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RESEARCH MEMORANDUM

EFFECT OF LENGTH-BEAM RATIO ON THE AERODYNAMIC CHARACTERISTICS OF FLYING-BOAT HULLS WITHOUT WING INTERFERENCE

By

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SUMMARY

Hull-alone tests were made in the Langley 300 MPH 7- by 10-foot tunnel on a family of hulls with length-beam ratios ranging from 6 to 15, and a comparison was made with previous tests on the hulls with wing interference.

The tests indicated the same general minimum-drag-coefficient reduction and slight increase in longitudinal stability with increasing length-beam ratio as indicated by previous tests on the hulls with wing interference. As expected, the hull-alone drag coefficients were consistently larger than the hull-drag-coefficient values with wing interference.

INTRODUCTION

The investigation at the Langley Laboratory of aerodynamic characteristics of flying-boat hulls as affected by hull dimensions and hull shape (references 1 to 3) has included the interference effects of a 21-percent-thick wing. Since new high-speed water-based aircraft will use extremely thin wings of low aspect ratio and/or large amounts of sweep, it was desirable to obtain the aerodynamic characteristics of the aforementioned hulls without wing interference. The results obtained for the hull without wing interference could be more easily compared with either theoretical or experimental results for other hull and fuselage shapes. It is known that the results obtained with wing interference will differ from the values obtained on the hull or fuselage alone because the wing, in addition to adding interference drag, also effectively reduces the drag coefficient because of the portion of the wing submerged in the body (reference 4).

The present investigation includes the aerodynamic characteristics of a family of flying-boat hulls varying in length-beam ratio from 6 to 15 without any wing interference. The hulls have approximately the same hydrodynamic performance with respect to spray and resistance characteristics, regardless of length-beam ratio.

COEFFICIENTS AND SYMBOLS

The results of the tests are presented as standard NACA coefficients of forces and moments. Pitching moments are given about the location shown in figure 1 which are the same as those used in reference 1. In using this center of moments, a direct comparison of the longitudinal stability can be made with the hulls with wing interference. The coefficients and Reynolds number, as in reference 1, are based on the wing area and the mean aerodynamic chord of a hypothetical flying boat described in reference 1. The data are referred to the stability axes, which are a system of axes having their origin at the center of moments shown in figure 1 and in which the Z-axis is in the plane of symmetry and perpendicular to the relative wind, the X-axis is in the plane of symmetry and perpendicular to the Z-axis, and the Y-axis is perpendicular to the plane of symmetry. The positive directions of the stability axes are shown in figure 2.

The coefficients and symbols are defined as follows:

C_L lift coefficient $\left(\frac{\text{Lift}}{qS}\right)$

C_D drag coefficient $\left(\frac{\text{Drag}}{qS}\right)$

C_m pitching-moment coefficient $\left(\frac{M}{qS\bar{c}}\right)$

Lift = $-Z$

Drag = $-X$ when $\psi = 0$

X force along X-axis

Z force along Z-axis

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

S wing area of $\frac{1}{10}$-scale model of hypothetical flying boat (18.264 sq ft)

$\bar{c}$ wing mean aerodynamic chord (M.A.C.) of $\frac{1}{10}$-scale model of hypothetical flying boat (1.377 ft)

V air velocity, feet per second

ρ mass density of air, slugs per cubic foot

α angle of attack of hull base line, degrees

R Reynolds number, based on wing mean aerodynamic chord of $\frac{1}{10}$-scale model of hypothetical flying boat

C_{D_W} drag coefficient, based on surface area W of hull $\left(\frac{\text{Drag}}{qW}\right)$

$C_{m_\alpha} = \frac{\partial C_m}{\partial \alpha}$

L/b length-beam ratio, when L is distance from forward perpendicular (F.P.) to sternpost and b is maximum beam (fig. 1)

MODEL AND APPARATUS

The hulls used in this investigation were the same models that were used in the investigation reported in reference 1, with a support wing. Dimensions of the models are given in figure 1, and the tables of offsets are given in reference 1. The models were altered for testing alone by covering the wing gap with a thin sheet of aluminum. The volumes, surface areas, maximum cross-sectional areas, and side areas of the hulls are compared in the following table:

Langley tank model	L/b	Volume (cu in.)	Surface area (sq in.)	Maximum cross-sectional area (sq in.)	Side area (sq in.)
213	6	14,831	4540	226	1639
203	9	12,916	4581	182	1752
214	12	11,528	4654	150	1870
224	15	10,653	4760	130	1985

The models were mounted on a single strut for testing, as shown in figure 3.

