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RESEARCH MEMORANDUM

LIFT, DRAG, AND PITCHING MOMENT OF LOW-ASPECT-RATIO WINGS AT SUBSONIC AND SUPERSONIC SPEEDS - BODY OF REVOLUTION

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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LIFT, DRAG, AND PITCHING MOMENT OF LOW-ASPECT-RATIO WINGS AT SUBSONIC AND SUPERSONIC SPEEDS — BODY OF REVOLUTION

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SUMMARY

The lift, drag, and pitching moment of a body of revolution are presented for Mach numbers from 0.60 to 0.92 and from 1.20 to 1.70. These data were obtained at test Reynolds numbers of 0.64 million, 1.02 million, and 1.59 million.

INTRODUCTION

A research program is in progress at the Ames Aeronautical Laboratory to ascertain experimentally at subsonic and supersonic Mach numbers the characteristics of wings of interest in the design of high-speed fighter airplanes. The results of this program are presented in references 1 to 12. These references present the lift, drag, and pitching-moment characteristics of wing-body combinations employing wings designed specifically to study the effects of variations in plan form, twist, camber, and thickness. The shape of the body was derived from theoretical consideration of minimum pressure drag at supersonic speeds for a given length and volume. This report presents the results of tests of the body alone. As in references 1 to 12, the data herein are presented without analysis to expedite publication.

NOTATION

b actual length of body

l length of body including portion removed to accommodate sting

M Mach number

[redacted]

[redacted]

q free-stream dynamic pressure

R Reynolds number based on the maximum body diameter

r radius of body

r_o maximum body radius

S maximum body cross-sectional area

x longitudinal distance from nose of body

α angle of attack of body axis, degrees

C_D drag coefficient $\left(\frac{\text{drag}}{qS}\right)$

C_L lift coefficient $\left(\frac{\text{lift}}{qS}\right)$

C_m pitching-moment coefficient $\left(\frac{\text{pitching moment}}{qSb}\right)$

APPARATUS

Wind Tunnel and Equipment

The experimental investigation was conducted in the Ames 6- by 6-foot supersonic wind tunnel. In this wind tunnel, the Mach number can be varied continuously and the stagnation pressure can be regulated to maintain a given test Reynolds number. The air is dried to prevent formation of condensation shocks. Further information on this wind tunnel is presented in reference 13.

The model was sting mounted in the tunnel, the diameter of the sting being about 93 percent of the diameter of the body base. The pitch plane of the model support was horizontal. A 4-inch-diameter, four-component, strain-gage balance, enclosed within the body of the model, was used to measure the aerodynamic forces and moments. This balance is described in greater detail in reference 14.

Model

A plan view of the model and certain model dimensions are given in figure 1. Other important geometric characteristics of the model are as follows:

Actual fineness ratio (based on length b; fig. 1)	9.86
Fineness ratio (based on length l; fig. 1)	12.5
Cross-section shape	Circular
Maximum cross-sectional area, square feet	0.1235
Distance to the moment center from nose, feet	2.471

The body spar was steel and was covered with aluminum to form the body contours.

TESTS AND PROCEDURE

Range of Test Variables

The aerodynamic characteristics of the model (as a function of angle of attack) were investigated for a range of Mach numbers from 0.60 to 0.92 and from 1.20 to 1.70. Data were obtained at Reynolds numbers of 0.64 million, 1.02 million, and 1.59 million.

Reduction of Data

Factors which could affect the accuracy of these results, together with the corrections applied, are discussed in the following paragraphs:

Tunnel-wall interference.- No corrections were made to the subsonic results for the induced effects of the tunnel walls resulting from lift on the model since these effects were negligible.

The effects of constriction of the flow at subsonic speeds by the tunnel walls were taken into account by the methods of reference 15. This correction was calculated for conditions at zero angle of attack and was applied throughout the angle-of-attack range. At a Mach number of 0.90, this correction amounted to about 1.5-percent increase in the Mach number and in the dynamic pressure over that determined from a calibration of the wind tunnel without a model in place.

For the tests at supersonic speeds, the reflection from the tunnel walls of the Mach wave originating at the nose of the body did not cross the model. No corrections were required, therefore, for tunnel-wall effects.

