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# RESEARCH MEMORANDUM

## EFFECT OF NUMBER OF FINS ON THE DRAG OF A POINTED BODY OF REVOLUTION AT LOW SUPERSONIC VELOCITIES

By

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RESEARCH MEMORANDUM

# EFFECT OF NUMBER OF FINS ON THE DRAG OF A POINTED BODY OF REVOLUTION AT LOW SUPERSONIC VELOCITIES

By N. Mastrocola

## SUMMARY

Results of flight tests conducted at the test station of the Langley Pilotless Aircraft Research Division at Wallops Island, Va., to determine the effect of number of fins on the drag of a pointed body moving at low supersonic velocities, are presented.

The test data indicate that the interference drag increased with increased number of fins up to a Mach number of 1.35; above this value the effect is reversed to the end of the test Mach number range. The magnitude of interference effects, for the bluff fin sections used in these tests, is such as to make these effects important in estimating the drag of a multifin tail group. The fin drag was found to be comparatively large and was attributed to the blunt leading edge and square trailing edge of the fin airfoil section. Flight test data of a finless body are needed to further evaluate the interference effects.

## INTRODUCTION

The Pilotless Aircraft Research Division of the Langley Memorial Aeronautical Laboratory has undertaken a general flight investigation to provide data pertaining to the drag of bodies at supersonic velocities. As part of this investigation some tests were made to evaluate the effect of number of fins on the zero-lift drag of a pointed body of revolution at supersonic velocities.

The test data reported herein are results from flight tests of three- and five-fin bodies at speeds up to a Mach number of approximately 1.4. Data for a four-fin body, previously reported in reference 1, were reworked and are also presented for comparison.

These flight tests were conducted at the test station of the Langley Pilotless Aircraft Research Division at Wallops Island, Va.

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## BODIES AND TESTS

Bodies.- Photographs of the test bodies with the three-, four-, and five-fin tail groups are presented as figure 1. The principal dimensions of the body are given in figure 2 along with some details of the fins. The simplified airfoil section of the fins was dictated by the need for a reflector strip on the fin trailing edge and by the requirement for an easily fabricated shape.

Each body was propelled by a 3.25-inch-diameter Mk. 7 aircraft rocket motor enclosed within the body. At a preignition temperature of 69° F the rocket motors provided about 2200 pounds of thrust for approximately 0.87 second.

Tests.- Four test flights were made: two with a three-fin tail and two with a five-fin tail.

The three- and five-fin bodies, as well as the bodies in reference 1, were launched at an elevation angle of 75° to the horizontal. The trajectory of the bodies was approximately a straight line during the coasting flight, after the propellant was expended, because of the high elevation angle and the short burning duration of the rocket motor. The flight velocity was measured during the coasting flight by means of a CW Doppler radar set (AN/TPS-5) located near the point of launching.

## RESULTS AND DISCUSSION

A discussion of the procedure employed in the reduction of data obtained by the CW Doppler radar set to yield the variation of drag coefficient with Mach number is given in reference 1.

The variation of drag coefficient with Mach number for the fin arrangements tested is given in figure 3. Data for the four-fin model which were previously reported (reference 1) have been reworked yielding more accurate points and slightly altering the mean curve. These data are presented in figure 3 for comparison. The drag coefficients are based on the exposed area of one fin (0.237 sq ft). Each of the present test curves is a mean through the test points obtained from flight tests of two identical models.

Because of the relatively large scatter of the data shown in figure 3, it appears that no clear quantitative conclusions as to the variation in interference due to number of fins or with changing Mach number can be drawn, but some qualitative observations of the data can be made.

The increments between the curves of figure 3 are an indication of the drag of one fin plus the change in interference drag (effect of body on fins and effect of fins on body and on each other) caused by the change in number of fins. These increments plotted against Mach number (fig. 4), show the variation of fin drag plus the additional interference drag resulting from the addition of a fin to a three-fin and a four-fin tail group. The difference between these curves (fig. 4) is a measure of the increase in interference drag caused by an increase in number of fins from four to five and the resulting rearrangement of the fins. These data indicate that the interference drag increased with increased number of fins up to a Mach number of approximately 1.35 where the curves cross and the effect is reversed to the end of the Mach number range tested.

