CORRESPONDENCE.

To the Editor of the AERONAUTICAL JOURNAL.

SIR,—The AERONAUTICAL JOURNAL for December, 1919, contains an article by Sir Horace Darwin, F.R.S., on " The Static Head Turn Indicator for Aeroplanes," in the course of which (pages 623 and 624) he gives two alternative explanations of the action of this turn indicator on a properly banked turn. On page 624, line 16, the following words occur :—" Although these two ways of considering the forces which act on the air in the tube are so different, they are both correct." It is true that the *result* obtained by each method of attack is the same, but as the writer has found some of the statements difficult to follow the following comments may be useful :—

(i) On page 623, fourth line from bottom, we have :—" 1. As the banking is at the correct angle the resultant of gravity and centrifugal force acts at right angles to the direction of the tube and has no effect."

(ii) On page 624, dealing with the action of gravity from the second point of view (seventh line from top) occur the words :—" 1. Gravity acting on the air in the tube. As the tube is banked this will tend to make the air flow inwards," *i.e.,* down the tube.

(iii) Again, on page 624, top, we have :—" 3. The atmospheric pressure at the two static heads is not equal; as the aeroplane is banked, the outer end is higher up, and at a place where the air is at a less pressure. The differential manometer will show this difference of pressure." On page 624, line 9, the statement about inequality of atmospheric pressure is repeated with the remark that its effect on the manometer is " obviously equal and . . . opposite " to the tendency of the air in the tube to flow inward, due to the action of gravity.

The writer believes that students will find difficulty in obtaining a clear idea of the principle on which the action of the valuable instrument described by Sir Horace is based, and suggests the following method of procedure.

The action of *gravity* on the turn indicator may be examined by considering a tube open at each end and fitted at the middle of length with a flexible diaphragm, whose deflection may be taken to indicate a difference of pressure between its two sides. Suppose this tube at rest and supported with its long axis horizontal and in a horizontal plane where the atmospheric pressure is A. This pressure is the result of the action of gravity on the whole of the atmosphere from the ground upwards, and is assumed to be uniform over that plane so that there will be no deflection of the diaphragm. Now imagine the axis of the tube vertical and the diaphragm in the same horizontal plane as before; the upper extremity will be at a lower pressure and the lower one at a higher pressure than before, due to the pressure gradient in the atmosphere caused by the action of gravity; but there will be no pressure difference at the diaphragm, since the pressure gradient inside the tube will be the same as outside, and the pressure on either side of the diaphragm will be A as before. The same is true for any inclined position of the tube ; for any vertical displacement the pressure difference will remain zero though the absolute value of the pressure is changed.

If the ends of the tube are now connected to static heads the arrangement will be analogous to the turn indicator on an aeroplane. The result of connecting this hypothetical tube to static heads is to render the pressure in it independent of steady motion along a straight path, for as the name implies, these heads should be so designed that the pressure in them is always equal to the true or static pressure.

We may now say, therefore, that the turn indicator will not be affected by differences of air pressure due to the action of gravity or to the angle of bank.

The reading of the indicator will depend on the centrifugal force as explained by Sir Horace on page 624.

The statement on page 618 that " inequality of pressure is because it is impossible to make both static heads absolutely similar " does not accord with the writer's experience. The calibration of a static head of N.P.L. form on the whirling arm at the Laboratory* showed it to read the true pressure to within one-tenth of one per cent., which was the order of accuracy of the experiment, and later calibration of various forms of head shows that considerable modification in design is permissible if certain simple precautions are observed. It is probable that in ordinary use the static tube reads the true pressure to an order of accuracy higher than that of present methods of measurement.

Finally, on page 623, line 18, occurs " *Pitot tubes* (the italics are the present writer's) for this reason also, are better than Venturi tubes." Since pitot tubes cannot be used for turn indicators this is presumably an error for " *static tubes.*"

<div align="right">Yours faithfully,

J. R. PANNELL.</div>

<div align="center">*To the Editor of the* AERONAUTICAL JOURNAL.</div>

DEAR SIR,—I thank Mr. J. R. Pannell for pointing out that at the end of my paper on " The Static Head Turn Indicator " the words " pitot tubes " is an error. The comparison should be between Venturi tubes and static openings and not between Venturi tubes and pitot tubes.

Mr. J. R. Pannell's opinion on the accuracy of static openings can undoubtedly be taken as final, and it is satisfactory to know that considerable differences of form do not cause much error if certain simple precautions are observed. It is pointed out in my paper that when flying near the ground at 80 miles per hour in a circle of one mile radius, that the banking angle is 4deg. 10min., and the difference of pressures is about 1mm. head of water. This is about $1/10,000$ of atmospheric pressure or ten times the accuracy given by Mr. J. R. Pannell. If the flight is at a great height the difference of pressures may be half this amount, or 20 times the accuracy given. Mr. J. R. Pannell says: " It is probable that in ordinary use the static tube reads the true pressure to an order of accuracy higher than that of present methods of measurement." From this it would seem that a more refined method of measurement is required for testing this point when static openings are used for the special purpose of the turn indicator.

The explanation of the action of the turn indicator given by Mr. Pannell seems to me to be perfectly clear and most easy to understand.

<div align="right">Yours faithfully,

HORACE DARWIN.</div>

The Orchard, Huntingdon Road,
    Cambridge, January 18, 1920.

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* Report of the Advisory Committee for Aeronautics, 1912-13, p. 35.