Stream variations.— No corrections were made to the subsonic data of the present report for the effects of the stream inclination and stream curvature in the tunnel air stream. The effects of these stream irregularities upon the measured characteristics of the body should be small, since references 8 to 12 indicate only a small effect upon the measured characteristics of wing-body combinations. At subsonic speeds, the longitudinal variation of static pressure in the region of the model is not known accurately at present, but a preliminary survey has indicated that it is less than 2 percent of the dynamic pressure. No correction for this effect was made.

A survey of the air stream in the 6- by 6-foot supersonic wind tunnel at supersonic speeds (reference 13) has shown a stream curvature only in the yaw plane of the model. The effects of this curvature on the measured characteristics of the present model are not known, but are believed to be negligible. The survey also indicated that there is a static-pressure variation in the test section of sufficient magnitude to affect the drag results. A correction was added to the measured drag coefficient, therefore, to account for the longitudinal buoyancy caused by this static-pressure variation. This correction varied from as much as −0.016 at a Mach number of 1.30 to 0.012 at a Mach number of 1.70.

Support interference.— At subsonic speeds, the effects of support interference on the aerodynamic characteristics of the model are not known. For the present model, it is believed that such effects consisted primarily of a change in the pressure at the base of the model. In an effort to correct at least partially for this support interference, the base pressure was measured and the drag data were adjusted to correspond to a base pressure equal to the static pressure of the free stream.

At supersonic speeds, the effects of support interference for a body-sting configuration similar to that of the present model are shown by reference 16 to be confined to a change in base pressure. The previously mentioned adjustment of the drag for base pressure, therefore, was also applied at supersonic speeds.

RESULTS

The results are presented in this report without analysis in order to expedite publication. The variation of lift coefficient, drag coefficient, and pitching-moment coefficient with angle of attack at Reynolds numbers of 0.64 million, 1.02 million, and 1.59 million and at Mach numbers from 0.60 to 1.70 are shown in figure 2.

Ames Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Moffett Field, Calif.

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Equation of fuselage radii

$$\frac{r}{r_o} = \left[1-\left(1-\frac{2x}{l}\right)^2\right]^{3/4}$$

All dimensions shown in inches

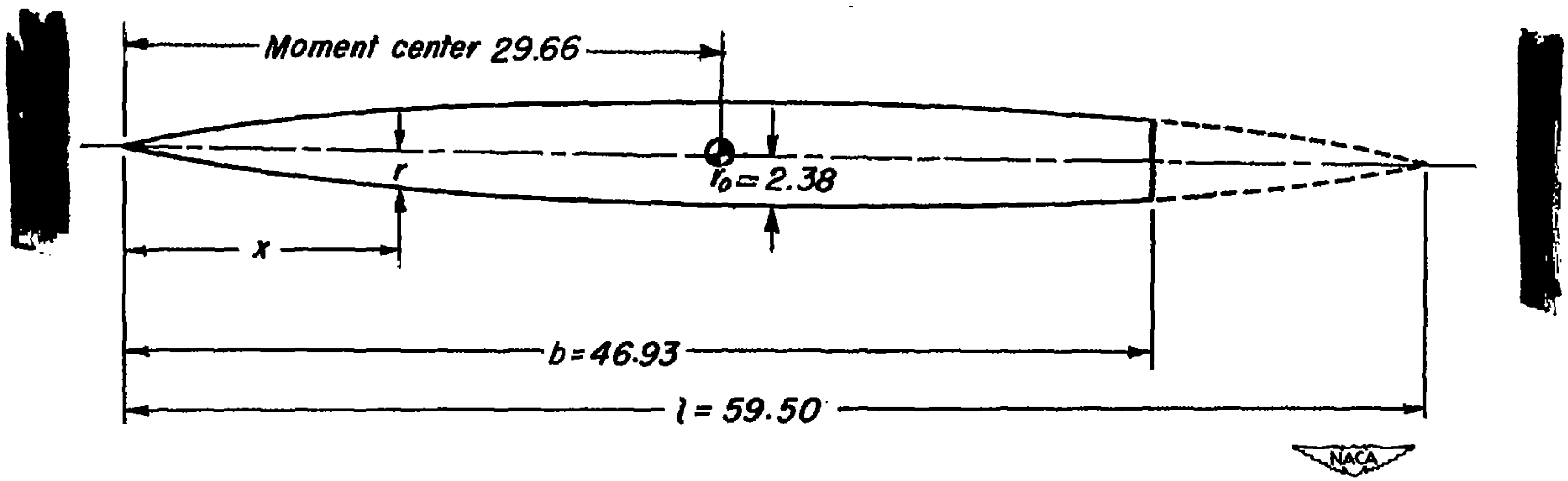

Figure 1.- Plan view of body.

