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RESEARCH MEMORANDUM

for the

U. S. Air Force

TRANSONIC ZERO-LIFT DRAG TESTS OF FOUR EQUIVALENT-BODY-OF-REVOLUTION MODELS REPRESENTING VARIATIONS OF THE CONVAIR F-102 AIRPLANE

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

Four 0.01643-scale equivalent-body-of-revolution models, designed to aid in the evaluation of the relative merits of various degrees of redesign of the existing (1955) Convair F-102 airplane, were launched from the helium gun at Wallops Island, Va., to determine their zero-lift drag at Mach numbers from 0.8 to 1.3. The data are presented with only sufficient analysis to validate their general subsonic level. Estimated values of the friction drag are presented at all Mach numbers to allow a comparison of the pressure drag values alone.

INTRODUCTION

The Convair F-102 configuration has been the subject of many tests by the National Advisory Committee for Aeronautics. Reference 1 presents the results for nine small equivalent-body-of-revolution models which were flown from the helium gun at Wallops Island, Va. These nine models were tested to determine the relative magnitude of the transonic drag rise of various modified versions of the F-102 configuration.

The present report deals with four equivalent-body models designed to aid in the evaluation of the relative merits of various degrees of redesign of the existing (1955) Convair F-102A airplane. Since it is not the purpose of this report to assess the equivalent-body drag results as they pertain to the full-scale airplane modifications, the configurations that the models represent will be described only briefly.

All models were designed and built by Convair. All tests were conducted by the Langley Pilotless Aircraft Research Division, and flight testing took place at Wallops Island, Va. The present tests are a continuation of a research project conducted at the request of the U. S. Air Force.

SYMBOLS

$$C_D = \frac{\text{Total drag force}}{qS}$$

q	free-stream dynamic pressure, lb/sq ft
S	scaled wing area, 0.1786 sq ft
L	total model length, in.
x	longitudinal model station measured from nose apex, in.
D_{max}	maximum diameter of model, in.
M	Mach number
A	model cross-sectional area, sq in.

MODELS AND TESTS

The model numbers used in this report are Convair designations and are

Model 15: This model represents the F-102A with Yellow Canary (afterbody extended fillets) and serves as a base for the comparison of the modifications.

Model 17: This model represents a fuselage like that of model 15 with the following two exceptions: (1) The duct inlets are moved back to a location near the wing leading edge and (2) the fuselage cross-sectional shape was changed to provide a flat surface ahead of the inlets.

Model 14: This model incorporates the changes of model 17. In addition, its afterbody has been designed for minumum cross-sectional area considering engine clearance and structural requirements.

Model 16: This model represents the same airplane as model 14 but with the ducts removed.

All the models represent the M = 1.0 area distributions of their full-scale counterparts. The inlet capture area has been subtracted from the gross airplane cross-sectional areas of models 14, 15, and 17 to account for duct mass flow.

A photograph of the models is presented in figure 1 and a drawing of a typical model showing fin location and size is given in figure 2. Area distributions for the four models appear in figure 3. These area distributions include the areas of the three fins.

The models were machined in two parts, a steel nose and an aluminum afterbody. The hexagonal-section swept fins were made of an aluminum alloy and were pinned in place.

The models were launched by the helium gun as described in reference 2. Velocity data were obtained by the use of a CW Doppler radar unit which was located on the ground next to the helium gun. Total zero-lift drag coefficients were determined from the radar measured velocity and from the variation of density, temperature, and wind velocity with altitude obtained by a radiosonde survey made at about the time of firing. These measurements are estimated from experience with previous models to be accurate within 0.0010 for C_D and 0.010 for M.

RESULTS AND DISCUSSION

The total zero-lift drag coefficients for the four models are shown in figure 4. These coefficients are all based on an area of 0.1786 square foot, which is the value of the wing area of the full-scale airplane reduced to the proportions of the test models. The Reynolds numbers based on model body length varied from 6×10^6 to 10×10^6 as the Mach numbers varied from 0.8 to 1.3.

The data were obtained to evaluate the transonic pressure drag rise of full-scale airplane configurations and the sum of the friction drag and the subsonic base-pressure drag has no bearing in such evaluations. The dashed lines in the figures represent an estimated friction plus subsonic base drag coefficient arrived at by continuing the measured subsonic drag at the slope given by the variation of friction drag with Reynolds number and Mach number as calculated by Van Driest (ref. 3). A comparison of the drag rises at M = 1.05 obtained in this manner shows the drag rises of models 14 and 17 to be about 18 and 25 percent lower, respectively, than those for models 15 and 16.

