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HIGH-SPEED AERODYNAMIC CHARACTERISTICS OF A FOUR-ENGINE TRANSPORT AIRPLANE AS DETERMINED FROM TESTS OF A 0.075-SCALE MODEL

By Robert H. Barnes

Ames Aeronautical Laboratory
Moffett Field, California

NACA

WASHINGTON

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Air Materiel Command, U. S. Army Air Forces

HIGH-SPEED AERODYNAMIC CHARACTERISTICS OF A FOUR-ENGINE TRANSPORT AIRPLANE AS DETERMINED FROM TESTS OF A 0.075-SCALE MODEL

By Robert H. Barnes

SUMMARY

The tests reported herein were made in order to determine the differences in high-speed aerodynamic characteristics between models of a four-engine transport airplane and a similar bomber airplane. The main conclusion to be drawn from the results is that the critical Mach number of the transport model is about 0.05 less than that of the bomber model.

INTRODUCTION

Tests of a 0.075-scale model of a four-engine transport airplane were carried out at the request of the Army Air Forces. The purpose was to determine the aerodynamic characteristics of the model at high speeds. Inasmuch as it was very similar to the model of a four-engine bomber airplane, extensive tests of which have been reported in reference 1, the tests were designed to detect differences between the characteristics of the two models only. Consequently they were brief.

APPARATUS AND METHOD

The tests were carried out in the Ames 16-foot high-speed wind tunnel. The model was mounted on a three-strut support system as shown in figure 1.

The transport model (fig. 2) was the same as the model of a bomber airplane except for the fuselage shape and size and the empennage location. Figure 3 shows a comparison of the fuselages. The same wing, empennage, and nacelles were used for both models. Owing to the difference between the fuselages, the position of the empennage with respect to the wing differed for the two models as shown. A detailed description of the wing of the model appears in reference 1. The principal dimensions and areas of the model were as follows:

Model scale	0.075 full scale
Wing area	9.65 square feet
Wing span	10.592 feet
Mean aerodynamic chord	0.965 foot
Aspect ratio	11.62
Tail area (including elevators)	1.873 square feet
Tail length	4.42 feet

The tests reported herein were made with all the control surfaces fixed in their neutral positions. Inasmuch as the same wing and support system were used for both models, the same tunnel-wall corrections and values of the flow inclination were used. No corrections for tares were applied and the change in pitching-moment-coefficient correction due to the change of tail position was neglected.

SYMBOLS

The symbols used in this report are:

q	dynamic pressure $(\frac{1}{2}\rho V^2)$, pounds per square foot
ρ	mass density, slugs per cubic foot
V	velocity, feet per second
S	wing area, square feet

M.A.C.	mean aerodynamic chord, feet
α	angle of attack of wing-chord plane
$\Delta\alpha$	angle-of-attack correction due to tunnel-wall effects and flow inclination
C_L	lift coefficient $\left(\frac{\text{lift}}{qS}\right)$
$C_{D_{gross}}$	drag coefficient $\left(\frac{\text{measured drag}}{qS} + \Delta C_D\right)$
ΔC_D	drag-coefficient correction due to tunnel-wall effects and flow inclination
$C_{m_{c/4}}$	pitching-moment coefficient $\left[\frac{\text{pitching moment}}{qS\ (\text{M.A.C.})}\right]$
ΔC_m	pitching-moment-coefficient correction due to tunnel-wall effects
M	Mach number $\left(\frac{\text{free-stream velocity}}{\text{velocity of sound}}\right)$

RESULTS AND DISCUSSION

The results of the tests are shown in figures 4 to 6 and are presented as comparisons between the characteristics of the transport and bomber models. Figure 4 shows the variation of the angle of attack, drag coefficient, and pitching-moment coefficient with lift coefficient for the tail-off conditions; and figure 5 shows the corresponding variations for the tail on. Figure 6 shows the variation of the pitching-moment coefficient, drag coefficient, and lift coefficient with Mach number. The first two are given for constant values of the lift coefficient, while the lift coefficient is given for constant values of the angle of attack.

For Mach numbers below those approaching the critical, there are no important changes in the lift coefficients at constant angle of attack, while at supercritical speeds the transport model has a lift coefficient about 0.075 less than that of the bomber. At subcritical speeds the transport

model has about 0.004 greater drag coefficient than the bomber, and at supercritical speeds this difference is increased about fivefold.

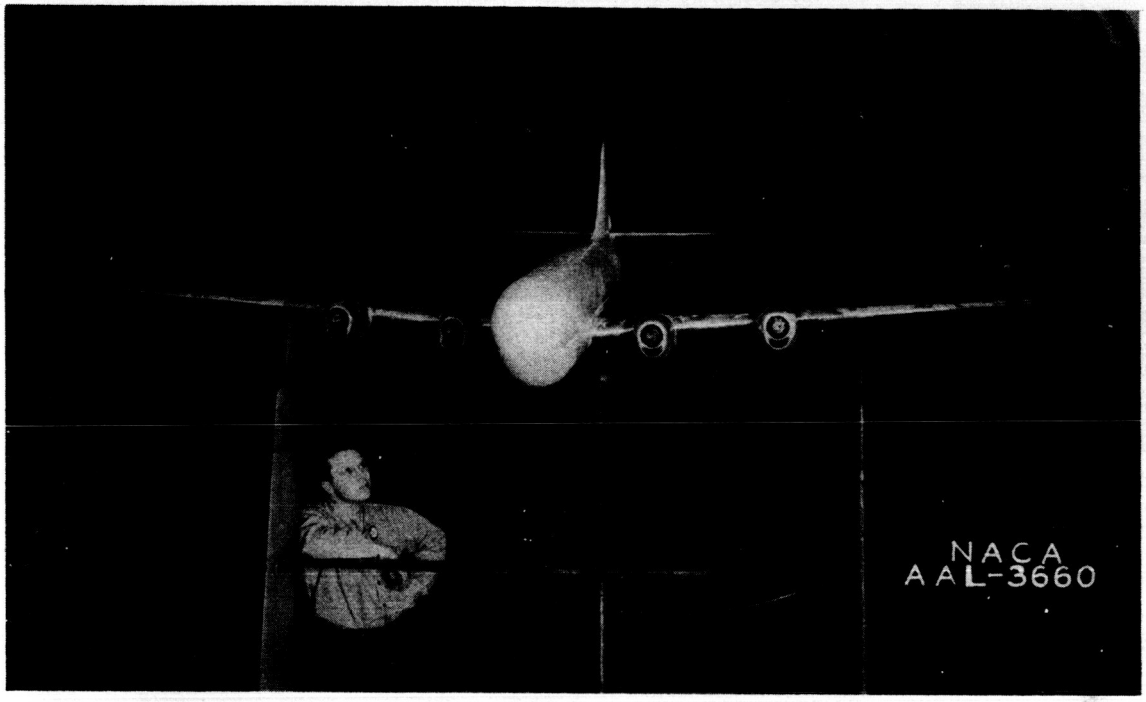
From inspection of figure 6(a) it is seen that the pitching-moment coefficients begin to decrease rapidly at a lower Mach number for the transport model, the magnitude of the Mach number difference being approximately 0.05. Figures 6(b) to 6(d) show that marked changes in the lift and drag coefficients also occur at lower Mach numbers with the transport model. These facts indicate that the critical speed of the transport airplane is less than that of the bomber. This difference is believed to be due to the difference in shape and fineness ratio of the fuselages. The change of 0.05 in the critical Mach number is equivalent to 35 miles per hour at 20,000 feet altitude.

Inasmuch as the transport and bomber airplanes are similar, it may be expected that the transport airplane will have similar characteristics to those predicted in reference 1, for the bomber, except insofar as their critical Mach numbers are involved.

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

REFERENCE

1. Barnes, Robert H.: High-Speed Aerodynamic Characteristics of the XB-29 Airplane as Determined from Tests of a 0.075-Scale Model. NACA CNR, Jan. 1944.



