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STATIC LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF A PROPOSED DECELERATOR TEST VEHICLE

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SUMMARY

Tests were conducted to determine the static longitudinal aerodynamic force and moment characteristics of a proposed decelerator test vehicle through a Mach number range from 0.6 to 2.86 and angles of attack from approximately -4° to 20°.

The investigation yielded the following results: (1) At angles of attack below approximately 6°, there was no variation in normal-force or pitching-moment characteristics; however, at higher angles of attack, variations in these characteristics were noted. Two configurations were tested and both were unstable over the Mach number and angle-of-attack range. (2) The base axial force is the major portion of the axial force (approximately one-half) at the lower Mach numbers, and, although the base axial force decreases with increasing Mach number, approximately one-third of the axial force at Mach 2.86 is still due to the base axial force.

INTRODUCTION

A wind-tunnel investigation has been conducted in the Langley Unitary Plan wind tunnel and the Langley 8-foot transonic pressure tunnel on a decelerator test vehicle. The purpose of this investigation was to determine the static longitudinal aerodynamic characteristics of the proposed test vehicle in order to evaluate the aerodynamics of various decelerator test configurations. The Mach number range of the investigation was from 0.6 to 2.86 and the Reynolds number per meter was held constant at about 9.84×10^6. The angle-of-attack range was from about -4° to 20°.

SYMBOLS

Aerodynamic force and moment data are referred to the body system of axes, with coefficients based on the cross-sectional area of the cylindrical portion of the model, 0.00578 meter^2, and the corresponding body diameter of 8.57 centimeters. Moments are measured about a point located on the body center line, 1.599 reference diameters forward of the model base. (See fig. 1.)

A reference cross-sectional area, 0.00578 meter^2

C_A axial-force coefficient, $\frac{\text{Axial force}}{qA}$

$C_{A,b}$ base axial-force coefficient, including force acting on base of pods, $\frac{\text{Base axial force}}{qA}$

C_m pitching-moment coefficient, $\frac{\text{Pitching moment}}{qAd}$

C_{m_α} pitching-moment-curve slope taken 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} normal-force-curve slope taken at $\alpha \approx 0^\circ$, $\frac{\partial C_N}{\partial \alpha}$, per degree

d reference body diameter, 8.57 centimeters

M Mach number

q free-stream dynamic pressure, newtons/meter^2

R radius, meters

x_{cp} center-of-pressure location, reference body diameters forward of model base

α angle of attack of body center line, degrees

APPARATUS AND TESTS

Apparatus

The supersonic portion of the investigation was conducted in the low supersonic speed test section of the Langley Unitary Plan wind tunnel. The test section is 1.22 meters square and the length is approximately 2.13 meters.

The transonic portion of the investigation was conducted in the Langley 8-foot transonic pressure tunnel. This tunnel has a test section which is approximately 2.16 meters square and has a length of approximately 3.45 meters. Further details of both tunnels can be found in reference 1.

Model

A 1/4-scale model of a proposed decelerator test vehicle was used in the present investigation. The configuration consisted of a spherically blunted nose cone and a cylinder, followed by a flared afterbody. Three spherically blunted cone-cylinder pods were located, equally spaced about the flare, near the base of the model as shown in figure 1. Two configurations were tested; configuration 2 is configuration 1 inverted.

Tests and Procedures

The investigation was conducted at a constant Reynolds number of 9.84×10^6 per meter. The total temperature was held at approximately 322° K for the transonic portion of the investigation and 339° K for the supersonic phase. The angle-of-attack range was from -4° to 20° and the Mach number range was 0.6 to 2.86.

The investigation was conducted with a transition strip of No. 60 carborundum grains located at the juncture of the spherical portion and the conical portion of the nose or at 4.06 percent of the body length.

CORRECTIONS AND ACCURACY

The angles of attack of the model have been corrected for deflection of the balance and sting under load and for tunnel-flow angularity.

Based upon instrument calibration and repeatability of data, it is estimated that the various measured quantities are accurate within the limits given in the following table:

	Transonic-speed range ($M = 0.6$ to 1.30)	Supersonic-speed range ($M = 1.5$ to 2.86)
C_N	±0.015	±0.015
C_A	±0.015	±0.015
$C_{A,b}$	±0.005	±0.005
C_m	±0.04	±0.03
α, deg . . .	±0.10	±0.10
M	±0.003	±0.015

PRESENTATION OF RESULTS

The results of this investigation are presented in the following figures:

Flagged symbols which appear in the center-of-pressure data in figure 6 represent results obtained by using the values of $C_{m_{\alpha}}$ and $C_{N_{\alpha}}$ at approximately 0° angle of attack.

RESULTS AND DISCUSSION

Figure 2 shows that, for angles of attack up to about 10° for the transonic case and up to about 6° for the supersonic case, there is no effect of configuration geometry on the normal-force coefficient. However, at higher angles of attack, the results for configuration 1 indicate a higher normal-force-curve slope than do the results for configuration 2.

For the transonic case shown in figure 3(a), the data indicate that above $\alpha \approx 4^{\circ}$ configuration 1 is statically more unstable than configuration 2. However, at supersonic Mach numbers (fig. 3(b)), the stability level above $\alpha \approx 4^{\circ}$ for configuration 1 increases and configuration 1 becomes less unstable than configuration 2. Both configurations over the angle-of-attack and Mach number range are statically unstable.

The normal-force-curve slope and pitching-moment-curve slope at $\alpha \approx 0^{\circ}$ are shown as a function of Mach number in figure 7. As can be seen, there is virtually no effect of configuration geometry on either the normal-force-curve slope or the pitching-moment-curve slope.

Figure 4 shows the variation of axial-force coefficient with angle of attack. In general, there is little effect of configuration geometry on the axial-force coefficient.

Comparison of figures 4 and 5 shows that approximately half of the axial force at the lower Mach numbers is from the base. Even though the base axial force decreases with Mach number, approximately one-third of the axial force at the highest Mach number is due to the base axial force.

Figure 6 shows the center of pressure to be relatively independent of angle of attack, configuration, and Mach number.

CONCLUSIONS

An investigation conducted in the Langley Unitary Plan wind tunnel and the Langley 8-foot transonic pressure tunnel to determine the static longitudinal aerodynamic force and moment characteristics for a proposed decelerator test vehicle yielded the following results:

1. At angles of attack below $\approx 6^\circ$, there was no variation in normal-force or pitching-moment characteristics; however, at higher angles of attack, variations in these characteristics were noted. Both configurations tested were statically unstable over the Mach number and angle-of-attack range.

2. The base axial force is the major portion of the axial force (approximately one-half) at the lower Mach numbers, and, although the base axial force decreases with increasing Mach number, approximately one-third of the axial force at Mach 2.86 is due to the base axial force.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Station, Hampton, Va., September 19, 1966,
709-08-00-01-23.

REFERENCE

1. Schaefer, William T., Jr.: Characteristics of Major Active Wind Tunnels at the Langley Research Center. NASA TM X-1130, 1965.

