TECHNICAL MEMORANDUM

X-339

EFFECTS OF CANTED FORWARD FACES ON THE STATIC LONGITUDINAL STABILITY CHARACTERISTICS OF THE ESCAPE AND EXIT CONFIGURATIONS OF A PROJECT MERCURY CAPSULE MODEL AT A MACH NUMBER OF 2.01

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON October 1960

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EFFECTS OF CANTED FORWARD FACES ON THE STATIC LONGITUDINAL STABILITY CHARACTERISTICS OF THE ESCAPE AND EXIT CONFIGURATIONS OF A PROJECT MERCURY CAPSULE MODEL AT A MACH NUMBER OF 2.01*

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SUMMARY

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An investigation has been made in the Langley 4- by 4-foot supersonic pressure tunnel at a Mach number of 2.01 to determine the aerodynamic characteristics in pitch of the escape and exit configurations of the proposed Project Mercury capsule. The forward faces of the two configurations were canted to provide a few degrees of trim angle of attack and several cant angles were investigated.

The results indicate that, by canting the forward faces of the configurations, relatively large increments in pitching moment can be obtained at a Mach number of 2.01 with little change in lift and drag.

INTRODUCTION

The problems associated with launching a manned vehicle into orbit about the earth are many. One problem of primary concern is the possibility that a malfunction may occur in the booster rocket system during the initial phases of the launch. It is evident that some means of escape must be provided for the occupant during this critical period of the mission. The stability characteristics of one proposed escape system are reported in reference 1. The escape system that is being considered by the Space Task Group of the National Aeronautics and Space Administration for the Project Mercury Capsule utilizes a small rocket mounted on a tower-like structure forward of the capsule. In the event of a malfunction during launch, the escape rocket separates the capsule from its booster vehicle and propells it to an altitude from which a landing is made by parachute. The required lateral velocity component

*Title, Unclassified.

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provided by the escape rocket to miss the booster imposes high lateral loads on the occupant of the capsule. Unpublished calculations by the Space Task Group indicate that use of a few degrees of trim angle of attack can reduce the lateral loads and increase the miss distance of the escape configuration. The proposed trim control was obtained by canting the forward face of the escape rocket.

Another problem associated with a manned orbital vehicle is that of achieving proper orientation for the reentry phase of flight. The Mercury capsule has been designed to reenter the earth's atmosphere blunt
end first and it is this portion of the vehicle that has been designed to L
withstand the high stagnation temperatures. Wind-tunnel tests of the 1
capsule in the exit configuration (antenna canister forward and without 1
the escape tower) have shown that it is statically stable at some Mach 6
numbers. This stability is undesirable since it may allow the capsule 4
to reenter antenna canister first. In order to insure that the proper reentry attitude can be attained, the forward face of the antenna canister was canted several degrees.

The purpose of the present investigation was to determine the effects on static longitudinal stability at a Mach number of 2.01 of canting the forward faces of the escape rocket and the antenna canister on the proposed Project Mercury escape and exit configurations, respectively. The tests were made in the Langley 4- by 4-foot supersonic pressure tunnel.

SYMBOLS

All the forces and moments are referred to the body-axis system except the lift and drag coefficients which are referred to the stability-axis system.

C_A axial-force coefficient, F_A/qS

C_D drag coefficient, D/qS

C_L lift coefficient, L/qS

C_m pitching-moment coefficient, M_Y/qSd

C_N normal-force coefficient, F_N/qS

$C_{p,b}$ base pressure coefficient, $\frac{p_b - p}{q}$

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D	drag
d	capsule base diameter, 0.690 ft
F_A	axial force
F_N	normal force
L	lift
M	free-stream Mach number
M_Y	pitching moment, moment about Y-axis
p	free-stream static pressure
p_b	base pressure
q	free-stream dynamic pressure
S	capsule base area, 0.374 sq ft
α	angle of attack

MODELS AND APPARATUS

Sketches of the two configurations that were tested are shown in figure 1. Photographs of the models are shown in figure 2. The configurations were 1/9-scale models of the proposed Project Mercury capsule escape (fig. 1(a)) and exit (fig. 1(b)) configurations.

The forward portions of the escape rocket for the escape configuration and of the antenna canister for the exit configuration were removable so that the effects of several cant angles could be investigated. Escape-rocket face angles of 0°, 5°, 10°, and 25° and antenna-canister face angles of 0° and 12° were tested. A photograph of the escape-rocket faces is shown in figure 2(c) and a photograph of the antenna-canister faces is shown in figure 2(d).

The models were sting supported from the rear in the test section of the Langley 4- by 4-foot supersonic pressure tunnel. A three-component internally mounted strain-gage balance was used for obtaining force and moment data. Base pressures were obtained by means of tubes located just inside the bases of the models.

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TEST, CORRECTIONS, AND ACCURACY

The tests were conducted in the Langley 4- by 4-foot supersonic pressure tunnel at a Mach number of 2.01 and a Reynolds number of 3.62×10^6 per foot. Stagnation temperature was 100° F and stagnation pressure was 2,112 pounds per square foot absolute. In order to prevent condensation from occurring in the test section, the stagnation dewpoint was maintained at less than -25° F throughout the tests. Force and moment data were recorded throughout an angle-of-attack range of about -15° to about 15°. Corrections were made to the angles of attack to account for deflections in the balance and sting under load. Drag and axial-force data have not been corrected for base pressure.

