STATIC PROBE DEVELOPMENT

FOR USE IN SUPERSONIC FLOW

H.R. GIBSON

C.A. Parsons and Co.

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STATIC PROBE DEVELOPMENT FOR USE IN SUPERSONIC FLOW

In the development of a probe suitable for measuring static pressure in a supersonic flow three designs were considered.

CYLINDRICAL STATIC PRESSURE PROBE

The probe is basically a cylinder with a rearward facing tapping in the region of separated flow behind the cylinder (Fig. 1). The axis of the probe is normal to the flow direction.

PLANO-CONVEX STATIC PRESSURE PROBE

The plano convex probe head design (Fig. 2a) has a single pressure tapping at the centre of the plane face.

The first stem design (Fig. 2b) was modified to Fig. 2c after calibrations had been impaired by stem distortions in the flow.

BI-CONVEX STATIC PRESSURE PROBE

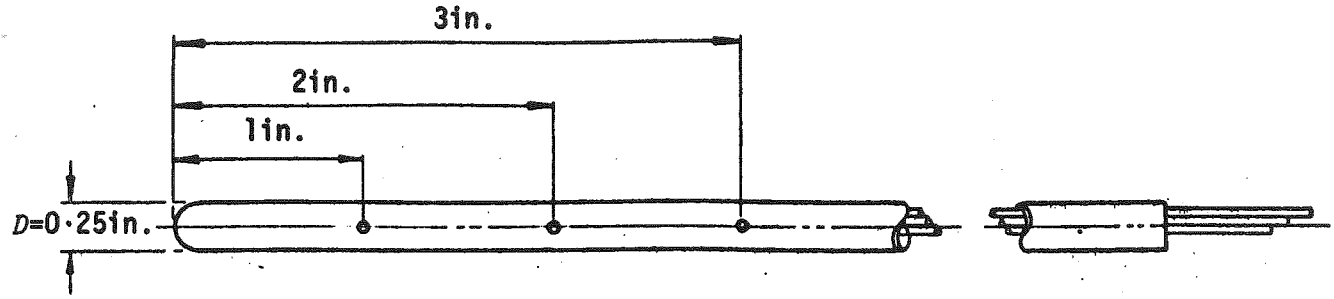
The bi-convex probe head design (Fig. 3a) has a pressure tapping in each face, interconnected to give an average pressure measurement. Like the plano-convex probe the stem design was modified (Figs. 3b and 3c). At a later stage the diameter of the head was reduced from 0.5in. to 0.25in.

Calibration curves (at a nominal Mach number of 1.4) giving the variation of calibration factor with yaw and pitch angle are shown in Figs. 4, 5 and 6.

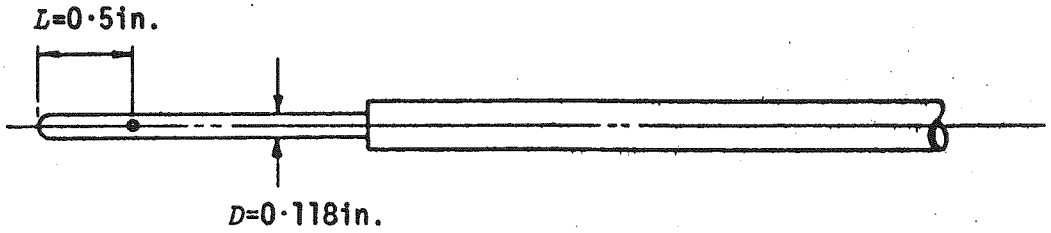
Fig. 5 shows that the plano-convex probe is insensitive to yaw angle but is sensitive to pitch angle over the small range investigated. At zero pitch an accuracy to within $\pm 1\%$ of the true static pressure could be obtained. For use downstream of a two-dimensional cascade, however, a cumulative pitch variation of 1° due, say, to setting errors increases the measuring error to $\pm 5\%$ (see Fig. 7 for $C = .01$ and $\Delta C = \pm .05$).

Fig. 4a shows that the tapping position has a small influence in the calibration of the cylindrical probe. A full calibration at a nominal Mach number of 1.4 is given in Fig. 4b and demonstrates insensitivity to yaw angle and a small degree of sensitivity to pitch. Although a calibration factor of -0.70 is a disadvantage (Fig. 7), relative insensitivity to pitch and yaw angle does allow an accuracy to within ±2% of the true static pressure.

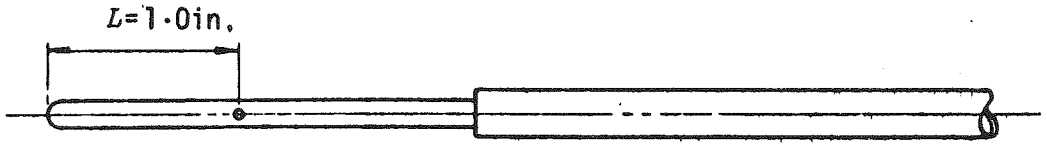
Fig. 5 shows that the calibration of the bi-convex probe is encouraging. Although the mean value of the calibration factor is about -0.195 compared to 0.01 for the plano-convex probe at Mn = 1.4, reference to Fig. 7 shows that this is not a serious disadvantage. The probe's relative insensitivity to yaw angle and small sensitivity to pitch, indicates that providing the pitch errors in the cascade tunnel are kept $< 2^{\circ}$, the true static pressure can be determined from measurement to within ±2%. Further tests were made on this probe and Fig. 8 shows the variation of calibration factor with Mach number and Fig. 9 shows the influence of Reynolds number in the range of interest.