Because the interference drag increase is due to the change of interference effects on five fins caused by the rearrangement of the fins, only 1/5 of the drag increment can be attributed to one fin. Then, the increase of interference drag of a single fin in a five-fin tail group is approximately 8 percent at $M = 1.0$ and 0 percent at $M = 1.35$ based on the drag of a single fin plus the interference drag in a four-fin group. The magnitude of these effects, for the bluff fin section used, is large enough to make them important in estimating the drag of a multifin tail group.

The lower curve of figure 4 may also be considered to be a measure of the drag of one fin if the interference drag of a four-fin group is assumed to be very small. This curve, then, can be used in conjunction with the three-fin data of figure 3 to obtain the basic body drag. The variation of body drag with Mach number, computed in the above manner, is shown in figure 5. The body drag curve is different from the curves for similar bodies at supersonic speeds apparently because the assumption of negligible interference effects on a four-fin tail group is false. It may be concluded then, that the interference drag of a four-fin tail group, with a blunt fin section, is not small and that the magnitude of the effects cannot be determined unless drag data for a finless body are made available. Such data would allow the separation of fin and body drag and so permit the evaluation of the effects of number of fins on the interference drag. The inherent difficulties involved in flying a finless body, however, have delayed attempts to obtain such data by means of pilotless aircraft flights.

The drag coefficient for a single fin (fig. 4) is of the order of 0.04 or 0.05. These values are comparatively high for the aspect ratio and angle of sweepback employed on the fin and must be attributed to the fin airfoil section. The blunt leading edge and thick square trailing edge incorporated in the section make high values of drag seem very probable. It is advisable, therefore, to use a fin section more suited to supersonic flight if other fin requirements can also be fulfilled.

## CONCLUDING REMARKS

The flight tests reported herein, although not sufficient for the quantitative evaluation of fin-interference effects, do provide some qualitative information:

1. The magnitude of fin and body interference effects, for a bluff fin section, appears high enough to make these effects important in estimating the drag of a multifin tail group.

2. The interference drag increased with increased number of fins up to a Mach number of 1.35; above this value the effect is reversed to the end of the test Mach number range.

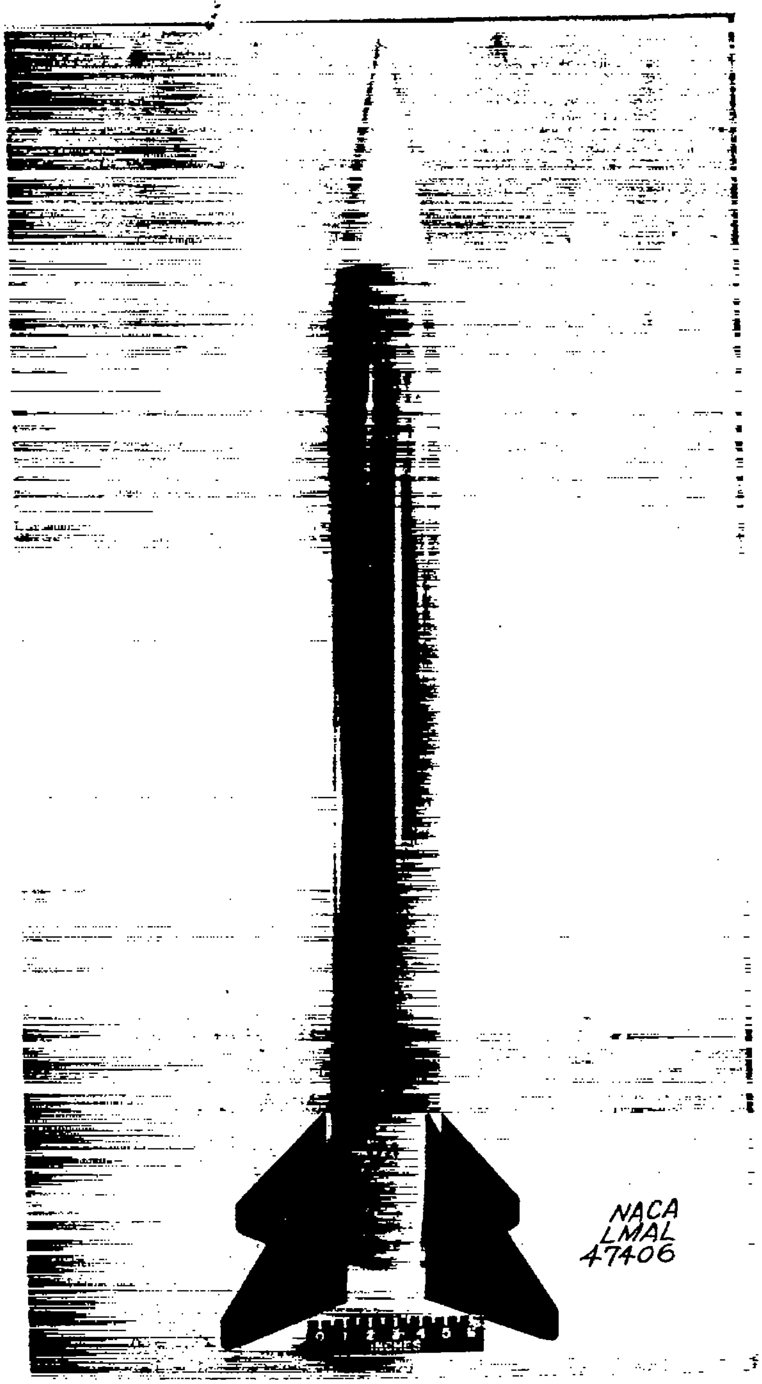
3. The fin drag was found to be comparatively large and was probably caused by the blunt leading edge and thick square trailing edge of the fin airfoil section.