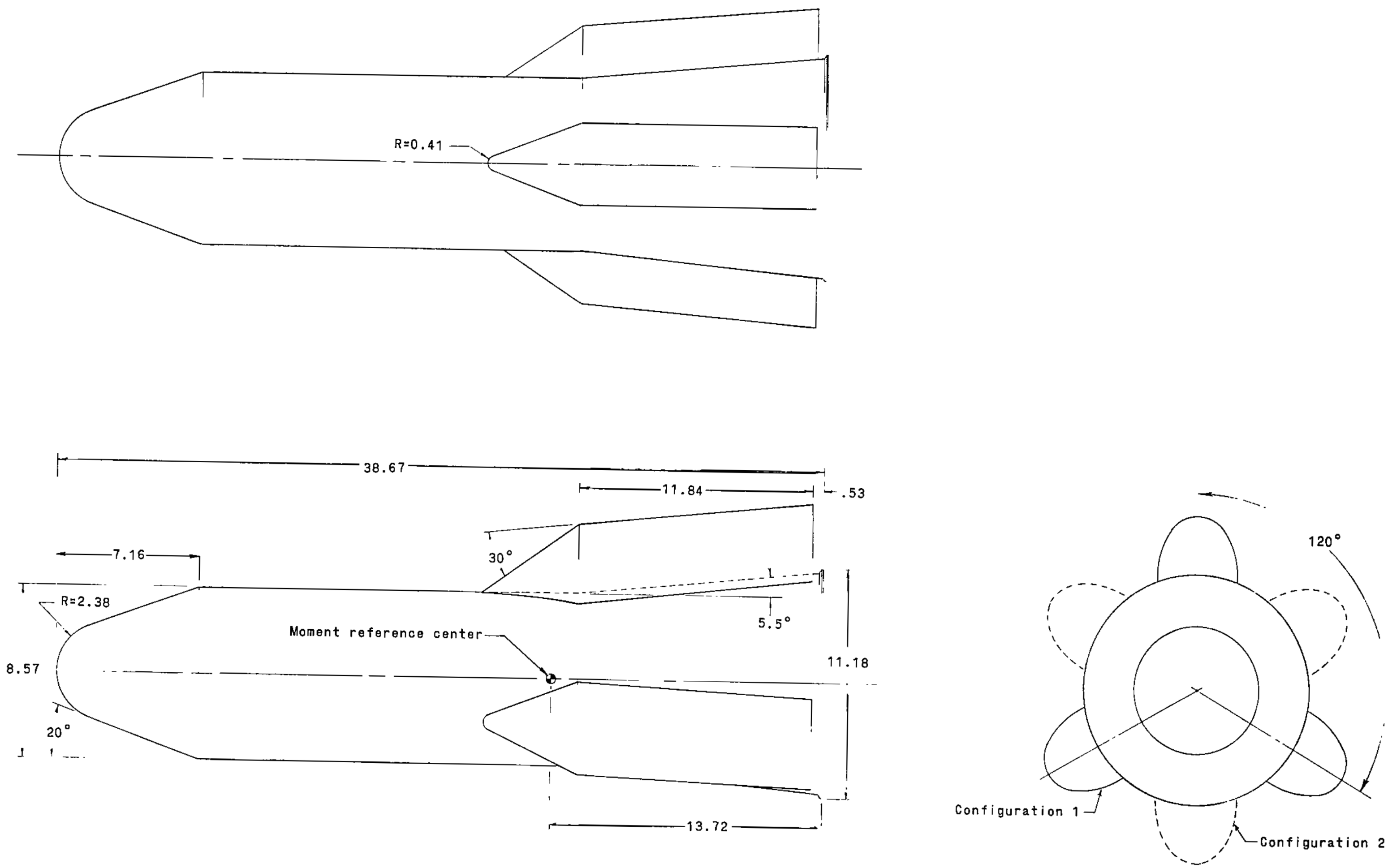
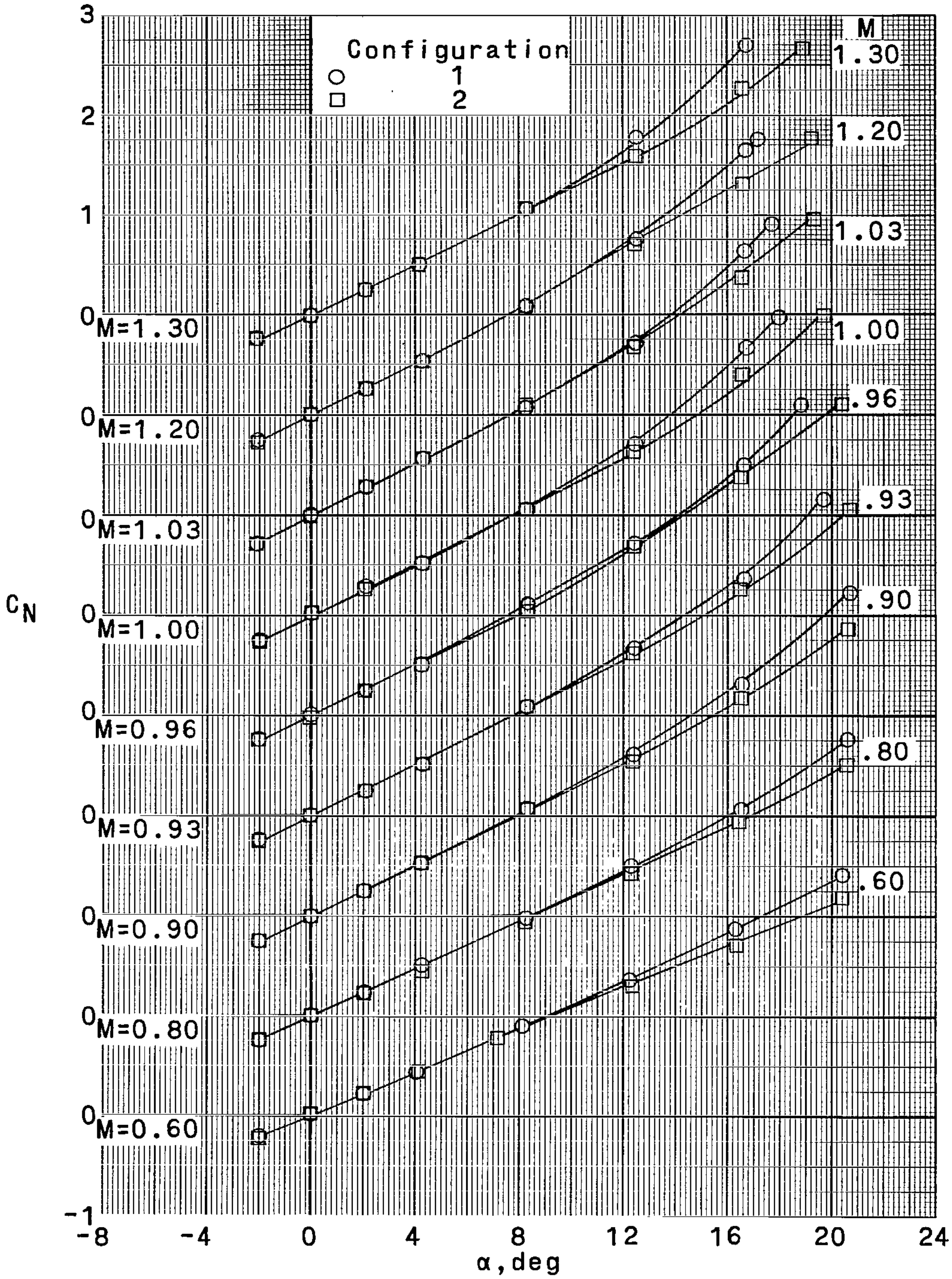
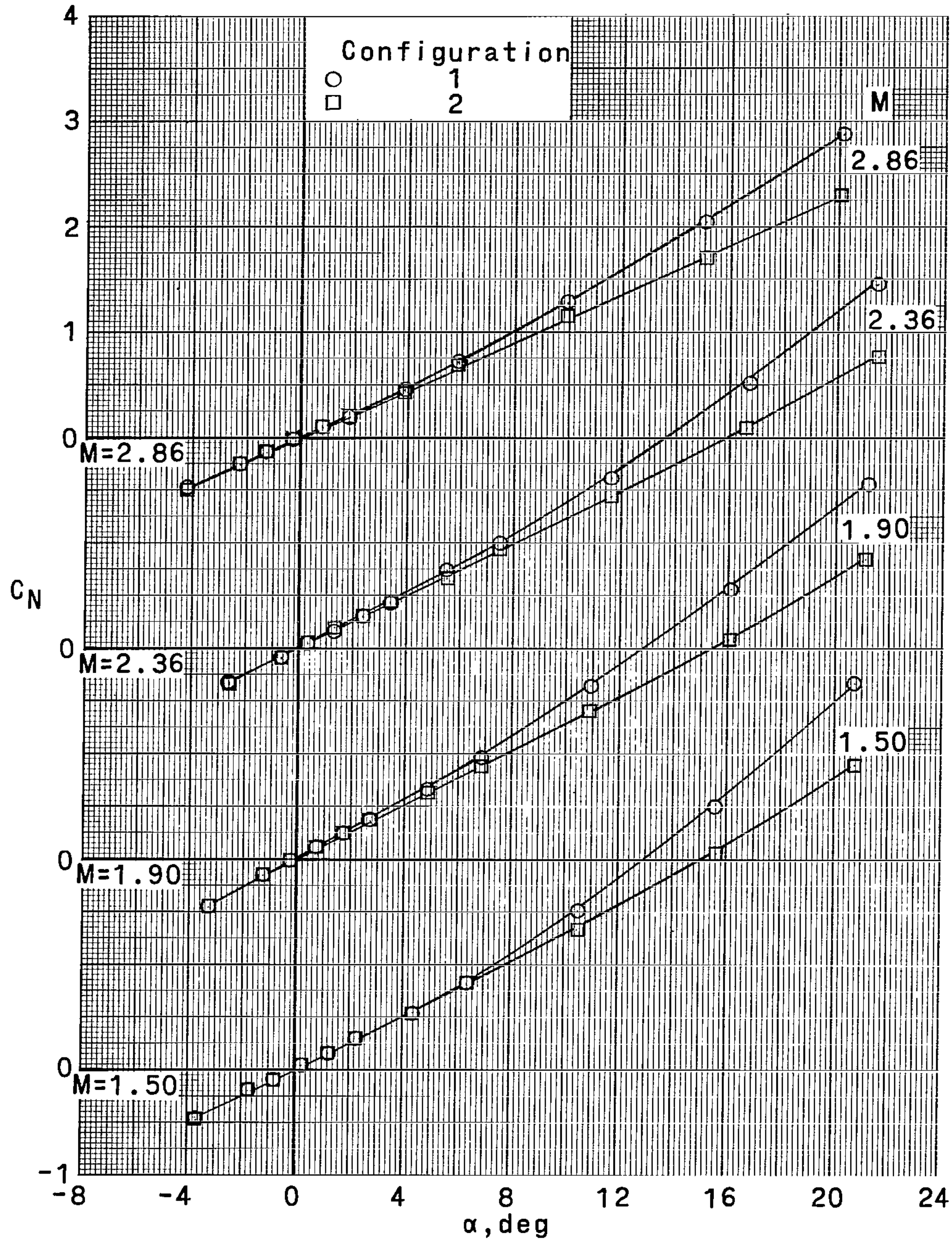


