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TECHNICAL MEMORANDUM

X-305

INVESTIGATION OF THE STATIC LONGITUDINAL

STABILITY CHARACTERISTICS OF AN AIR-TO-SURFACE CANARD

MISSILE CONFIGURATION IN THE TRANSONIC

MACH NUMBER RANGE

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TECHNICAL MEMORANDUM X-305

INVESTIGATION OF THE STATIC LONGITUDINAL STABILITY CHARACTERISTICS OF AN AIR-TO-SURFACE CANARD MISSILE CONFIGURATION IN THE TRANSONIC MACH NUMBER RANGE*

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SUMMARY

The static longitudinal stability and control characteristics of a canard missile configuration were investigated in the Langley 8-foot transonic tunnel to obtain the variation of the longitudinal stability parameter $\left(dC_m/dC_L\right)_{trim}$ with Mach number and canard deflection in the transonic Mach number range. Data indicated that the configuration became progressively more stable in the trim lift-coefficient range with an increase in horizontal canard deflection to 20°. It was also evident that the parameter $\left(dC_m/dC_L\right)_{trim}$ showed the least variation with Mach number for canard deflections of 5° and 10°.

INTRODUCTION

An investigation of the static longitudinal stability and control characteristics of an air-to-surface missile was made at transonic speeds in the Langley 8-foot transonic tunnel. This investigation was made to define the longitudinal stability parameter $\left(dC_m/dC_L\right)_{trim}$ in the transonic Mach number range to supplement existing unpublished wind-tunnel results.

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*Title, Unclassified.

SYMBOLS

The data presented herein are referred to the stability system of axes with the origin located at the 60-percent body station.

d	body diameter, 3.1 in.
q	free-stream dynamic pressure, lb/sq ft
R	Reynolds number
S	body cross-sectional area, 7.546 sq in.
M	Mach number
C_L	lift coefficient, $\frac{\text{Lift}}{qS}$
C_m	pitching-moment coefficient, $\frac{\text{Pitching moment}}{qSd}$
C_D	drag coefficient, $\frac{\text{Drag}}{qS}$
$\left(dC_m/dC_L\right)$	static longitudinal stability parameter
α	angle of attack, deg
δ	canard deflection angle (positive, leading edge up), deg
L/D	lift-drag ratio

The subscript trim indicates the value for $C_m = 0$.

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APPARATUS

Tunnel

The investigation was conducted in the Langley 8-foot transonic tunnel. The Mach number can be varied continuously from about 0.2 to 1.20 and the wind tunnel operates at approximately atmospheric stagnation pressure. (See ref. 1.)

Model

The general arrangement of the air-to-surface missile is given in figure 1. The model is a canard configuration with four canard fins attached to a conical forebody having a rounded nose. The canards have a trapezoidal plan form and employ a double-wedge airfoil section. The body is a cylinder with a flared tail section on which four tail fins are attached interdigitated with the canards.

MEASUREMENTS AND ACCURACY

The investigation was conducted for Mach numbers varying from 0.9 to 1.18 at angles of attack from -4° to 14° for horizontal canard deflections of 0°, 5°, 10°, and 20°. The Reynolds number, based on body diameter, was approximately 1×10^6, as shown in figure 2.

Forces and moments were determined by means of an internal strain-gage balance mounted in the cylindrical portion of the model. Base-pressure measurements were made and corrections for the condition of free-stream static pressure on the base of the model were made. The coefficients of the forces and moments were based on body diameter and cross-sectional area and are estimated to be accurate within the following limits: C_L, ±0.030; C_D, ±0.014; C_m, ±0.050.

Model angle of attack was measured by means of a fixed pendulum strain-gage unit mounted in the rear of the tunnel sting. The angle of attack was corrected for a 0.1° upflow in the test section and sting deflection. The angle of attack is estimated to be accurate to within $\pm 0.1^\circ$.

RESULTS AND DISCUSSION

The basic aerodynamic data are given for a range of Mach numbers from 0.90 to 1.18 in figure 3. Analysis data are shown in figures 4 to 6.

Static Longitudinal Stability Characteristics

For canard deflections above 0°, figure 3 indicates erratic and unstable longitudinal stability characteristics at the low and medium angles of attack, which become stable at the higher angles of attack.

The unstable region becomes more severe as the canard deflection is increased to 20°. Since it is the intention to maintain trimmed flight, only the trimmed condition was considered for analysis.

The static longitudinal stability parameter $\left(dC_m/dC_L\right)_{trim}$ was determined for each canard deflection and Mach number investigated and is shown in figure 4. The data indicate that the configuration became progressively more stable with an increase in horizontal canard deflection to 20°. It is also evident that the parameter $\left(dC_m/dC_L\right)_{trim}$ showed the least variation with Mach number for horizontal canard deflections of 5° and 10°. L 7 9 0

It is not only necessary that the canards provide sufficient control to maintain a trimmed condition but also provide some maneuverability. The range of trim lift coefficients required for maximum L/D is shown in figure 5; however, it is evident from figure 6 that the ability of the canards to provide maneuverability has begun to decrease if a high C_L is required to trim.

Drag Characteristics

As indicated in figure 5, the maximum $(L/D)_{trim}$ varies from a value of 2.80 at a Mach number of 0.90 to 1.75 at a Mach number of 1.08. Figure 5 also shows that the maximum $(L/D)_{trim}$ occurs within a range of trim lift coefficients from 2.3 to 3.0 for the Mach number range investigated.

CONCLUSIONS

The following conclusions have been made as a result of an investigation of the static longitudinal stability and control characteristics of a canard missile configuration:

1. The static longitudinal stability characteristics in the trim lift-coefficient range indicate that the configuration became progressively more stable as the canard deflection was increased to 20°. Data also indicated that the least variation of the longitudinal stability parameter $\left(dC_m/dC_L\right)_{trim}$ with Mach number would occur within the canard deflection angles of 5° and 10°.

2. Within the range of the trim lift coefficients required for maximum trim lift-drag ratio, the ability of the canards to provide maneuverability has begun to decrease.

3. The maximum lift-drag ratio for the trimmed condition varies from 2.80 at a Mach number of 0.90 to 1.75 at a Mach number of 1.08. The maximum trim lift-drag ratio occurs at lift coefficients between 2.3 and 3.0.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., May 10, 1960.

REFERENCE

1. Ritchie, Virgil S., and Pearson, Albin O.: Calibration of the Slotted Test Section of the Langley 8-Foot Transonic Tunnel and Preliminary Experimental Investigation of Boundary-Reflected Disturbances. NACA RM L51K14, 1952.