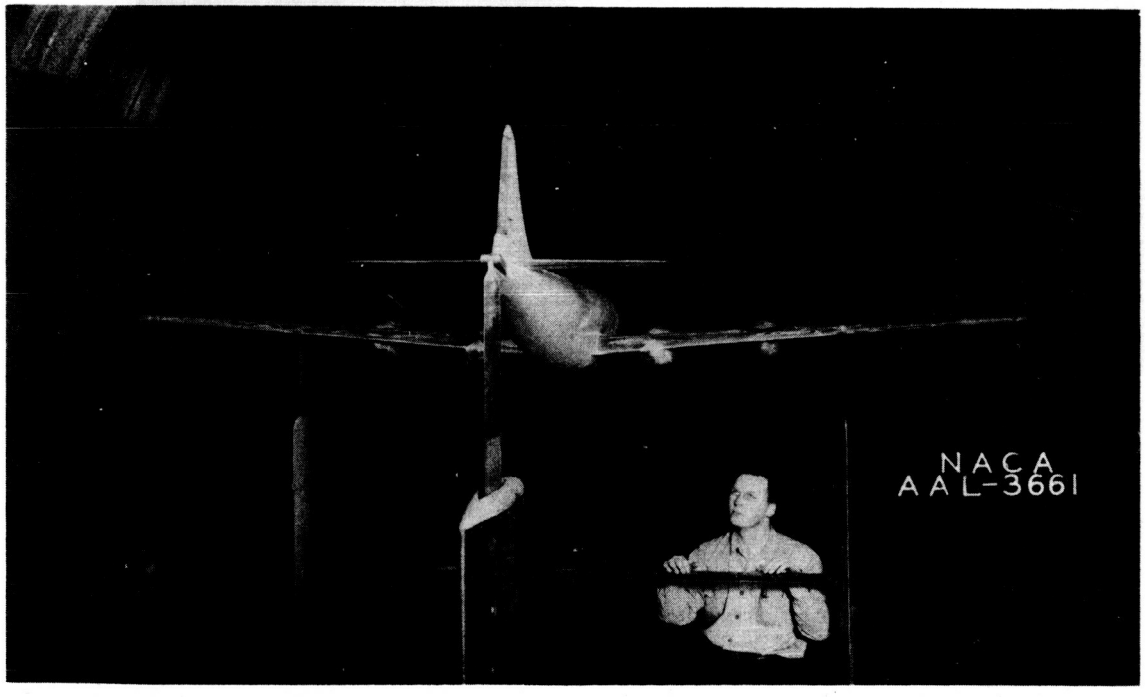


Figure 1.- The four-engine transport airplane model mounted in the 16-foot wind tunnel.

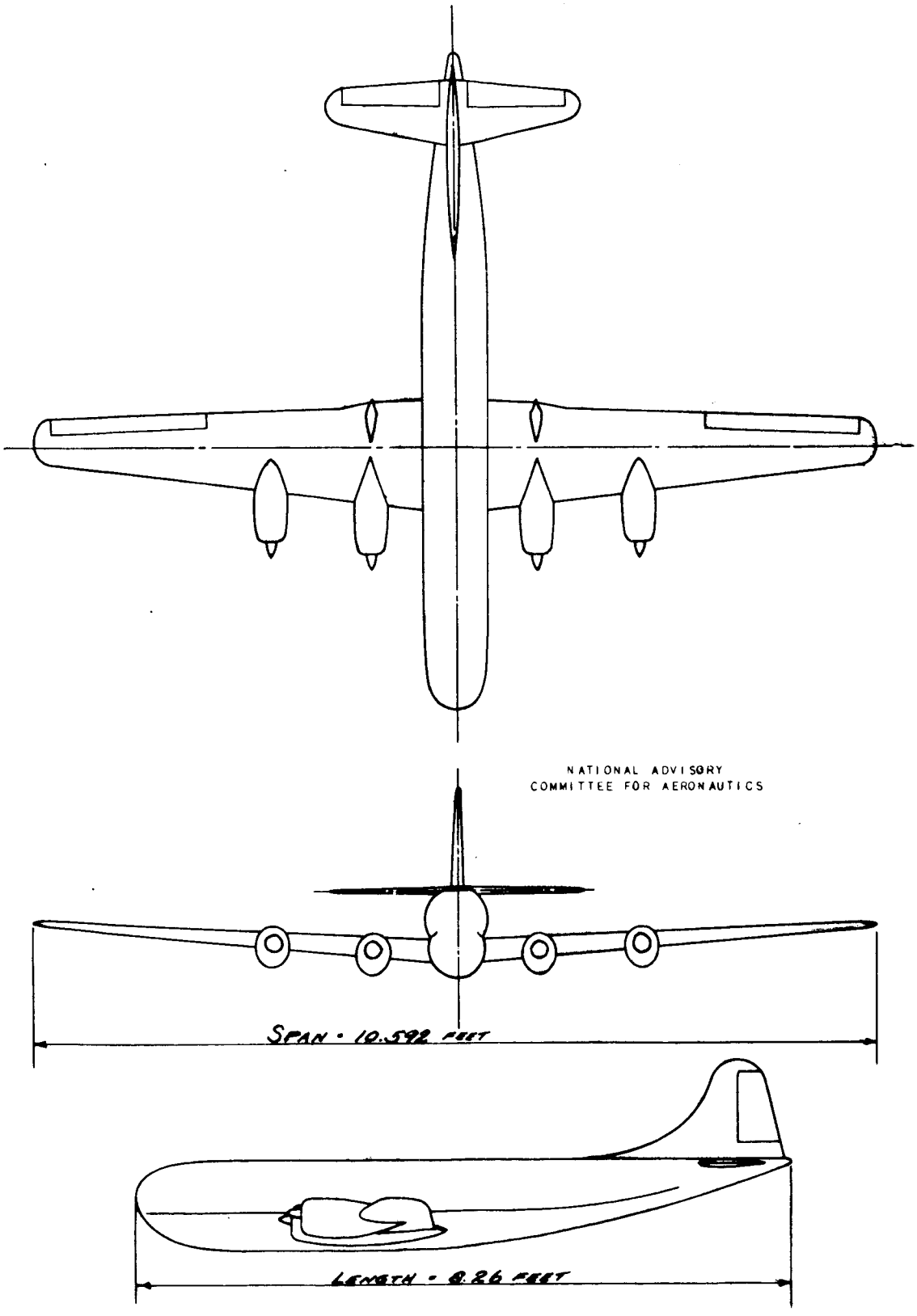
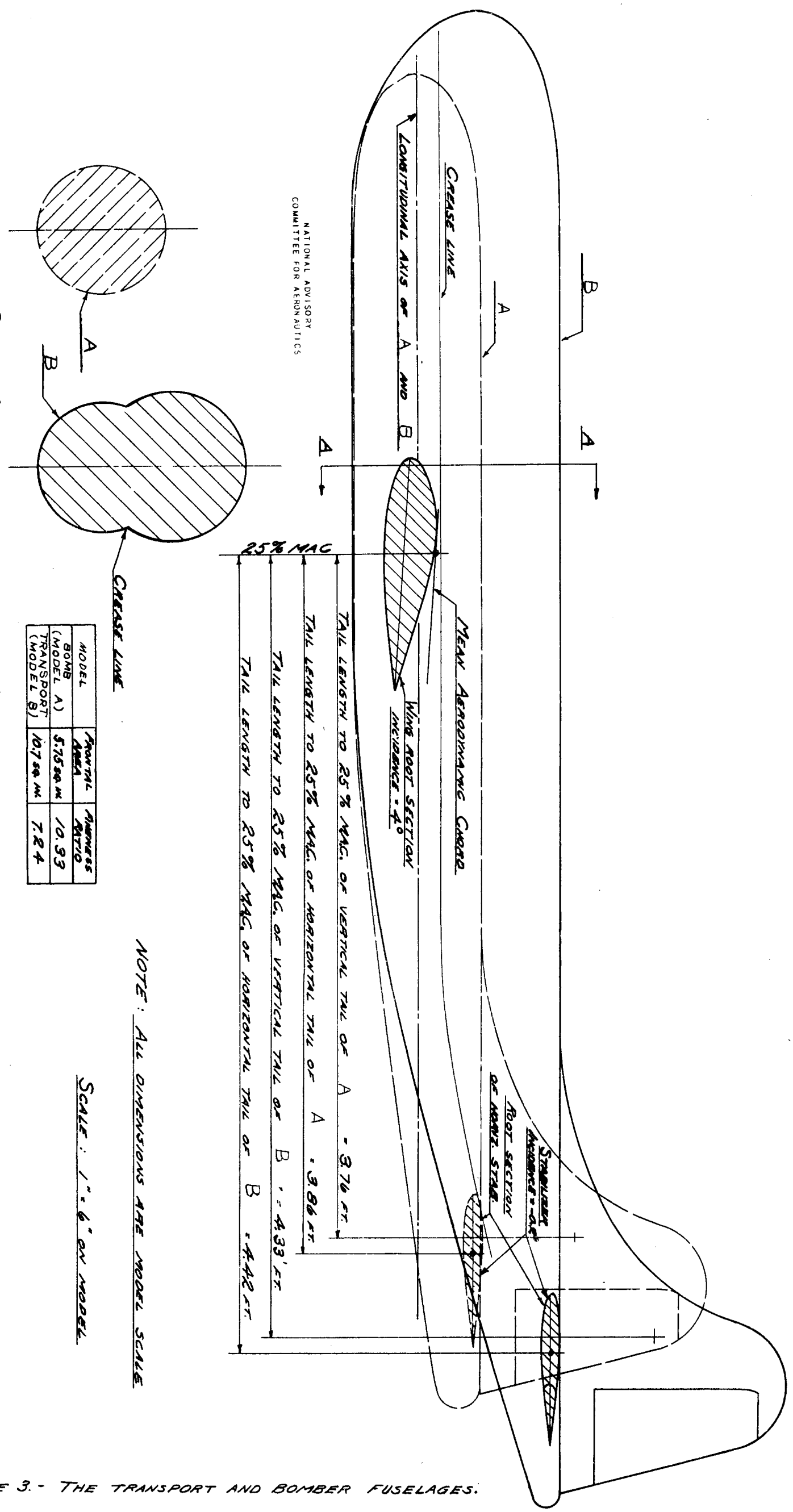


FIGURE 2. - THREE-VIEW DRAWING OF THE TRANSPORT MODEL.