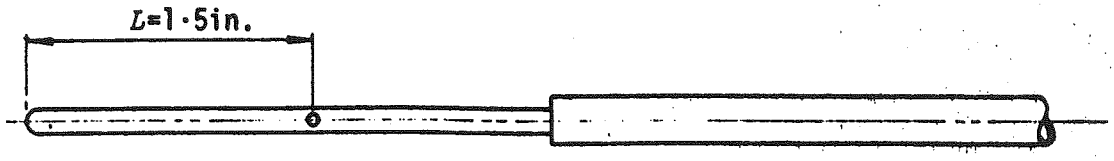
(a) FIRST DESIGN



(b) SECOND DESIGN (L/D = 4·25)



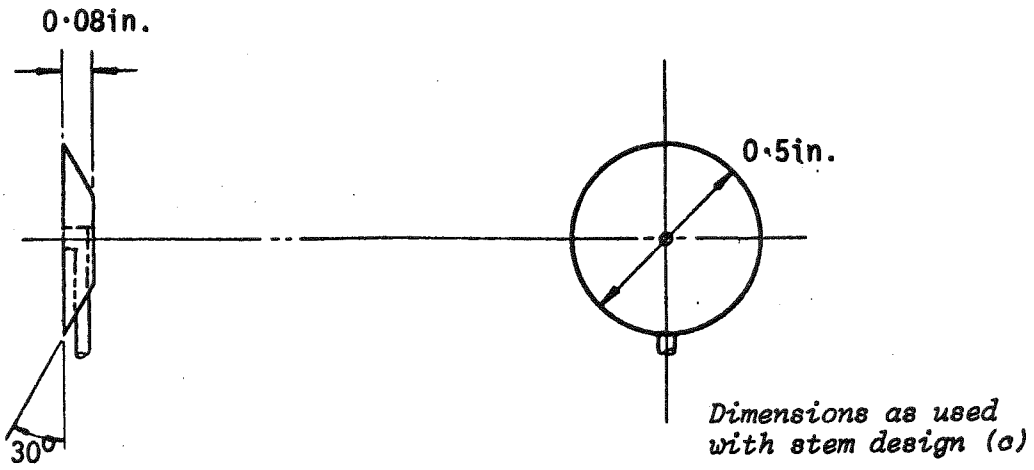
(c) SECOND DESIGN (L/D = 8·5)



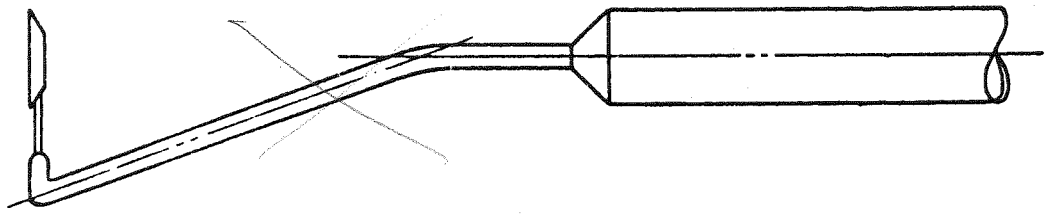
(d) SECOND DESIGN (L/D = 12·75)

CYLINDRICAL STATIC PRESSURE PROBES
(NOT TO SCALE)

