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TECHNICAL MEMORANDUM

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WIND-TUNNEL INVESTIGATION AT MACH NUMBERS FROM 3.0 TO 6.8 OF THE STATIC AERODYNAMIC CHARACTERISTICS OF MODIFIED MERCURY EXIT AND ESCAPE CAPSULE CONFIGURATIONS

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SUMMARY

The pitching-moment, normal-force, and axial-force characteristics of 5.37-percent-scale models of exit and escape configurations of a modified Mercury capsule were investigated at Mach numbers from 3.0 to 6.8 for angles of attack from approximately -5° to 25° in a 2-foot low-density hypersonic tunnel located at Langley Research Center.

The results of the investigation show that the modifications to the exit configuration had a negligible effect on the stability of the model but shifted the pitching-moment curves so that no trim point existed for the angles of attack investigated. The modifications to the escape configuration tended to increase the stability but had a negligible effect on the trim characteristics and pitch-up tendencies of the model. The modifications reduced the slopes of the normal-force coefficients but had a negligible effect on axial-force coefficients near zero angle of attack for both the exit and escape configurations.

INTRODUCTION

Results obtained from transonic and supersonic wind-tunnel investigations of a reentry capsule for use in Project Mercury are given in references 1 and 2, respectively. Since the time when these results were published, several modifications to the capsule have been proposed. These modifications consist in the addition of a destabilizer flap to the exit model, an increase in the parachute-housing diameter of exit, reentry, and escape configurations, and the addition of a Marman clamp to the escape configuration. Additional wind-tunnel tests over large

*Title, Unclassified.

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Mach number ranges have, therefore, been begun by the National Aeronautics and Space Administration to determine the static aerodynamic characteristics of models having these modifications.

The present investigation was made in a 2-foot low-density hypersonic tunnel located at Langley Research Center, and static aerodynamic data at supersonic and hypersonic speeds were obtained for a model incorporating the above-mentioned modifications. The model was tested as an exit configuration (small cylindrical end facing the relative wind) and as an escape configuration (same as the exit configuration but
with a tower and simulated rocket container attached to the cylindrical L
end). The investigation was made at Mach numbers from about 3.0 to 6.8 1
at angles of attack from approximately -5° to 25°. The Reynolds number, 1
based on maximum body diameter, varied from about 0.27×10^{6} 6
to 0.50×10^{6}. 8

SYMBOLS

The data presented herein are referred to the body system of axes with the origin located at the model center-of-gravity position. The positive directions of forces, moments, and displacements are shown in figure 1. The coefficients and symbols are defined as follows:

C_m	pitching-moment coefficient, $\frac{\text{Pitching moment}}{qAd}$
C_{m_α}	slope of pitching-moment coefficient at $\alpha \approx 0^{\circ}$, $\frac{\partial C_m}{\partial \alpha}$, per deg
C_N	normal-force coefficient, $\frac{\text{Normal force}}{qA}$
C_{N_α}	slope of normal-force coefficient at $\alpha \approx 0^{\circ}$, $\frac{\partial C_N}{\partial \alpha}$, per deg
C_A	axial-force coefficient, $\frac{\text{Axial force}}{qA}$
$C_{A,\alpha\approx 0}$	axial-force coefficient at $\alpha \approx 0^{\circ}$
M	free-stream Mach number

q free-stream dynamic pressure, lb/sq ft

R Reynolds number based on maximum body diameter and free-stream conditions

d maximum body diameter, ft, or in., as indicated

r radius, in.

A maximum body cross-sectional area, sq ft

α angle of attack of model center line, deg

p_t free-stream stagnation pressure, lb/sq ft

T_t free-stream stagnation temperature, $^{\circ}F$

APPARATUS AND METHODS

Wind Tunnel

The tests were conducted in a 2-foot low-density hypersonic tunnel at Langley Research Center, which is a variable-pressure, continuous-flow, closed-circuit ejector-type tunnel. The nozzle, diffuser, and ejector blocks forming the upper and lower walls can be moved independently of one another and permit a continuous variation in test section Mach number from approximately 3.0 to 7.0.

Models

Details of the 5.37-percent-scale model configurations tested are shown in figure 2, and photographs are presented in figure 3. The capsule used for the exit configuration was a hollow body of revolution made from steel and similar in shape to the model tested for reference 2. For the present investigation the model was tested with a destabilizer flap as shown in figure 2(a) and the diameter of the parachute housing was increased over that of reference 2. This increase of diameter represents a full-scale enlargement of approximately 2 inches. For this configuration the small cylindrical end faced the relative wind. The escape configuration was composed of a cylindrical aluminum-alloy body, simulating a rocket container, mounted on a tower made from three cross-braced steel rods attached to the nose of the exit configuration. The two lower rods of the tower were in a horizontal plane. This model

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incorporated the increased parachute-housing diameter and also a Marman clamp as shown in figure 2(b).

Test Conditions

Tests were performed at angles of attack from about -5° to 25° at the following conditions:

Exit Model L-1168

M	p_t, lb/sq ft	T_t, °F	q, lb/sq ft	R
3.02	2,082	263	351	0.501×10^6
3.96	2,174	265	165	.317
4.70	3,538	282	148	.352
5.75	5,958	312	110	.346
6.82	7,656	334	75	.269

Escape Model

M	p_t, lb/sq ft	T_t, °F	q, lb/cu ft	R
3.15	2,155	263	326	0.479×10^6
3.92	2,158	279	169	.310
4.73	3,586	313	146	.332
5.72	6,013	333	110	.349
6.80	7,948	328	77	.280

The dewpoint temperature was maintained at a temperature such that the airflow was essentially free of condensation effects. All tests were conducted with natural boundary-layer transition.

Measurements and Corrections

Normal force, axial force, and pitching moment were determined by means of an electrical strain-gage balance housed within the model. The balance, in turn, was rigidly fastened to a sting support system. The axial-force results are gross values and have not been adjusted to a condition of free-stream static pressure at the model base. Corrections were applied to the measured angles of attack for model sting and balance deflections.

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Accuracy

Based upon calibrations and balance accuracy, it is estimated that the various measured quantities are accurate within the following limits:

C_m	±0.024
C_N	±0.048
C_A	±0.032
M	±0.10
α, deg	±0.20

RESULTS

Static Stability and Trim Characteristics

The basic aerodynamic characteristics are shown as a function of angle of attack and Mach number for the exit configuration in figure 4 and for the escape configuration, in figure 5. Summary curves of the static aerodynamic parameters in pitch are plotted against Mach number for both configurations in figure 6.

The basic data of figures 4(a) and 5(a) and the summary data of figure 6 indicate that at the lower angles of attack, the exit configuration is statically unstable at the lower Mach numbers but is statically stable at Mach numbers above about 4.0; the escape configuration is statically stable at all Mach numbers investigated. At angles of attack greater than about 10° the exit model is unstable at all Mach numbers of this investigation. Pitch-up occurs at angles of attack near 20° for the escape configuration.