TESTS

Test Conditions

The tests were made in the Langley 300 MPH 7- by 10-foot tunnel at a dynamic pressure of 100 pounds per square foot, which corresponded to an airspeed of about 200 miles per hour. The Reynolds number, based on the mean aerodynamic chord of the wing of the hypothetical flying boat, was about $2\frac{1}{2} \times 10^6$. The corresponding Mach number was about 0.22.

Corrections

Blocking corrections have been applied to the hull data. The drag of the hulls has been corrected for horizontal buoyancy effects caused by a tunnel static-pressure gradient. The effect of the support strut has been subtracted from the data.

Test Procedure

The hulls were tested with the transition fixed by a $\frac{1}{2}$-inch-wide strip of 0.008-inch diameter carborundum particles located approximately 5 percent of the hull length aft of the bow. In order to determine the tare values which were subtracted from the data, the effects of the support strut were determined by using an image system.

RESULTS AND DISCUSSION

The effects of length-beam ratio on the variation of aerodynamic characteristics with angle of attack are presented in figure 4. A comparison of these data with the data obtained including the wing interference (reference 1) indicates that the minimum drag occurs nearer zero angle of attack for the hull alone. This effect might be expected since the support wing used in reference 1 had considerable camber and was set at 4° angle of incidence, which tends to give body minimum drags at positive angles of attack (reference 4). The hull-alone data showed about the same variation of pitching-moment coefficient with angle of attack as was shown for the hulls with wing interference. Smaller values of lift coefficient were obtained for the hull alone than were obtained for the hull in the presence of the wing. Comparison of the minimum drag coefficient and the stability parameter C_{m_α} for the hulls alone and hulls with wing interference (fig. 5) shows minimum drag coefficients for the hulls alone considerably larger than for the hulls with wing interference and very slight changes in the parameter of C_{m_α}. This relatively large increase in minimum drag was to be expected since the results of reference 5 indicated that the minimum drags of fuselages were lower by an amount roughly equal to the drag on the support wing submerged within the fuselage. The interference effect caused by the interaction of the velocity fields in the fuselage and wing, in general, increases the drag coefficient; however, the increase is small compared to the favorable effect of the submerged wing.

It should be noted that the variation of minimum drag coefficient with length-beam ratio is about the same for the hull alone as reported in reference 1 for the hull in the presence of the wing. This fact would indicate, therefore, that the comparative drag coefficients of the other hulls (references 2 and 3), although representing a value lower than the hull-alone value, should indicate the relative merits of the various hulls. It is realized, of course, that the values presented in references 1 to 3 are truly representative only for a flying boat using a wing very similar to the support wing used in those investigations and that any other wing either thinner, less cambered, or with sweep would be expected to give different values of minimum drag coefficient and would also be expected to present similar trends with hull modifications. In order to indicate the relative efficiency of the length-beam-ratio series hulls, the minimum drag coefficients based on the wetted area of the hull C_{D_W} have been compared in figure 6 with theoretical values of C_{D_W} for streamlined bodies, as given in reference 5. To obtain a more nearly comparable value of fineness ratio than is indicated by length-beam ratio, the fineness ratio of the hulls was calculated using the ratio of the diameter of a circle with an area equal to the frontal area of the hull and the over-all length of the hull (the distance from the fore perpendicular to the aft perpendicular). It is realized that in this comparison the skin area of the equivalent body is less than that for the actual hull. From the comparison shown in figure 6, it can be seen that a large percentage of the drag of the $\frac{L}{b} = 6$ hull (fineness ratio 6.5) was caused by form drag because the theoretical drag was largely skin friction. The form drag becomes a smaller part of the total drag as the fineness ratio increases. The trend of the two curves indicates that considerable reduction in hull drag coefficient might be expected for hulls of larger length-beam ratio.

CONCLUSIONS

The results of wind-tunnel tests of a family of hulls without wing interference having length-beam ratios of 6, 9, 12, and 15 and comparison of the results with previous tests of the hulls with wing interference indicated the following:

1. The minimum drag coefficient decreased when the length-beam ratio was extended from 6 to 15 in a manner similar to that indicated for hulls in the presence of a wing.