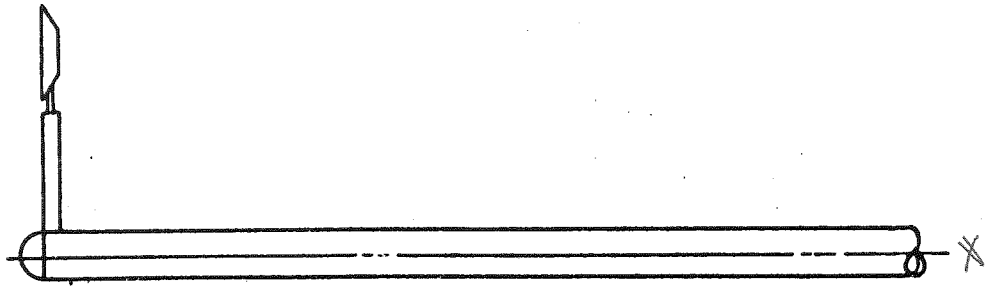
FIG. 1



(a) PROBE HEAD DESIGN



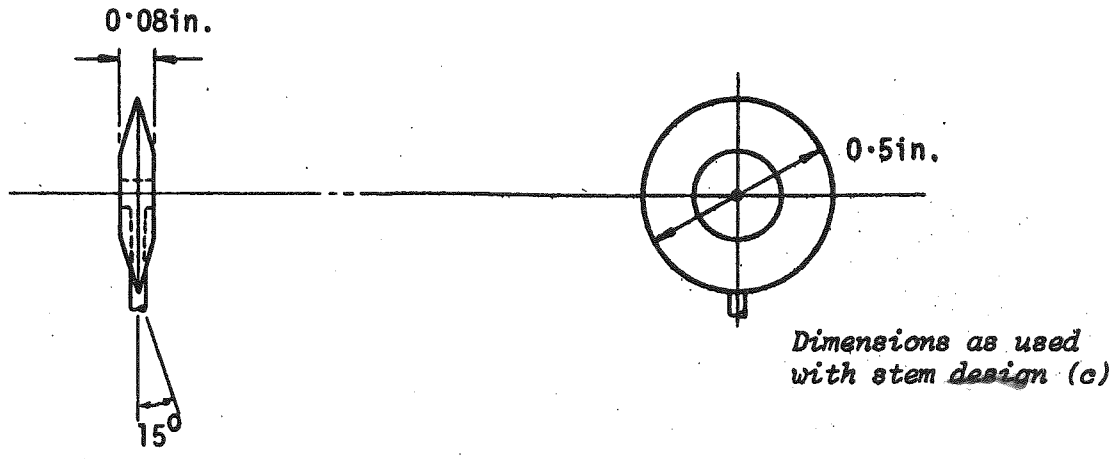
(b) FIRST STEM DESIGN



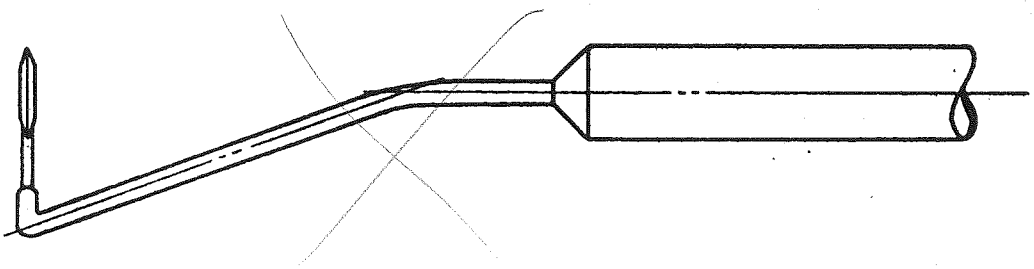
(c) SECOND STEM DESIGN

PLANO-CONVEX STATIC PRESSURE PROBE
(NOT TO SCALE)