TABLE I.- PHYSICAL CHARACTERISTICS

Body:	
Length, in.	33.50
Maximum diameter, in.	3.10
Fineness ratio	10.81
Maximum cross-sectional area, sq in.	7.546
Nose radius, in.	0.397
Nose half-angle, deg	10.0
Nose length, in.	6.90
Canard (one surface):	
Section	Double wedge
Tip chord, in.	1.200
Theoretical root chord, in.	3.390
Theoretical taper ratio	0.354
Theoretical semispan, in.	2.173
Theoretical area, sq in.	4.987
Theoretical aspect ratio	0.947
Exposed area, sq in.	1.441
Leading-edge sweep, deg	45.27
Hinge point (station)	5.350
Deflection (only two canard surfaces at once), deg	±5, ±10, ±20
Flare:	
Length, in.	7.750
Half-angle, deg	11.0
Base area, including body, sq in.	29.336
Fin (one surface):	
Section	Double wedge, half-angle 7.5
Leading-edge sweep, deg	45
Theoretical root chord, in.	9.300
Tip chord, in.	5.600
Theoretical taper ratio	0.602
Theoretical semispan, in.	3.6
Theoretical area, sq in.	26.8
Theoretical aspect ratio	0.483
Exposed area, sq in.	9.735
Angle of tip model center line, deg	0

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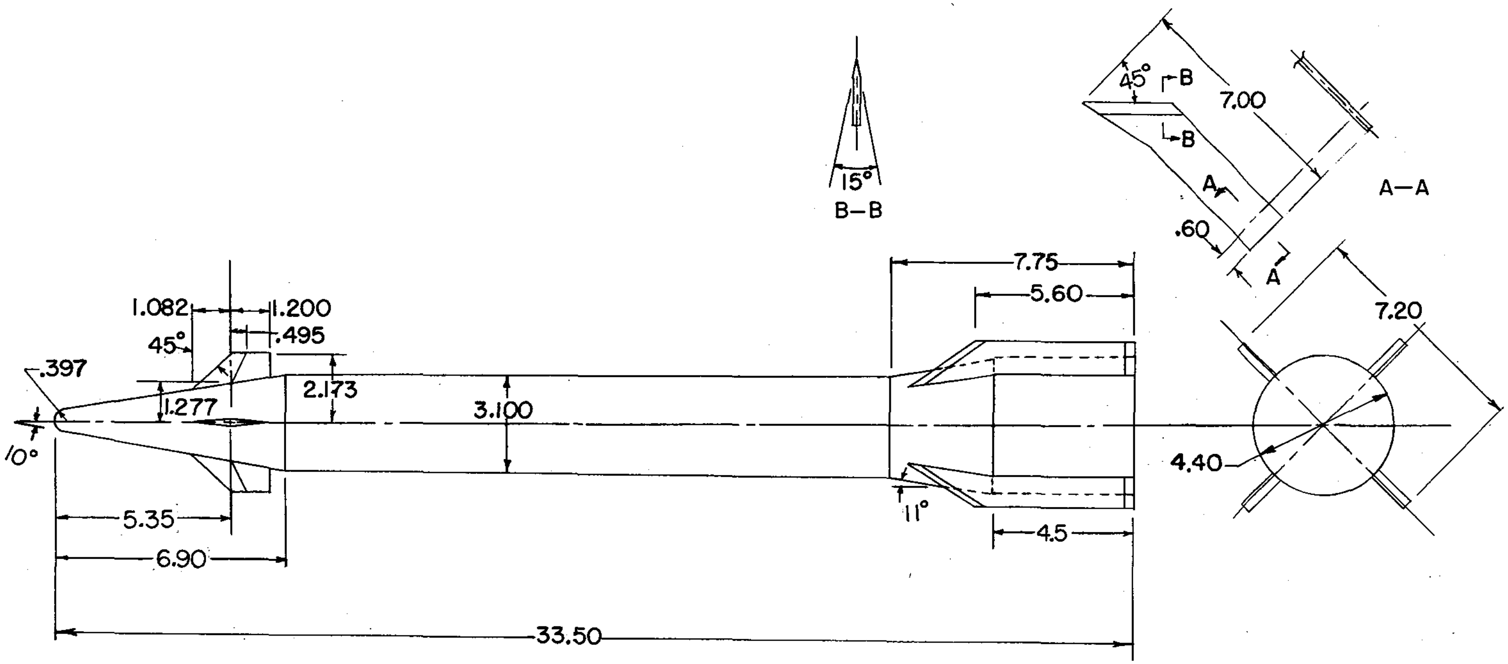

Figure 1.- General arrangement of test model. All dimensions are in inches except as otherwise noted.

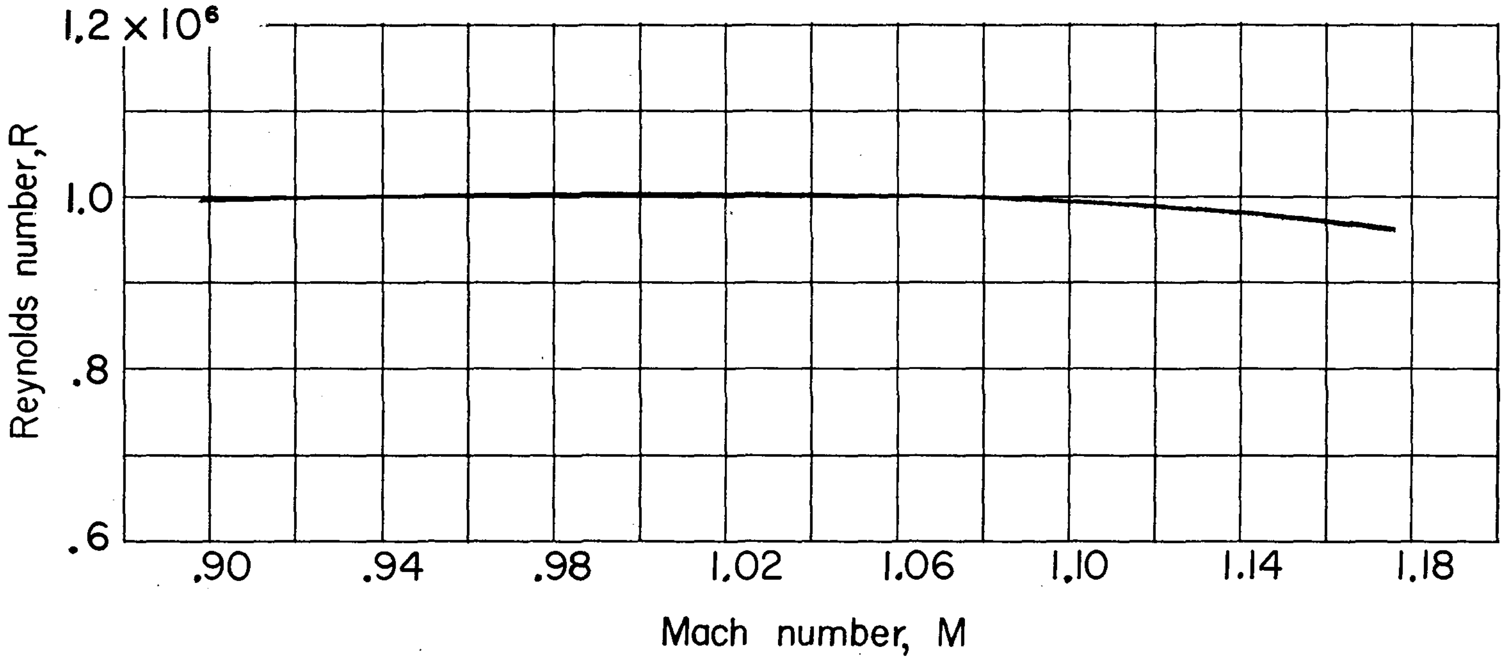

Figure 2.- Variation with Mach number of average Reynolds number based on body diameter.

