N70-31806

NASA TECHNICAL MEMORANDUM

NASA TM X-2031

NASA TM X-2031

EFFECTS OF NOSE BLUNTNESS ON AERODYNAMIC CHARACTERISTICS OF CRUCIFORM-FINNED MISSILE CONFIGURATION AT MACH 1.50 TO 2.86

by Lloyd S. Jernell

Langley Research Center
Hampton, Va. 23365

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • JUNE 1970

1. Report No. NASA TM X-2031	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle EFFECTS OF NOSE BLUNTNESS ON AERODYNAMIC CHARACTERISTICS OF CRUCIFORM-FINNED MISSILE CONFIGURATION AT MACH 1.50 TO 2.86		5. Report Date June 1970
		6. Performing Organization Code
7. Author(s) Lloyd S. Jernell		8. Performing Organization Report No. L-7066
		10. Work Unit No. 720-01-11-01
9. Performing Organization Name and Address NASA Langley Research Center Hampton, Va. 23365		11. Contract or Grant No.
		13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

An investigation was conducted to determine the effects of various magnitudes of spherical nose bluntness on model stability. The effectiveness of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration was also investigated. Data were obtained at angles of attack up to about 22° at sideslip angles of approximately 0° and 4° and roll angles of 0° and 45°. The tests were conducted over a Mach number range of 1.50 to 2.86 at a Reynolds number of 2.5×10^6 per foot (8.2×10^6 per meter).

17. Key Words (Suggested by Author(s)) Nose bluntness; Cruciform-finned missile		18. Distribution Statement Unclassified – Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 26	22. Price* $3.00

*For sale by the Clearinghouse for Federal Scientific and Technical Information
Springfield, Virginia 22151

EFFECTS OF NOSE BLUNTNESS ON AERODYNAMIC CHARACTERISTICS OF CRUCIFORM-FINNED MISSILE CONFIGURATION AT MACH 1.50 TO 2.86

By Lloyd S. Jernell
Langley Research Center

SUMMARY

An investigation has been conducted in the Langley Unitary Plan wind tunnel to determine the effects of spherical nose bluntness on the aerodynamic characteristics of a typical cruciform-finned short-range missile configuration for roll angles of 0° and 45° and Mach numbers from 1.50 to 2.86. Also investigated was the effectiveness of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration.

The results indicated that the effects of nose bluntness and nose spike on the longitudinal stability were small. For roll angles of both 0° and 45°, the greatest effects of nose bluntness on the aerodynamic-center location near zero angle of attack occurred at a Mach number of 2.86, where for each roll position, a rearward shift of approximately 3.5 percent of the body length occurred as bluntness was increased. Although large magnitudes of nose bluntness were accompanied by high axial-force coefficients, significant reductions in the axial-force coefficient of a blunt-nose configuration were achieved with the use of the nose spike.

There were no noteworthy effects of nose bluntness on either the directional stability or side-force parameters. However, for high angles of attack at a Mach number of 1.50 increased nose bluntness generally resulted in decreased effective dihedral.

INTRODUCTION

The use of electronic guidance systems in the forebodies of missiles and aircraft usually requires the incorporation of a considerable amount of nose bluntness in order to minimize electronic signal distortion. Increasing the bluntness, of course, results in increased drag and may also affect the lift and stability characteristics. The purpose of the present investigation is to determine the effects of nose bluntness on the aerodynamic characteristics of a typical cruciform-finned short-range missile configuration at Mach numbers from 1.50 to 2.86. Spherical bluntness was progressively applied to an ogive nose until a hemispherical forebody was attained. Also investigated was the effectiveness of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration.

Reference 1 presents the results of tests in which nose shapes (identical to three of the nose shapes studied herein) were investigated as forebodies of two cruciform-finned missile configurations at a Mach number of 2.01. The results of other investigations concerned with the effects of nose bluntness and/or nose spikes are reported in references 2 to 7.

SYMBOLS

The data are referred to the body-axis system. The moment center is located as shown in figure 1.

A	model cross-sectional area
C_A	axial-force coefficient, $\frac{\text{Axial force}}{qA}$
$C_{A,o}$	axial-force coefficient at $\alpha = 0^{\circ}$
C_m	pitching-moment coefficient, $\frac{\text{Pitching moment}}{qAd}$
C_{m_α}	slope of pitching-moment curve at $\alpha \approx 0^{\circ}$, $\frac{\partial C_m}{\partial \alpha}$, per degree
C_N	normal-force coefficient, $\frac{\text{Normal force}}{qA}$
C_{N_α}	slope of normal-force curve at $\alpha \approx 0^{\circ}$, $\frac{\partial C_N}{\partial \alpha}$, per degree
C_n	yawing-moment coefficient, $\frac{\text{Yawing moment}}{qAd}$
C_l	rolling-moment coefficient, $\frac{\text{Rolling moment}}{qAd}$
C_{l_β}	effective-dihedral parameter, $\frac{\Delta C_l}{\Delta \beta}$, per degree
C_{n_β}	directional stability parameter, $\frac{\Delta C_n}{\Delta \beta}$, per degree
C_Y	side-force coefficient, $\frac{\text{Side force}}{qA}$
C_{Y_β}	side-force parameter, $\frac{\Delta C_Y}{\Delta \beta}$, per degree
d	body diameter

l	length of model with ogive nose
M	Mach number
q	dynamic pressure
r_b	body radius
r_n	radius of spherical segment of nose
x_{ac}	location of aerodynamic center from apex of ogive nose
α	angle of attack of model center line, degrees
β	angle of sideslip of model center line, degrees
ϕ	angle of roll (zero with fins in horizontal and vertical planes, positive for right roll), degrees

APPARATUS

Model

Details of the model are shown in figure 1. The basic configuration consisted of an ogive forebody, a cylindrical afterbody, and cruciform delta-planform fins. The ogive nose was modified by applying spherical bluntness in various magnitudes until a hemispherical nose was attained. An additional configuration consisted of the addition of a forward-protruding nose spike to one of the blunt-nose configurations.

Tunnel

The investigation was conducted in the low Mach number test section of the Langley Unitary Plan wind tunnel, which is a variable-pressure, continuous-flow facility. The test section is 4 feet (1.22 meters) square and approximately 7 feet (2.13 meters) in length. The nozzle leading to the test section is of the asymmetric sliding-block type, which permits a continuous variation in Mach number from about 1.47 to 2.86.

MEASUREMENTS, CORRECTIONS, AND TEST CONDITIONS

Aerodynamic forces and moments were measured by means of a sting-supported, six-component, strain-gage balance mounted within the model. The tests were conducted at Mach numbers of 1.50, 1.90, 2.36, and 2.86 and at a Reynolds number of 2.5×10^6 per foot (8.2×10^6 per meter). The angle-of-attack range was from about -4^o to 22^o at angles of sideslip of approximately 0^o and 4^o and angles of roll of 0^o and 45^o.

The angles of attack and sideslip have been corrected for tunnel flow angularity and for the deflection of the model support system due to load. The axial-force coefficient has been adjusted to a condition of free-stream static pressure at the base of the model. The stagnation dewpoint was maintained below -30^o F (239^o K) to avoid moisture condensation effects. A transition strip 0.06 inch (0.15 cm) wide and composed of No. 50 carborundum grains embedded in a plastic adhesive was affixed around the nose 1.20 inches (3.05 cm) rearward of the nose apex (measured along the surface). For the blunt-nose configurations, the measurement was made from the stagnation point. Similar transition strips were applied to the fins 0.40 inch (1.02 cm) rearward (streamwise) of the leading edge.

DISCUSSION

The basic longitudinal aerodynamic characteristics of the model with various degrees of nose bluntness are presented for roll angles of 0^o and 45^o in figures 2 and 3, respectively. All pitching-moment data reflect considerable longitudinal stability. This result is expected since the longitudinal position of the moment center corresponds to tha of the juncture of the fin leading edge with the body. (See fig. 1.) Neither the pitching-moment nor normal-force coefficients exhibit any large nonlinear variations with angle of attack. Throughout the angle-of-attack range, the pitching-moment and normal-force coefficients for both roll angles reflect relatively small changes due to increased nose bluntness; this result indicates that the effects of bluntness on the longitudinal stability are small.

Figure 4 presents the longitudinal aerodynamic characteristics of the model with nose configuration $\frac{r_n}{r_b} = 0.70$ and the spike for a roll angle of $\phi = 0^o$. The trends of the normal-force and pitching-moment data are similar to those of the model without the spike (fig. 2(d)). This similarity indicates negligible effects of the spike on the longitudinal stability.

The normal-force and pitching-moment data of figures 2 to 4 are summarized in figure 5 for an angle of attack of approximately zero. The effects of nose bluntness on the parameters presented in this figure are relatively small. For roll angles of both 0^o and 45^o, the greatest effect of nose bluntness on the aerodynamic-center location occurs at $M = 2.86$, where, for each roll position, a rearward shift of approximately 3.5 percent of the total body length occurs as bluntness is increased. The data for the model equipped with the nose spike, represented by the point symbols, indicate minor effects of the spike on C_{m_α}, C_{N_α}, and the aerodynamic-center location.

The effects of the various nose configurations on the axial-force coefficients at $\alpha = 0^{\circ}$ are summarized in figure 6. Spherically blunting the ogive nose initially has little effect on the axial-force coefficient. However, for r_n/r_b greater than approximately 0.2, the $C_{A,o}$ begins to increase rapidly. The effect of bluntness also becomes greater as Mach number is increased. The effect of adding the spike to nose configuration $\frac{r_n}{r_b} = 0.70$ is indicated by the point symbols. It will be noted that with the addition of the spike the increase in the axial-force coefficient due to bluntness (over that of the ogive nose) is reduced approximately 50 percent at $M = 1.50$. The magnitude of this reduction increases to about 80 percent at $M = 2.86$.

The lateral stability derivatives of the model are presented for roll angles of 0° and 45° in figures 7 and 8, respectively. For both roll positions, the data show no noteworthy effects of nose bluntness on either the directional stability parameter C_{n_β} or the side-force parameter C_{Y_β}. For $\phi = 0^{\circ}$ at Mach numbers of 1.50 and 1.90, there is a noticeable decrease in the directional stability as the angle of attack is increased above approximately 10°. At the higher Mach numbers, however, the directional stability is not significantly affected by change in angle of attack. Unlike the data for $\phi = 0^{\circ}$, the directional stability at $\phi = 45^{\circ}$ generally exhibits an increase as the angle of attack is increased, particularly at the lower Mach numbers. Data at both roll angles reflect a decrease in directional stability with increasing Mach number except for $\phi = 0^{\circ}$ at the higher angles of attack where there is little Mach number effect.

In some instances the trends of the effective-dihedral parameter C_{l_β} at $\phi = 0^{\circ}$ differ greatly from those at $\phi = 45^{\circ}$. For angles of attack above approximately 4° the effective-dihedral parameter generally increases with α for $\phi = 0^{\circ}$, whereas the data at $\phi = 45^{\circ}$ generally exhibit a decrease in C_{l_β} as α is increased. For high angles of attack at $M = 1.50$, increased nose bluntness generally resulted in decreased effective dihedral.

CONCLUSIONS

An investigation has been conducted to determine the effects of spherical nose bluntness on the aerodynamic characteristics of a typical cruciform-finned short-range missile configuration for roll angles of 0° and 45° and Mach numbers from 1.50 to 2.86. Also investigated was the effectiveness of a forward-protruding nose spike in reducing the axial-force coefficient of a blunt-nose configuration. The conclusions are summarized as follows:

1. The effects of nose bluntness and nose spike on the longitudinal stability are small.

2. For roll angles of both 0° and 45°, the greatest effects of nose bluntness on the aerodynamic-center location near zero angle of attack occur at a Mach number of 2.86, where for each roll position, a rearward shift of approximately 3.5 percent of the body length occurs as bluntness is increased.

