NACA

RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

RESULTS OF THE FLIGHT TEST OF A DUMMY OF THE MX-656 ROCKET-PROPELLED MODELS

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SUMMARY

The data obtained from the flight of a simplified (dummy) rocket-propelled model of the MX-656 have been analyzed to determine the booster-model characteristics and the model-alone characteristics up to a Mach number of 1.3.

The data indicate that the model-booster combination is satisfactory. The model alone is longitudinally stable in the Mach number range covered by the test (0.9 to 1.3) with the center of gravity at -15 percent of the mean aerodynamic chord. With the stabilizer setting at 0° the variation of normal-force coefficient with Mach number is not large. The total-drag-coefficient variation with Mach number is not unusual. About 12 percent of the total drag at a Mach number of 1.3 can be attributed to body base drag.

INTRODUCTION

At the request of the Air Materiel Command, U. S. Air Force, flight tests of rocket-propelled models of the MX-656 are to be made.

The models are designed to be boosted to supersonic speeds by a Deacon rocket motor. The configuration is quite unsymmetrical as compared to previous rocket-propelled models tested by the National Advisory Committee for Aeronautics. Therefore a dummy model was built and flown to obtain data on the performance, stability, and separation characteristics of the booster-model combination, and the longitudinal stability, trim change, and drag characteristics of the dummy alone. This paper presents the results obtained from the flight of this dummy model.

SYMBOLS

C_N	normal-force coefficient $\left(\frac{a_n}{g}\frac{W/S}{q}\right)$
C_c	chord-force coefficient $\left(-\frac{a_l}{g}\frac{W/S}{q}\right)$
a_n	normal acceleration, feet per second per second
a_l	longitudinal acceleration, feet per second per second
C_{m_α}	static longitudinal stability, per radian
$\left(\frac{\Delta p}{q}\right)_b$	base pressure coefficient
$\Delta p = p_b - p$	
p	free-stream static pressure, pounds per square foot
p_b	base pressure, pounds per square foot
q	dynamic pressure, pounds per square foot
W	weight, pounds
S	wing area (including that enclosed within fuselage), square feet
g	acceleration due to gravity, feet per second per second

MODEL AND TEST

Model

The basic geometry of the dummy is given in figure 1. Since the dummy was designed for ease of construction there are certain important differences between it and the MX-656 models. These differences are listed in table I.

For this test the weight of the model was 128.5 pounds, the pitching moment of inertia was 12.81 slug-feet square, and the center of gravity was at -15 percent of the mean aerodynamic chord. All surfaces were fixed at zero deflection relative to the model reference line. The booster was a Deacon rocket with stabilizing fins on the rear and a special adapter on the front to transmit the thrust to the model. The model and booster rocket are shown on the launcher ready for firing in figure 2.

Test

The data from the flight were obtained from photography and from telemeter, velocity-radar, flight-path-radar, and radiosonde records.

The telemetered data recorded were the normal and longitudinal accelerations of the model and booster, and two model base pressures. Mach number and dynamic pressure were obtained from radar and radiosonde data. The launching and boosted phases of the flight were recorded by 16-millimeter motion-picture cameras.

The Reynolds number of the test varied from 6.6×10^6 at $M = 0.9$ to 10.9×10^6 at $M = 1.3$.

RESULTS AND DISCUSSION

Combination Characteristics

The booster-model combination was found to perform satisfactorily during the three phases of flight: launching, free flight, and separation. This performance was determined from an examination of the telemeter record and the 16-millimeter motion pictures. Visual observation at the time of firing offered additional proof. The maximum Mach number obtained was about 1.34, and the model was free and well away from the influence of the booster by the time it had decelerated to a Mach number of 1.3. An auxiliary flap fastened to the booster adapter to give additional separating force apparently worked as desired. This flap which remained closed during positive acceleration was triggered by deceleration and gave the booster additional drag and a downward pitching moment at the time of separation.

