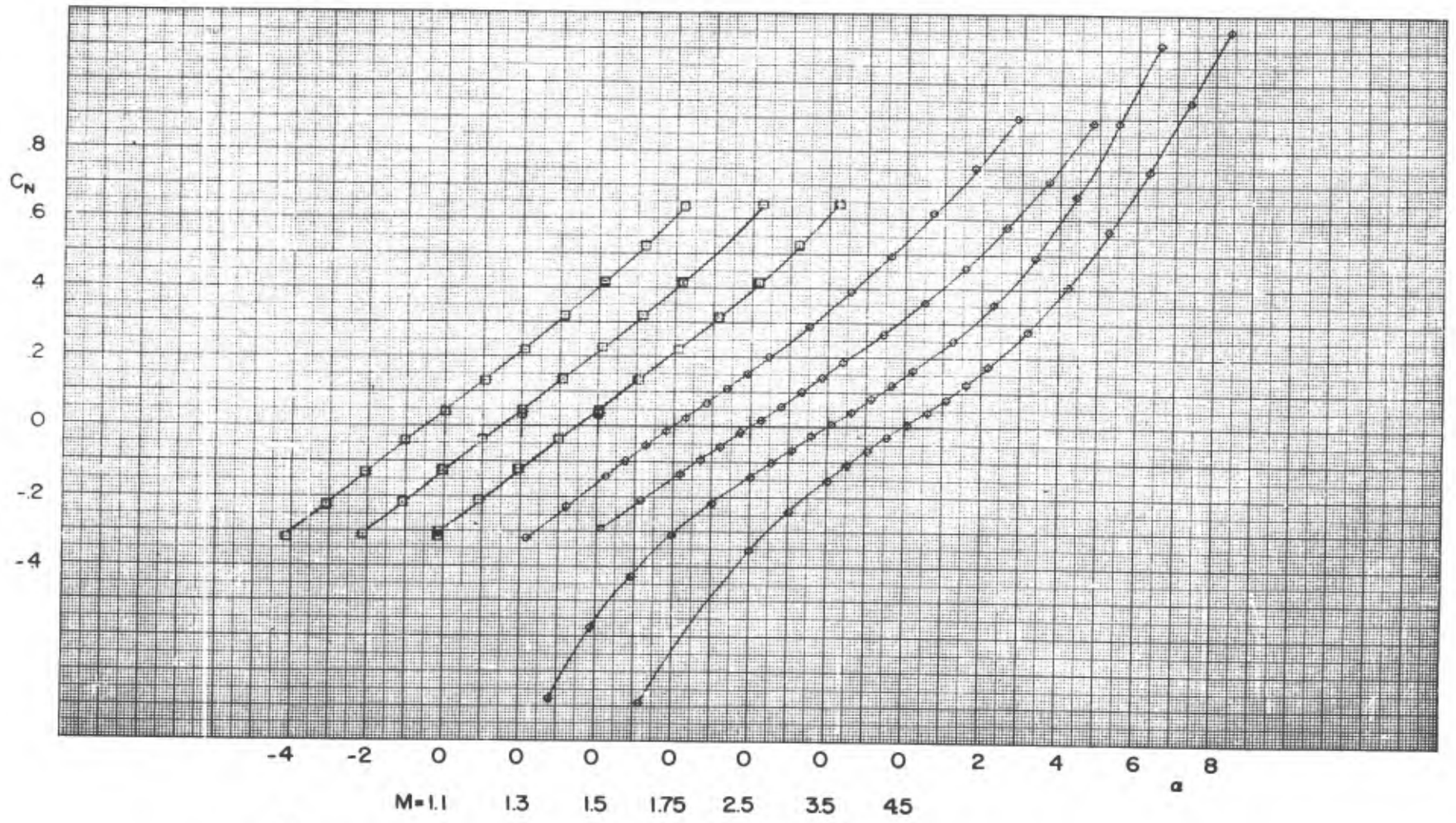
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 5. CONCLUDED



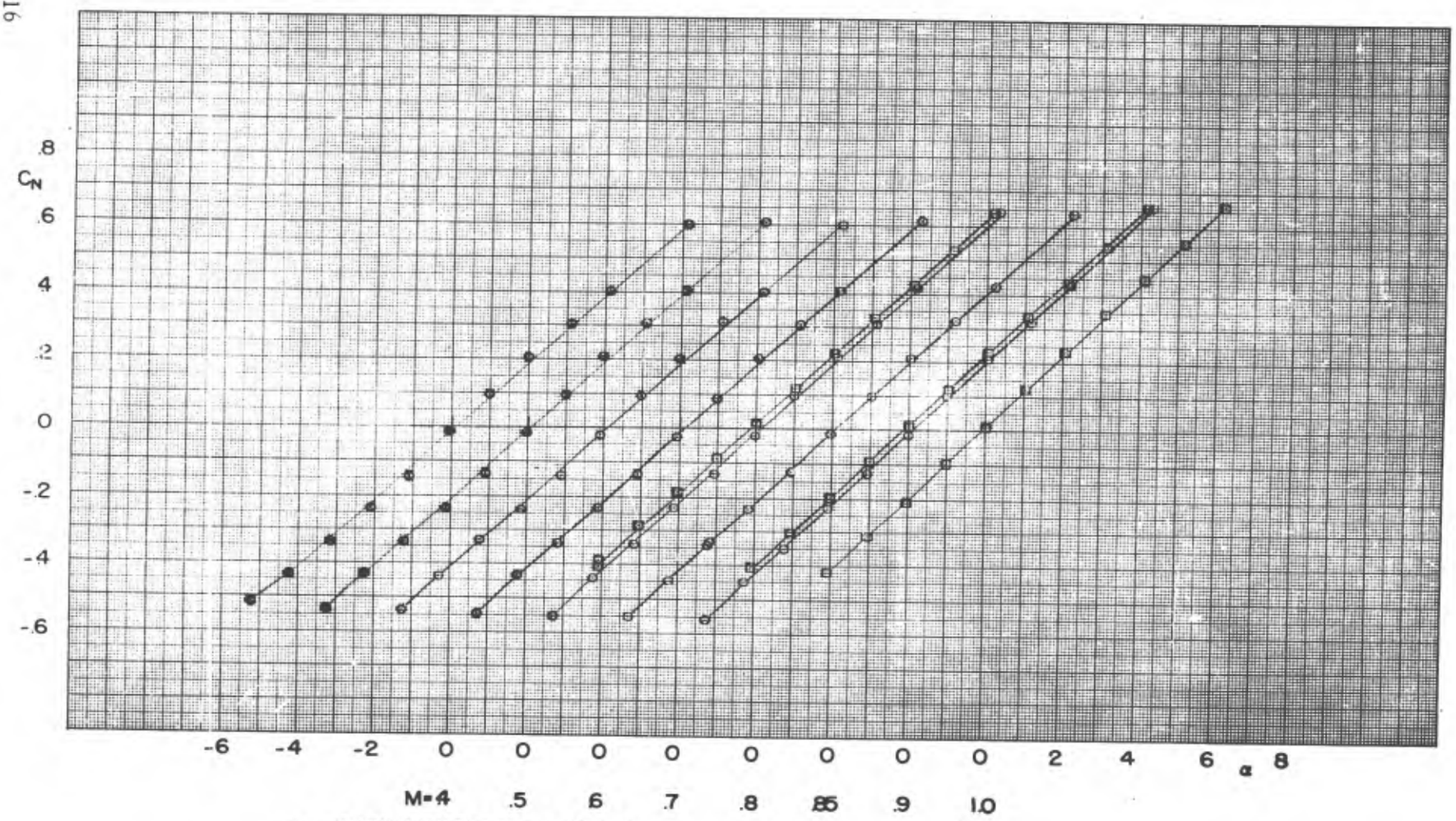
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 6. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 4



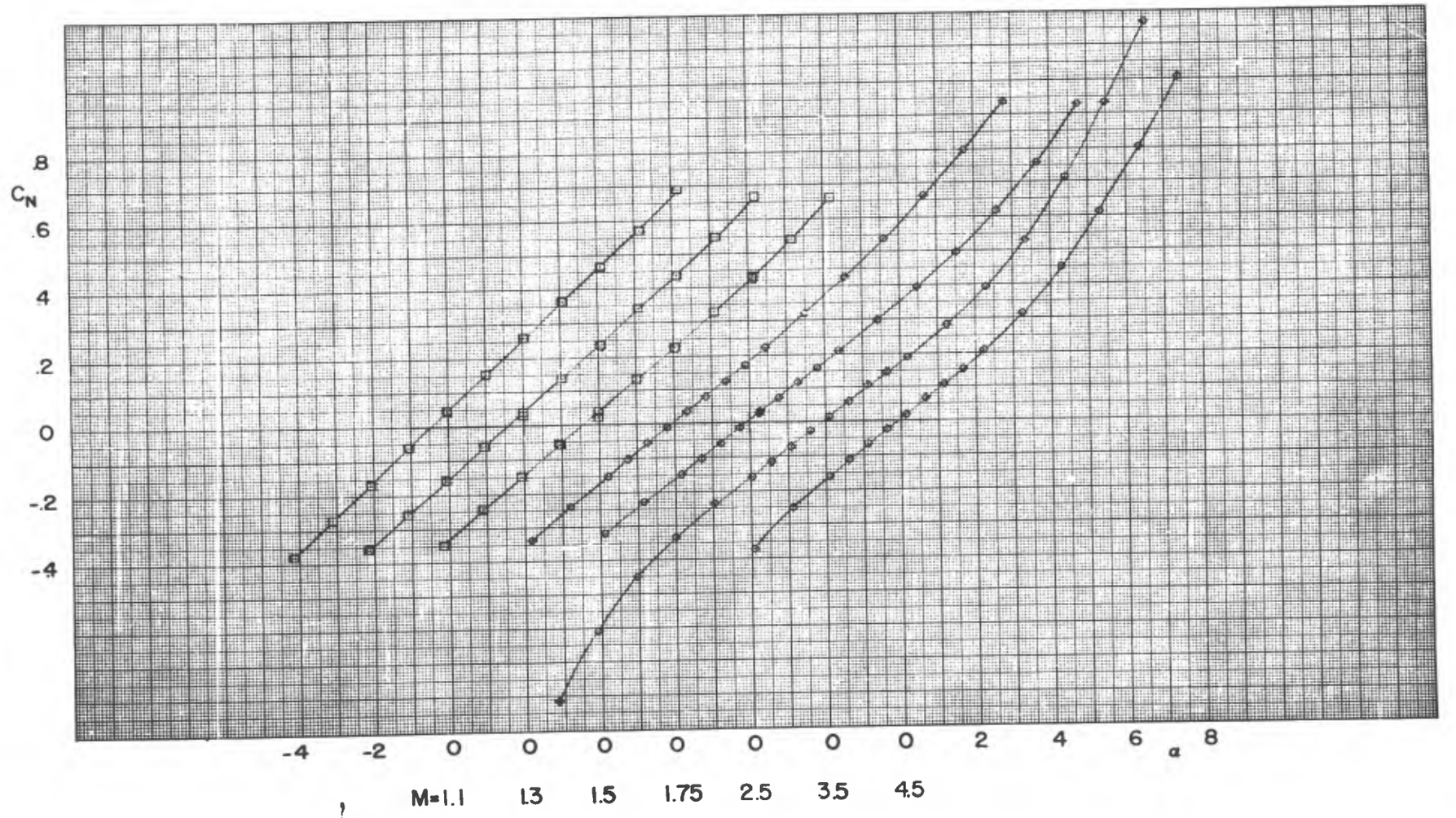
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 6. CONCLUDED



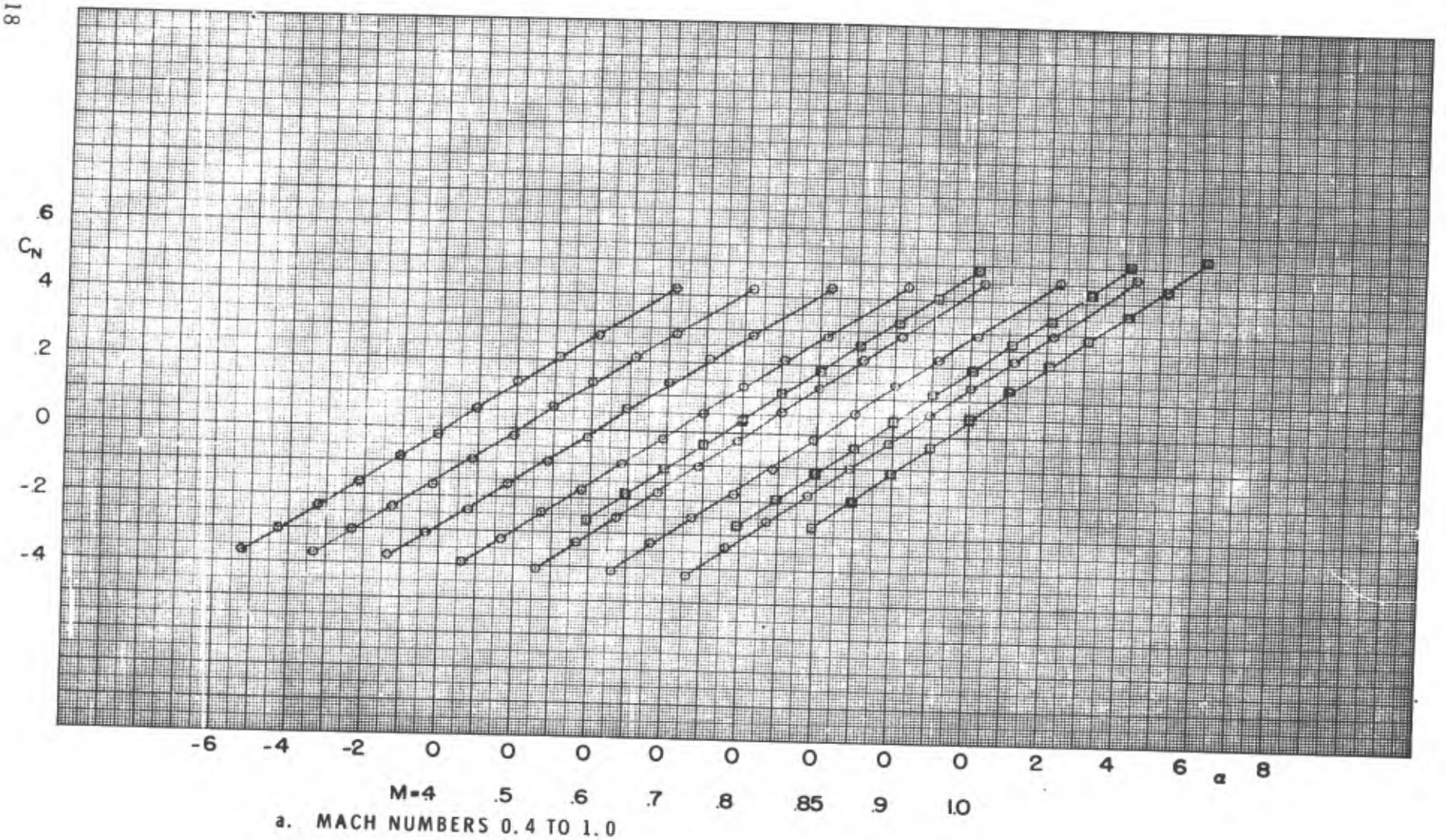
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 7. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 5



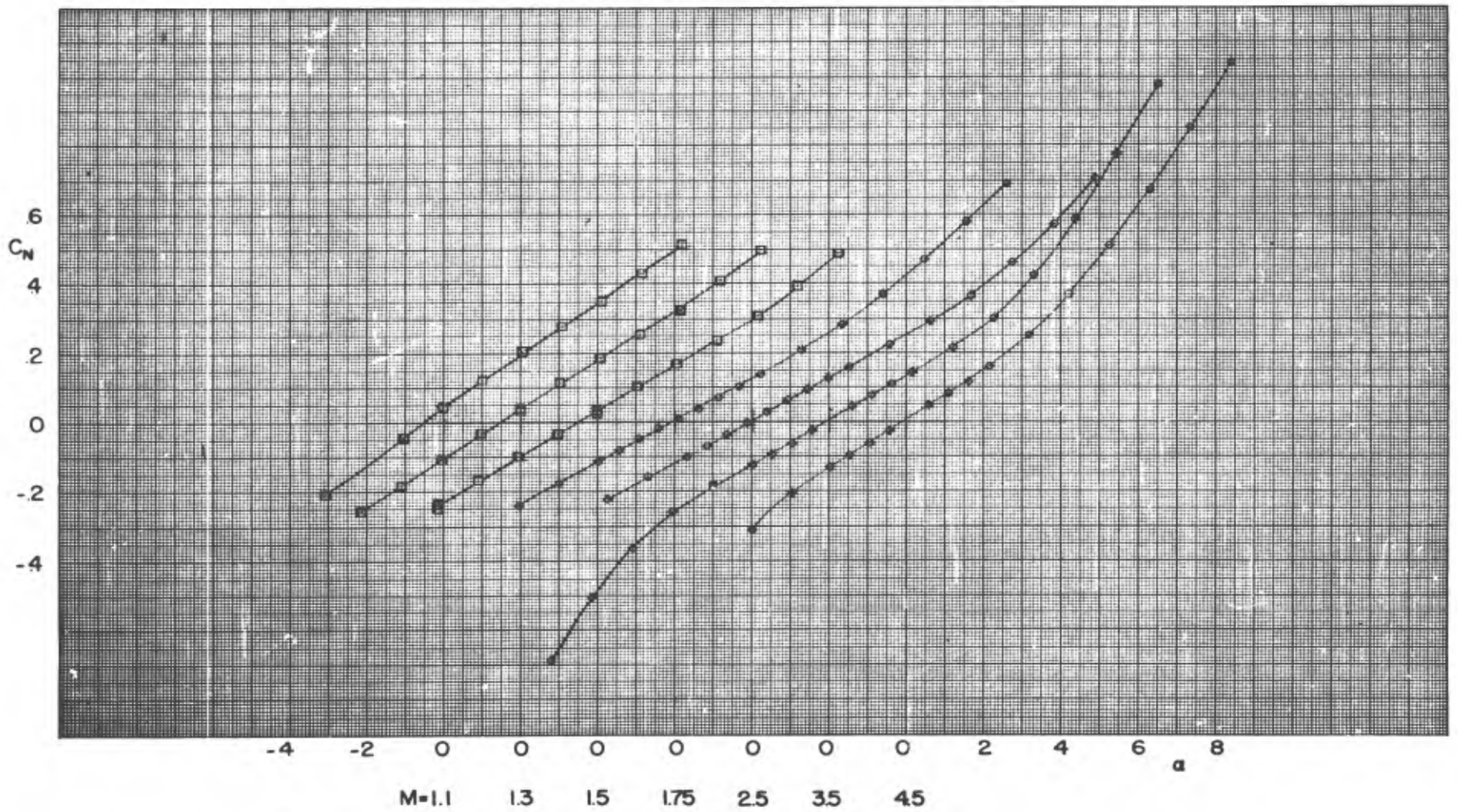
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 7. CONCLUDED



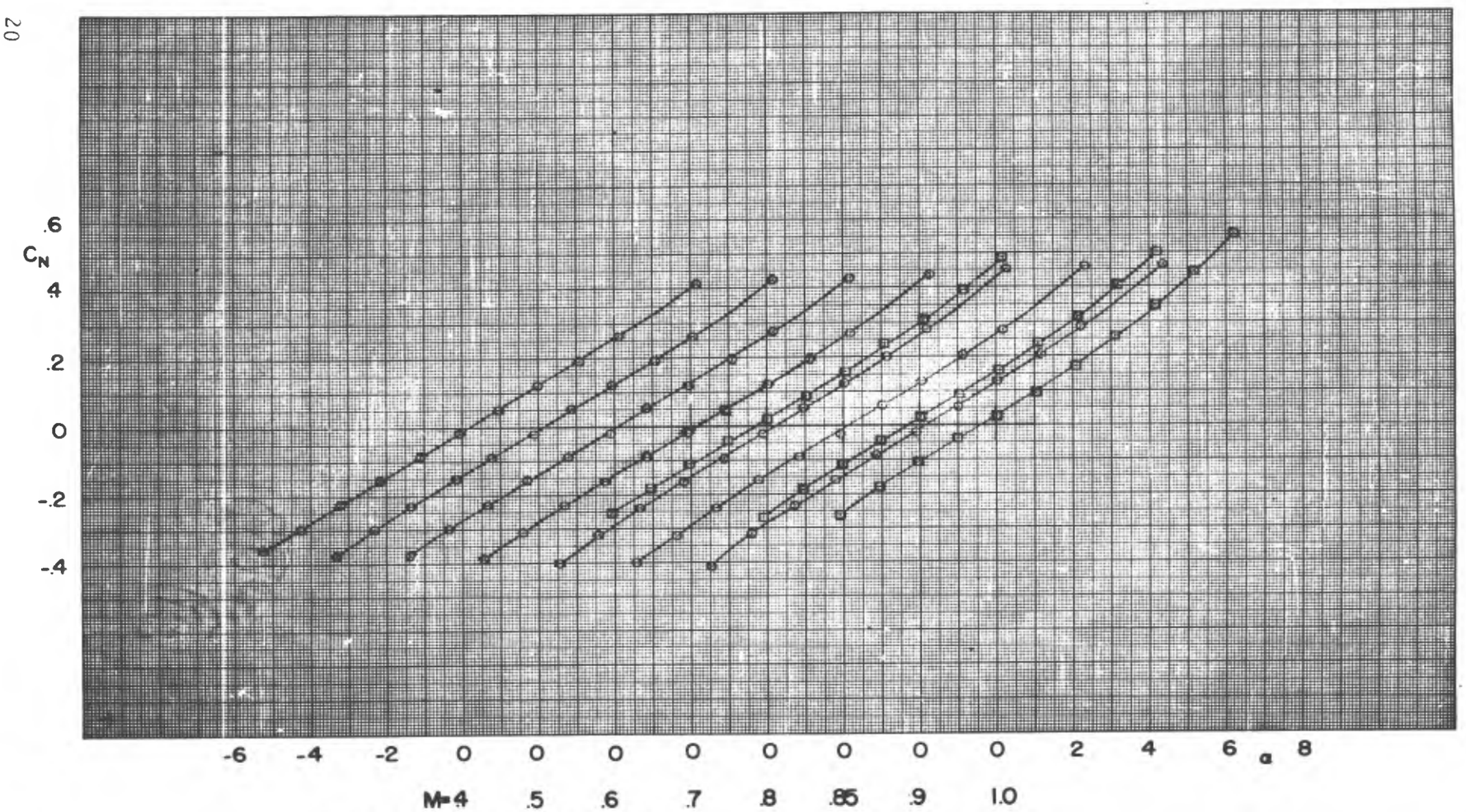
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 8. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 6



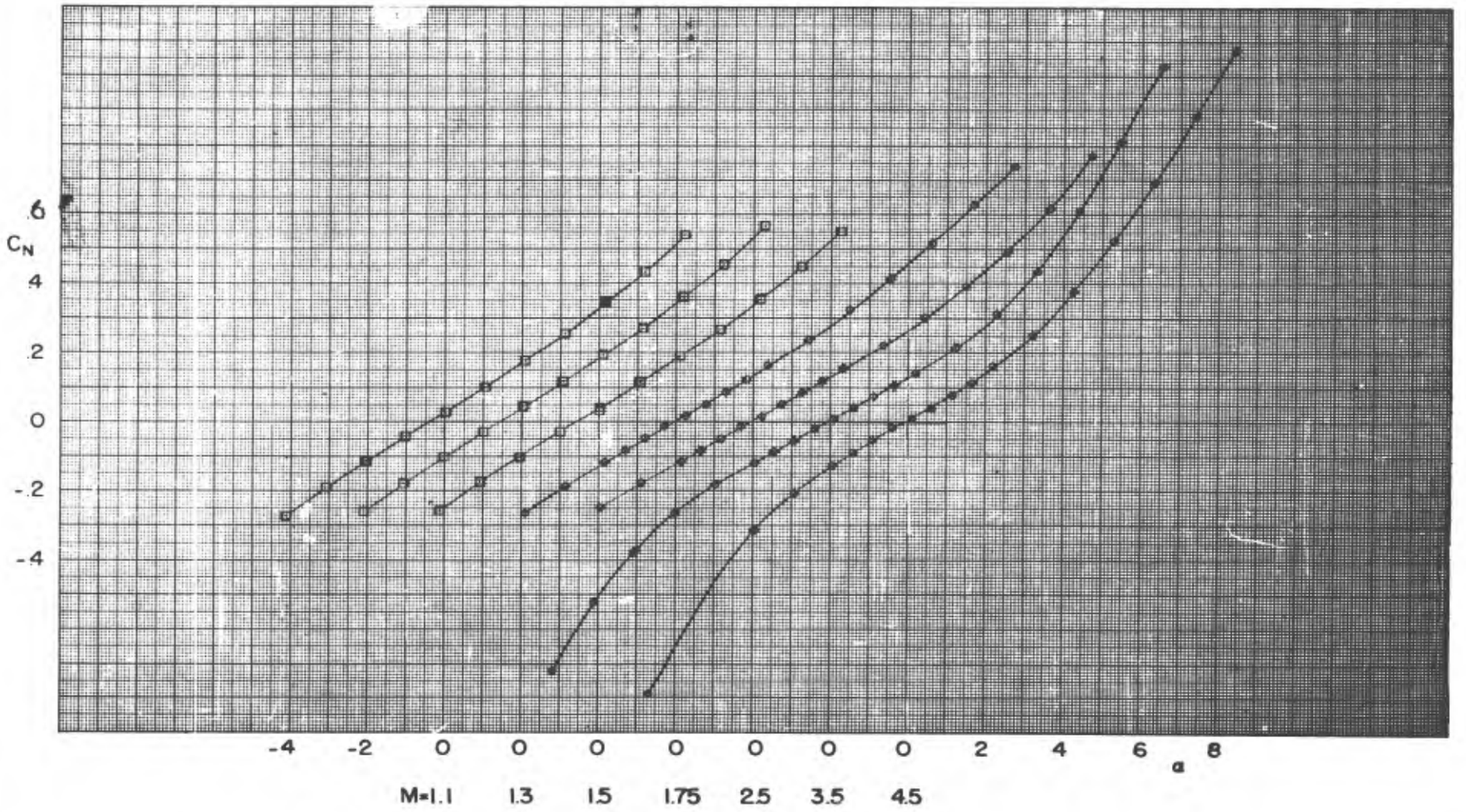
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 8. CONCLUDED



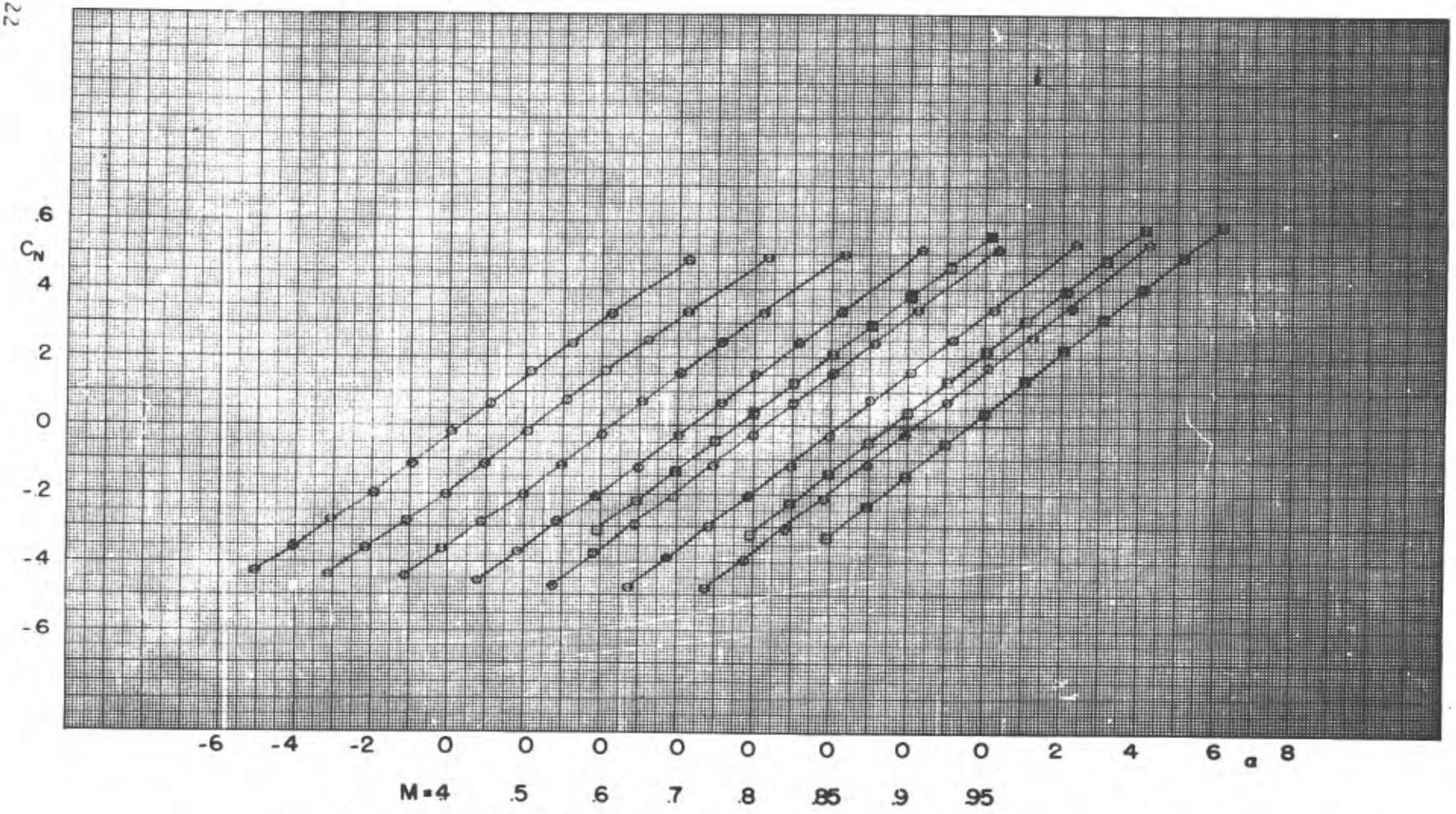
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 9. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 7



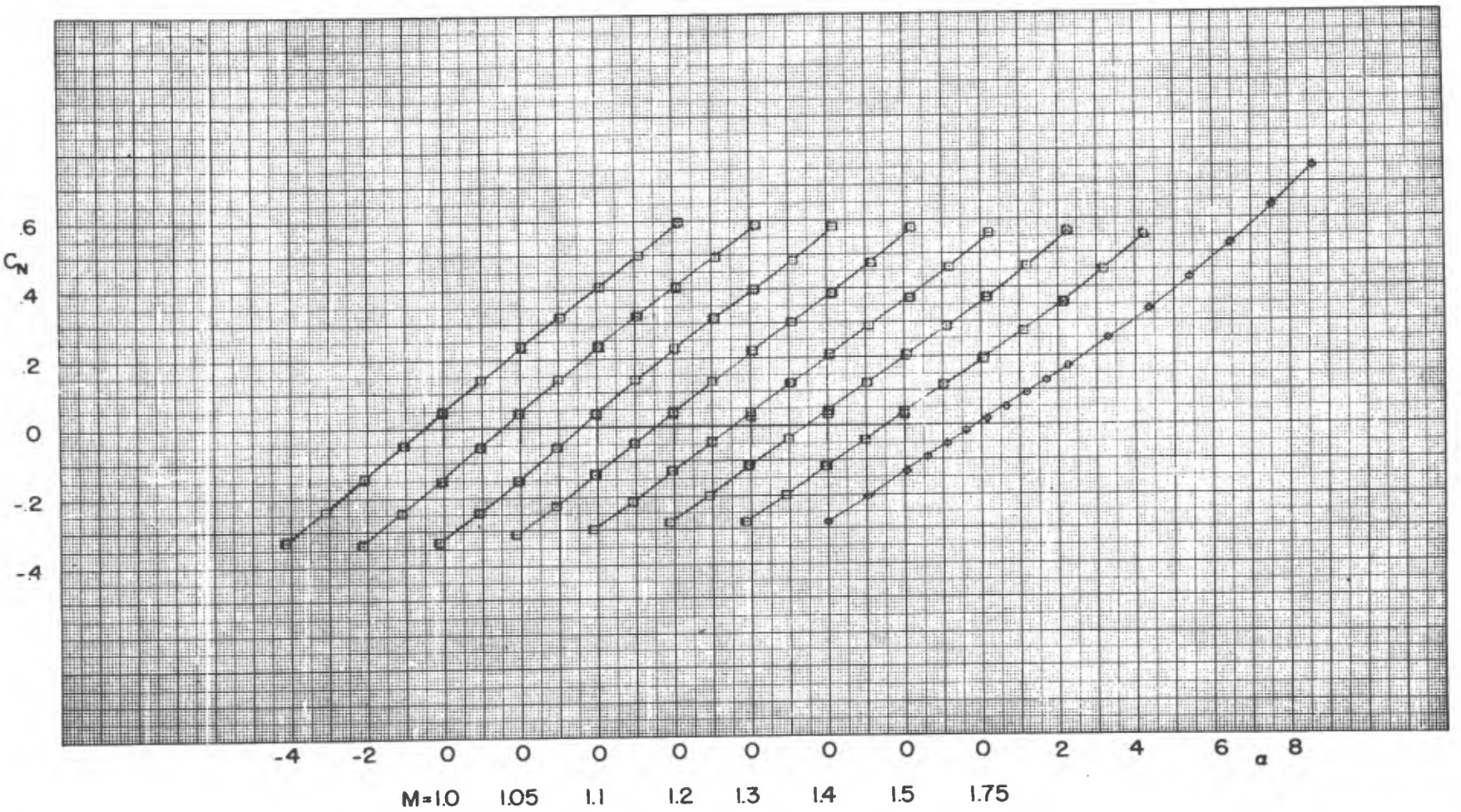
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 9. CONCLUDED



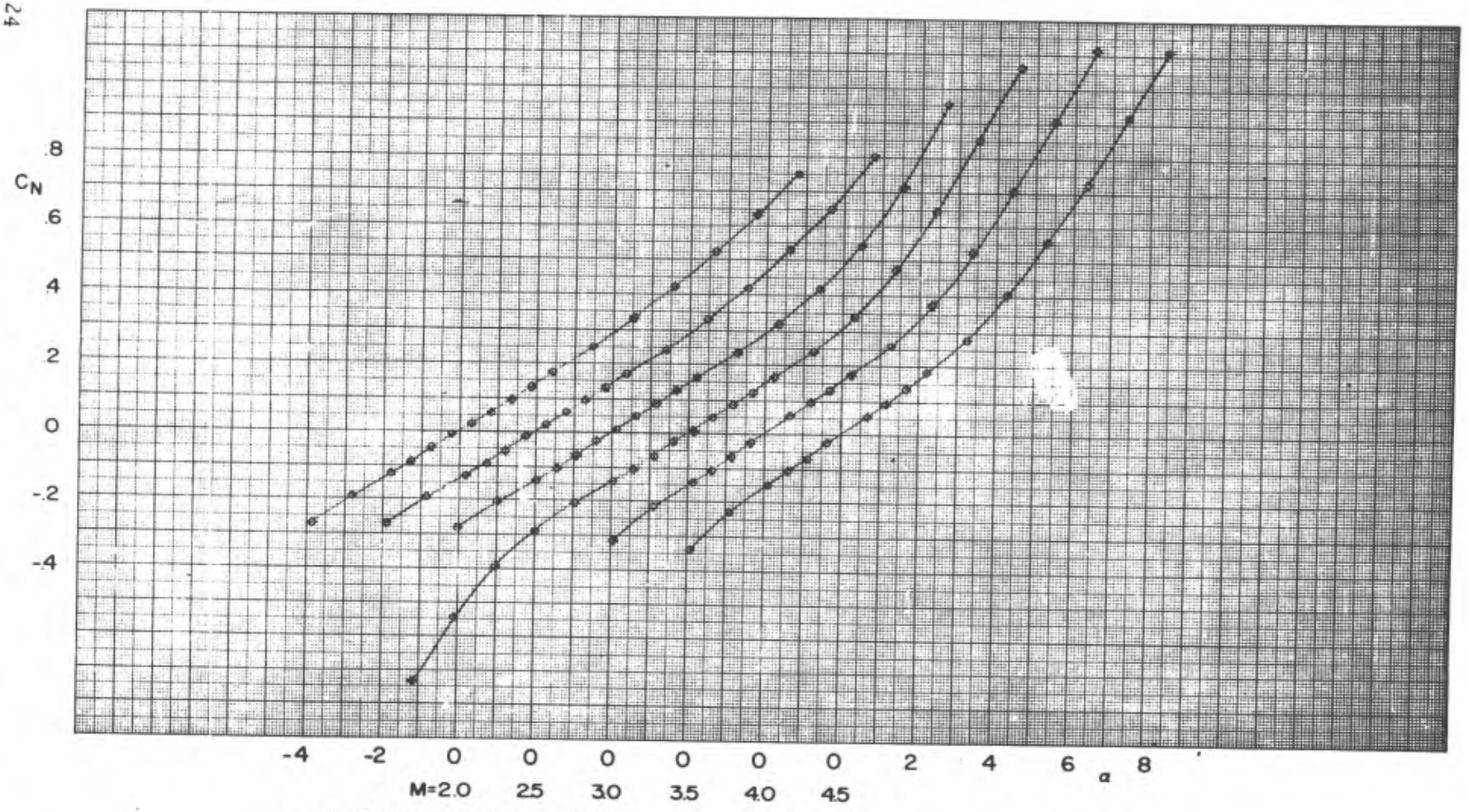
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 10. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 8



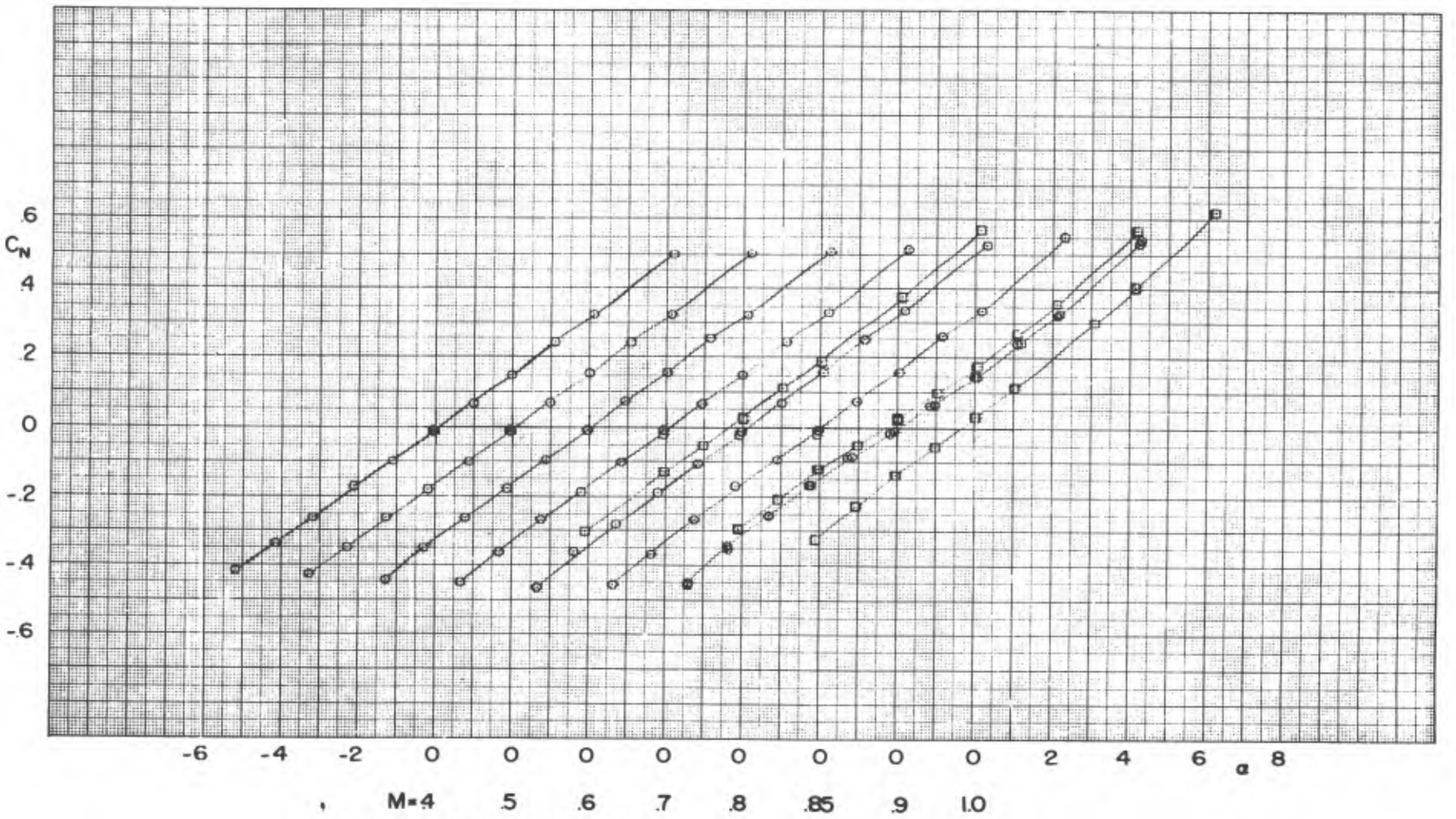
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 10 CONTINUED



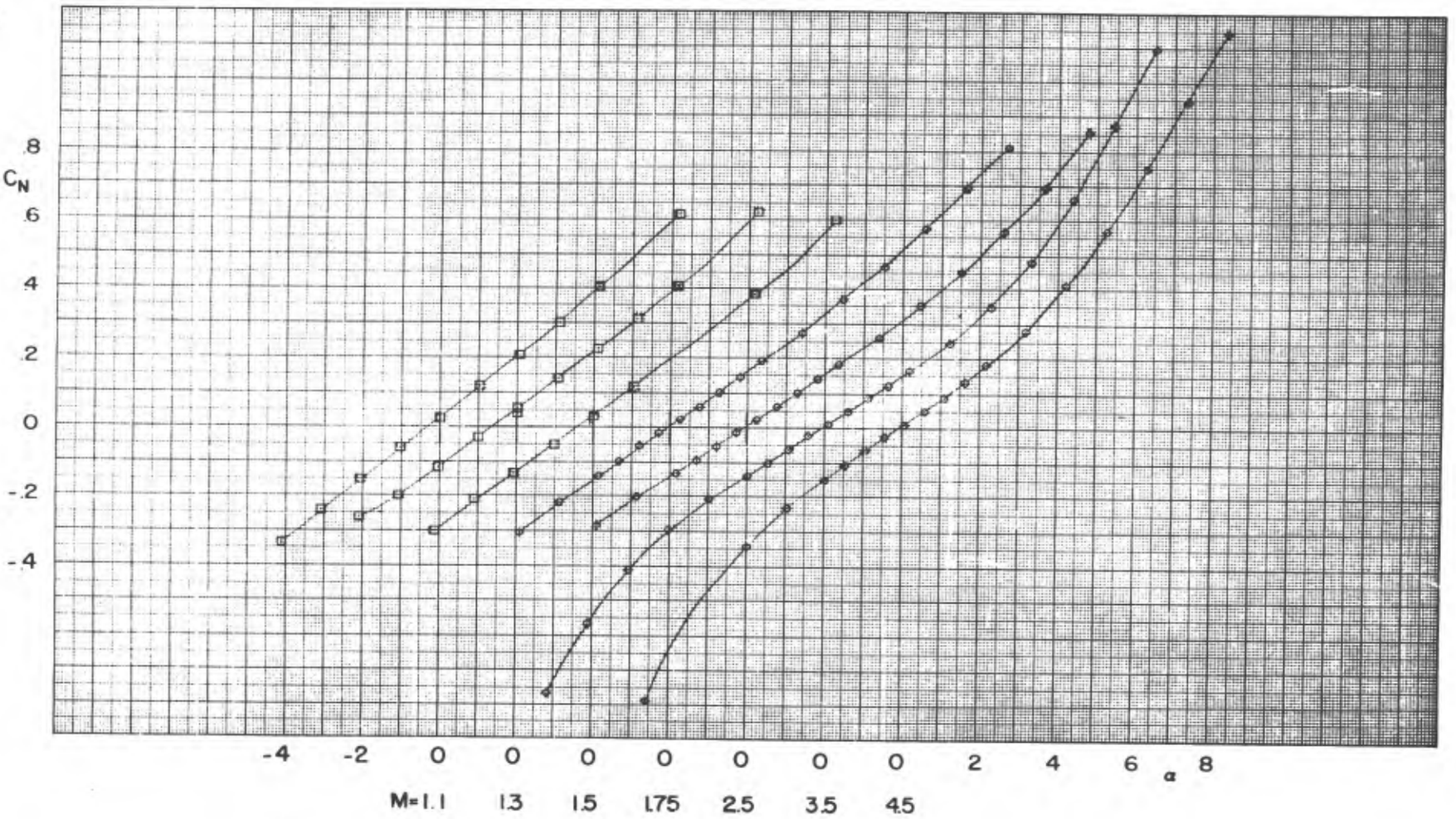
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 10. CONCLUDED



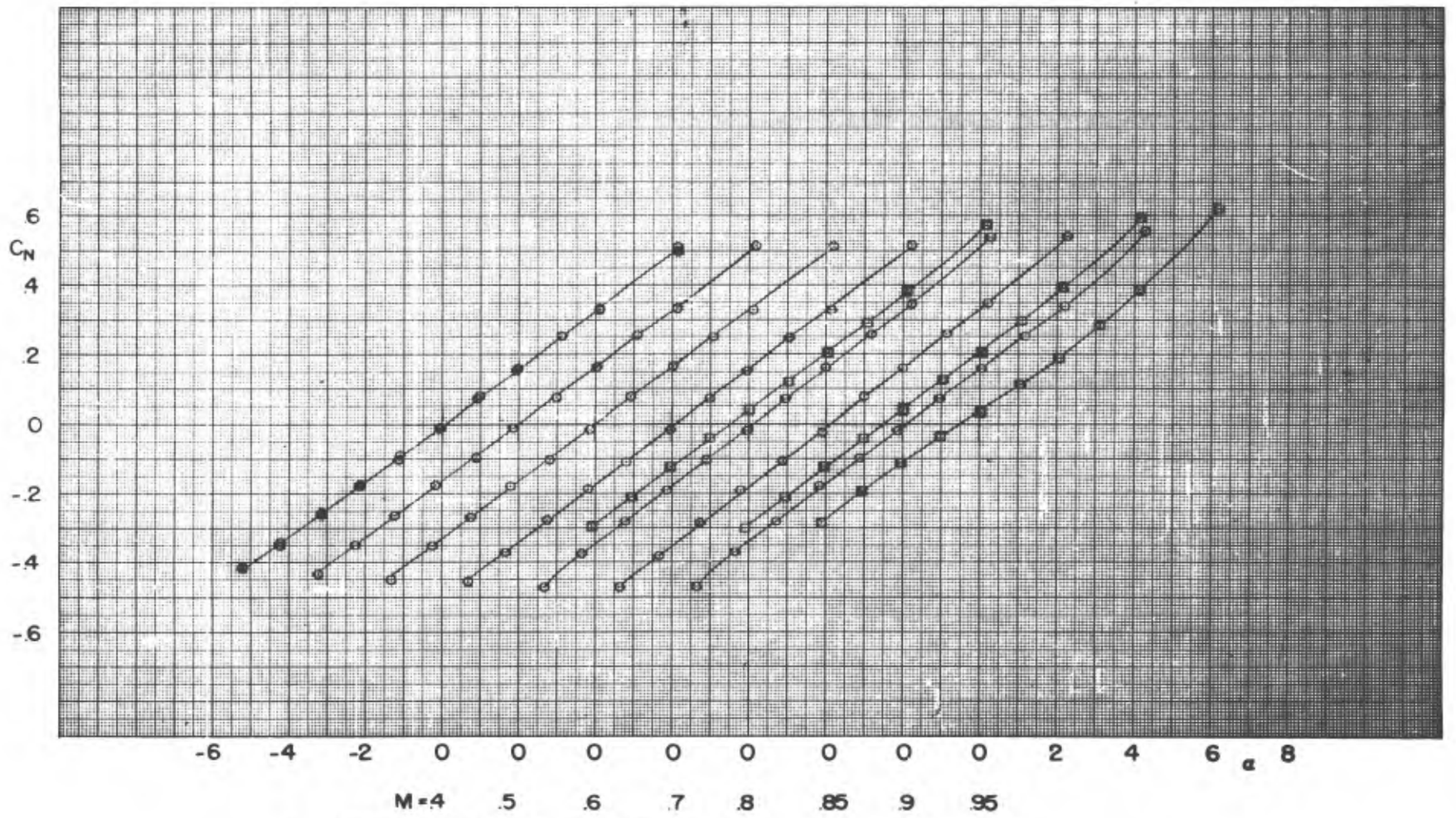
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 11. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 9



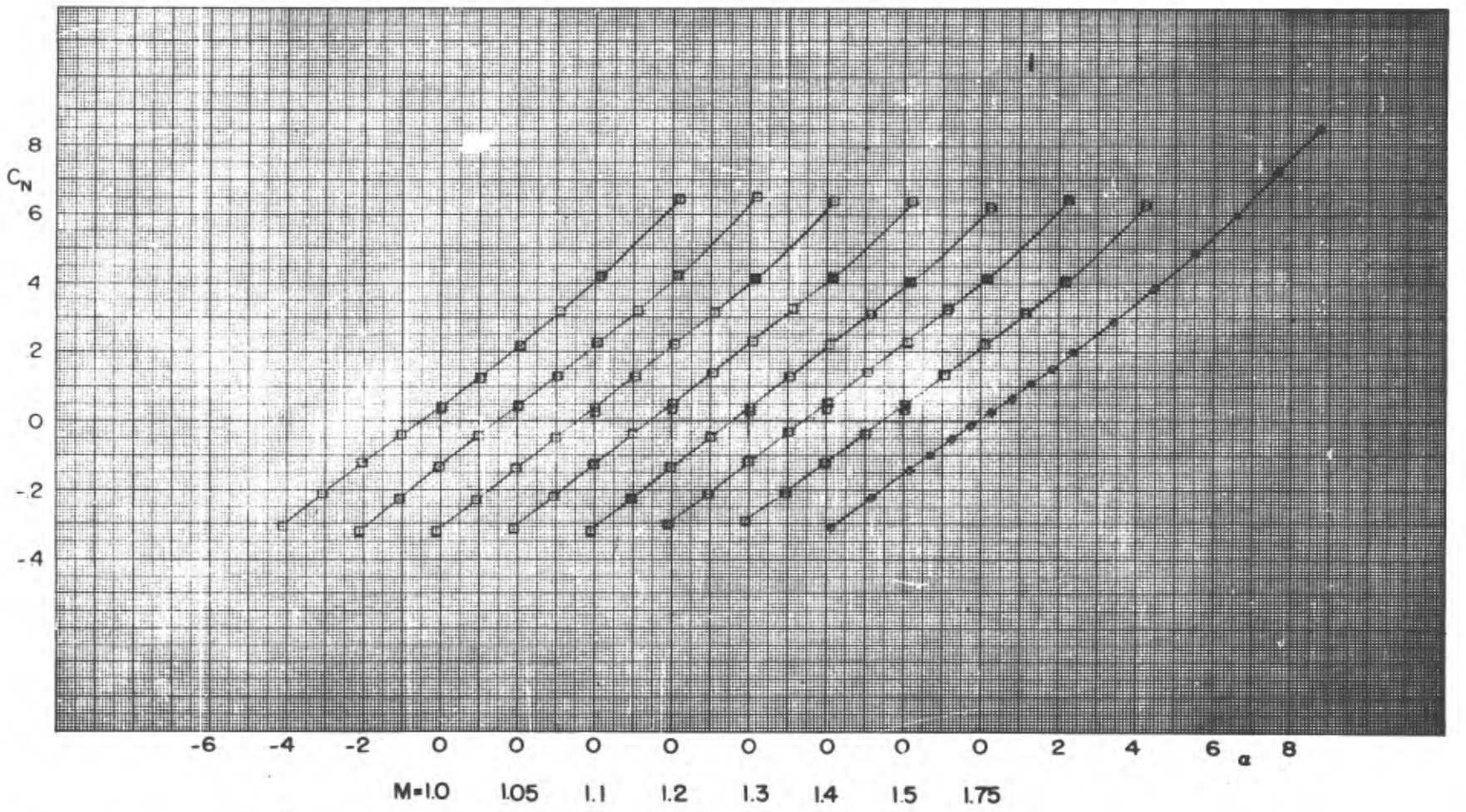
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 11. CONCLUDED



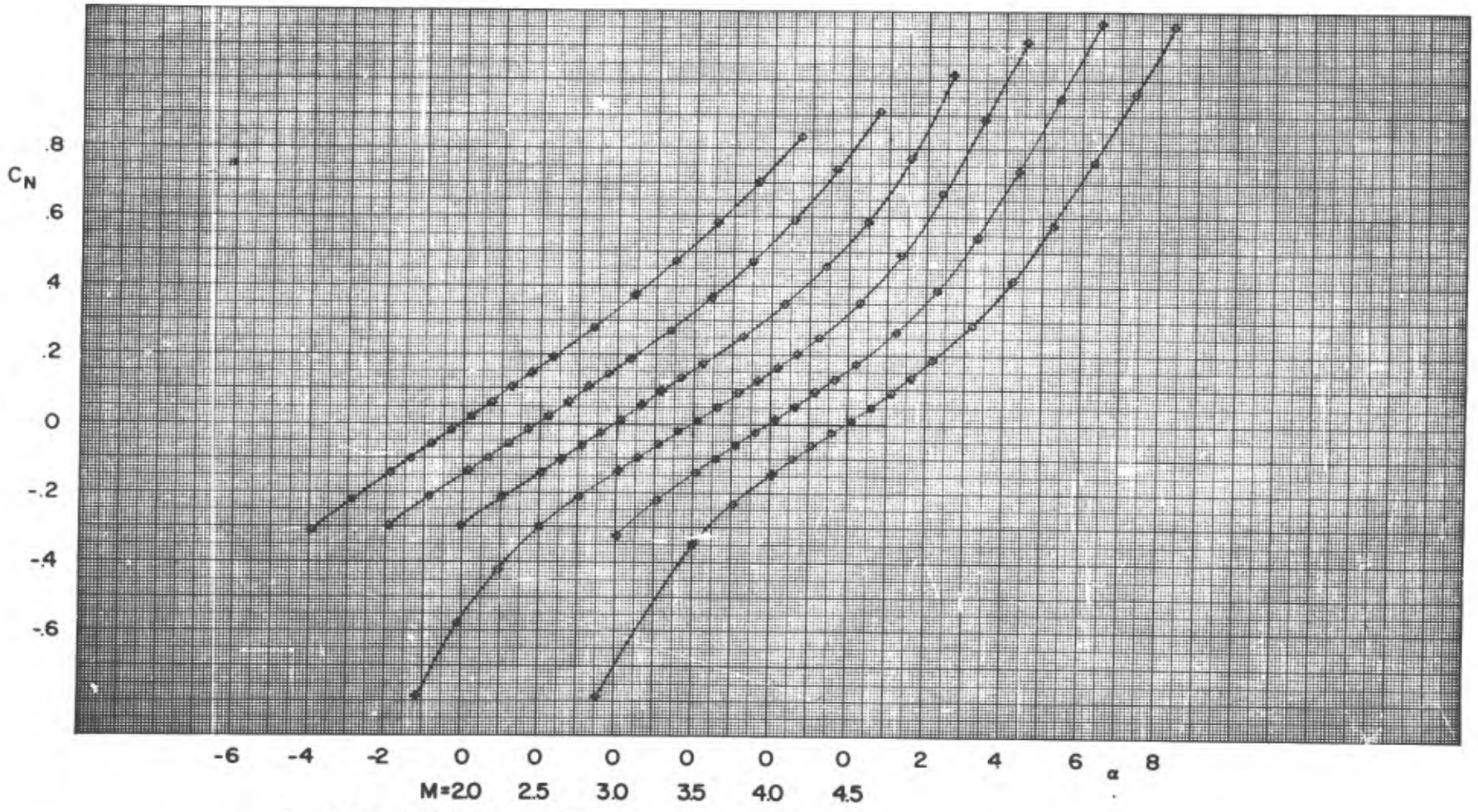
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 12. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 10



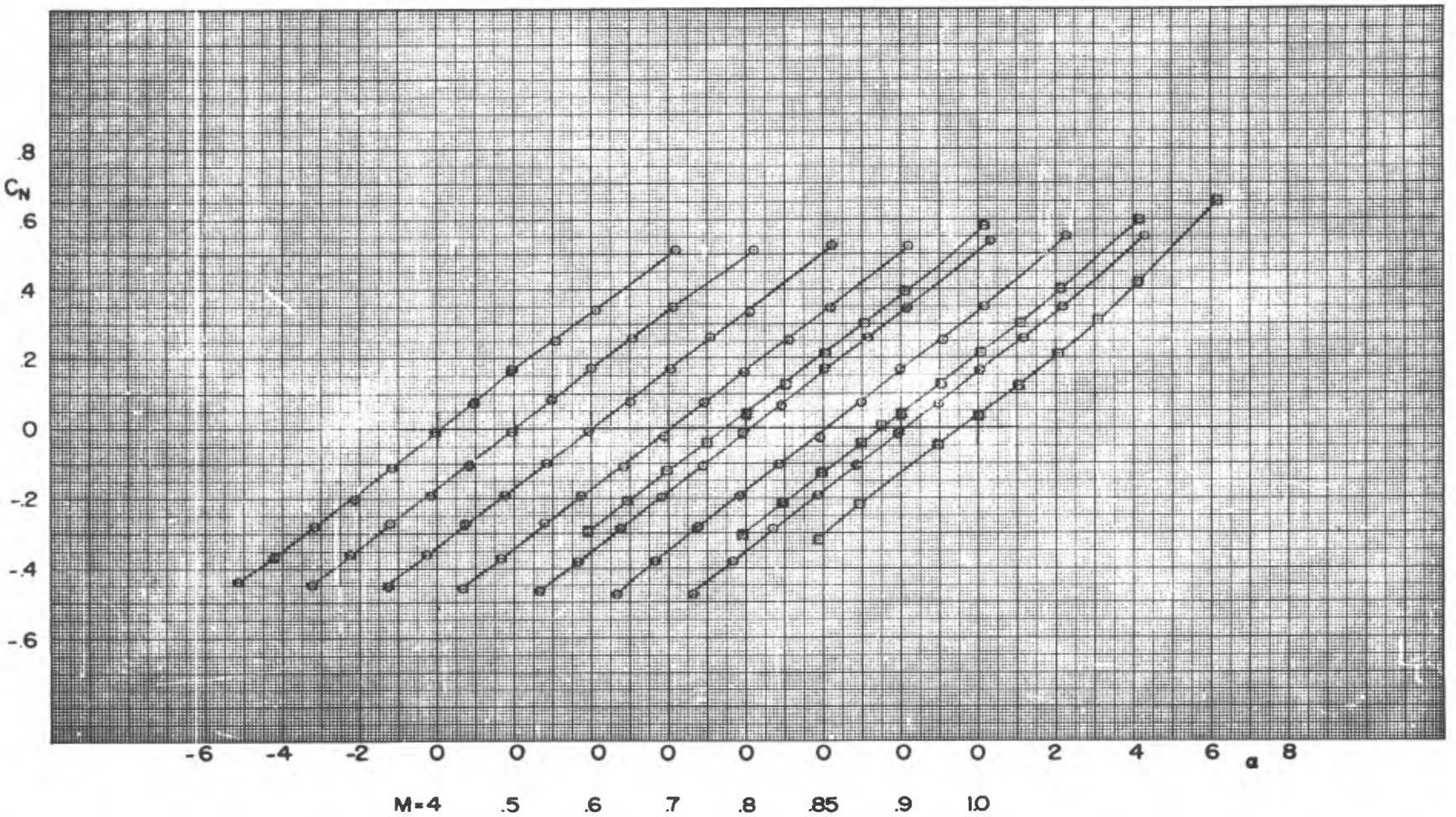
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 12. CONTINUED



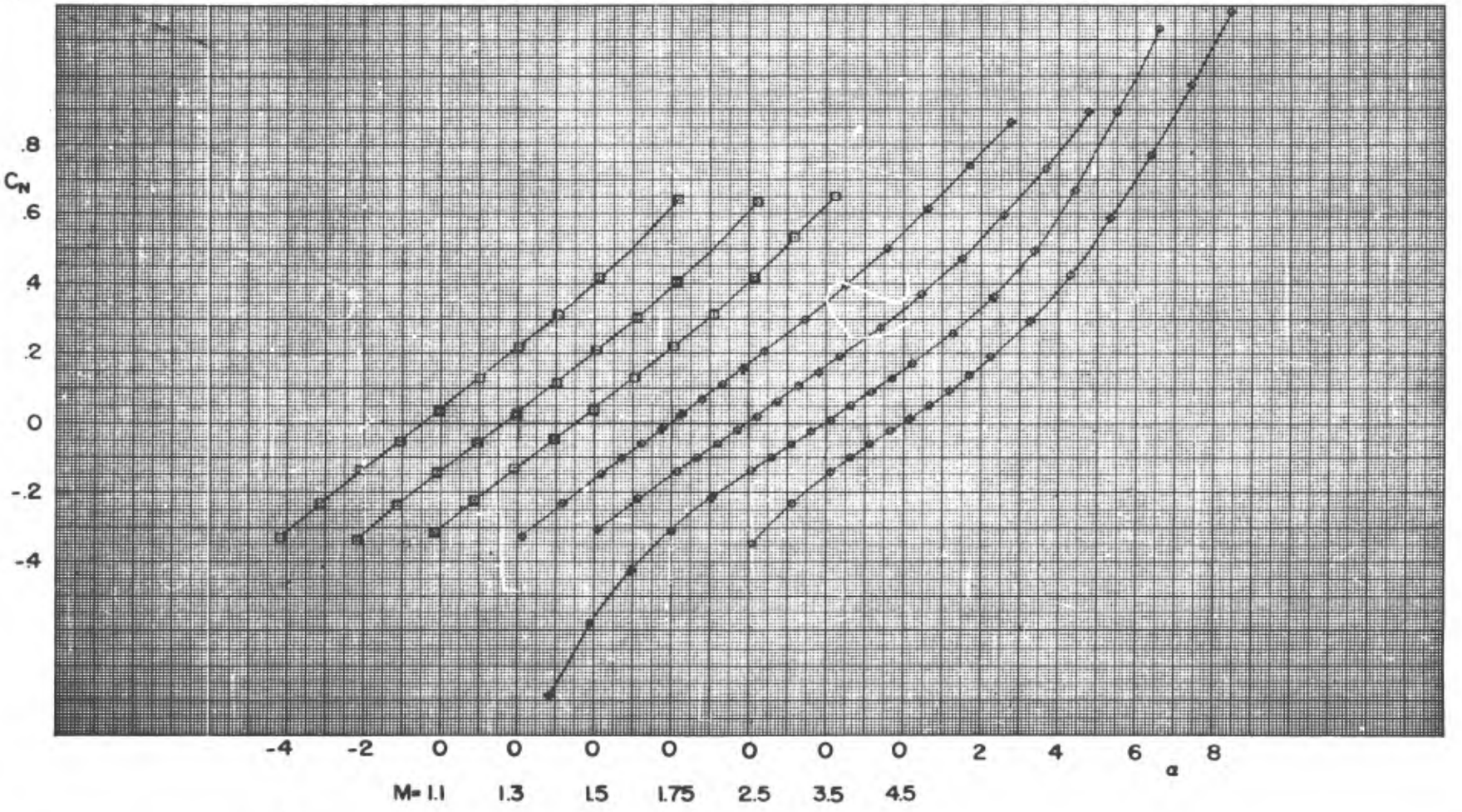
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 12. CONCLUDED



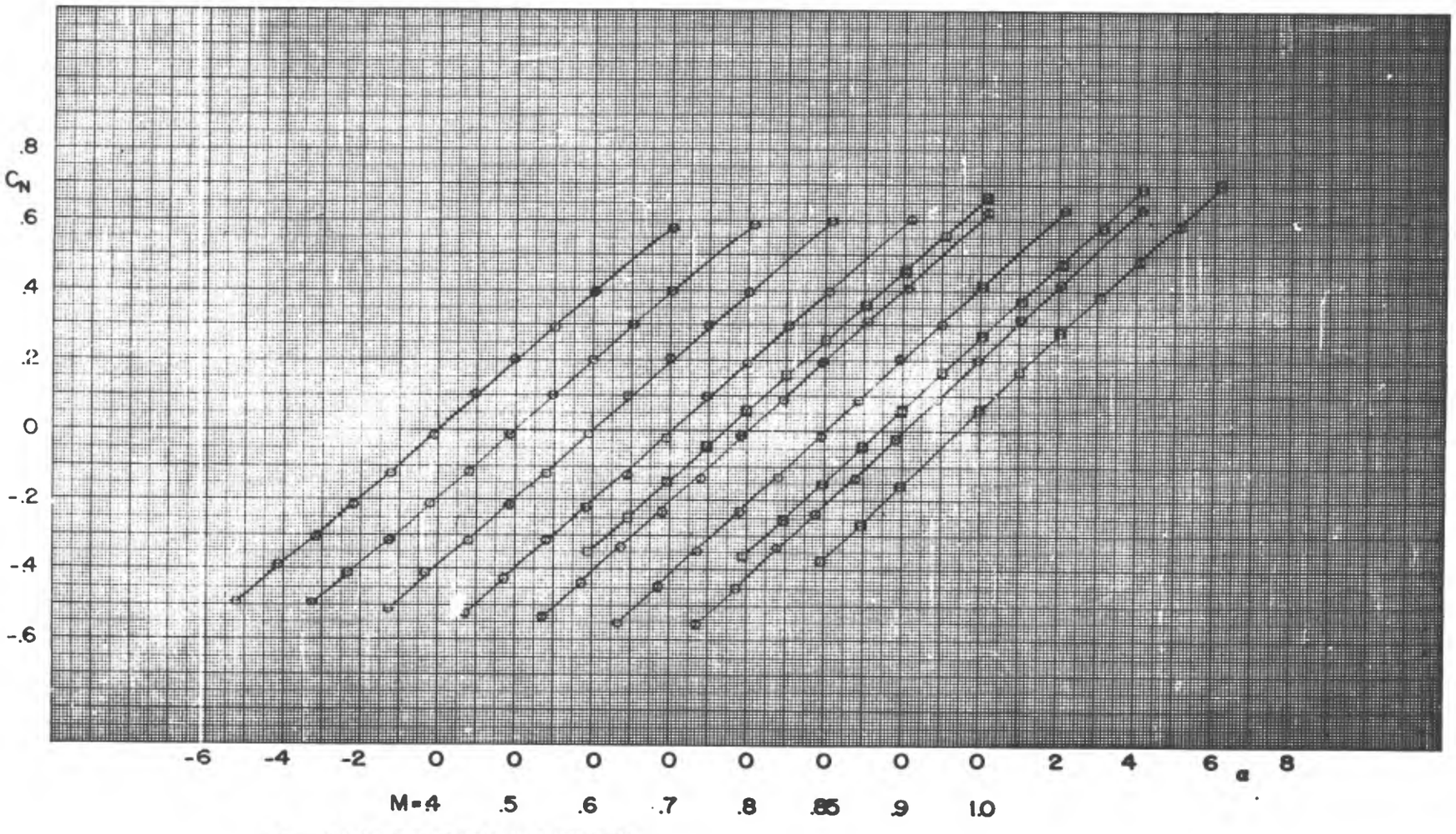
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 13. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 11



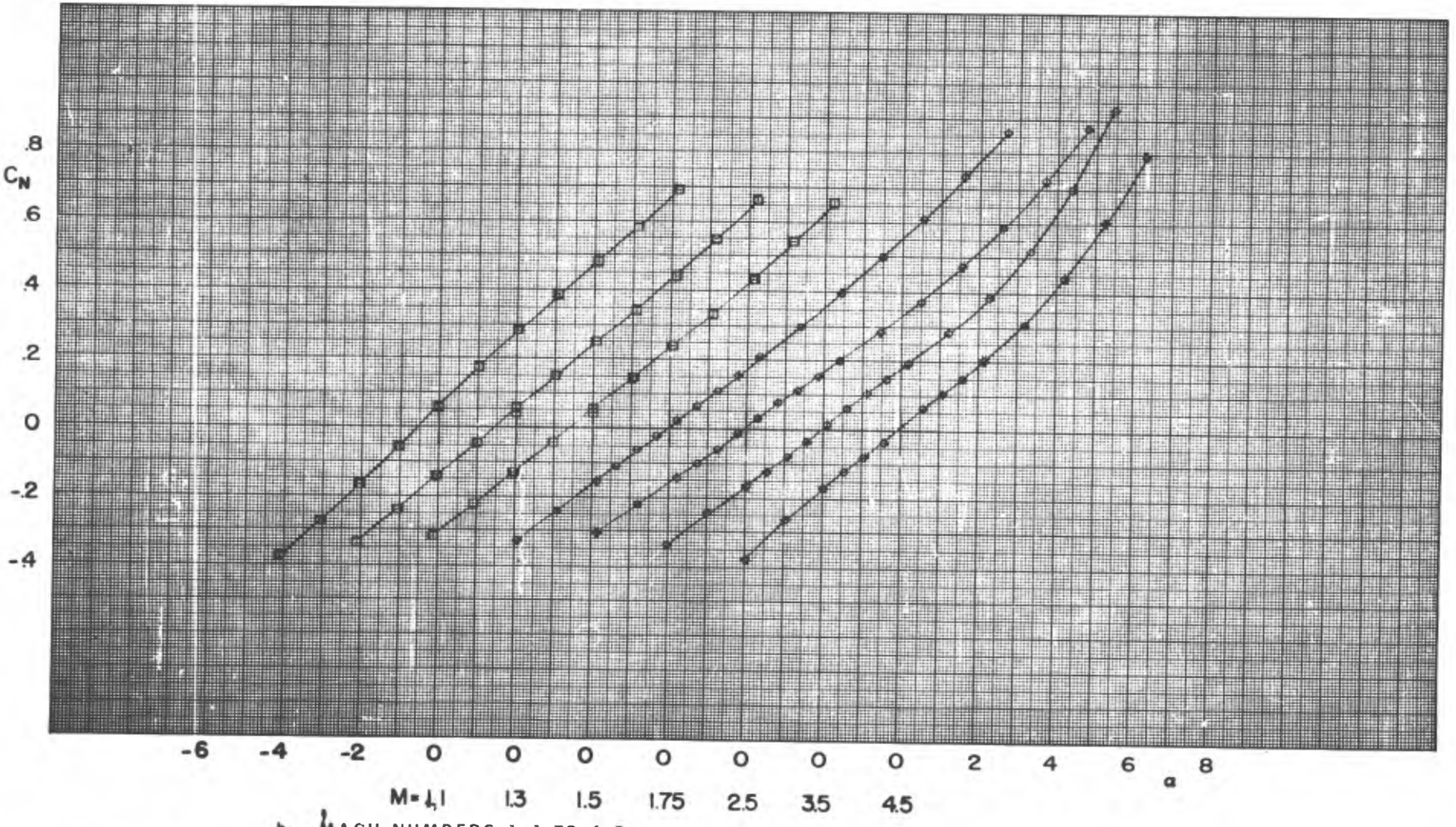
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 13. CONCLUDED



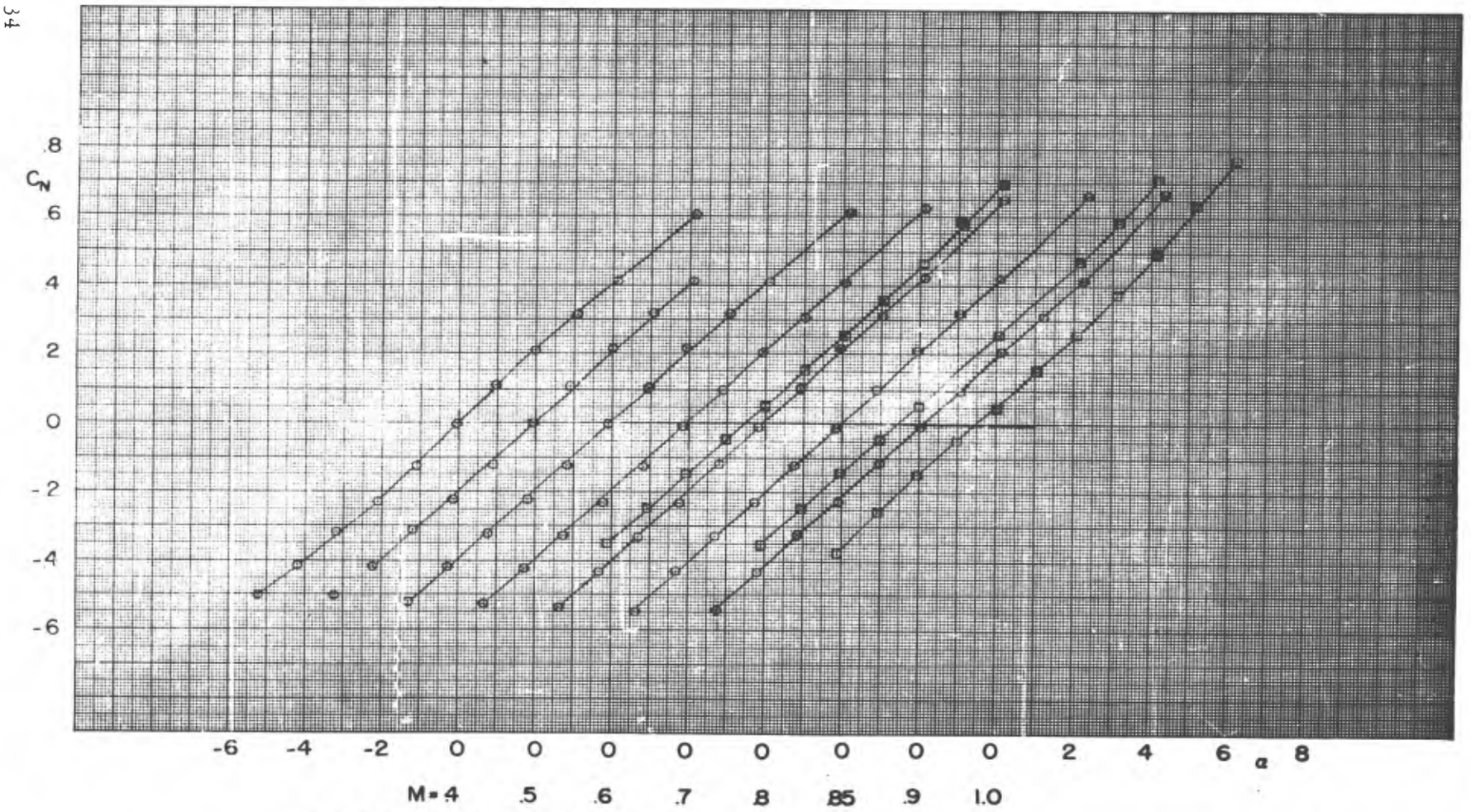
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 14. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 12



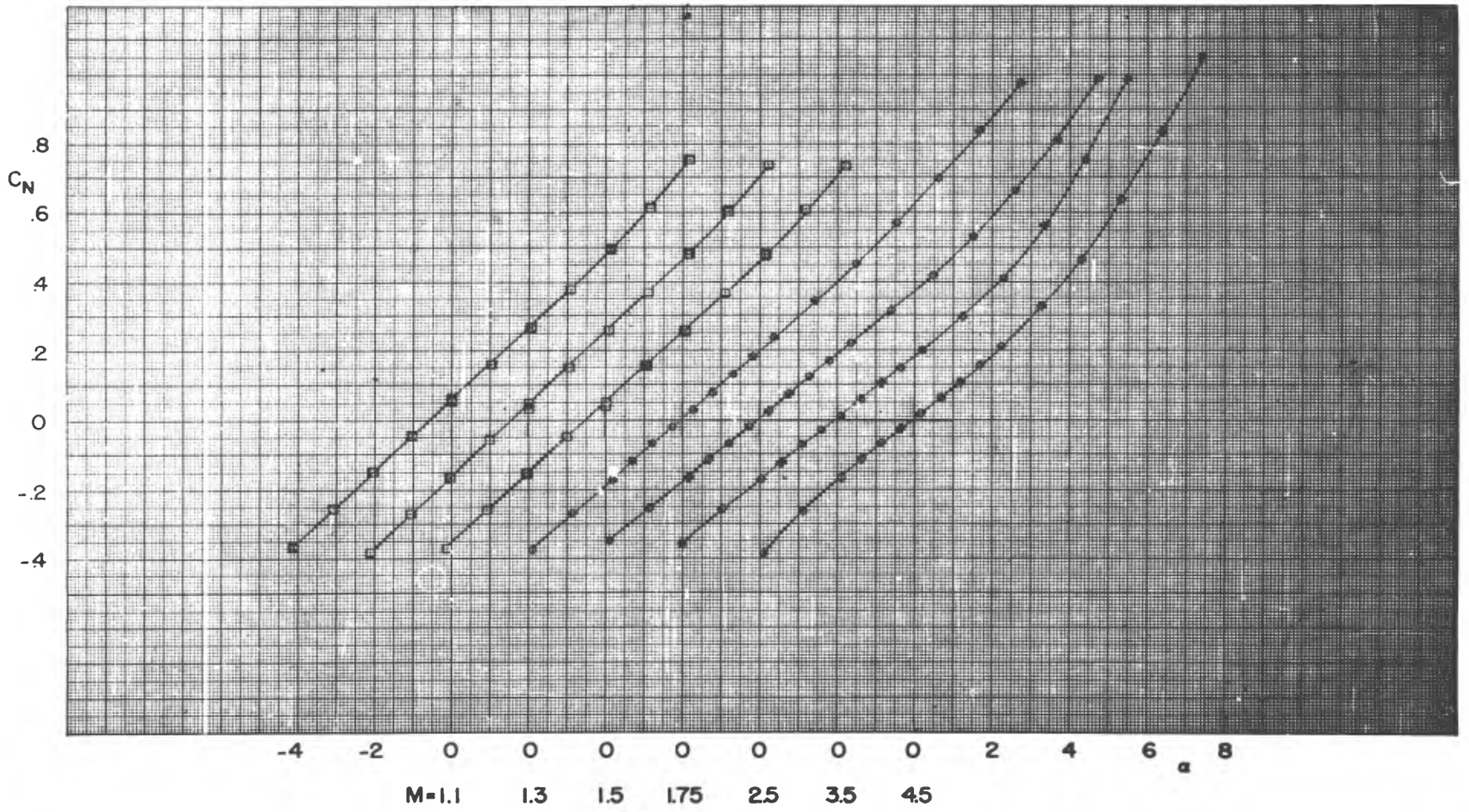
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 14. CONCLUDED



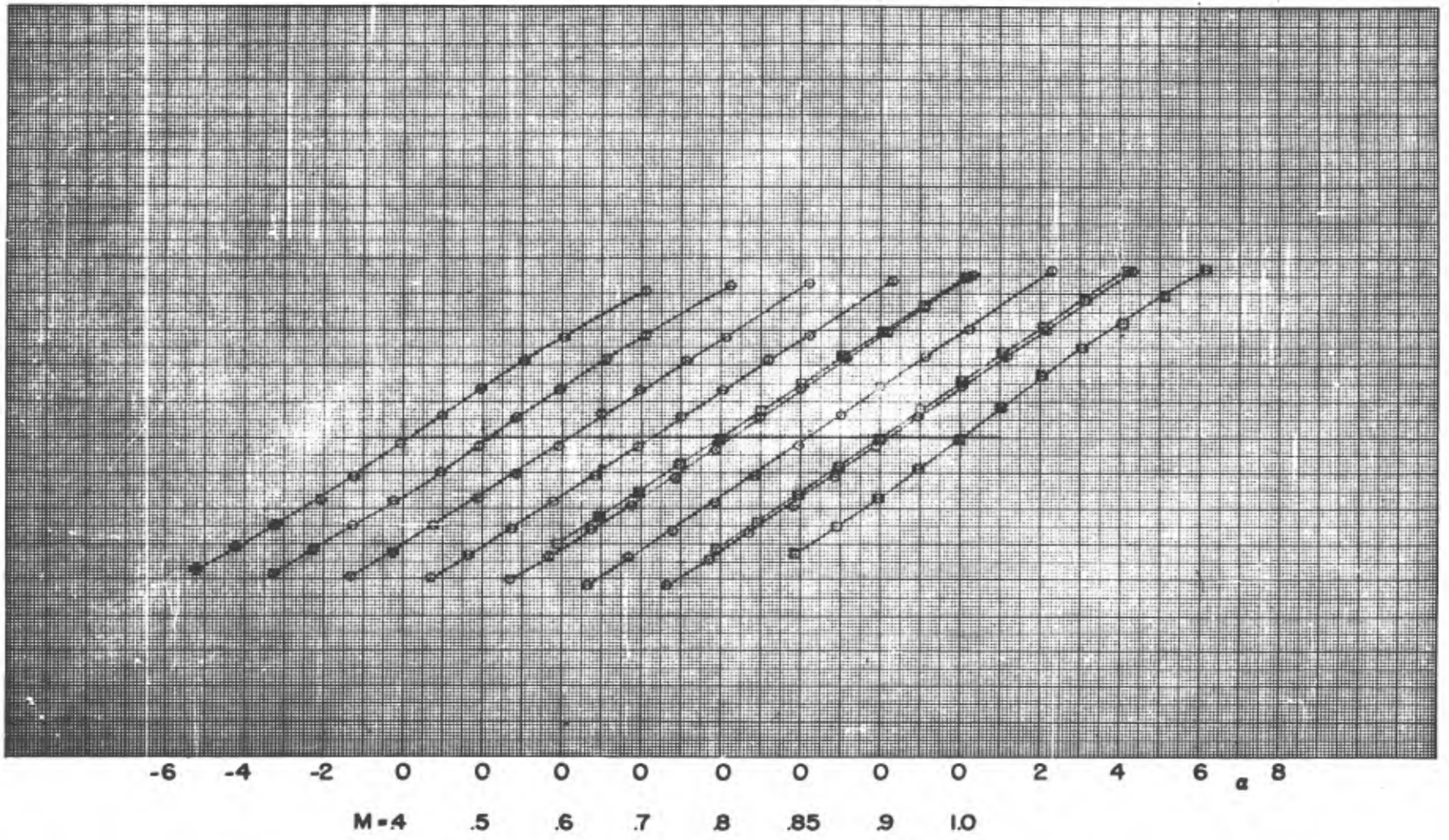
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 15. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 13



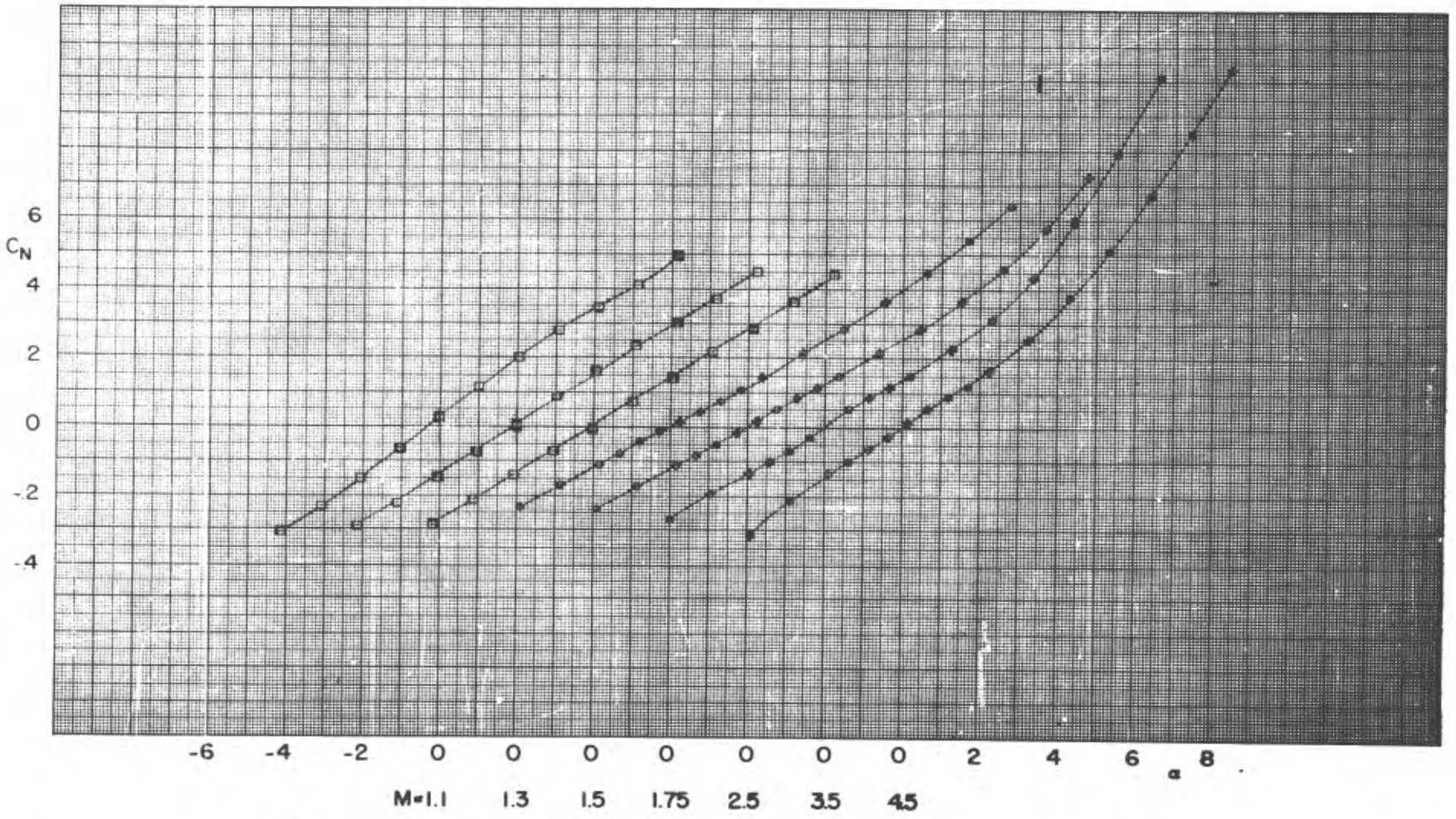
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 15. CONCLUDED



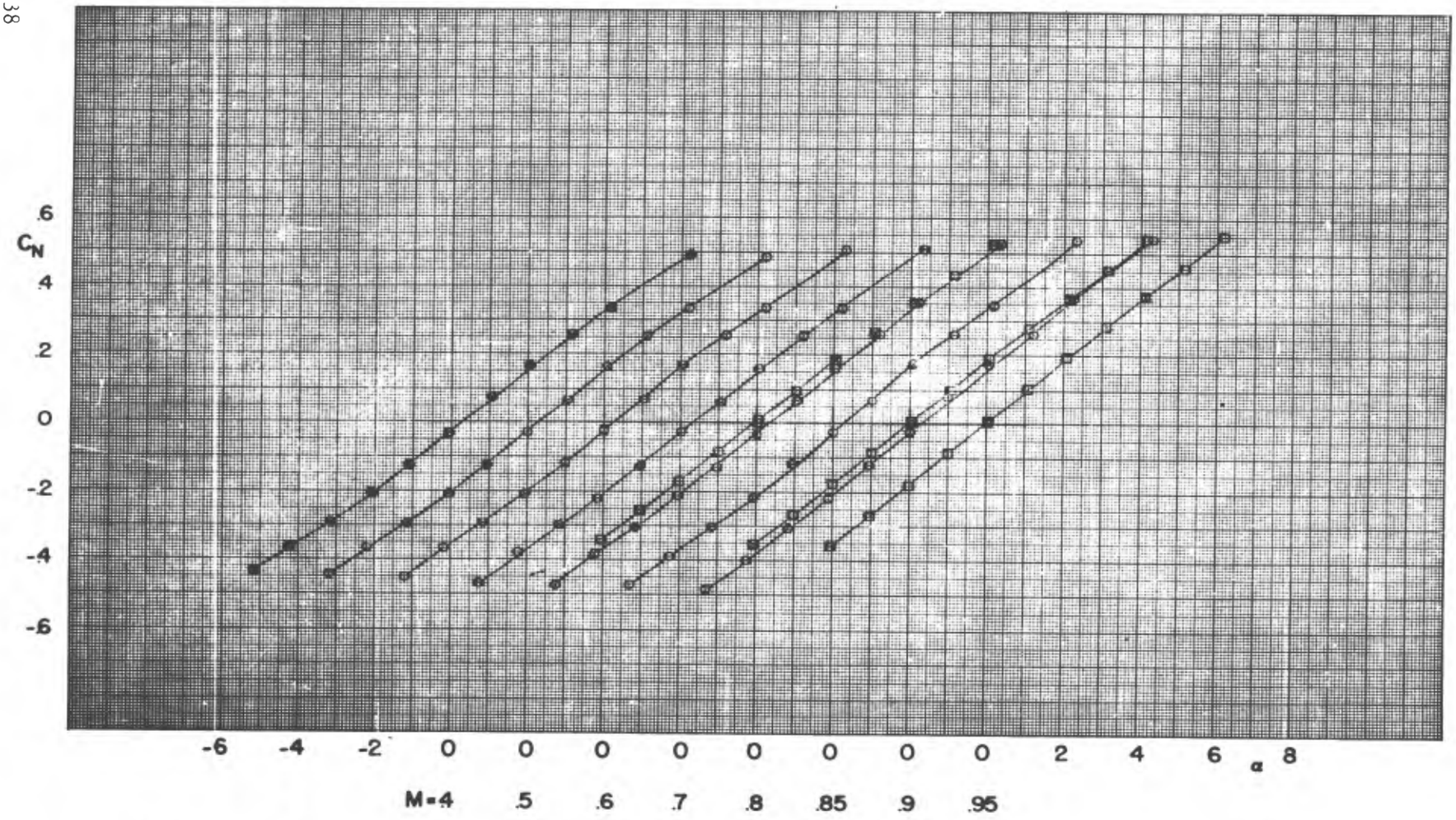
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 16. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 14



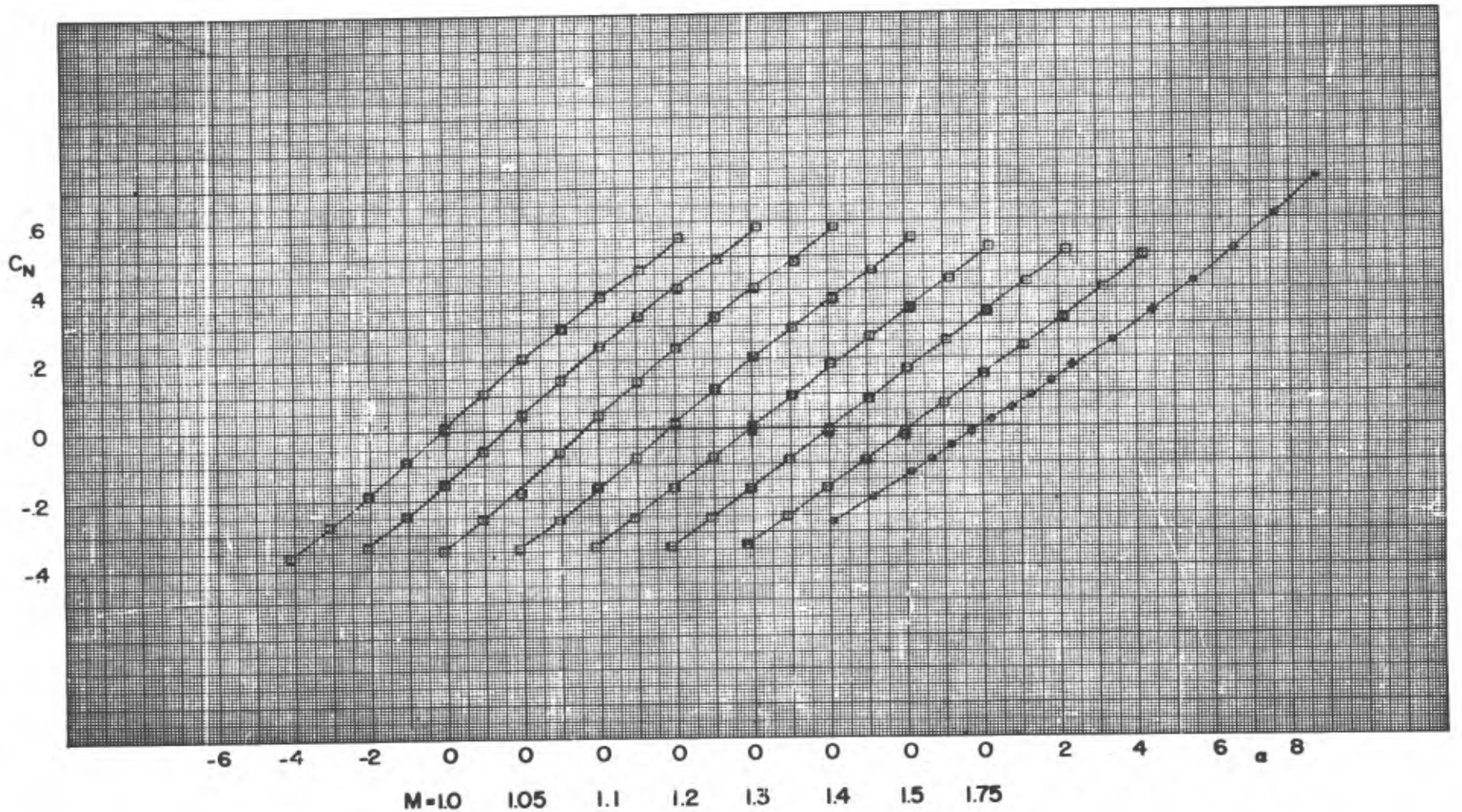
b. MACH NUMBERS 1.1 to 4.5

FIGURE 16. CONCLUDED



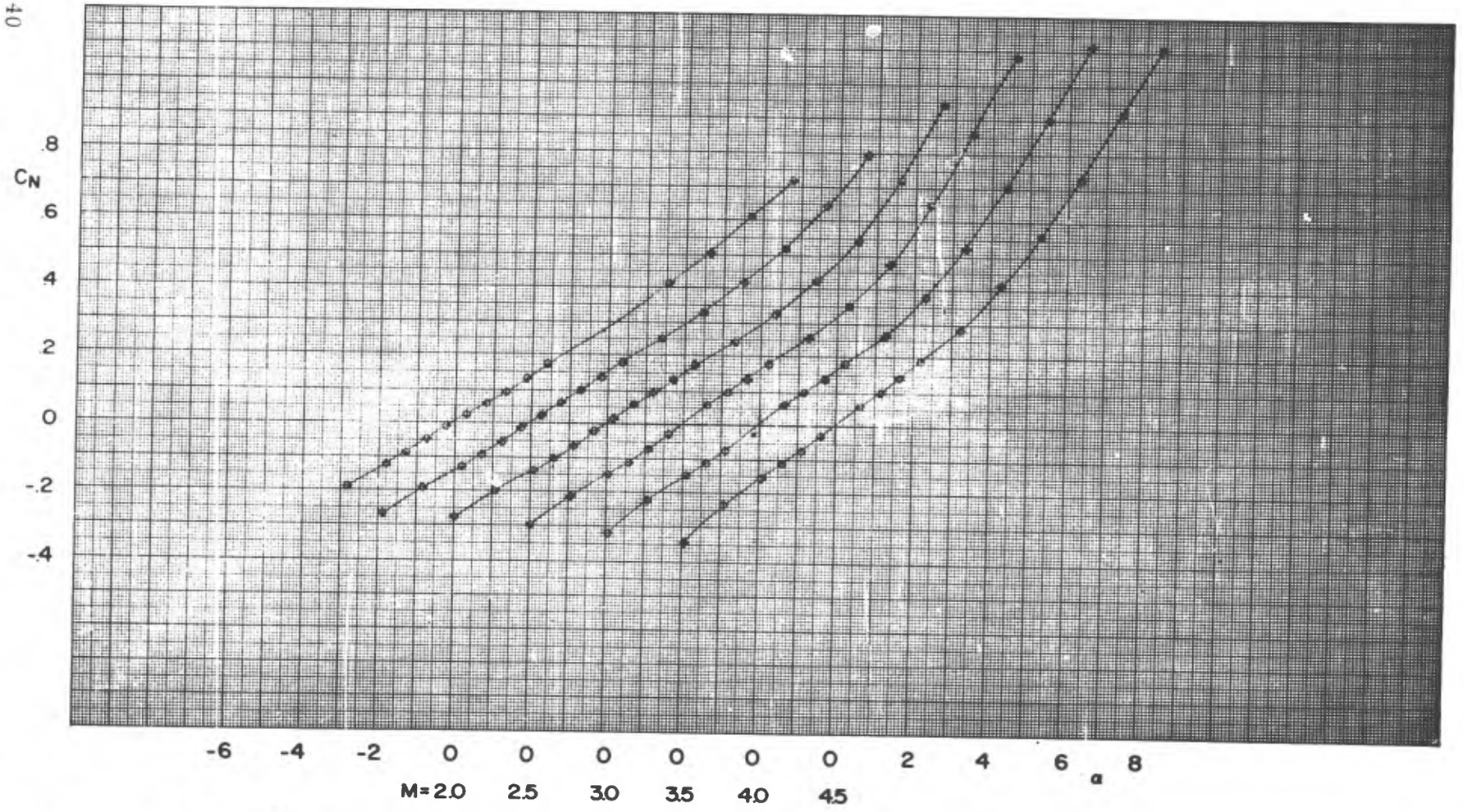
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 17. VARIATION OF NORMAL FORCE COEFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 15



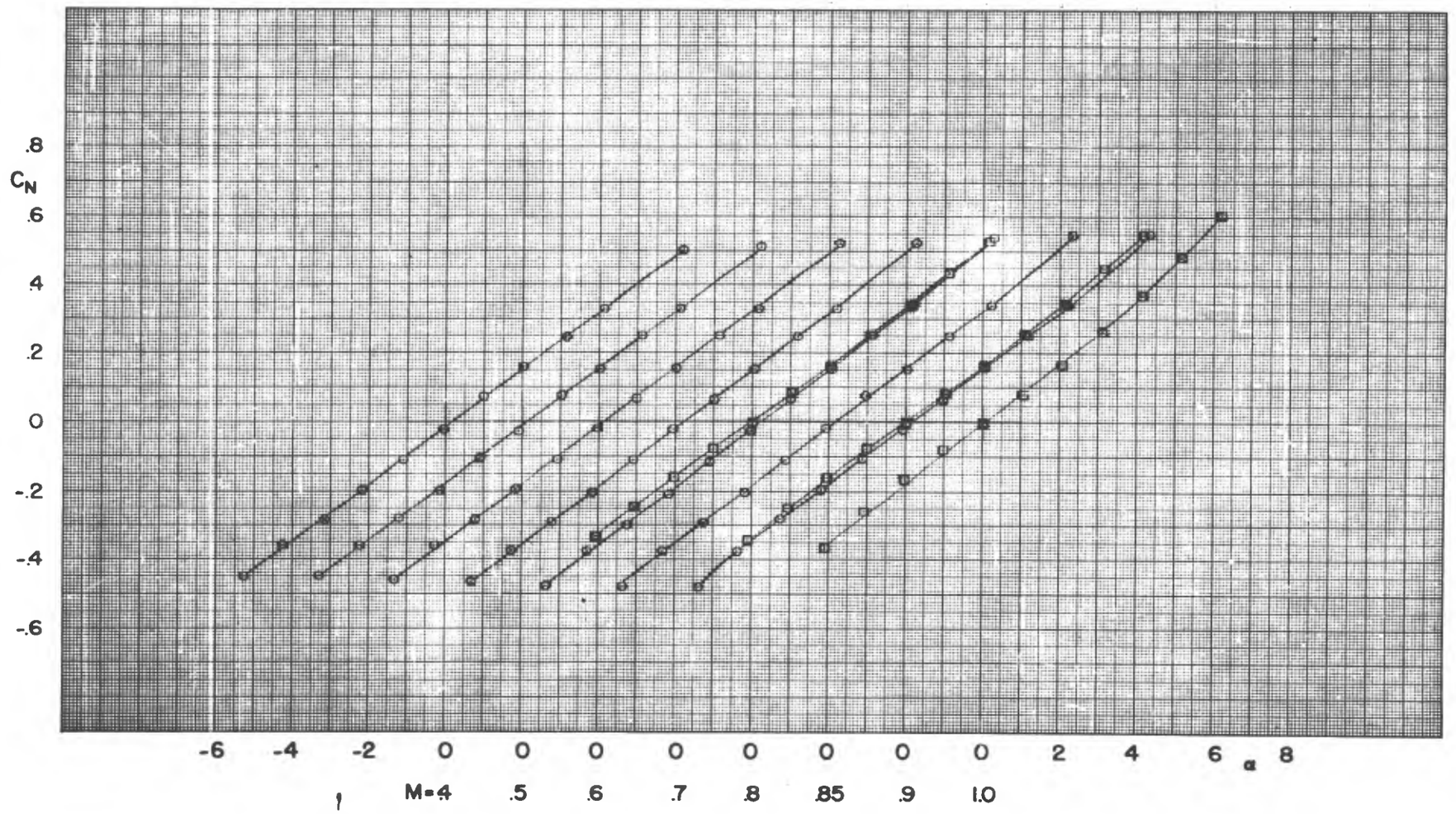
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 17. CONTINUED



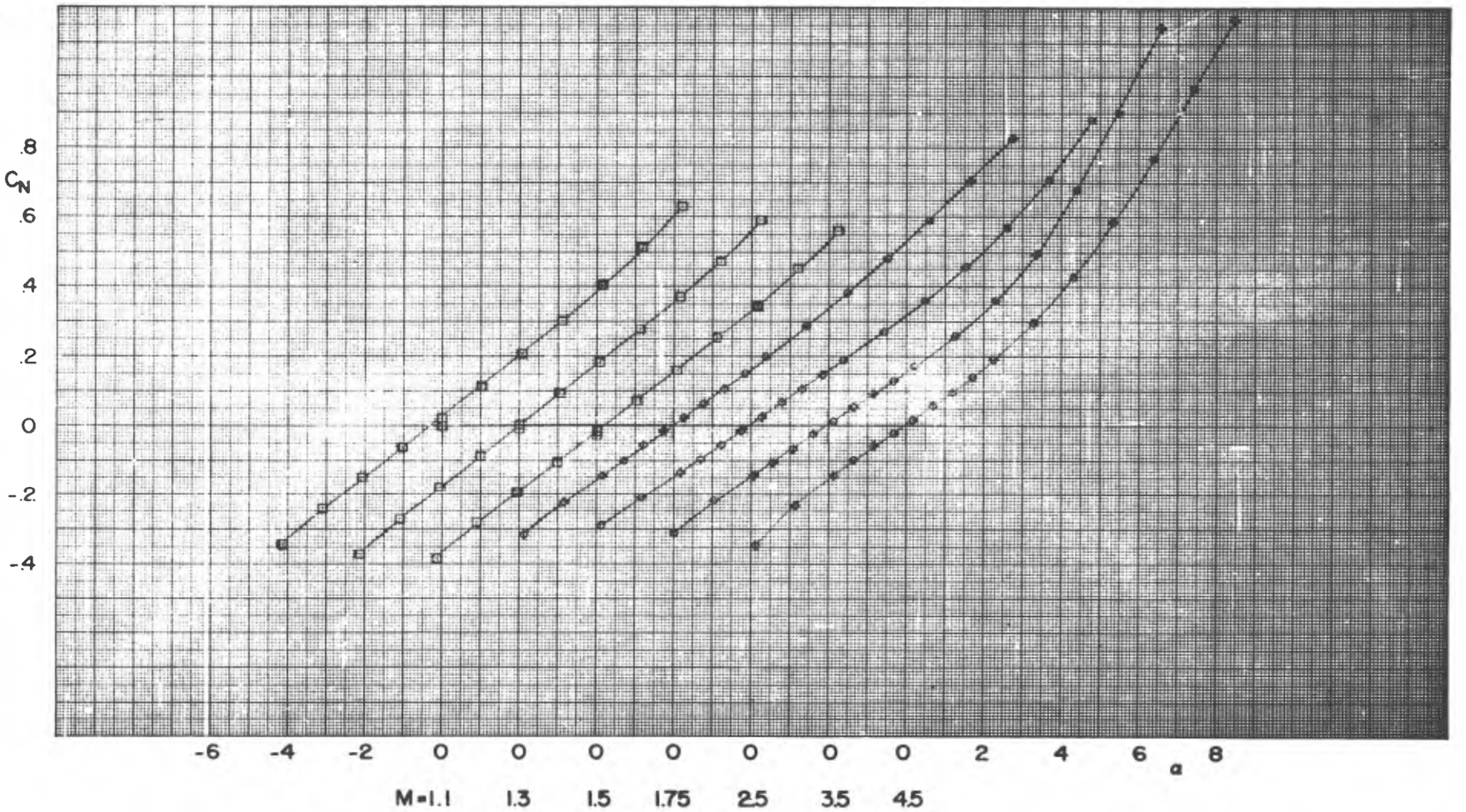
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 17. CONCLUDED



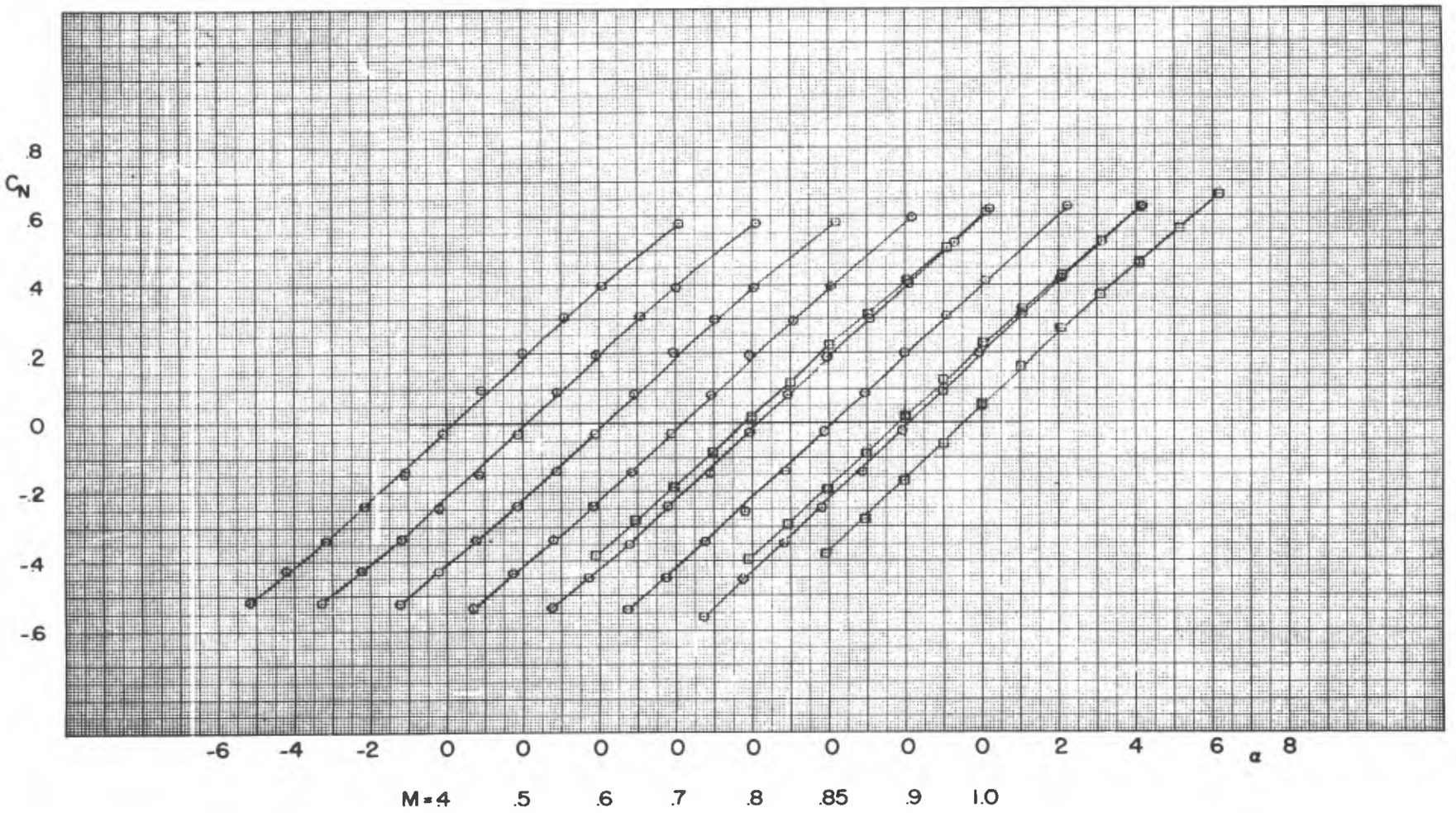
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 18. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 16



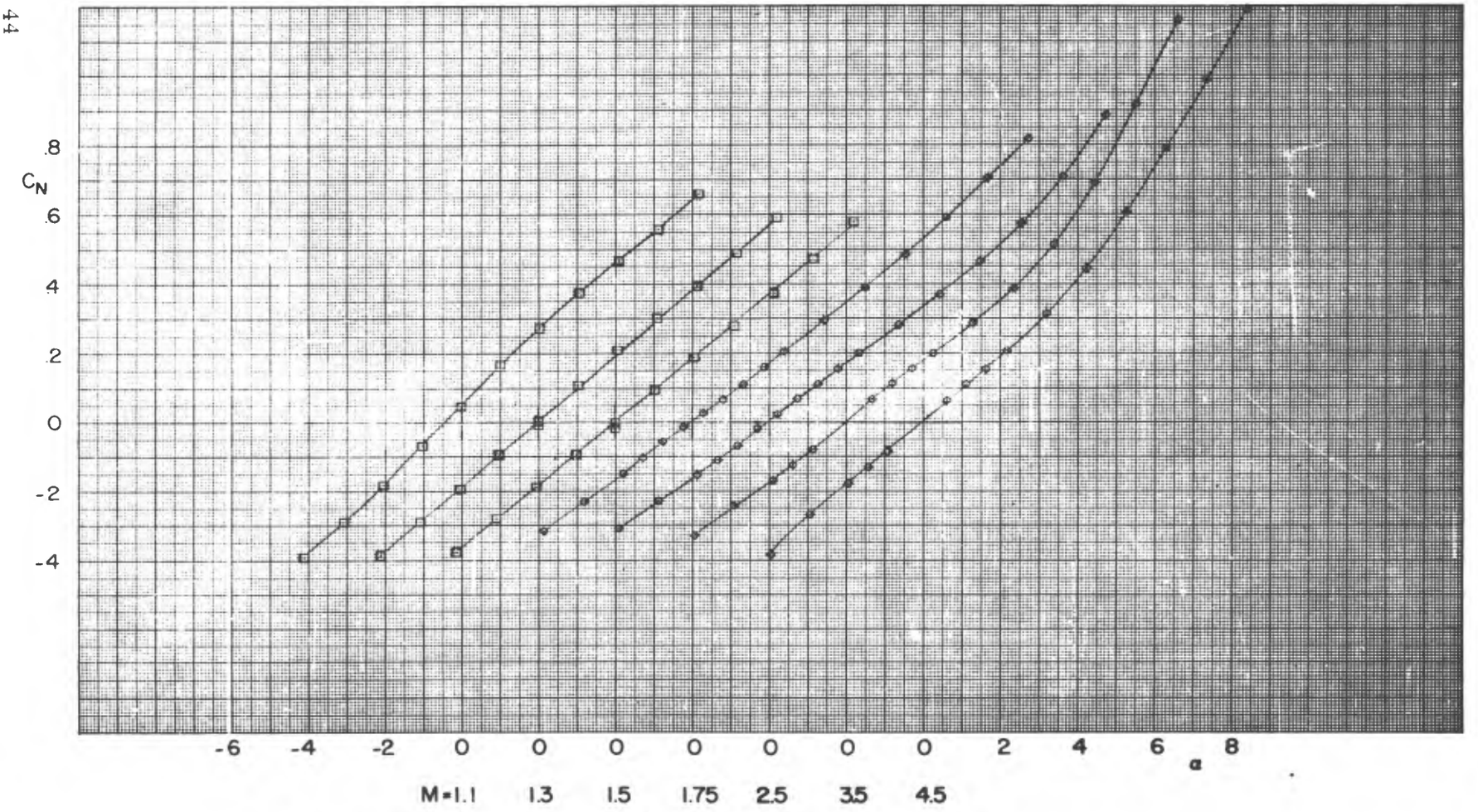
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 18. CONCLUDED



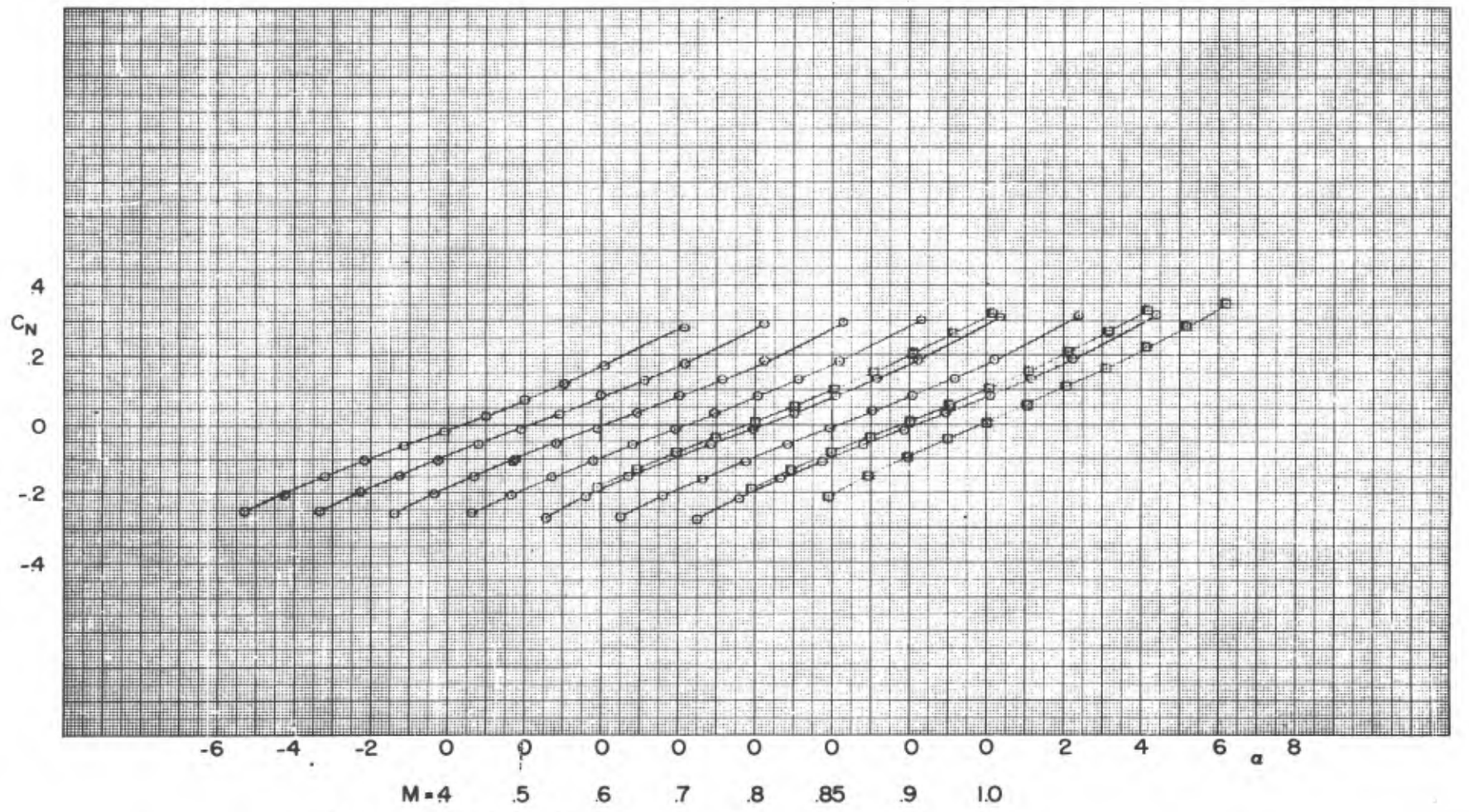
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 19. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 17