3. Although large magnitudes of nose bluntness are accompanied by high axial-force coefficients, significant reductions in the axial-force coefficient of a blunt-nose configuration were achieved with the use of the nose spike.

4. There are no noteworthy effects of nose bluntness on either the directional stability or side-force parameters. However, for high angles of attack at a Mach number of 1.50 increased nose bluntness generally resulted in decreased effective dihedral.

Langley Research Center,
National Aeronautics and Space Administration,
Hampton, Va., April 24, 1970.

REFERENCES

1. Spearman, M. Leroy; and Robinson, Ross B.: Longitudinal Stability and Control Characteristics of a Winged and Flared Hypersonic Missile Configuration With Various Nose Shapes and Flare Modifications at a Mach Number of 2.01. NASA TM X-693, 1962.

2. Gapcynski, John P.; and Robins, A. Warner: The Effect of Nose Radius and Shape on the Aerodynamic Characteristics of a Fuselage and a Wing-Fuselage Combination at Angles of Attack. NACA RM L53I23a, 1953.

3. Robins, A. Warner: Preliminary Investigation of the Effects of Several Seeker-Nose Configurations on the Longitudinal Characteristics of a Canard-Type Missile at a Mach Number of 1.60. NACA RM L53I18, 1953.

4. Jones, Jim J.: Flow Separation From Rods Ahead of Blunt Noses at Mach Number 2.72. NACA RM L52E05a, 1952.

5. Jones, Jim J.: Experimental Drag Coefficients of Round Noses With Conical Windshields at Mach Number 2.72. NACA RM L55E10, 1955.

6. Beastall, D.; and Turner, J.: The Effect of a Spike Protruding in Front of a Bluff Body at Supersonic Speeds. R. & M. No. 3007, British A.R.C., 1957.

7. Crawford, Davis H.: Investigation of the Flow Over a Spiked-Nose Hemisphere-Cylinder at a Mach Number of 6.8. NASA TN D-118, 1959.

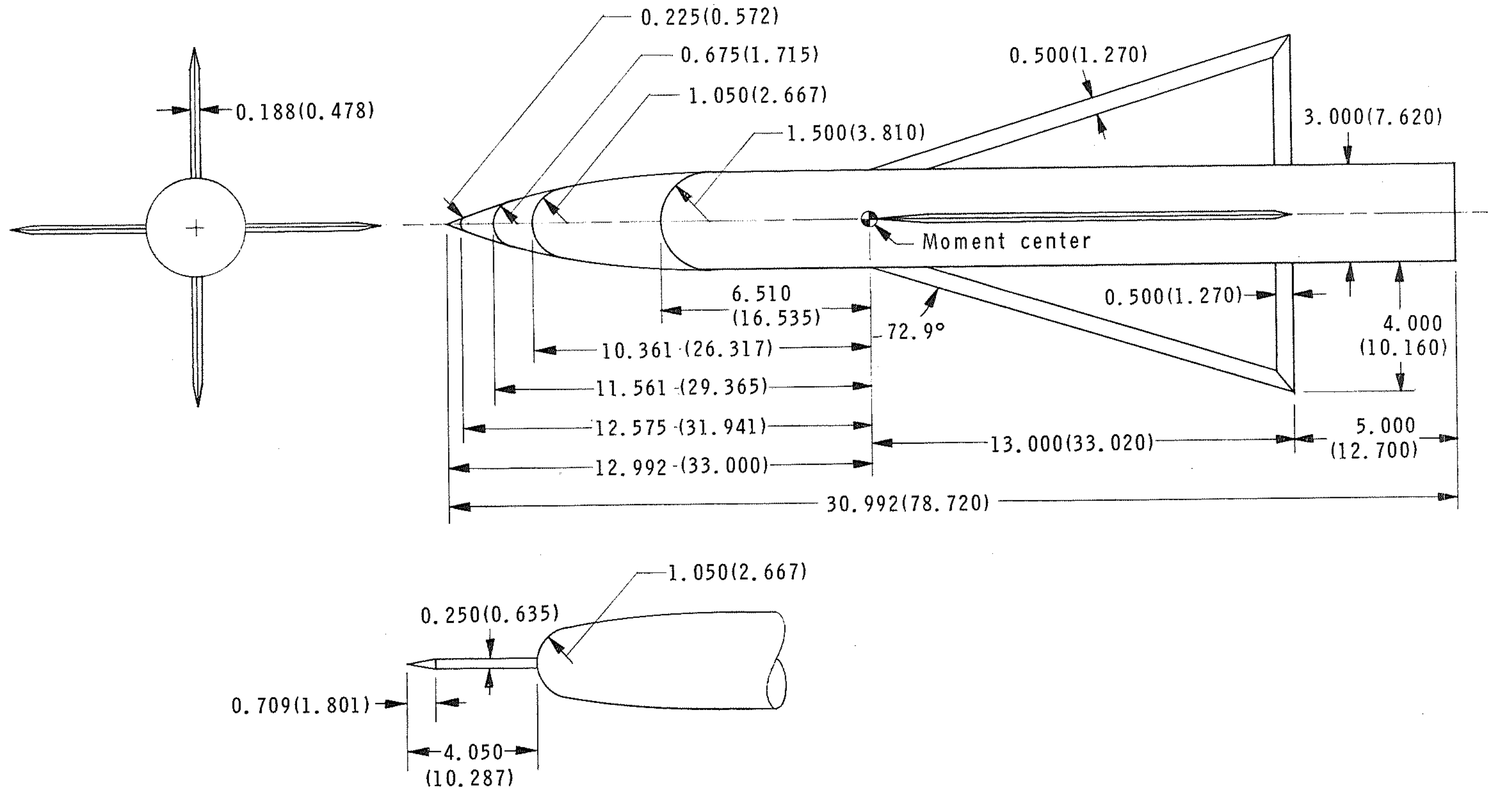
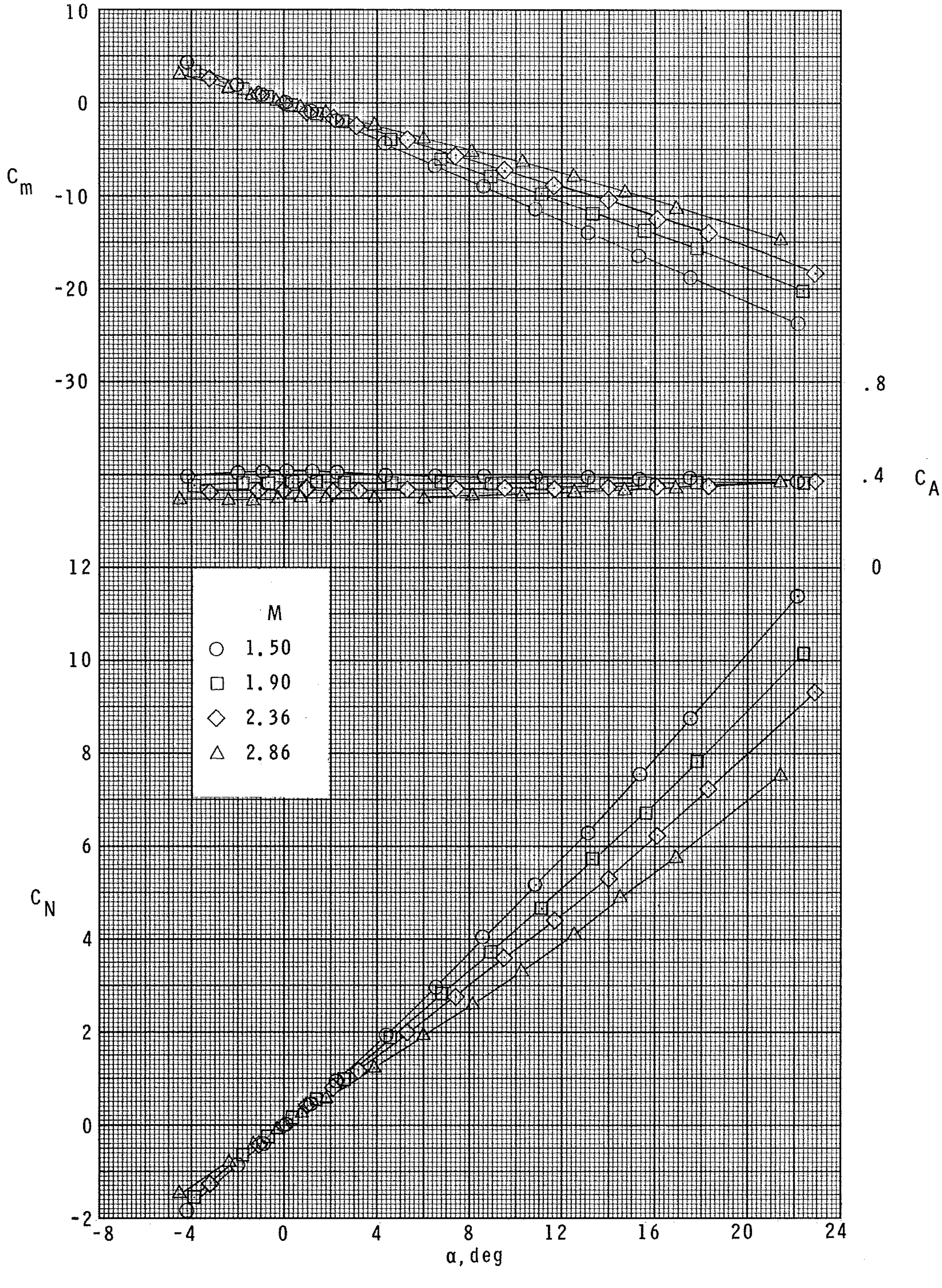
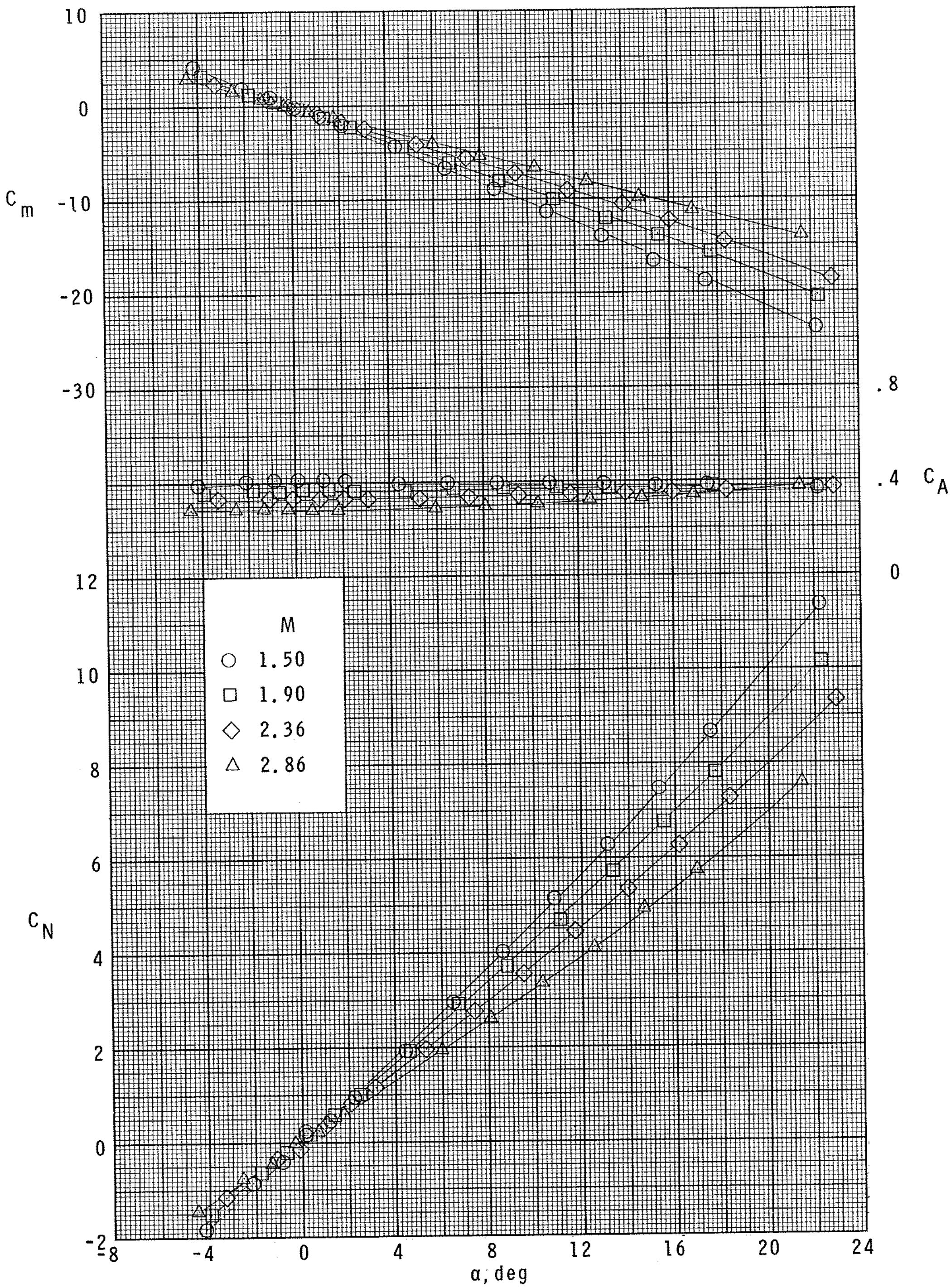