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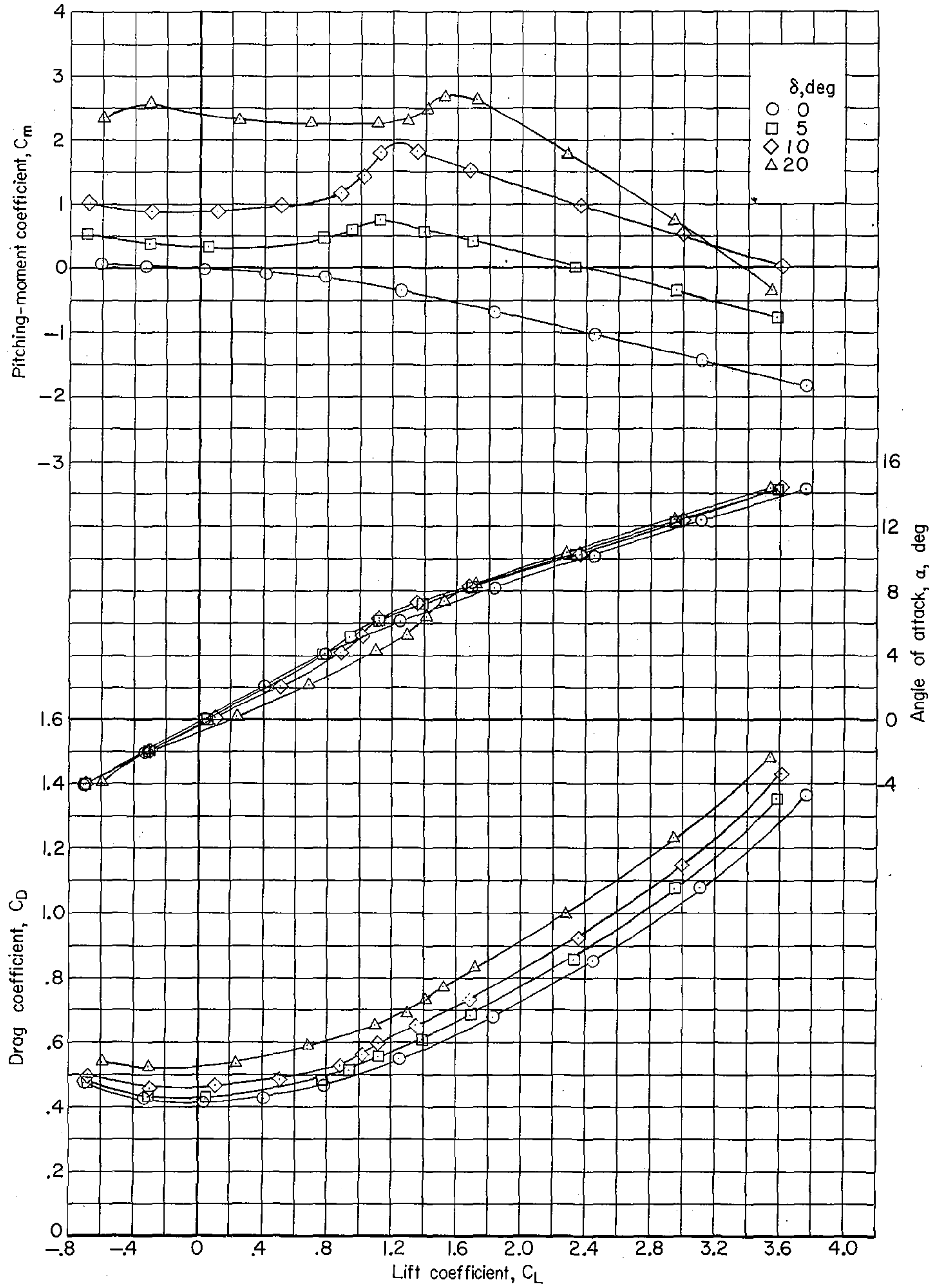
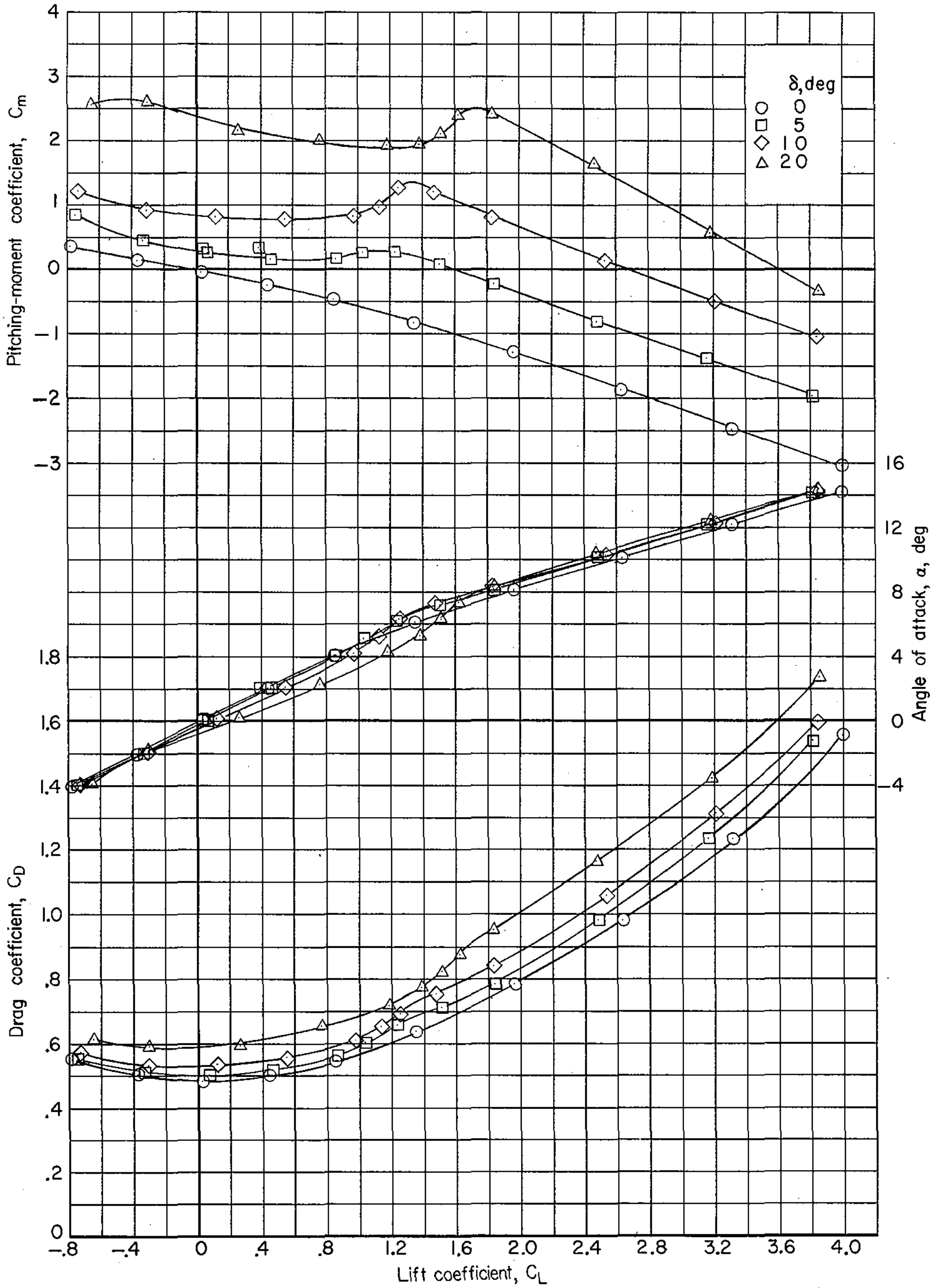


(a) M = 0.90.

