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RESEARCH MEMORANDUM

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LIFT, DRAG, AND PITCHING MOMENT OF LOW-ASPECT-RATIO WINGS AT SUBSONIC AND SUPERSONIC SPEEDS - PLANE TRIANGULAR WING OF ASPECT RATIO 4 WITH 3-PERCENT-THICK ROUNDED NOSE SECTION

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Moffett Field, Calif.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON
August 29, 1951

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

LIFT, DRAG, AND PITCHING MOMENT OF LOW-ASPECT-RATIO WINGS AT SUBSONIC AND SUPERSONIC SPEEDS — PLANE TRIANGULAR WING OF ASPECT RATIO 4 WITH 3-PERCENT-THICK ROUNDED NOSE SECTION

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SUMMARY

A wing-body combination having a plane triangular wing of aspect ratio 4 and 3-percent-thick rounded nose sections in streamwise planes has been investigated at both subsonic and supersonic Mach numbers. The lift, drag, and pitching moment of the model are presented for Mach numbers from 0.60 to 0.92 and from 1.20 to 1.70 at Reynolds numbers of 2.91 million and 4.15 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 effects of variations in plan form, twist, camber, and thickness are being investigated. The results of this program to date are presented in references 1 to 9.

This report is one of a series pertaining to this program and presents results of a wing-body combination having a plane triangular wing of aspect ratio 4. The model is the same as that used in reference 9, except that the 3-percent-thick biconvex section of reference 9 was modified. This modification consisted of replacing the portion of the biconvex section, forward of the midchord location, with an elliptical profile. The tangent to the airfoil section at the 50-percent-chord position was horizontal. Figure 1 shows pictorially the extent of this modification.

As in references 1 to 9, the data herein are presented without analysis to expedite publication.

NOTATION

b	wing span
$\bar{c}$	mean aerodynamic chord $\left(\dfrac{\int_0^{b/2} c^2\,dy}{\int_0^{b/2} c\,dy}\right)$
c	local wing chord
l	length of body including portion removed to accommodate sting
$\frac{L}{D}$	lift-drag ratio
$\left(\frac{L}{D}\right)_{max}$	maximum lift-drag ratio
M	Mach number
q	free-stream dynamic pressure
R	Reynolds number based on the mean aerodynamic chord
r	radius of body
r_o	maximum body radius
S	total wing area, including area formed by extending leading and trailing edges to plane of symmetry
x	longitudinal distance from nose of body
y	distance perpendicular to plane of symmetry
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 referred to quarter point of mean aerodynamic chord $\left(\frac{\text{pitching moment}}{qS\bar{c}}\right)$

$\frac{dC_L}{d\alpha}$ slope of the lift curve measured at zero lift, per degree

$\frac{dC_m}{dC_L}$ slope of the pitching-moment curve measured at zero lift

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 10.

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, described in reference 11, enclosed within the body of the model, was used to measure the aerodynamic forces and moments.

Model

A plan and a front view of the model and certain model dimensions are given in figure 2. Other important geometric characteristics of the model are as follows:

Wing

Aspect ratio	4
Taper ratio	0
Airfoil section (streamwise) . .	3-percent-thick modified biconvex
Total area, S, square feet	2.425

Wing

Mean aerodynamic chord, $\bar{c}$, feet	1.038
Dihedral, degrees	0
Camber	None
Twist, degrees	0
Incidence, degrees	0
Distance, wing-chord plane to body axis, feet	0

Body

Fineness ratio (based upon length l; fig. 2)	12.5
Cross-section shape	Circular
Maximum cross-sectional area, square feet	0.1235
Ratio of maximum cross-sectional area to wing area	0.0509

The wing contour of the present model was obtained by covering the solid steel wing of reference 9 with a tin bismuth alloy. The body spar was steel and was covered with aluminum to form the body contours. The surfaces of the wing and body were polished smooth.

TESTS AND PROCEDURE

Range of Test Variables

The 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. The data were obtained at Reynolds numbers of 2.91 million and 4.15 million.

Reduction of Data

The test data have been reduced to standard NACA coefficient form. Factors which could affect the accuracy of these results, together with the corrections applied, are discussed in the following paragraphs.

Tunnel-wall interference.- Corrections to the subsonic results for the induced effects of the tunnel walls resulting from lift on the model were made according to the methods of reference 12. The numerical values of these corrections (which were added to the uncorrected data) were:

$$\Delta\alpha = 0.592\ C_L$$

$$\Delta C_D = 0.01035\ C_L{}^2$$

No corrections were made to the pitching-moment coefficients.

The effects of constriction of the flow at subsonic speeds by the tunnel walls were taken into account by the method of reference 13. 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 a 2-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.— Tests at subsonic speeds in the 6- by 6-foot supersonic wind tunnel of the present symmetrical model in both the normal and inverted positions have indicated a stream inclination of -0.05° and a stream curvature capable of producing a pitching-moment coefficient of -0.004 at zero lift. No corrections were made to the data of the present report for the effect of these stream irregularities. No measurements have been made of the stream curvature in the yaw plane. 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 wind tunnel at supersonic speeds (reference 10) 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 small as judged by the results of reference 14. The survey of reference 10 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 -0.0008 at a Mach number of 1.30 to 0.0006 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 tailless 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 of a body-sting configuration similar to that of the present model are shown by reference 15 to be confined to a change in base pressure. The previously mentioned adjustment of the drag for base pressure, therefore, was applied at supersonic speeds.

