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Low Speed Wind Tunnel Calibration of a New Pitot-Static Head (Mk.10) Insensitive to Incidence

by

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LOW SPEED WIND TUNNEL CALIBRATION OF A NEW PITOT-STATIC HEAD (MK.10) INSENSITIVE TO INCIDENCE

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D. G. Mabey, M.Sc.(Eng)

SUMMARY

A new pitot-static head (a Mk.10) with a static hole configuration chosen to reduce the static error due to incidence, and a Mk.9H pitot-static head were calibrated in a low speed wind tunnel.

On the Mk.10 head the static error due to incidence is virtually eliminated from -5° to $+25^{\circ}$ and the static error due to sideslip within the range of $\pm 4^{\circ}$ is not much worse than on the Mk.9H head.

Replaces R.A.E. Technical Note No. Aero 2924 - A.R.C.25,707.

CONTENTS

ILLUSTRATIONS

1 INTRODUCTION

This Note reports comparative tests in the R.A.E. Bedford 13' × 9' low speed wind tunnel of two pitot-static heads. The first was a Mk.9H head with static slots. The second was a new head, the Mk.10, with static holes positioned to give a smaller static error due to incidence than the Mk.9H head.

2 DESCRIPTION OF TESTS

Two heads were tested (Fig.1). The Mk.9H head had two rows of static slots. The Mk.10 head was identical except that the slots were replaced by two rows of holes[1,2] (Fig.2) carefully positioned to reduce the static error due to incidence*.

The parallel section of each head fitted into the model sting support used in the 13' × 9' low speed wind tunnel. This support pivots, traversing the static vents in an arc across the tunnel working-section.

The static pressures were measured against a calibrated hole in the tunnel wall by a Betz manometer. Pitot pressures were measured against tunnel settling chamber pressure on a U-tube. The tunnel speed was 202 ft/second and incidence varied from -5° to $+25^{\circ}$ at 0° and 4° sideslip. Sideslip varied from -5° to $+25^{\circ}$ at zero incidence.

3 RESULTS

Fig.3 shows the variation of static pressure coefficient with incidence (α) for both heads. The Mk.9H head has a large variation in static error which agrees with a previous calibration of a Mk.9A head**. The new head has hardly any static error from $\alpha = -5^{\circ}$ to $+25^{\circ}$; the measured pressure coefficients for both heads are compared in Table 1.

The static error due to incidence is eliminated at the expense of some increase in the static error due to sideslip (β) at angles greater than $\pm 4^{\circ}$ although the Mk.10 head is not much worse than the Mk.9H head (Fig.4). However, even at $\beta = 4^{\circ}$ there is still a negligible variation of static error with incidence (Fig.5). Since aircraft static pressure is normally only required accurately within the range

$$-5^{\circ} < \alpha < 25^{\circ}, \ -4^{\circ} < \beta < +4^{\circ}$$

the new head represents a better compromise between the errors due to incidence and sideslip than the Mk.9H head.

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* These static holes also improve the fatigue life of the heads. On the Mk.9H head the large size of the slots weaken the head and the ends of the slots act as stress raisers.

** The only aerodynamic difference between Mk.9A and Mk.9H heads is the absence of a drain hole[4] between the pitot and static tubes on the Mk.9H head.

The pitot pressures measured in both heads were similar to those of the previous calibration[3] and are not presented.

4 CONCLUSIONS

On the Mk.10 head the location of the static holes virtually eliminated the variation of static error with incidence within the range

$$-5^\circ < \alpha < +25^\circ .$$

This improvement is obtained at the expense of an increase in static error due to sideslip but the Mk.10 head is not much worse than the Mk.9H head within the range $-4^\circ < \beta < +4^\circ$. The Mk.10 head thus provides a better compromise between incidence and sideslip static errors for most aircraft.

SYMBOLS

$C_p = \frac{P_s - P}{q}$	pressure coefficient
P_s	indicated static pressure
P	reference static pressure
$q = \frac{1}{2}\rho_o V_o^2$	kinetic pressure
V_o	velocity
α	incidence
β	sideslip
ρ_o	density

suffix

o	free stream conditions

REFERENCES

No.	Author	Title, etc
1	Gracey, W.	Measurement of static pressure on aircraft. NACA TN 4184, November 1957, also NACA Report 1364, 1958.
2	Richardson, N.R. Pearson, A.O.	Wind tunnel calibrations of a combined pitot-static tube, vane type flow direction transmitter, and stagnation temperature element at Mach numbers from 0.60 to 2.87. NASA TN D-122, October 1959.
3	Nethaway, J.E.	Low speed wind tunnel calibration of a Mk.9a pitot-static head. ARC CP 244. March 1955.
4	Mabey, D.G.	The calibration at transonic speeds of a Mk.9a pitot-static head with and without flow through the static slots. ARC CP 384. March 1957.