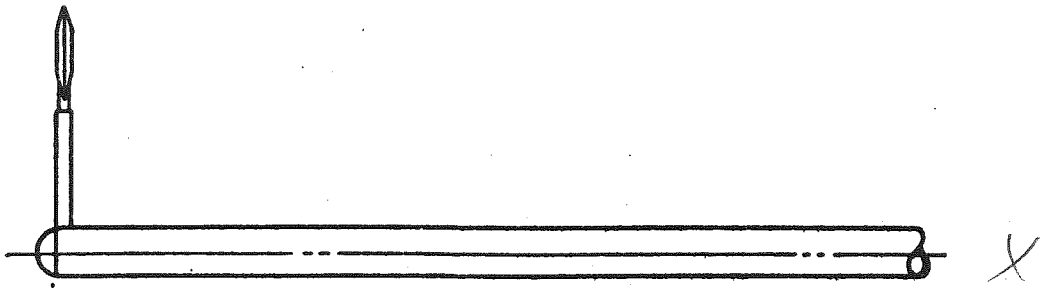
FIG. 2



(a) PROBE HEAD DESIGN



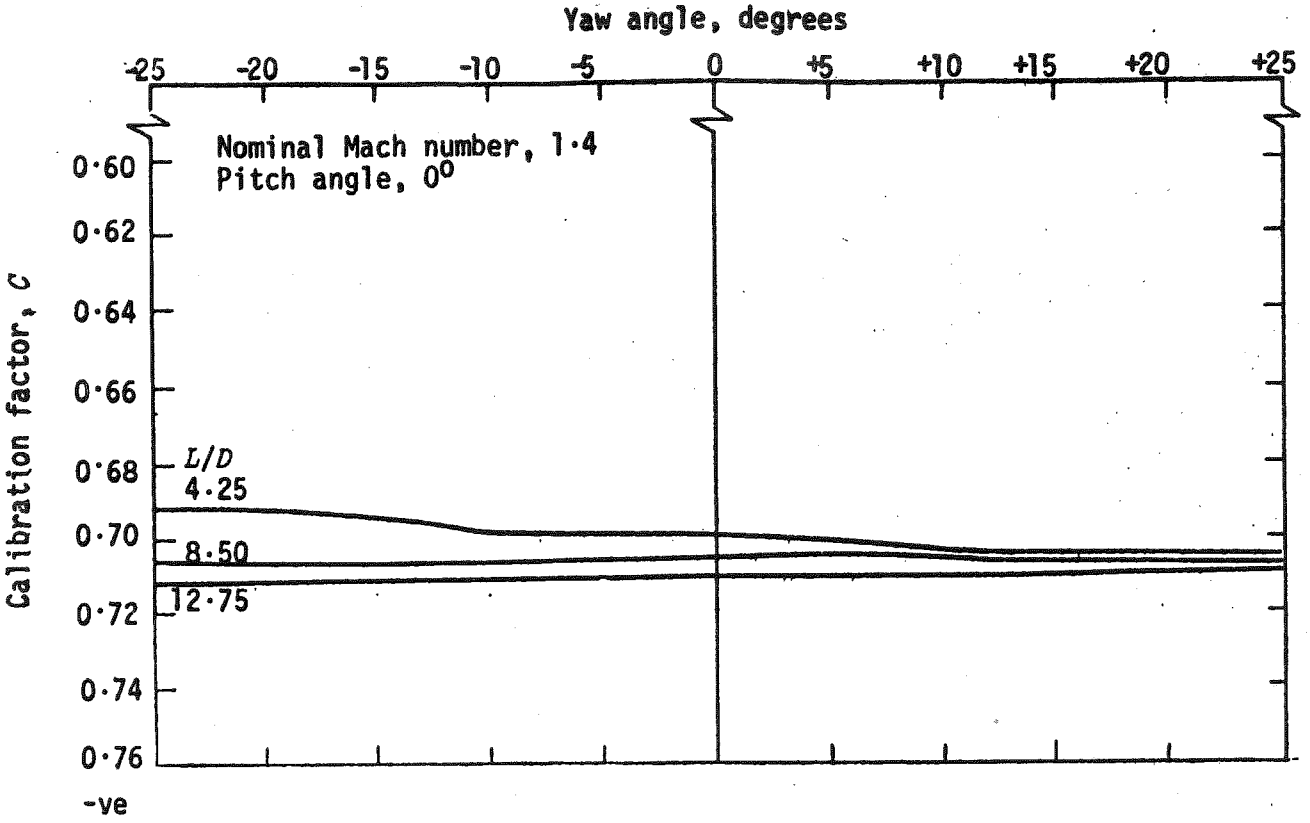
(b) FIRST STEM DESIGN



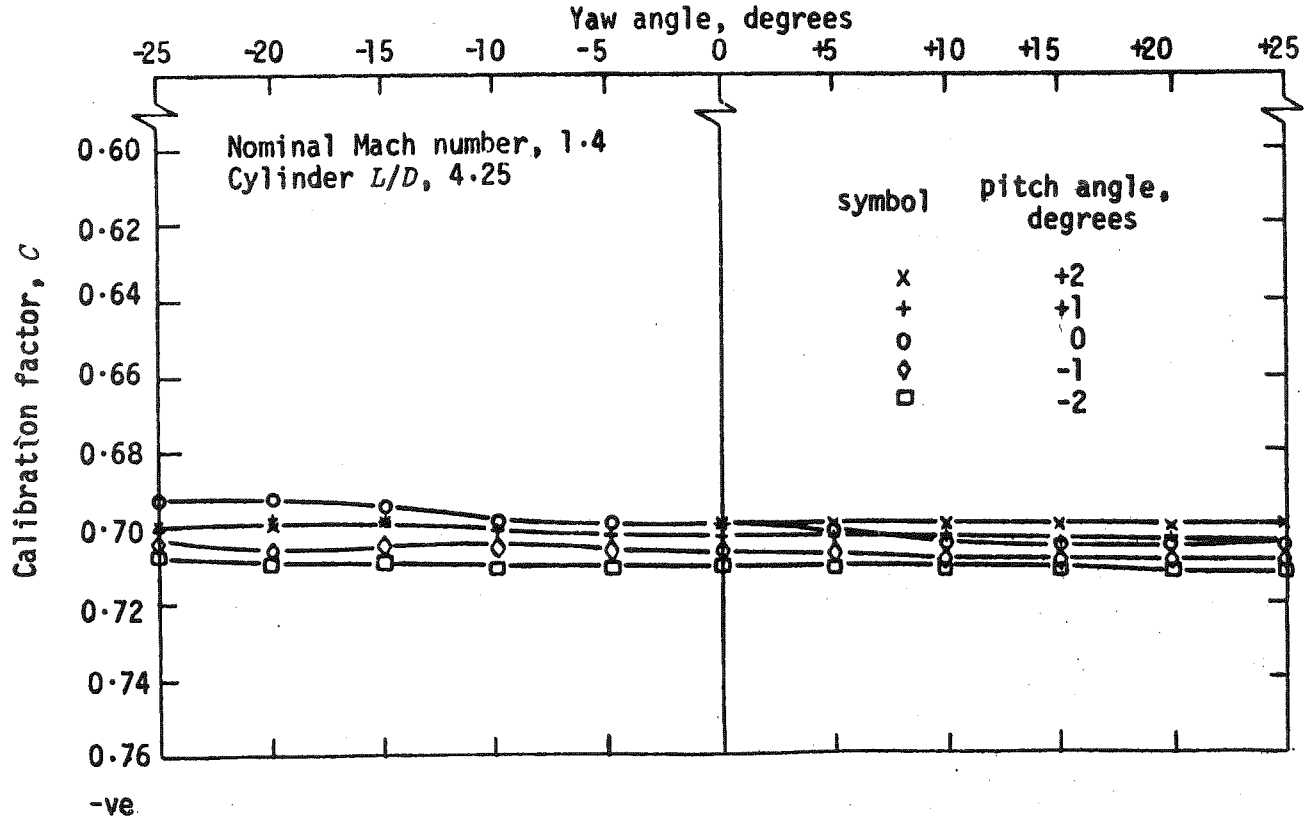
(c) SECOND STEM DESIGN

BI-CONVEX STATIC PRESSURE PROBE
(NOT TO SCALE)