MODEL	FRONTAL AREA	ASPECT RATIO
BOMB (MODEL A)	5.75 sq. in.	10.93
TRANSPORT (MODEL B)	10.7 sq. in.	7.24

NOTE: ALL DIMENSIONS ARE MODEL SCALE

SCALE: 1" = 6" ON MODEL

FIGURE 3.- THE TRANSPORT AND BOMBER FUSELAGES.

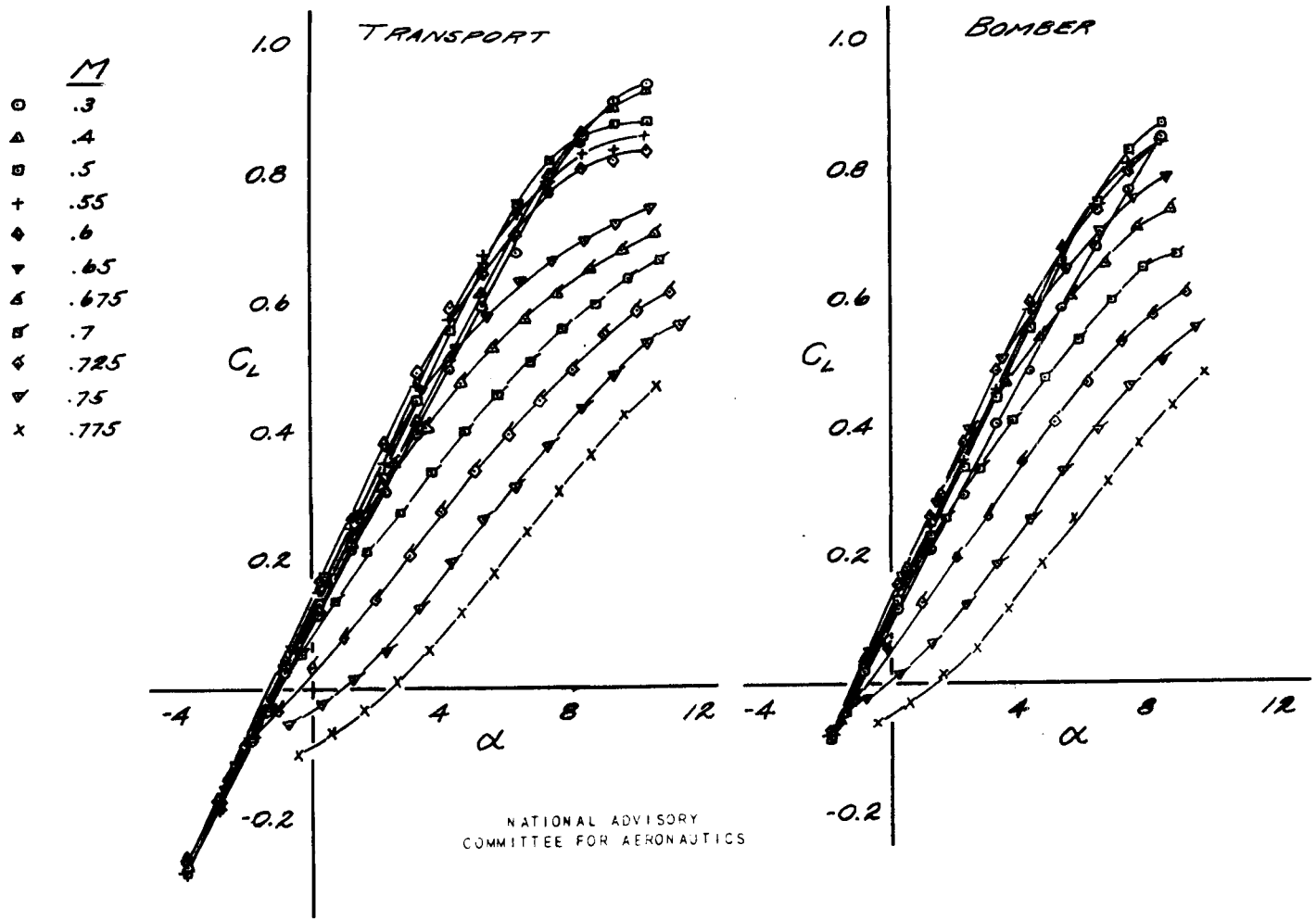


FIGURE 4(a).- VARIATION OF THE LIFT COEFFICIENT WITH ANGLE OF ATTACK FOR THE TRANSPORT AND BOMBER MODELS. TAIL OFF.

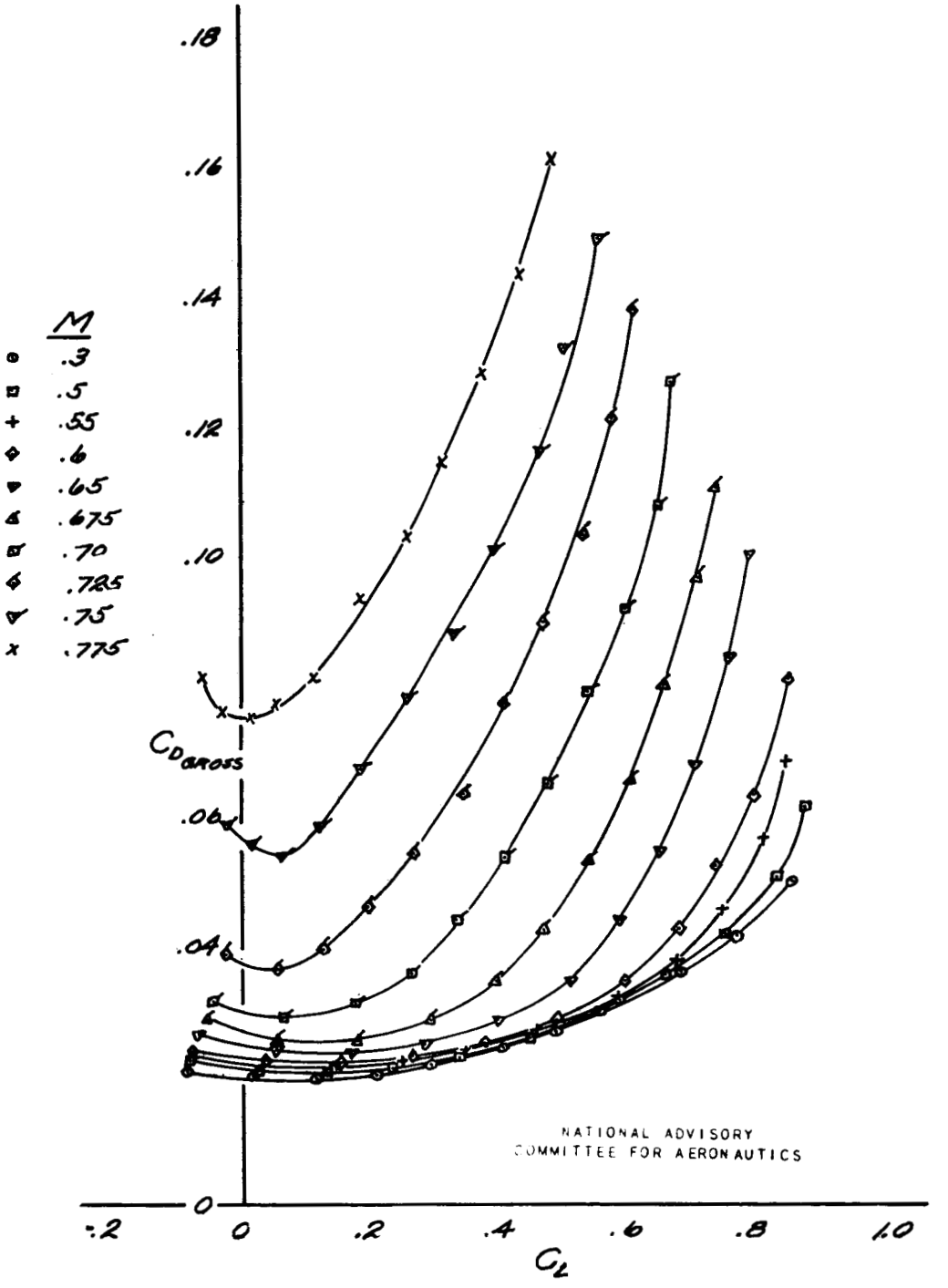


FIGURE 4(b). - VARIATION OF THE DRAG COEFFICIENT WITH LIFT COEFFICIENT FOR THE BOMBER MODEL FOR VARIOUS MACH NUMBERS. TAIL OFF.