TABLE 1

Comparison of static error (C_p) due to incidence: Mk.9H and Mk.10 heads

Incidence degrees	Mk.9H head	Mk.10 head
-5	-0.004	-0.003
0	0.000	-0.001
+5	-0.004	+0.001
+10	-0.026	+0.001
+15	-0.056	-0.001
+20	-0.082	-0.001
+25	-0.116	-0.001

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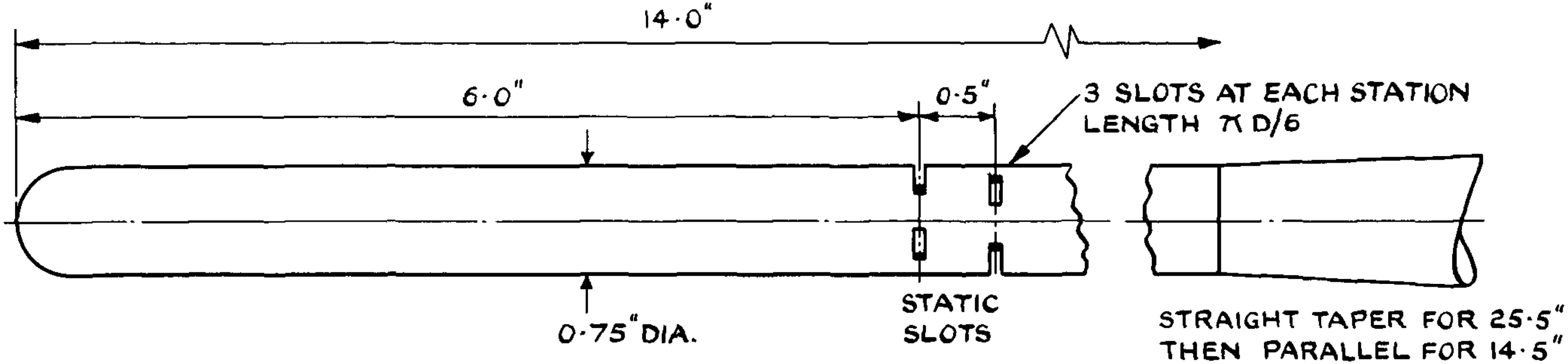
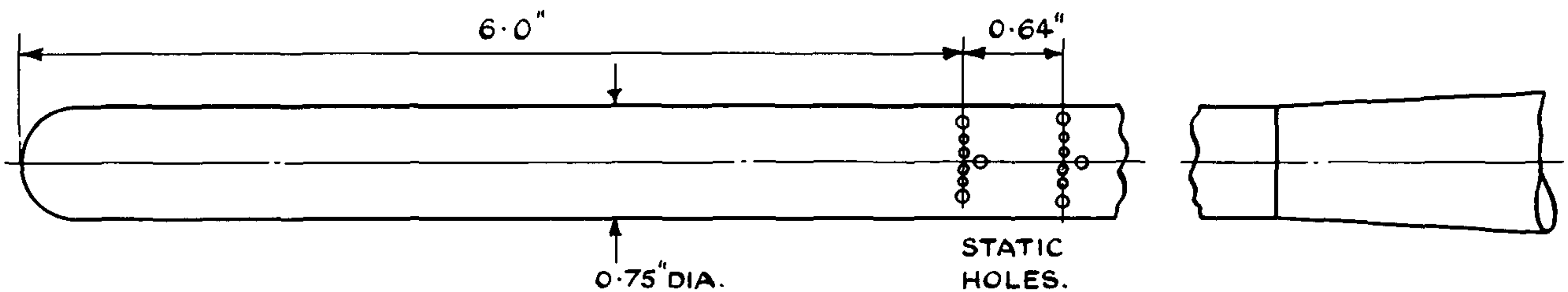


(a) MK. 9H PITOT-STATIC HEAD



(b) MK. 10 PITOT-STATIC HEAD WITH STATIC HOLES

FIG 1. G.A. OF THE TWO PITOT-STATIC HEADS TESTED.

