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RESEARCH MEMORANDUM

FLIGHT INVESTIGATION AT MACH NUMBERS FROM 0.8 TO 1.5 OF THE DRAG OF A CANOPY LOCATED AT TWO POSITIONS ON A PARABOLIC BODY OF REVOLUTION

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

Results of an exploratory free-flight investigation of two drag research models equipped with canopies are presented for a Mach number range of 0.8 to 1.5. The two models differed mainly in that one had the leading edge of its canopy located at the 15-percent fuselage station and the other had an identical canopy located at the 25-percent fuselage station. The canopies were semibodies of revolution distorted to fit the contours of the fuselage. The ratio of frontal areas of the canopy to the fuselage was approximately 1:10.

The additional drag due to the canopies amounted to about 10 to 20 percent of the total configuration drag at supersonic speeds. At supersonic speeds the more favorable location of the canopy was at the rearward station, although at transonic speeds the forward location was the more favorable.

INTRODUCTION

The National Advisory Committee for Aeronautics is at present conducting tests to determine the drag of practical fuselage shapes at transonic and supersonic speeds. One phase of this program, pertaining to the effects of nose bluntness on the total drag of a body, was presented in reference 1. In the present paper the drag results of a canopy at two body locations are presented. The canopies for both configurations were developed from bodies of revolution and were located such that their leading edges were at the 15- and 25-percent fuselage stations on a body of revolution having a parabolic-arc profile. The ratio of frontal areas of the canopy to the fuselage was approximately 1:10.

The tests were conducted at the Pilotless Aircraft Research Station at Wallops Island, Va., by means of rocket-propelled models. The tests covered a Mach number range from 0.8 to 1.5 which corresponds to a Reynolds number range from 22,000,000 to 55,000,000 based upon the fuselage length.

MODELS AND TESTS

The general arrangement of the two test models used in this investigation is shown in figure 1 and photographs of the models are shown as figure 2.

The fuselage for both configurations was a parabolic body of revolution having a fineness ratio of 8.91. The coordinates of the fuselage are shown in table I. The canopies for both configurations were derived from a parabolic body of revolution identical to configuration 9 of reference 2, except for an extension of the cut-off base (of the reference configuration) to a point and a reduction in scale by a factor of 0.46. The resulting body had a fineness ratio of 7.8 with maximum diameter located at its 15.5-percent station. The body was then split along its longitudinal axis to form a semibody and bent so that the axis of the semibody coincided with the contour of the fuselage. The cross sections of the bent semibody were then sheared to conform with the circular cross sections of the fuselage body. This development of the canopy is shown graphically in figure 3, and the coordinates of the canopies before and after distortion are presented in table II. The frontal area of the canopy was approximately 10 percent of the frontal area of the fuselage body. An identical body without a canopy was flown in order to determine the incremental drag produced by the addition of the canopies.

The models were propelled by a two-stage system utilizing a 3.25-inch Mk.7 rocket for a sustainer and a 5-inch HVAR motor as a booster. Test data were obtained and reduced by the methods described in reference 3. The velocity was obtained from the CW Doppler velocimeter, and the trajectory and atmospheric data from an NACA modified SCR584 radar tracking unit combined with radiosonde observations. The drag coefficients obtained are based on the frontal area of the basic fuselage (0.307 sq ft) and include fin and interference drag. The estimated errors in the values of drag coefficient are within ± 0.01 at a Mach number of 1.00 and ± 0.005 at a Mach number of 1.4. The estimated errors in Mach number are within ± 0.01.

In figure 4 the average Reynolds number R for the configurations tested based on a body length of 5.57 feet is plotted against Mach number M.

RESULTS

Total-drag coefficients C_D of the two canopy-fuselage configurations tested are plotted against Mach number M and presented in figure 5 along with the drag curve of a configuration having no canopy.

At the lowest Mach numbers investigated there were no measurable differences in the drag of the configurations tested. In the Mach number range from about 0.95 to 1.12 the test data indicated that the drag of the forward located canopy configuration was less than that of the rearward located canopy and was even less than the drag of the basic body through part of this Mach number range. Although no positive explanation can be advanced to account for the reduction of drag due to adding the fore canopy to the basic body, this effect is, however, in agreement with that noted in reference 4. Above $M = 1.05$, both canopies caused a 10- to 20-percent increase in drag; however, the rearward station tended to be the more favorable location at the higher Mach numbers.