Comparisons of the data of the present investigation with those for the unmodified capsule of reference 2 and with data from the Langley 11-inch hypersonic tunnel for the higher Mach numbers (figs. 4(a) and 6(a)) show that the modifications to the exit configuration had a negligible effect on the stability but shifted the pitching-moment curves so that no trim point existed for the angles of attack investigated. The modifications to the escape configuration had a negligible effect on the trim characteristics and pitch-up tendencies of the model but tended to increase the stability (figs. 5(a) and 6(b)).

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Normal and Axial-Force Characteristics

The normal-force characteristics for the exit and escape configurations are shown in figures 4(b) and 5(b), respectively, and are summarized in figure 6. The axial-force characteristics are shown in figures 4(c) and 5(c), respectively, and are also summarized in figure 6. Comparisons of these results with those for the unmodified capsule of reference 2 and with data from the Langley 11-inch hypersonic tunnel at the higher Mach numbers show that the modifications to the exit and escape configurations reduce the slopes of the normal-force coefficients by about 15 percent and 6 percent, respectively, at a Mach number near 4.65. In general, the modifications had a negligible effect on $C_{A,\alpha \approx 0}$.

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CONCLUDING REMARKS

The static aerodynamic characteristics of models of exit and escape configurations of a Project Mercury capsule modified to include a destabilizer flap and increased parachute-housing diameter on the exit configuration and a Marman clamp and increased parachute-housing diameter on the escape configuration were investigated at Mach numbers from 3.0 to 6.8. The results warranted the following conclusions:

1. The modifications to the exit configuration had a negligible effect on the stability level of the model but shifted the pitching-moment curves so that no trim point existed for the angles of attack investigated.

2. The modifications to the escape configuration tended to increase the stability level but had no effect on the trim characteristics and pitch-up tendencies of the model.

3. The modifications reduced the slopes of the normal-force coefficients but had a negligible effect on the axial-force coefficient near zero angle of attack for both the exit and escape configurations.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., June 9, 1960.

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REFERENCES

1. Pearson, Albin O.: Wind-Tunnel Investigation at Mach Numbers From 0.50 to 1.14 of the Static Aerodynamic Characteristics of a Model of a Project Mercury Capsule. NASA TM X-292, 1960.

2. Shaw, David S., and Turner, Kenneth L.: Wind-Tunnel Investigation of Static Aerodynamic Characteristics of a 1/9-Scale Model of a Project Mercury Capsule at Mach Numbers From 1.60 to 4.65. NASA TM X-291, 1960.

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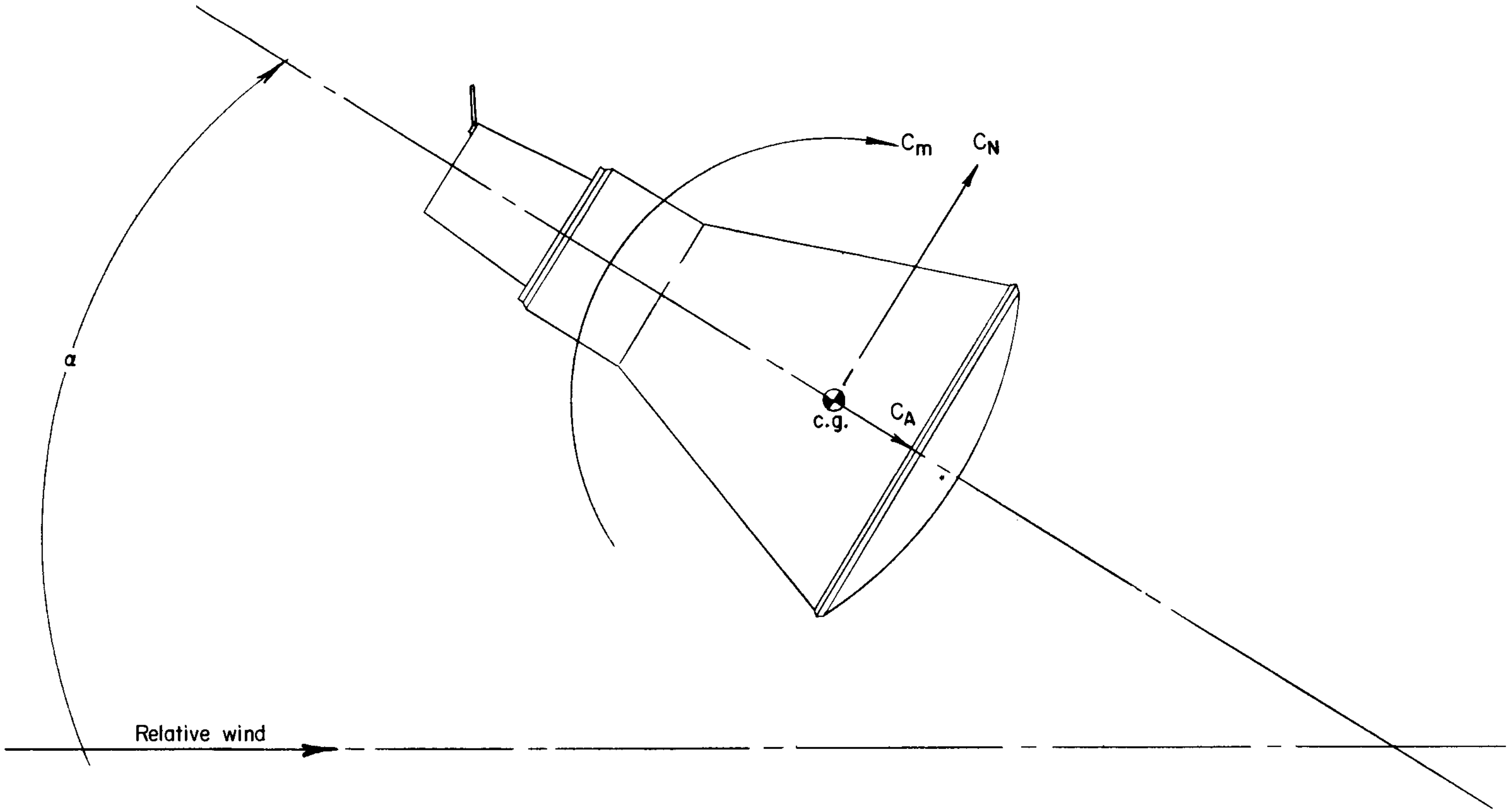

Figure 1.- Body axis system. (Arrows indicate positive direction.)