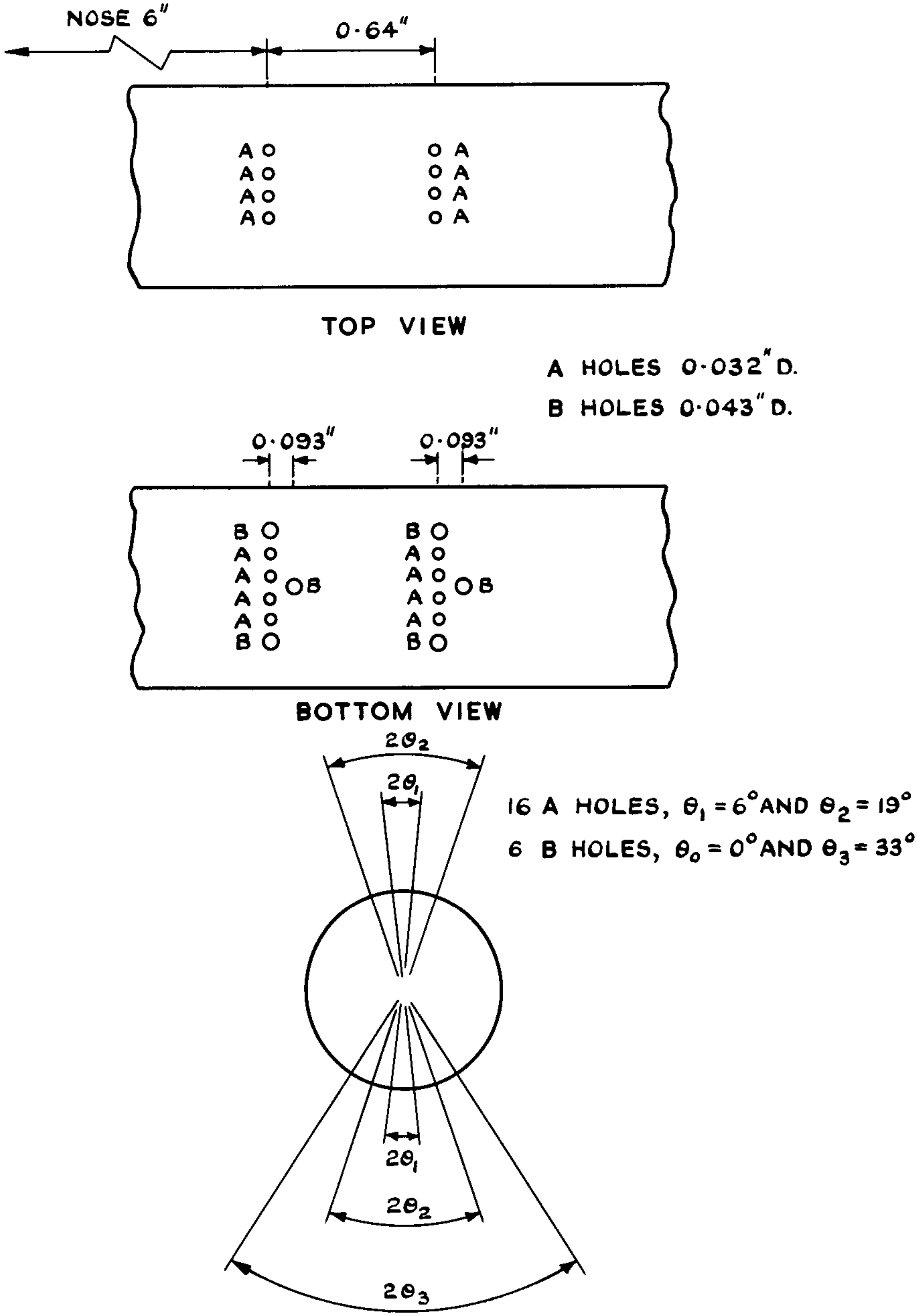


FIG. 2. POSITION OF STATIC HOLES ON MK. 10 HEAD

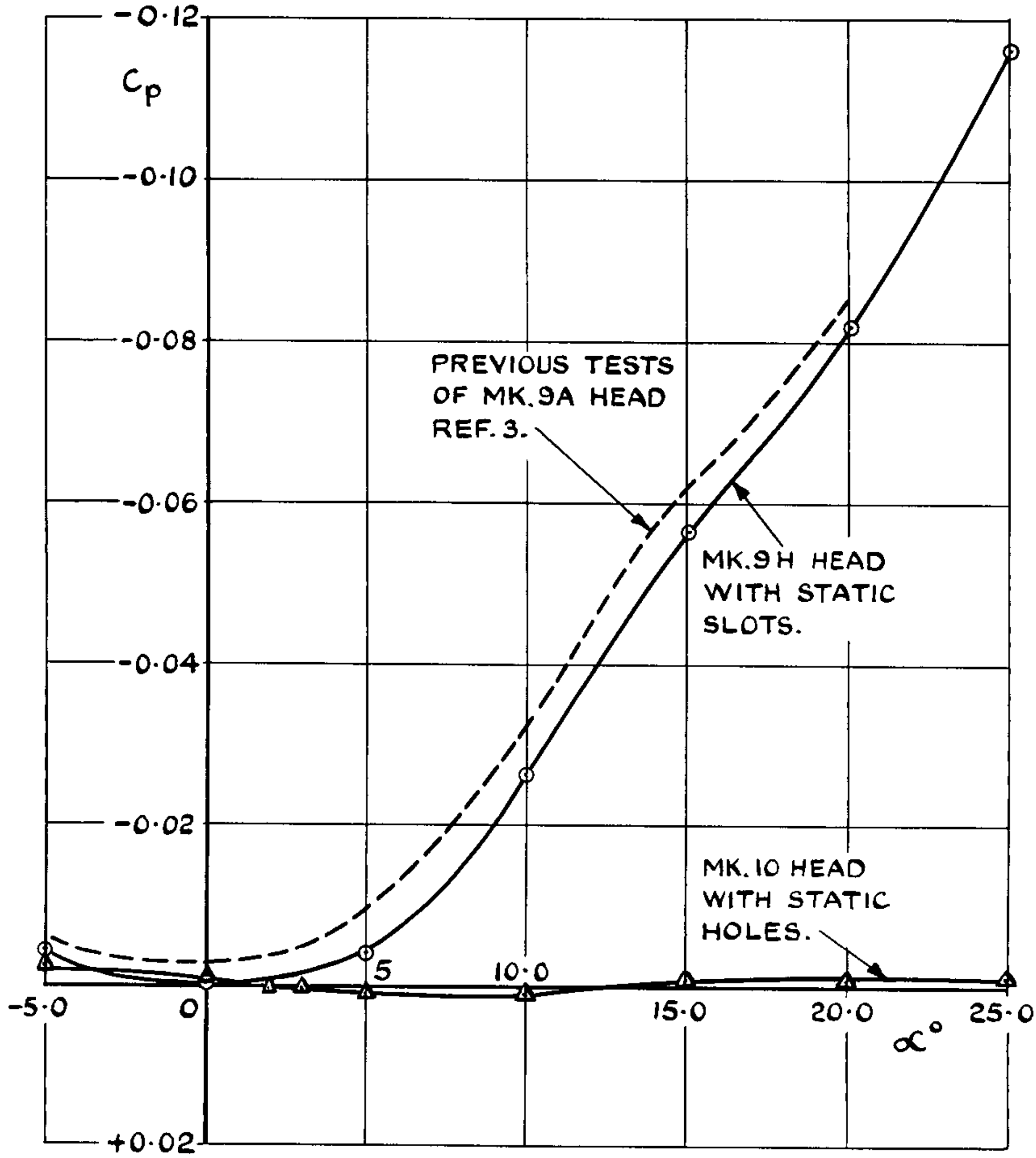


FIG. 3. COMPARISON OF PITOT - STATIC HEADS.