4. Data, similar to those of the present tests, for a finless body are necessary to separate fin and body drag and to further evaluate interference effects. It is also advisable to obtain fin-drag data for fin sections more suited to supersonic flight than those of the present tests.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va.

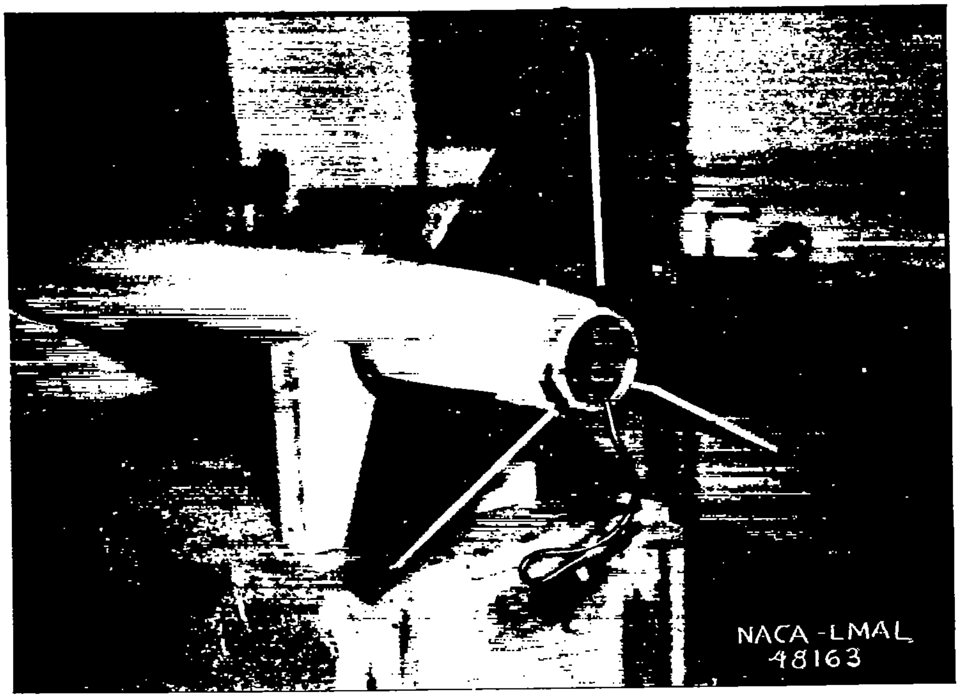
## REFERENCE

1. 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 No. L6J16a, 1946.



(a) Four-fin body.

Figure 1.- General views of the test bodies.