Model Characteristics

Table I lists certain comparative geometric and structural details of the MX-656 models and the dummy model, and the differences should be kept well in mind when making conclusions about the MX-656 from the dummy data. The lower stiffness of the dummy boom and empennage, for instance, may affect the stability and trim adversely. The relatively thick wings and empennage of the dummy are believed to have a large adverse influence on the total drag.

Longitudinal stability.- At separation a pitching oscillation was induced by the difference in model trim attitude on and off the booster. The oscillation (fig. 3) is damped; this fact indicates that the model has dynamic and static stability in this speed range (M = 1.2 to 1.3) and at the test center of gravity (-15 percent of the mean aerodynamic chord). An analysis of this oscillation was made by the method of reference 1. Since no lift-curve-slope data on the configuration are available with which to calculate the longitudinal damping coefficients, only the stability parameter C_{m_α} was estimated. The values of C_{m_α} are given in figure 4 as a function of Mach number. As stated previously, the stability may be greatly influenced by the stiffness characteristics of the dummy. The rather sharp negative increase in C_{m_α} at a Mach number of 1.23, however, is in agreement with other tests, notably those of reference 1, which also indicate this sudden increase in stability near a Mach number of 1.2.

Longitudinal-trim change.- The longitudinal-trim change as determined by the variation with Mach number of the normal-force coefficient for a constant stabilizer setting (0°) is given in figure 5. At this center of gravity and tail setting the trim change near a Mach number of 1.0 is small and is in the nose-up direction. The model trims at very nearly zero normal-force coefficient at all Mach numbers covered by the test.

Total drag.- Since the normal-force coefficients were very nearly zero, the chord-force coefficients obtained from the longitudinal accelerations are taken equal to minimum drag coefficients. Values of the minimum drag coefficients so determined are shown in figure 6. The drag coefficient is practically constant in the Mach number range of 1.3 to 1.0. As previously noted, it is believed that the actual models will have appreciably lower drag coefficients.

Base drag.- The pressure was recorded at two points on the base, one in the plane of symmetry 2.34 inches from the bottom of the fuselage, and the other at a point corresponding to the center of the duct outlet on the MX-656 models (about 3.3 inches from the plane of symmetry and 2.2 inches from the bottom). The variation of the base pressure coefficient $\left(\frac{\Delta p}{q}\right)_b$ with Mach number is given in figure 7. As can be seen, both base pressure coefficients become positive at a Mach number of about 0.98. This positive base pressure (indicating negative base drag) at high subsonic speeds has been observed on other boattail bodies (unpublished data) and at present no explanation is available. An average base pressure coefficient was assumed from figure 7 and the contribution of the base to the total drag coefficient calculated. The base drag coefficient is plotted in figure 6. It can be seen that the base drag at supersonic speeds is appreciable (about 12 percent of the total drag at a Mach number of 1.3).

CONCLUDING REMARKS

A simplified rocket-propelled dummy model of the MX-656 has been flown and the following conclusions may be made from the test data:

1. The booster-model combination performed satisfactorily.

2. The dummy is longitudinally stable in the Mach number range covered by the test (0.9 to 1.3) with the center of gravity at -15 percent of the mean aerodynamic chord.

3. The longitudinal-trim change near a Mach number of 1.0 is a pitching-up tendency of small magnitude.

4. The total minimum drag coefficient is very nearly constant between a Mach number of 1.0 and 1.3.

5. The base drag is of the order of 12 percent of the total drag at a Mach number of 1.3.

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REFERENCE

1. Gillis, C. L., Peck, R. F., and Vitale, A. James: Preliminary Results from a Free-Flight Investigation at Transonic and Supersonic Speeds of the Longitudinal Stability and Control Characteristics of an Airplane Configuration with a Thin Straight Wing of Aspect Ratio 3. NACA RM L9K25a, 1950.

