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RESEARCH MEMORANDUM

EFFECT ON TRANSONIC AND SUPERSONIC DRAG OF A FUSELAGE PROTUBERANCE DESIGNED TO IMPROVE THE AREA DISTRIBUTION OF AN ESSENTIALLY UNSWEPT WING-FUSELAGE COMBINATION

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation of the effect on transonic and supersonic drag of a fuselage protuberance designed to improve the over-all longitudinal distribution of cross-sectional area of an essentially unswept wing-fuselage combination has been made with free-flight rocket models. The wing-fuselage configuration was tested with and without a fuselage protuberance designed to relieve the steep area gradient over the rear portion of the wing. The protuberance had no measurable effect on the drag of the wing-fuselage configuration at Mach numbers up to approximately 1; above this Mach number the protuberance increased the drag substantially.

INTRODUCTION

The transonic area rule demonstrated experimentally in reference 1 has received considerable attention recently in regard to the estimation of the transonic drag rise of configurations (refs. 2 and 3) and more importantly in regard to the design of airplane configurations having reduced drag at transonic and supersonic speeds (ref. 4). Since the more or less general acceptance of the area rule, several airplane designers have expressed interest in the possibility of improving the transonic drag of airplanes having basically unfavorable area distributions by the addition of fuselage protuberances designed to improve the over-all area distribution. Although such protuberances would generally be expected to increase the drag of the fuselage, some over-all drag reduction was hoped for on the basis of the area rule. The purpose of the present investigation was to examine the foregoing premise experimentally.

The configuration investigated employed a nearly unswept wing having hexagonal sections attached to the cylindrical midsection of a fuselage. This configuration was tested with and without a fuselage protuberance designed to relieve the steep area gradient over the rear portion of the wing.

Free-flight rocket-propelled test vehicles launched at the Pilotless Aircraft Research Station, Wallops Island, Va., were employed.

SYMBOLS

C_D	drag coefficient based on wing area equal to 1.73 square feet
M	Mach number
A	total cross-sectional area
r	radius corresponding to A
x	distance from nose of fuselage
l	length of fuselage

MODELS AND TESTS

The general arrangement of the models is shown in figure 1; model 1 had no fuselage protuberance and model 2 did. Figure 2 contains model photographs, nondimensional longitudinal cross-sectional area distributions, and plots of the equivalent body radii. Equivalent body geometry is presented in table I.

The wing geometry was: aspect ratio, 3.87; root and tip thickness ratio, 0.038 and 0.061, respectively; taper ratio, 0.63; and leading- and trailing-edge sweepback, 13.38° and 0°, respectively. The rather odd dimensions result from the fact that the wings were salvaged from other investigations in the interest of speed and economy.

The models were boosted by means of a 5-inch HVAR motor. Second-stage propulsion was provided by a 3.25-inch MK 7 rocket motor. A photograph showing the model-booster-launcher arrangement is shown in figure 3.

The models contained no instrumentation. The variation of drag coefficient with Mach number was obtained from CW Doppler velocimeter, space-position radar (modified SCR 584), and radiosonde measurements by the method of reference 5. The winds-aloft velocities were measured and accounted for in the data reduction.

The errors are estimated to be within the following limits:

C_D . . . . ±0.0015
M . . . . ±0.005

The Mach number range of the tests was from 0.7 to 1.7. The corresponding Reynolds numbers varied from 2.1×10^6 to 7.5×10^6 based on the mean aerodynamic chord of the wings.

RESULTS AND DISCUSSION

The test results given in figure 4 indicate that the fuselage protuberance had no measurable effect on the drag below $M \approx 1$; at higher Mach numbers the protuberance increased the drag. At the highest Mach number tested, the measured difference in drag coefficient between the models is equal to the drag coefficient of the protuberance calculated from reference 6. Apparently, at a Mach number of 1, the additional drag of the protuberance offset any drag reduction due to favorable interaction of the pressure field generated by the protuberance on that of the wing. As the Mach number was increased above 1, these pressure fields could interact favorably to a decreasing extent and the difference in drag between the models would, and did, tend to approach the drag of the protuberance.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., October 23, 1953.