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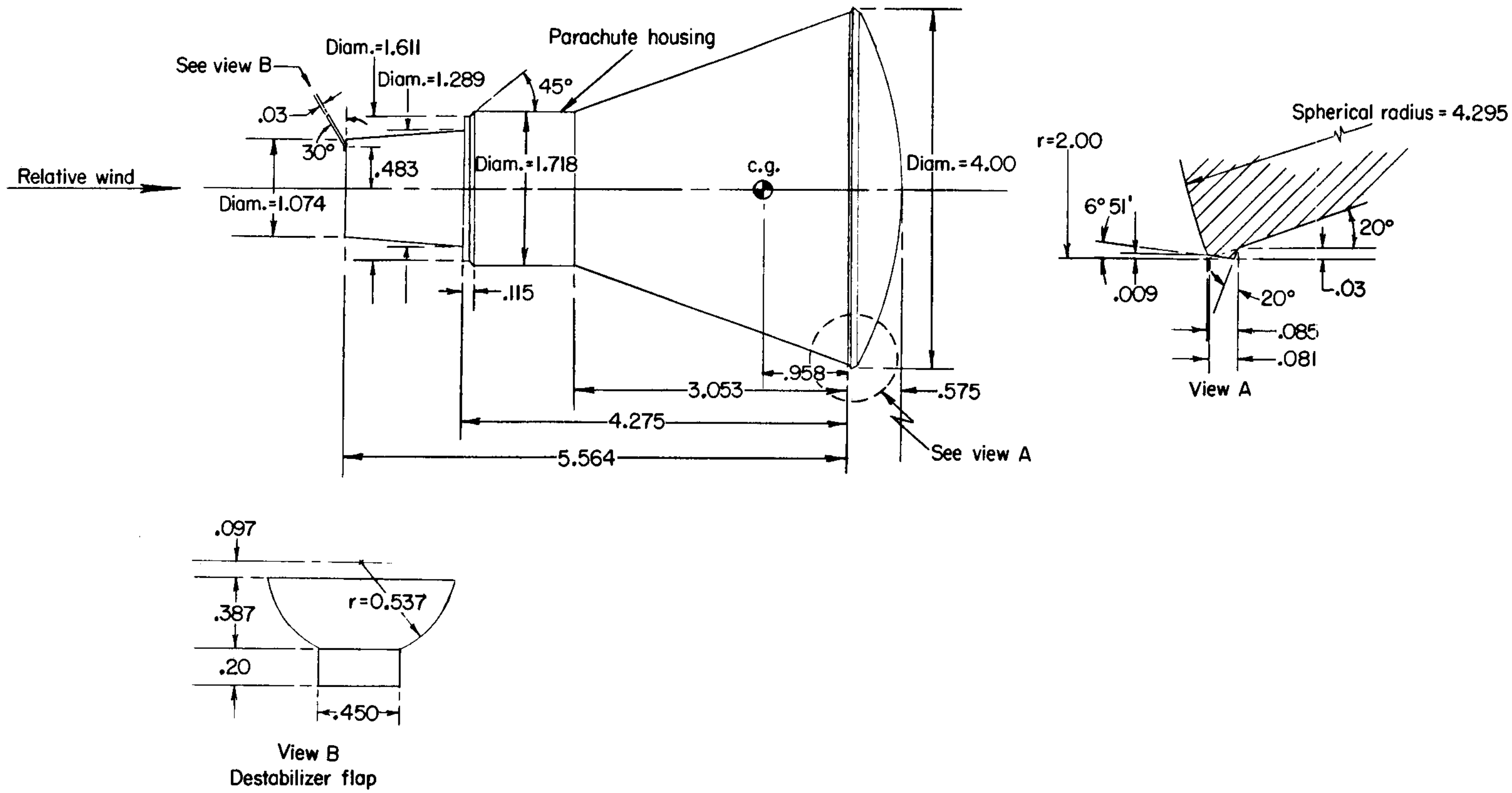

(a) Exit configuration.

Figure 2.- Details of model configurations. All dimensions are in inches unless otherwise noted.

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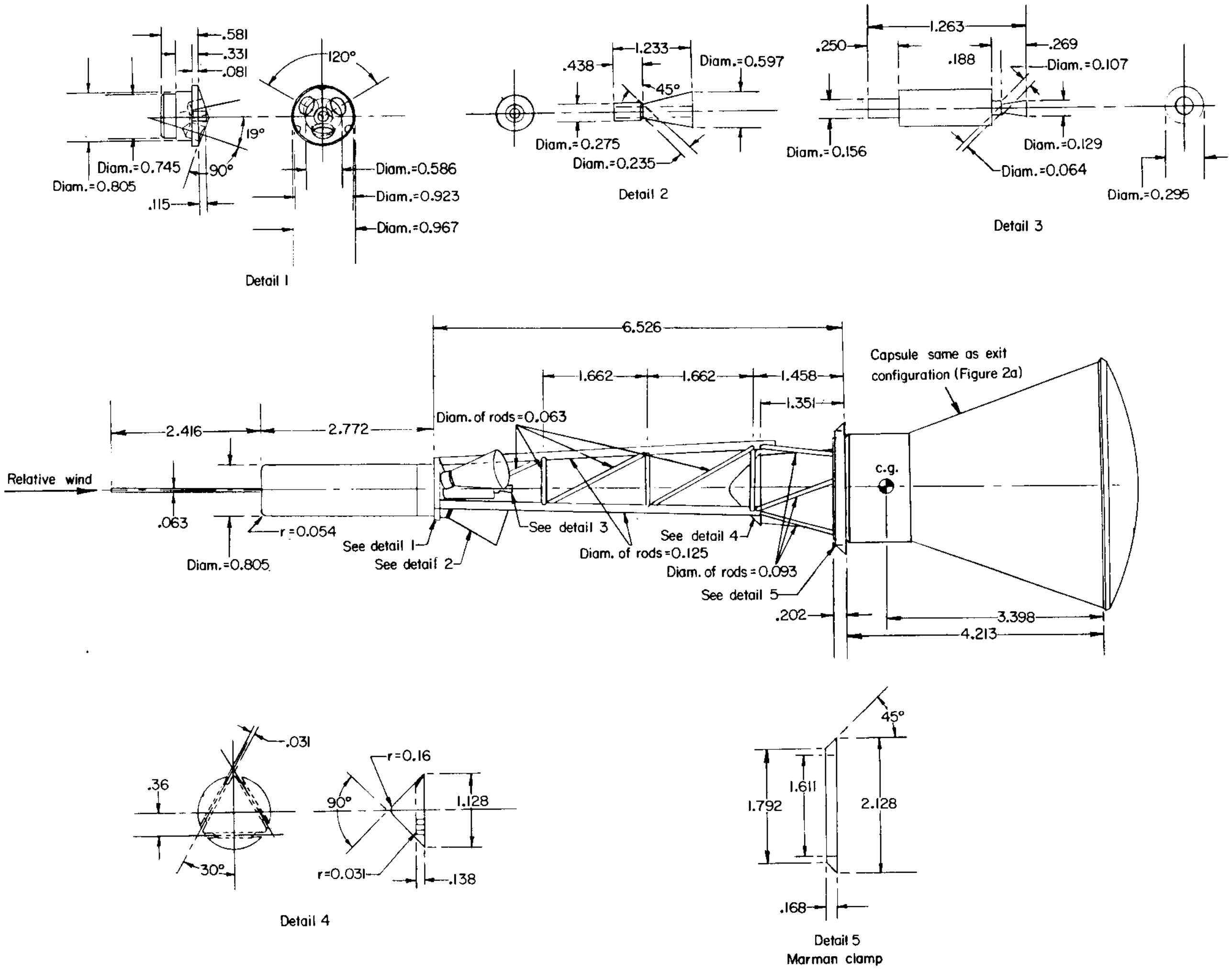

(b) Escape configuration.

Figure 2.- Concluded.

