Effect of design variables on a pitot probe

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SECURITY CLASSIFICATION OPEN

SUBJECT EFFECT OF DESIGN VARIABLES ON A PITOT PROBE

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ISSUED TO Internal

EFFECT OF DESIGN VARIABLES ON A PITOT PROBE

PURPOSE OF TEST

Conflicting aerodynamic and structural requirements made it necessary to investigate the effect of certain design-variables on indicated total pressure at various angles of attack, in the case of a pitot probe designed for jet pipe pressure measurements on an aircraft.

The variables tested were:

1. Presence or absence of a streamlined tail to the cylindrical strut on which the pitot tube proper was mounted.
2. Length of pitot tube projecting from strut.
3. Square-cut or countersunk form of pitot tube nose.
4. Presence of cooling air issuing from slits just behind the nose of the tube.

DESCRIPTION OF PROBE

The probe consisted of a 1/4" diameter cylinder (of copper tube) with a .050" diameter pitot tube projecting radially out of the cylinder, as shown in Figure 1. The length of this small tube was reduced in steps during the tests, and its nose was cut off square and flat, or countersunk, as required. A streamlined fairing of balsa was attached with adhesive cellophane tape when needed.

The cooling air test was done on a larger probe, of 3/16" pitot tube diameter, as shown in Figure 2.

METHOD OF TEST

The probe was mounted in a 2" open jet wind tunnel in the Engine Laboratory. The tunnel speed was recorded on a water 'U' tube, and the probe indicated total pressure led to the suction side of a water micromanometer. The tunnel calibration shows that total pressure in the working section is within .01" H_2O of atmospheric. The other side of the micromanometer was left open to atmosphere. When the probe was rotated to various angles of attack, the error of indicated total pressure was therefore read directly on the micromanometer. The tunnel speed was corrected at each attack angle setting, to nullify any small change of blockage correction produced by rotating the probe.

In the case of the test on the effect of cooling air, the probe was set up at zero attack angle, and the tunnel got running steadily. The indicated total pressure was then read on the micro-manometer. Cooling air was then turned on, and its pressure increased slowly to 20 lbs./in^2. Meanwhile the indicated total pressure showed no change at all. Yawing the probe showed that the flexible gauge-lines were clear by the immediate response of the manometer.

TEST RESULTS

The indicated total pressure error ΔP_t was divided by the local dynamic pressure P_d to give a non-dimensional error coefficient, which has been plotted against θ° angle of attack in Figures 3 and 4.

CONCLUSIONS

1. The form of the strut (cylindrical or with streamlined tail) does not materially alter the performance of the probe, provided that the pitot tube proper is within the range of lengths tested.

2. Within the limits tested, the length of pitot tube protruding upstream from the strut leading edge does affect the yaw response. A tube of length equal to one strut diameter has a yaw insensitive range roughly twice that of a tube one-quarter of this length.

3. The countersunk nose tested is yaw insensitive over about $1\frac{1}{2}$ times the range of a square-cut, flat-nosed tube. This agrees with the findings of Lyster (N.A.E. Lab. Memo. FR22(c)), Gettelman & Krause (NACA RM E 51 G09), and NACA/TIB/2392 (16).

4. The presence of cooling air blown out of a number of slits near the nose of the tube (one diameter back) has no effect on the indicated total pressure.

5. It is concluded that the probe designed for thrust evaluation in a reheated aircraft tailpipe, having cooling slits, a stream-lined tail to prevent flameholding and buffeting, and a counter-sunk nosed tube more than one strut diameter long, should be satisfactory at least over $\pm$ 15° of yaw, which is much greater than that expected in flight.