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The estimated maximum probable errors in Mach number, angle of attack, and force and moment data based on repeatability of the results, zero-shifts, calibration, and random instrument errors are as follows:

C_A or C_D at $\alpha = 0^\circ$	±0.007
C_m	±0.002
C_N or C_L at $\alpha = 0^\circ$	±0.008
M	±0.015
α, deg	±0.10

PRESENTATION OF RESULTS

Base pressure coefficients for the various configurations tested are shown in figure 3. The results of this investigation are presented as follows:

	Figure
Effects of escape-rocket face angle on the aerodynamic characteristics in pitch of the escape configuration	4
Effects of antenna-canister face angle on the aerodynamic characteristics in pitch of the exit configuration	5

SUMMARY OF RESULTS

The results of this investigation indicate that canting the forward face of the escape rocket provides an effective means of obtaining a few degrees of trim angle of attack on the escape configuration. Although

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little effect on the lift and drag coefficients was observed, increasing the rocket face angle on the escape configuration produced relatively large increments in pitching moment. Similarly, increasing the antenna-canister face angle on the exit configuration produced appreciable increments in pitching moment.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., June 30, 1960.

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4

REFERENCE

1. Robinson, Ross B., and Harris, Roy V., Jr.: Static Longitudinal Stability Characteristics at a Mach Number of 1.98 of a Nonlifting-Space-Capsule Model With Finned-Adapter Escape System. NASA TM X-261, 1960.

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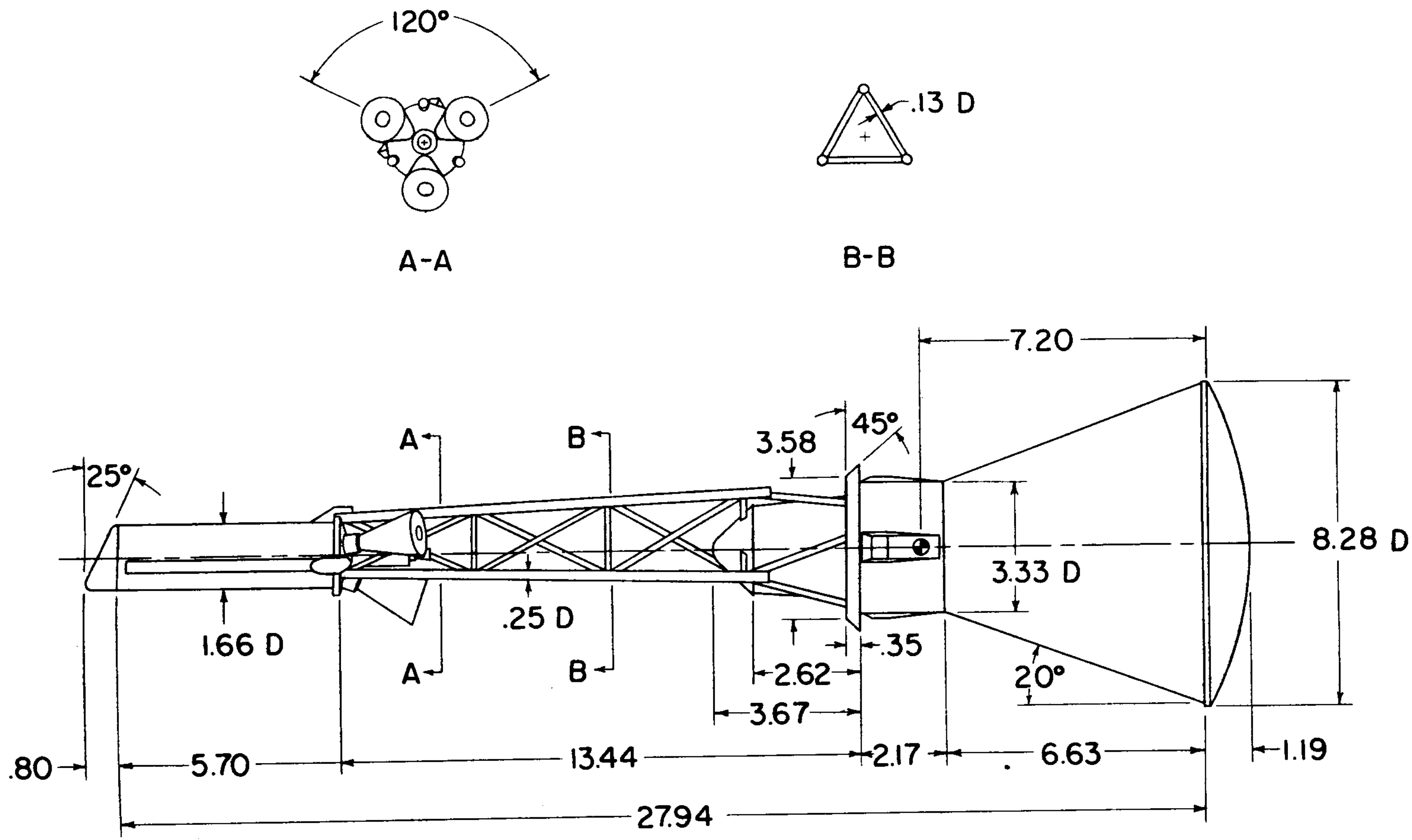

(a) Escape configuration.

Figure 1.- Drawings of the capsule models. All dimensions are in inches unless otherwise specified.

