https://ntrs.nasa.gov/search.jsp?R=19930086280 2020-06-17T13:11:40+00:00Z

RM L50C21

NACA RM L50C21

NACA

RESEARCH MEMORANDUM

AERODYNAMIC CHARACTERISTICS WITH FIXED AND FREE TRANSITION OF A MODIFIED DELTA WING IN COMBINATION WITH A FUSELAGE AT HIGH SUBSONIC SPEEDS

By Edward C. Polhamus and Thomas J. King, Jr.

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

May 2, 1950

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

AERODYNAMIC CHARACTERISTICS WITH FIXED AND FREE TRANSITION OF A MODIFIED DELTA WING IN COMBINATION WITH A FUSELAGE AT HIGH SUBSONIC SPEEDS

By Edward C. Polhamus and Thomas J. King, Jr.

SUMMARY

An investigation has been made in the Langley high-speed 7- by 10-foot tunnel to determine the aerodynamic characteristics with fixed and free transition at high subsonic speeds of a modified delta wing in combination with a fuselage. The wing had an aspect ratio of 3, a taper ratio of 0.313, a sweepback of 27.7°, and an NACA 64_1A012 airfoil section.

The results indicate that the lift-force-break Mach number was about 0.84 for both the transition free and fixed conditions; however, with fixed transition the lift curve was nonlinear in the high Mach number range and the slopes in the low-lift range were considerably lower than with free transition. The drag force break occurred at a Mach number of about 0.84 for both the transition-free and transition-fixed conditions, but for the transition-fixed condition, the drag was considerably higher.

Mach number had little effect on the aerodynamic-center location for the free-transition case up to a Mach number of about 0.80 above which there is a rearward movement of approximately 5 percent mean aerodynamic chord followed by a rapid forward movement at a Mach number of about 0.87. At the higher Mach numbers with fixed transition the pitching-moment characteristics were nonlinear and the aerodynamic-center position was considerably forward of its position with free transition.

INTRODUCTION

An investigation of the high-speed aerodynamic characteristics of a modified delta wing in combination with a fuselage was conducted in the

Langley high-speed 7- by 10-foot tunnel. The model was tested on the sting support system through a Mach number range of 0.40 to 0.90 with both free and fixed transition. Because of the nature of the transition effect, the results seemed to be of general interest and are presented in the present paper.

COEFFICIENTS AND SYMBOLS

The system of axes used for the presentation of the data, together with an indication of the positive forces, moments, and angles, is presented in figure 1. Pertinent symbols are defined as follows:

C_L lift coefficient (Lift/qS)

C_D drag coefficient (Drag/qS)

C_m pitching-moment coefficient measured about the 25-percent mean-aerodynamic-chord position (Pitching moment/qSc')

q free-stream dynamic pressure, pounds per square foot $\left(\rho V^2/2\right)$

S wing area, square feet

c' wing mean aerodynamic chord, feet

b wing span, feet

V air velocity, feet per second

a speed of sound, feet per second

M Mach number (V/a)

R Reynolds number $(\rho Vc'/\mu)$

μ absolute viscosity, pound-seconds per square foot

ρ mass density of air, slugs per cubic foot

α angle of attack of the fuselage, measured from the X-axis to the fuselage center line, degrees

$$C_{L_\alpha} = \left(\frac{\partial C_L}{\partial \alpha}\right)$$

$$C_{m_{C_L}} = \left(\frac{\partial C_m}{\partial C_L}\right)$$

APPARATUS AND METHODS

Tunnel and Model

The tests were conducted in the Langley high-speed 7- by 10-foot tunnel, which is a closed, rectangular tunnel of the return-flow type with a contraction ratio of 15.7 to 1.

The wing of the model was constructed of steel and the fuselage of aluminum. Details of the model as tested are presented in figure 2. The wing was a modified delta wing having a quarter-chord sweep angle of 27.7°, an aspect ratio of 3, a taper ratio of 0.313, and an NACA 64_1A012 airfoil section parallel to the plane of symmetry.

For the tests with transition fixed, the leading upper and lower 8 percent of the chord measured along the surface was covered with number 60 carborundum.

Support System

A sting support system was used to support the model in the tunnel and a photograph of the test setup is presented as figure 3. The sting extended from the rear of the fuselage to a vertical strut located behind the test section. This strut was mounted on the tunnel balance system and was shielded from the air stream by a streamline fairing. The tare forces and moments produced by the sting were determined by mounting the model on two wing tare stings, which were also attached to the vertical strut, and by testing the model with and without the center sting. A photograph of the model mounted on the tare stings is presented as figure 4. Angles of attack were changed by the use of interchangeable couplings in the stings rearward of the model. The deflections of the support system under load were determined from static loading tests.

CORRECTIONS

The test results have been corrected for the tare forces and moments produced by the support system. The corrections due to the jet-boundary induced upwash were computed from the following equations, which were determined by the method of reference 1:

$$\alpha = \alpha_m + 0.363C_L$$

$$C_D = C_{D_m} + 0.0063{C_L}^2$$

where the subscript m indicates measured value. The streamline-curvature corrections to the pitching moment and angle of attack were negligible.

The drag has been corrected for the buoyancy produced by the longitudinal static-pressure gradient in the tunnel, and the dynamic pressure and Mach number have been corrected for blockage effects by the method of reference 2.

TESTS

The model was tested through a Mach number range of 0.40 to 0.90 at various angles of attack. The variation of test Reynolds number with Mach number for average test conditions is presented in figure 5. The degree of turbulence of the tunnel is not known but is believed to be small because of the high contraction ratio. Experience has indicated that, for a model of this size, constriction effects should not invalidate the test results at corrected Mach numbers below about 0.91.