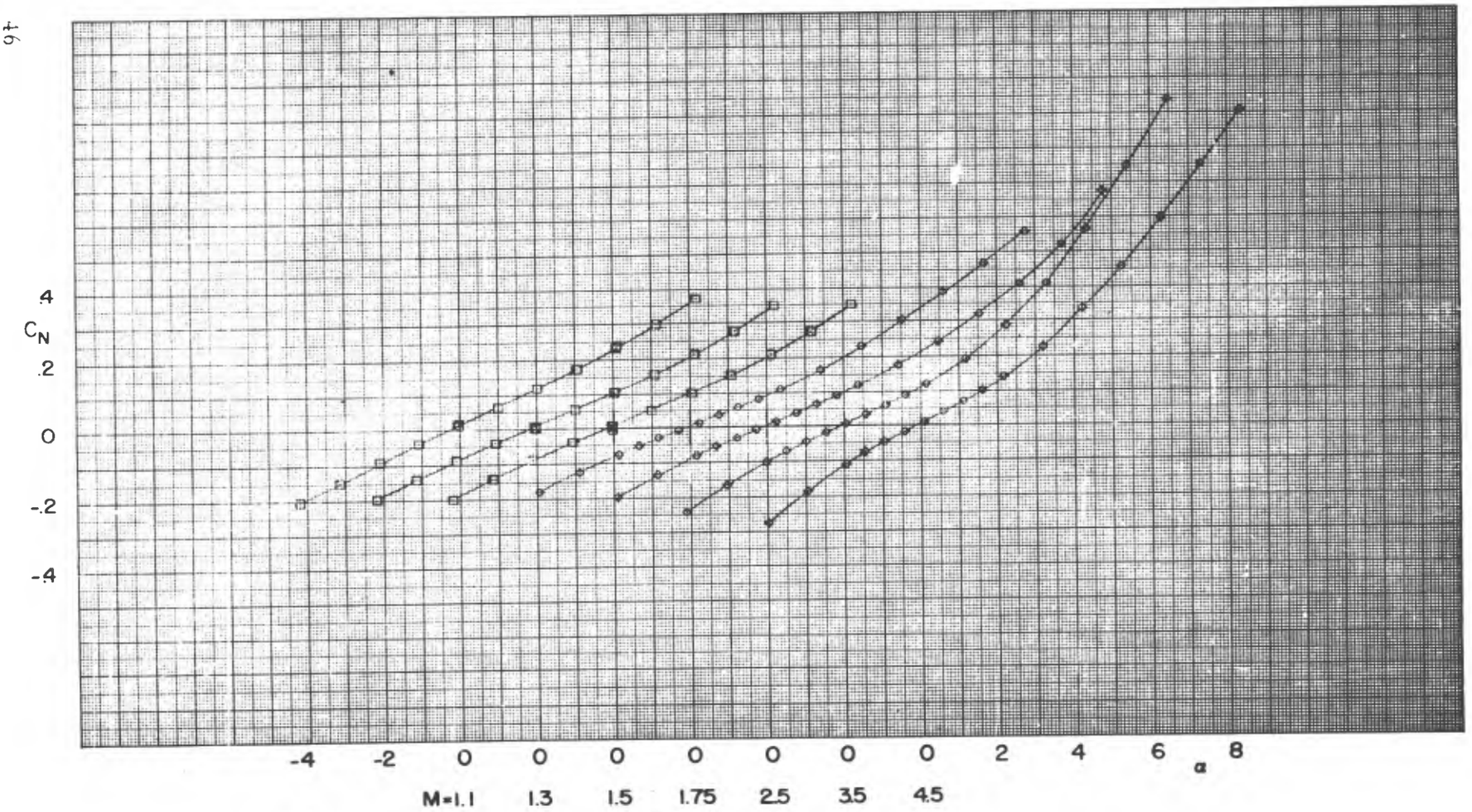
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 19. CONCLUDED



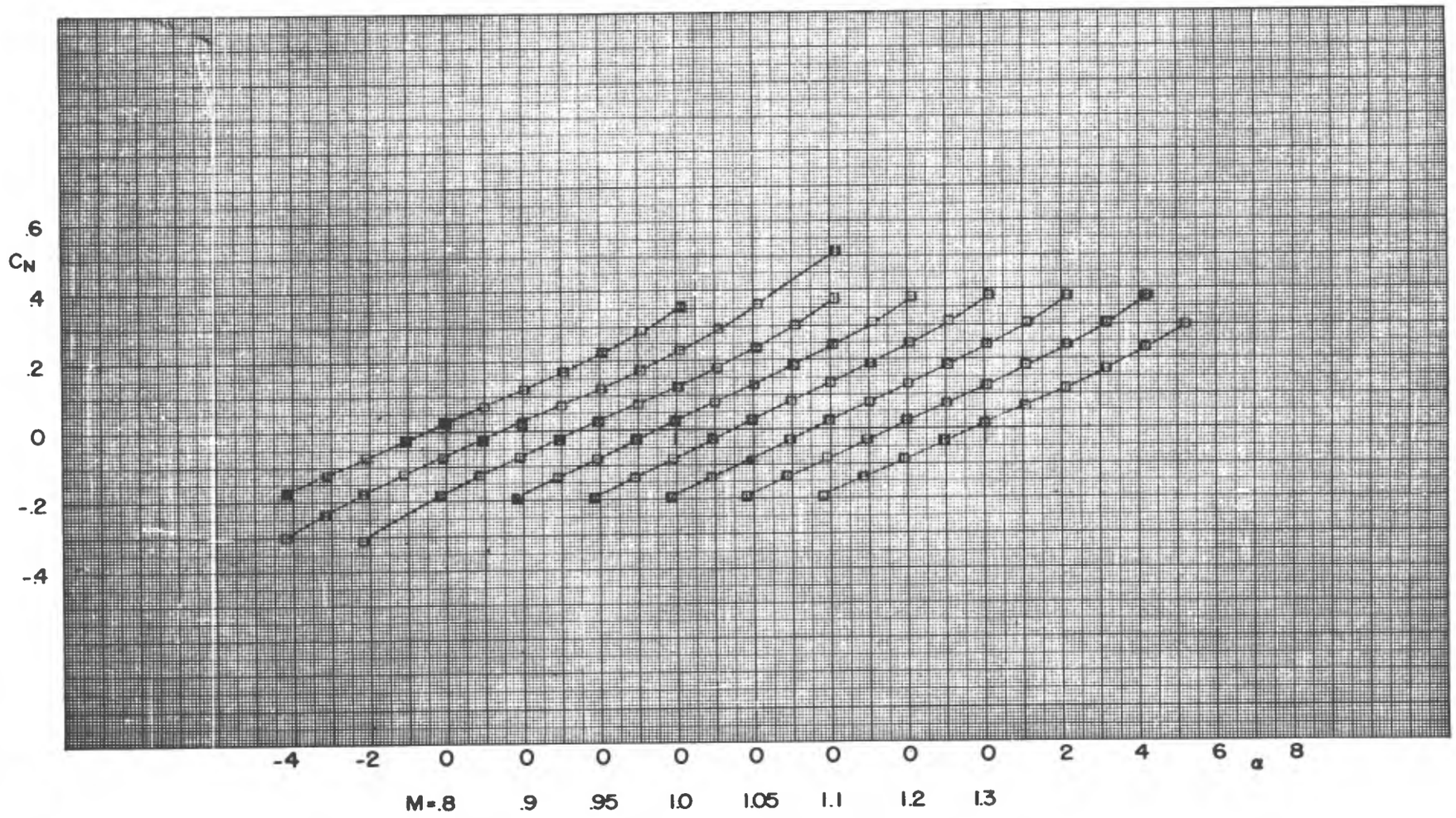
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 20. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 18



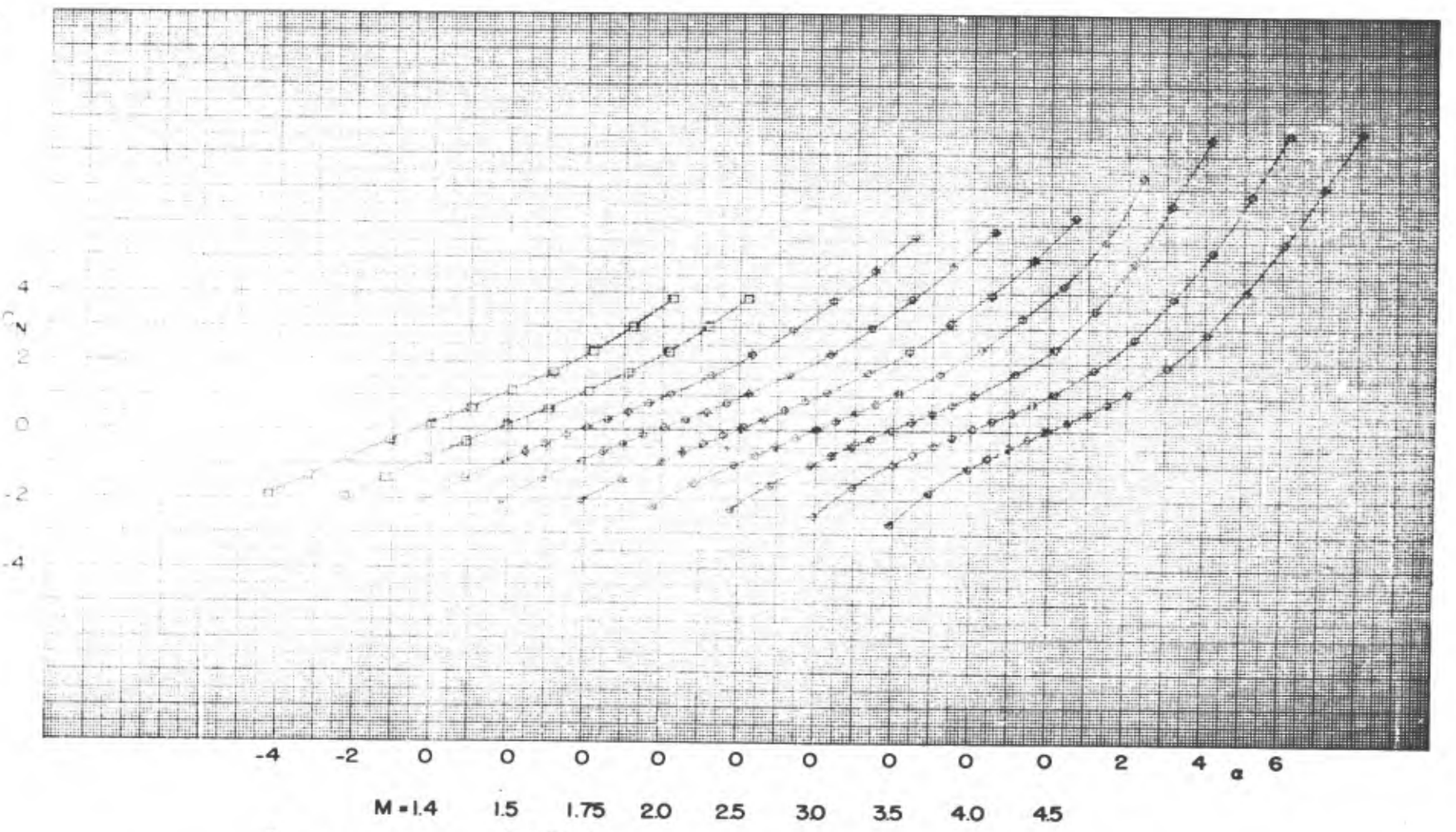
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 20. CONCLUDED



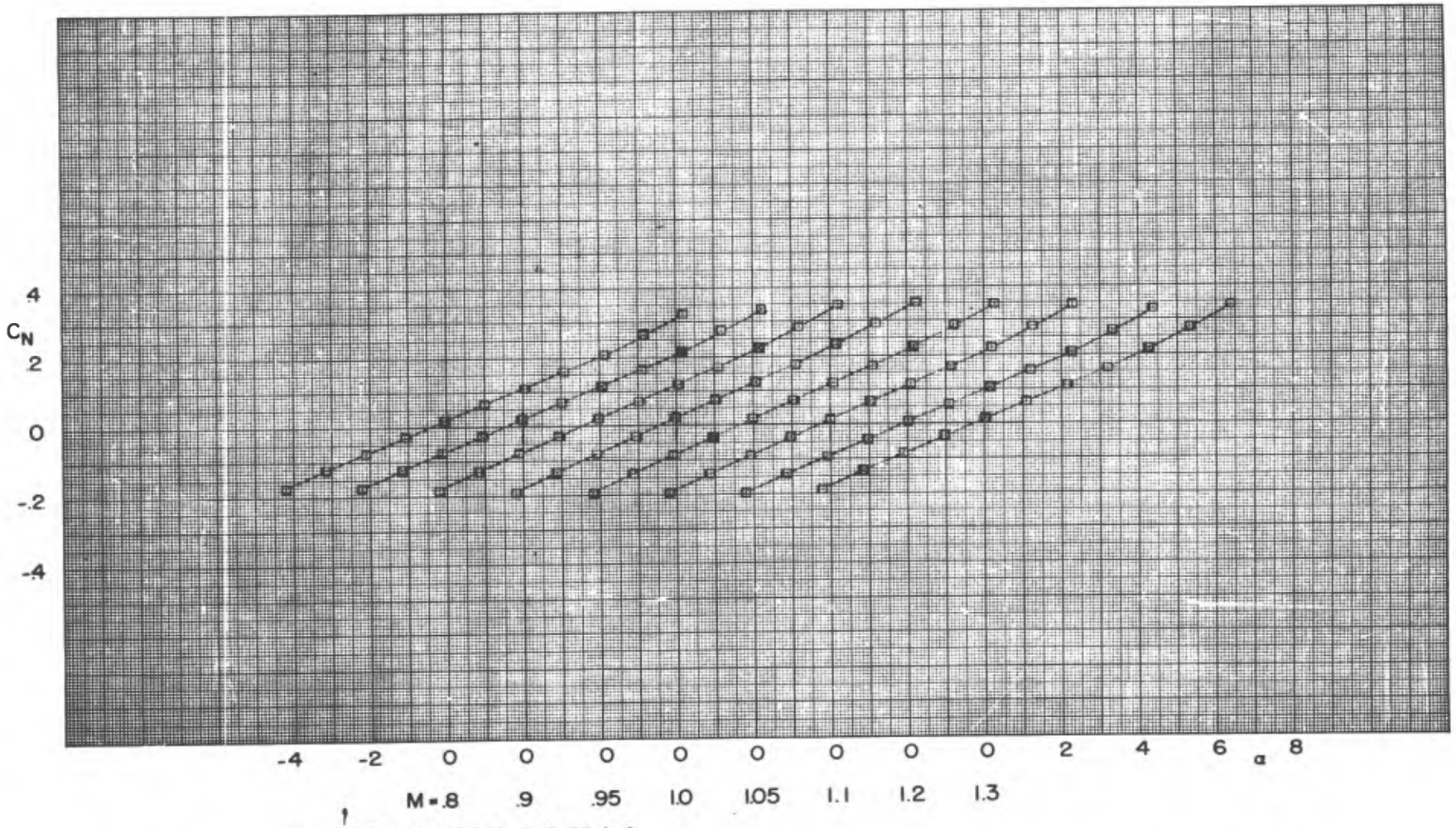
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 21. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 19



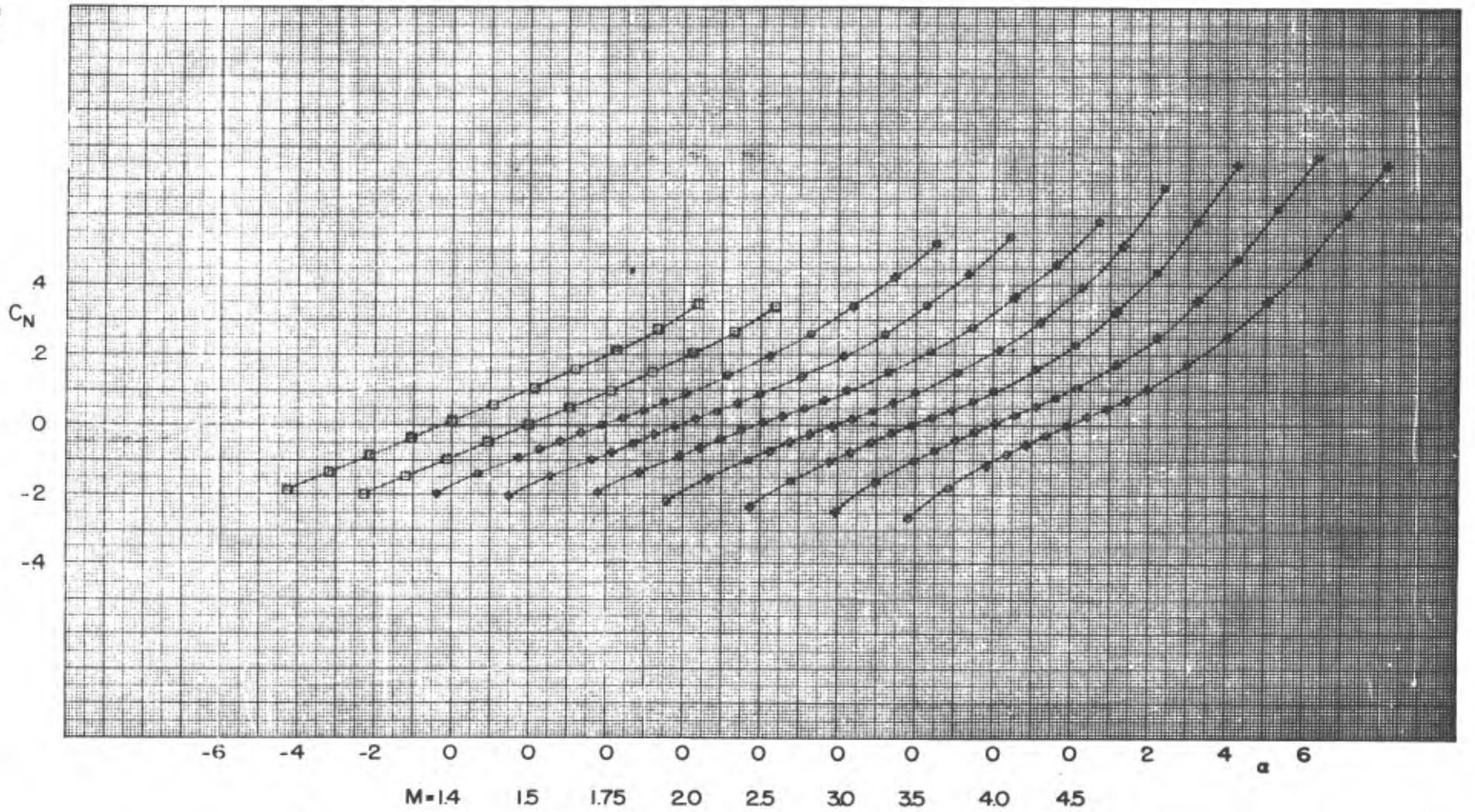
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 21. CONCLUDED



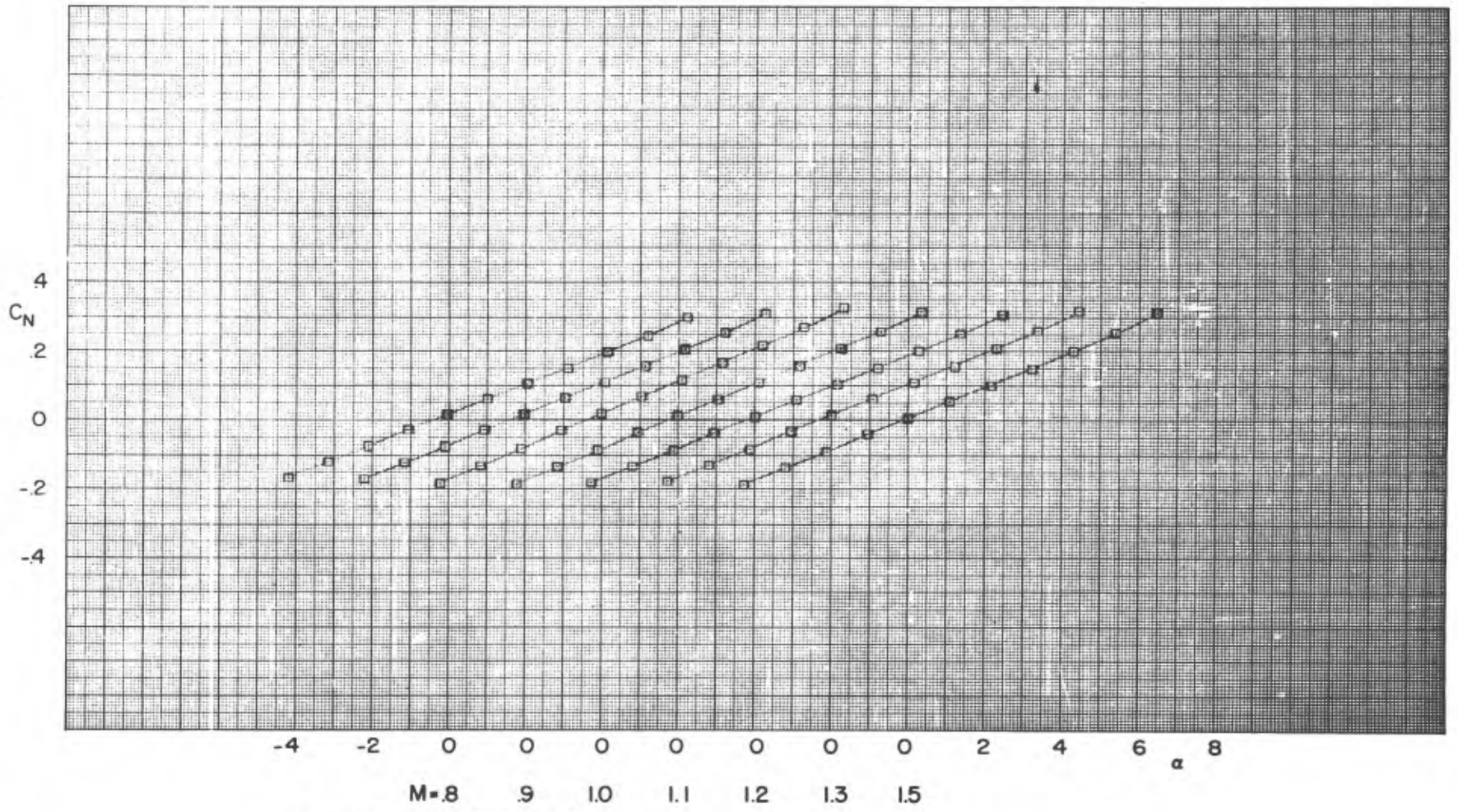
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 22. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 20



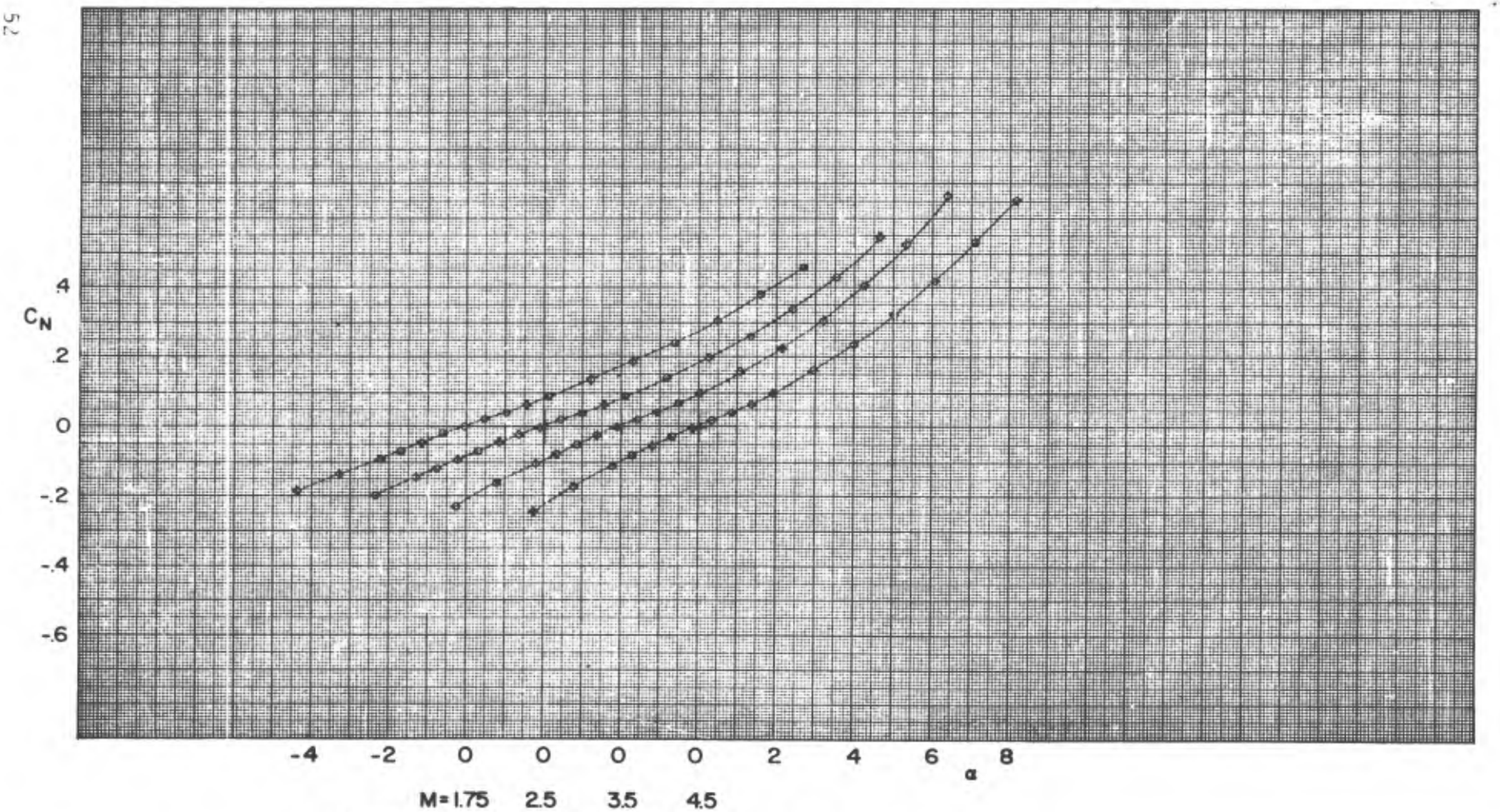
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 22. CONCLUDED



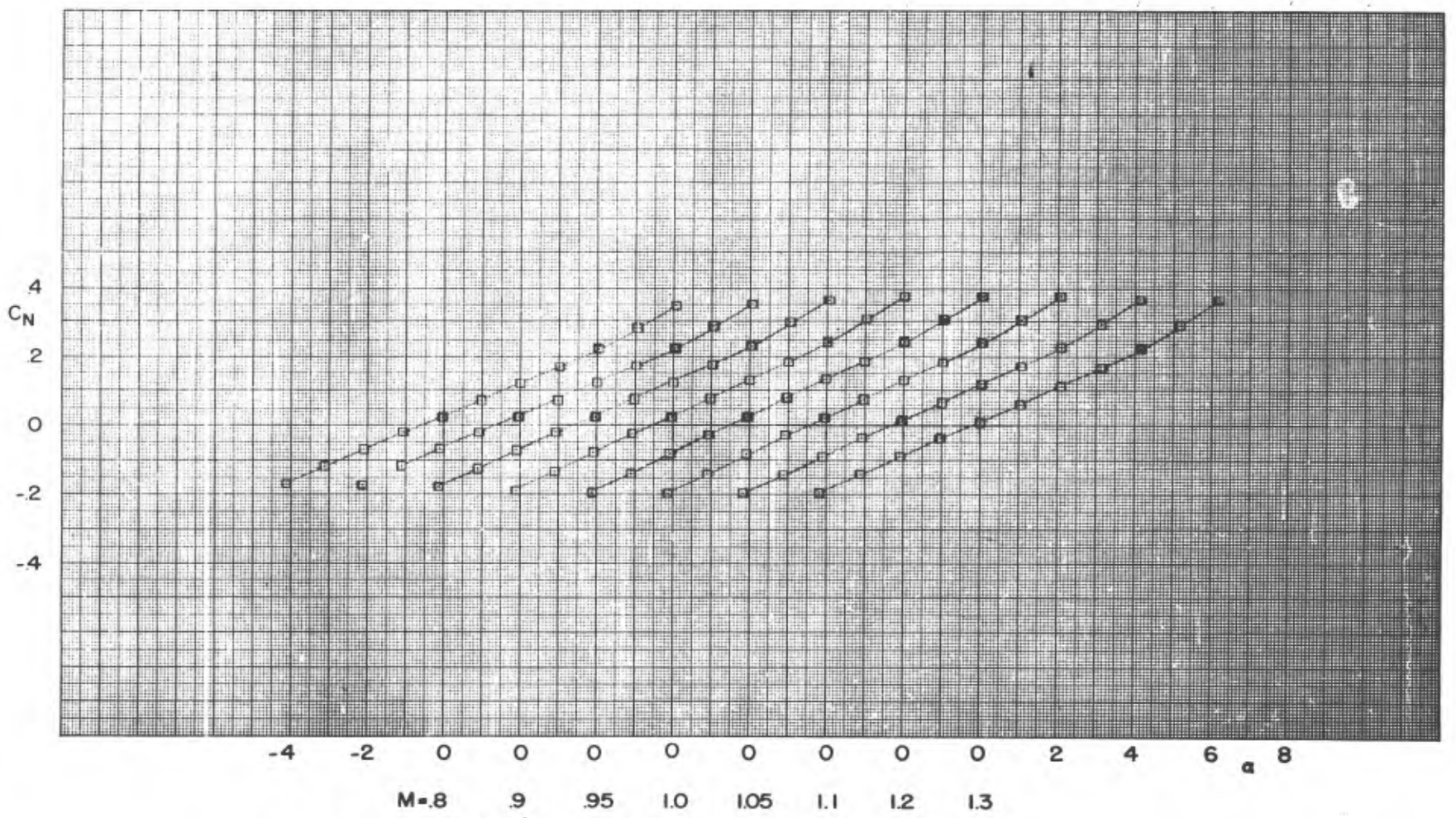
a. MACH NUMBERS 0.8 TO 1.5

FIGURE 23. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 21



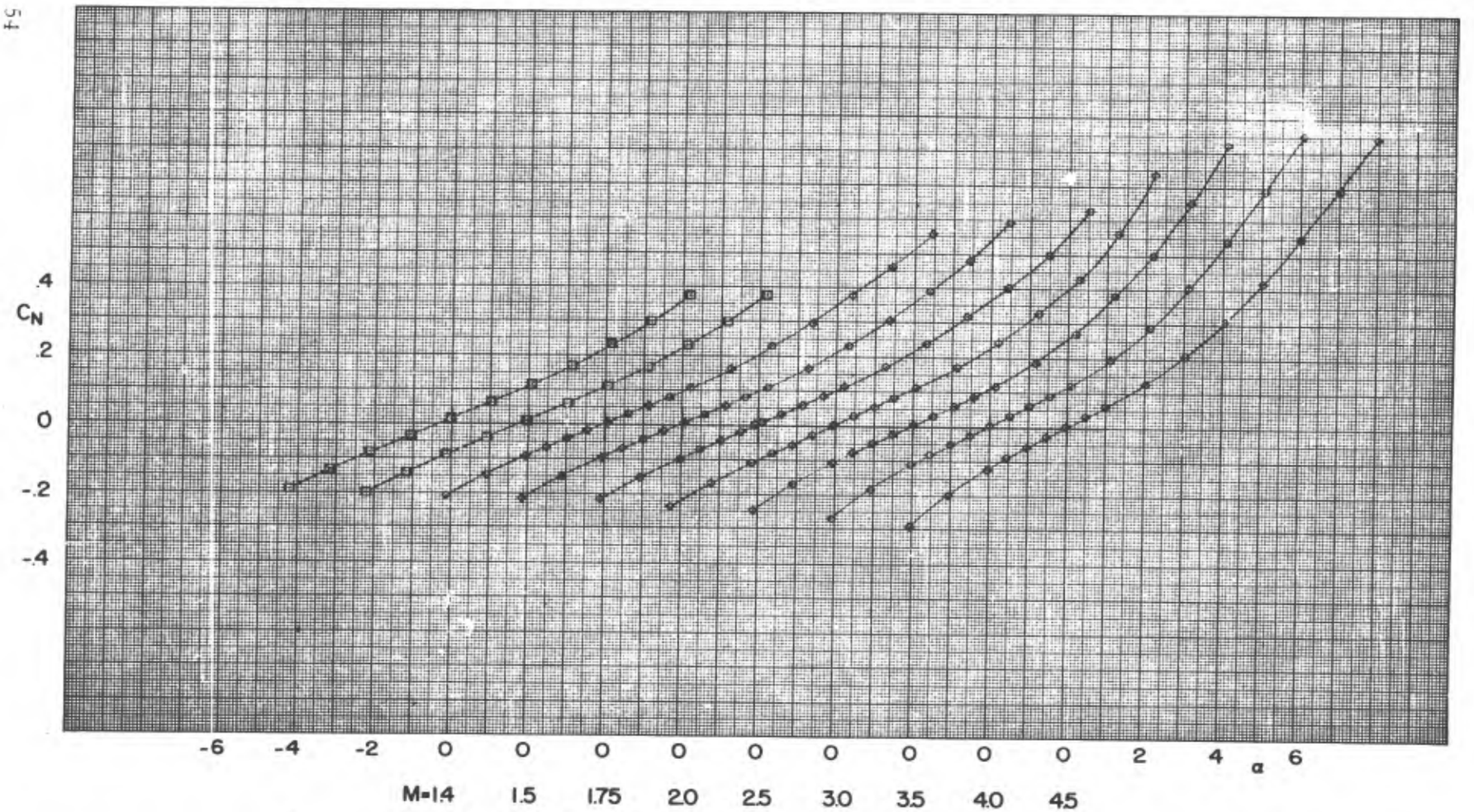
b. MACH NUMBERS 1.75 TO 4.5

FIGURE 23. CONCLUDED



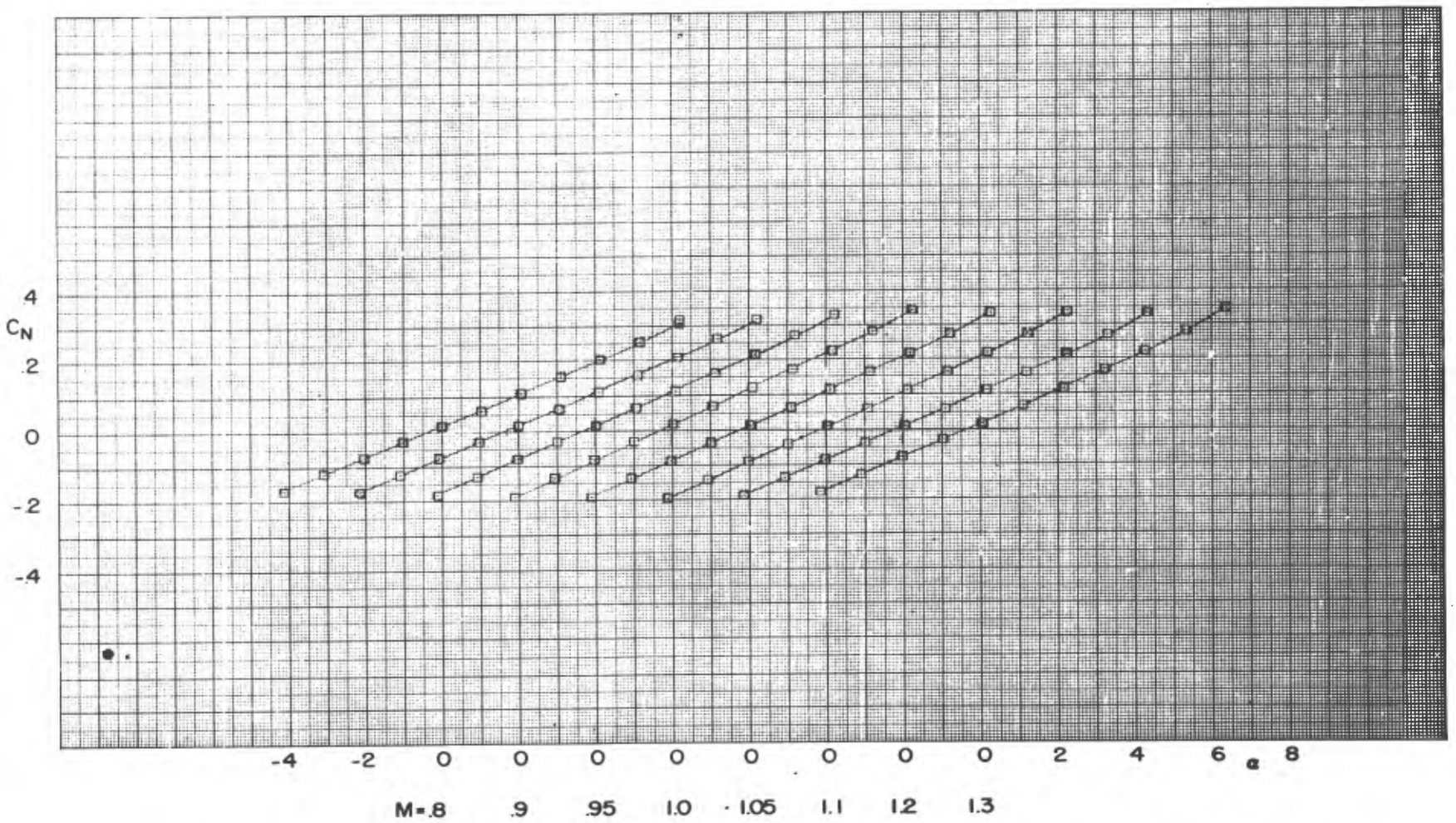
a. MACH NUMBERS OF 0.8 TO 1.3

FIGURE 24. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 22



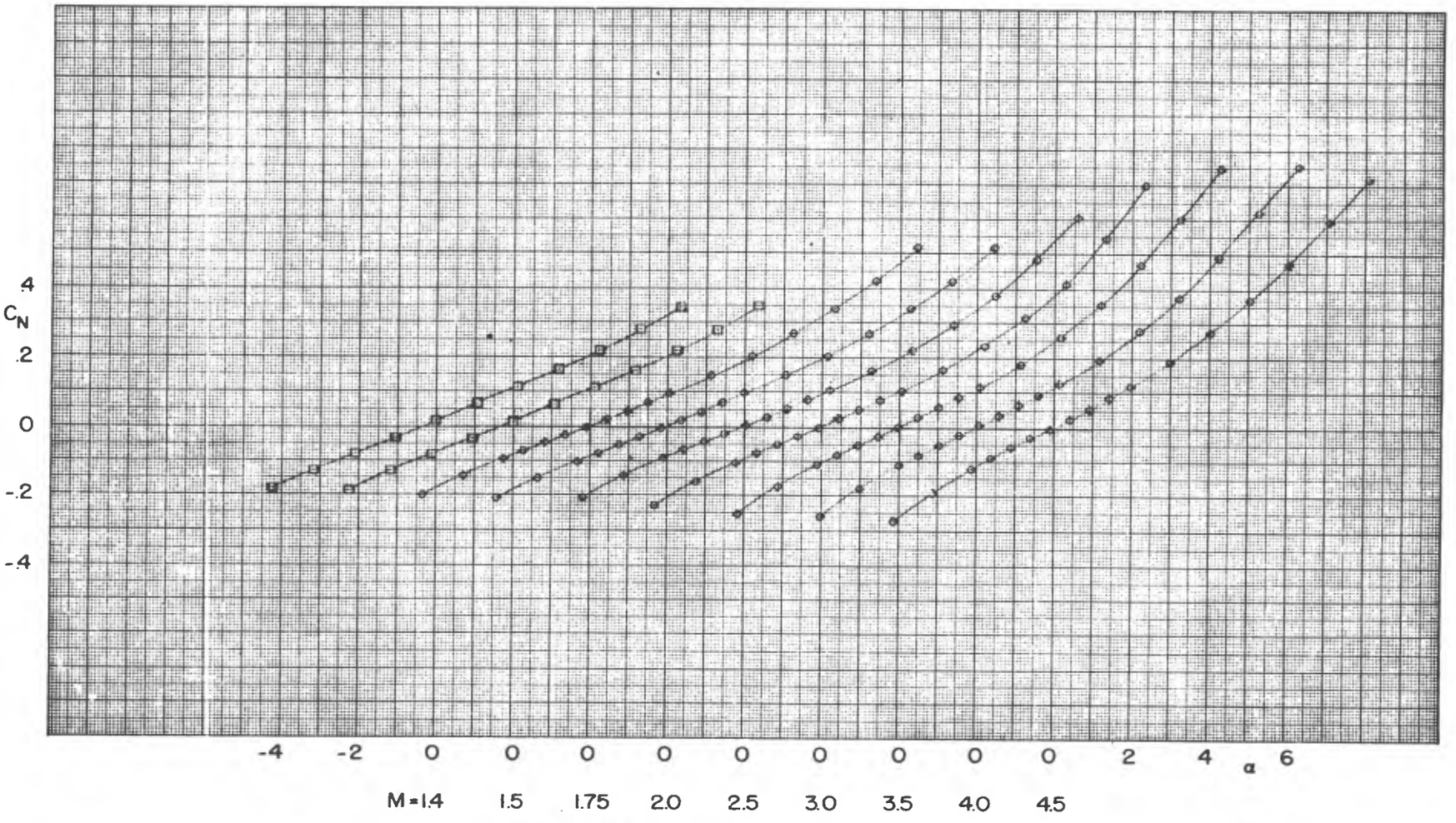
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 24. CONCLUDED



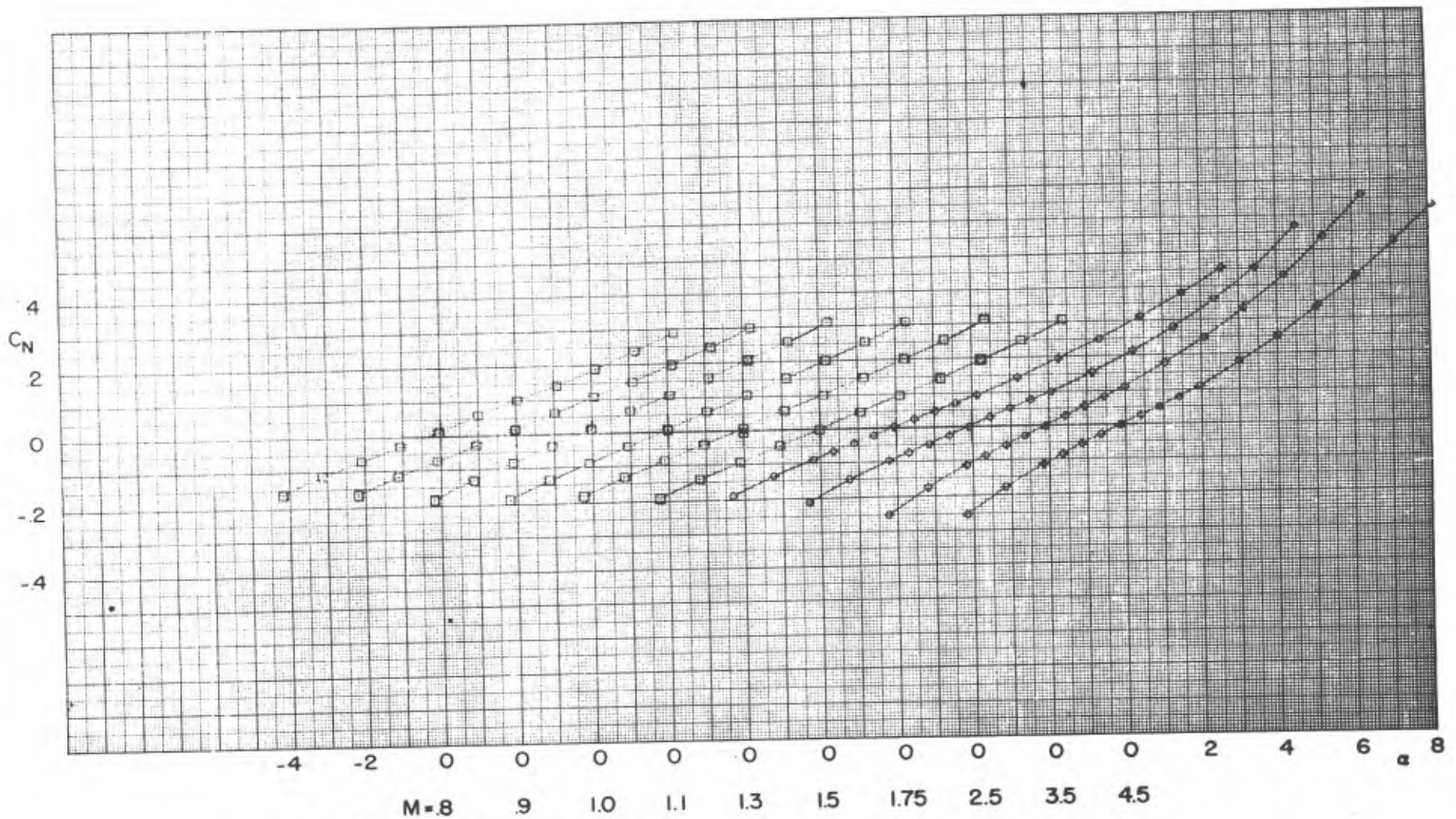
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 25. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 23



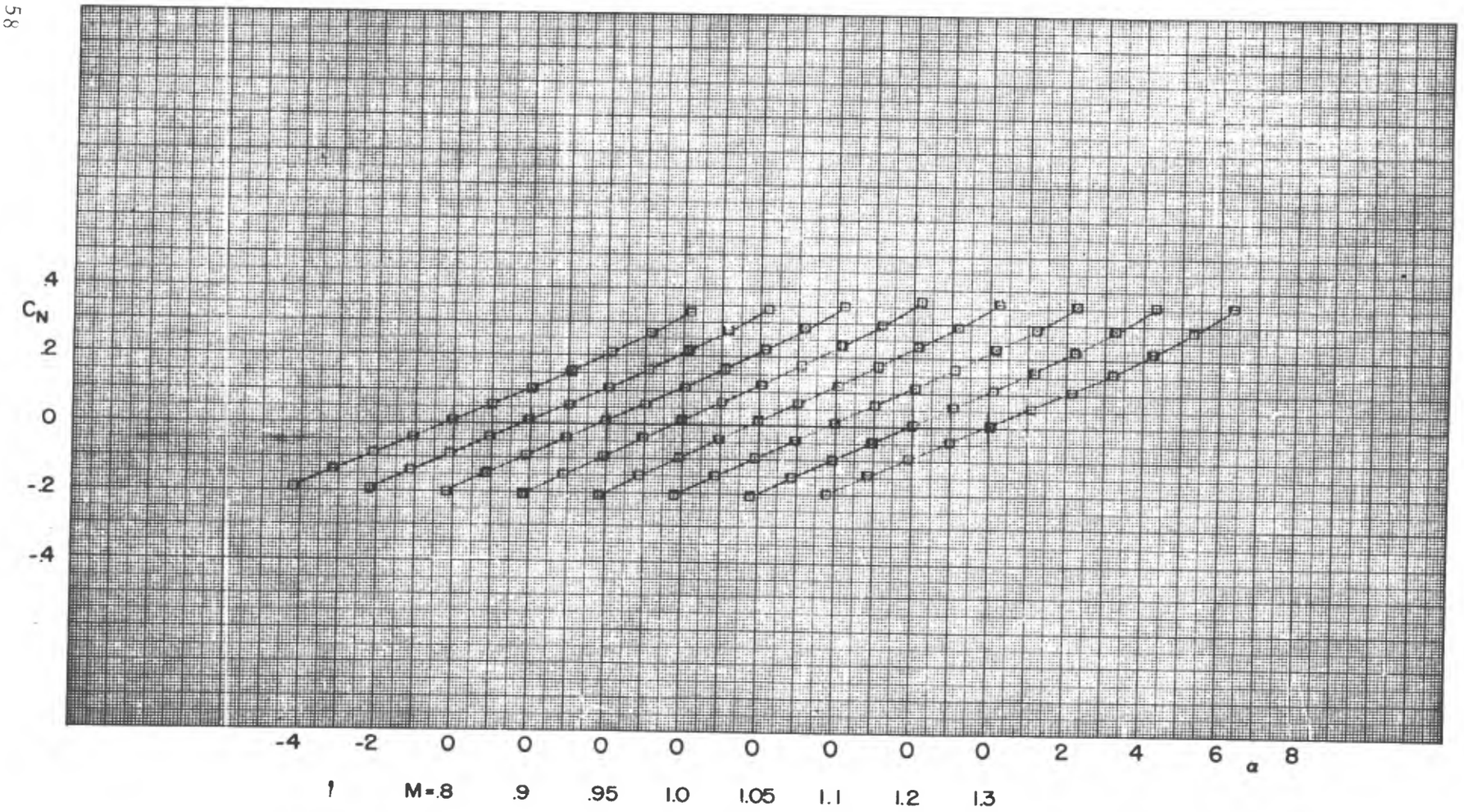
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 25. CONCLUDED



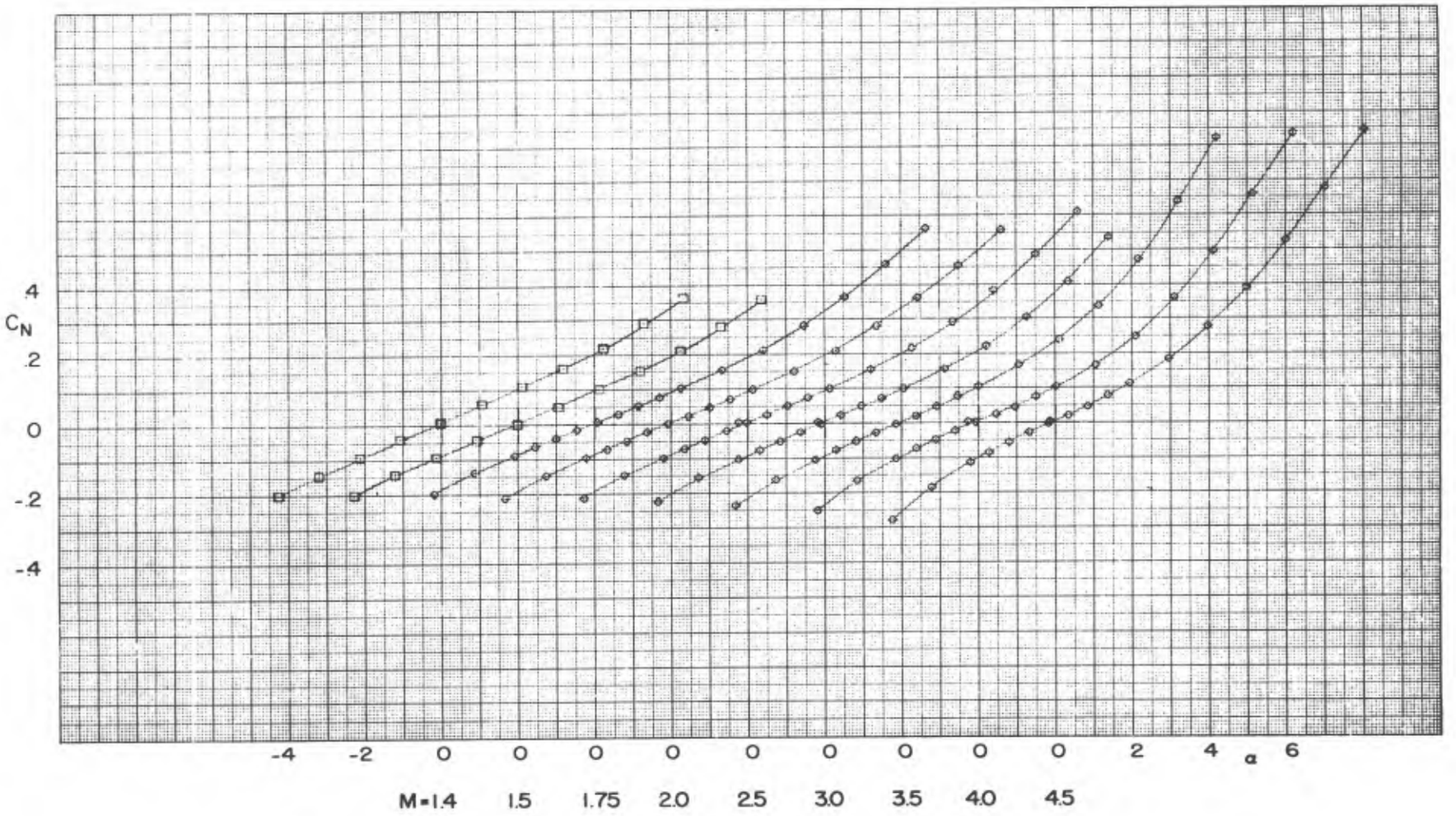
a. MACH NUMBERS 0.8 TO 4.5

FIGURE 26. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 24



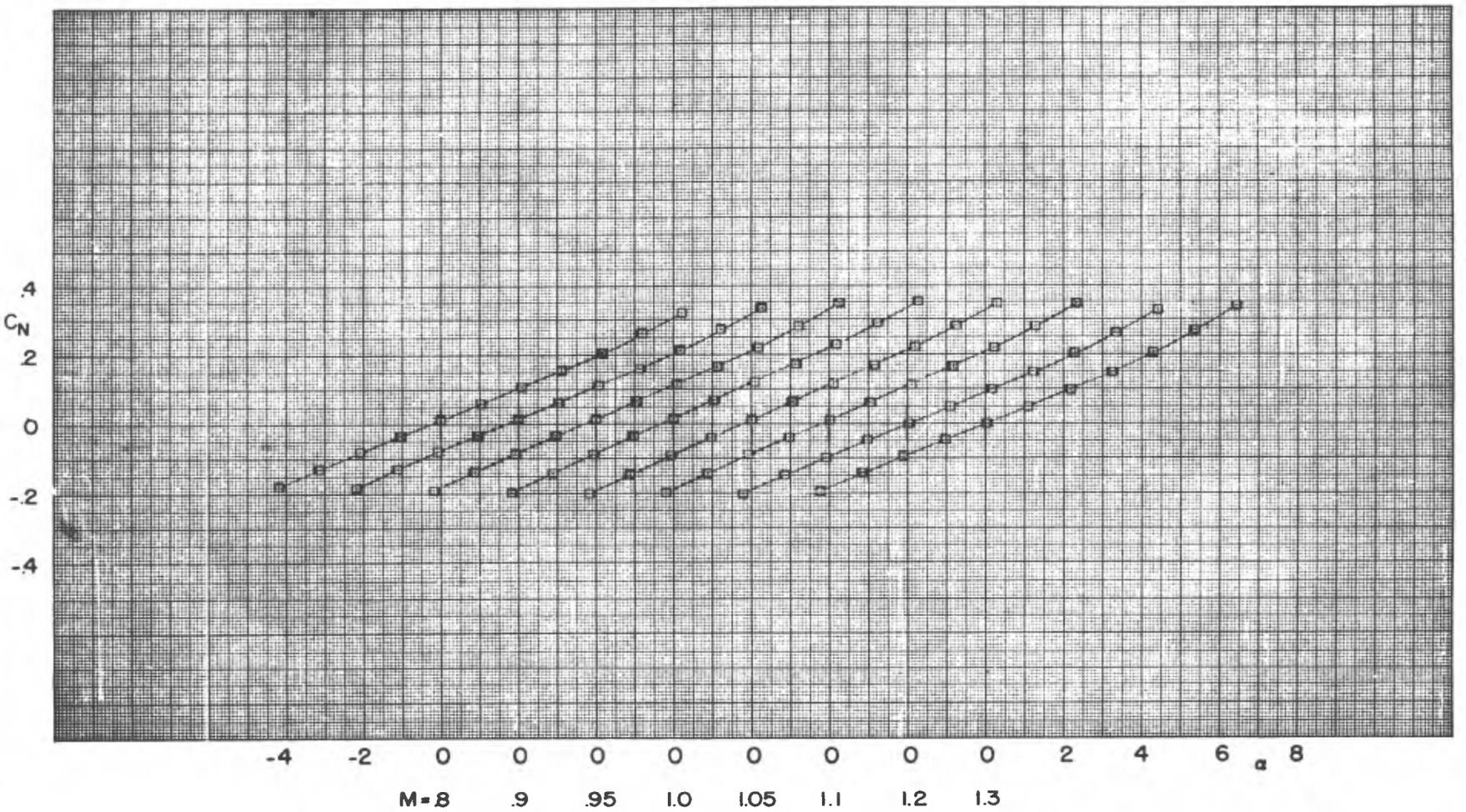
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 27. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 25



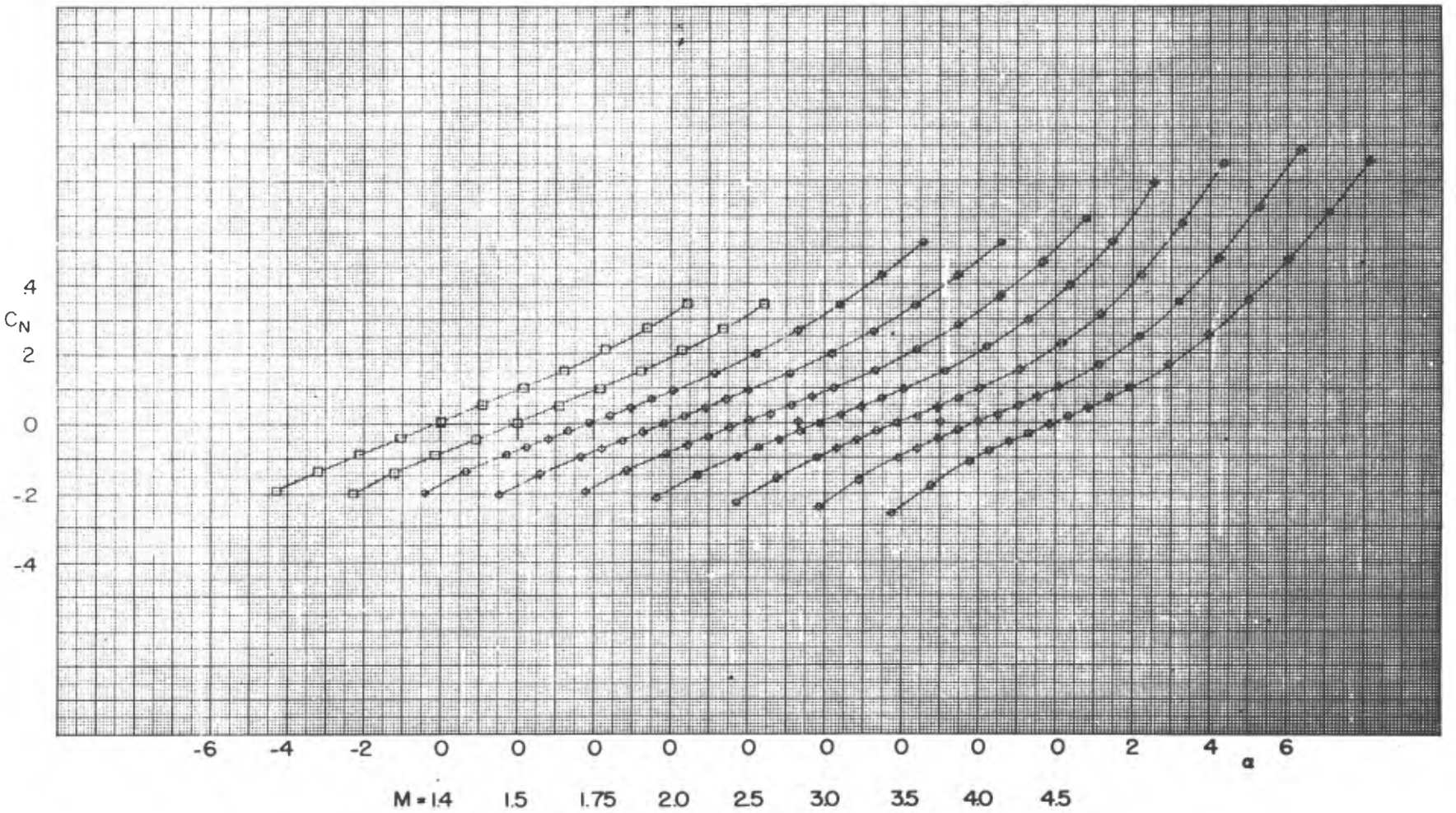
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 27. CONCLUDED



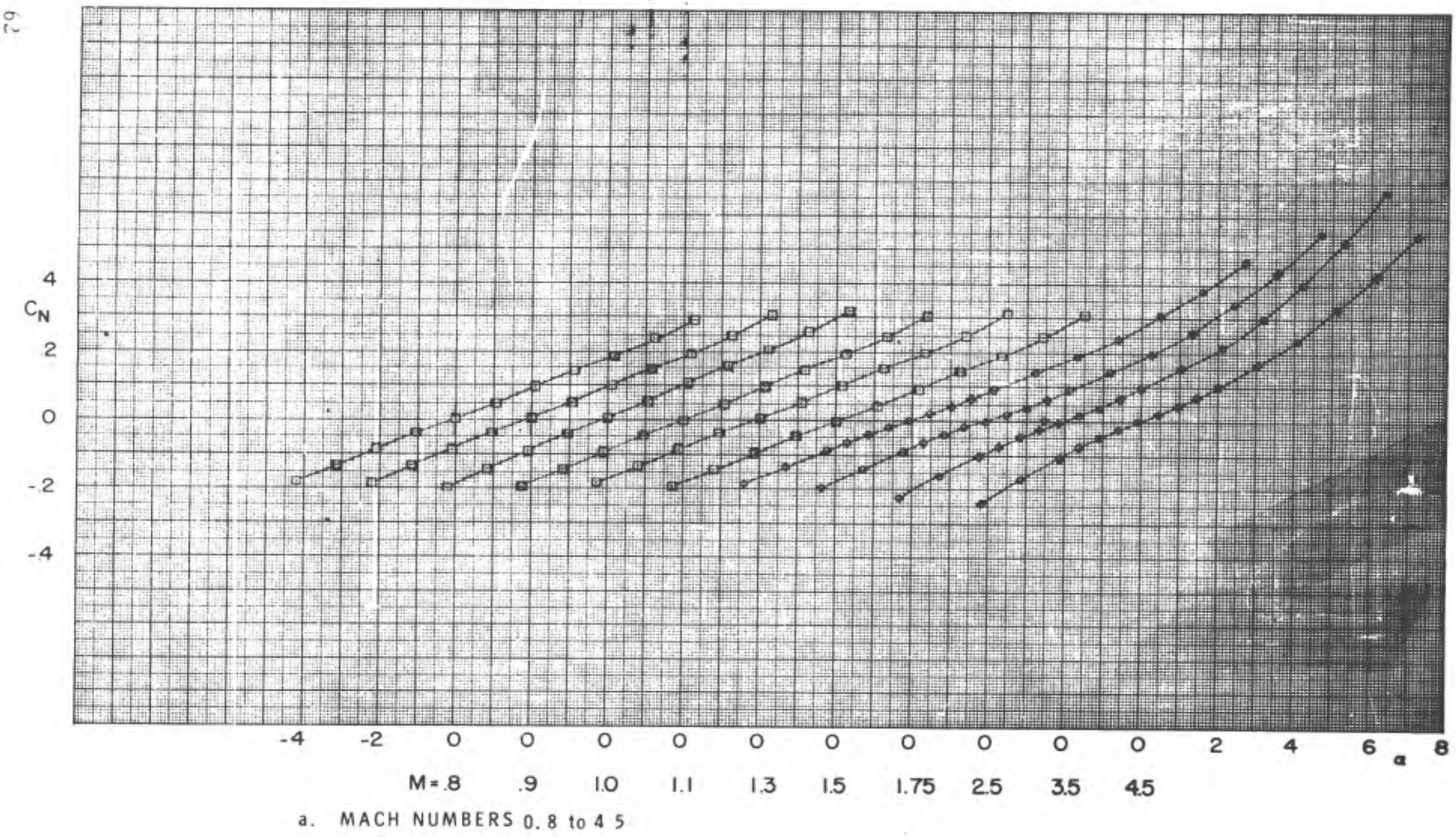
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 28. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 26



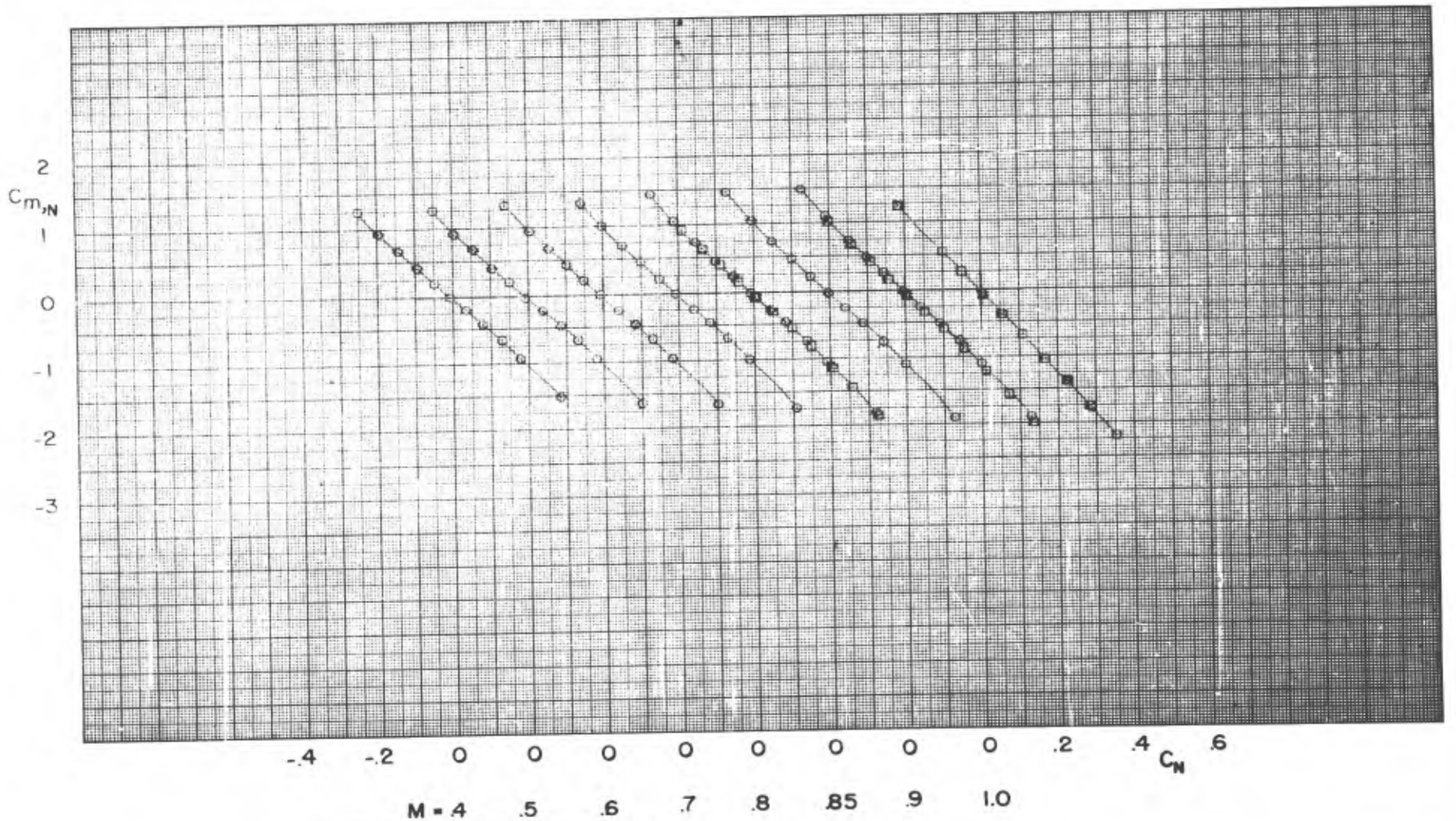
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 28. CONCLUDED



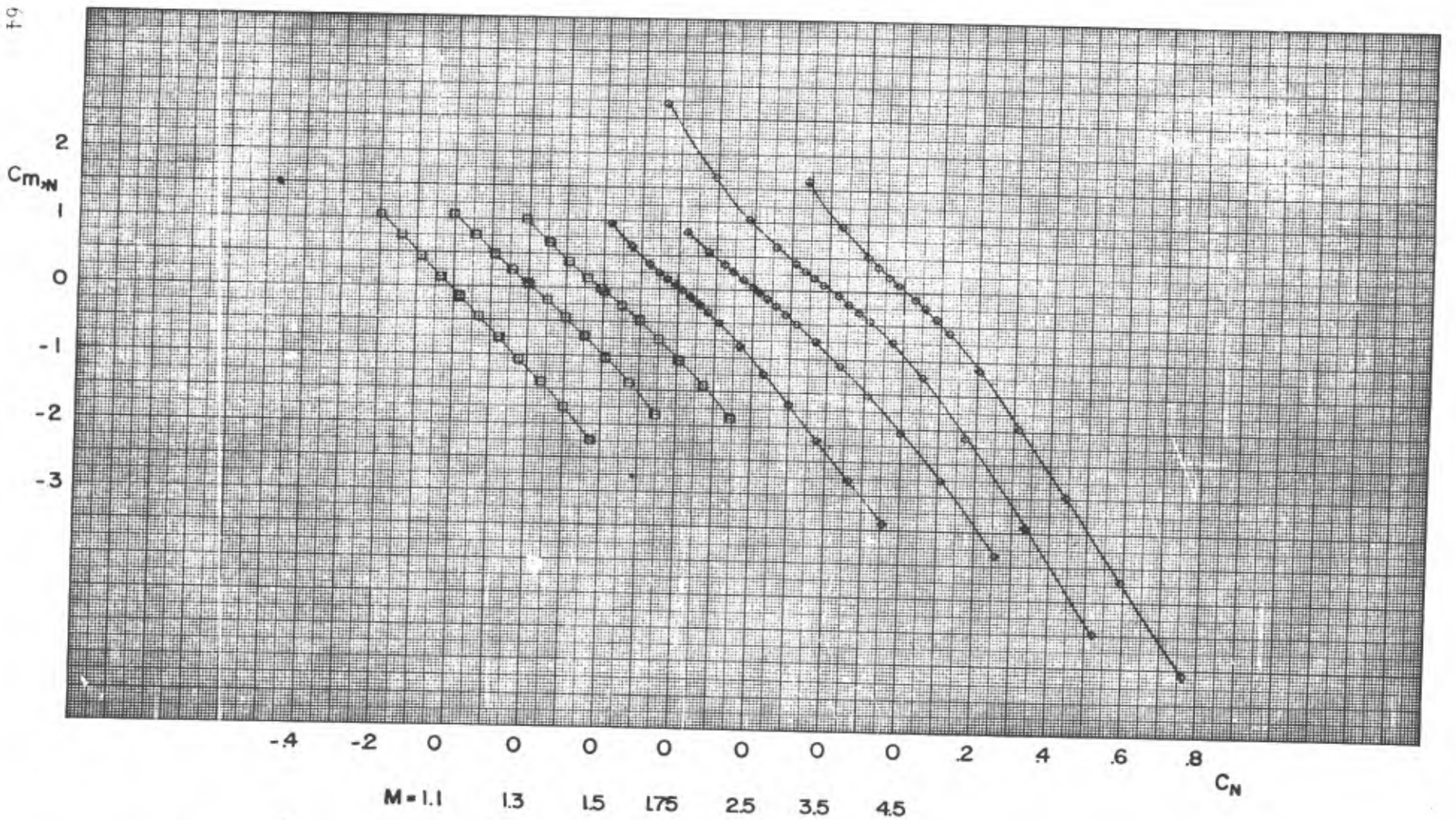
a. MACH NUMBERS 0.8 to 4.5

FIGURE 29. VARIATION OF NORMAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 27



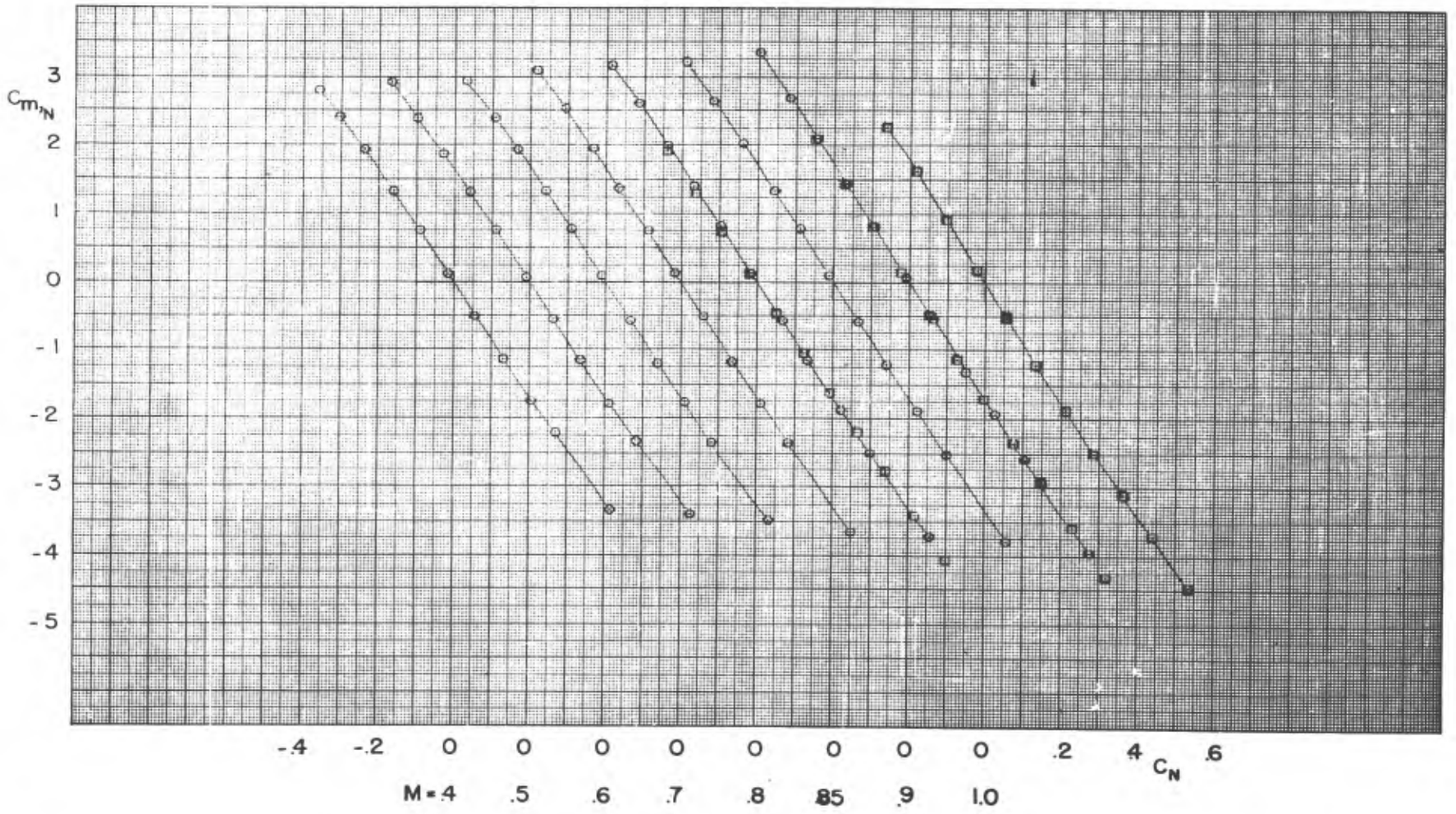
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 30. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 1



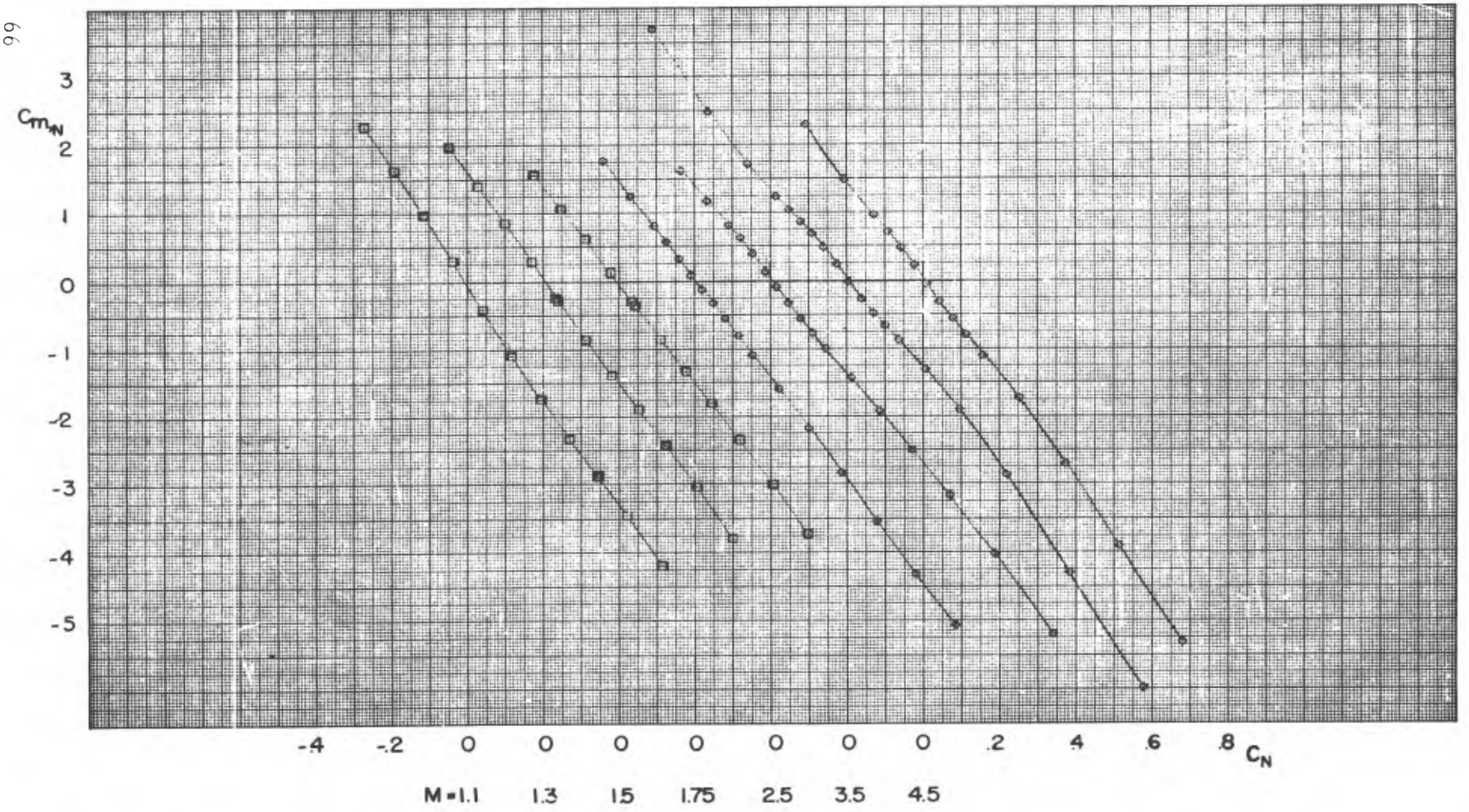
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 30. CONCLUDED



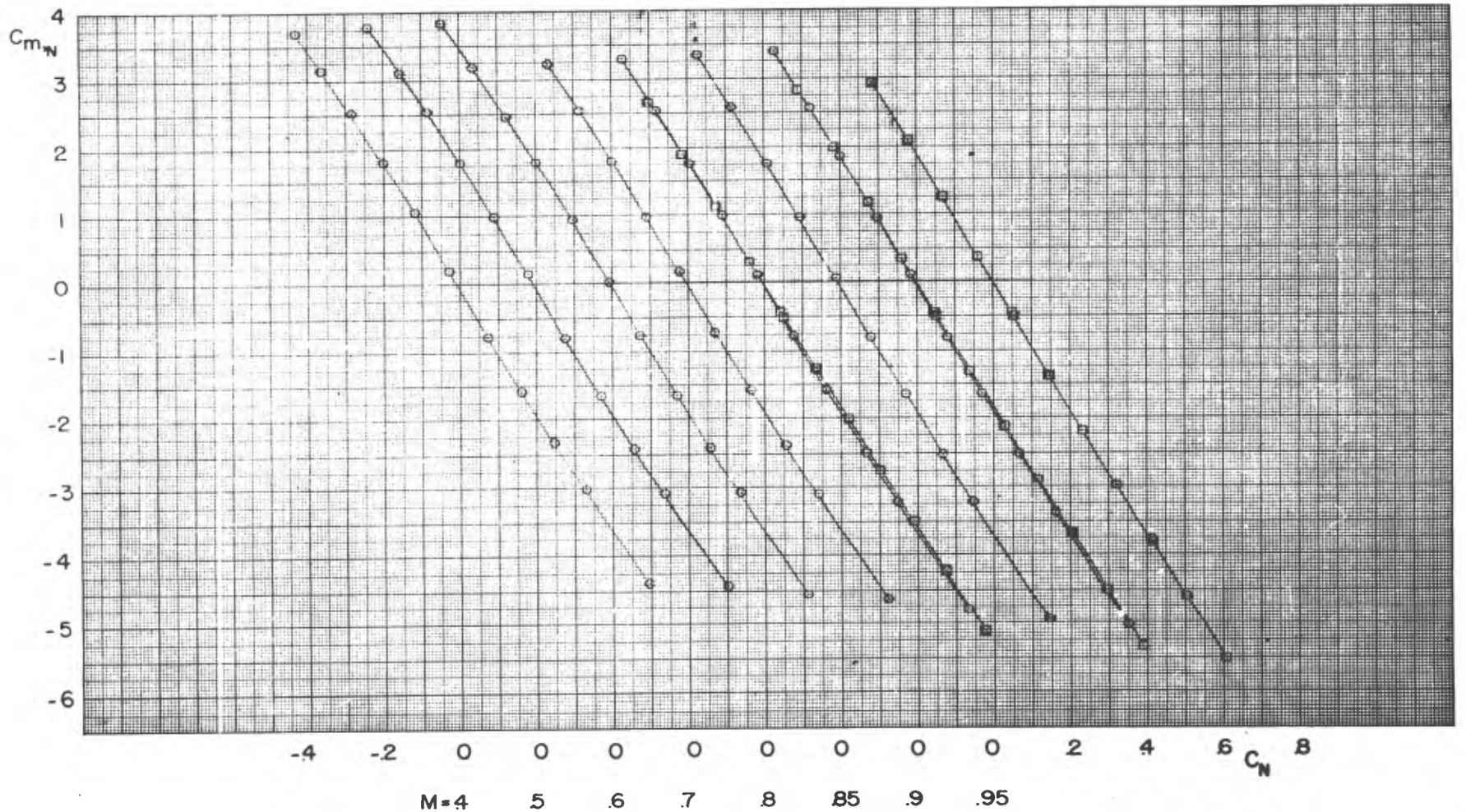
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 31. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 2



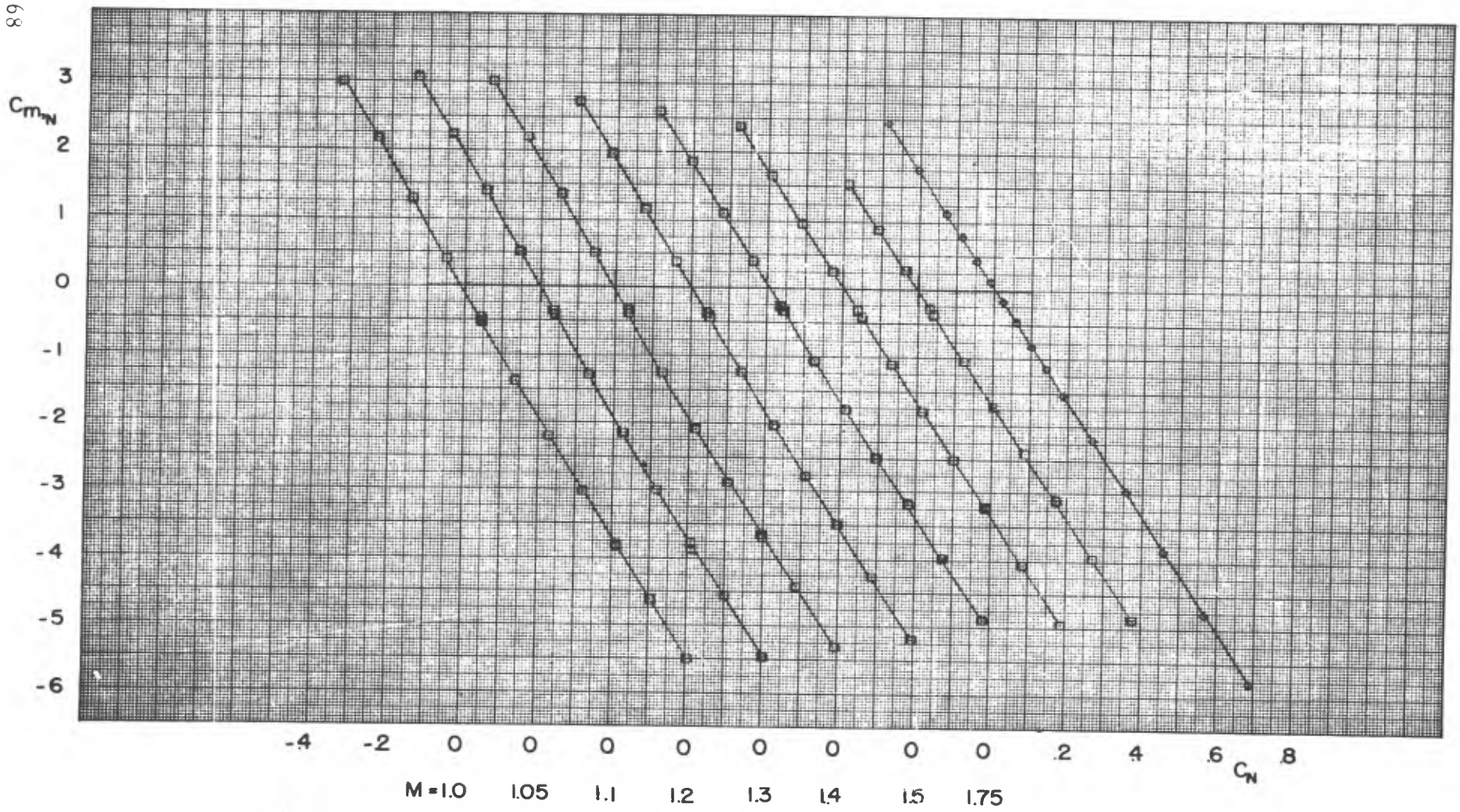
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 31. CONCLUDED



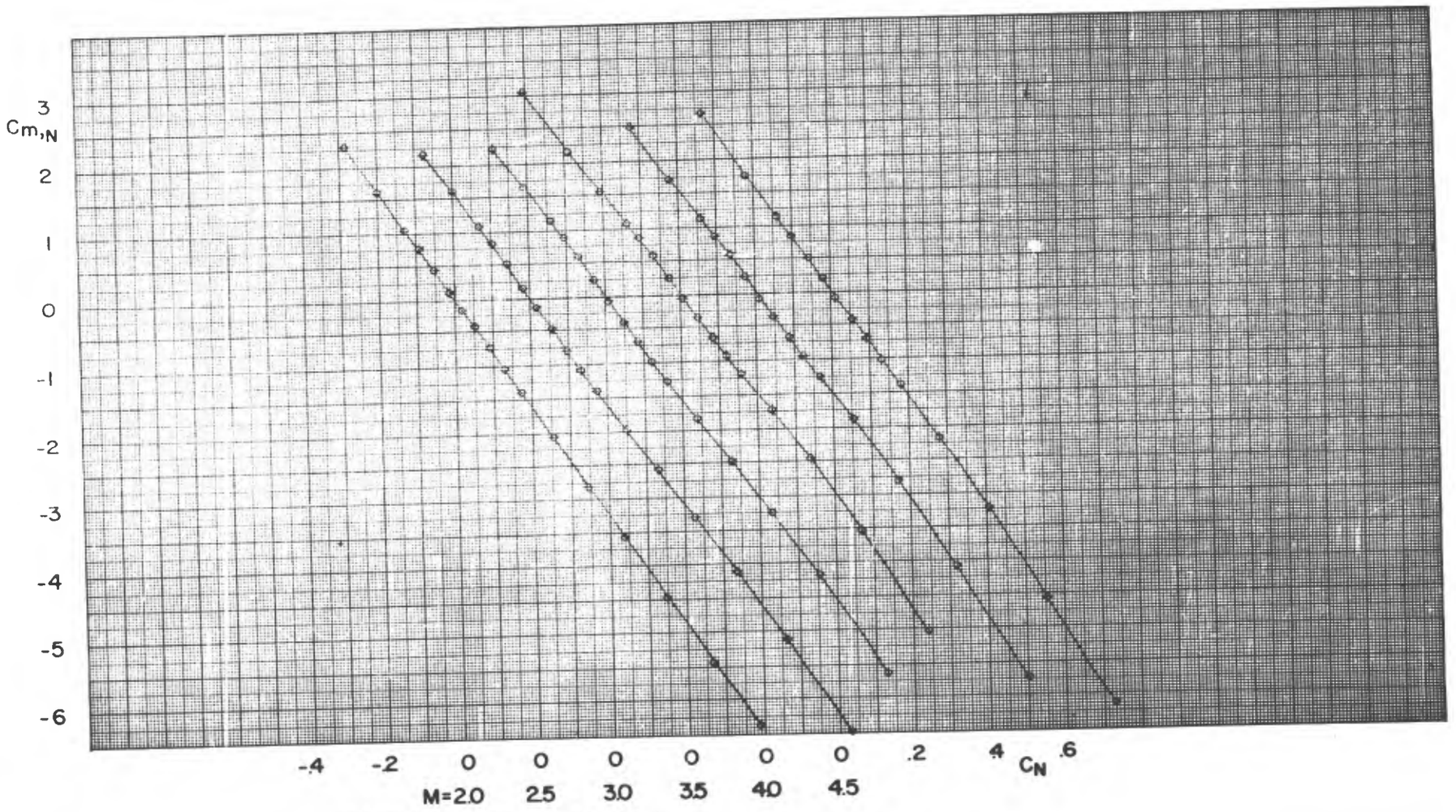
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 32. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 3



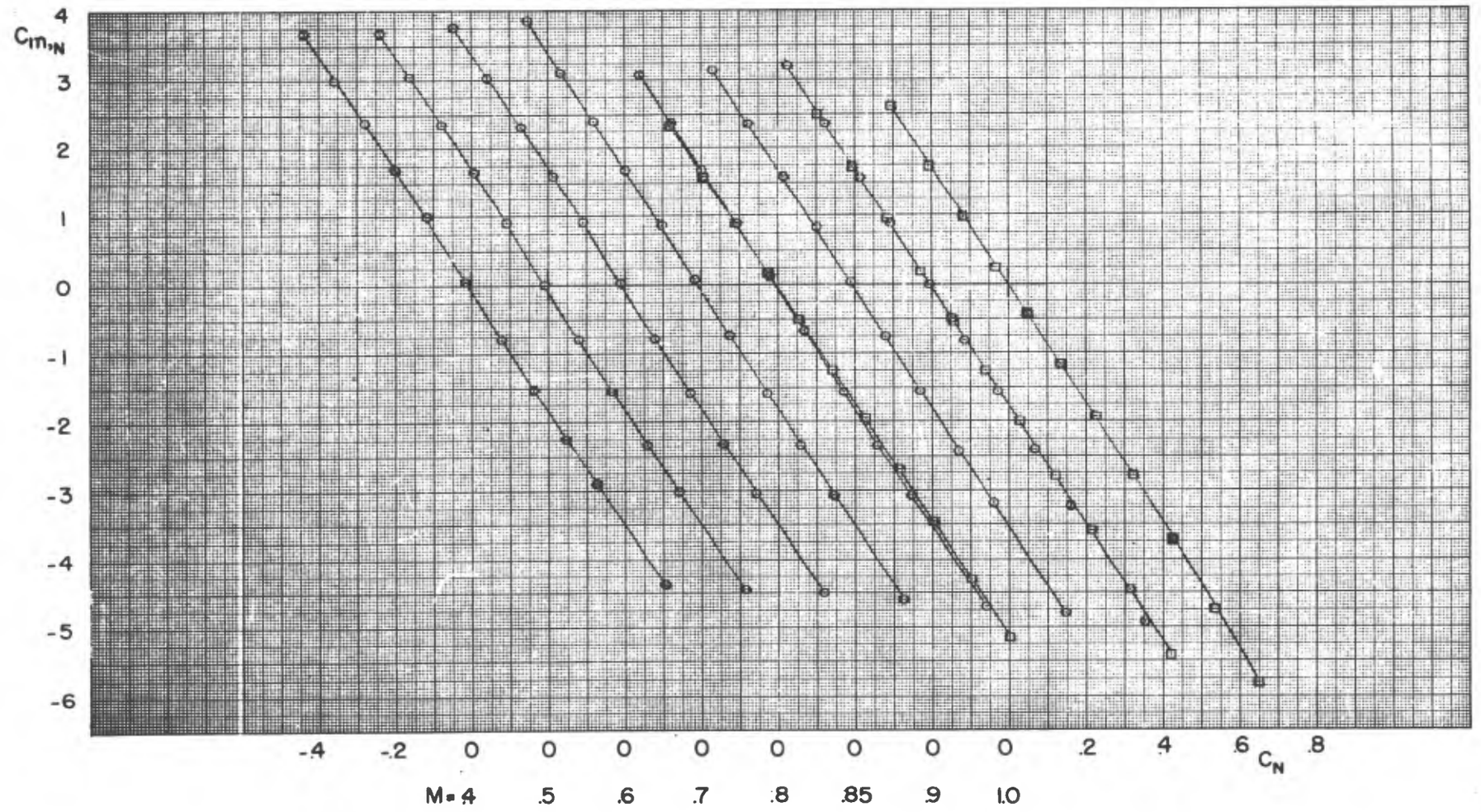
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 32. CONTINUED



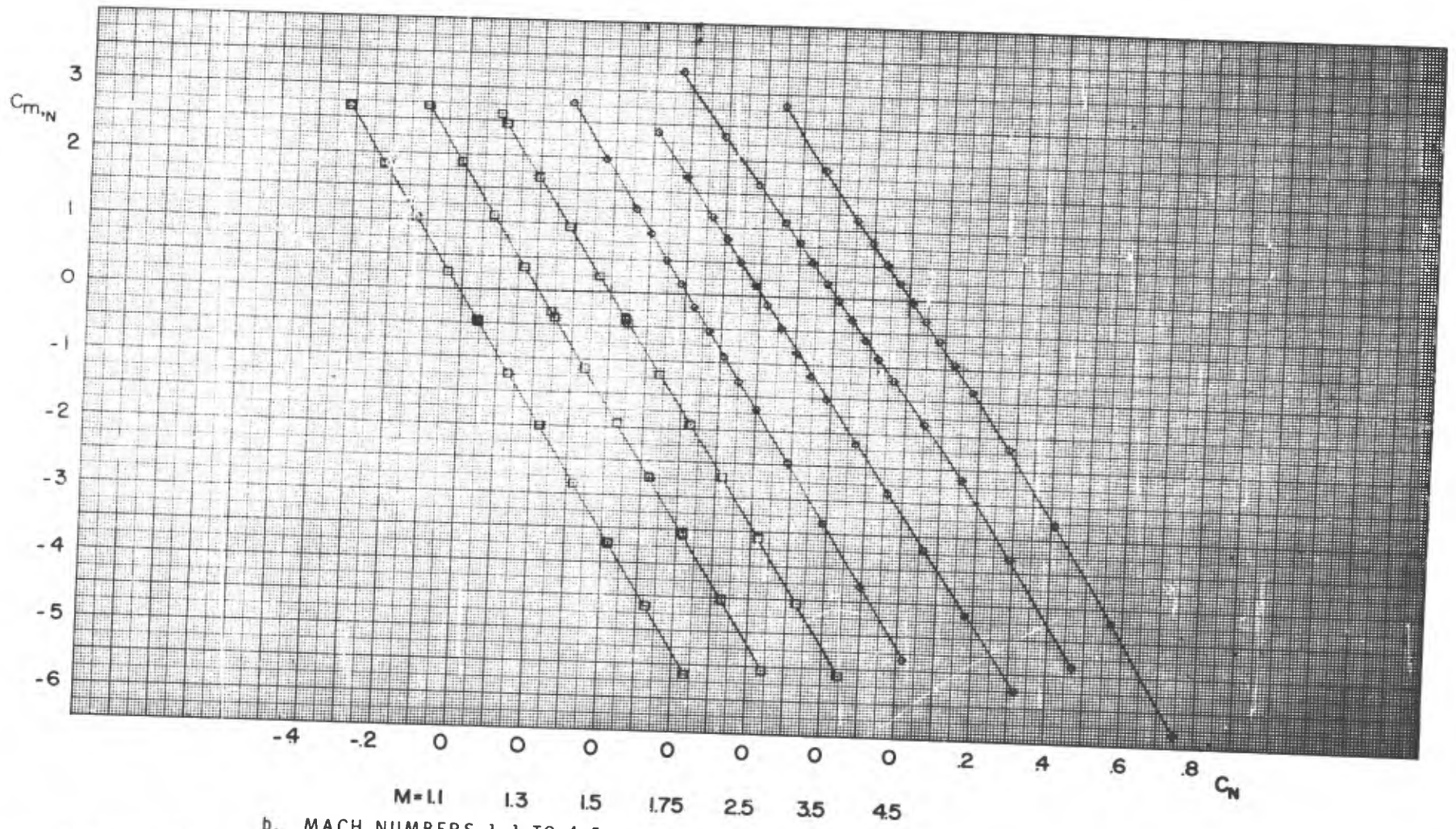
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 32. CONCLUDED



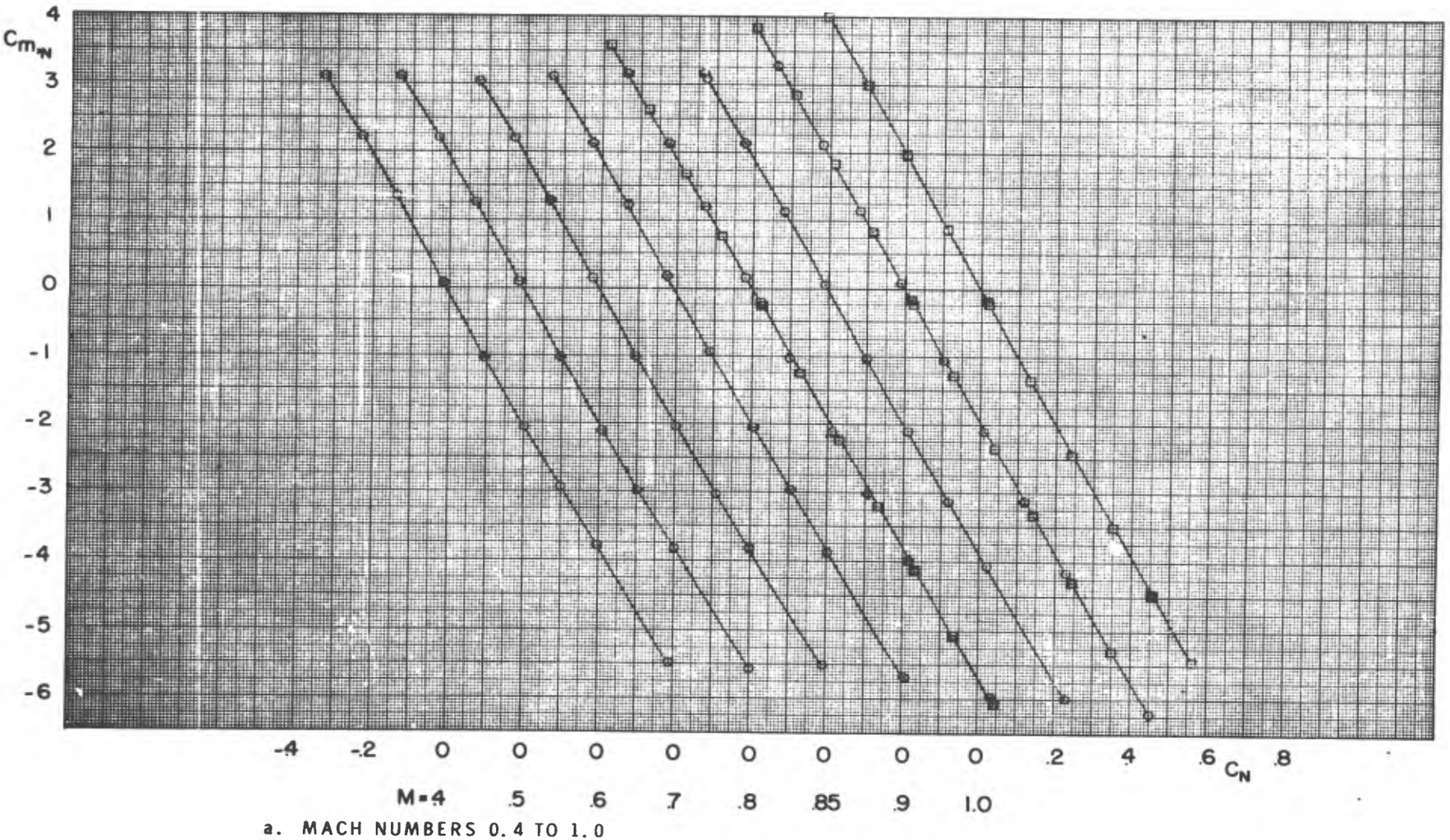
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 33. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 4



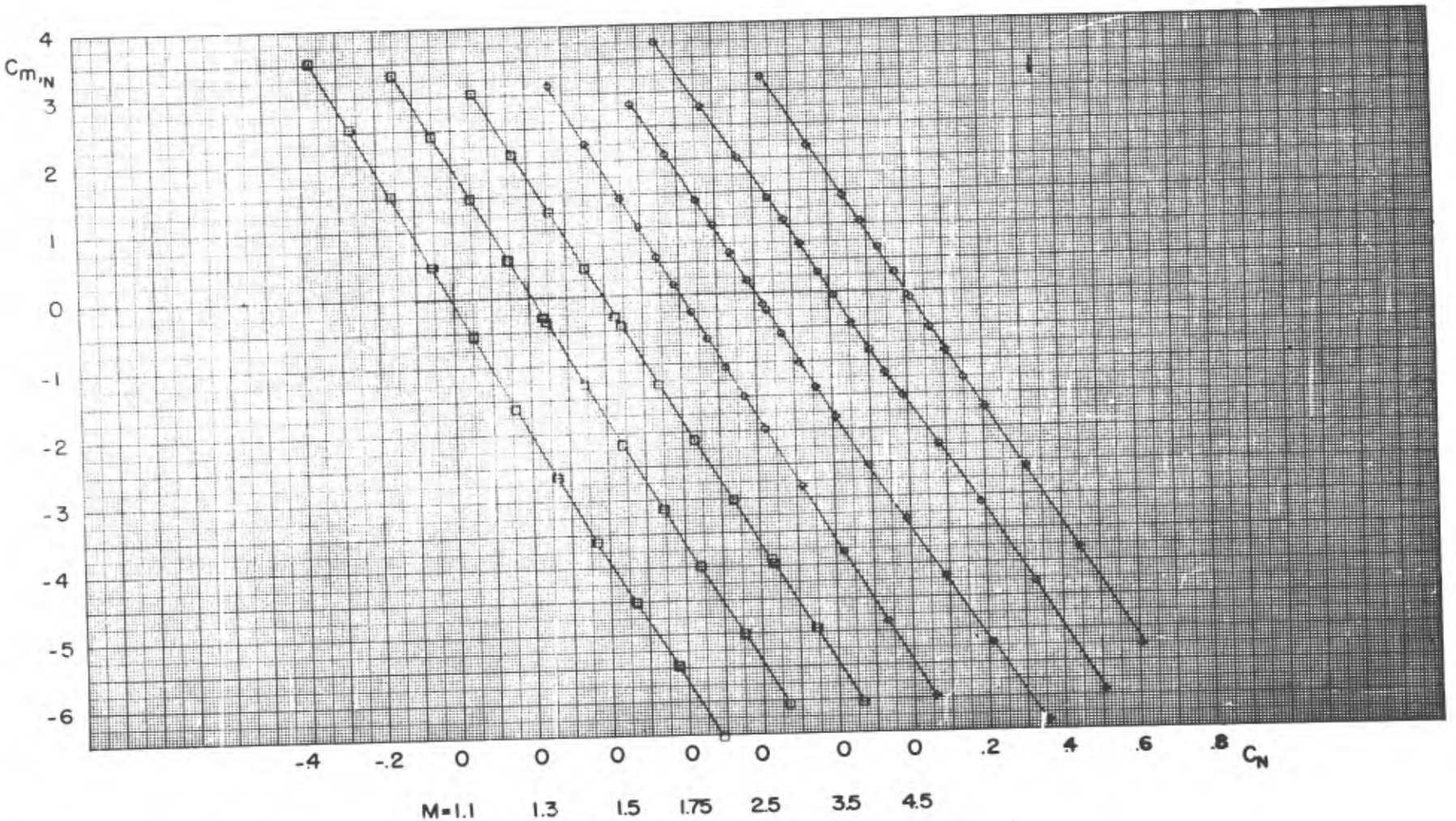
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 33. CONCLUDED



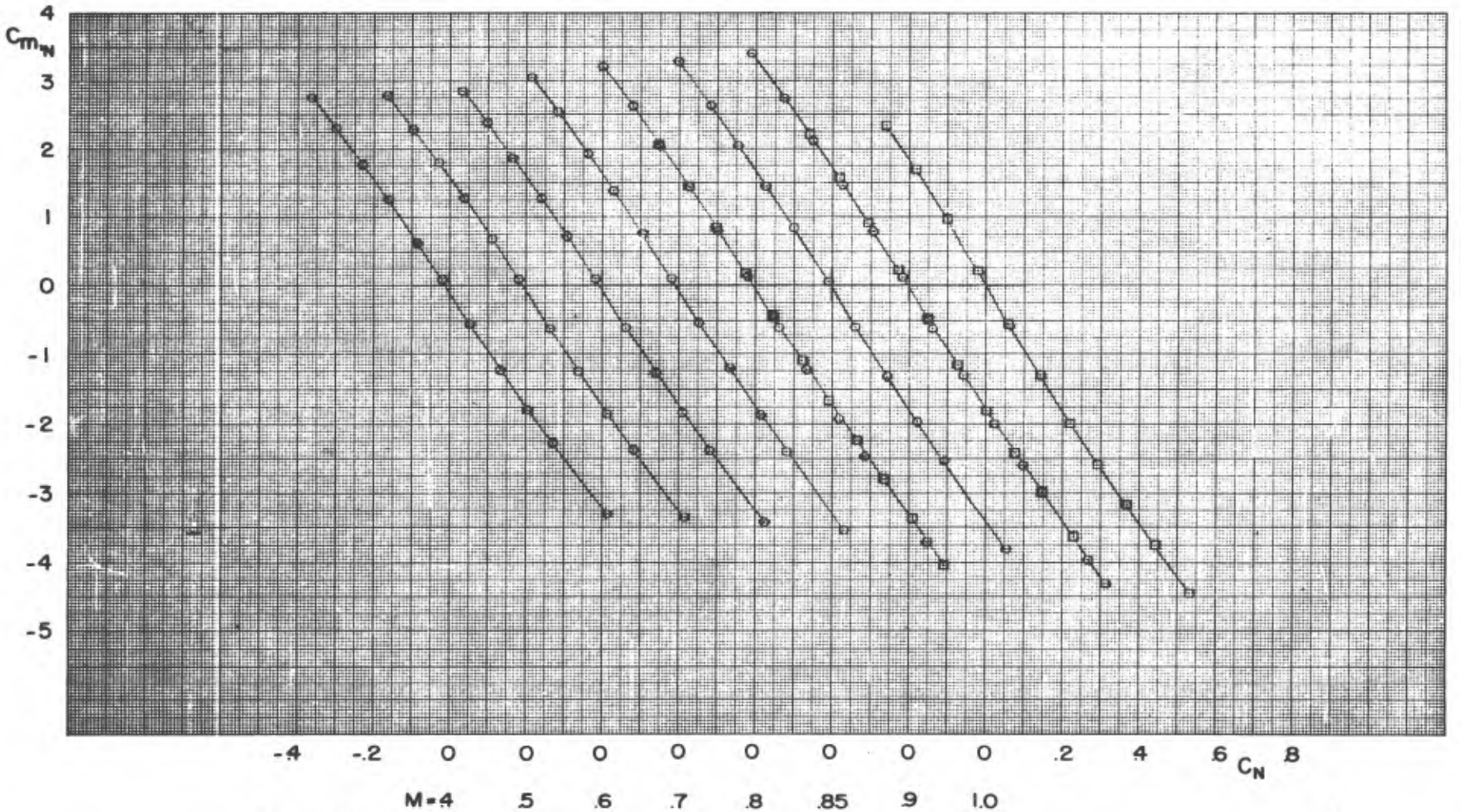
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 34. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 5



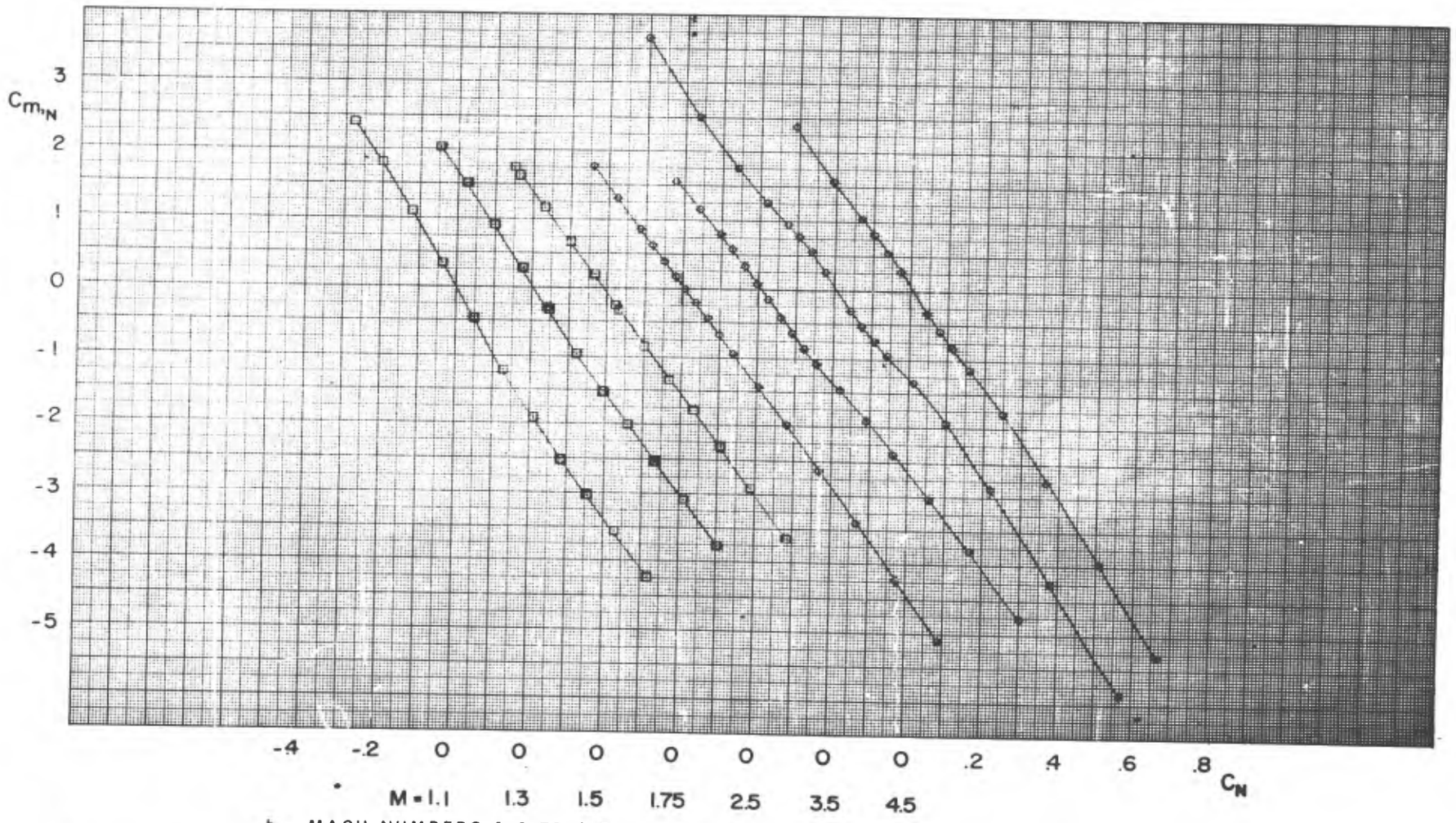
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 34. CONCLUDED



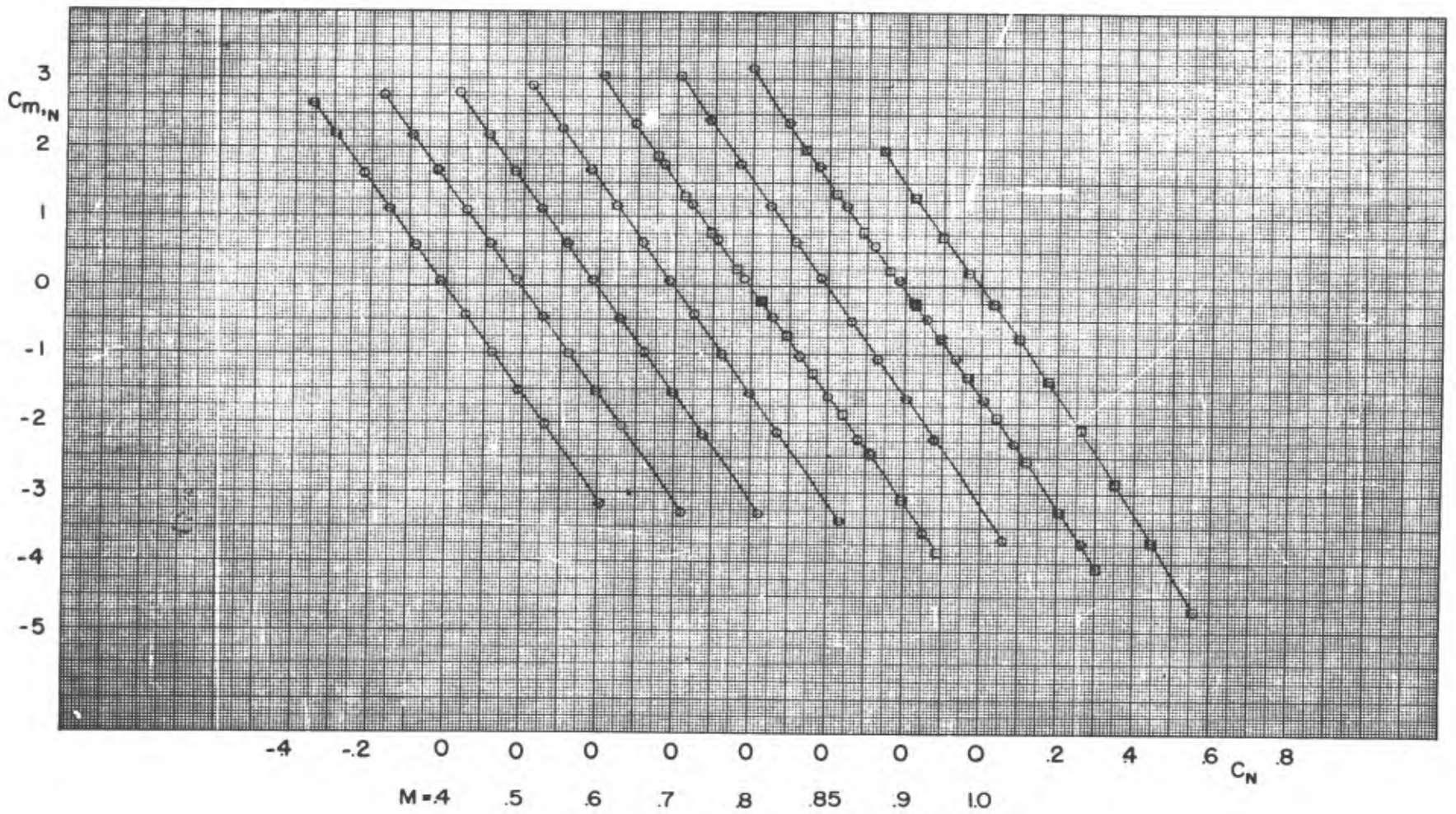
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 35. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 6