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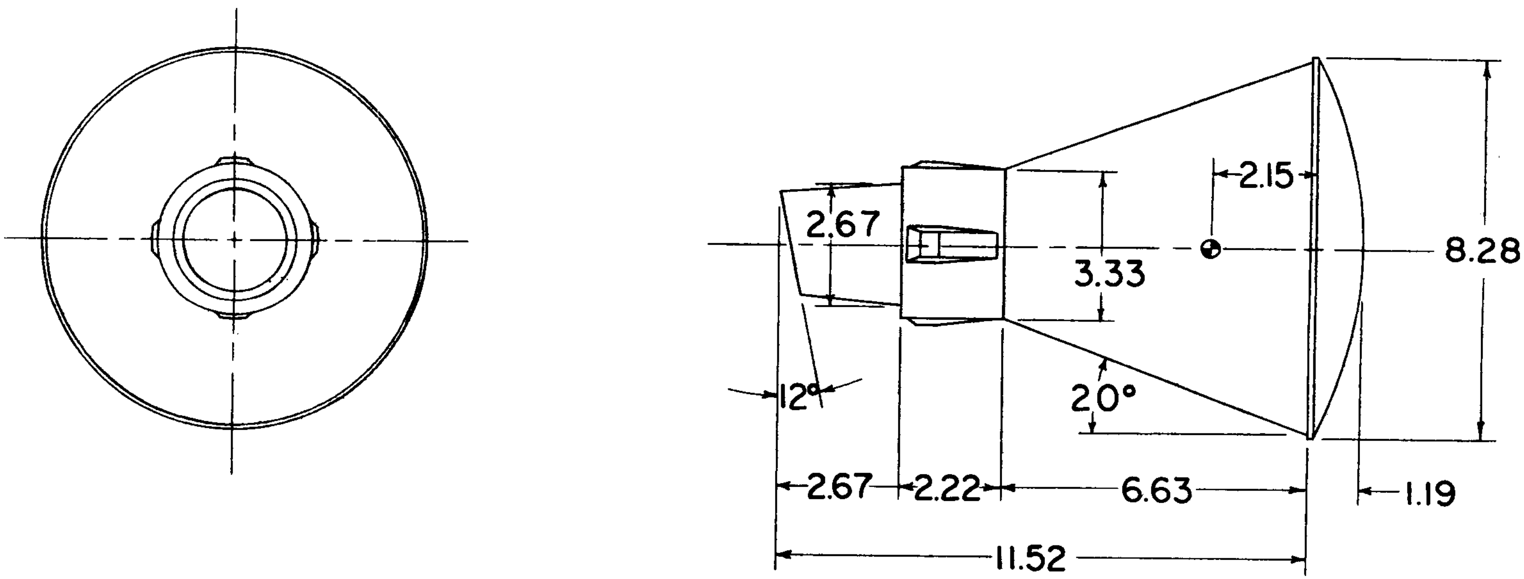

(b) Exit configuration.

Figure 1.- Concluded.

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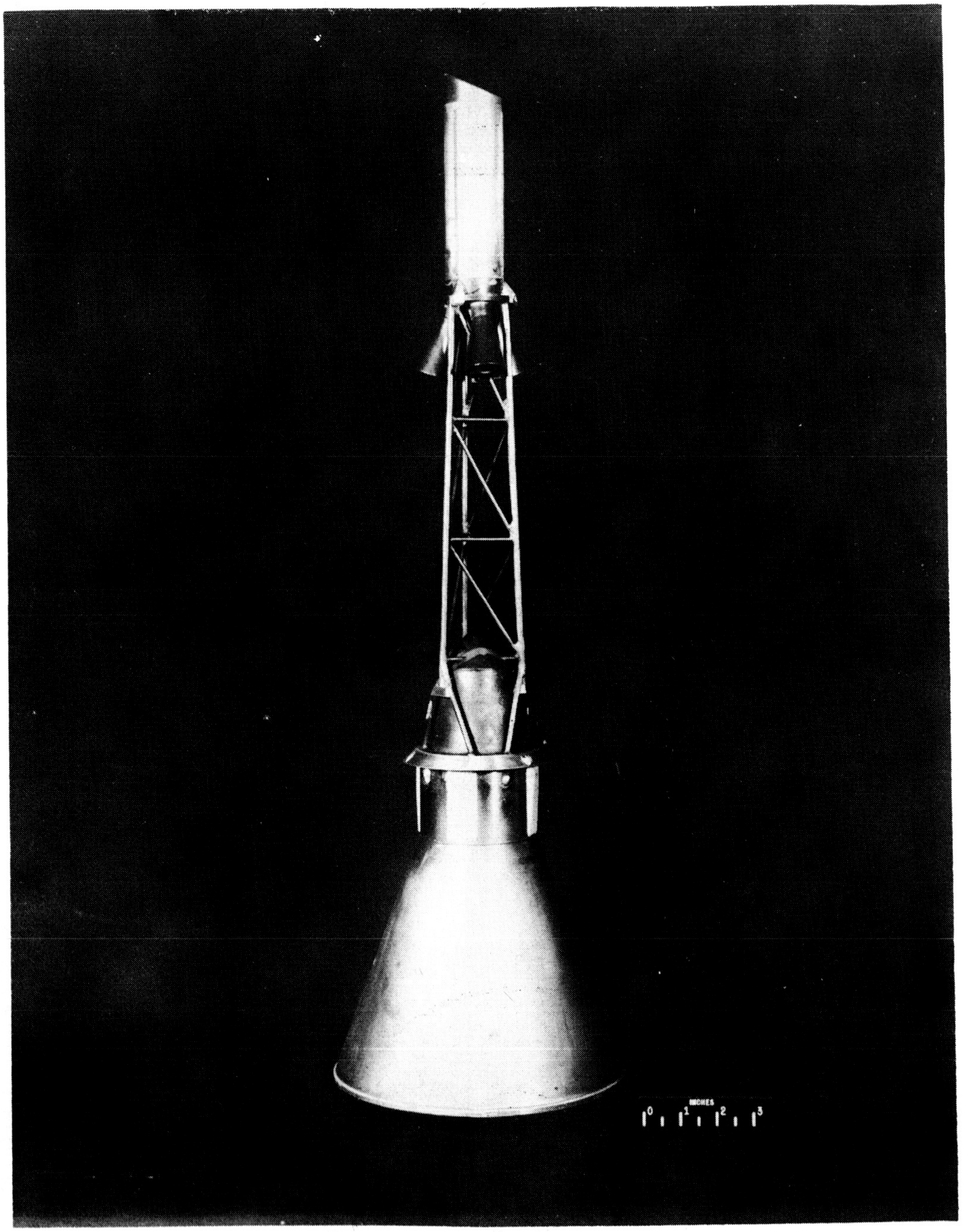

(a) Escape configuration. L-60-1874

Figure 2.- Photographs of the capsule models and escape-rocket and antenna-canister faces.