RESULTS AND DISCUSSION

Presentation of Results

The results are presented in figure 6 as plots of angle of attack, drag coefficient, and pitching-moment coefficient against lift coefficient for different Mach numbers ranging from 0.40 to 0.90. Results are presented for both the transition-free and transition-fixed conditions. A summary of the data is presented in figure 7.

Discussion of Results

Lift.- The results indicate that the lift-curve slope, for both the transition-free and transition-fixed conditions, increases with Mach number up to a Mach number of about 0.84 above which there is a rather rapid decrease.

Fixing transition had a large effect on the lift characteristics of this wing in the high Mach number range as can be seen from figures 6 and 7. With fixed transition the lift curve was nonlinear in the high Mach number range (fig. 6(a)) and the slopes in the low-lift range were considerably lower than with free transition (figs. 6(a) and 7). Although the transition strip had an effect on the lift, it caused only a slight decrease in the lift-force-break Mach number (fig. 7). Although no pressure distributions were obtained for this wing, some have been obtained on a 12-percent-thick, two-dimensional airfoil with and without a transition strip and the results are presented in reference 3. The results indicated that when the transition strip was added to the airfoil the location of the shock was moved forward and a loss in lift resulted. Throughout the present paper it should be kept in mind that transition from a laminar to a turbulent boundary layer was effected artificially by the use of roughness and therefore this transition does not necessarily represent the natural transition process that would occur on a smooth surface.

Drag.- For both the transition-free and transition-fixed cases the drag-rise Mach number in the low-lift range is about 0.84 (fig. 7). Transition caused a rather large increase in the drag (fig. 7) but had little effect on the drag-rise Mach number or the rate of the drag rise. The increase in drag is probably due to a longer run of turbulent boundary layer or an increased wake due to earlier separation caused by the forward movement of the shock mentioned earlier, or both.

The transition strip had little effect on the drag due to lift below a lift coefficient of about 0.3, but above this lift coefficient the drag due to lift was generally higher for the transition-fixed case.

Pitching moment.- For the transition-free case there is little effect of Mach number on the aerodynamic center up to a Mach number of about 0.80 above which there is a rearward movement of about 5 percent mean aerodynamic chord followed by a rapid forward movement at a Mach number of about 0.87. With transition fixed there is a gradual forward movement of the aerodynamic center up to a Mach number of about 0.85 followed by a very rapid forward shift. At the higher Mach numbers (above about 0.80) the transition strip had a very pronounced effect on the pitching-moment characteristics. For example, at a Mach number of 0.90 the aerodynamic center with transition fixed was approximately 60 percent mean aerodynamic chord forward of that with transition free (fig. 7).

The pressure distributions of reference 3 indicate that the loss in lift mentioned previously occurs over the rearward portion of the wing and this fact accounts for the forward shift of the aerodynamic center. At the higher Mach numbers the pitching-moment curves for the transition fixed case are very nonlinear (fig. 6(c)).

CONCLUSIONS

Based on high subsonic wind-tunnel tests, with fixed and free transition, of a modified delta wing having an aspect ratio of 3, a sweepback of 27.7°, a taper ratio of 0.313, and an NACA 64_1A012 airfoil section in combination with a fuselage, the following conclusions have been reached:

1. The lift-force-break Mach number was about 0.84 for both the transition-free and transition-fixed conditions. However, with fixed transition the lift curve was nonlinear in the high Mach number range and the slopes in the low lift range were considerably lower than with free transition.

2. The drag force break occurred at a Mach number of about 0.84 for both the transition-free and transition-fixed conditions, but for the transition-fixed condition, the drag was considerably higher.

3. Mach number had little effect on the aerodynamic-center location for the free-transition case up to a Mach number of about 0.80, above which there is a rearward movement of approximately 5 percent mean aerodynamic chord followed by a rapid forward movement at a Mach number of about 0.87. At the higher Mach numbers with fixed transition the pitching-moment characteristics were nonlinear and the aerodynamic-center position was considerably forward of its position with free transition.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

REFERENCES

1. Gillis, Clarence L., Polhamus, Edward C., and Gray, Joseph L., Jr.: Charts for Determining Jet-Boundary Corrections for Complete Models in 7- by 10-Foot Closed Rectangular Wind Tunnels. NACA ARR L5G31, 1945.

2. Herriot, John G.: Blockage Corrections for Three-Dimensional-Flow Closed-Throat Wind Tunnels, with Consideration of the Effect of Compressibility. NACA RM A7B28, 1947.

3. Allen, H. Julian, Heaslet, Max A., and Nitzberg, Gerald E.: The Interaction of Boundary Layer and Compression Shock and Its Effect upon Airfoil Pressure Distributions. NACA RM A7A02, 1947.