2. The minimum drag coefficient was considerably higher than that obtained in the presence of the wing.

3. The minimum drag for all hulls tested generally occurred in the angle-of-attack range of about 0° to 2°.

4. The longitudinal stability of the hulls was unaffected by the wing interference.

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REFERENCES

ok 1. Yates, Campbell C., and Riebe, John M.: Effect of Length-Beam Ratio on the Aerodynamic Characteristics of Flying-Boat Hulls. NACA TN No. 1305, 1947.

ok 2. Yates, Campbell C., and Riebe, John M.: Aerodynamic Characteristics of Three Planing-Tail Flying-Boat Hulls. NACA TN No. 1306, 1947.

X 3. Riebe, John M., and Naeseth, Rodger L.: Aerodynamic Characteristics of Three Deep-Step Planing-Tail Flying-Boat Hulls. ~~NACA TN No.~~ RM L7C18 BuAer withdrew OK for T.N. Must remain Classified Rest.

ok 4. Jacobs, Eastman N., and Ward, Kenneth E.: Interference of Wing and Fuselage from Tests of 209 Combinations in the N.A.C.A. Variable-Density Tunnel. NACA Rep. No. 540, 1935.

ok 5. Young, A. D.: The Calculation of the Total and Skin Friction Drags of Bodies of Revolution at Zero Incidence. R. & M. No. 1874, British A.R.C., 1939.