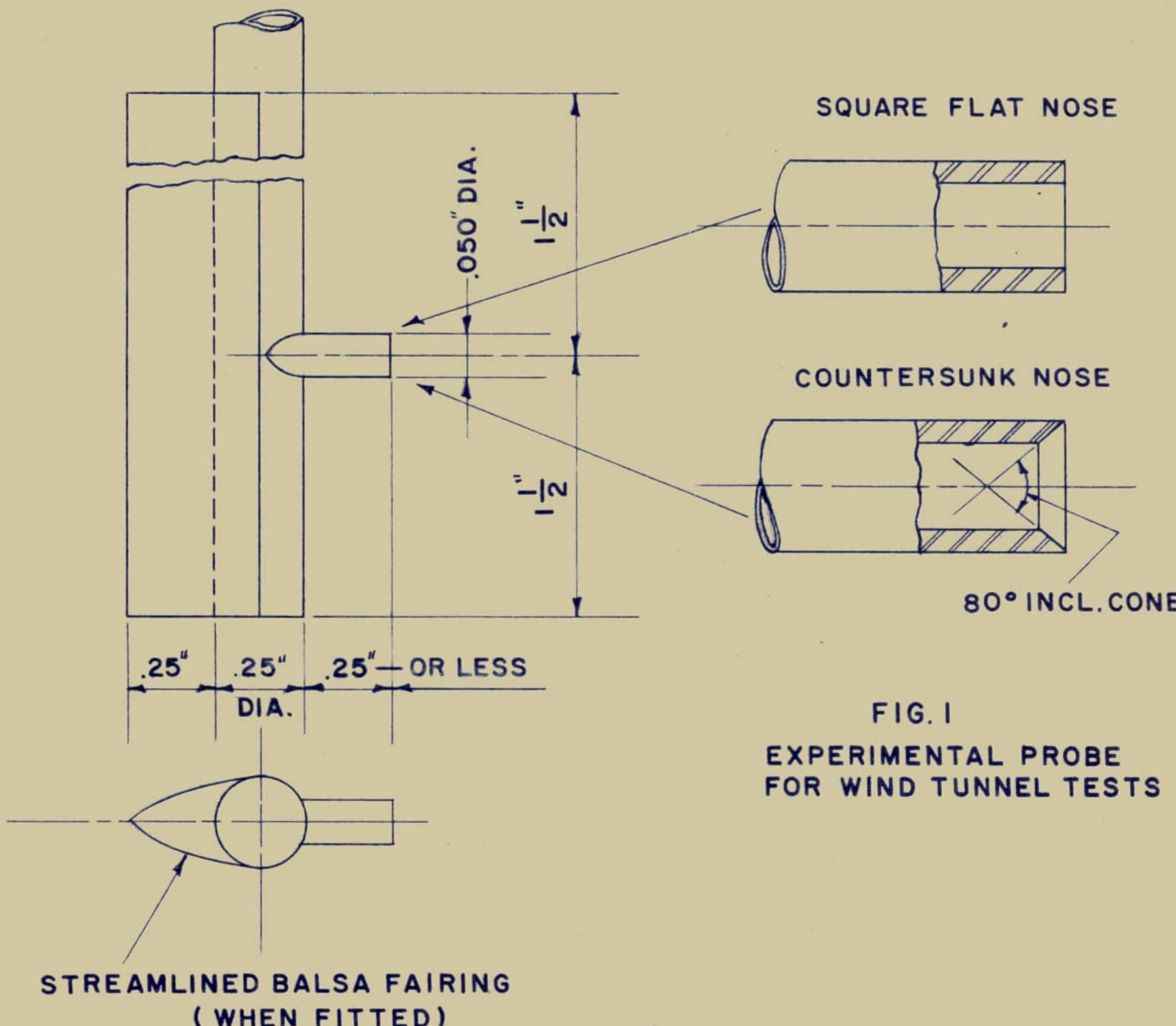

FIG. I
EXPERIMENTAL PROBE
FOR WIND TUNNEL TESTS

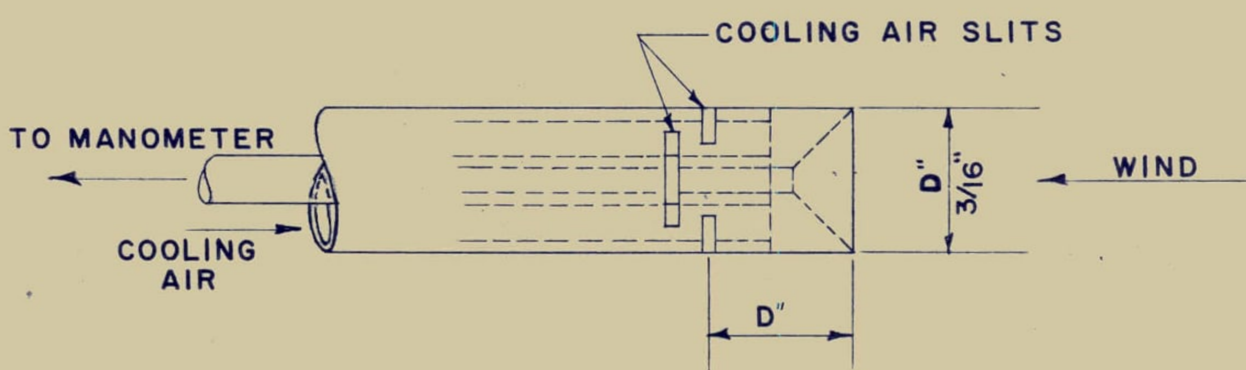

FIG. 2
WIND TUNNEL MODEL OF
AIRCOOLED PROBE

SERIES OF RUNS SHOWING EFFECT OF SHORTENING PITOT-TUBE PROPER
(WITH AND WITHOUT STREAMLINED TAIL)