TABLE I

DIFFERENCES BETWEEN MX-656 MODEL AND DUMMY MODEL

Details	MX-656 Model	Dummy Model
Scoops	Open	Faired into fuselage
Ducts	Open	Closed
Airfoils:		
Wing	Constant percent thickness, 4.5 percent	Constant thickness, 0.625 inch
Horizontal tail	Constant percent thickness, 4.5 percent	Constant thickness, 0.50 inch
Vertical tail	Constant percent thickness, 4.5 percent	Constant thickness, 0.44 inch
Construction material:		
Wing	Duralumin	Duralumin
Tail	Duralumin	Plywood
Body	Duralumin and magnesium	Pine

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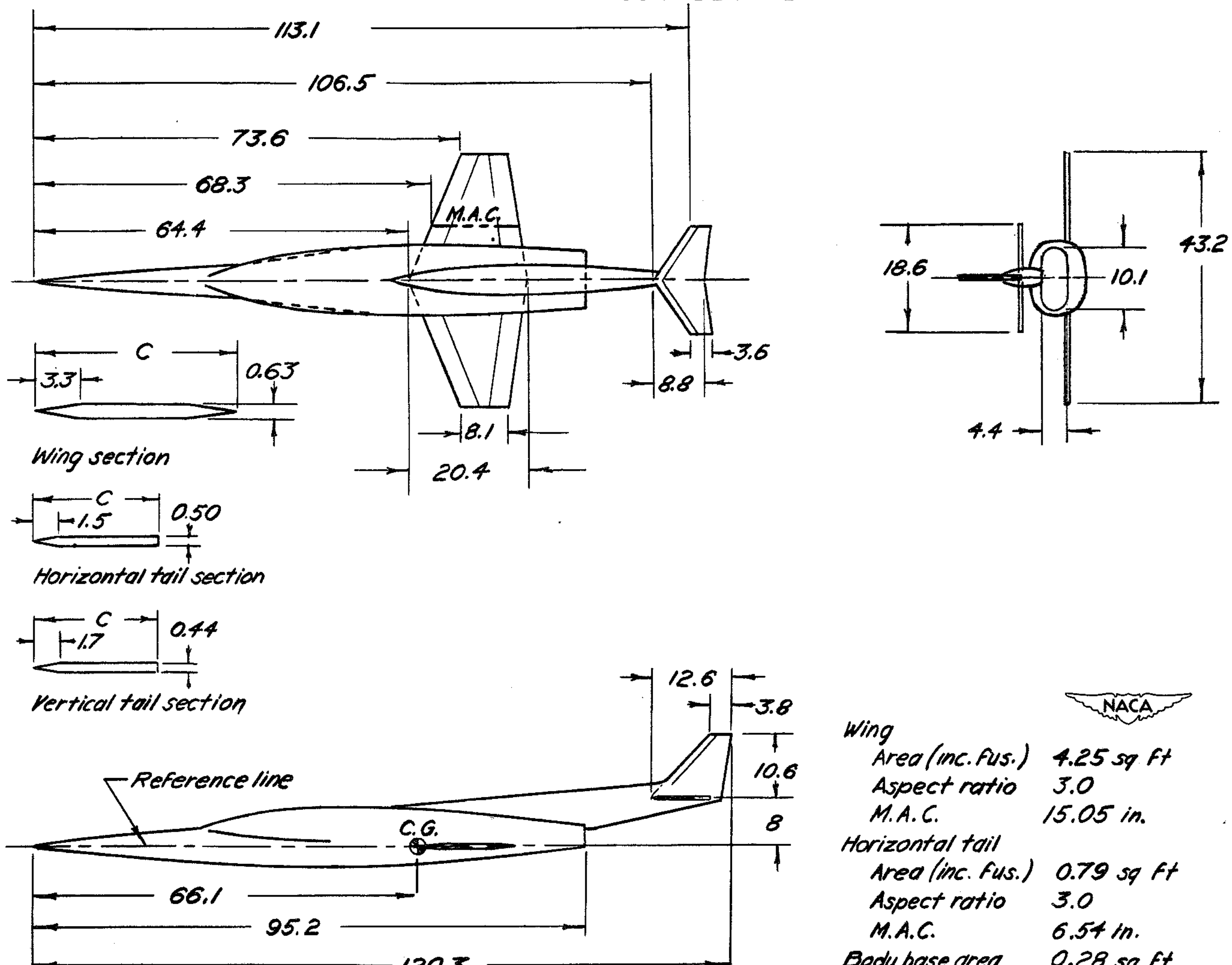