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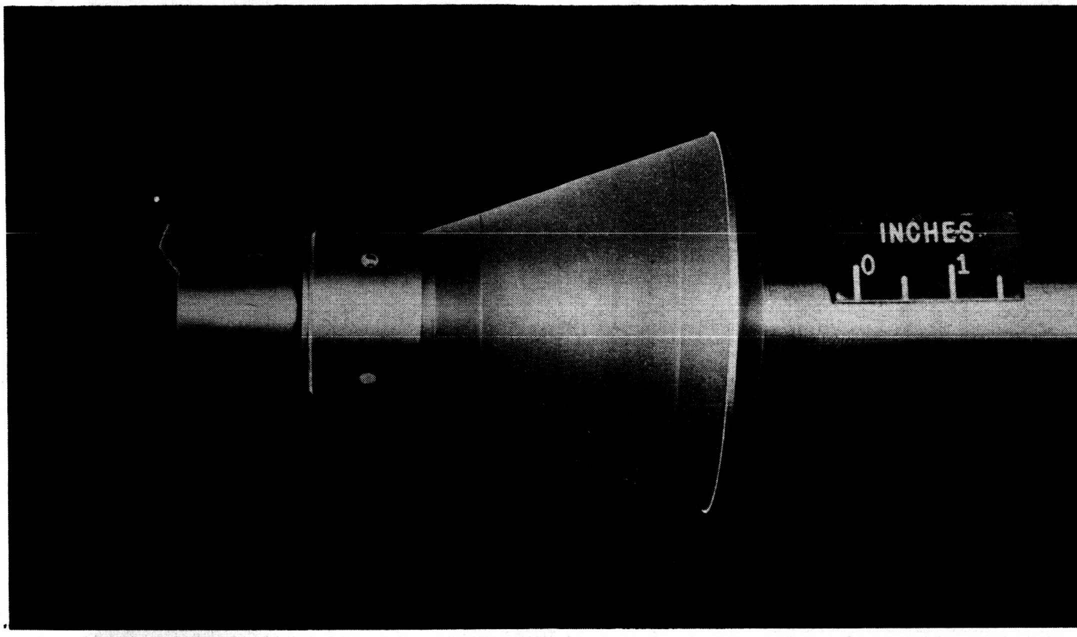
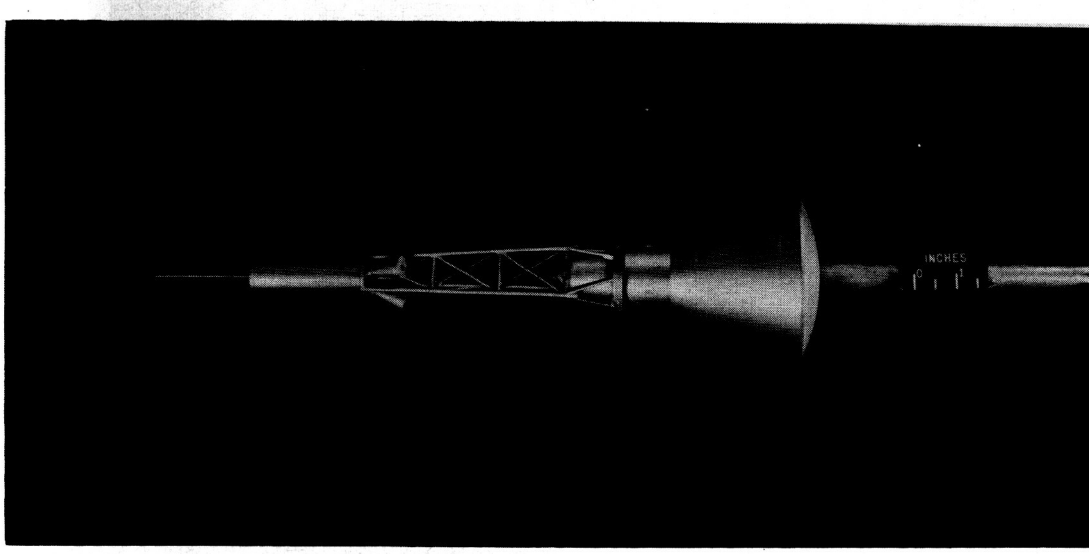


(a) Exit configuration. L-60-2680



(b) Escape configuration L-60-1228

Figure 3.- Photographs of model.

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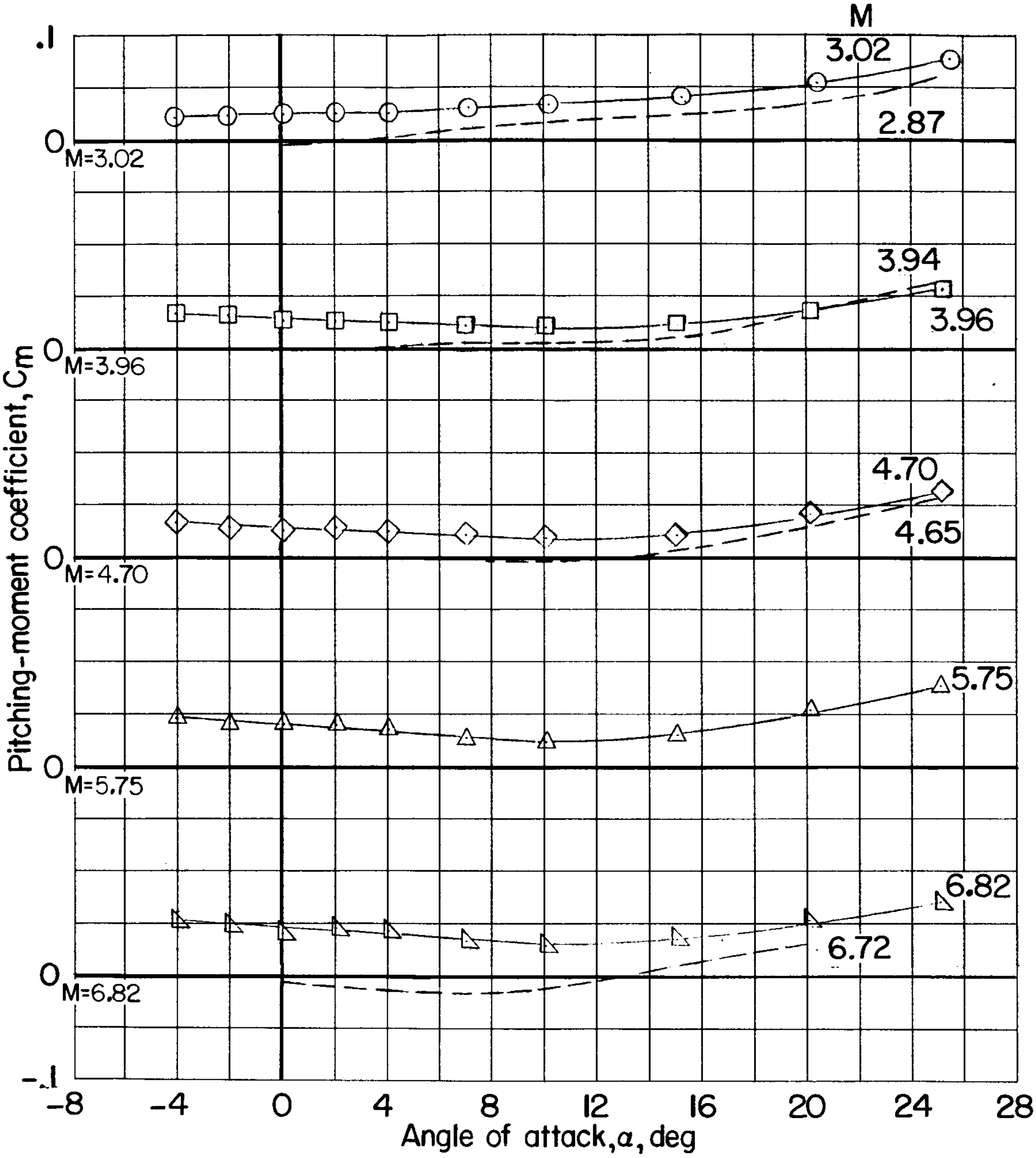

(a) Variation of C_m with α.