RESULTS

The results are presented in this report without analysis in order to expedite publication. The variation of lift coefficient with angle of attack and the variations of pitching-moment coefficient, drag coefficient, and lift-drag ratio with lift coefficient at Mach numbers from 0.60 to 1.70 and at Reynolds numbers of 2.91 million and 4.15 million are shown in figure 3.

The results presented in figure 3 for a Reynolds number of 4.15 million have been summarized in figure 4 to show some important parameters as functions of Mach number. Also presented in figure 4, for comparison purposes, are the data of reference 9 at a Reynolds number of 4.15 million. The slope parameters in this figure have been measured at zero lift.

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National Advisory Committee for Aeronautics,
Moffett Field, California.

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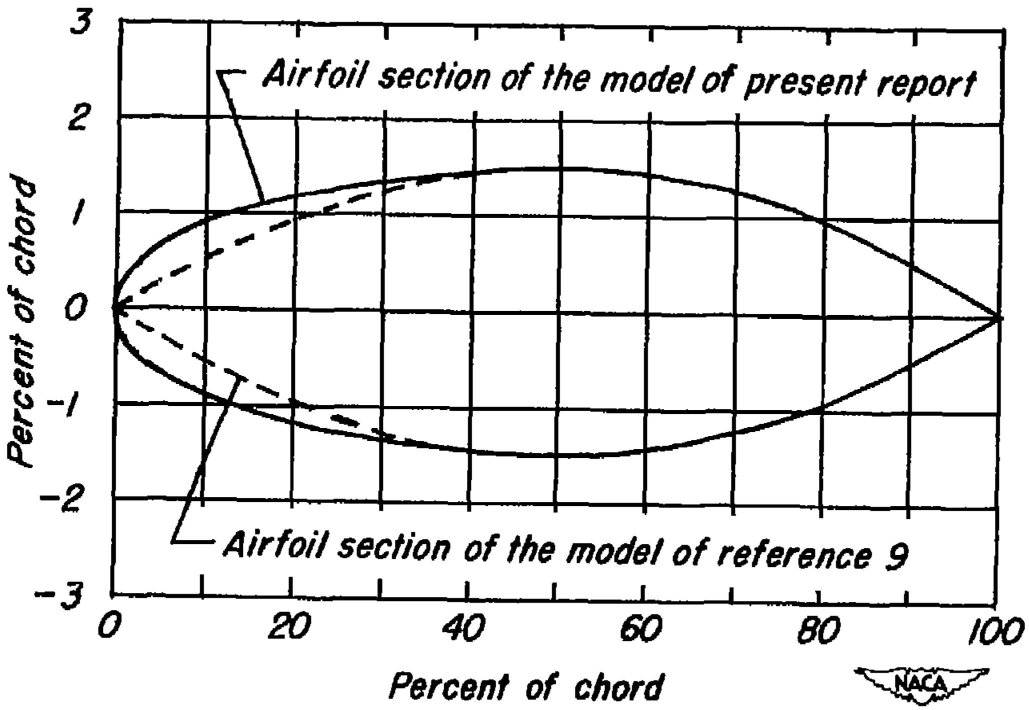


Figure 1.-Comparison of the airfoil section of the present report with that of reference 9.