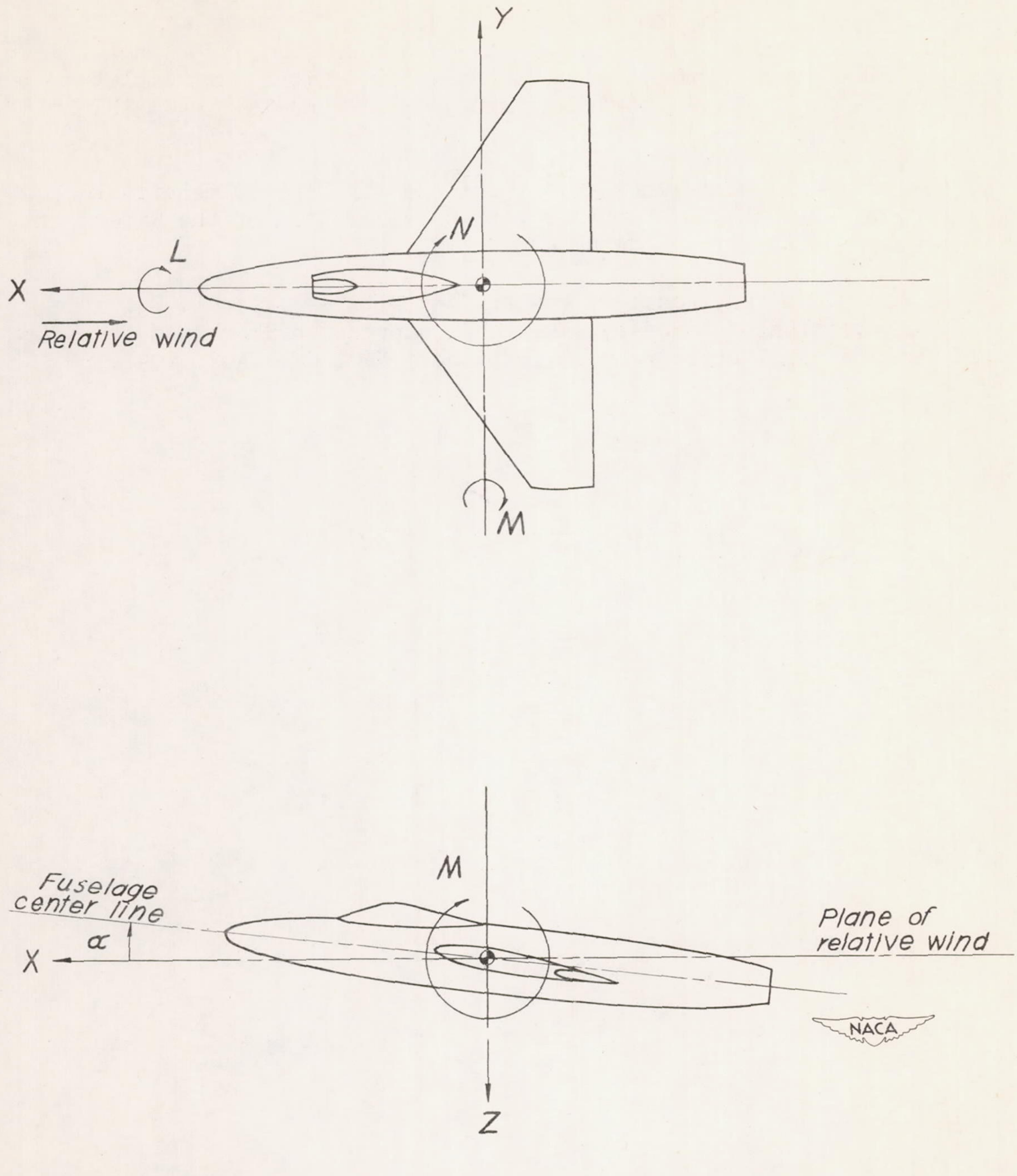


Figure 1.- System of axes with positive values of forces, moments, and angles indicated by arrows.