Figure 4.- Variation of static aerodynamic characteristics in pitch of model. Exit configuration. (Dashed lines indicate data from ref. 2 or from unpublished data from Langley 11-inch hypersonic tunnel.)

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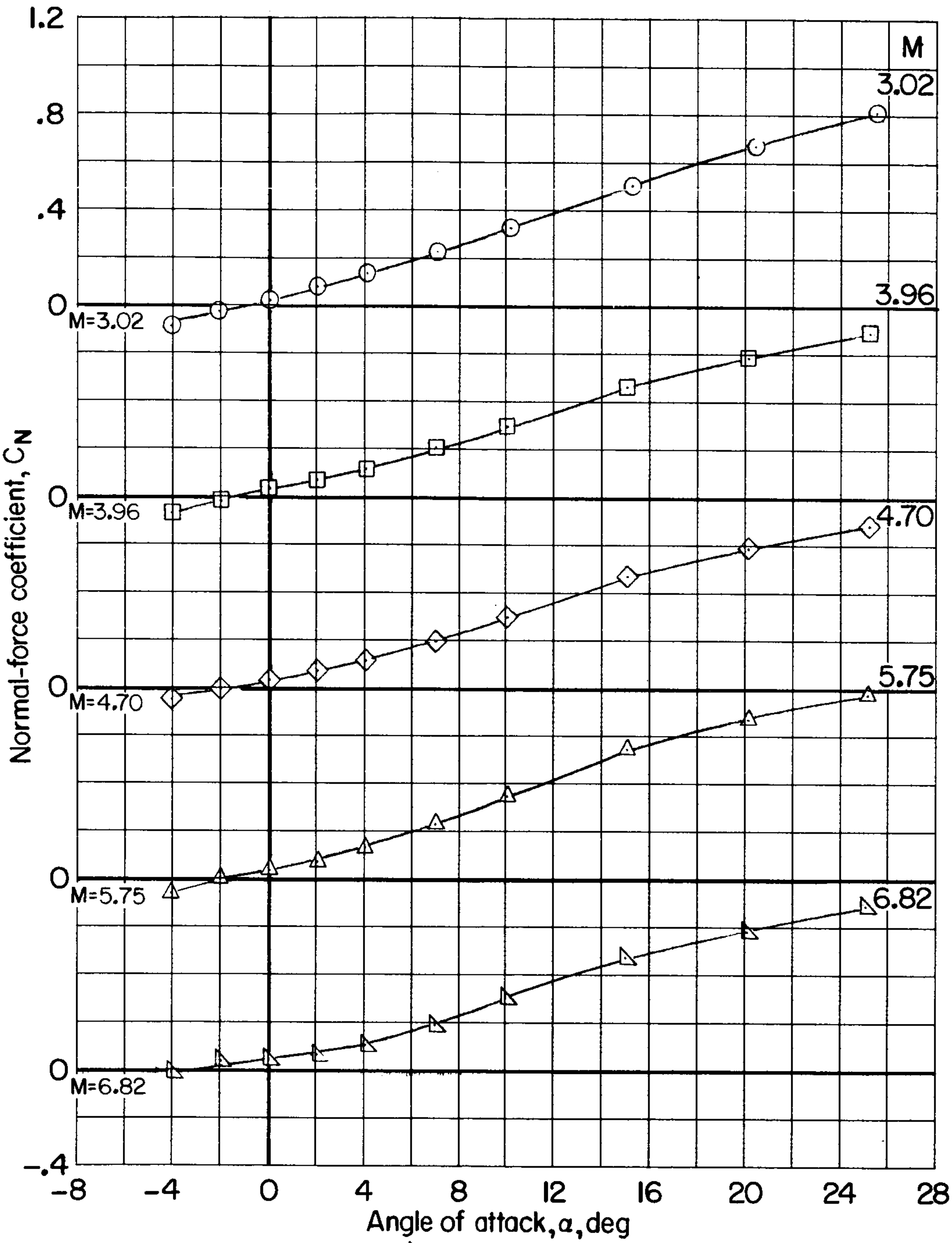

(b) Variation of C_N with α.

Figure 4.- Continued.

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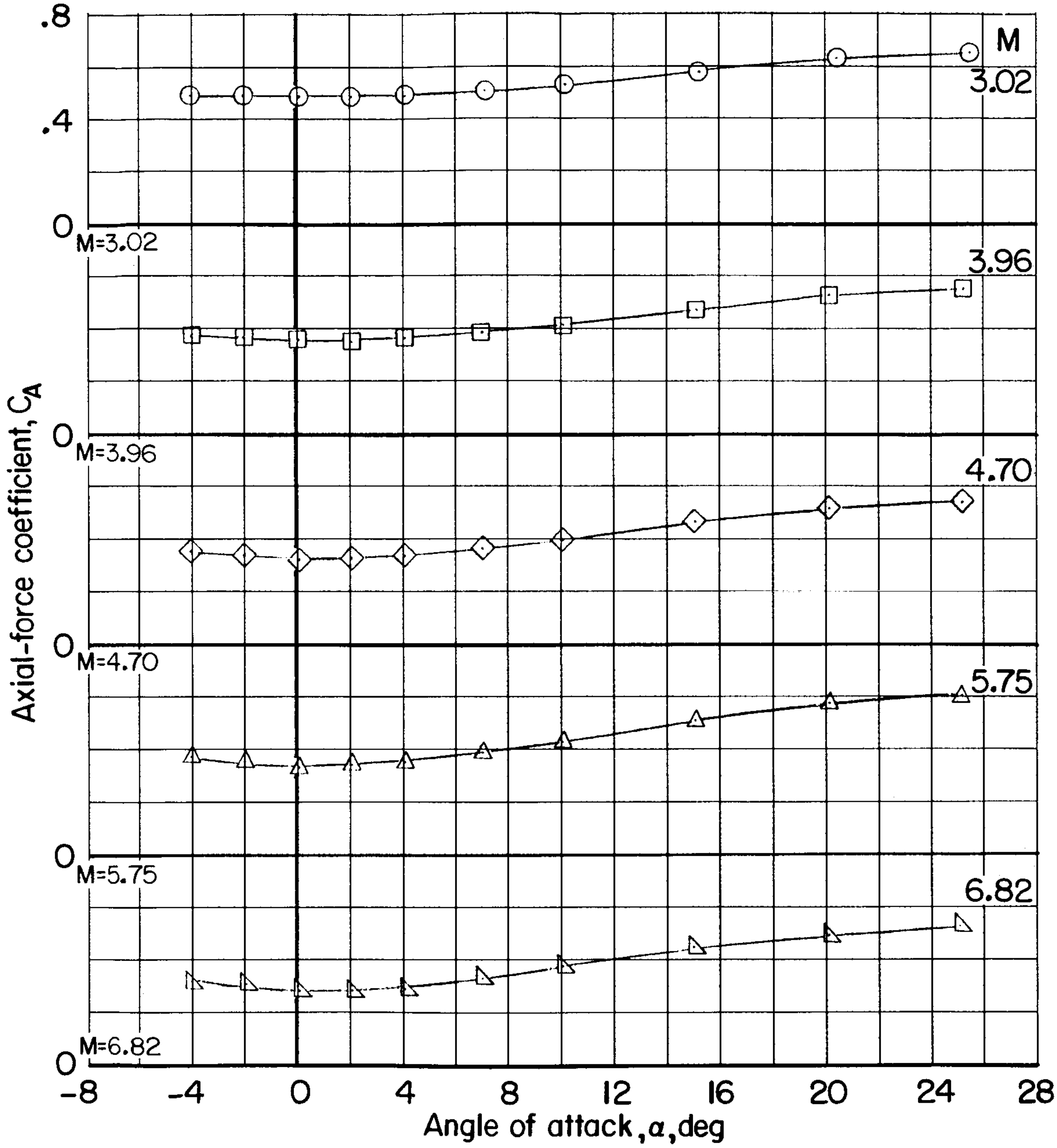