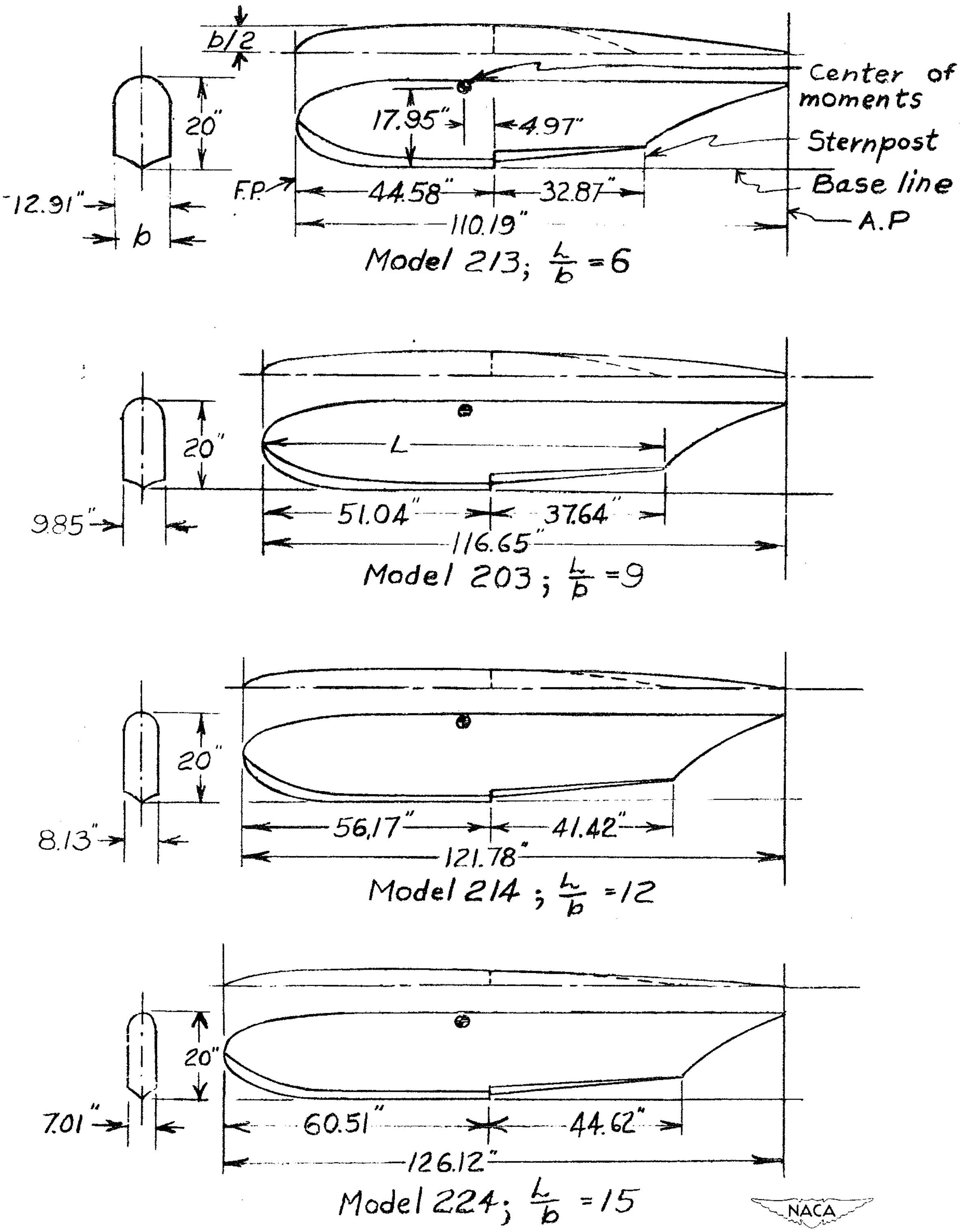

Figure 1.– Lines of Langley tank models 203, 213, 214, and 224.