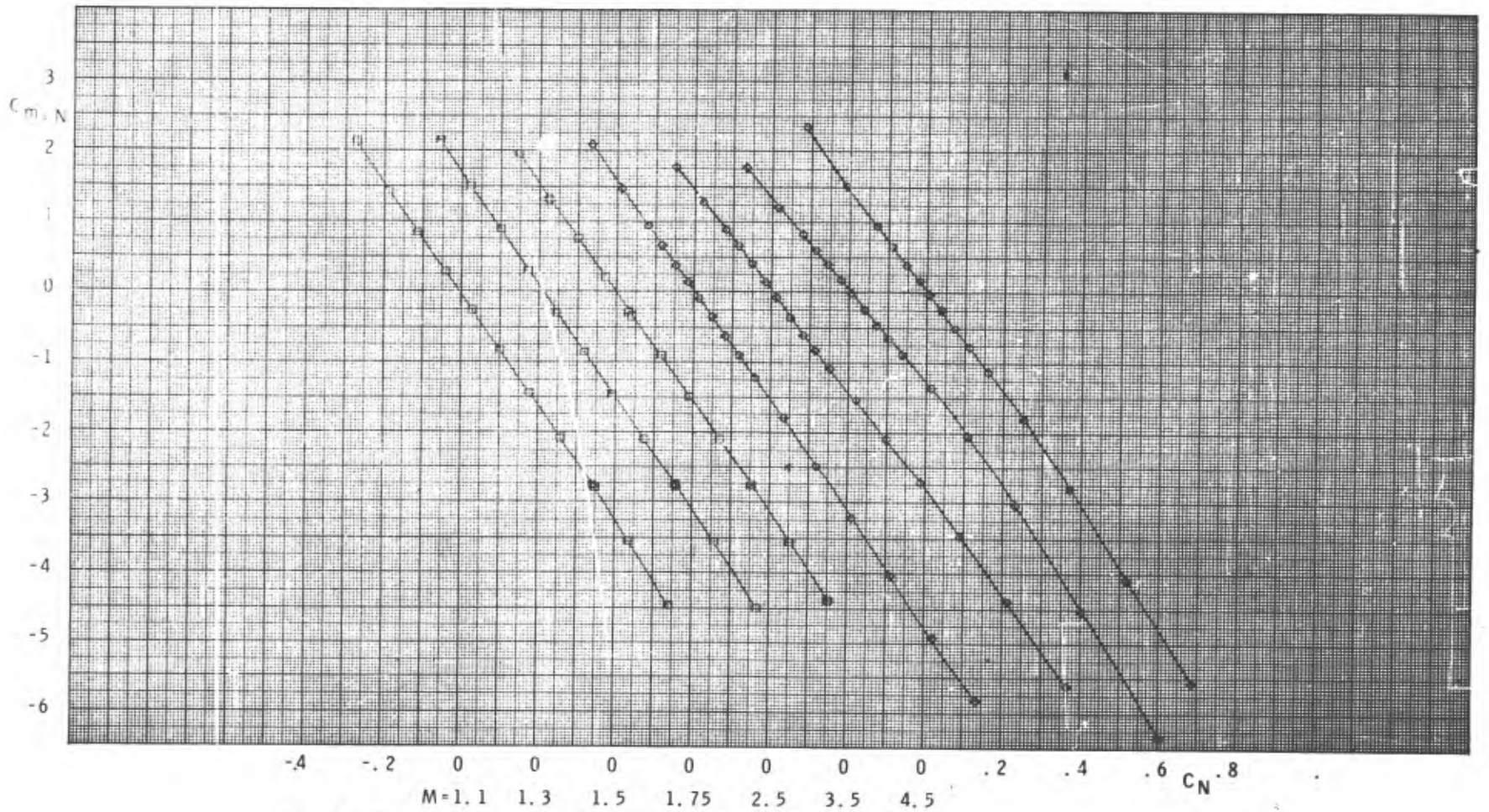
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 35. CONCLUDED



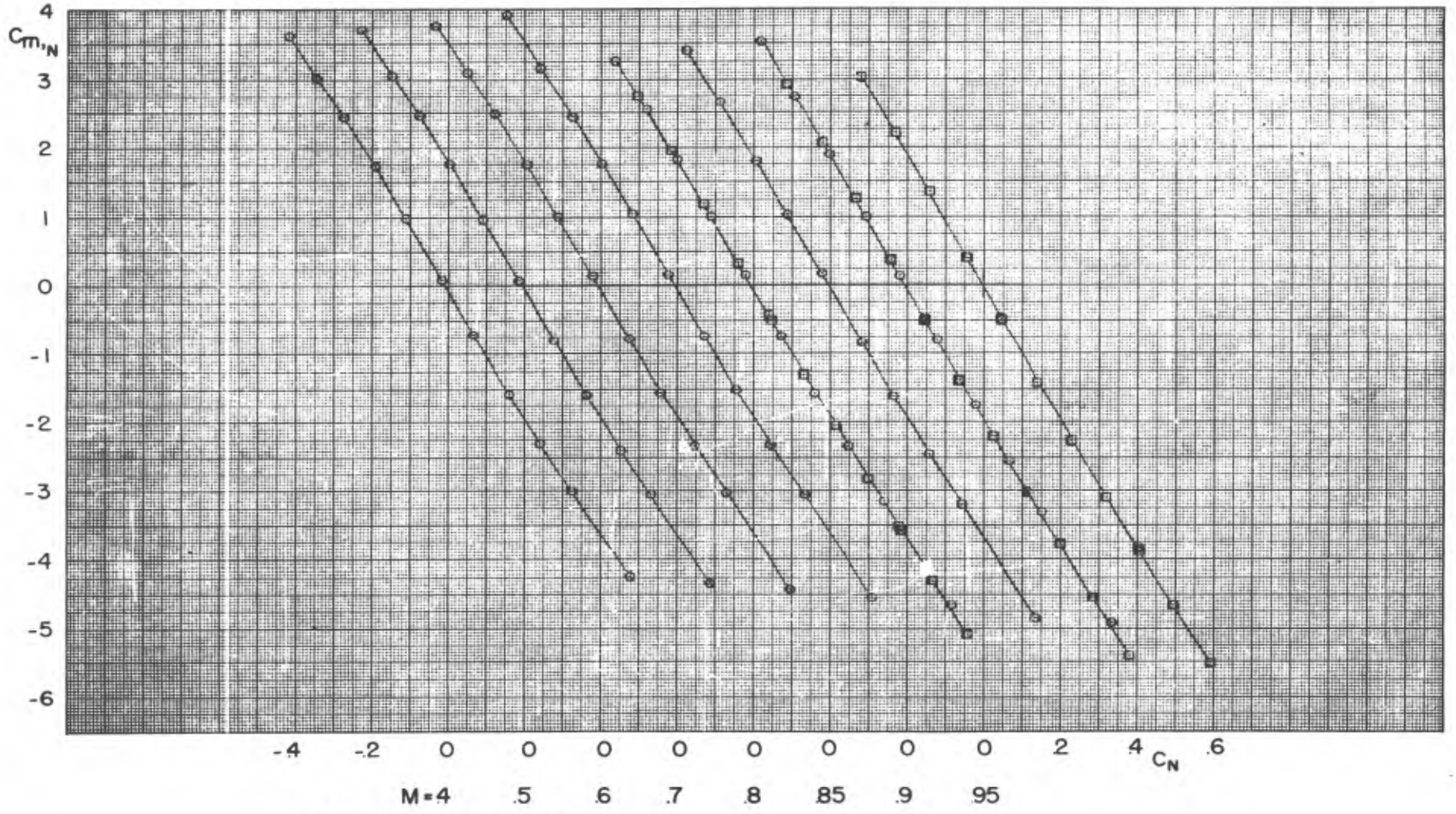
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 36. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 7



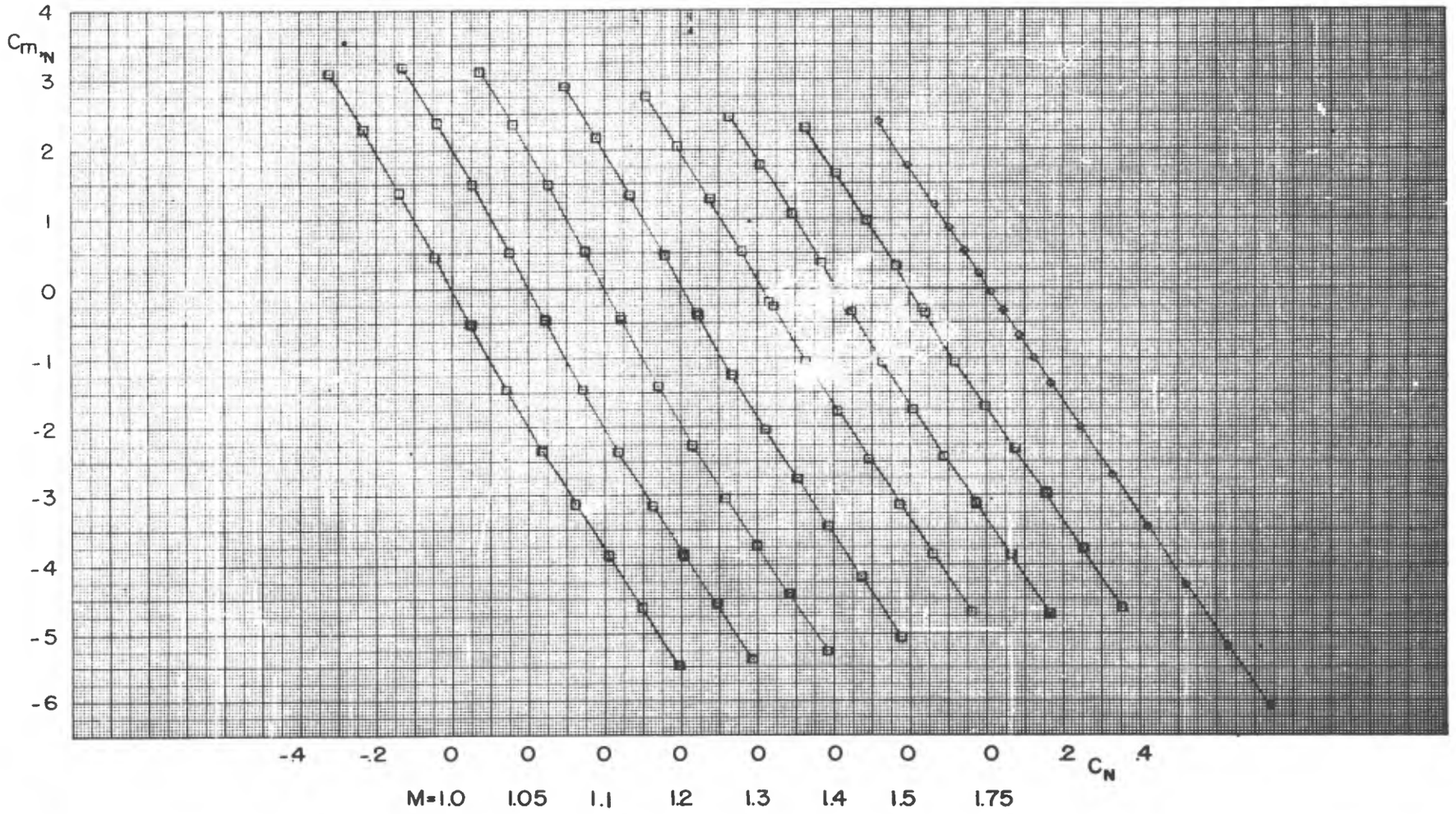
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 36. CONCLUDED



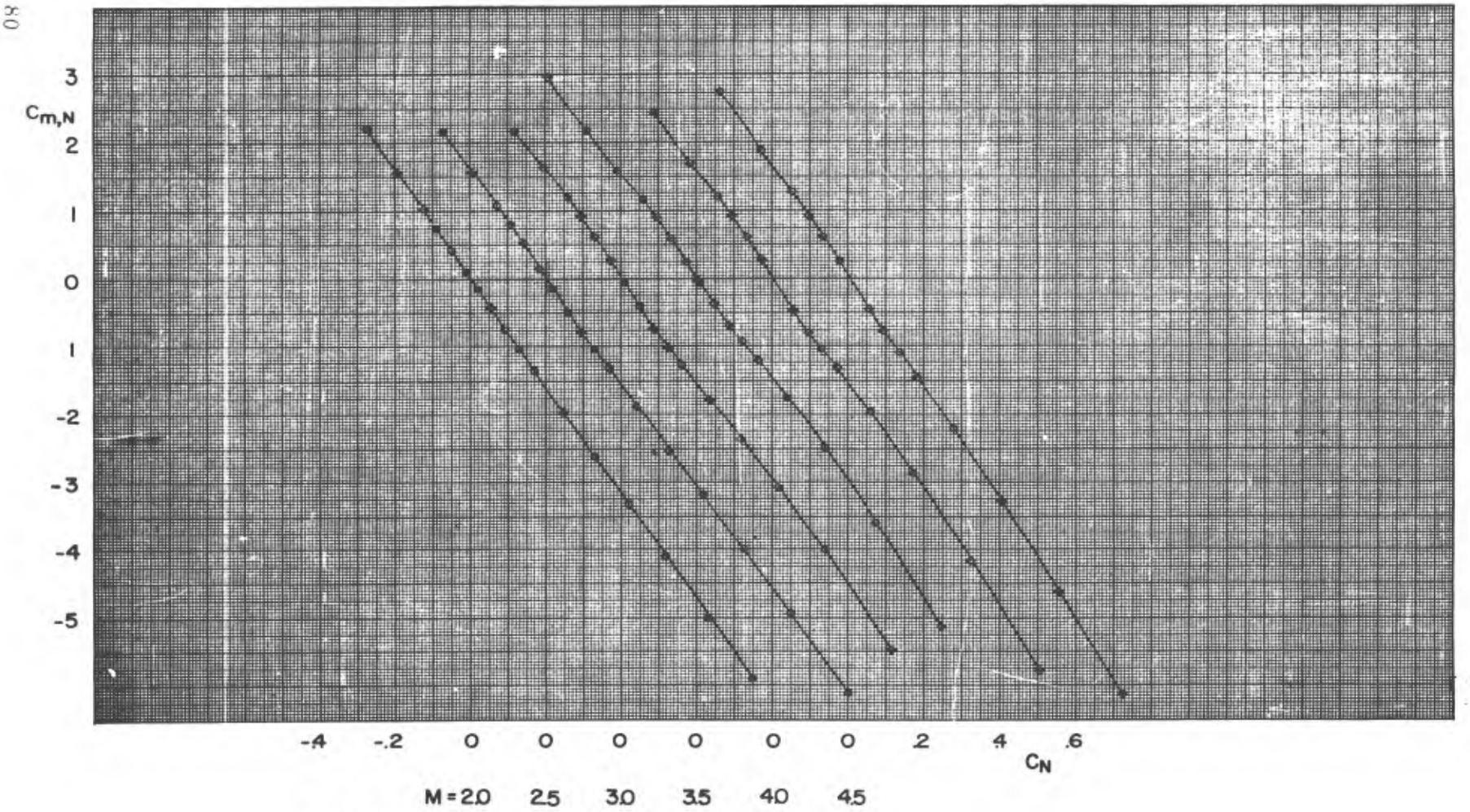
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 37. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 8



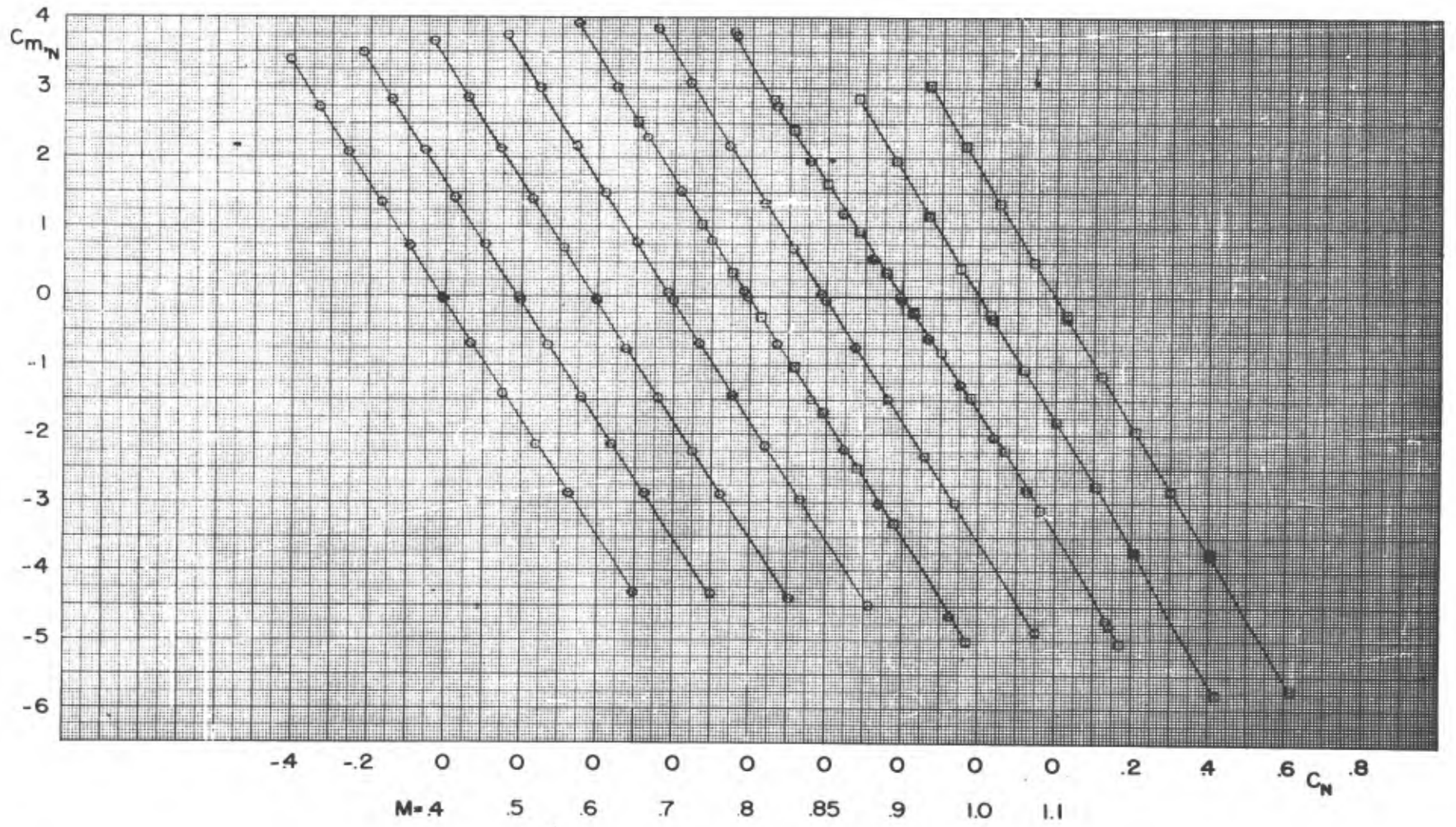
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 37. CONTINUED



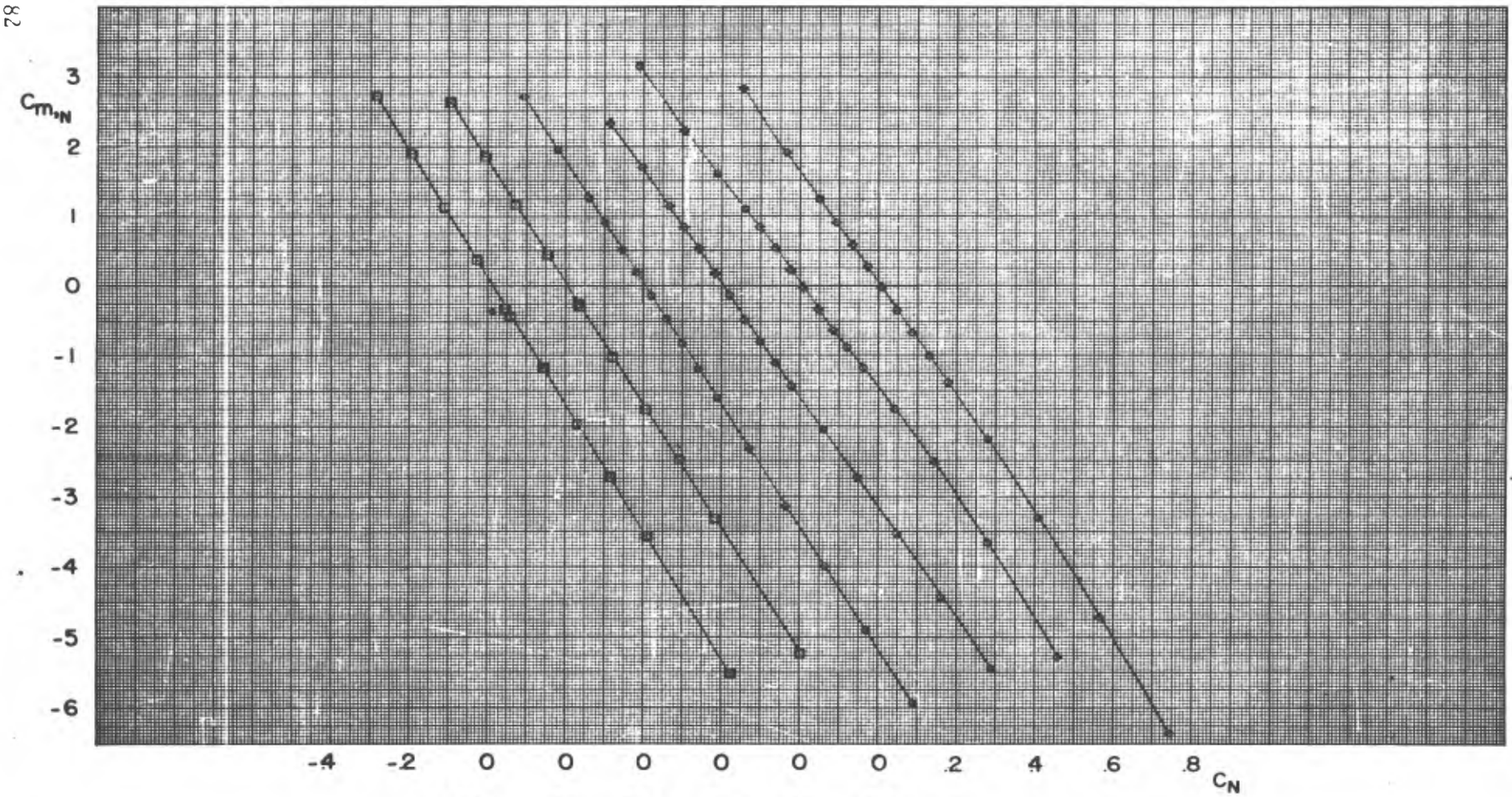
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 37. CONCLUDED



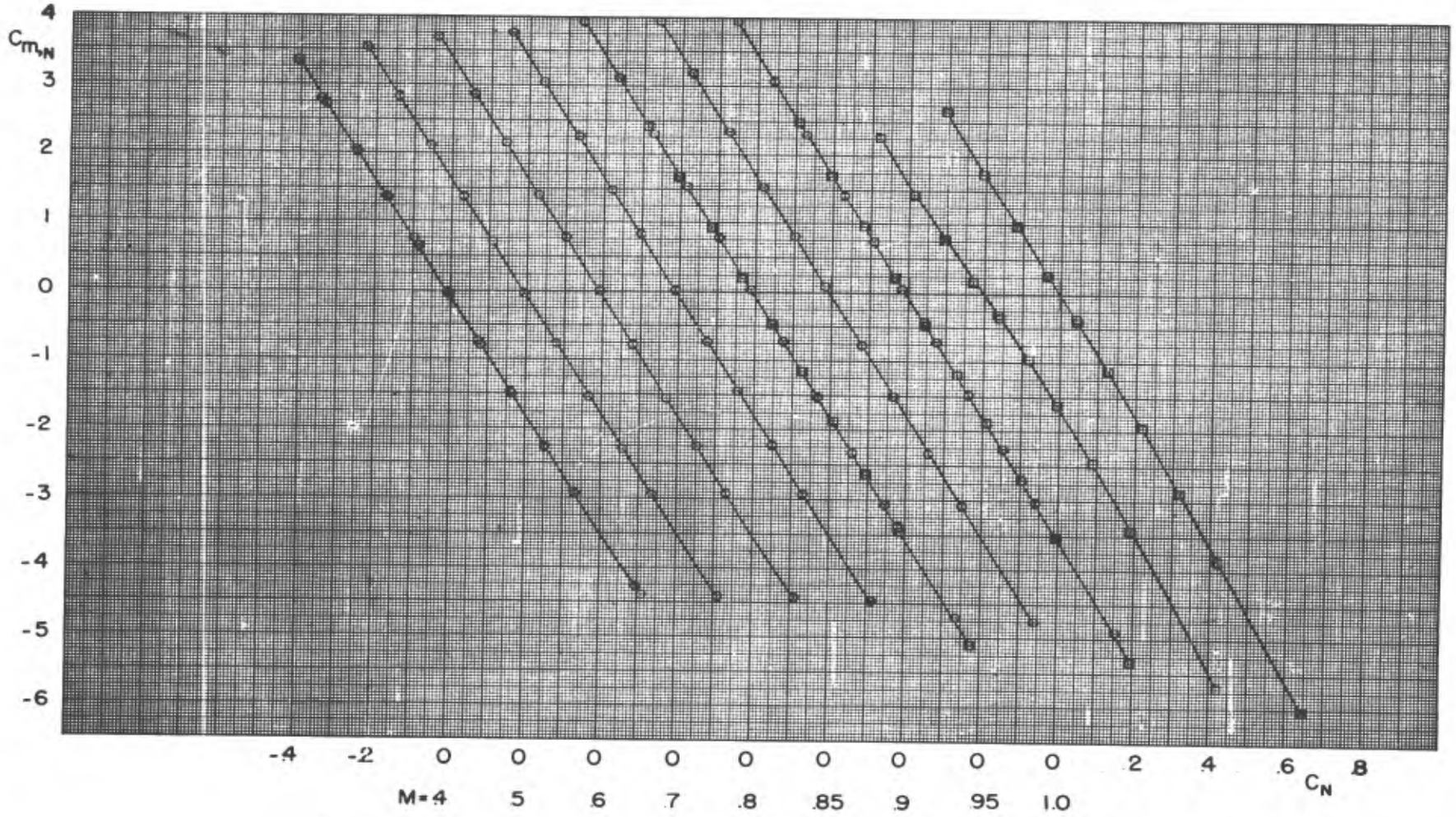
a. MACH NUMBERS 0.4 TO 1.1

FIGURE 38. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 9



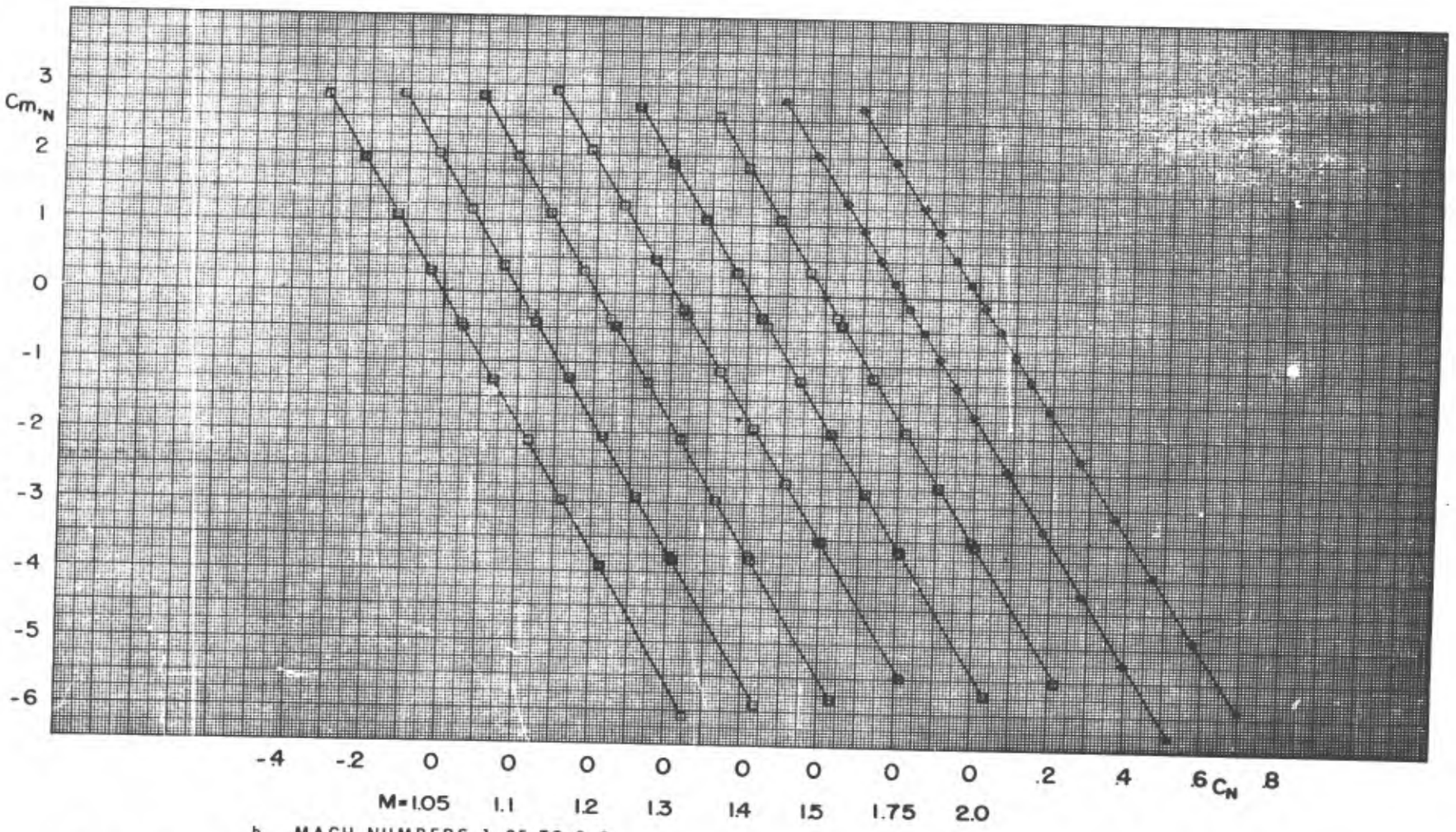
b. MACH NUMBERS 1.3 TO 4.5

FIGURE 38. CONCLUDED



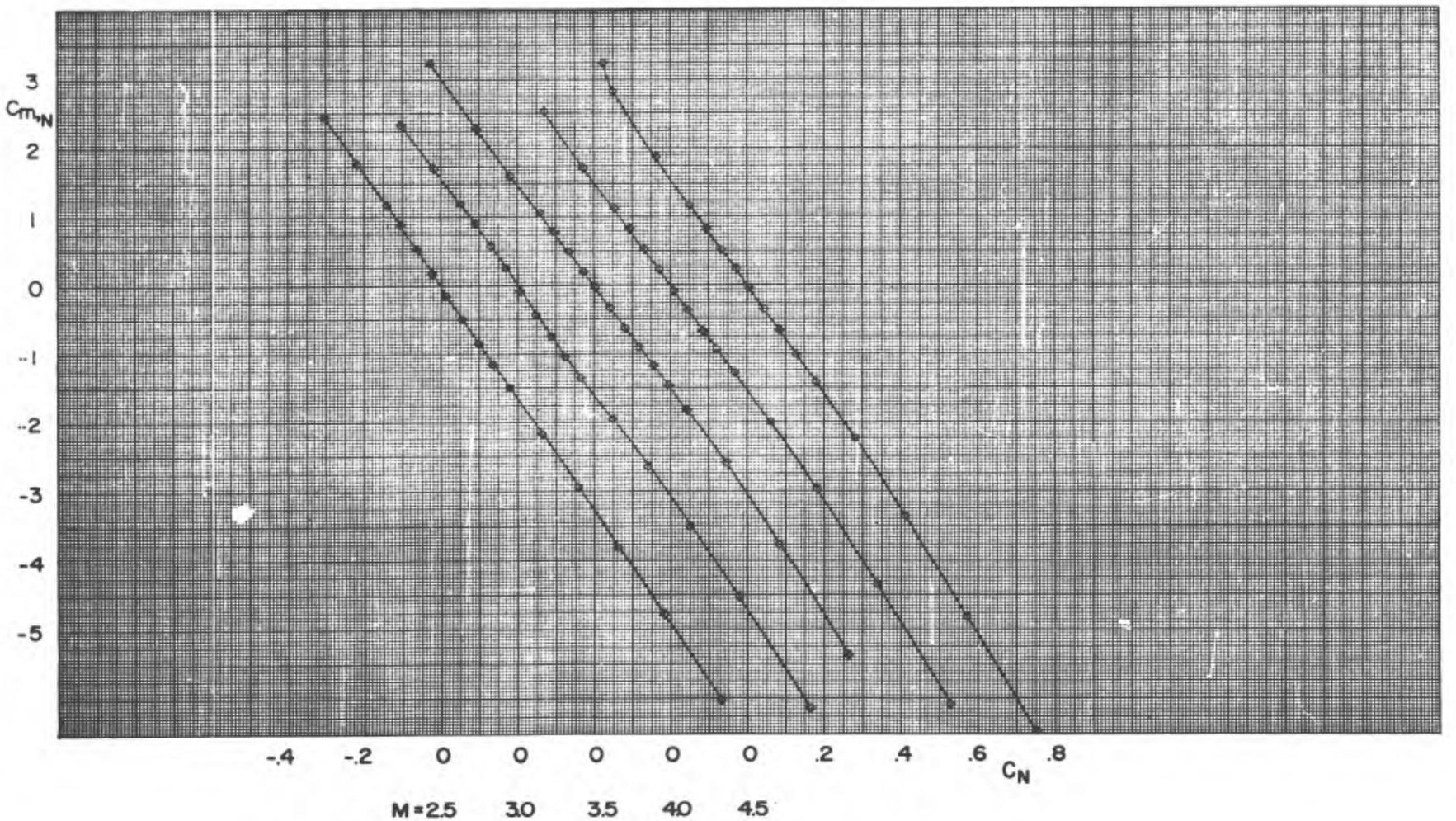
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 39. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 10



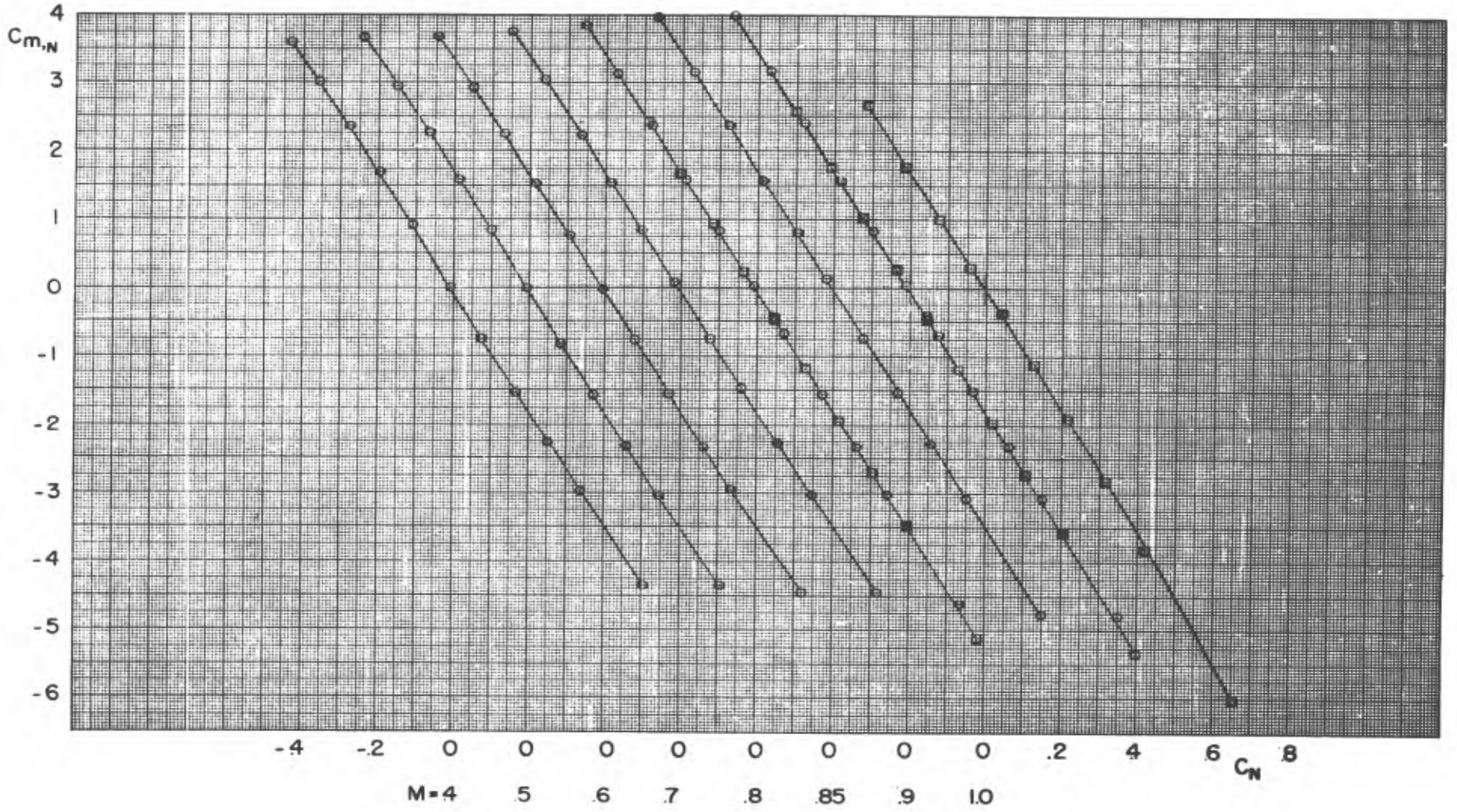
b. MACH NUMBERS 1.05 TO 2.0

FIGURE 39. CONTINUED



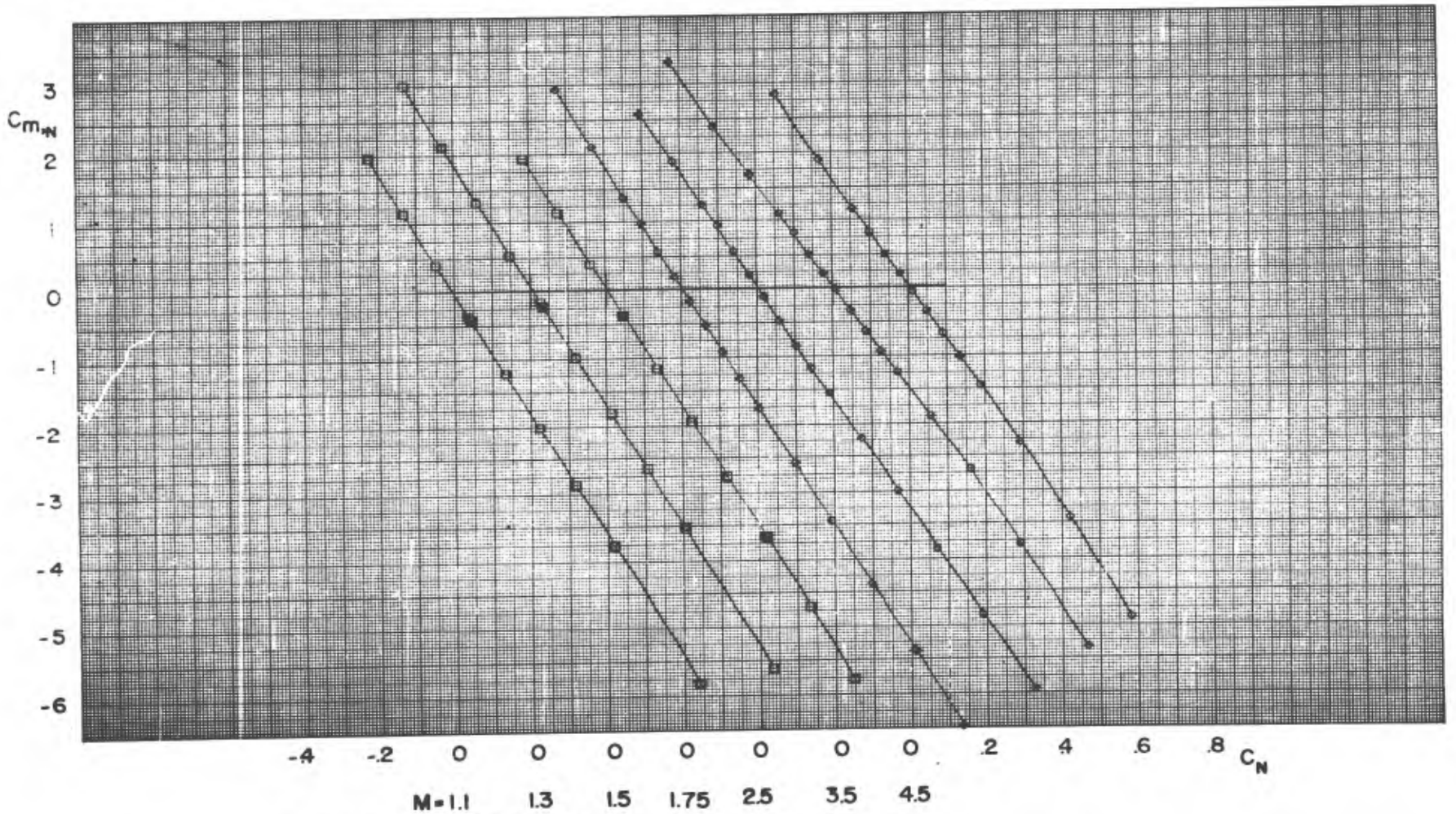
c. MACH NUMBERS 2.5 TO 4.5

FIGURE 39. CONCLUDED



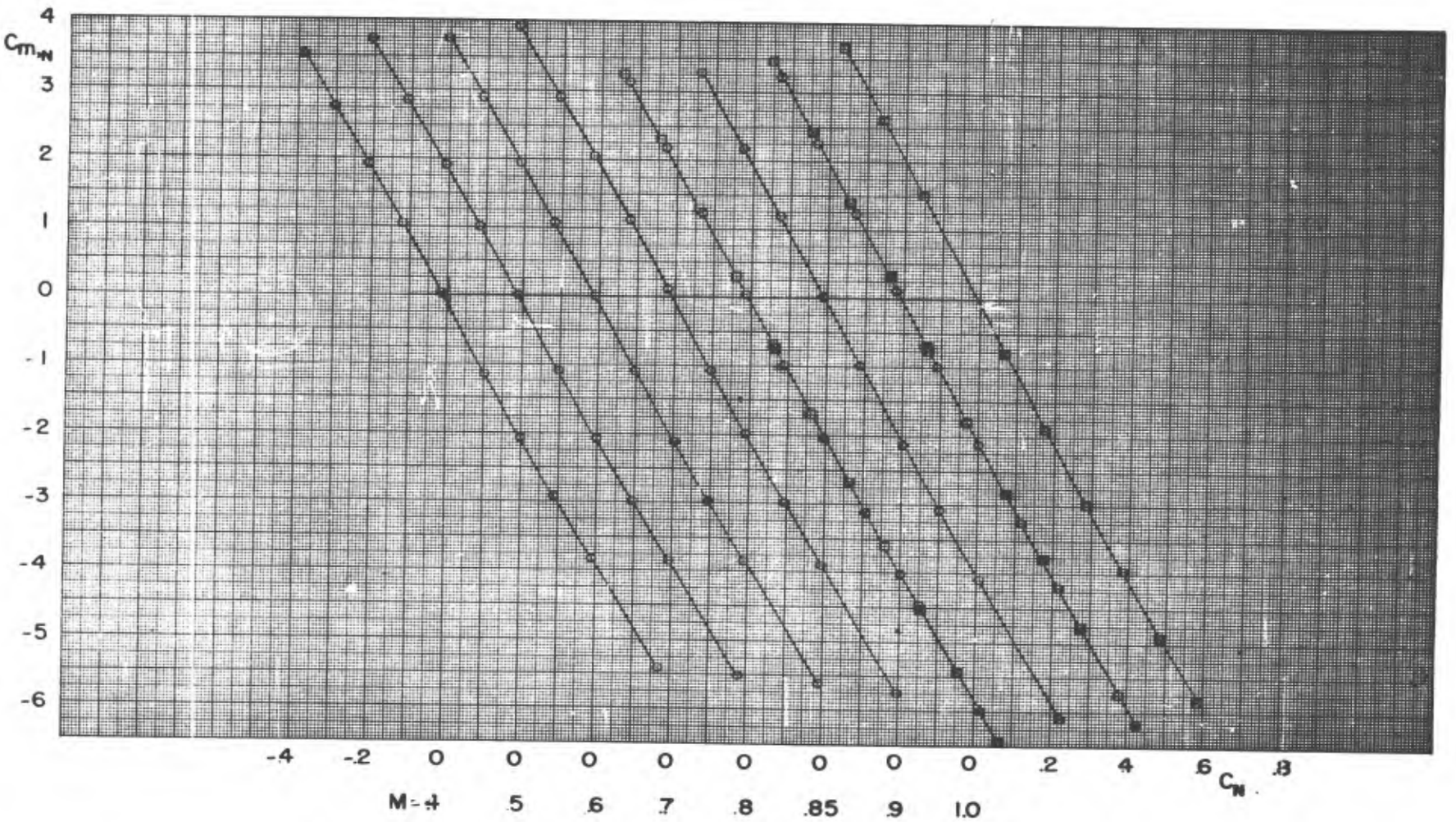
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 40. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 11



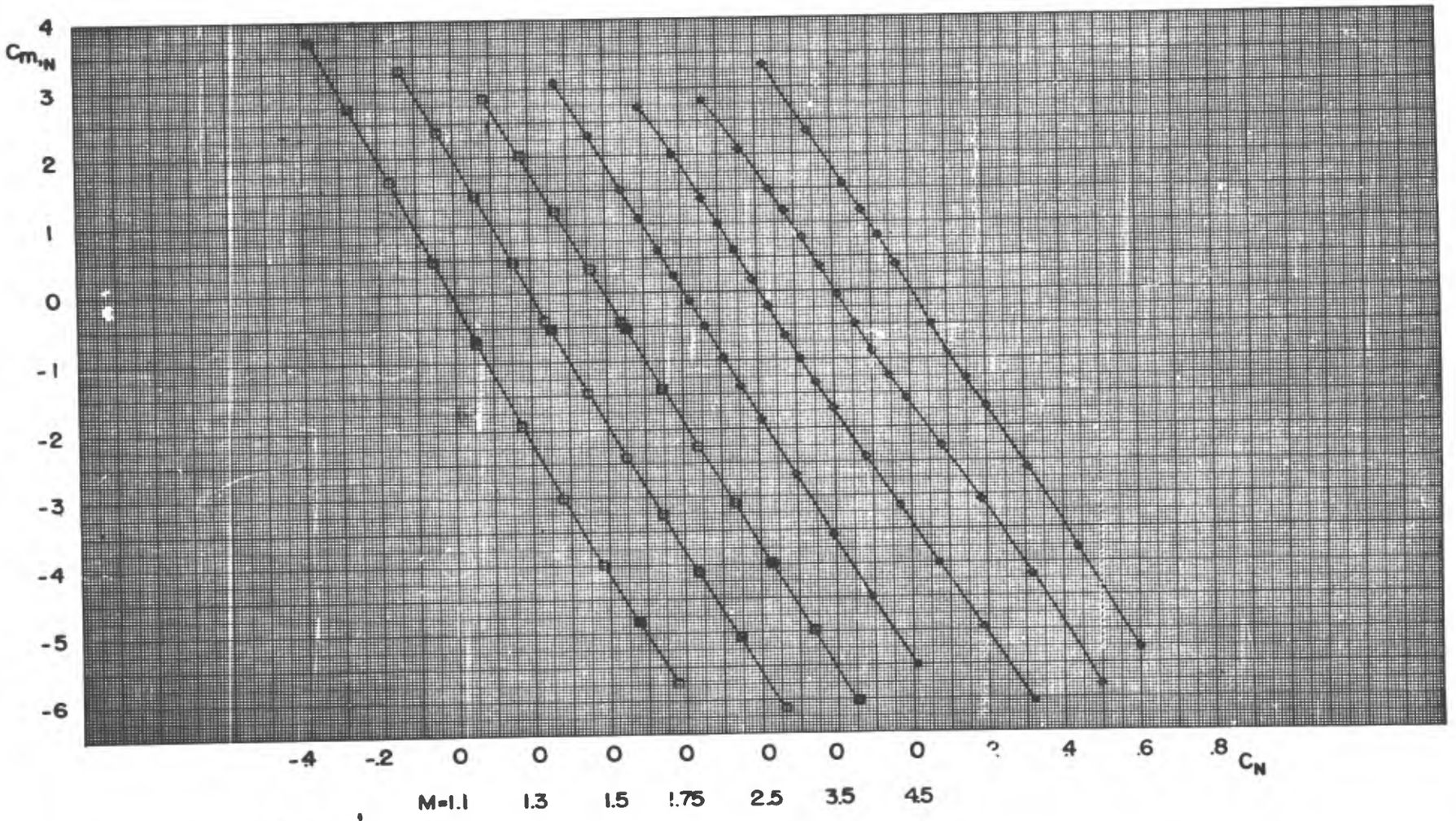
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 40. CONCLUDED



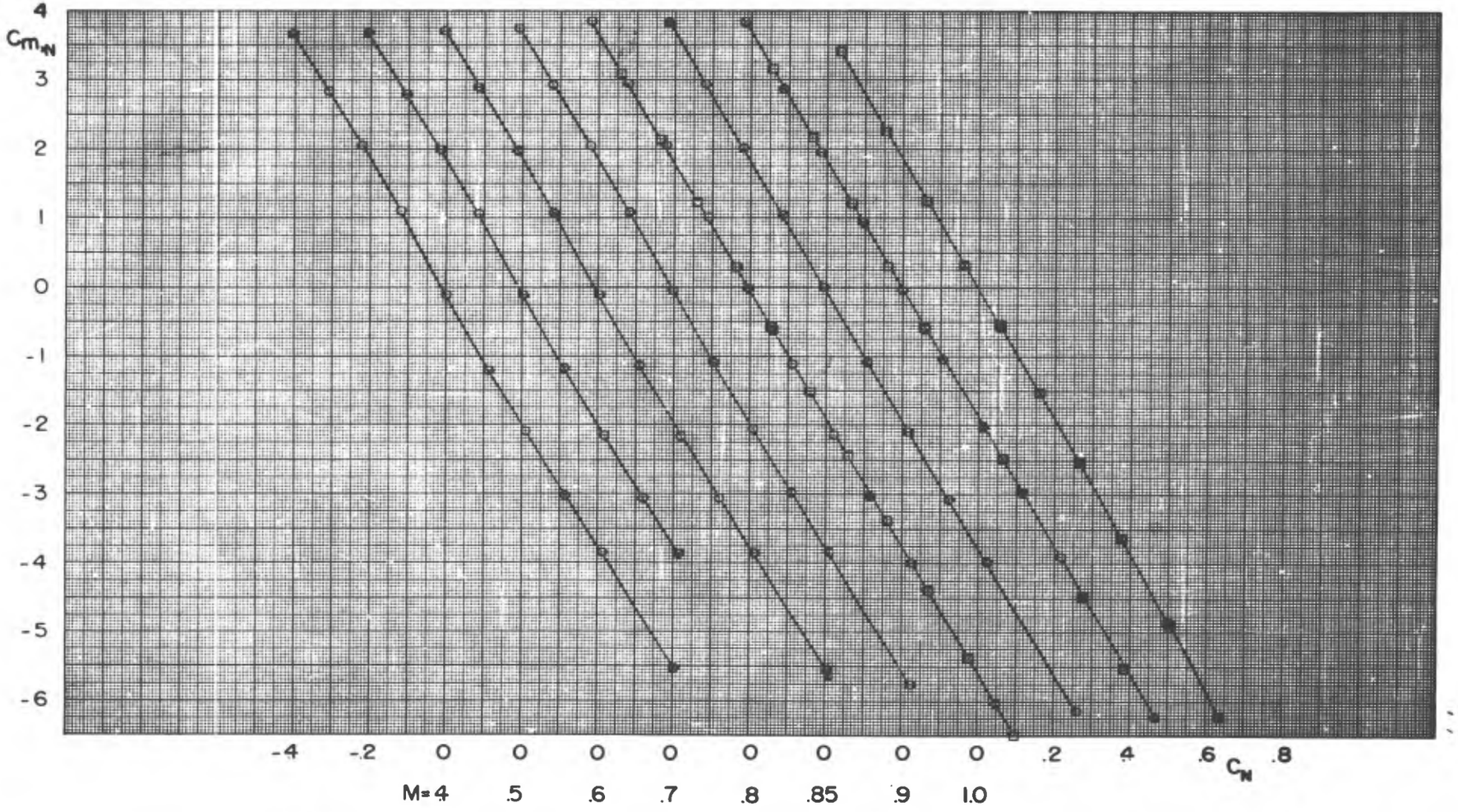
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 41. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 12



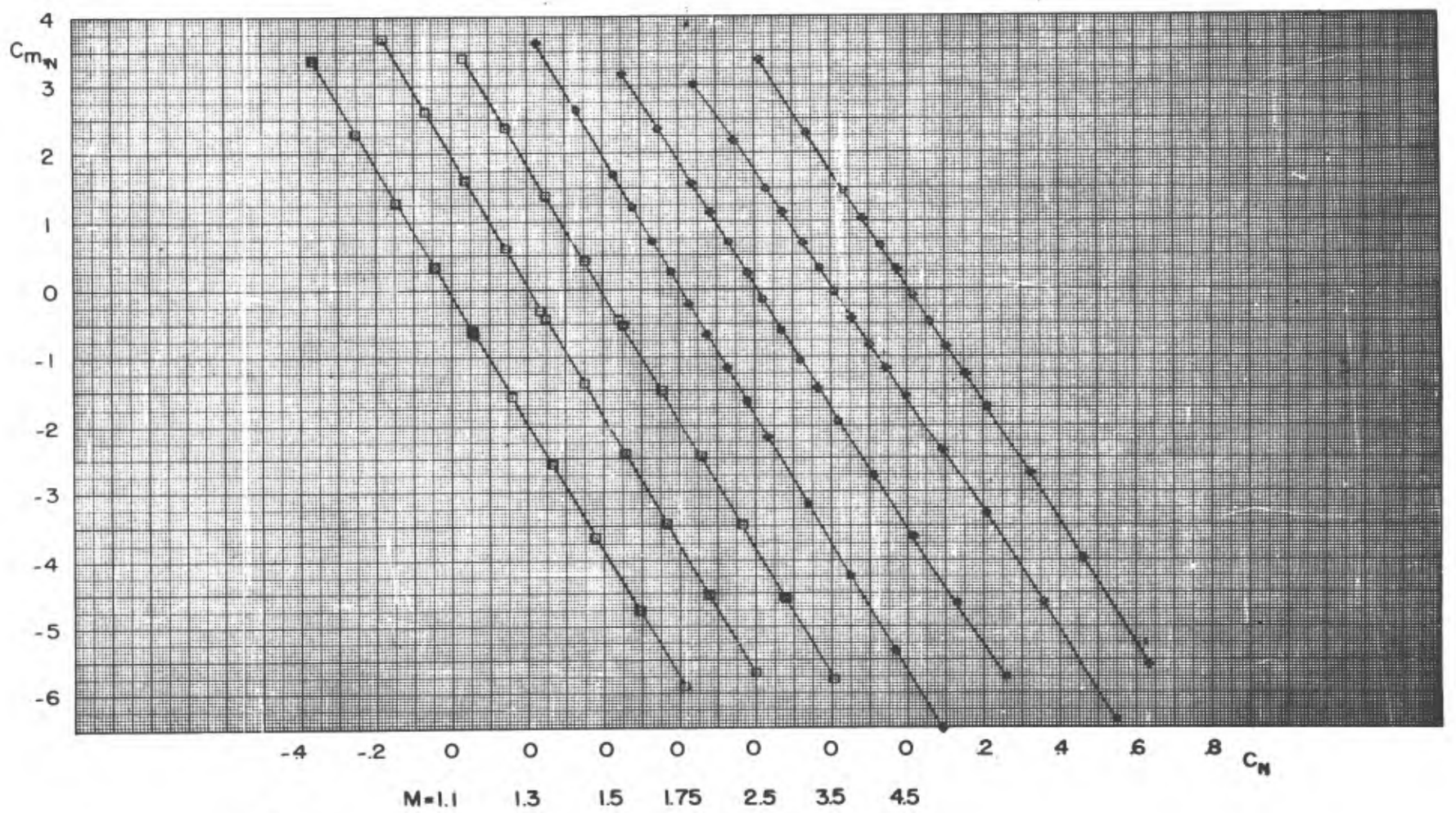
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 41. CONCLUDED



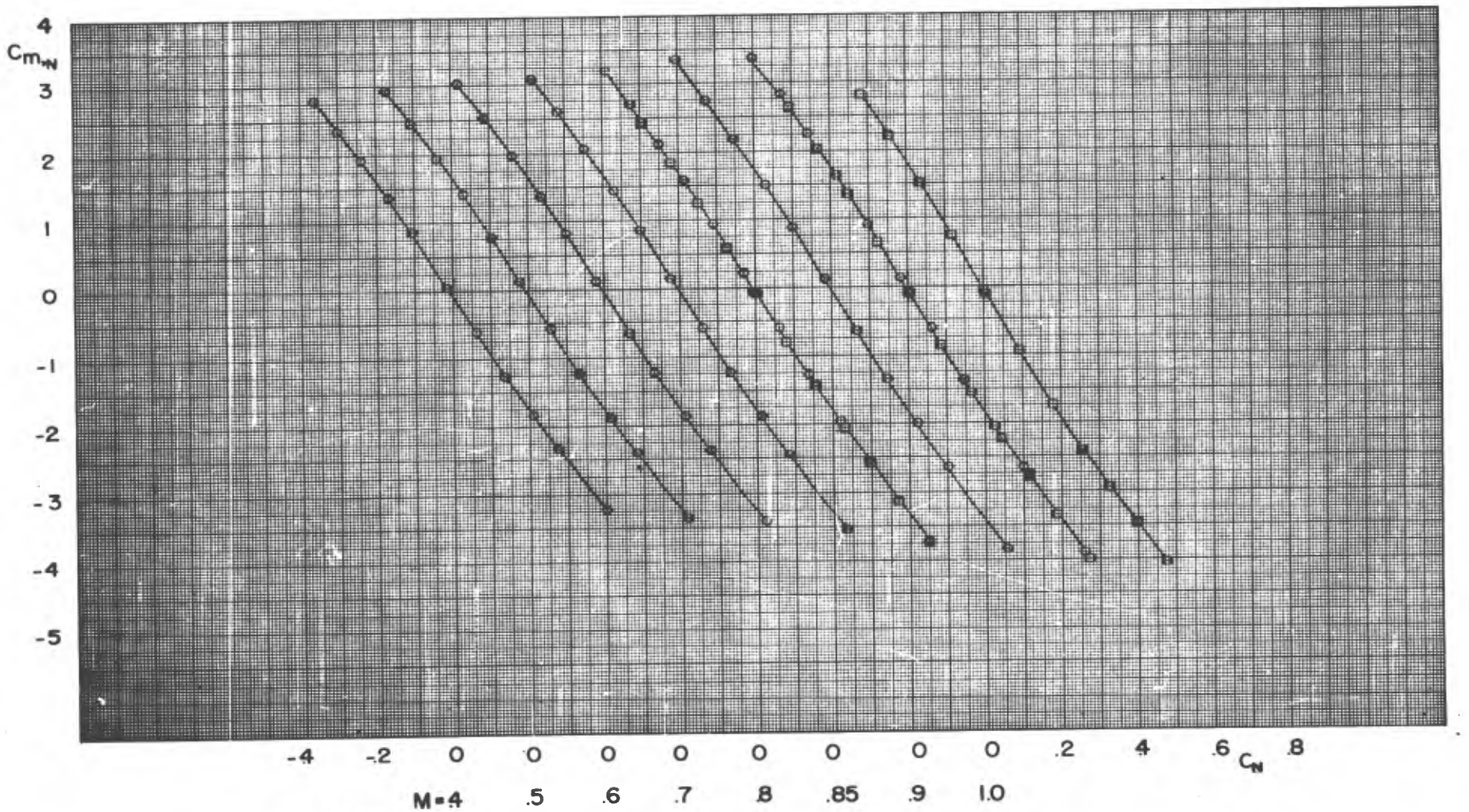
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 42. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 13



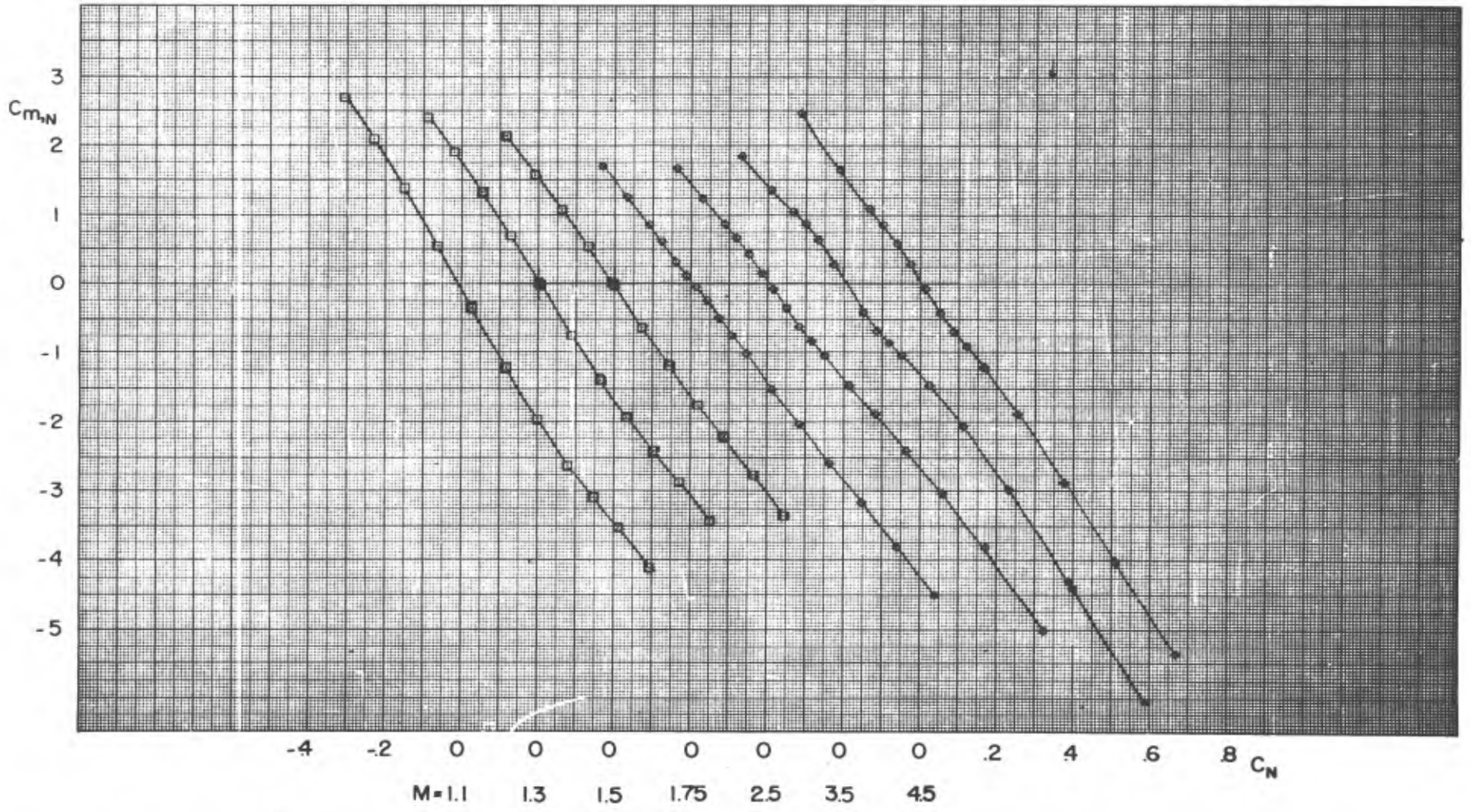
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 42. CONCLUDED



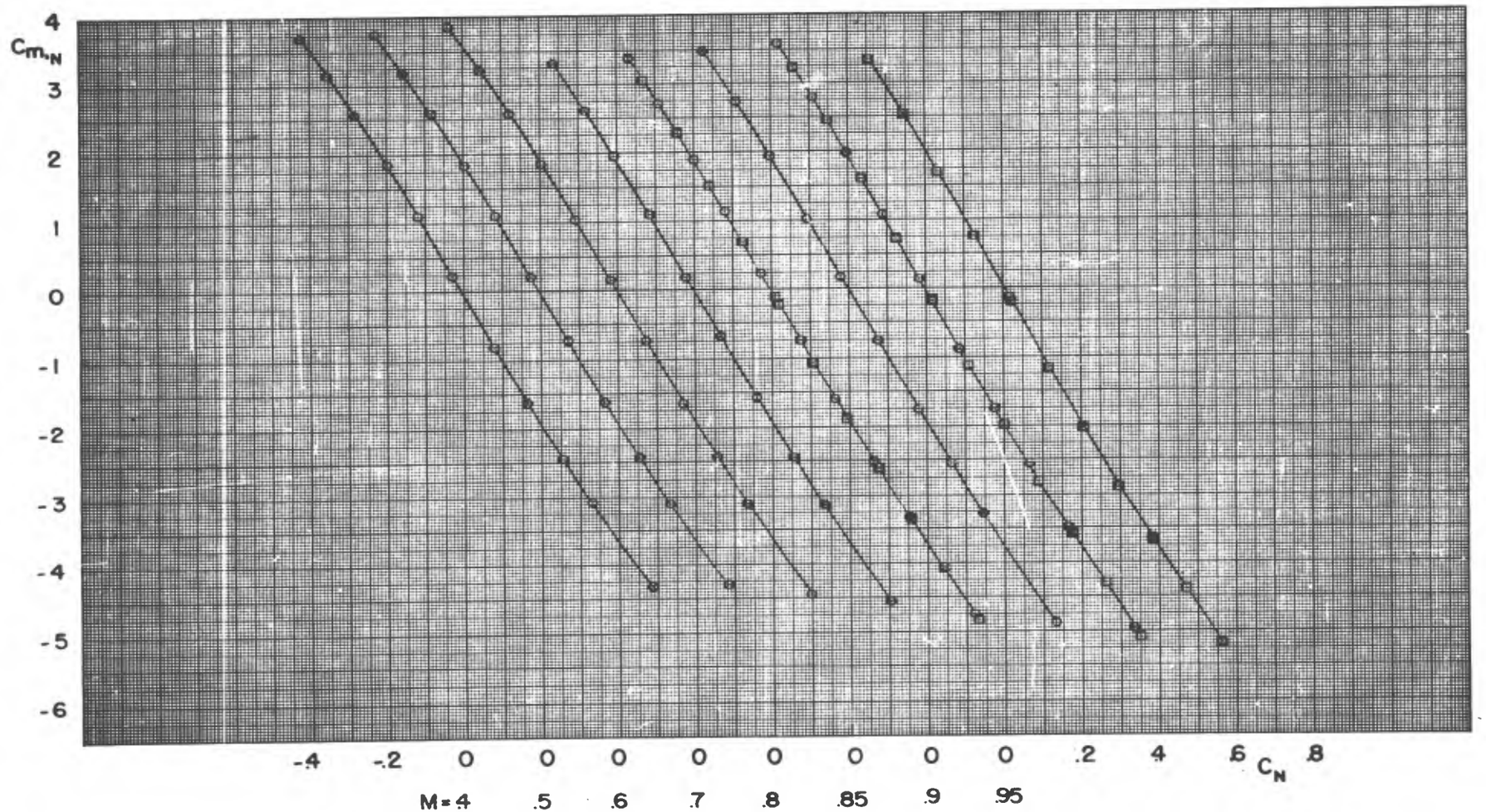
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 43. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 14



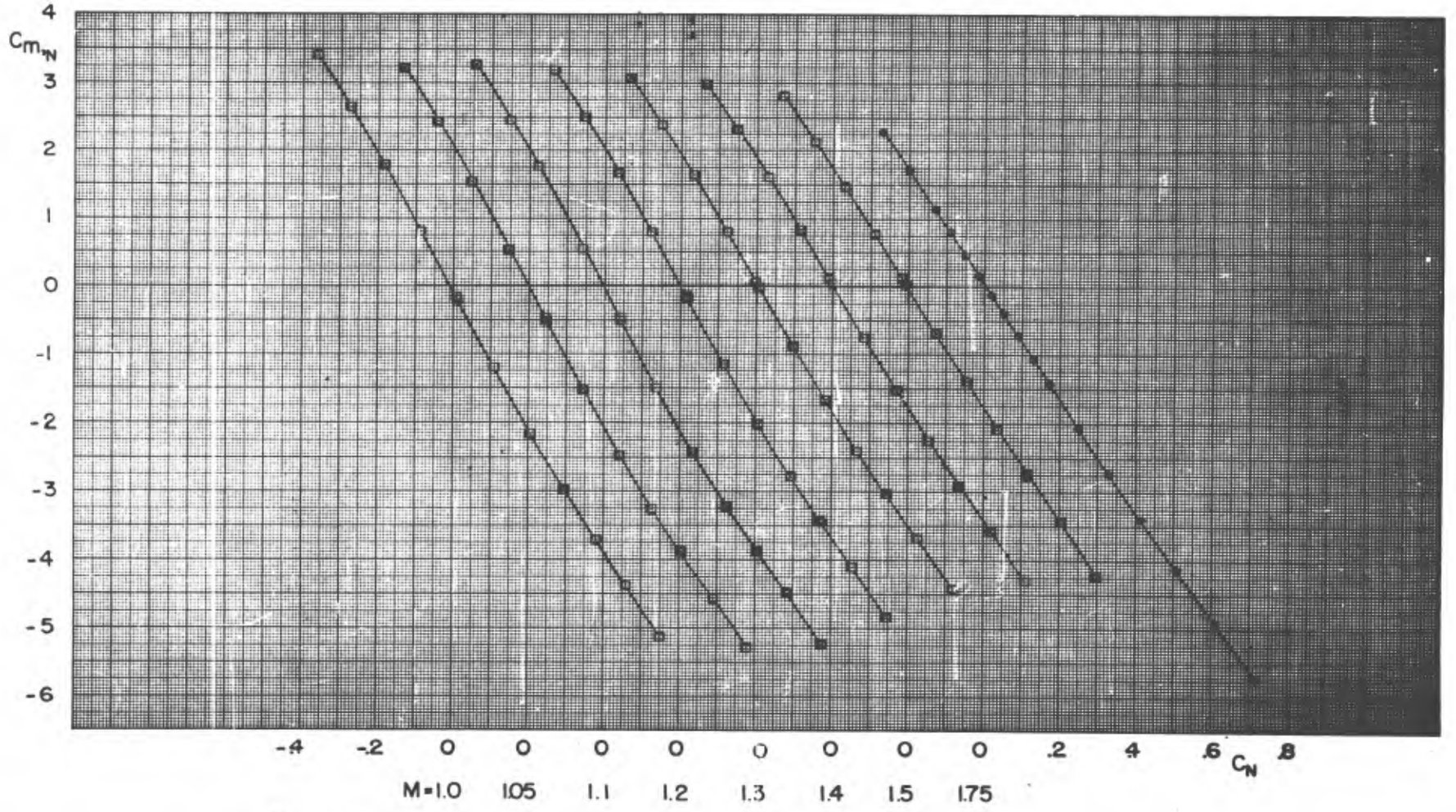
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 43. CONCLUDED



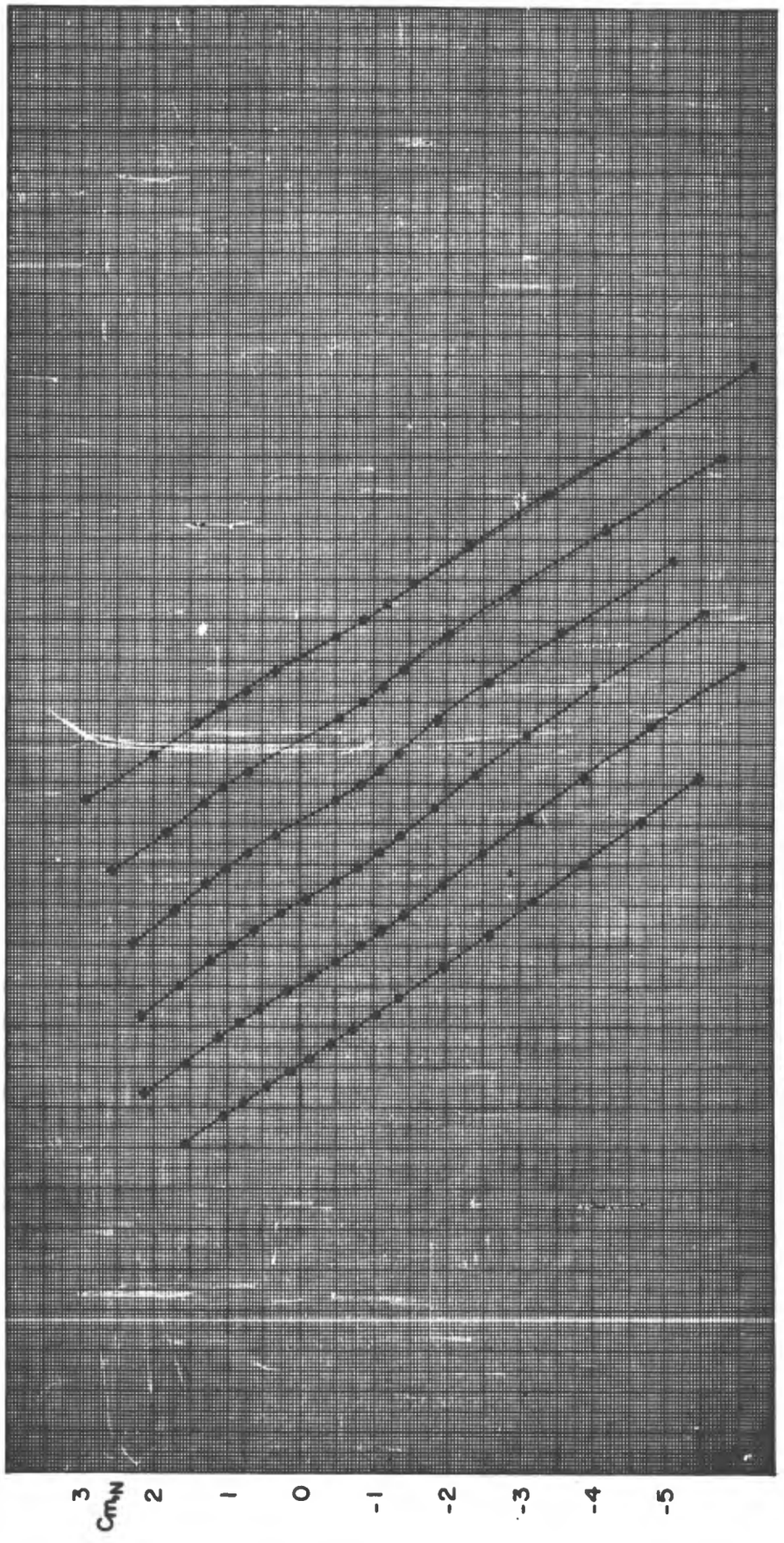
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 44. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 15



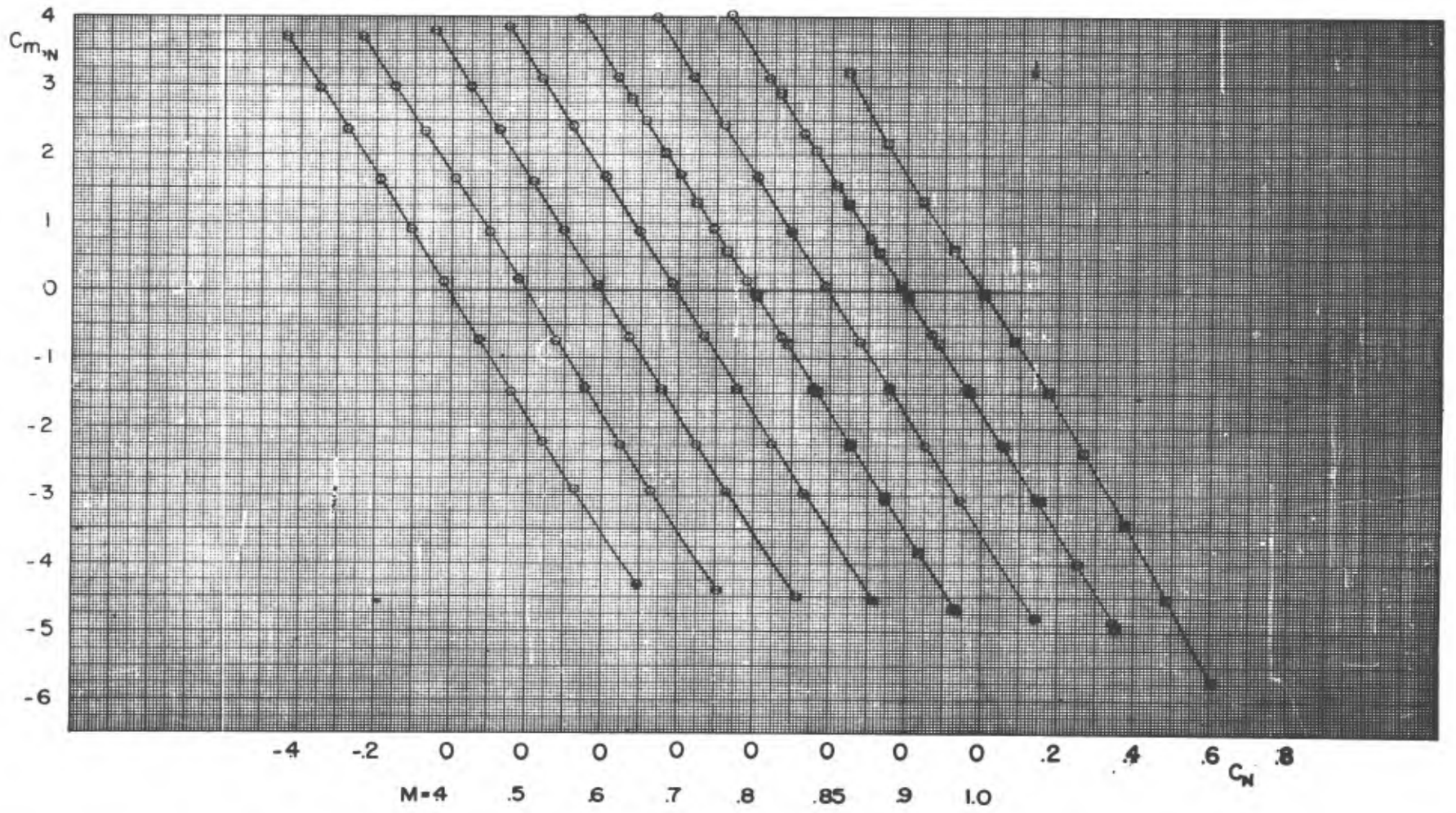
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 44. CONTINUED



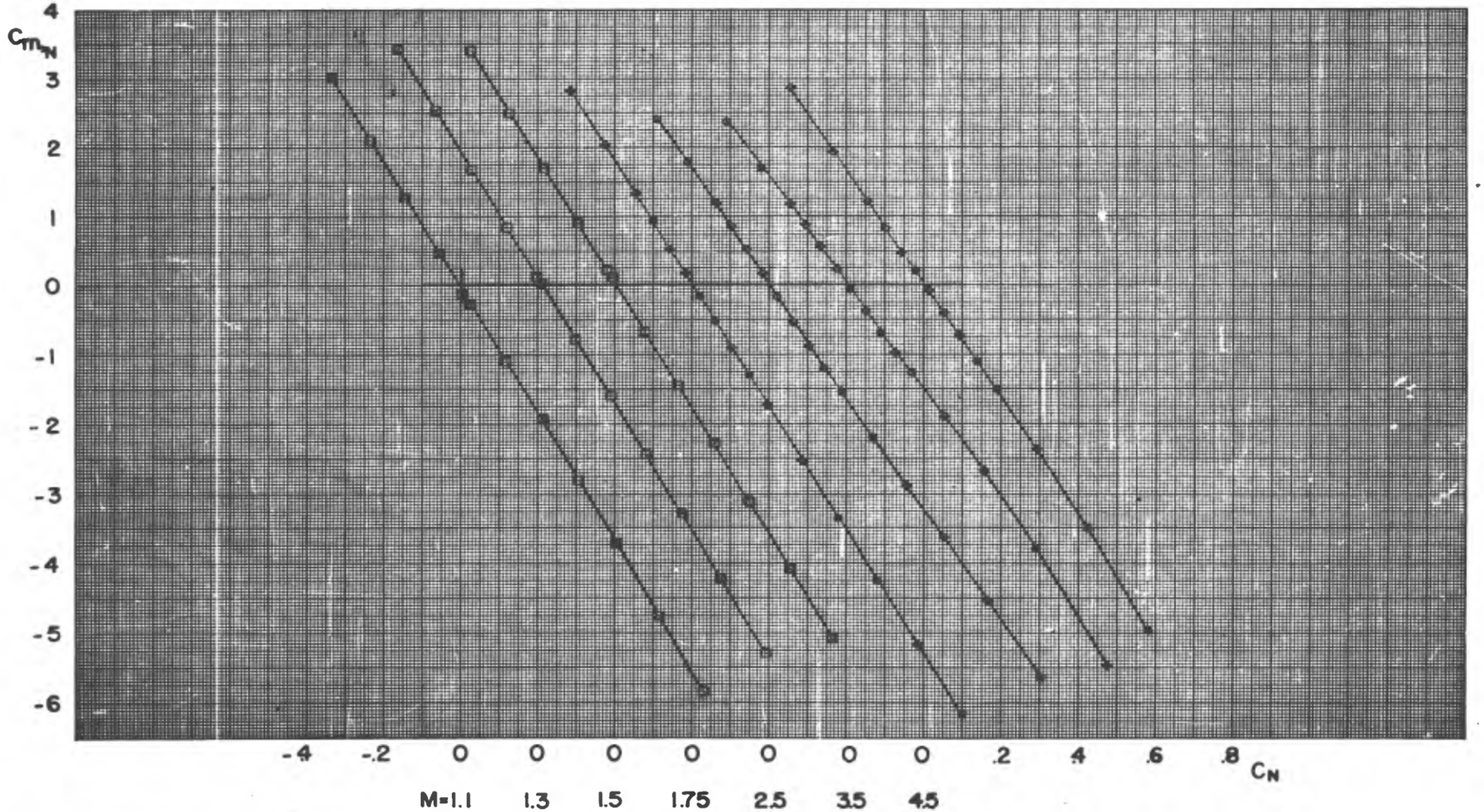
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 44. CONCLUDED



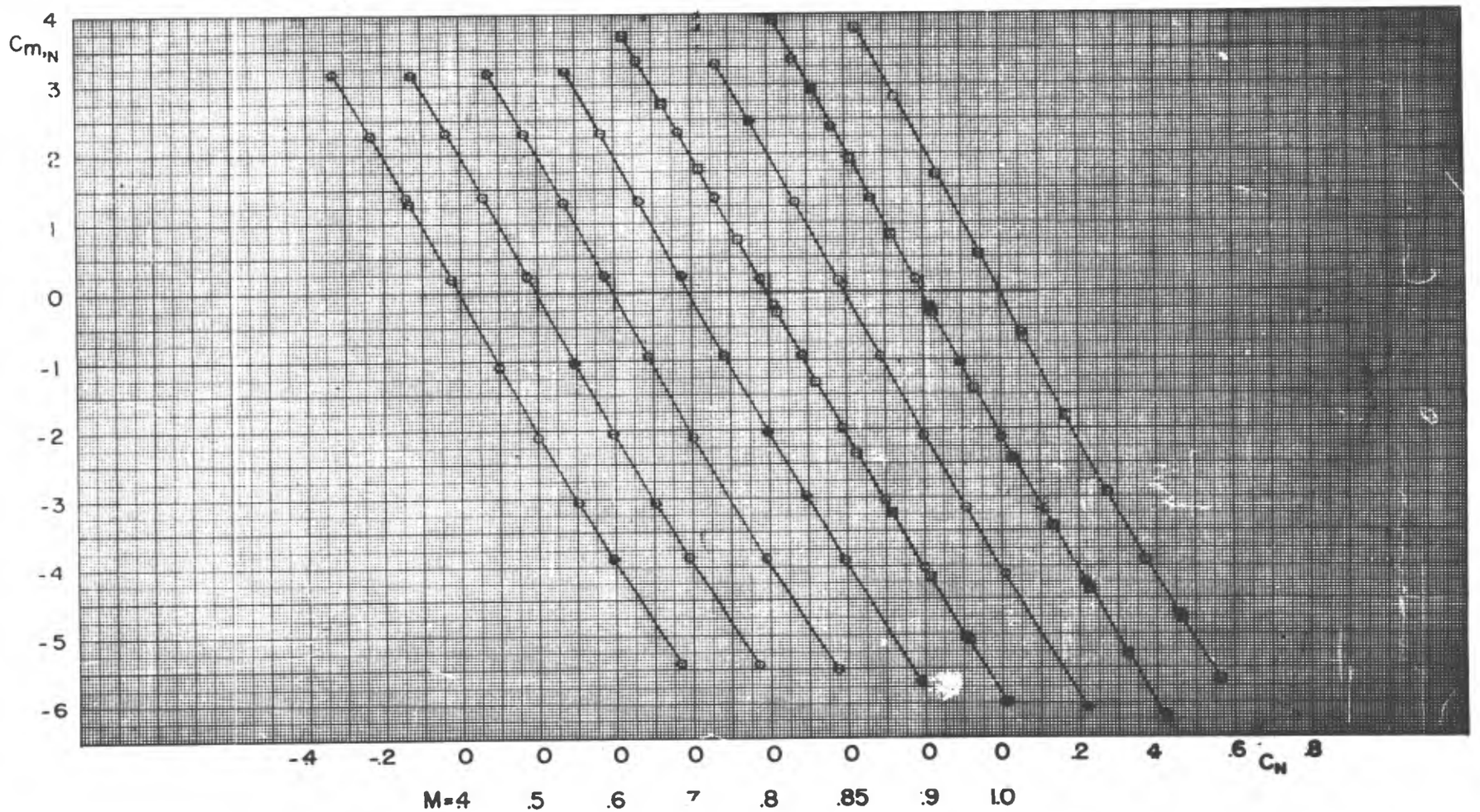
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 45. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 16



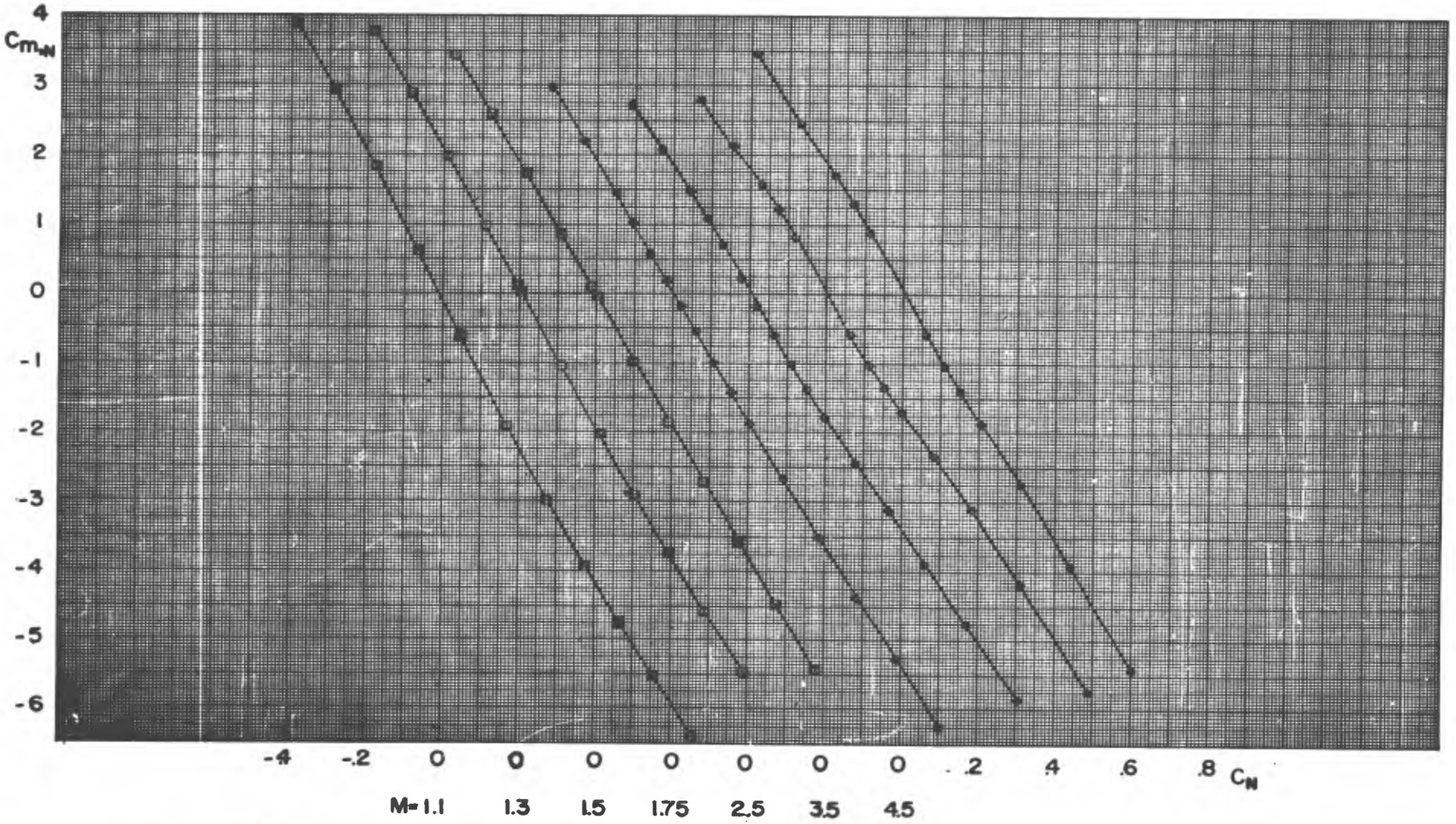
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 45. CONCLUDED



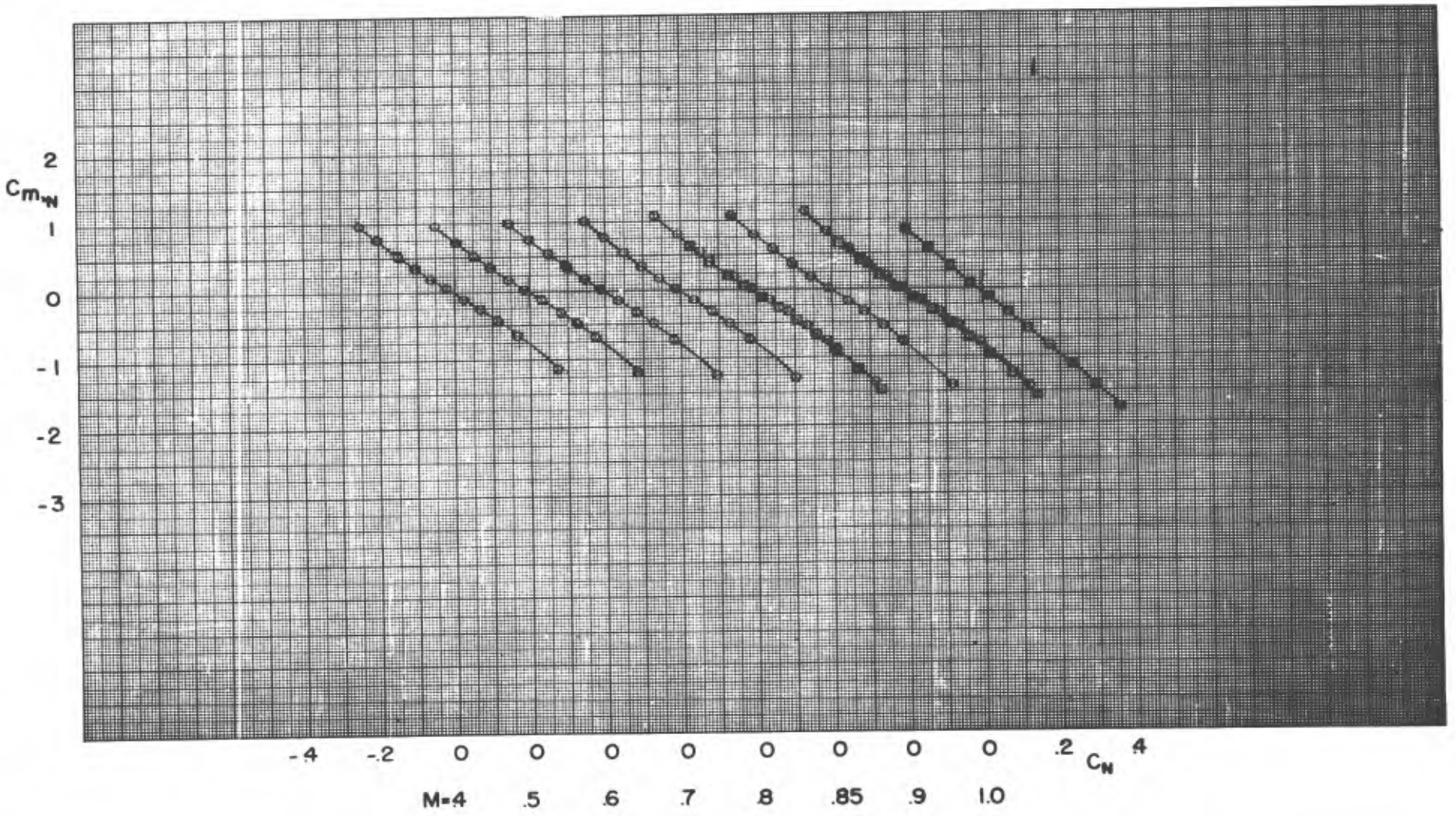
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 46. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 17



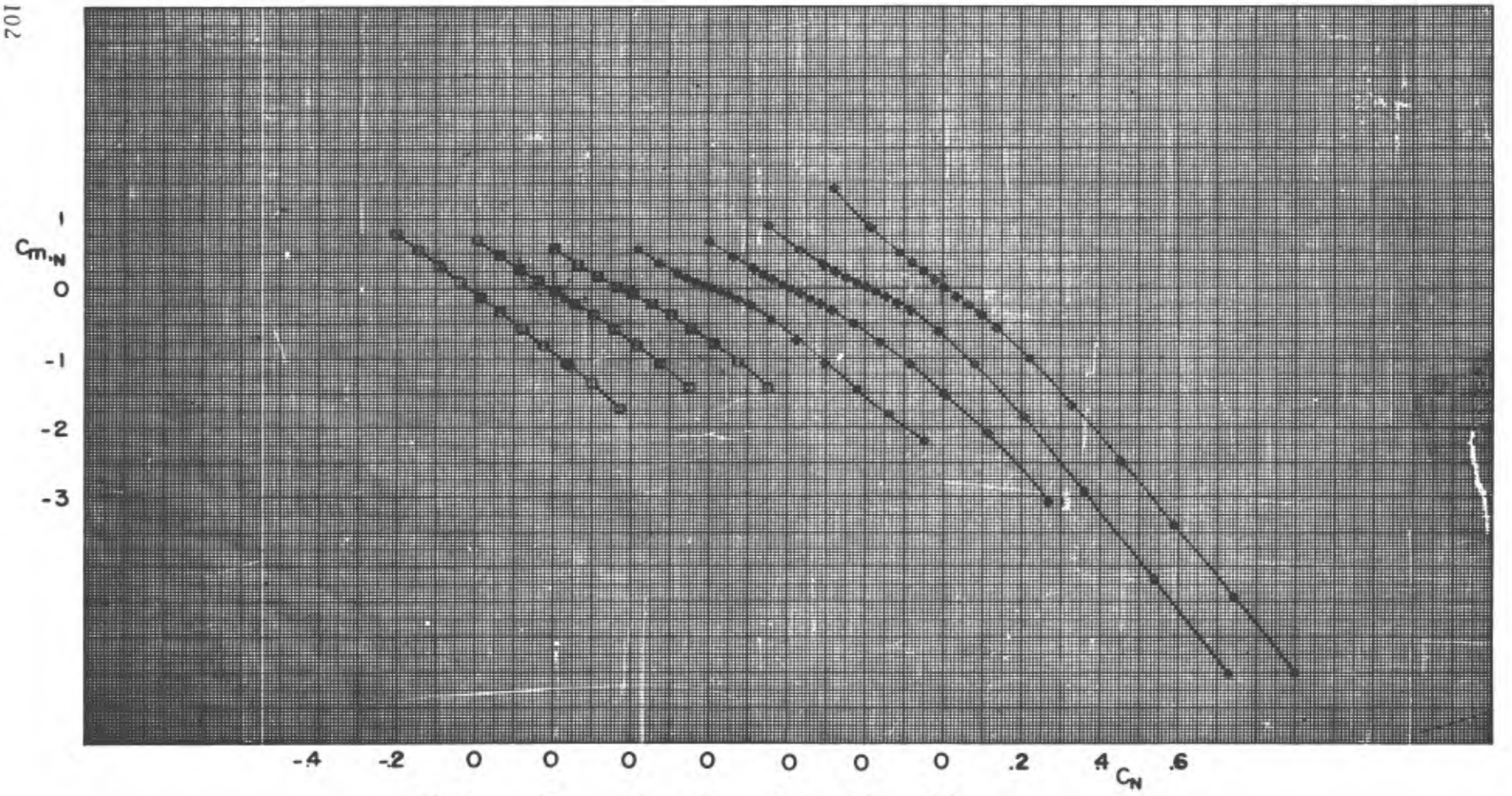
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 46. CONCLUDED



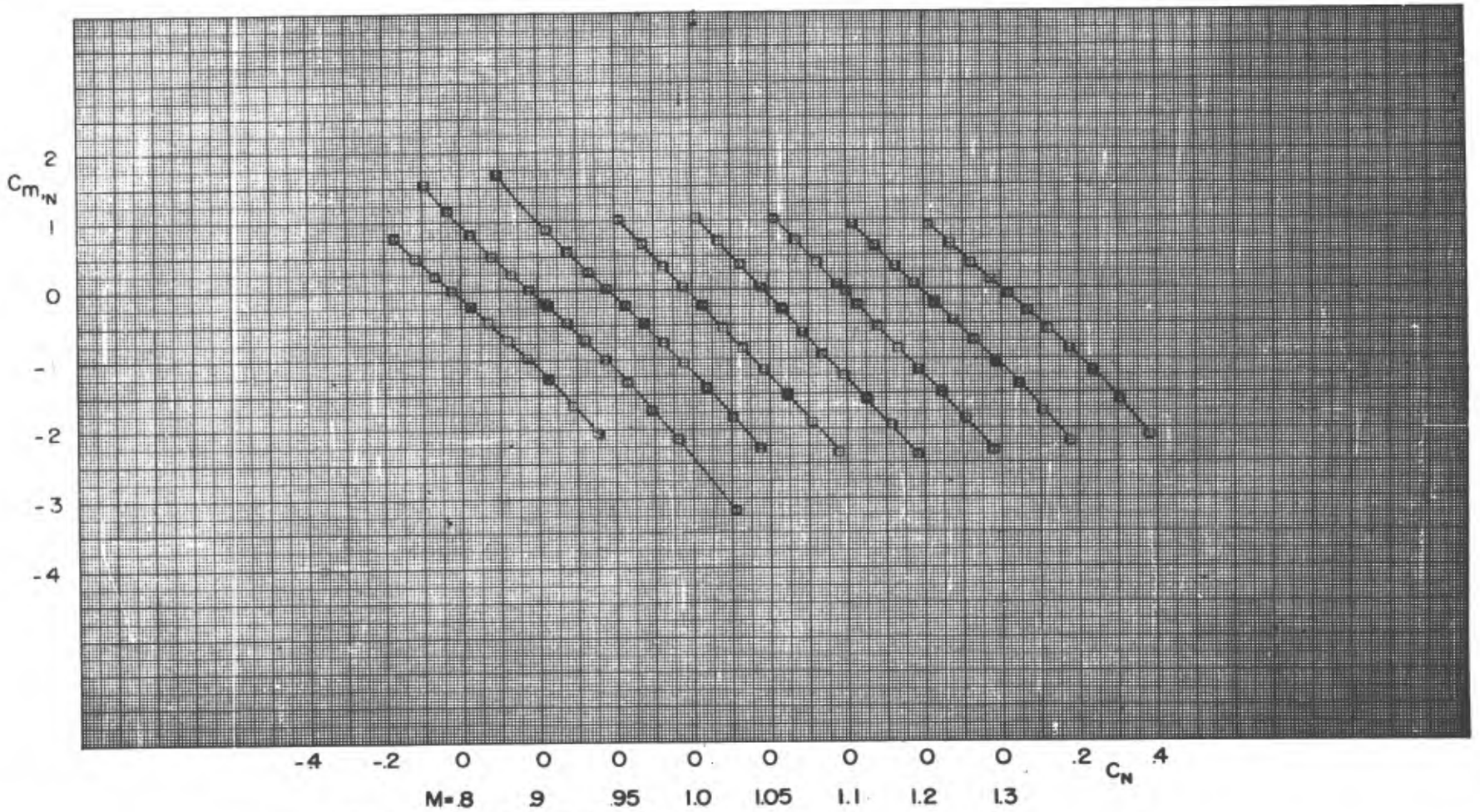
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 47. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 18



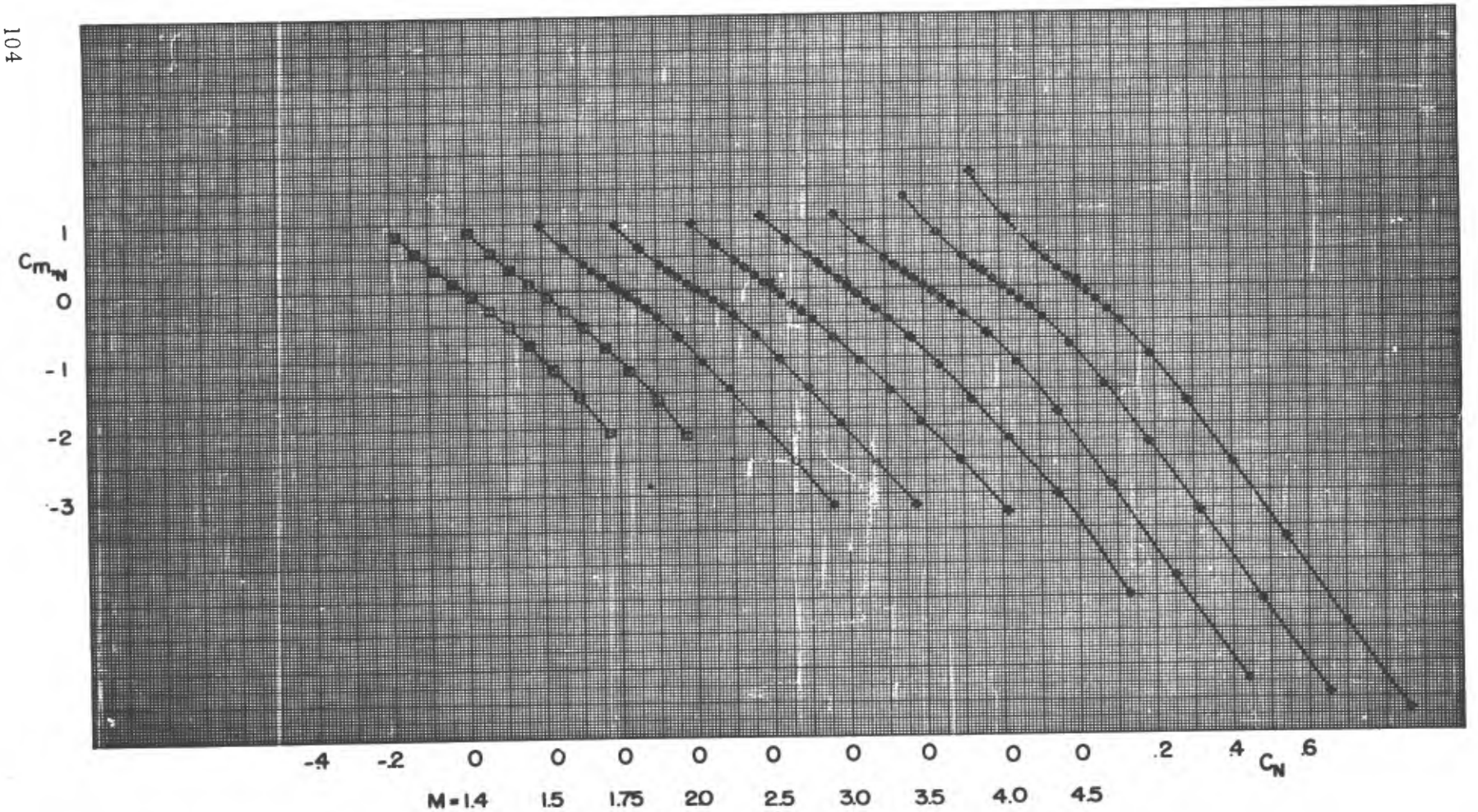
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 47. CONCLUDED



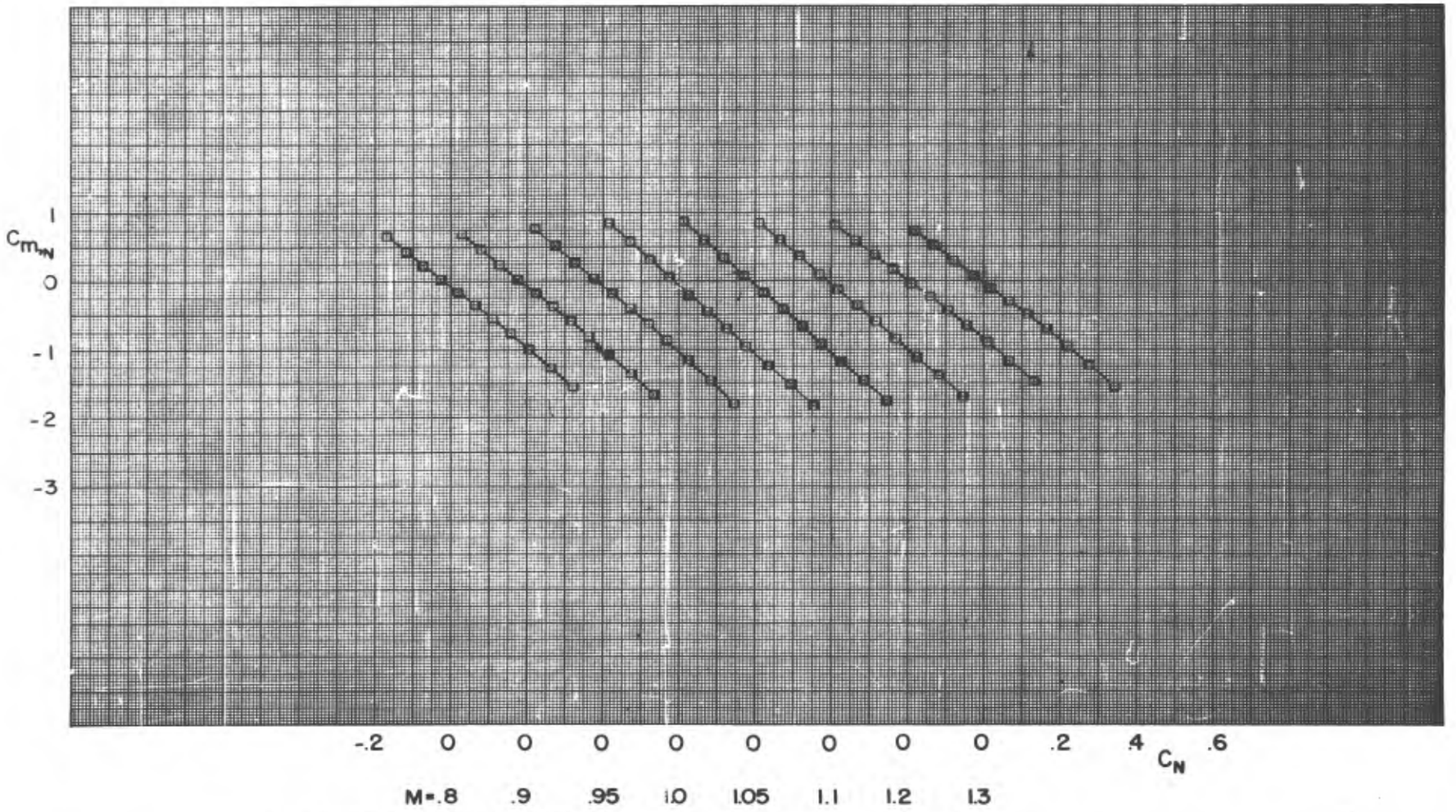
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 48. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 19



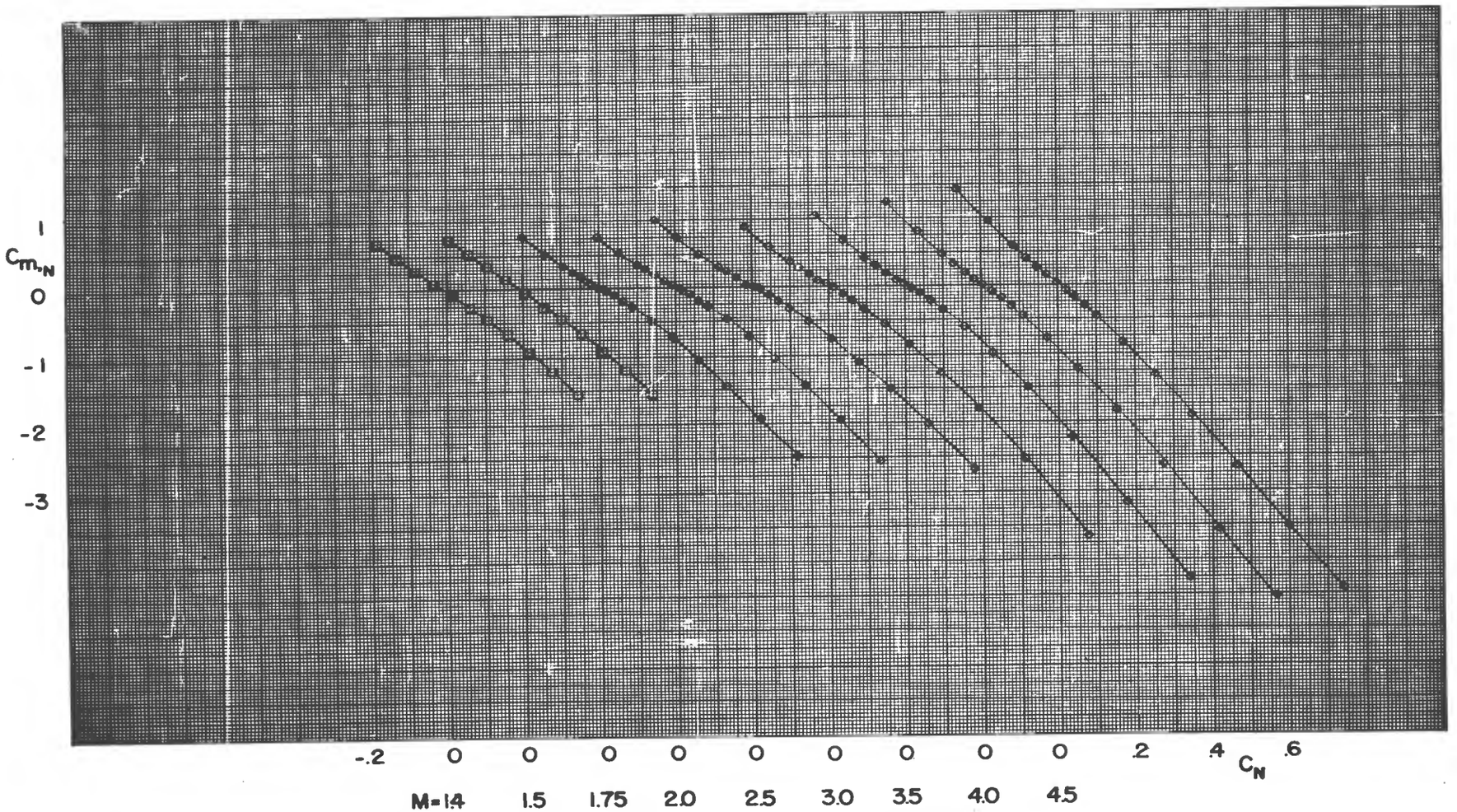
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 48. CONCLUDED