Also shown in figure 5 is an estimated drag curve obtained from the summation of the experimental drag of the fuselage and the drag of an isolated canopy for free-stream conditions; the isolated canopy drag was assumed equal to one-half of the experimental drag of the scaled-down original body (reference 2) from which the canopy was developed. The estimated curve has been included to provide a comparison between an engineering approximation of the drag of a fuselage-canopy configuration and measured values.

CONCLUDING REMARKS

An exploratory rocket-powered flight investigation of two drag research models equipped with canopies has been conducted in the Mach number range from 0.8 to 1.5. The models differed mainly in canopy locations, one canopy's leading edge being located at the 15-percent fuselage station and the other at the 25-percent fuselage station. The canopies were semibodies of revolution distorted to fit the contours of the fuselage. The ratio of frontal areas of the canopy to the fuselage was approximately 1:10.

The additional drag due to the canopies amounted to about 10 to 20 percent of the total configuration drag at supersonic speeds. The rearward canopy location configuration had the lesser drag at supersonic speeds; however, at transonic speeds the forward located canopy configuration had the lesser drag.

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REFERENCES

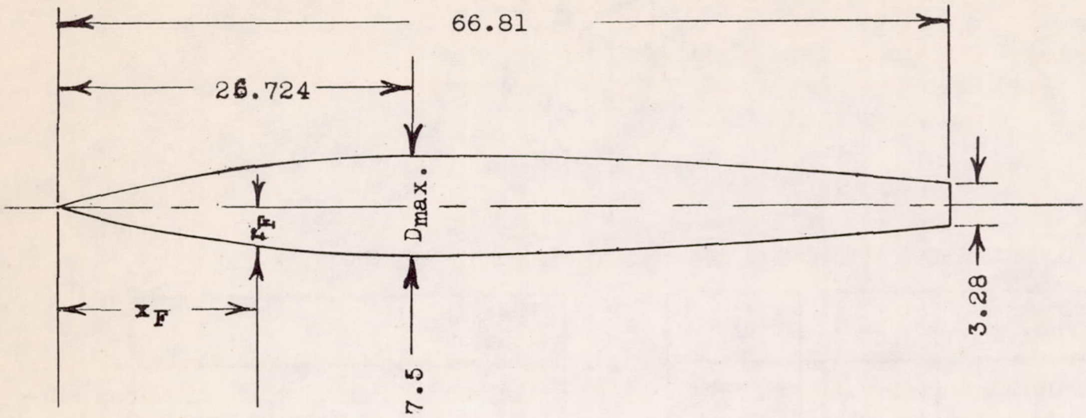
1. Hart, Roger G.: Flight Investigation at Mach Numbers from 0.8 to 1.5 to Determine the Effects of Nose Bluntness on the Total-Drag of Two Fin-Stabilized Bodies of Revolution. NACA RM L50I08a, 1950.

2. Katz, Ellis R.: Flight Investigation at High-Subsonic, Transonic, and Supersonic Speeds to Determine Zero-Lift Drag of Bodies of Revolution Having Fineness Ratio of 6.04 and Varying Positions of Maximum Diameter. NACA RM L9F02, 1949.

3. Morrow, John D., and Katz, Ellis: Flight Investigation at Mach Numbers from 0.6 to 1.7 to Determine Drag and Base Pressures on a Blunt-Trailing-Edge Airfoil and Drag of Diamond and Circular-Arc Airfoils at Zero Lift. NACA RM L50E19a, 1950.

4. Alexander, Sidney R.: Effect of Windshield Shape of a Pilot's Canopy on the Drag of an NACA RM-2 Drag Research Model in Flight at Transonic Speeds. NACA RM L8E04, 1948.

TABLE I



$0 < x_F < 26.724$, $r_F = 3.75 - 23.45(0.4 - 0.01498x_F)^2$

$26.724 < x_F < 66.81$, $r_F = 3.75 - 5.86(0.01498x_F - 0.4)^2$

All dimensions are in inches.