VARIATION OF STATIC ERROR WITH INCIDENCE. $\beta = 0°$

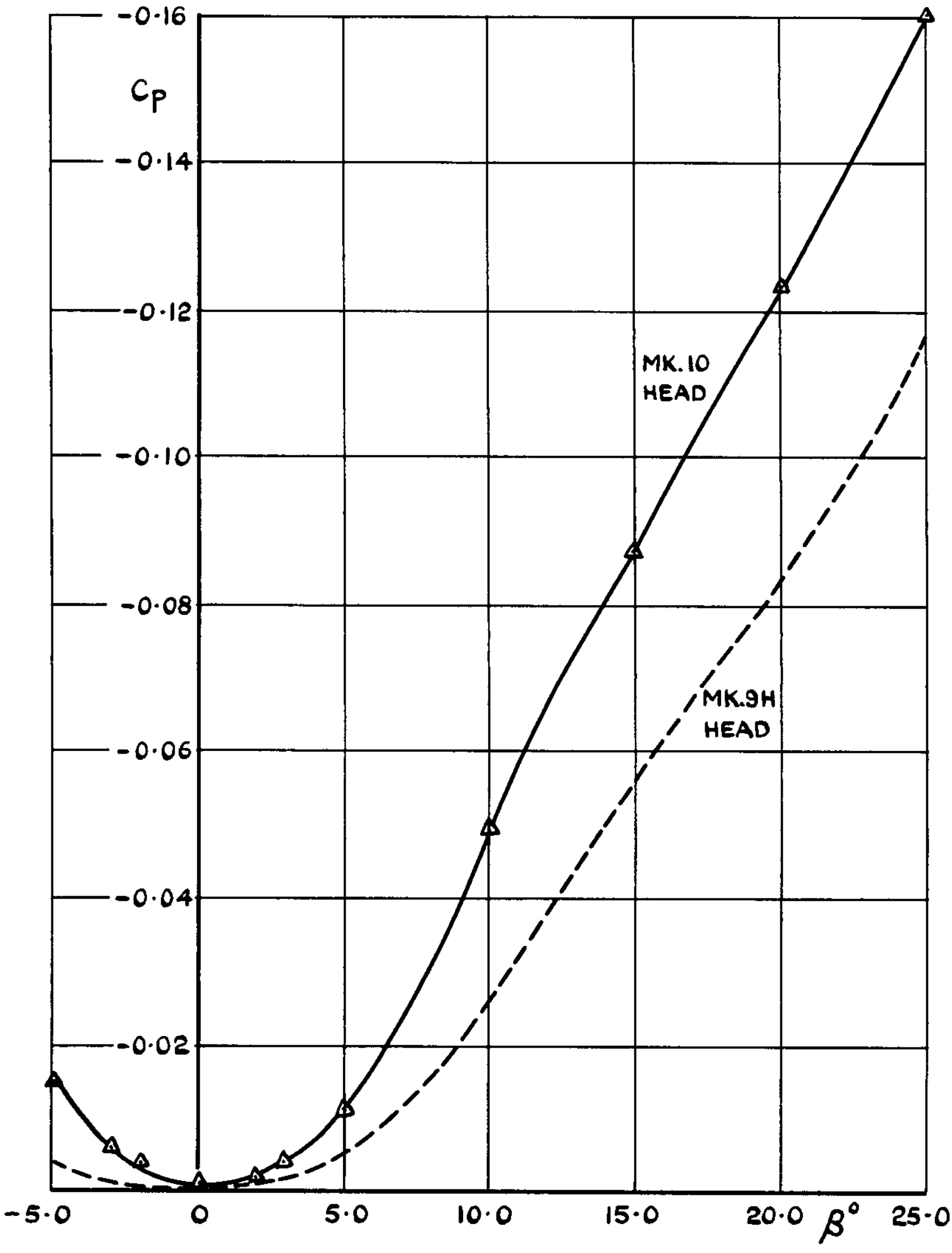


FIG. 4. COMPARISON OF PITOT-STATIC HEADS.
VARIATION OF STATIC ERROR WITH SIDESLIP. $\alpha = 0°$