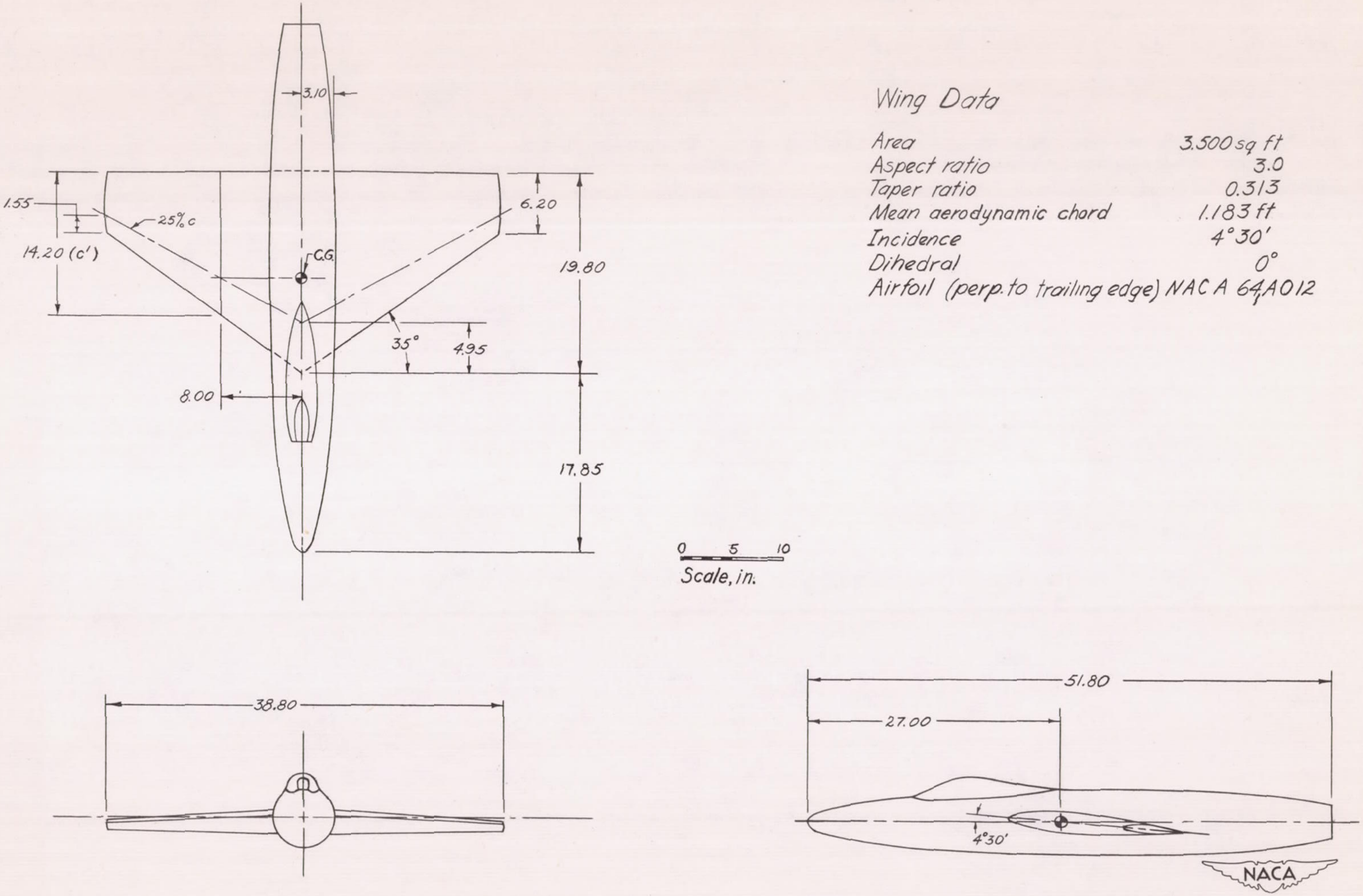


Figure 2.- General arrangement of wing with 27.7° sweepback, aspect ratio 3.0, and taper ratio 0.313.

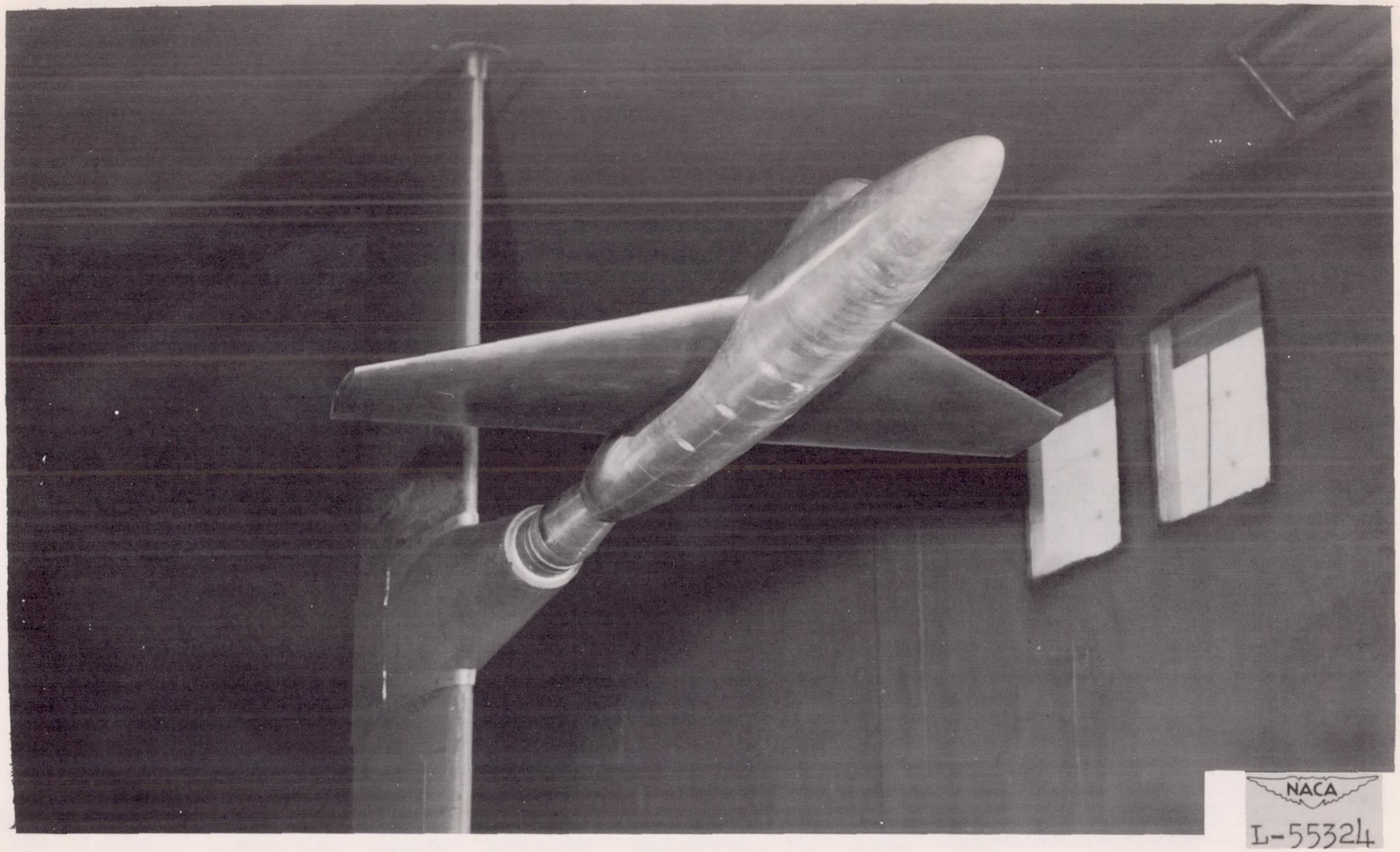


Figure 3.- Photograph of the model mounted on the center sting.