FUSELAGE COORDINATES

x_F	r_F	x_F	r_F
0	0	36.00	3.64
2	.54	38.00	3.58
4	1.04	40.00	3.52
6	1.50	42.00	3.44
8	1.91	44.00	3.36
10	2.28	47.00	3.21
12	2.61	50.00	3.04
14	2.90	53.00	2.84
16	3.15	56.00	2.62
18	3.35	58.00	2.47
20	3.51	60.00	2.30
22	3.63	62.00	2.12
24	3.71	64.00	1.93
27	3.75	66.00	1.72
30	3.74	68.81	1.64
33	3.70	-----	----

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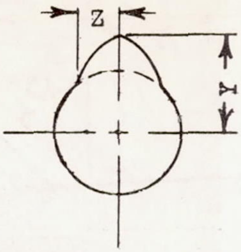
TABLE II

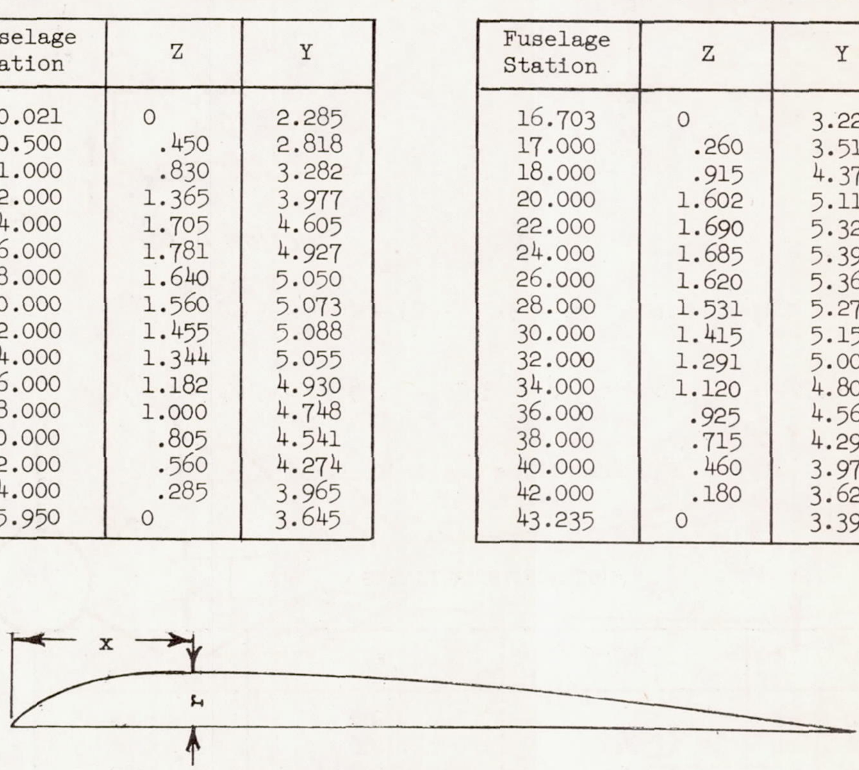


COORDINATES 15-PERCENT CANOPY

Fuselage Station	Z	Y
10.021	0	2.285
10.500	.450	2.818
11.000	.830	3.282
12.000	1.365	3.977
14.000	1.705	4.605
16.000	1.781	4.927
18.000	1.640	5.050
20.000	1.560	5.073
22.000	1.455	5.088
24.000	1.344	5.055
26.000	1.182	4.930
28.000	1.000	4.748
30.000	.805	4.541
32.000	.560	4.274
34.000	.285	3.965
35.950	0	3.645

COORDINATES 25-PERCENT CANOPY

Fuselage Station	Z	Y
16.703	0	3.223
17.000	.260	3.513
18.000	.915	4.375
20.000	1.602	5.115
22.000	1.690	5.323
24.000	1.685	5.396
26.000	1.620	5.368
28.000	1.531	5.279
30.000	1.415	5.151
32.000	1.291	5.005
34.000	1.120	4.800
36.000	.925	4.562
38.000	.715	4.298
40.000	.460	3.979
42.000	.180	3.624
43.235	0	3.392



COORDINATES UNDISTORTED CANOPY

x	r
0	0
.909	.672
1.818	1.170
2.725	1.510
3.640	1.680
4.540	1.704
5.450	1.700
6.350	1.685
7.270	1.665

x	r
8.170	1.645
9.090	1.615
12.250	1.465
16.350	1.176
19.100	.914
22.000	.568
24.000	.388
26.000	.124
26.267	0

