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RESEARCH MEMORANDUM

EFFECT OF CONICAL AND FLAT STING-MOUNTED WINDSHIELDS ON THE ZERO-LIFT DRAG OF A FLARE-STABILIZED BLUFF BODY AT MACH NUMBERS FROM 0.6 TO 1.15

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

Zero-lift drag data are presented for a flare-stabilized bluff body of fineness ratio 4.4 alone and with conical and flat windshields. Continuous data were obtained at Mach numbers from 0.6 to 1.15, at Reynolds numbers between 1.35×10^6 and 2.58×10^6, respectively.

The model with the flat windshield had the lowest drag at Mach numbers up to 1.05. There was little difference in drag of the three models at Mach numbers above 1.05. The rate of change of drag coefficient with Mach number reached higher maximum values for the model with the flat windshield than for the model alone or with the conical windshield.

INTRODUCTION

Because of their good release or ejection characteristics (ref. 1), bluff shapes are considered as possible configurations for internal bombs to be released or ejected from aircraft traveling at supersonic speeds. Accurate drag data are required to predetermine the trajectories of such bombs. In order to provide some information on the drag of one such shape, the Langley Pilotless Aircraft Research Division has conducted flight tests of a flare-stabilized bluff body of fineness ratio 4.4. The models were launched from the helium gun (ref. 2) located at the testing station at Wallops Island, Va. The basic body was tested with and without conical and flat windshields. Other investigations of sting-mounted windshields may be found in references 3 to 6. Zero-lift drag data were obtained at Mach numbers from 0.6 to 1.15.

SYMBOLS

M	free-stream Mach number
C_D	drag coefficient, $\frac{\text{Drag}}{qS}$
q	dynamic pressure, lb/sq ft
S	cross-sectional area of cylindrical portion of the body, sq ft
dC_D/dM	rate of change of drag coefficient with Mach number
R	Reynolds number, based on body length

MODELS, TESTS, AND ANALYSIS

Figure 1 is a drawing of the basic body and the conical and flat windshields. The models were machined from steel, had a wall thickness of about 0.040 inch, and were ballasted with lead to obtain a center-of-gravity location 36 percent body length behind the bluff nose.

Two models each were tested of the basic body alone (plain nose) and with conical and flat sting-mounted windshields. Figure 2 is a photograph of the six models tested. The basic body consisted of a 1.00-inch diameter cylinder with a bluff nose and a flared base of 1.20-inch diameter. Body length (including the flared base) was 4.40 inches. The flare angle (with respect to the center line) was 7.6°.

The helium-gun test technique and a description of the equipment used are presented in reference 2. The drag data were obtained by the CW Doppler radar technique, which is described fully in reference 7. The drag data presented are mean curves from values obtained for both models of each configuration.

ACCURACY

Mach number measurements are believed to be accurate within ±0.01; drag coefficient, within ±0.05 and ±0.1 at $M = 1.1$ and $M = 0.7$, respectively. The figures quoted are maximum probable values, and in general the errors are appreciably smaller than the quoted values.

RESULTS AND DISCUSSION

Reynolds number, based on body length, varied from about 1.35×10^6 at $M = 0.6$ to 2.58×10^6 at $M = 1.15$ for the six models tested, as is shown in figure 3.

Presented in figure 4 are zero-lift drag data for the basic body alone (plain nose) and with conical and flat windshields. The model with the flat windshield had the lowest drag at Mach numbers from 0.6 to 1.05. The configurations with the plain nose and with the conical windshield had about the same drag at $M = 0.7$ ($C_D \cong 1.25$, based on the frontal area of the cylindrical body), but the model with the flat windshield had 32 percent less drag ($C_D \cong 0.85$). There was little difference at $M = 1.15$, where $C_D \cong 1.85$ with the plain nose, $C_D \cong 2.00$ with the conical windshield, and $C_D \cong 1.90$ with the flat windshield. The rate of change of drag coefficient with Mach number reaches appreciably higher values ($dC_D/dM \cong 7.0$) for the configuration with the flat windshield than for either of the other configurations ($dC_D/dM \cong 3.0$). Also shown in figure 4 is drag data from reference 8 for a similar (fineness ratio 4.0, flared base) body with plain nose.

CONCLUDING REMARKS

The investigation reported herein was exploratory in nature, and no general conclusions can be made. It is evident from these tests, however, that for a bluff body the addition of a flat windshield can result in large drag reductions at subsonic and transonic speeds. Although the conical windshield reported herein did not yield favorable drag effects, it is possible that conical windshields of other sizes or shapes might induce drag reductions.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., June 28, 1957.