(b) Three-fin body.

Figure 1.- Continued.

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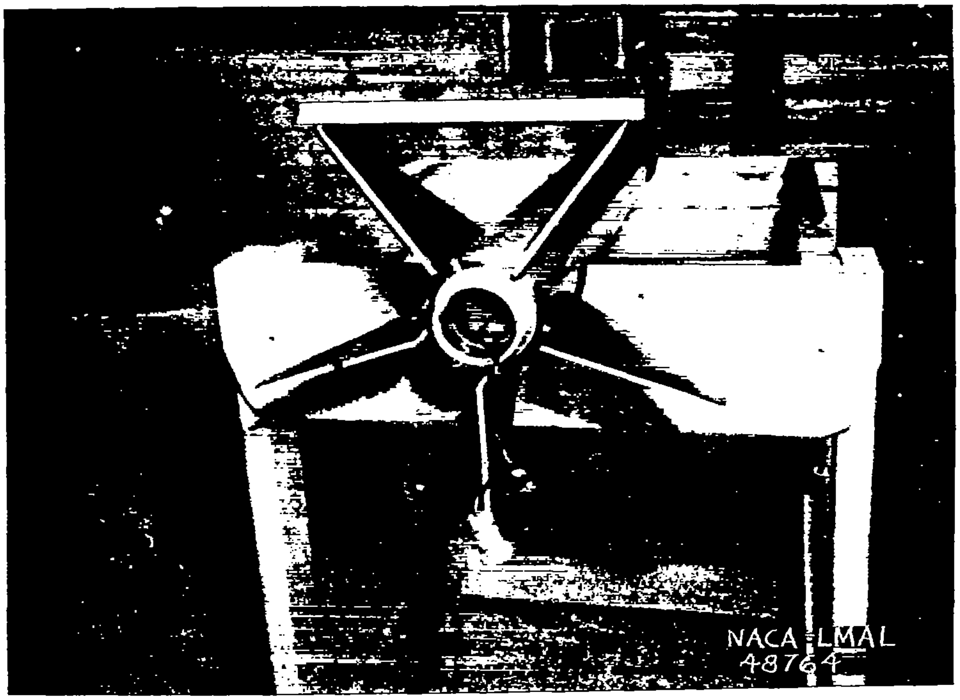

(c) Five-fin body.

Figure 1.- Concluded.

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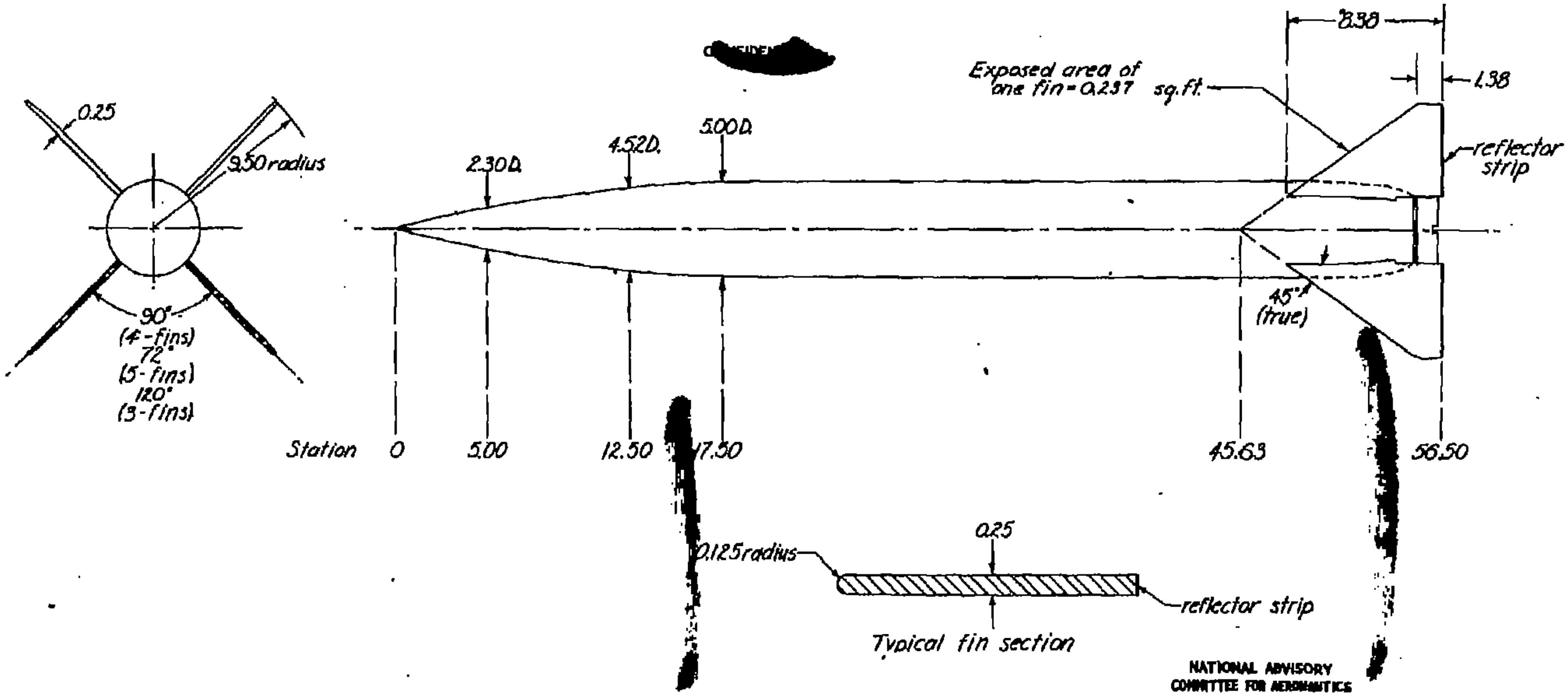