(c) Variation of C_A with α.

Figure 4.- Concluded.

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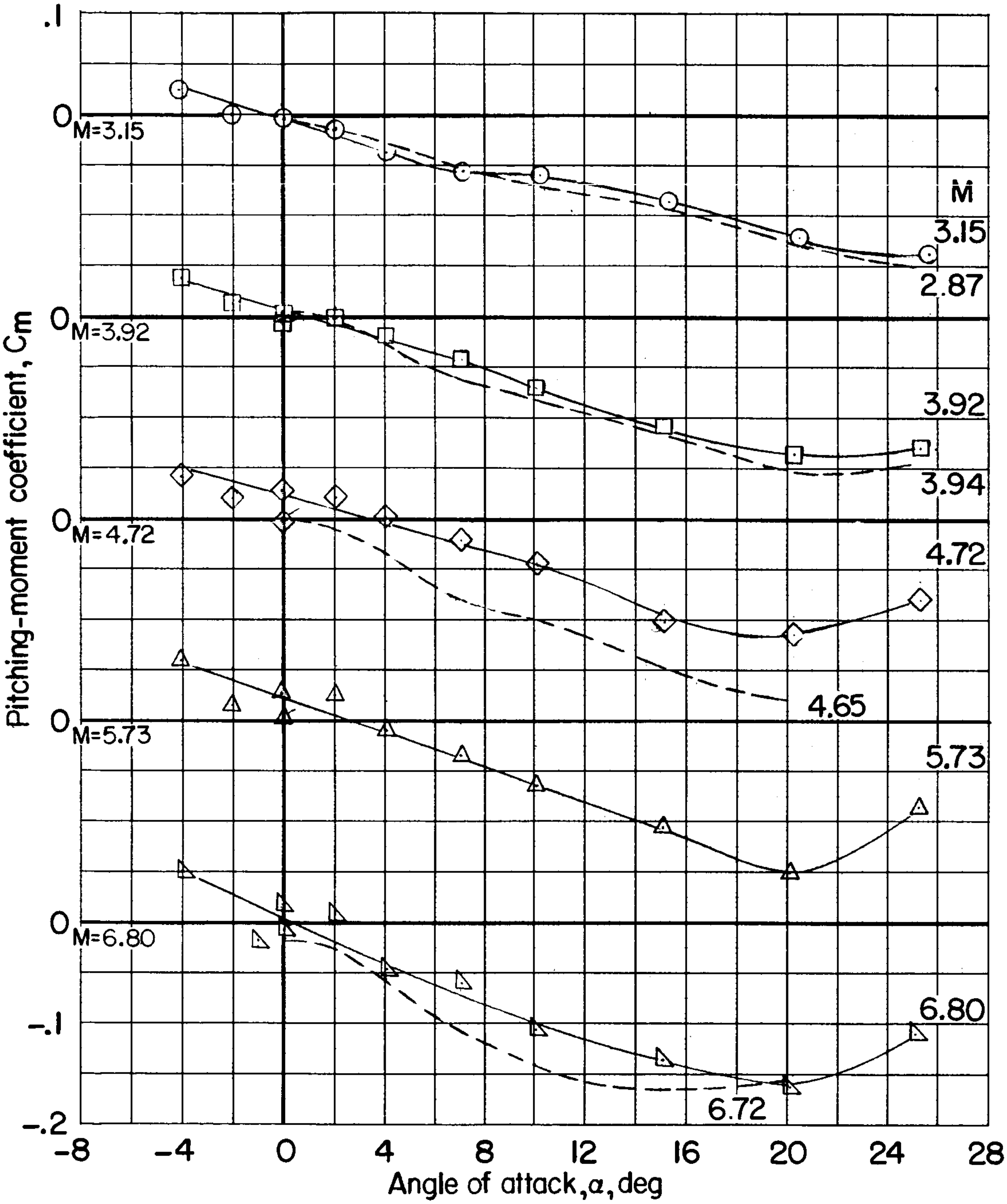

(a) Variation of C_m with α.

Figure 5.- Variation of static aerodynamic characteristics in pitch of model. Escape configuration. (Dashed lines indicate data from ref. 2 or from unpublished data from Langley 11-inch hypersonic tunnel.)