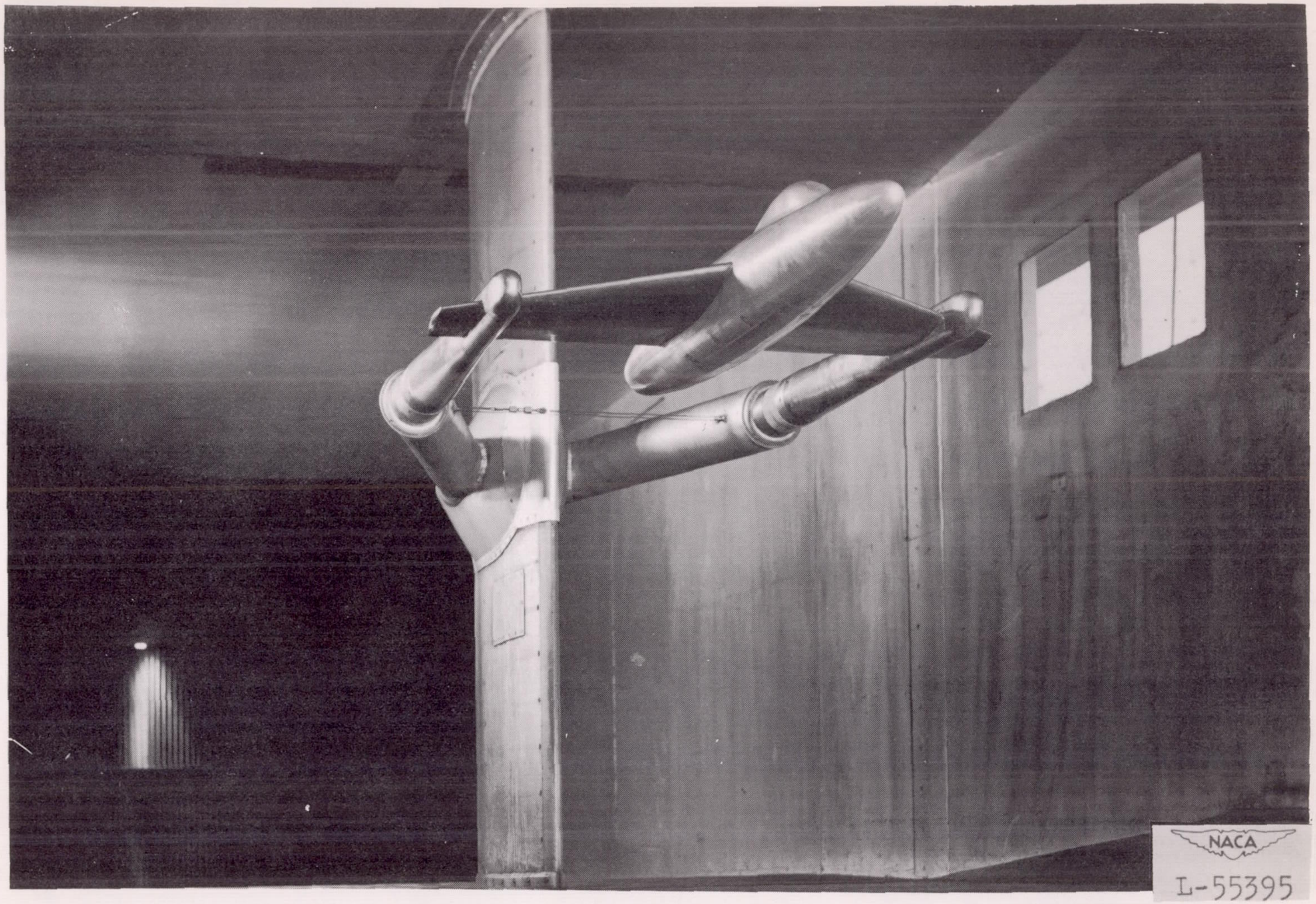


Figure 4.- Photograph of the model mounted on the tare stings.