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Figure 2.-General arrangement of test body.

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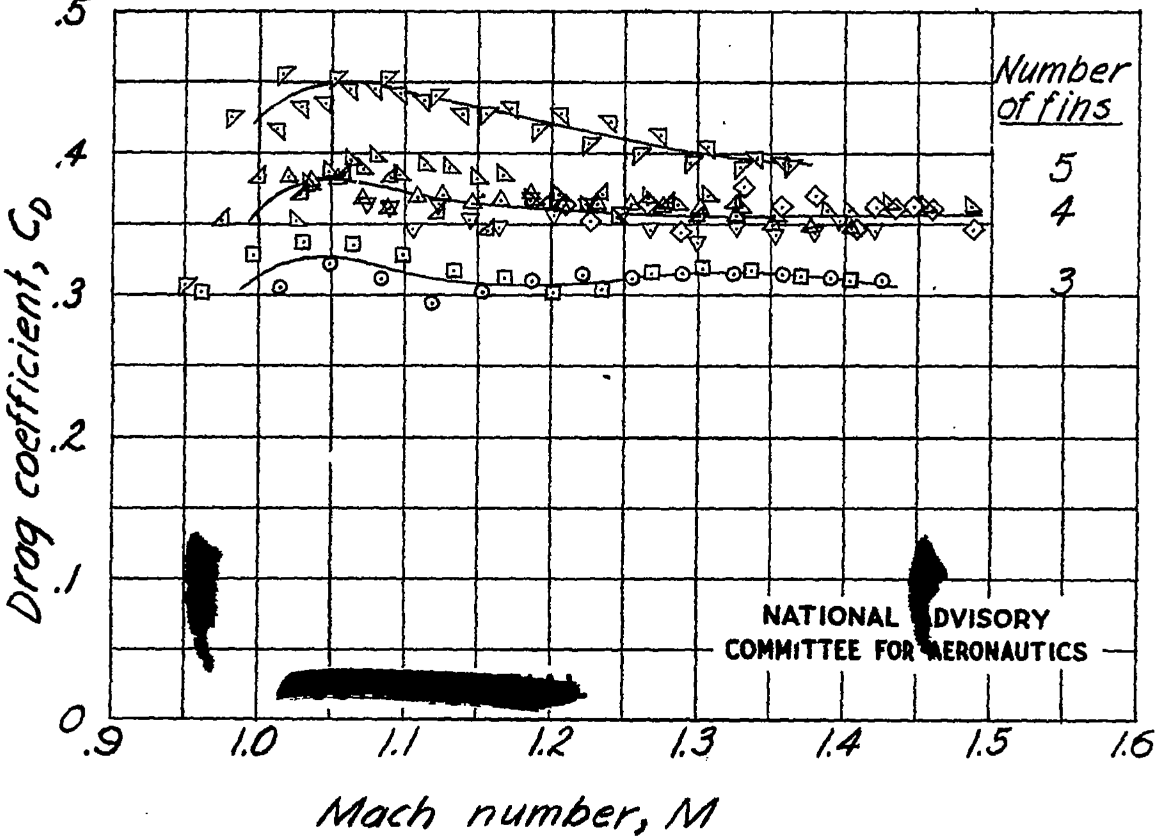