Figure 1.- Model drawing. (Linear dimensions are given in inches and parenthetically in centimeters.)



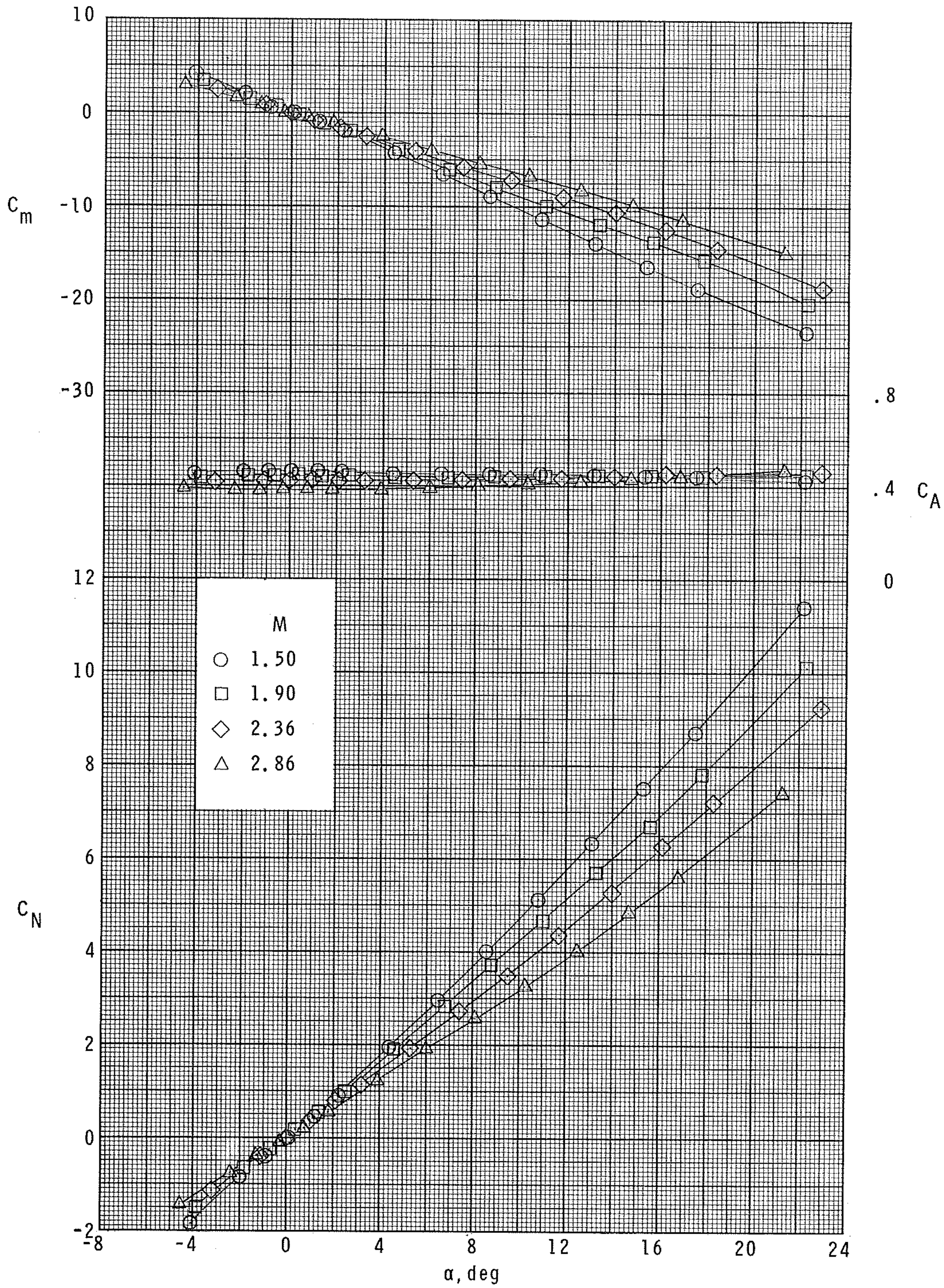
(a) $\frac{r_n}{r_b} = 0.00.$

Figure 2.- Longitudinal aerodynamic characteristics of model with various degrees of nose bluntness; $\Phi = 0^0$.



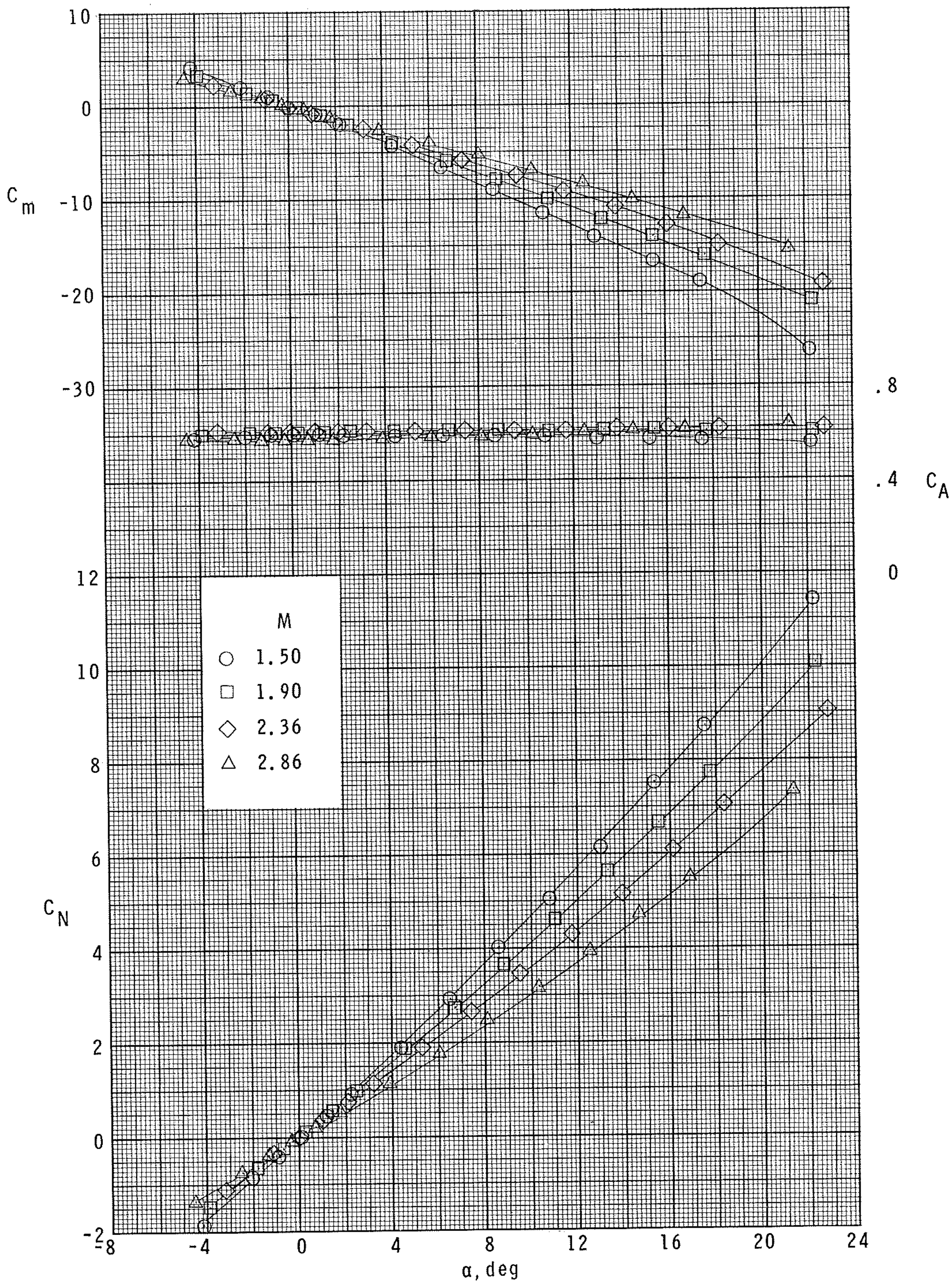
(b) $\frac{r_n}{r_b} = 0.15.$

Figure 2.- Continued.