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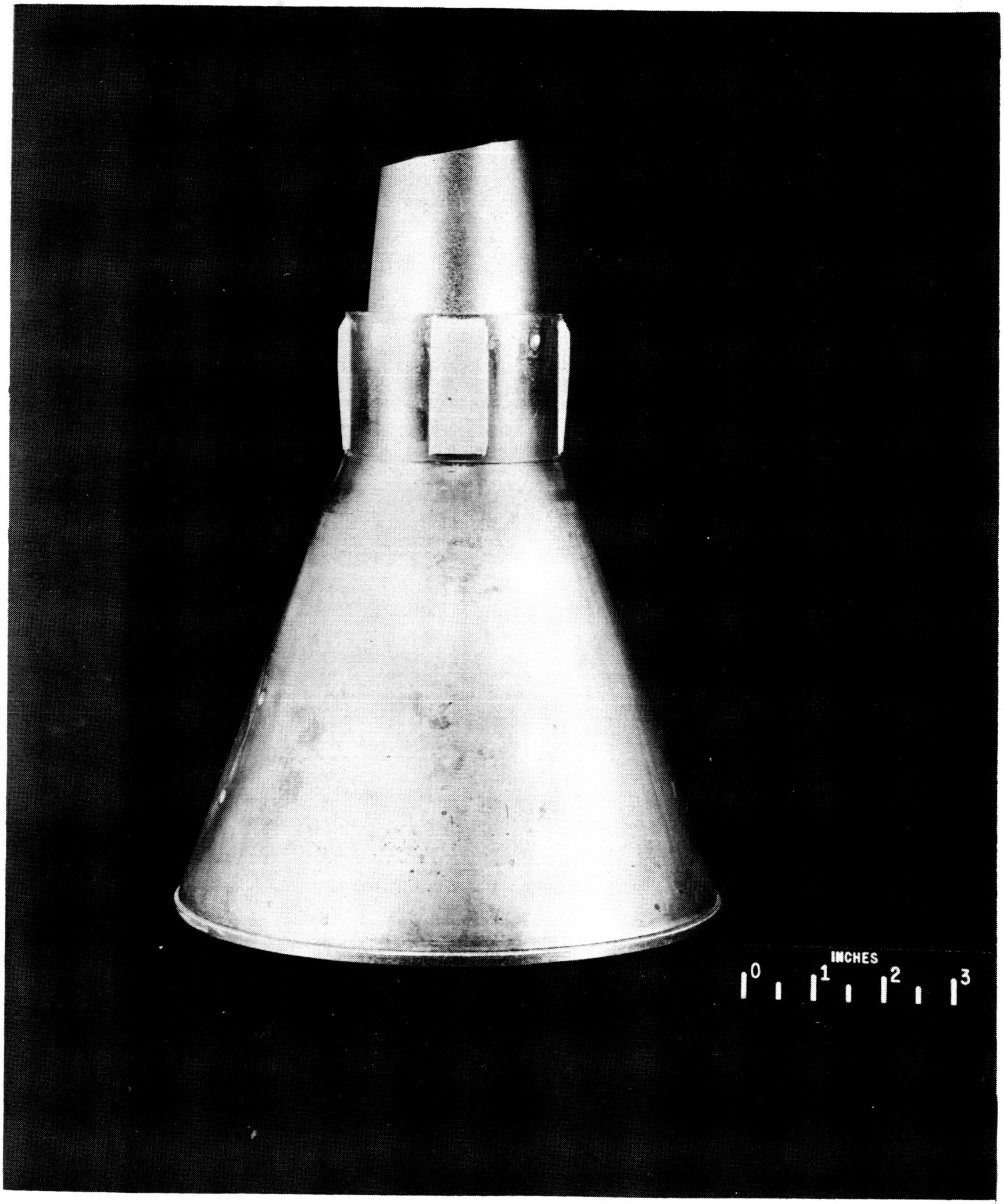

(b) Exit configuration. L-60-1877

Figure 2.- Continued.