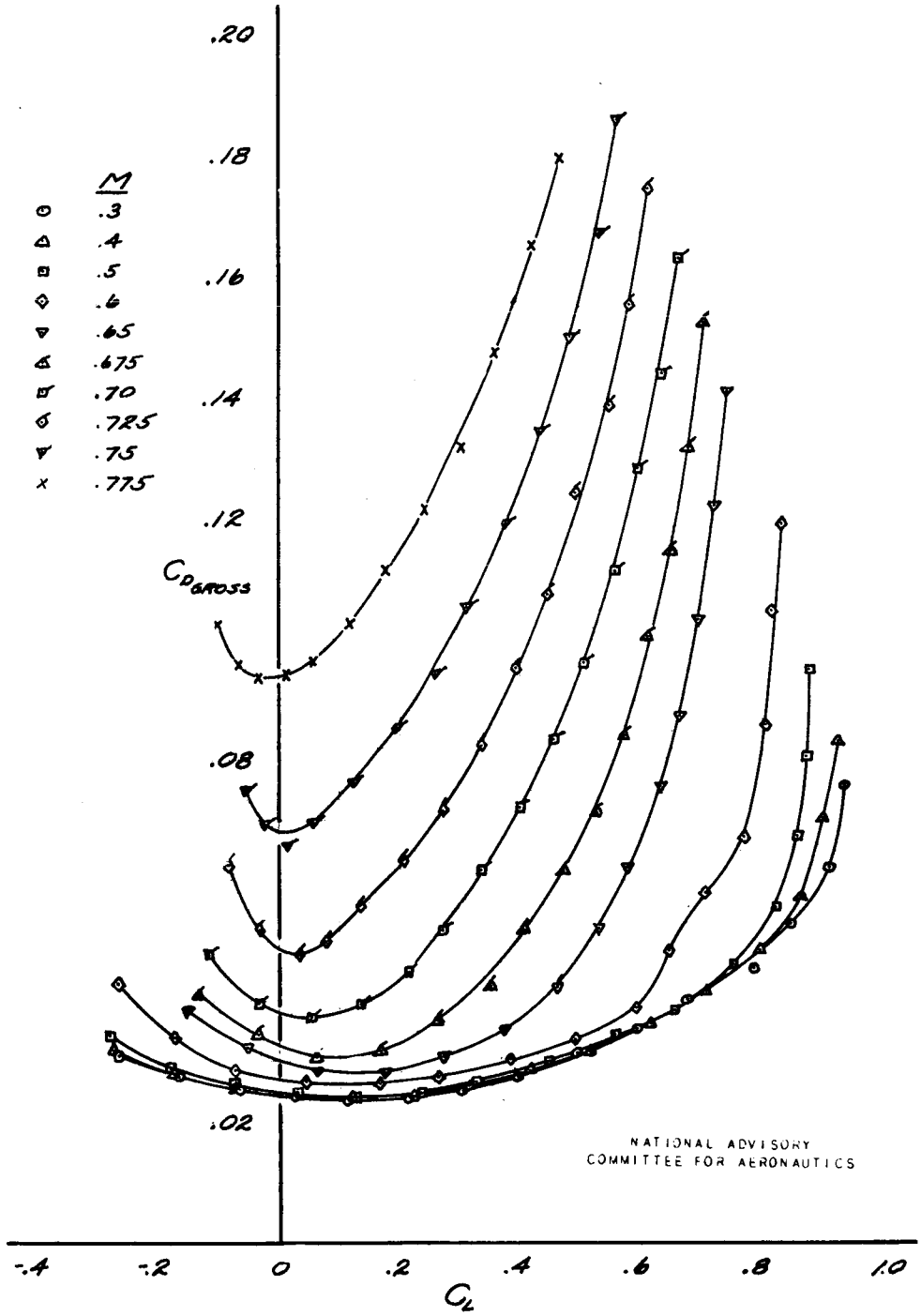


FIGURE 4(c).- VARIATION OF THE DRAG COEFFICIENT WITH LIFT COEFFICIENT FOR THE TRANSPORT MODEL FOR VARIOUS MACH NUMBERS. TAIL OFF.

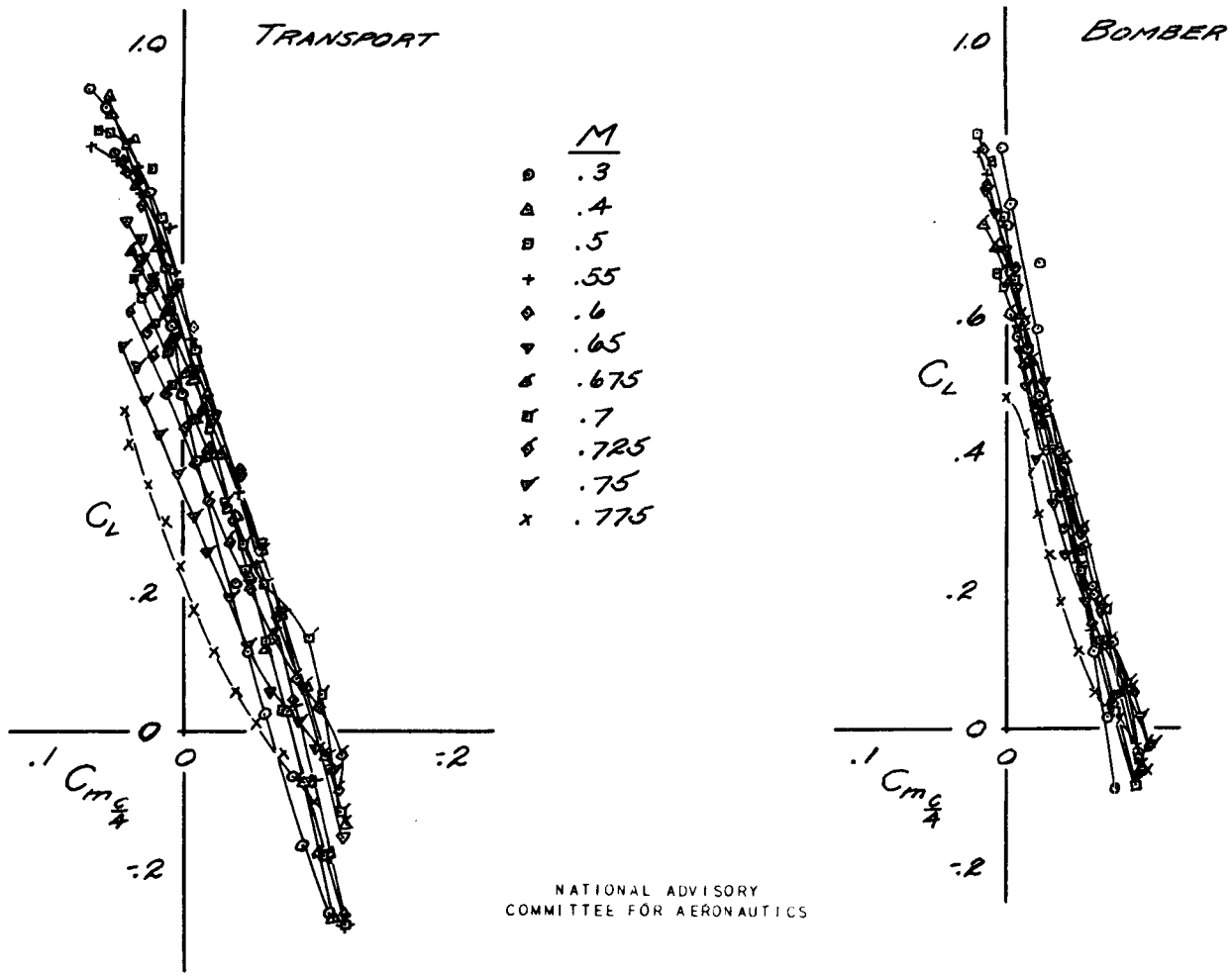


FIGURE 4(d).- VARIATION OF THE PITCHING-MOMENT COEFFICIENT WITH LIFT COEFFICIENT FOR VARIOUS MACH NUMBERS FOR THE TRANSPORT AND BOMBER MODELS. TAIL OFF.