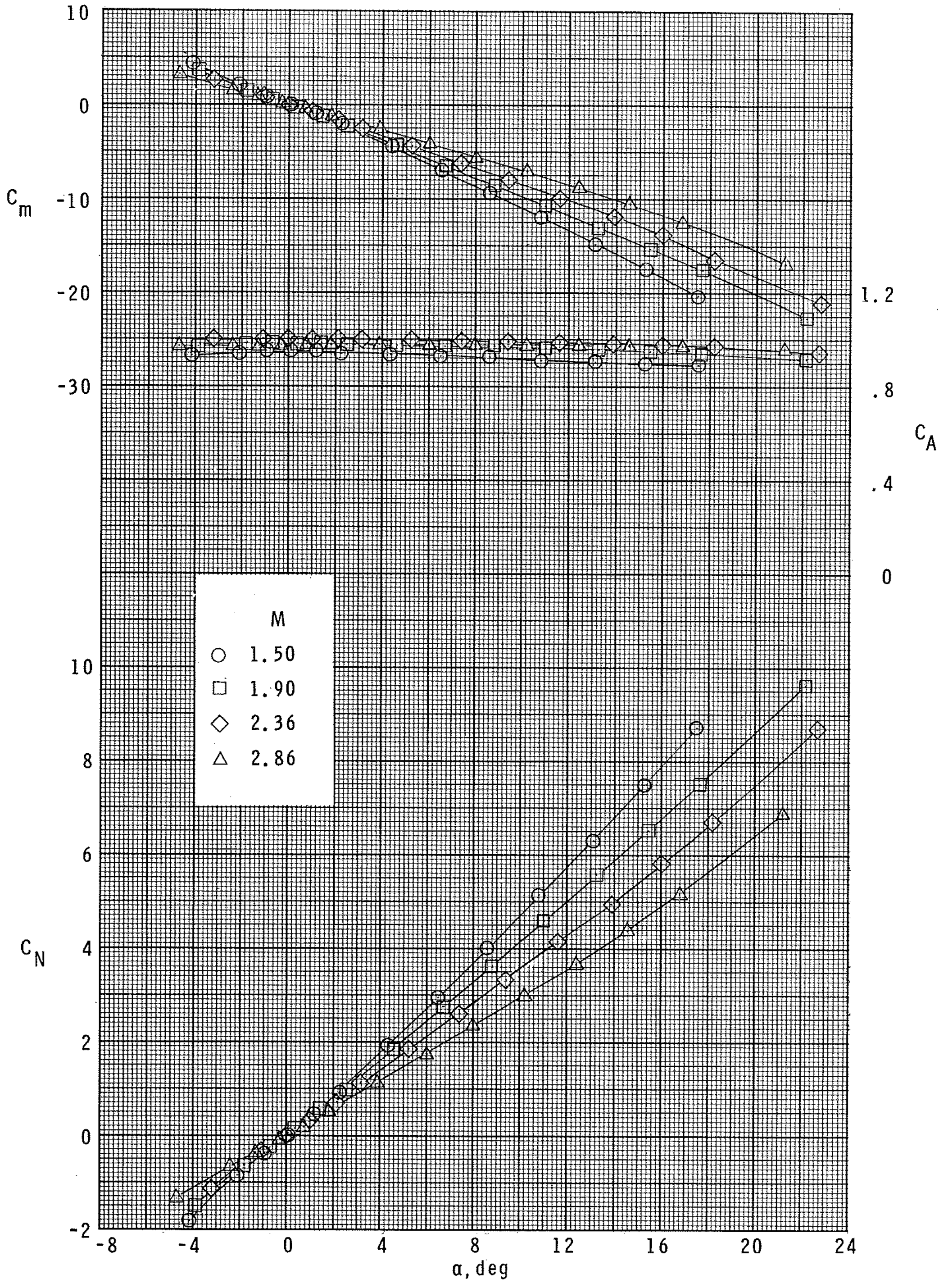
(c) $\frac{r_n}{r_b} = 0.45.$

Figure 2.- Continued.



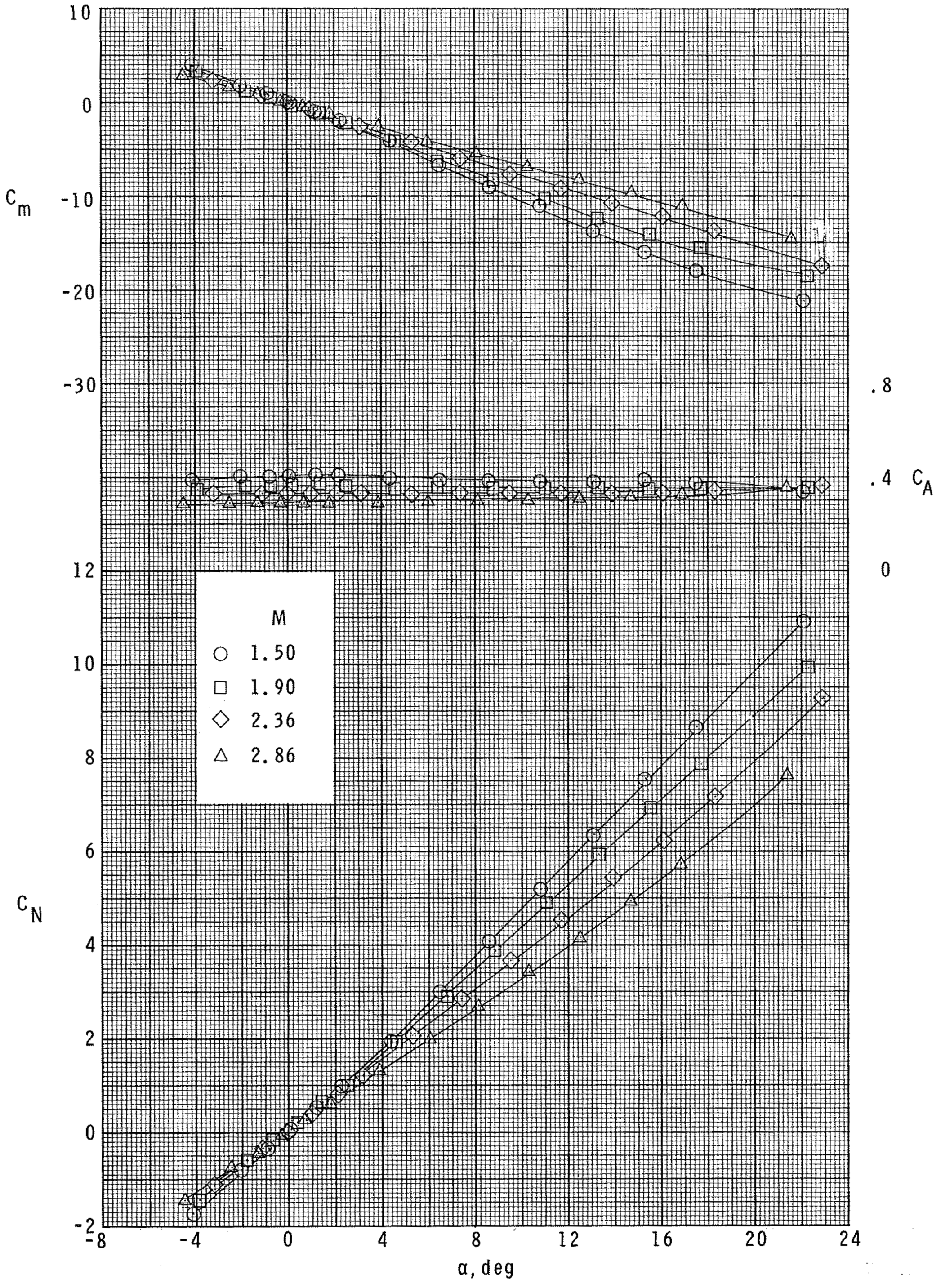
(d) $\frac{r_n}{r_b} = 0.70.$

Figure 2.- Continued.



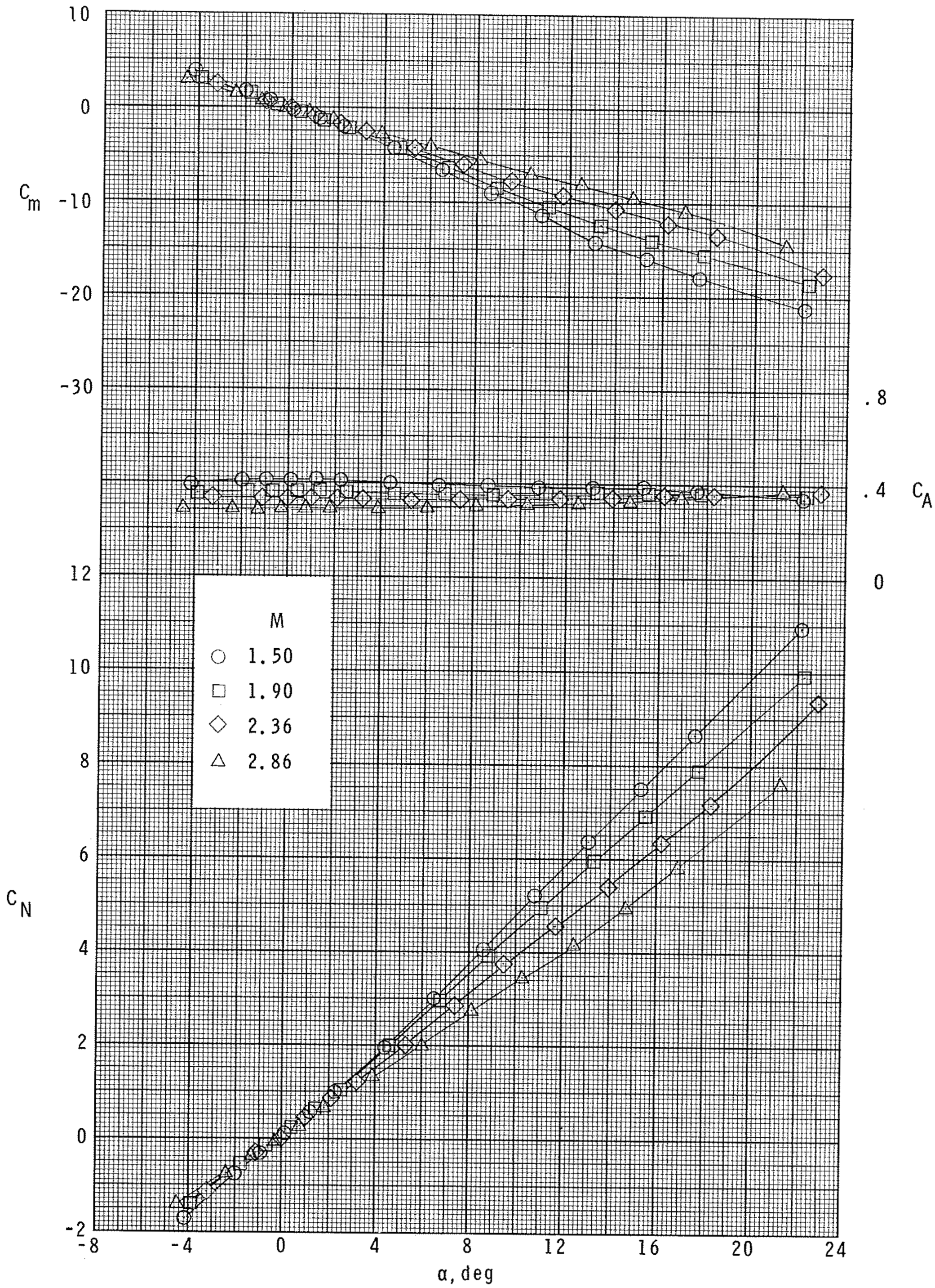
(e) $\frac{r_n}{r_b} = 1.00.$

Figure 2.- Concluded.