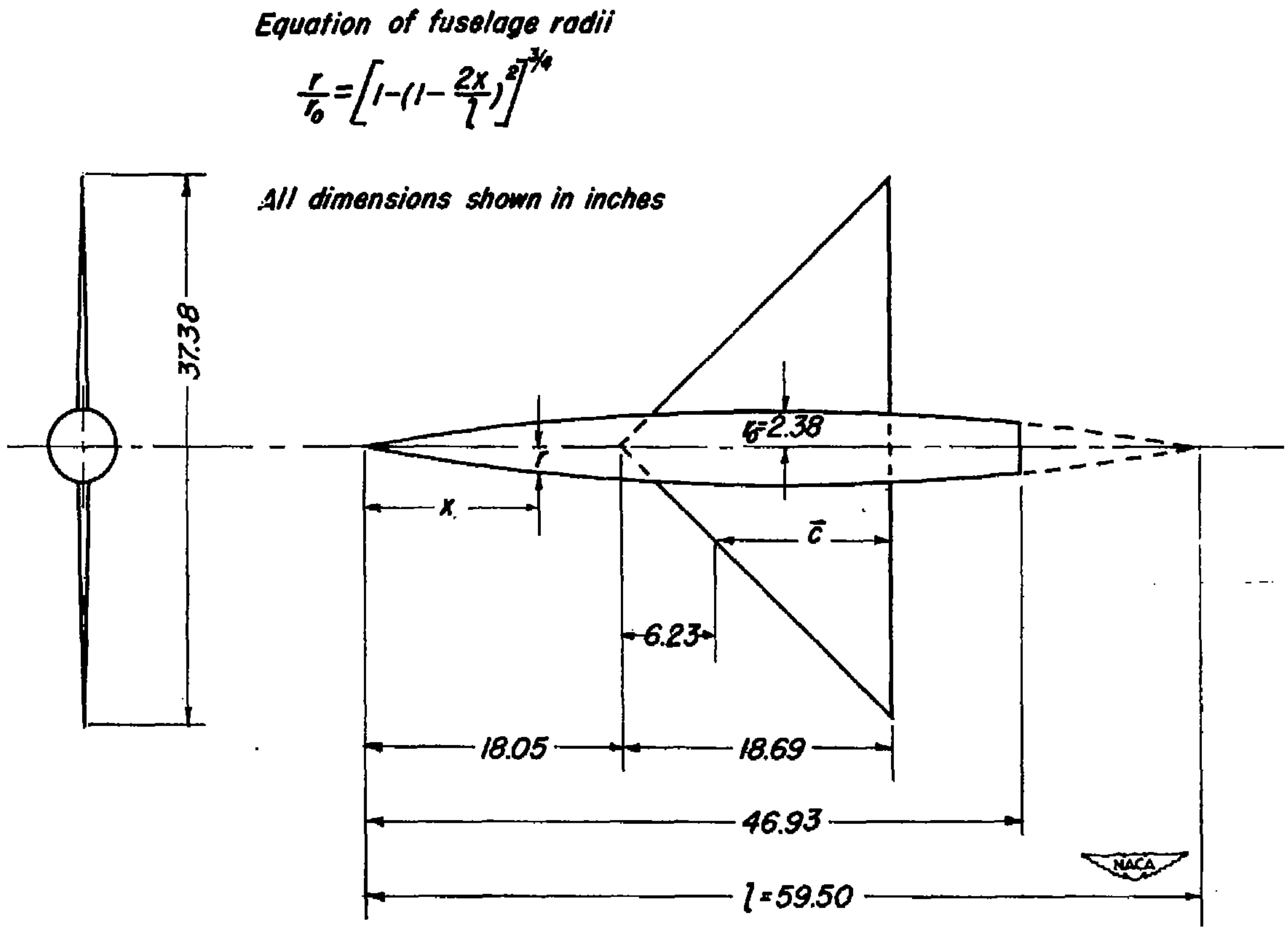
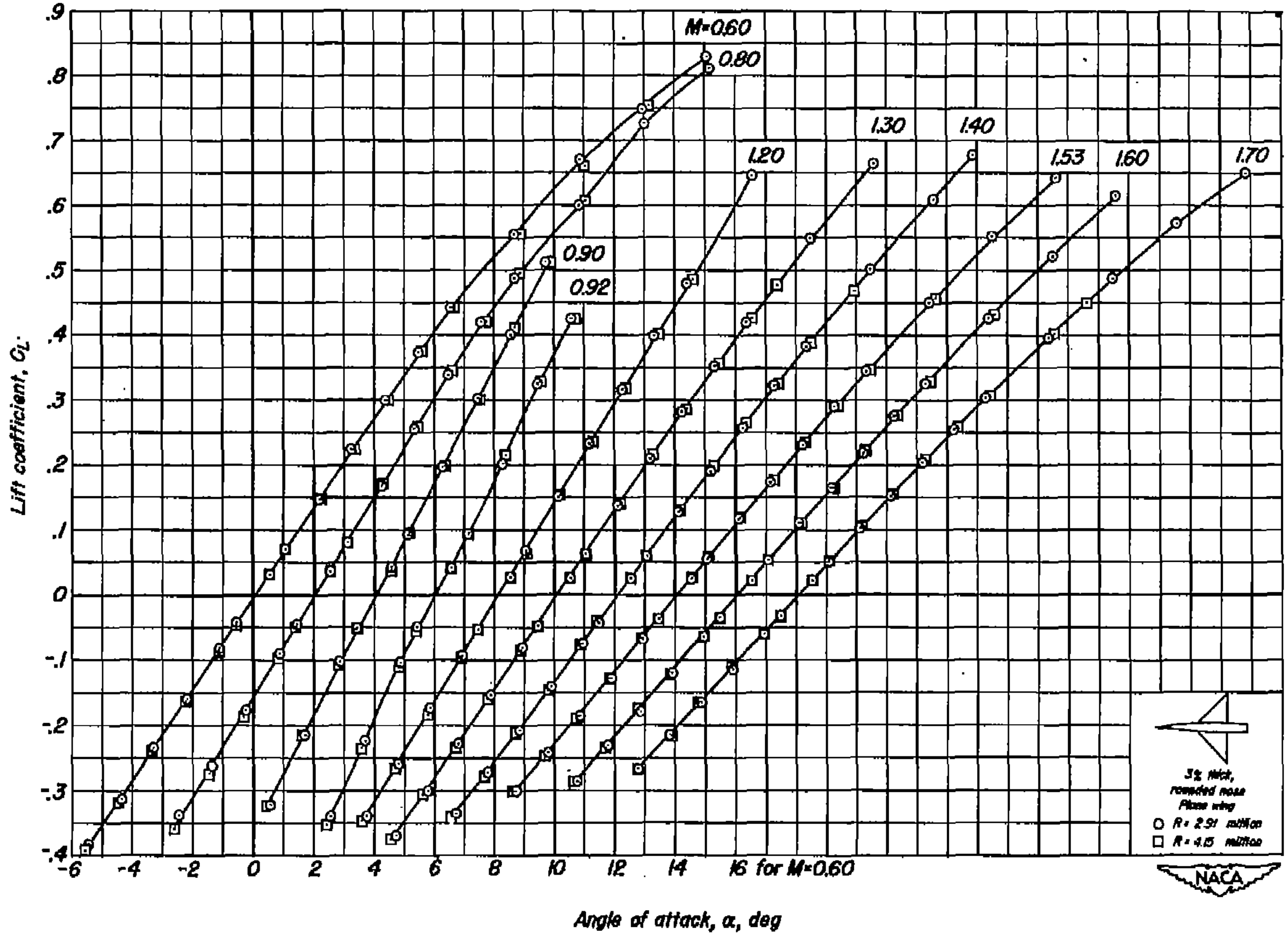