Figure 1.- Model drawing of configuration 1. All linear dimensions are in centimeters. Configuration 2 is configuration 1 inverted.



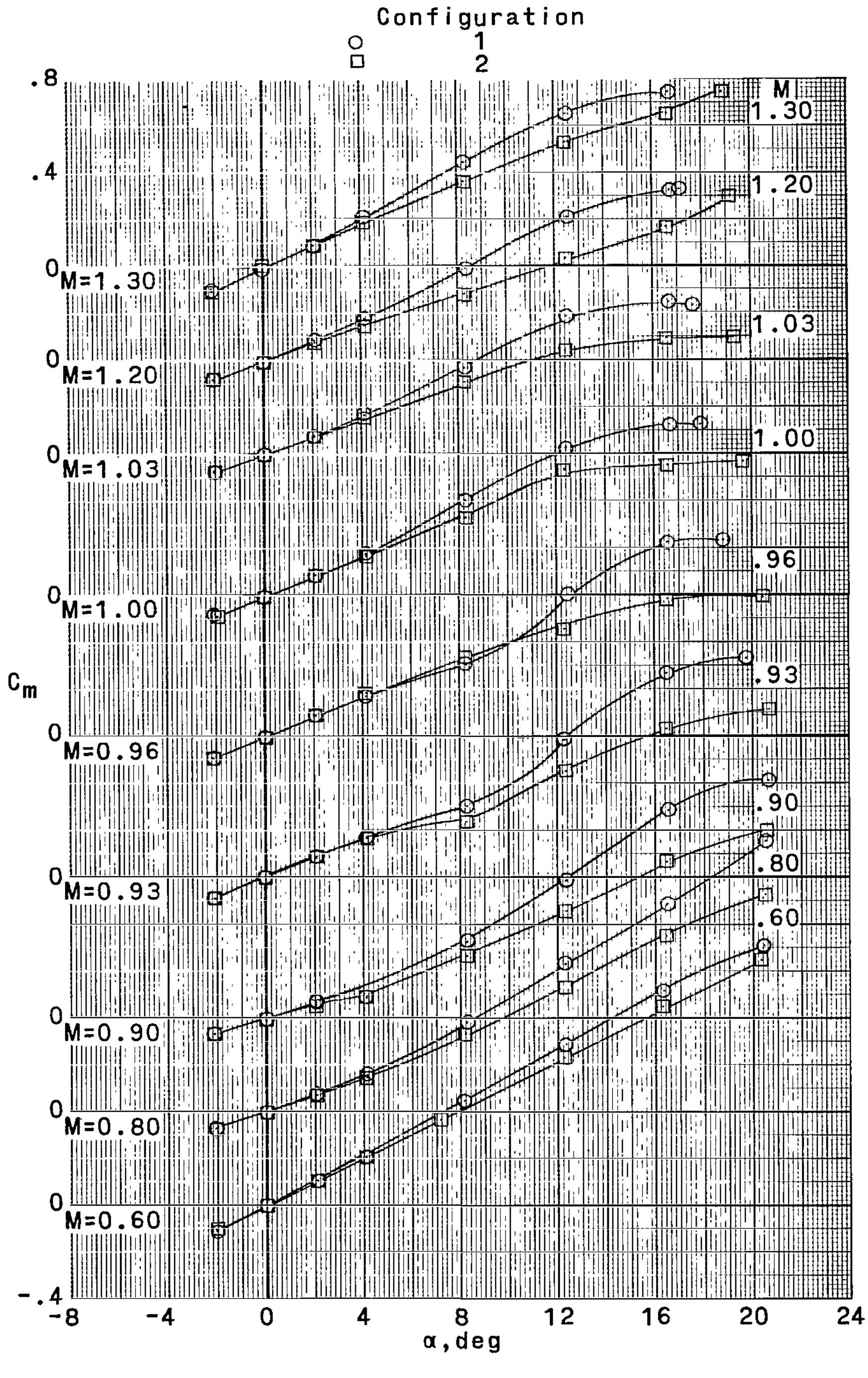
(a) Transonic.