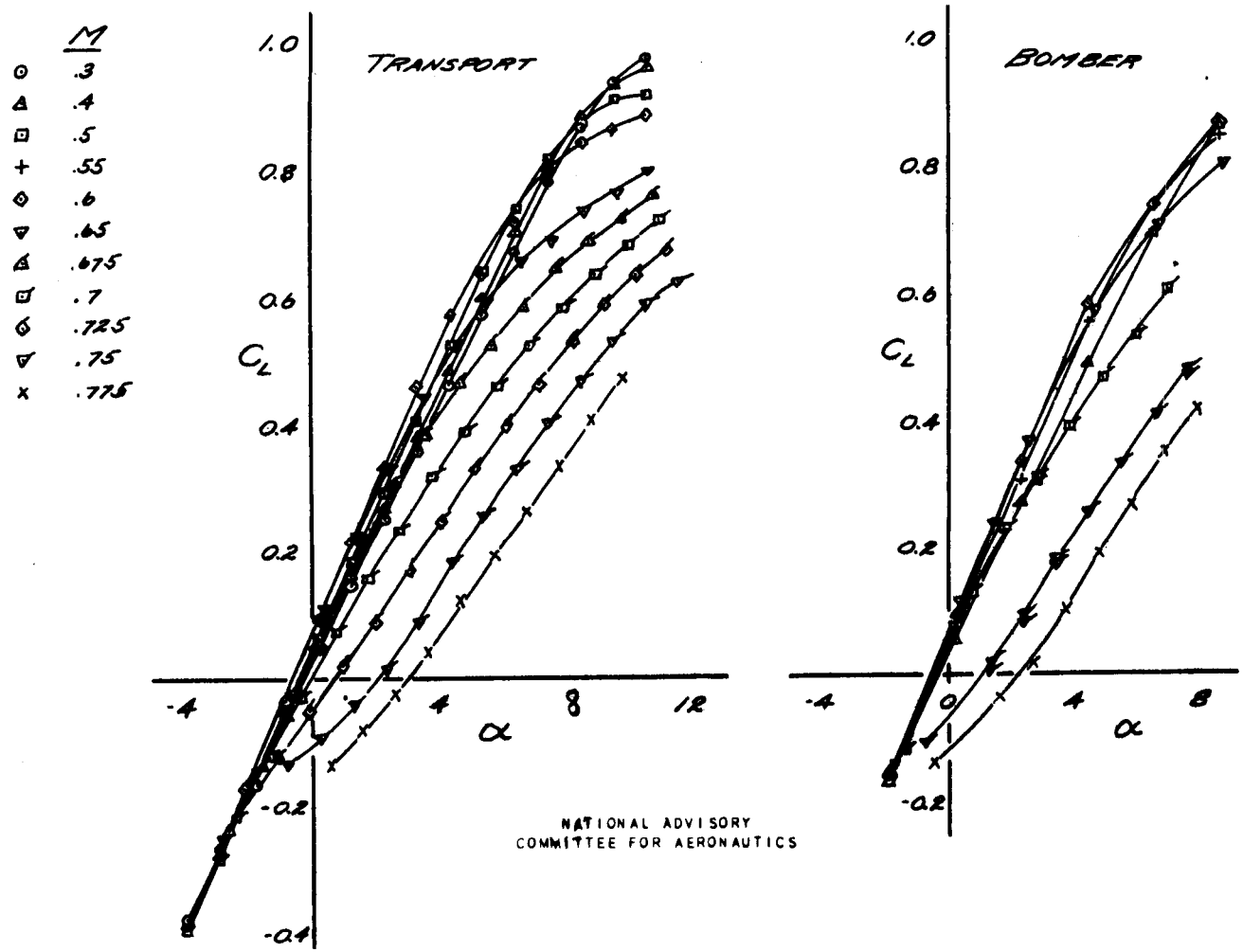


FIGURE 5(a).- VARIATION OF THE LIFT COEFFICIENT WITH ANGLE OF ATTACK FOR VARIOUS MACH NUMBERS FOR THE TRANSPORT AND BOMBER MODELS. TAIL ON.

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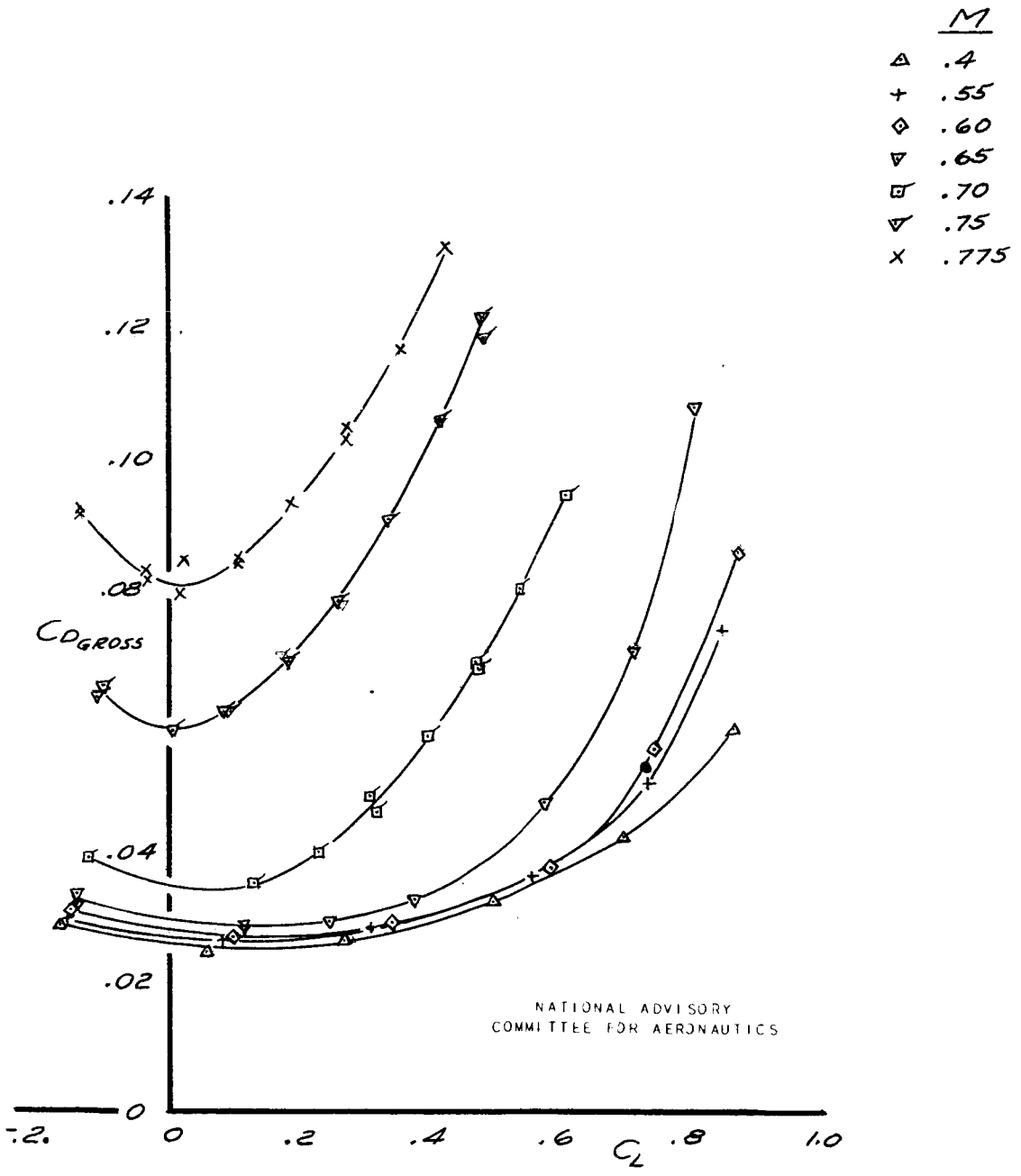

FIGURE 5(b). - VARIATION OF THE DRAG COEFFICIENT WITH LIFT COEFFICIENT FOR VARIOUS MACH NUMBERS FOR THE BOMBER MODEL. TAIL ON.