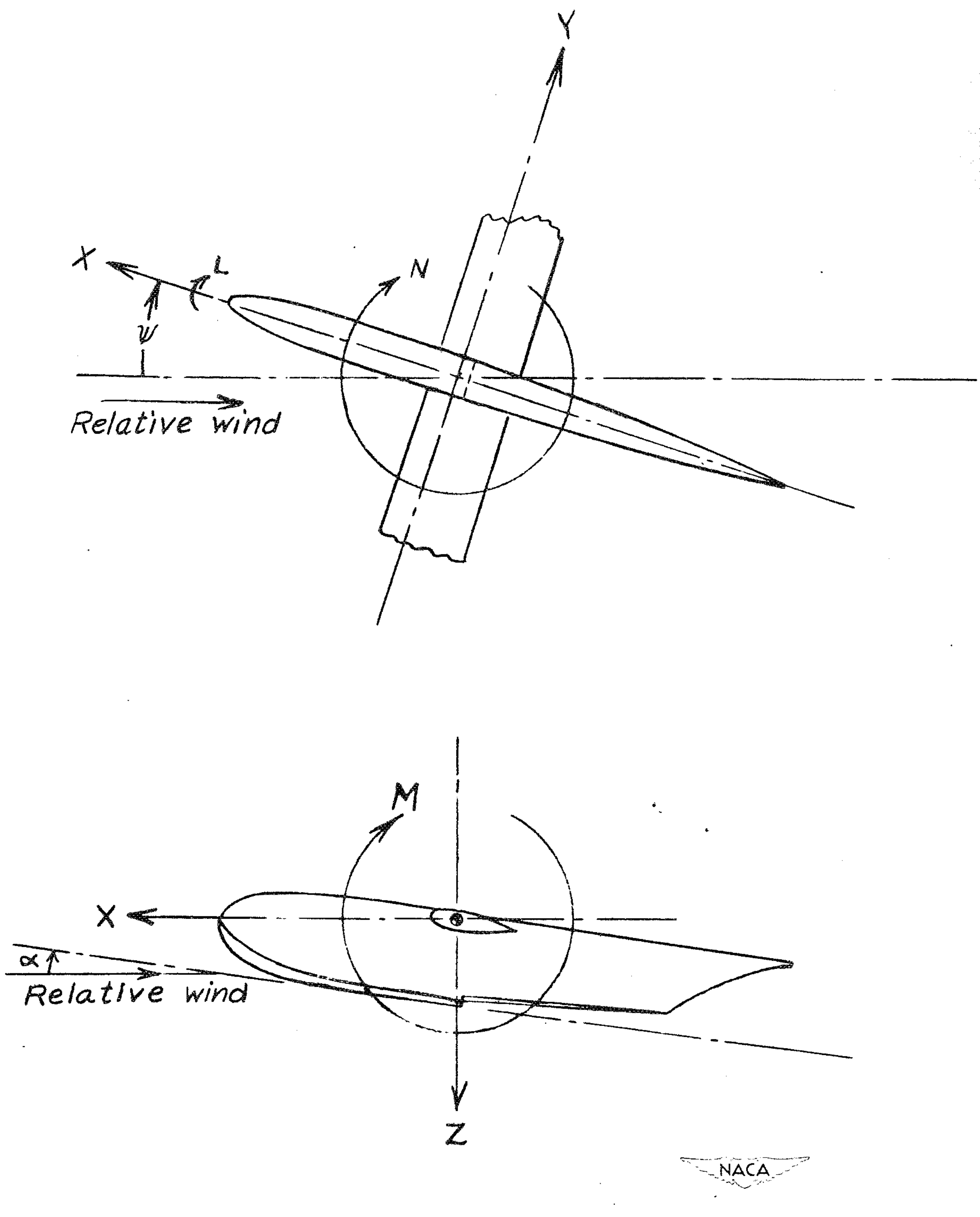

Figure 2.- System of stability axes. Positive directions of forces, moments, and angles are indicated by arrows.

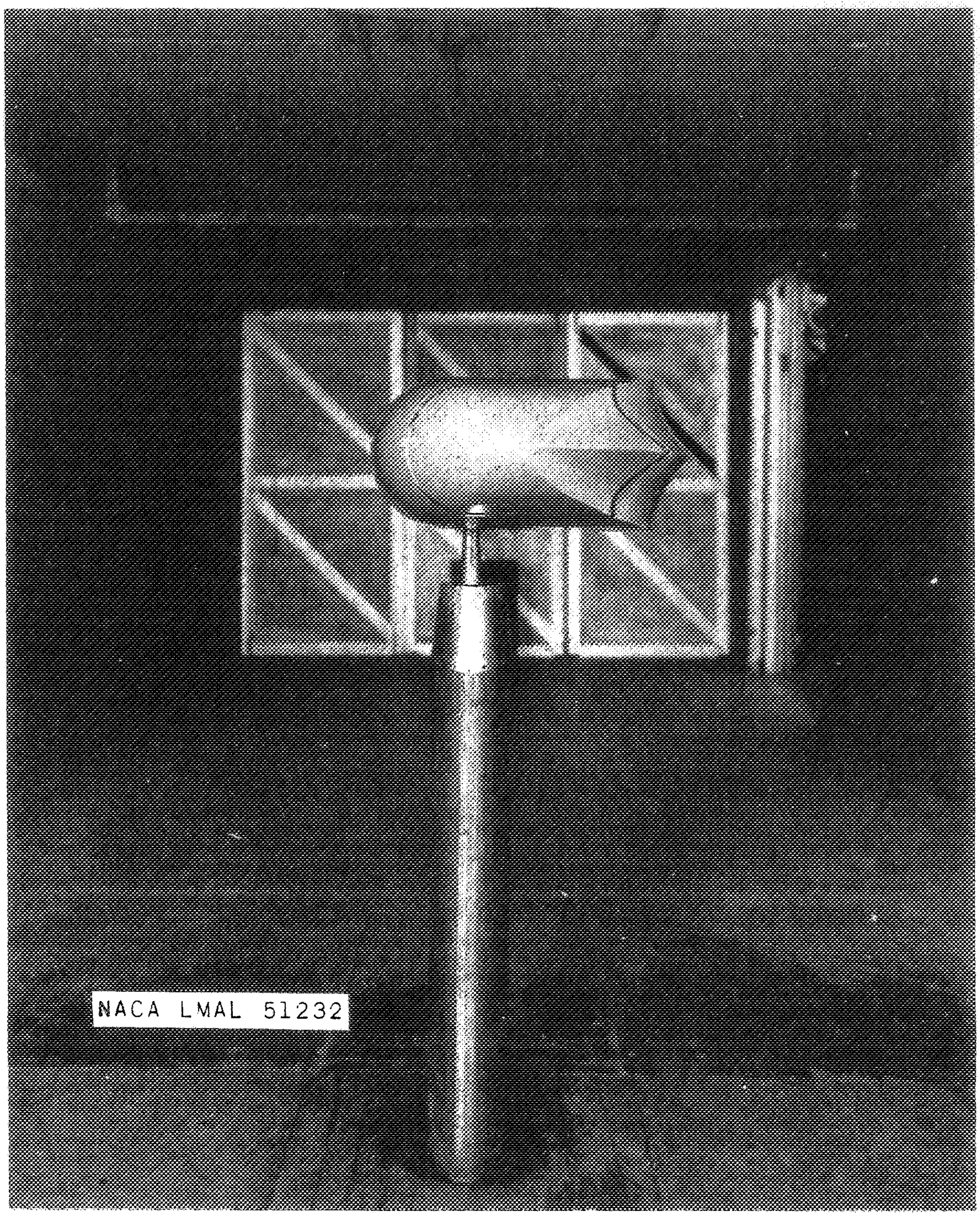

Figure 8.- Hull mounted on single support strut in the Langley 300 MPH 7- by 10-foot tunnel.