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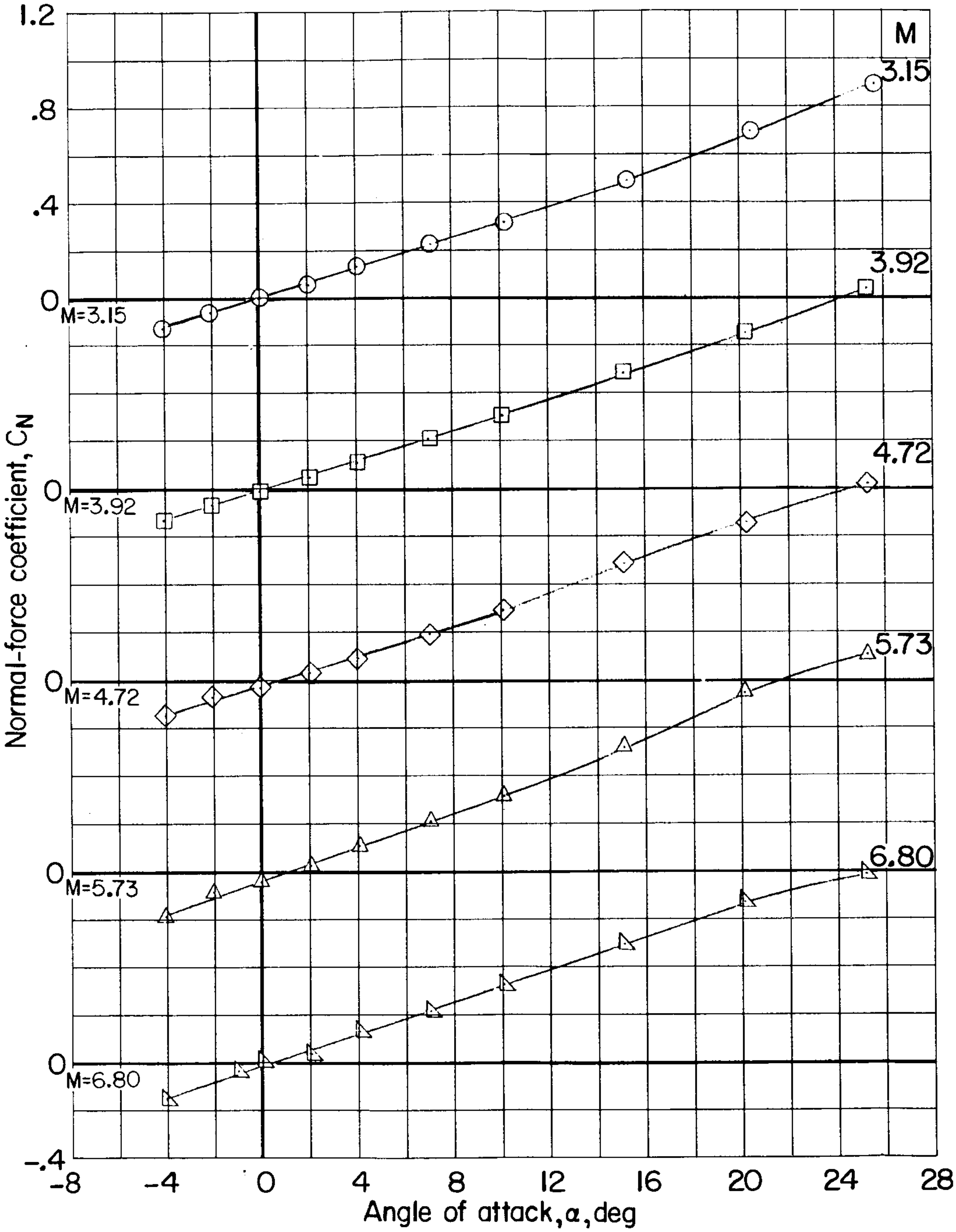

(b) Variation of C_N with α.

Figure 5.- Continued.

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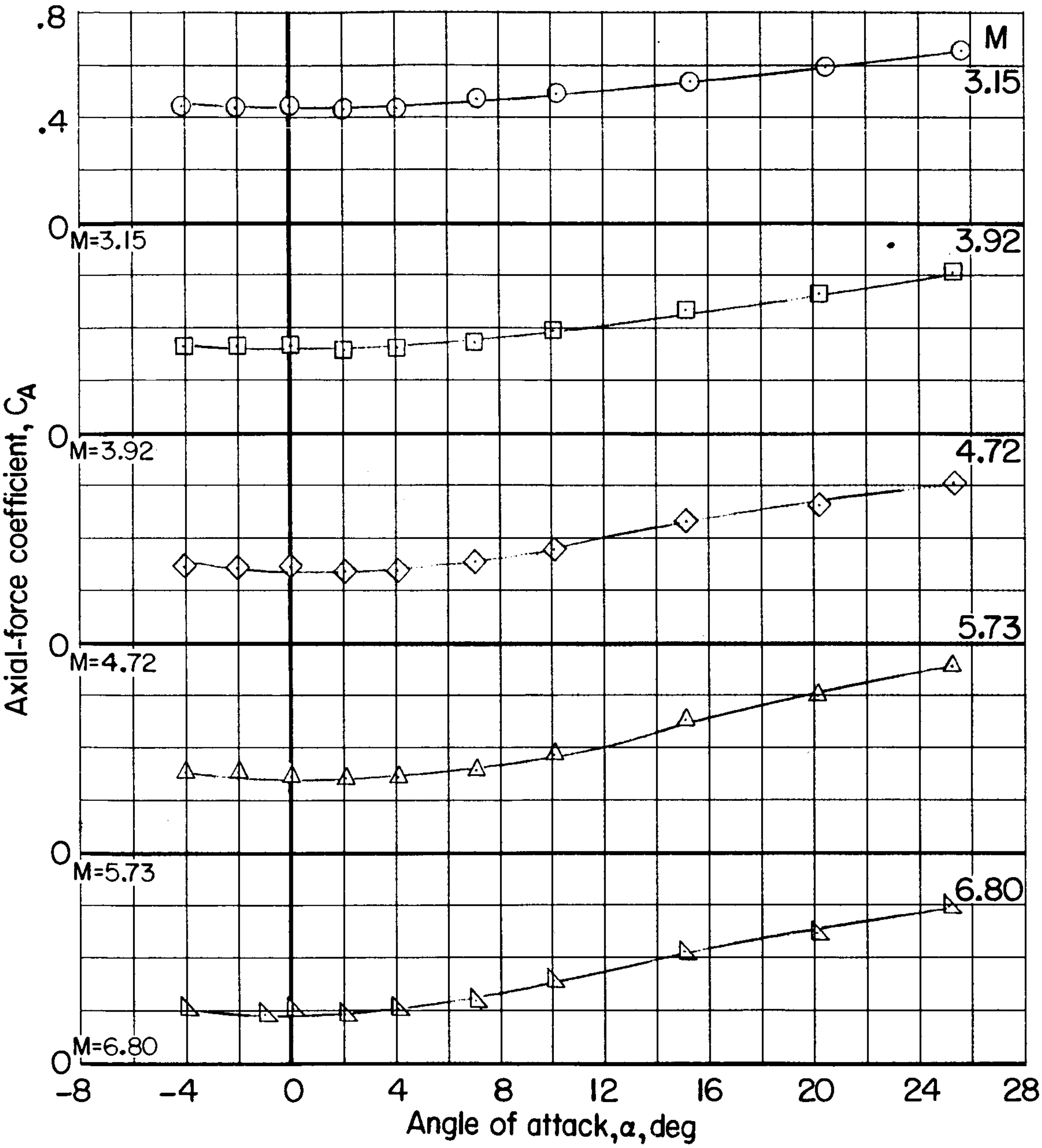

(c) Variation of C_A with α.

Figure 5.- Concluded.