FIG. 3



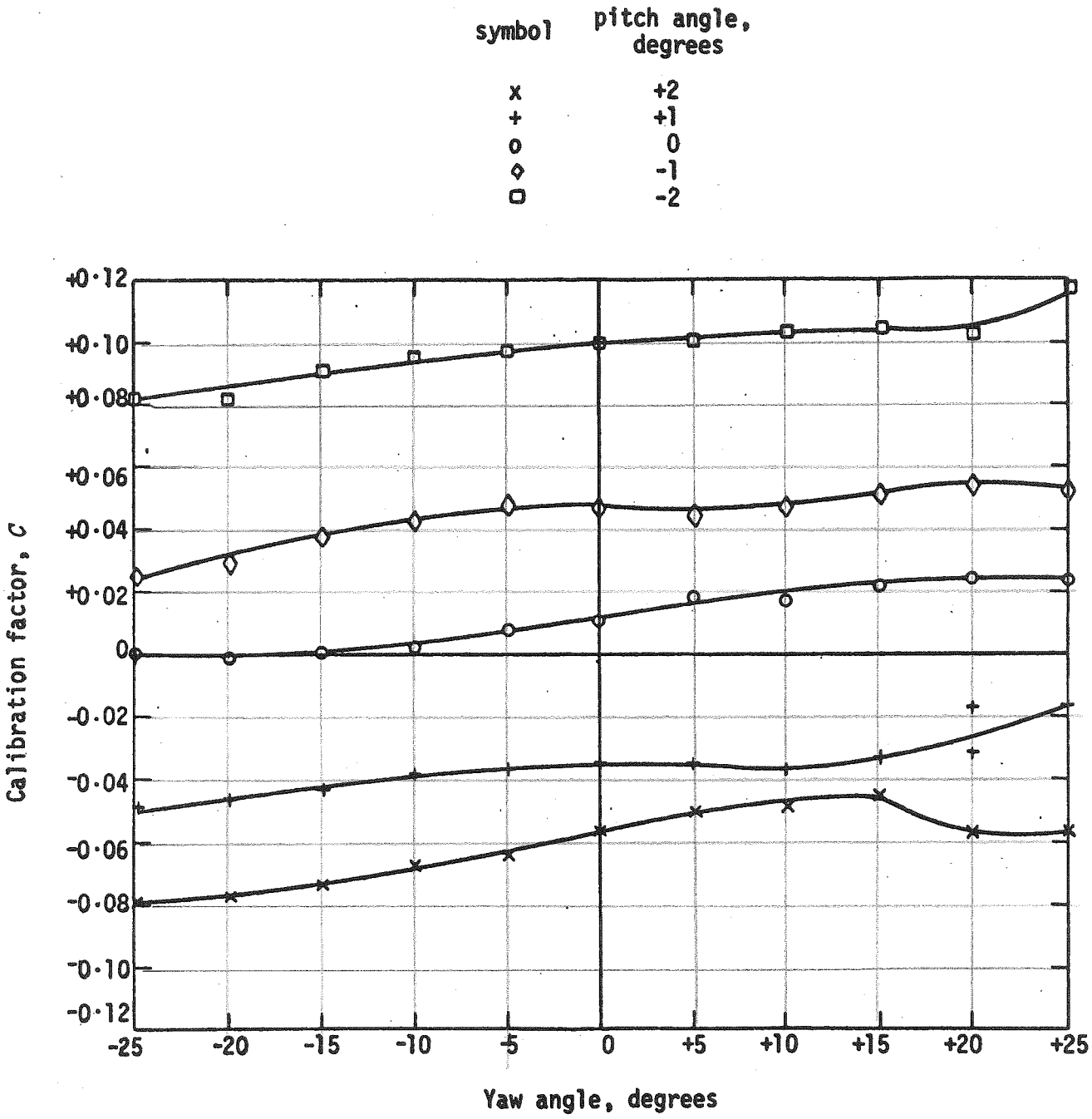
(a) INFLUENCE OF TAPPING POSITION



(b) INFLUENCE OF PITCH AND YAW ANGLES

CYLINDRICAL STATIC PRESSURE PROBE CALIBRATIONS