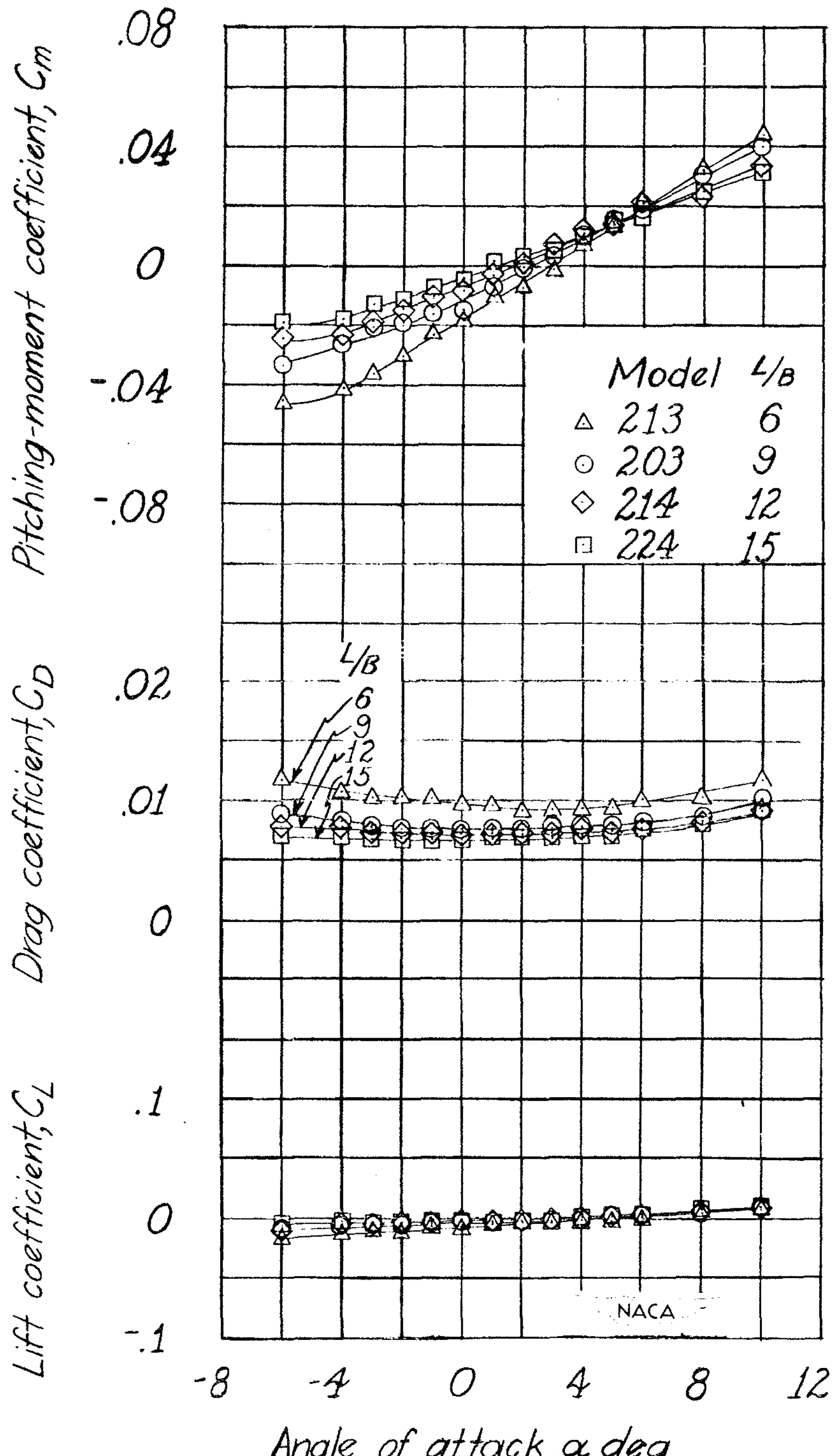

Figure 4.- Effect of length-beam ratio on the aerodynamic characteristics in pitch of the 1/10-scale hulls of a hypothetical flying boat.