REFERENCES

1. Lee, John B., and Carter, Howard S.: An Investigation of Ejection Releases of Submerged and Semisubmerged Dynamically Scaled Stores From a Simulated Bomb Bay of a Fighter-Bomber Airplane at Supersonic Speeds. NACA RM L56I10, 1956.

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. Jones, Jim J.: Experimental Drag Coefficients of Round Noses With Conical Windshields at Mach Number 2.72. NACA RM L55E10, 1955.

4. Karpov, B. G., and Piddington, M. J.: Effect on Drag of Two Stable Flow Configurations Over the Nose Spike of the 90mm T316 Projectile. Tech. Note No. 955, Ballistic Res. Labs., Aberdeen Proving Ground, Oct. 1954.

5. Piland, Robert O.: Preliminary Free-Flight Investigation of the Zero-Lift Drag Penalties of Several Missile Nose Shapes for Infrared Seeking Devices. NACA RM L52F23, 1952.

6. Alexander, Sidney R., and Katz, Ellis: Flight Tests to Determine the Effect of Length of a Conical Windshield on the Drag of a Bluff Body at Supersonic Speeds. NACA RM L6J16a, 1947.

7. Wallskog, Harvey A., and Hart, Roger G.: Investigation of the Drag of Blunt-Nosed Bodies of Revolution in Free Flight at Mach Numbers From 0.6 to 2.3. NACA RM L53D14a, 1953.

8. McFall, John C., Jr.: Dynamic Stability Investigation of Two Right Circular Cylinders in Axial Free Flight at Mach Numbers from 0.4 to 1.7 - Fineness-Ratio-2.56 Cylinder and Fineness-Ratio-4.0 Cylinder With Flared Afterbody. NACA RM L56L28, 1957.