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Figure 1.- General arrangement of the dummy model. All dimensions in inches.

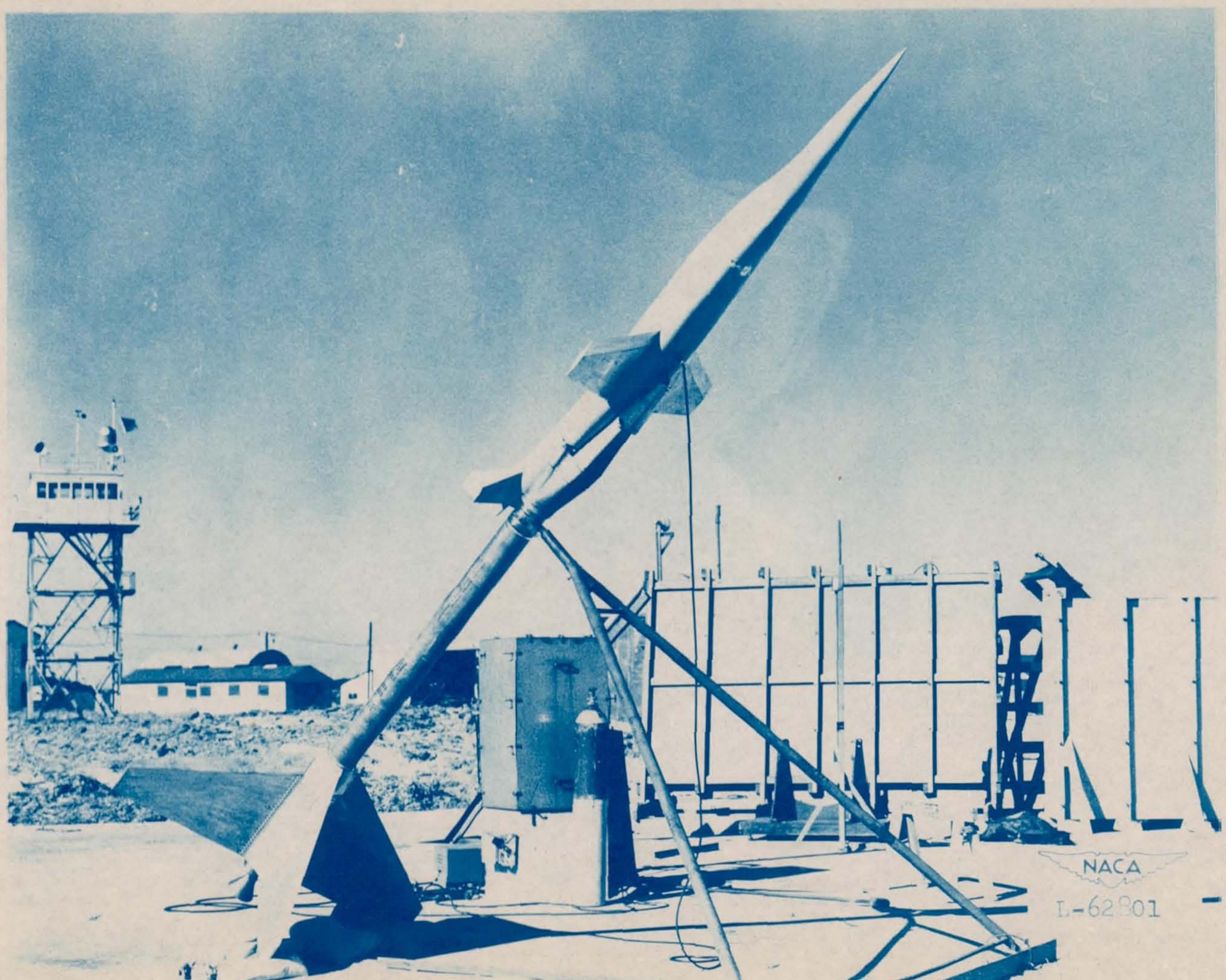