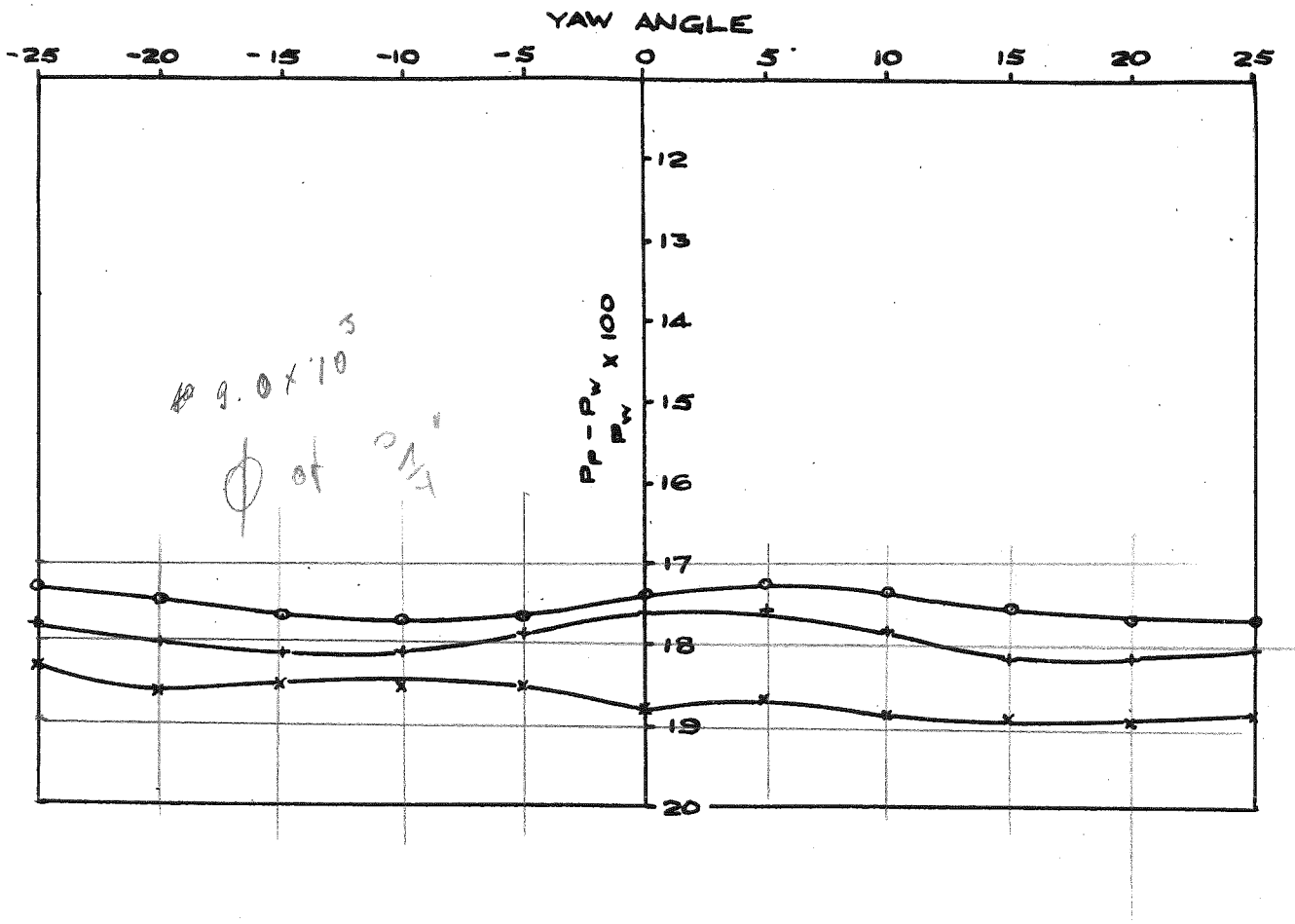
FIG. 4

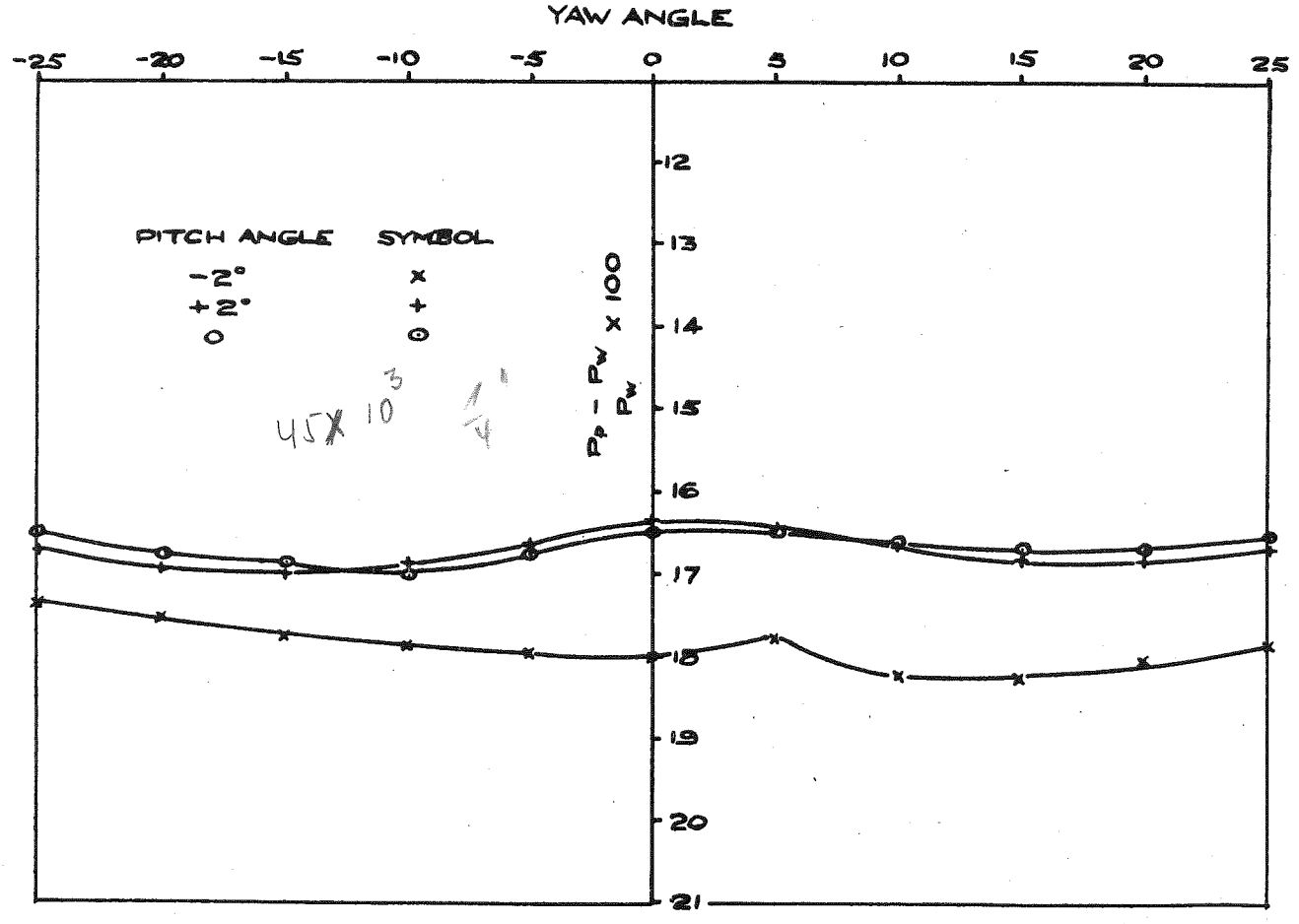


PLANO-CONVEX PRESSURE PROBE CALIBRATION

(M_n = 1·4 NOMINAL)