Figure 3.- Effect of horizontal canard deflection on the static longitudinal stability characteristics.



(b) M = 0.95.

Figure 3.- Continued.

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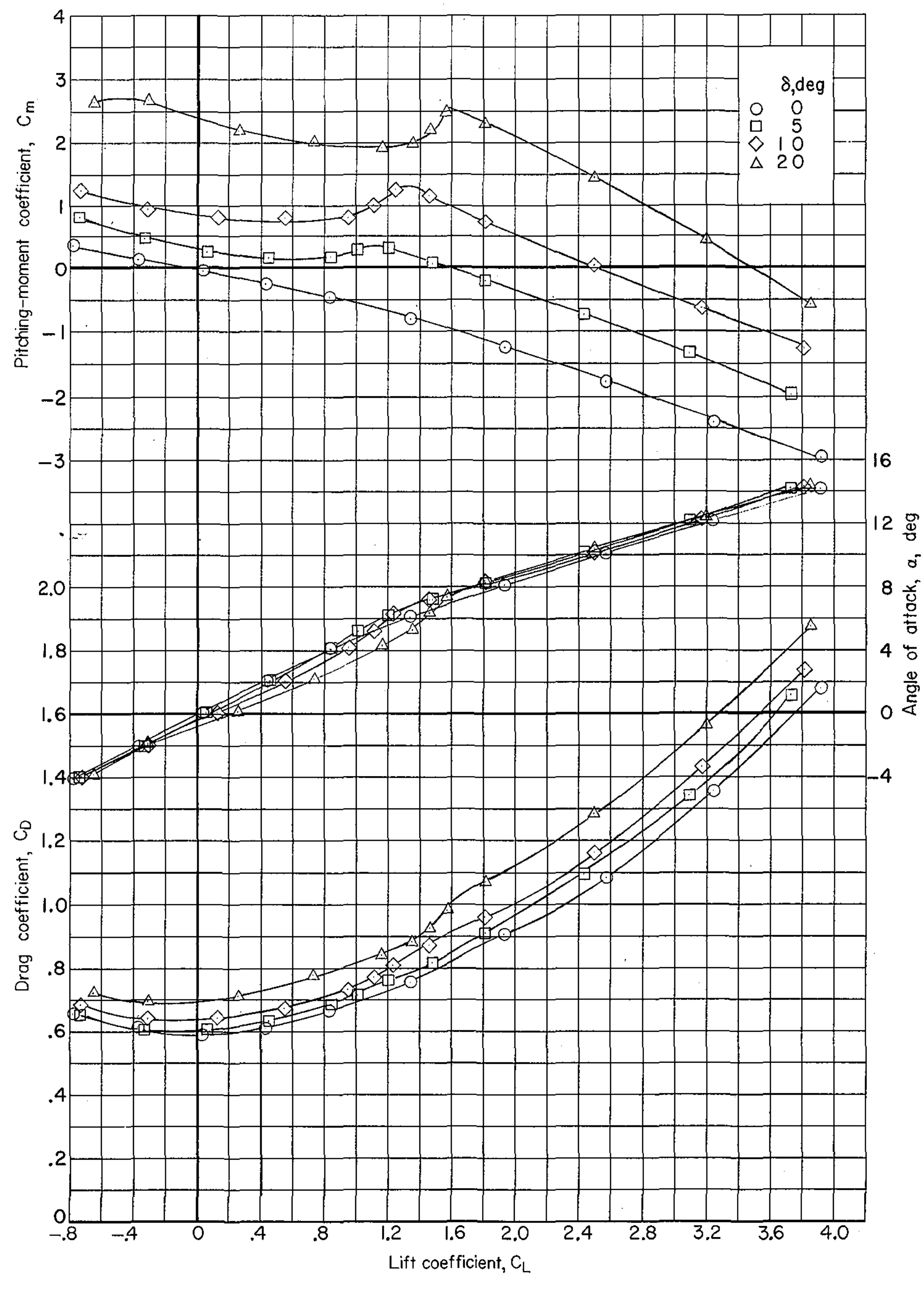
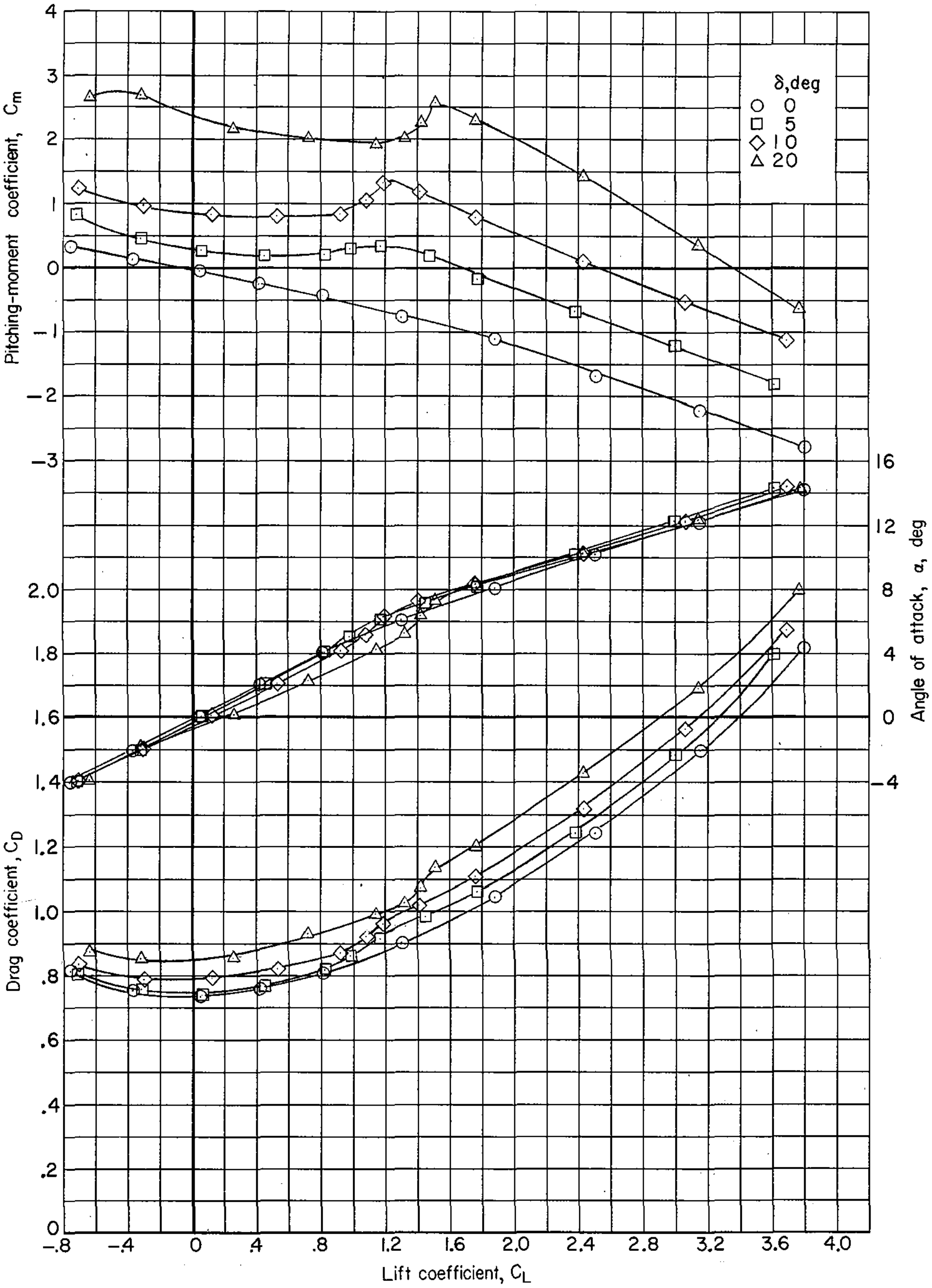