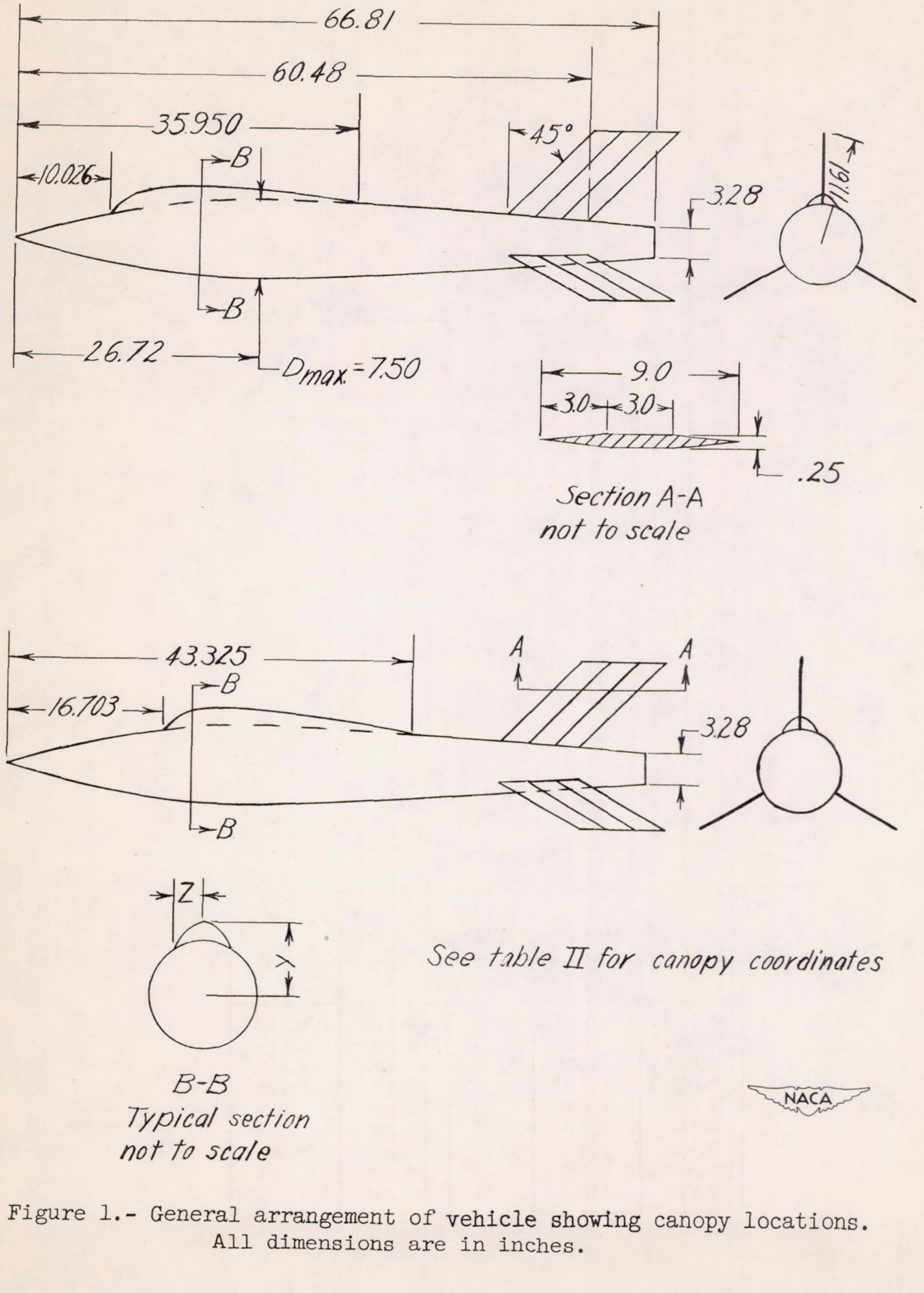