Figure 2.- Variation of normal-force coefficient with angle of attack.



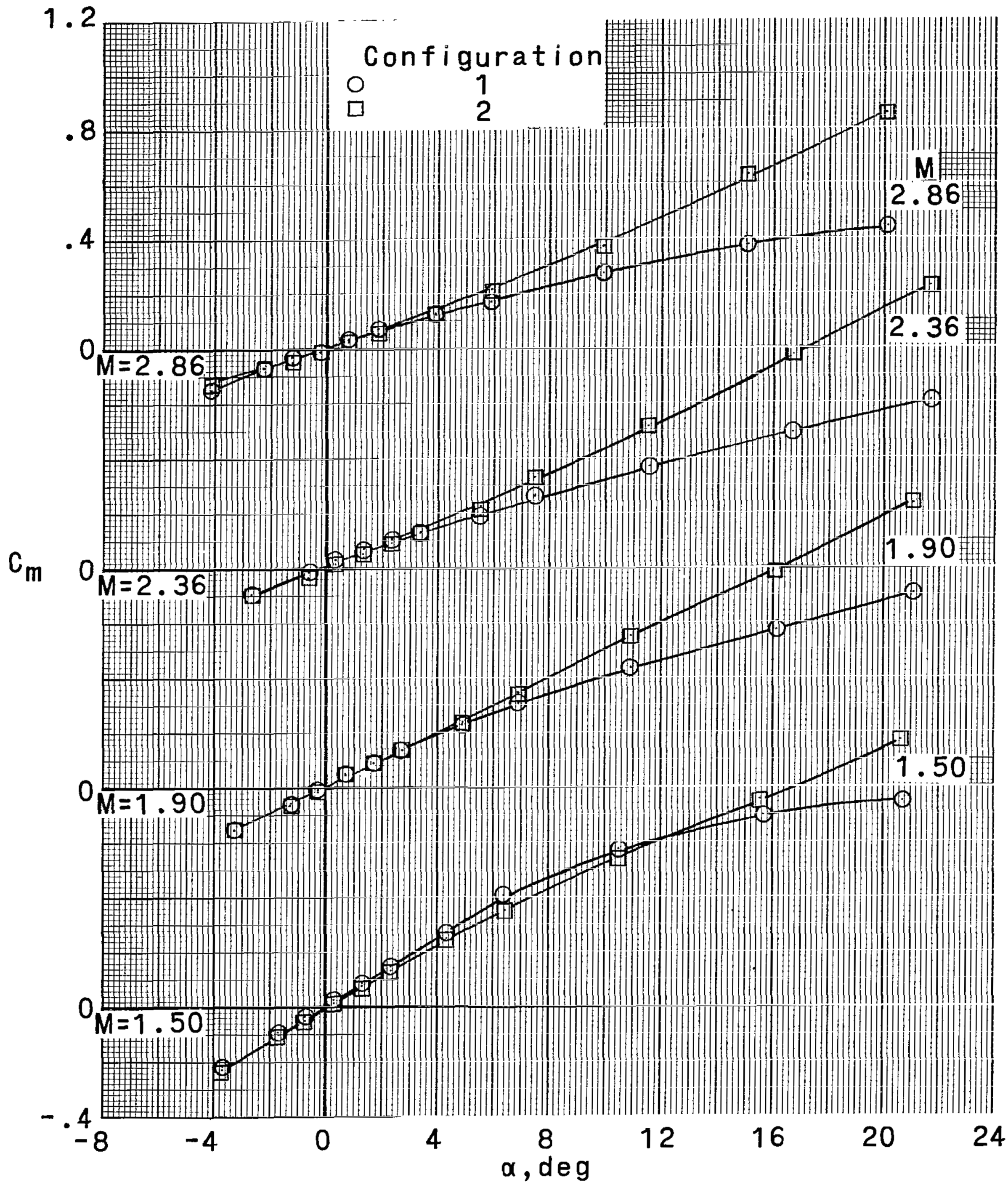
(b) Supersonic.

Figure 2.- Concluded.



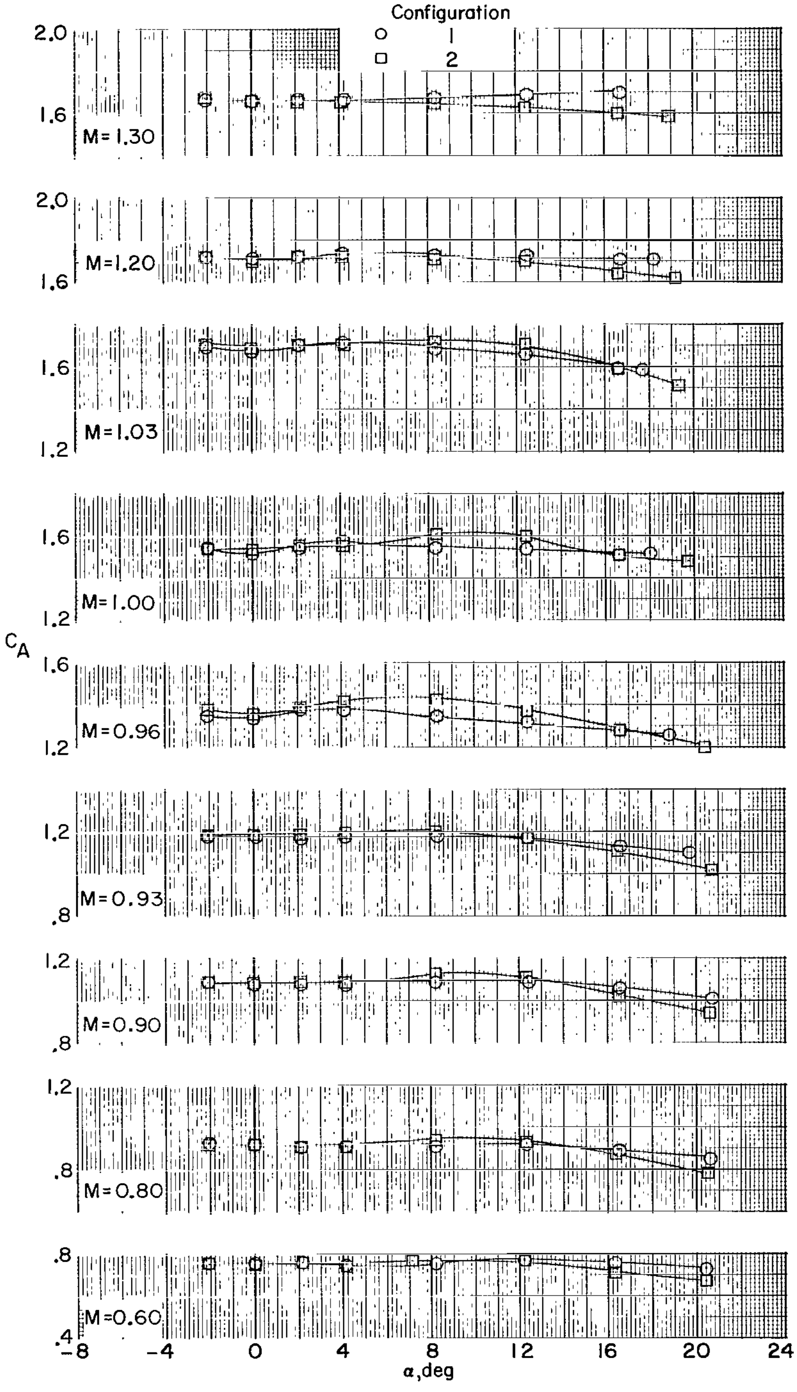
(a) Transonic.