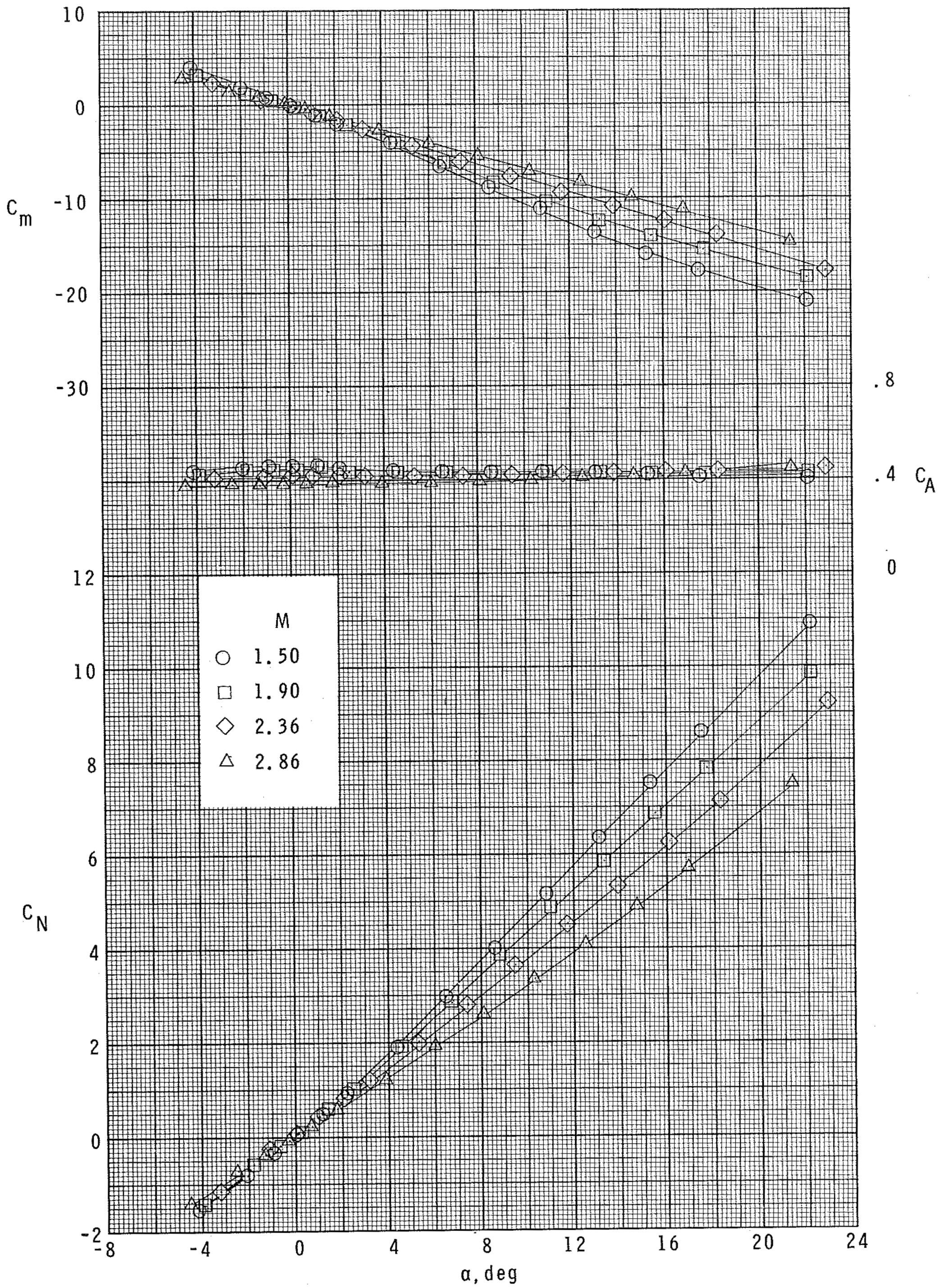
(a) $\frac{r_n}{r_b} = 0.00.$

Figure 3.- Longitudinal aerodynamic characteristics of model with various degrees of nose bluntness; $\Phi = 45^0$.



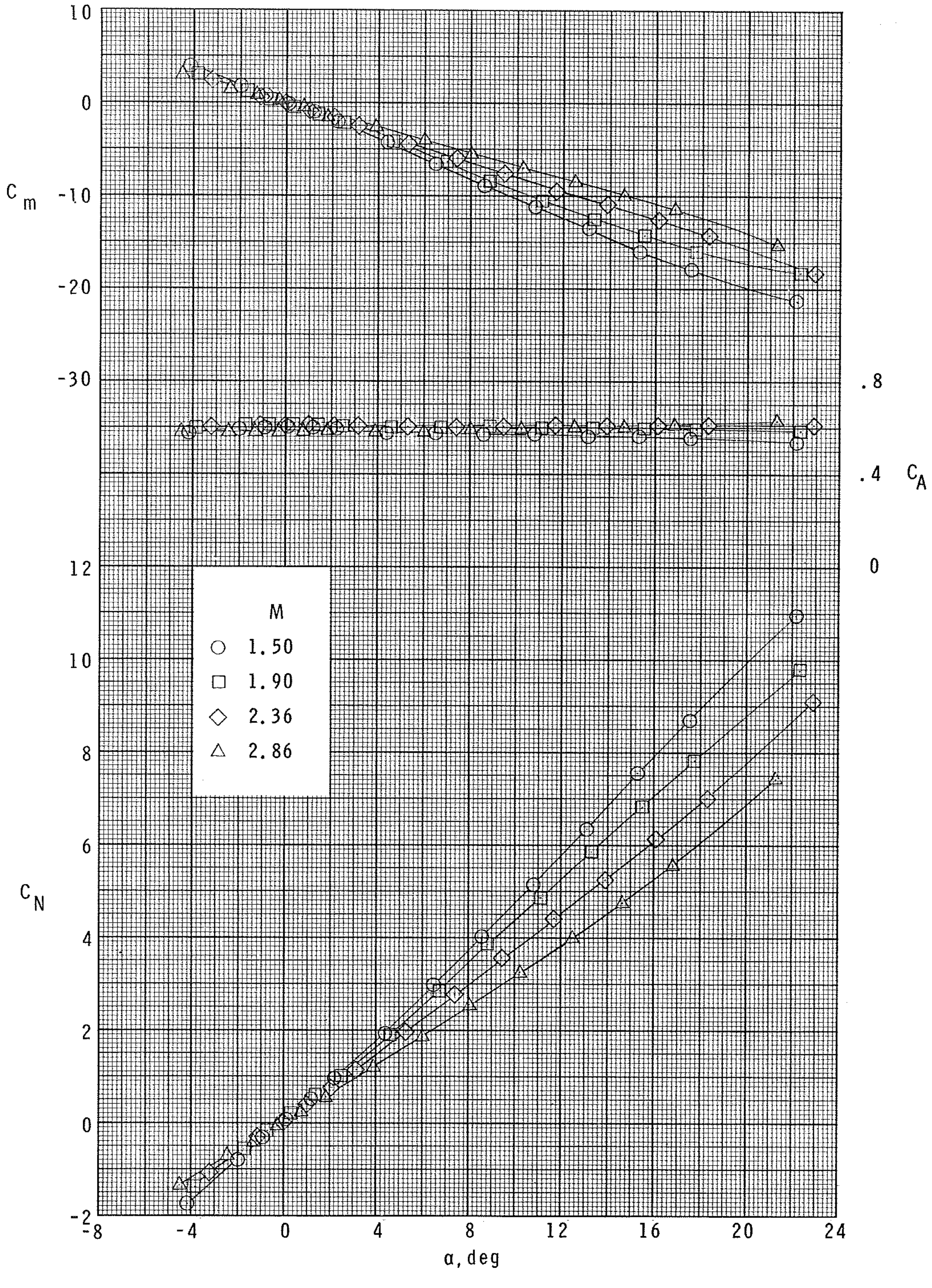
(b) $\frac{r_n}{r_b} = 0.15.$

Figure 3.- Continued.



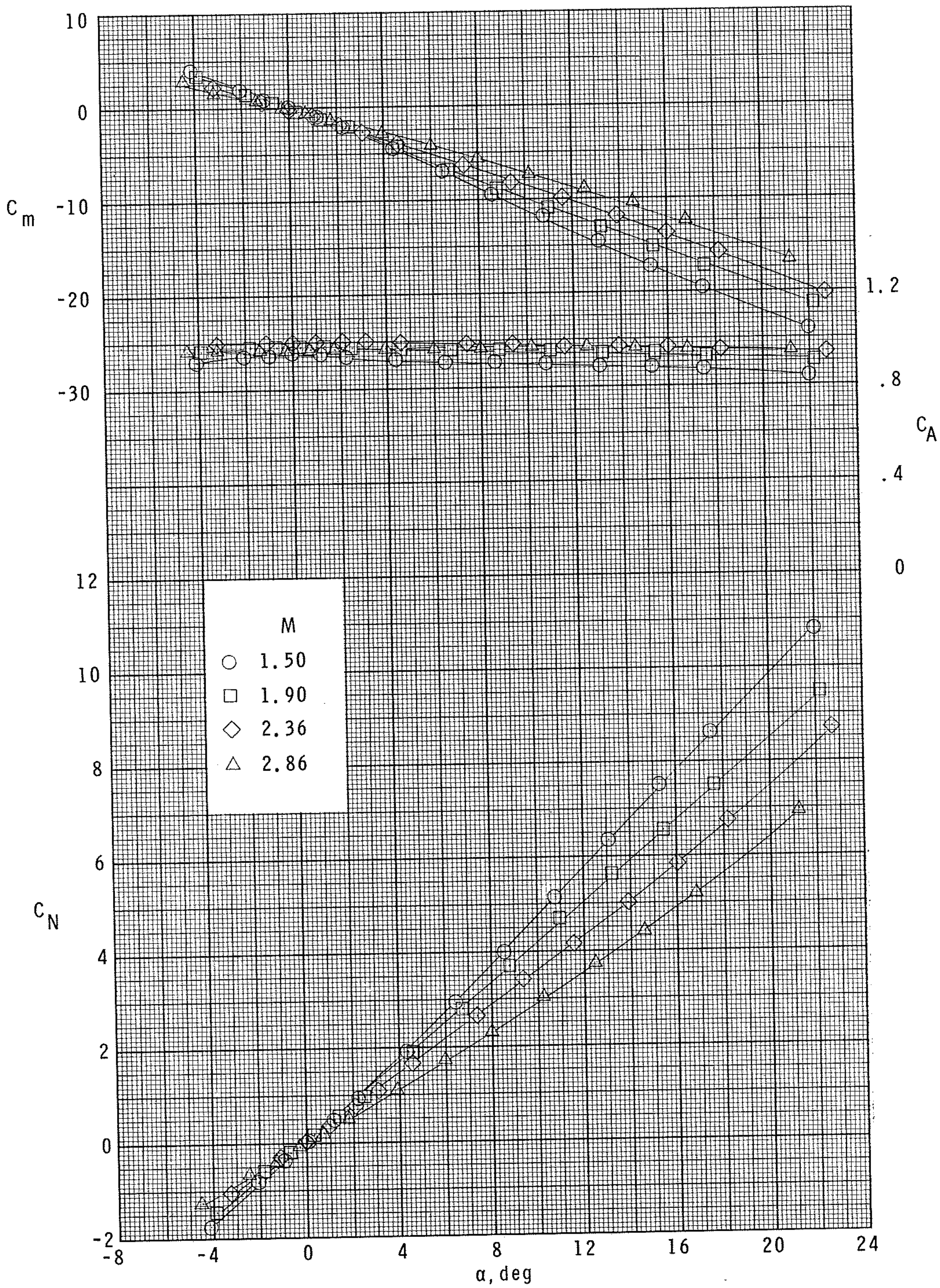
(c) $\frac{r_n}{r_b} = 0.45.$

Figure 3.- Continued.



(d) $\frac{r_n}{r_b} = 0.70.$

Figure 3.- Continued.



(e) $\frac{r_n}{r_b} = 1.00.$

Figure 3.- Concluded.