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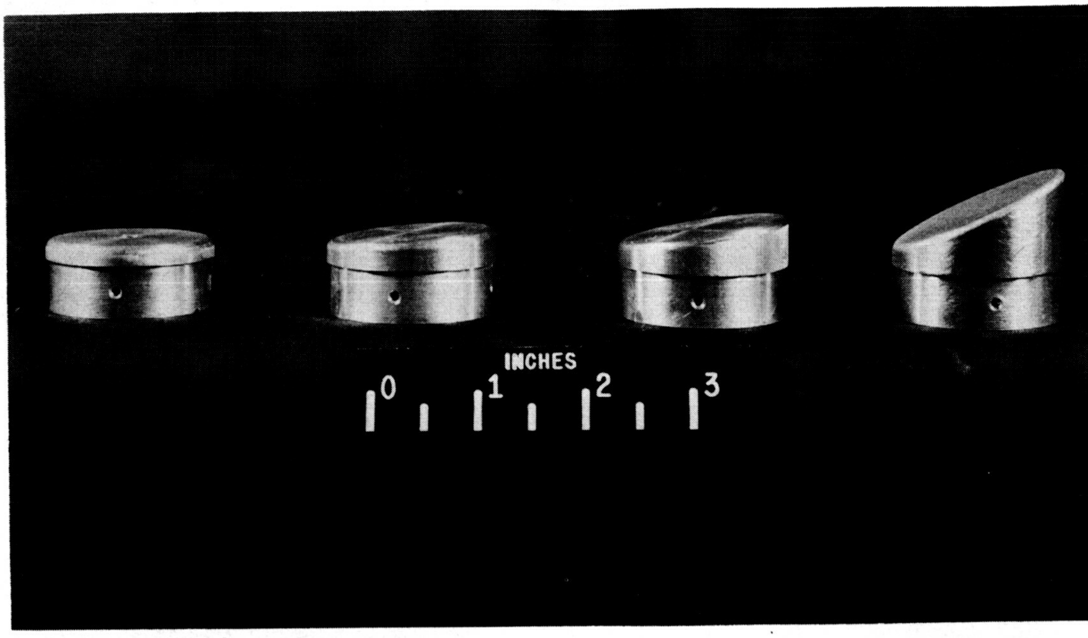
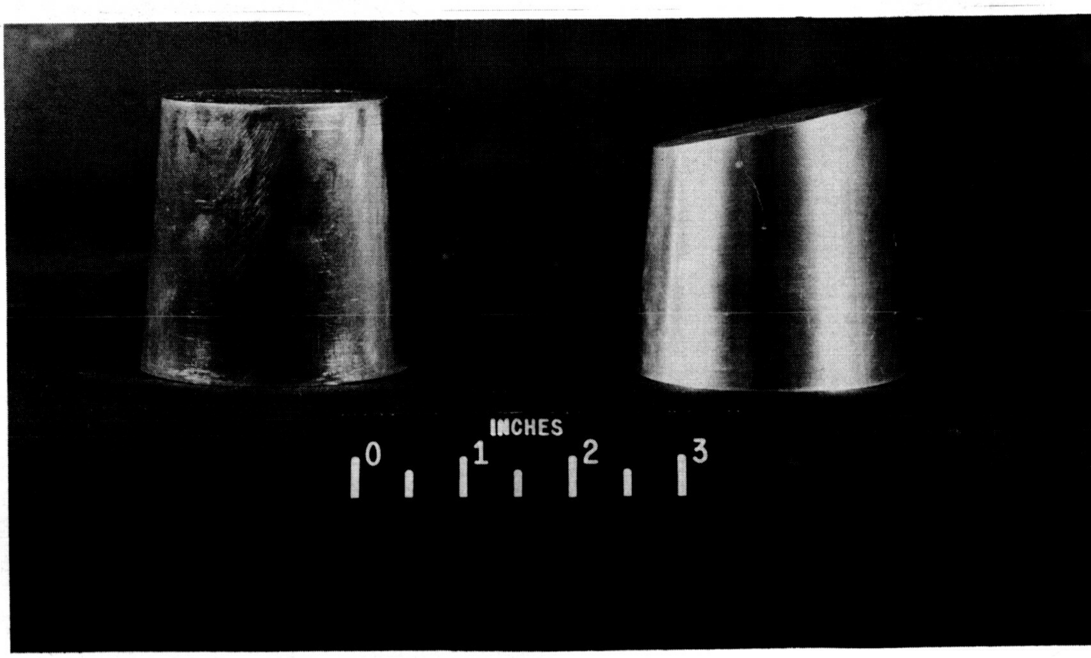


(c) Escape-rocket faces. L-60-1875



(d) Antenna-canister faces. L-60-1876

Figure 2.- Concluded.

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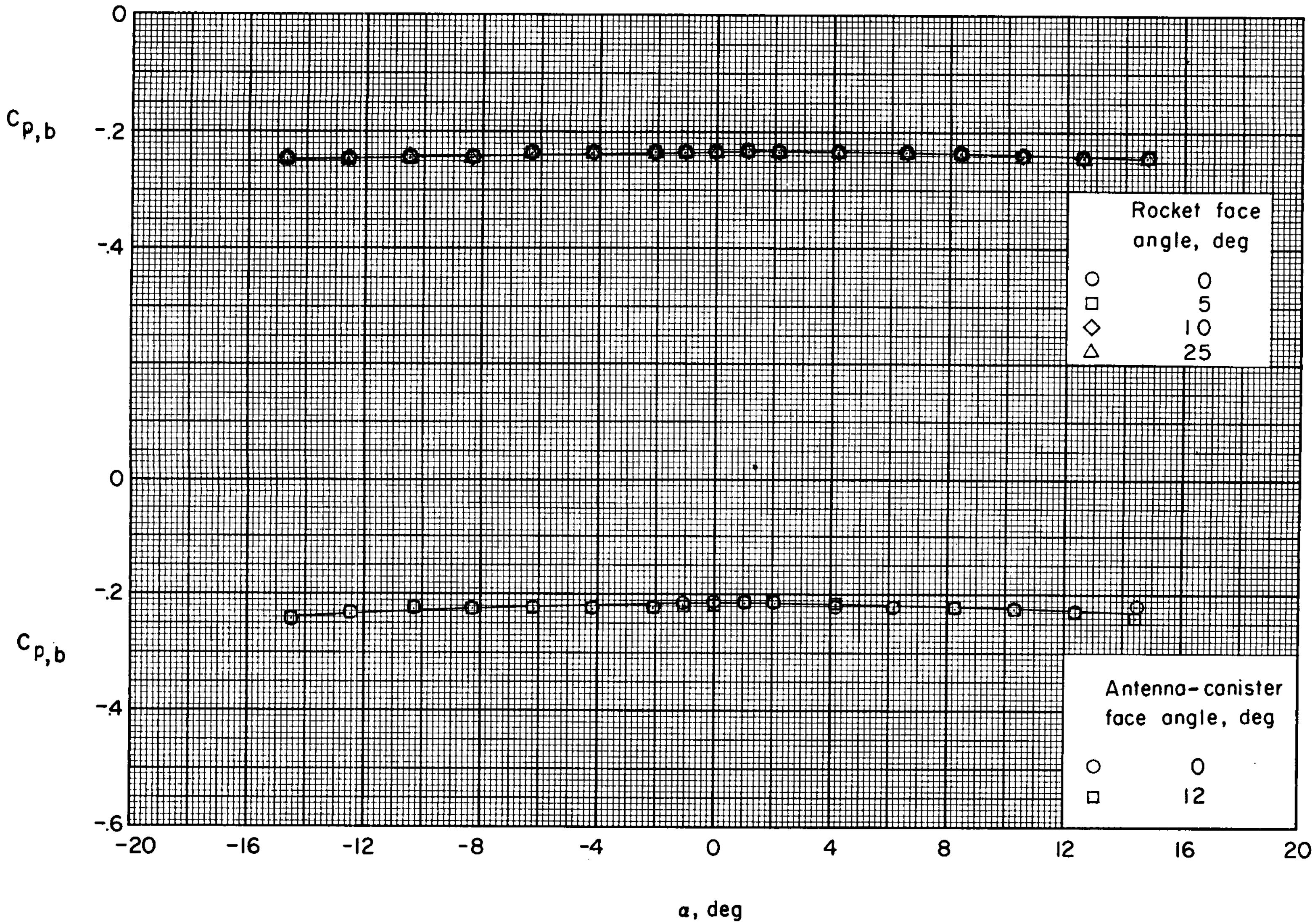