(c) M = 0.98.

Figure 3.- Continued.



(d) M = 1.00.

Figure 3.- Continued.

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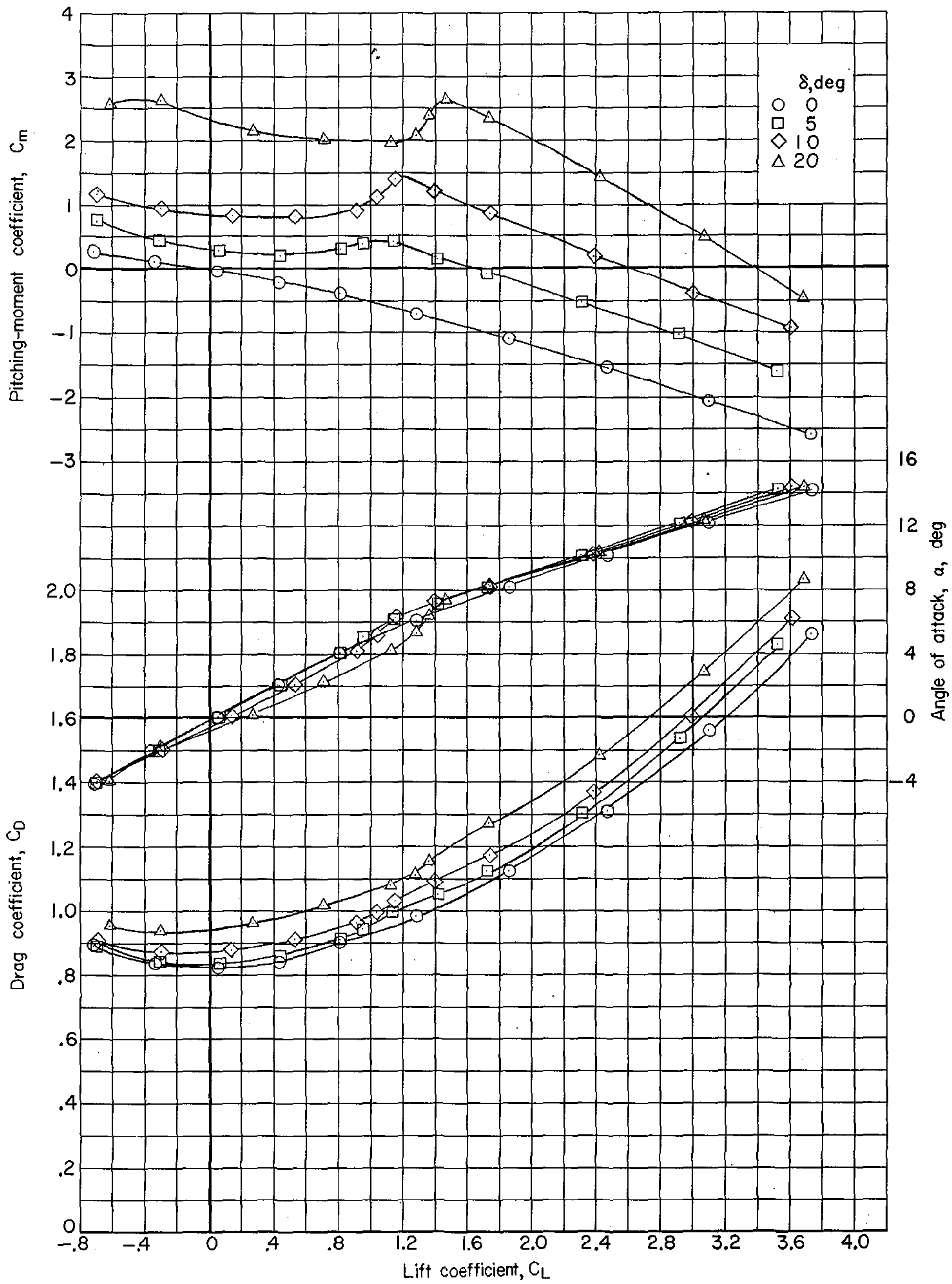
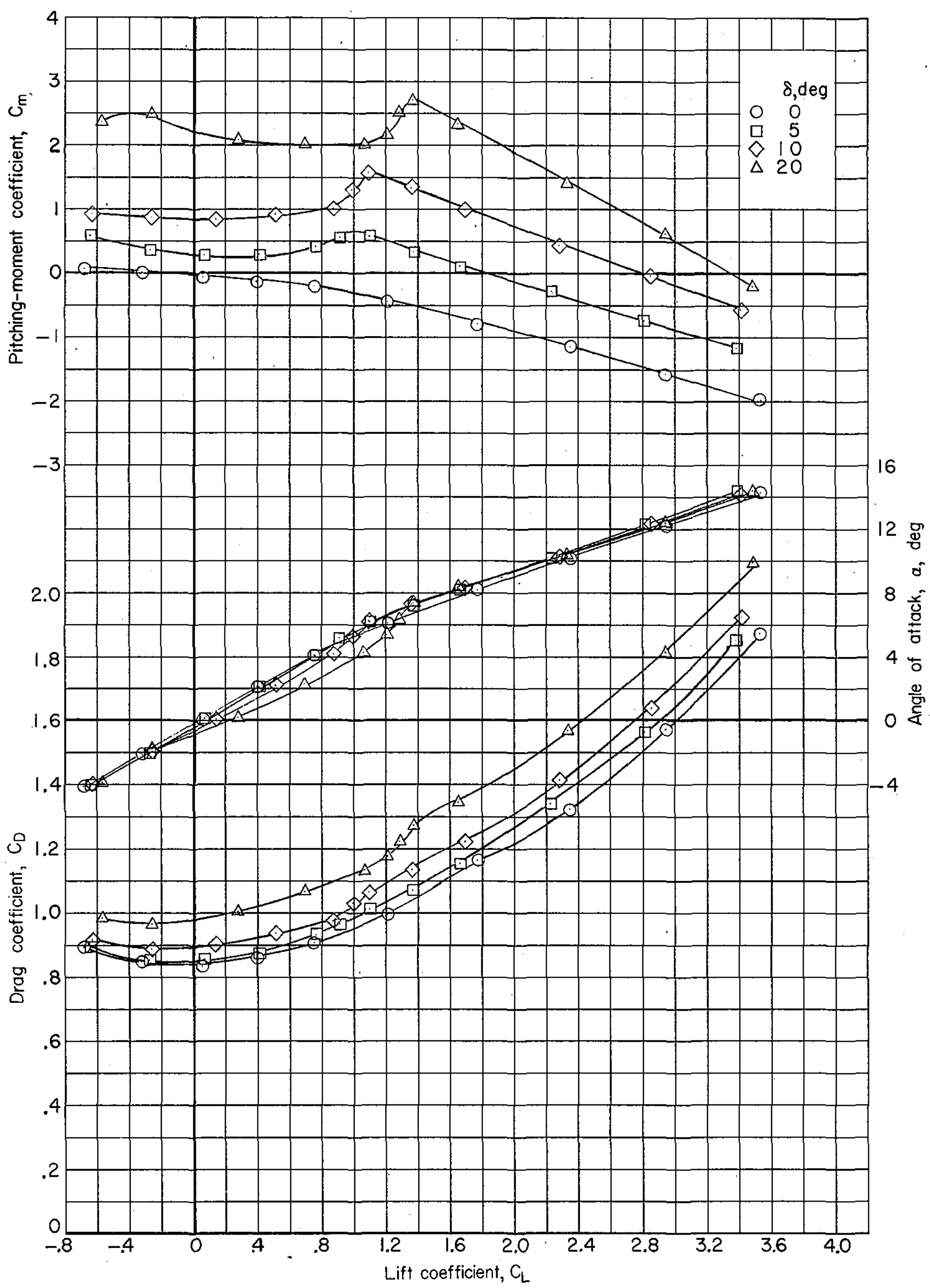