Figure 2.- Dummy model and booster on launcher.

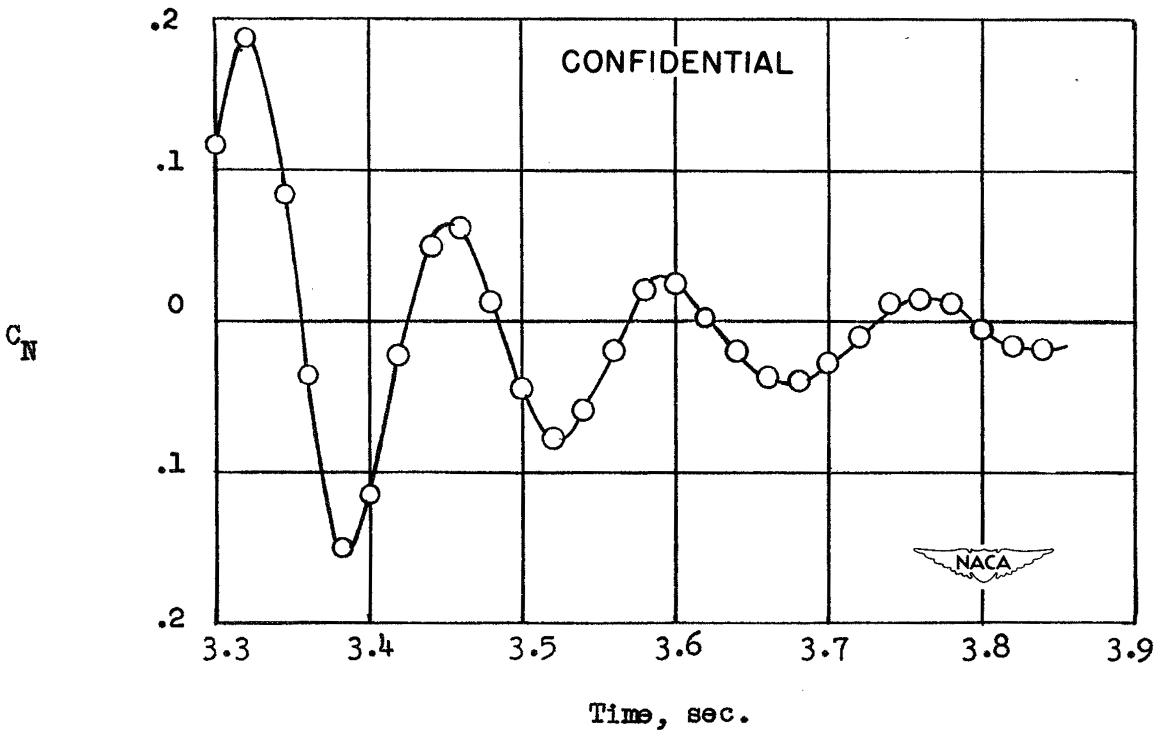

Figure 3.- Variation of normal-force coefficient C_N with time during pitching oscillation.