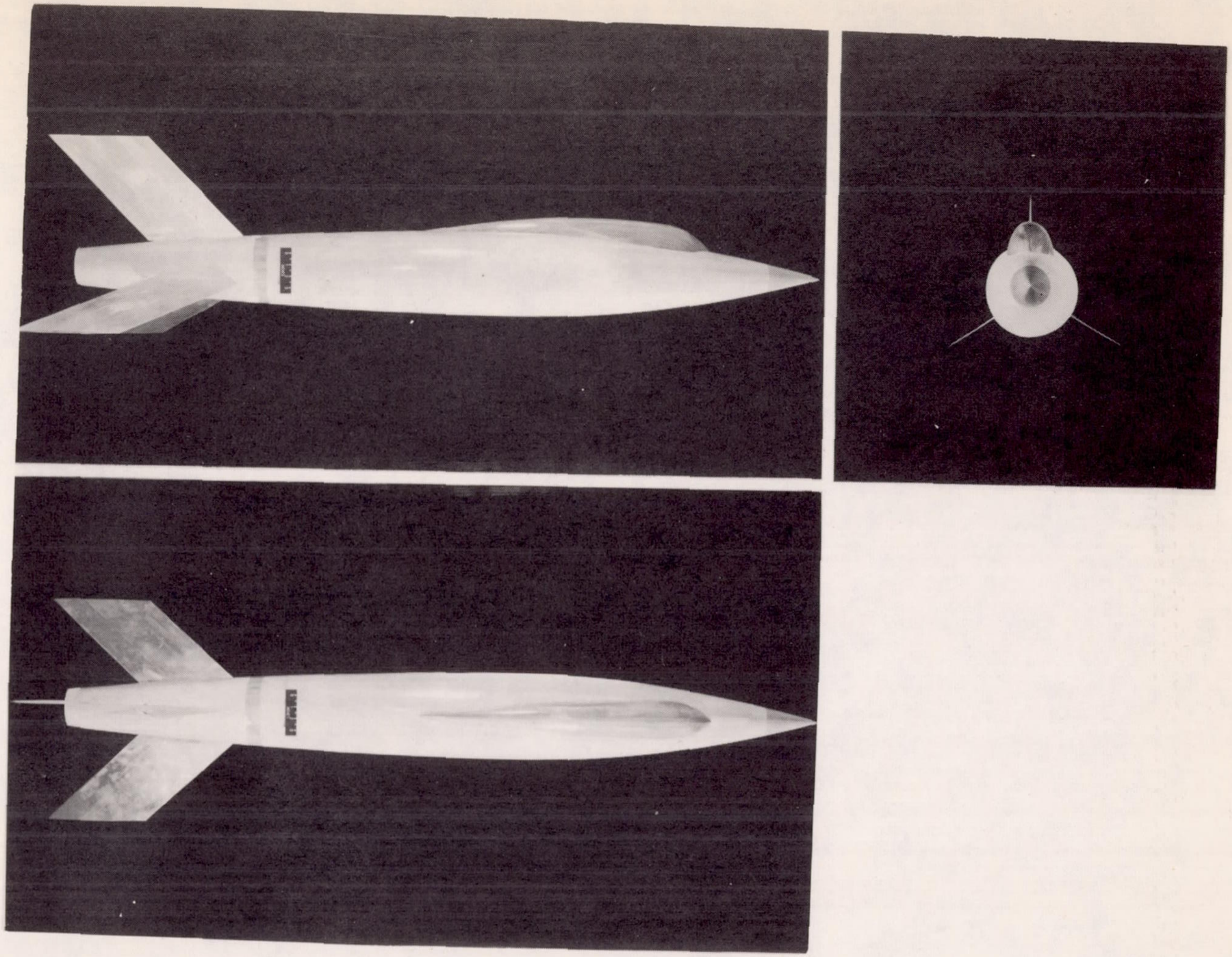