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Figure 3.- The variation of drag coefficient with Mach number for three fin arrangements.

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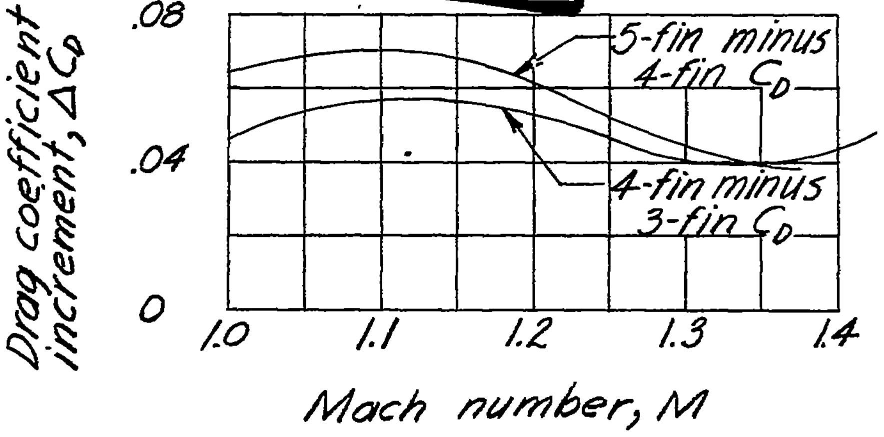

Figure 4.- The variation of fin drag-coefficient increment with Mach number.

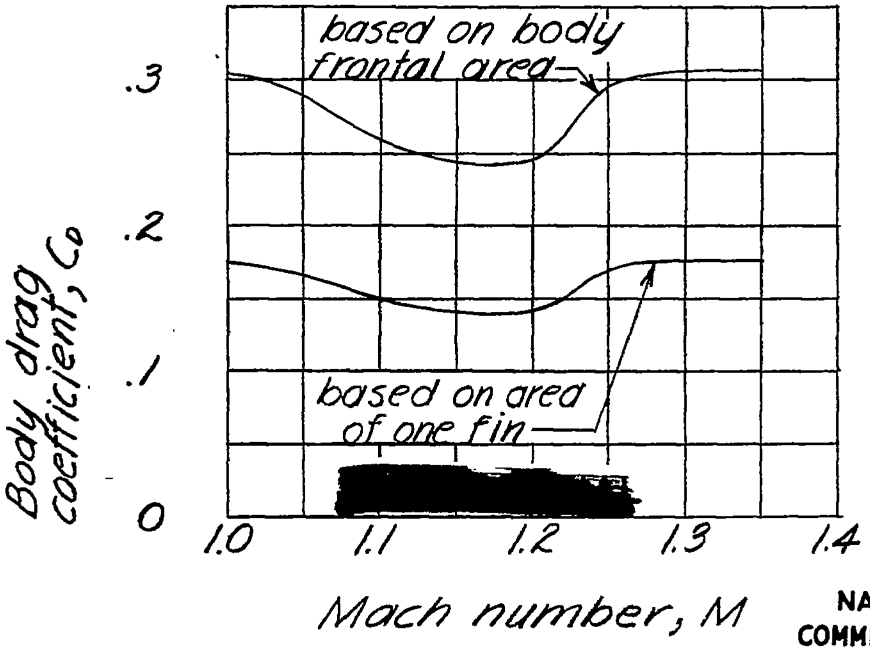

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Figure 5 - The variation of body drag-coefficient with Mach number. Extrapolated from finned-body drag data.