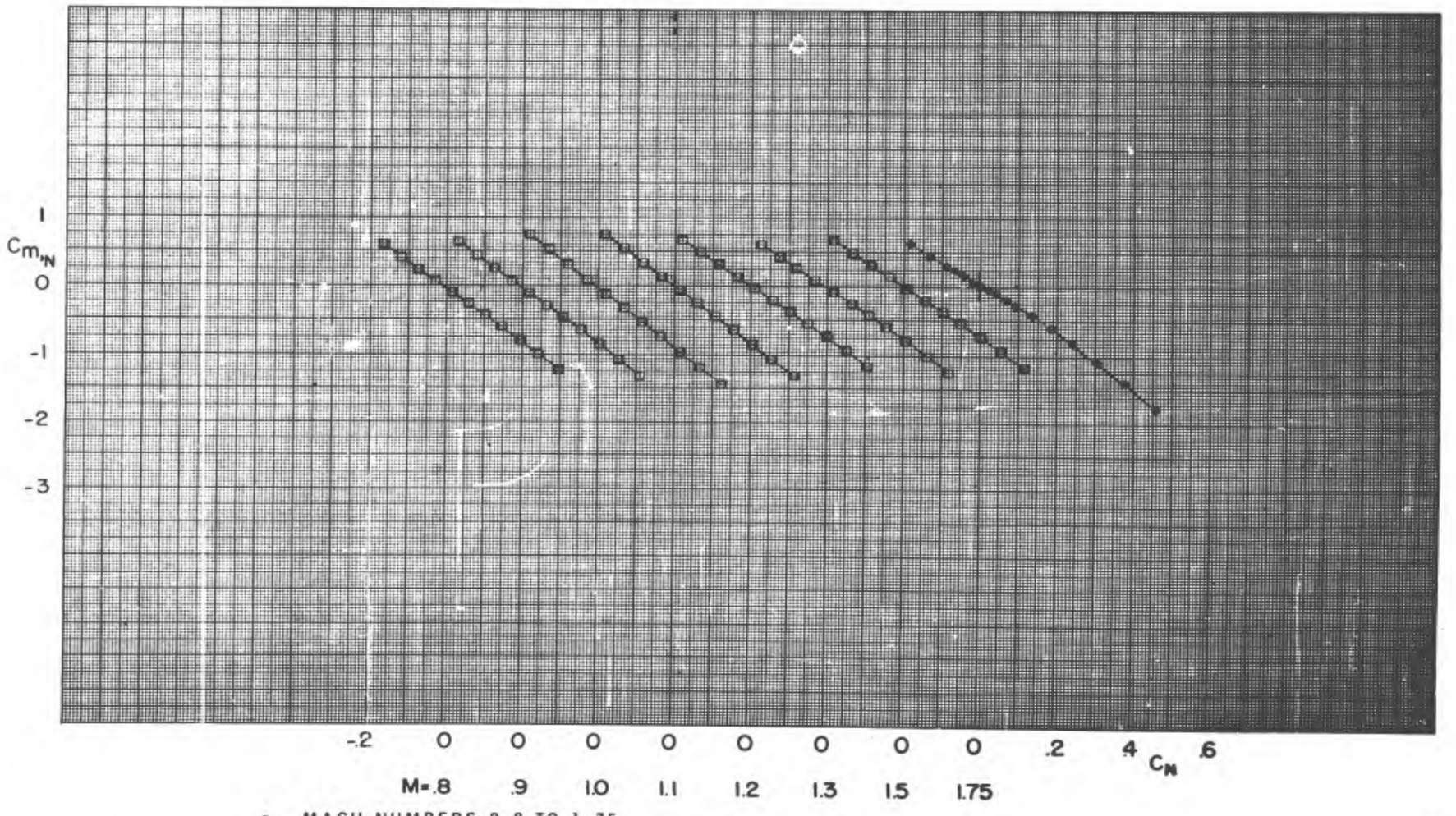
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 49. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 20



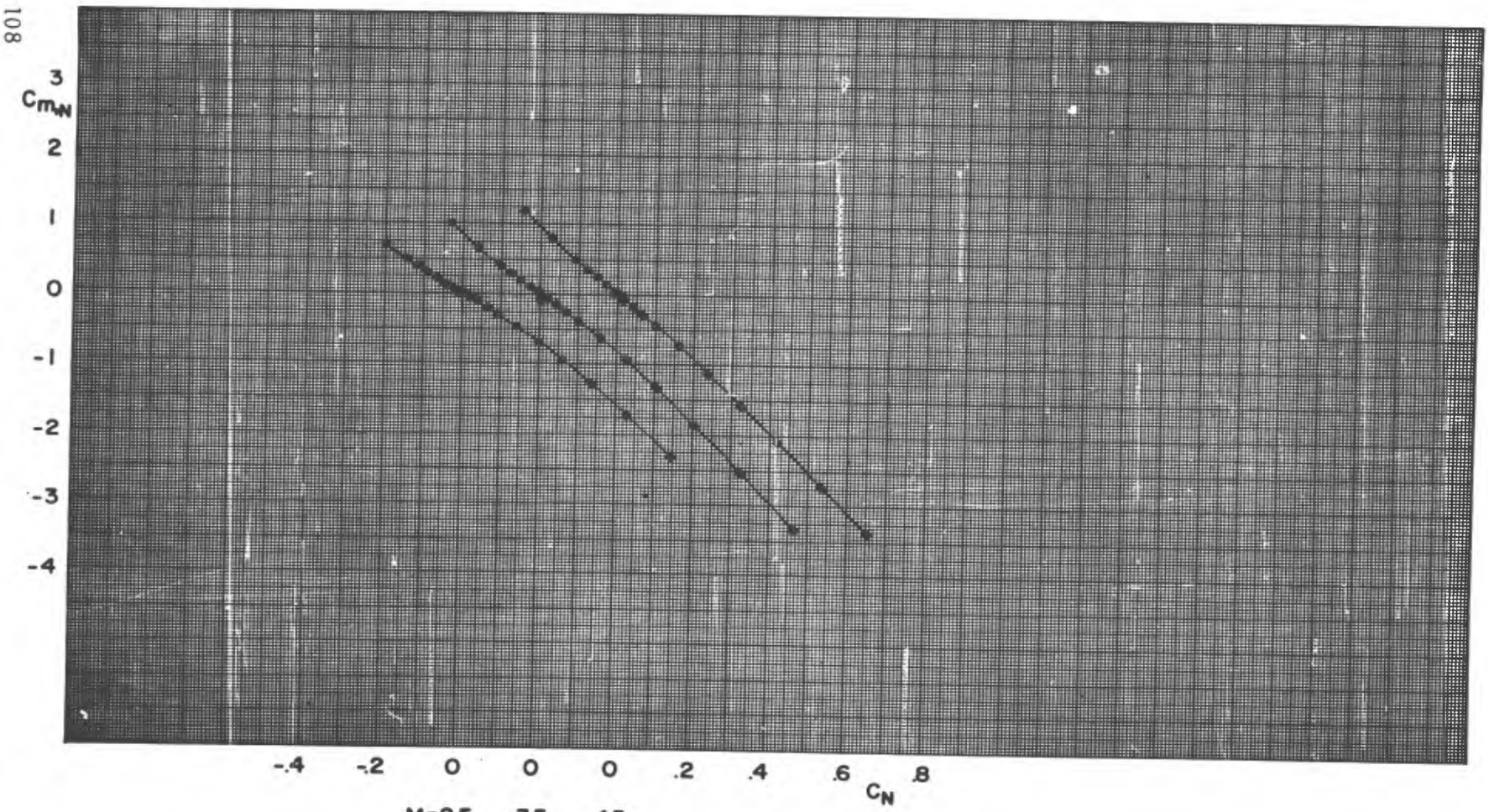
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 49. CONCLUDED



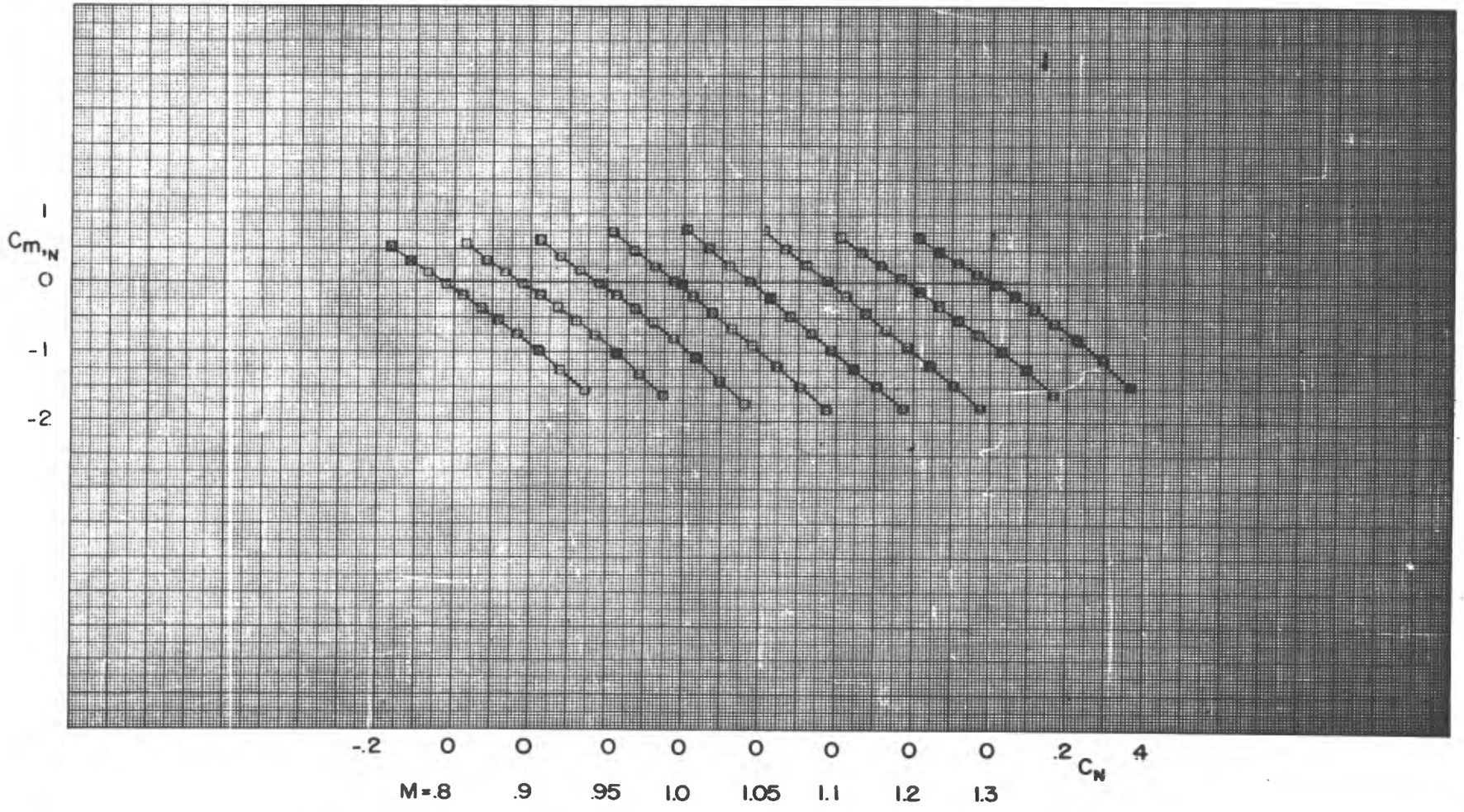
a. MACH NUMBERS 0.8 TO 1.75

FIGURE 50. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 21



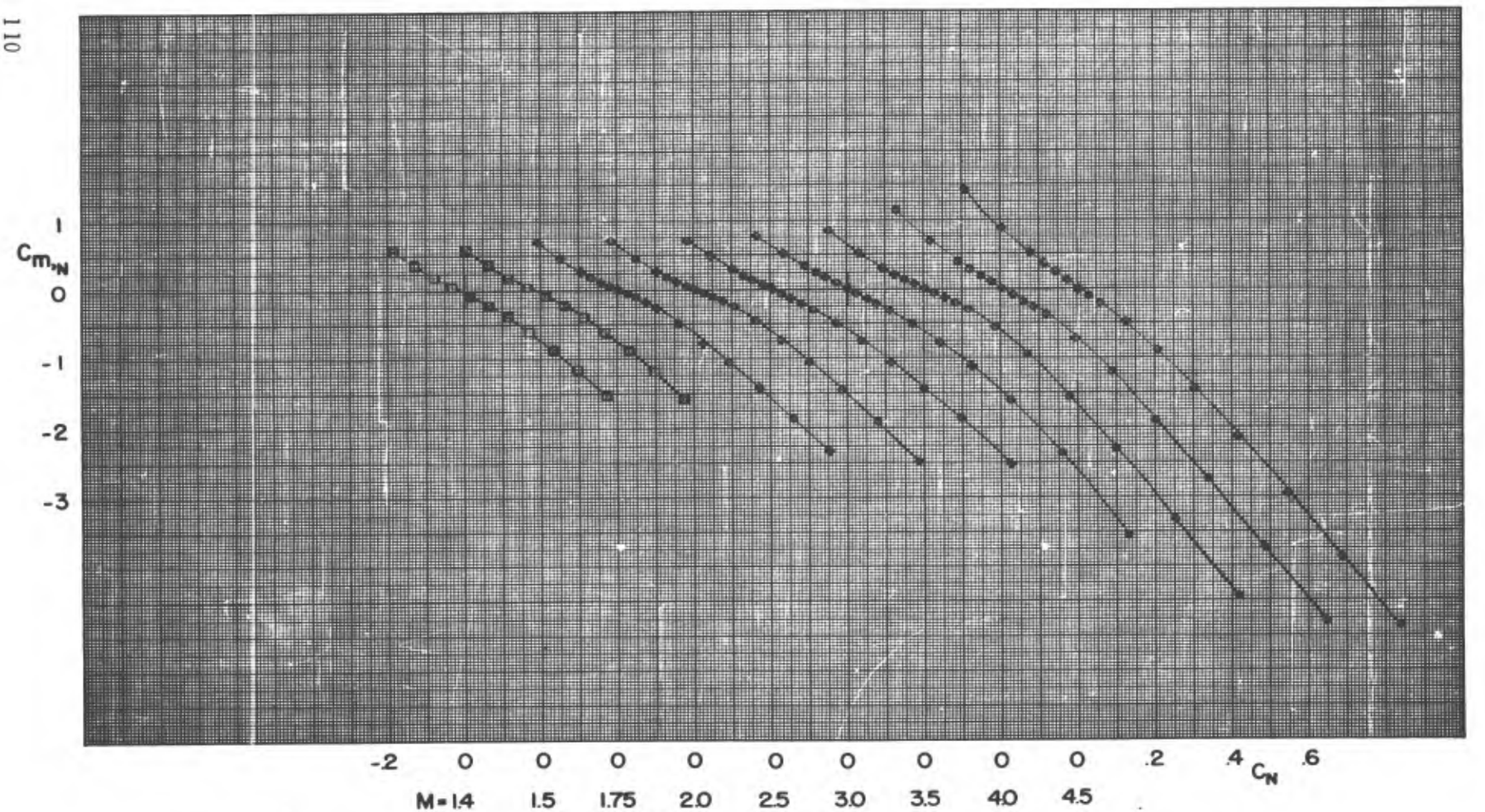
b. MACH NUMBERS 2.5 TO 4.5

FIGURE 50. CONCLUDED



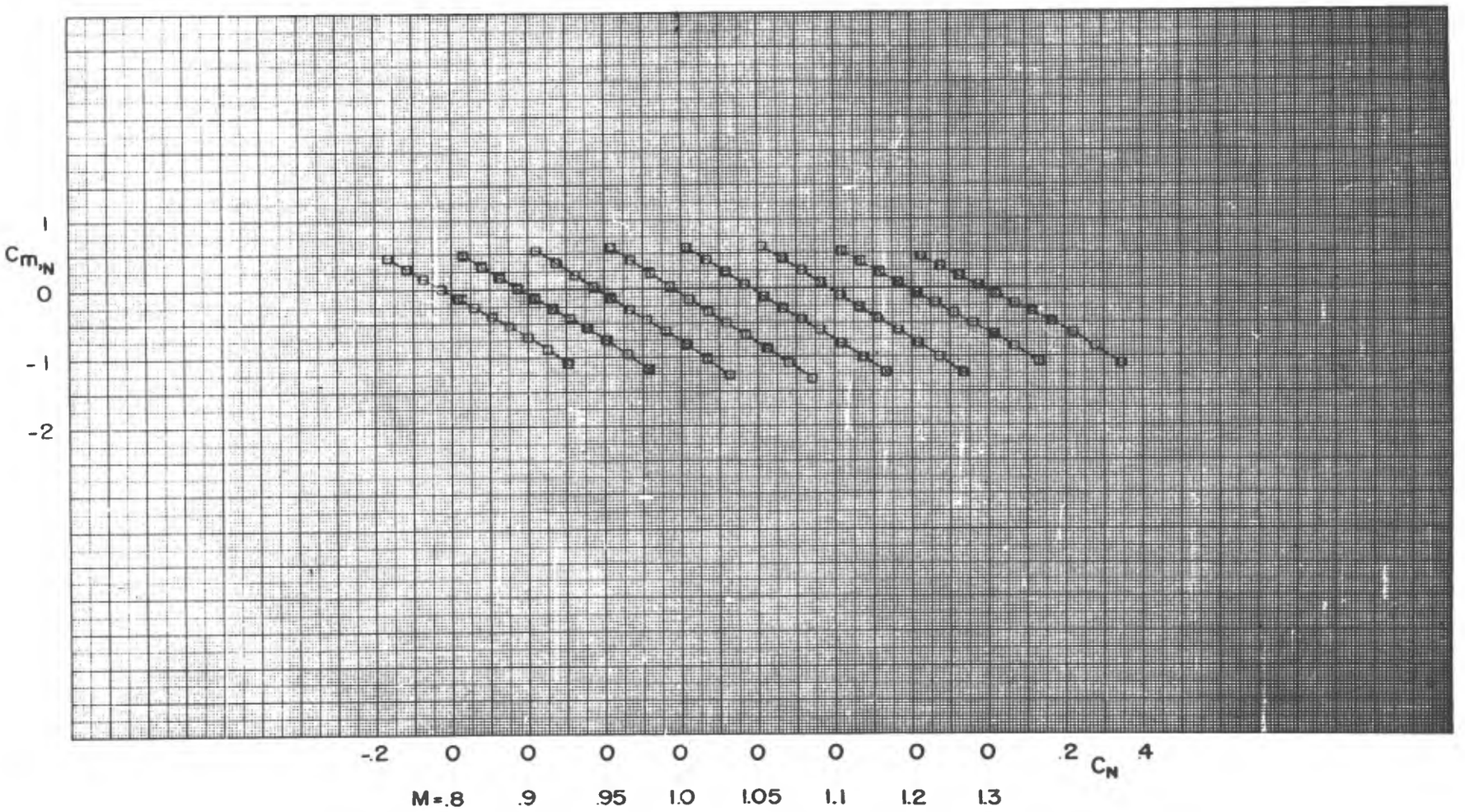
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 51. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 22



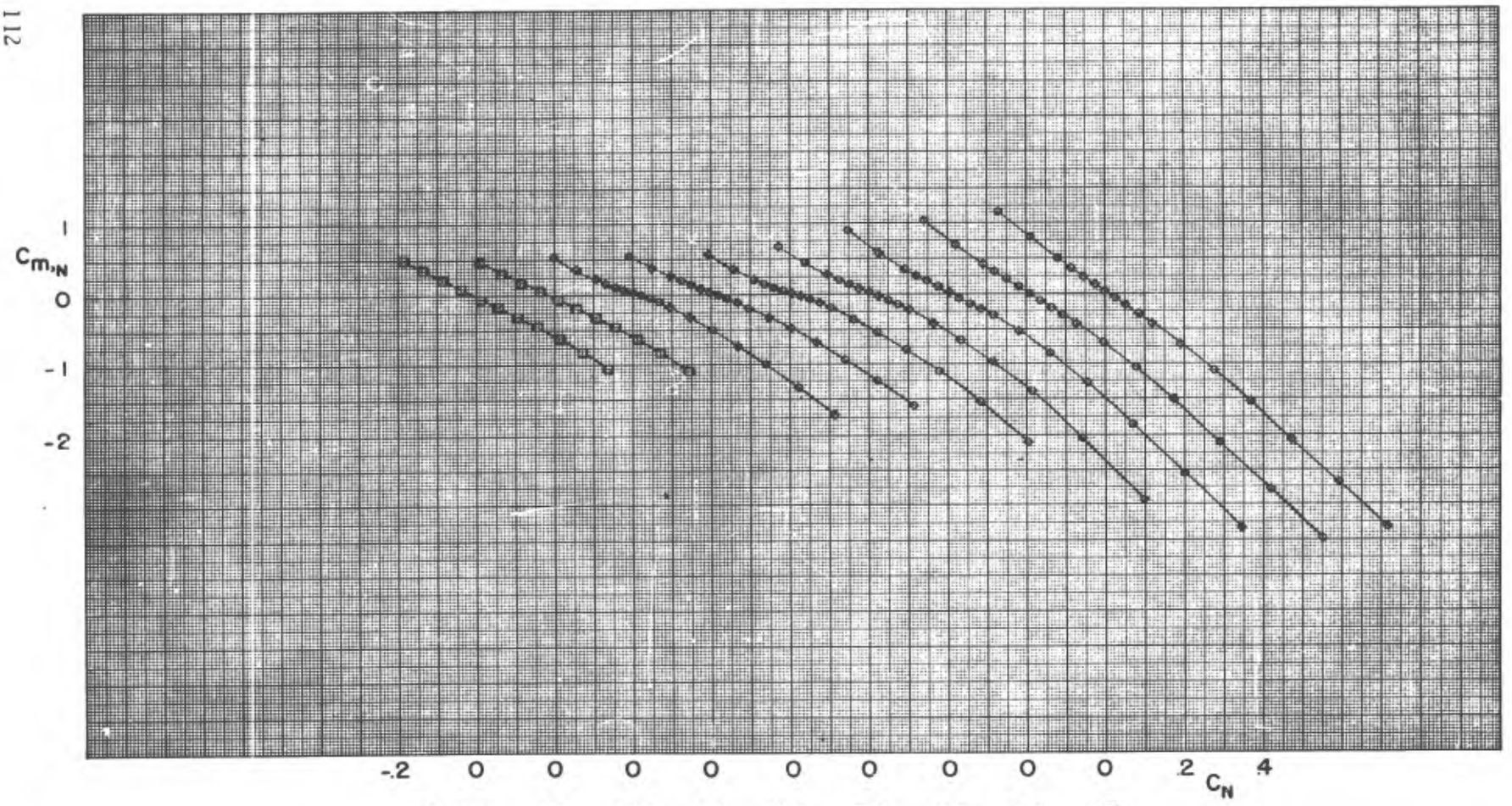
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 51. CONCLUDED



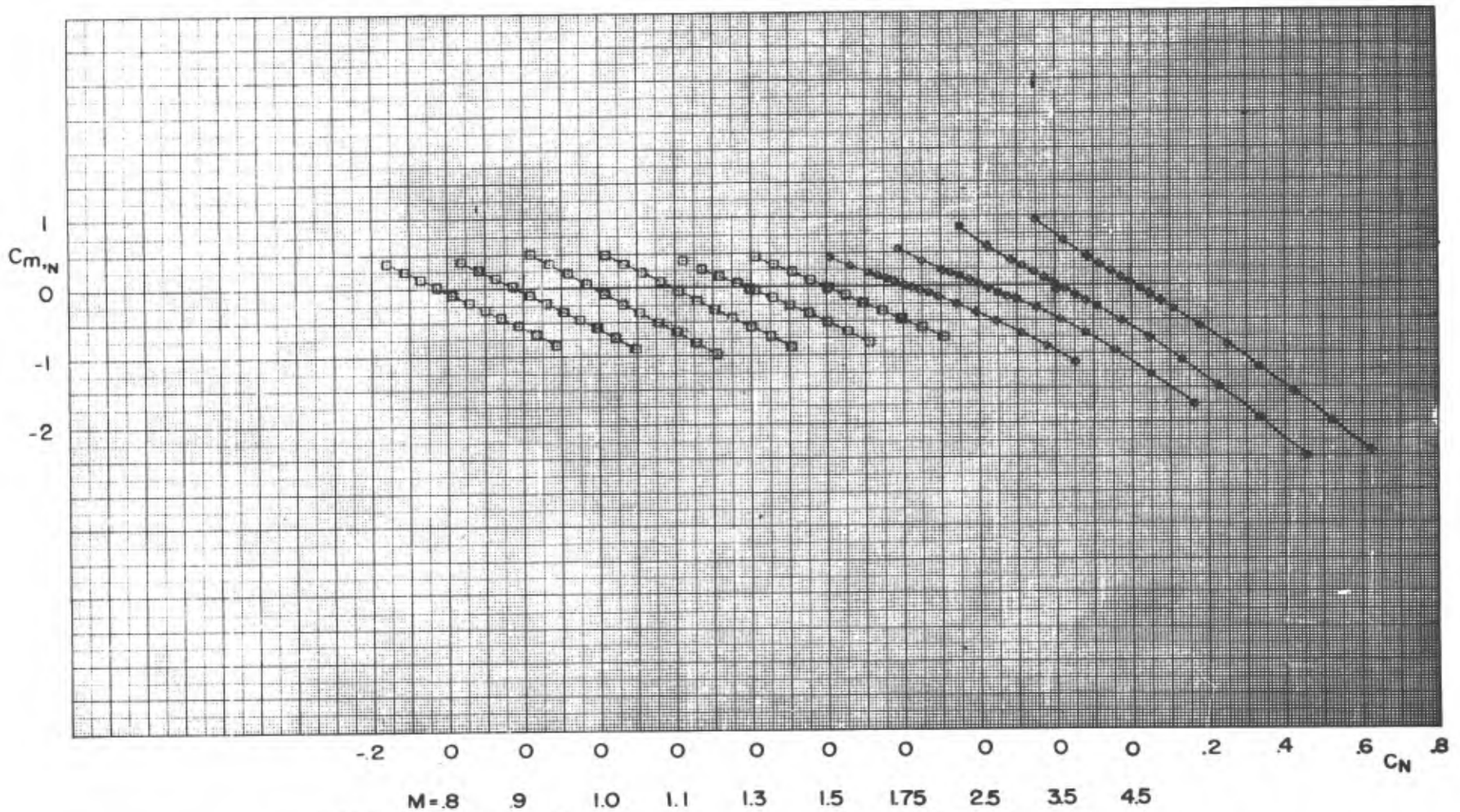
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 52. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 23



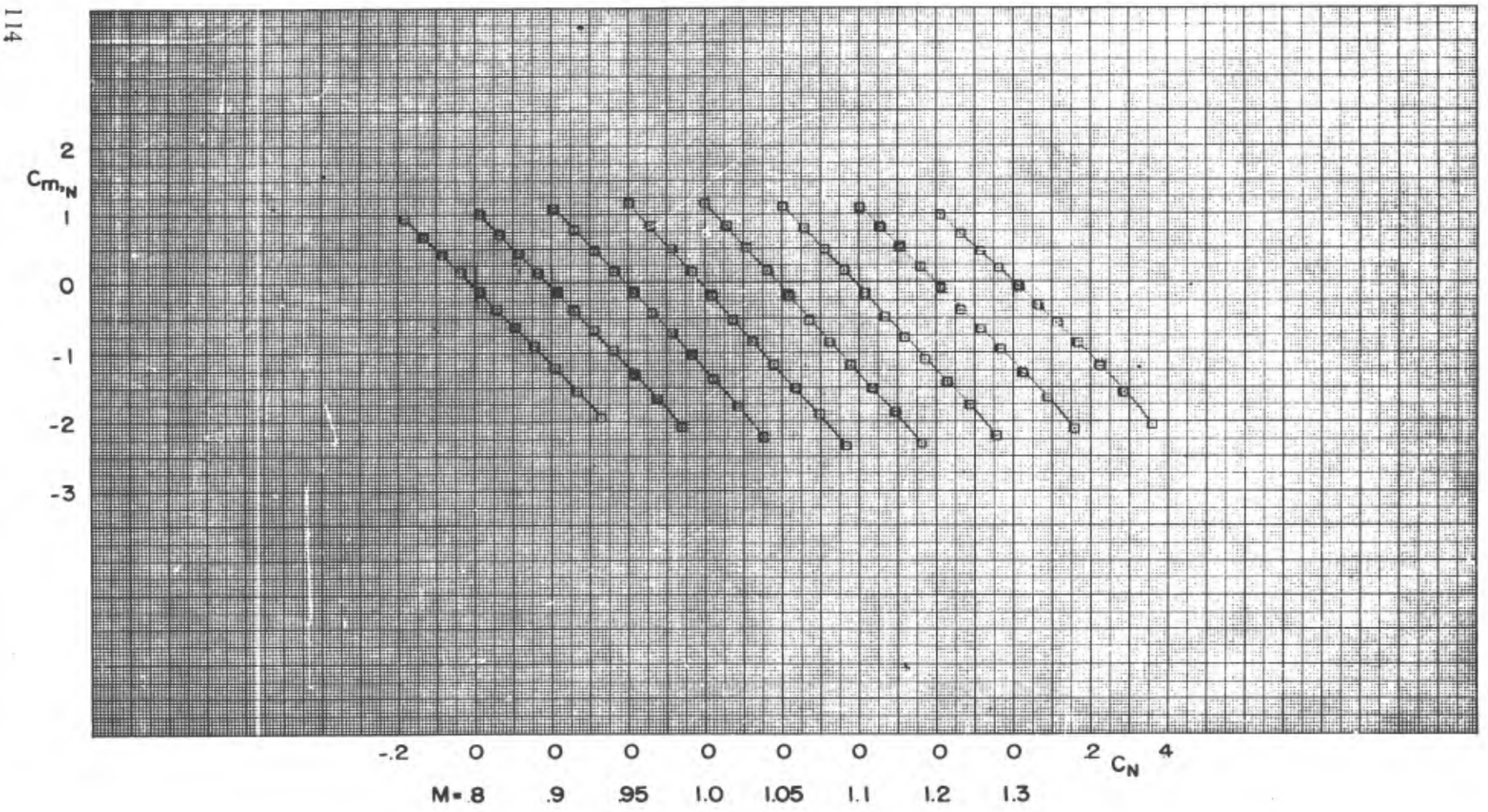
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 52. CONCLUDED



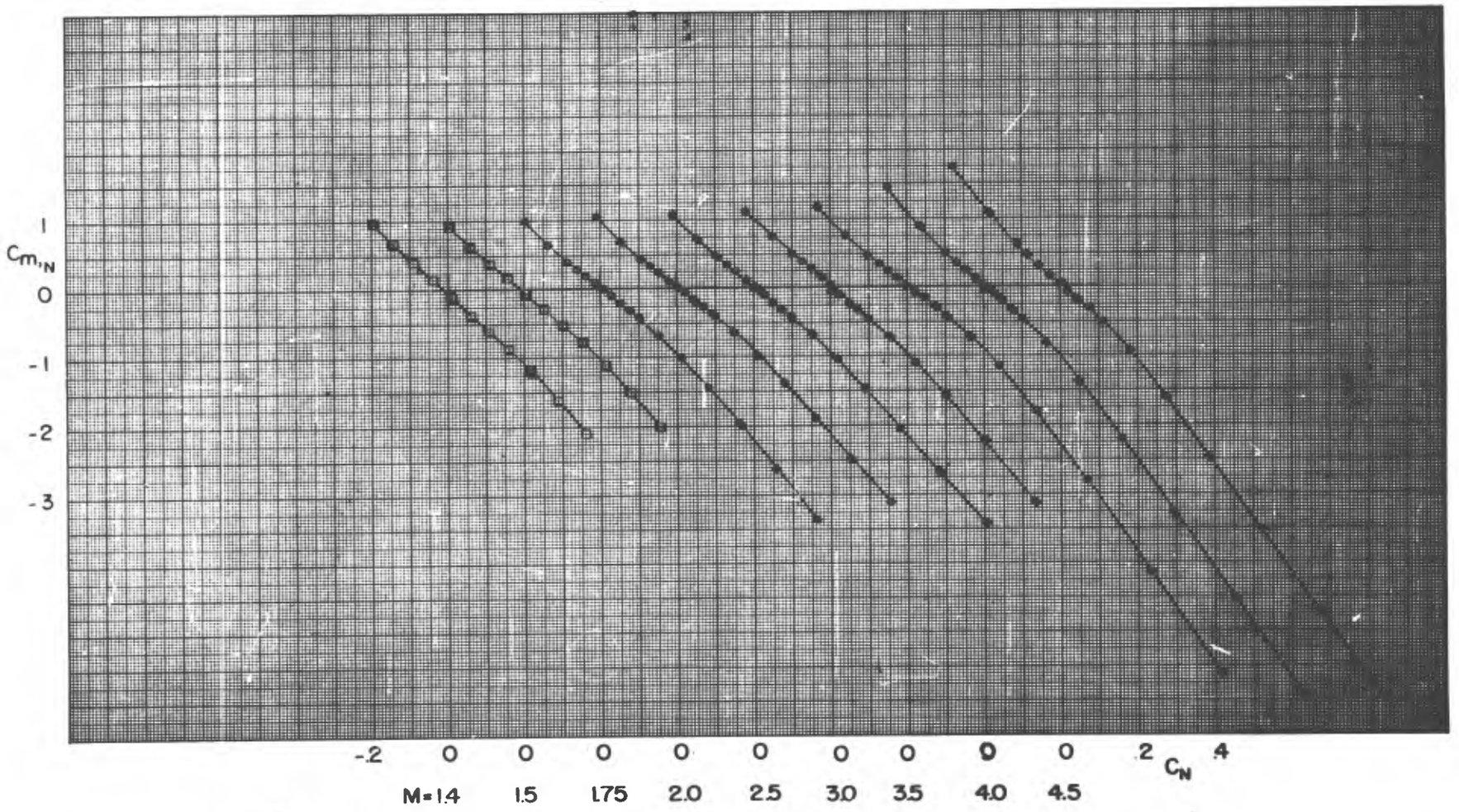
a. MACH NUMBERS 0.8 TO 4.5

FIGURE 53. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 24



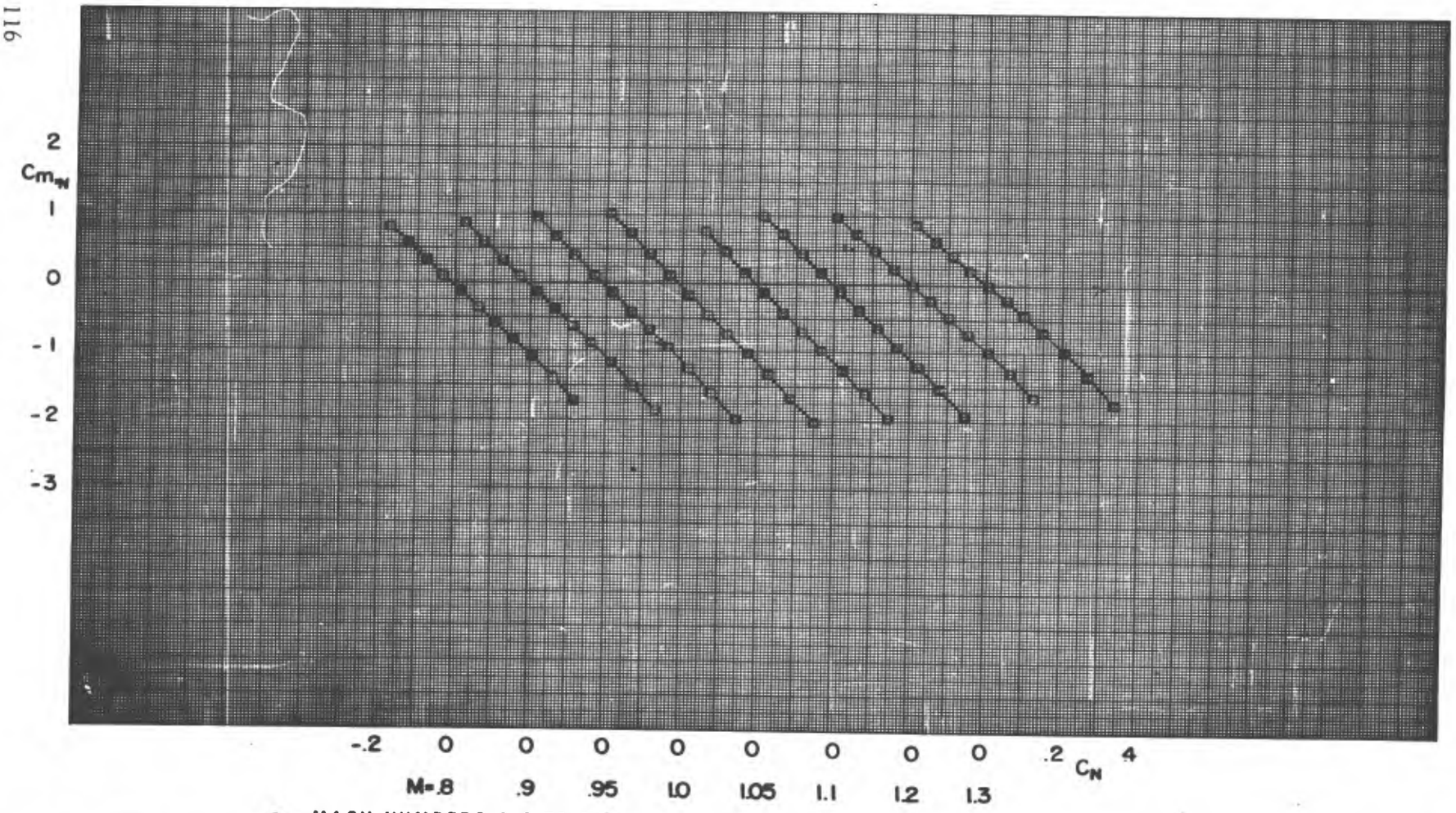
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 54. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 25



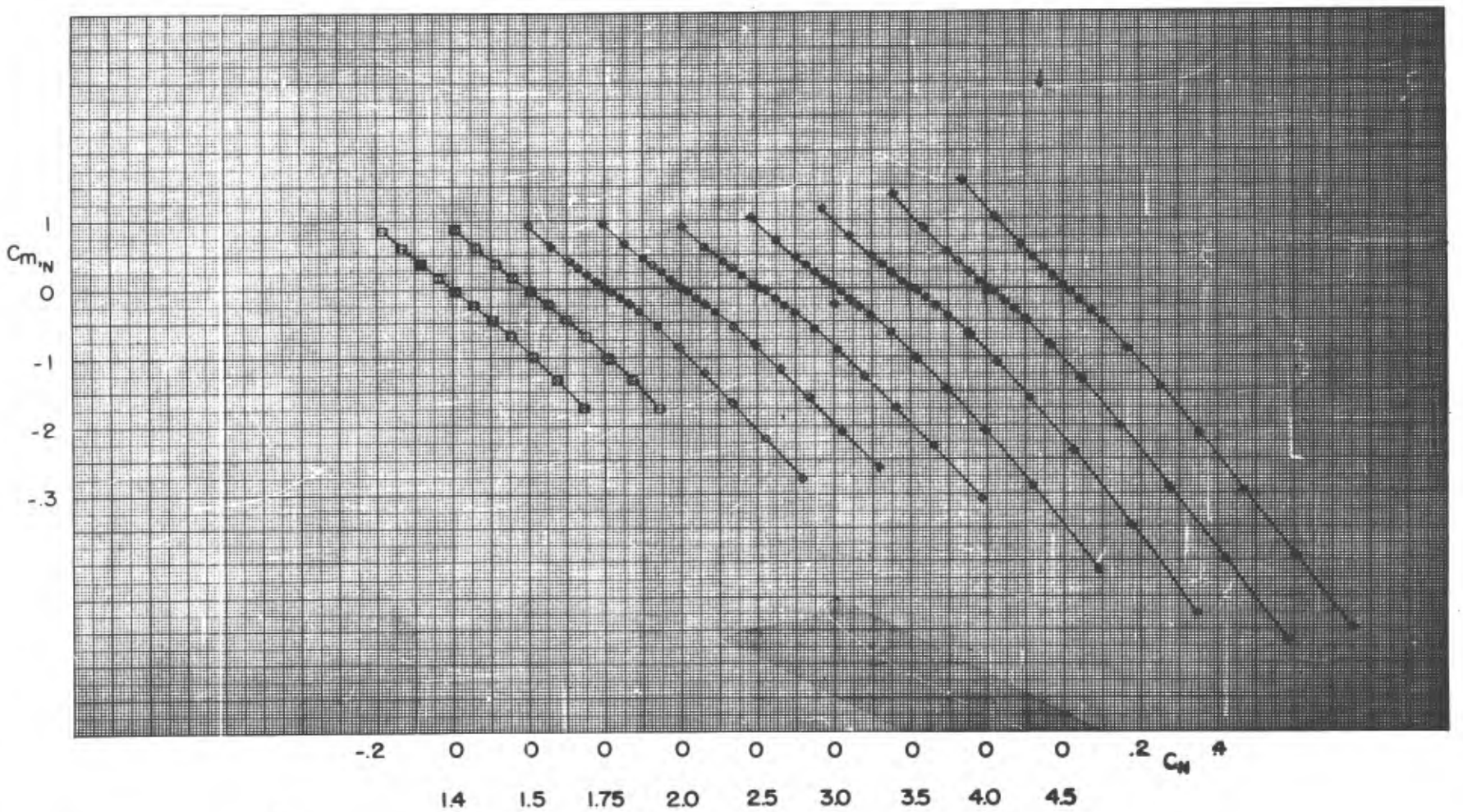
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 54. CONCLUDED



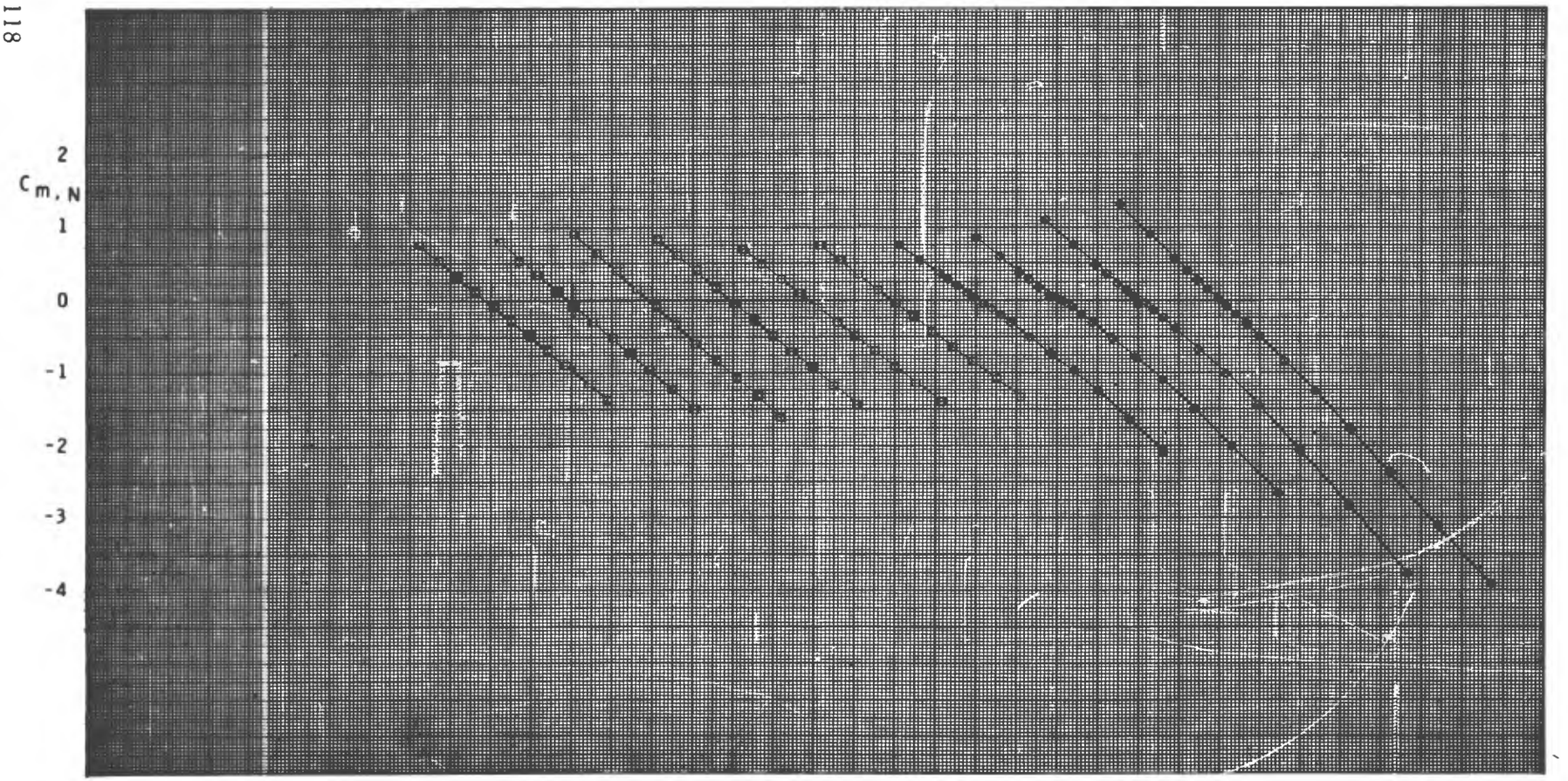
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 55. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 26



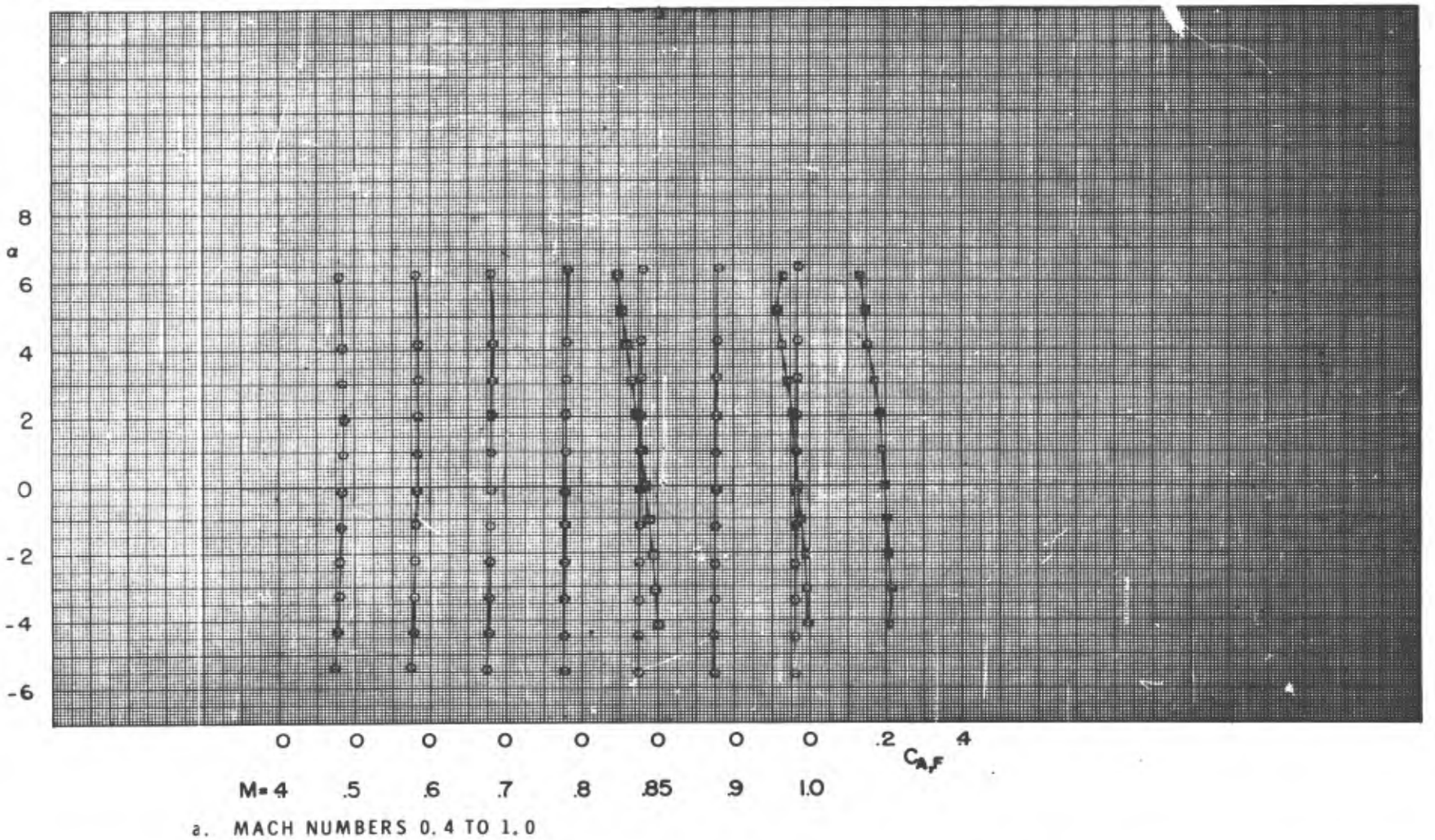
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 55. CONCLUDED



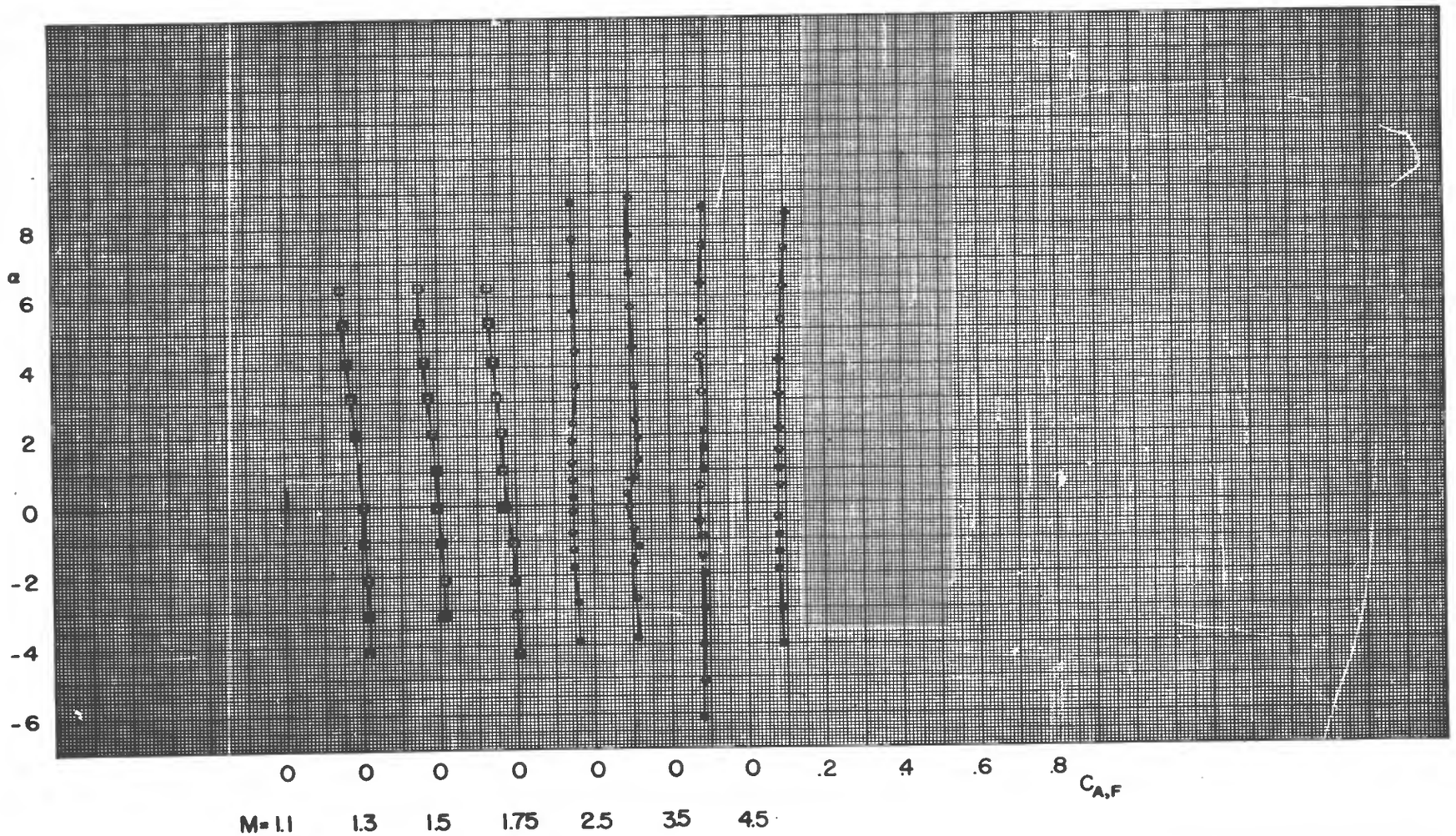
a. MACH NUMBERS 0.8 TO 4.5

FIGURE 56. VARIATION OF PITCHING MOMENT COEFFICIENT WITH NORMAL FORCE COEFFICIENT FOR CONFIGURATION 27



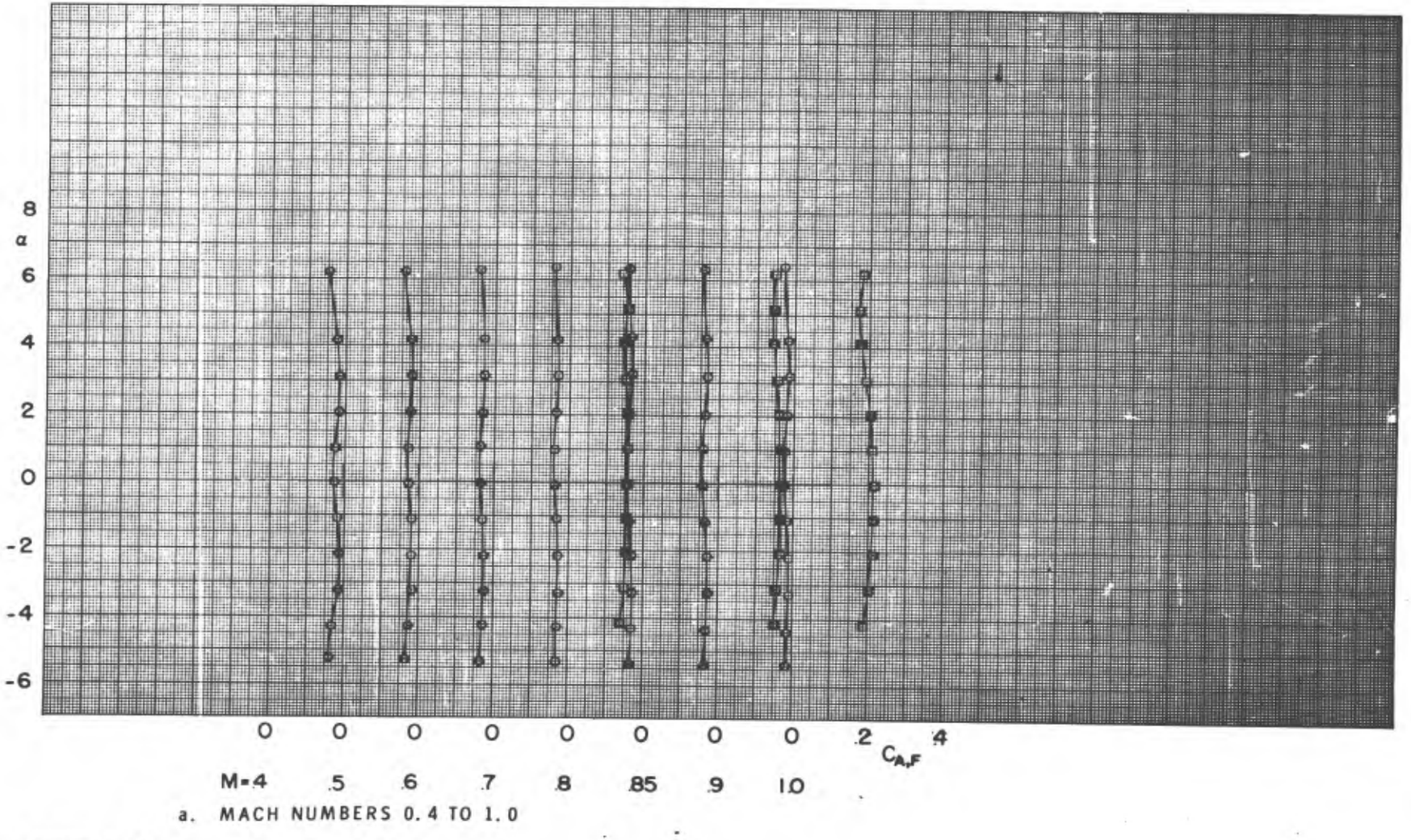
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 57. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 1



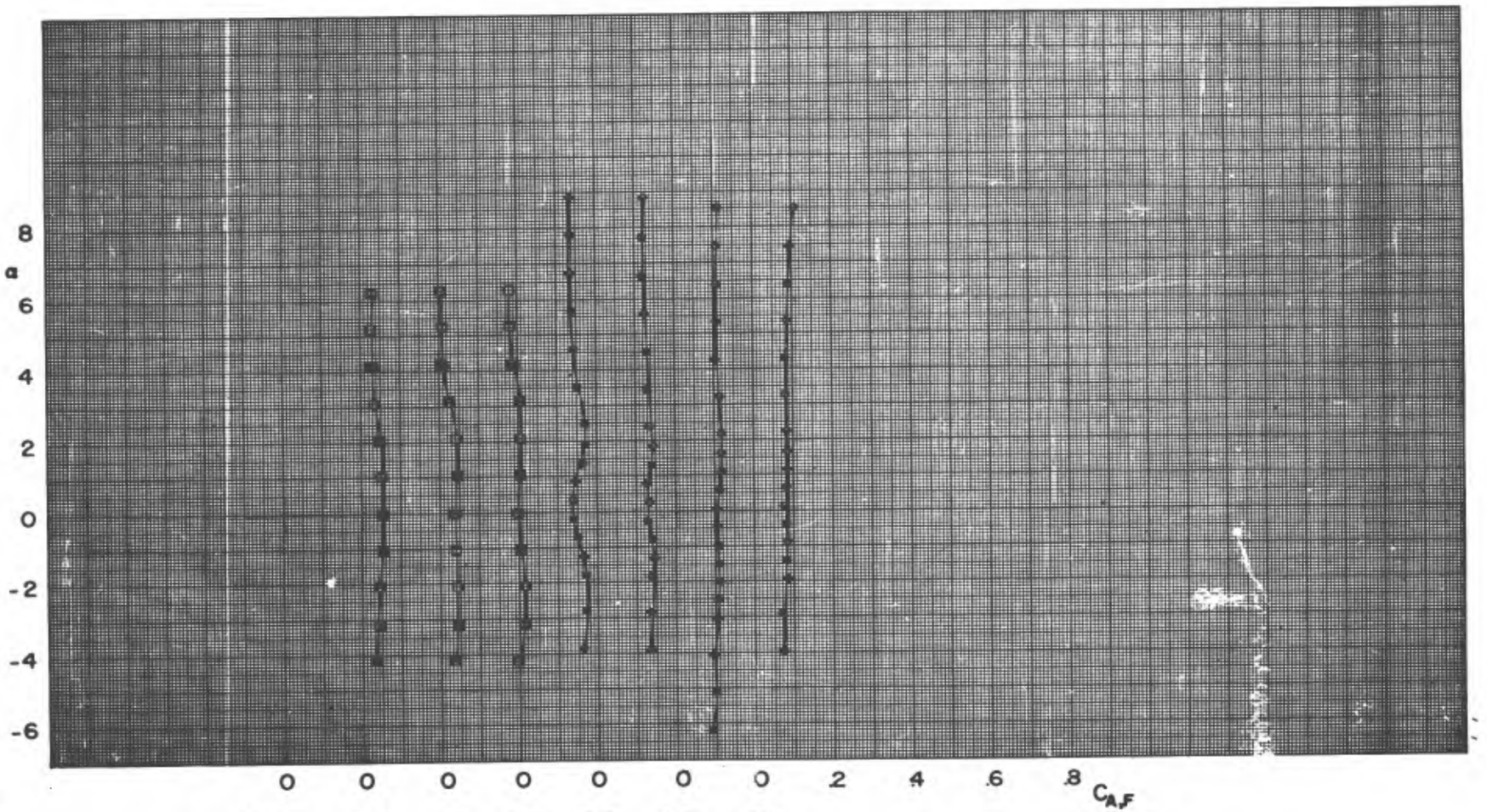
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 57. CONCLUDED



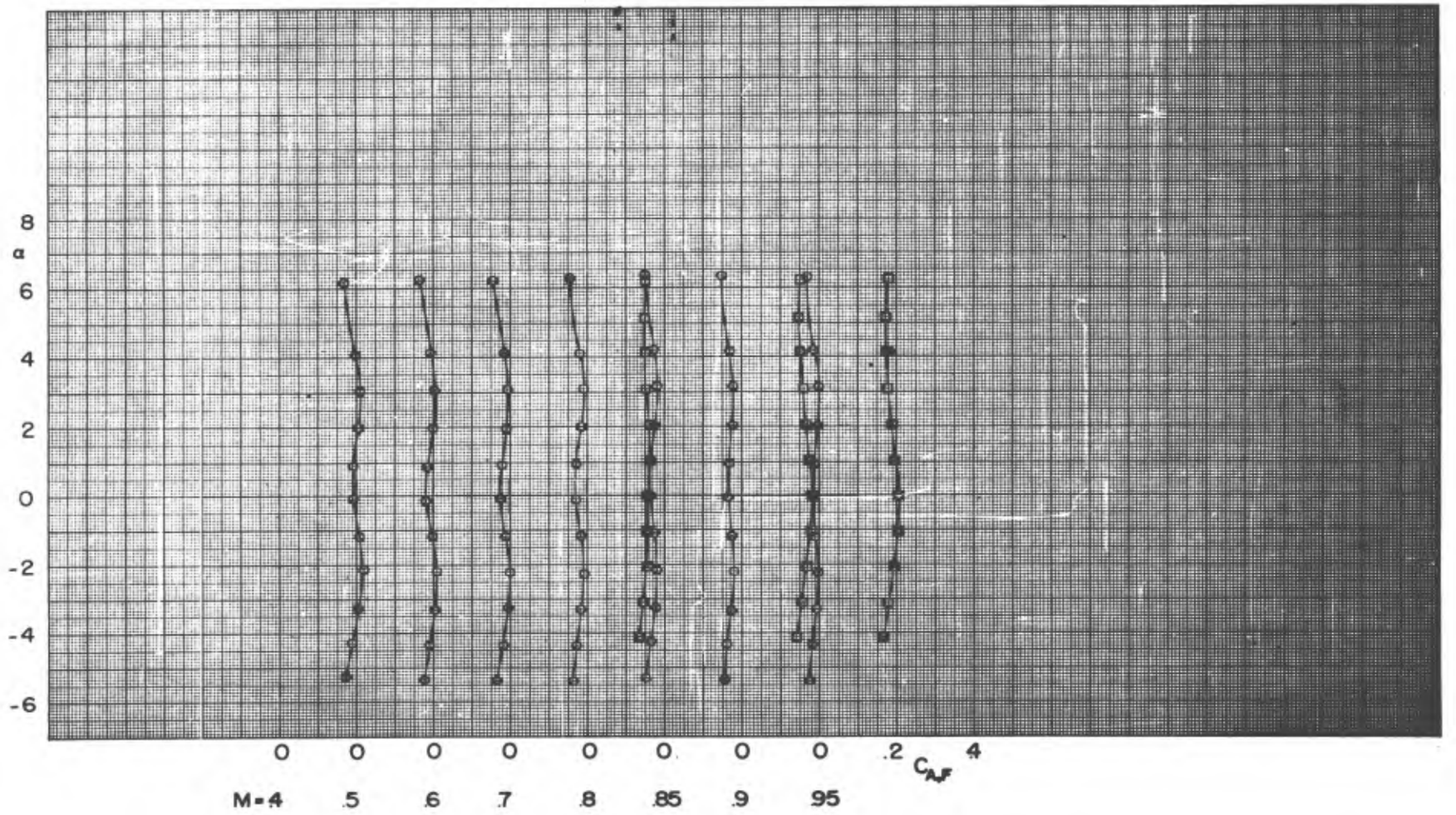
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 58. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 2



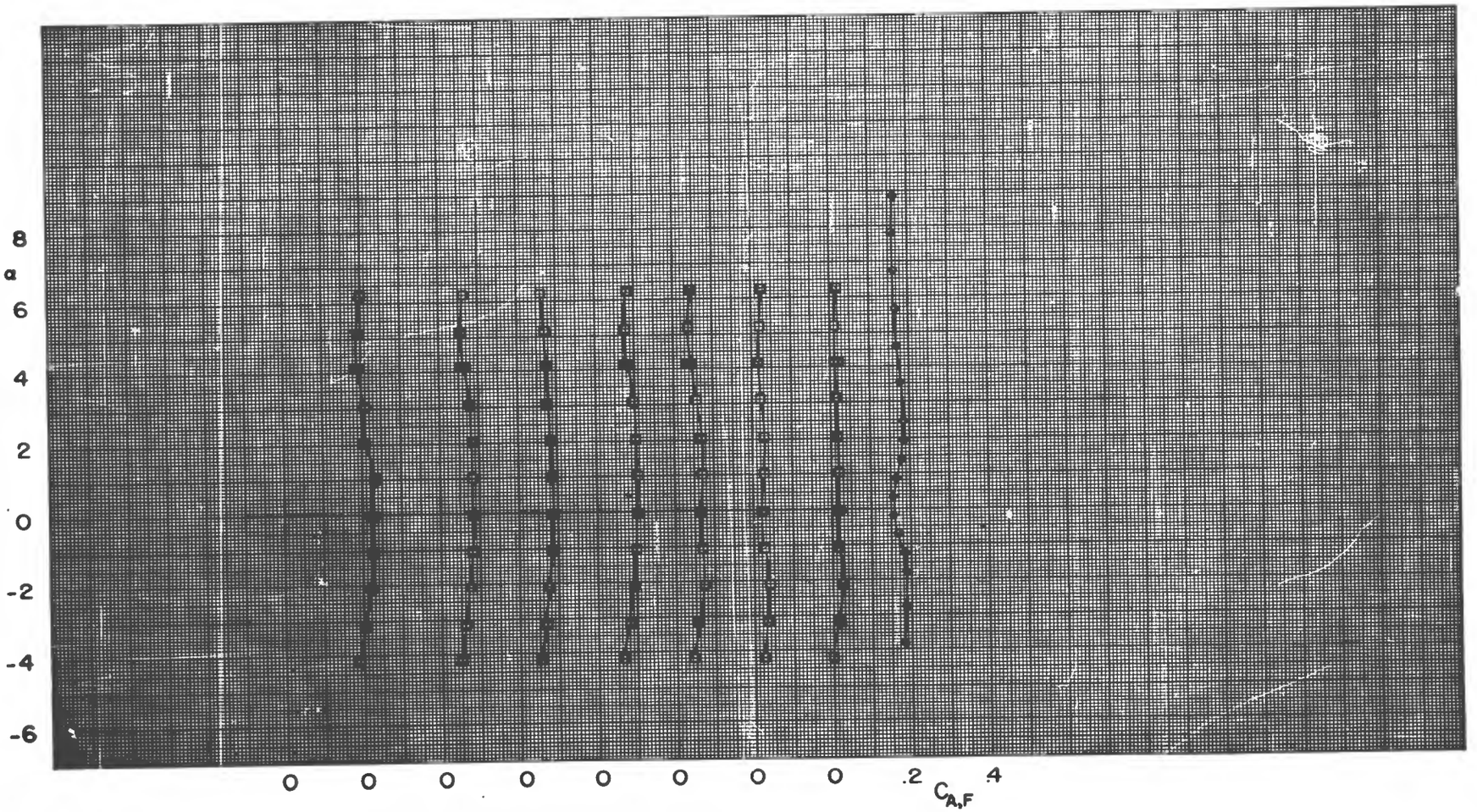
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 58. CONCLUDED



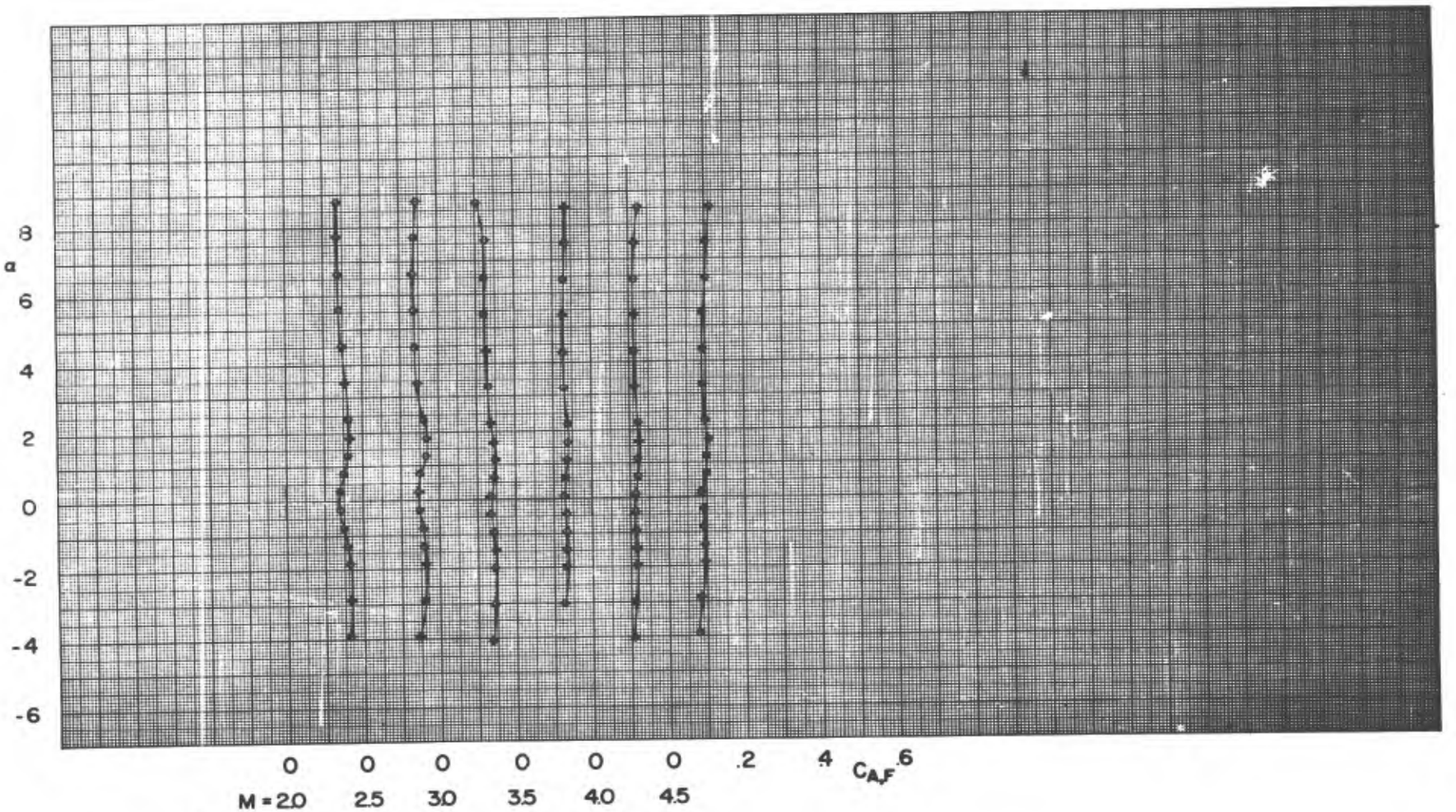
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 59. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 3



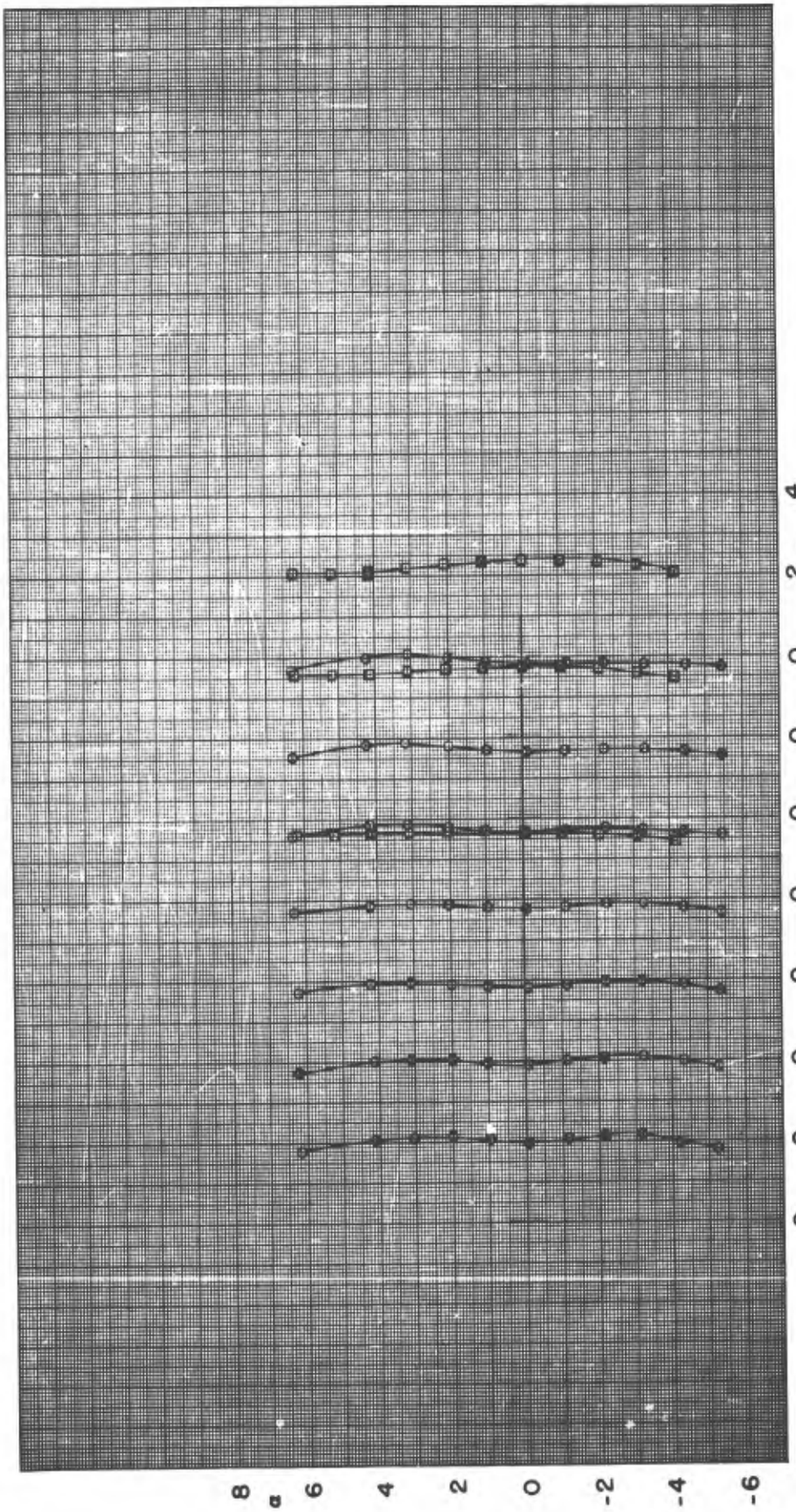
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 59. CONTINUED



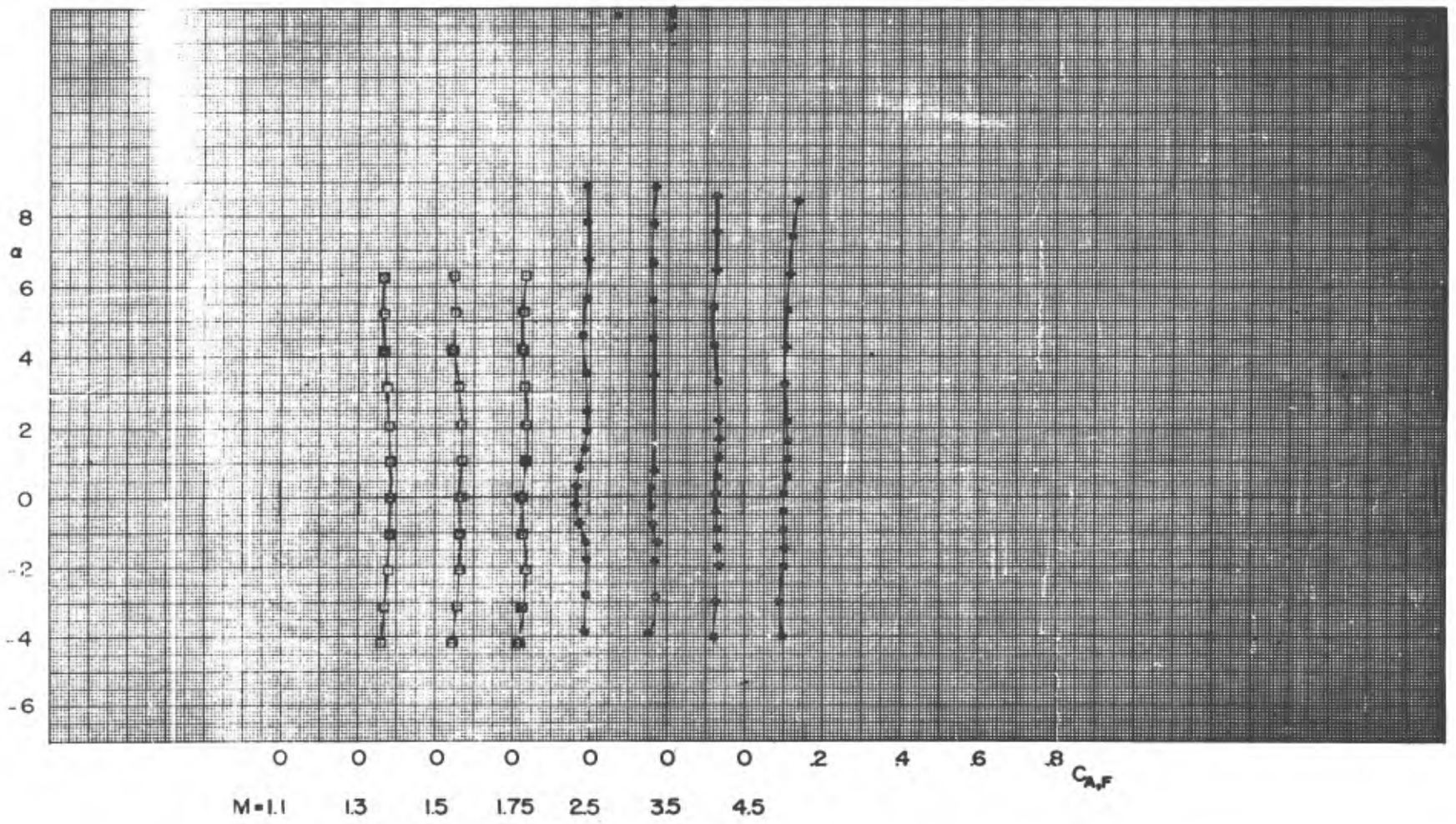
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 59. CONCLUDED



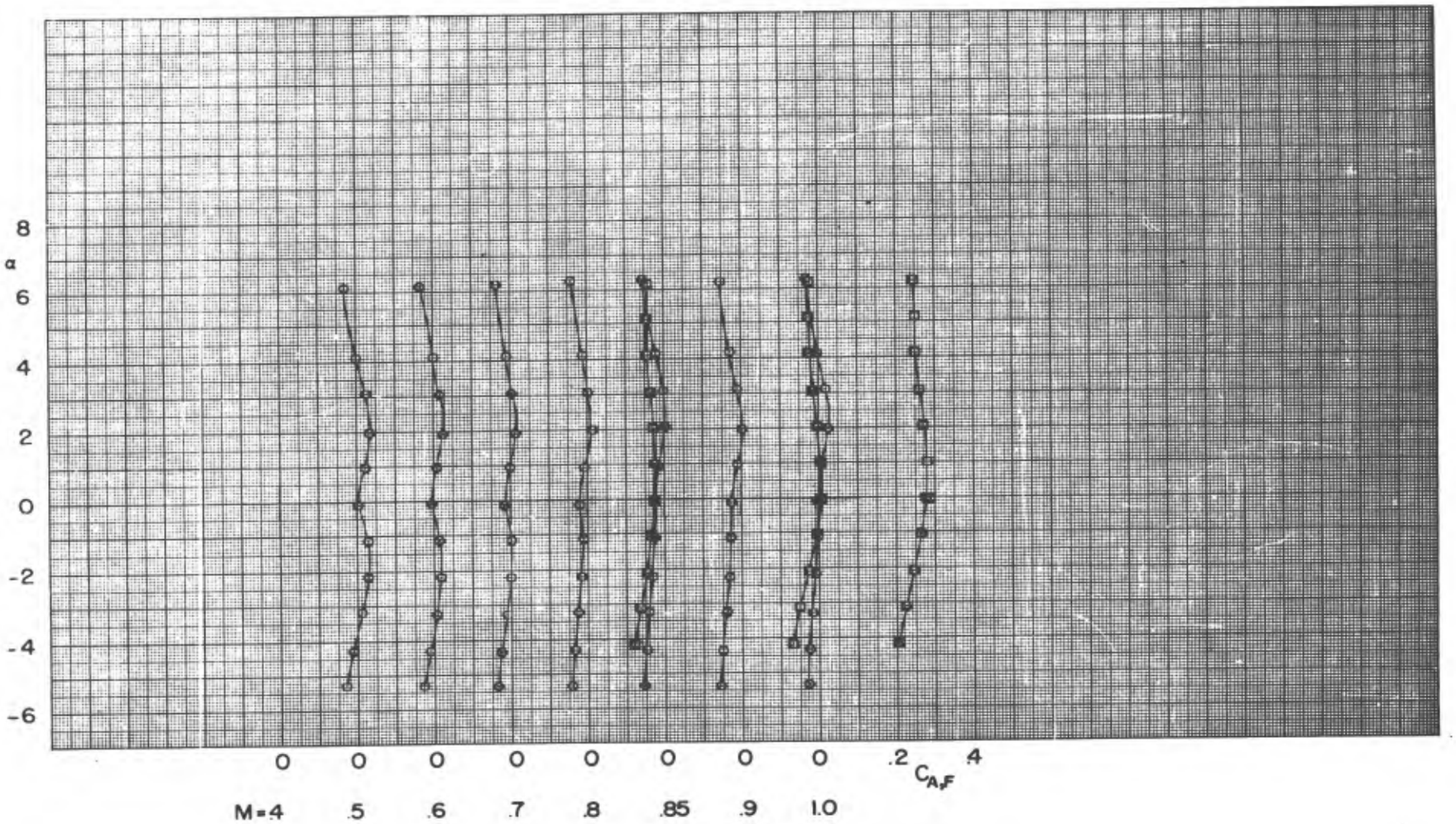
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 60. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 4



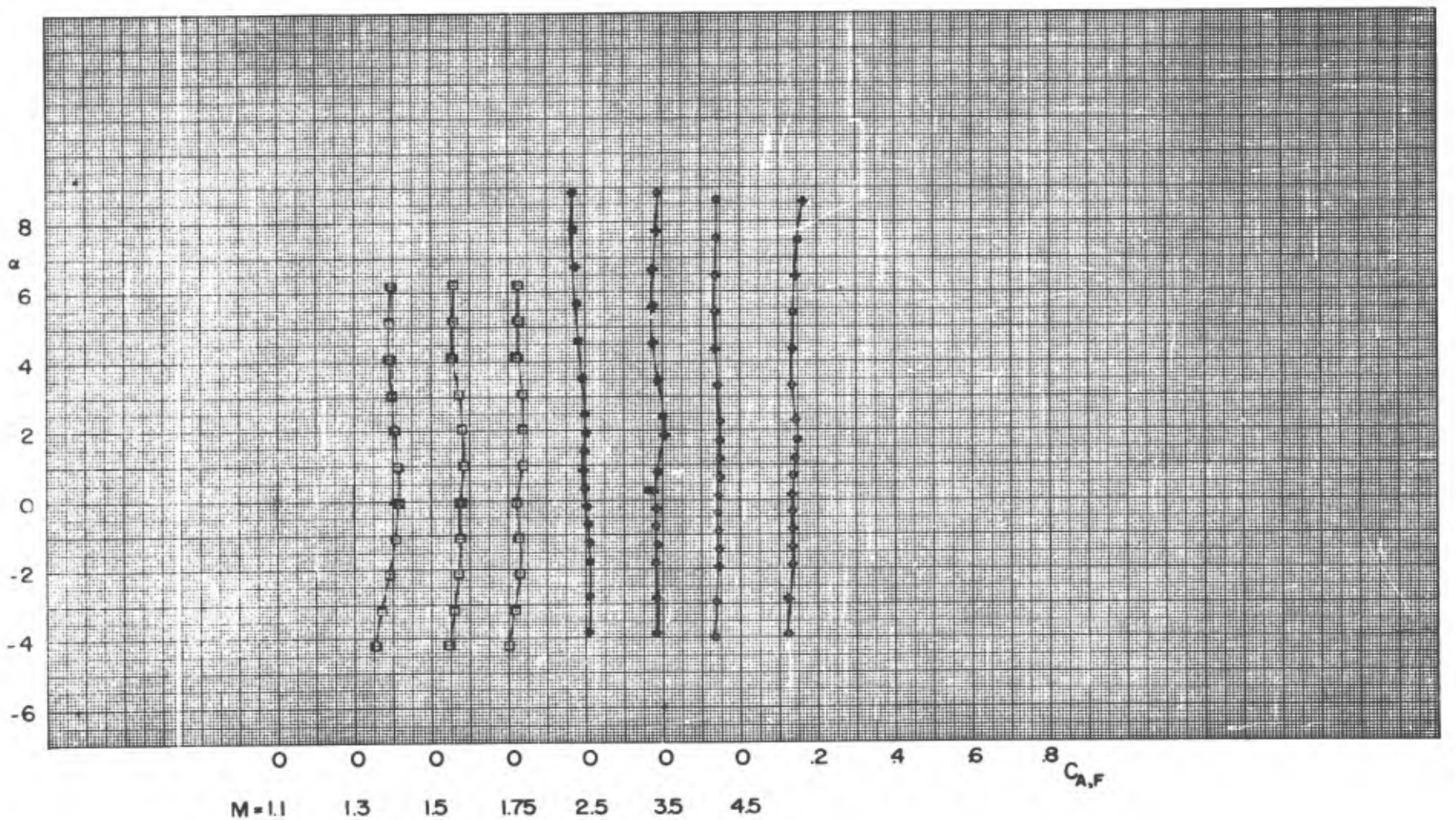
b MACH NUMBERS 1.1 TO 4.5

FIGURE 60. CONCLUDED



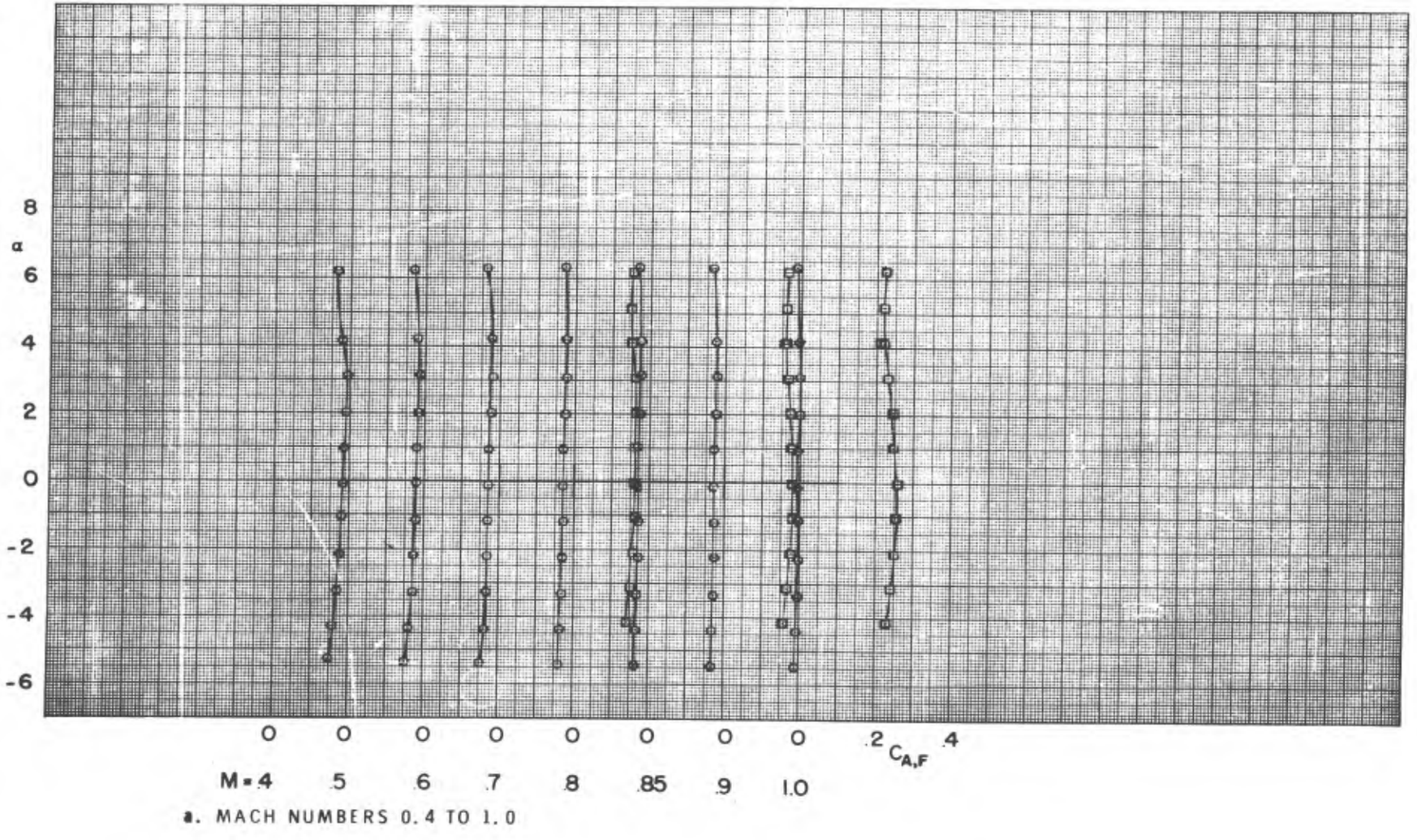
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 61. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 5



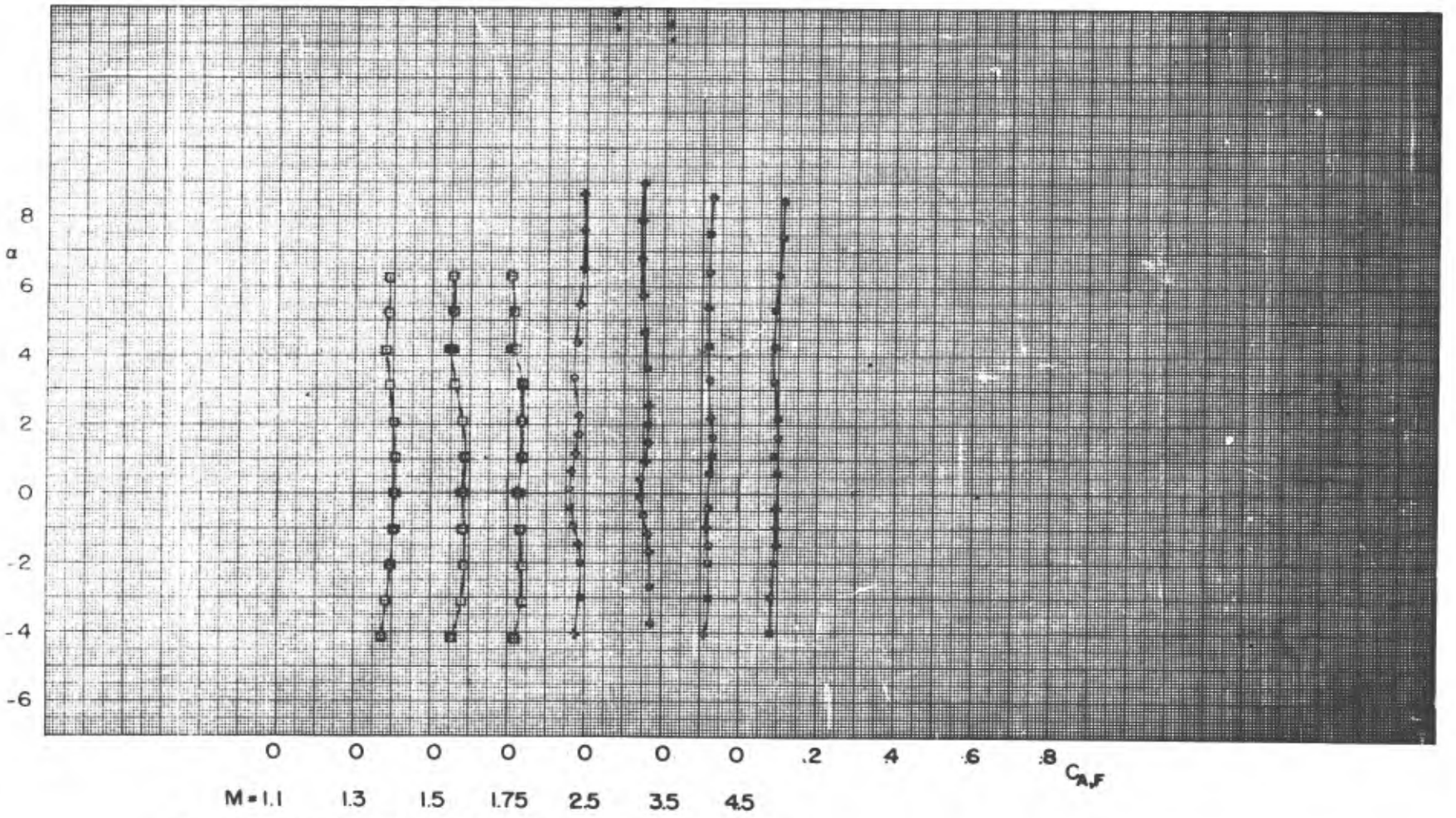
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 61. CONCLUDED



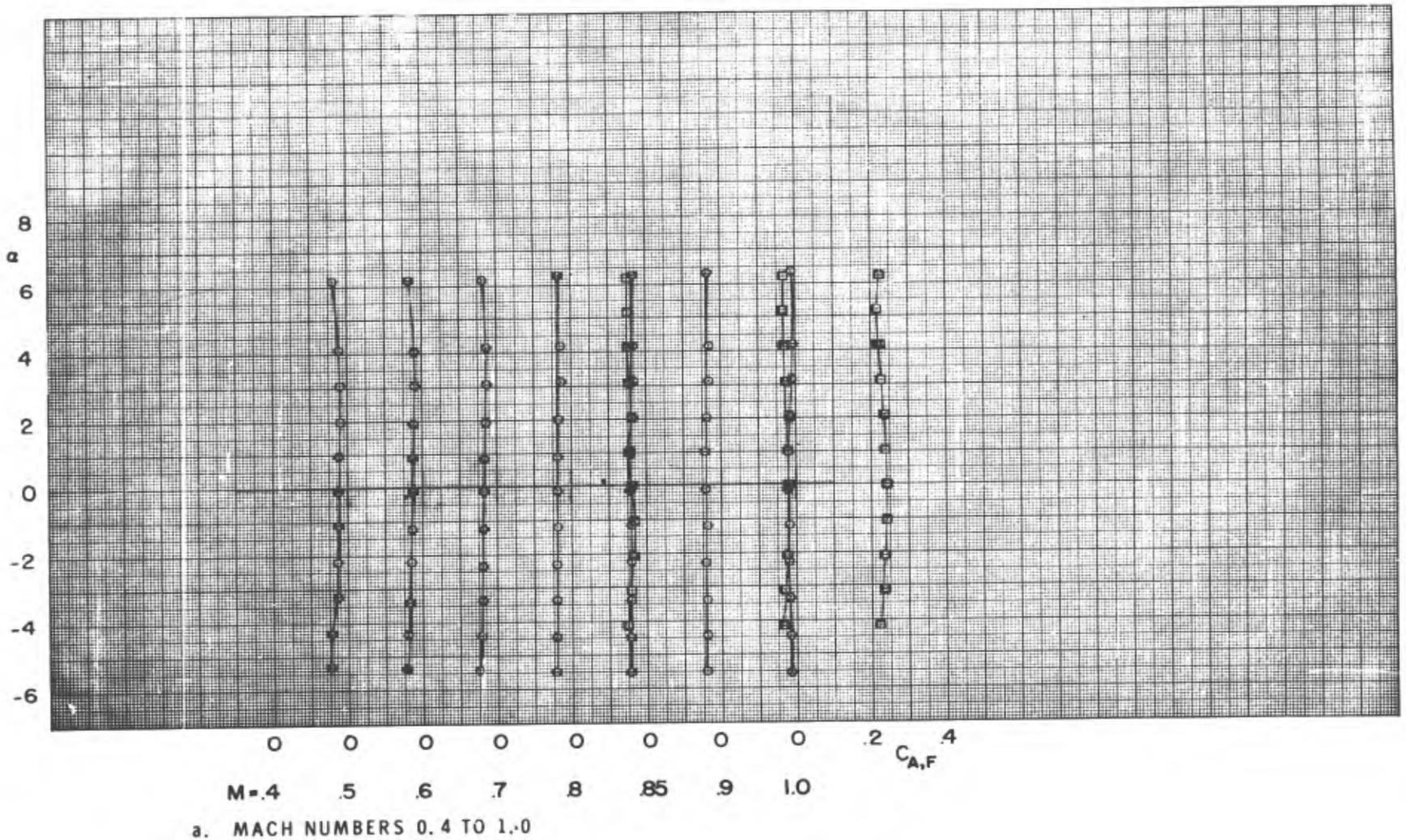
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 62. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 6



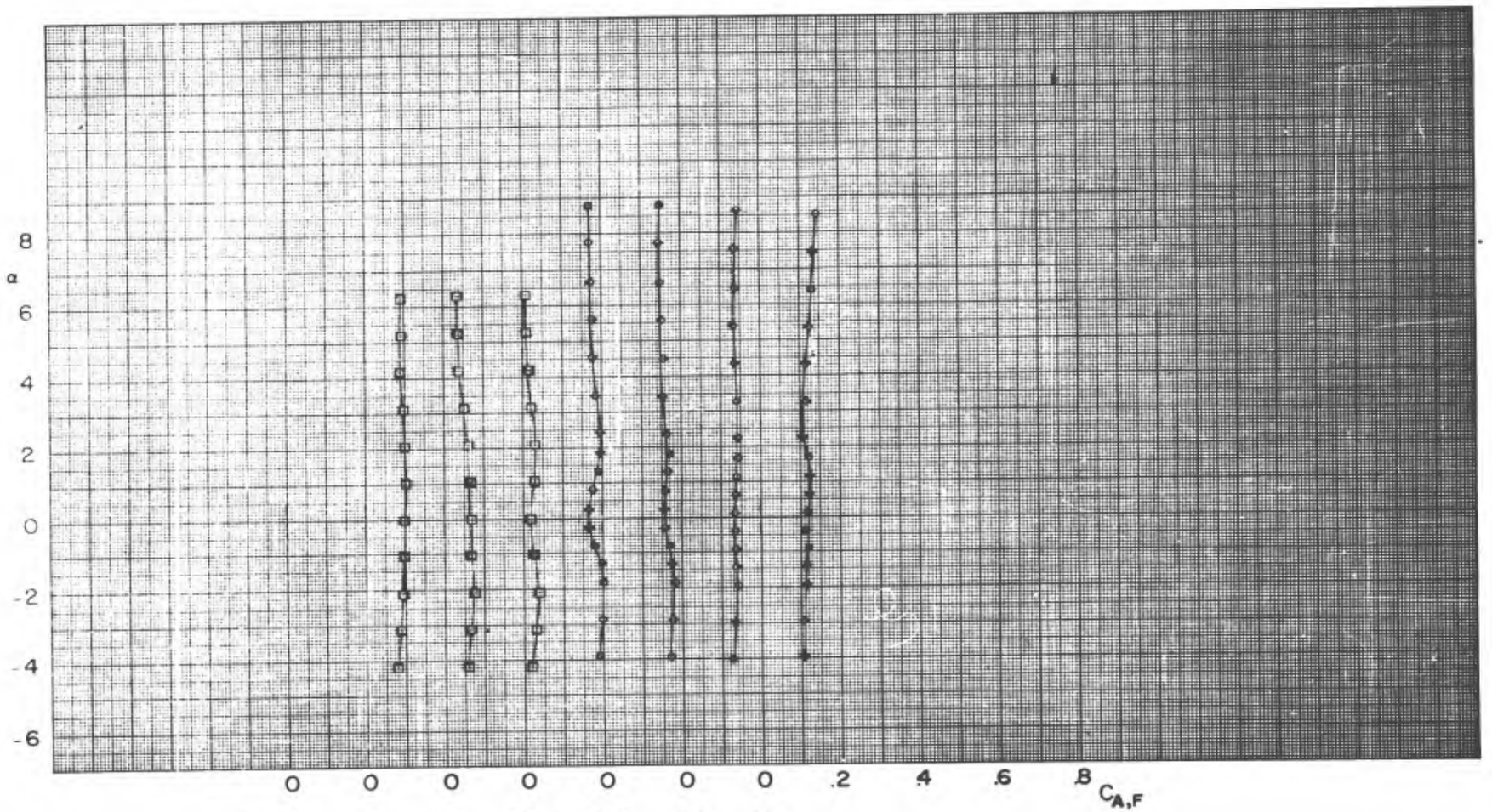
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 62. CONCLUDED



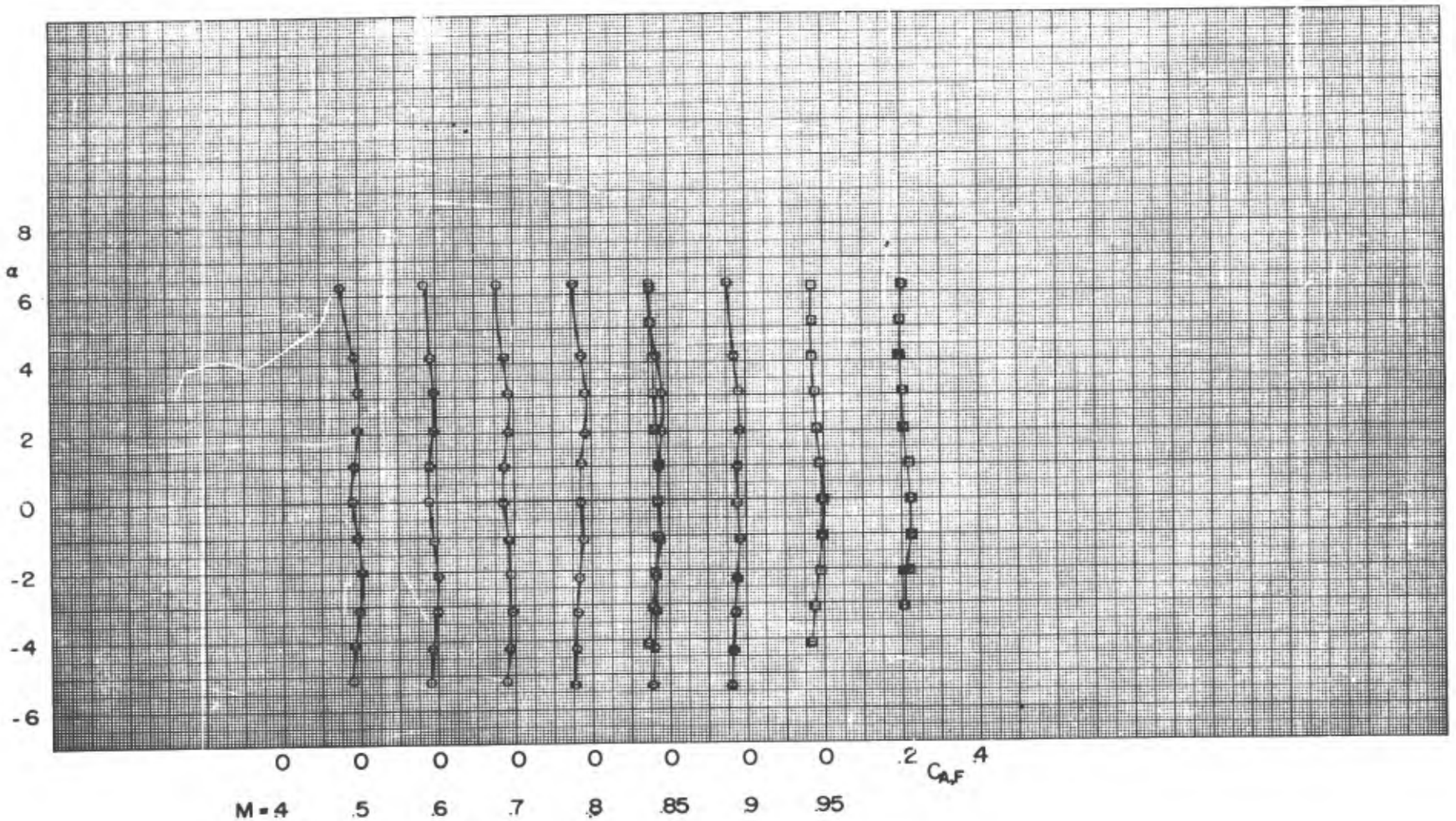
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 63. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 7



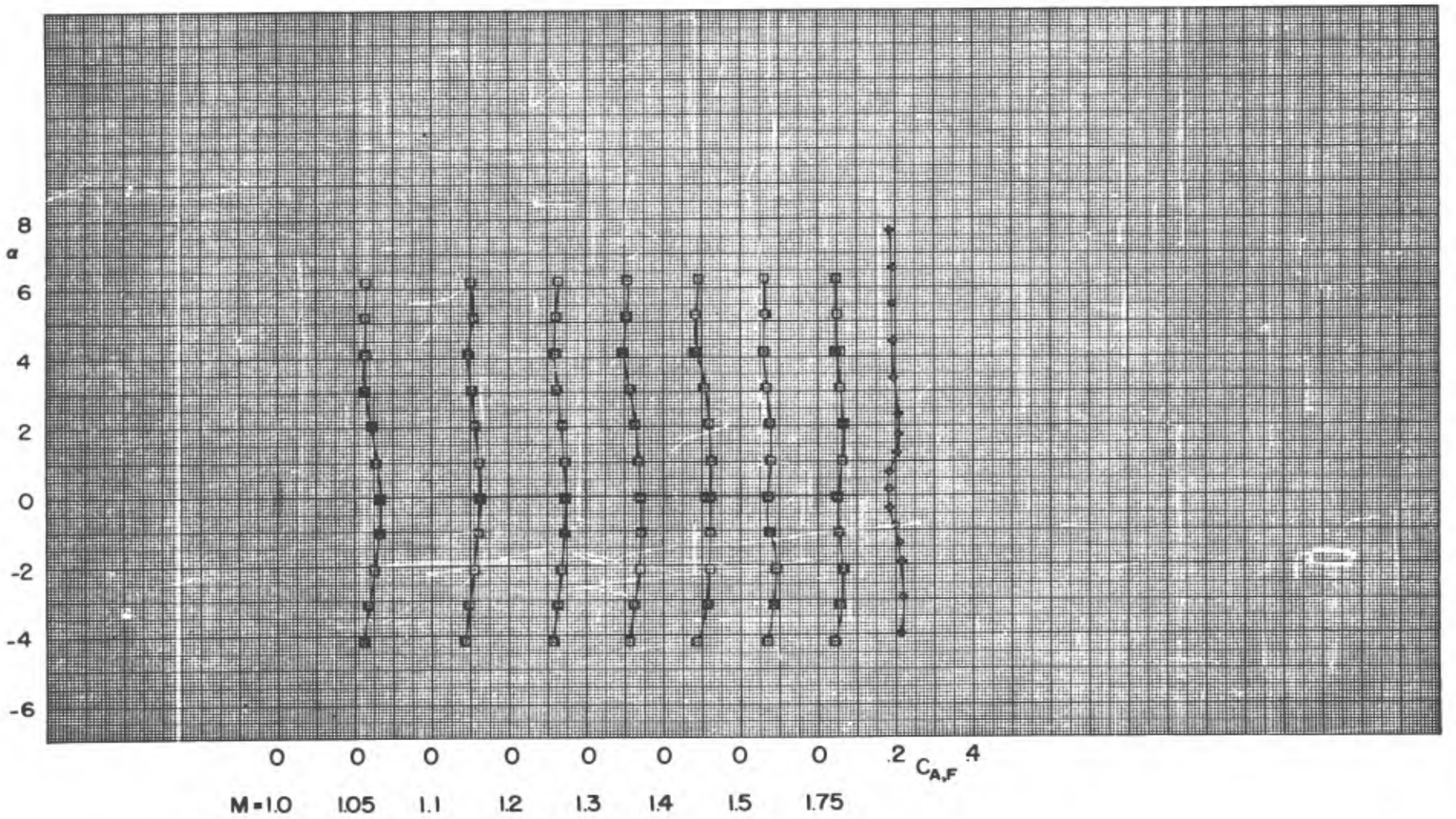
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 63. CONCLUDED



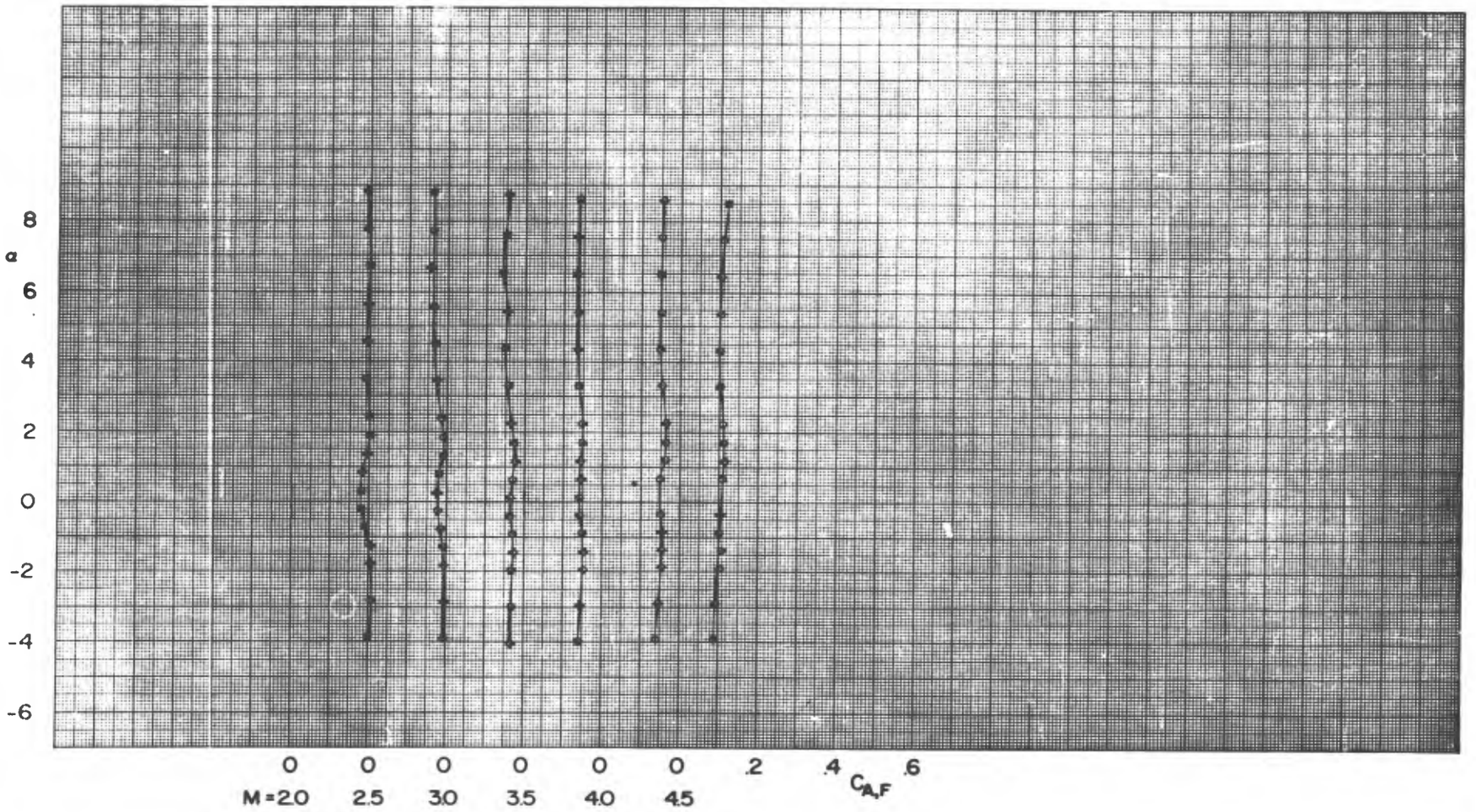
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 64. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 8



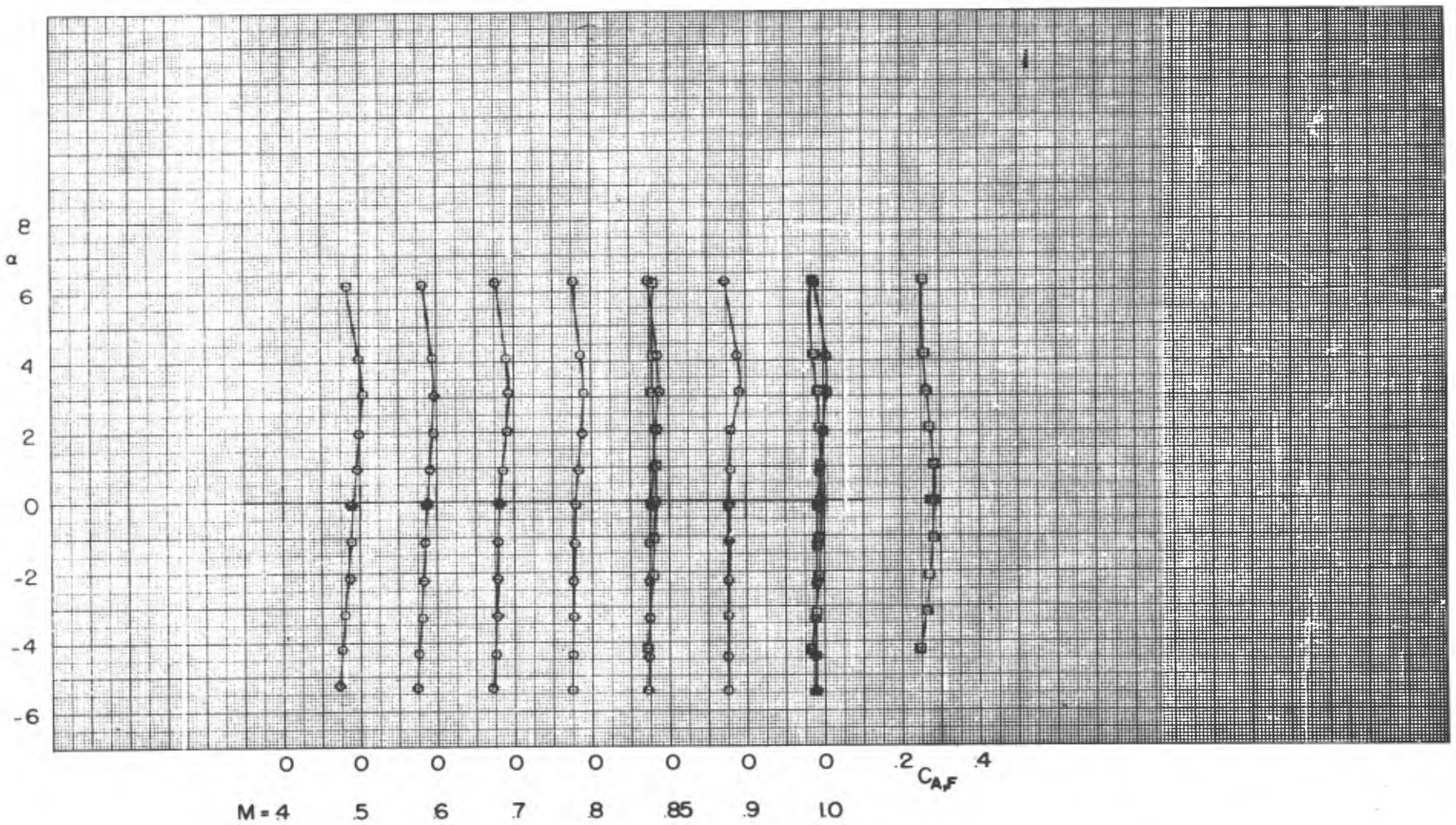
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 64. CONTINUED