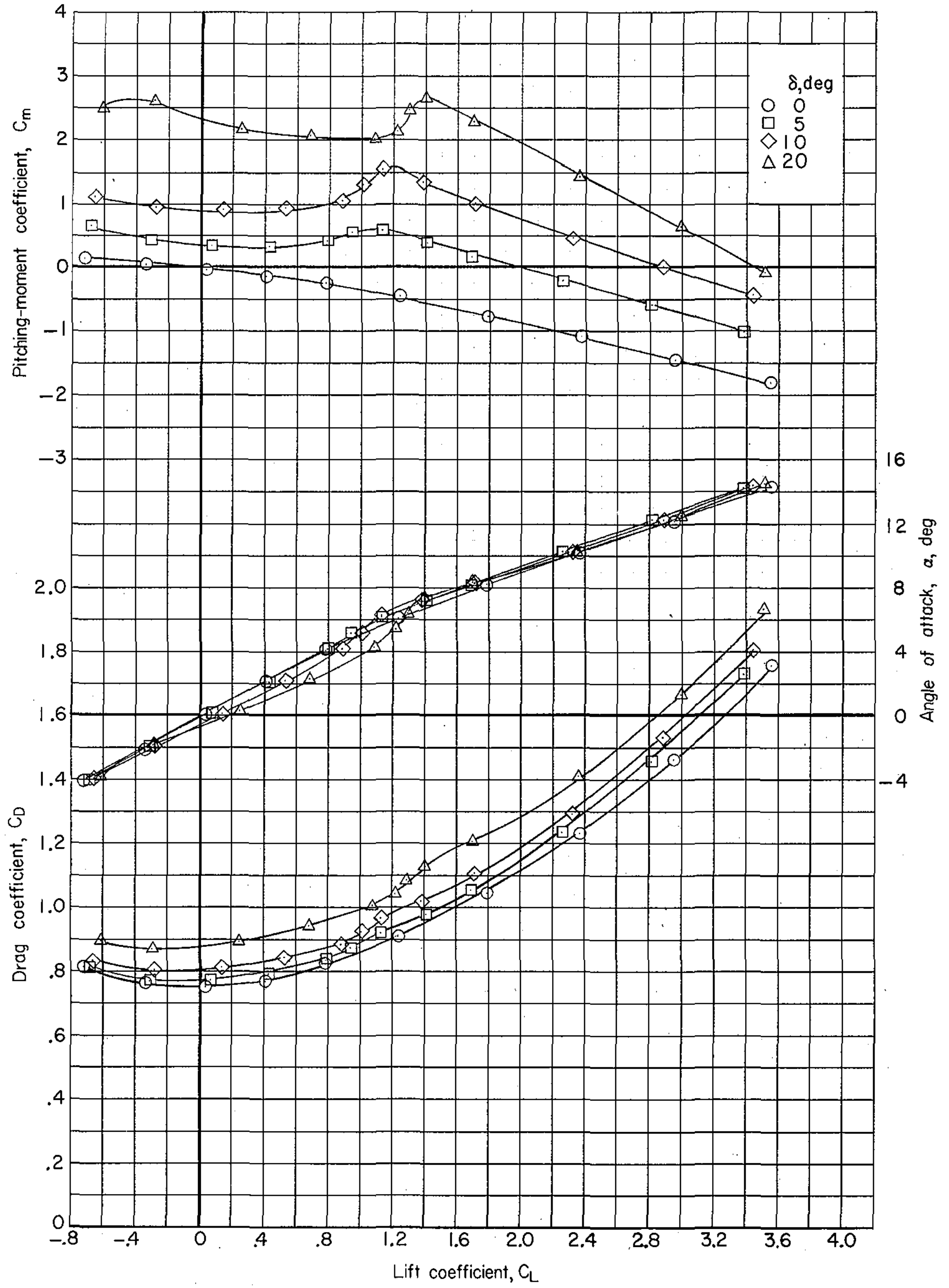
(e) M = 1.03.

Figure 3.- Continued.