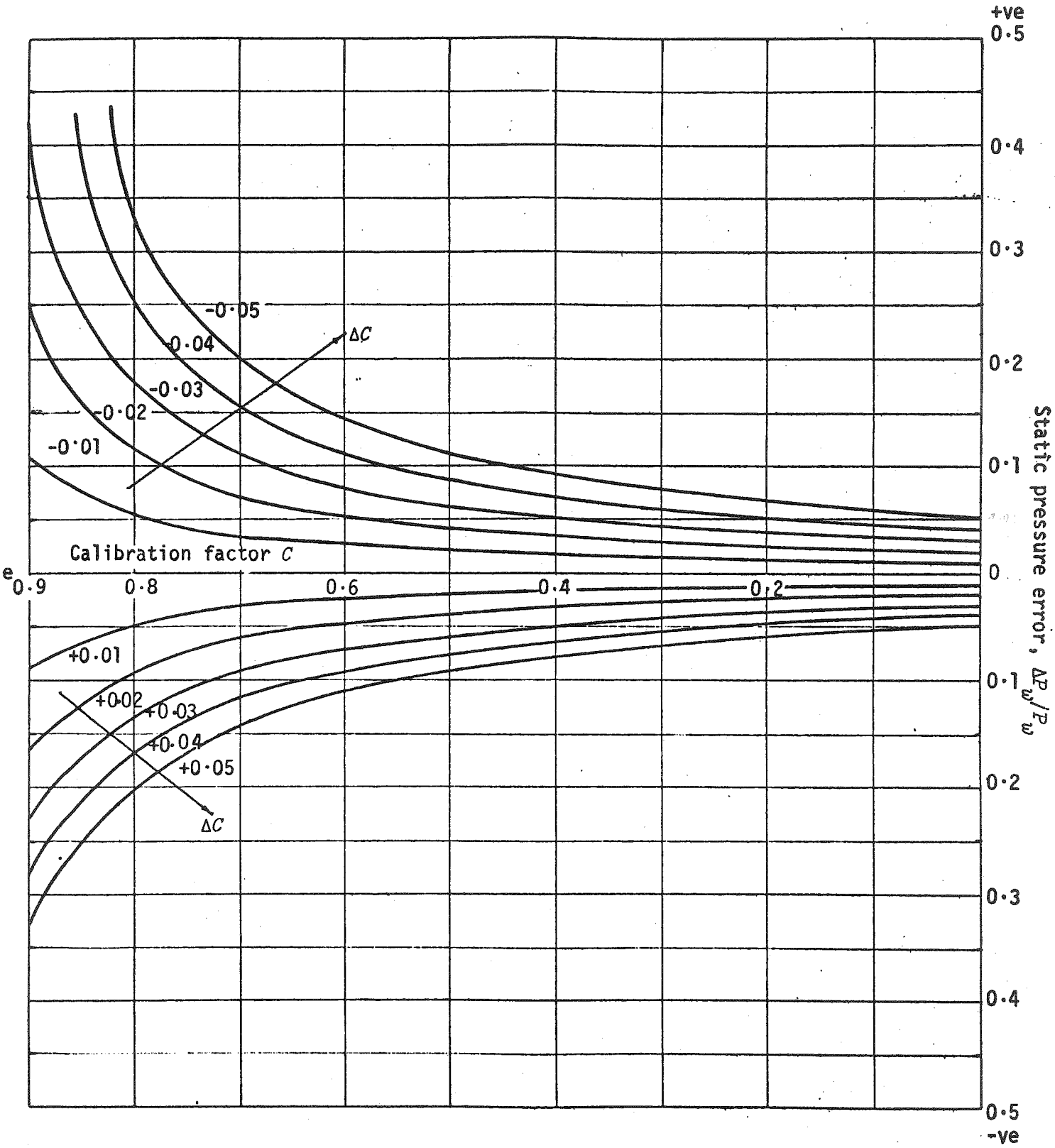
FIG. 5





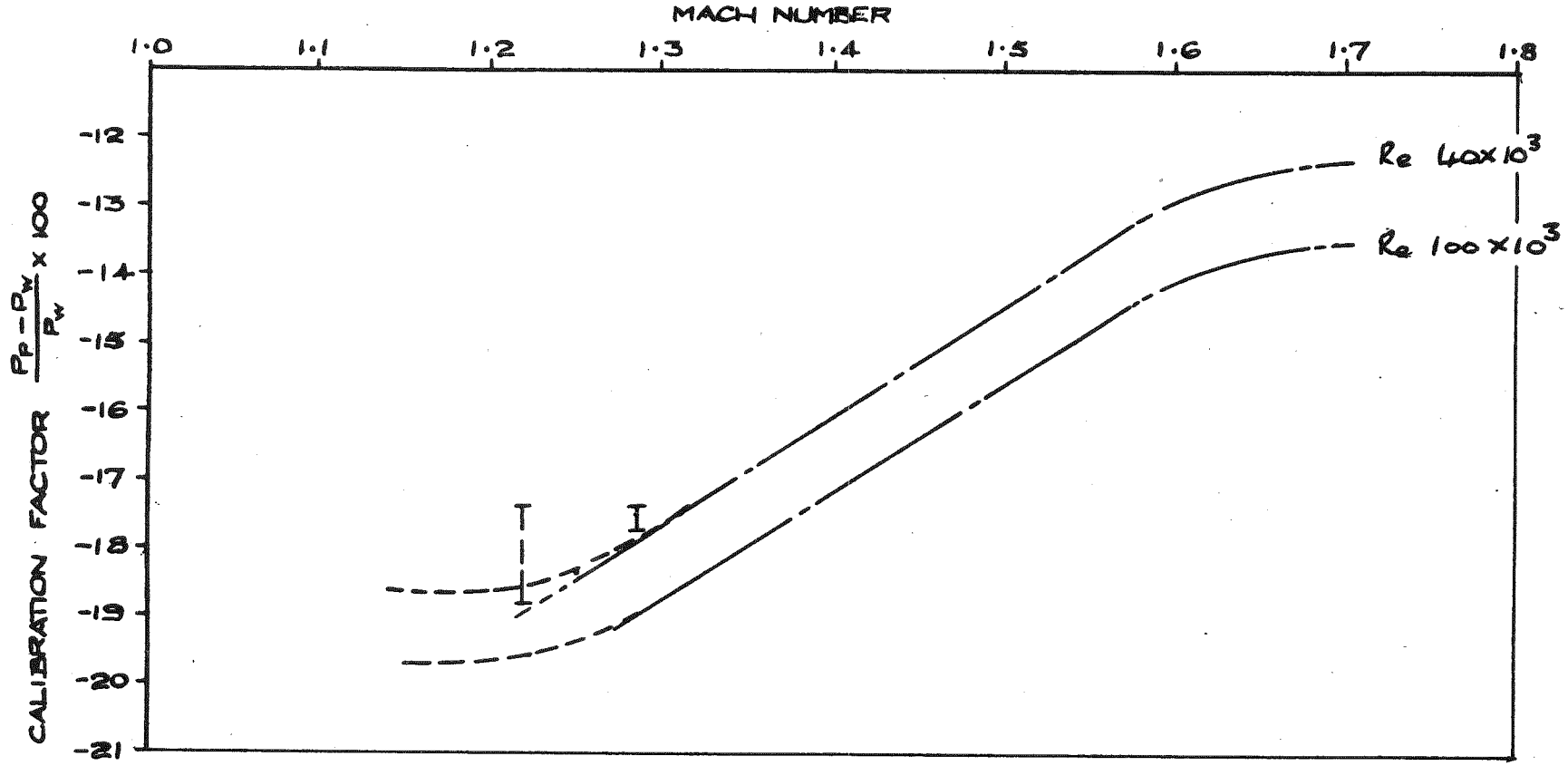
CALIBRATION OF BI-CONVEX STATIC PRESSURE PROBE (NOMINAL $M_N = 1.4$)