Figure 3.- Base pressure coefficients.

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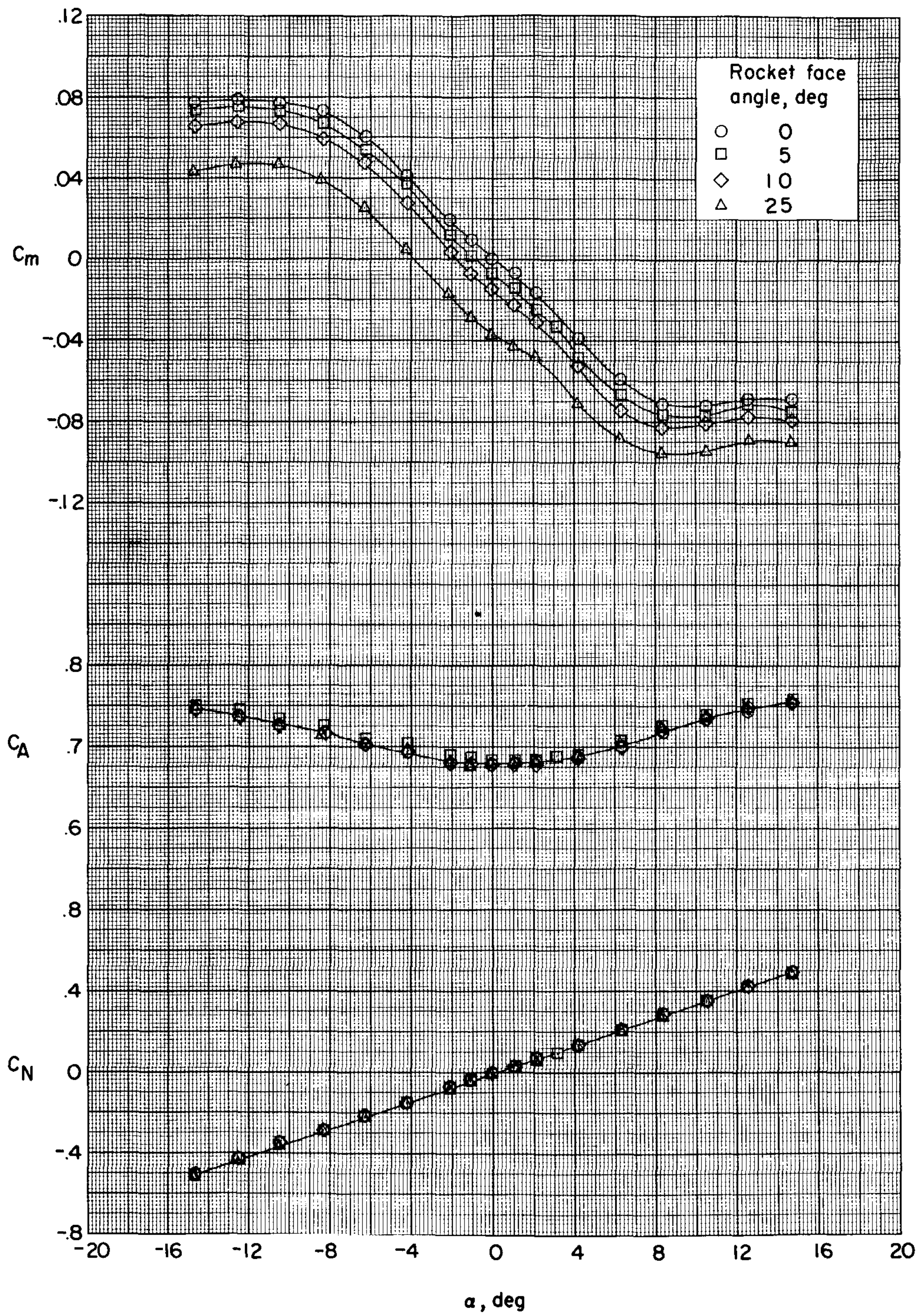

Figure 4.- Effects of escape-rocket face angle on the aerodynamic characteristics in pitch. Escape configuration.