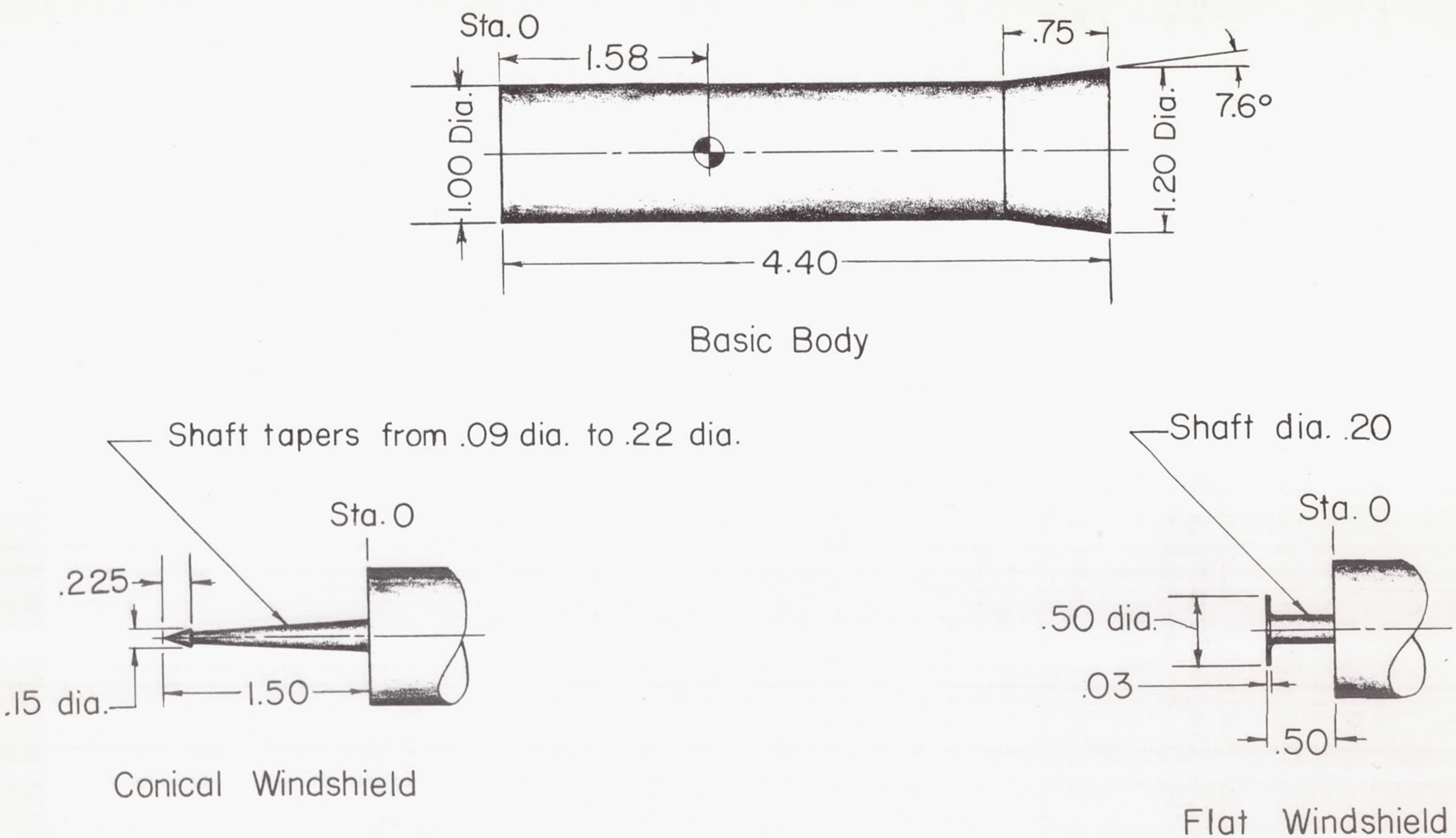

Figure 1.- Drawing of the basic body, the conical windshield, and the flat windshield. (All dimensions are in inches unless otherwise noted.)