FIG 6



STATIC PRESSURE ERRORS RESULTING FROM ERRORS IN CALIBRATION FACTOR C

FIG. 7



BI-CONVEX STATIC PRESSURE PROBE

ZERO PITCH FLOW

FIG 8

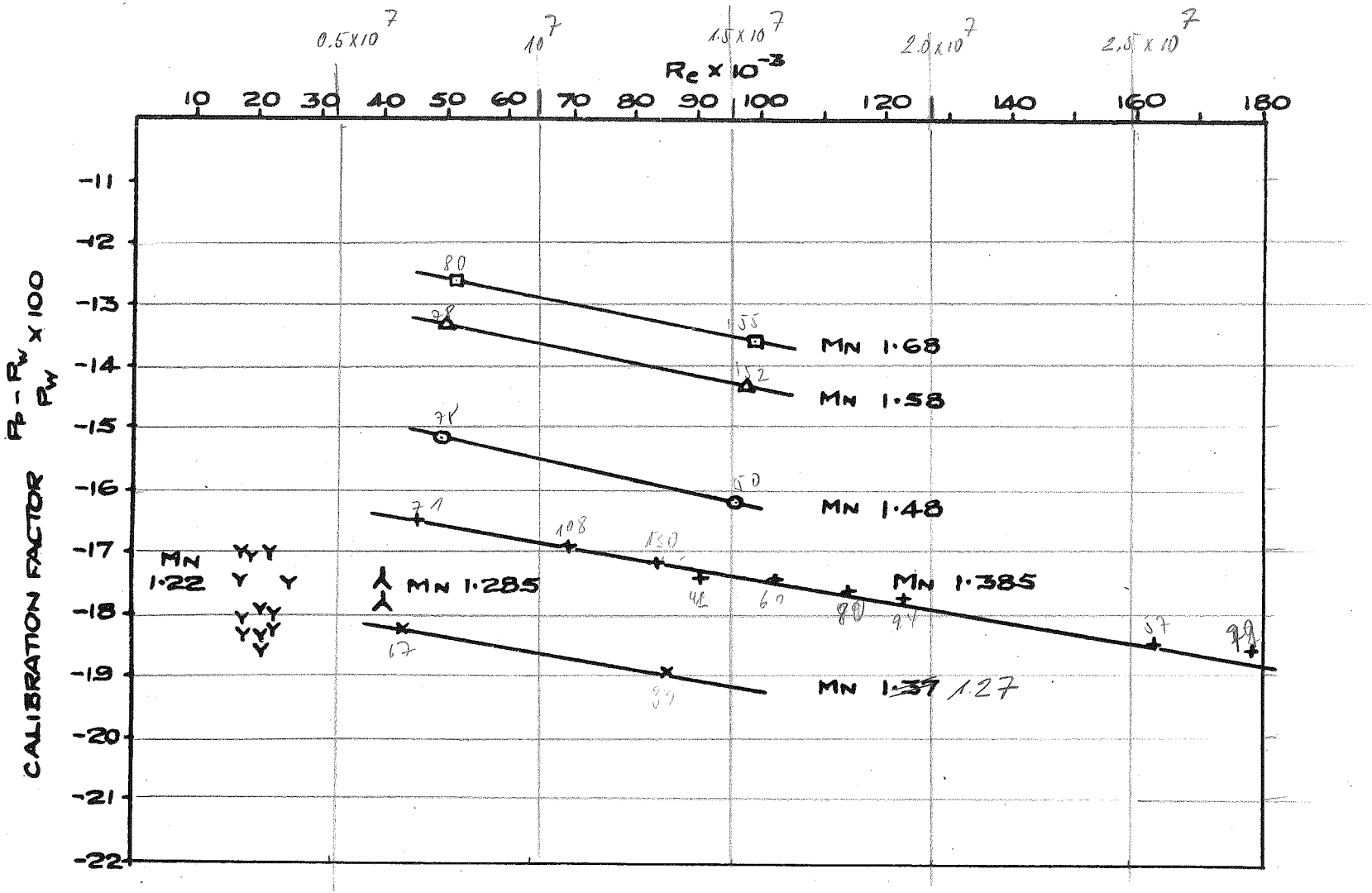


FIG 9

BI-CONVEX STATIC PRESSURE PROBE

ZERO PITCH FLOW