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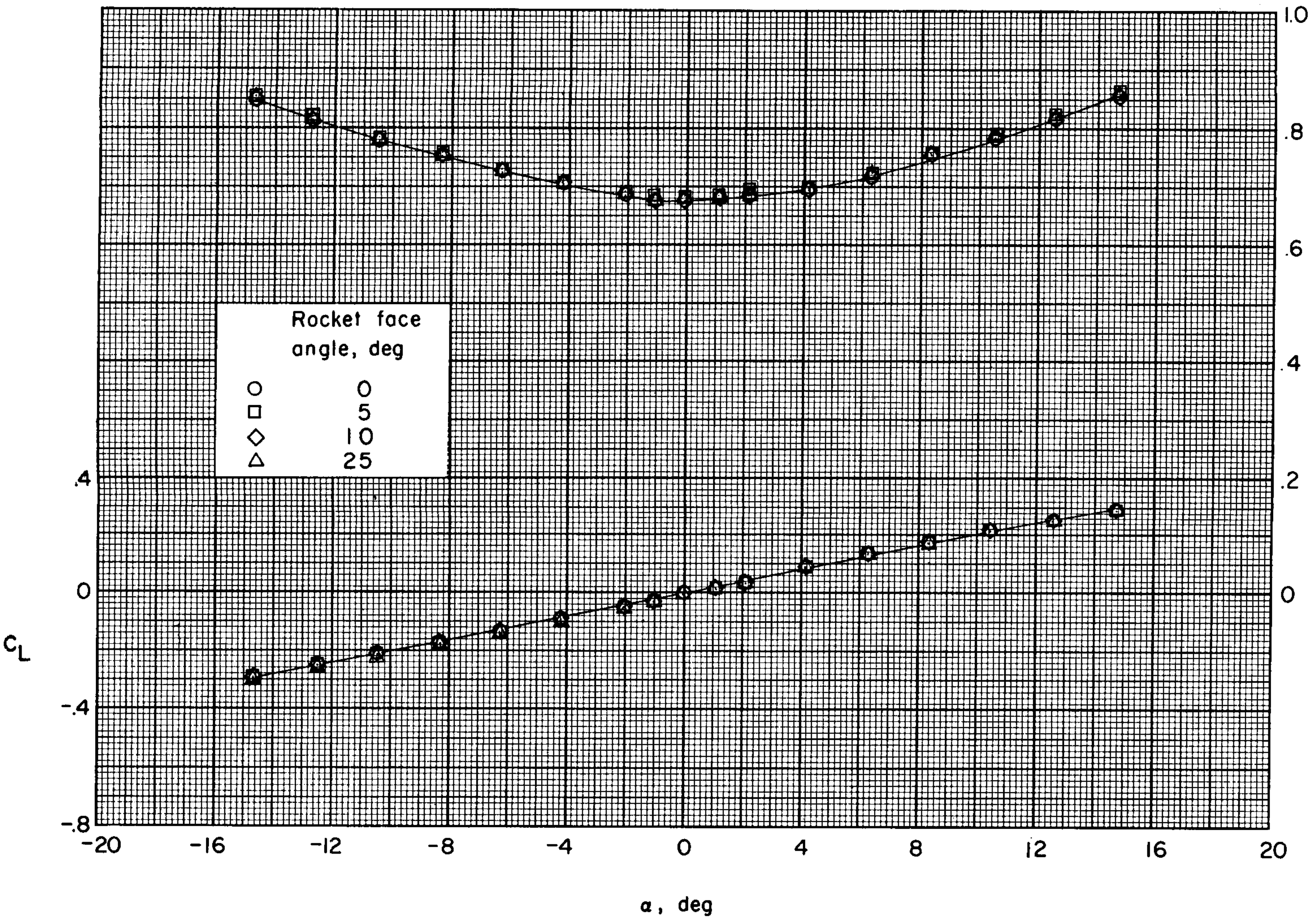

Figure 4.- Concluded.

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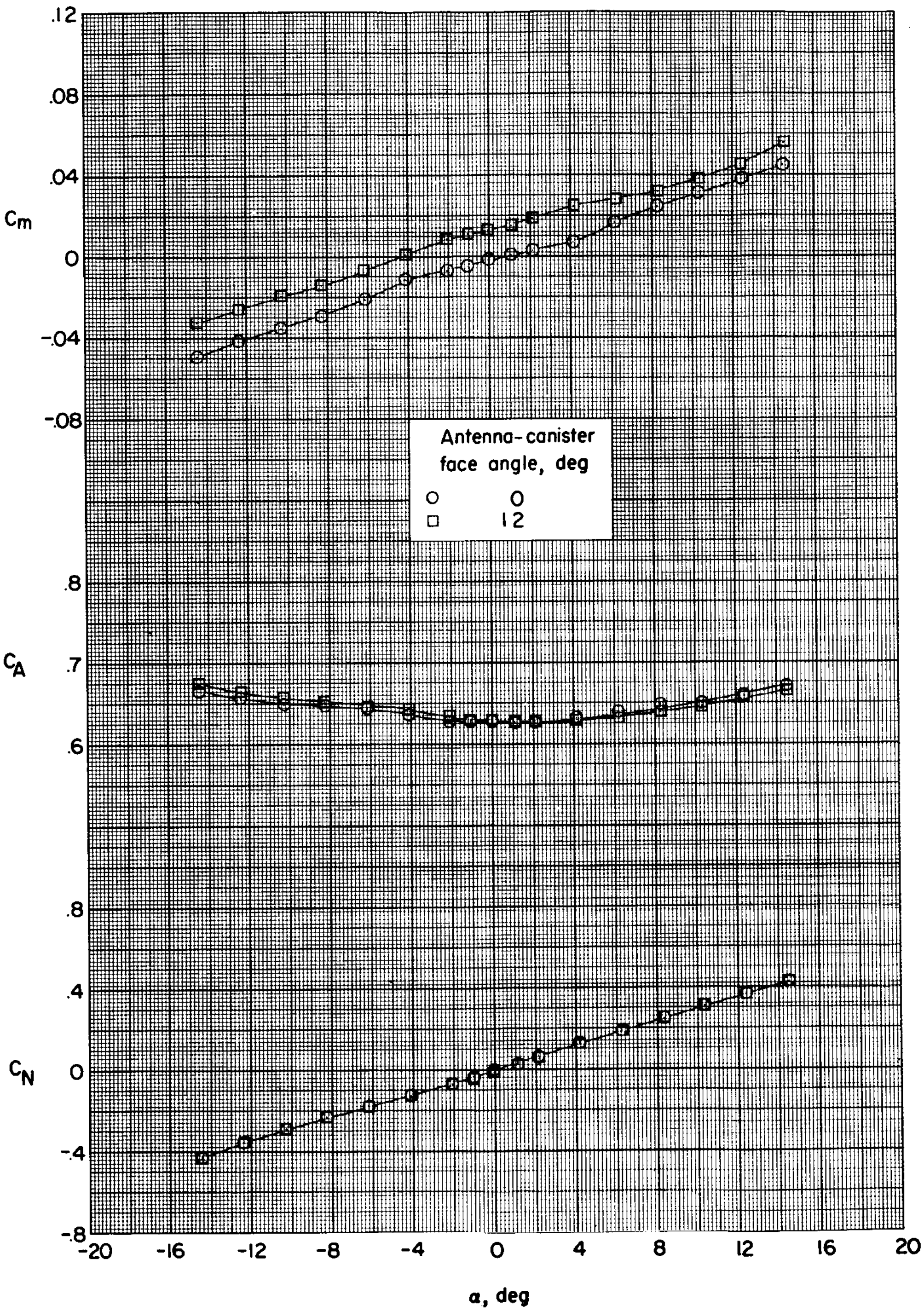