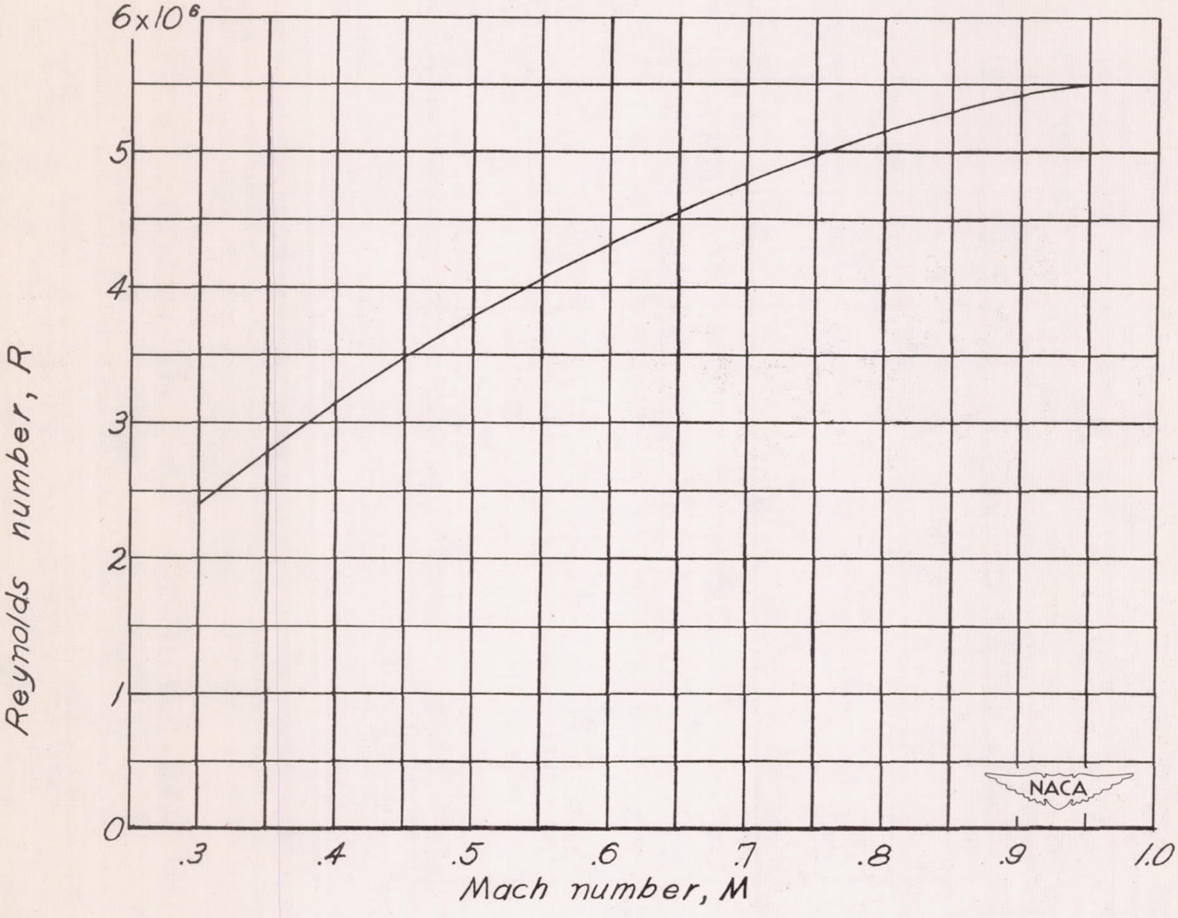
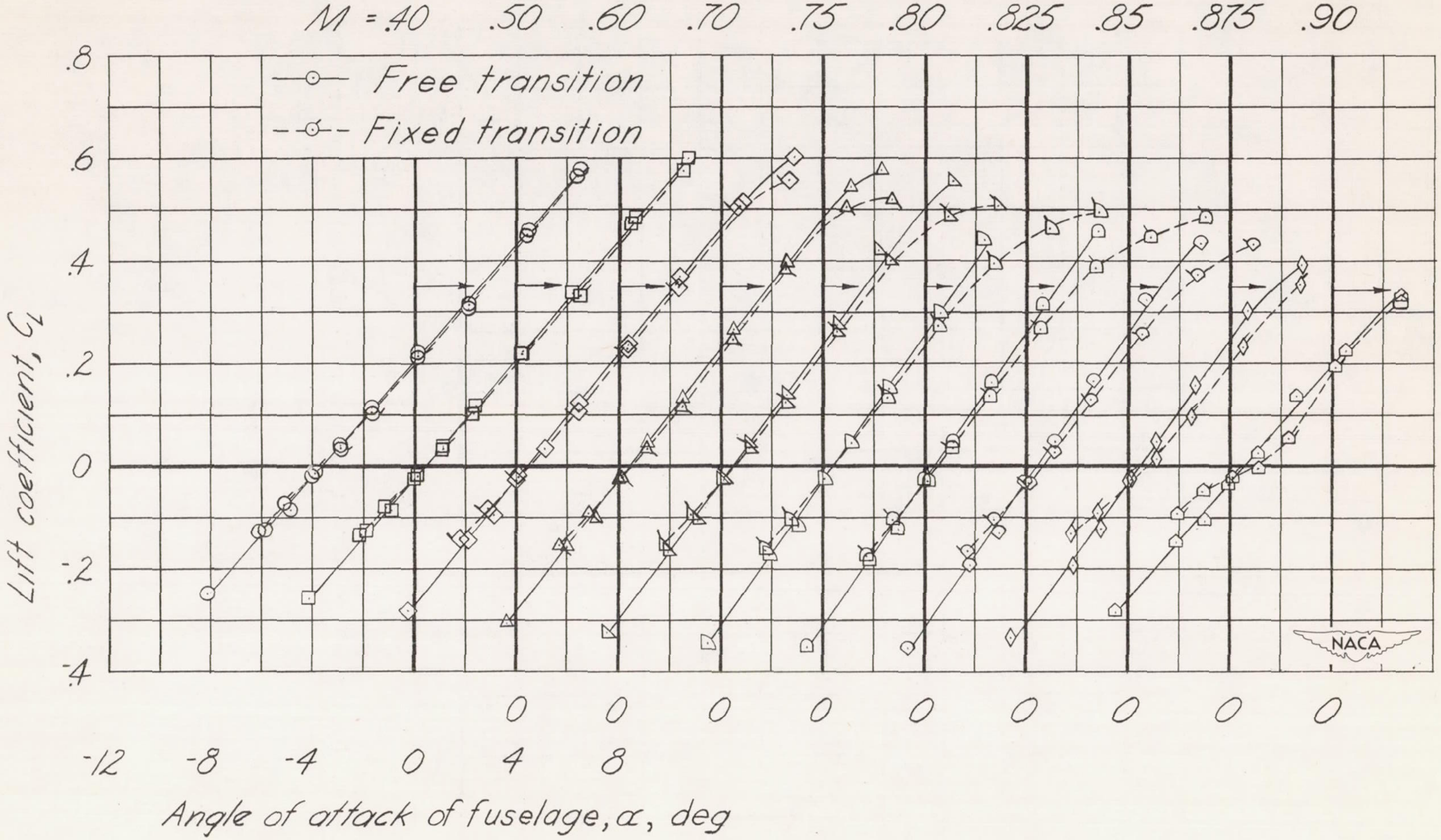
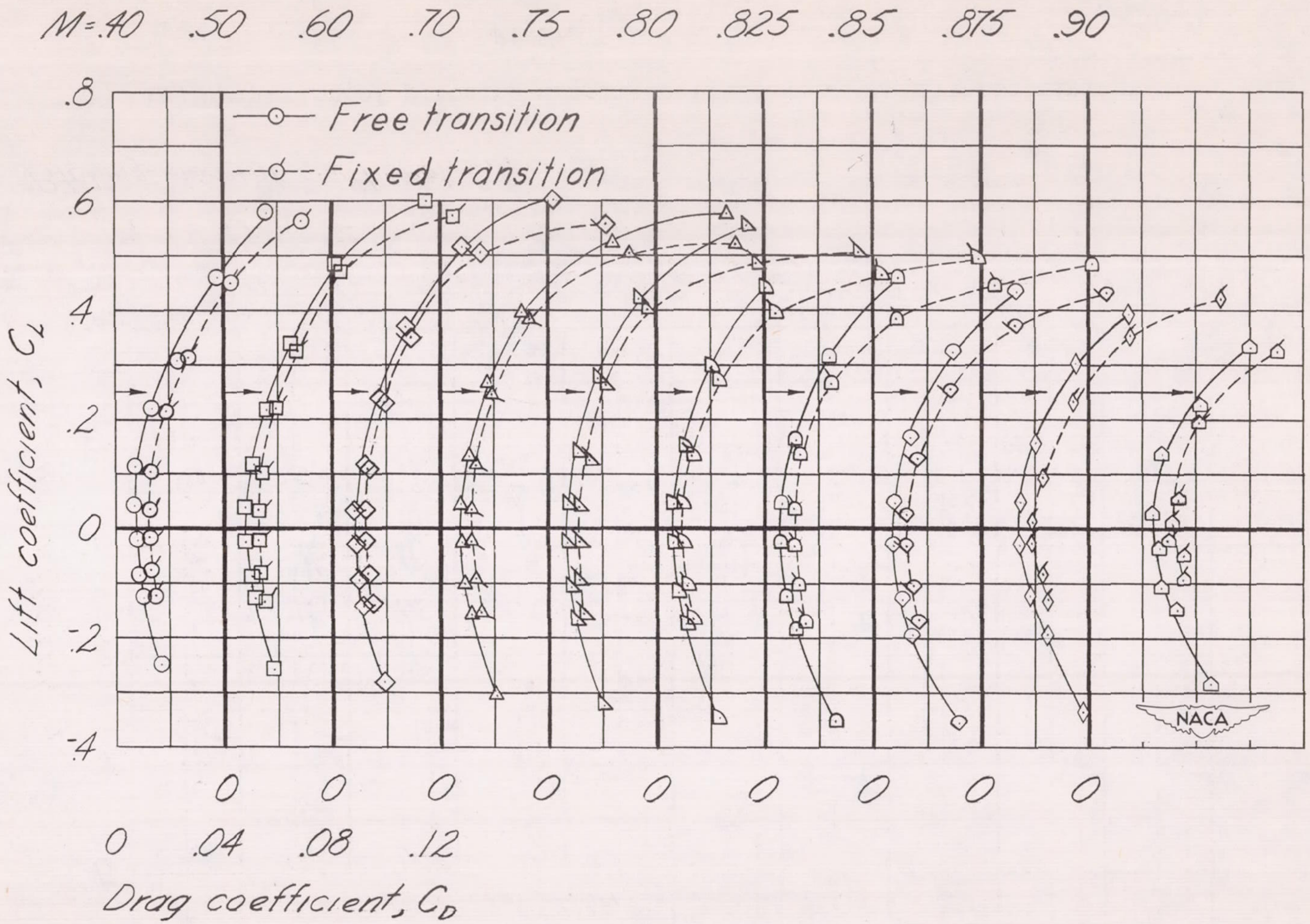