Figure 3.- Variation of pitching-moment coefficient with angle of attack.



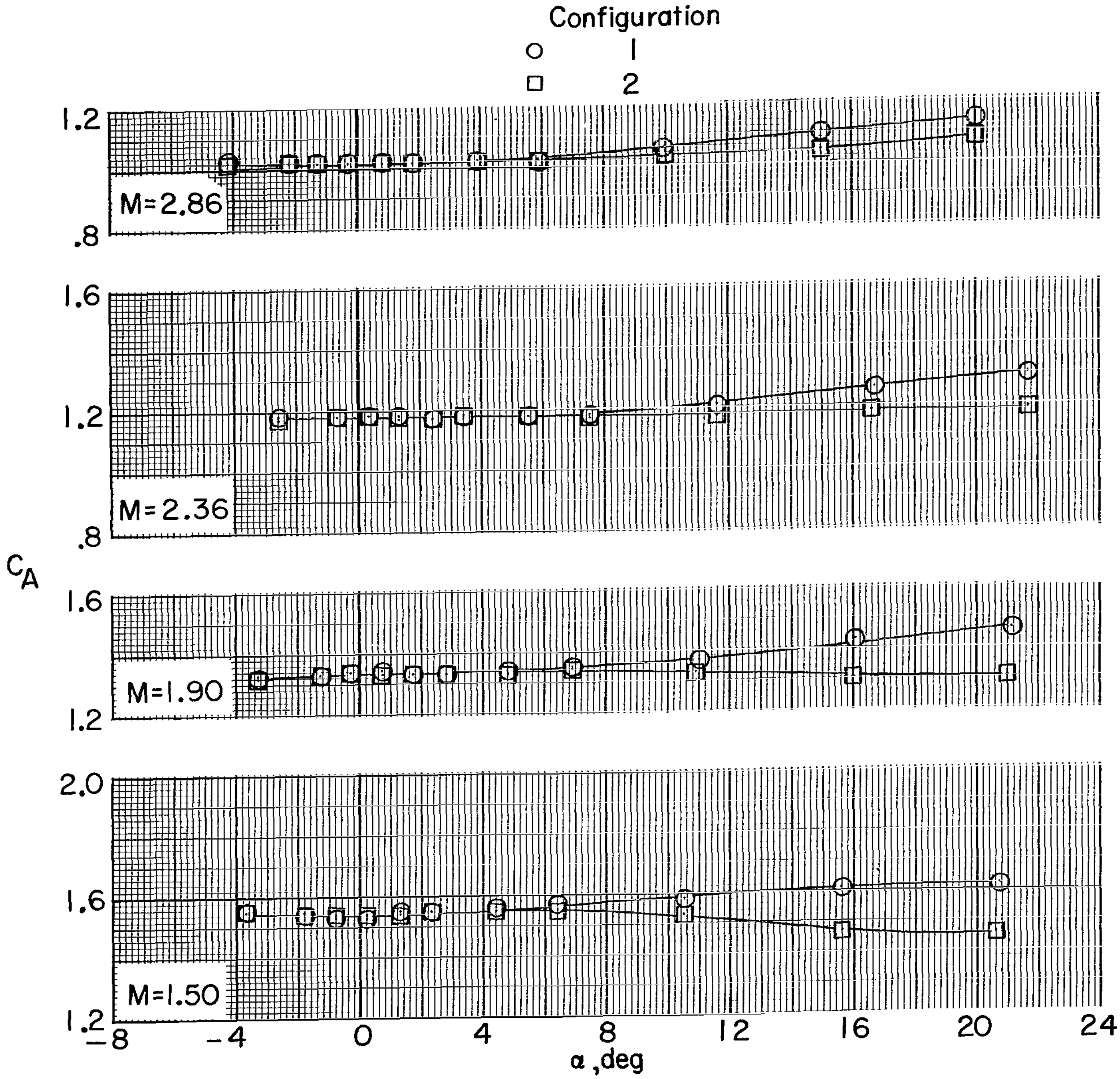
(b) Supersonic.

Figure 3.- Concluded.



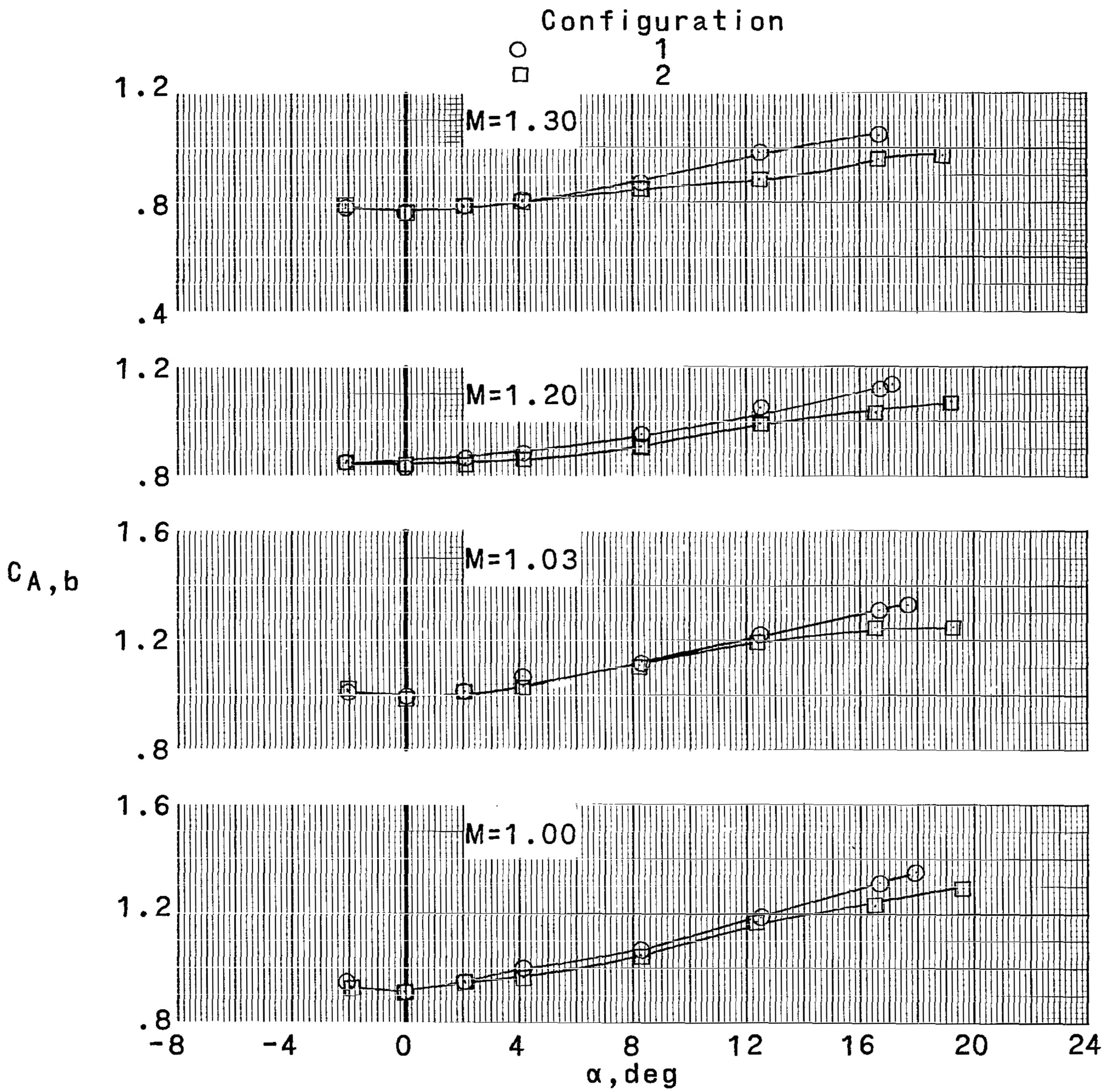
(a) Transonic.