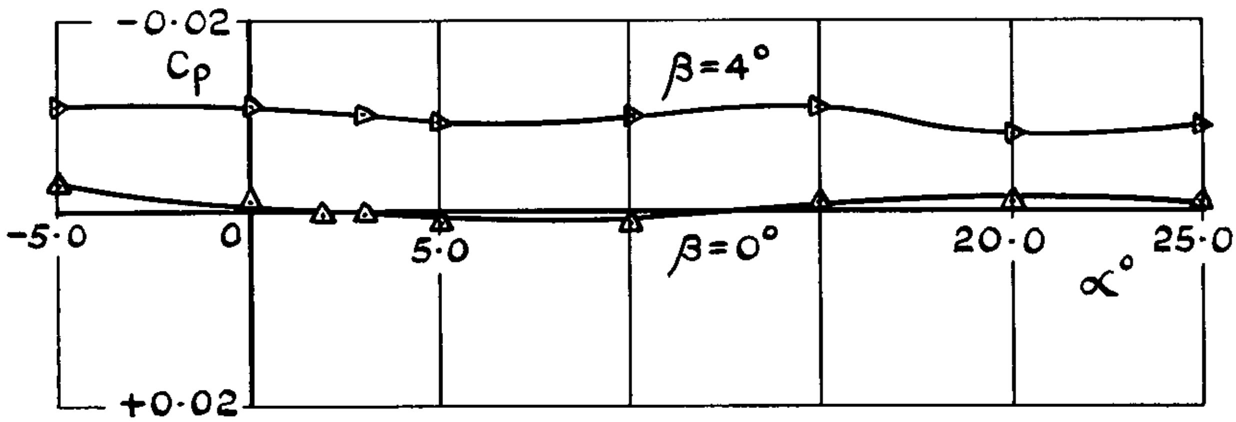


FIG. 5. VARIATION OF STATIC ERROR WITH INCIDENCE AT CONSTANT SIDESLIP MK.10 PITOT-STATIC HEAD.

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