Figure 5.- Variation of mean test Reynolds number with Mach number.



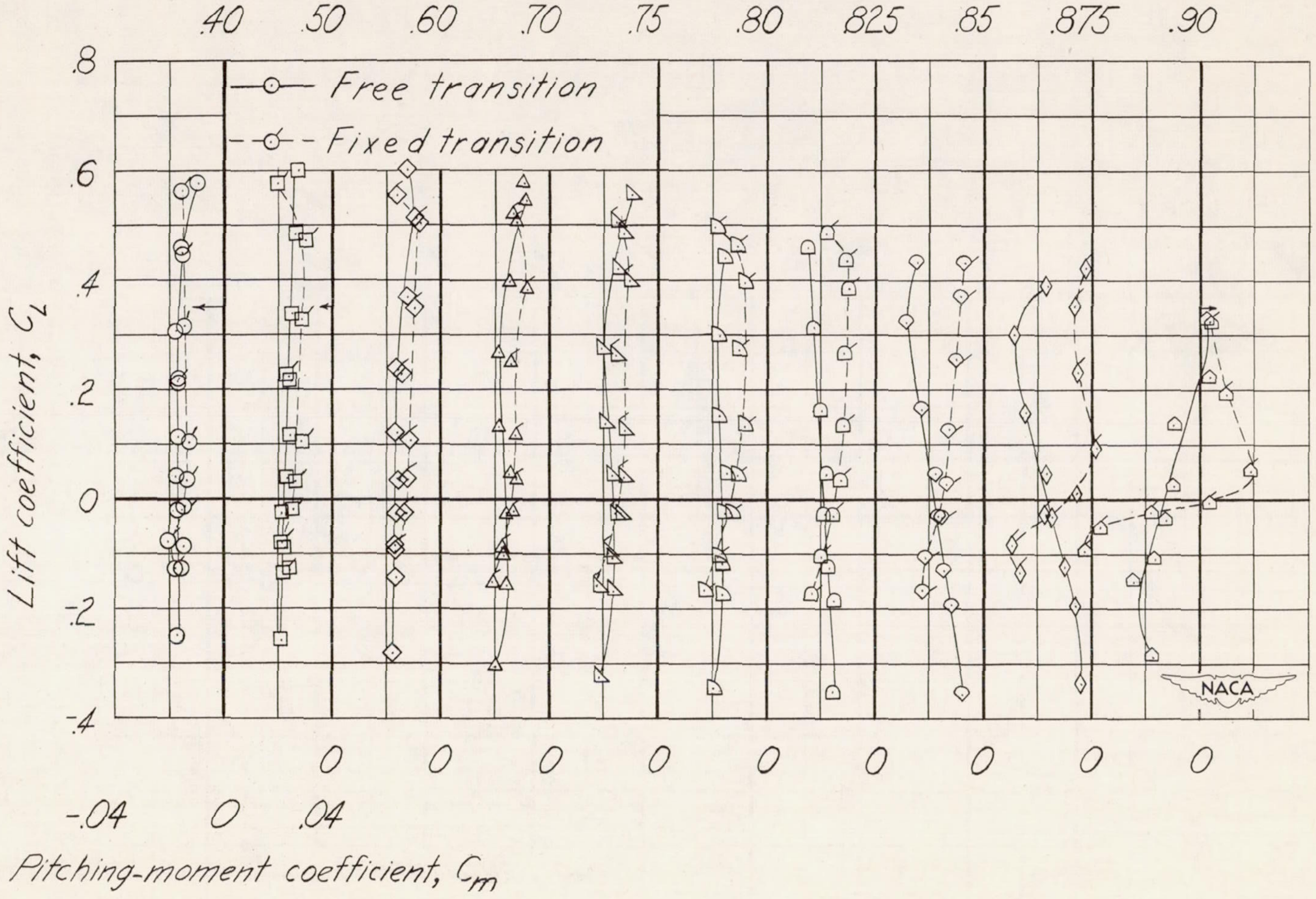
(a) Variation of lift coefficient with angle of attack.

