RESEARCH MEMORANDUM

LARGE-SCALE FLIGHT MEASUREMENTS OF ZERO-LIFT DRAG AT
MACH NUMBERS FROM 0.86 TO 1.5 OF A WING-BODY
COMBINATION HAVING A 60° TRIANGULAR WING
WITH NACA 65A003 SECTIONS

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SUMMARY

Flight tests were made at high-subsonic and supersonic speeds and
at high Reynolds numbers to determine the zero-lift drag of a fin-
stabilized body and a wing-body configuration. The 60° triangular wing
had NACA 65A003 airfoil sections. The body was parabolic in profile,
had a fineness ratio of 10 and a ratio of body frontal area to wing area
of 0.0306.

The test results indicate that the wing-body combination had a
low drag at supersonic speeds. The drag coefficient based on wing
area was approximately 0.0115 for the wing and body with two fins and
0.0068 for the body plus four fins at supersonic speeds. At subsonic
speeds the drag coefficient was 0.0065 for the wing and body with two
fins and 0.0026 for the body plus four fins. The wing and body with two
fins had a force-break Mach number of 0.995. The force-break Mach number
for the body with four fins was 0.975.

INTRODUCTION

As part of an NACA program on transonic research, the Langley
Pilotless Aircraft Research Division is performing a series of rocket-
powered flight tests at Wallops Island, Va., to investigate the aero-
dynamic characteristics of several wing-body configurations. These tests
provide continuous data from high-subsonic to supersonic speeds at high
Reynolds numbers.
This paper presents zero-lift drag data for a fin-stabilized body and a wing-body configuration having a $60^\circ$ triangular wing with NACA 65AO03 airfoil section. The body was of parabolic profile with maximum diameter at 40 percent of the length and had a fineness ratio of 10. The body frontal area was 3.06 percent of the total wing area.

The wing-body configuration was designed in an attempt to obtain low supersonic drag by properly combining a wing and body, each having low drag, so as to take advantage of favorable interference effects. The low drag characteristics of thin triangular wings are well known. As reported in reference 1, parabolic bodies having maximum diameters in the neighborhood of 40 to 60 percent of the length were found to have low drag. Reference 2 shows that a favorable wing-body interference exists when the wing is placed behind the body maximum diameter. A triangular wing when placed on a body will have a large chord at the wing-body juncture and thus it was necessary to select a parabolic body with maximum diameter at 40 percent of the length in order to place the wing chord completely behind the maximum diameter and take advantage of the possible favorable interference.

The Mach number range was from 0.86 to 1.5. Reynolds number, based on the wing mean aerodynamic chord of 4.84 feet, varied from $20 \times 10^6$ to $50 \times 10^6$.

MODEL AND TESTS

The general arrangement of the test configurations is presented in figure 1. Photographs of the models on the launching platform are shown as figure 2. The body was identical for both configurations and had a profile formed by two parabolic arcs each having its vertex at the maximum diameter which was located at 40 percent of the body length. The body had a fineness ratio of 10 with body frontal area of 3.06 percent of the wing area. The body and wing profile coordinates are given in table I. The $60^\circ$ triangular wing was modified by rounding off the wing tips so that the resulting wing area was $99\frac{1}{2}$ percent of the basic triangular area. The wing had NACA 65AO03 airfoil sections parallel to the model center line. Four stabilizing fins were used on the wingless body and two vertical fins were used on the winged configuration. The plan form and section of the tail surfaces are given in figure 1.

With the exception of the metal stabilizing fins, the models were principally of wooden construction.
Each model was propelled by a Deacon rocket motor which delivers approximately a thrust of 6200 pounds for 3.2 seconds.

Velocity data were obtained from Doppler radar. Drag data were acquired from Doppler radar and longitudinal accelerations telemetered from the models. Trajectory and atmospheric data were obtained from an SCR-584 radar set and by radiosonde observations.

Some data on base pressure were obtained during both flights. The contribution of the base to the total drag was indicated to be small, being of the order of 6 percent or less.

The estimated accuracy of the results is as follows:

Mach number ........................................... ±0.005
Drag coefficient ..................................... ±0.0005

The variation of Reynolds number with Mach number is shown in figure 3. The difference between the two curves may be attributed to different flight altitudes and air temperatures.

RESULTS AND DISCUSSION

Curves of drag coefficient against Mach number are given in figure 4. The data for the wing and body with two fins are given in figure 4(a). The data for the body with four fins are given in figure 4(b). From these data and unpublished data on fin drag the wing-plus-interference drag has been determined and the results are presented in figure 4(c). In determining the wing-plus-interference drag, drag coefficients for two fins of 0.0008 at Mach numbers above 1 and of 0.0005 at Mach numbers below 1 were subtracted from the body plus four-fin data. The resulting data for a body with two fins, in turn, were subtracted from the wing and body with two-fin data.

The test results in figure 4(a) show that the wing and body with two fins had a low supersonic drag coefficient. The supersonic drag coefficient for this configuration, based on total wing area, varied from 0.012 to 0.011. At subsonic speeds the drag coefficient was 0.0065. The force-break Mach number was 0.995. The telemeter test point at a Mach number of 0.995 should not be regarded as a stray point since the continuous telemeter record of the model's longitudinal acceleration showed a decrease in drag between Mach numbers of 0.99 and 0.995. This decrease in drag did not occur for the body having four fins.
The drag coefficient for the body with four fins varied from 0.0072 to 0.0064 at supersonic speeds and was 0.0026 at subsonic speeds. The force break for this model occurred at a Mach number of 0.975.

The wing-plus-interference drag coefficient was only slightly greater at supersonic speeds than at subsonic speeds. As shown in figure 4(c), the drag coefficient was 0.0044 at subsonic speeds and increased at supersonic speeds to a value of 0.0054. This small increase agrees with what would be expected for the wing alone and indicates that the objective of combining a wing and body without unfavorable interference effects was achieved. The dip in the wing-plus-interference drag-coefficient curve near a Mach number of 1.0 is also believed to be a favorable wing-body interference similar to that shown in reference 2.

REFERENCES


TABLE I

BODY AND WING COORDINATES FOR TEST MODELS

Body Coordinates In Inches

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Wing Coordinates In Percent Chord

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L.E. radius = 0.115c
T.E. radius = 0.007c
Figure 1.- General arrangement of test model. Wing-body configuration shown.
Figure 3.- Variation of Reynolds number with Mach number for test models. Reynolds numbers are based on wing mean aerodynamic chord of 4.84 feet.
Figure 4. Variation of drag coefficient with Mach number based on total wing area of 30.27 square feet.