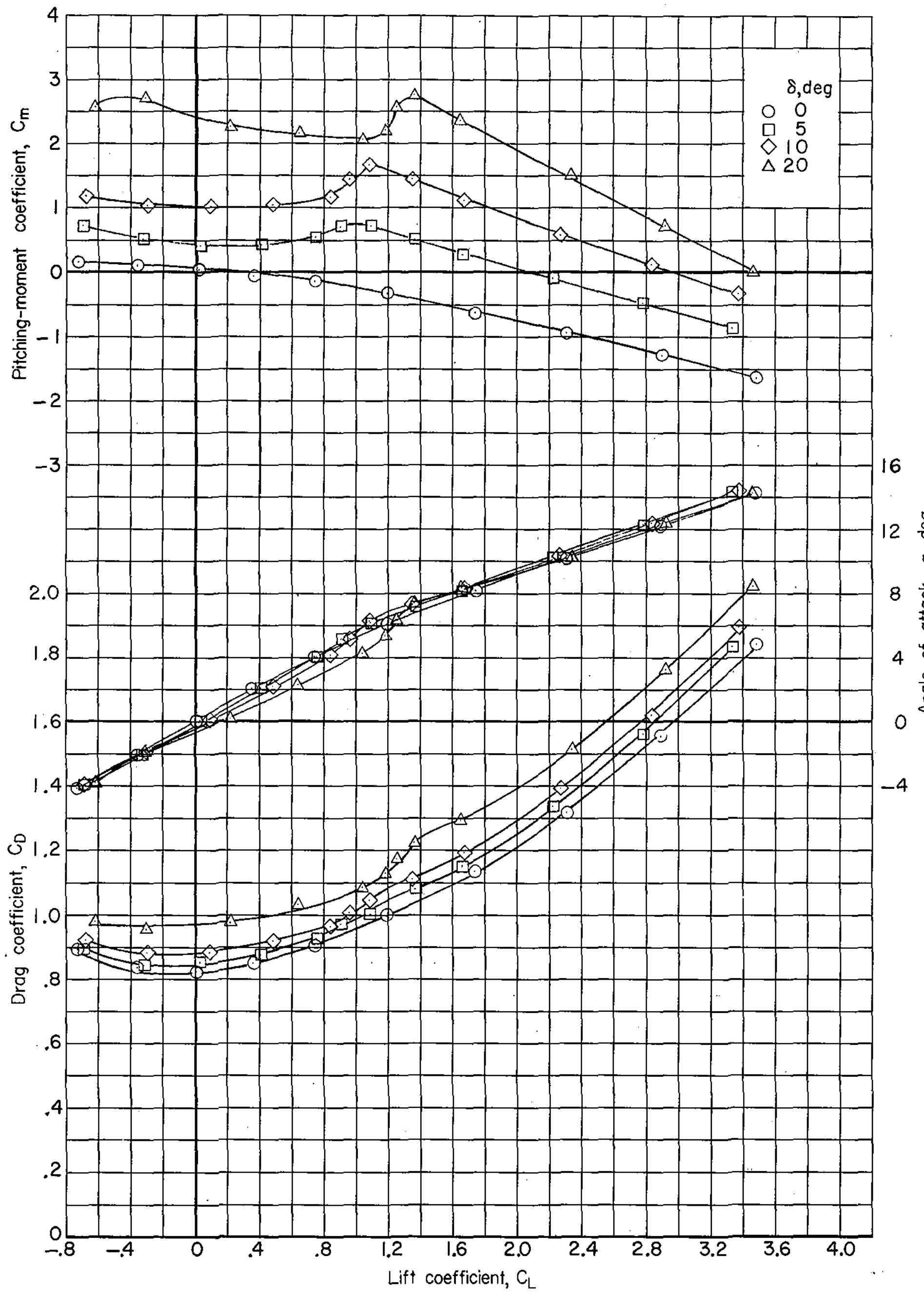
(f) M = 1.12.

Figure 3.- Continued.



(g) M = 1.15.

Figure 3.- Continued.



(h) M = 1.18.

Figure 3.- Concluded.

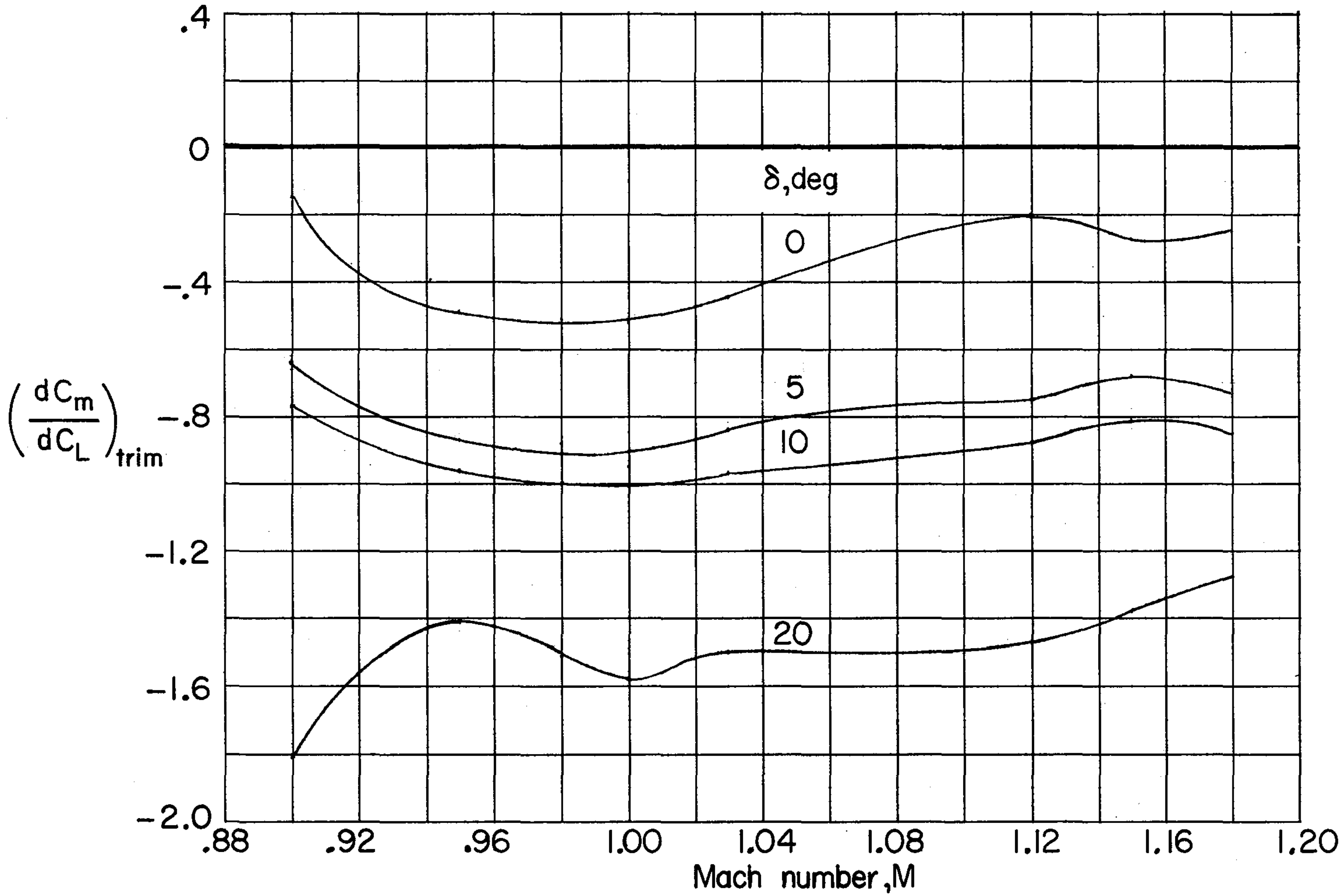


Figure 4.- Variations of the longitudinal stability parameter $\left(\frac{dC_m}{dC_L}\right)_{trim}$ with Mach number.