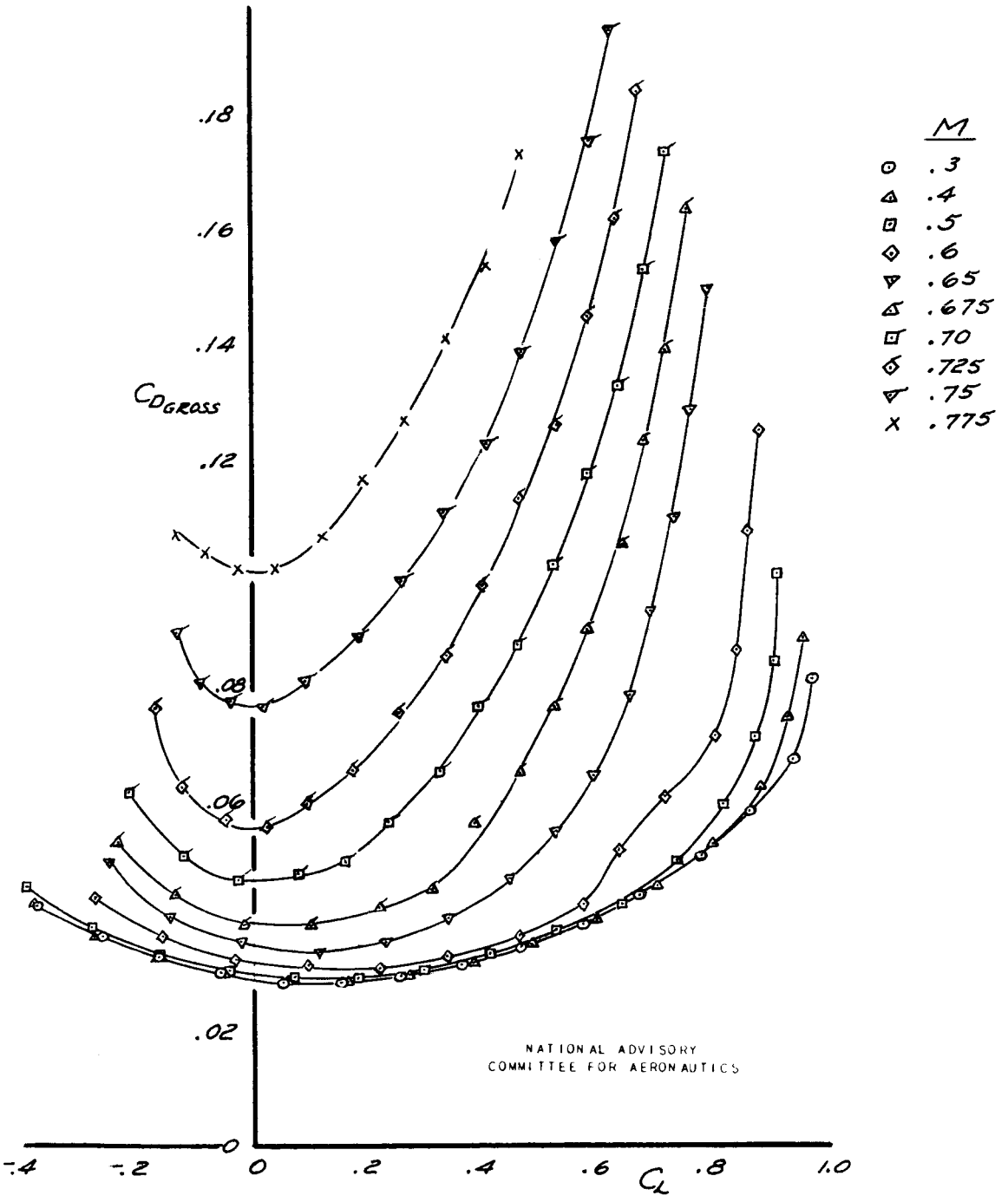

FIGURE 5(c).- VARIATION OF THE DRAG COEFFICIENT WITH LIFT COEFFICIENT FOR VARIOUS MACH NUMBERS FOR THE TRANSPORT MODEL. TAIL ON.

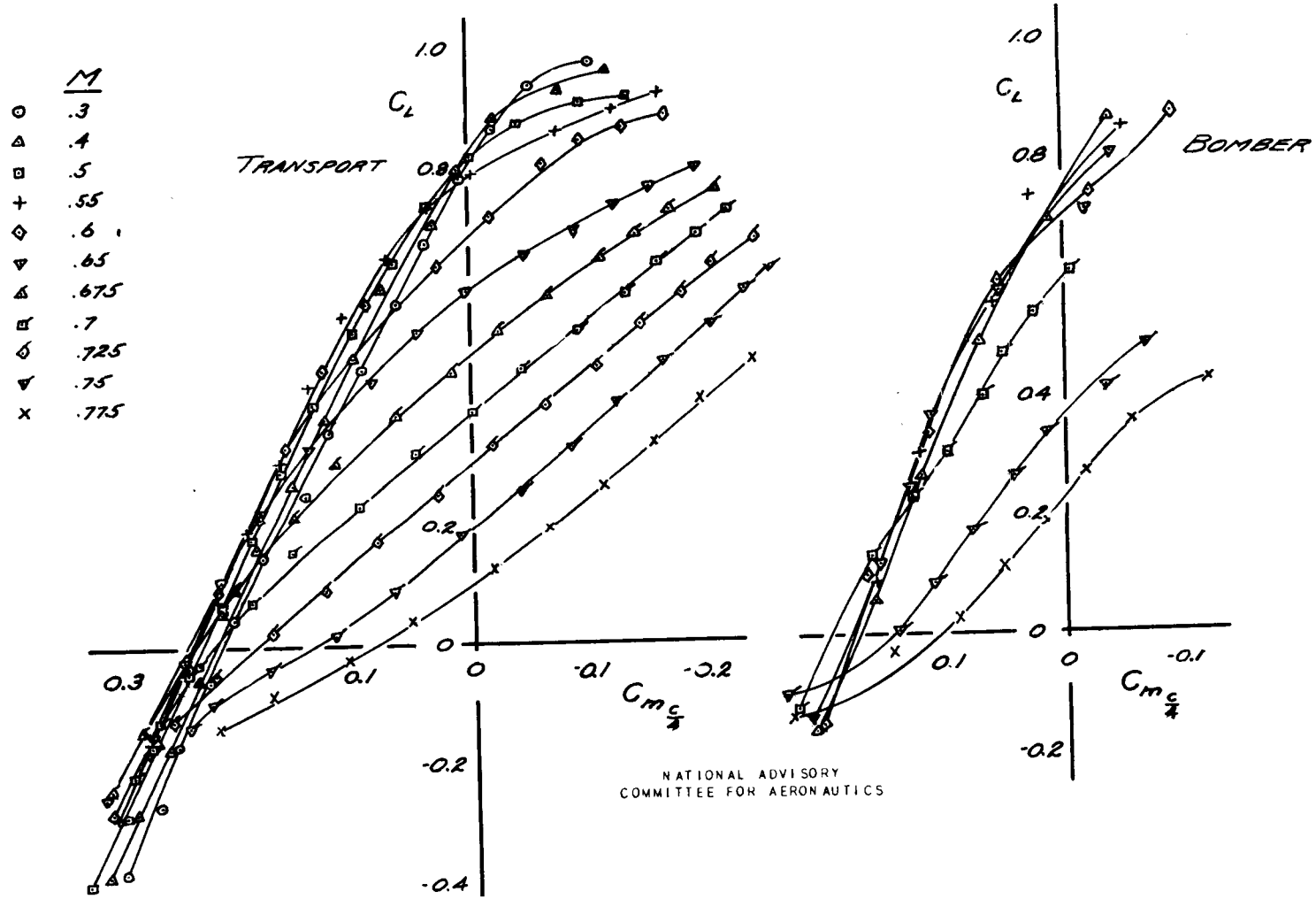

FIGURE 5(d).- VARIATION OF THE PITCHING-MOMENT COEFFICIENT WITH LIFT COEFFICIENT FOR VARIOUS MACH NUMBERS FOR THE TRANSPORT AND BOMBER MODELS. TAIL ON.

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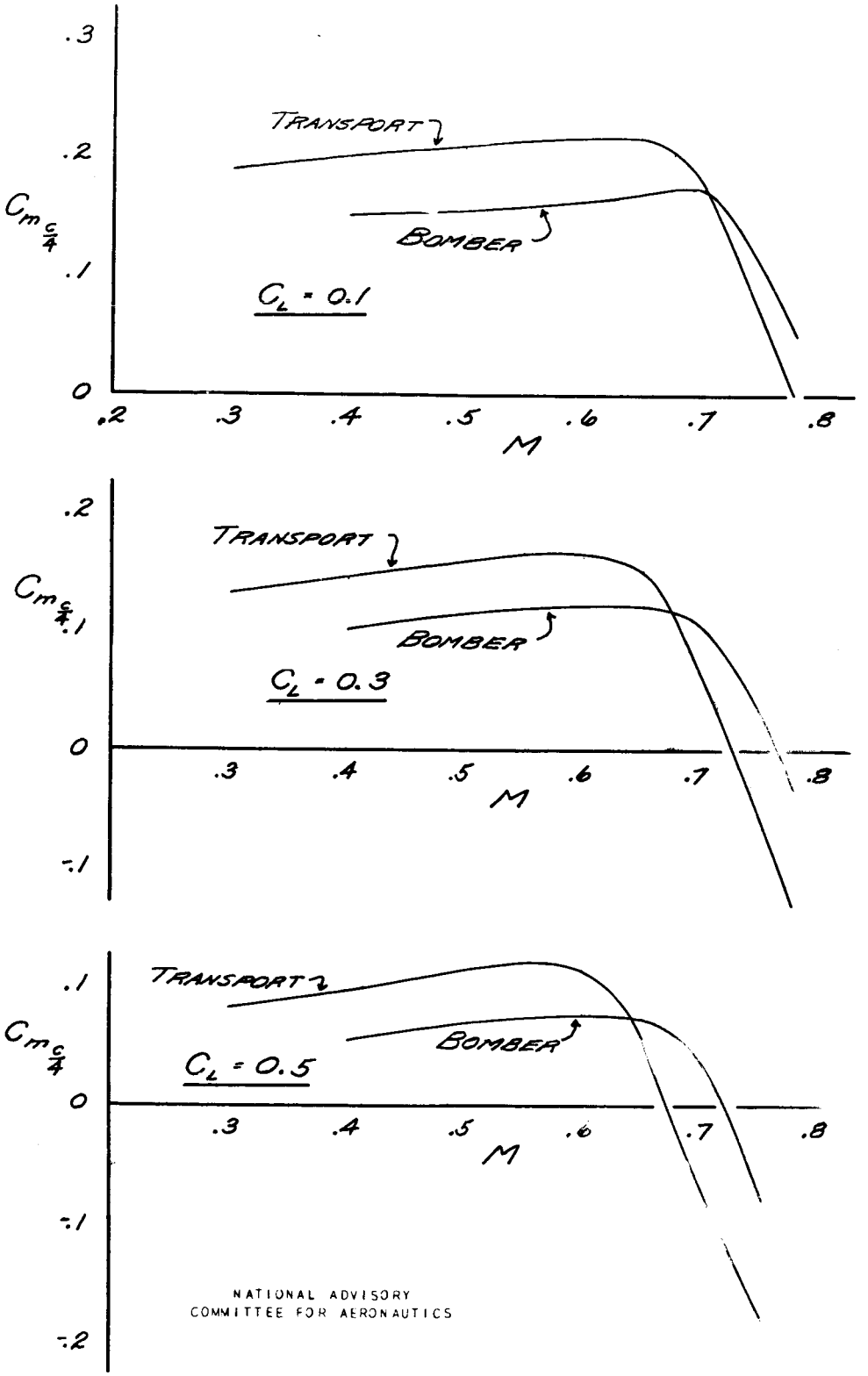