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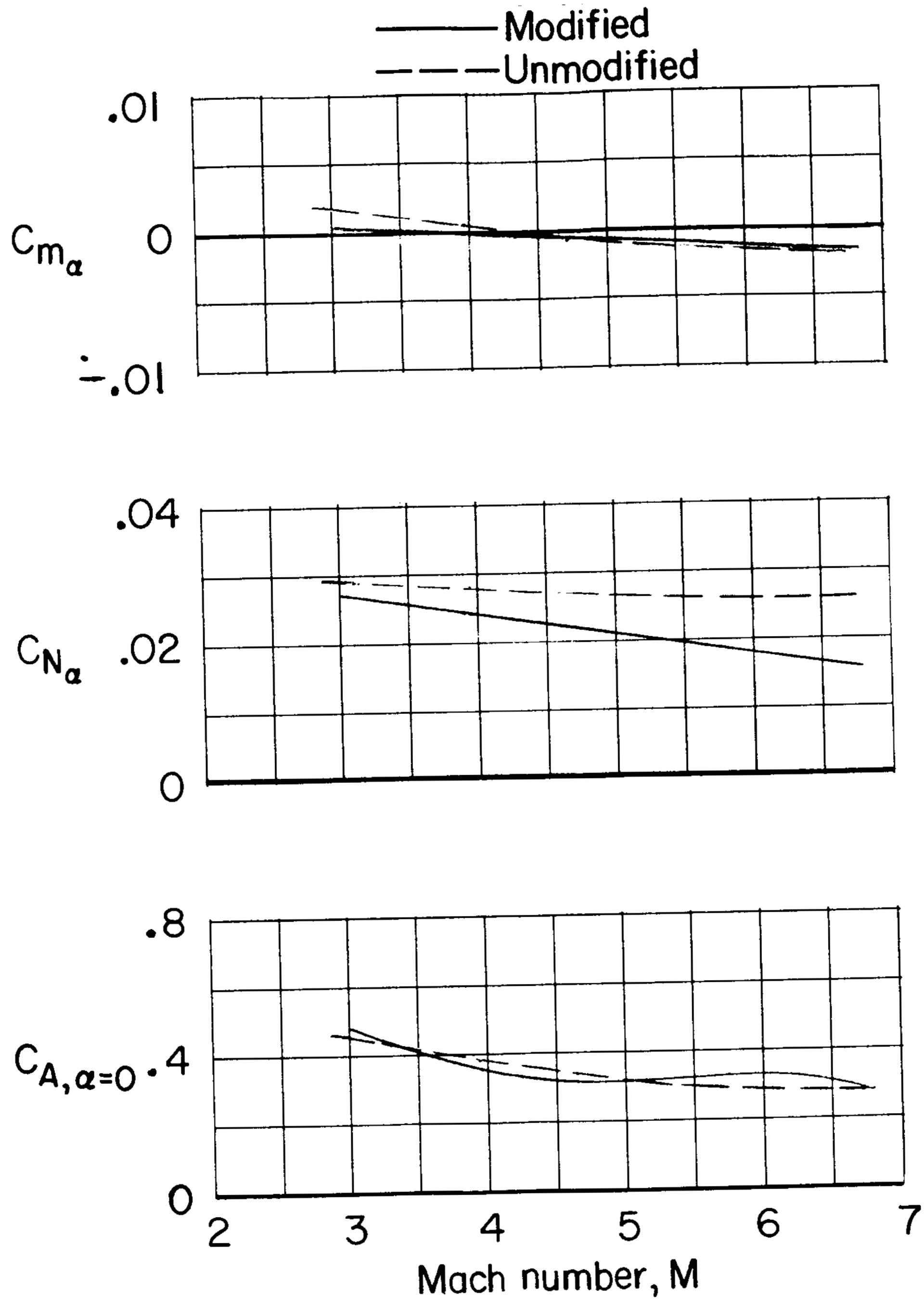

(a) Exit configuration.

Figure 6.- Summary of static aerodynamic characteristics in pitch of model. (Dashed lines indicate data from ref. 2 or from unpublished data from Langley 11-inch hypersonic tunnel.)

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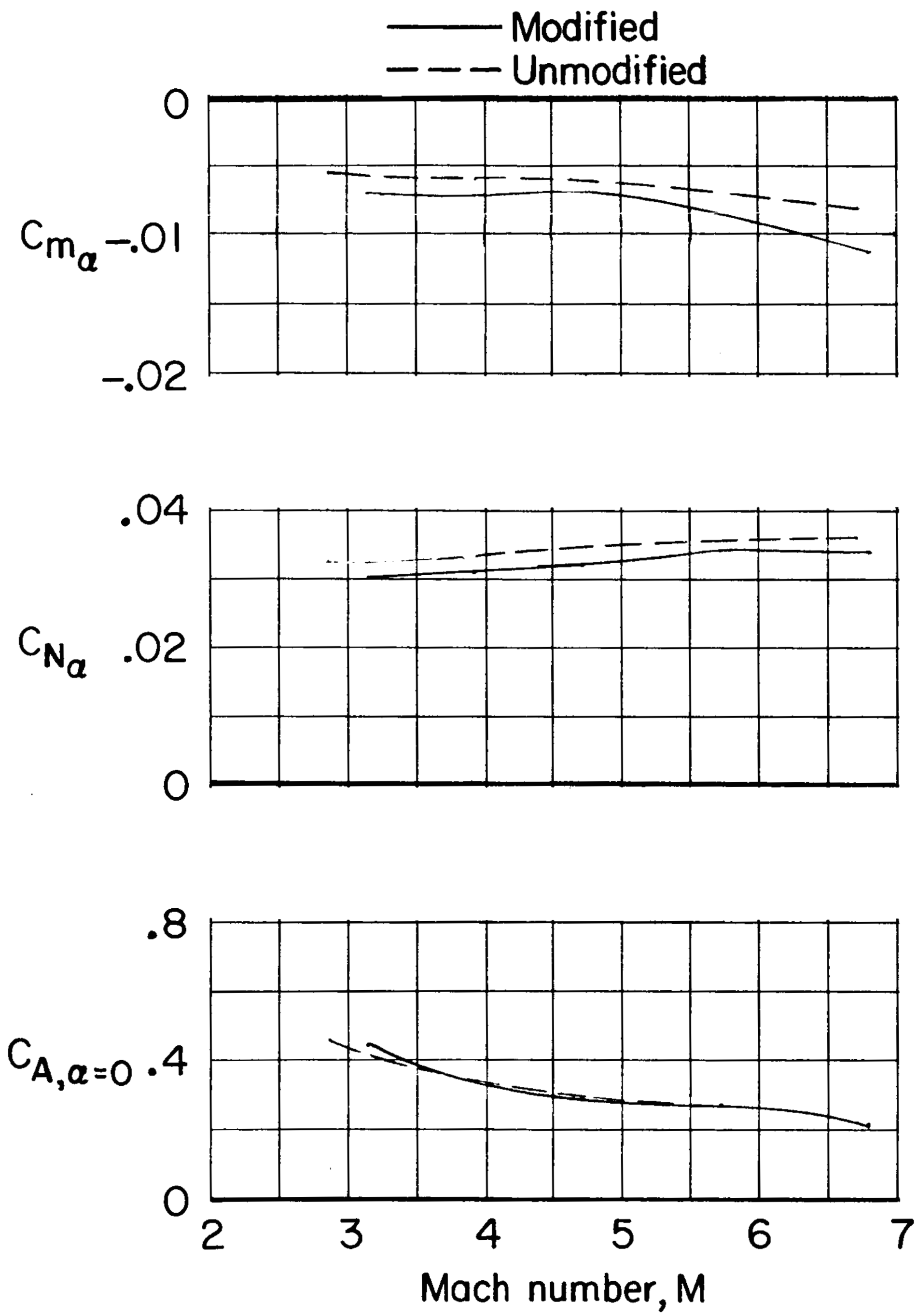

(b) Escape configuration.

Figure 6.- Concluded.