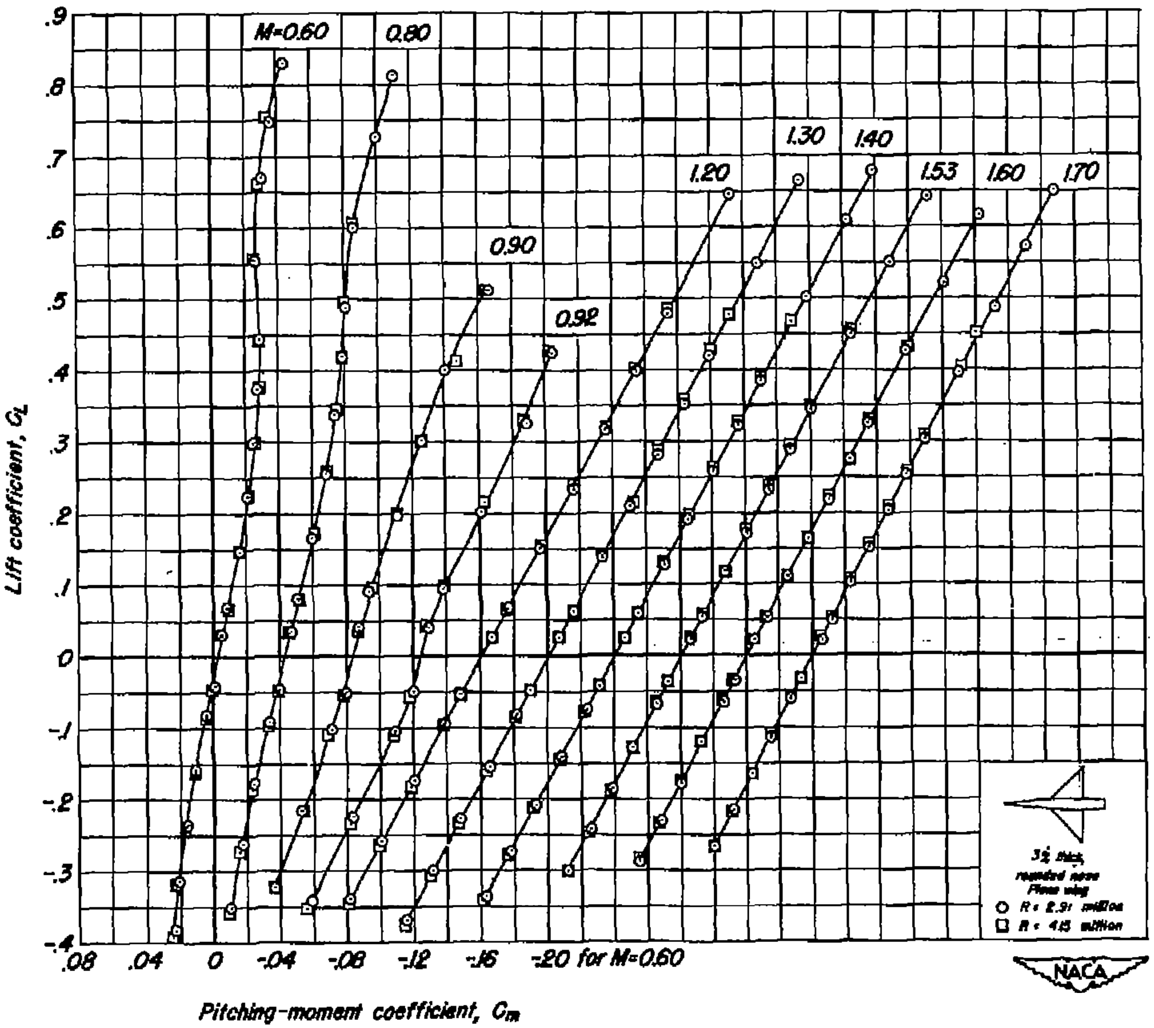