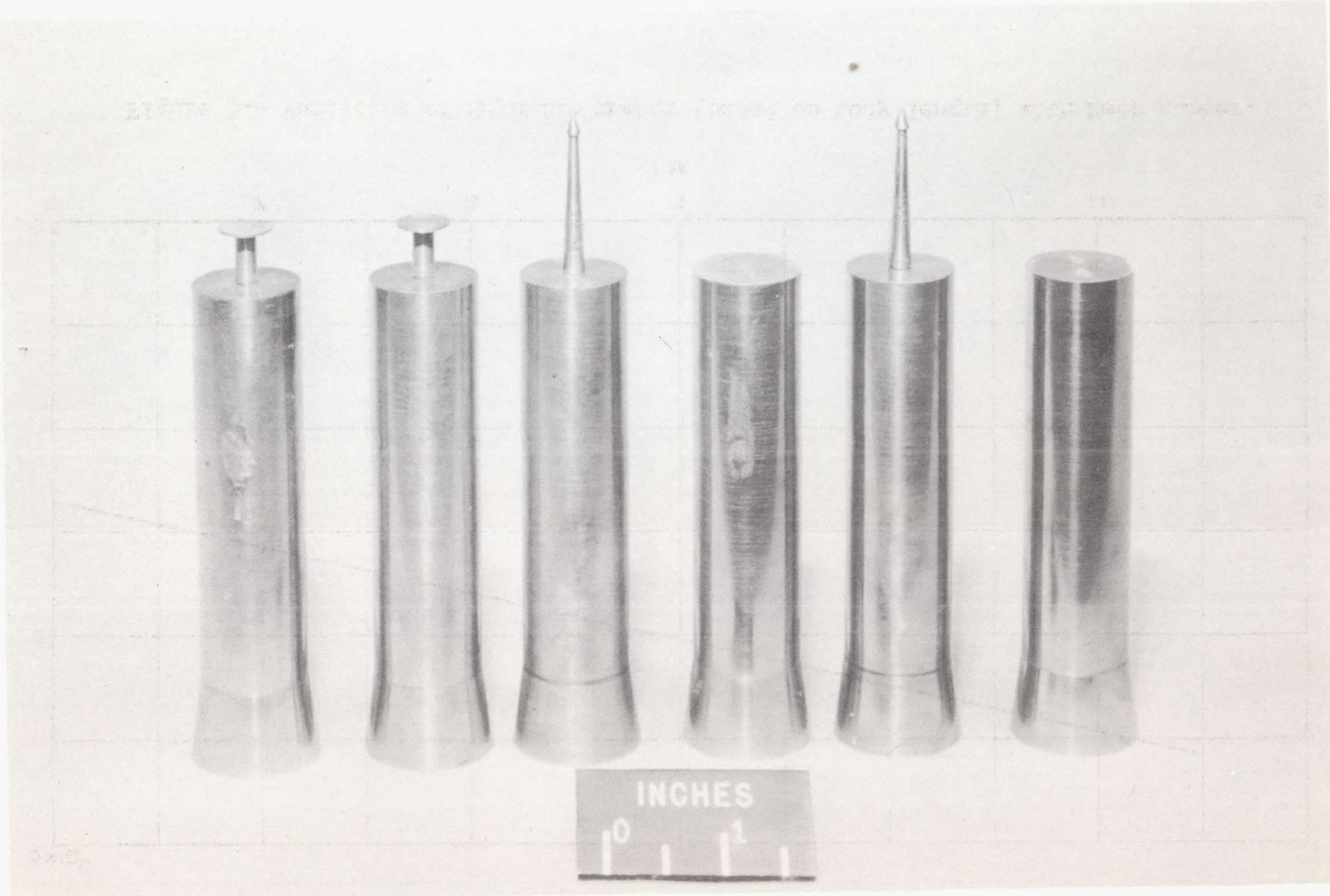

Figure 2.- Photograph of the models tested. L-93644

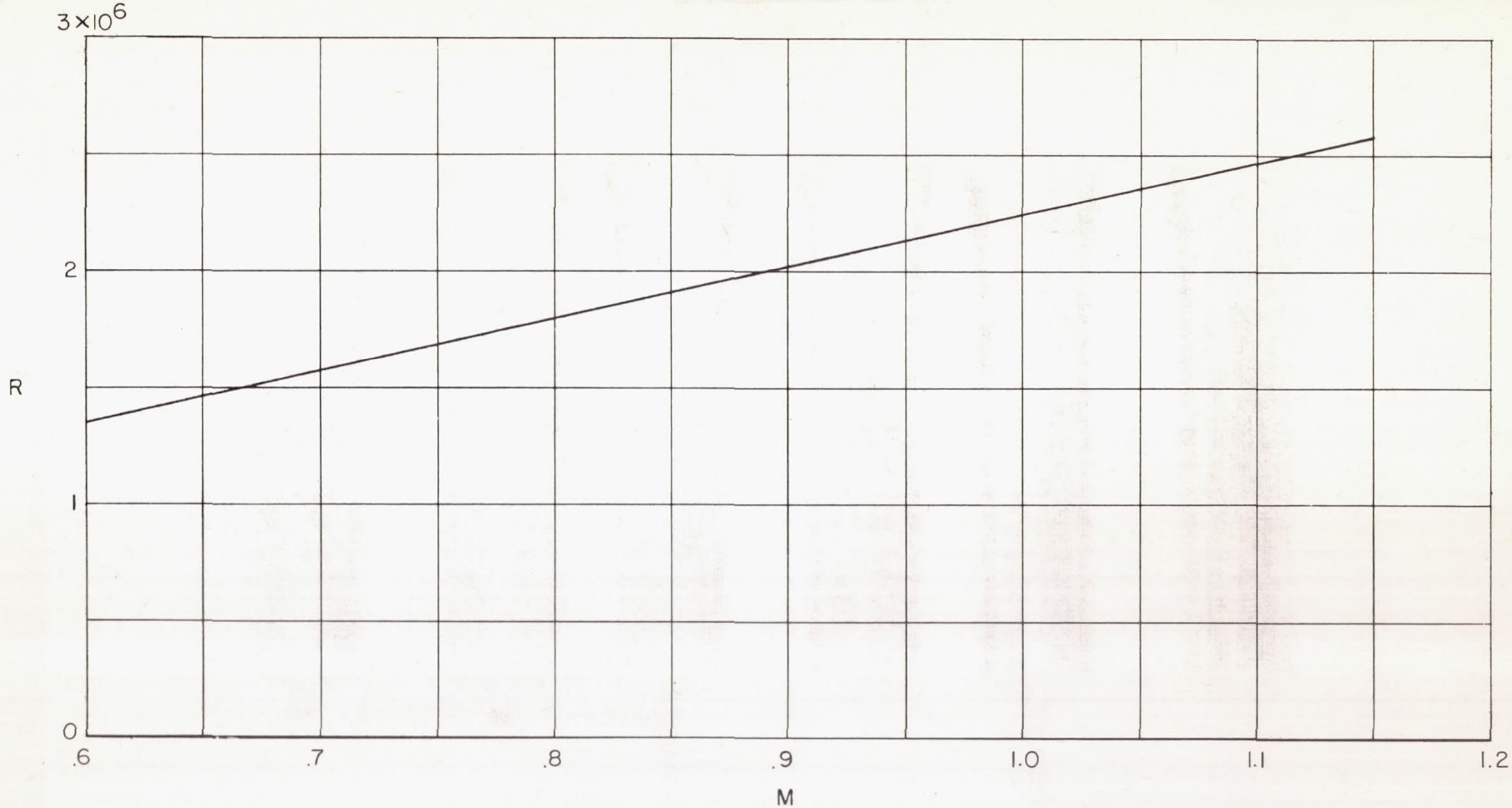

Figure 3.- Variation of Reynolds number (based on body length) with Mach number.