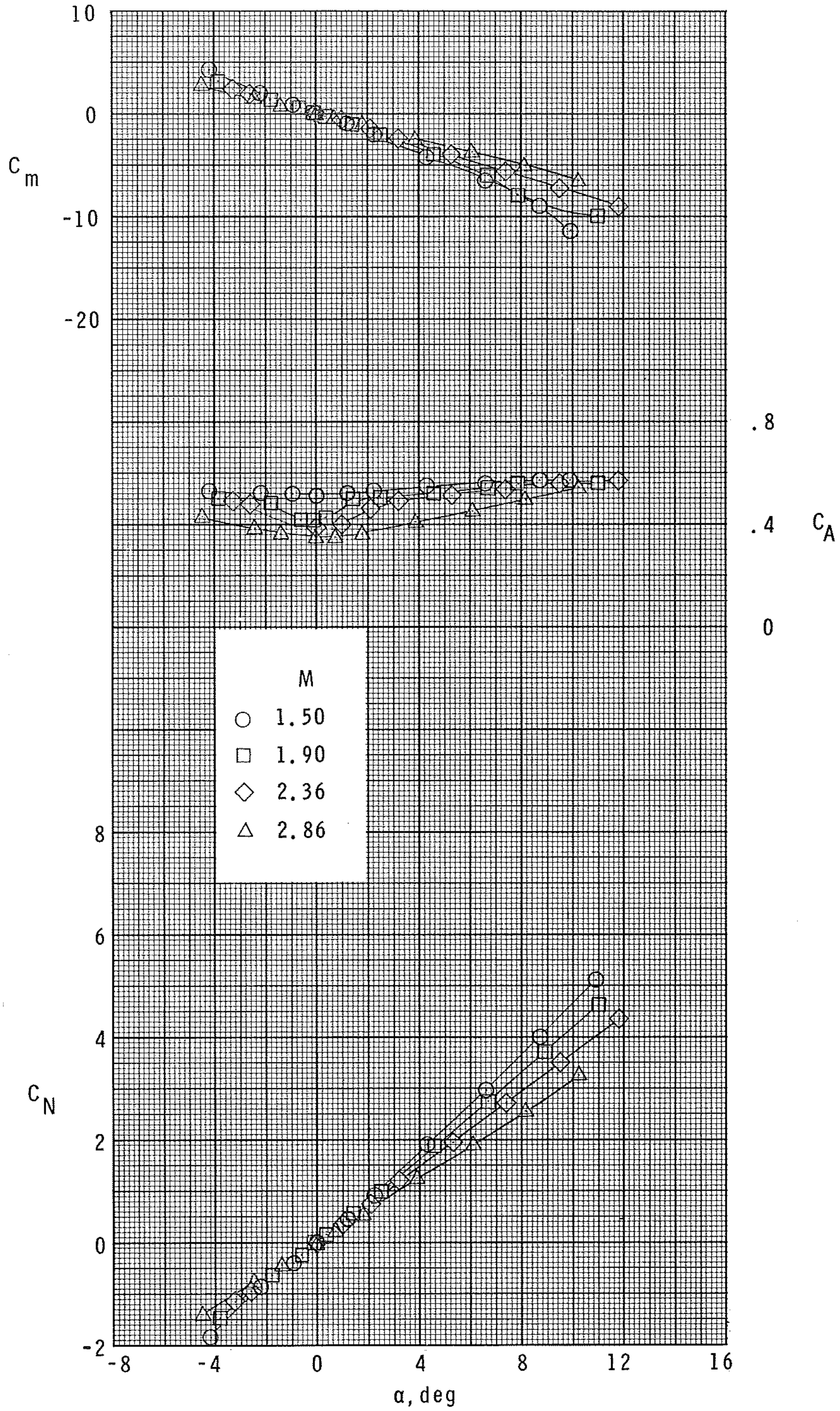


Figure 4.- Longitudinal aerodynamic characteristics of model with nose configuration $\frac{r_n}{r_b} = 0.70$ and spike; $\Phi = 0^o$.

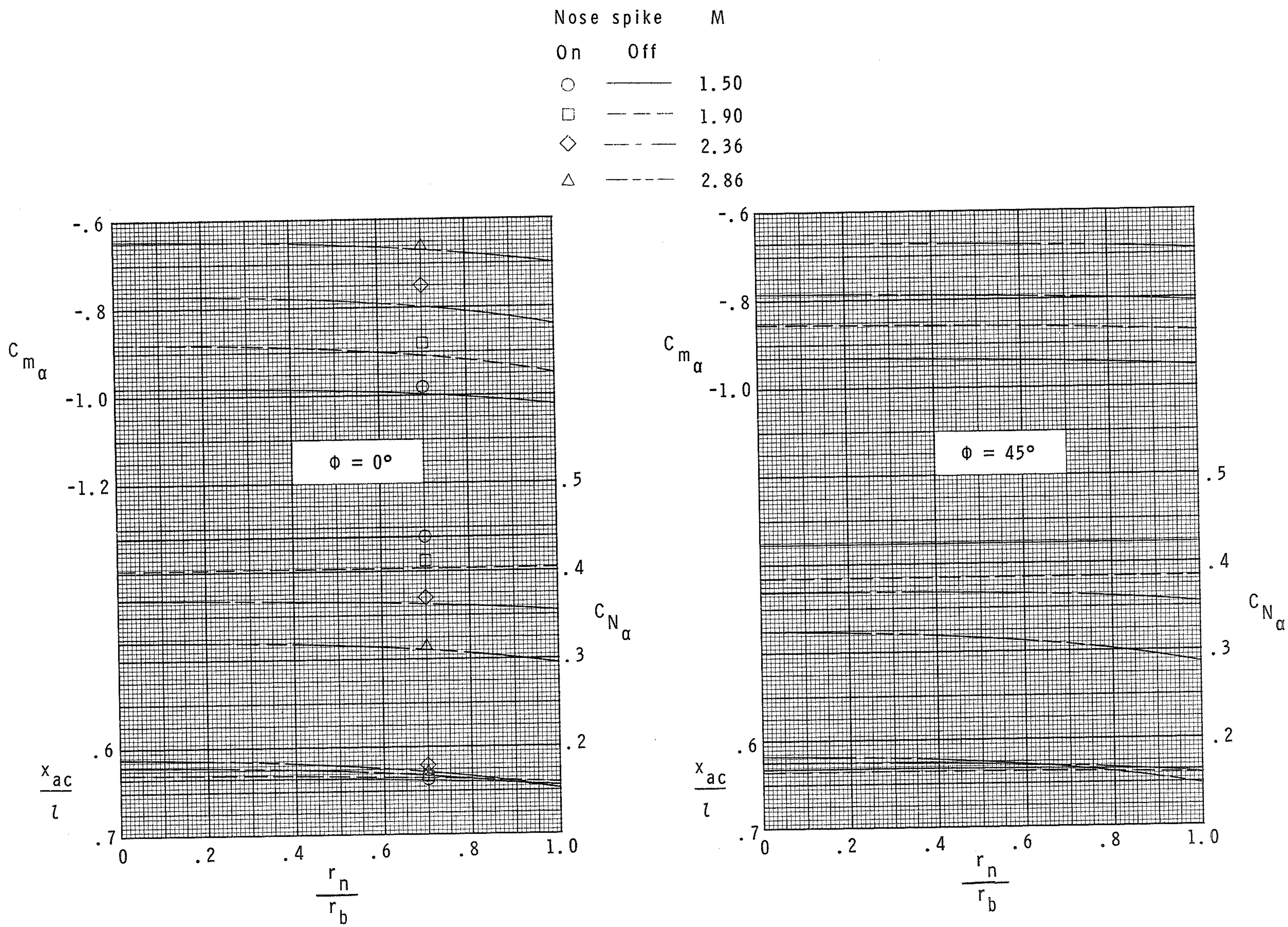


Figure 5.- Summary of the longitudinal aerodynamic characteristics. $\alpha = 0^0$.