Although no general analysis of the data was attempted, a check on the general level of the data was made by a breakdown of the drag at

M = 0.8 into its various components as follows (all values based on the hypothetical wing area): The theory of reference 3 shows the body skin-friction drag coefficient to be equal to 0.0042. The measured values of base drag made on bodies with roughly similar afterbodies presented in reference 4 indicate that the subsonic base drags may be assumed equal to zero. The test results presented in reference 5 show that the skin-friction drag coefficient of the fins may vary between 0.0024 and 0.004, probably depending on the nature of the boundary layer.[1] It appears that in all the present tests the latter turbulent value is the correct one, since when this value is assumed the subsonic drag coefficient equals 0.0082 which value agrees with the test results quite well. It is noted as a matter of possible interest that the above references also indicate that the fins contribute 0.0014 and the base contributes a maximum of 0.001 to the total drag rise of any of the test models.

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[1]To avoid possible confusion this statement must be explained more fully. Reference 5 shows explicitly only fin skin-friction values obtained from flight tests of special models and these are the results which lead to the lower value quoted. However, an analysis, similar to the present drag breakdown, of the data from the majority of the models of the reference report indicates a value which leads to the higher number quoted. This higher figure has also been obtained in unpublished wind-tunnel tests run at about the same Mach numbers and Reynolds numbers.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics
Langley Field, Va., October 17, 1955.

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Aeronautical Research Scientist

Approved: Joseph A. Shortal
Joseph A. Shortal
Chief of Pilotless Aircraft Research Division

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REFERENCES

1. Wallskog, Harvey A.: Summary of Free-Flight Zero-Lift Drag Results From Tests of 1/5-Scale Models of the Convair YF-102 and F-102A Airplanes and Several Related Small Equivalent Bodies at Mach Numbers From 0.70 to 1.46. NACA RM SL54J25, U. S. Air Force, 1954.

2. Hall, James Rudyard: Comparison of Free-Flight Measurements of the Zero-Lift Drag Rise of Six Airplane Configurations and Their Equivalent Bodies of REvolution at Transonic Speeds. NACA RM L53J21a, 1954.

3. Van Driest, E. R.: Turbulent Boundary Layer in Compressible Fluids. Jour. Aero. Sci., vol. 18, no. 3, Mar. 1951, pp. 145-160, 216.

4. Katz, Ellis, and Stoney, William E., Jr.: Base Pressures Measured on Several Parabolic-Arc Bodies of Revolution in Free Flight at Mach Numbers From 0.8 to 1.4 and at Large Reynolds Numbers. NACA RM L51F29, 1951.

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CONFIDENTIAL

Model 14 Model 16 Model 15 Model 17 L-87764

Figure 1.- Photographs of test models.

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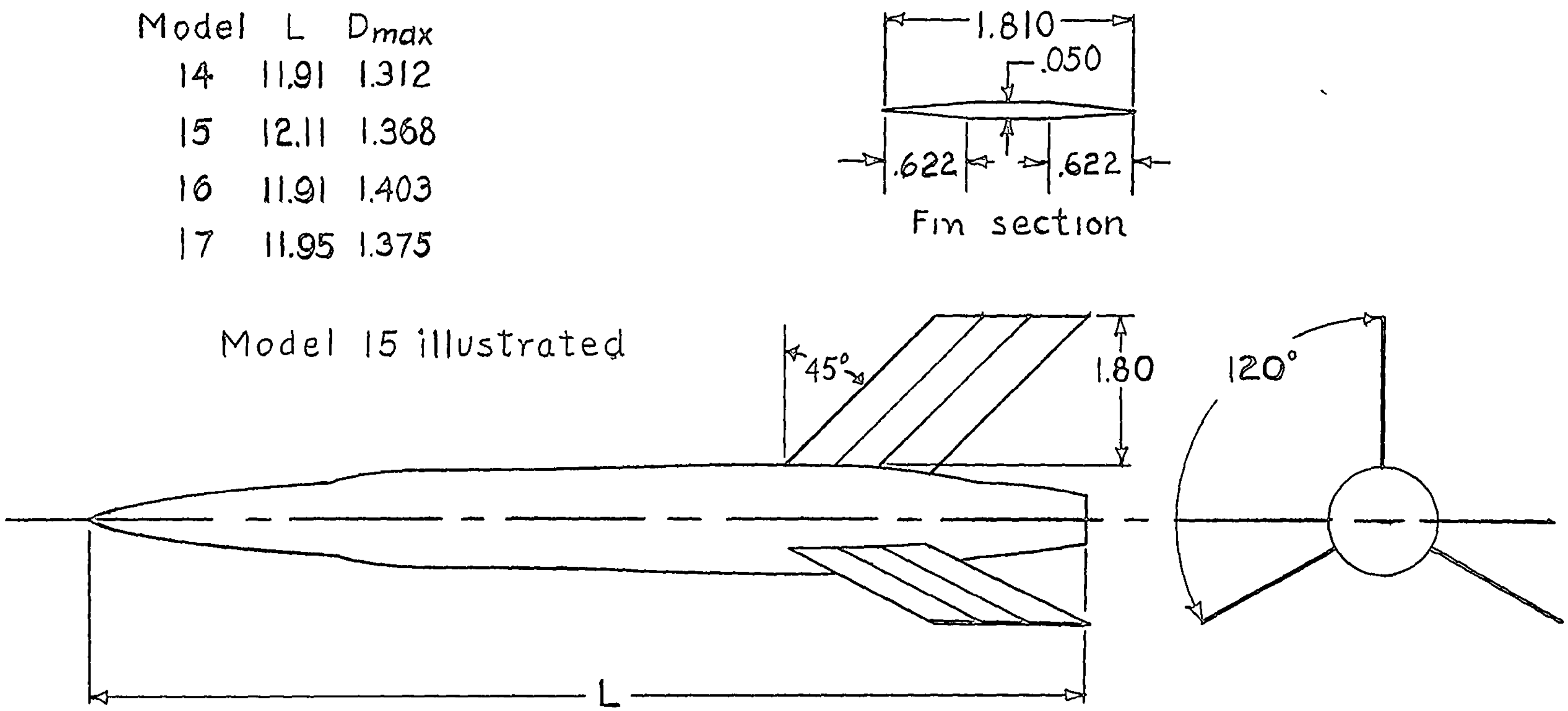