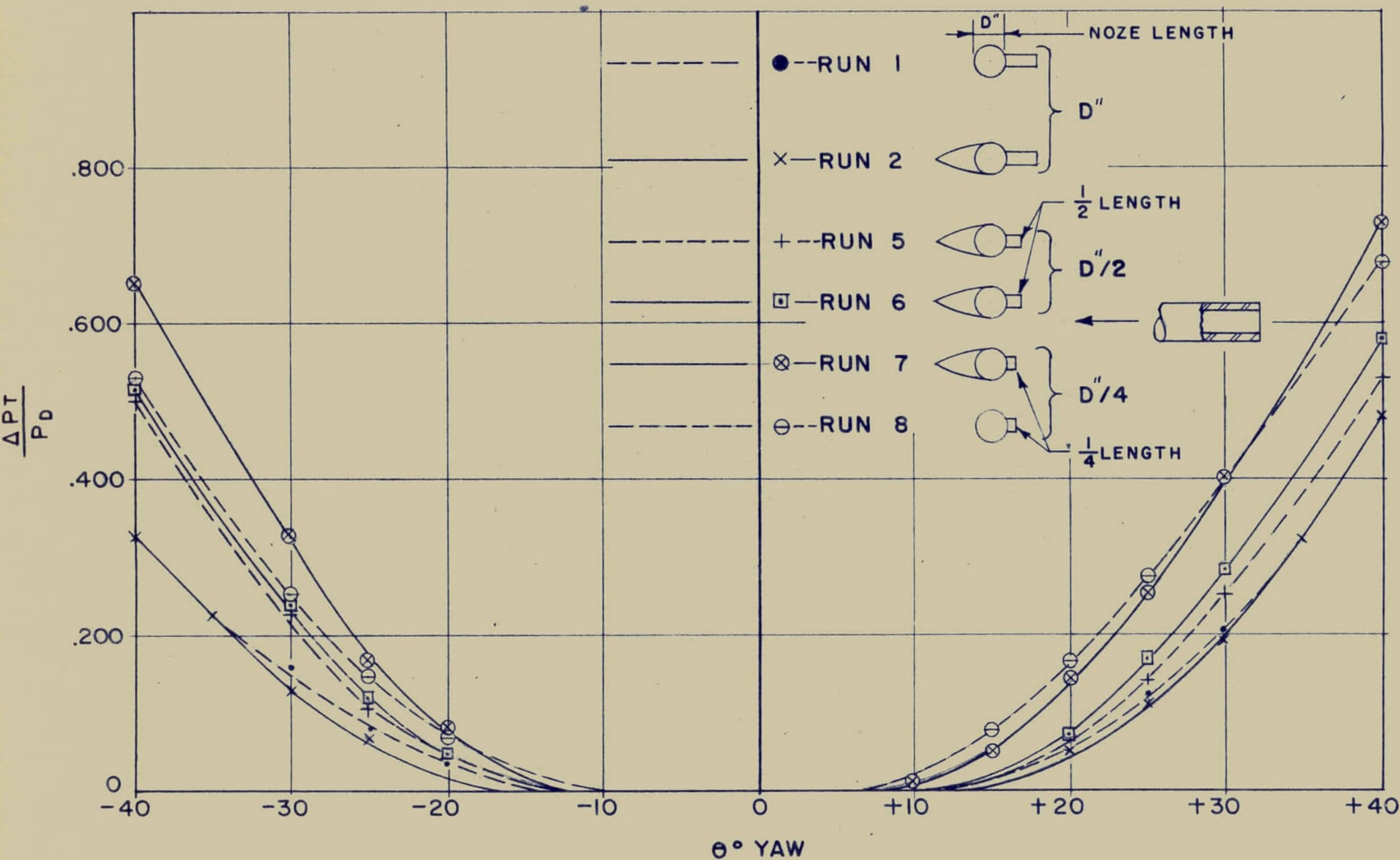

FIG. 3

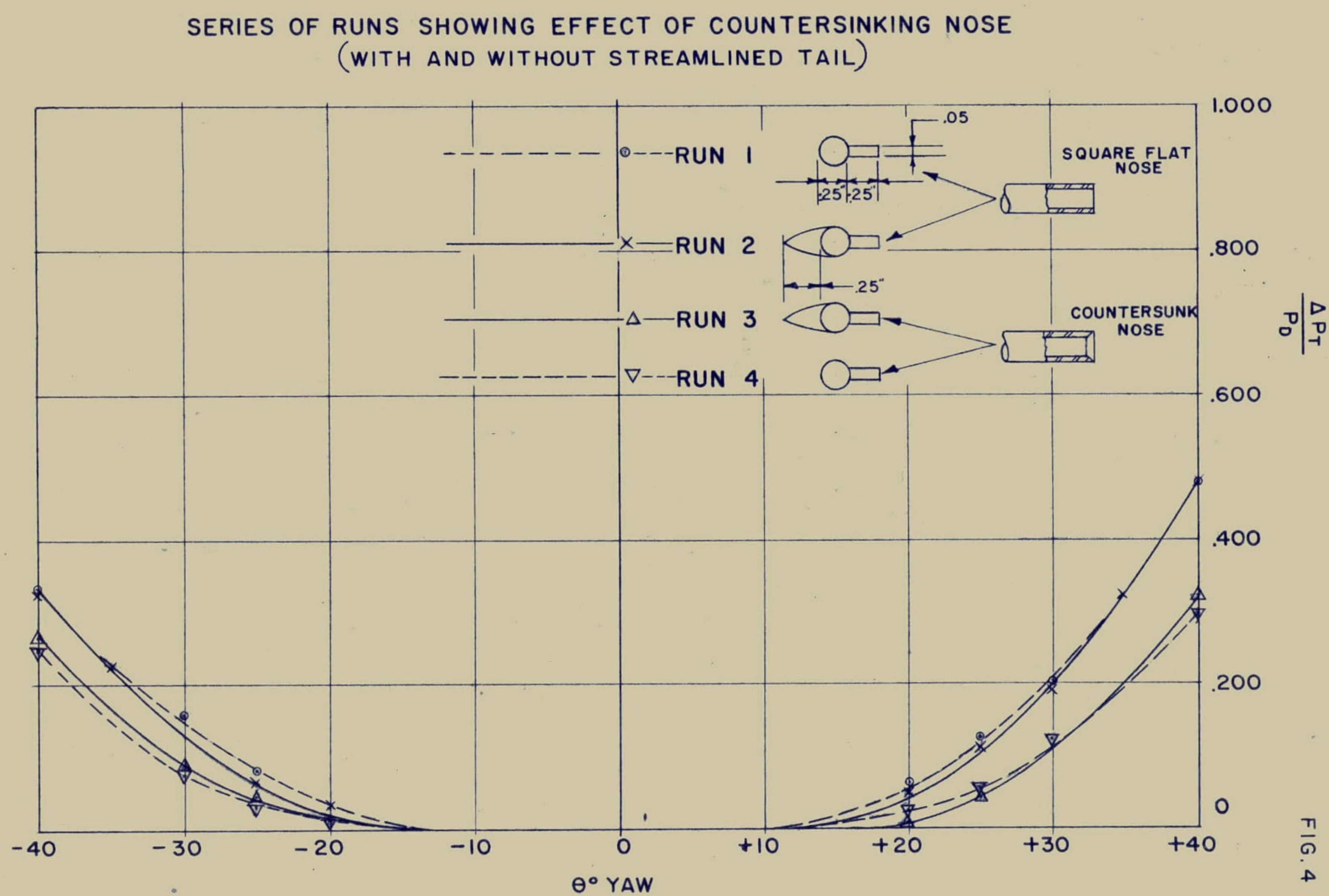
SERIES OF RUNS SHOWING EFFECT OF COUNTERSINKING NOSE
(WITH AND WITHOUT STREAMLINED TAIL)
RUN 1
RUN 2
RUN 3
RUN 4
.05
.25"
.25"
.25"
SQUARE FLAT NOSE
COUNTERSUNK NOSE
1.000
.800
.600
.400
.200
0
$\frac{\Delta P_T}{P_D}$
-40
-30
-20
-10
0
+10
+20
+30
+40
θ° YAW

FIG. 4