Figure 2.–Front and plan views of the model.



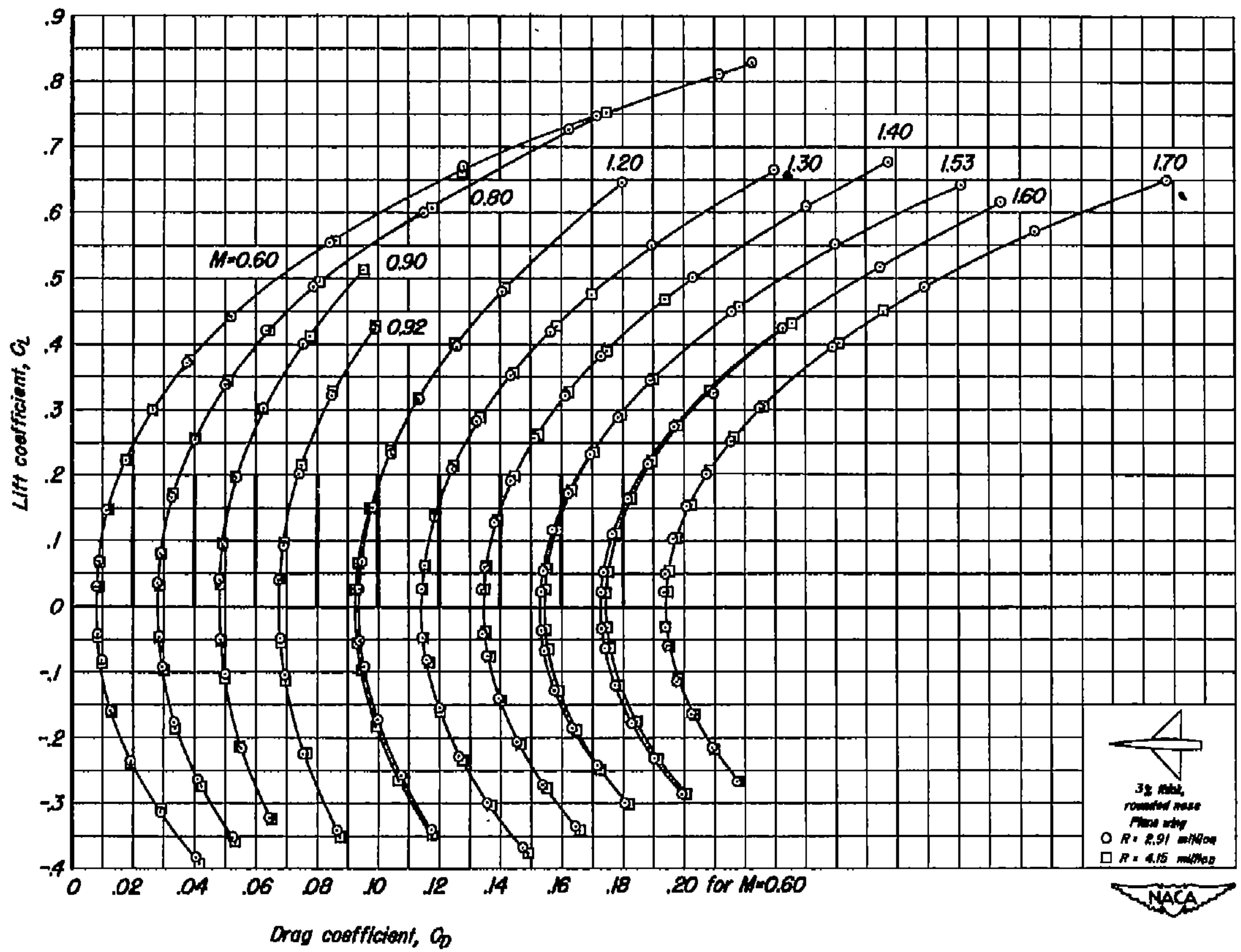
(a) C_L vs α

Figure 3.–The variation of the aerodynamic characteristics with lift coefficient at various Mach numbers.