Figure 1.- General arrangement of vehicle showing canopy locations. All dimensions are in inches.



(a) 15-percent-canopy location.

Figure 2.- Photographs showing general arrangement of canopy-body configurations.

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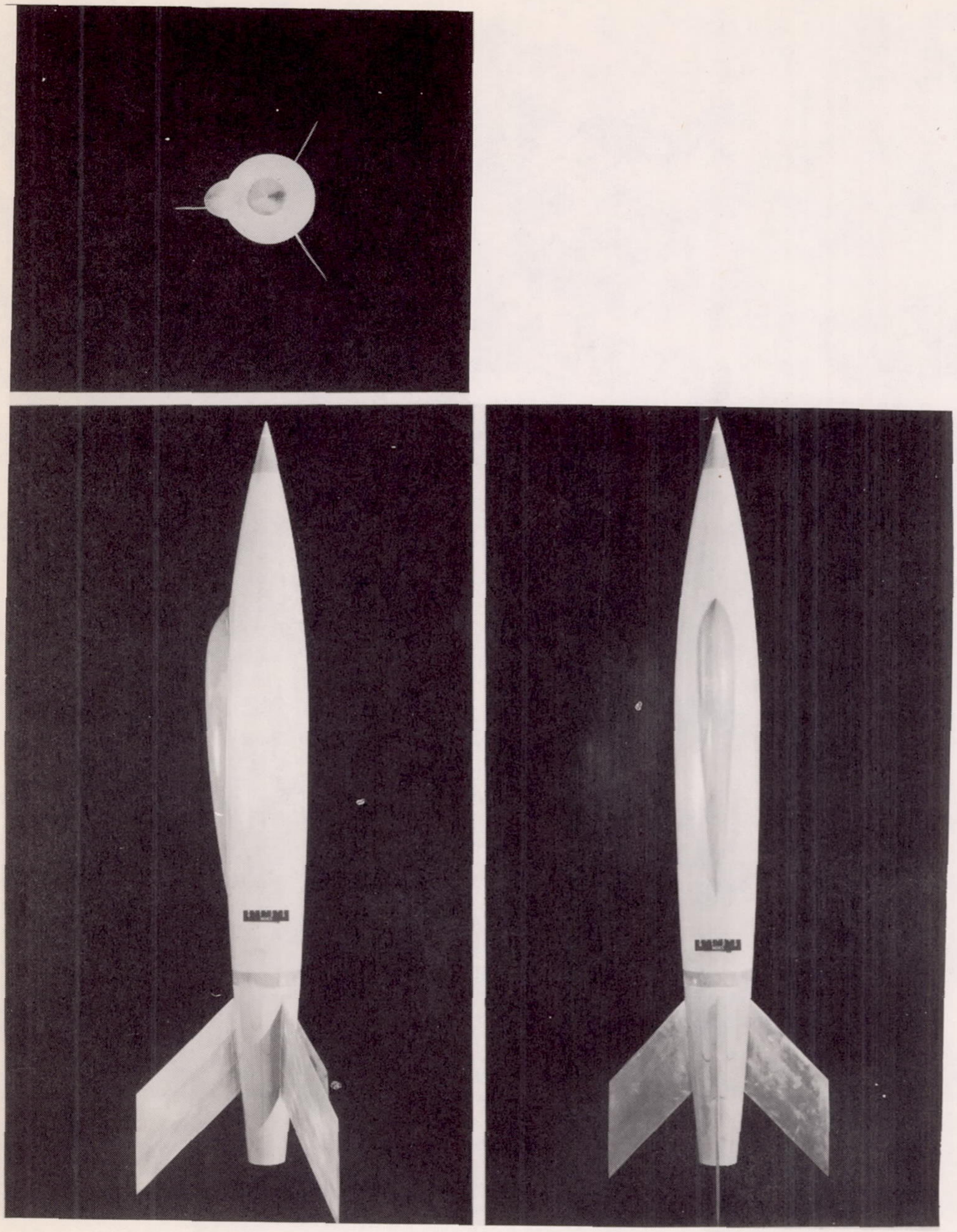

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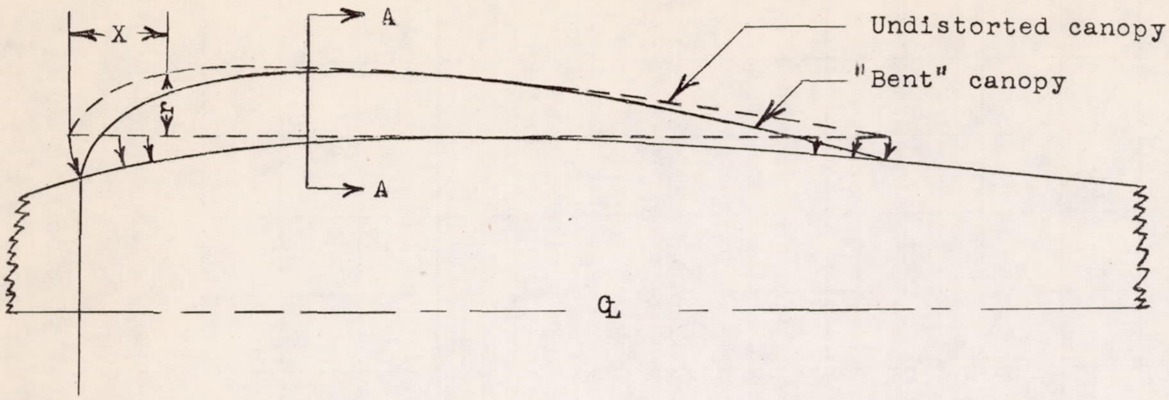
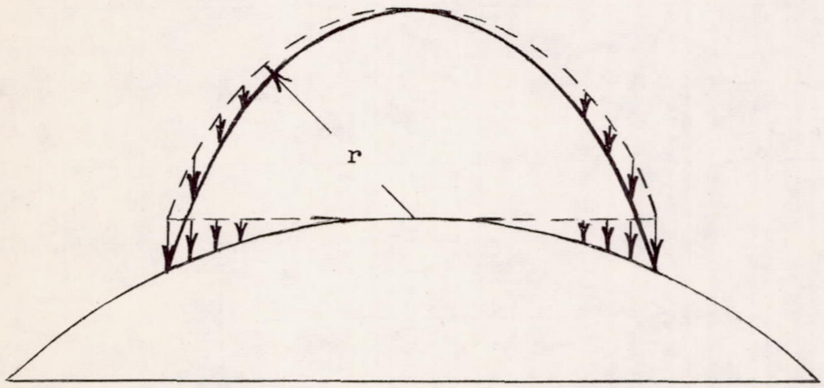
(b) 25-percent-canopy location.