Figure 2.- Fin installation of a typical model (same for all models). All dimensions are in inches.

[redacted]

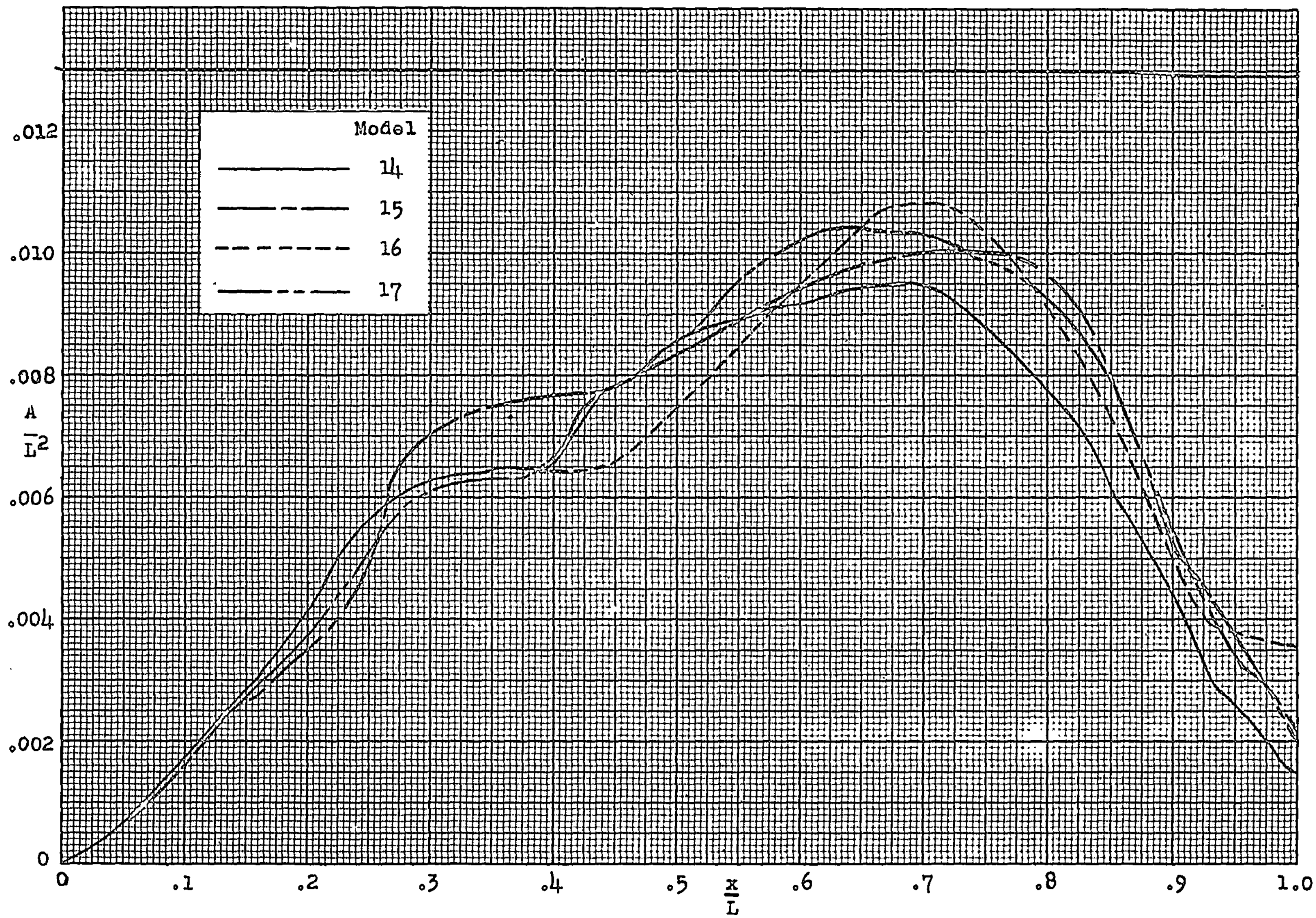