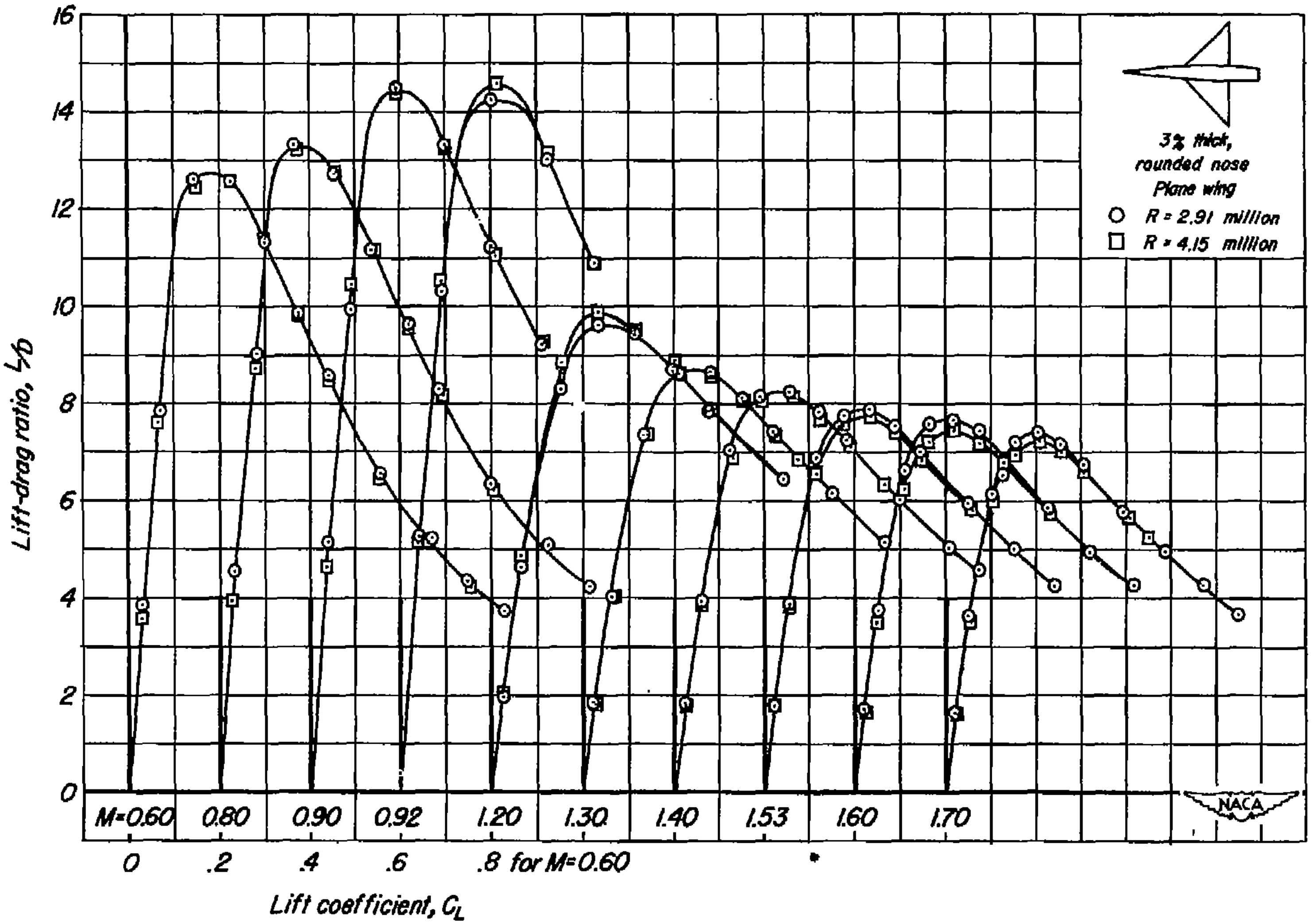
(b) C_L vs C_m

Figure 3.—Continued.



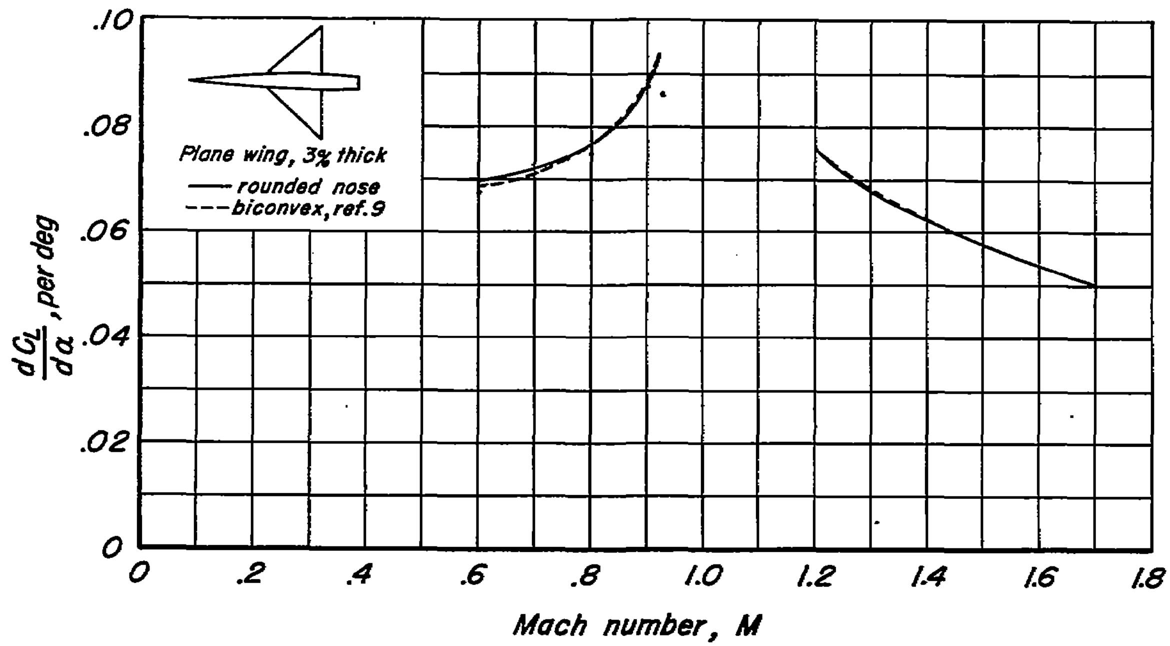
(c) C_L vs C_D

Figure 3.–Continued.