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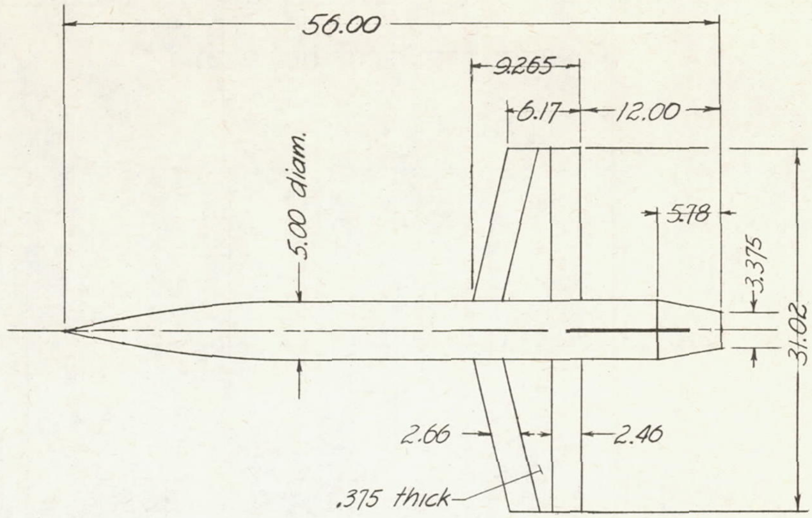
TABLE I

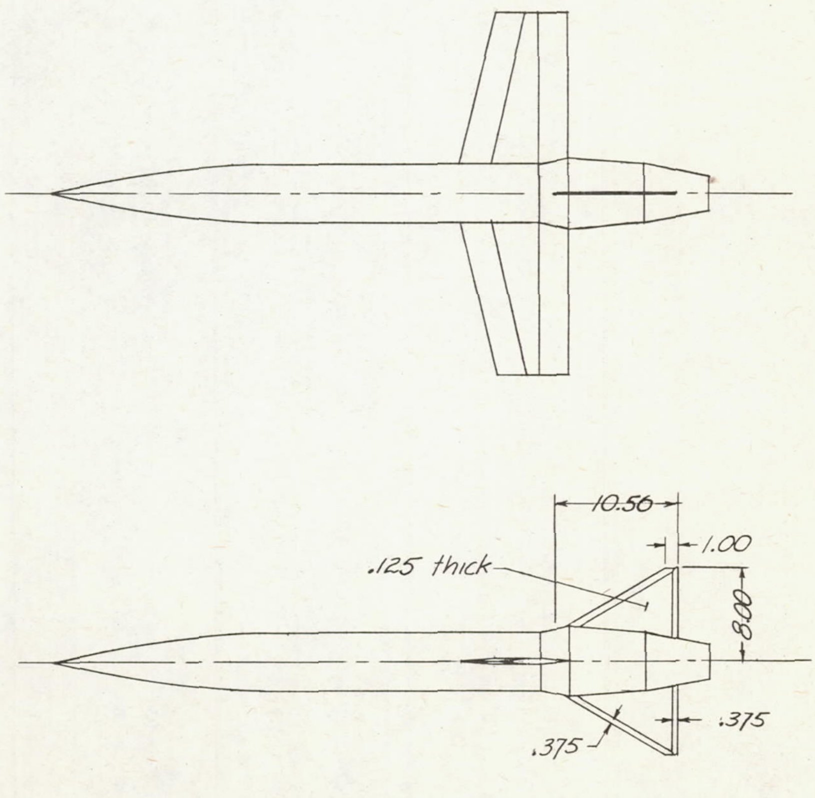
EQUIVALENT BODY GEOMETRY

[Tail fins included]

Body station, in.	Model 1		Model 2	
	Radius, in.	Area, sq in.	Radius, in.	Area, sq in.
0	0	0	0	0
1.00	.250	.196	.250	.196
2.00	.480	.723	.480	.723
3.00	.710	1.583	.710	1.583
5.00	1.130	4.011	1.130	4.011
7.50	1.570	7.743	1.570	7.743
10.00	1.955	12.007	1.955	12.007
12.50	2.252	15.932	2.252	15.932
15.00	2.429	18.383	2.429	18.383
17.50	2.500	19.635	2.500	19.635
34.735	2.500	19.635	2.500	19.635
36.00	2.566	20.680	2.566	20.680
37.00	2.704	22.971	2.704	22.971
38.00	2.878	26.017	2.878	26.017
39.00	3.002	28.313	3.002	28.313
40.00	3.054	29.303	3.054	29.303
40.49	3.059	29.391	3.059	29.391
41.54	3.059	29.391	3.059	29.391
42.00	2.967	27.641	2.570	20.750
43.00	2.743	23.637	2.570	23.758
44.00	2.511	19.816	2.920	26.876
45.00	2.521	19.964		
46.00	2.530	20.111	2.802	24.668
47.00	2.539	20.259		
48.00	2.549	20.407	2.686	22.668
49.00	2.558	20.555		
50.00	2.567	20.703	2.587	21.018
50.22	2.569	20.736	2.569	20.736
51.00	2.478	19.290	2.478	19.290
52.00	2.349	17.340	2.349	17.340
52.625	2.282	16.358	2.282	16.358
53.00	2.111	14.00	2.111	14.00
56.000	1.69	8.973	1.69	8.973