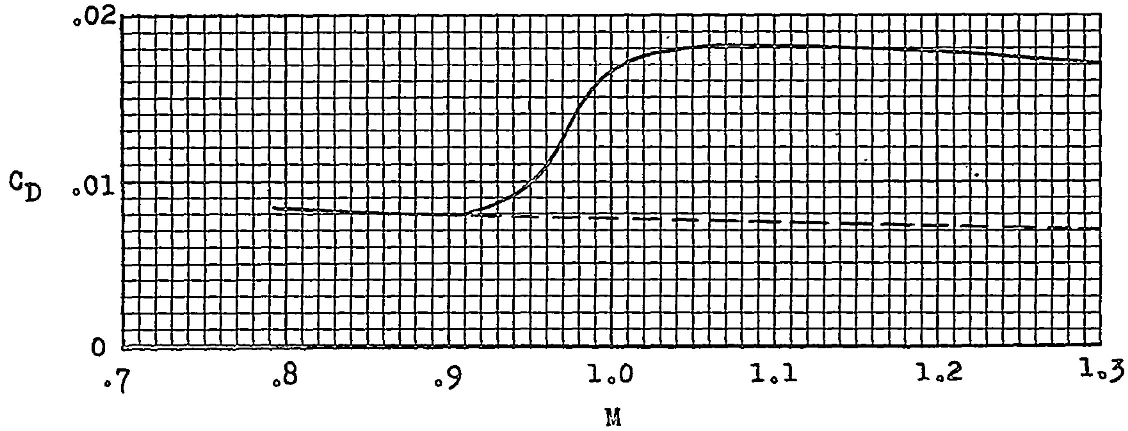
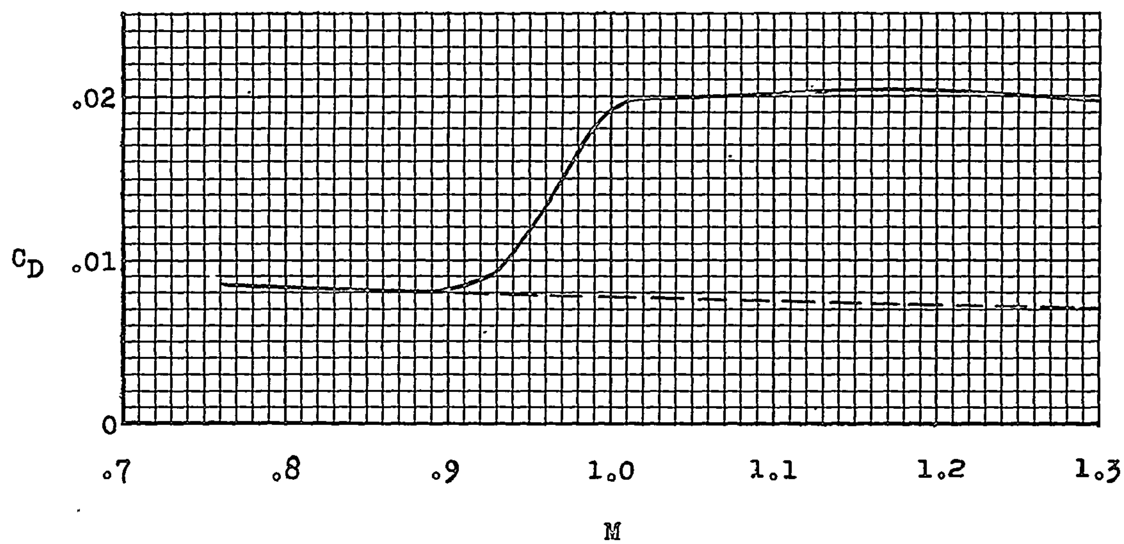


Figure 3.- Model area distributions (area of fins included).