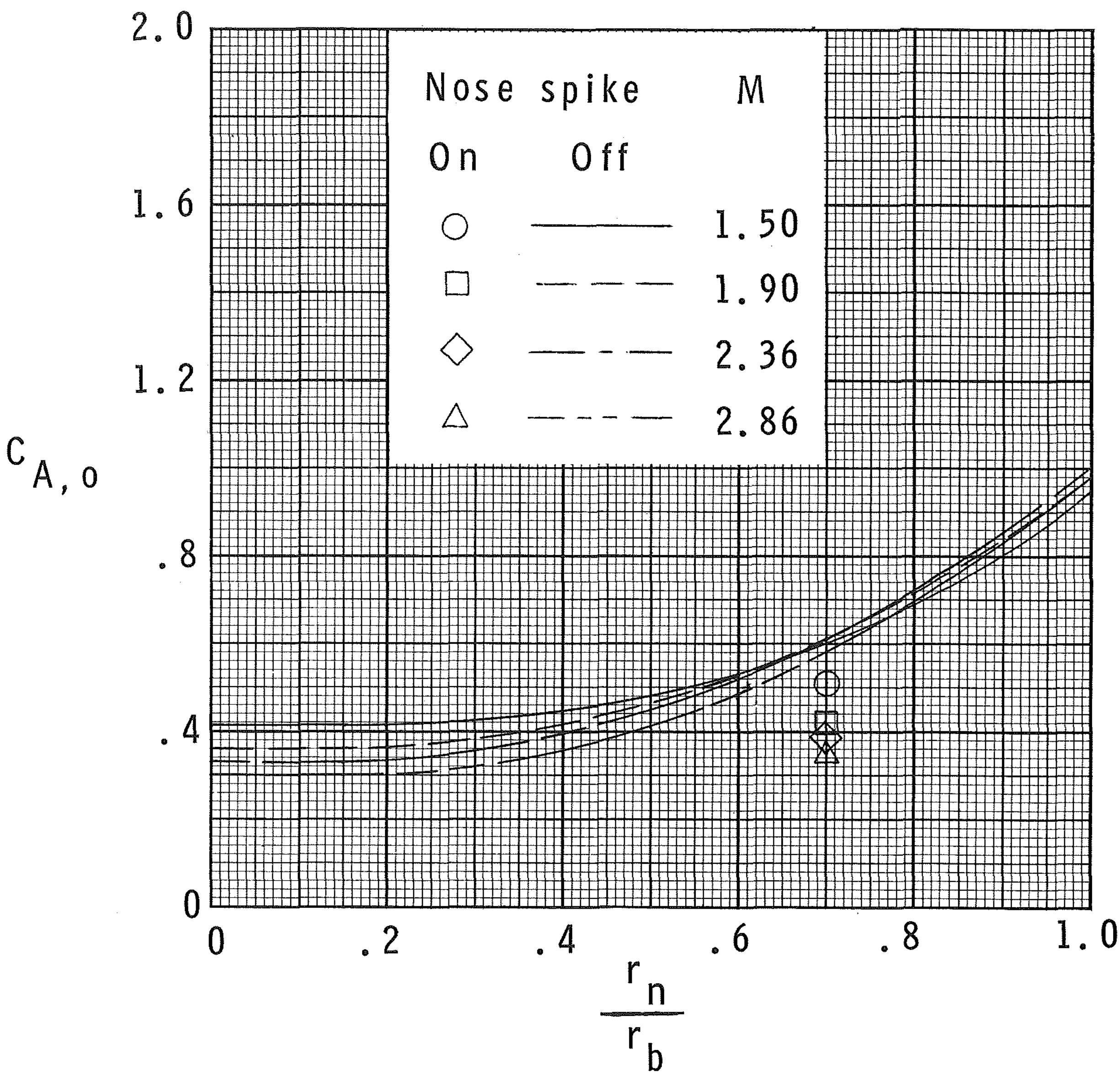
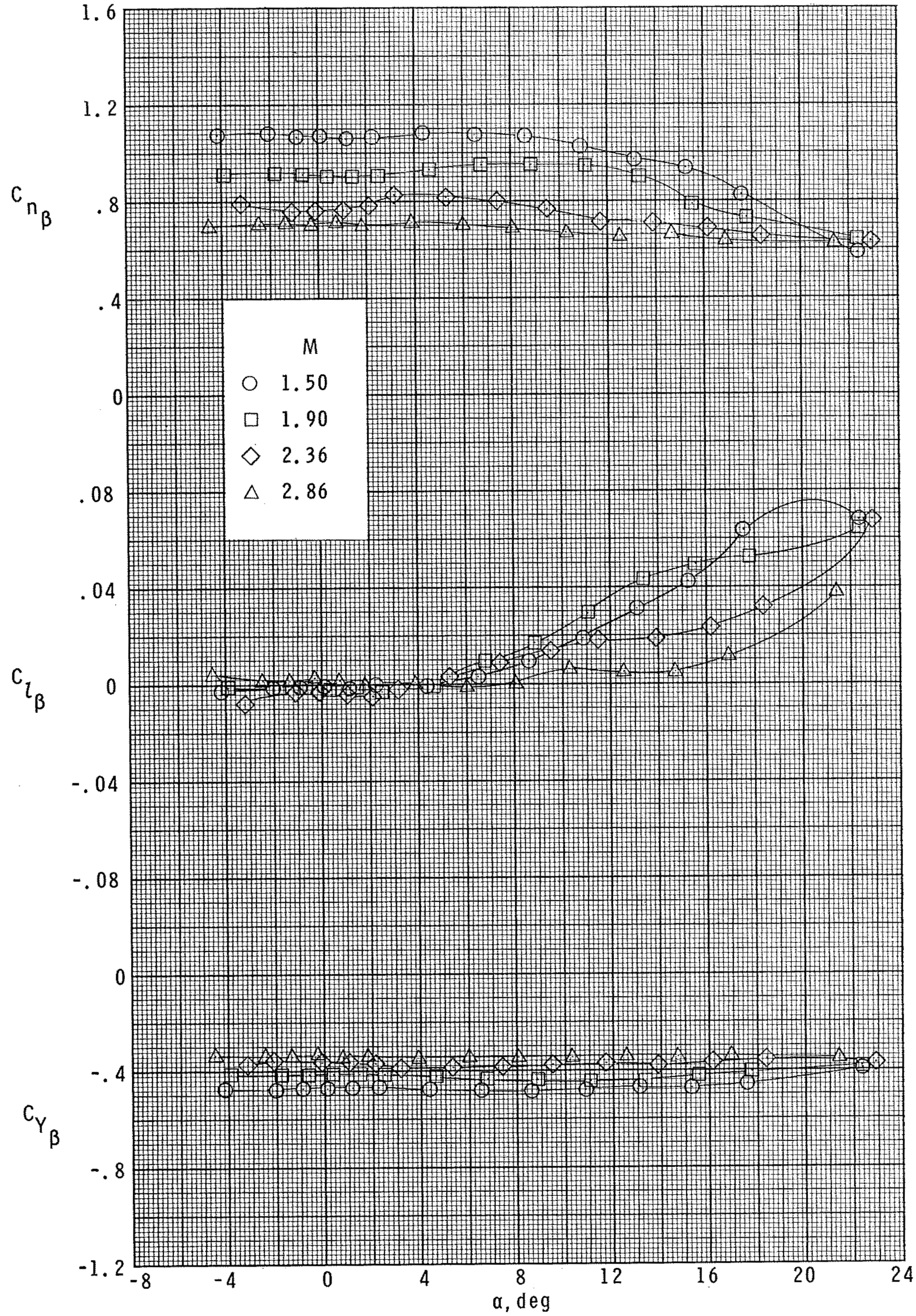
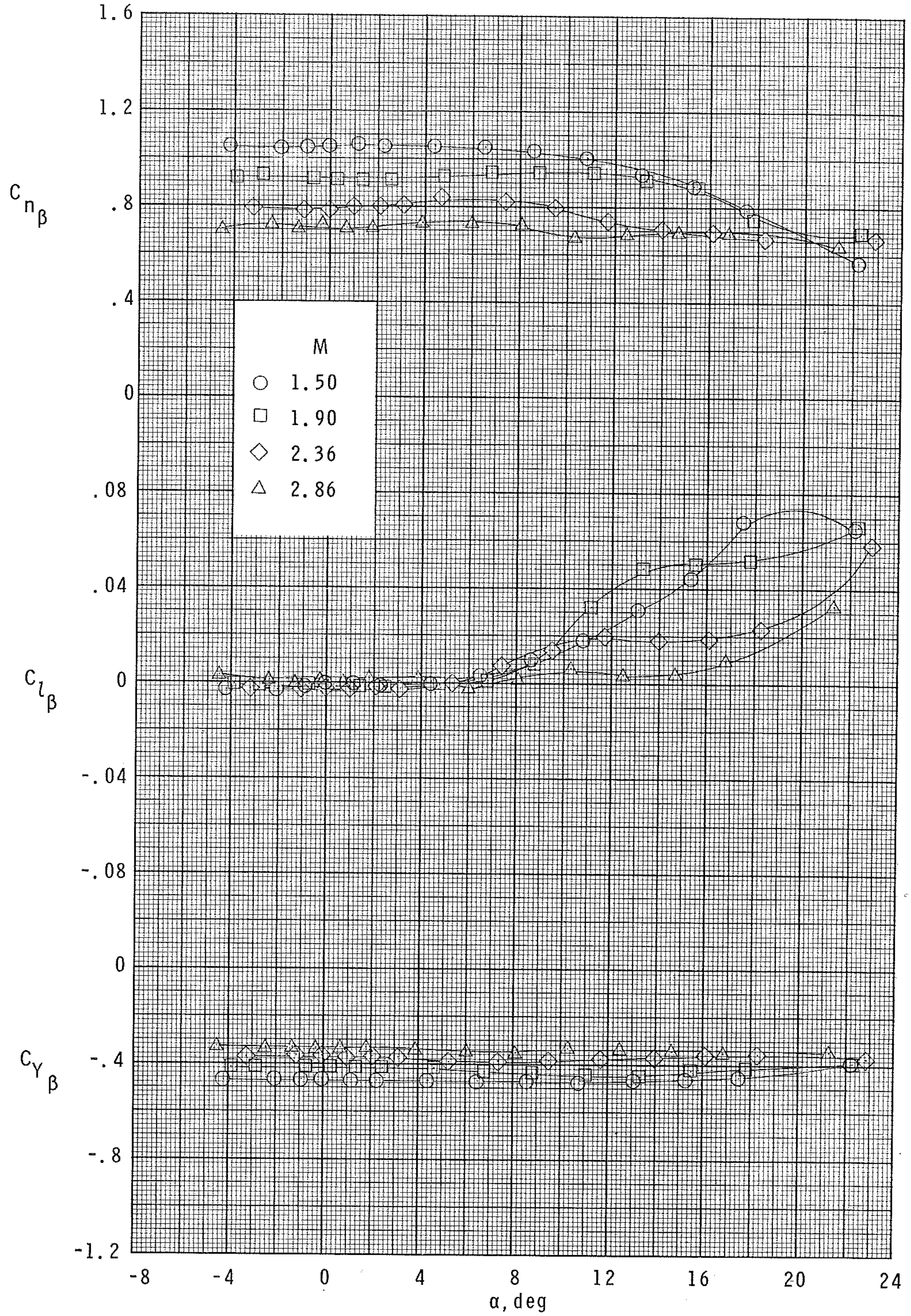


Figure 6.- Effects of nose radius and spike on axial-force coefficient at $\alpha = 0^0$.



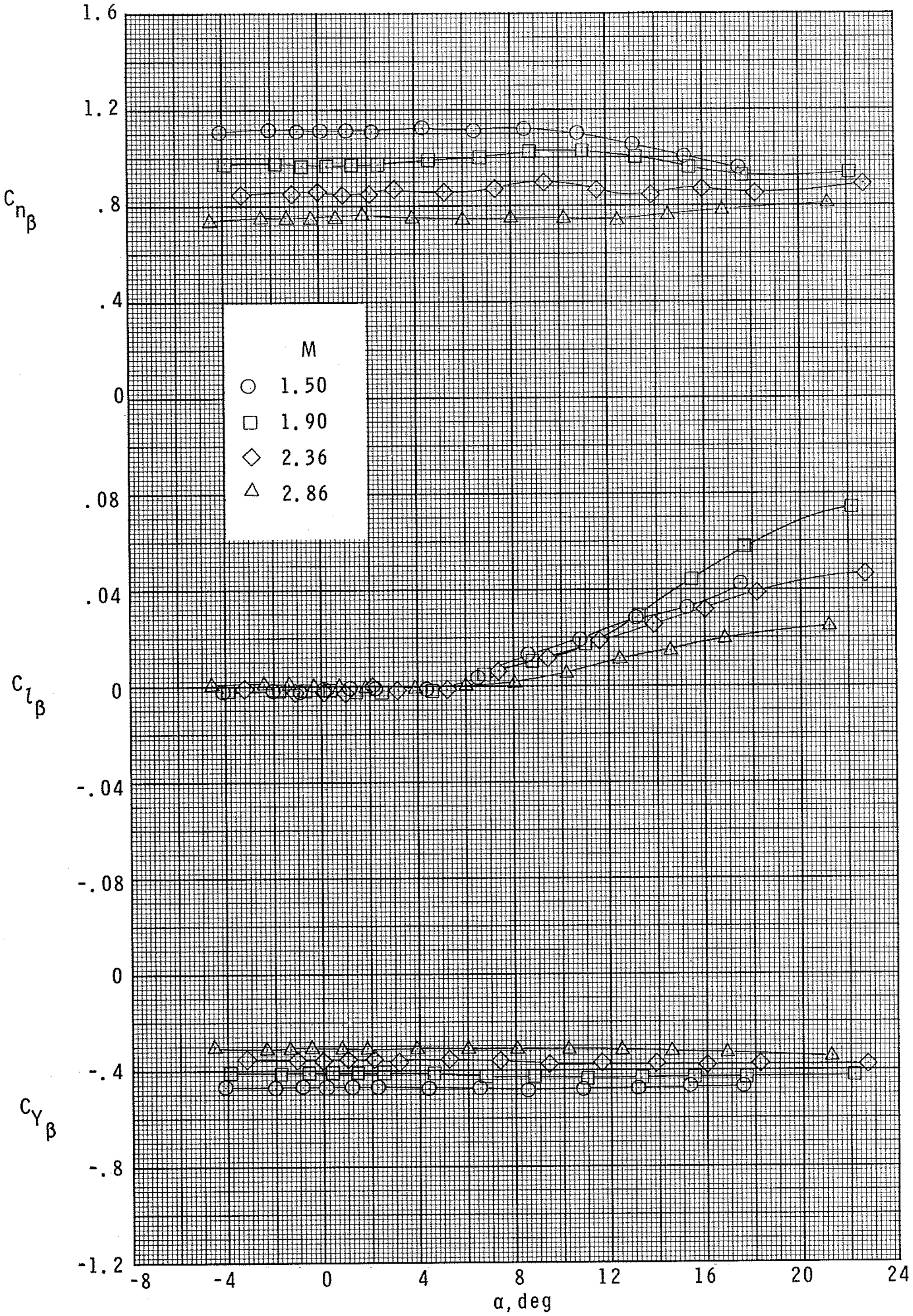
(a) $\frac{r_n}{r_b} = 0.00.$

Figure 7.- Lateral stability derivatives of model with various degrees of nose bluntness; $\Phi = 0^0$.