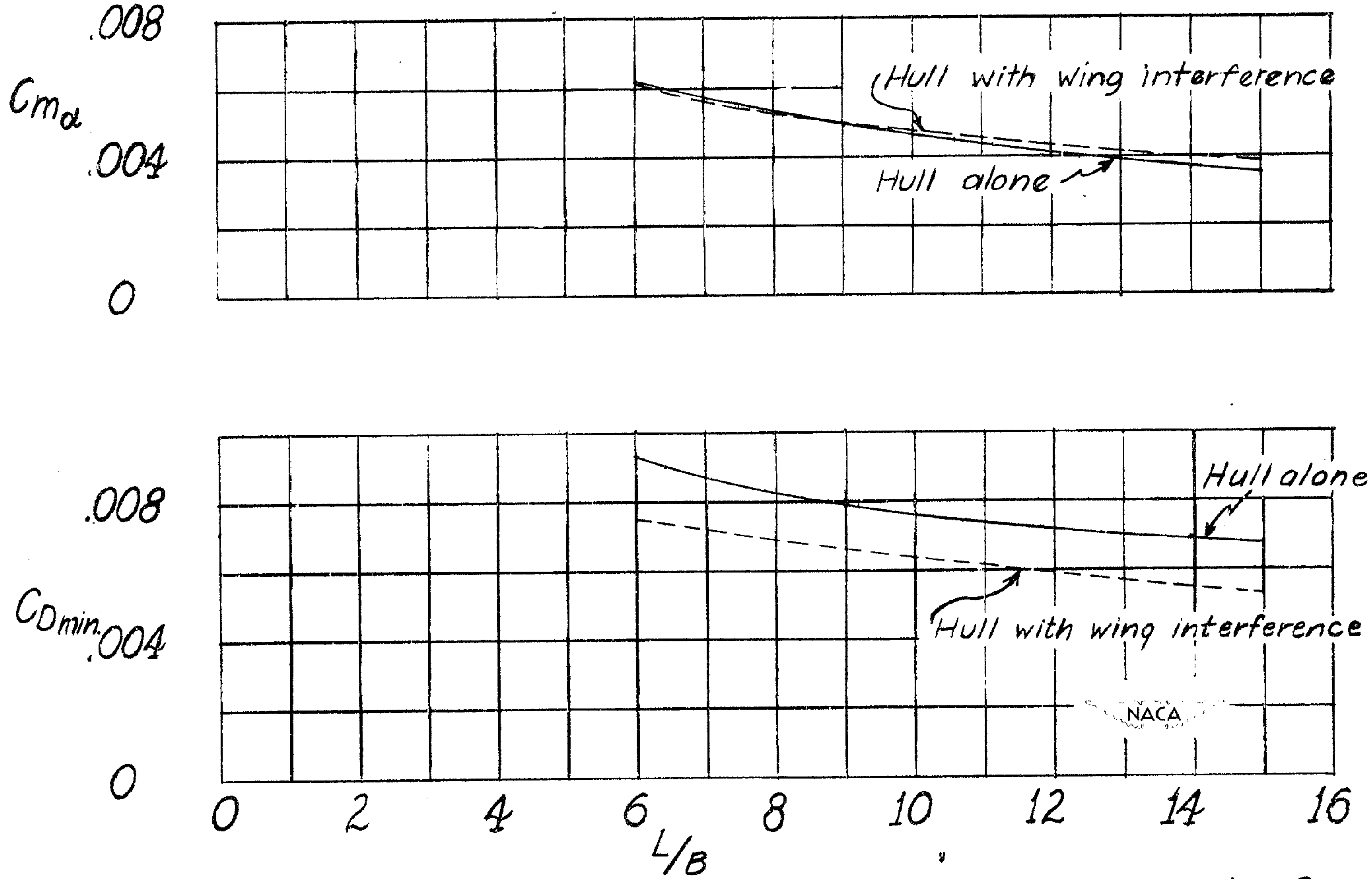

Figure 5.- Effect of length-beam ratio on $C_{D_{min}}$ and the parameter C_{m_α} for the 1/10-scale hulls of a hypothetical flying boat.