FIGURE 6(a).- VARIATION OF THE PITCHING-MOMENT COEFFICIENT WITH MACH NUMBER FOR CONSTANT VALUES OF THE LIFT COEFFICIENT. TAIL ON.

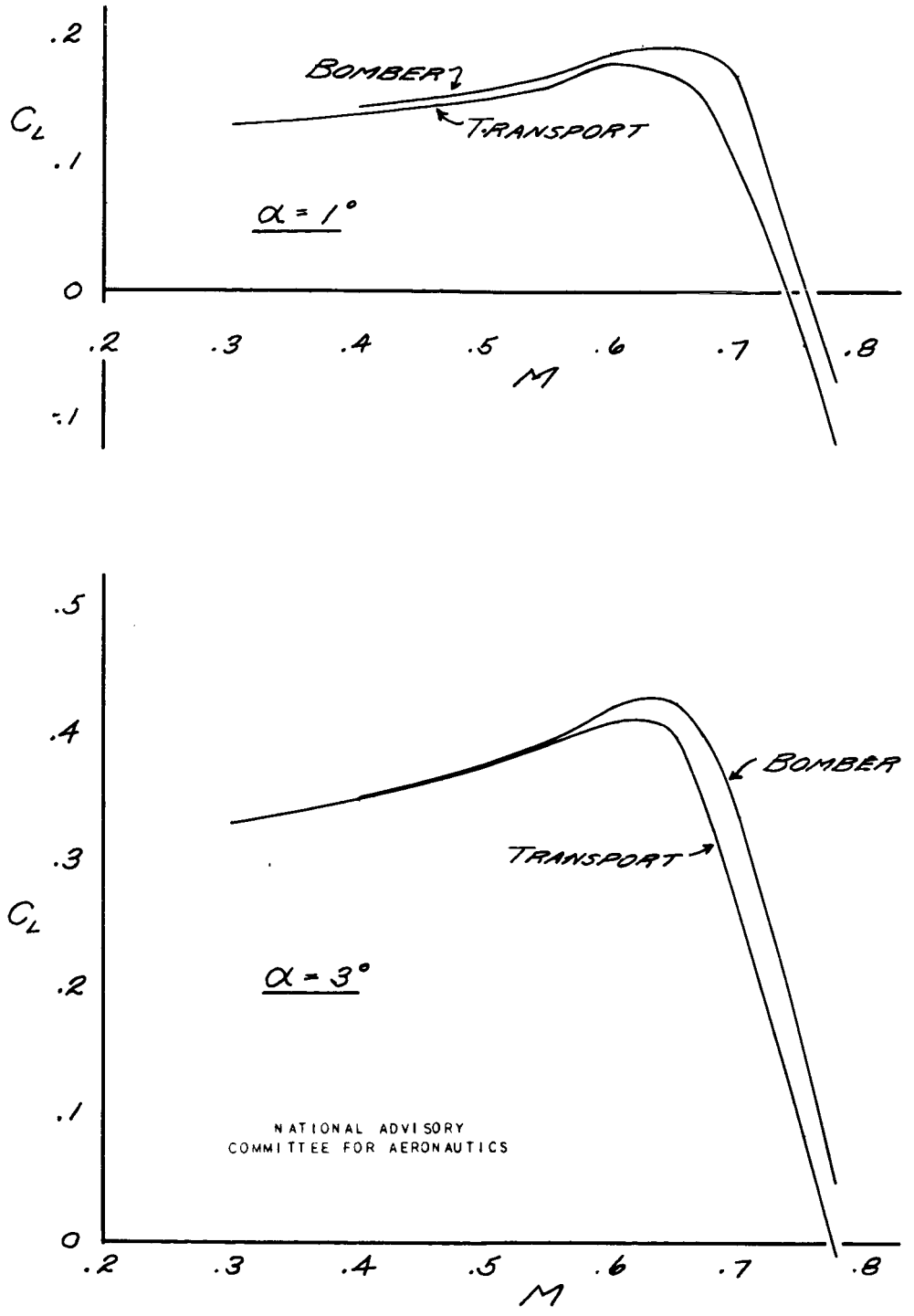

FIGURE 6(b).- VARIATION OF THE LIFT COEFFICIENT WITH MACH NUMBER FOR CONSTANT VALUES OF THE ANGLE OF ATTACK. TAIL ON.

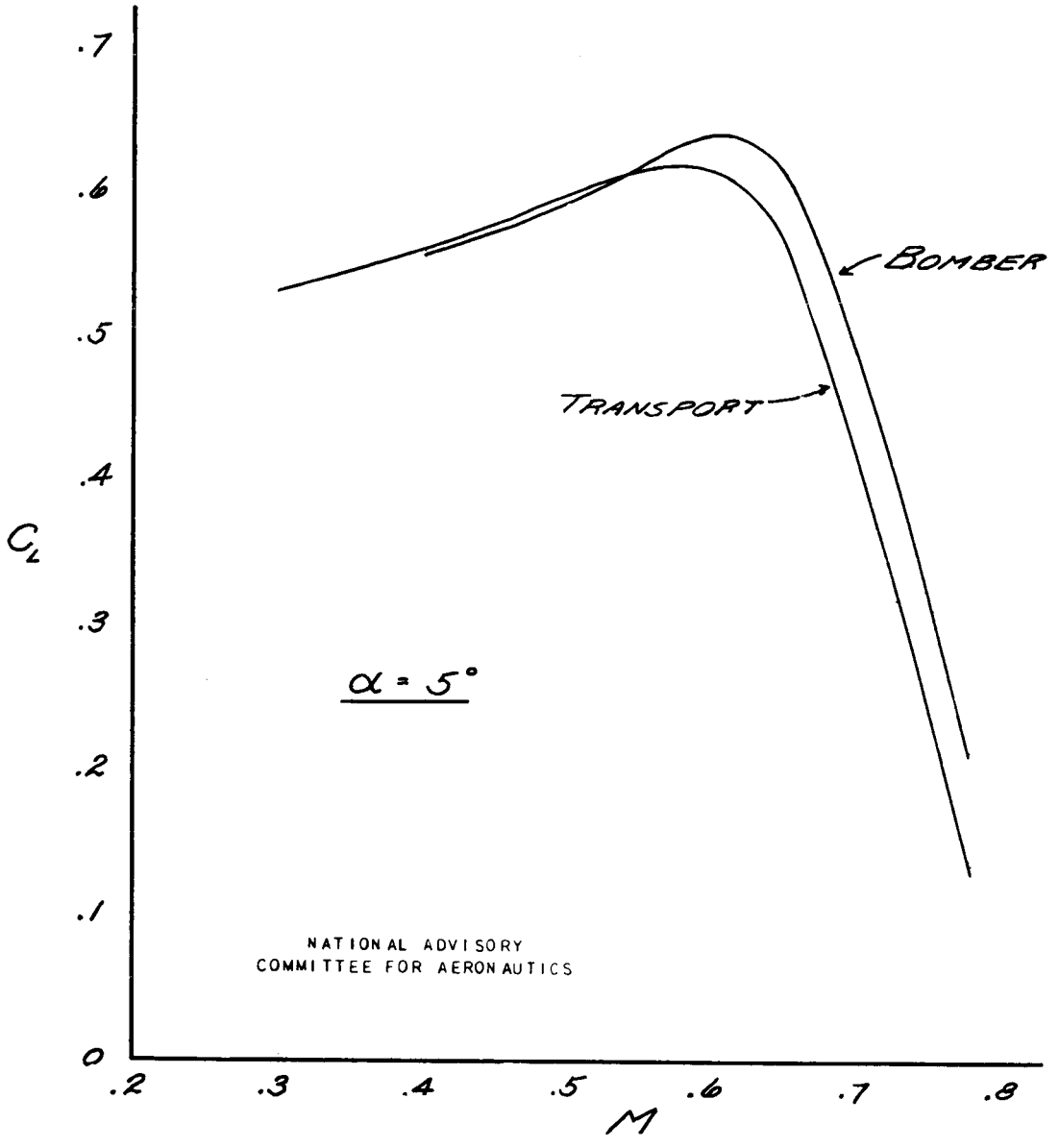

FIGURE 6(C).- VARIATION OF THE LIFT COEFFICIENT WITH MACH NUMBER FOR CONSTANT ANGLE OF ATTACK. TAIL ON.