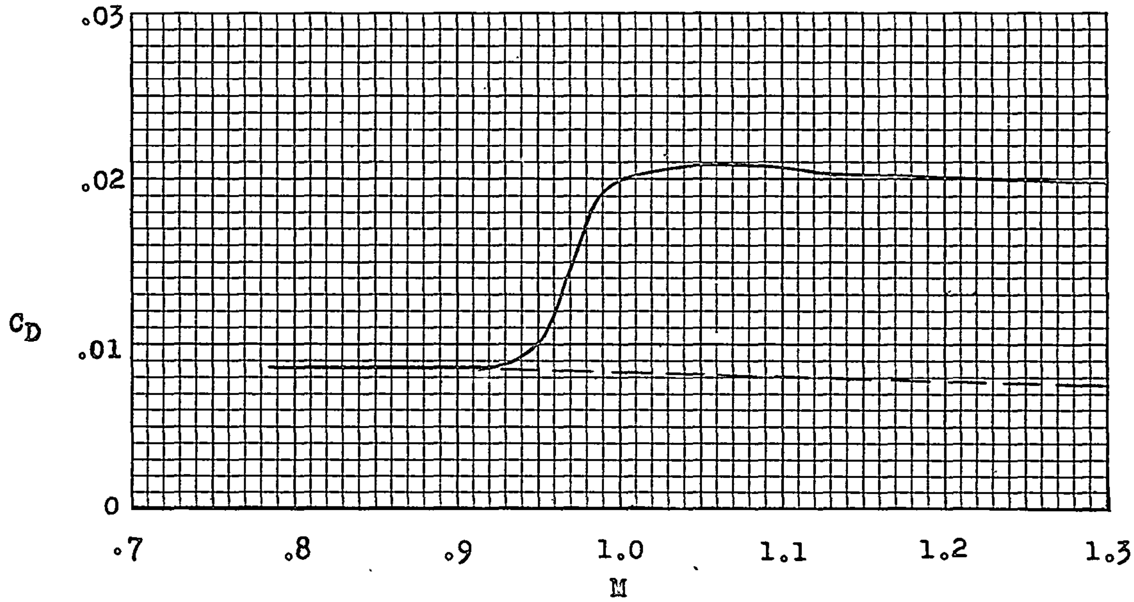


Model 14

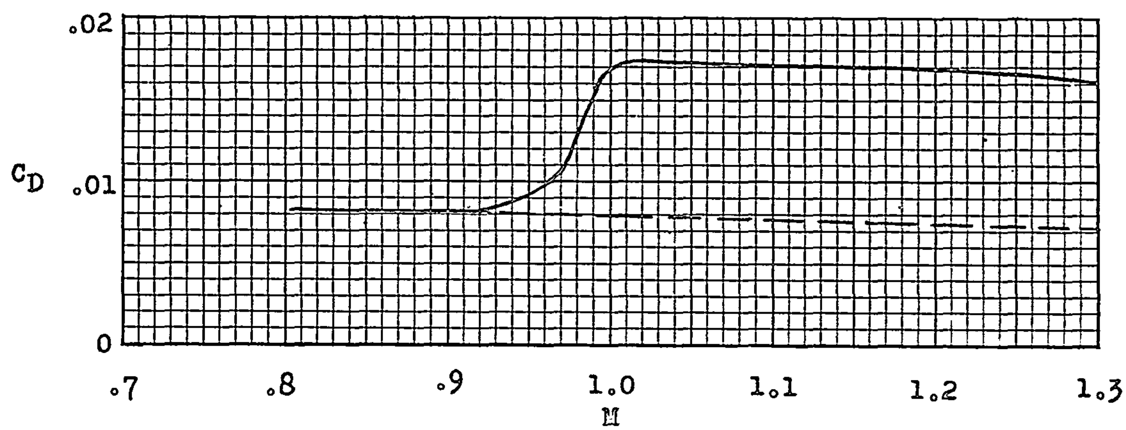


Model 15

Figure 4.- Drag coefficients based on equivalent wing area as a function of Mach number. Dashed lines represent estimated subsonic base drag plus friction drag.



Model 16



Model 17

Figure 4.- Concluded.