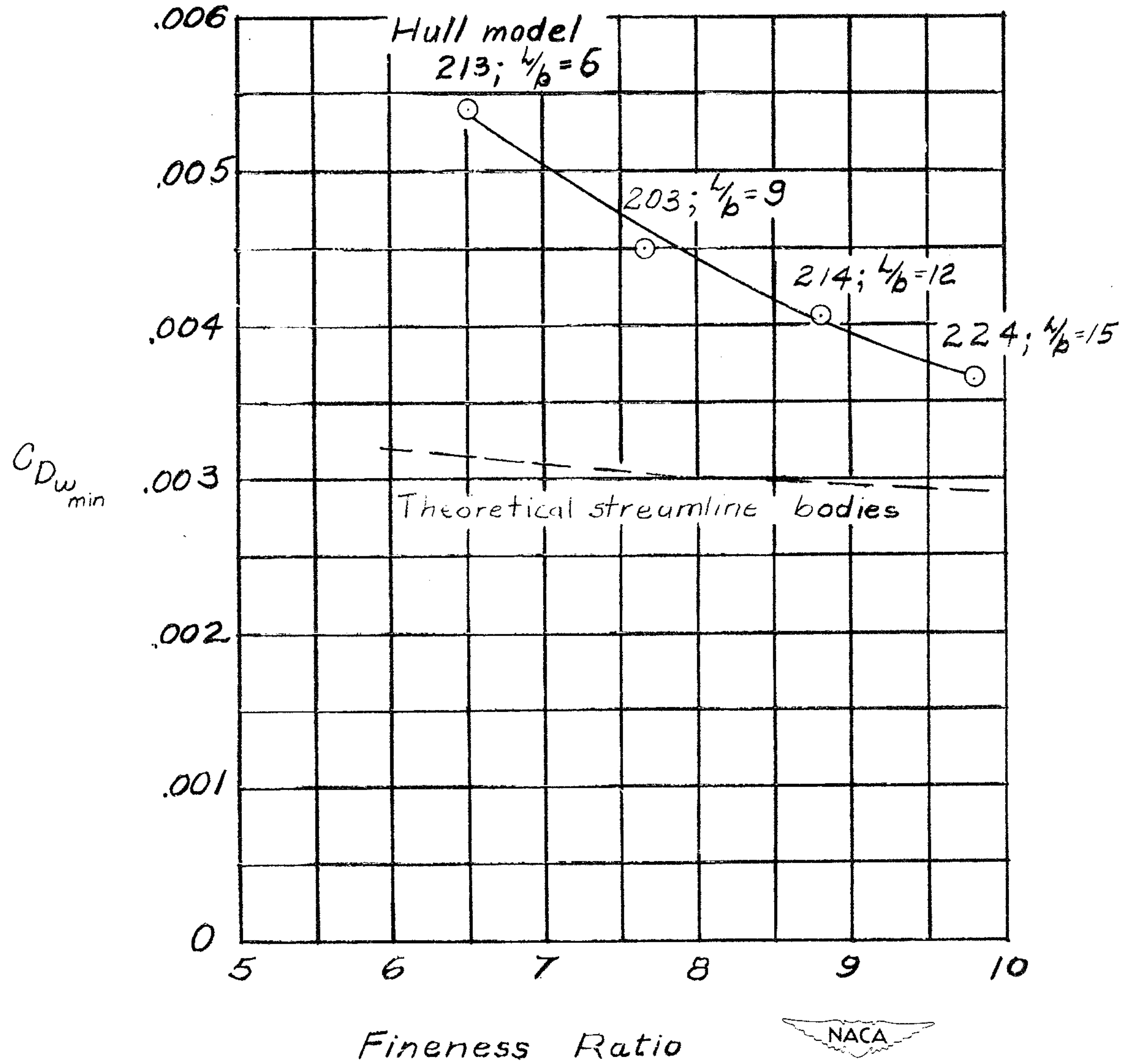

Figure 6.- Comparison of theoretical drag coefficient of streamlined bodies and flying-boat hulls of 6, 9, 12, and 15 length-beam ratios.

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ABSTRACT

Contains experimental results of an investigation of the aerodynamic characteristics of a family of flying-boat hulls of length-beam ratios 6, 9, 12, and 15 without wing interference.

The results are compared with those taken on the same family of hulls in the presence of a wing.