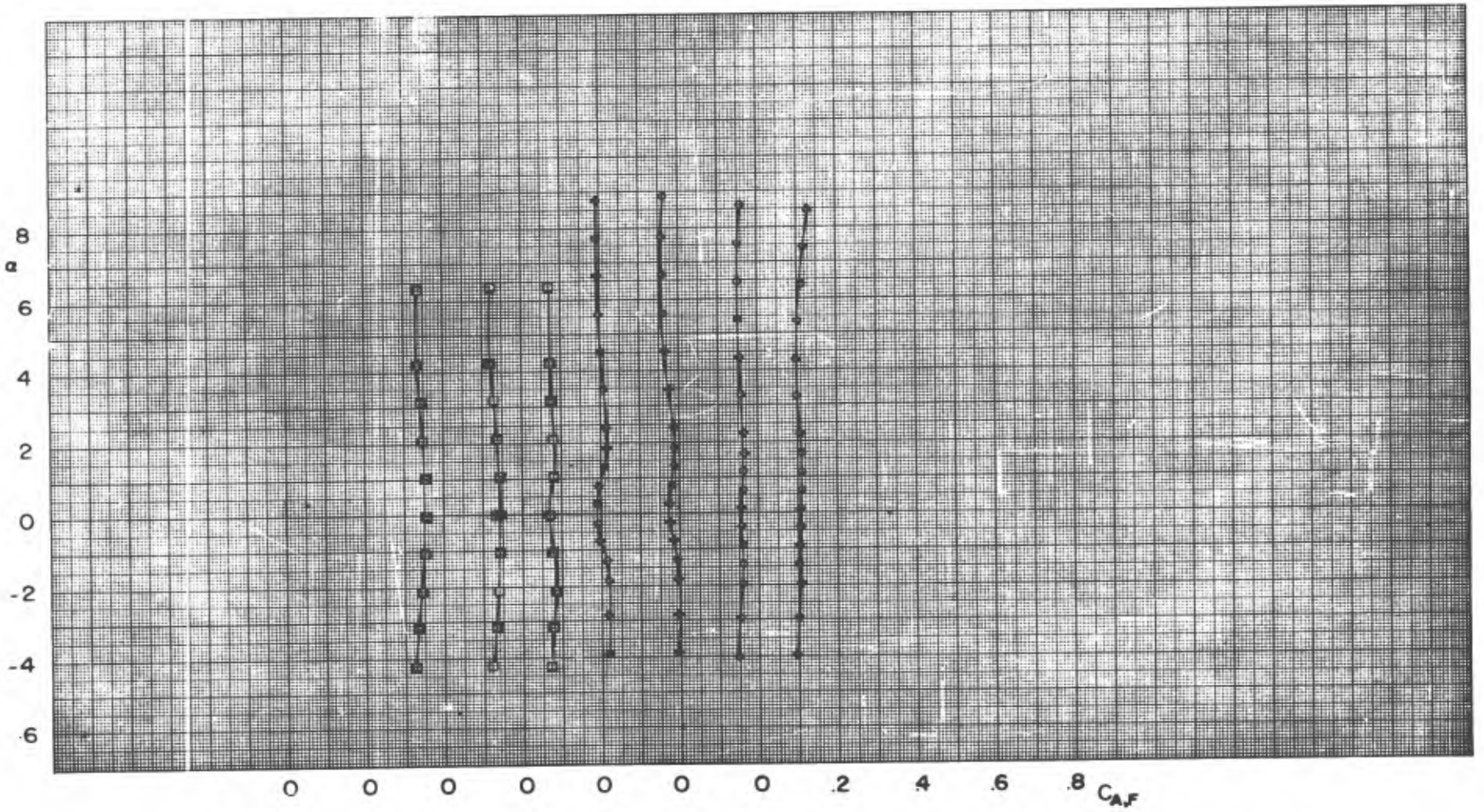
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 64. CONCLUDED



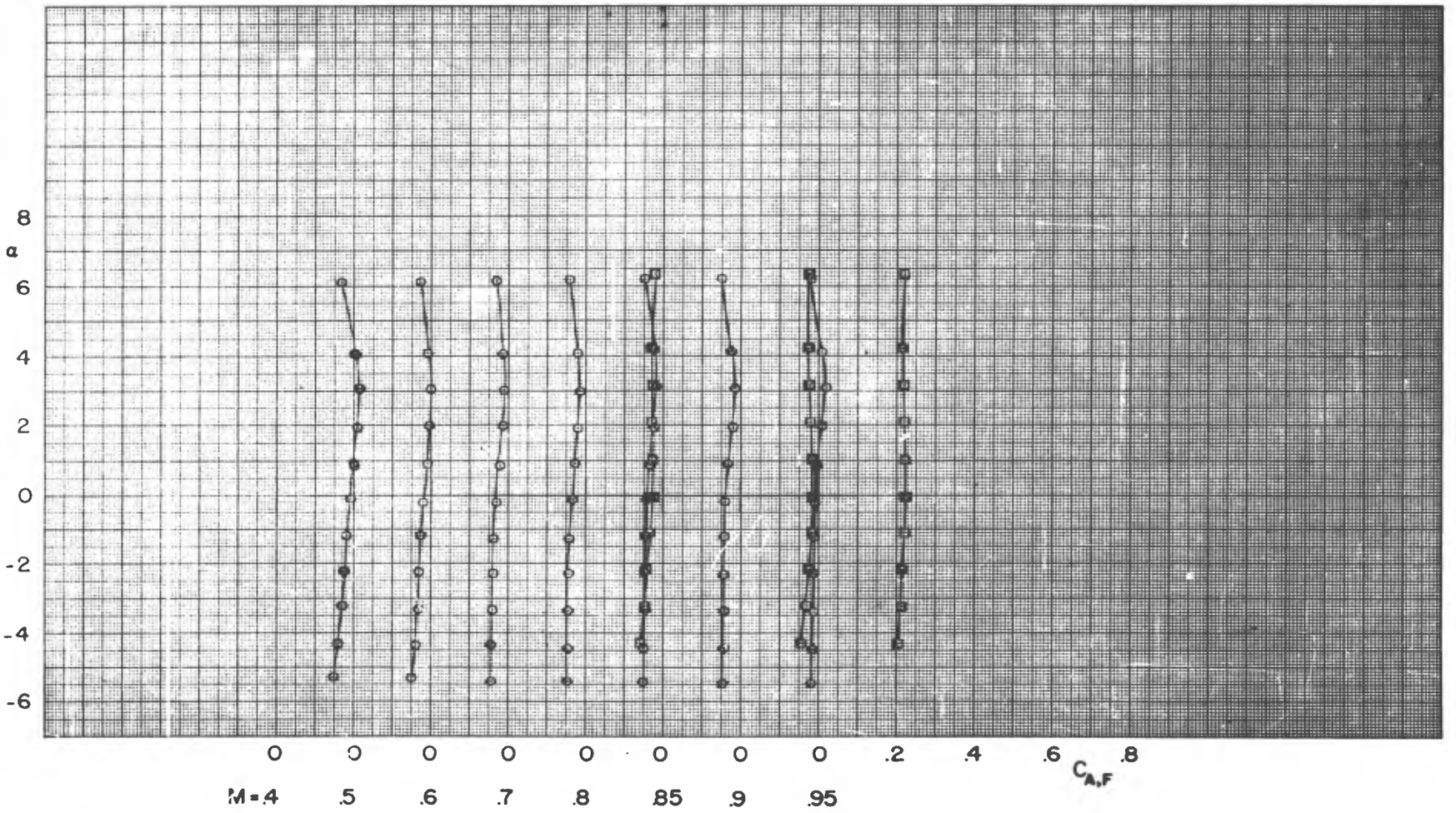
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 65 VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 9



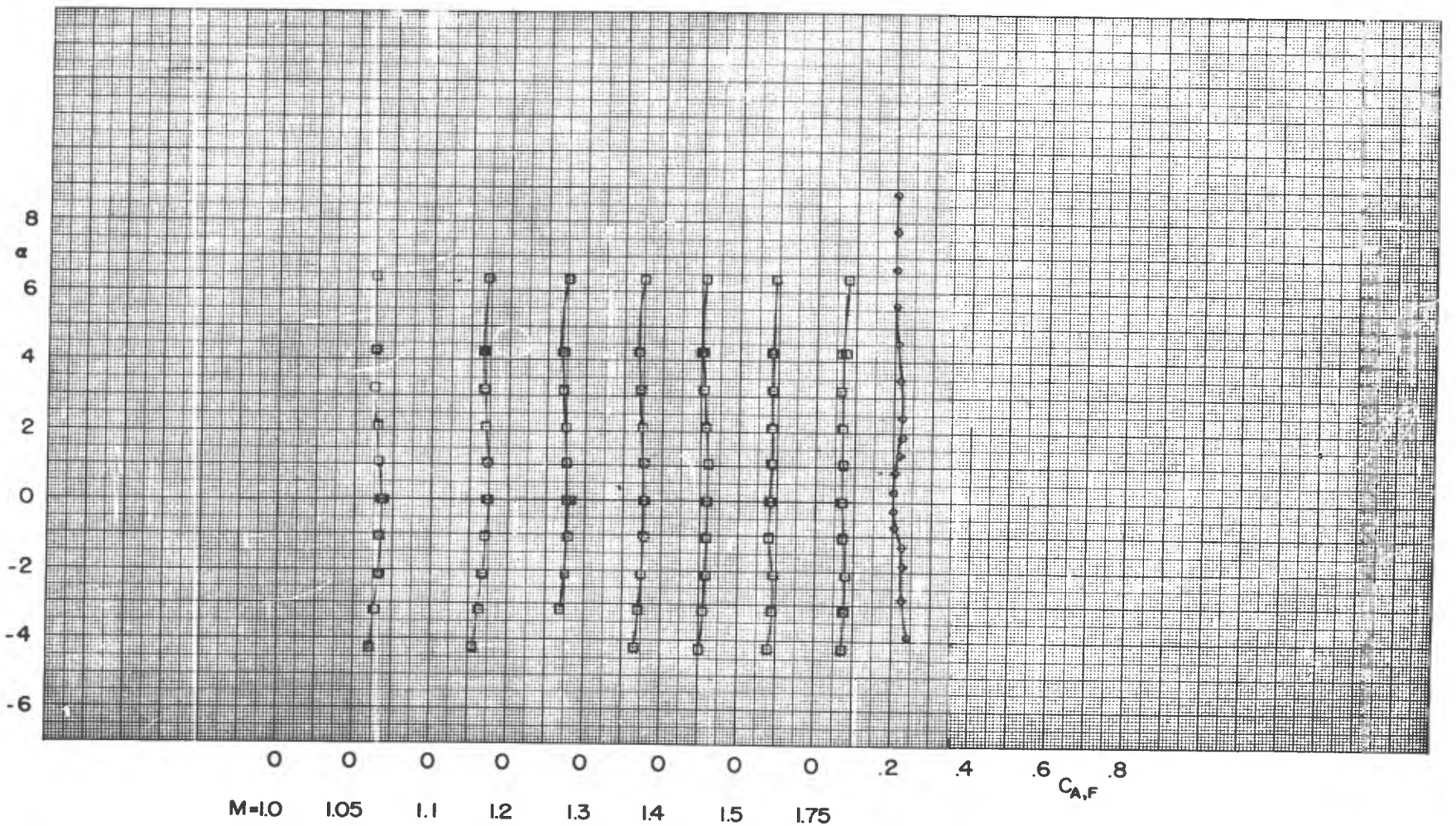
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 65. CONCLUDED



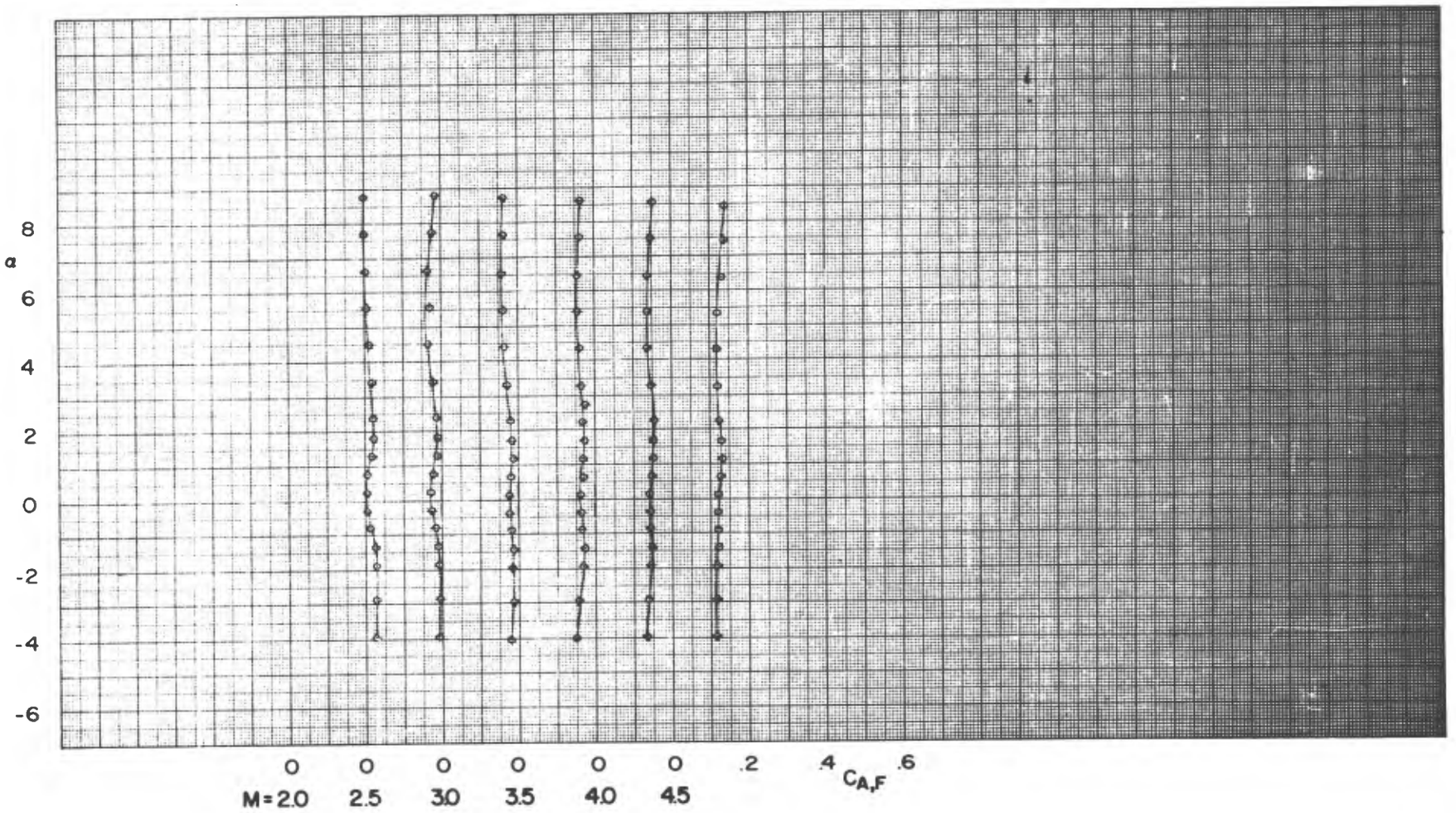
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 66. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 10



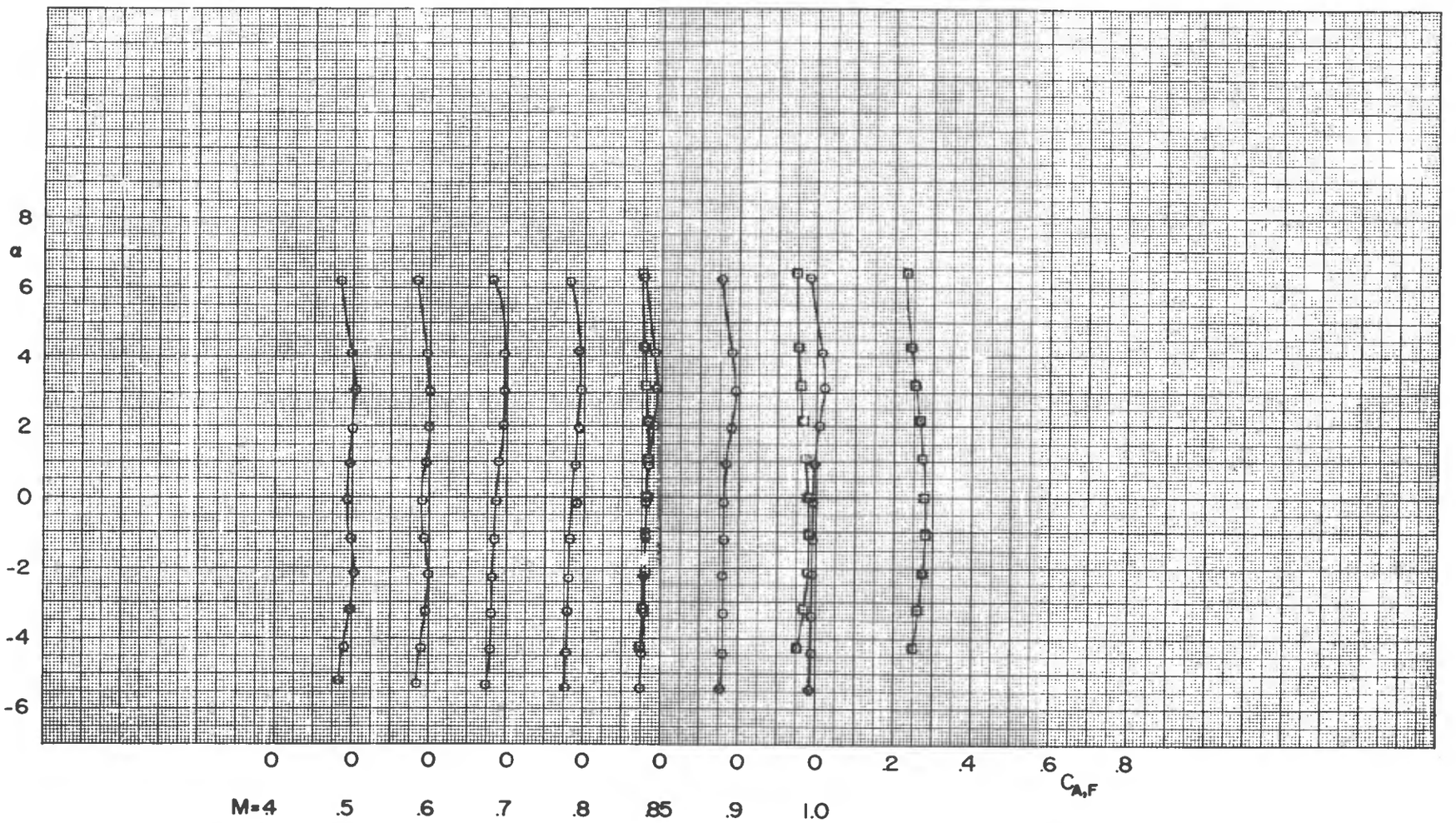
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 66. CONTINUED



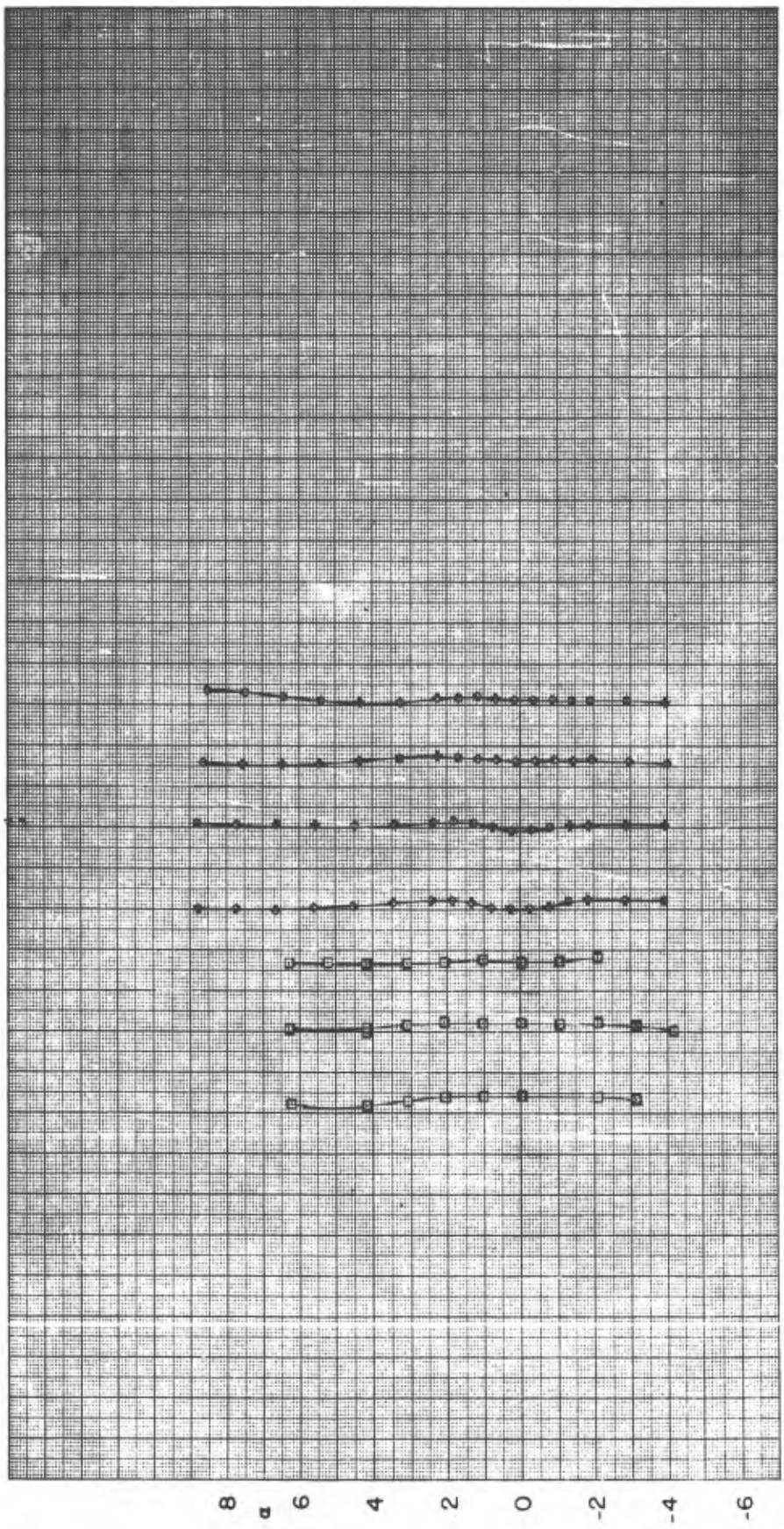
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 66. CONCLUDED



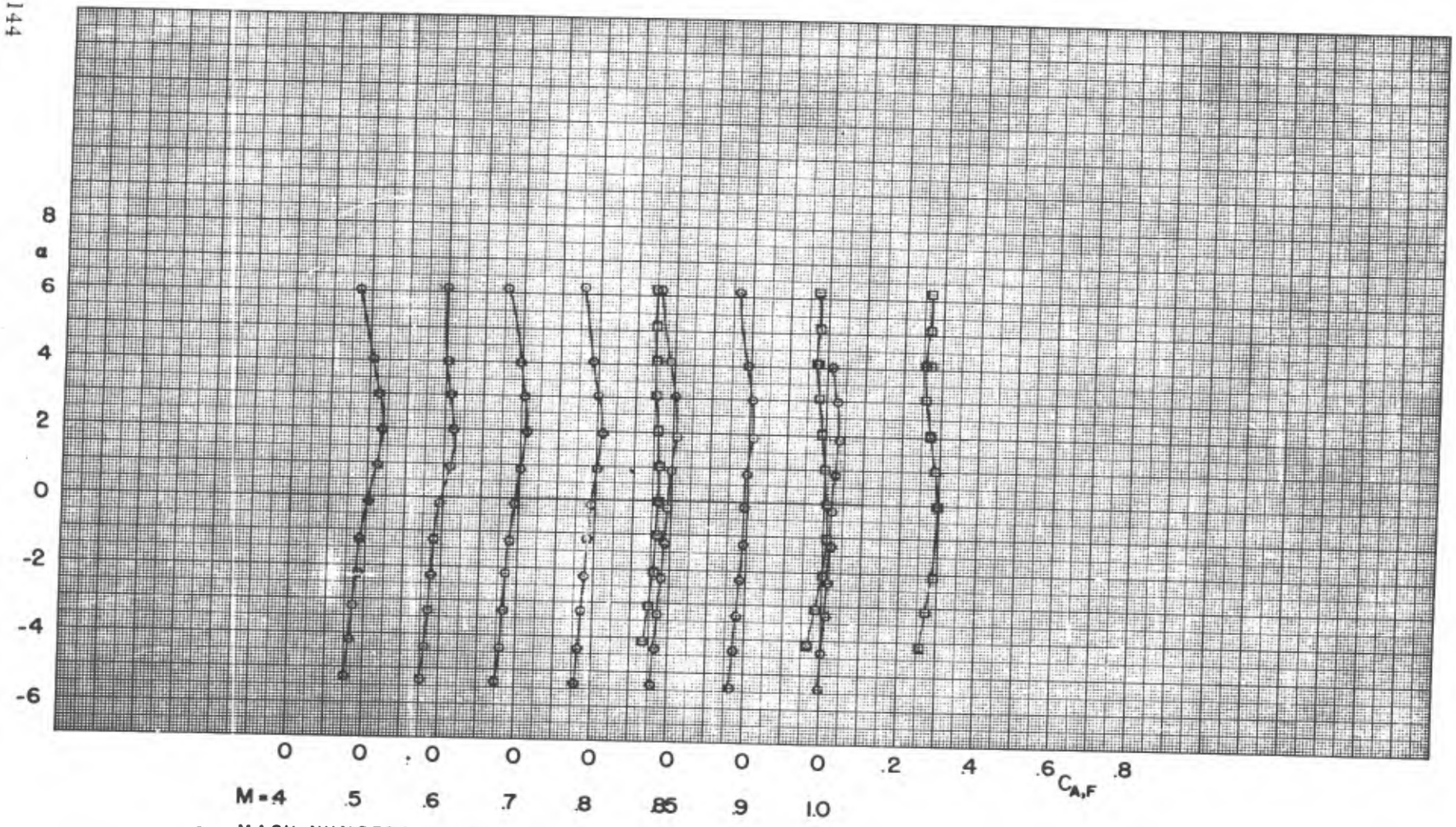
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 67. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 11



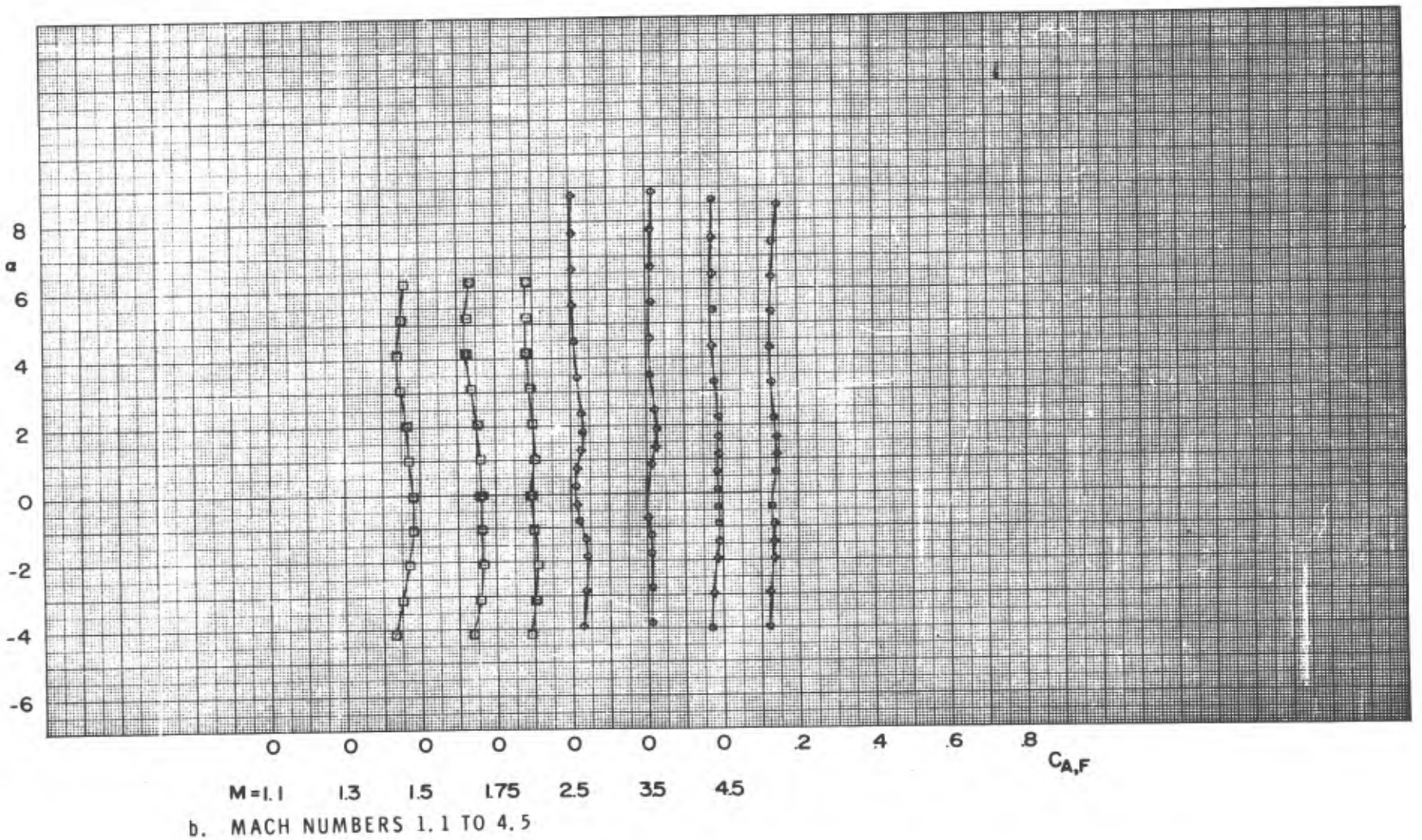
D. MACH NUMBERS 1.1 TO 4.5

FIGURE 67. CONCLUDED



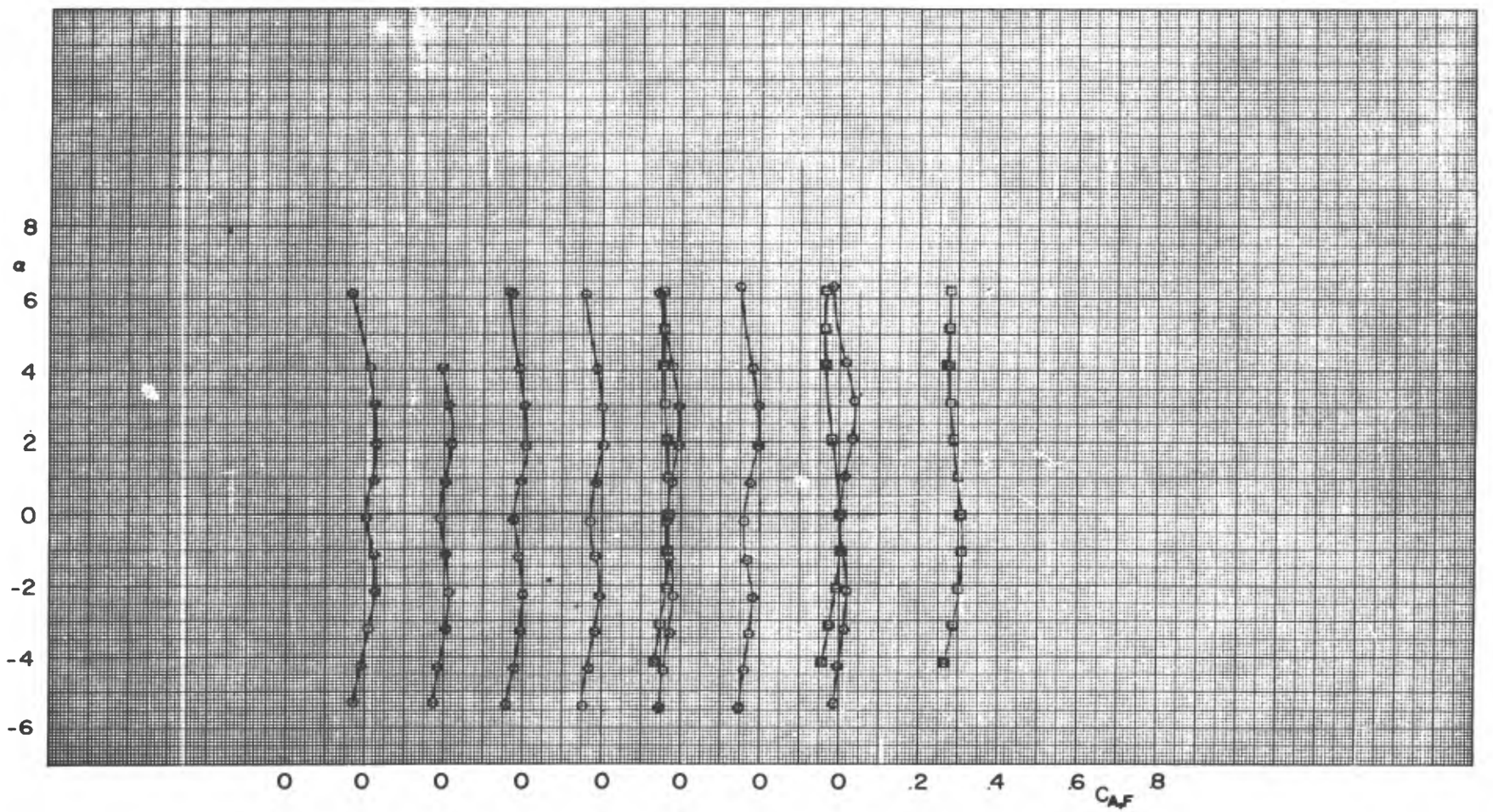
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 68. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 12



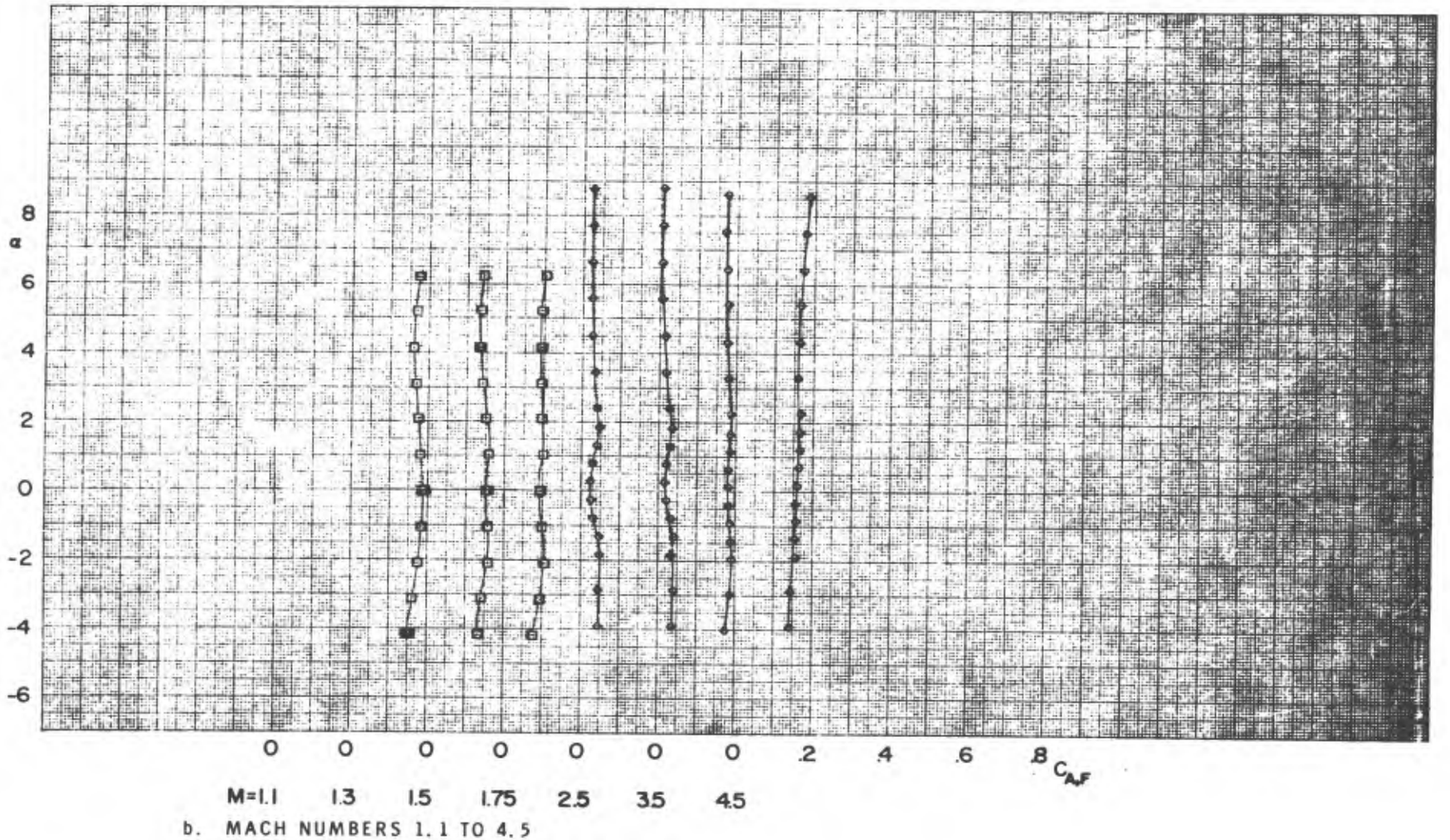
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 63. CONCLUDED



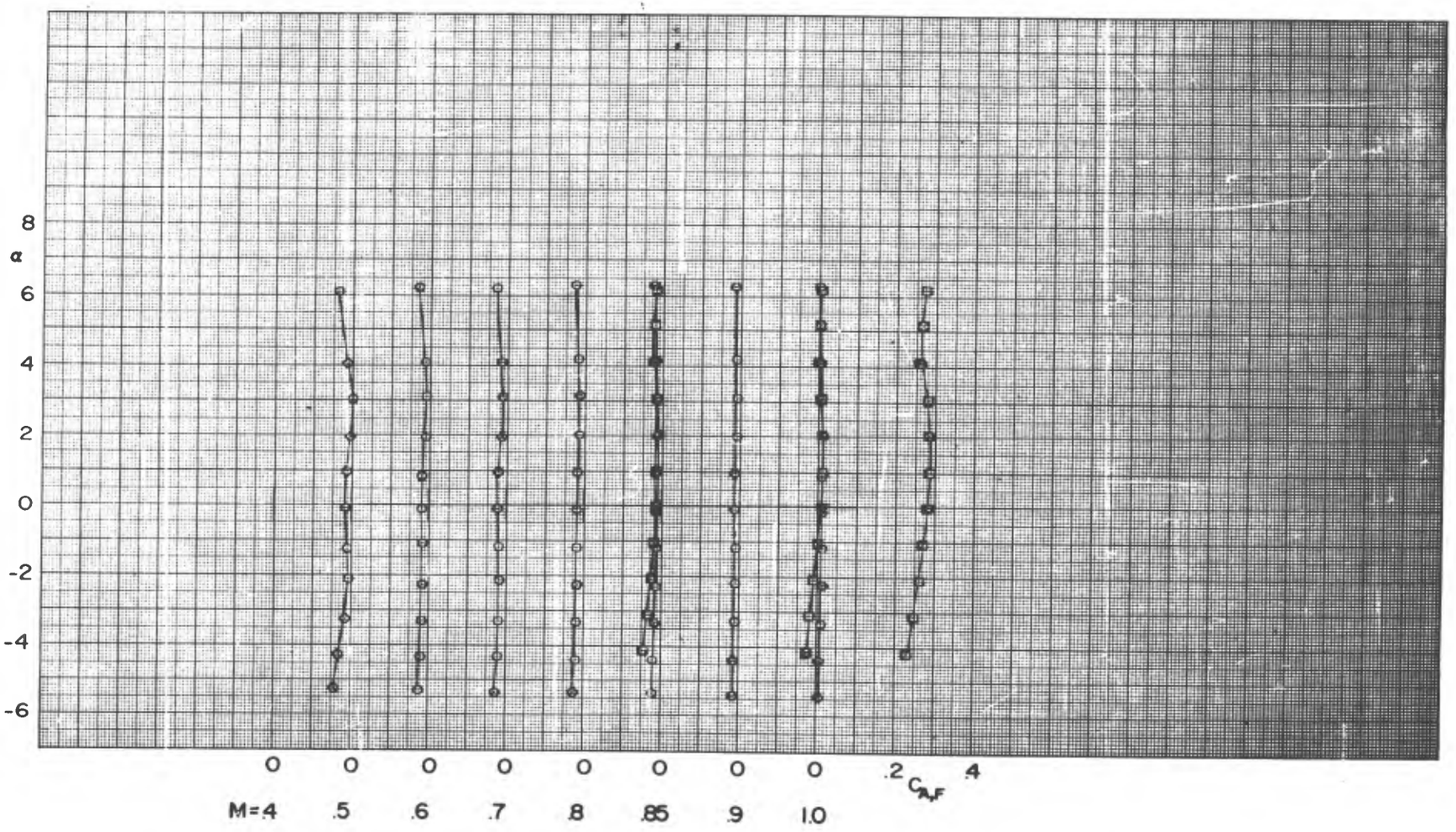
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 69. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 13



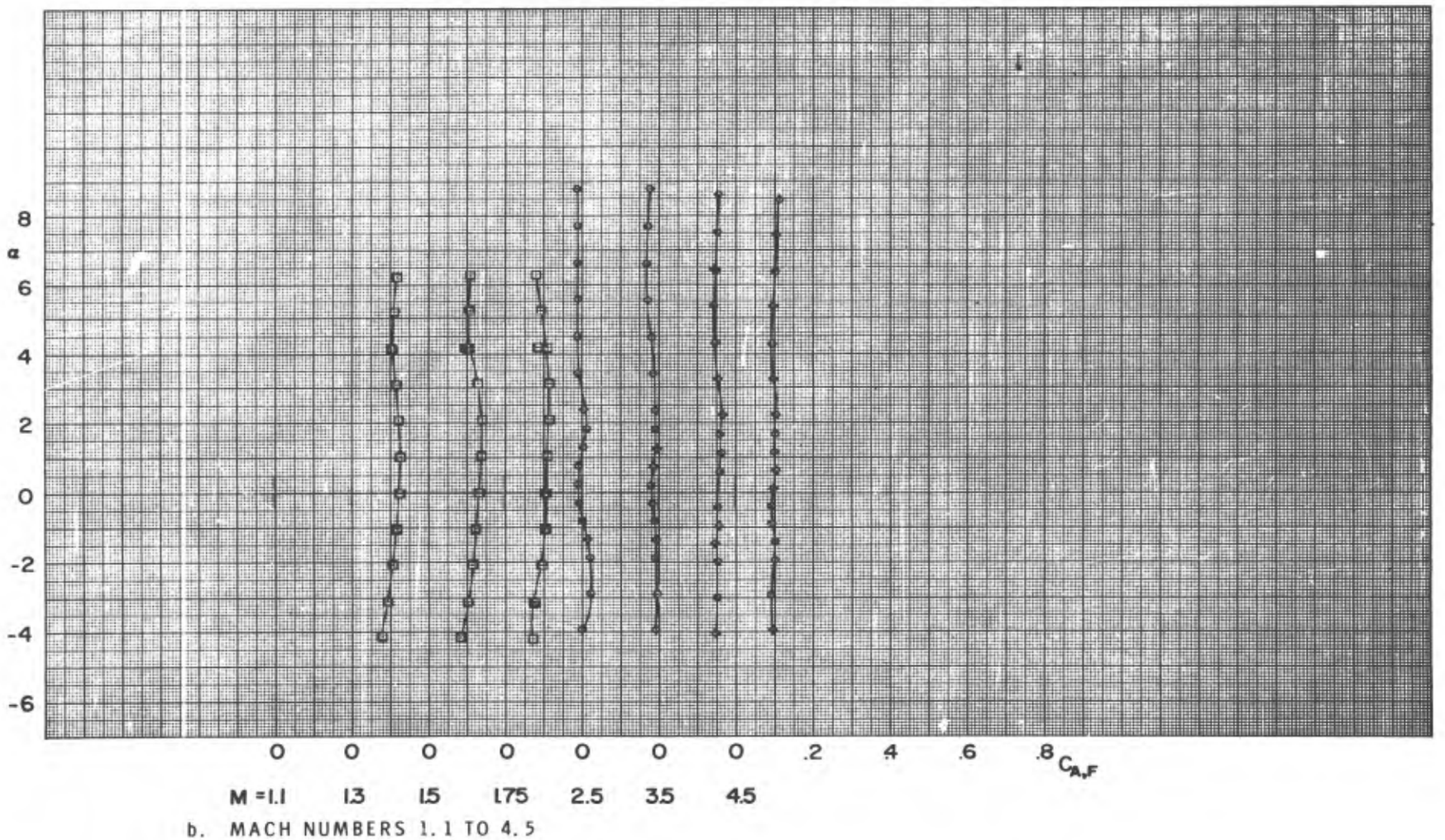
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 69. CONCLUDED



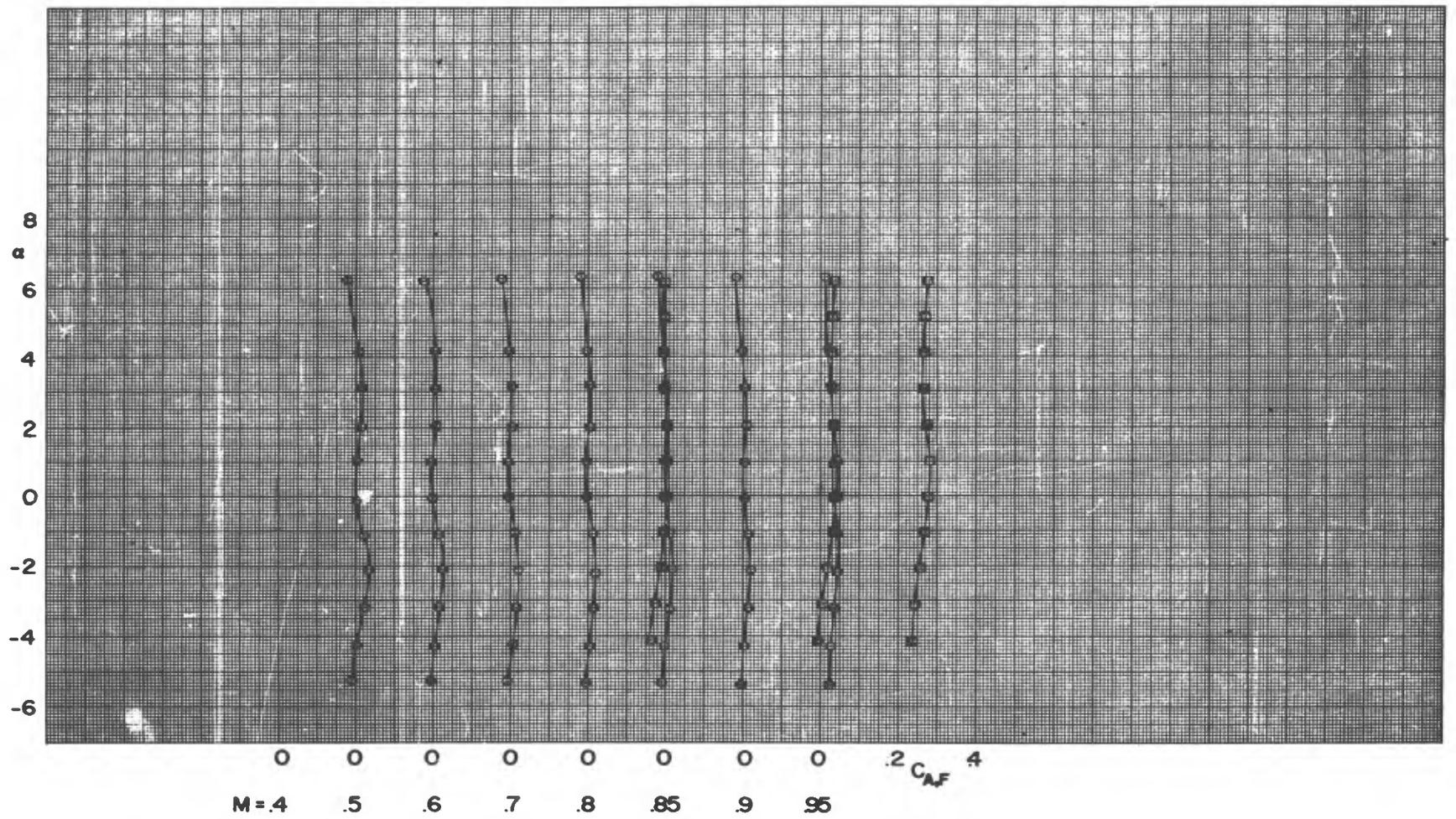
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 70. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 14



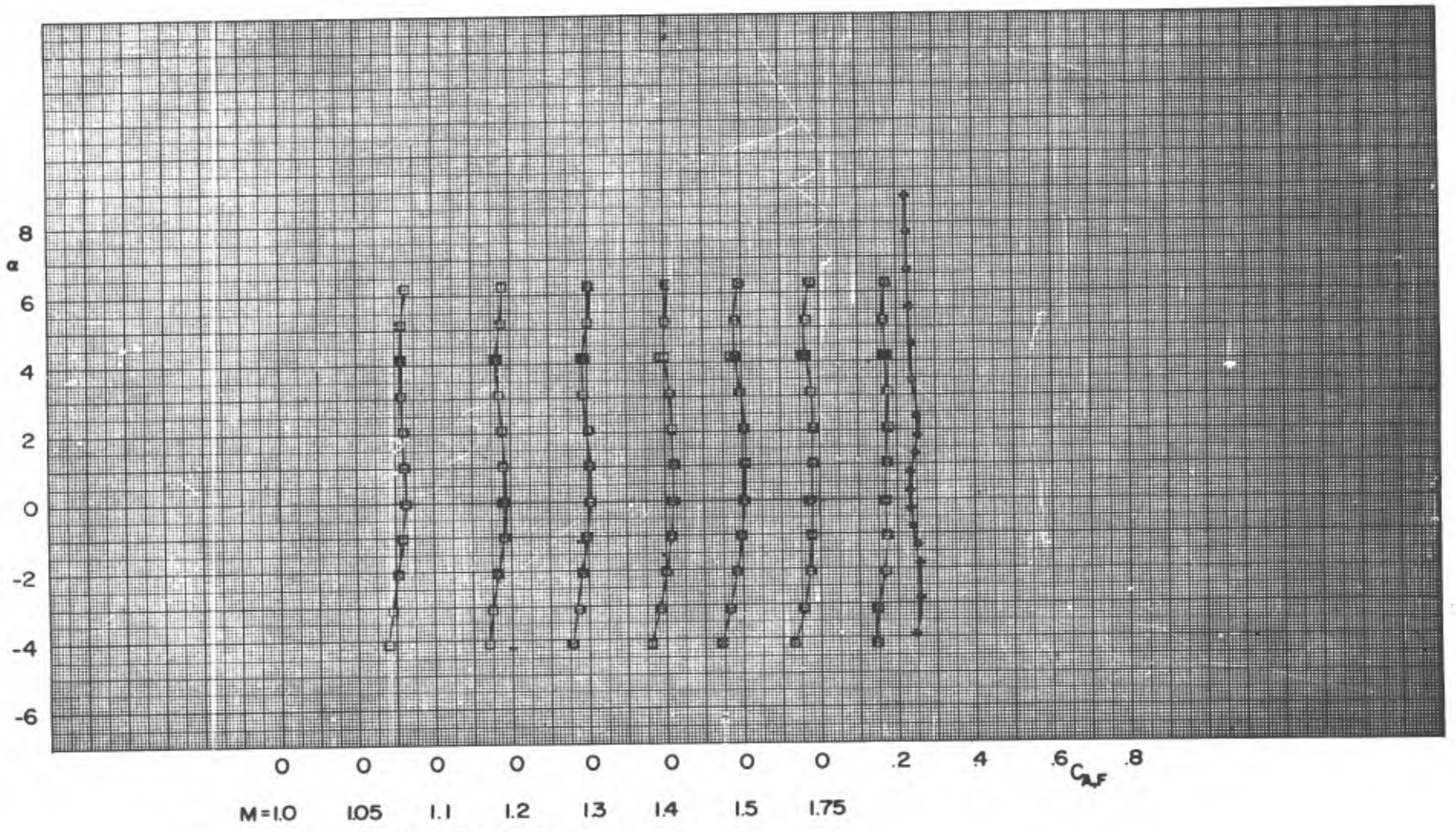
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 70. CONCLUDED



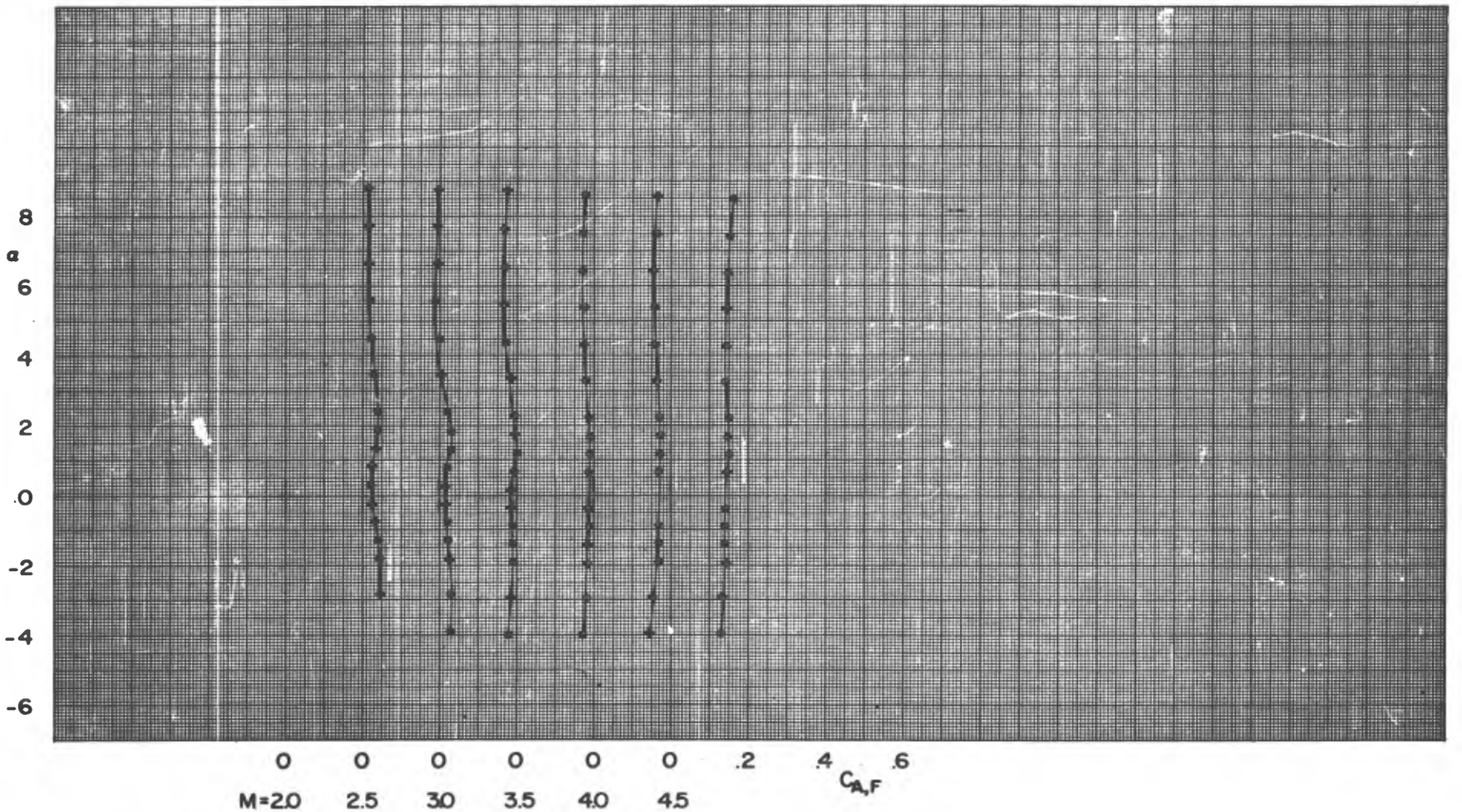
a. MACH NUMBERS 0.4 TO 0.95

FIGURE 71. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 15



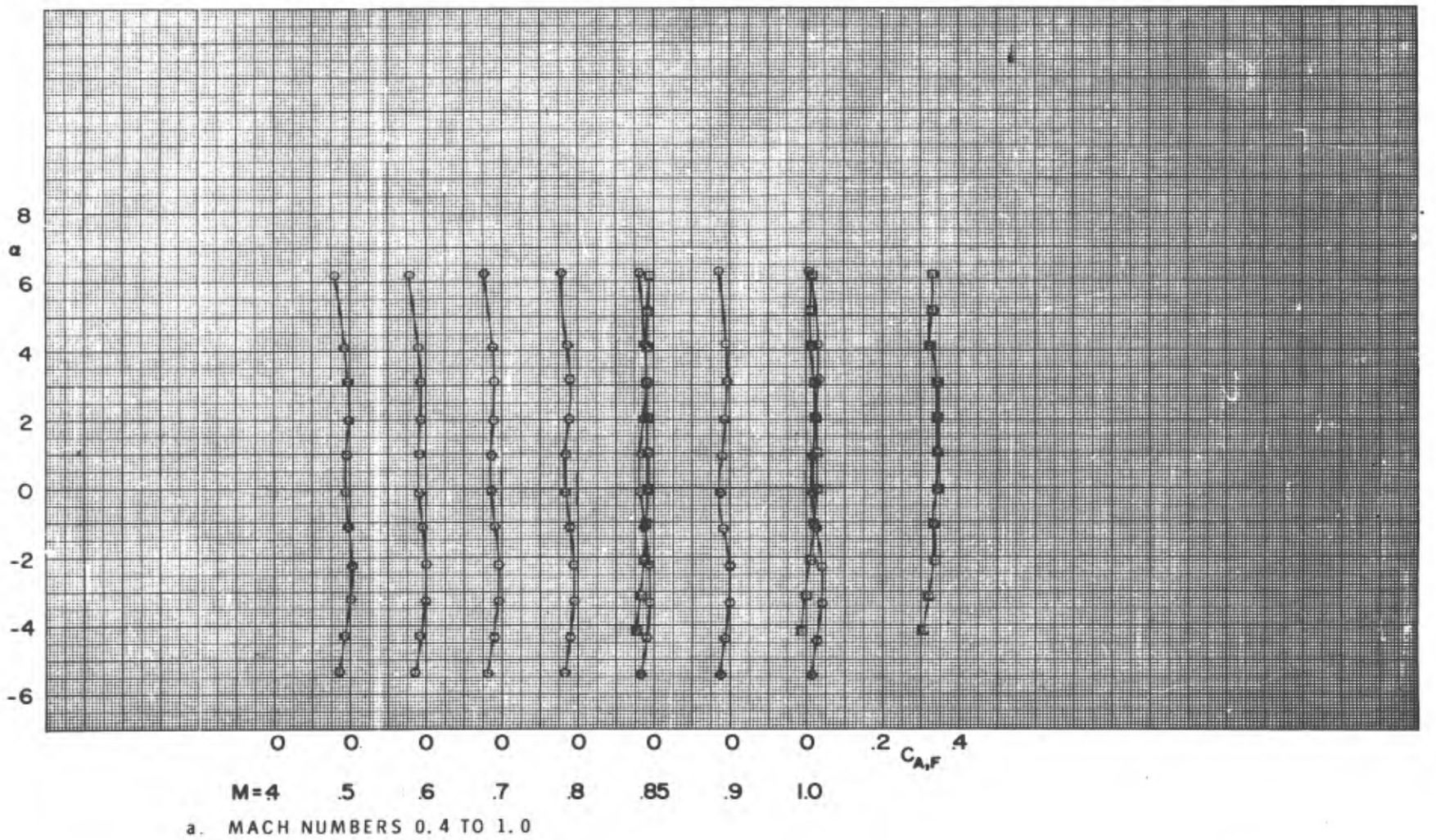
b. MACH NUMBERS 1.0 TO 1.75

FIGURE 71. CONTINUED



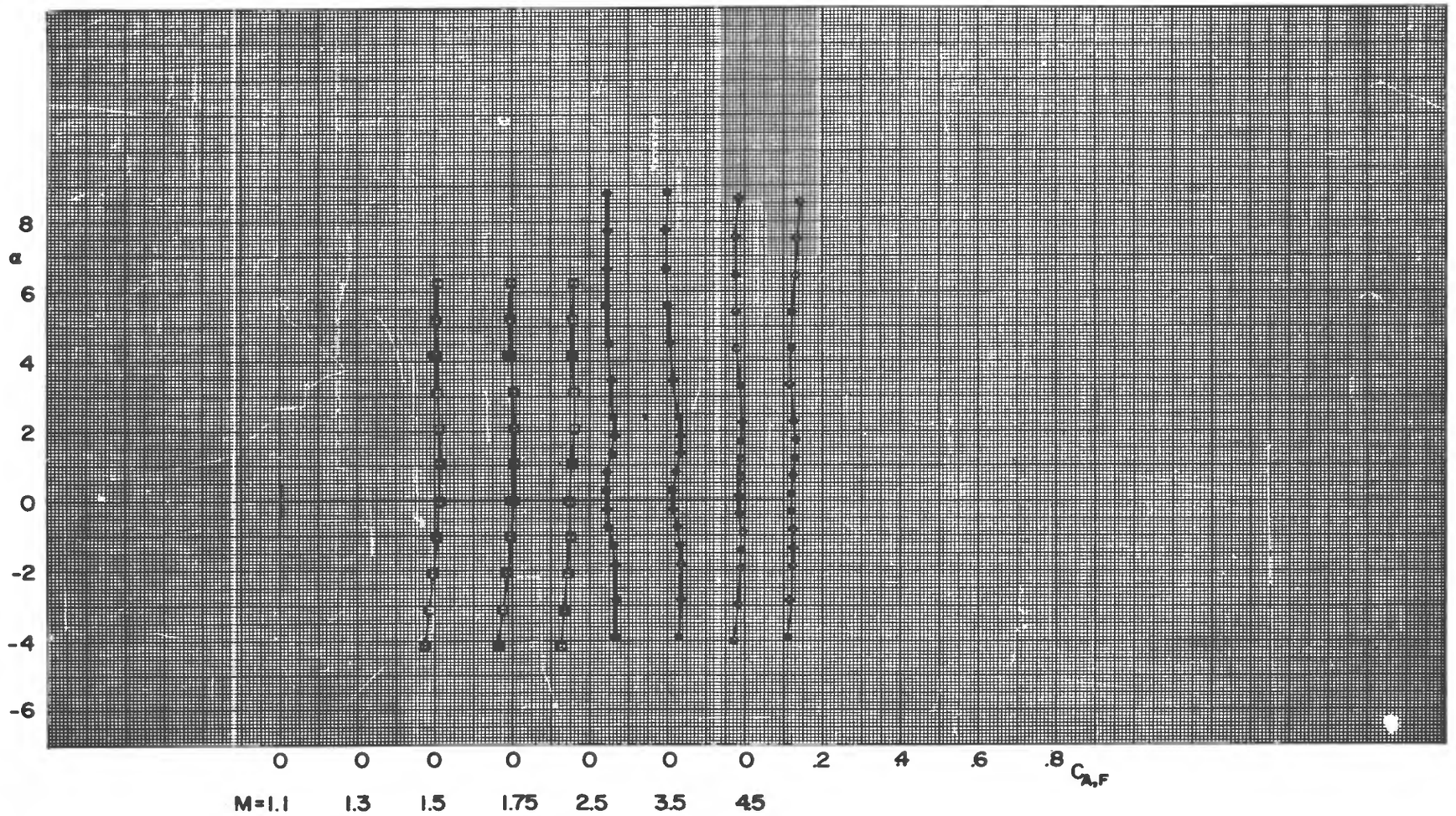
c. MACH NUMBERS 2.0 TO 4.5

FIGURE 71. CONCLUDED



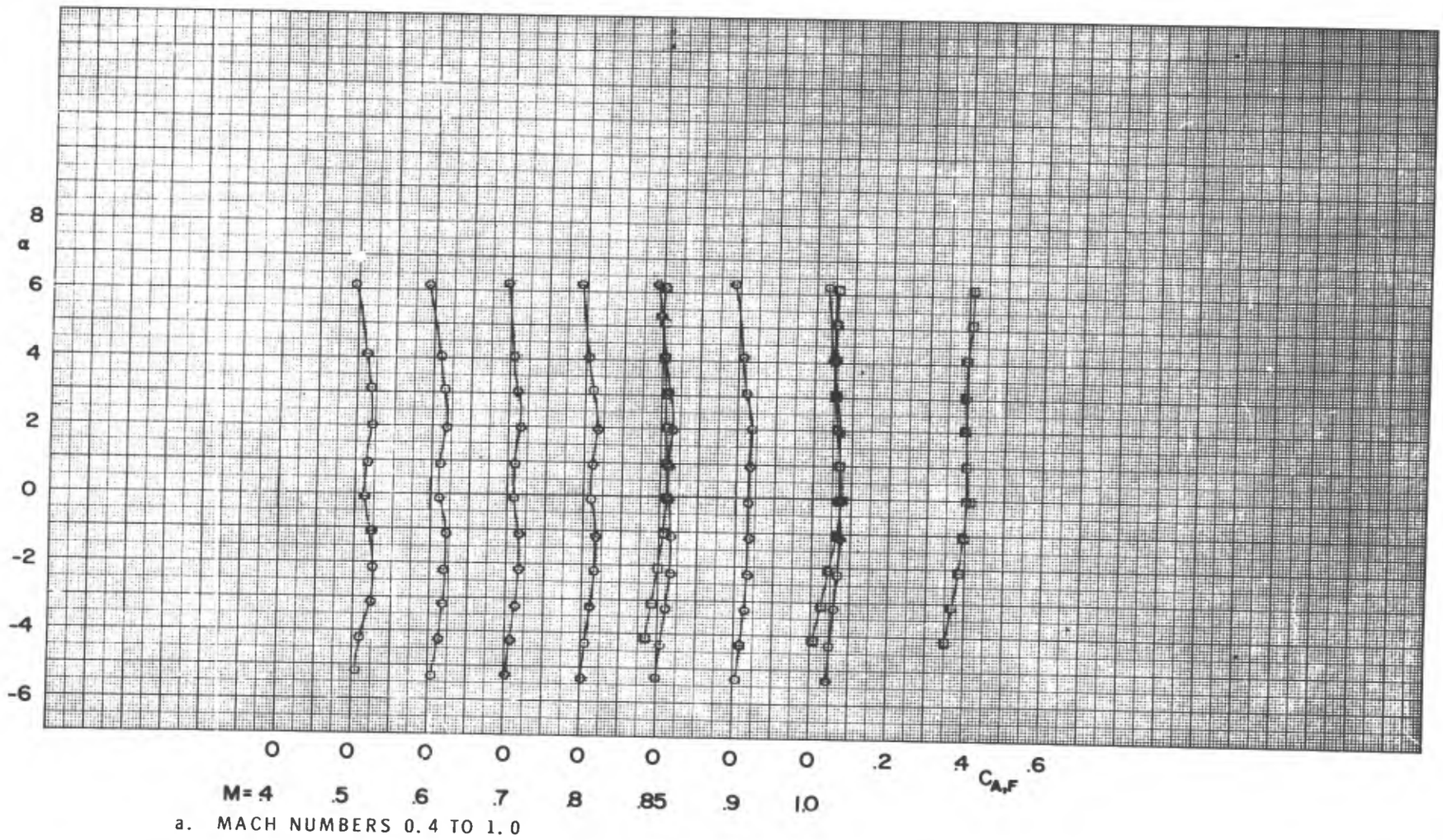
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 72. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 16



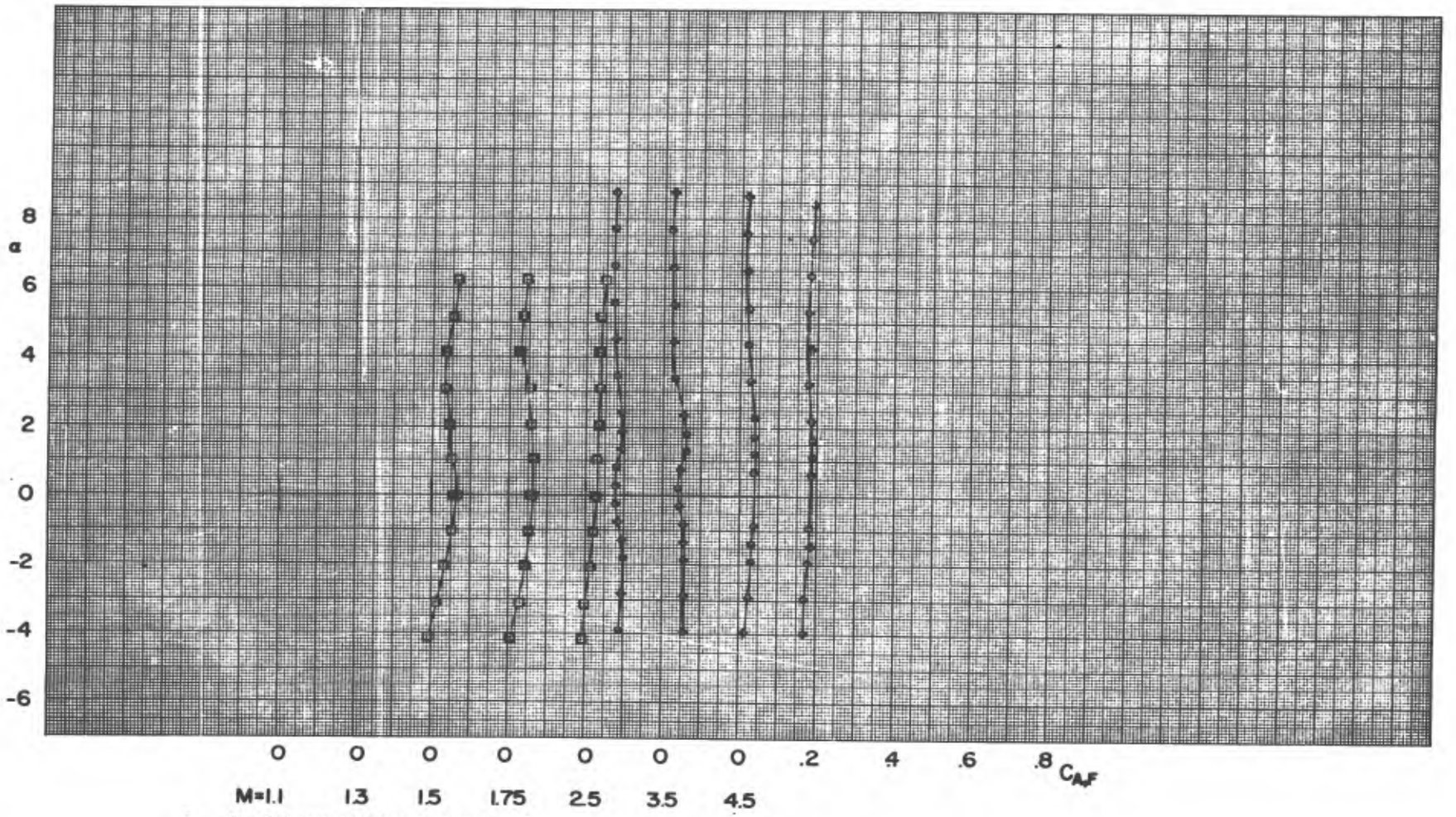
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 72. CONCLUDED



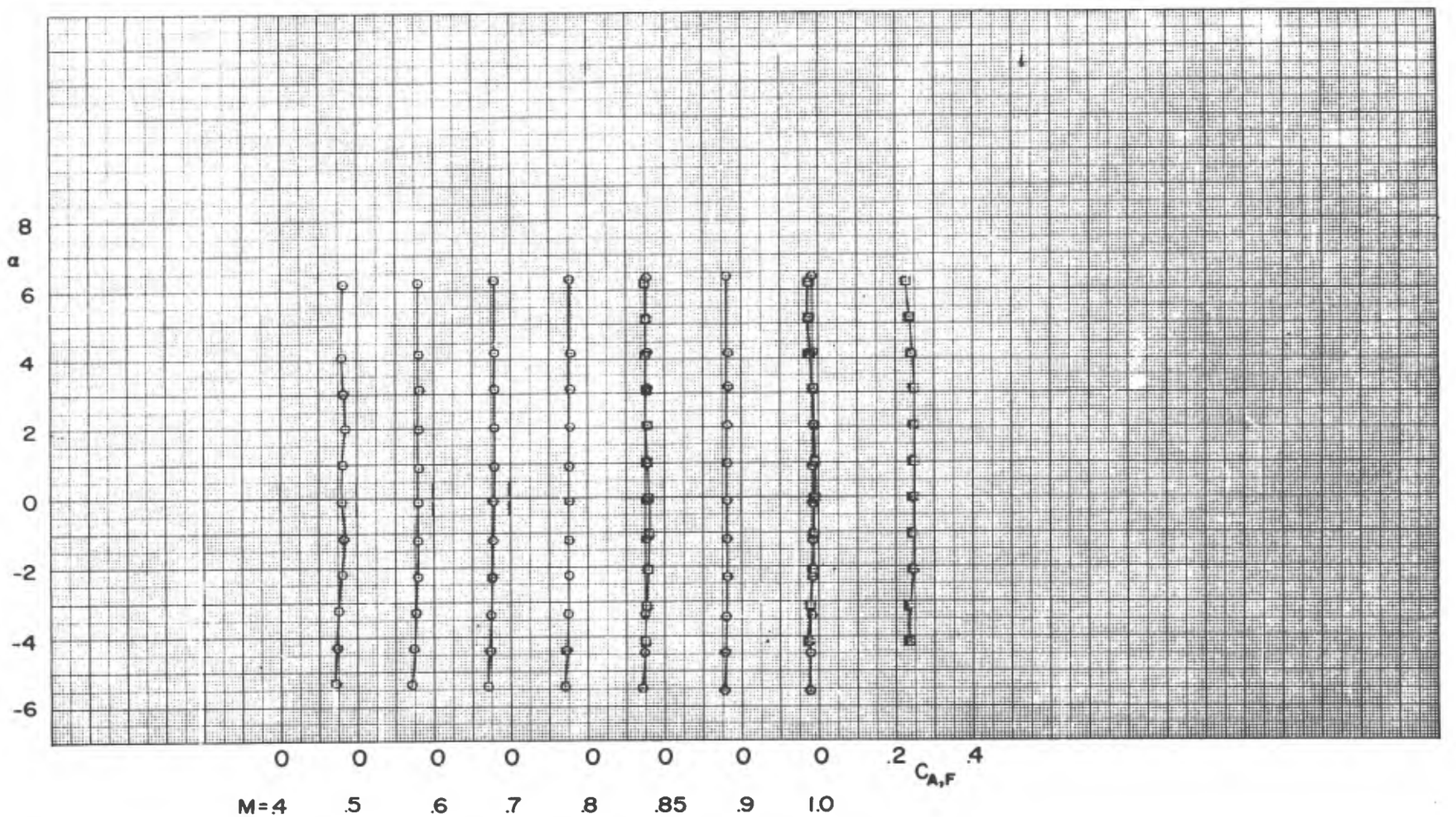
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 73. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 17



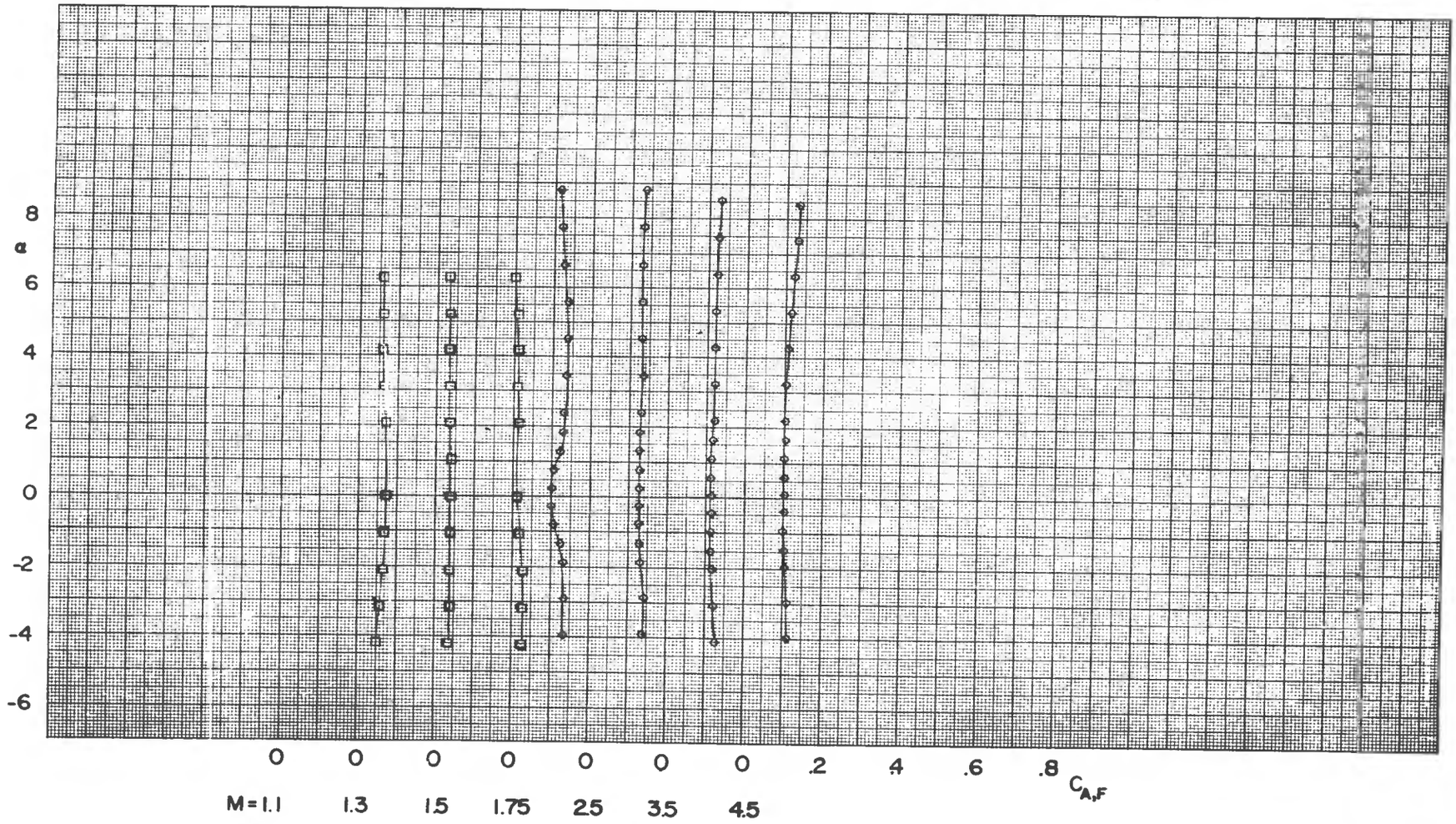
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 73. CONCLUDED



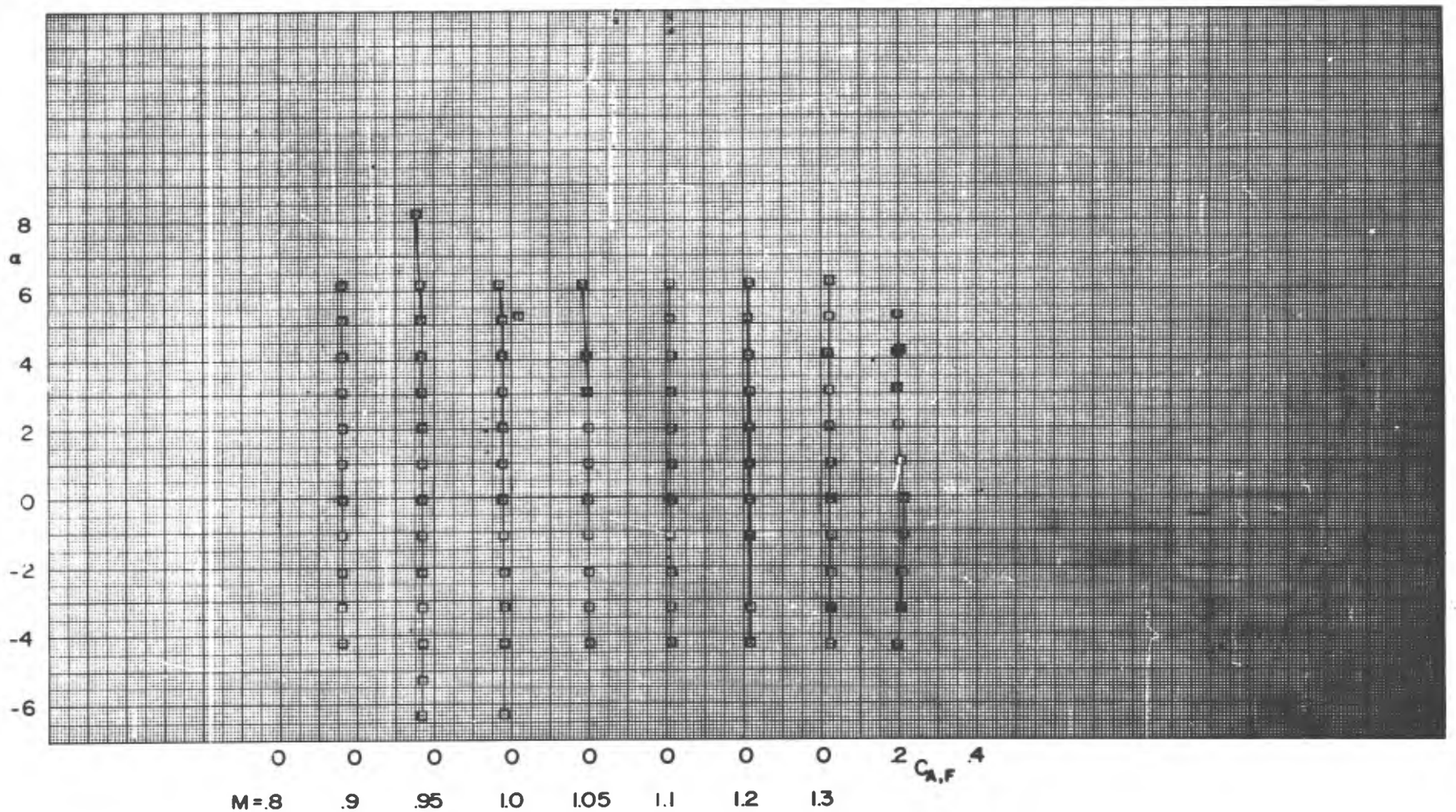
a. MACH NUMBERS 0.4 TO 1.0

FIGURE 74. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 18



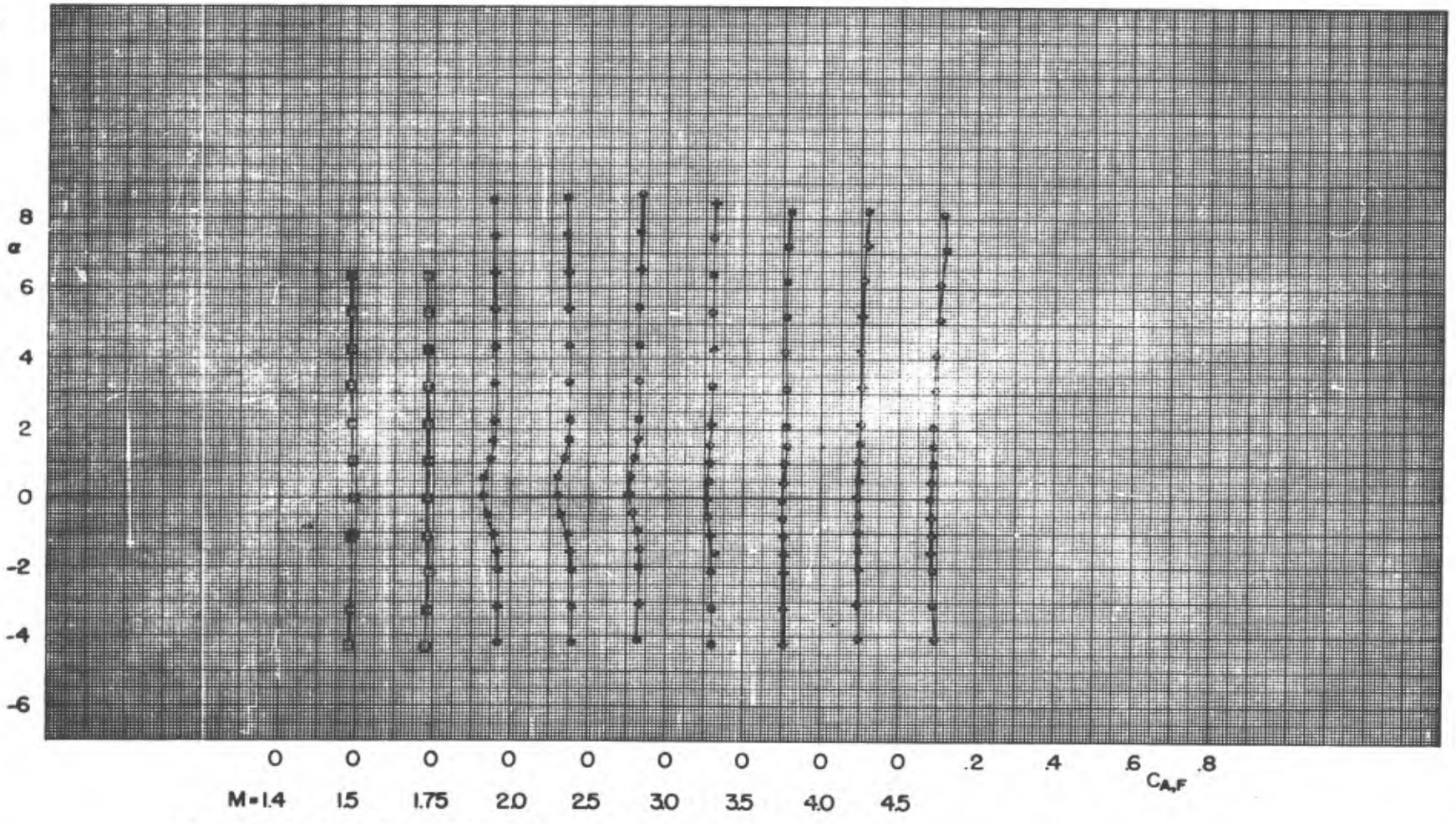
b. MACH NUMBERS 1.1 TO 4.5

FIGURE 74. CONCLUDED



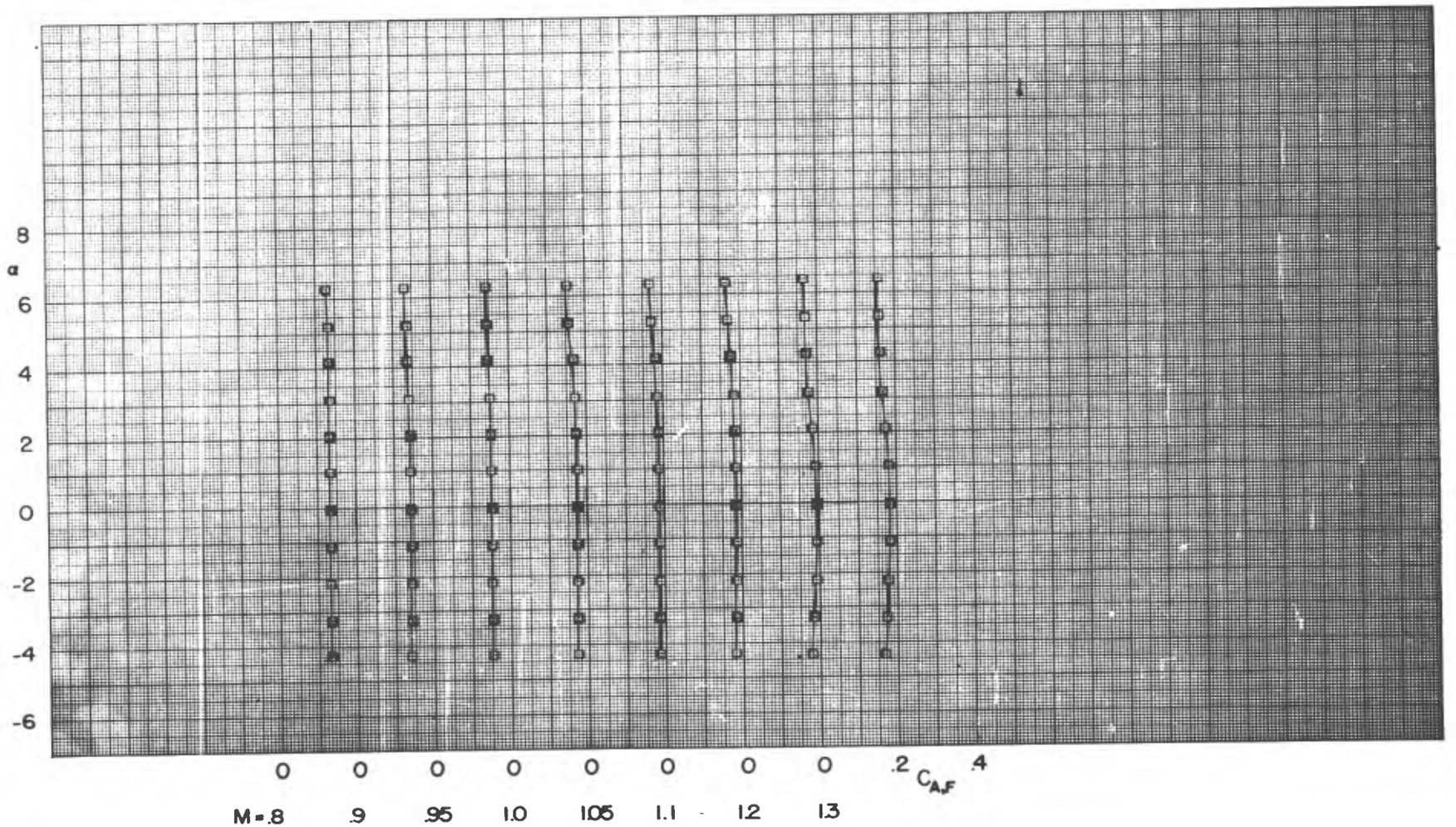
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 75. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 19



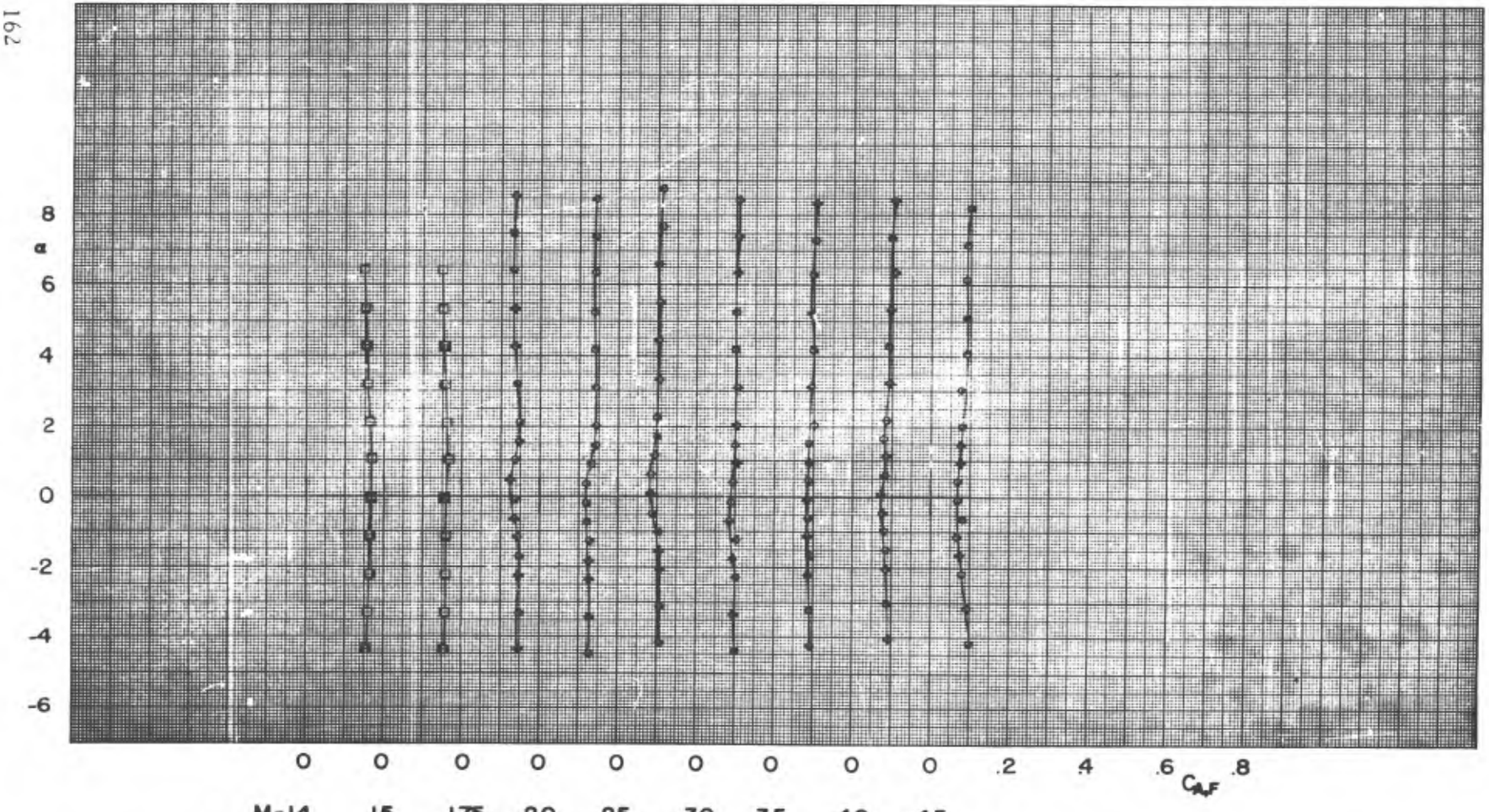
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 75. CONCLUDED



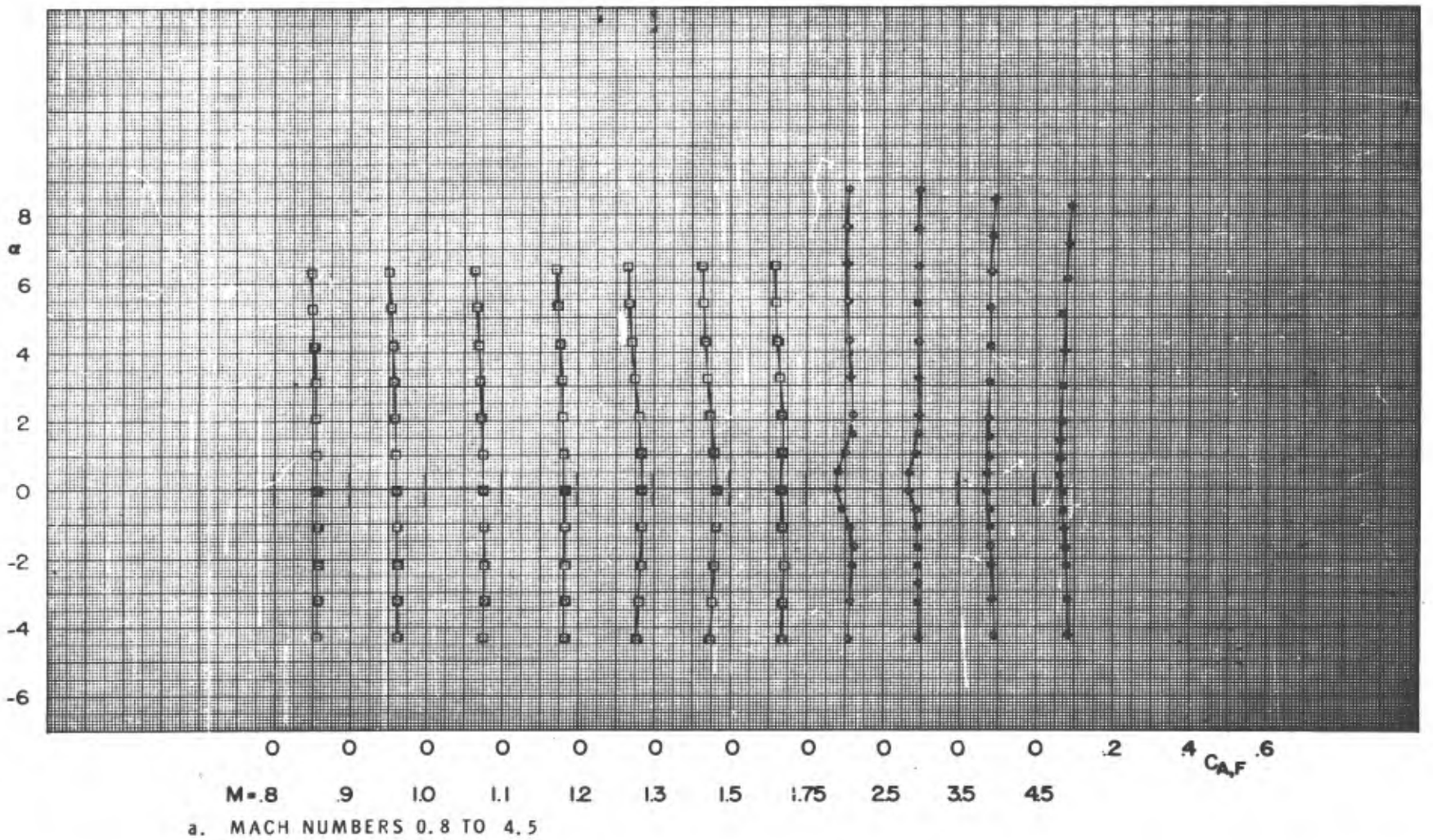
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 76. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 20



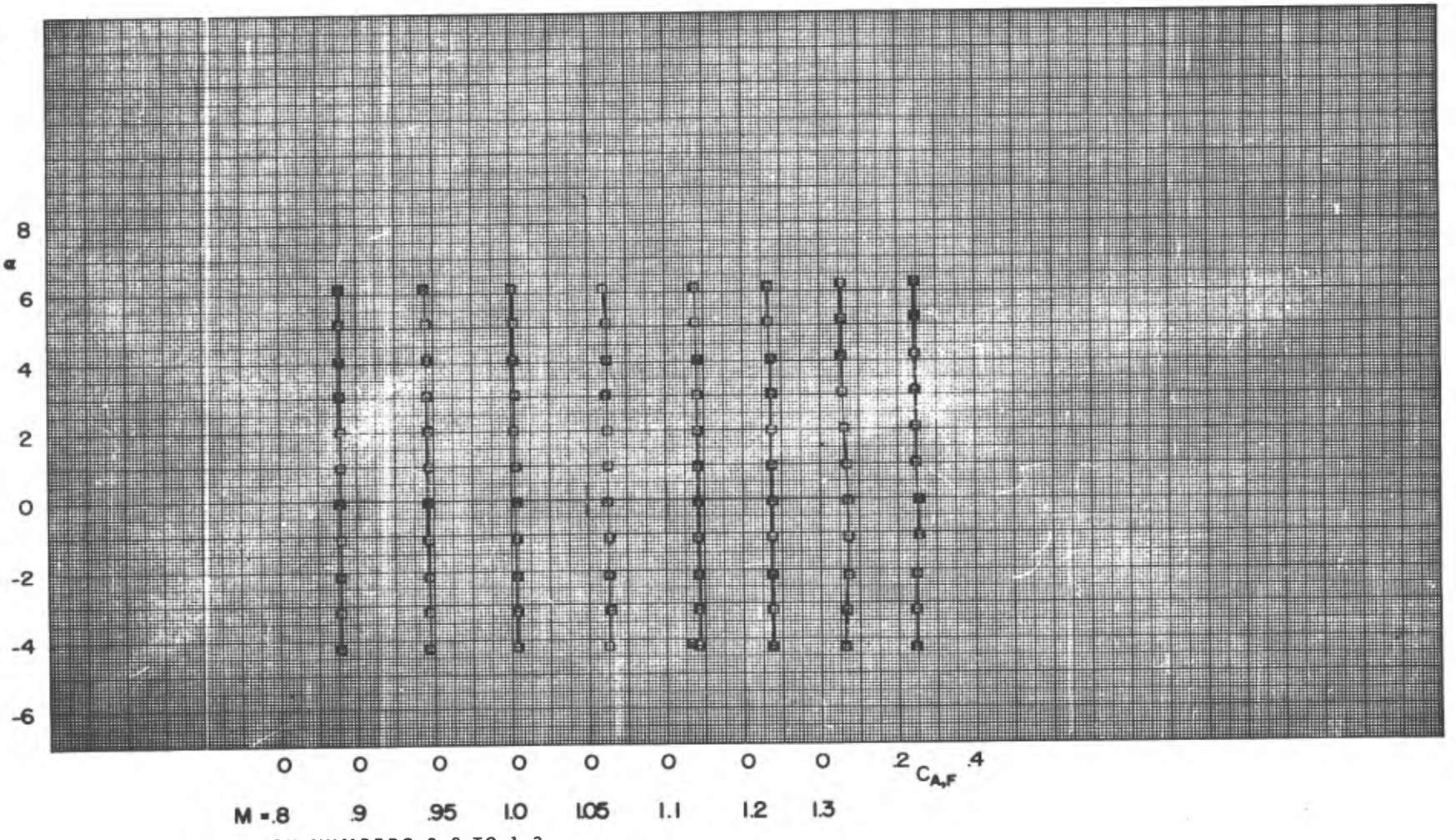
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 76. CONCLUDED



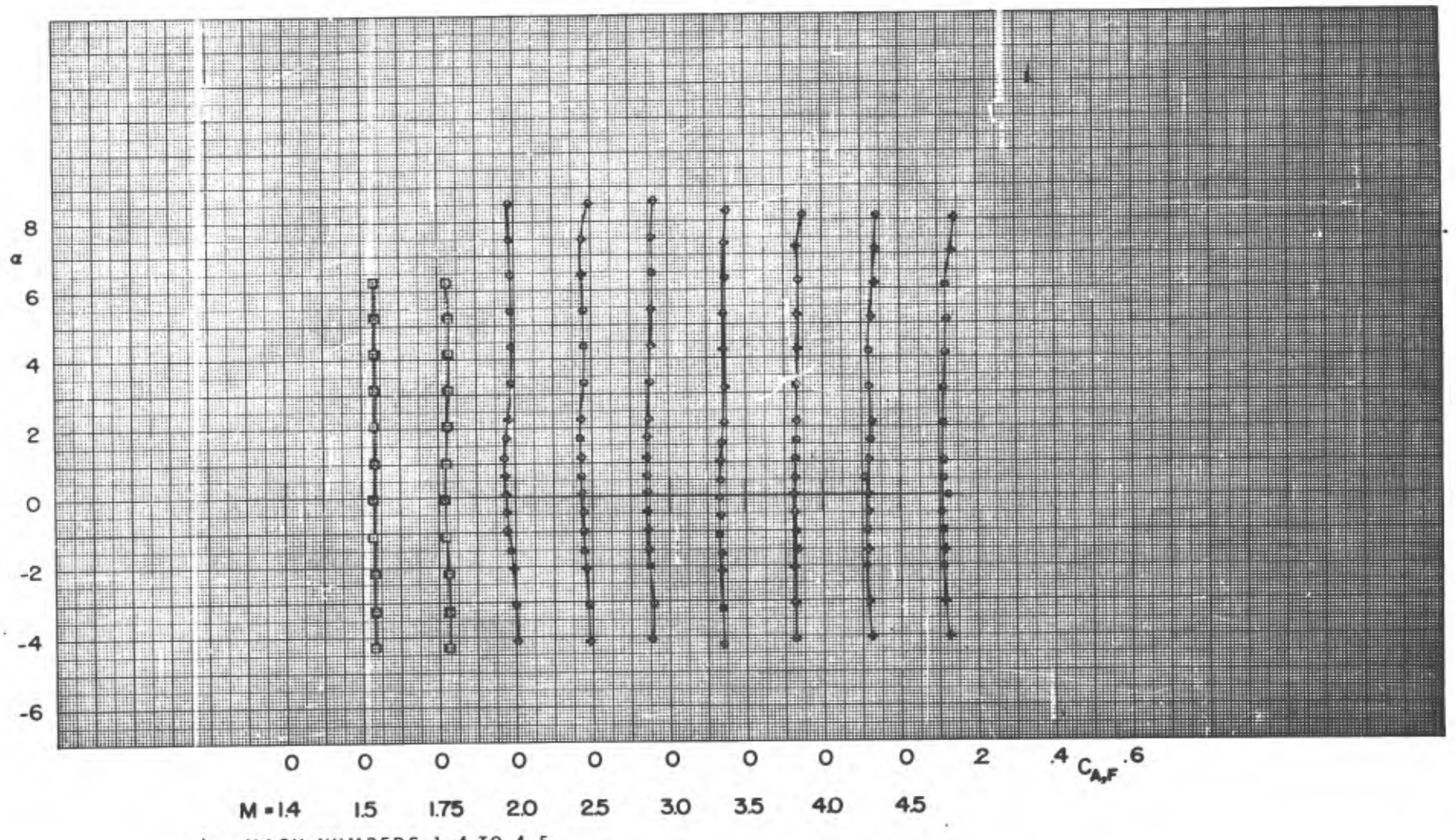
a. MACH NUMBERS 0.8 TO 4.5

FIGURE 77. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 21



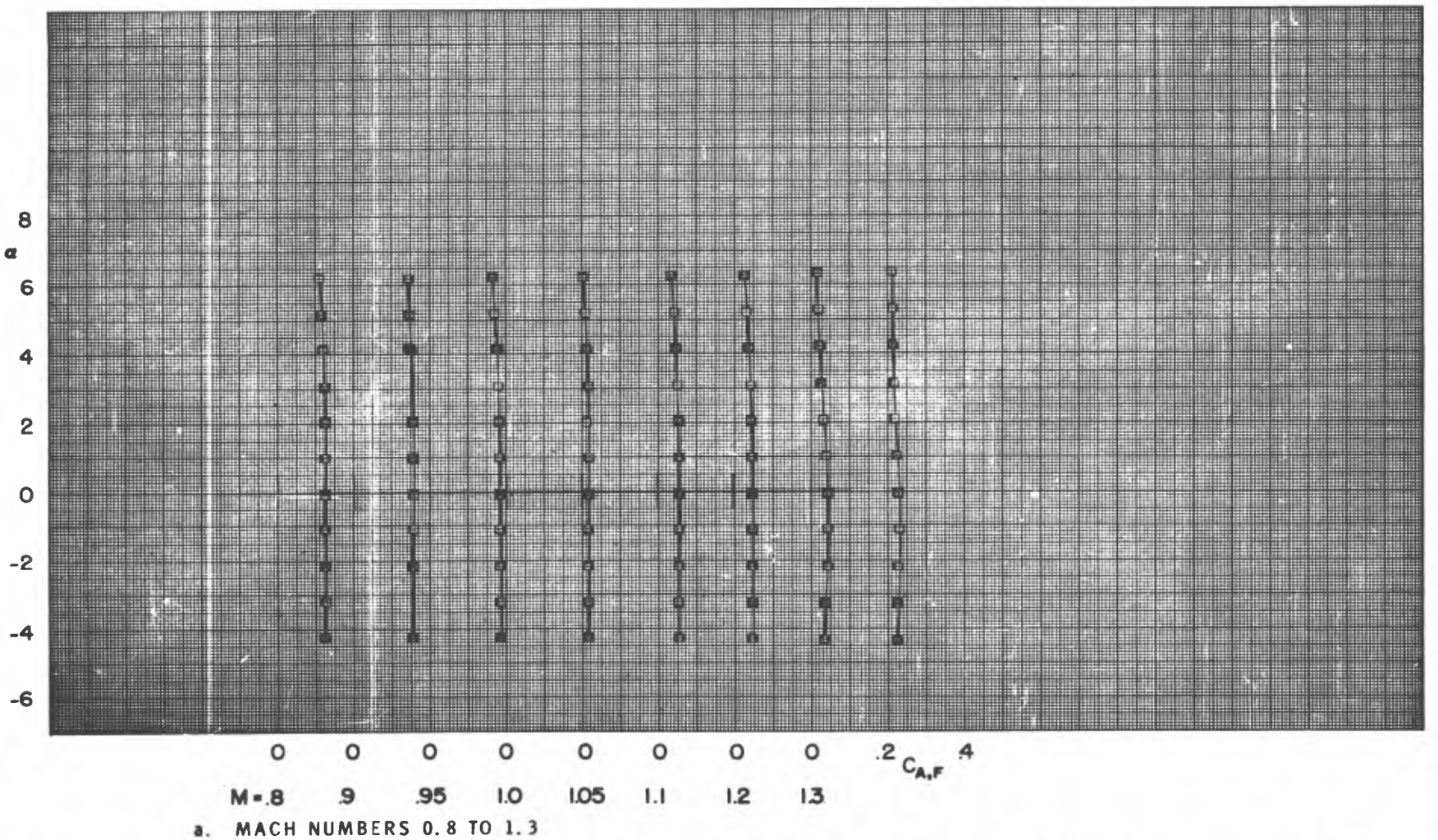
a. MACH NUMBERS 0, 8 TO 1. 3

FIGURE 78. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 22



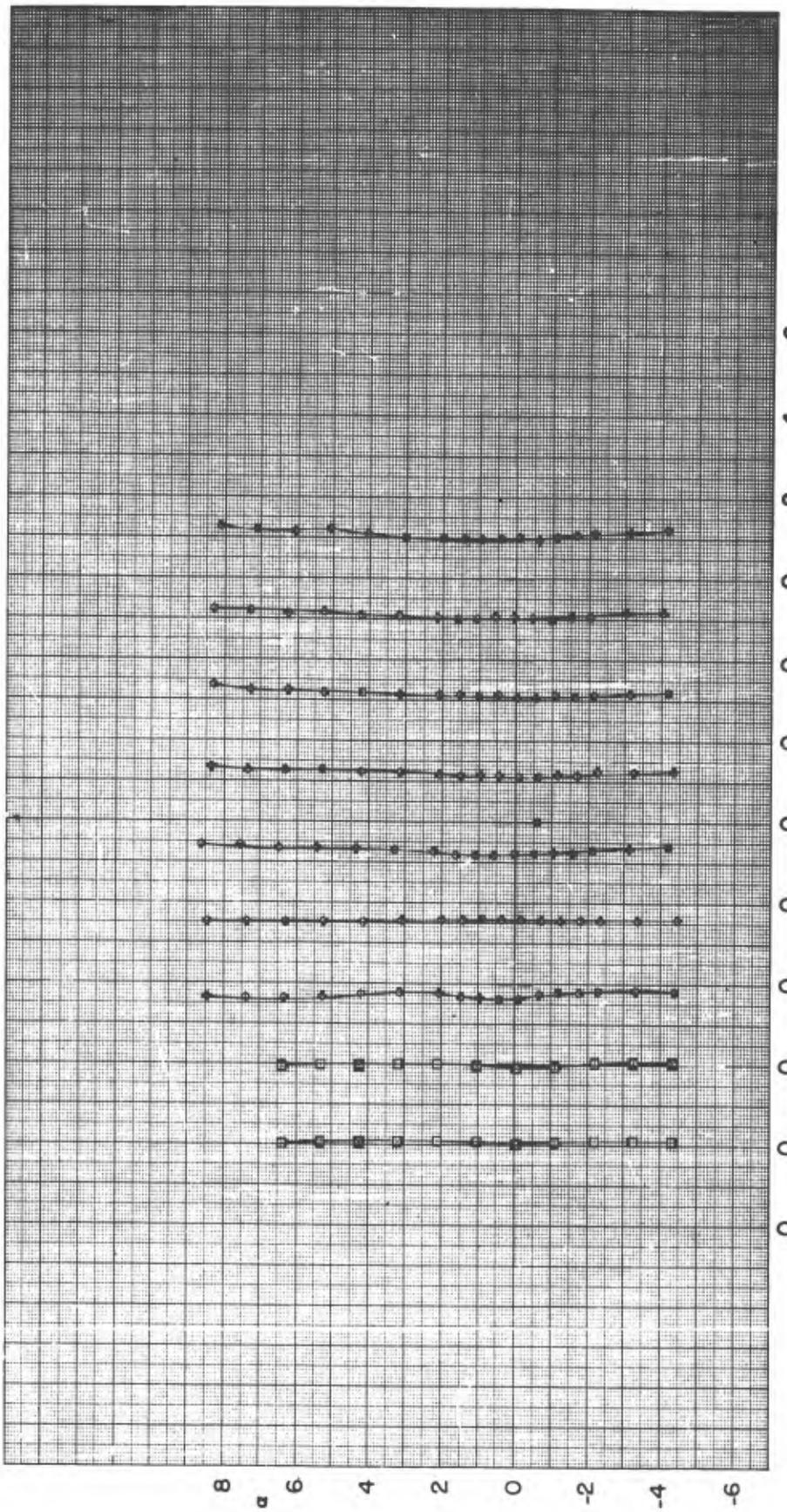
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 78. CONCLUDED



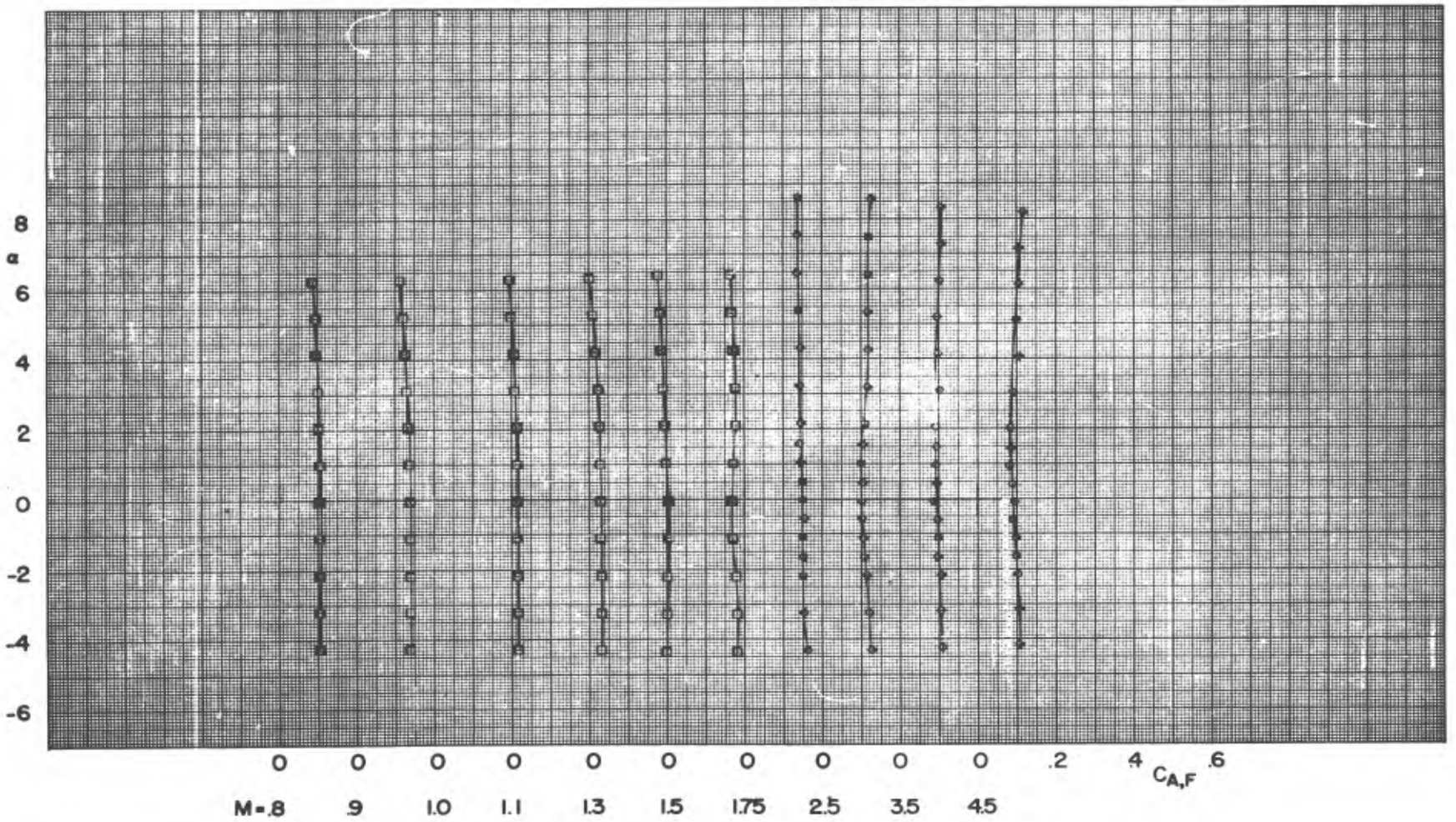
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 79. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 23