Figure 5.- Effects of antenna-canister face angle on the aerodynamic characteristics in pitch. Exit configuration.

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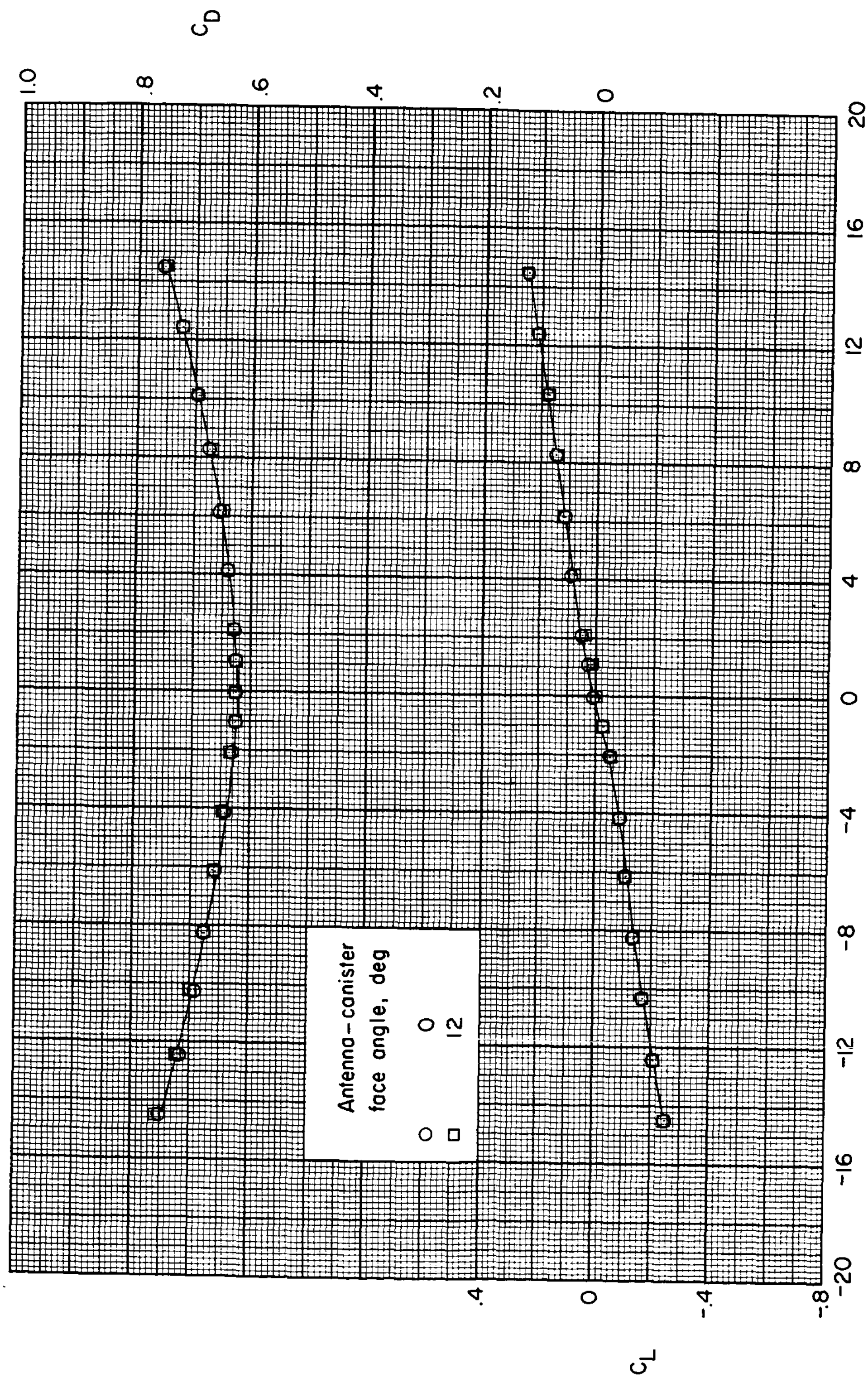

Figure 5.- Concluded.

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