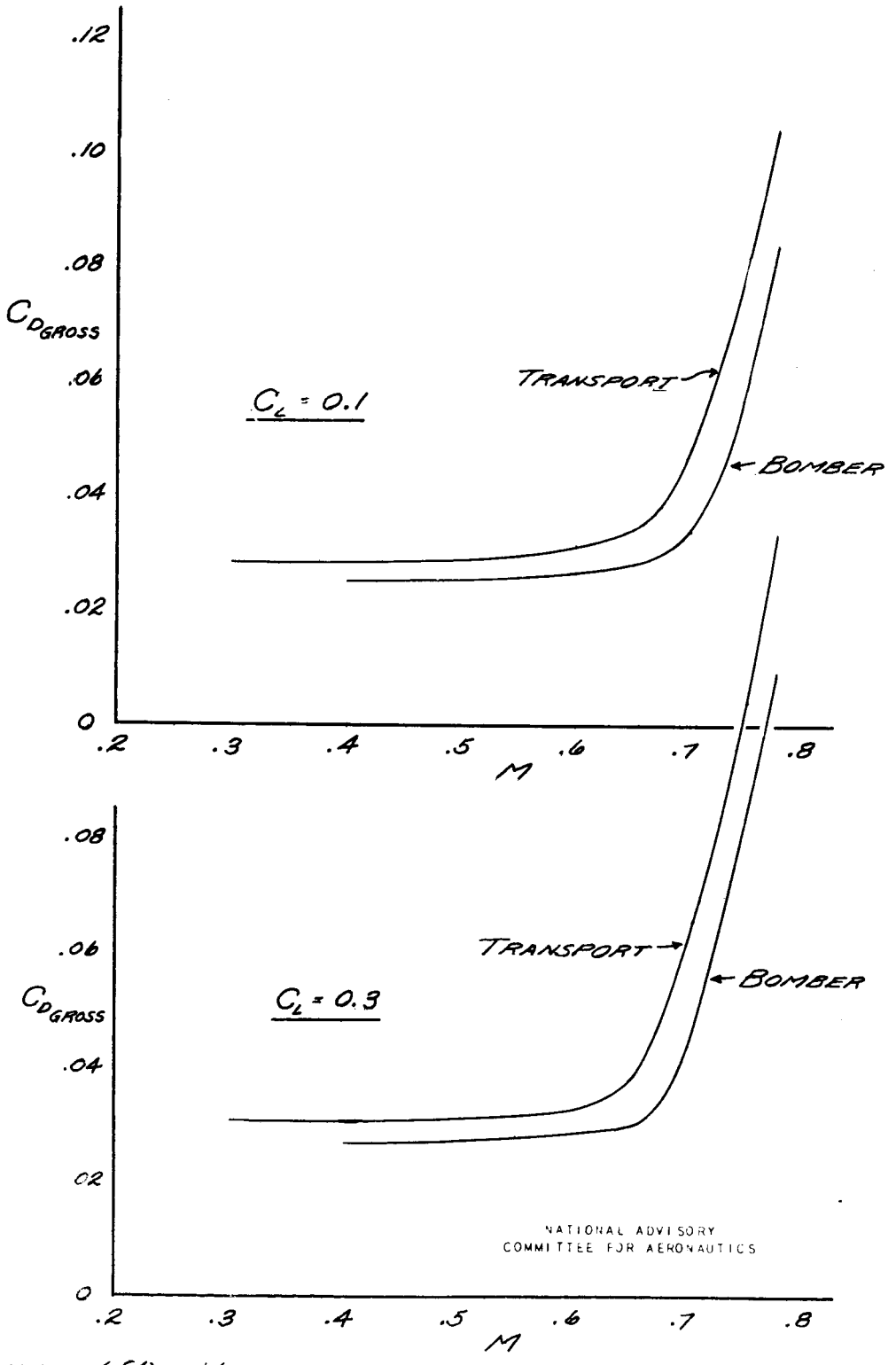

FIGURE 6(d).- VARIATION OF THE DRAG COEFFICIENT WITH MACH NUMBER FOR CONSTANT VALUES OF THE LIFT COEFFICIENT. TAIL ON.

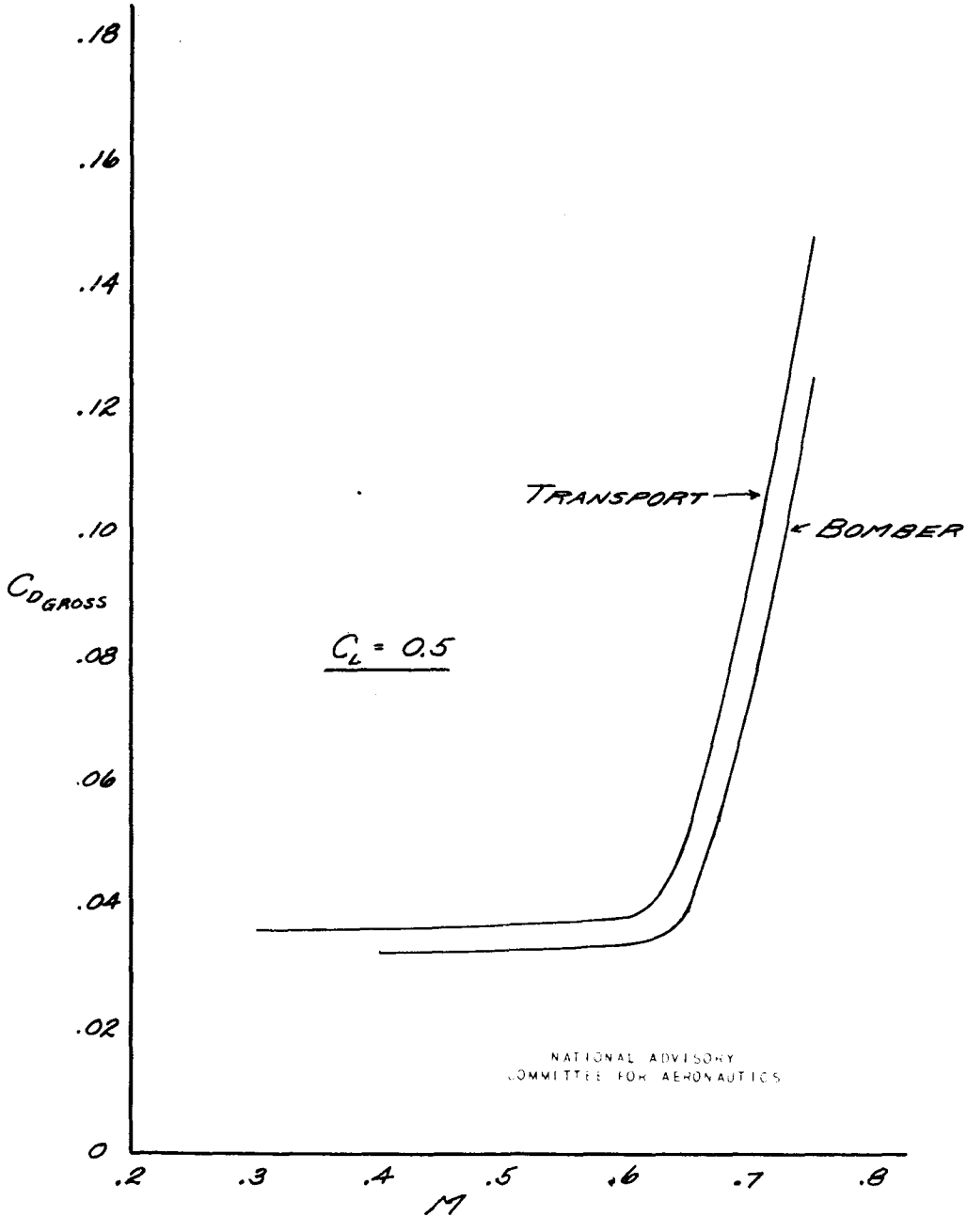

FIGURE 6(e).- VARIATION OF THE DRAG COEFFICIENT WITH MACH NUMBER FOR CONSTANT VALUES OF THE LIFT COEFFICIENT. TAIL ON.