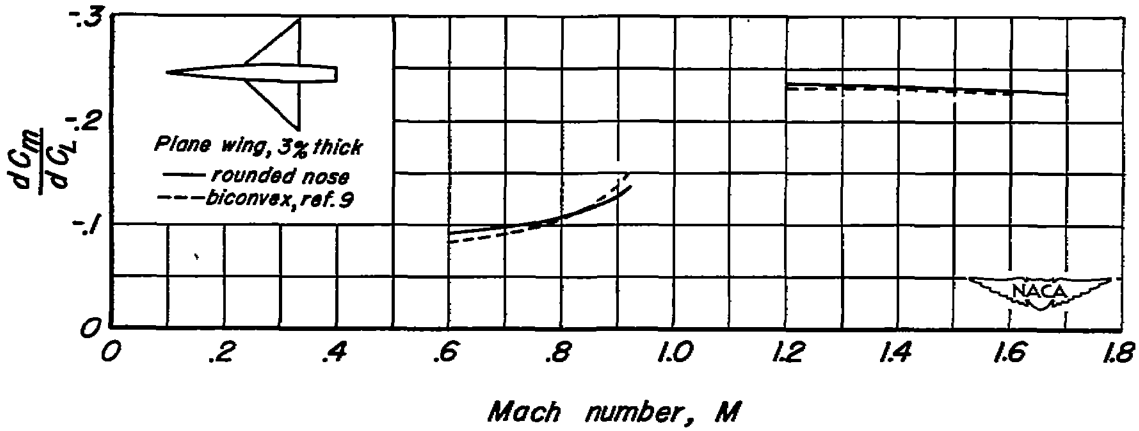


(d) C_L vs L/D

Figure 3.–Concluded.