Figure 2.- Concluded.



15- or 25-percent station

Step 1. (Bending of canopy): Undistorted semibody (canopy) is bent so that the axis of the canopy coincides with the surface of the fuselage and such that the radii r remain perpendicular to the axis of the distorted canopy.



Section A-A

Step 2. (Shearing of cross sections): Cross sections of bent canopy are assumed to be circular in a plane perpendicular to the fuselage center line and are "sheared" as shown to conform to the curvature of the fuselage.

Figure 3.- Explanation of method of mounting canopy on body. See table II for "bent" and undistorted canopy coordinates.

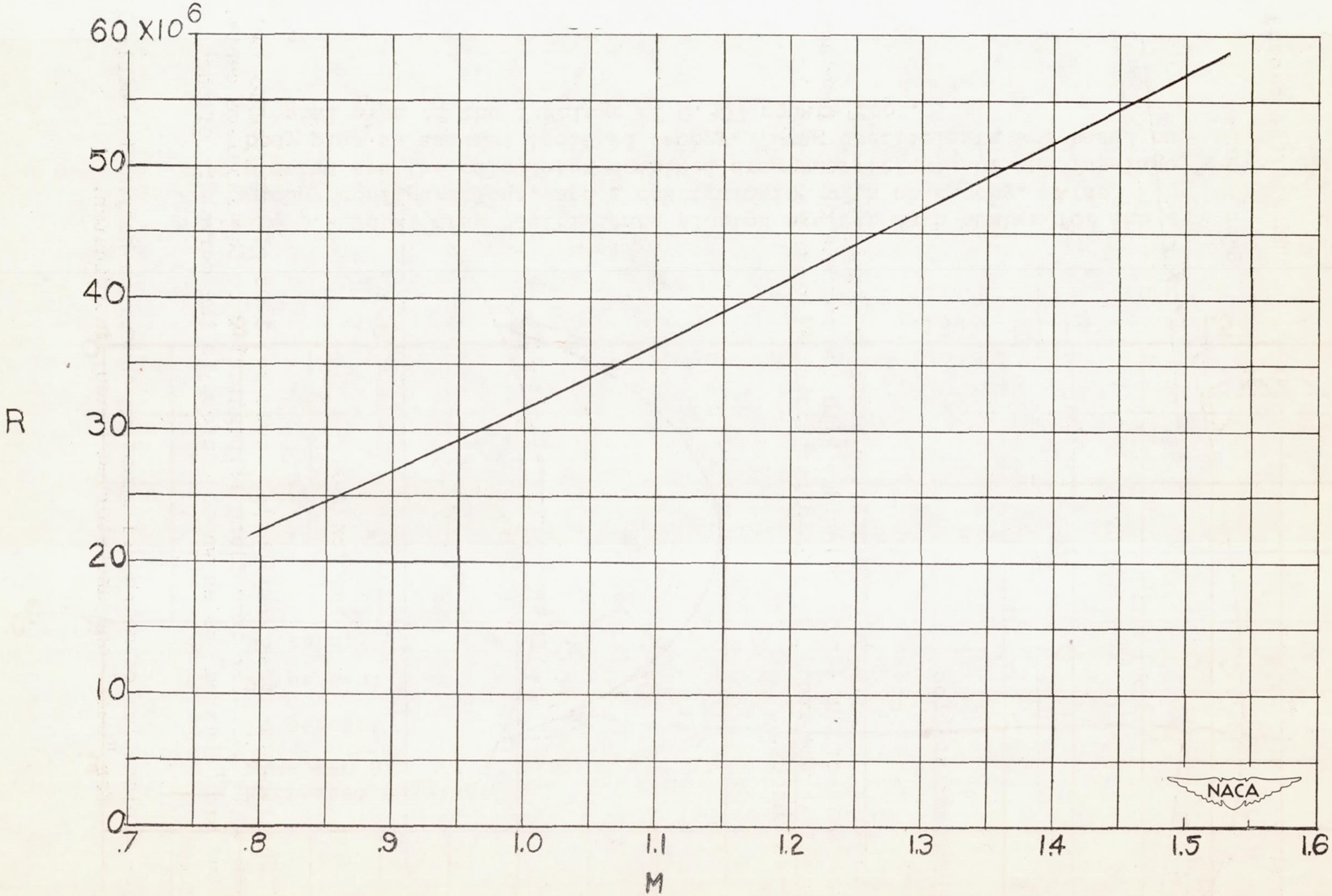


Figure 4.- Reynolds number based on body length of 5.57 feet plotted against Mach number.