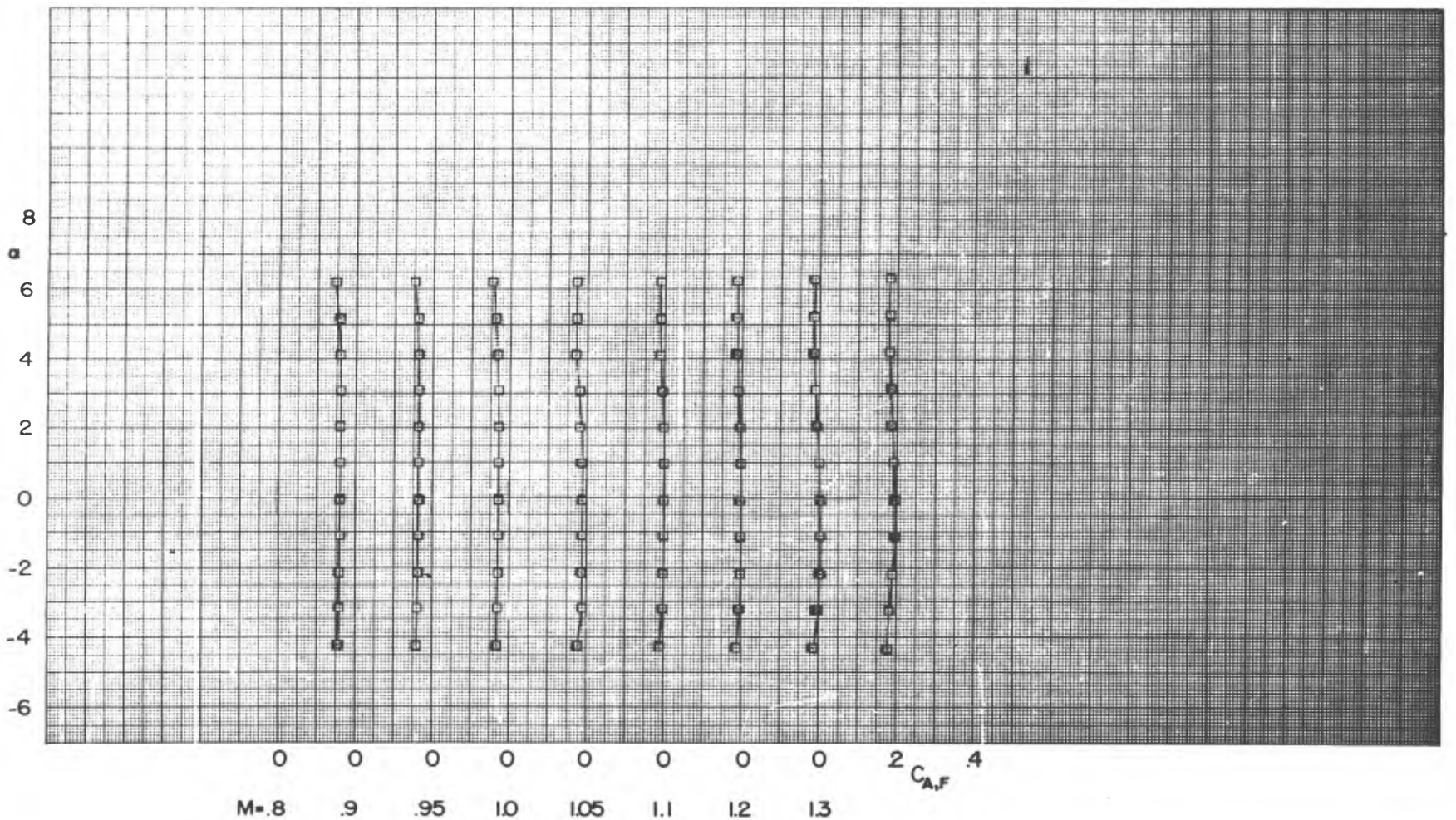
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 79. CONCLUDED



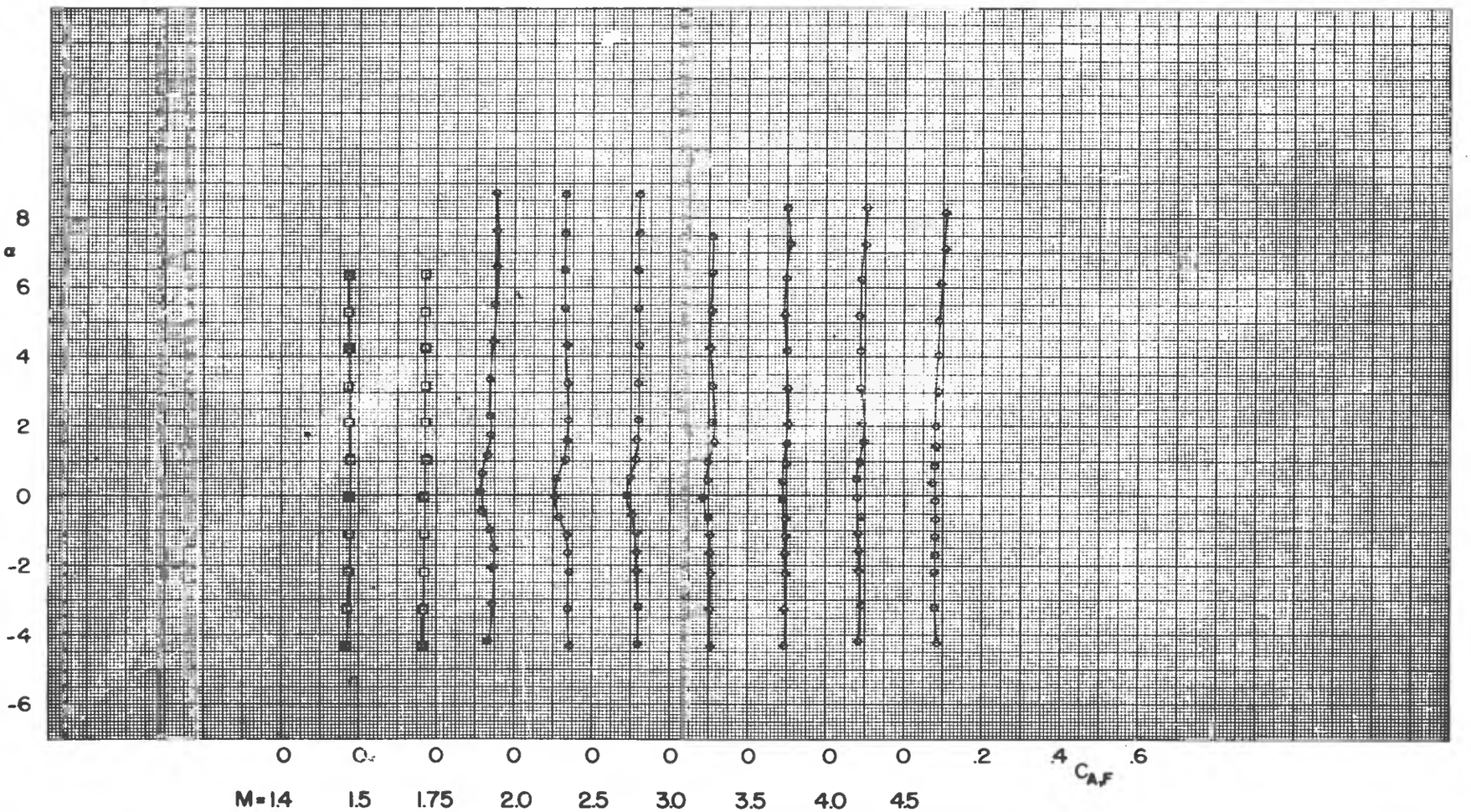
a. MACH NUMBERS 0.8 TO 4.5

FIGURE 80. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 24



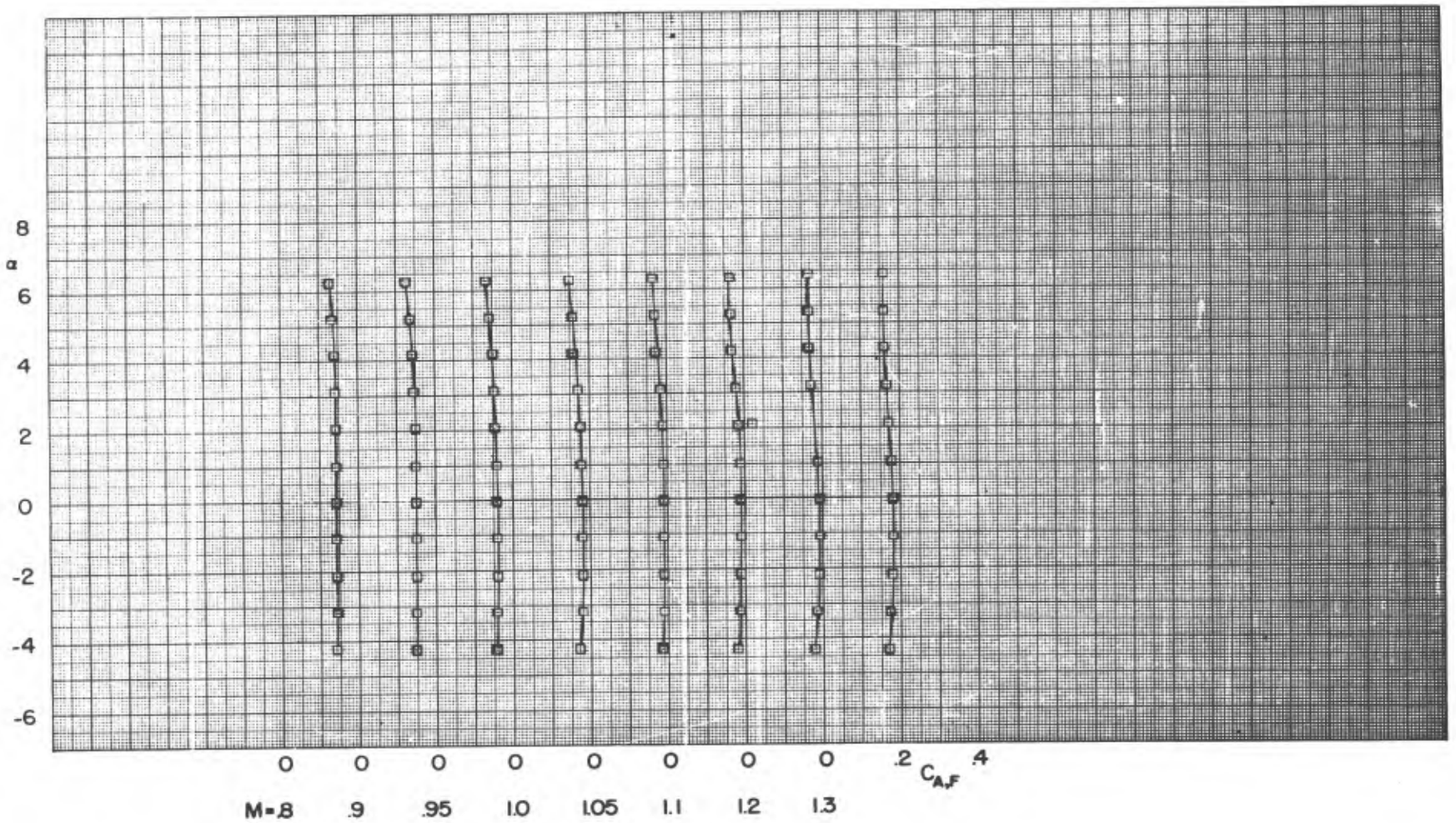
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 81. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 25



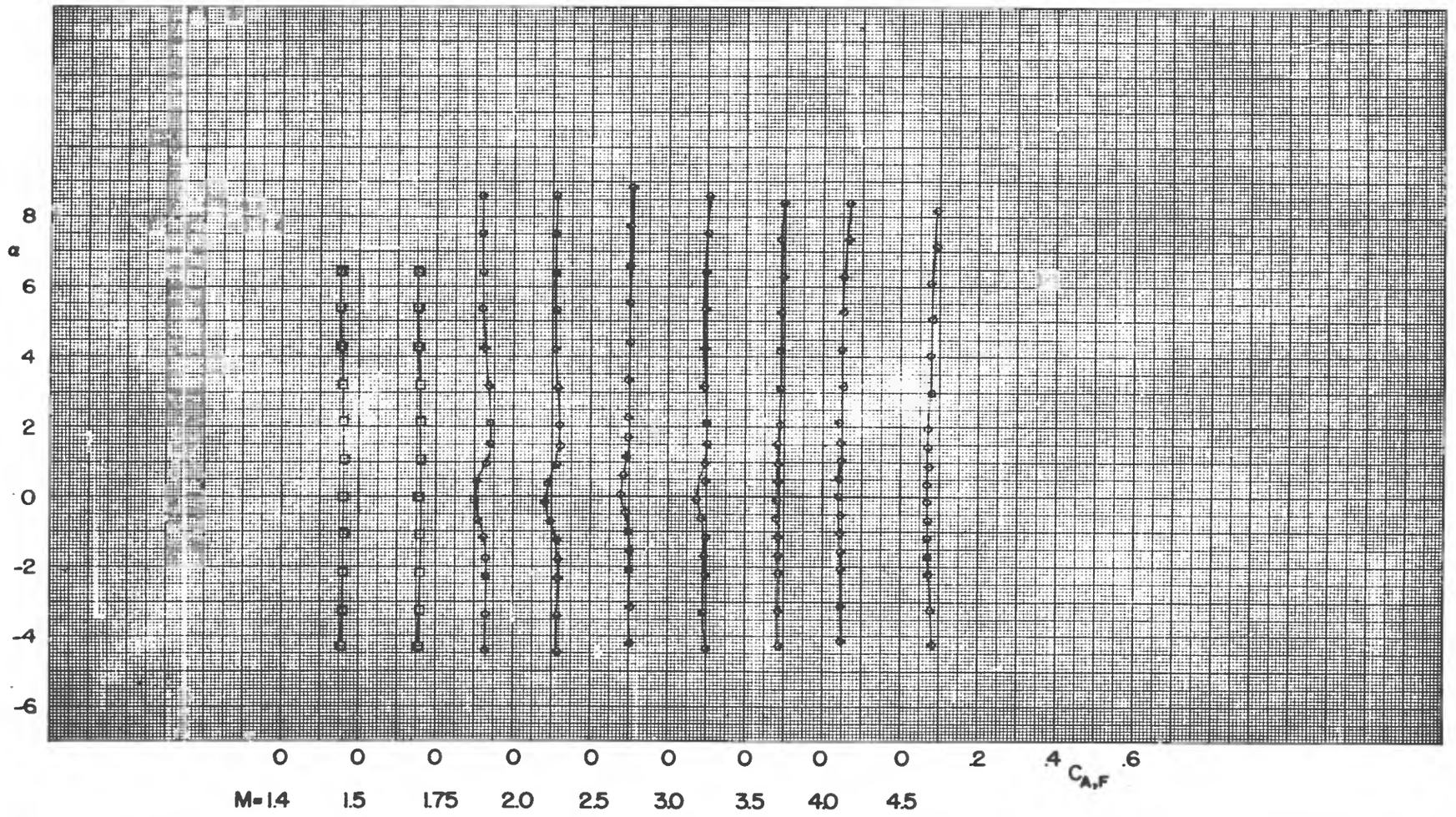
b. MACH NUMBERS 1.4 TO 4.5

FIGURE 81. CONCLUDED



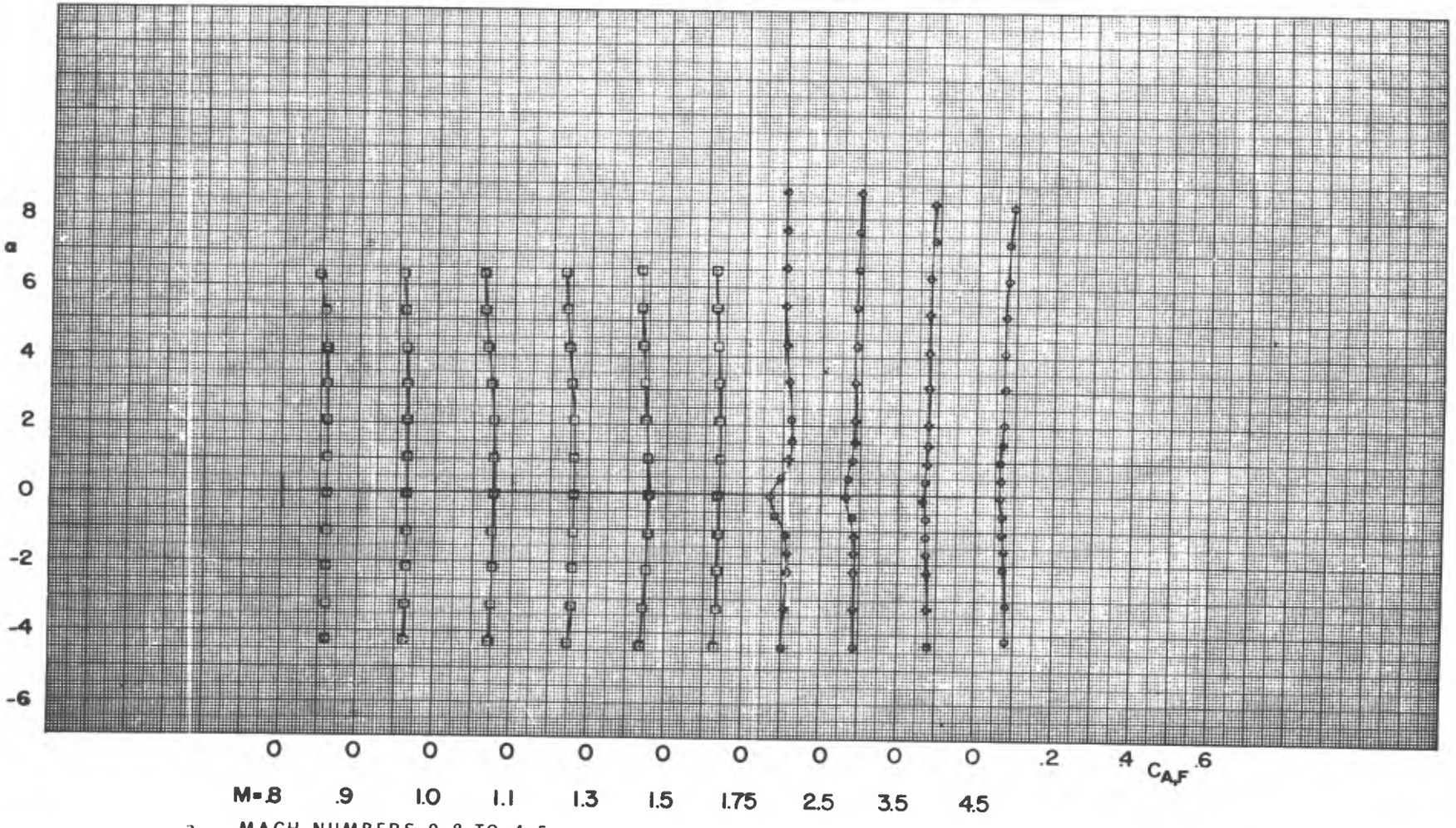
a. MACH NUMBERS 0.8 TO 1.3

FIGURE 82. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 26



b. MACH NUMBERS 1.4 TO 4.5

FIGURE 82. CONCLUDED



a. MACH NUMBERS 0.8 TO 4.5

FIGURE 83. VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT WITH ANGLE OF ATTACK FOR CONFIGURATION 27

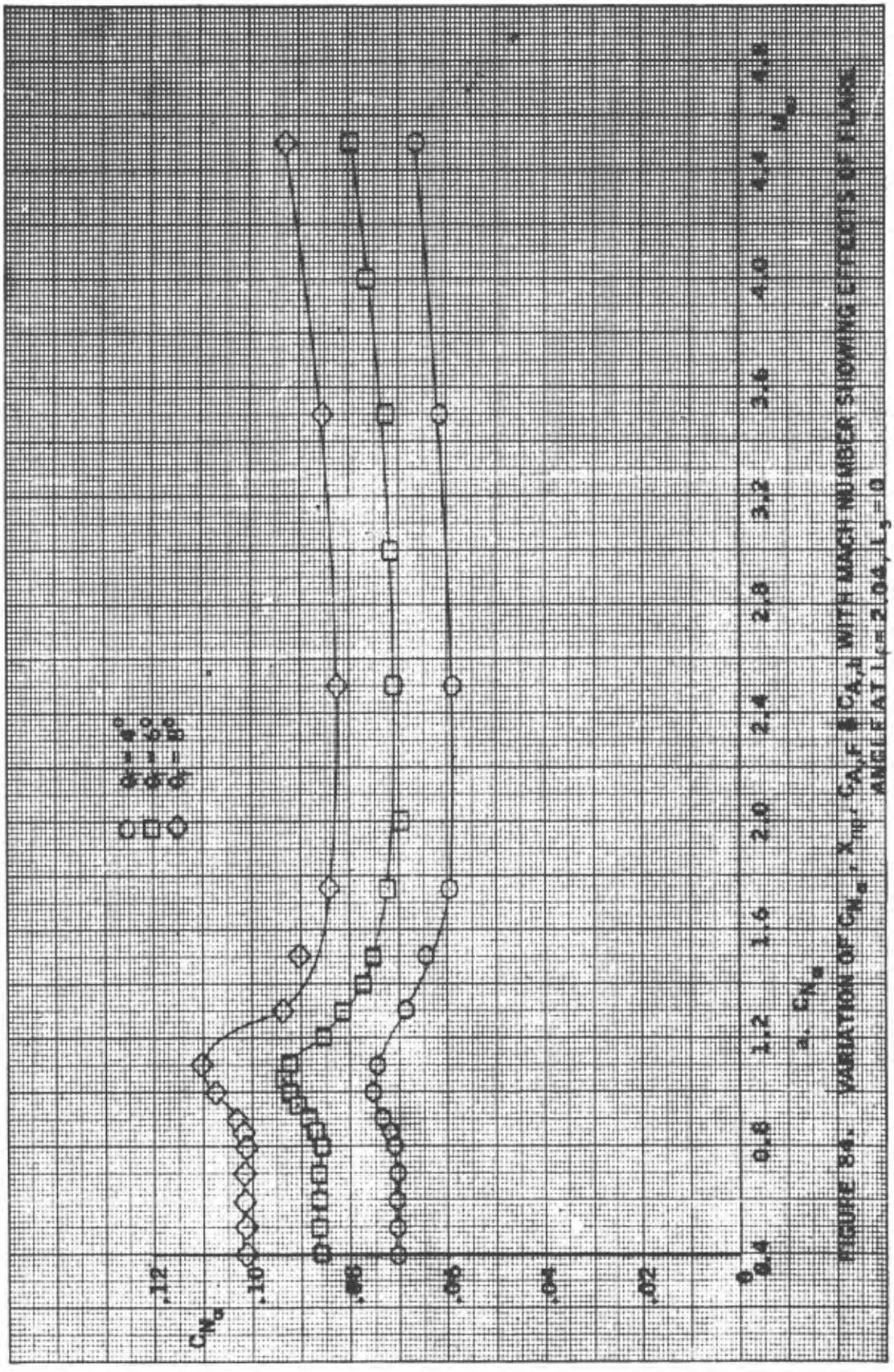
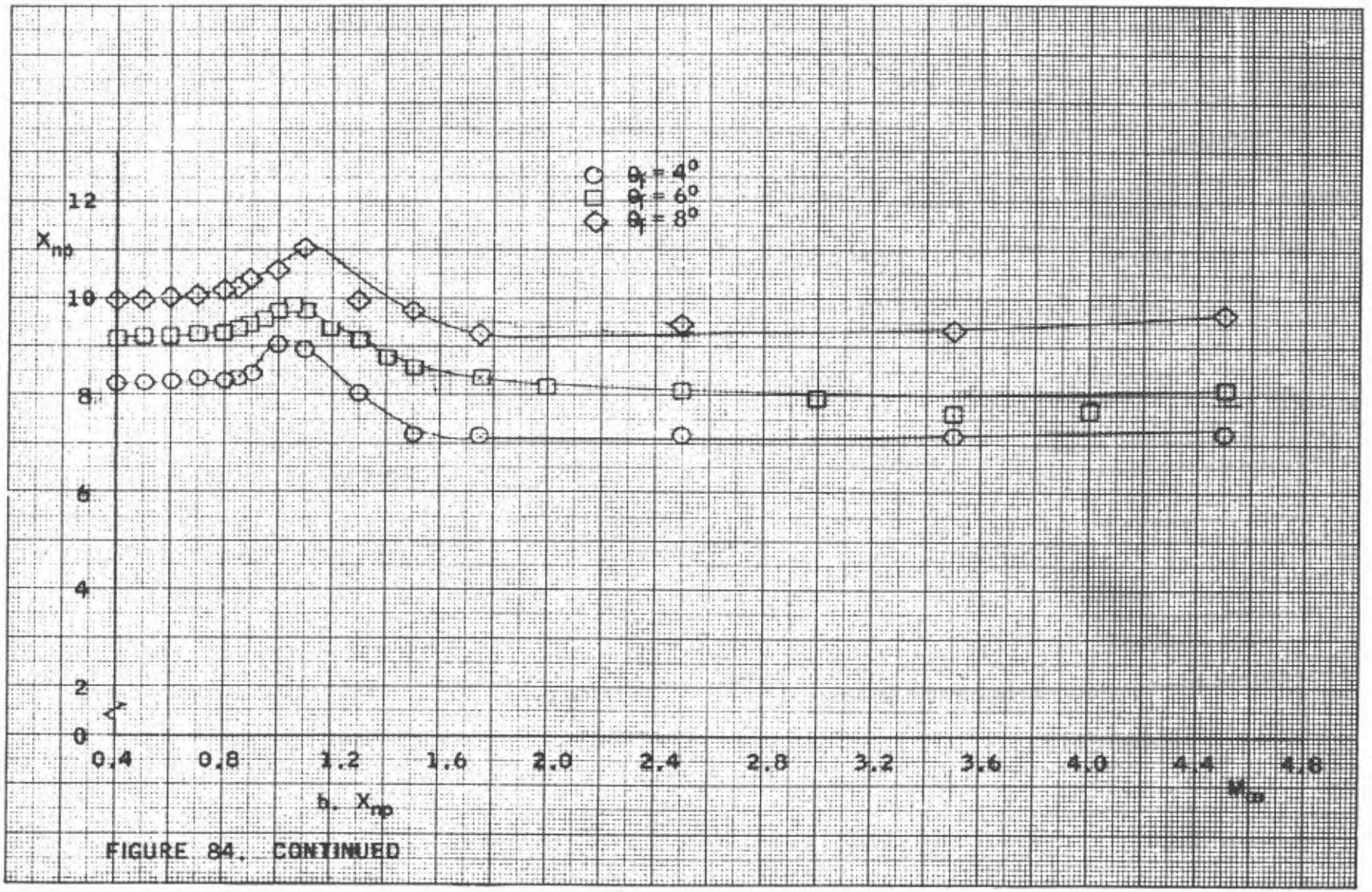
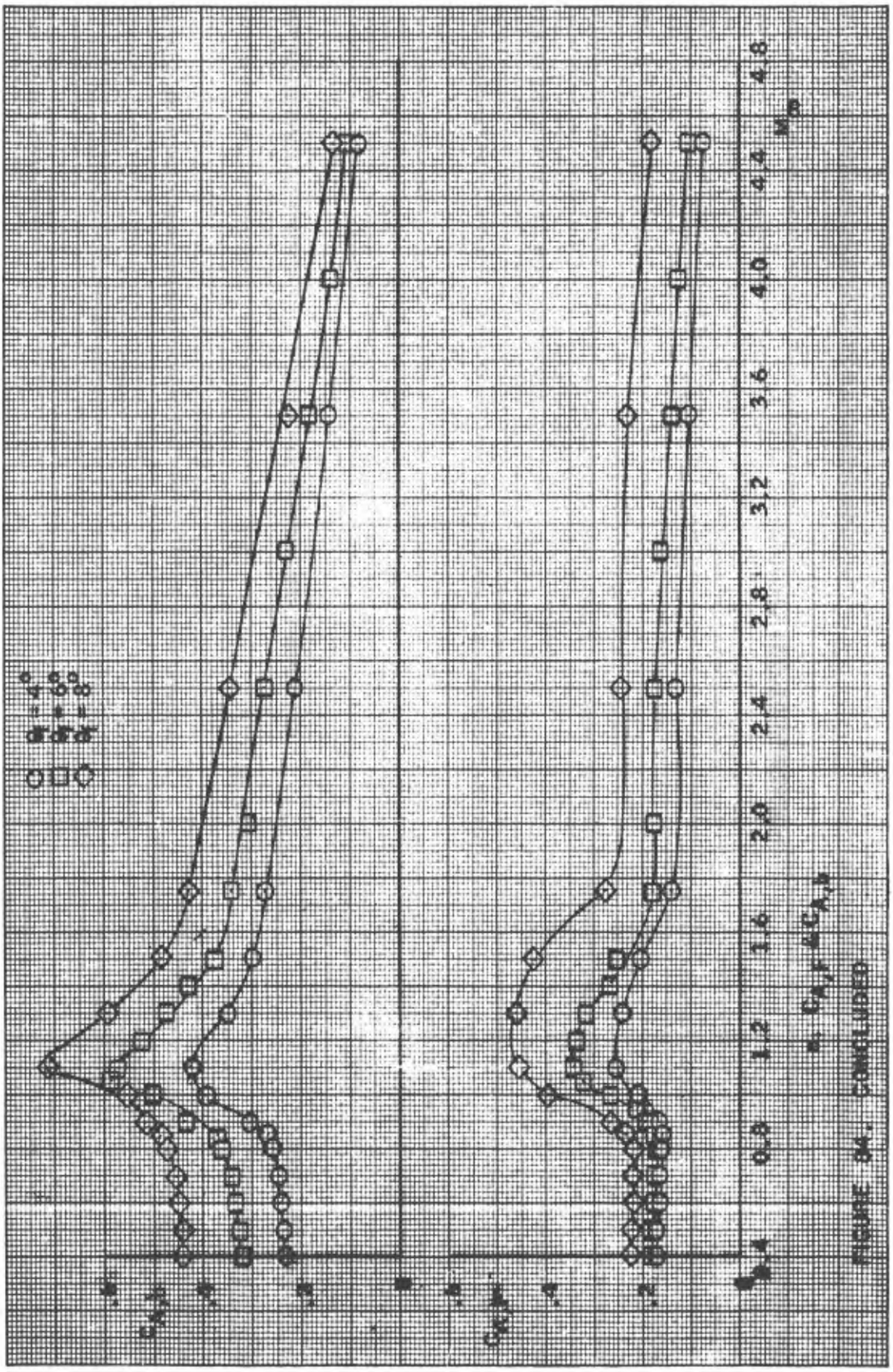


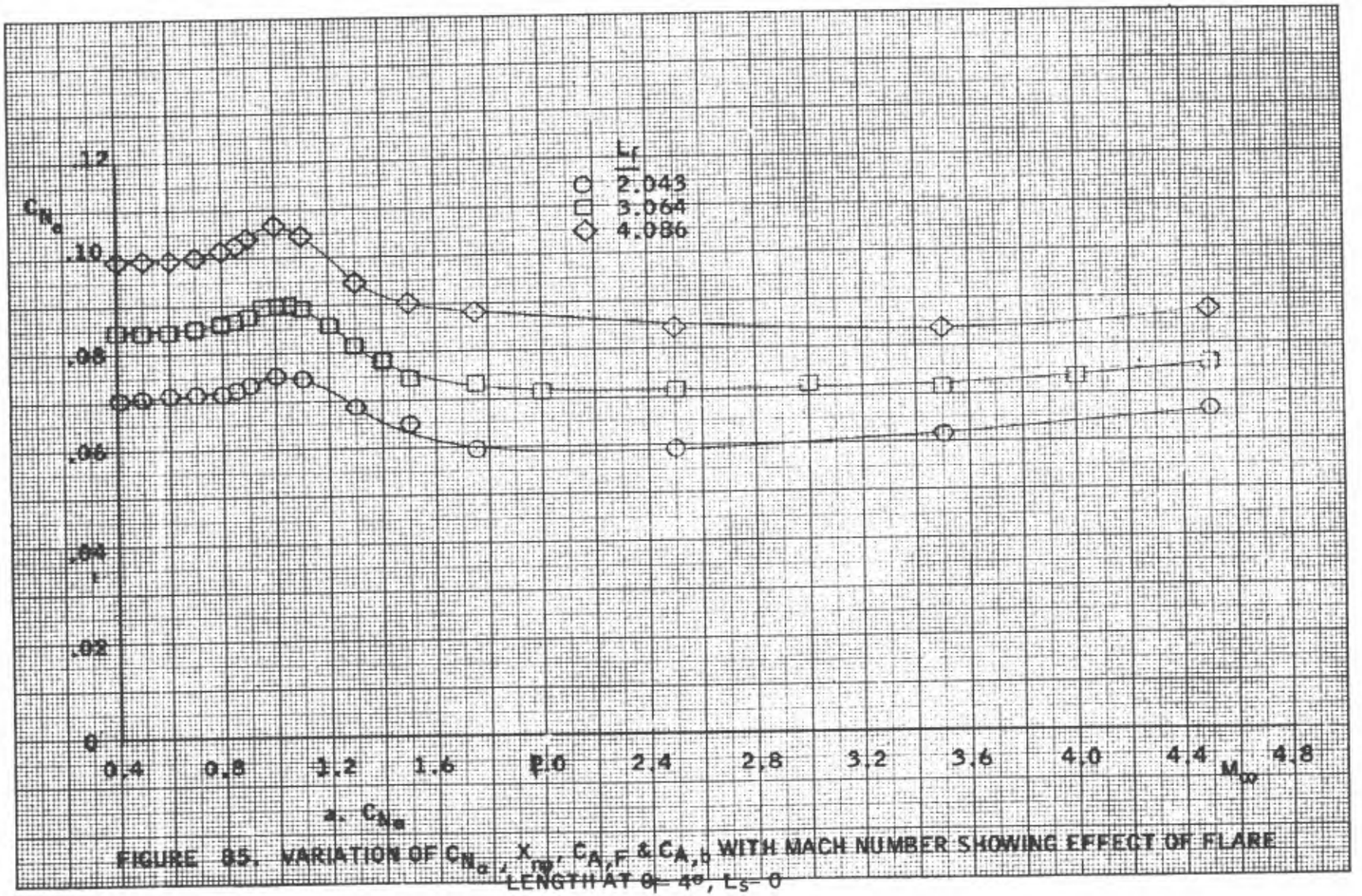
FIGURE 84. VARIATION OF C_{N_α}, X_{cp}, $C_{A,F}$, $C_{A,B}$ WITH MACH NUMBER SHOWING EFFECTS OF FLARE ANGLE AT $L_1/d = 2.04$, $L_2 = 0$



b. X_{np}

FIGURE 84. CONTINUED


4,8
4,4
4,0
3,6
3,2
2,8
2,4
2,0
1,6
1,2
0,8
0,4
FIGURE 34
CONFLUENCE



a. C_{N_α}

FIGURE 85. VARIATION OF C_{N_α}, X_{cp}, $C_{A,F}$ & $C_{A,b}$ WITH MACH NUMBER SHOWING EFFECT OF FLARE LENGTH AT $\alpha = 4^\circ$, $L_s = 0$

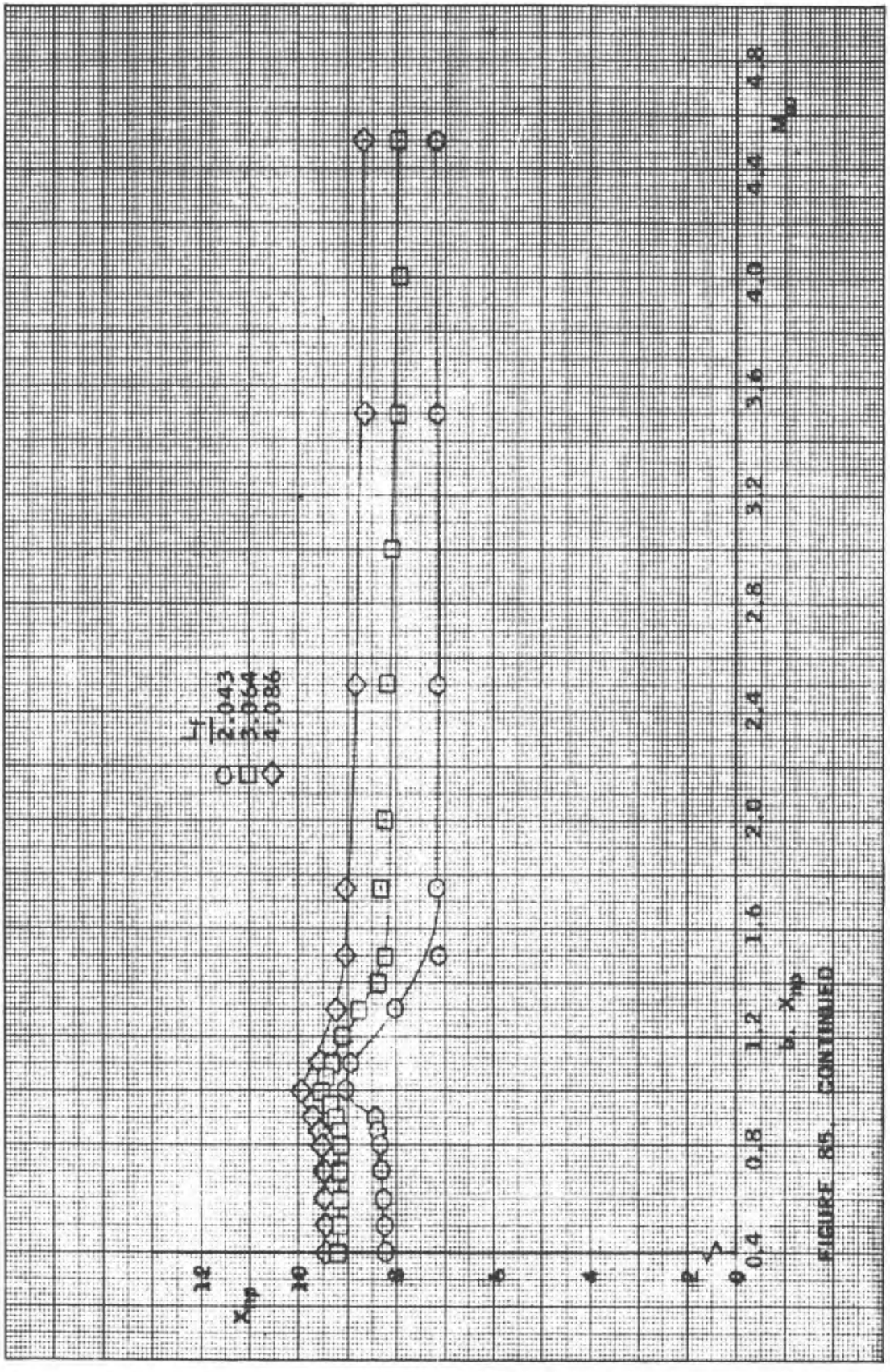
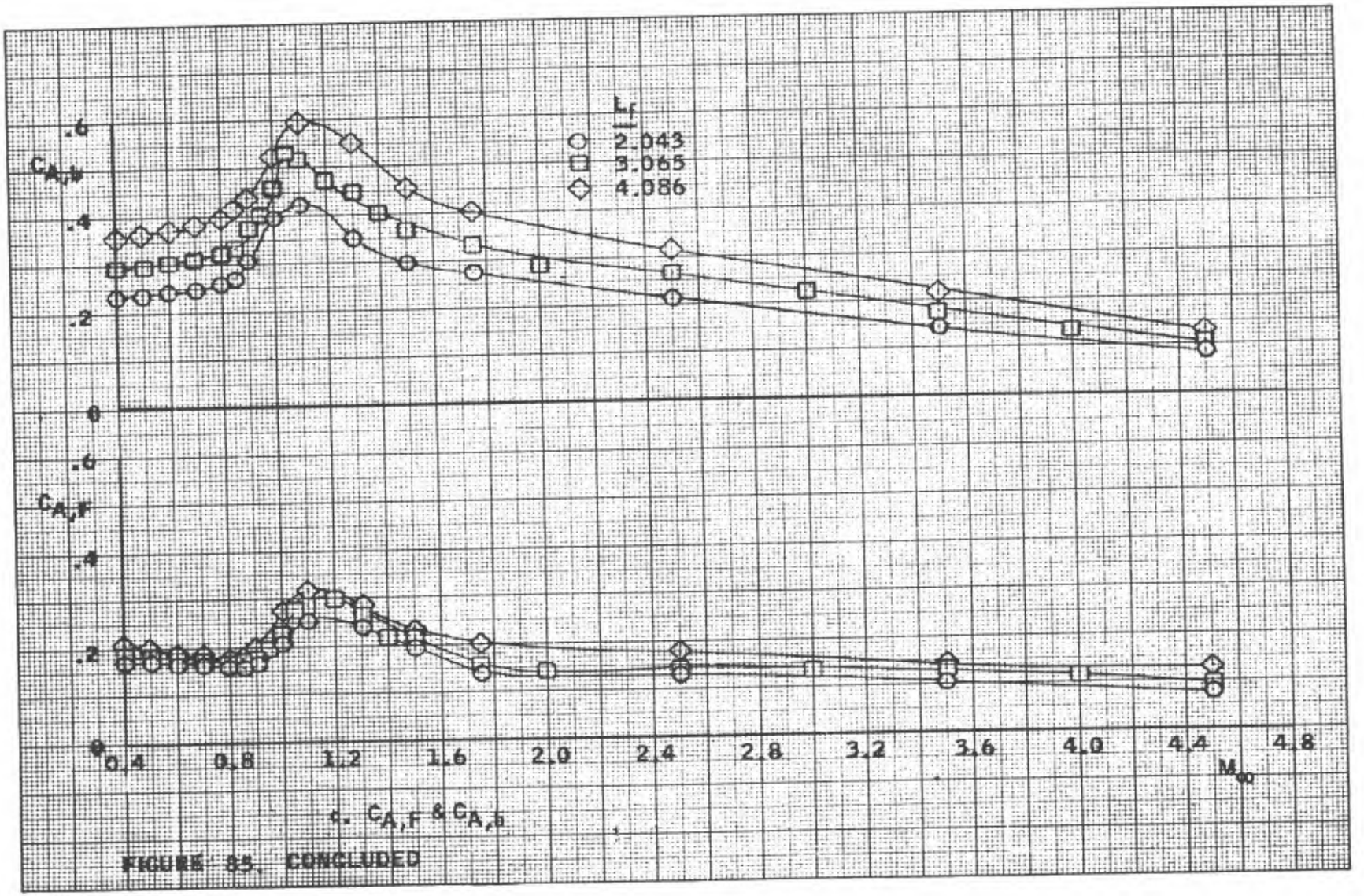
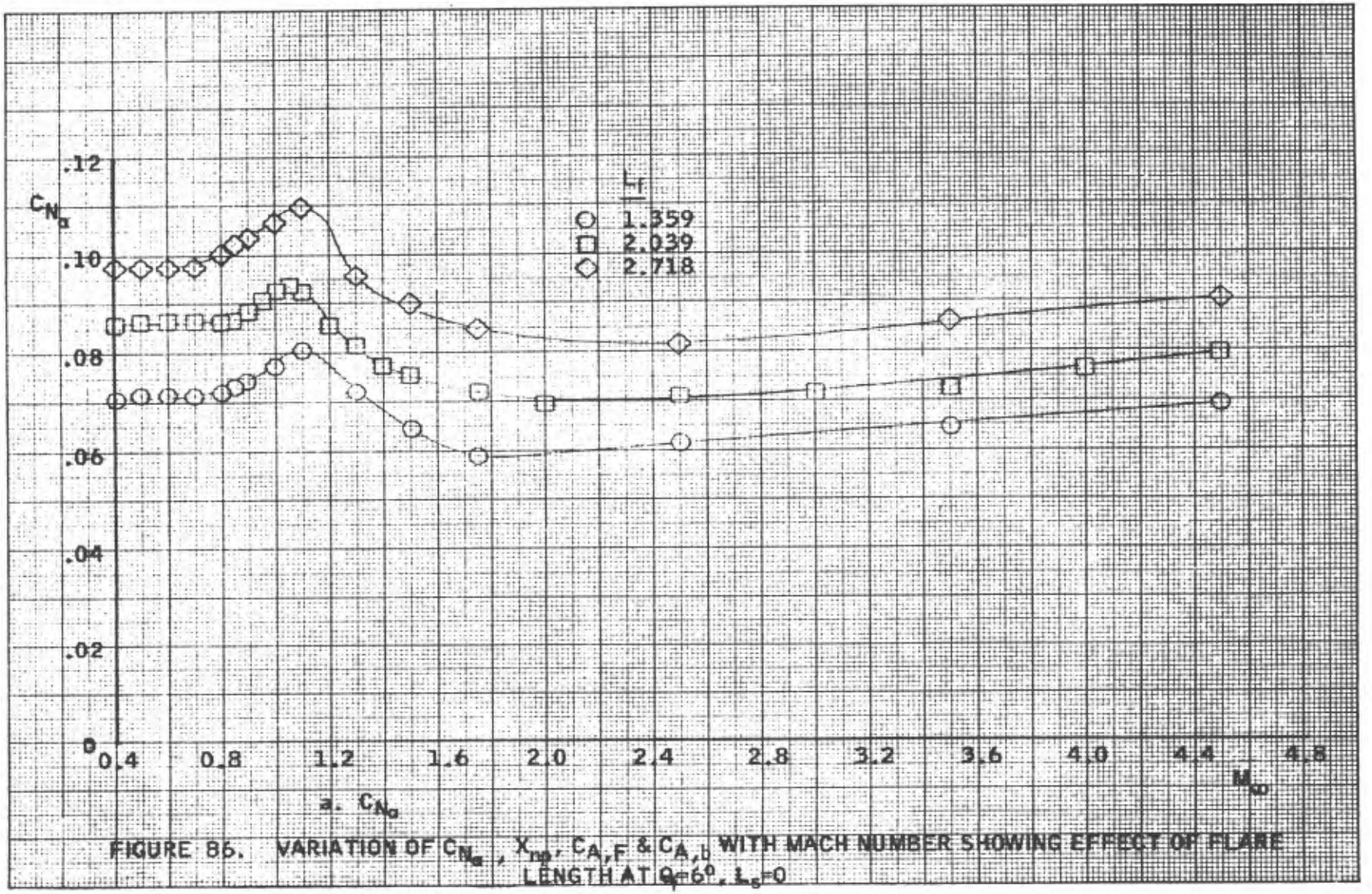


FIGURE 86. CONTINUED



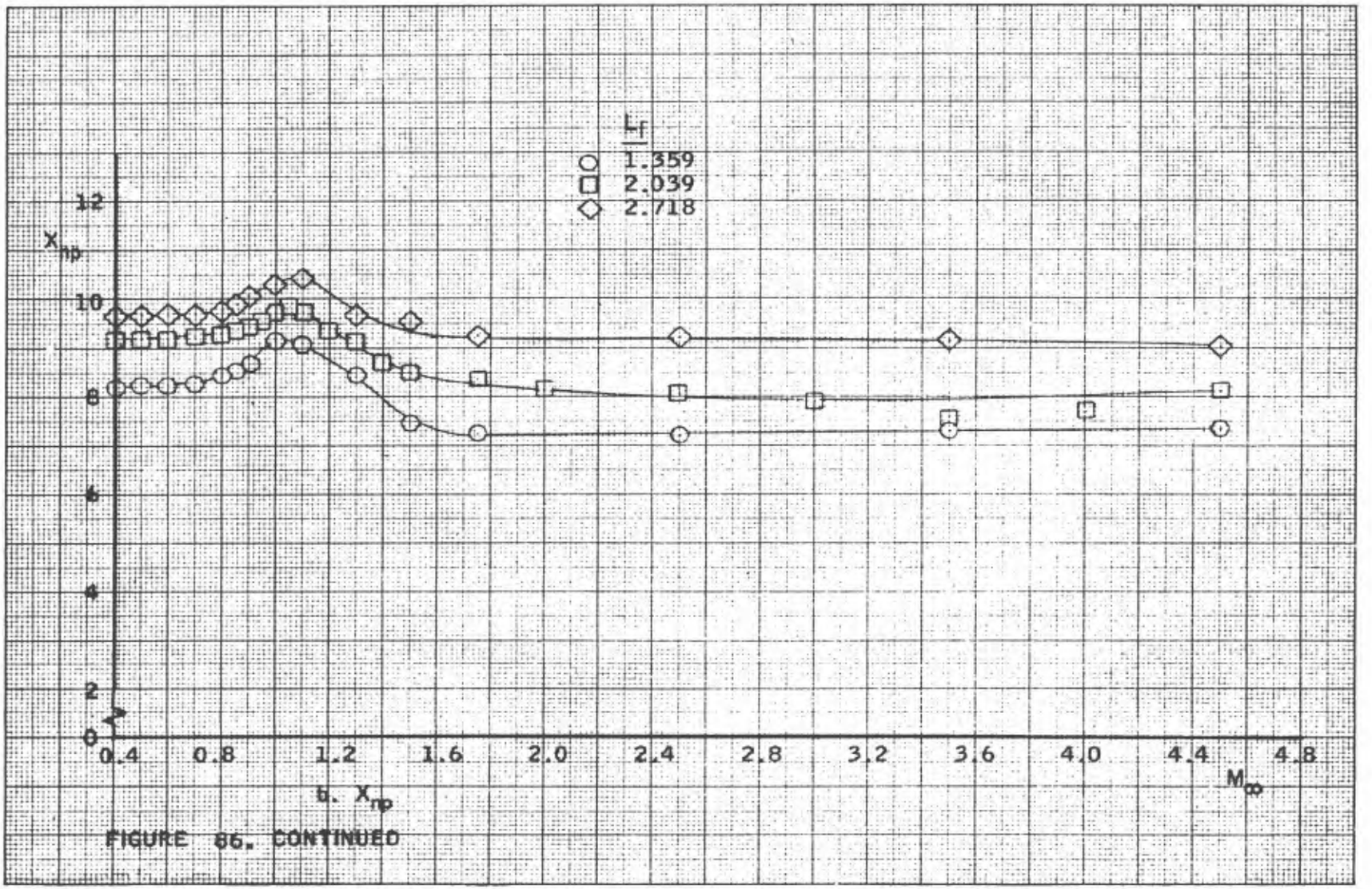
c. $C_{A,F}$ & $C_{A,b}$

FIGURE 85. CONCLUDED



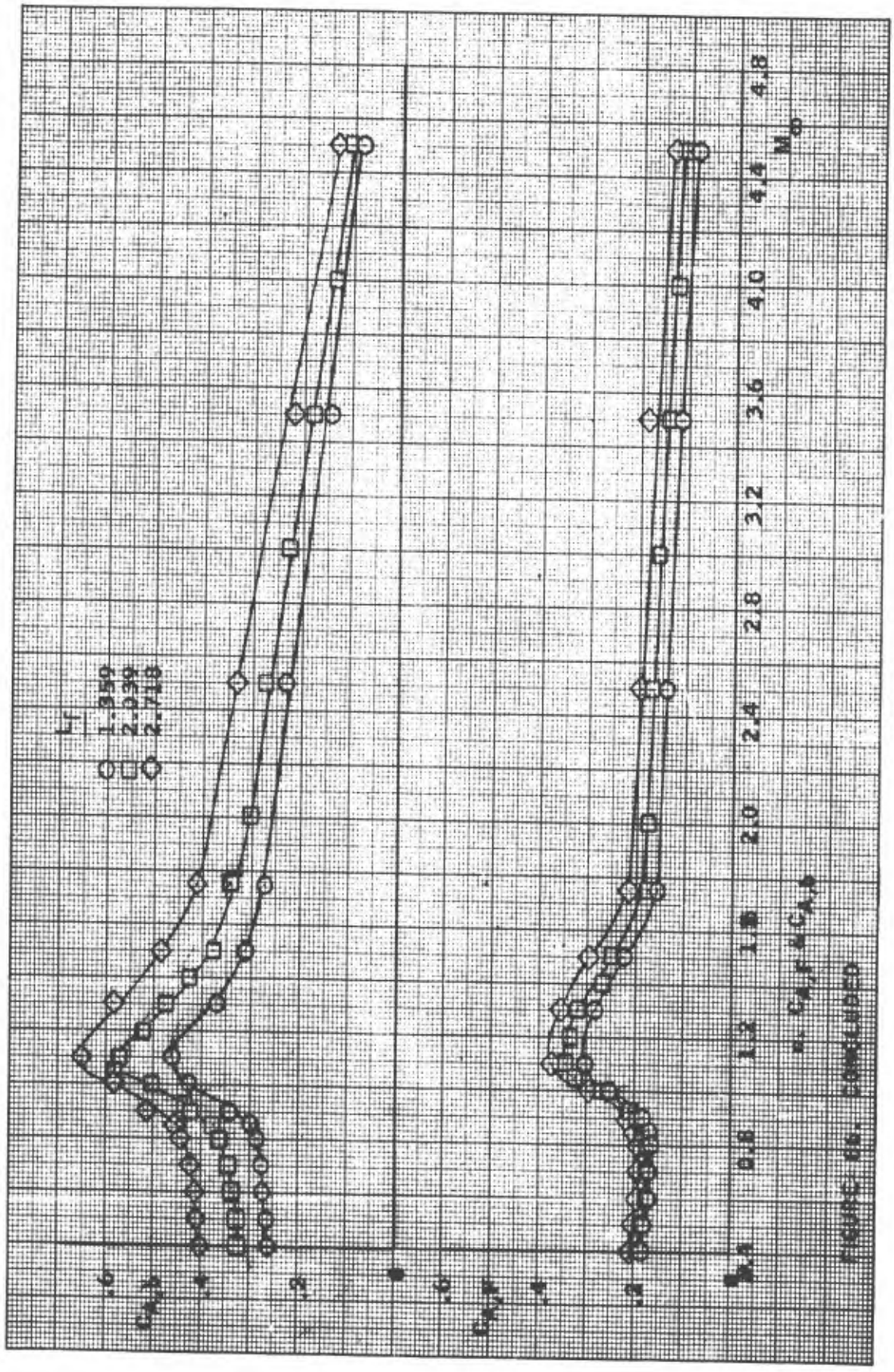
a. C_{N_α}

FIGURE 86. VARIATION OF C_{N_α}, X_{np}, $C_{A,F}$ & $C_{A,b}$ WITH MACH NUMBER SHOWING EFFECT OF FLARE LENGTH AT $\alpha_f=6^0$, $i_s=0$



b. X_{np}

FIGURE 86. CONTINUED


3.6
4.0
4.4
4.8
M_∞
2.8
3.2
2.4
2.0
1.6
1.2
0.8
C_{M_α}
C_{M_q}
$C_{M_{\dot{\alpha}}}$
C_{M_α}
C_{M_q}
$C_{M_{\dot{\alpha}}}$
C_{M_α}, C_{M_q}, $C_{M_{\dot{\alpha}}}$ COMPUTED

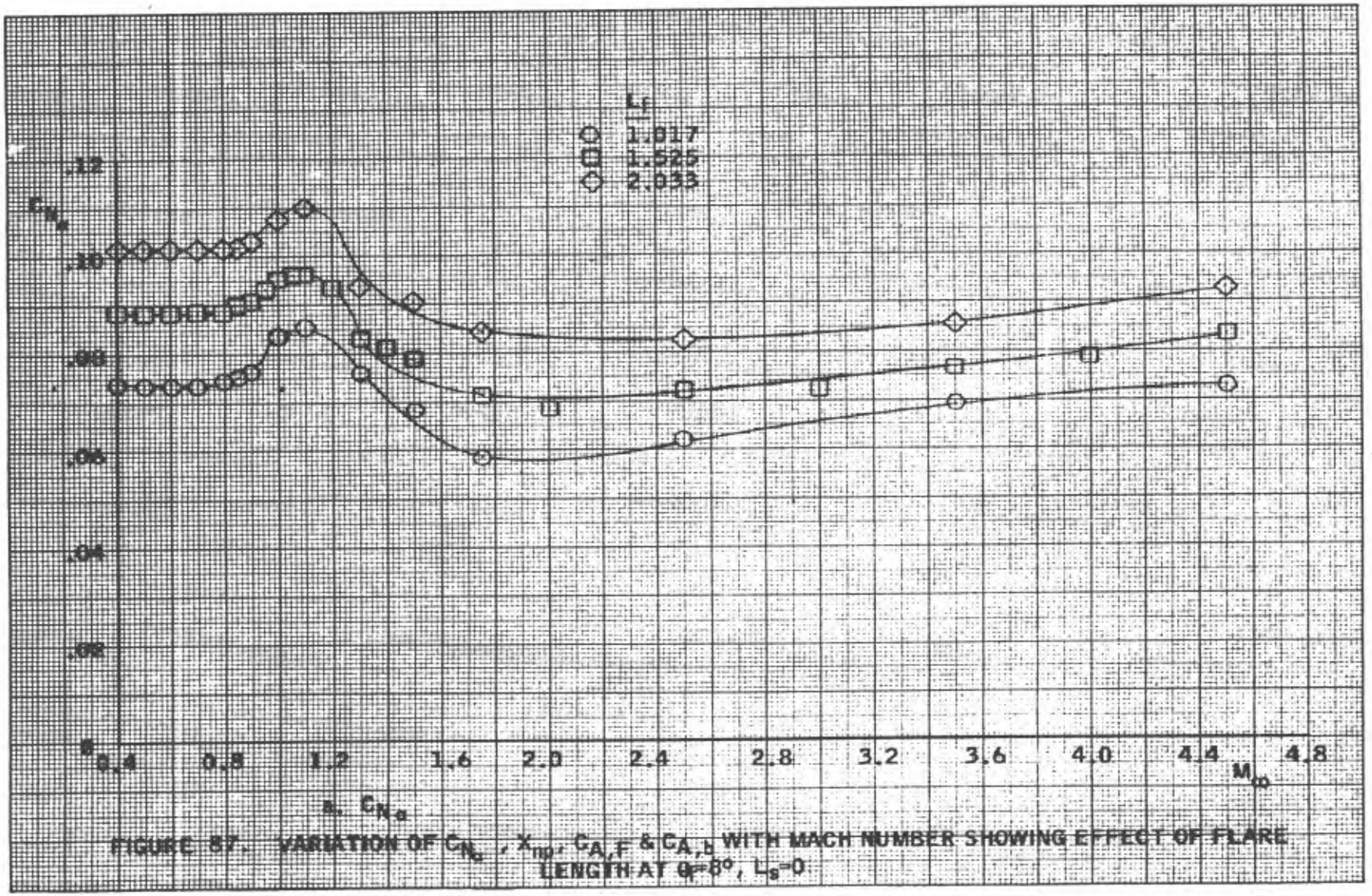
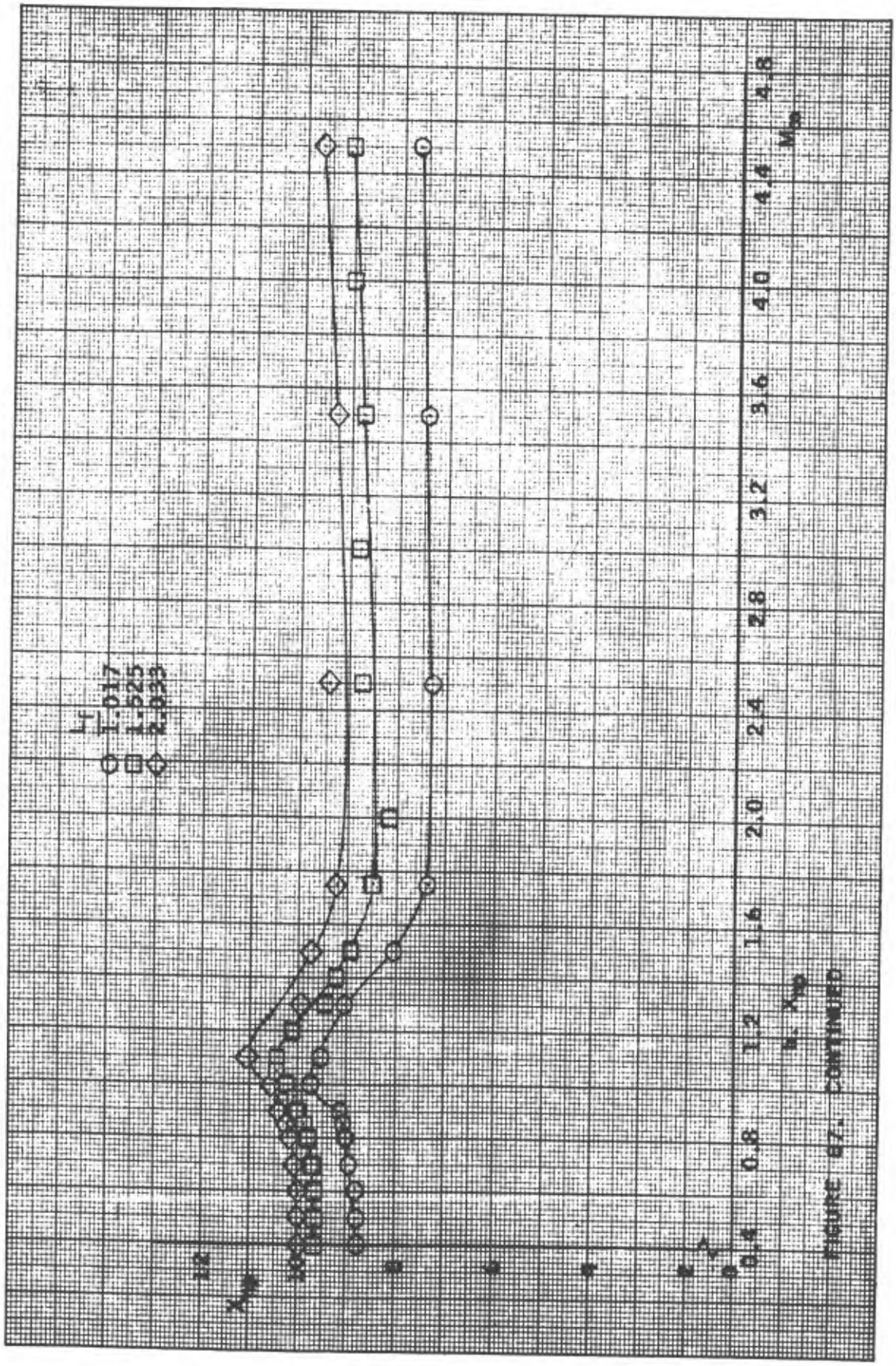
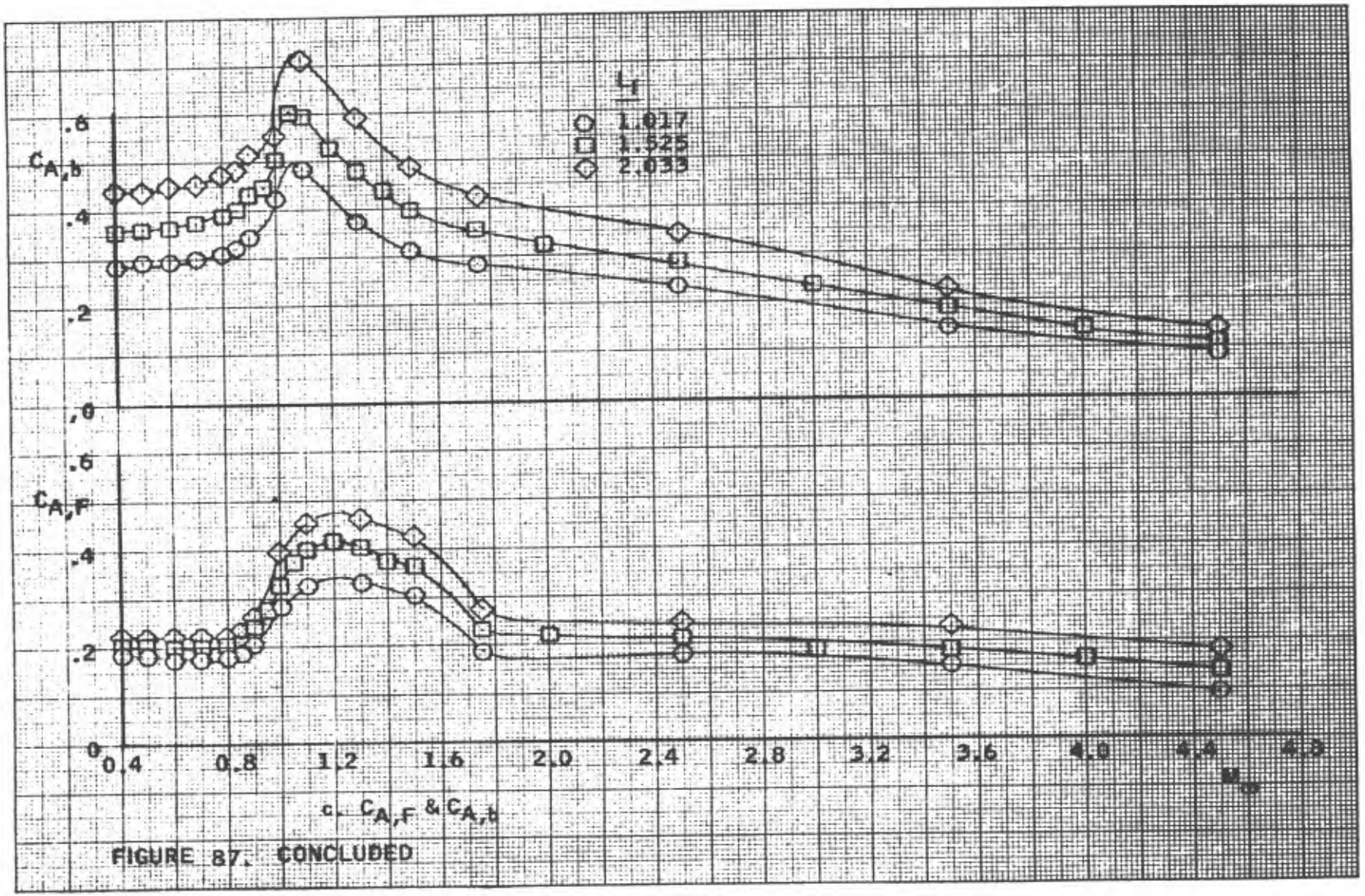


FIGURE 87. VARIATION OF C_{N_α}, X_{cp}, $C_{A,F}$ & $C_{A,b}$ WITH MACH NUMBER SHOWING EFFECT OF FLARE LENGTH AT θ_f=8°, L_s=0


LT
F.017
1.525
2.033
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
M∞
x, Xp
FIGURE 67. CONTINUED



c. $C_{A,F}$ & $C_{A,b}$

FIGURE 87. CONCLUDED

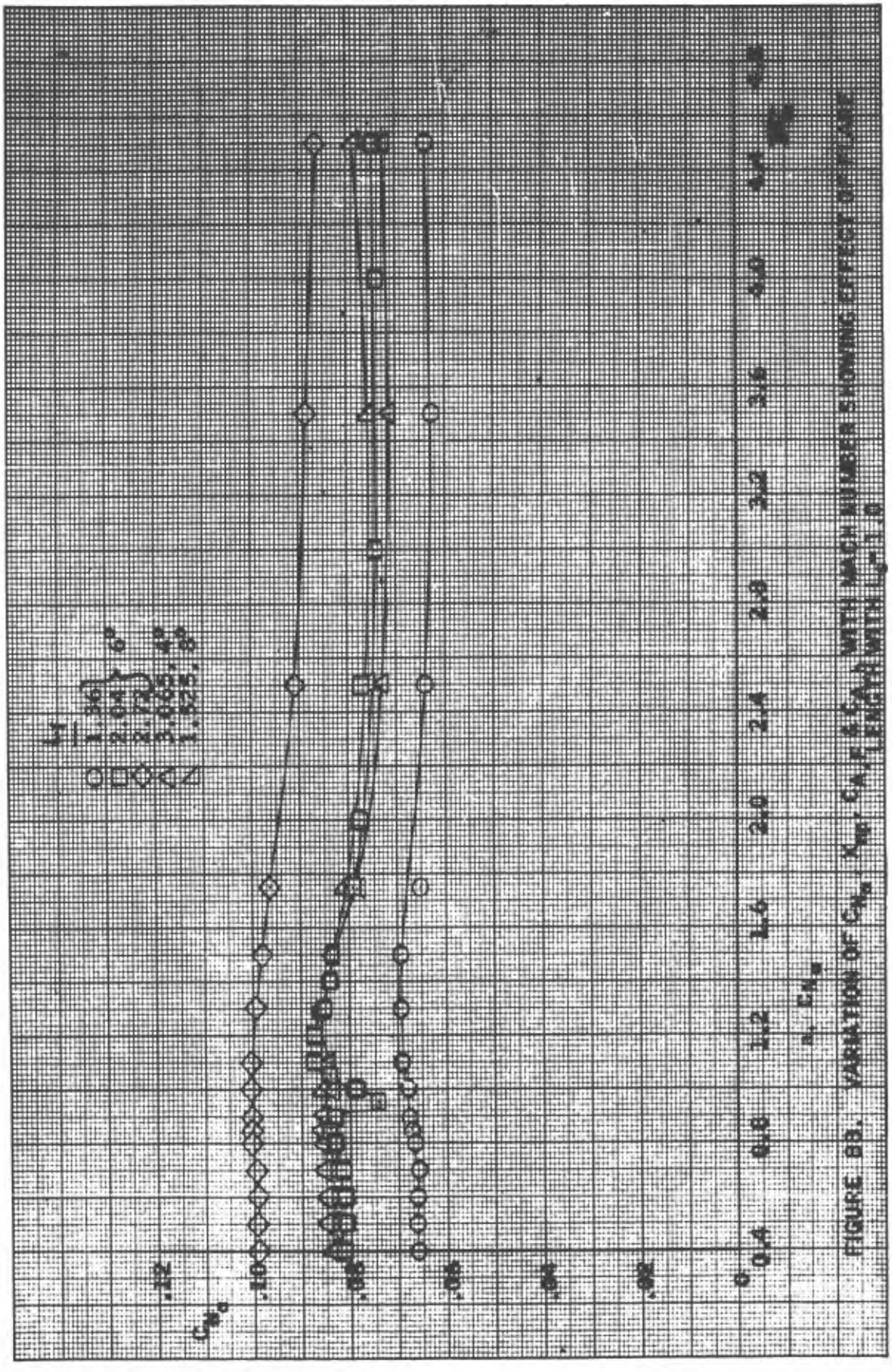


FIGURE 88. VARIATION OF C_{m_α} WITH K_{MF}, C_{N_α}, & C_{A_α} WITH MACH NUMBER SHOWING EFFECTS OF LENGTH OF AFT BODY WITH $L_n = 1.0$

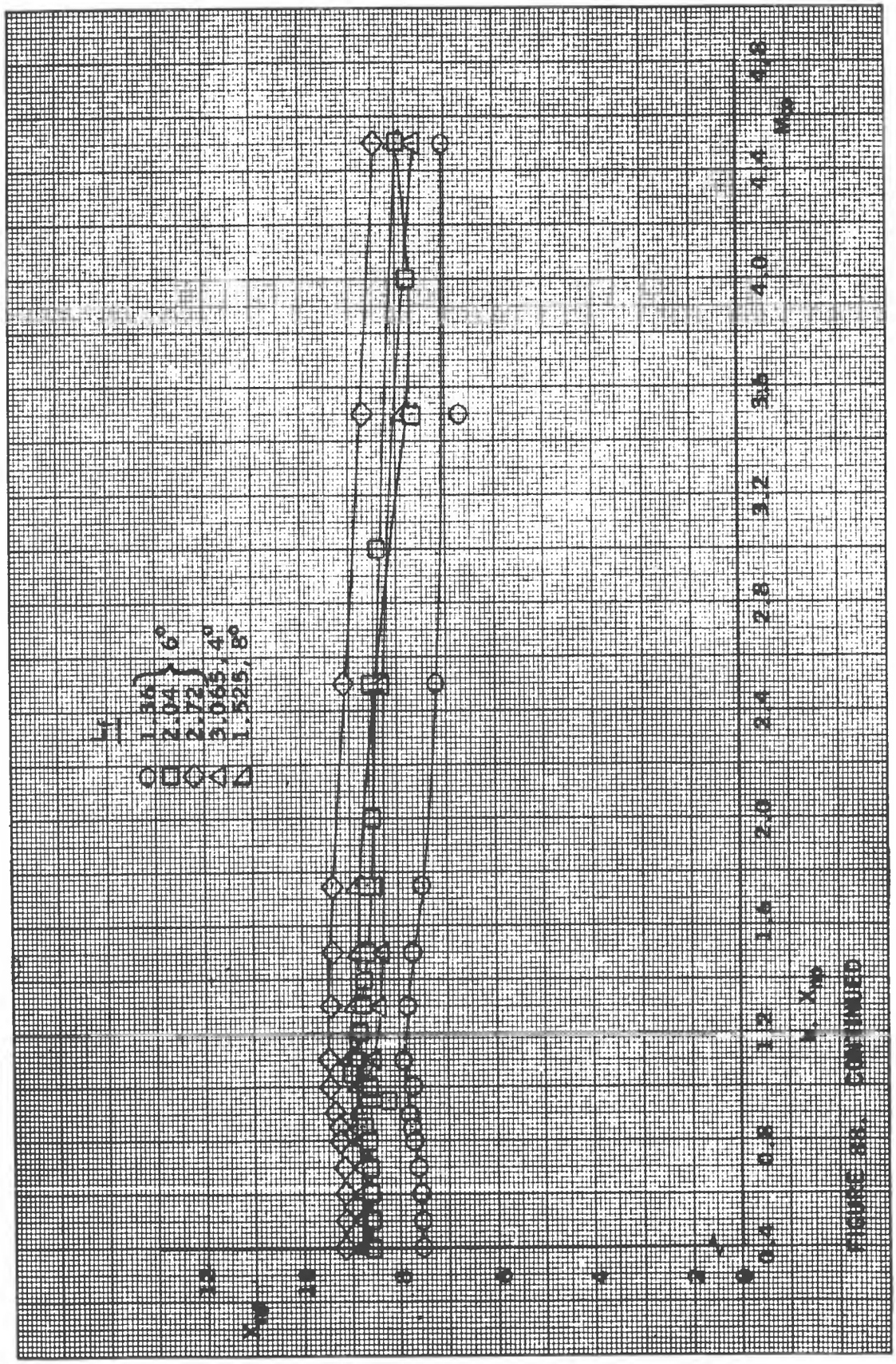
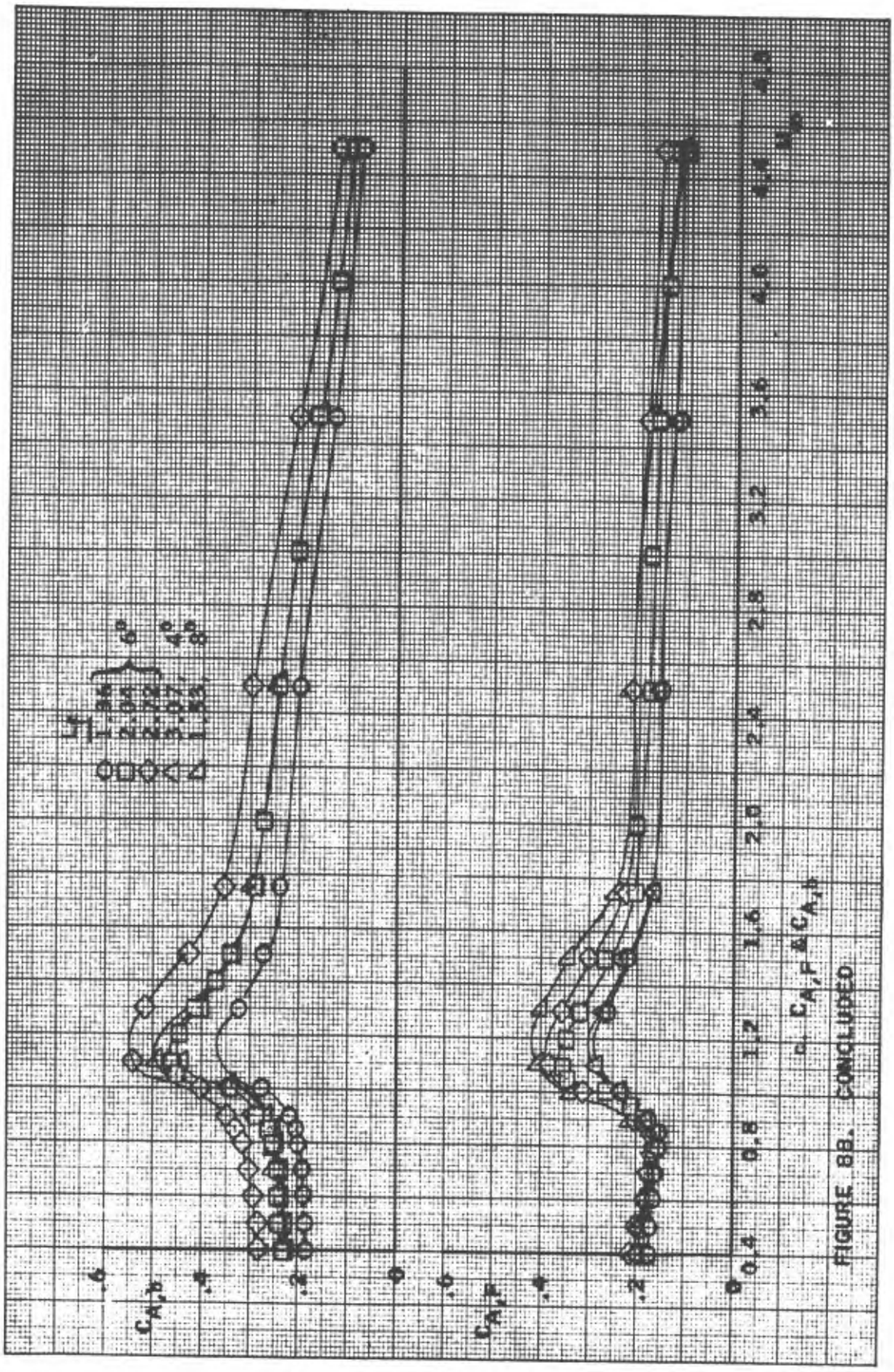


FIGURE 34.1
CONTINUED


$C_{A,b}$
$C_{A,F}$
$C_{A,F}$ & $C_{A,b}$
FIGURE 88. CONCLUDED

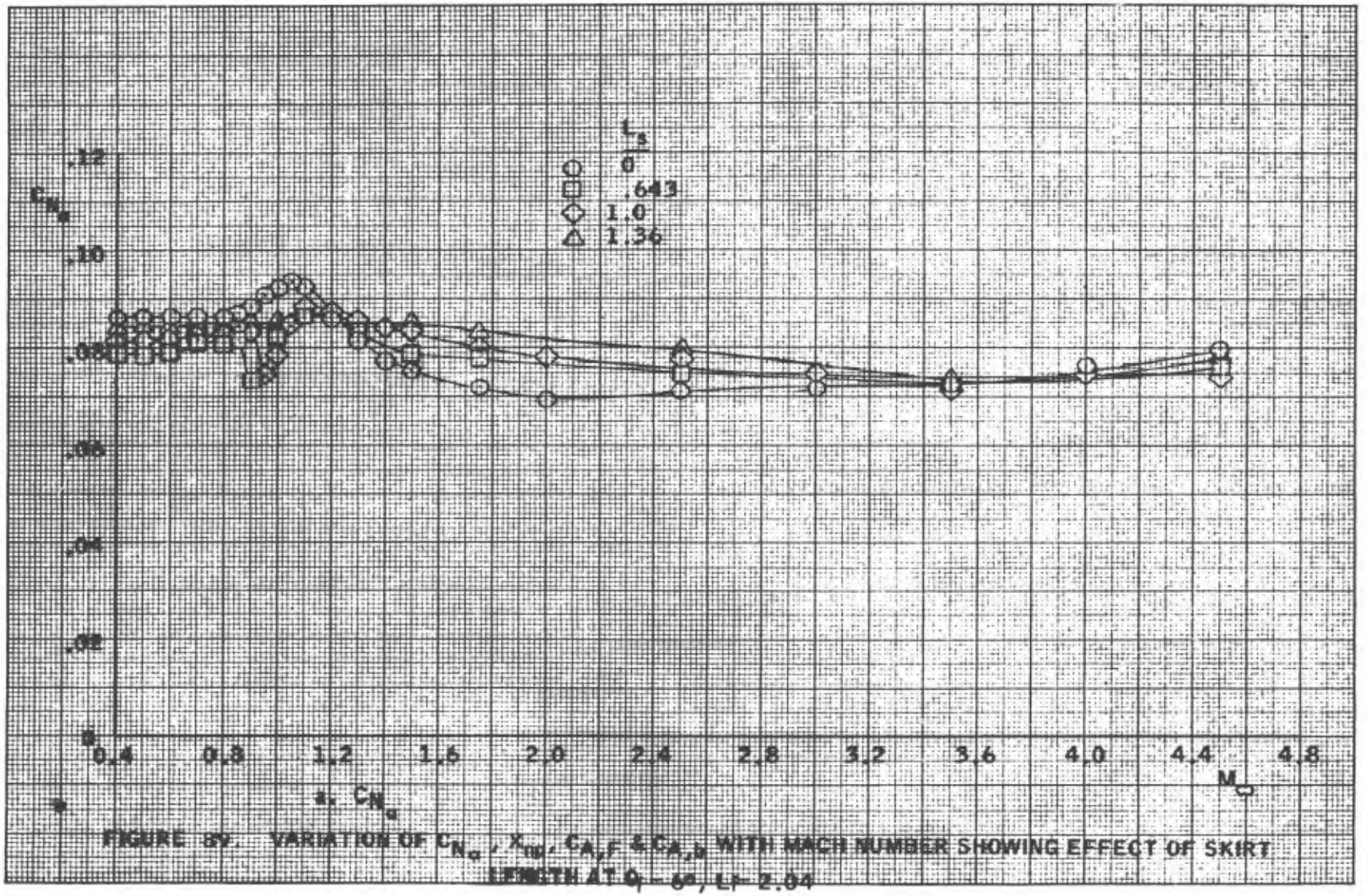


FIGURE 89. VARIATION OF C_{N_α}, X_{cp}, C_{A_1F} & C_{A_2b} WITH MACH NUMBER SHOWING EFFECT OF SKIRT LENGTH AT $\alpha_1 = \delta^\circ$, $L_1 = 2.04$

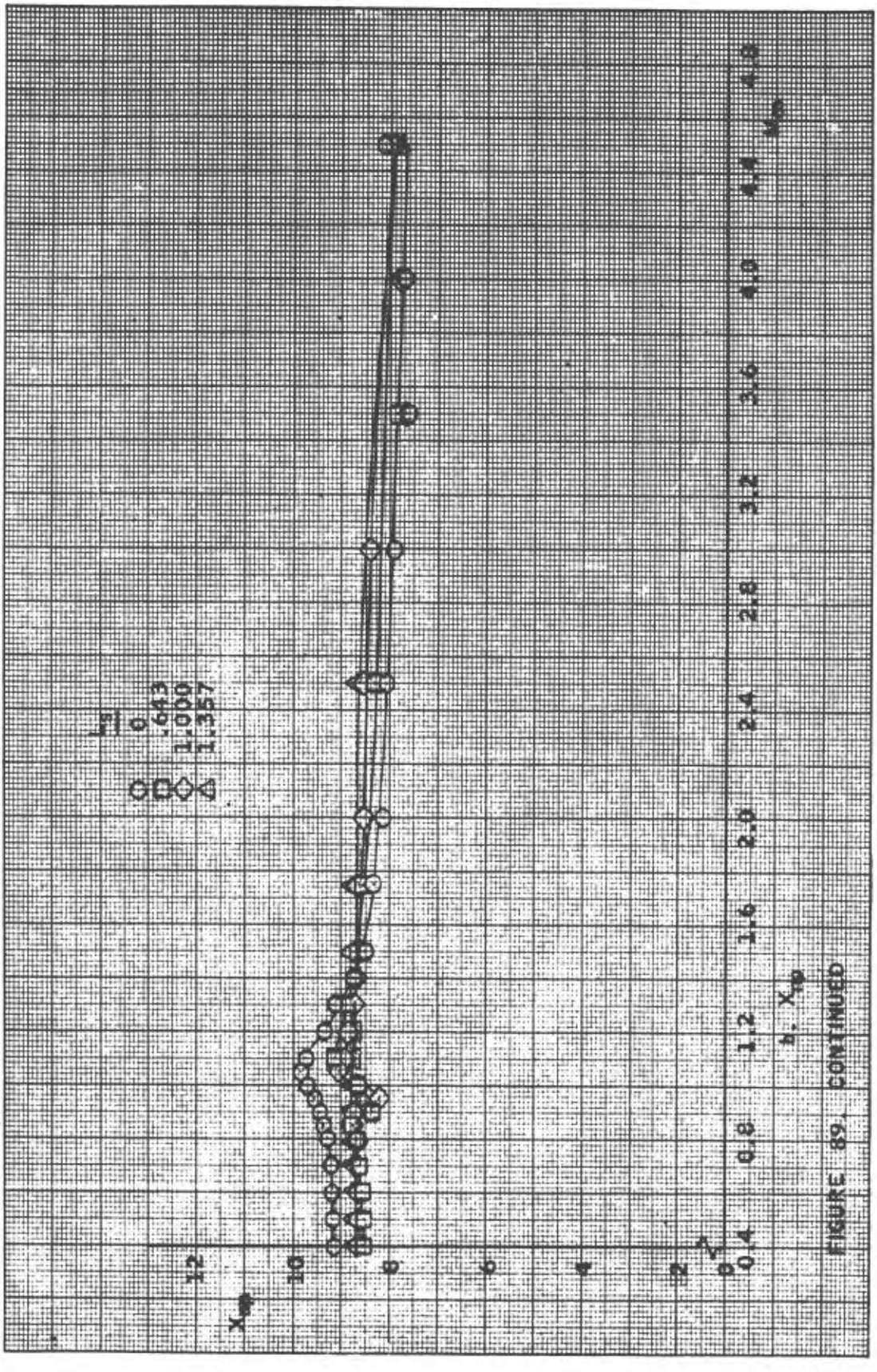


FIGURE 89. CONTINUED
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
2
4
6
8
10
12
.643
1.000
1.357

4.8
4.4
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
Mg
C, C_4F_8, SO_2F_2
FIGURE 89. CONCLUDED

FIGURE 90. VARIATION OF C_{N_α}, X_{np}, C_A, F & C_A, b WITH MACH NUMBER SHOWING EFFECT OF NOSE ANGLE FOR THE CONE-CYLINDER CONFIGURATIONS.

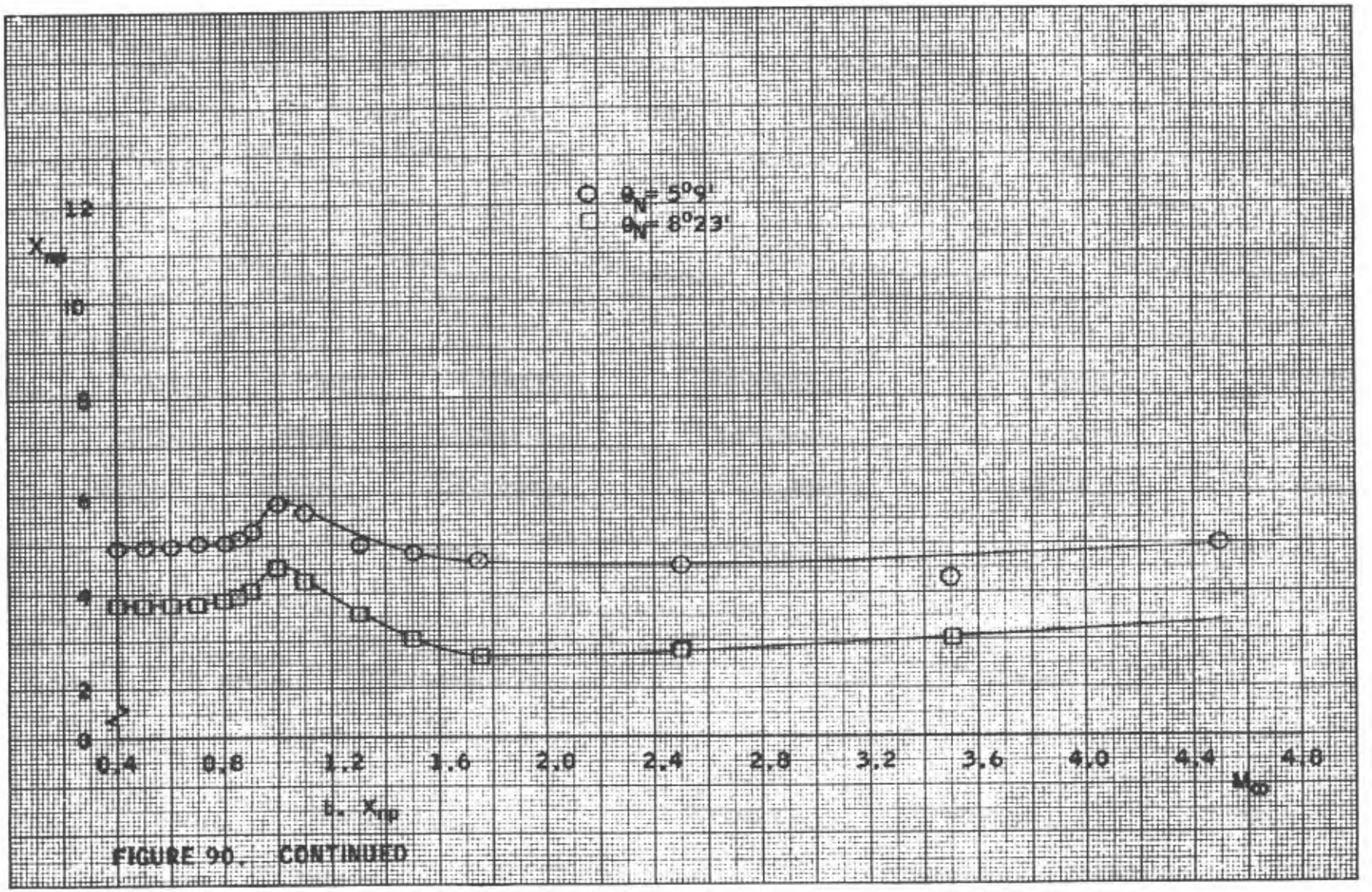


FIGURE 90. CONTINUED

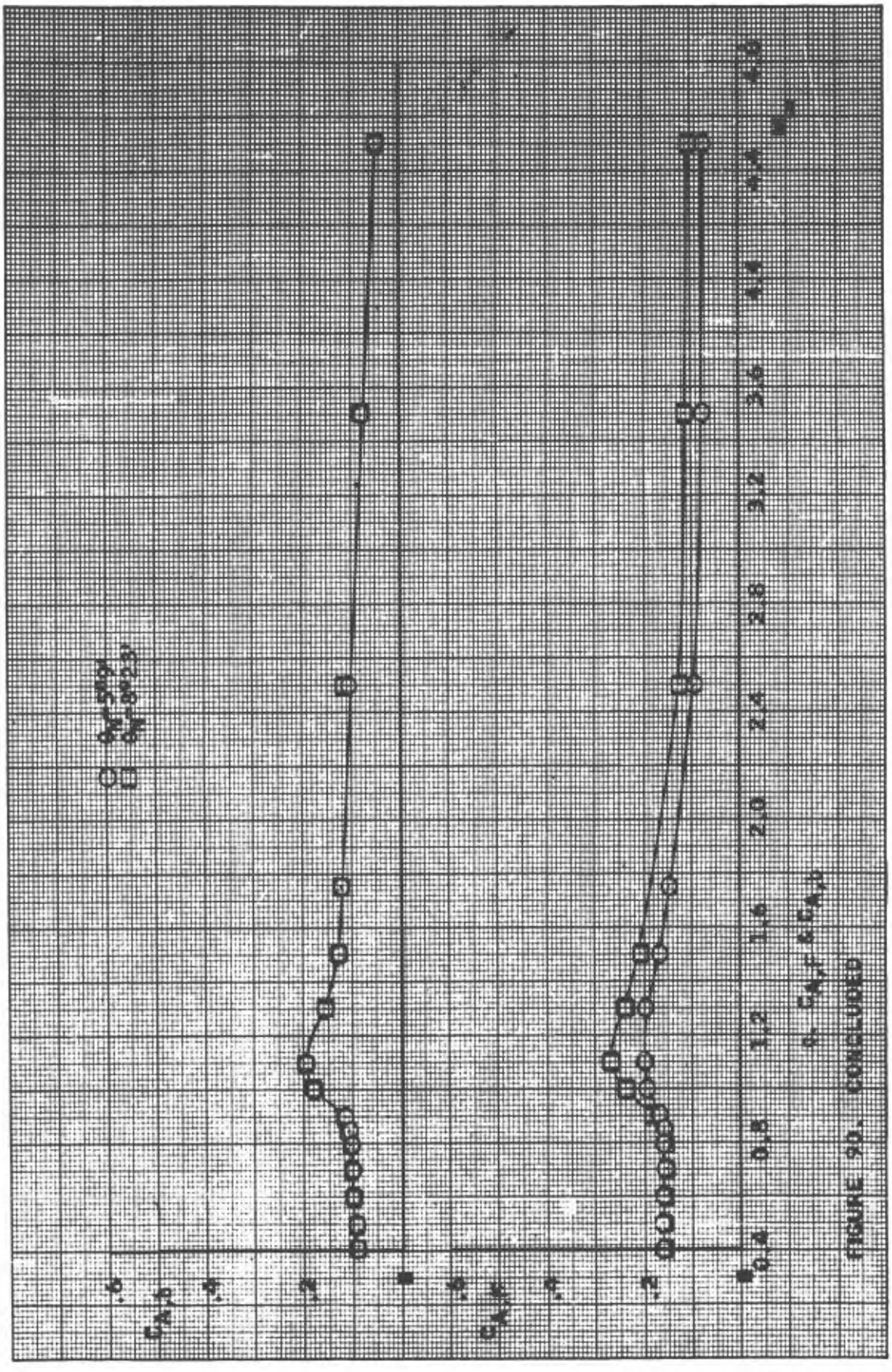


FIGURE 20. CONCLUDED

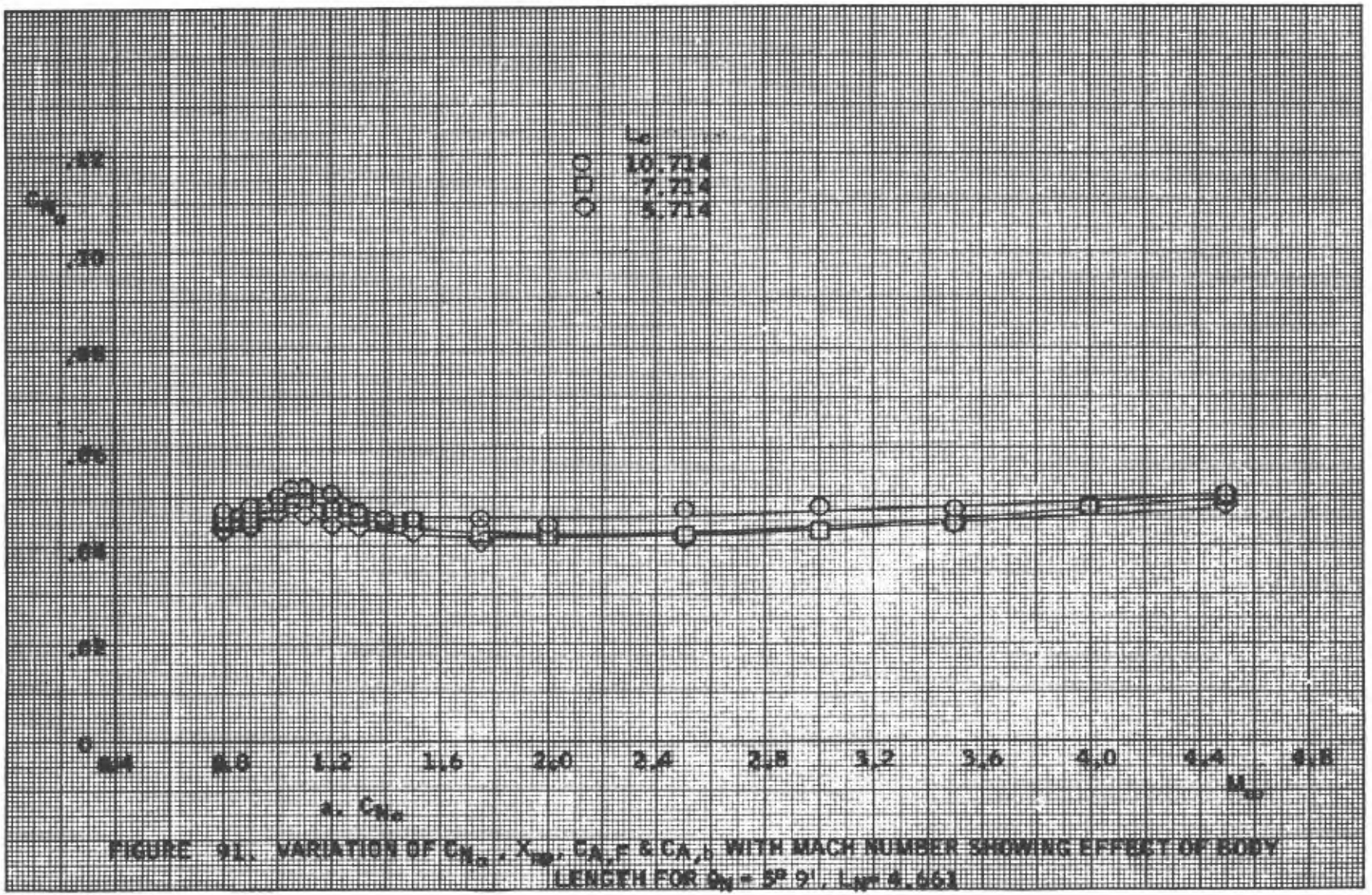


FIGURE 91. VARIATION OF C_{N_α}, X_{cp}, $C_{A,F}$ & $C_{A,b}$ WITH MACH NUMBER SHOWING EFFECT OF BODY LENGTH FOR $\delta_N = 5^P\ 9'$, $L_{ref} = 4.661$

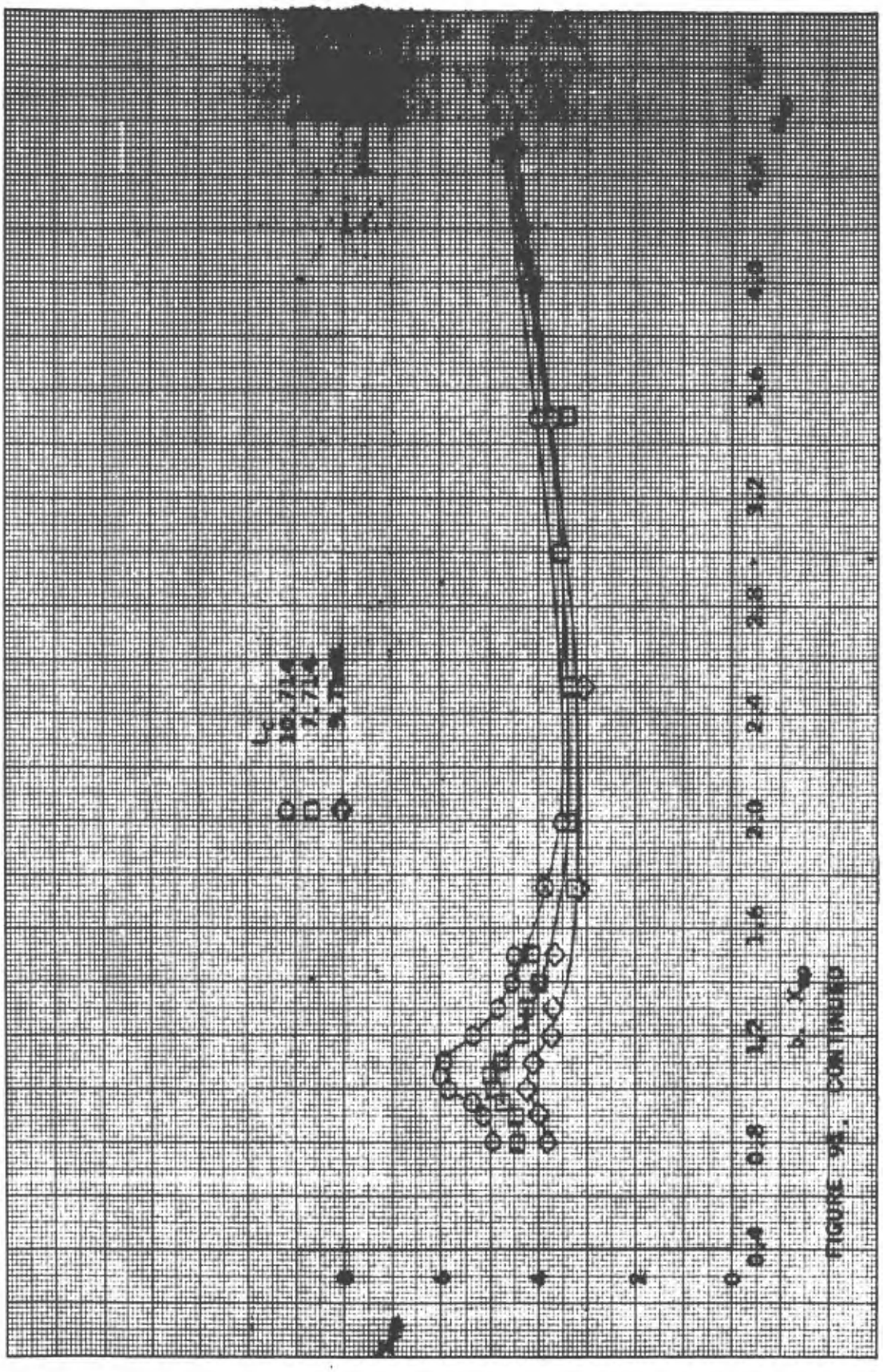
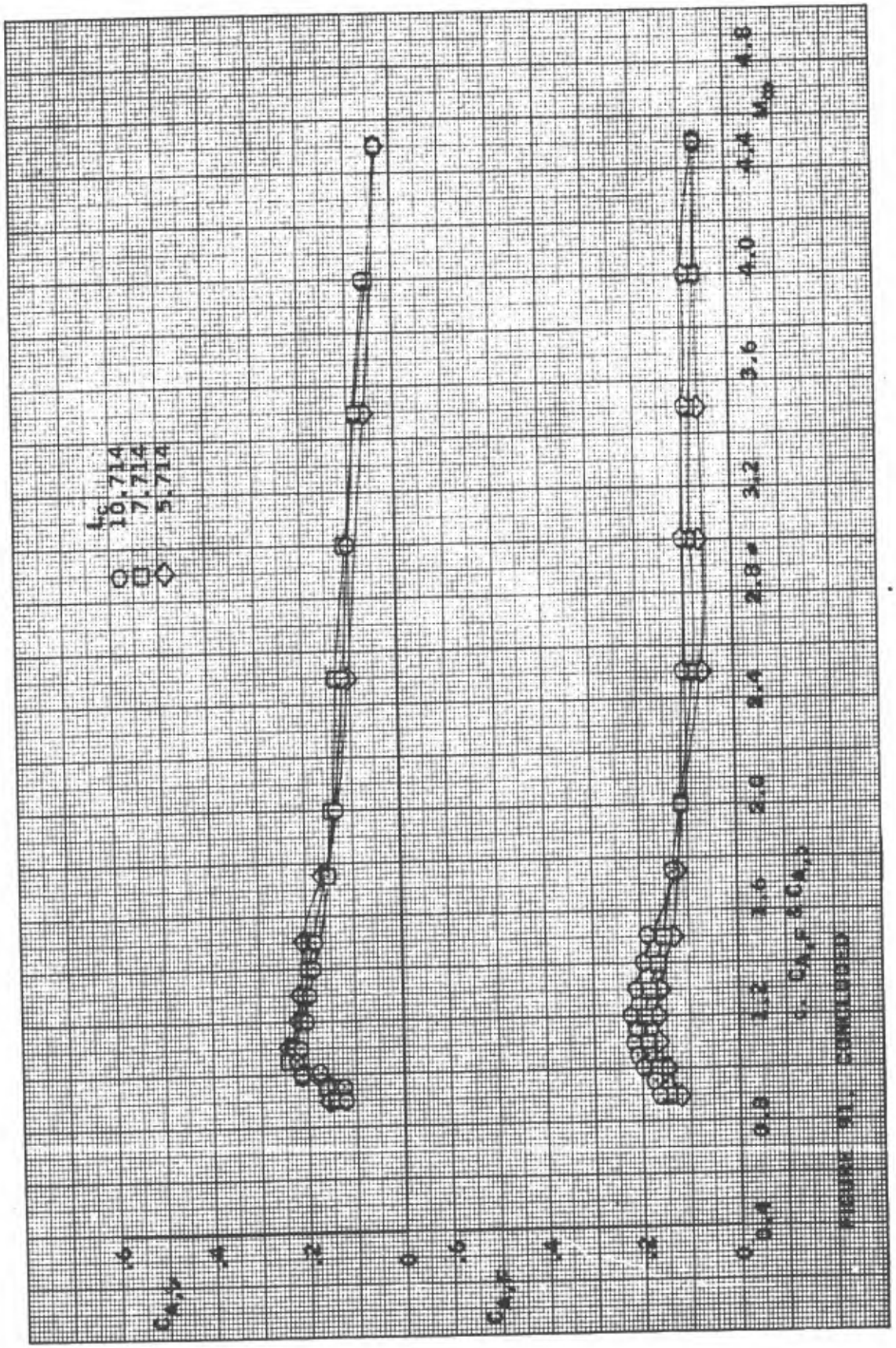


FIGURE 96. CONTINUED


t_c 10.714
7.714
5.714
Cm/s
Cm/s
Cm/s

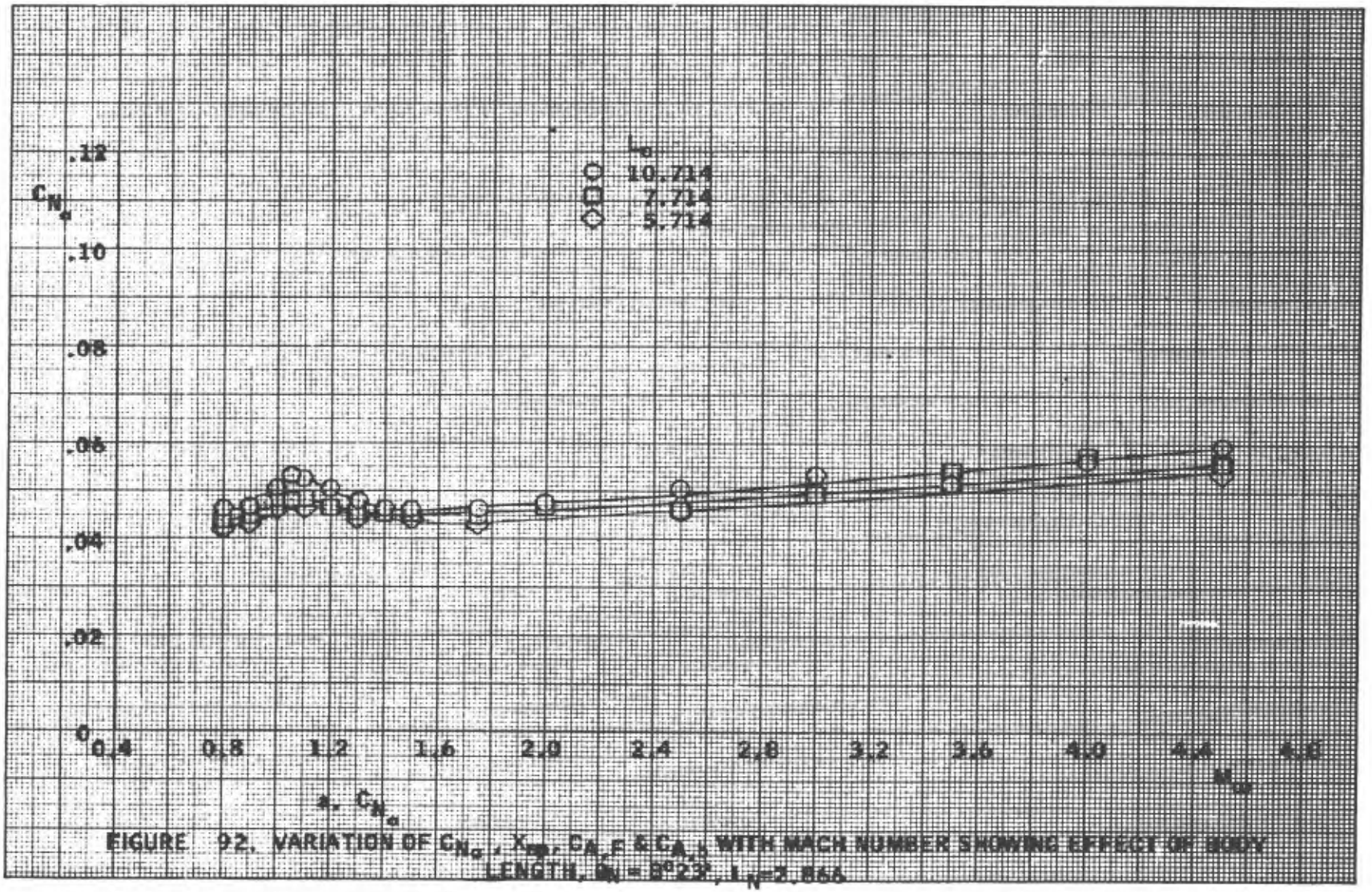
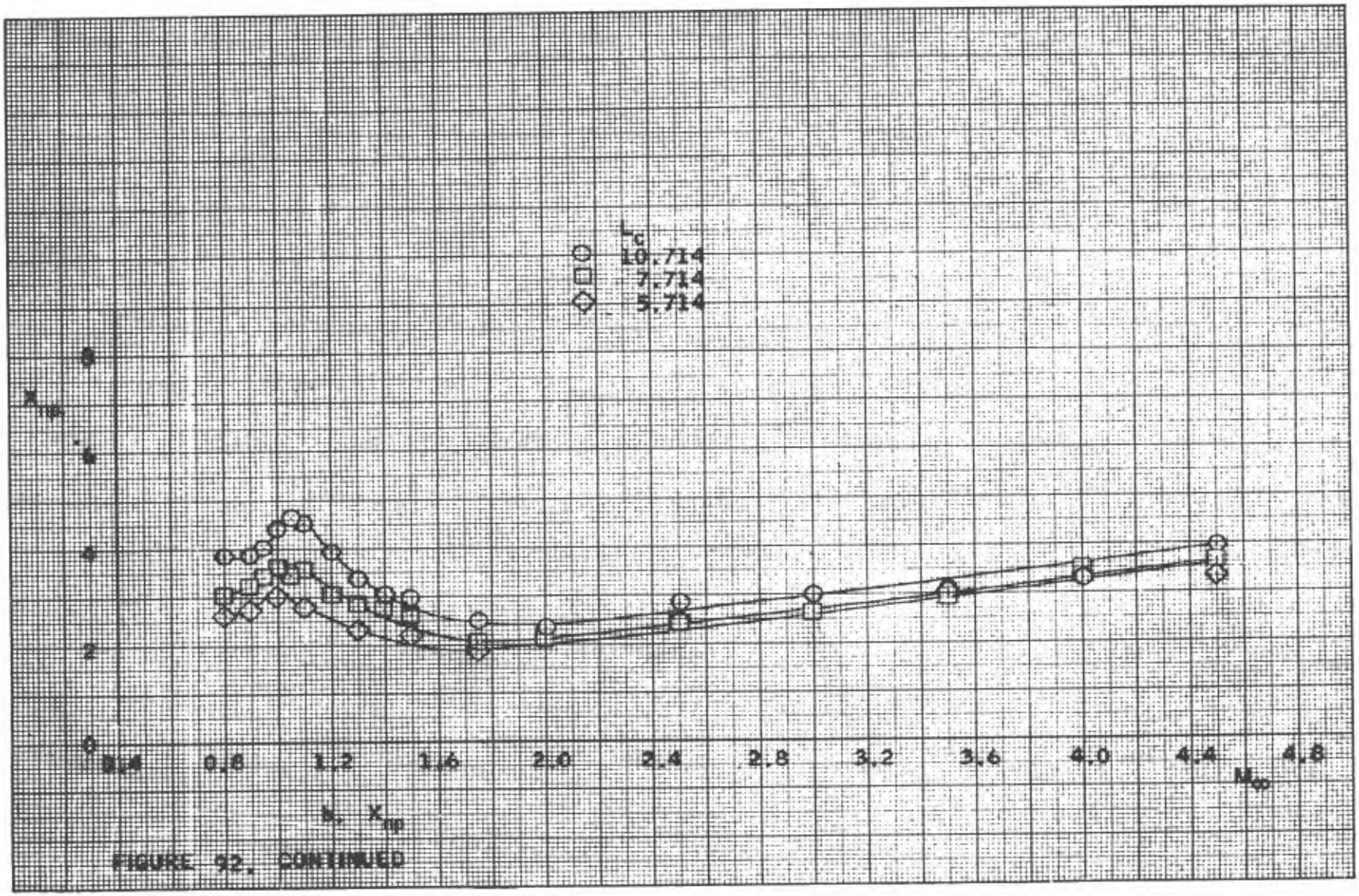
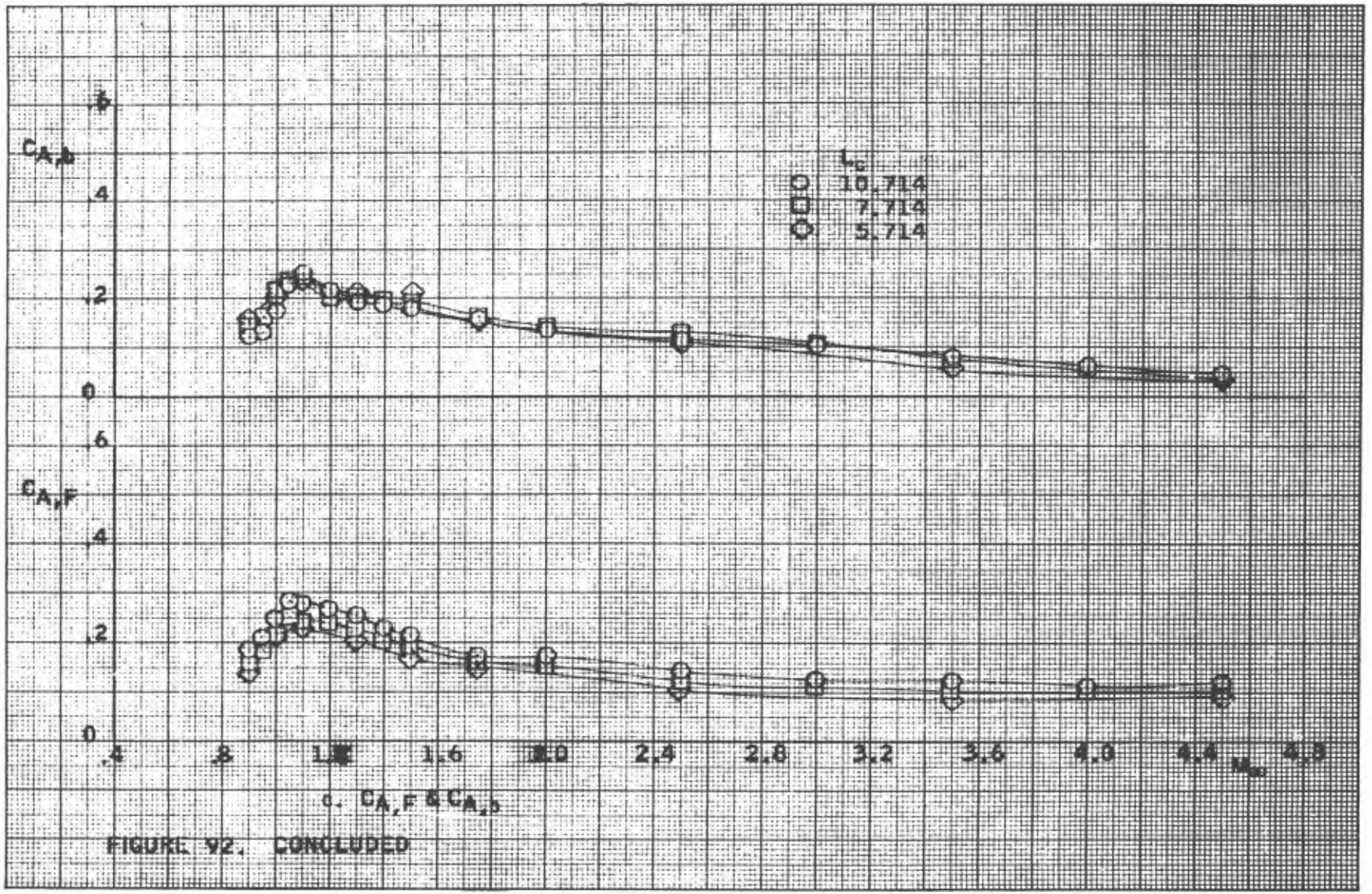