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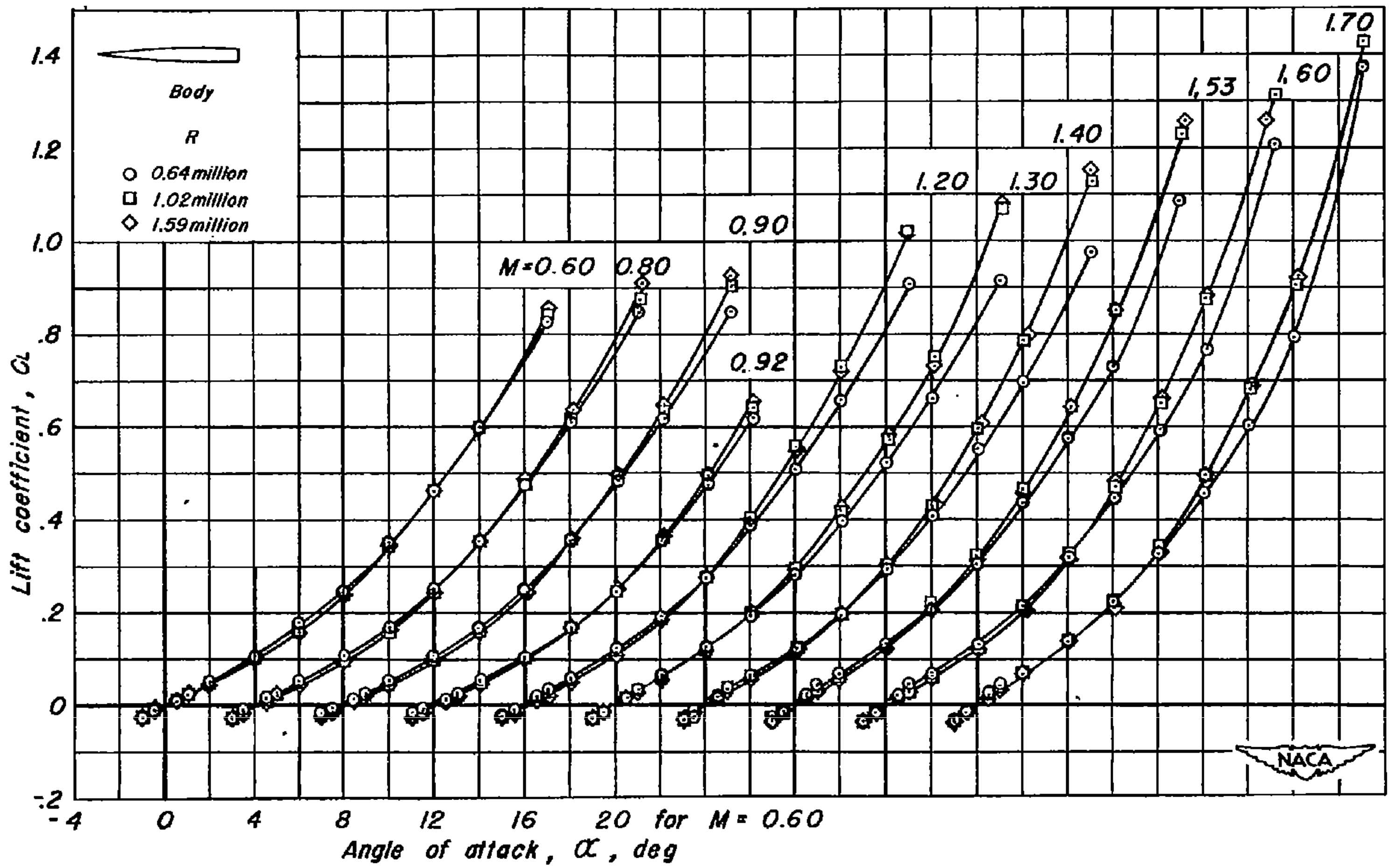
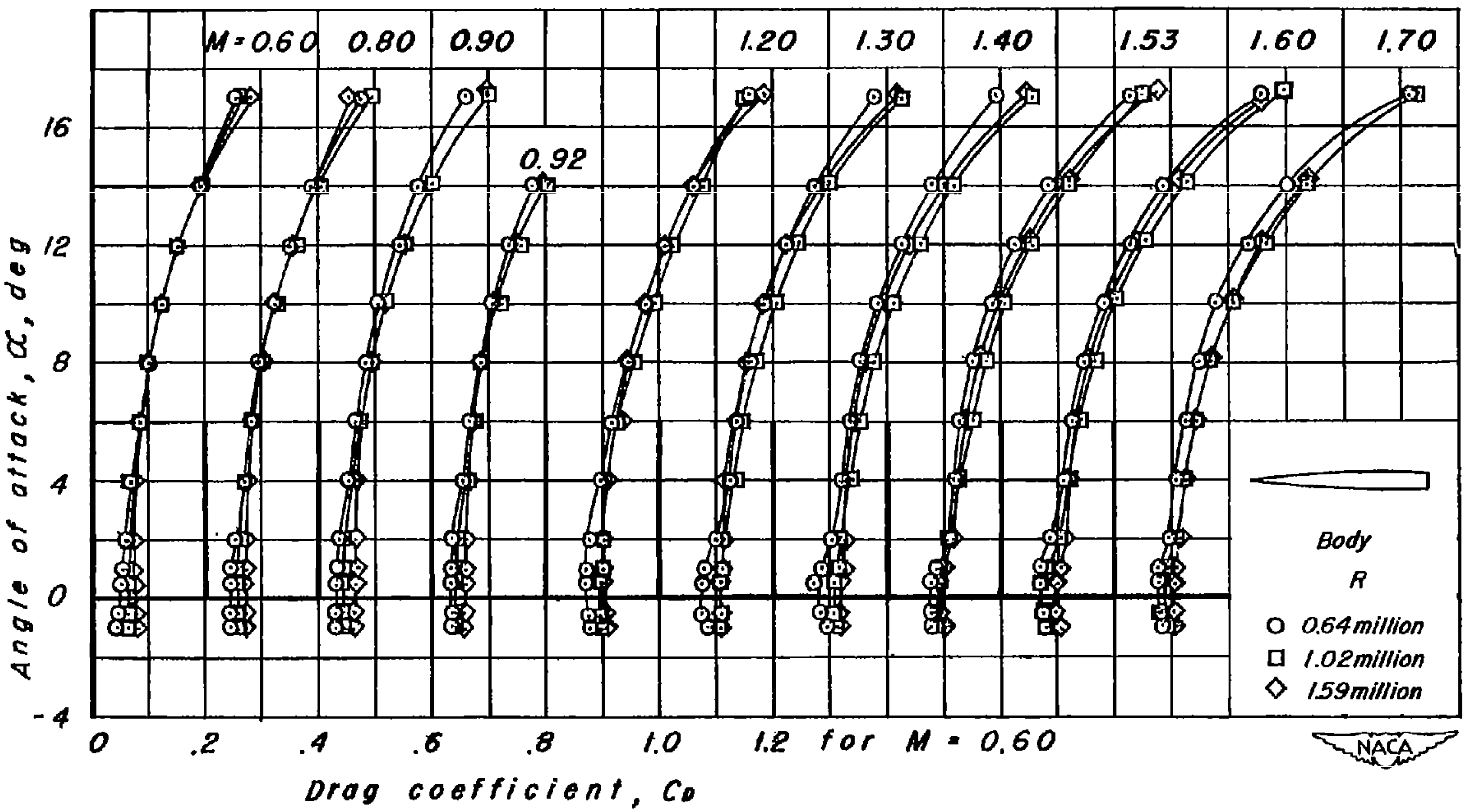