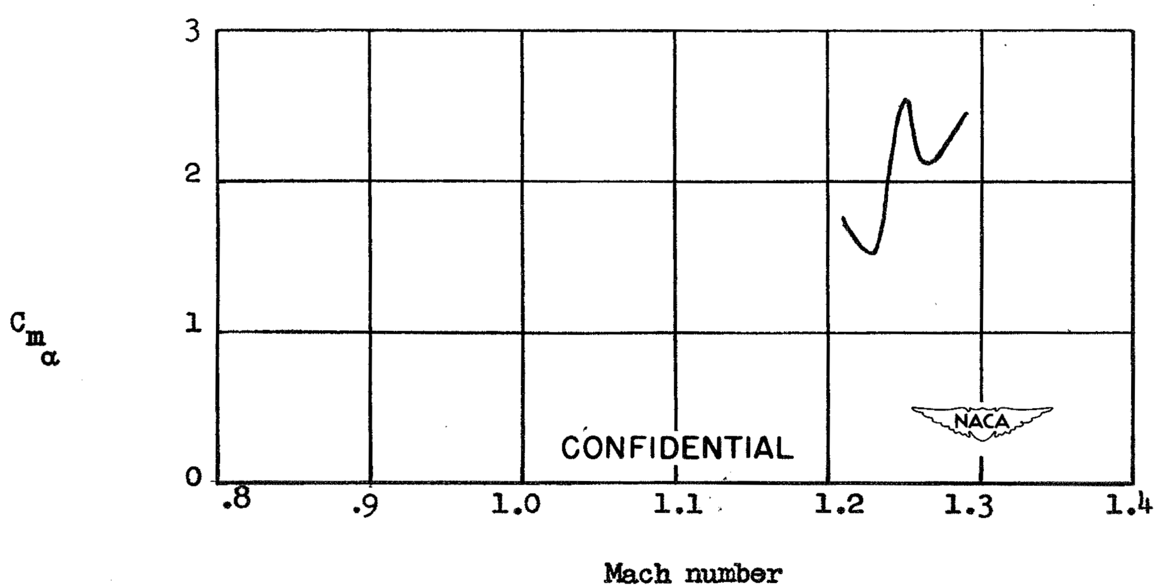

Figure 4.- Variation of static longitudinal stability with Mach number.

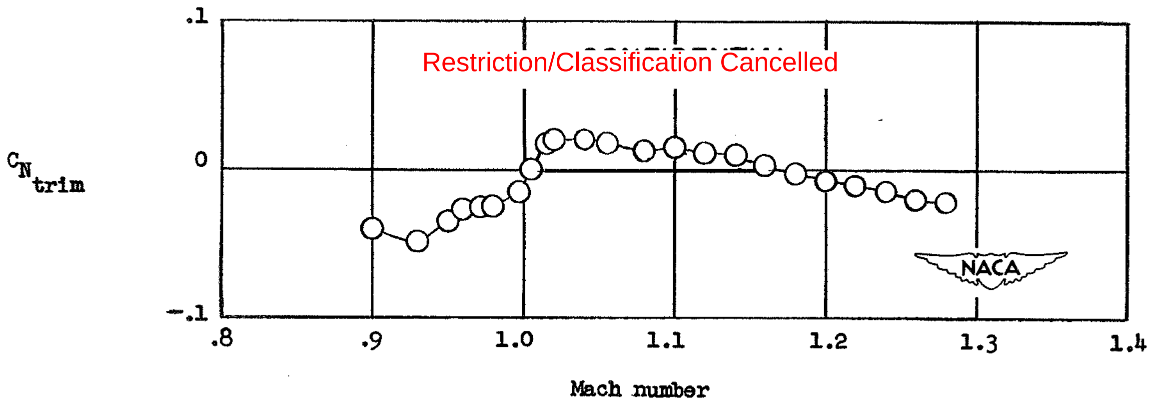

Figure 5.- Variation of trim normal-force coefficient with Mach number.