FIGURE 92. VARIATION OF C_{N_α}, X_{cp}, $C_{A,F}$ & $C_{A,b}$ WITH MACH NUMBER SHOWING EFFECT OF BODY LENGTH, $\delta_N = 8°23'$, $l_N = 2.868$



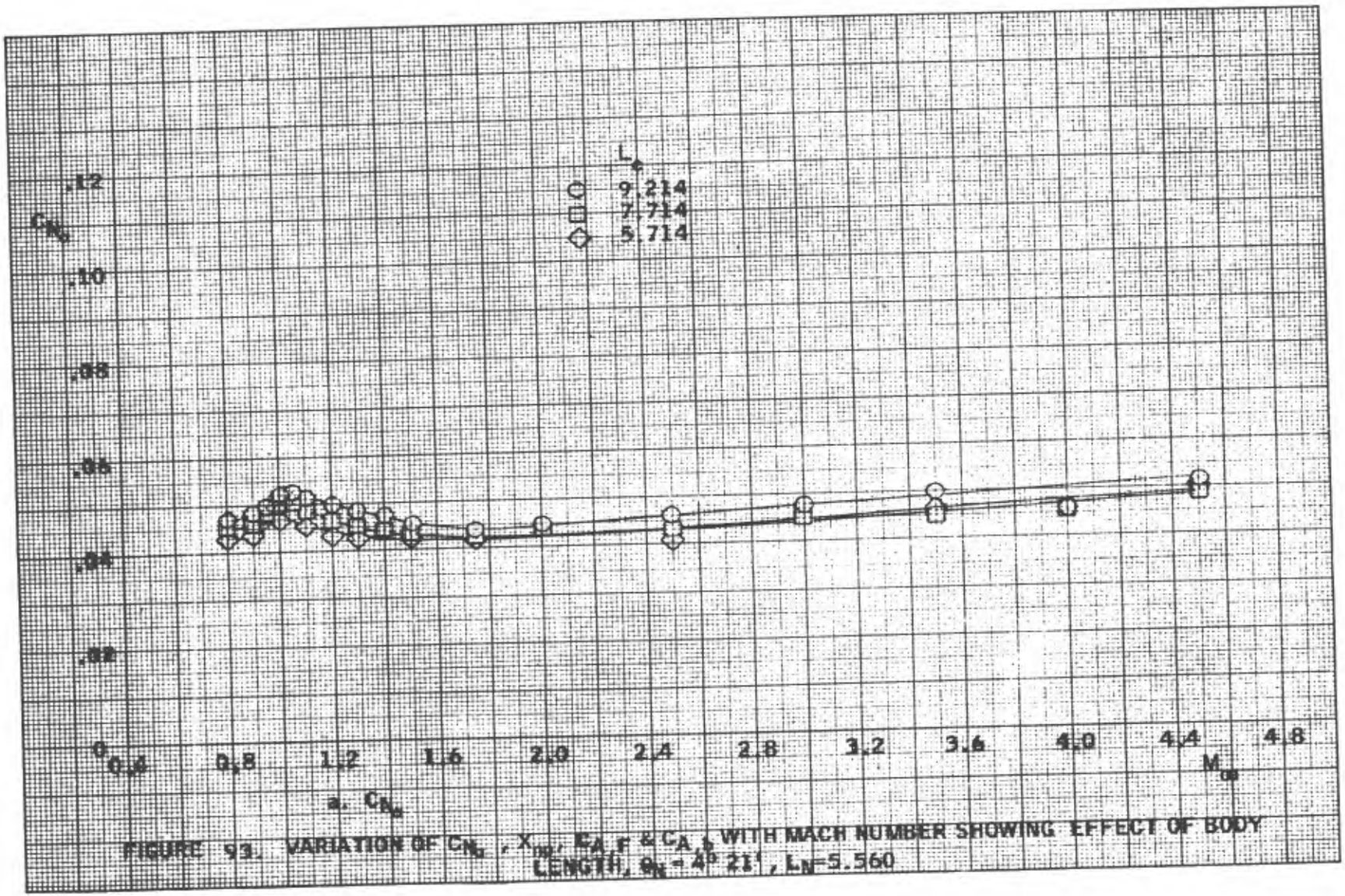
b. X_{cp}

FIGURE 92. CONTINUED



c. $C_{A,F}$ & $C_{A,b}$

FIGURE V2. CONCLUDED



a. C_{N_α}

FIGURE 93. VARIATION OF C_{N_α}, X_{cp}, $K_{A,F}$ & $C_{A,b}$ WITH MACH NUMBER SHOWING EFFECT OF BODY LENGTH, $\theta_c = 4^0\ 21'$, L_N=5.560

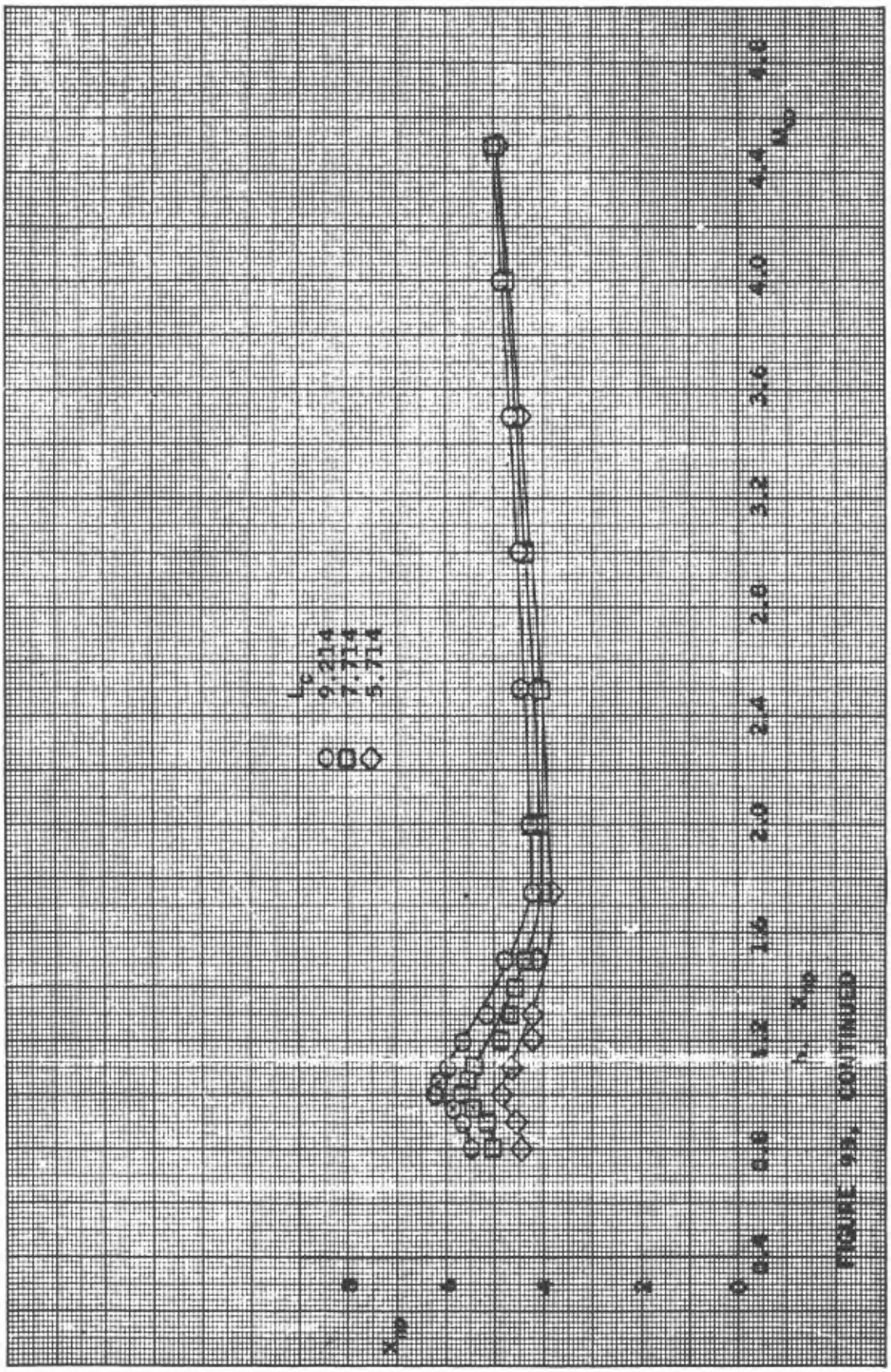
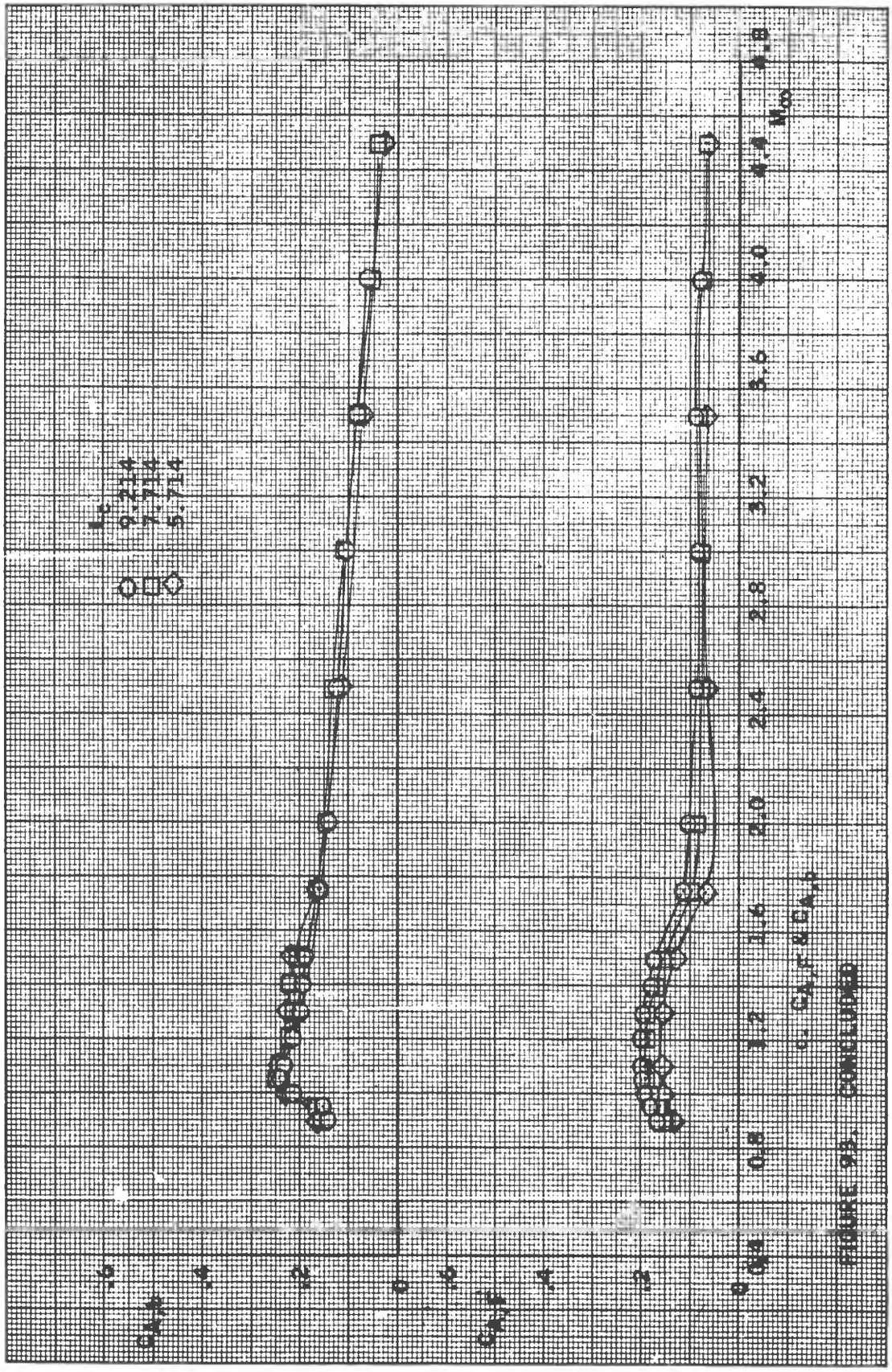
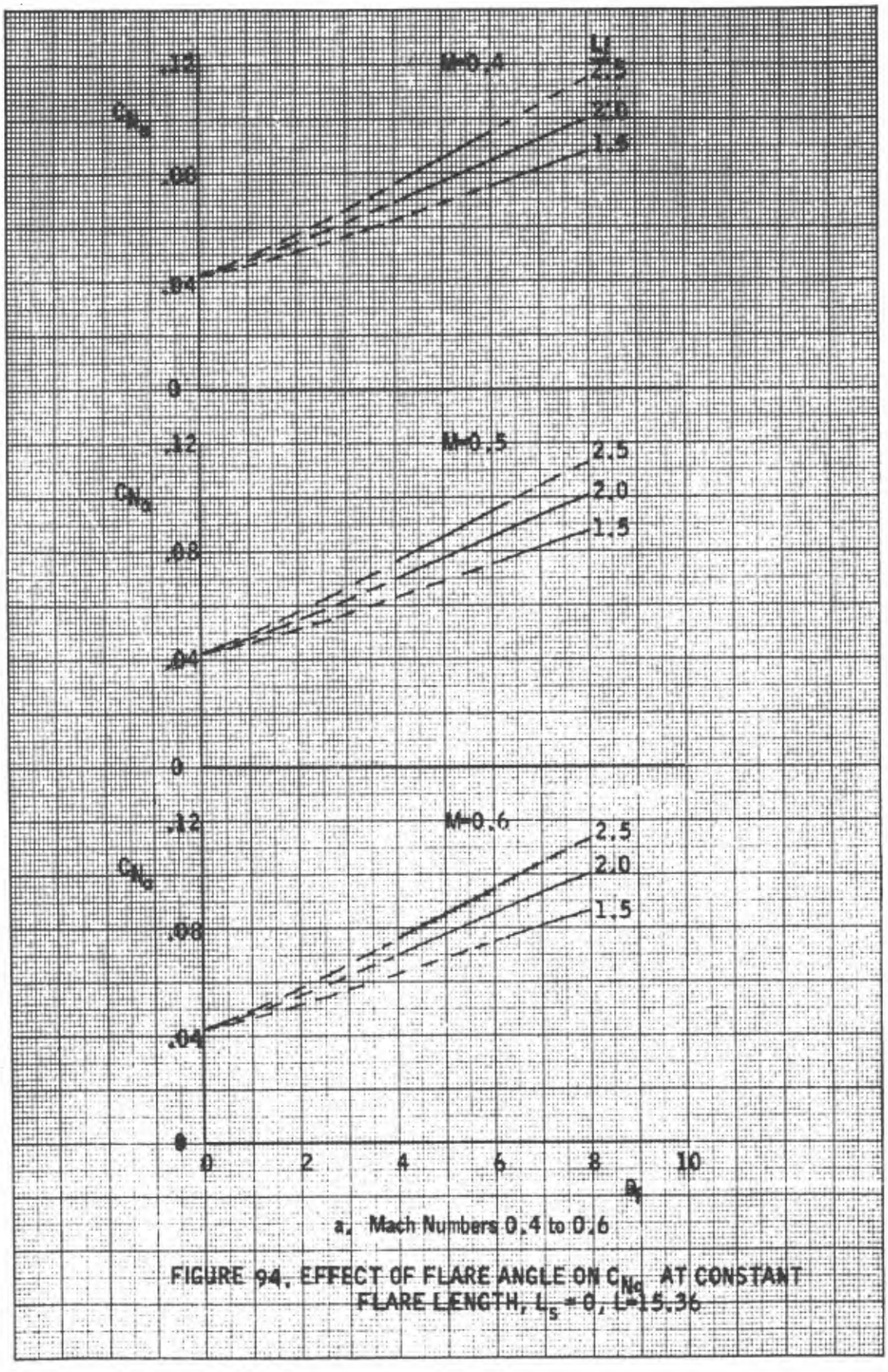