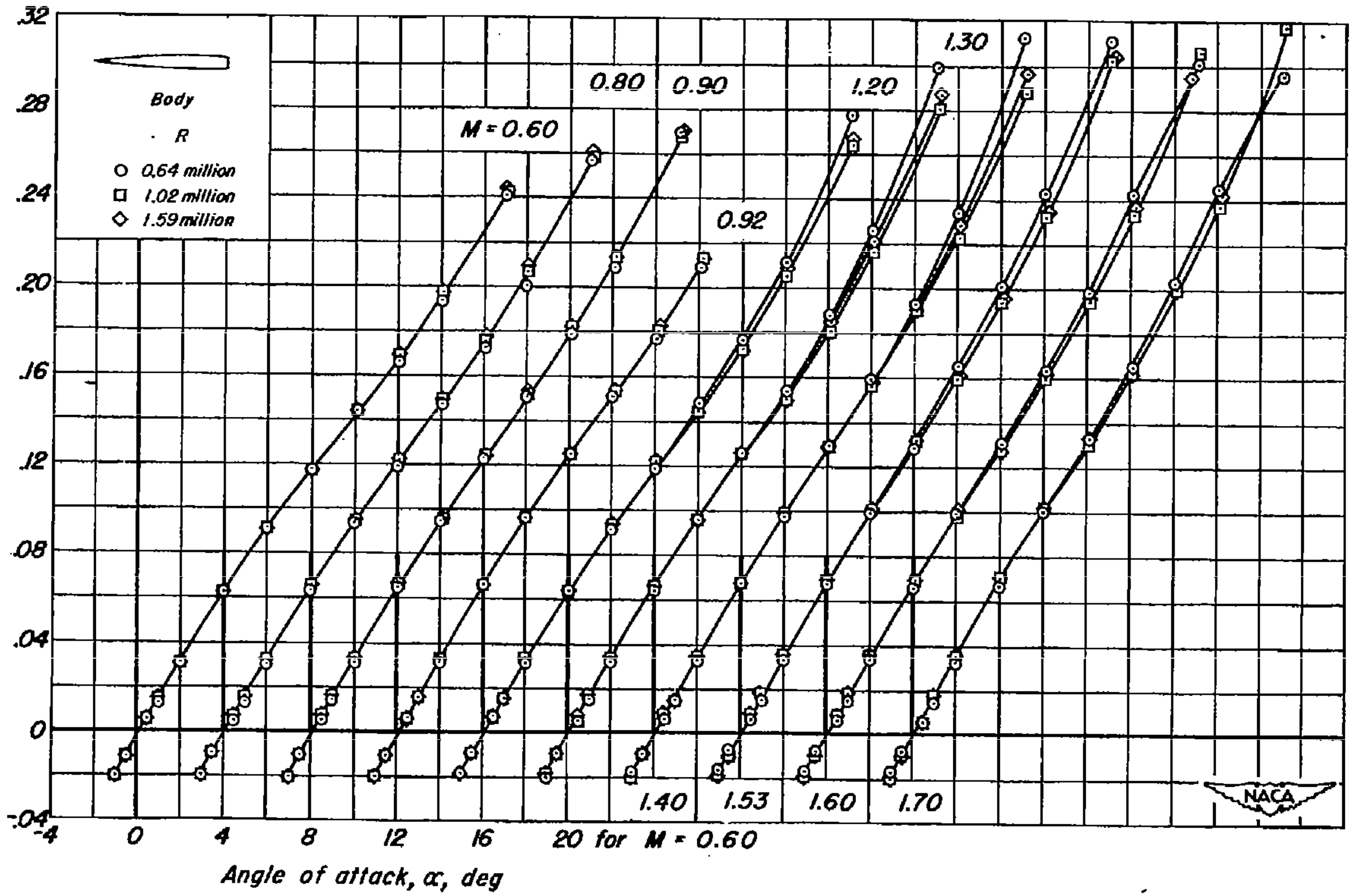
(a) C_L vs α

Figure 2.–The variation of the aerodynamic characteristics with angle of attack at various Mach numbers.



(b) C_D vs α

Figure 2.- Continued.



(c) C_m vs α

Figure 2.- Concluded.