Figure 4.- Variation of axial-force coefficient with angle of attack.



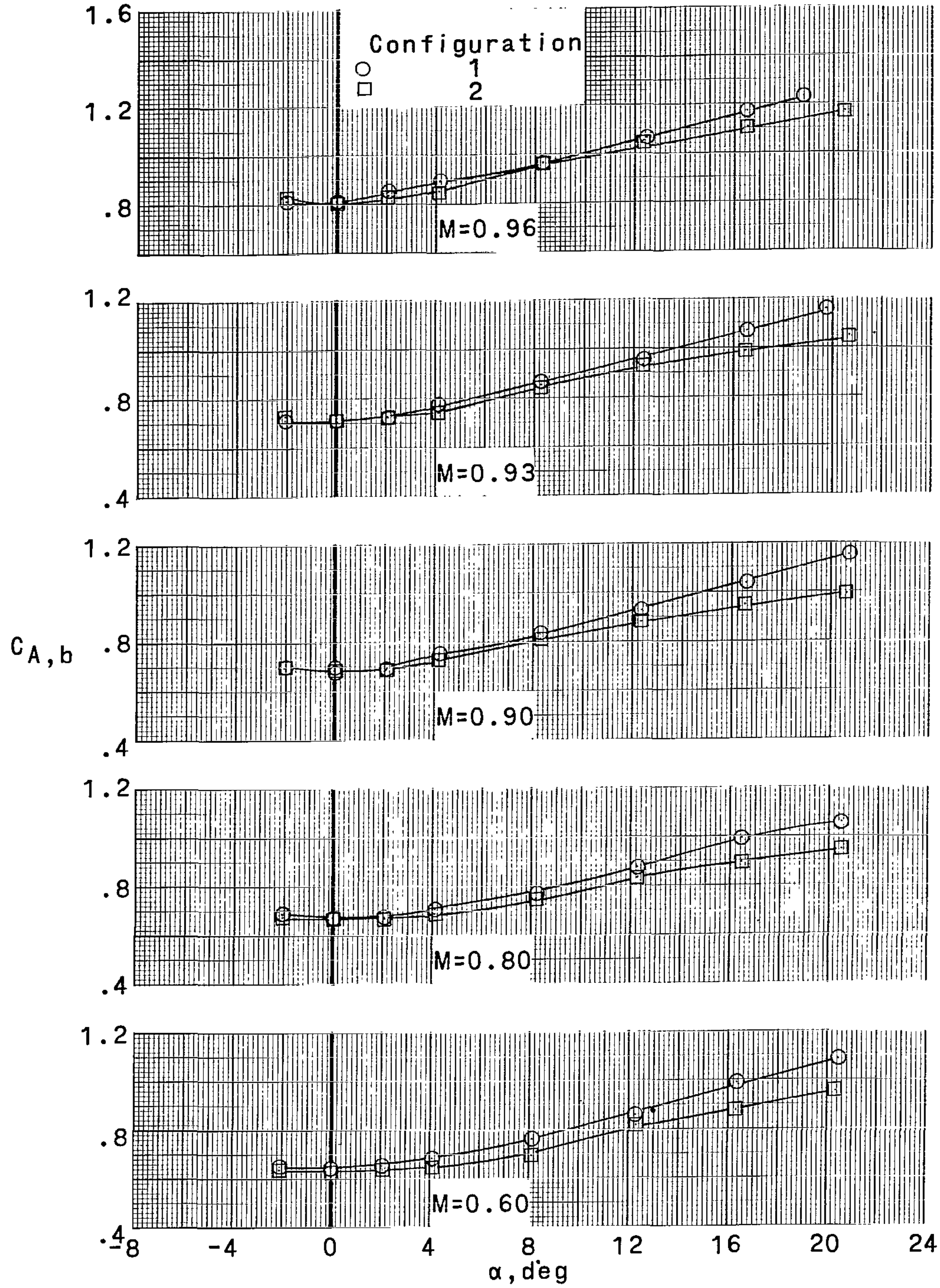
(b) Supersonic.

Figure 4.- Concluded.