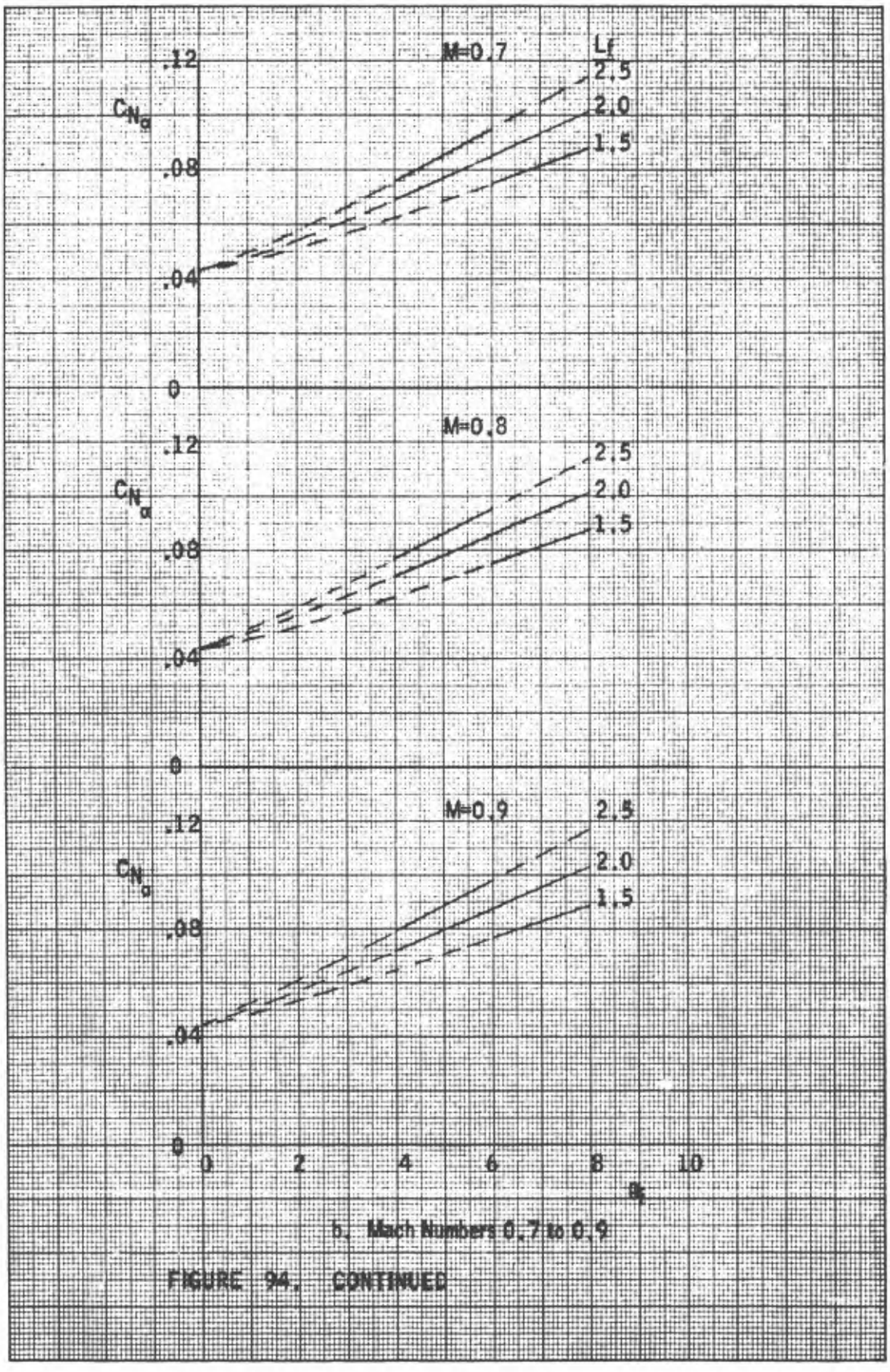
FIGURE 95, CONTINUED





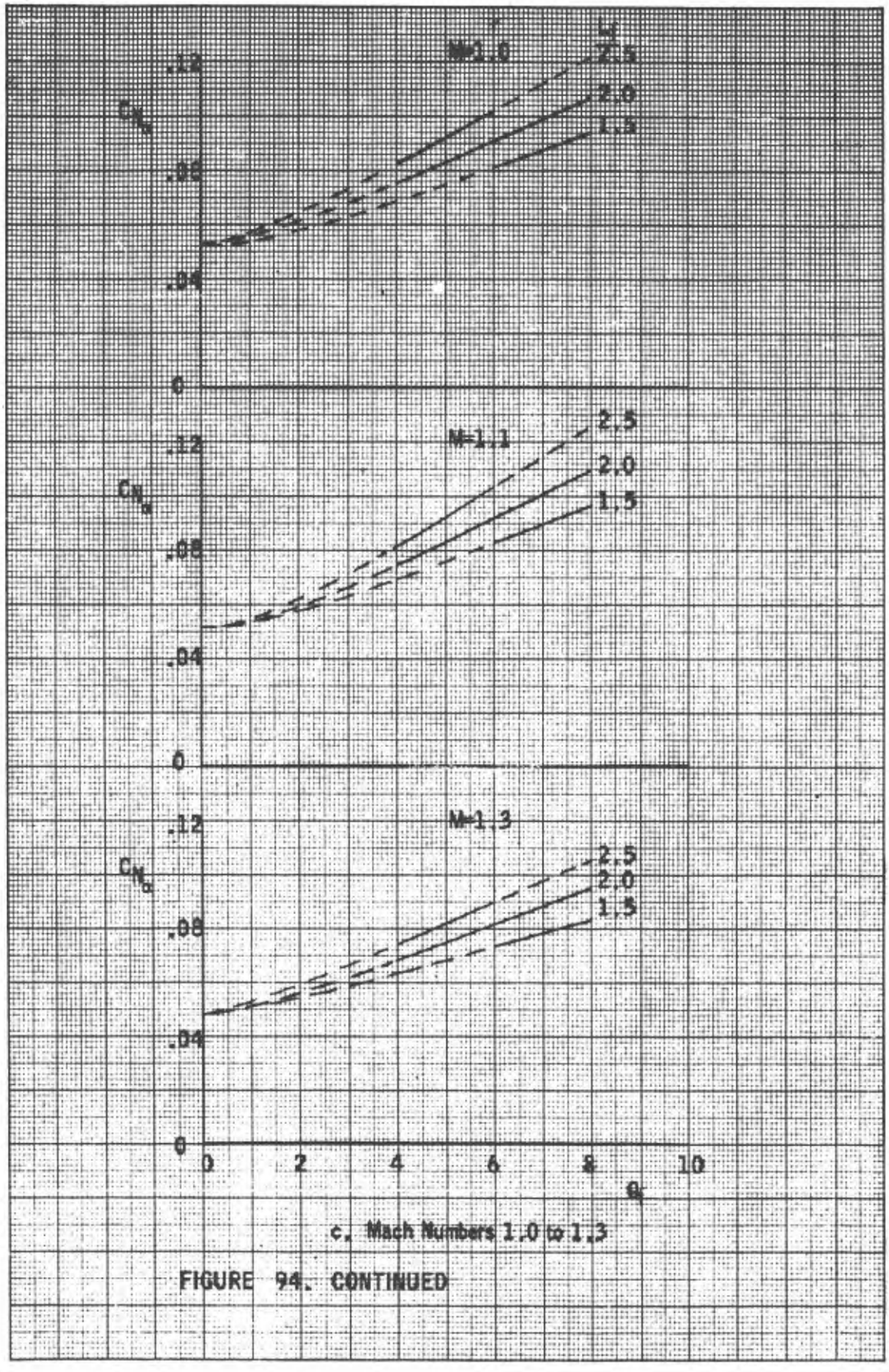
a. Mach Numbers 0.4 to 0.6

FIGURE 94. EFFECT OF FLARE ANGLE ON C_{N_0} AT CONSTANT FLARE LENGTH, $L_s = 0$, L=15.36



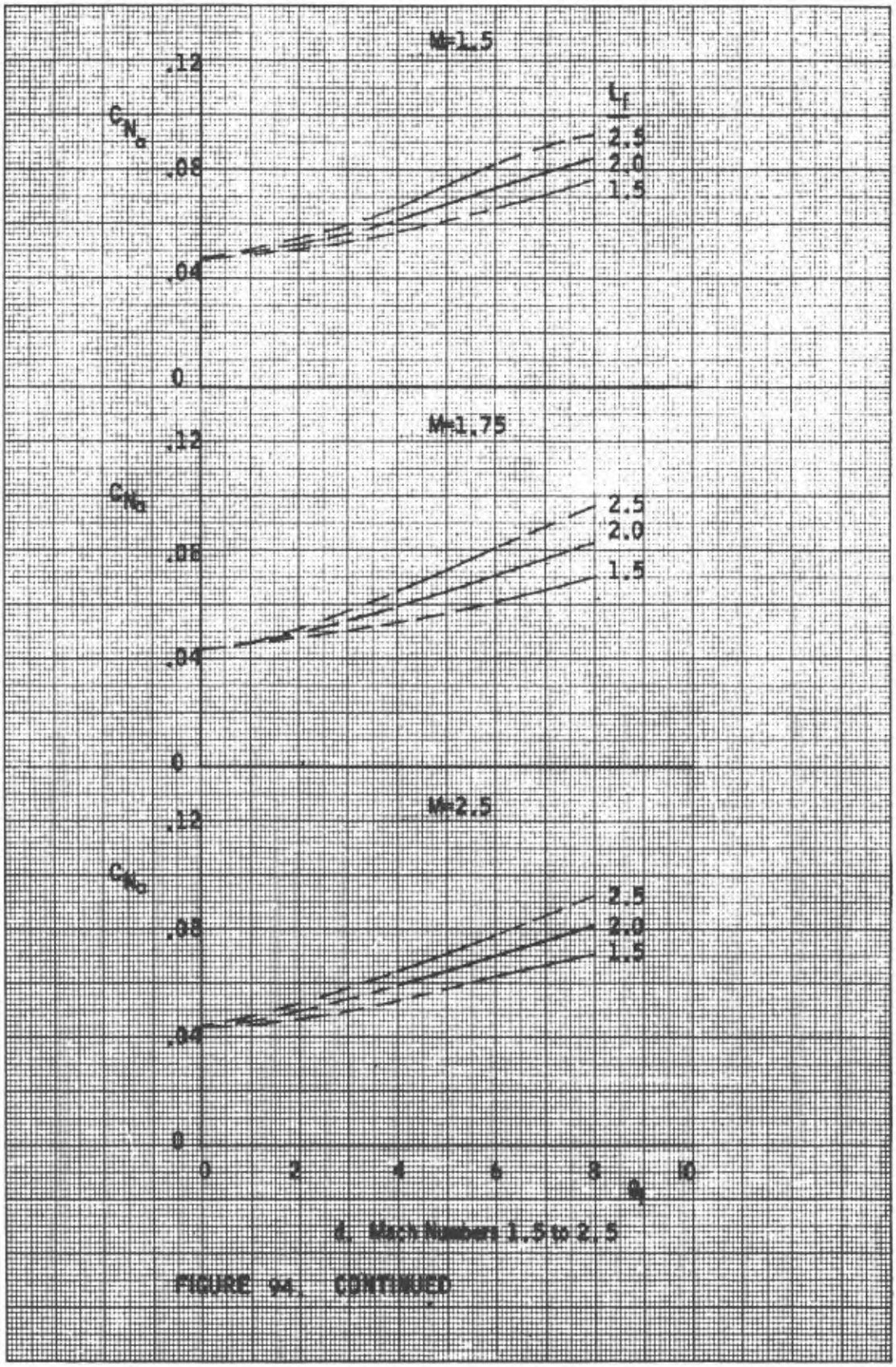
b. Mach Numbers 0.7 to 0.9

FIGURE 94. CONTINUED



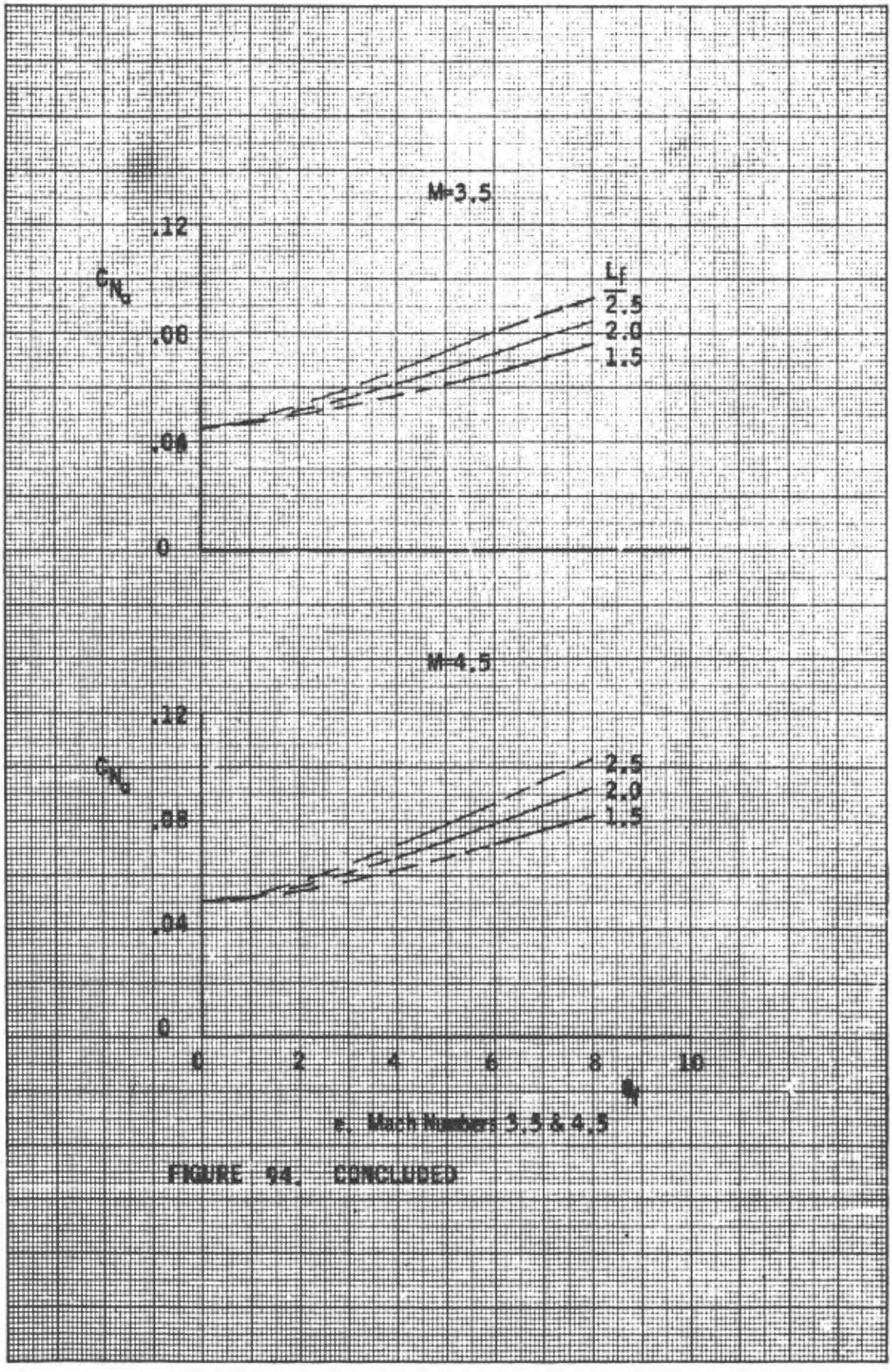
c. Mach Numbers 1.0 to 1.3

FIGURE 94. CONTINUED



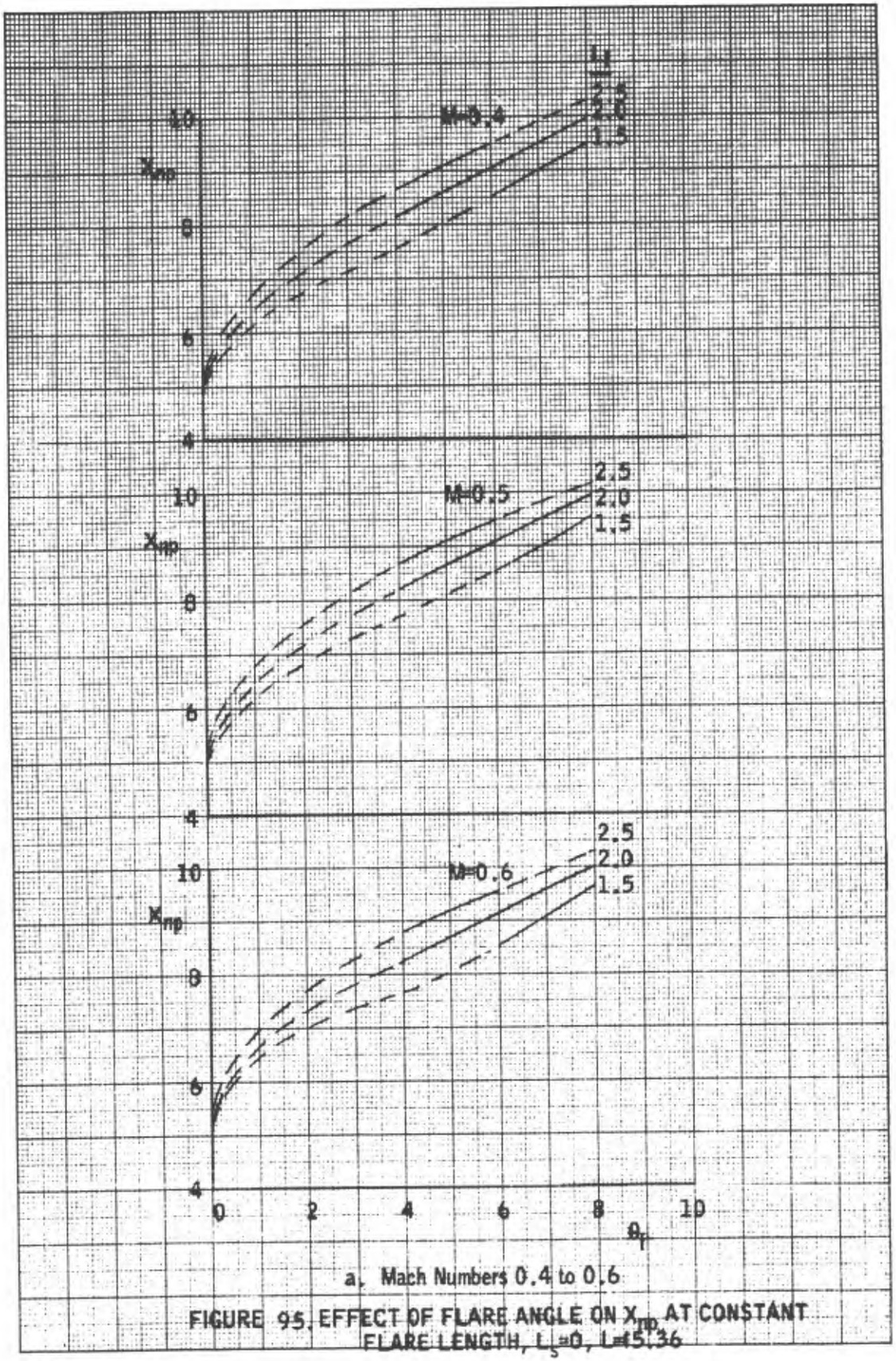
d. Mach Numbers 1.5 to 2.5

FIGURE 94. CONTINUED



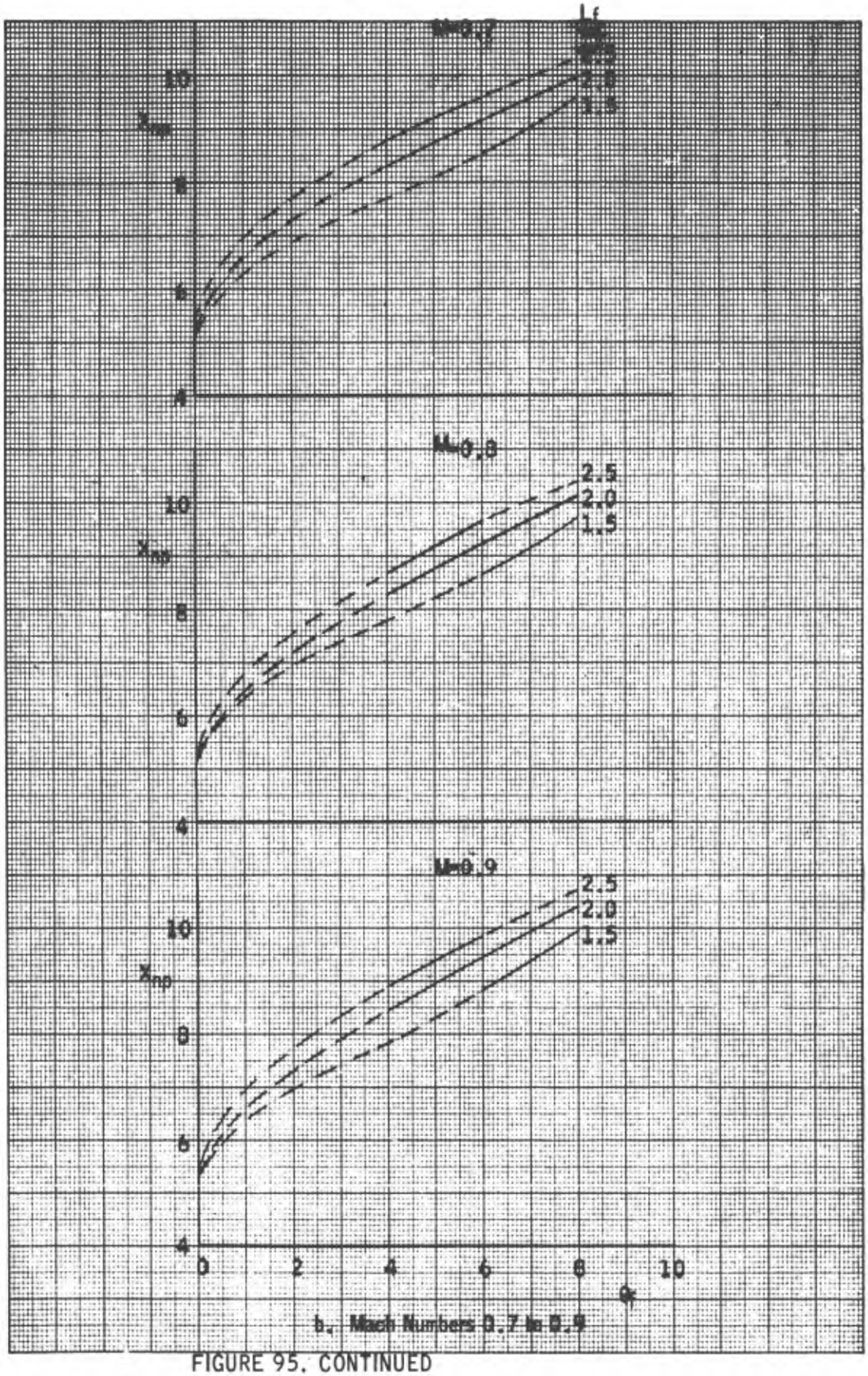
e. Mach Numbers 3.5 & 4.5

FIGURE 94. CONCLUDED



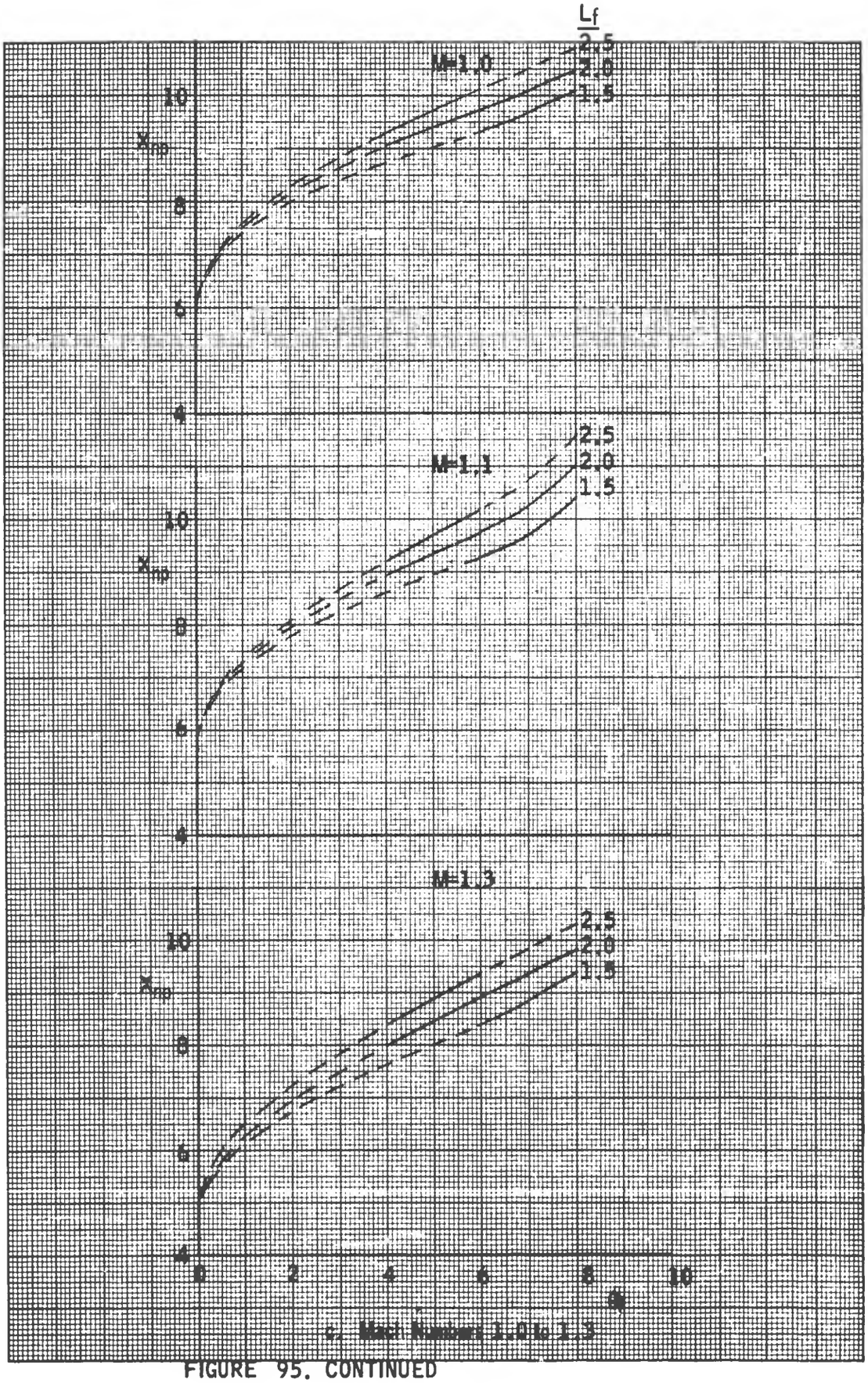
a. Mach Numbers 0.4 to 0.6

FIGURE 95. EFFECT OF FLARE ANGLE ON X_{mp} AT CONSTANT FLARE LENGTH, L_s=0, L=45.36



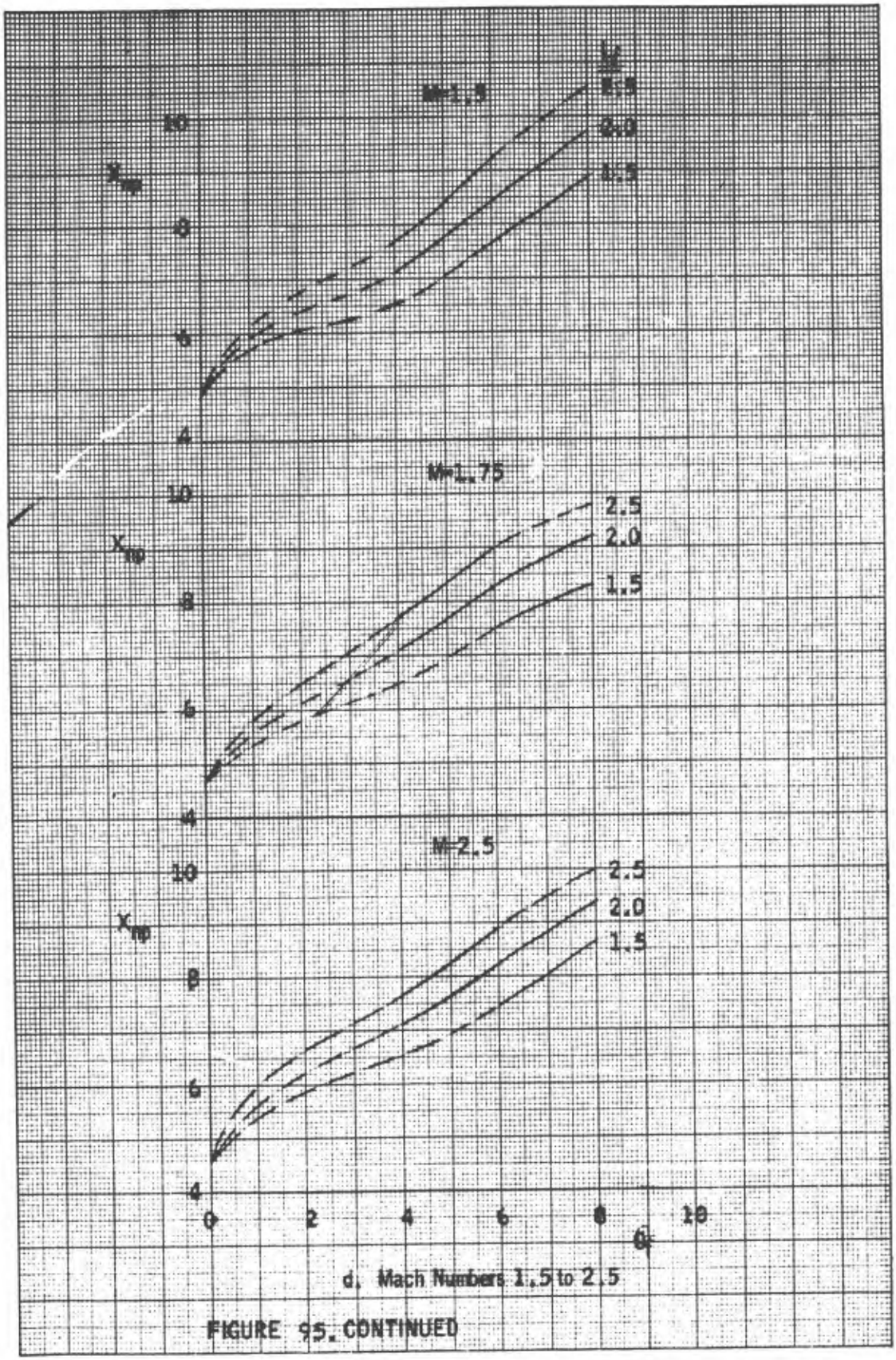
b. Mach Numbers 0.7 to 0.9

FIGURE 95. CONTINUED



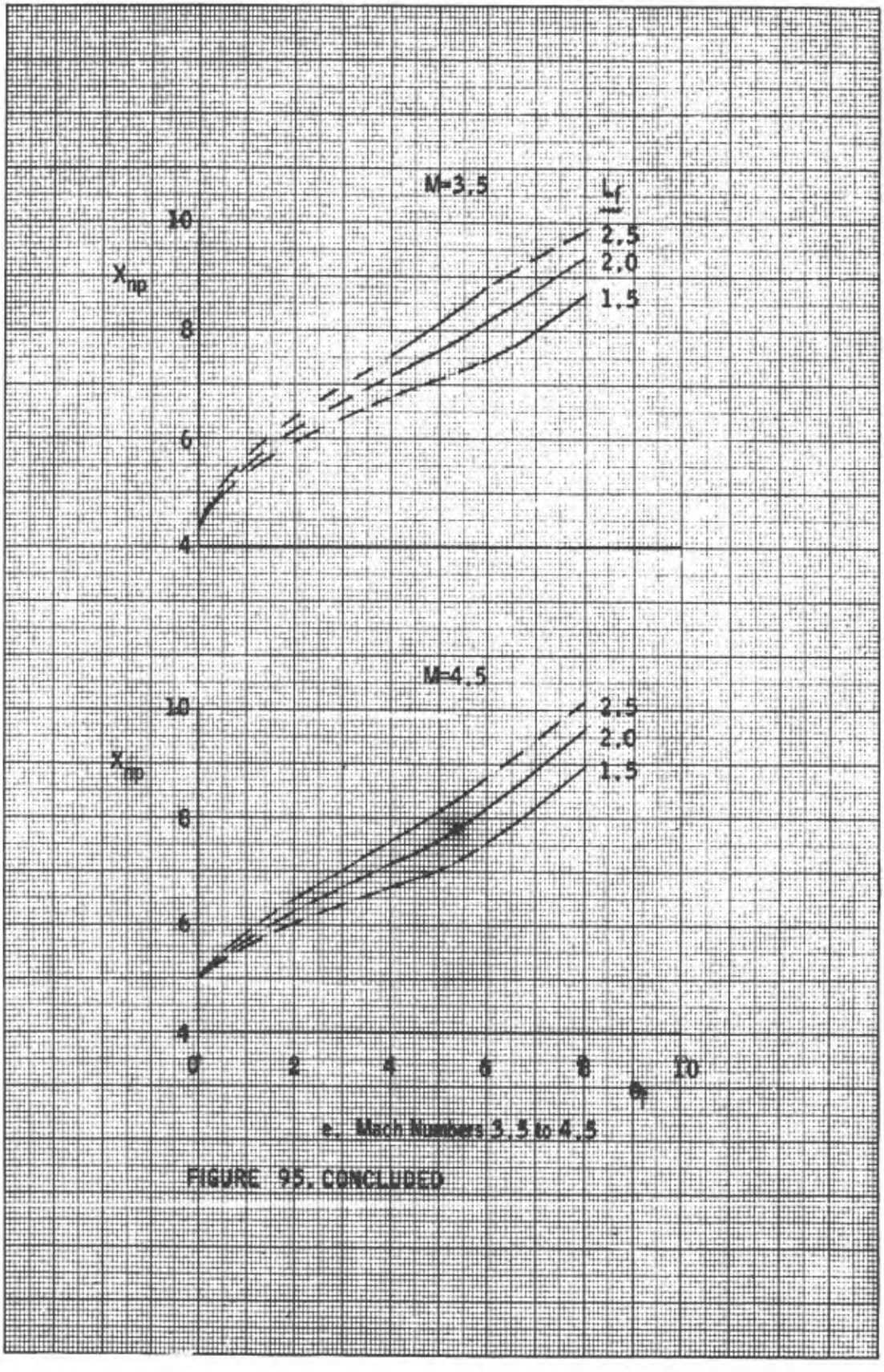
c. Mach Numbers 1.0 to 1.3

FIGURE 95. CONTINUED



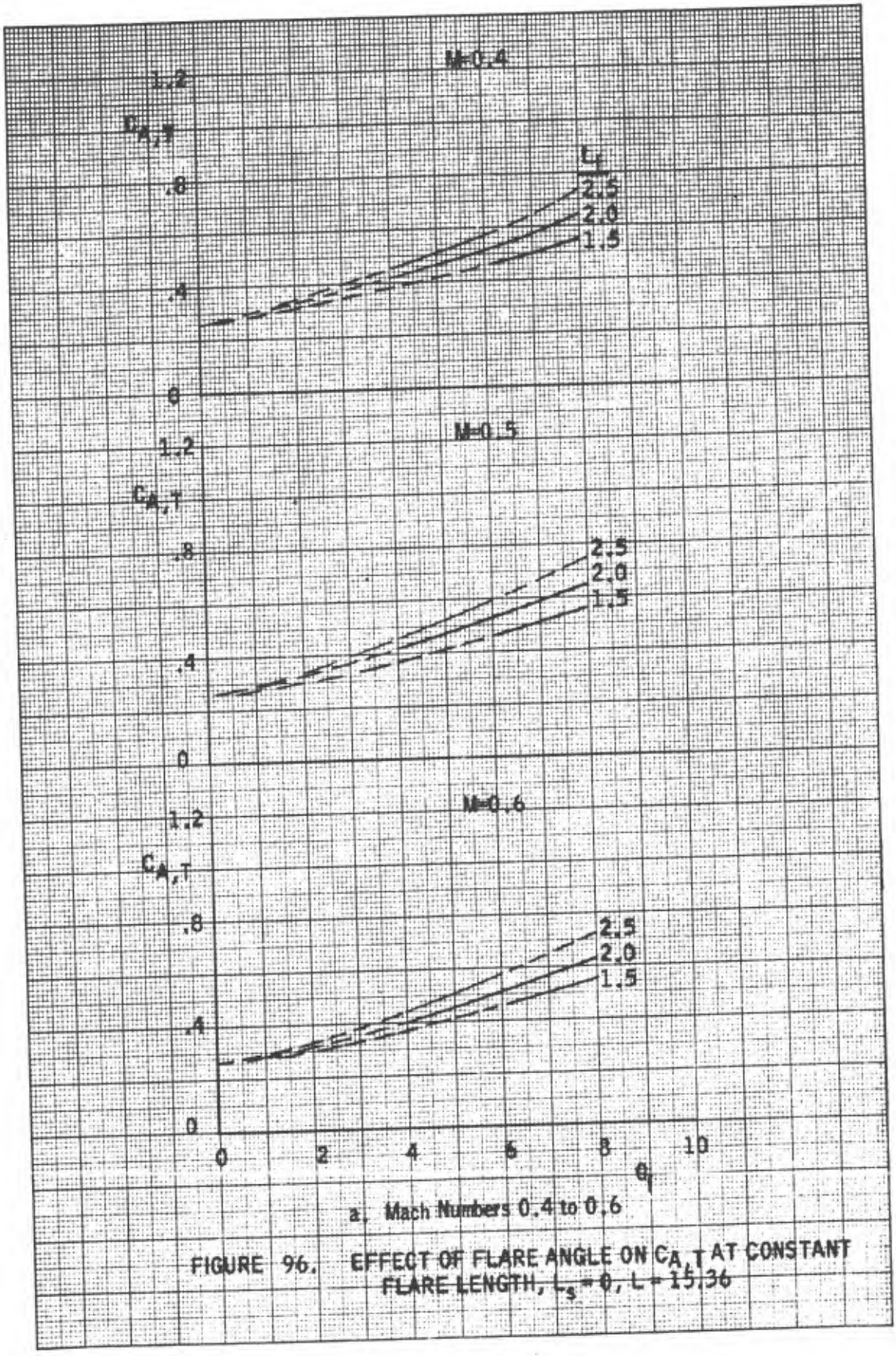
d. Mach Numbers 1.5 to 2.5

FIGURE 95. CONTINUED



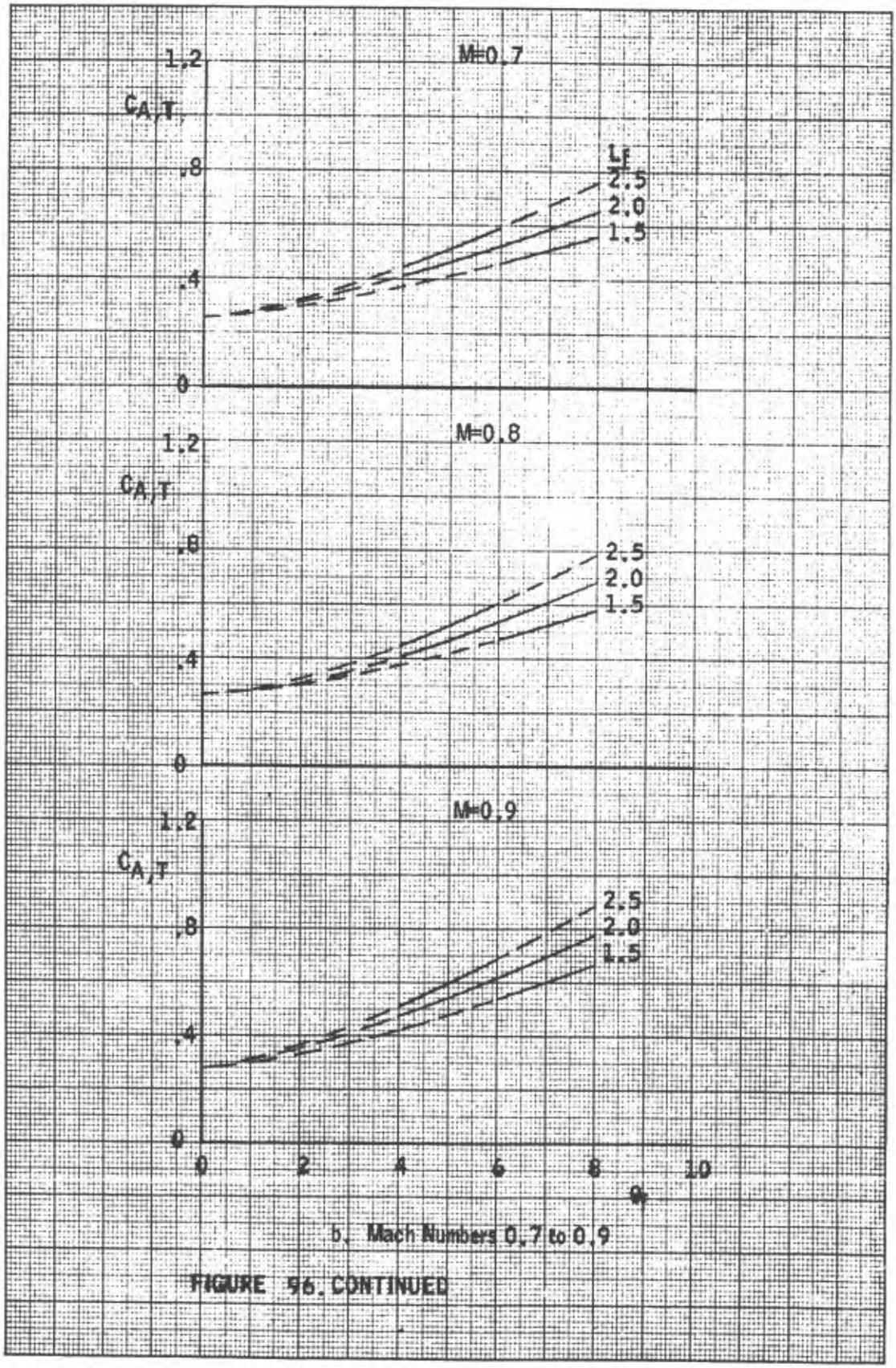
e. Mach Numbers 3.5 to 4.5

FIGURE 95. CONCLUDED



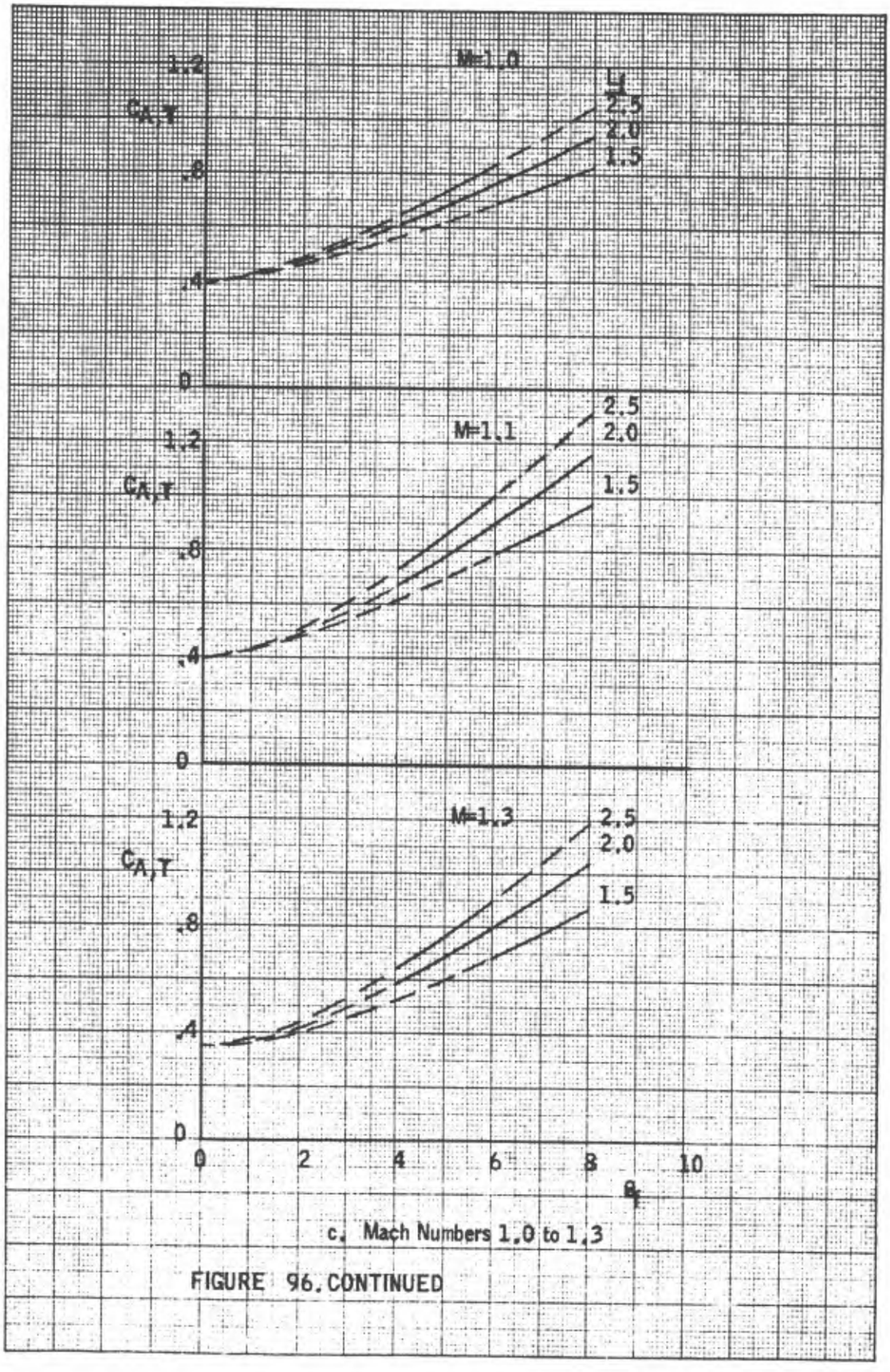
a. Mach Numbers 0.4 to 0.6

FIGURE 96. EFFECT OF FLARE ANGLE ON $C_{A,T}$ AT CONSTANT FLARE LENGTH, $L_s = 0$, $L = 15.36$



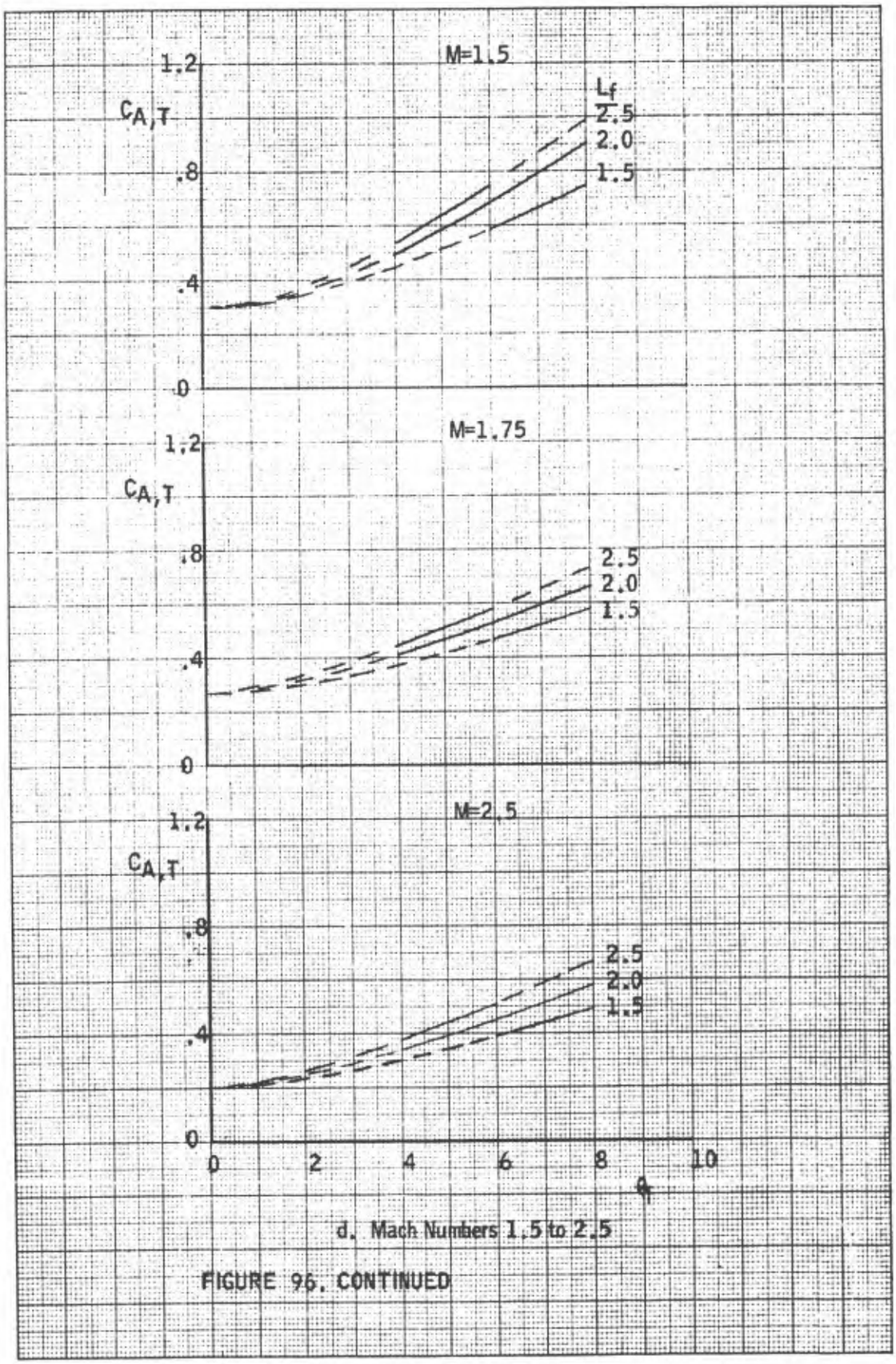
b. Mach Numbers 0.7 to 0.9

FIGURE 96. CONTINUED



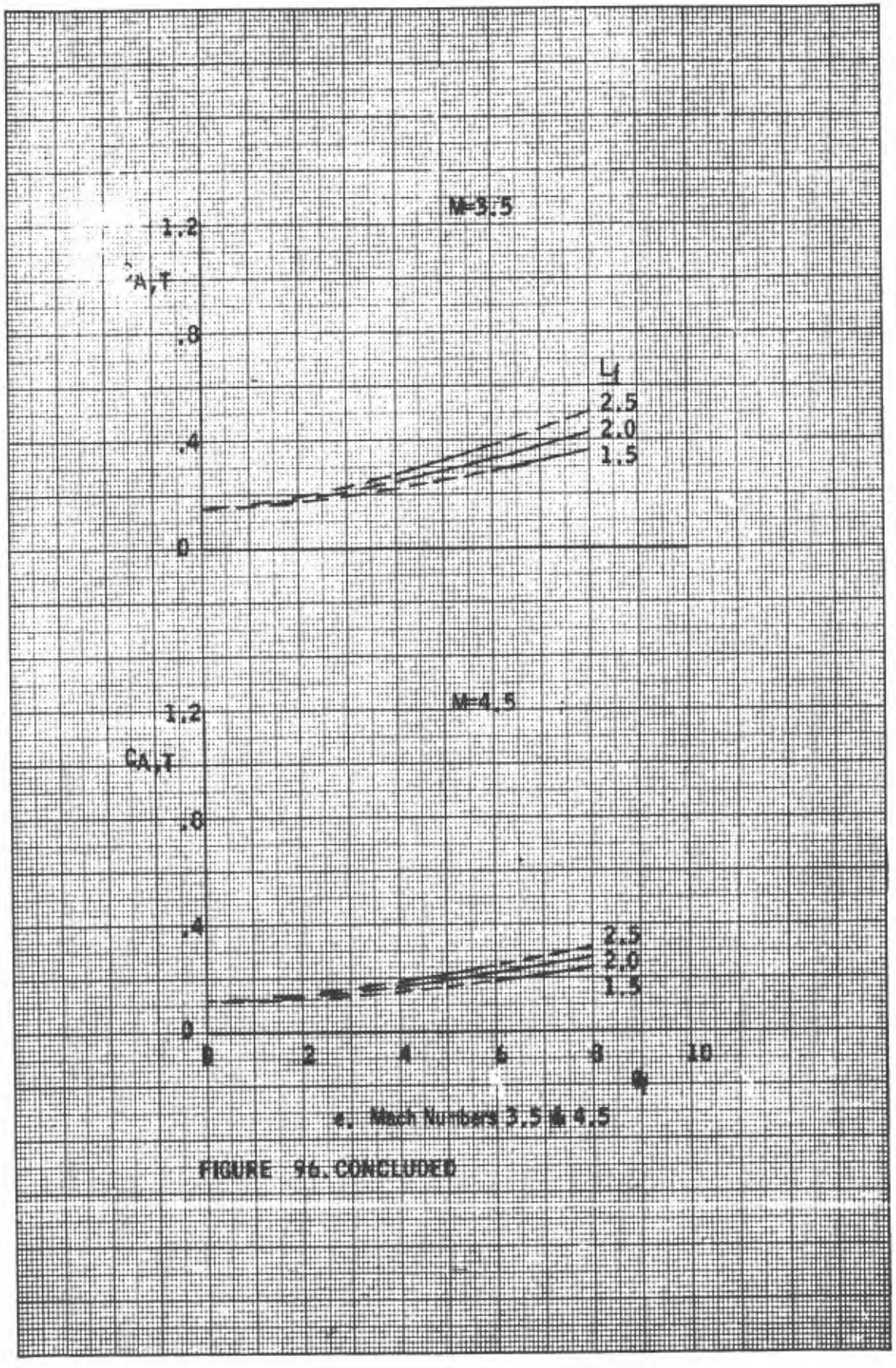
c. Mach Numbers 1.0 to 1.3

FIGURE 96. CONTINUED



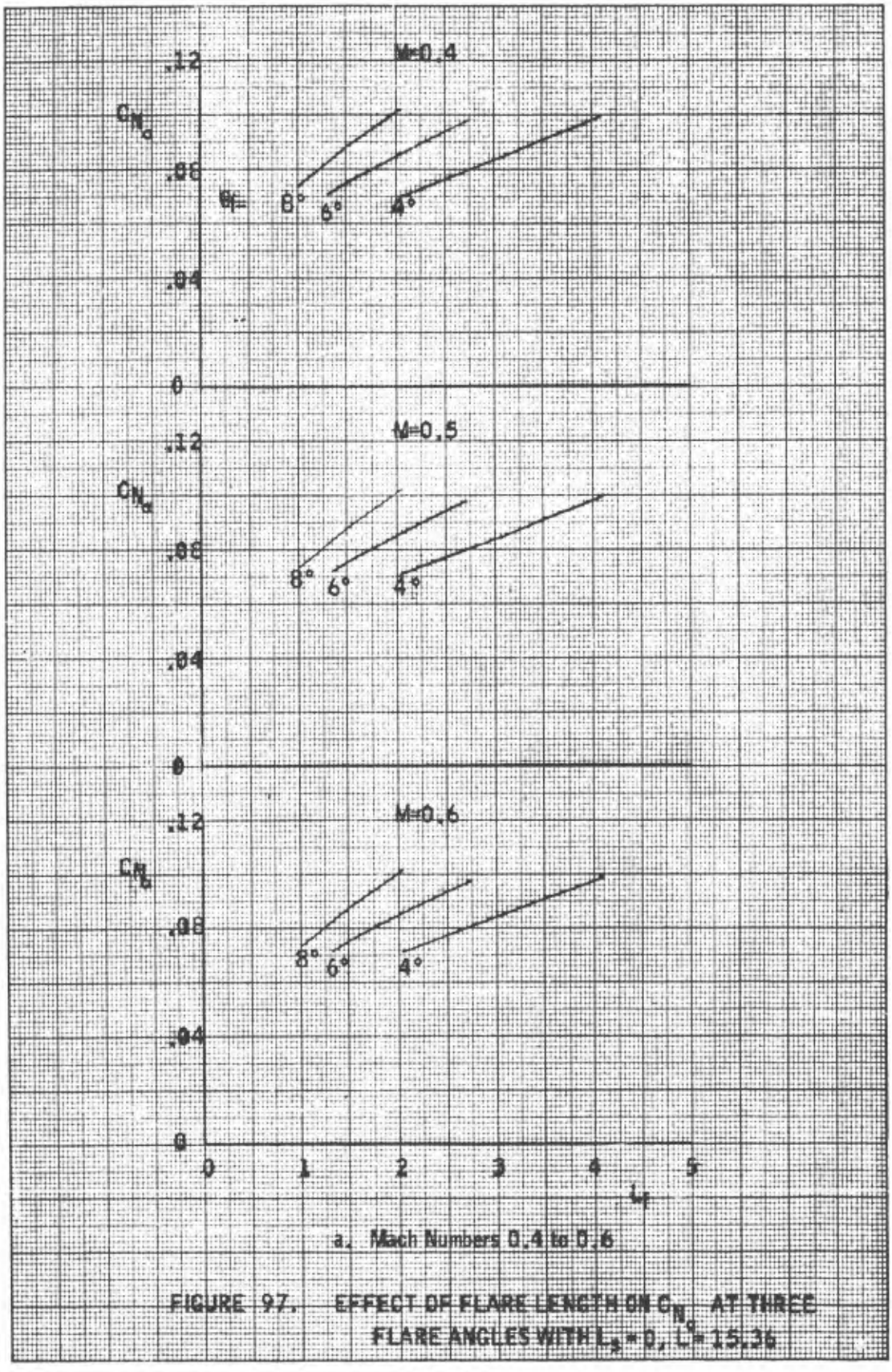
d. Mach Numbers 1.5 to 2.5

FIGURE 96. CONTINUED



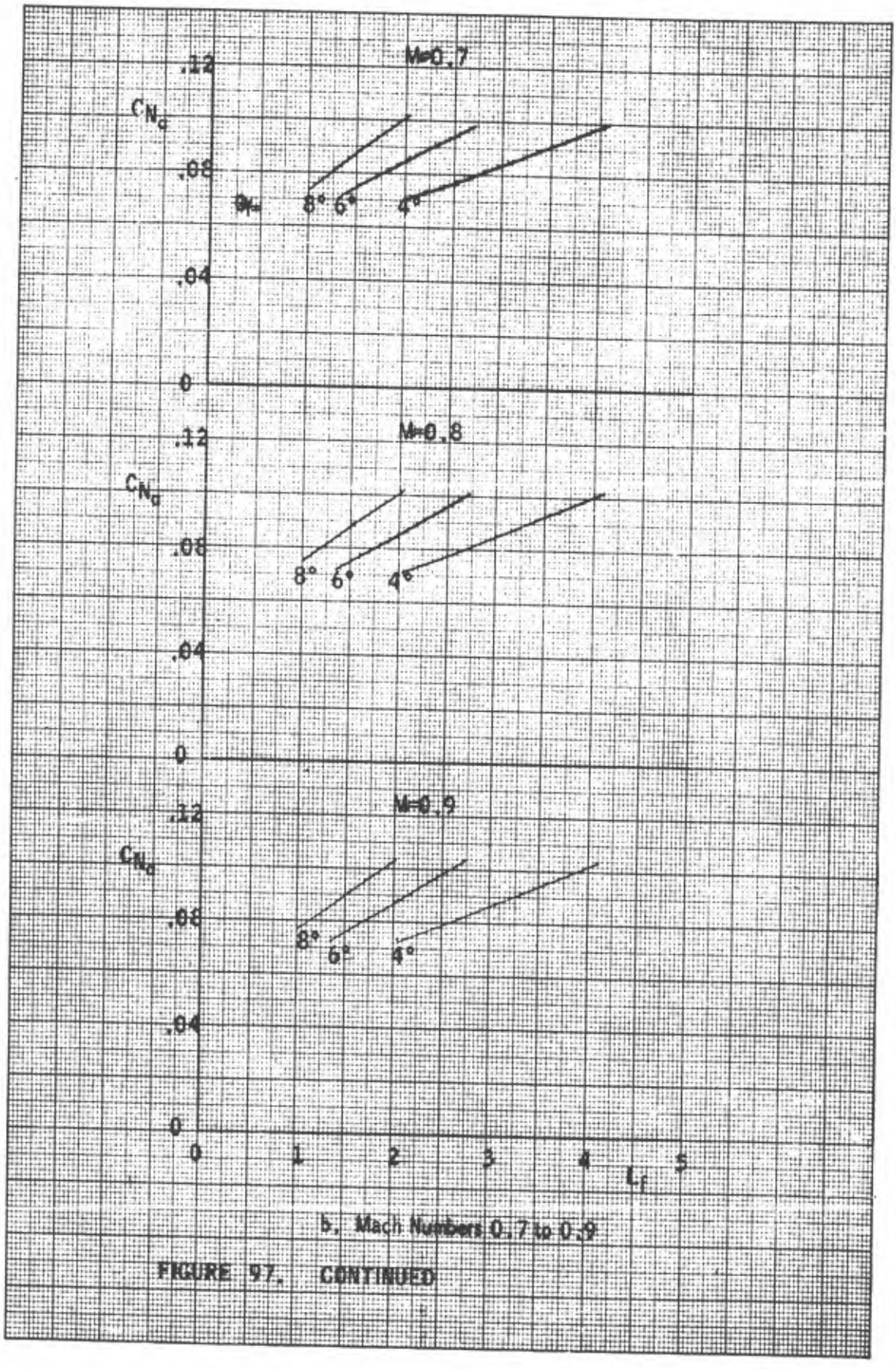
a. Mach Numbers 3.5 & 4.5

FIGURE 96. CONCLUDED



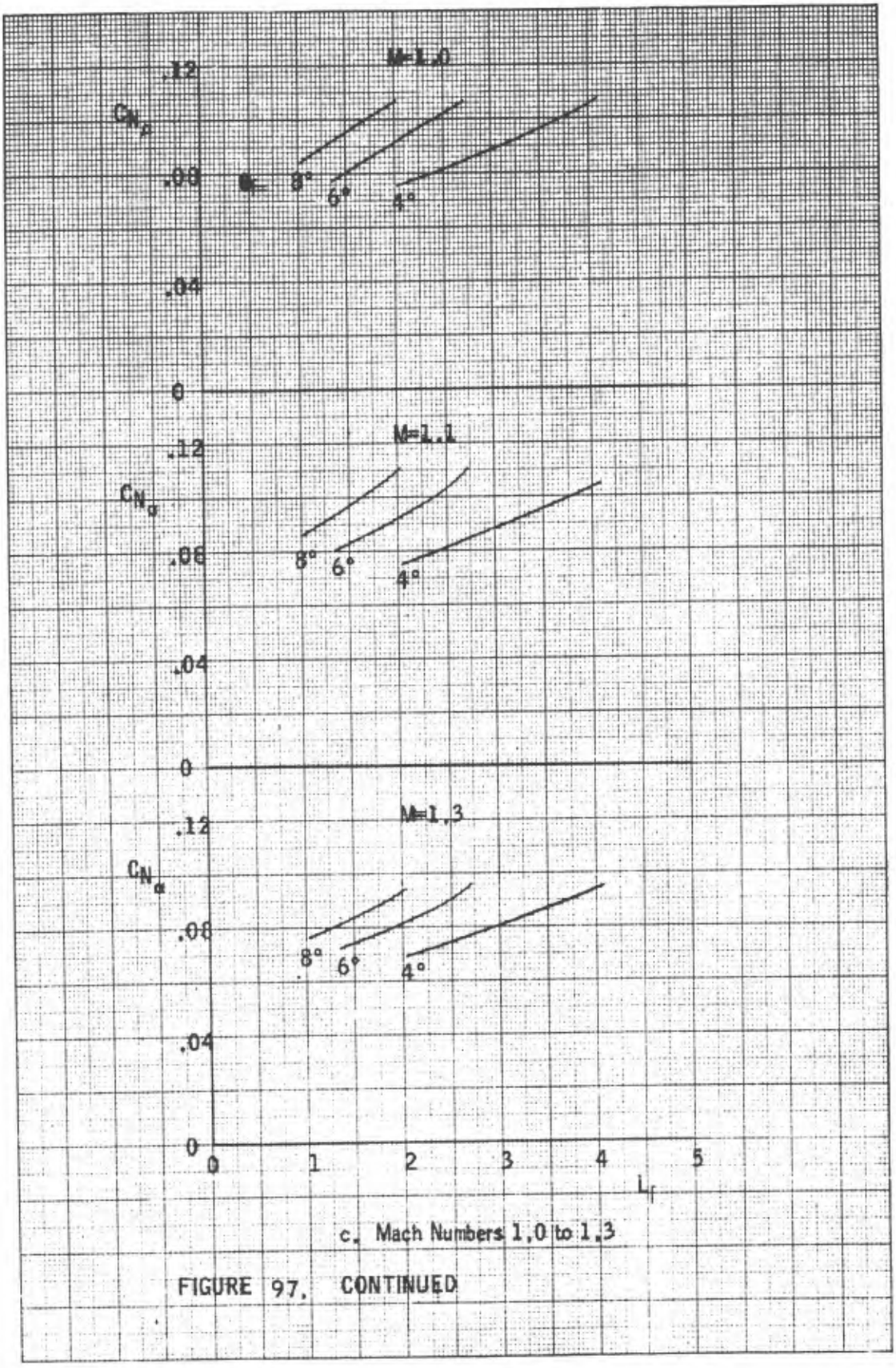
a. Mach Numbers 0.4 to 0.6

FIGURE 97. EFFECT OF FLARE LENGTH ON C_{N_α} AT THREE FLARE ANGLES WITH $L_s = 0$, $L^o = 15.36$



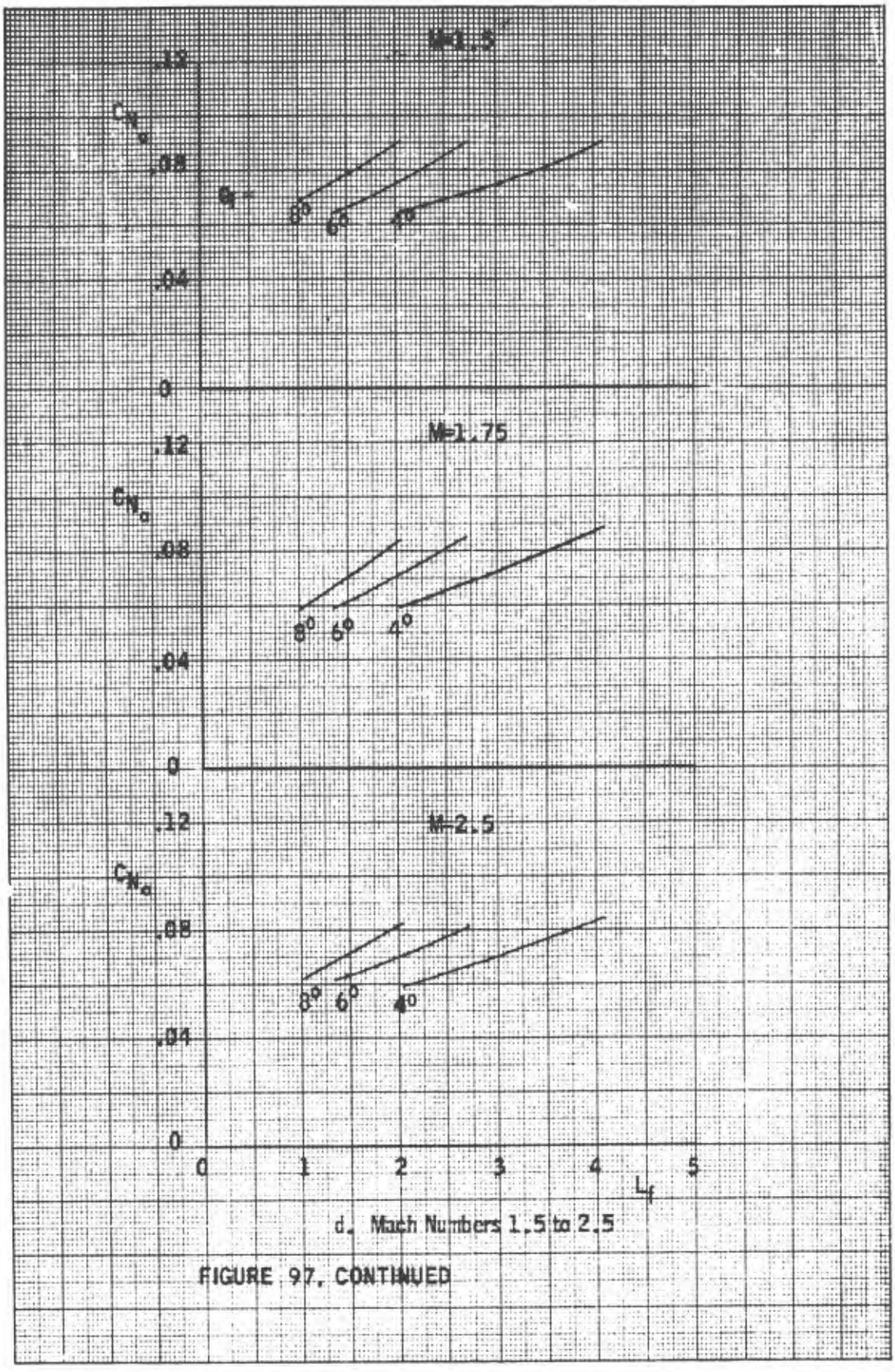
b. Mach Numbers 0.7 to 0.9

FIGURE 97. CONTINUED



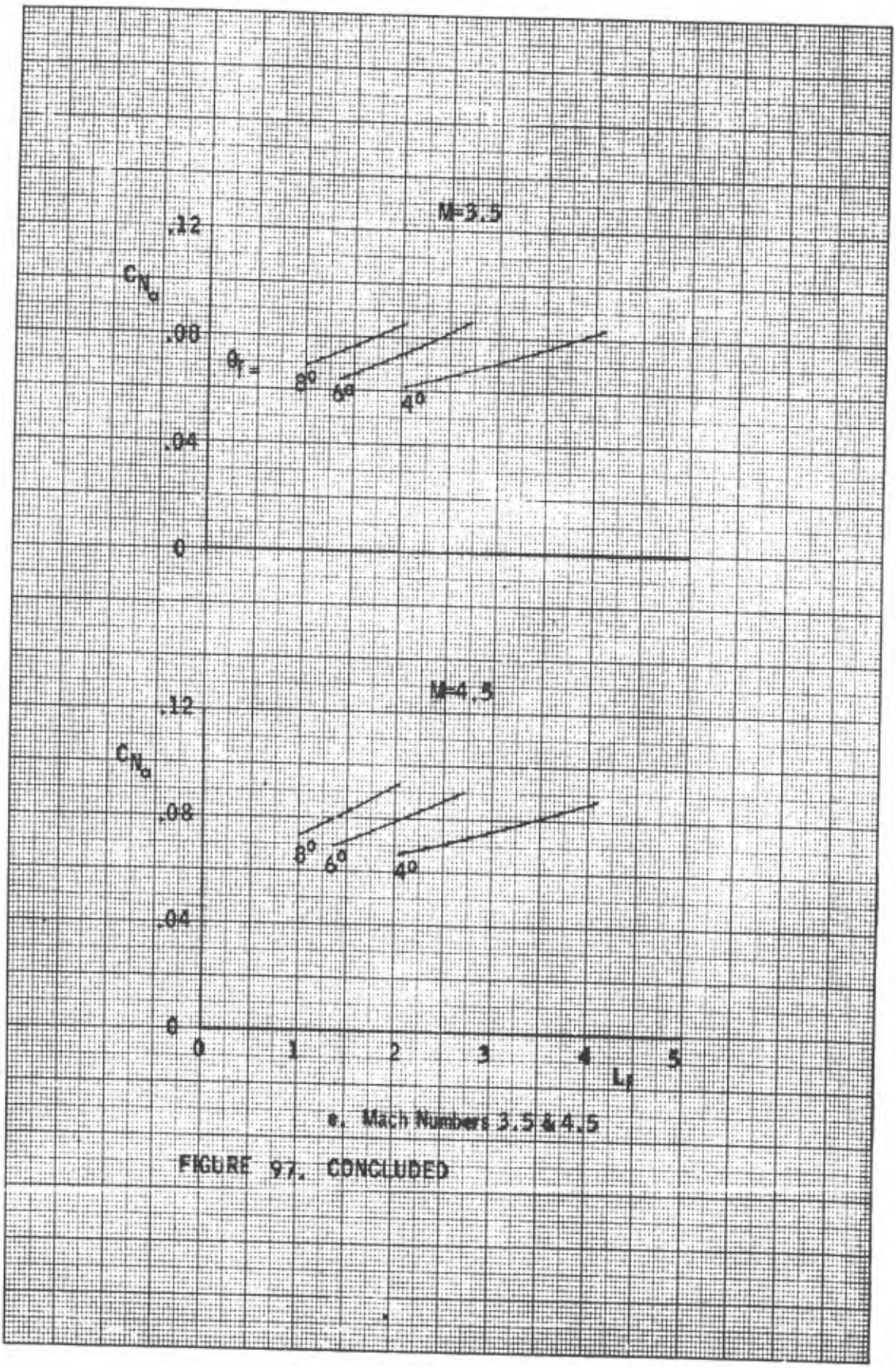
c. Mach Numbers 1.0 to 1.3

FIGURE 97. CONTINUED



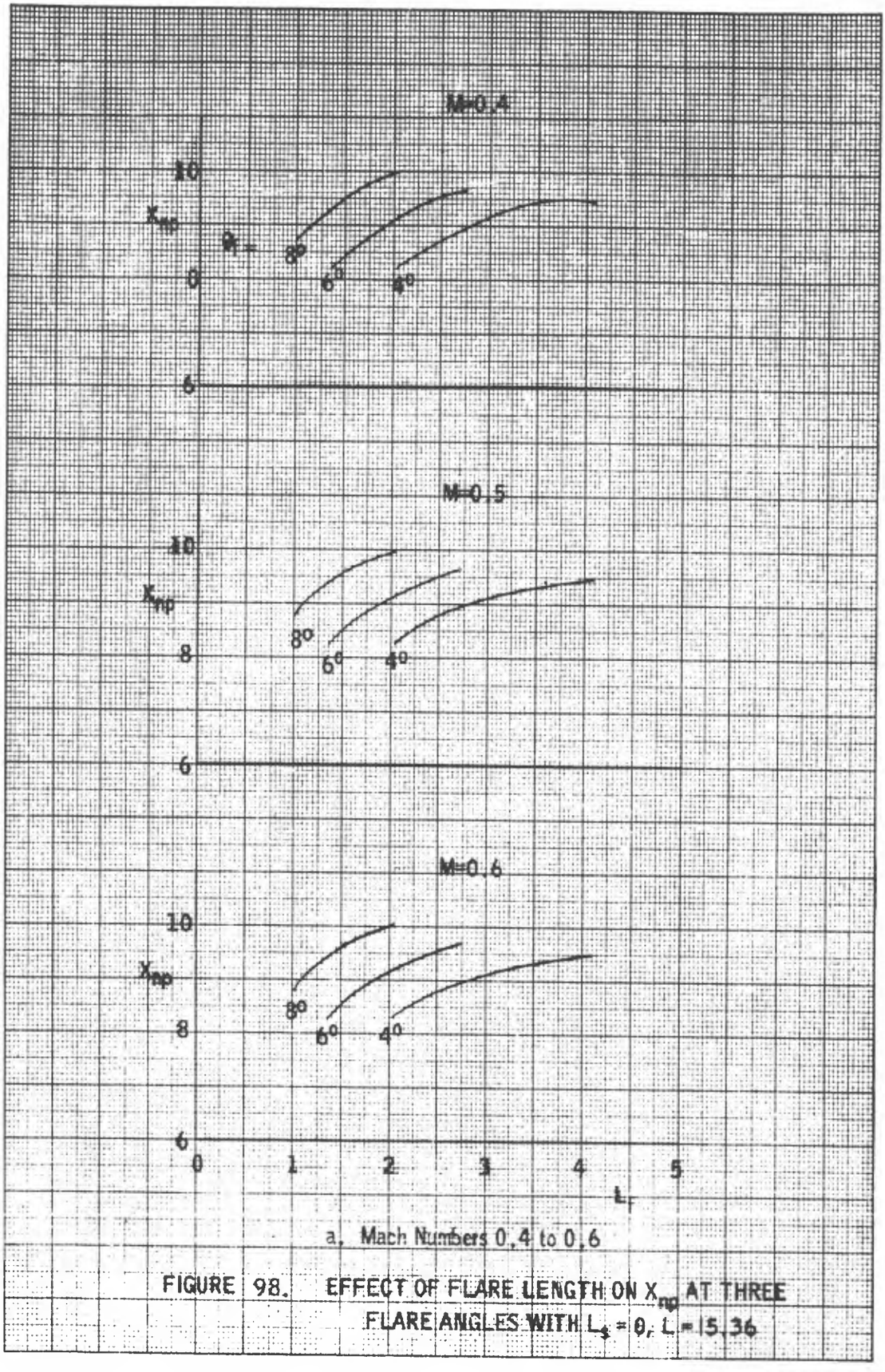
d. Mach Numbers 1.5 to 2.5

FIGURE 97. CONTINUED



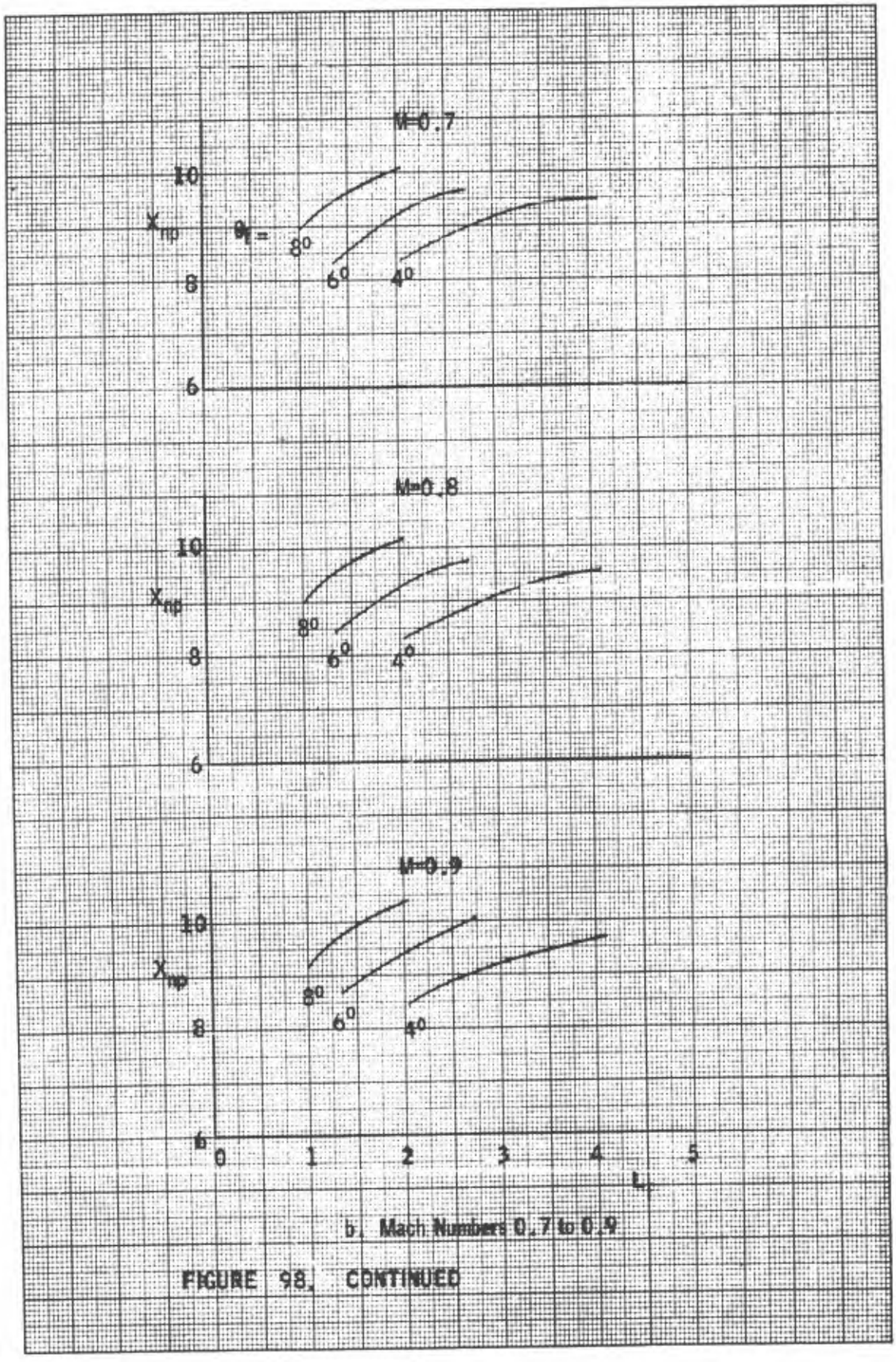
e. Mach Numbers 3.5 & 4.5

FIGURE 97. CONCLUDED



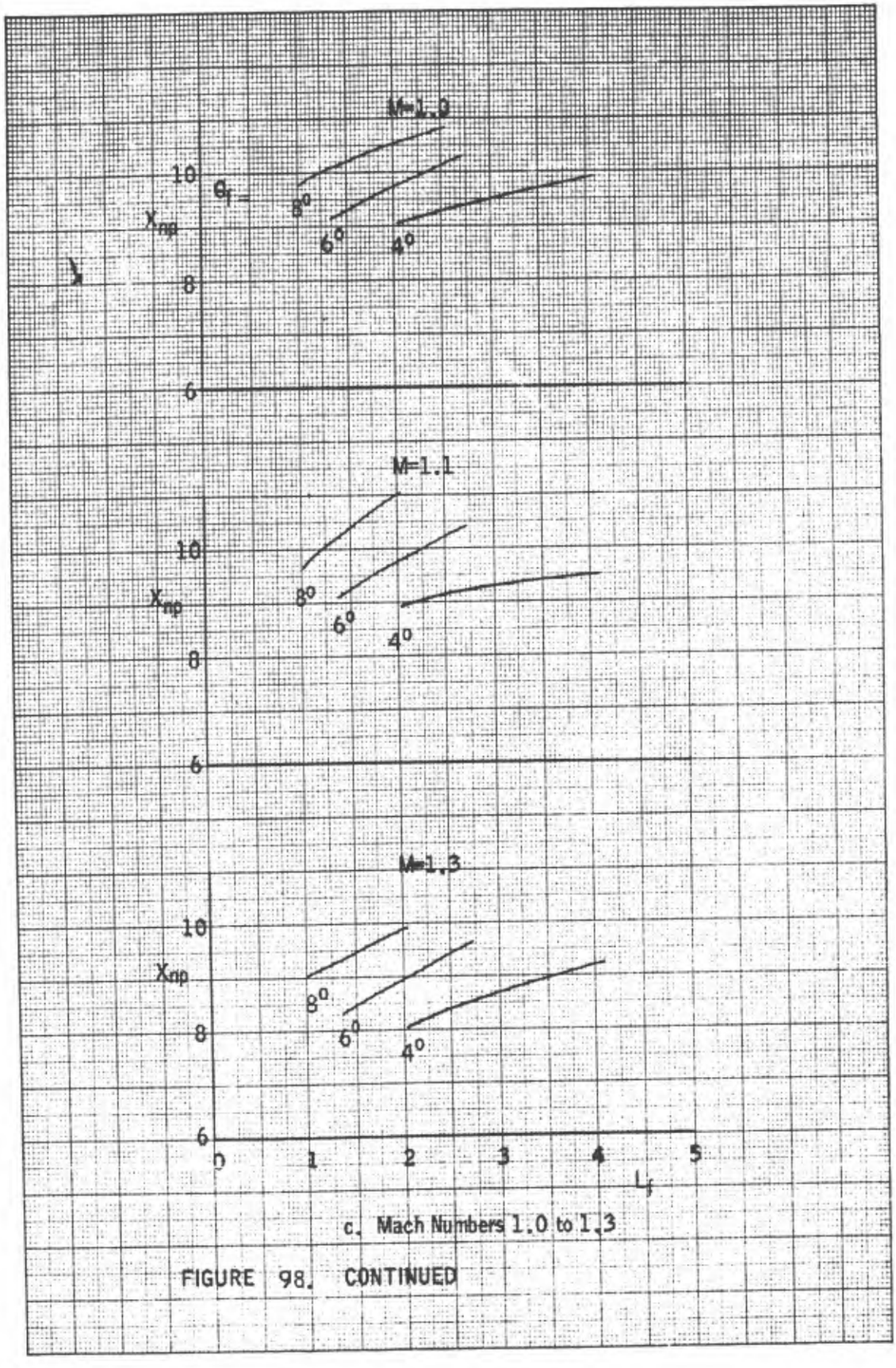
a. Mach Numbers 0.4 to 0.6

FIGURE 98. EFFECT OF FLARE LENGTH ON X_{np} AT THREE FLARE ANGLES WITH $L_s = 0$, $L = 15.36$



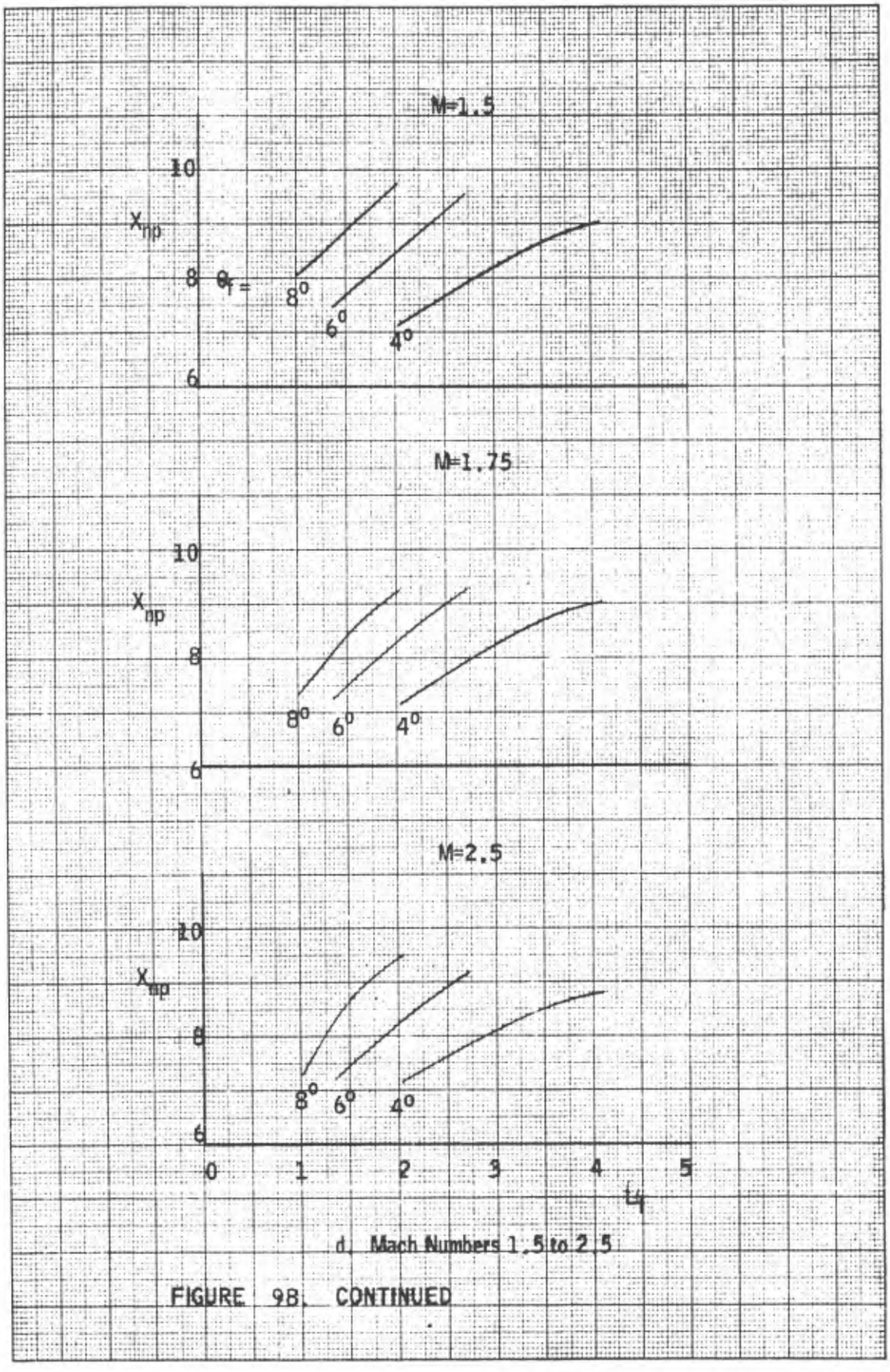
b. Mach Numbers 0.7 to 0.9

FIGURE 98. CONTINUED



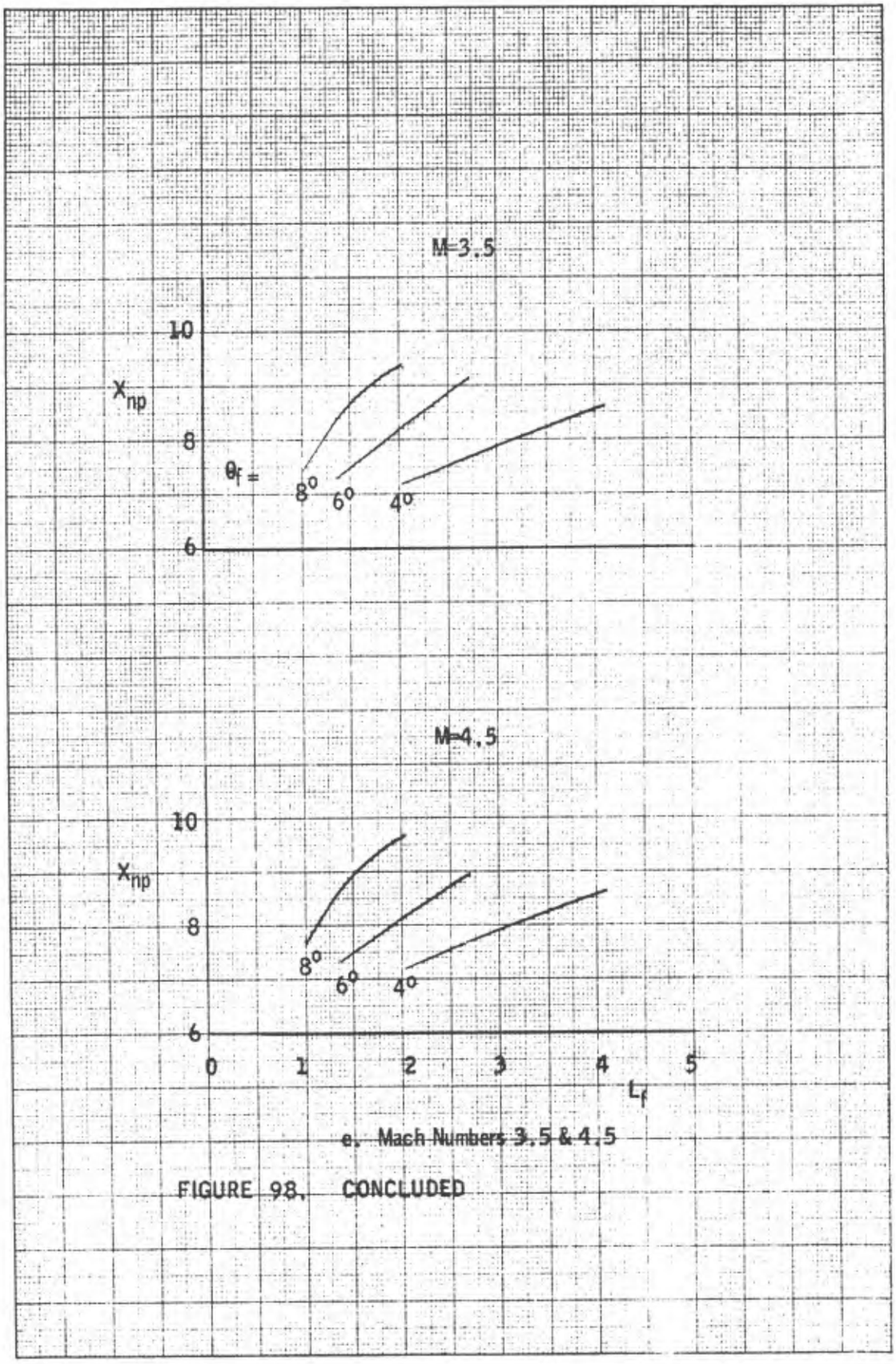
c. Mach Numbers 1.0 to 1.3

FIGURE 98. CONTINUED



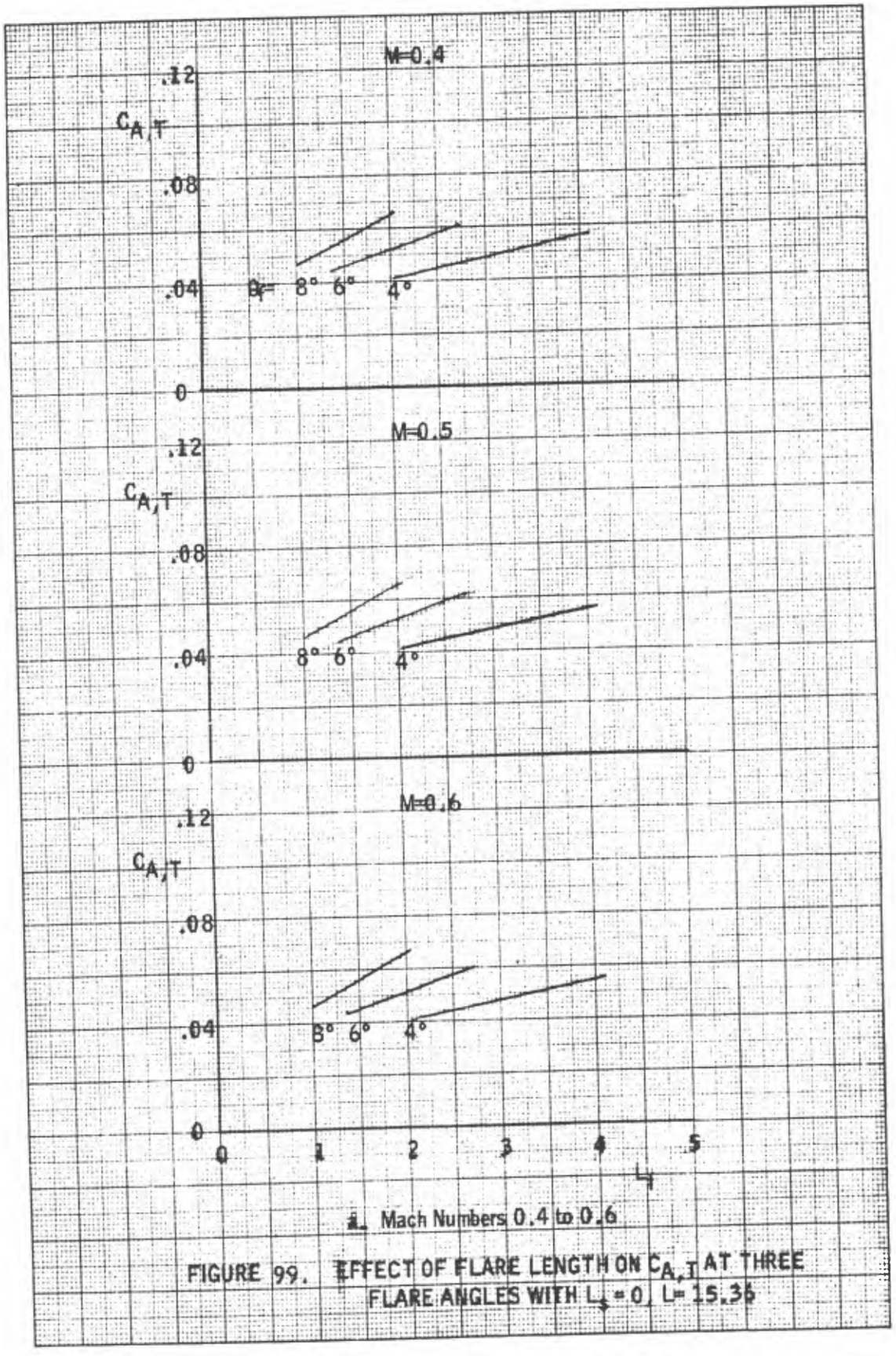
d. Mach Numbers 1.5 to 2.5

FIGURE 98. CONTINUED



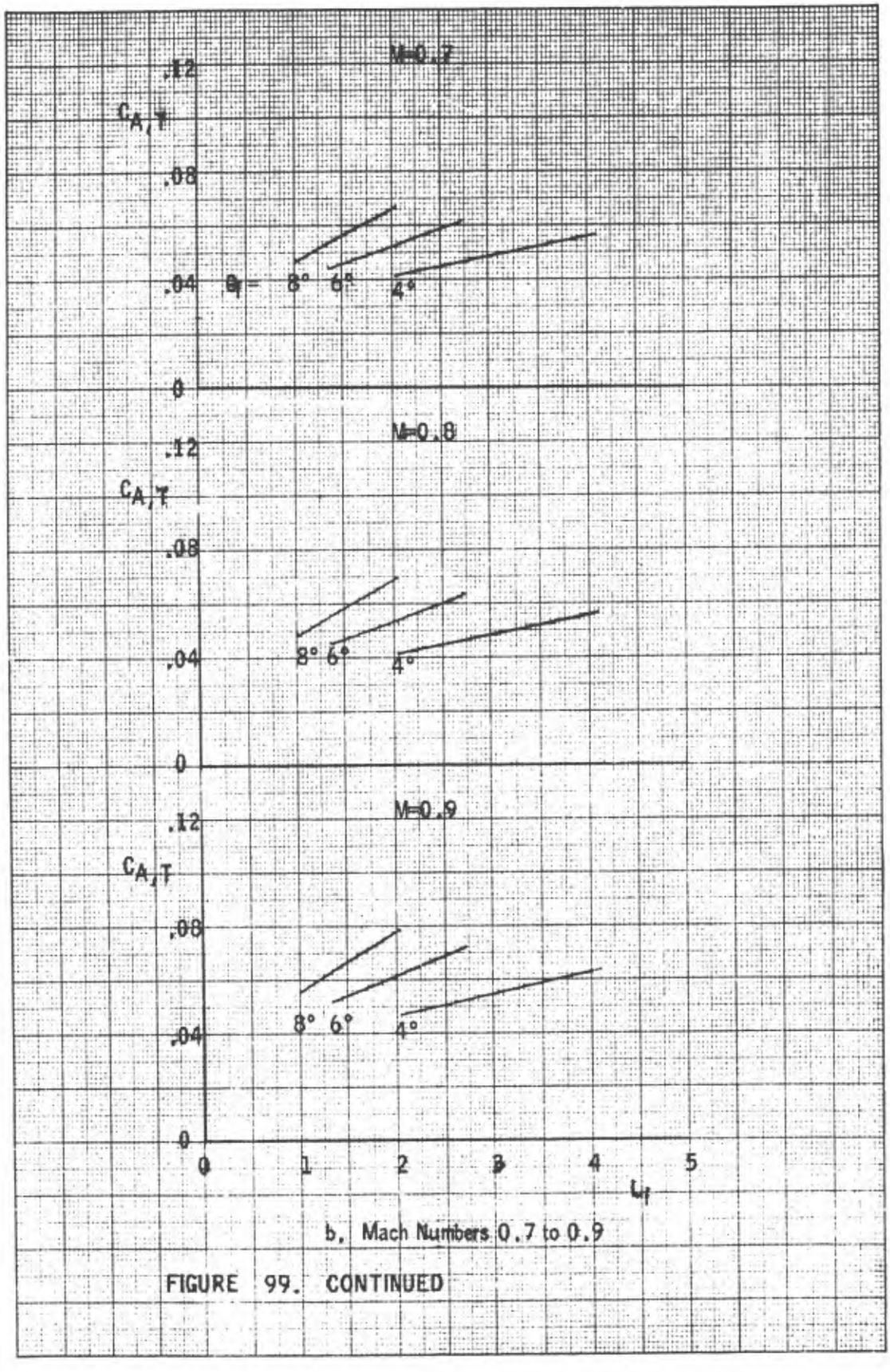
e. Mach Numbers 3.5 & 4.5

FIGURE 98. CONCLUDED



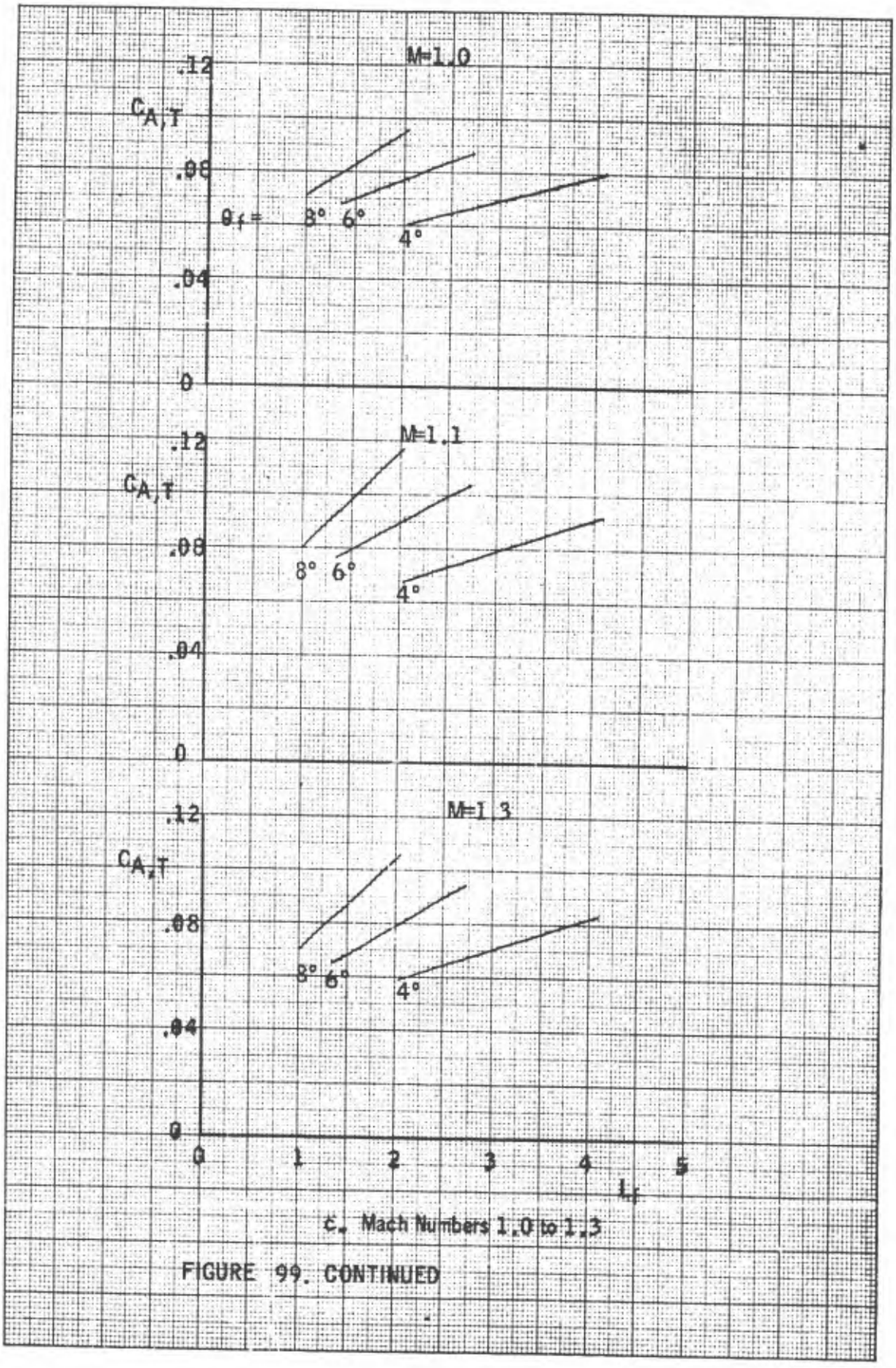
a. Mach Numbers 0.4 to 0.6

FIGURE 99. EFFECT OF FLARE LENGTH ON $C_{A,T}$ AT THREE FLARE ANGLES WITH $L_1 = 0$, $L = 15.36$



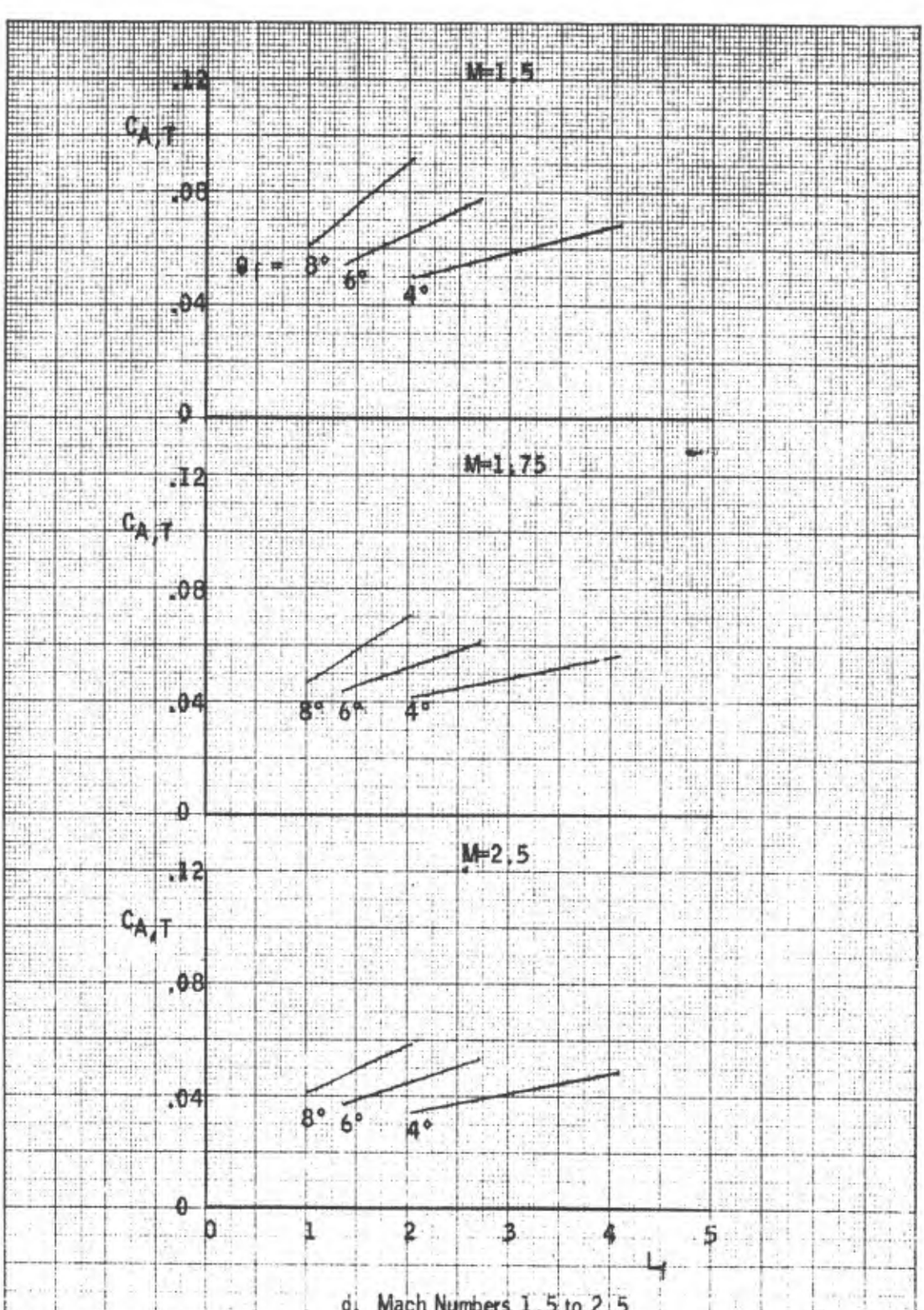
b, Mach Numbers 0.7 to 0.9

FIGURE 99. CONTINUED



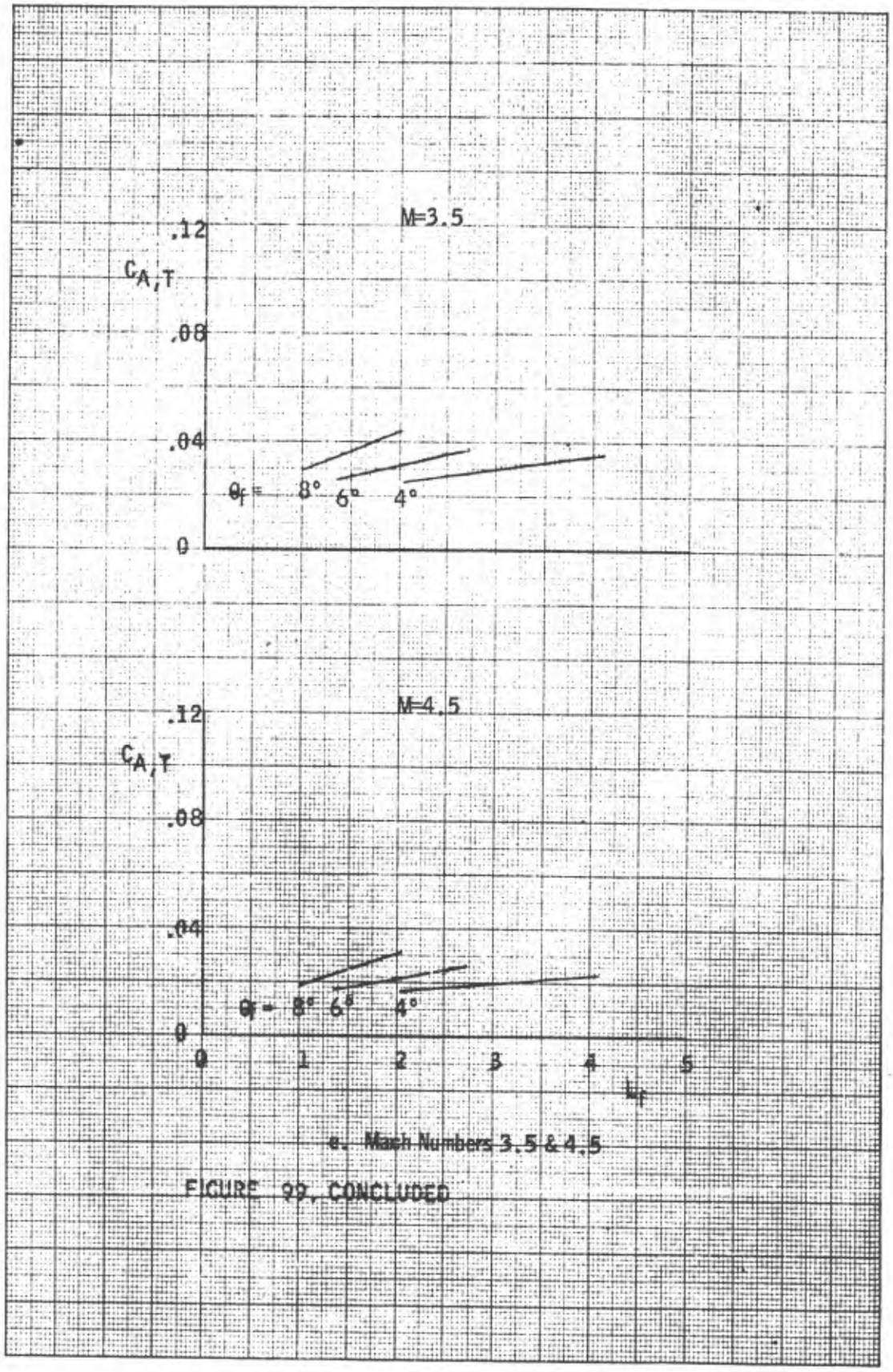
c. Mach Numbers 1.0 to 1.3

FIGURE 99. CONTINUED



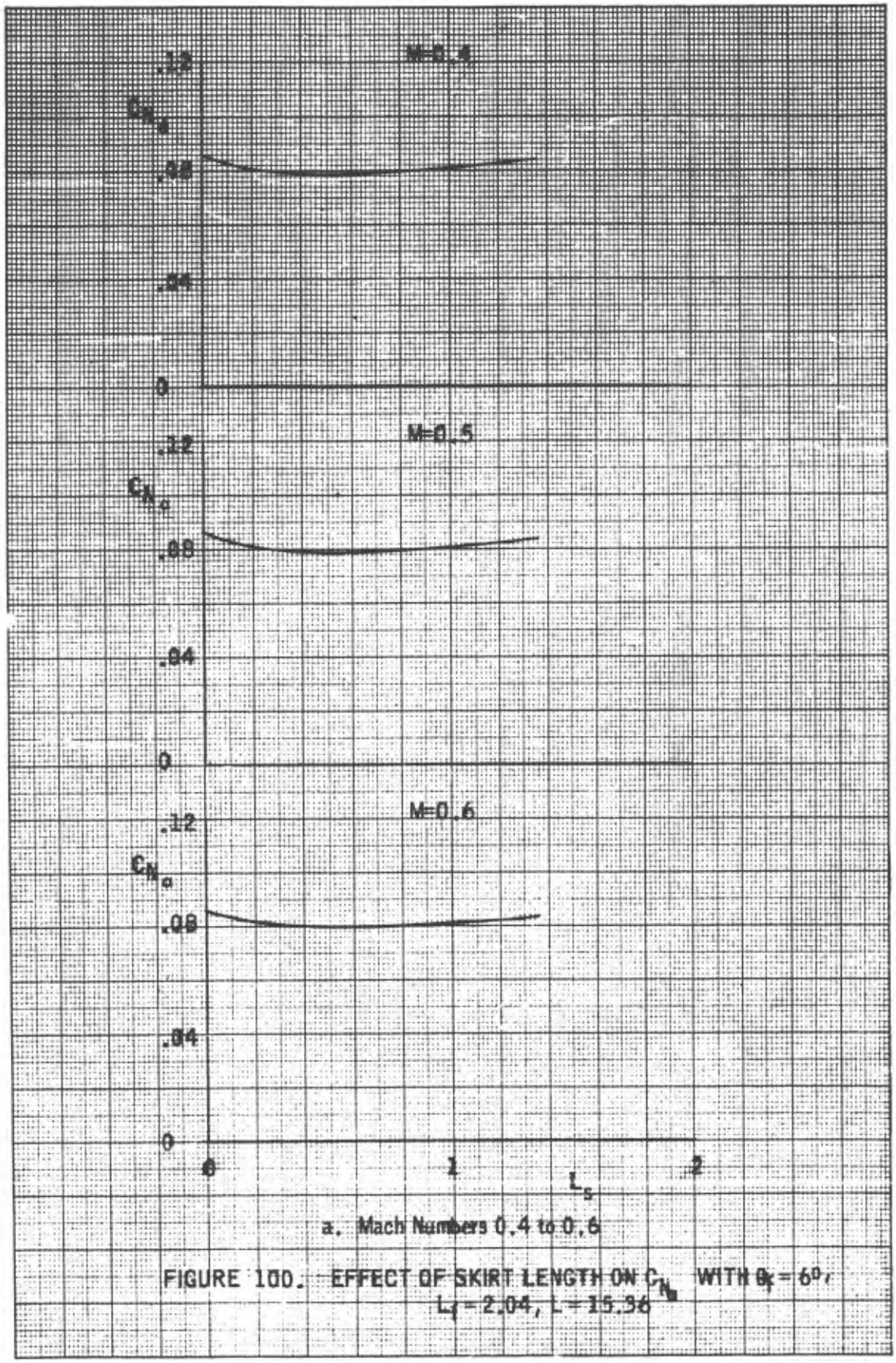
d, Mach Numbers 1.5 to 2.5

FIGURE 99. CONTINUED



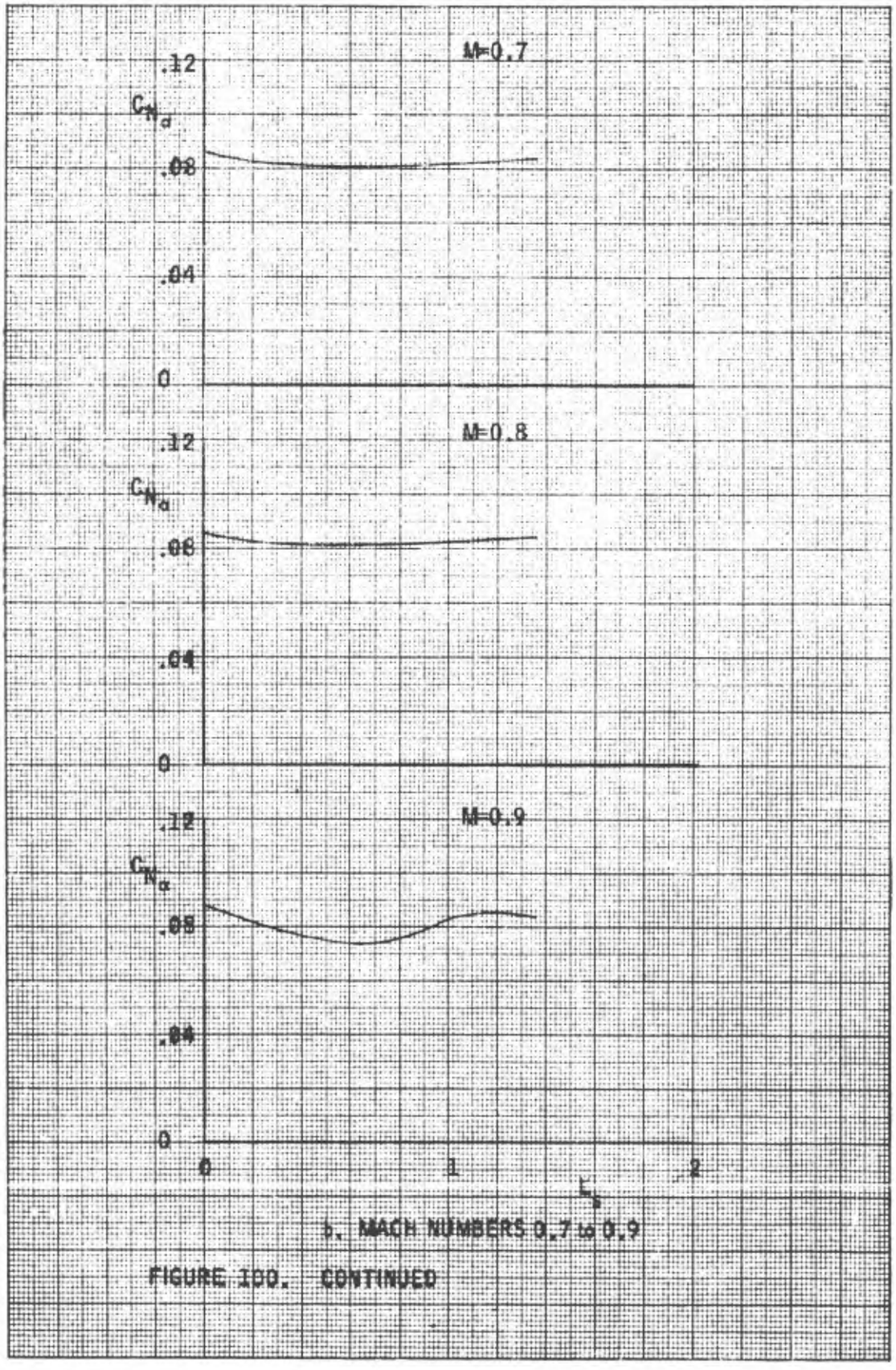
e. Mach Numbers 3.5 & 4.5

FIGURE 92. CONCLUDED



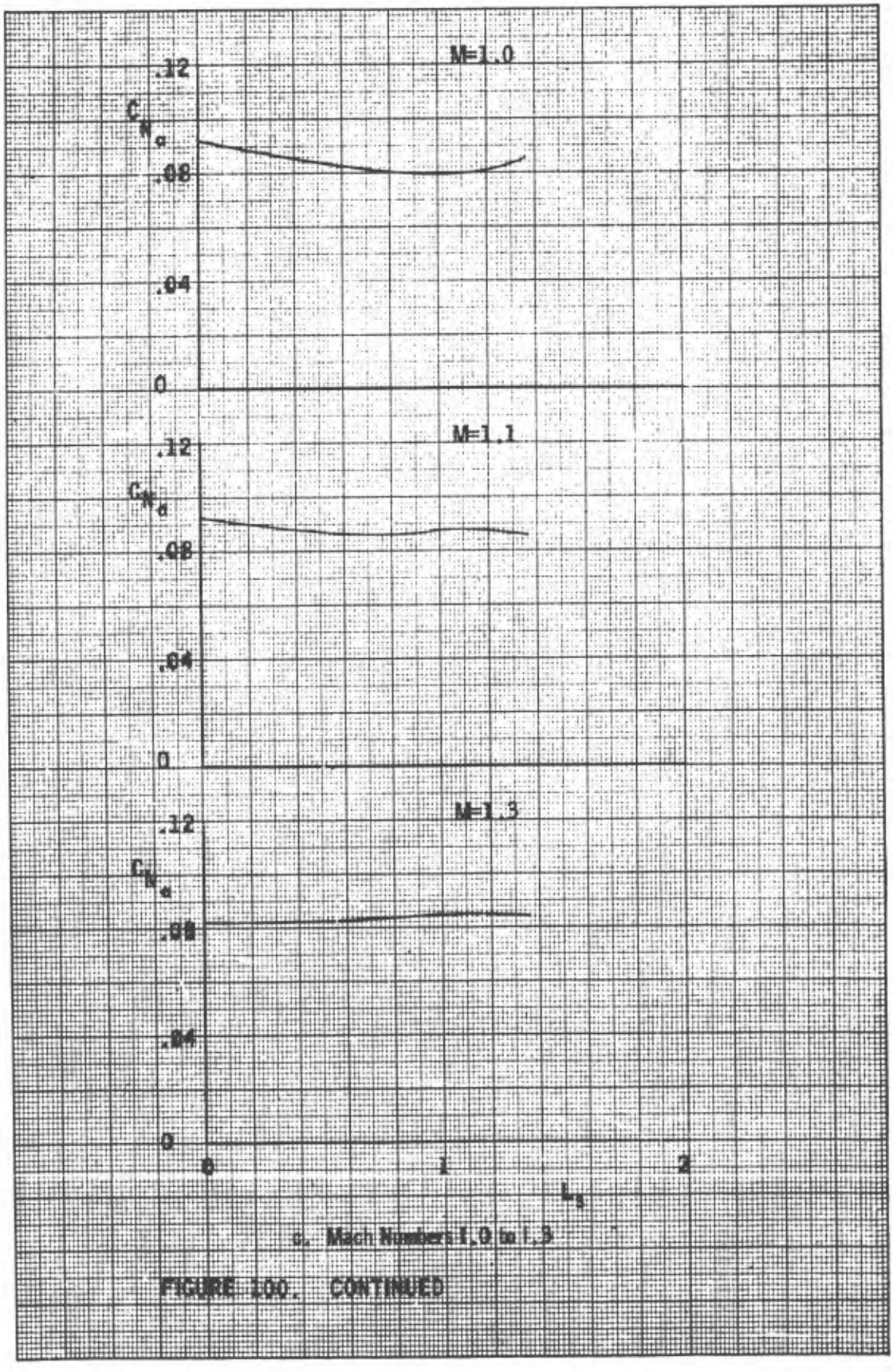
a. Mach Numbers 0.4 to 0.6

FIGURE 100. EFFECT OF SKIRT LENGTH ON C_{N_α} WITH $\theta_f = 6^0$, $L_f = 2.04$, $L = 15.36$



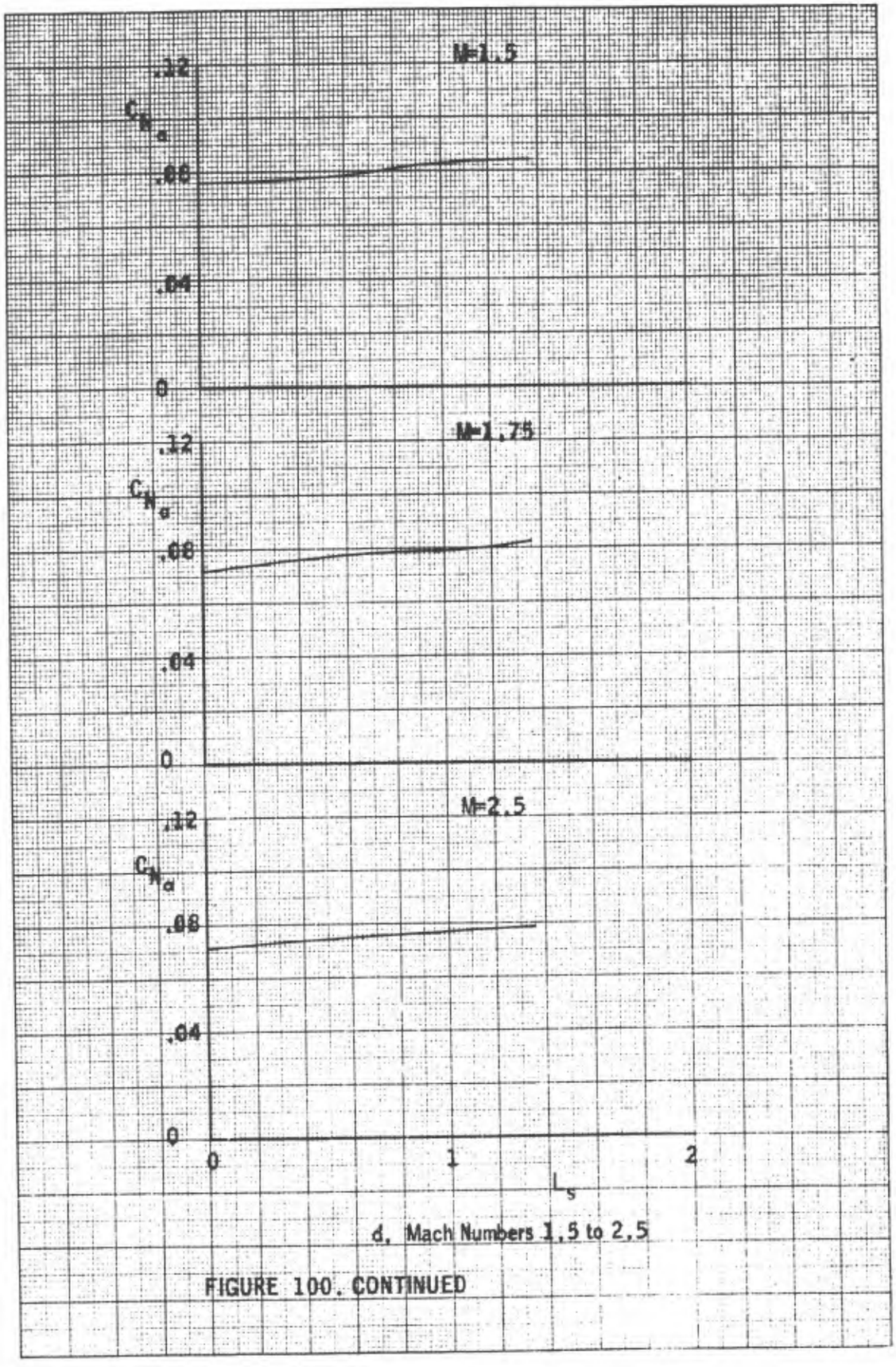
b. MACH NUMBERS 0.7 to 0.9

FIGURE 100. CONTINUED



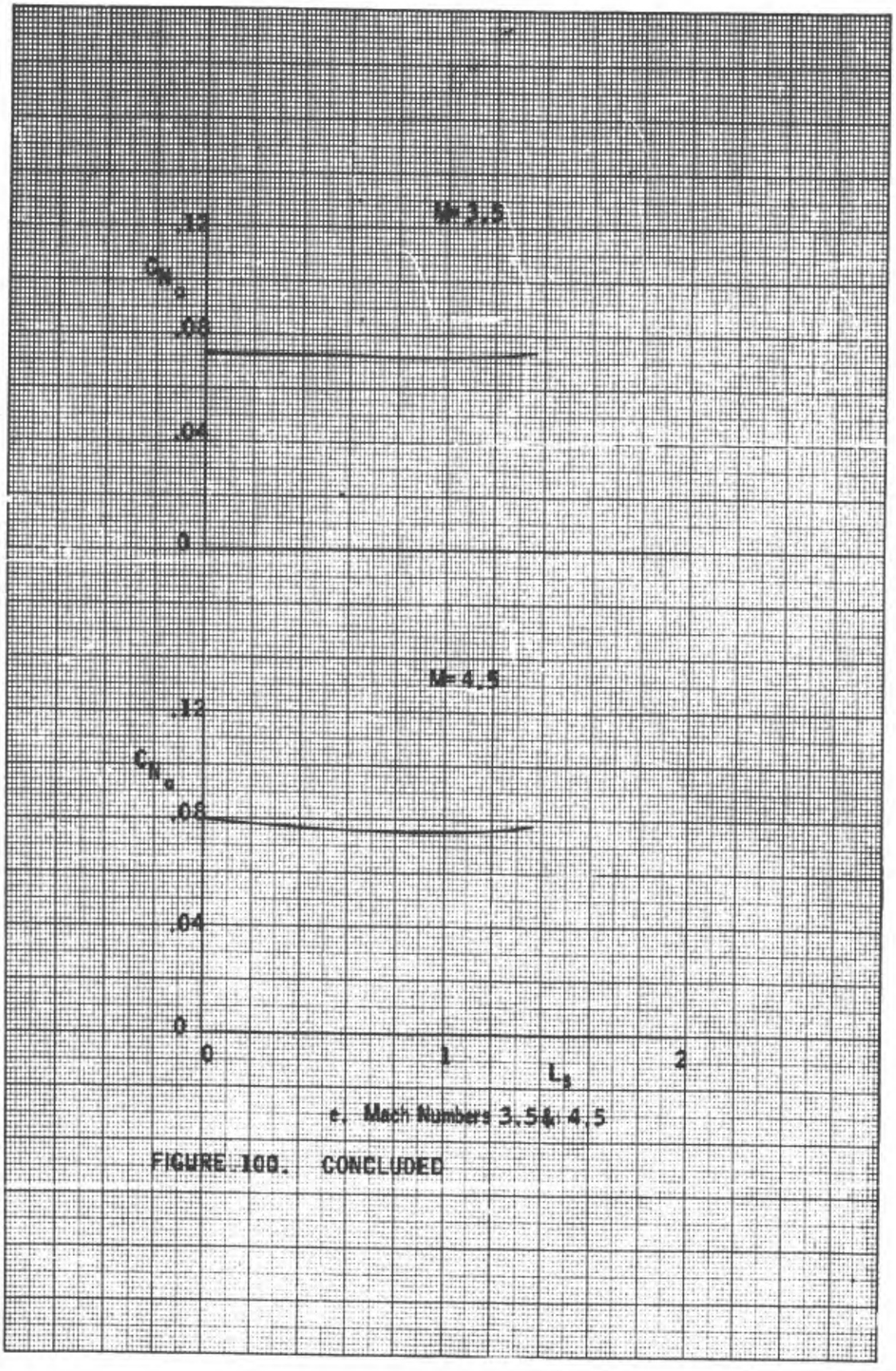
c. Mach Numbers 1.0 to 1.3

FIGURE 100. CONTINUED



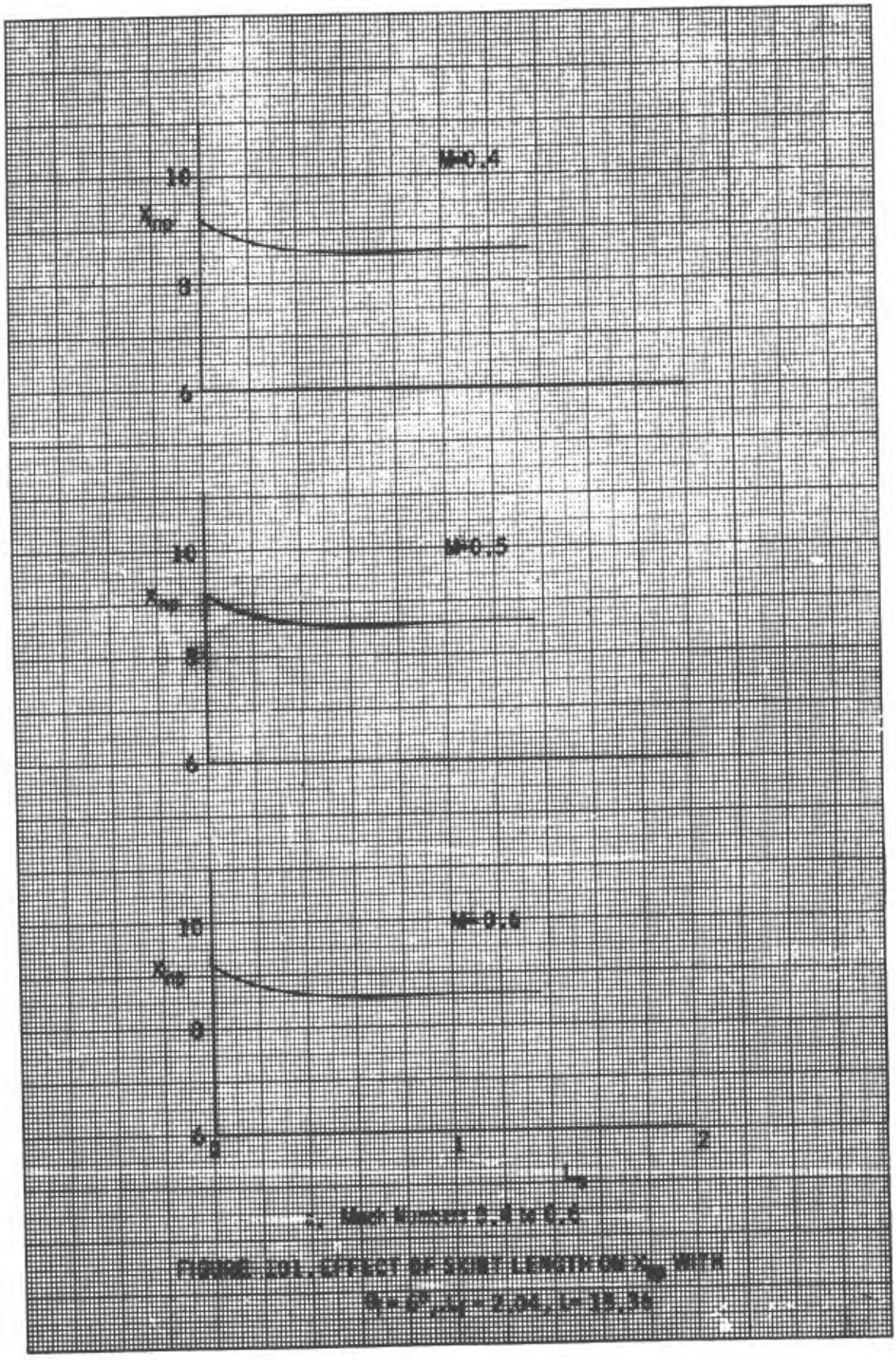
d. Mach Numbers 1.5 to 2.5

FIGURE 100. CONTINUED



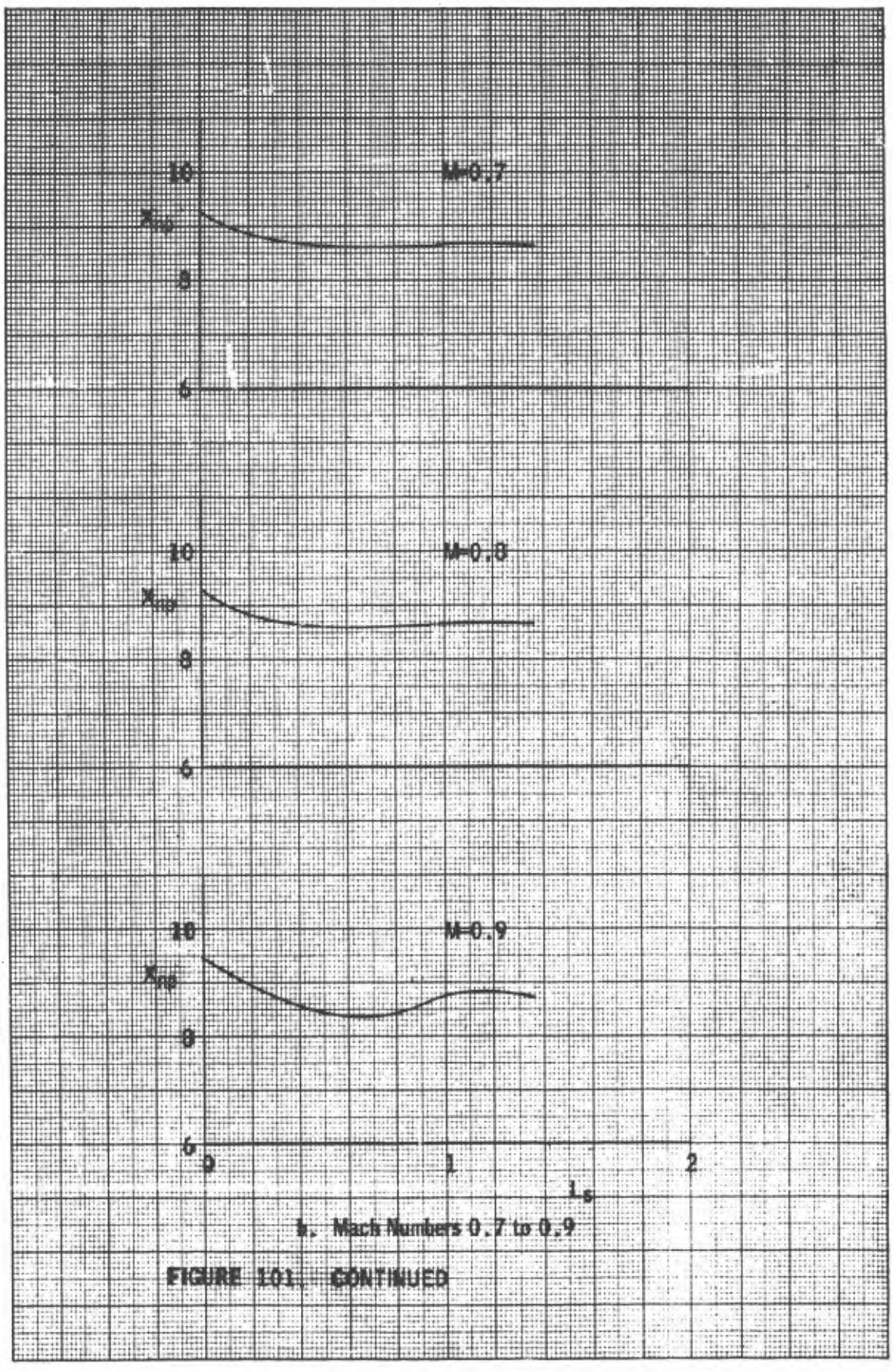
e. Mach Numbers 3.5 & 4.5

FIGURE 100. CONCLUDED



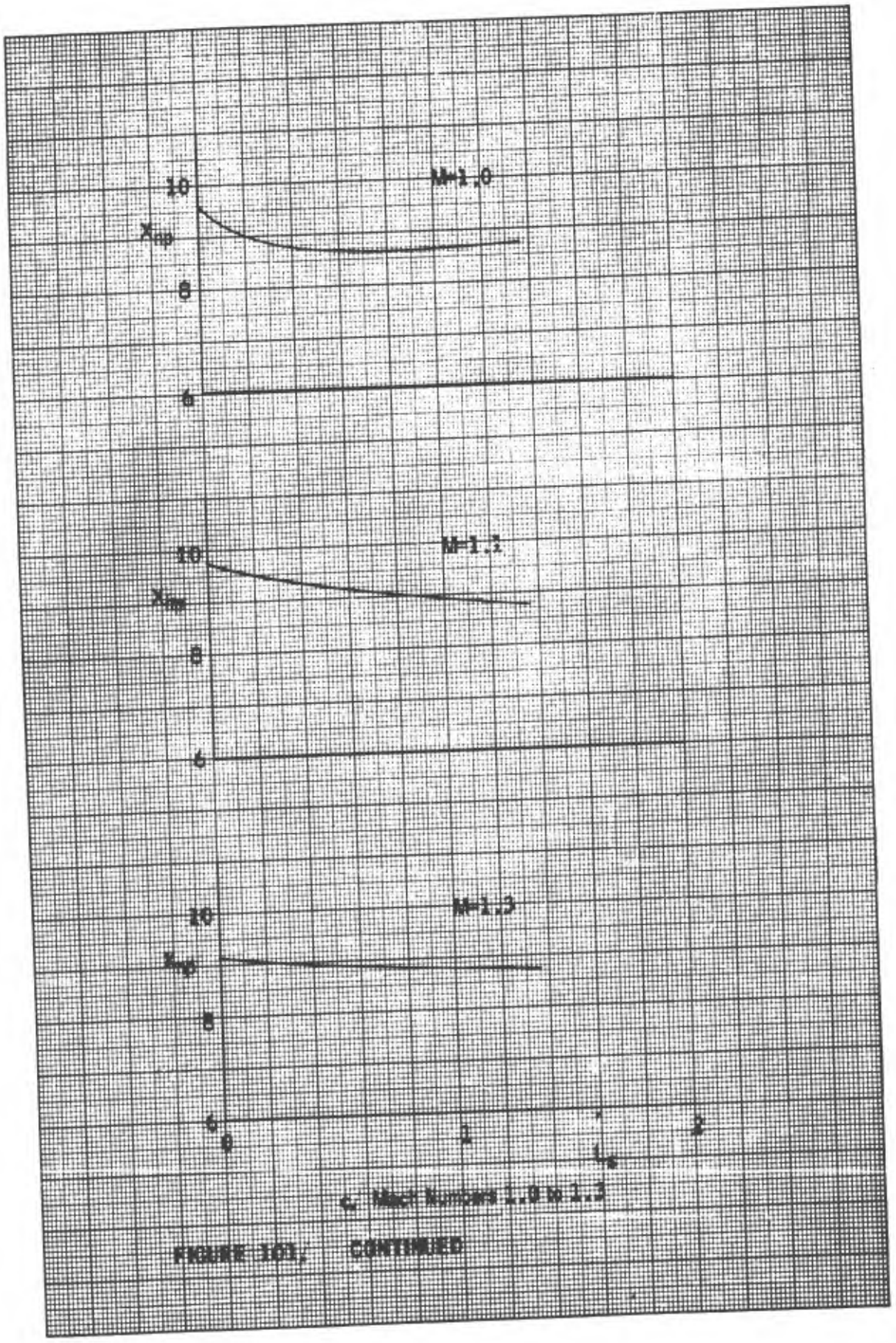
—, Mach Number 0.4 to 0.6

FIGURE 101. EFFECT OF SKIRT LENGTH ON X_{cp} WITH $\theta = \delta^* = 2.04$, $L = 15.35$



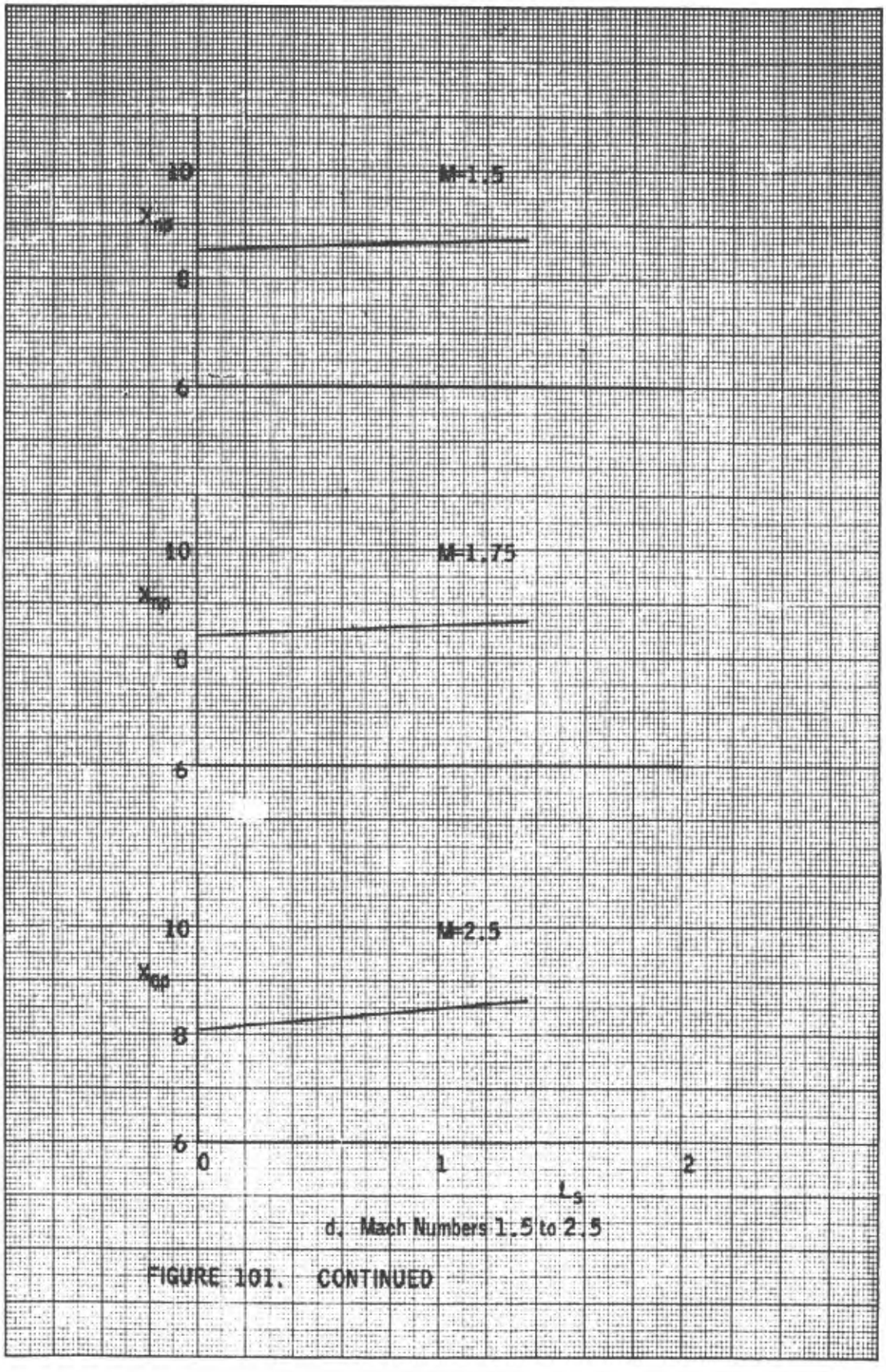
b. Mach Numbers 0.7 to 0.9

FIGURE 101. CONTINUED



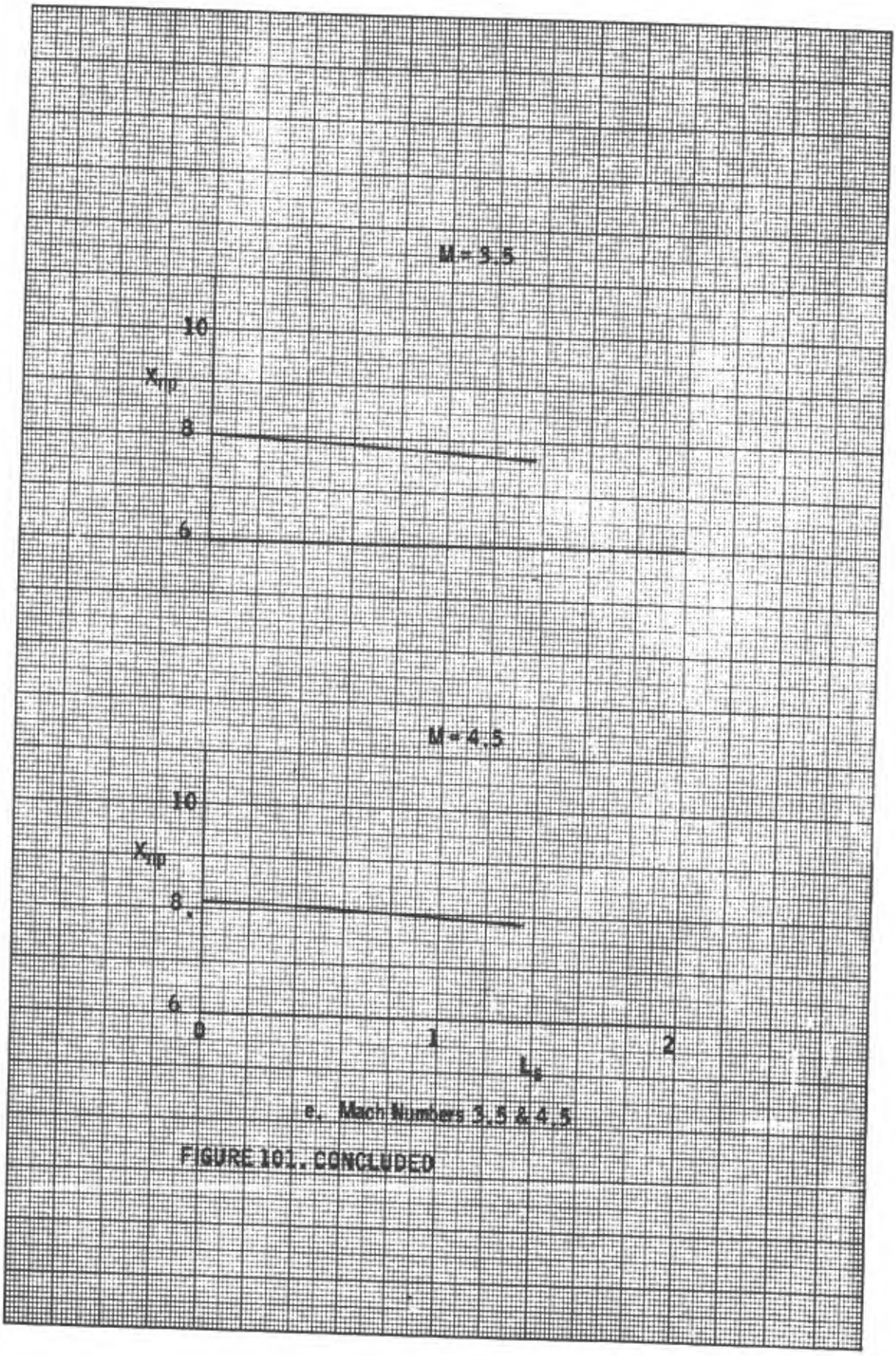
c. Mach Numbers 1.0 to 1.3

FIGURE 103. CONTINUED



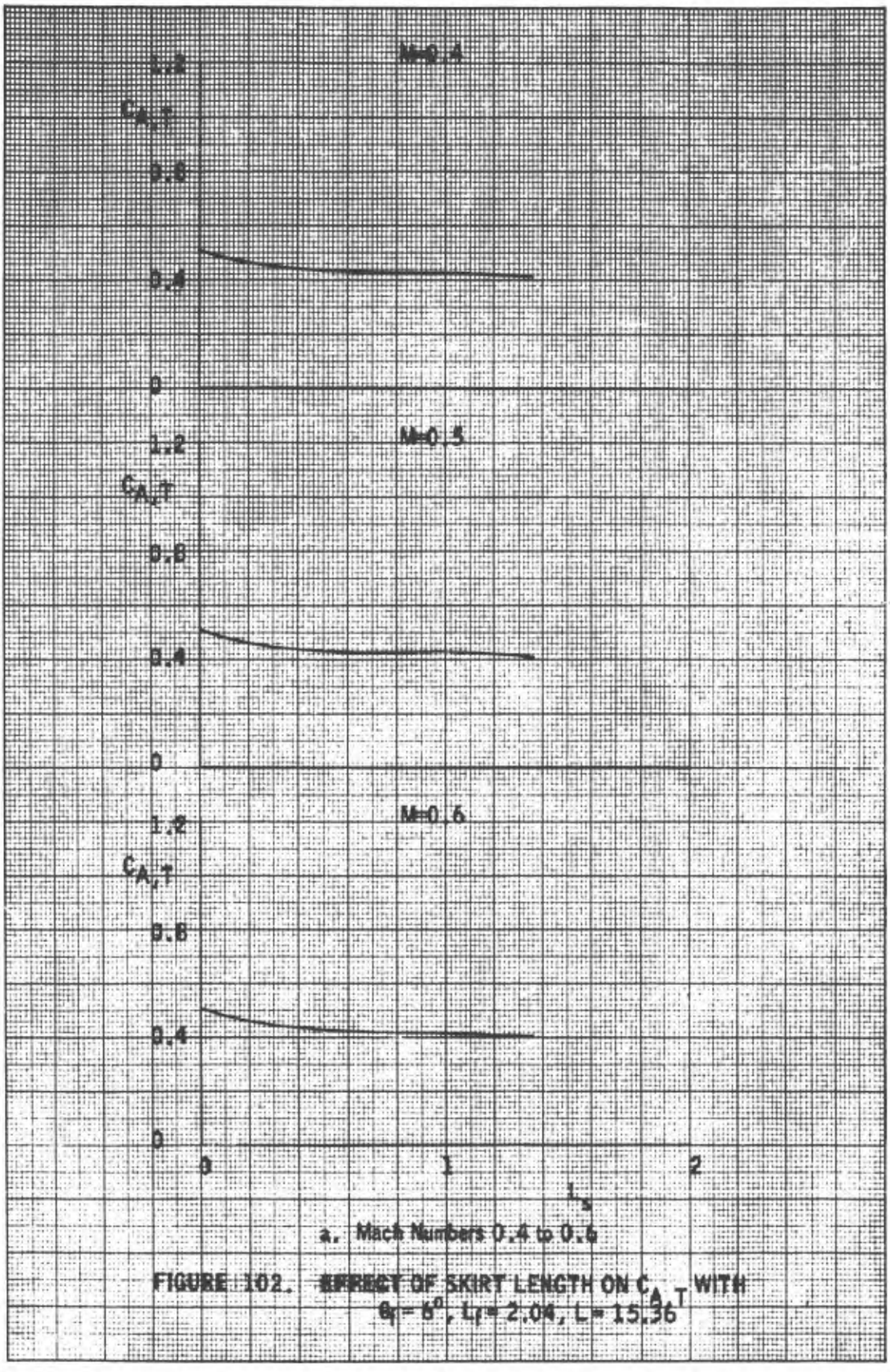
d. Mach Numbers 1.5 to 2.5

FIGURE 101. CONTINUED



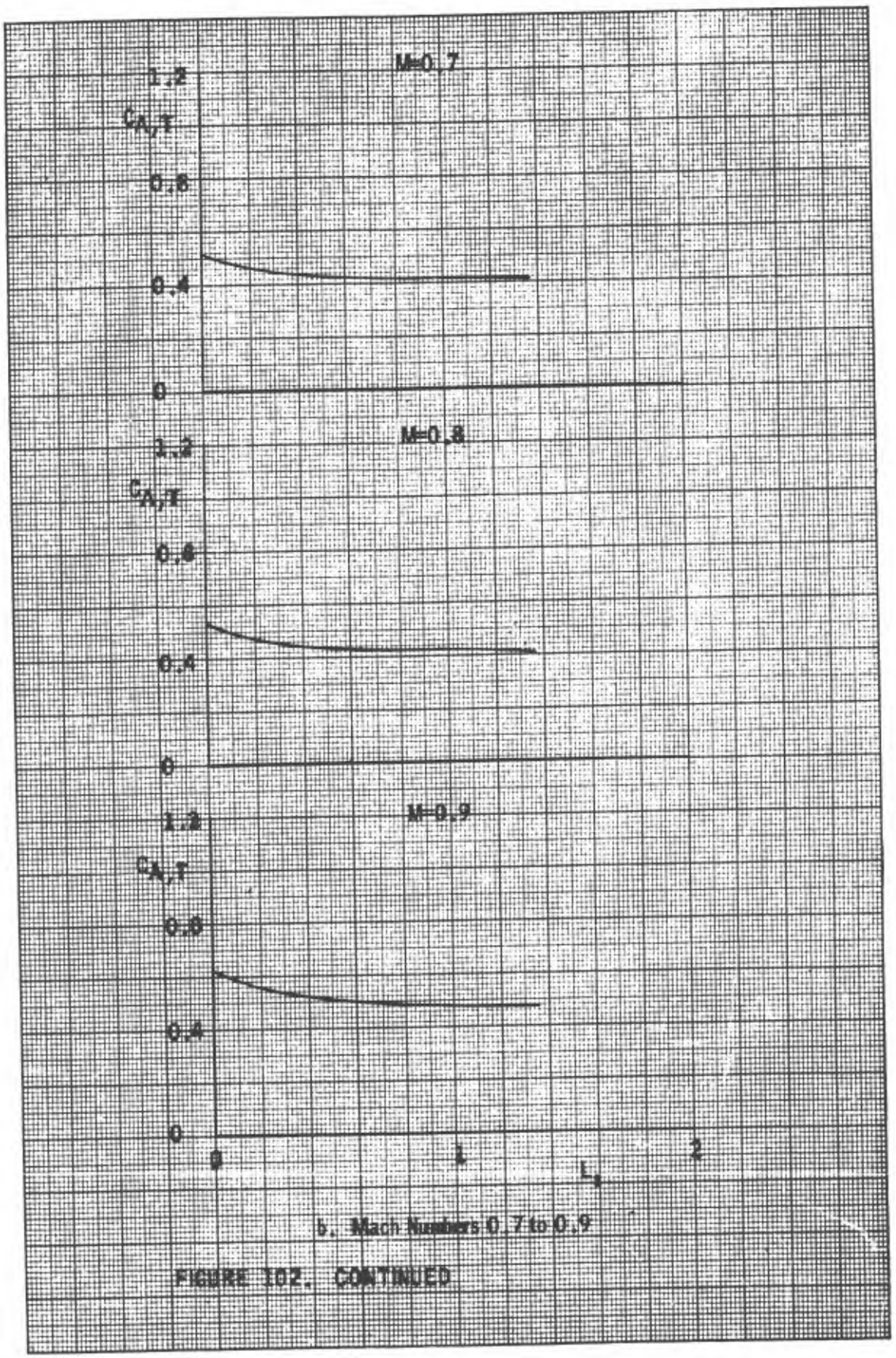
e. Mach Numbers 5.5 & 4.5

FIGURE 101. CONCLUDED



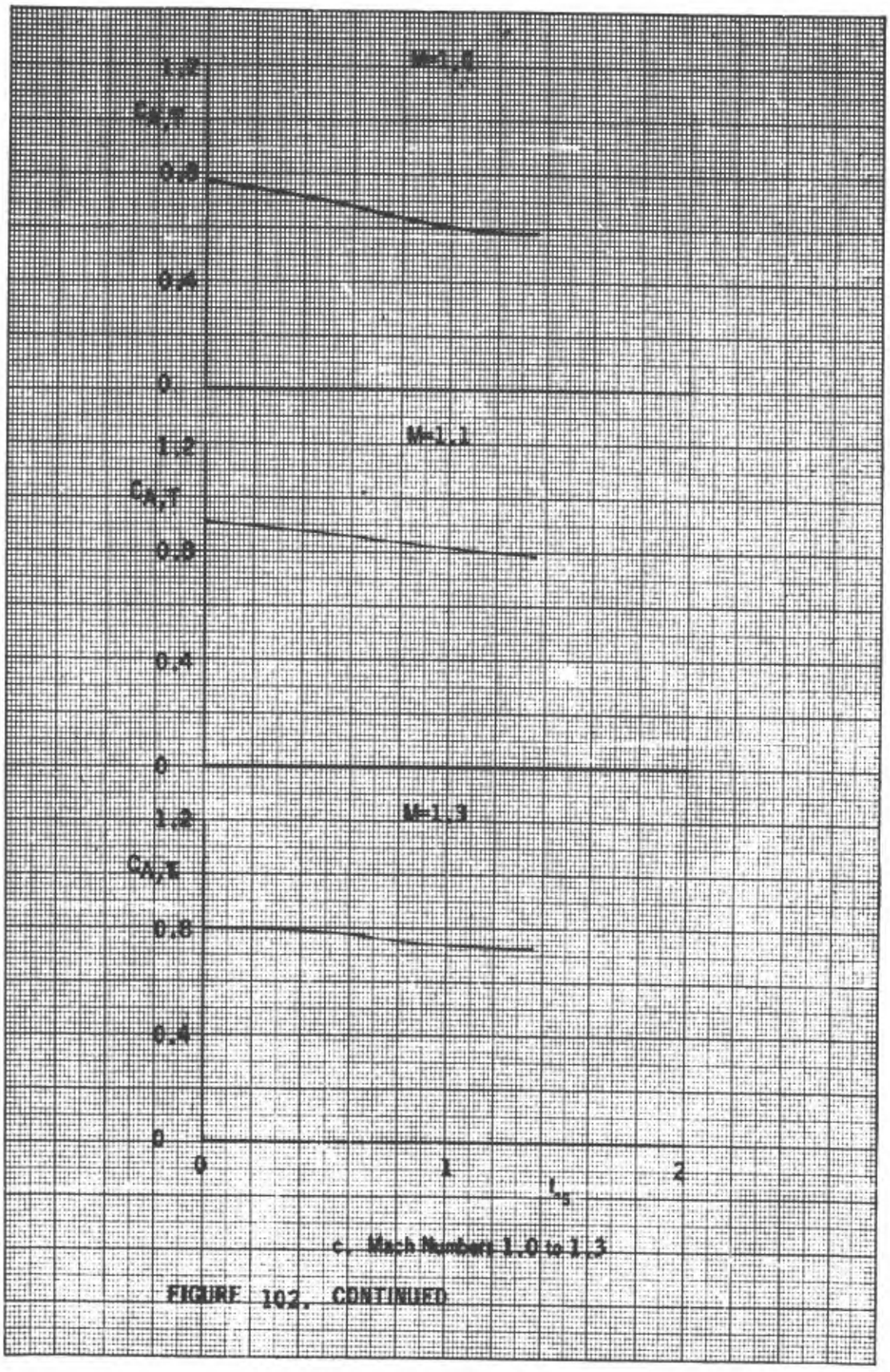
a. Mach Numbers 0.4 to 0.6

FIGURE 102. EFFECT OF SKIRT LENGTH ON $C_{A,T}$ WITH $\theta_f = 6^0$, $L_f = 2.0$, $L = 15.36$



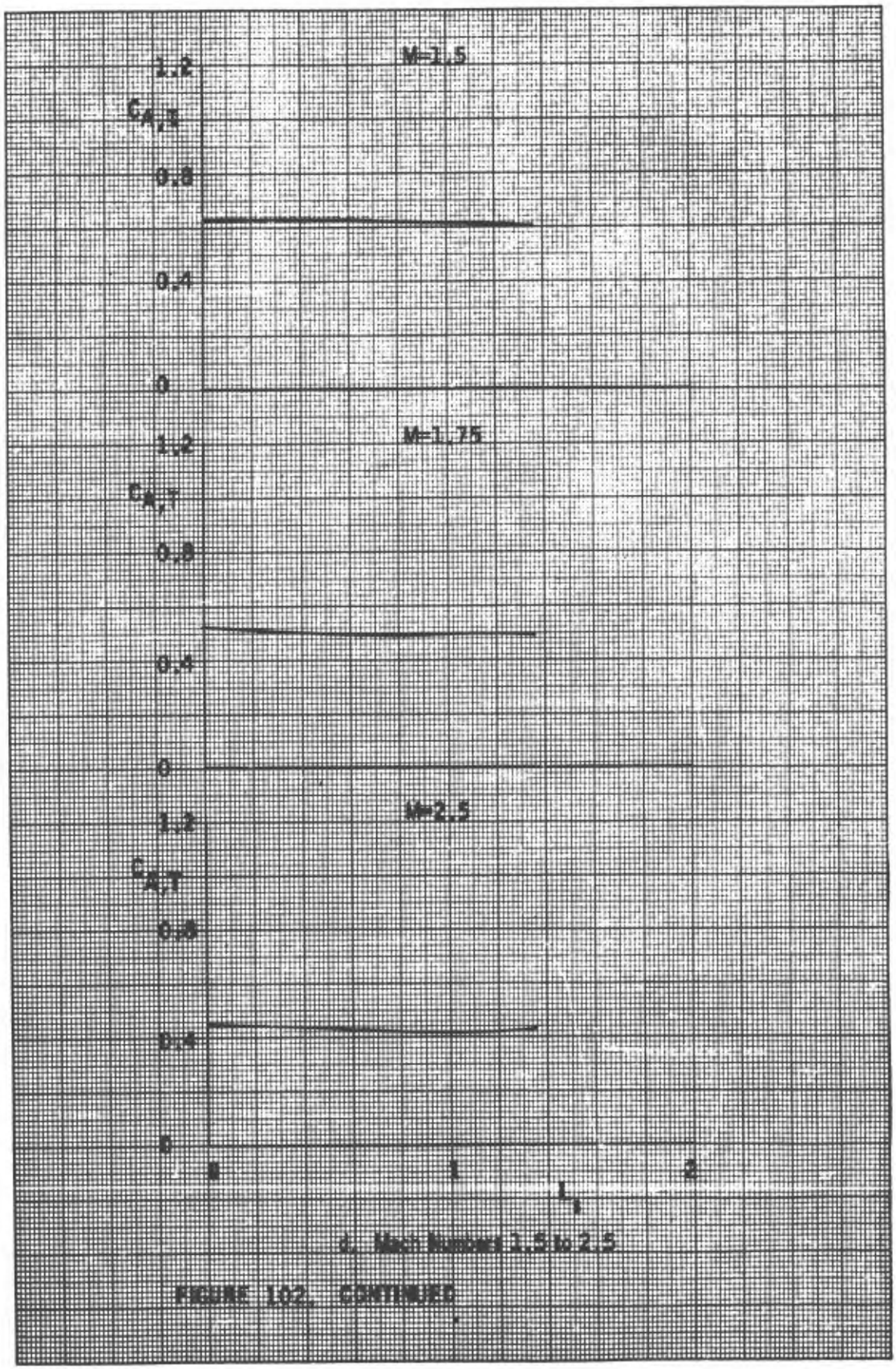
b. Mach Numbers 0.7 to 0.9

FIGURE 102. CONTINUED



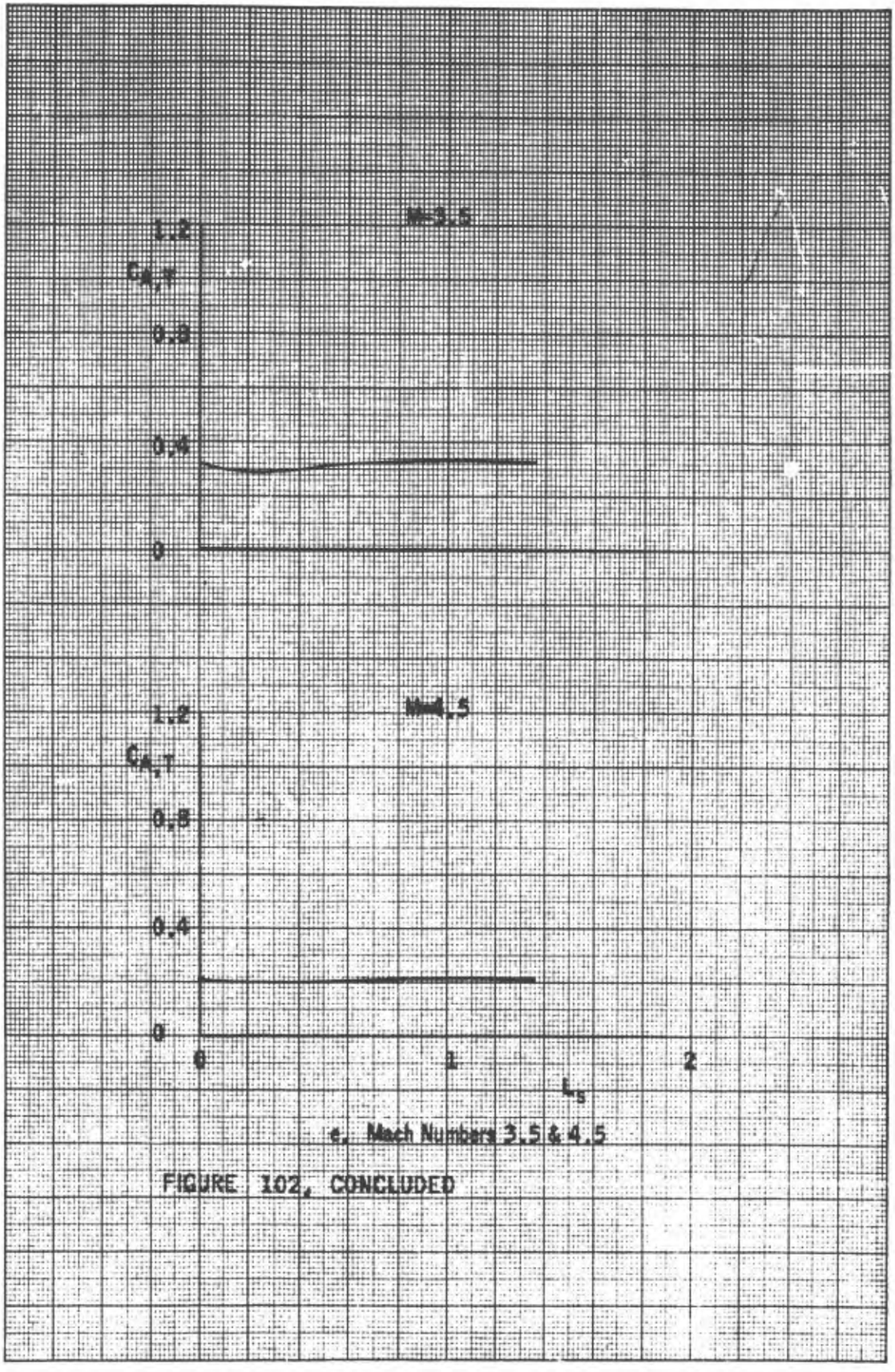
c. Mach Numbers 1.0 to 1.3

FIGURE 102. CONTINUED



d. Mach Numbers 1.5 to 2.5

FIGURE 102. CONTINUED



c. Mach Numbers 3.5 & 4.5

FIGURE 102, CONCLUDED

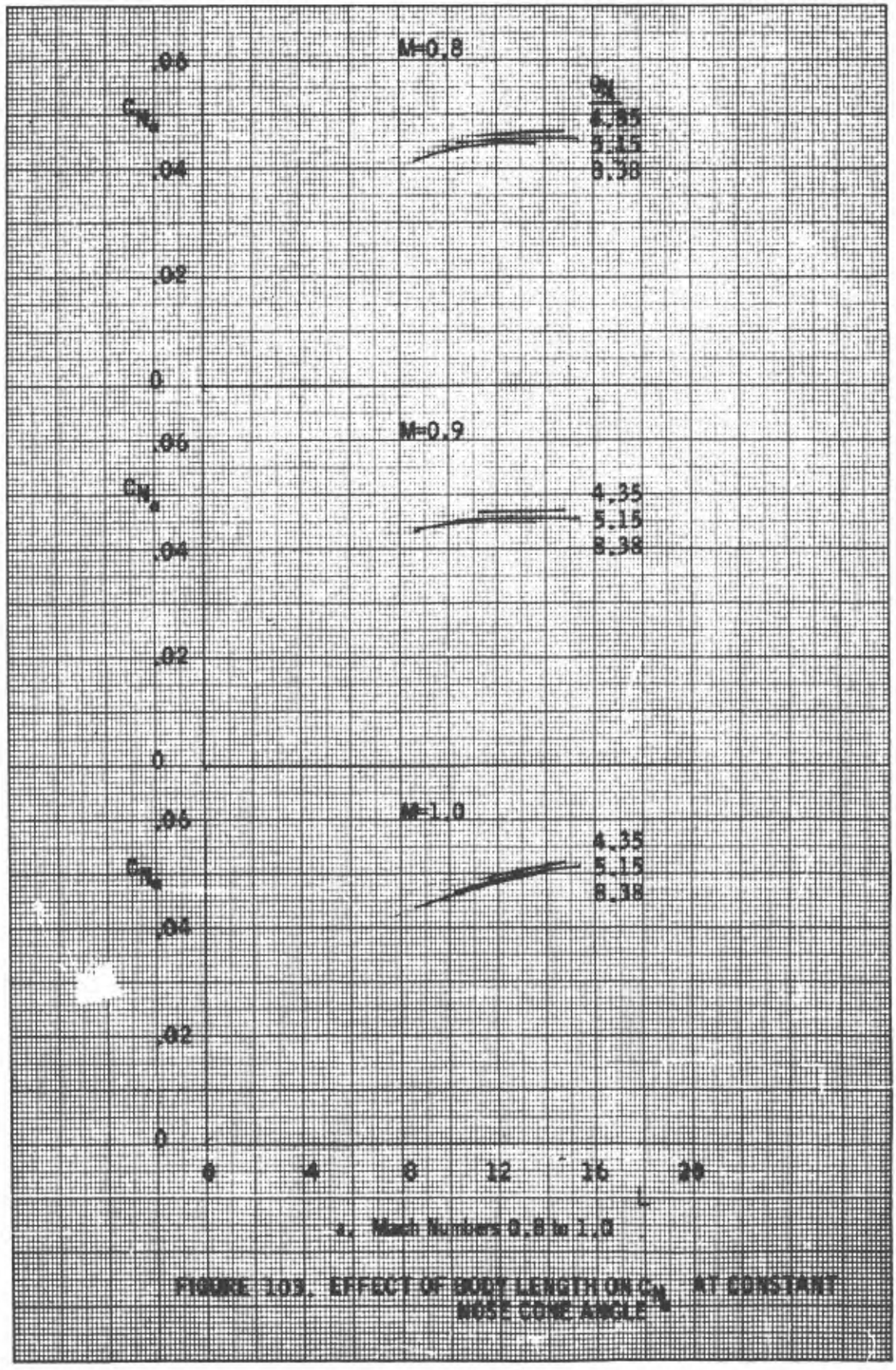
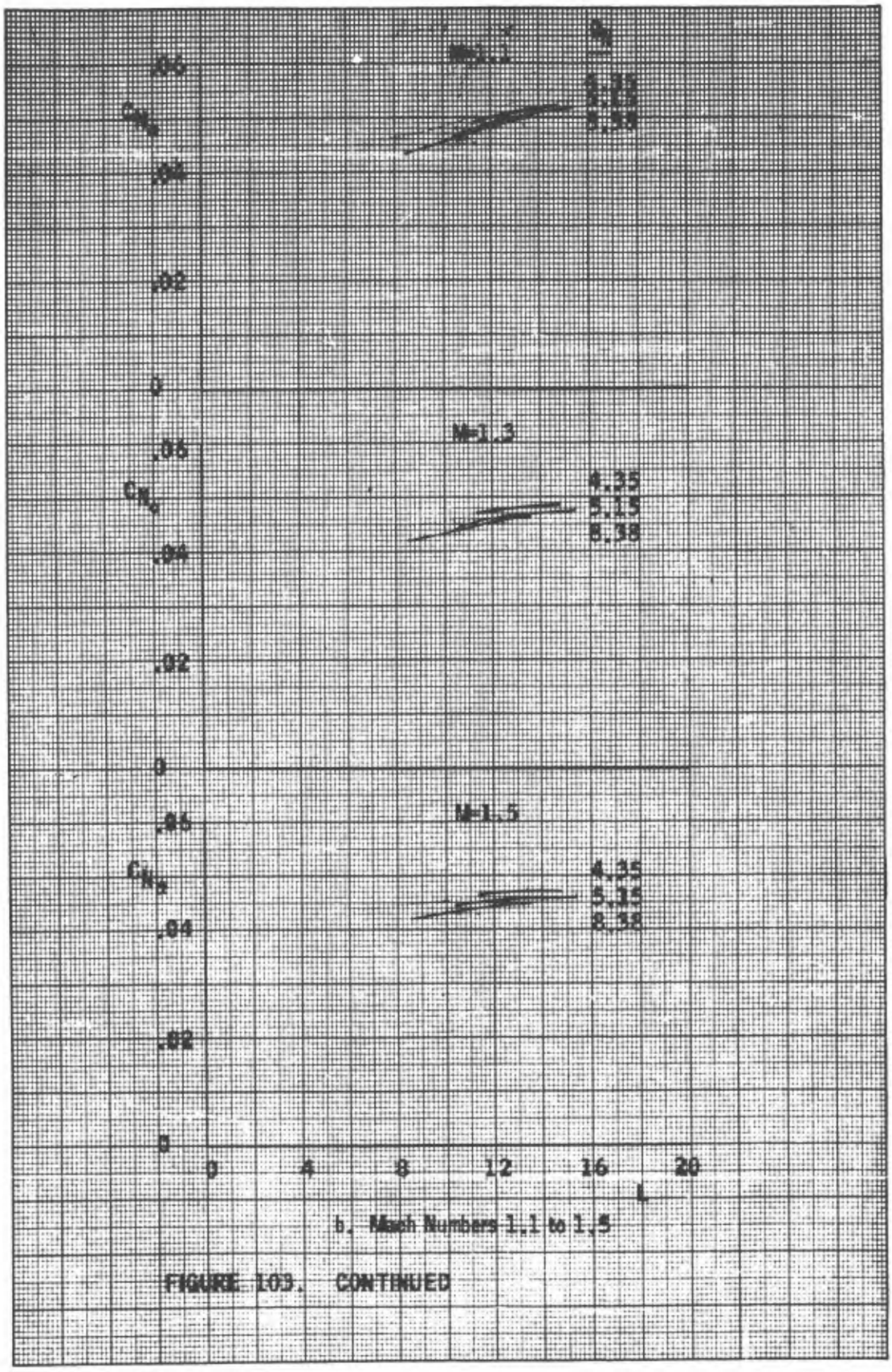
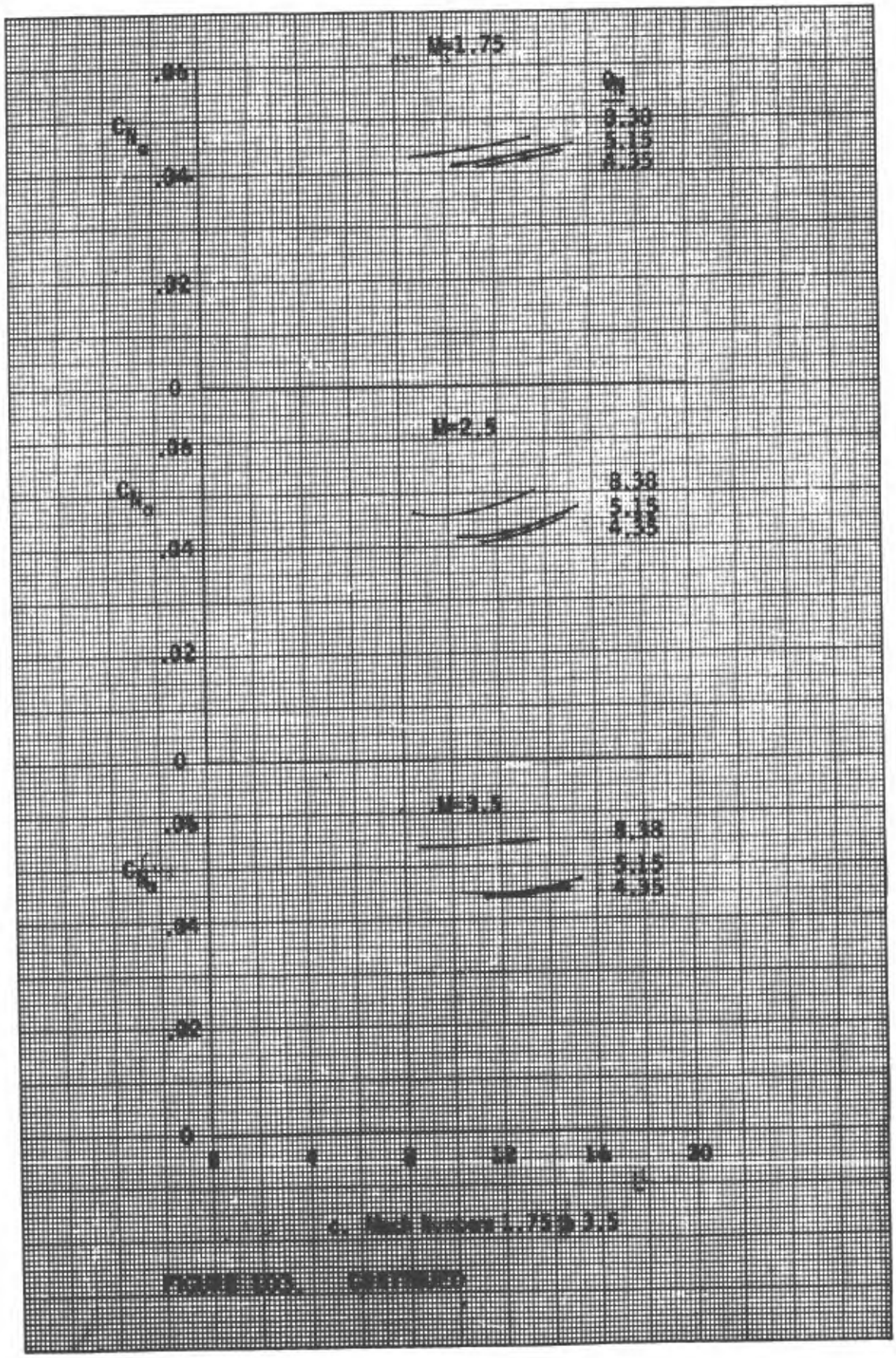


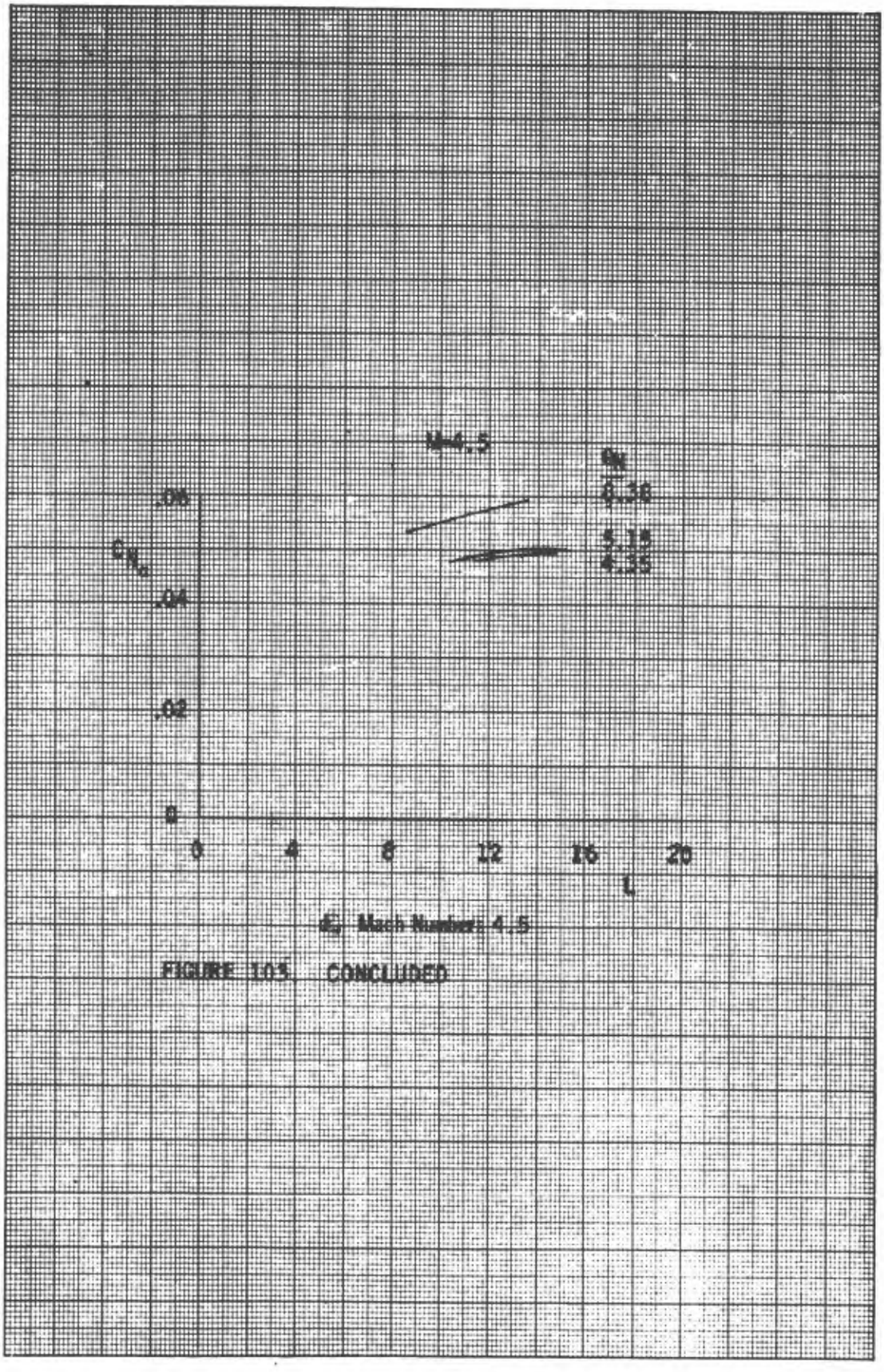
FIGURE 103. EFFECT OF BODY LENGTH ON C_{N_α} AT CONSTANT NOSE CONE ANGLE



b. Mach Numbers 1.1 to 1.5

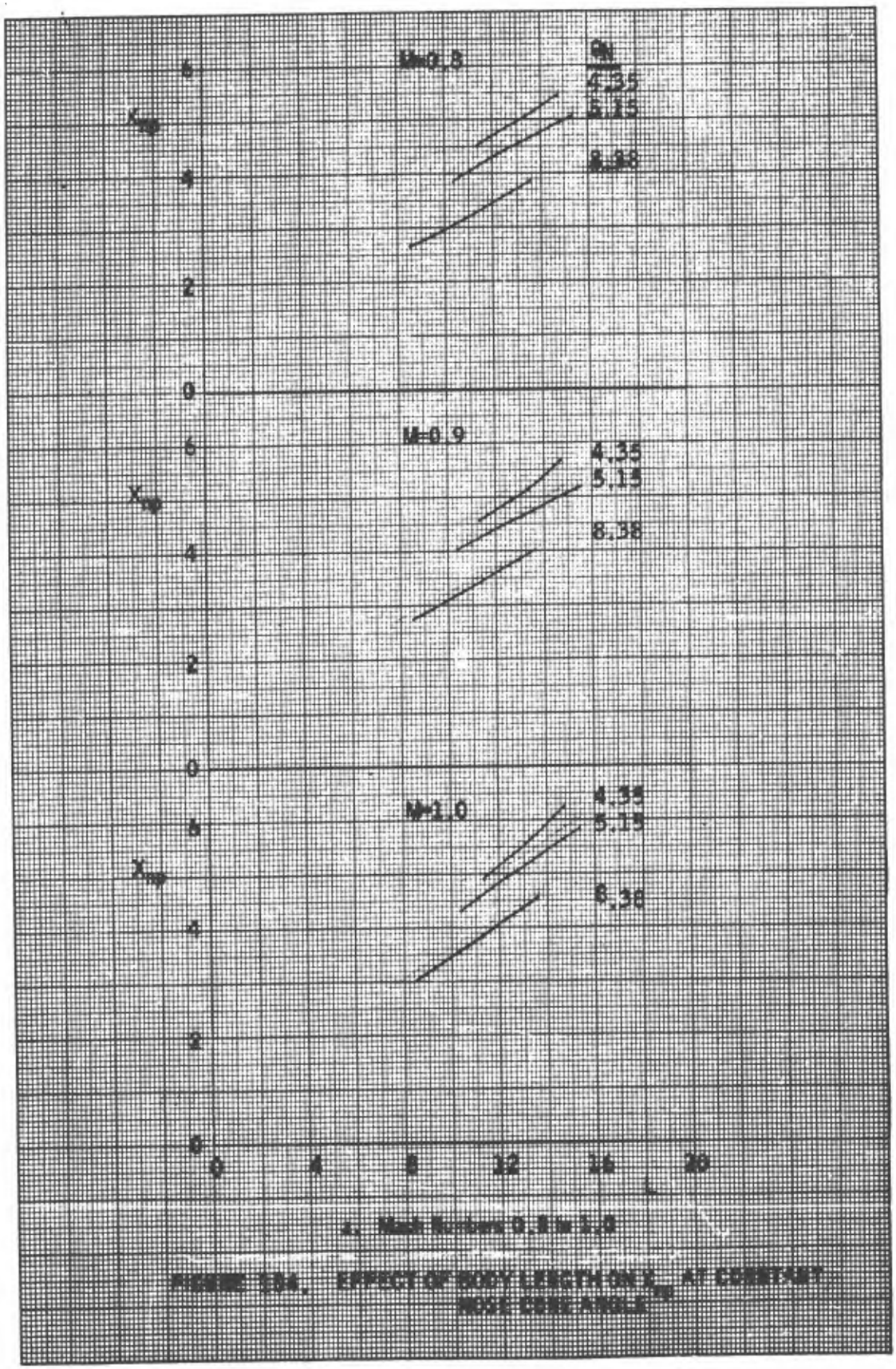
FIGURE 103. CONTINUED


M=1.75
M=2.5
M=3.5
.06
.04
.02
0
-.02
-.04
-.06
8.38
5.15
4.35
20



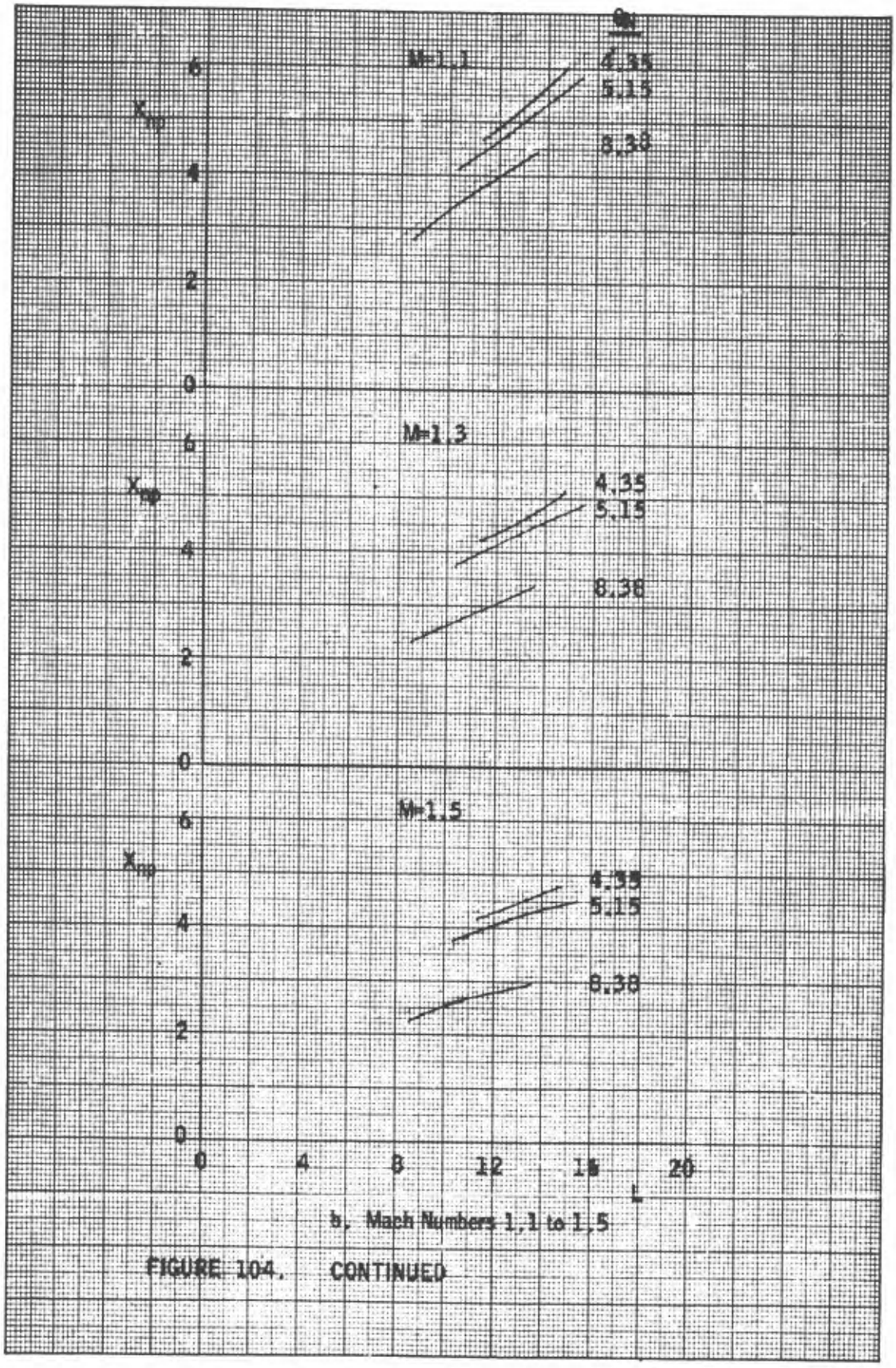
δ_f, Mach Number 4.5

FIGURE 103. CONCLUDED



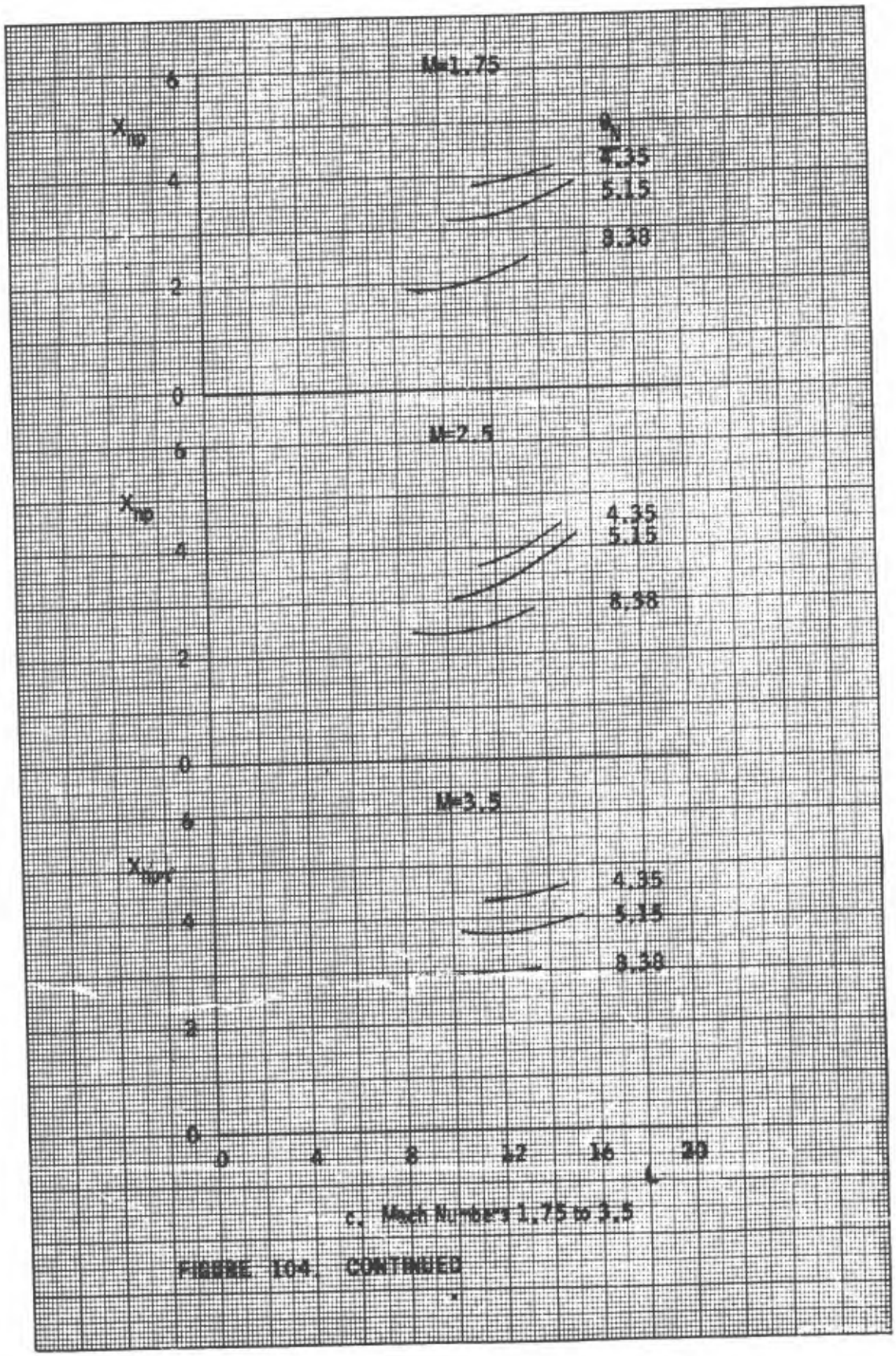
a. Mach Numbers 0.8 to 1.0

FIGURE 134. EFFECT OF BODY LENGTH ON X_{cp} AT CONSTANT NOSE CONE ANGLE



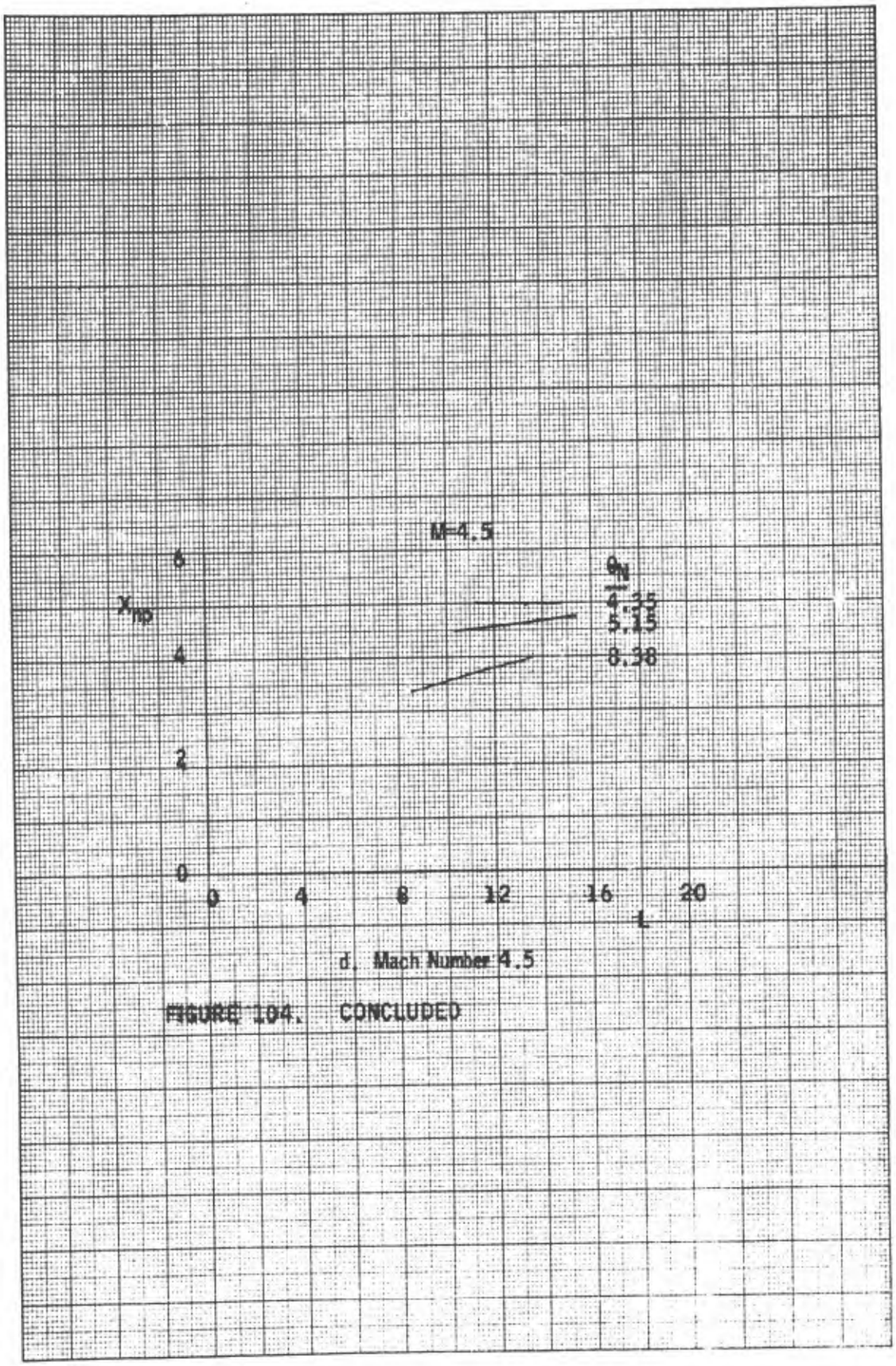
b. Mach Numbers 1.1 to 1.5

FIGURE 104. CONTINUED



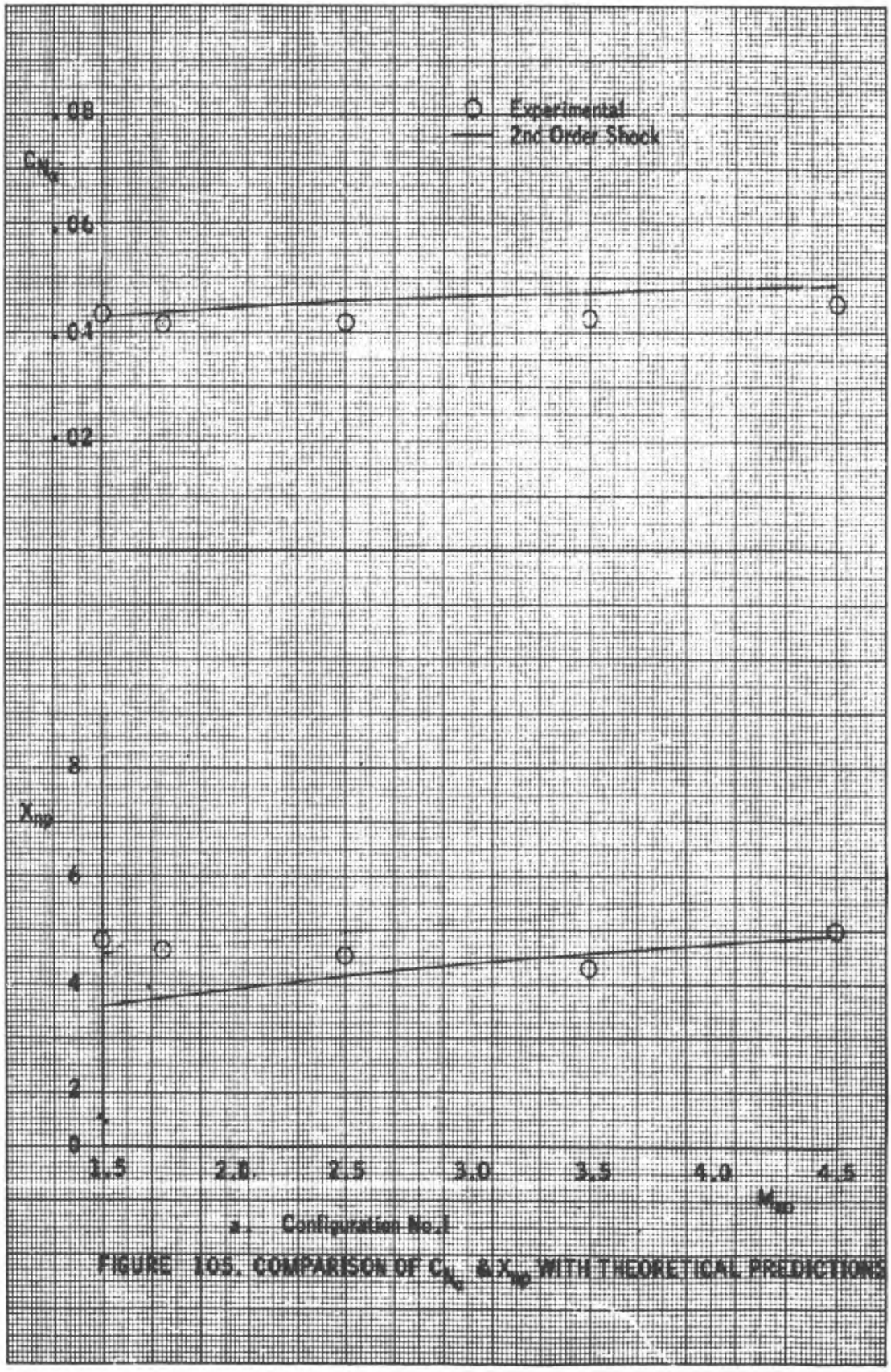
c. Mach Numbers 1.75 to 3.5

FIGURE 104. CONTINUED



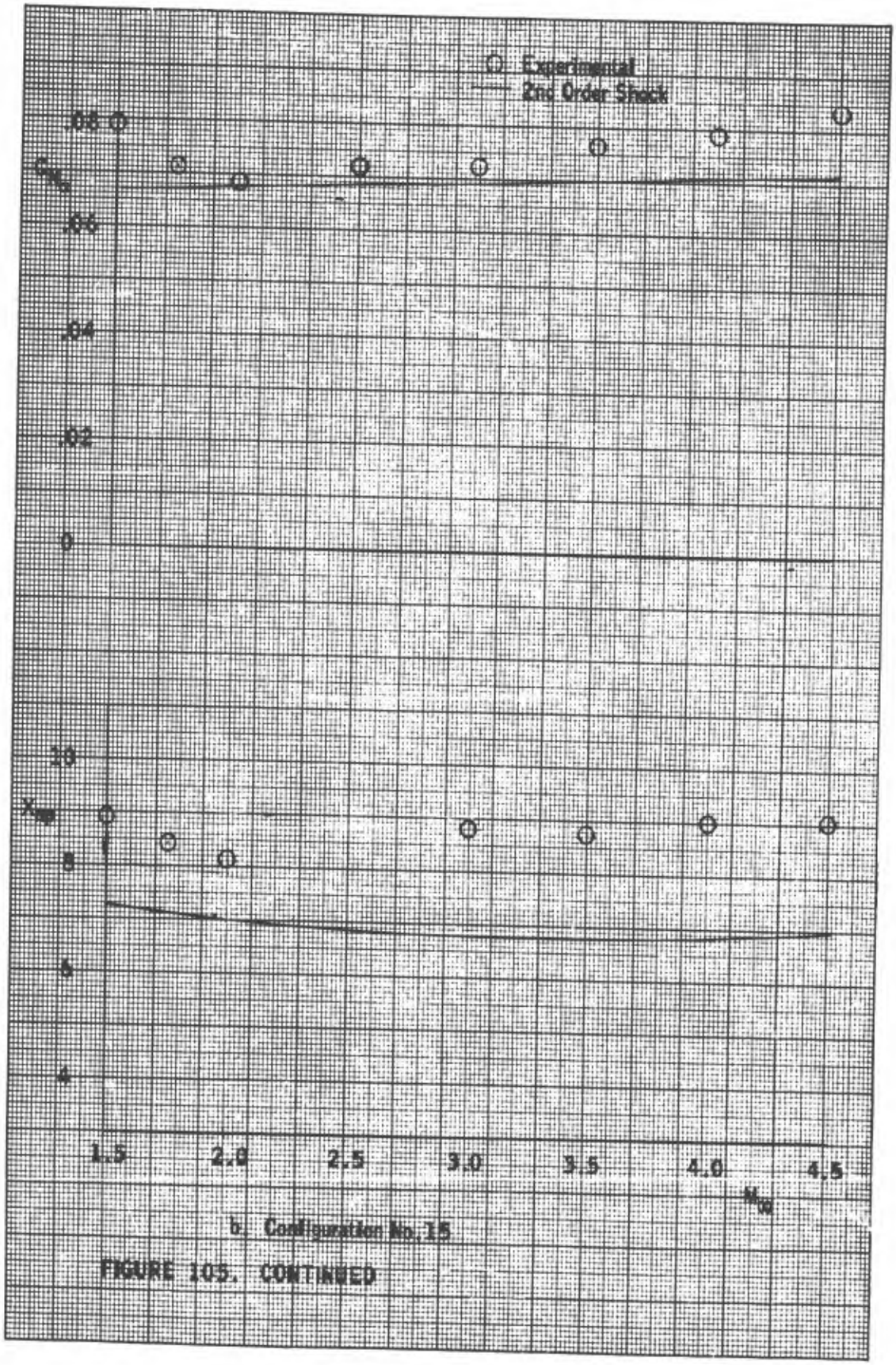
d. Mach Number 4.5

FIGURE 104. CONCLUDED



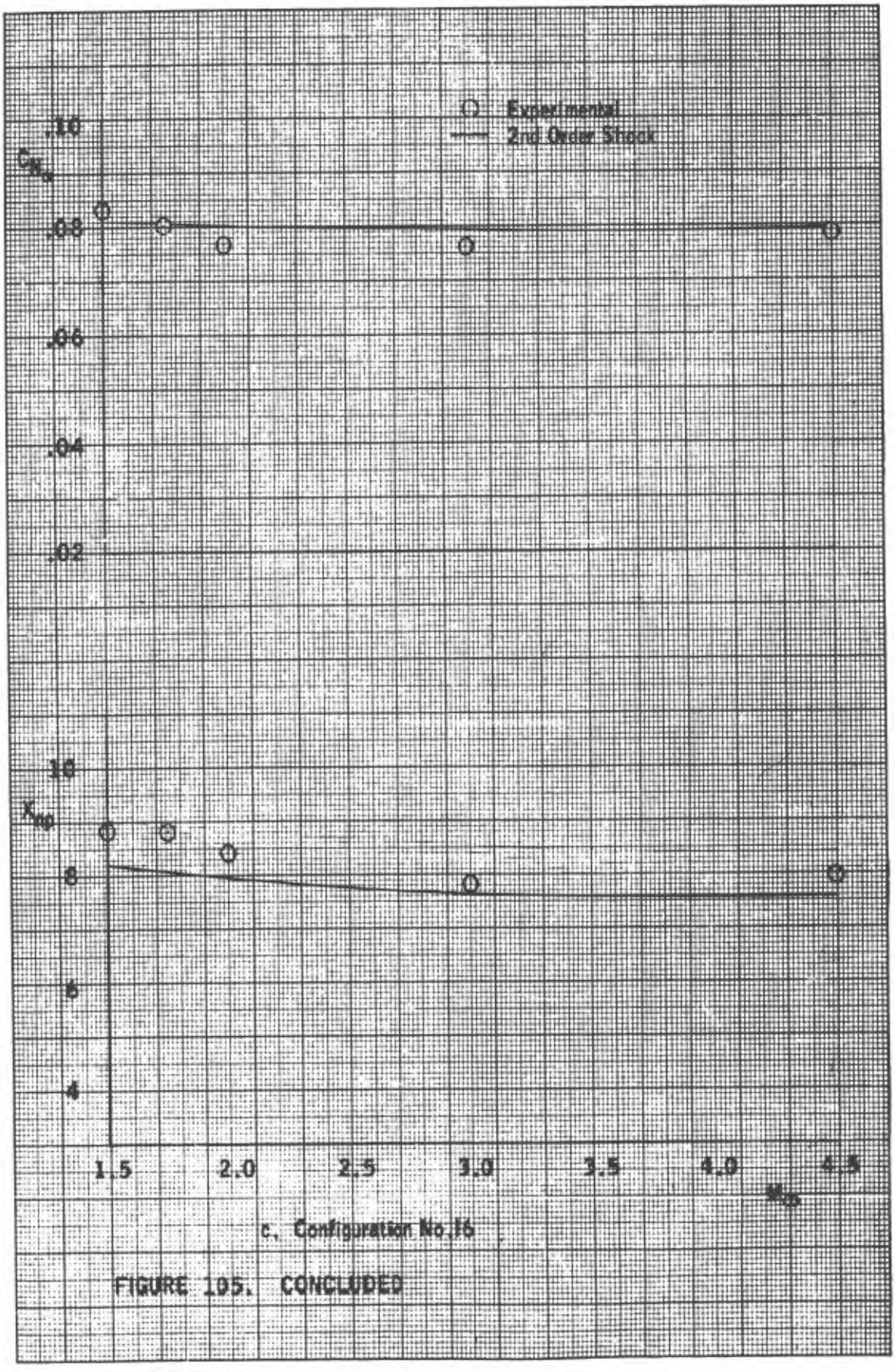
a. Configuration No. 1

FIGURE 105. COMPARISON OF C_{N_α} & X_{cp} WITH THEORETICAL PREDICTIONS



b. Configuration No. 15

FIGURE 105. CONTINUED



c. Configuration No. 16

FIGURE 105. CONCLUDED

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2. "Test Facilities Handbook," (4th Edition), Propulsion Wind Tunnel Facitity, Volume 3, Arnold Engineering Development Center, July 1962.

3. BRL Memo 1292, Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland, July 1960.

3 June 1963 Report No. RF-TR-63-14

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