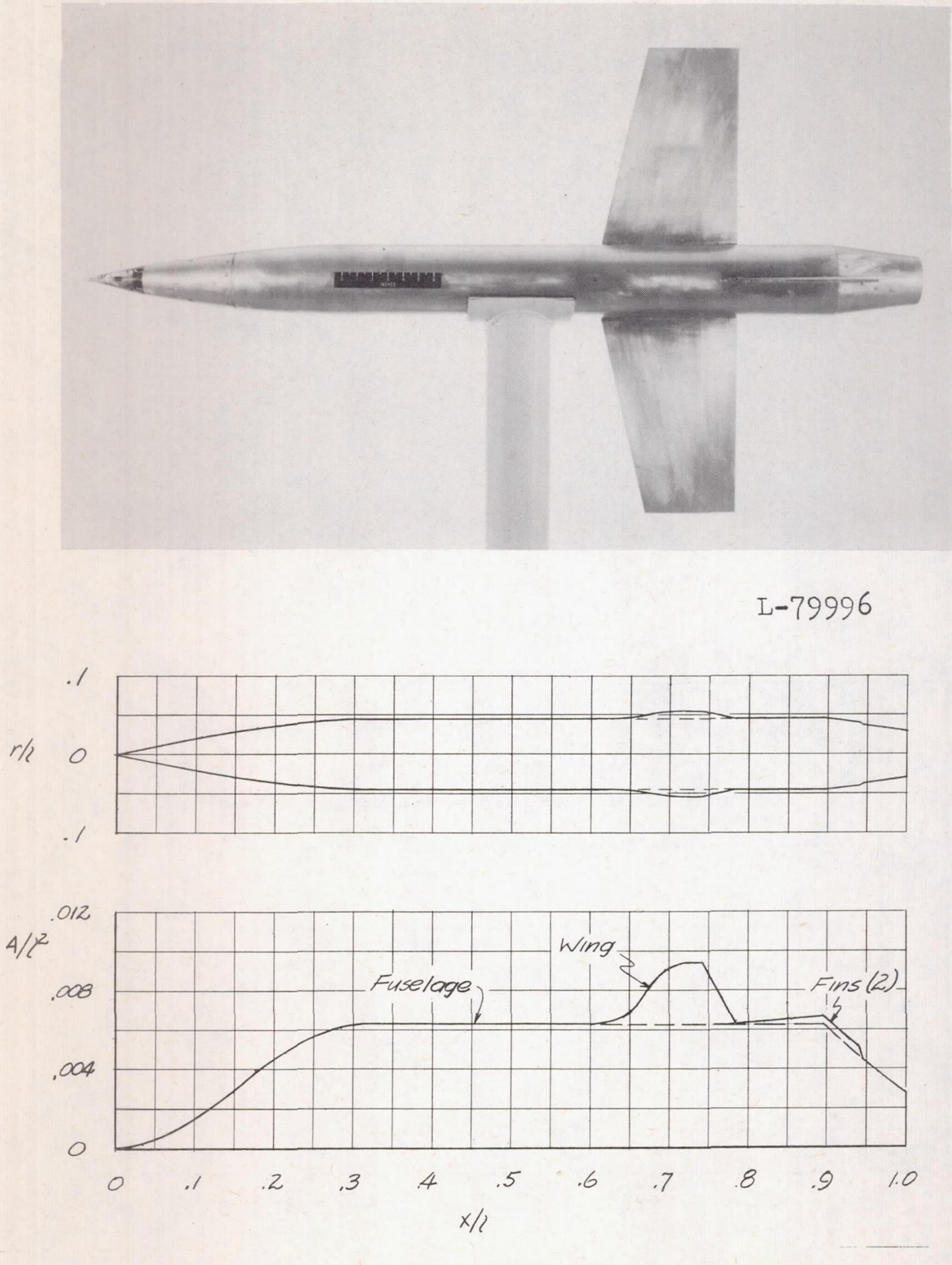


Model 1.