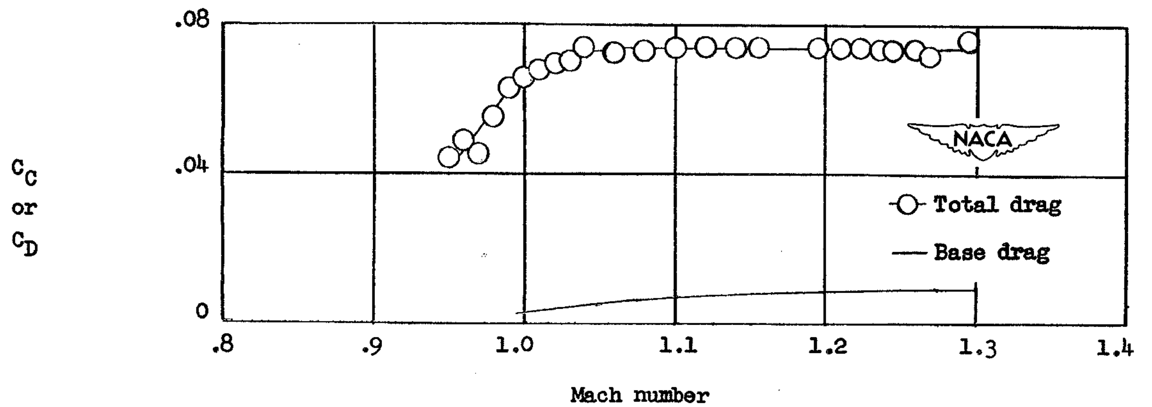

Figure 6.- Variation of drag coefficient with Mach number.

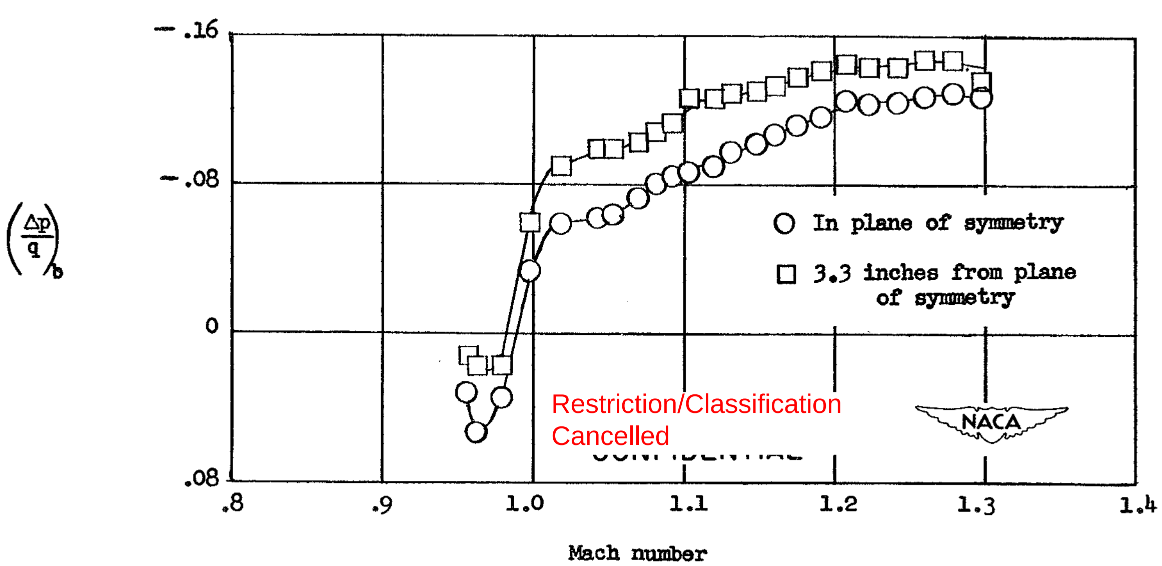

Figure 7.- Variation of base pressure coefficient with Mach number.