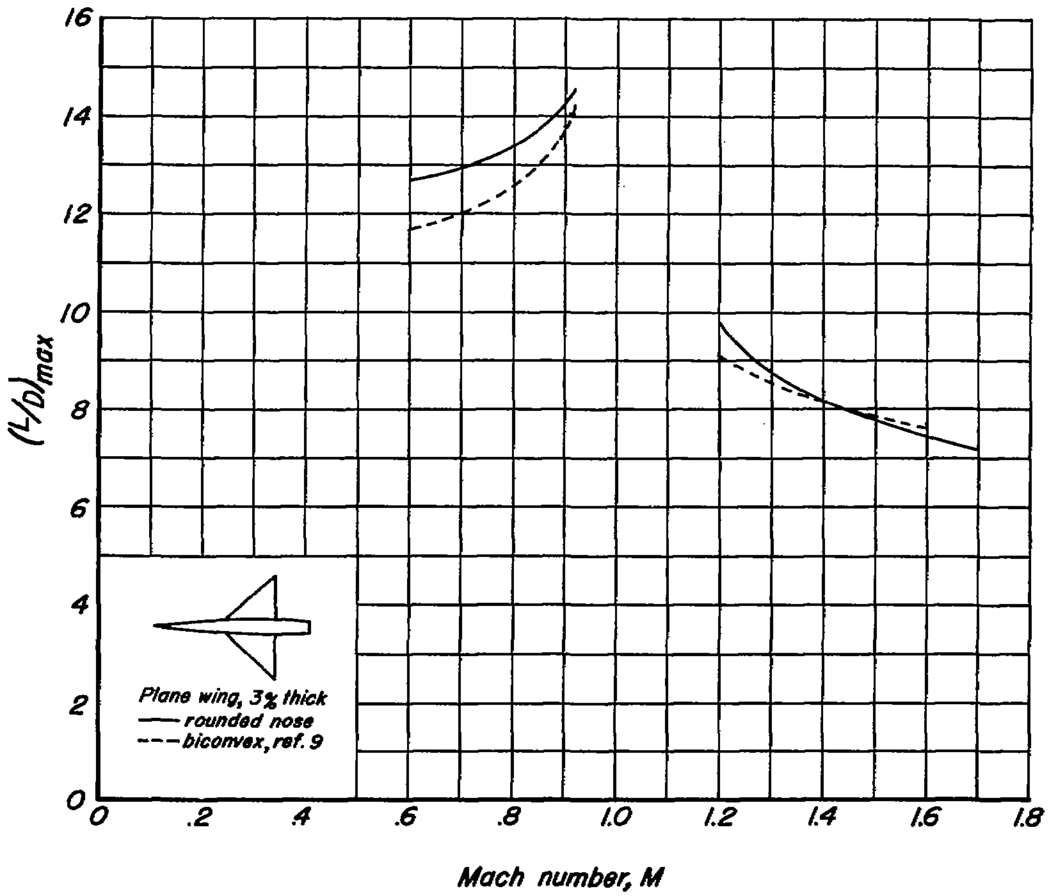


(a) $\frac{dC_L}{d\alpha}$ vs M

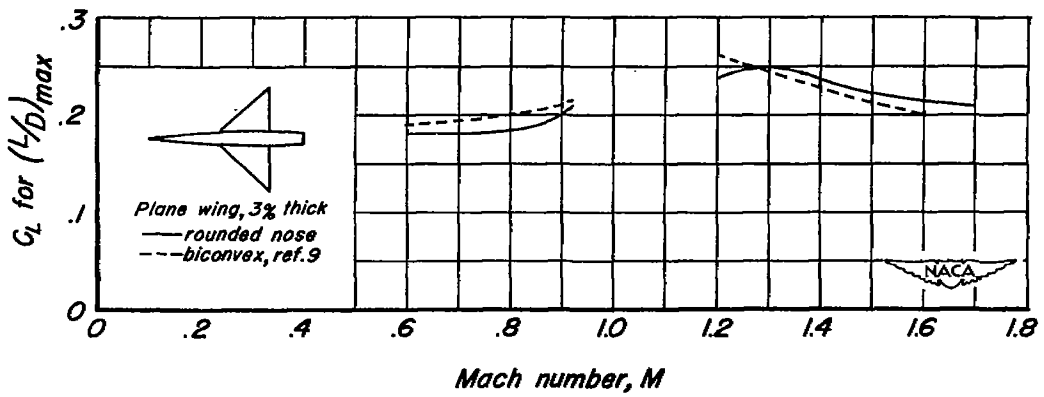


(b) $\frac{dC_m}{dC_L}$ vs M

Figure 4.- Summary of aerodynamic characteristics as a function of Mach number. Reynolds number, 4.15 million.

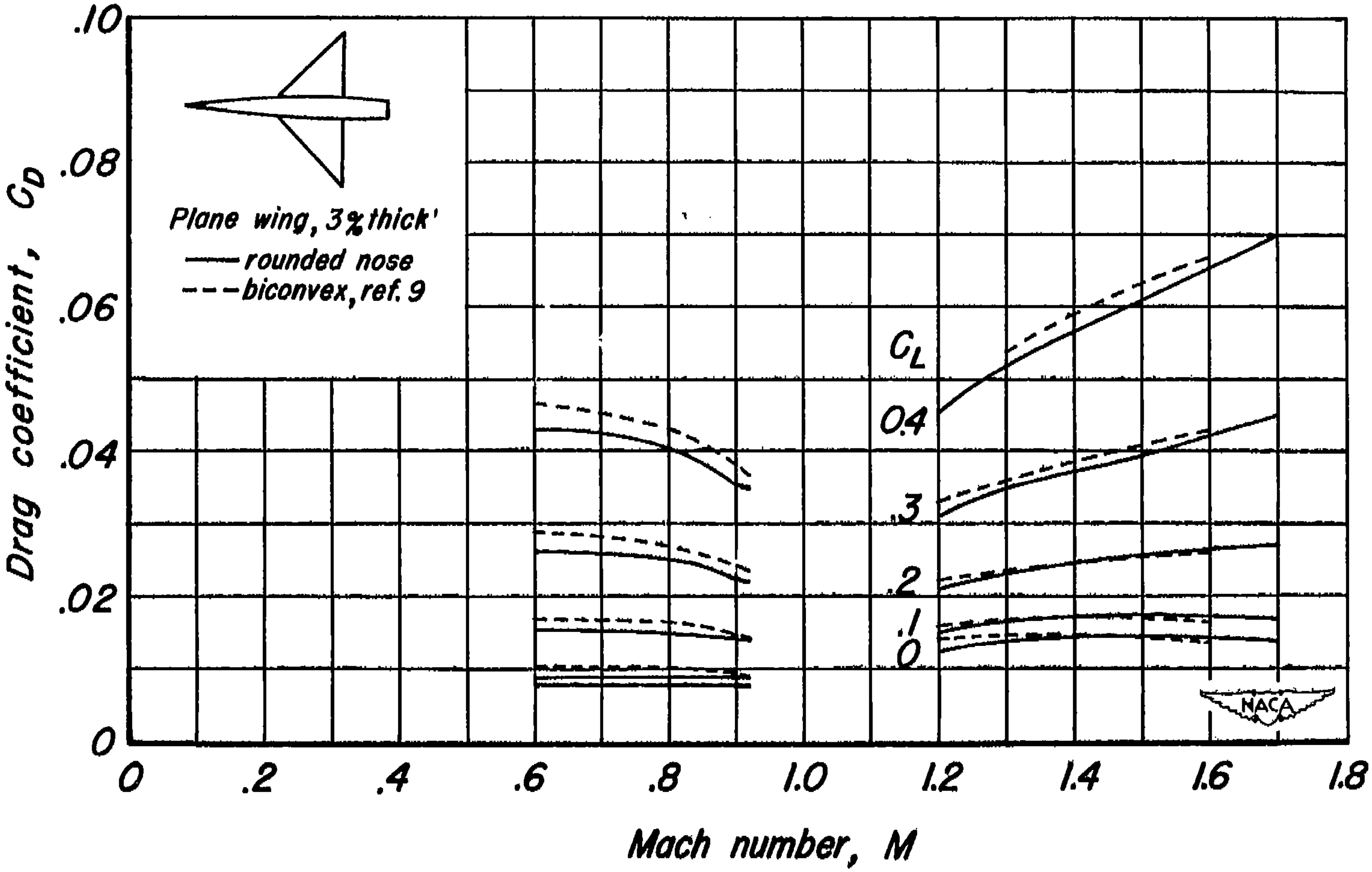


(c) $(L/D)_{max}$ vs M



(d) C_L for $(L/D)_{max}$ vs M

Figure 4.-Continued.



(e) C_D vs M

Figure 4.- Concluded.

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