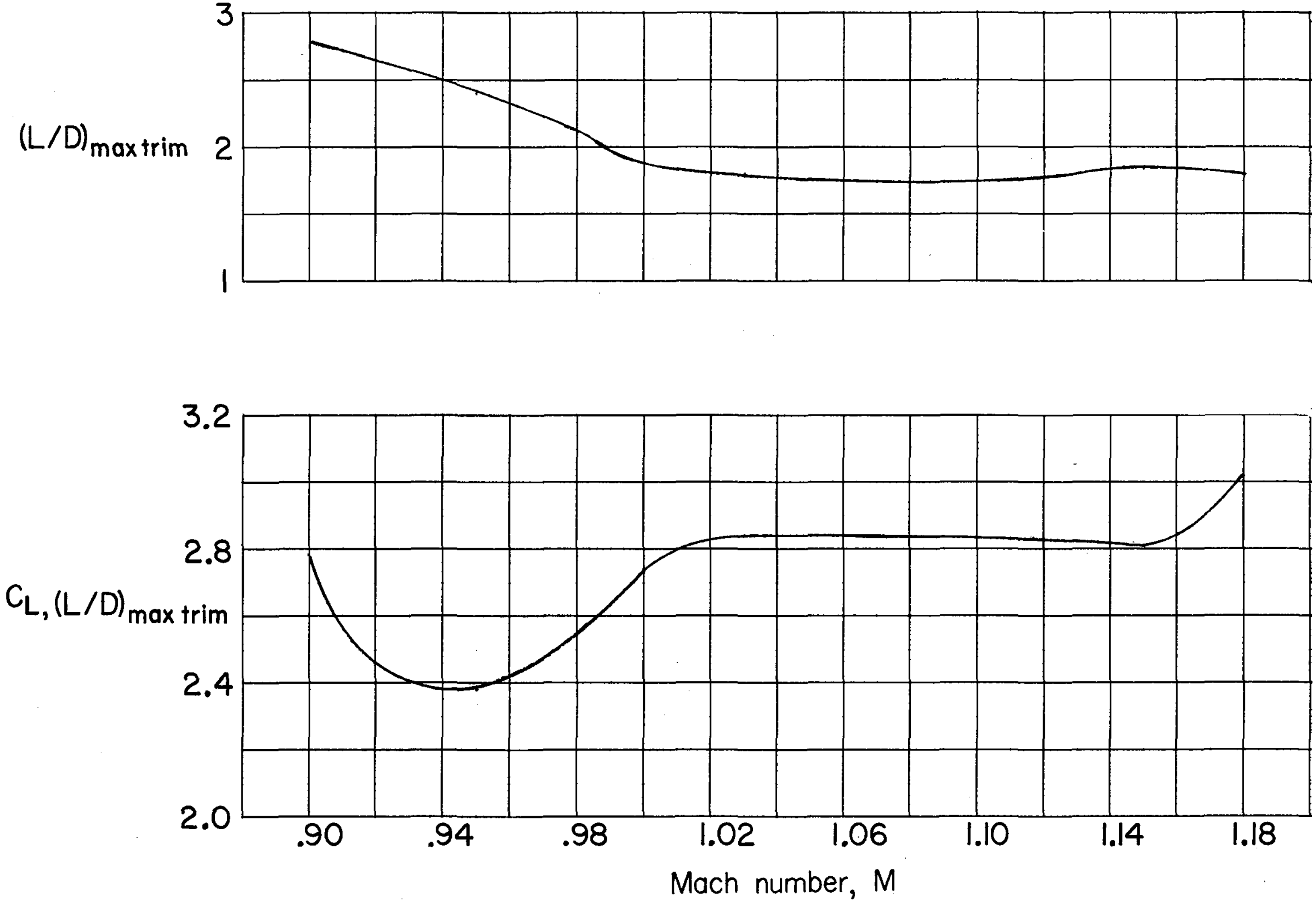


Figure 5.- Characteristics of the maximum trim lift-drag ratio.

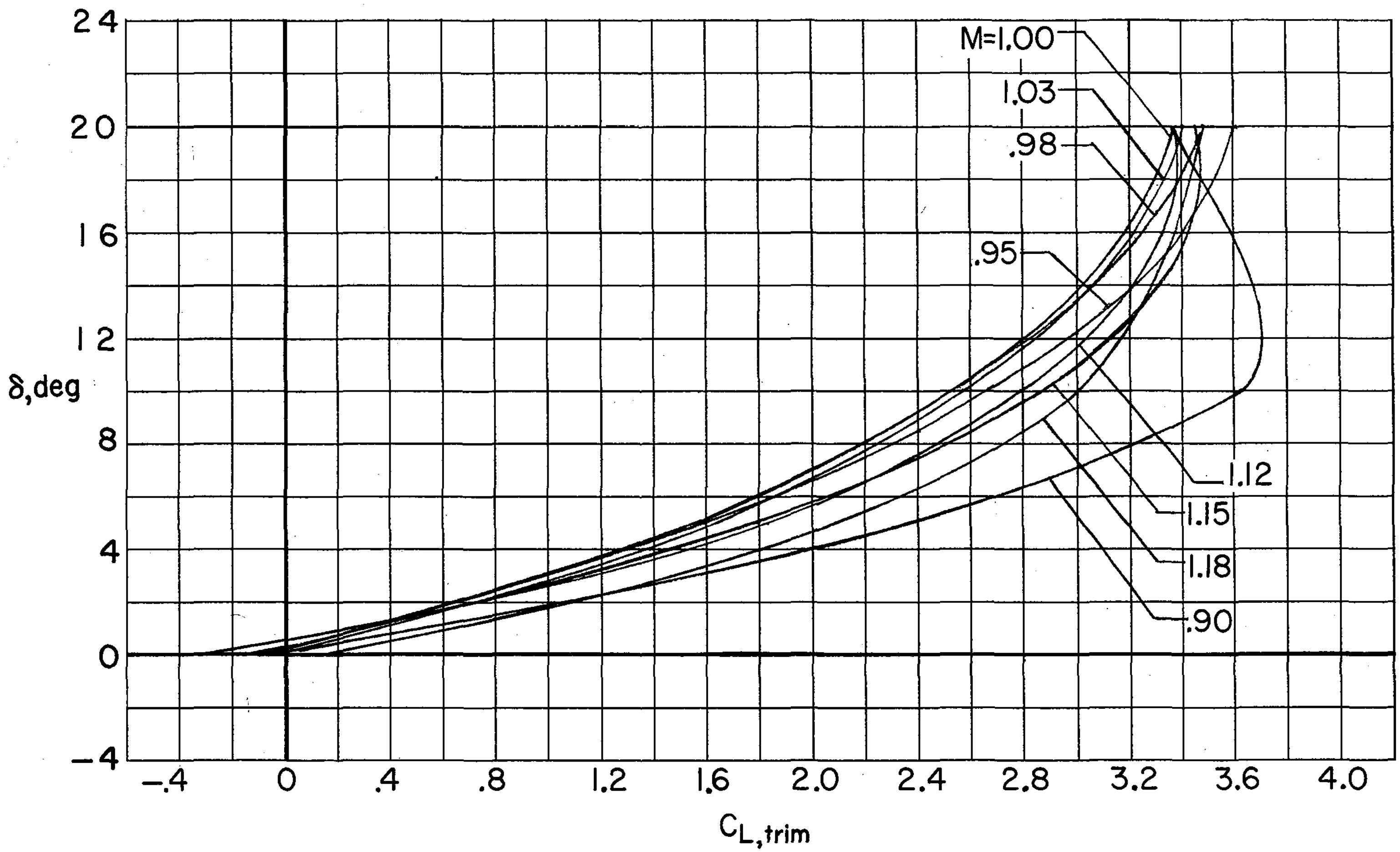


Figure 6.- Trim lift coefficient change per degree change in horizontal canard angle for each Mach number tested.