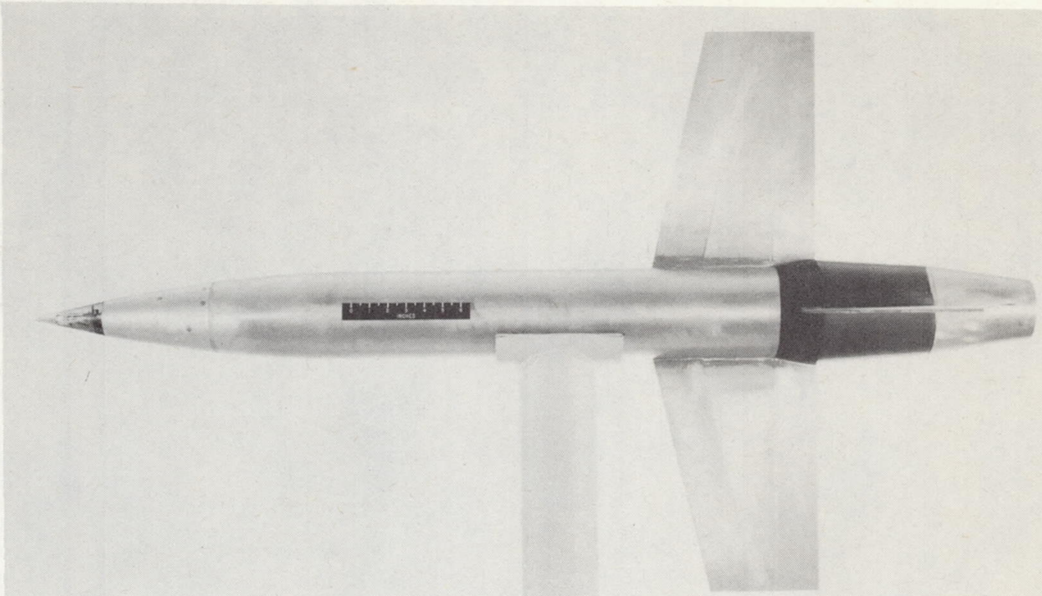
Model 2.

Figure 1.- General arrangement. All dimensions are in inches.



(a) Model 1.

Figure 2.- Photograph, equivalent body geometry, and cross-sectional area distribution of models.



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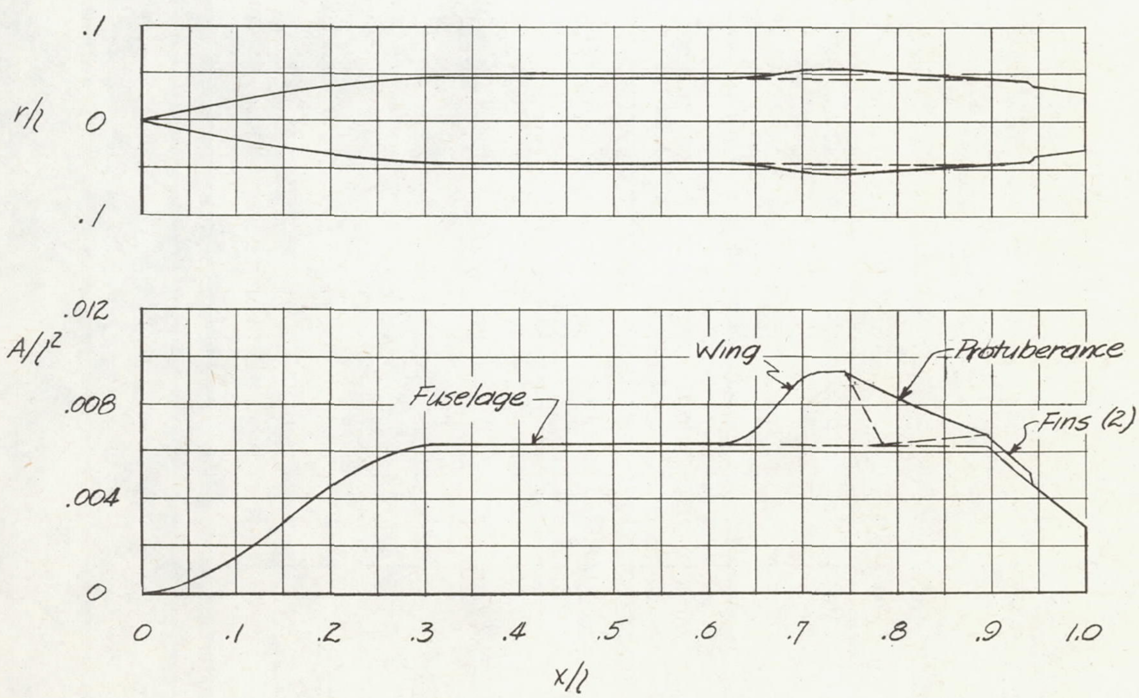

(b) Model 2.