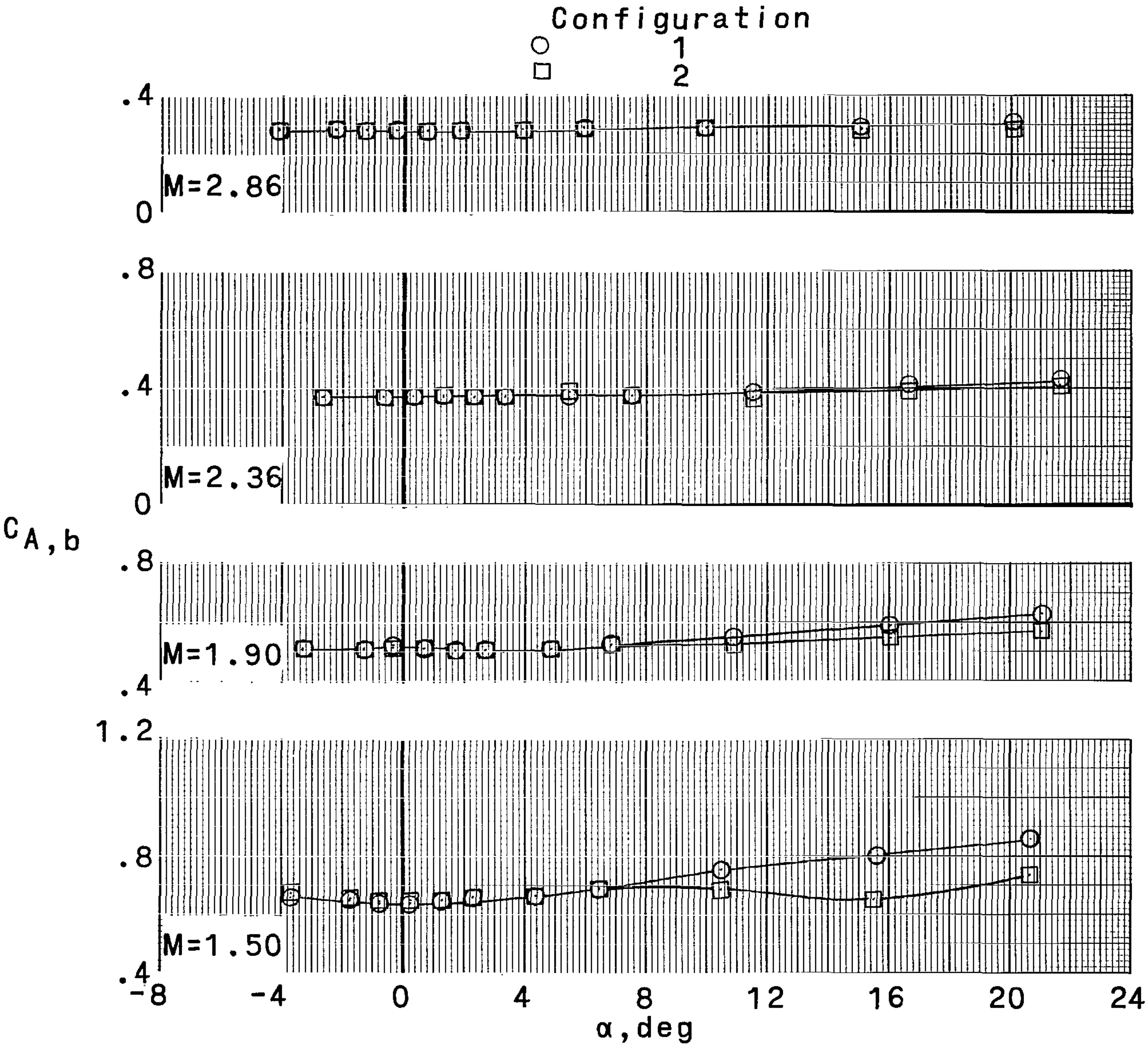
(a) Transonic.

Figure 5.- Variation of base axial-force coefficient with angle of attack.



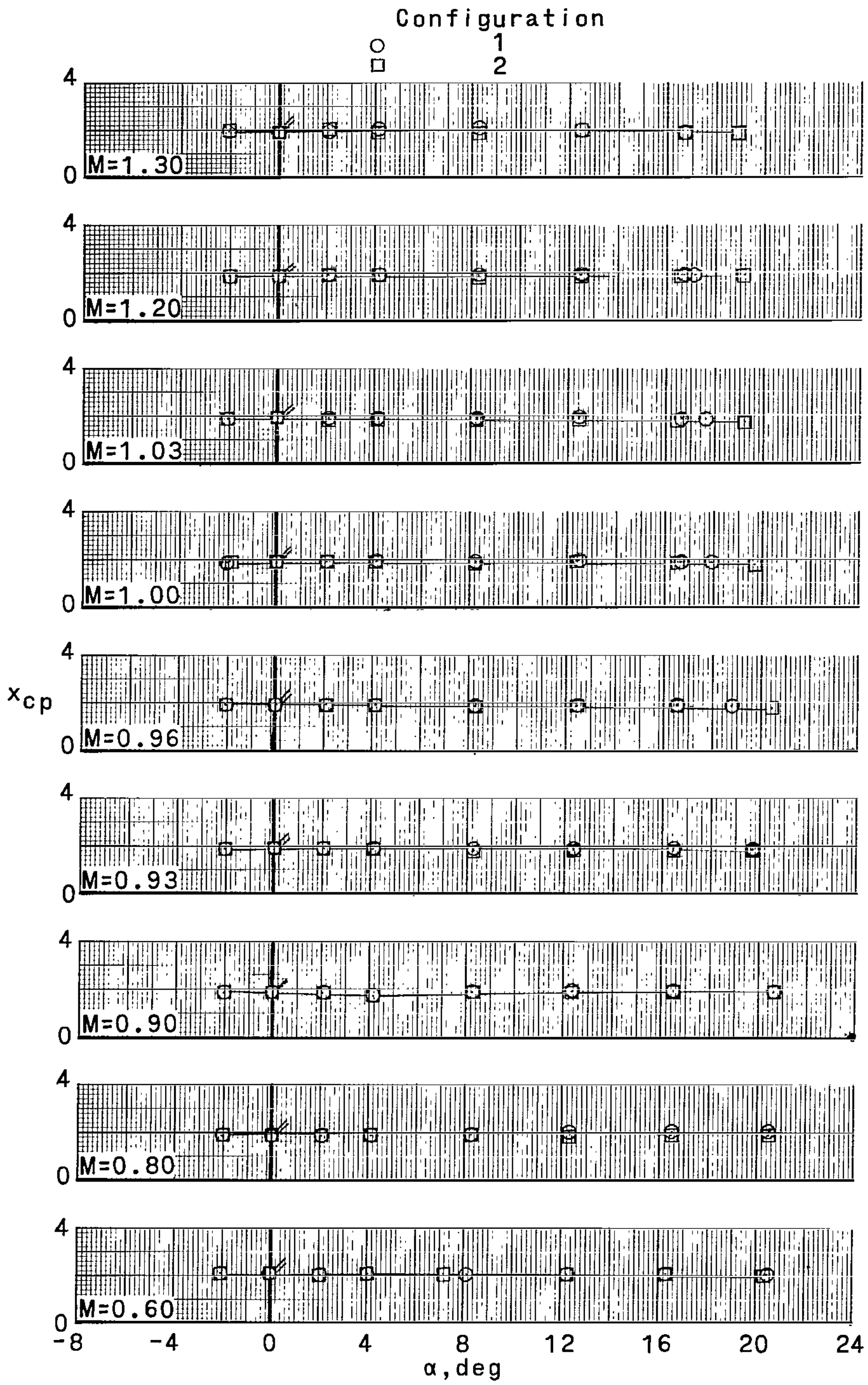
(a) Concluded.

Figure 5.- Continued.