Figure 6.- Aerodynamic characteristics with free and fixed transition of a wing-fuselage combination with 27.7° sweepback, aspect ratio 3.0, taper ratio 0.313, and NACA 64_1A012 airfoil.



(b) Variation of drag coefficient with lift coefficient.

Figure 6.- Continued.



(c) Variation of pitching-moment coefficient with lift coefficient.

Figure 6.- Concluded.

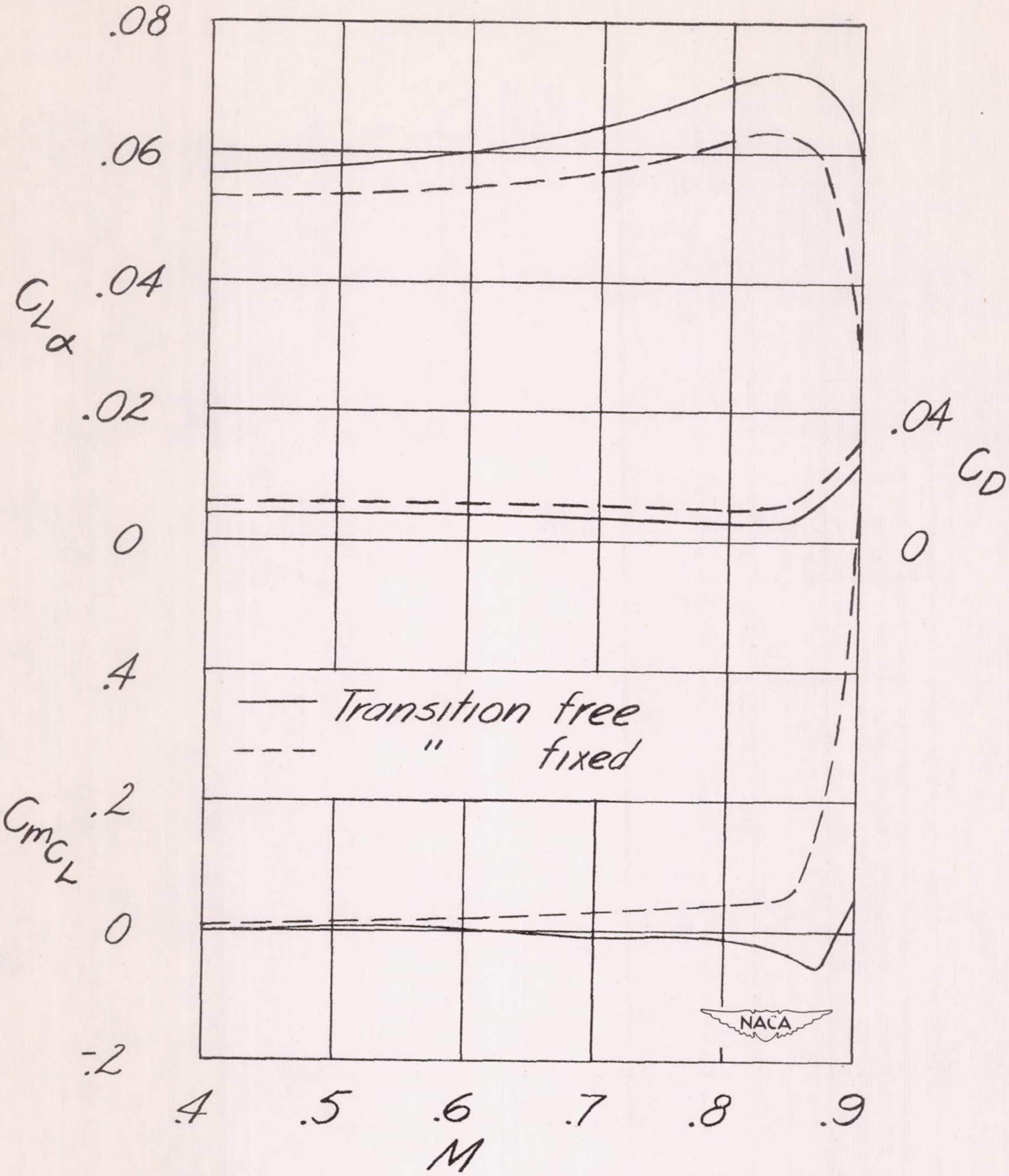


Figure 7.- Summary of the effect of Mach number on the aerodynamic characteristics in the low-lift range of a wing-fuselage combination with 27.7° sweepback, aspect ratio 3.0, taper ratio 0.313, and NACA 64_1A012 airfoil.