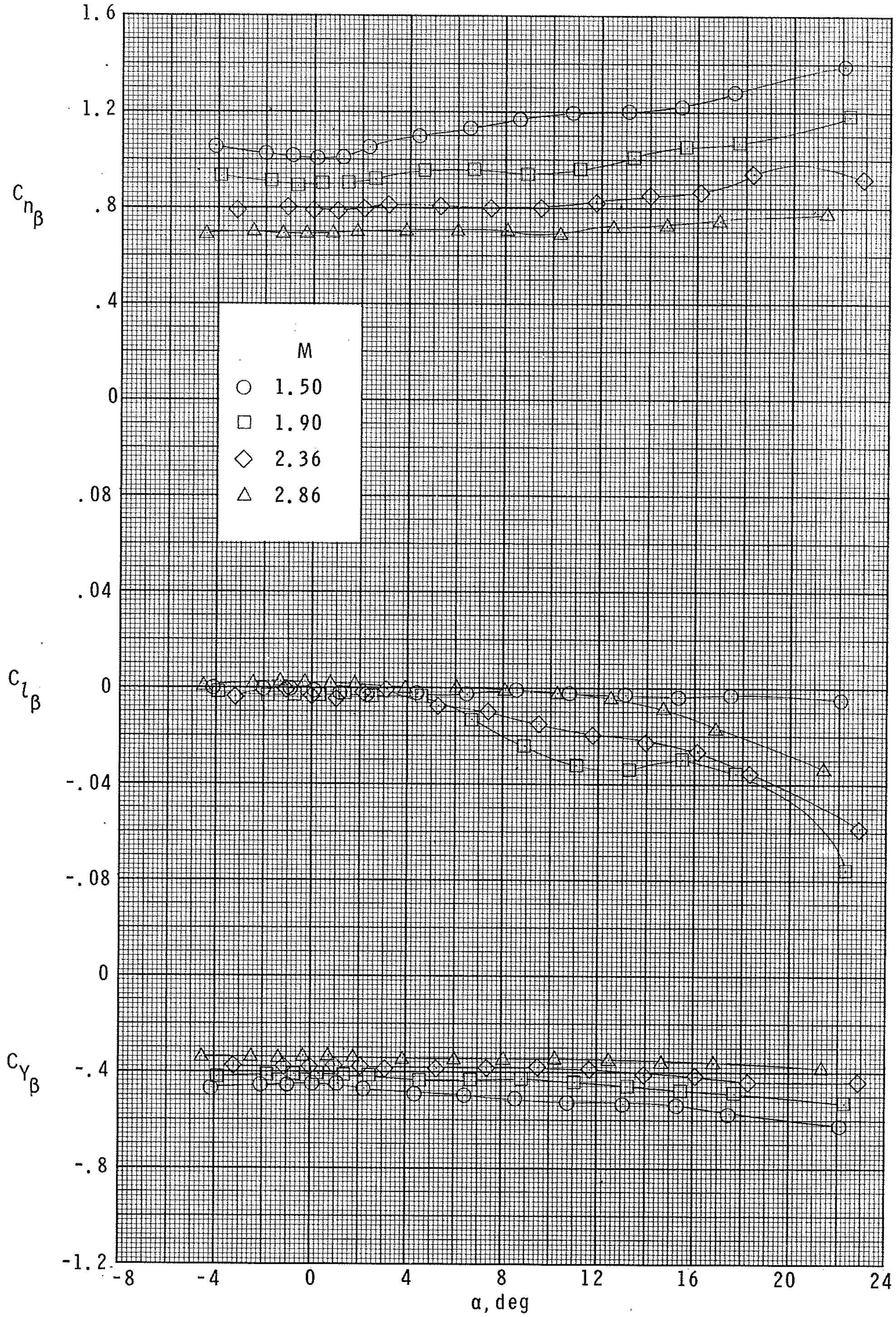
(b) $\frac{r_n}{r_b} = 0.45.$

Figure 7.- Continued.



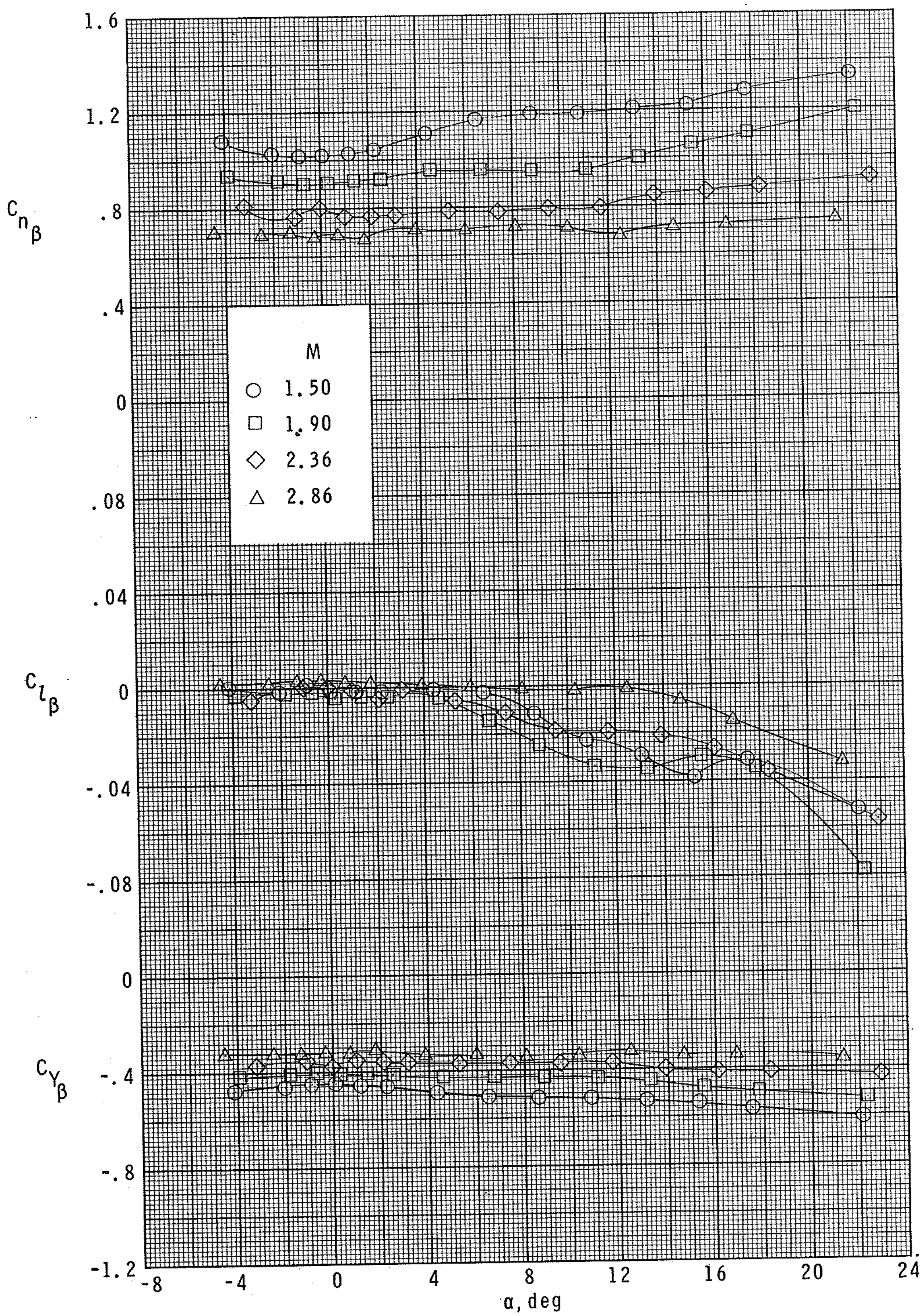
(c) $\frac{r_n}{r_b} = 1.00.$

Figure 7.- Concluded.



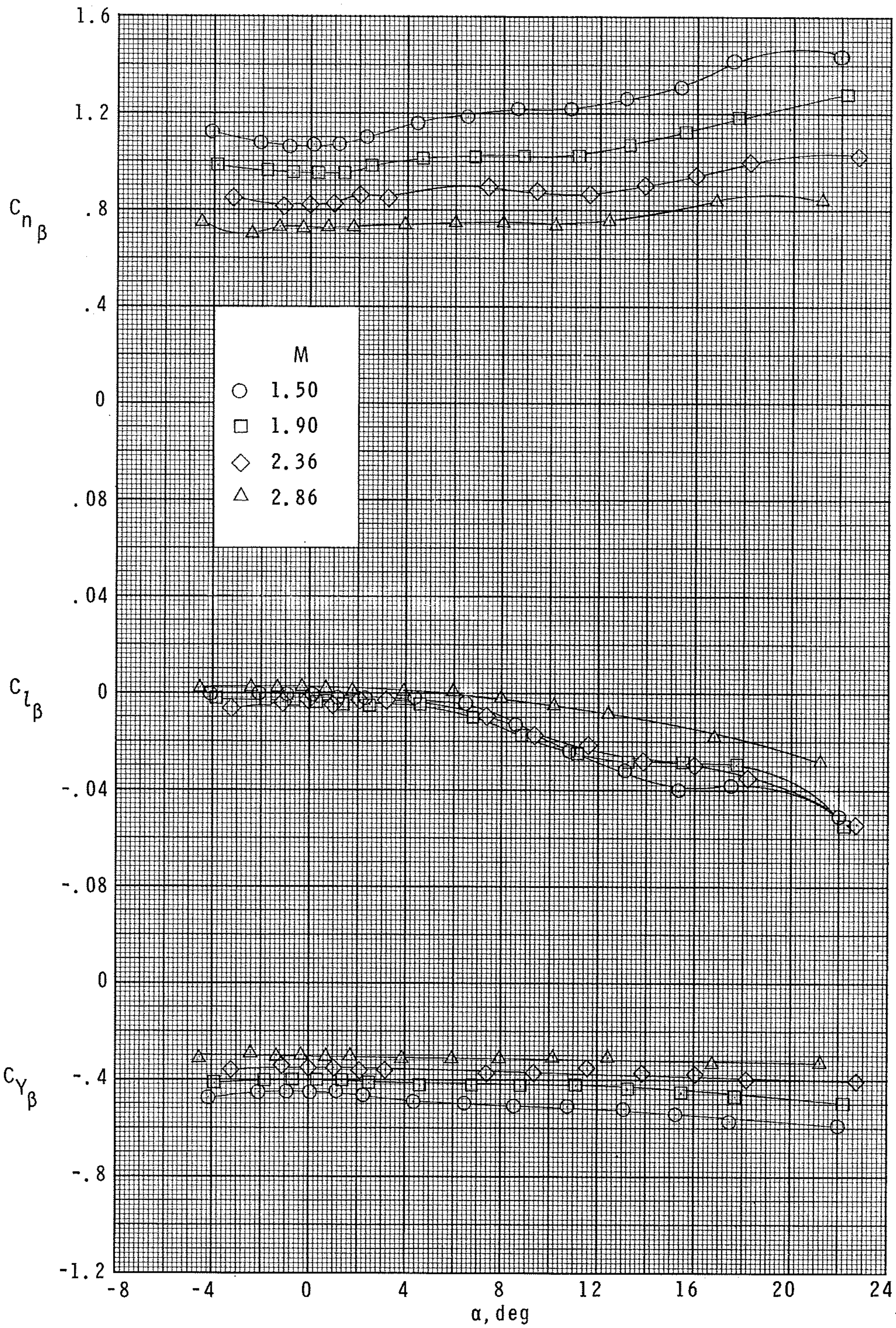
(a) $\frac{r_n}{r_b} = 0.00.$

Figure 8.- Lateral stability derivatives of model with various degrees of nose bluntness; $\Phi = 45^\circ$.



(b) $\frac{r_n}{r_b} = 0.45$

Figure 8.- Continued.



(c) $\frac{r_n}{r_b} = 1.00.$

Figure 8.- Concluded.

NASA-Langley, 1970 —— 1

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

— NATIONAL AERONAUTICS AND SPACE ACT OF 1958

NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include conference proceedings, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Notes, and Technology Surveys.

Details on the availability of these publications may be obtained from:

SCIENTIFIC AND TECHNICAL INFORMATION DIVISION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D.C. 20546