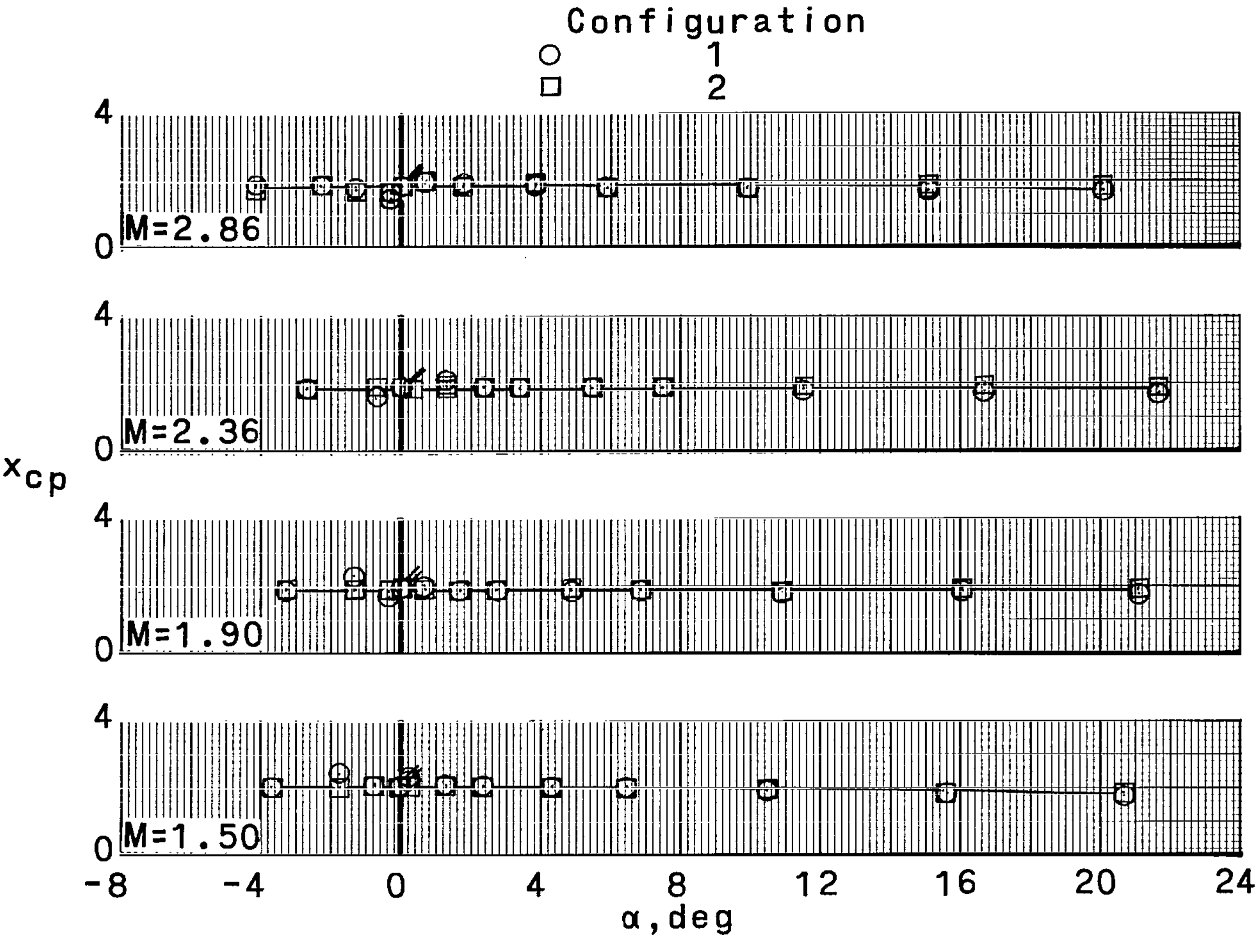
(b) Supersonic.

Figure 5.- Concluded.



(a) Transonic.

Figure 6.- Variation of center-of-pressure location with angle of attack. (Flagged symbols indicate values obtained by using C_{m_α} and C_{N_α} measured at $\alpha \approx 0^0$.)



(b) Supersonic.

Figure 6.- Concluded.

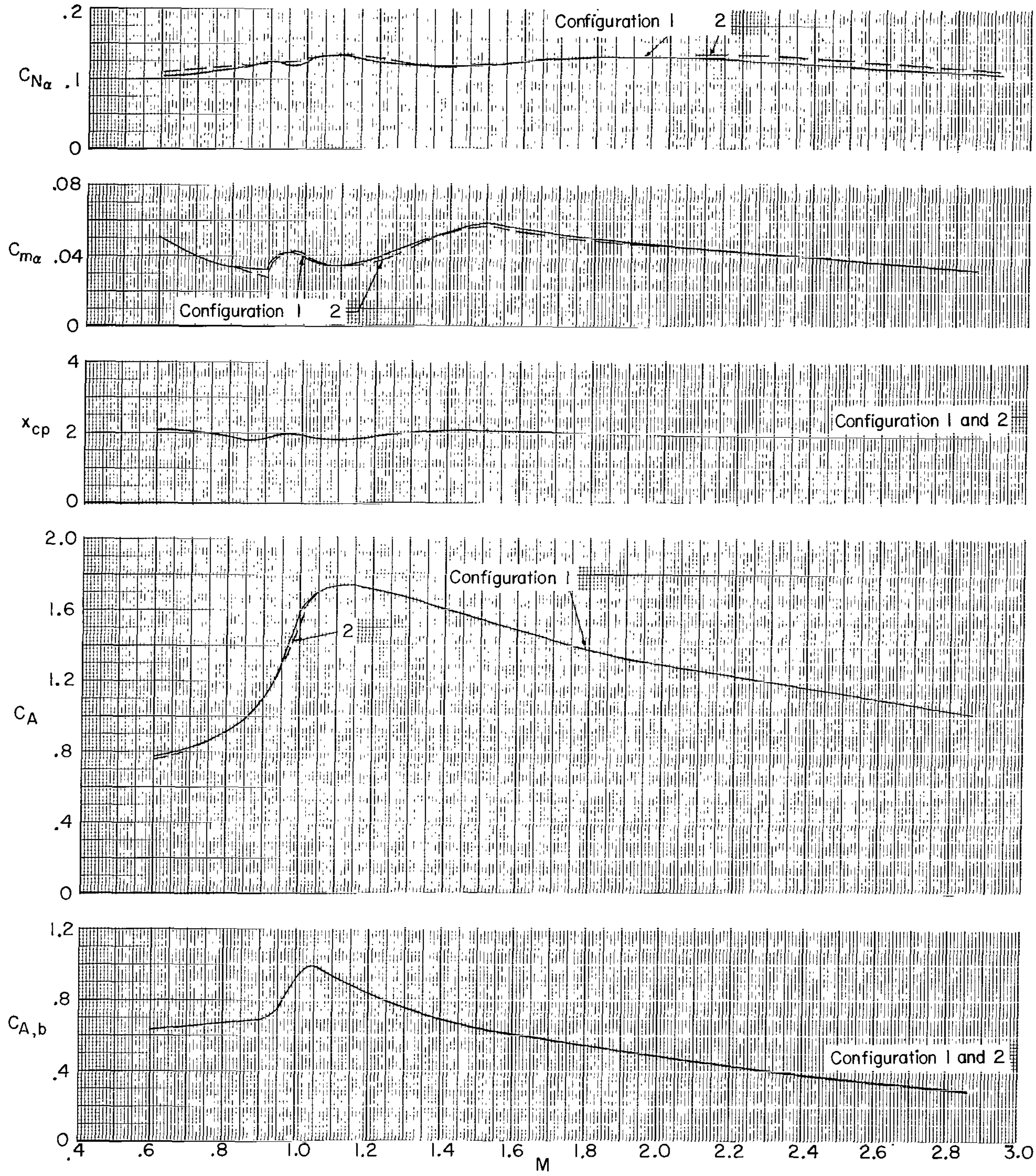


Figure 7.- Summary of aerodynamic characteristics in pitch; $\alpha \approx 0^{0}$.

NASA-Langley, 1967 L-5101

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