Figure 2.- Concluded.

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Figure 3.- Typical model-booster-launcher arrangement.

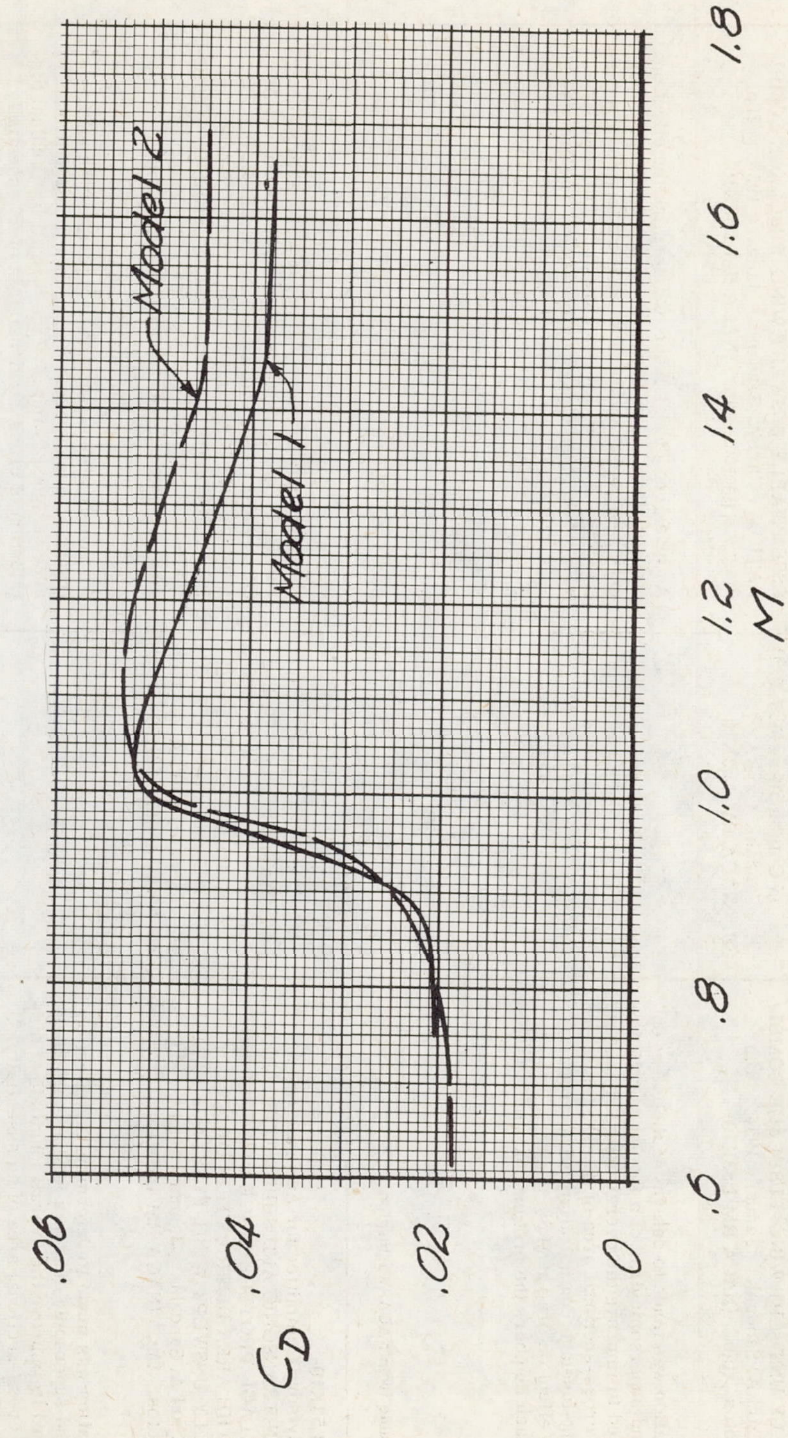

Figure 4.- Test results.