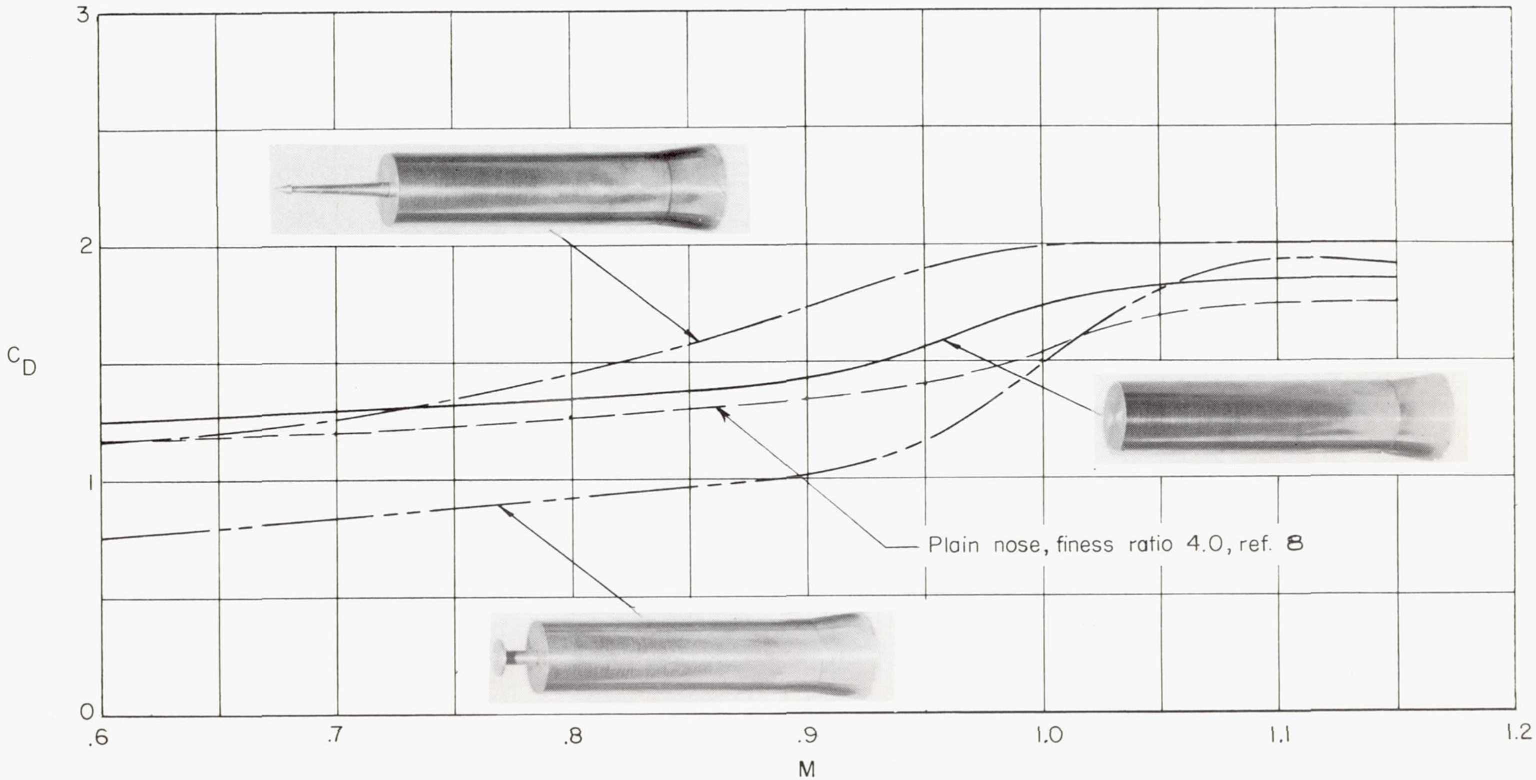

Figure 4.- Variation of drag coefficient (based on cylinder cross-sectional area) with Mach number.