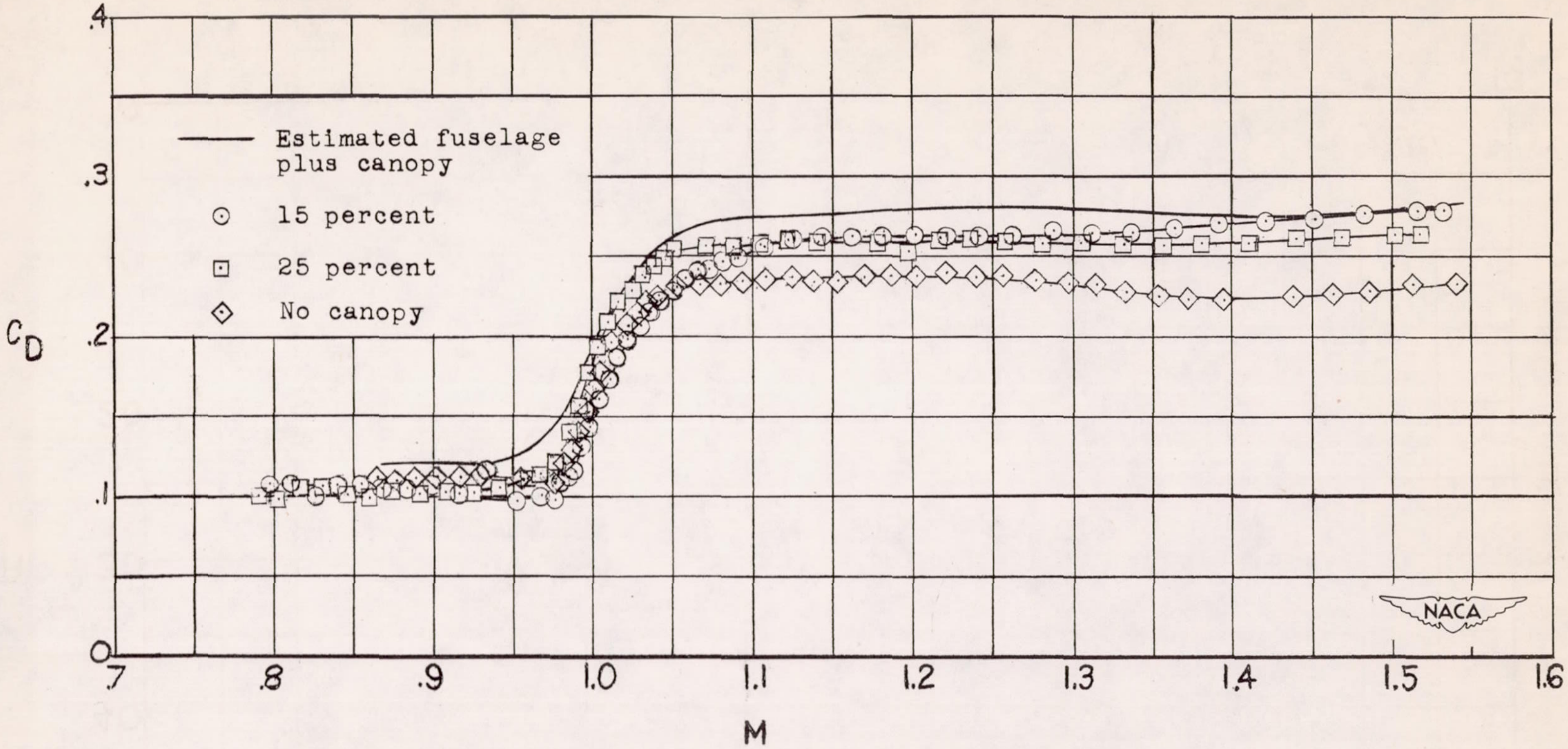


Figure 5.- Total drag coefficients plotted against Mach number for the canopy configurations, and a configuration with no canopy. Also plotted are the calculated combined drag coefficients of the fuselage body plus an assumed isolated canopy. Drag coefficients are based on frontal area of the fuselage of 0.307 square foot.

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