# CORRESPONDENCE.

*To the Editor of* THE AËRONAUTICAL JOURNAL.

DEAR SIR,—In response to the general invitation to discuss Mr. Watts' note on "The Theories of Screw Propulsion," published in the July number of the AËRONAUTICAL JOURNAL, I propose to make a few remarks on the subject of inflow velocity, and to indicate briefly the general trend of airscrew researches at the National Physical Laboratory.

The subject matter of Mr. Watts' note is not new and raises no contentious issue. The general nature of the air flow at the front of an airscrew, in so far as the aerofoil theory of an airscrew is concerned, is now fairly well understood. The case has been very clearly stated by Wood and Glauert, who point out that since an aerofoil disturbs the flow of air for some distance in front of its leading edge, the inflow velocity consists of two parts—(*a*) the disturbance of the air in front of the blade element under consideration, which is due to the blade element itself and corresponds to the disturbance around an ordinary aerofoil, and (*b*) the interference effects of the other blades and of the blade itself at angular distance of $\pm 2\pi n$. Obviously it is the latter part of the inflow velocity which should be used when calculating from aerofoil data the performance of an airscrew, since the former is automatically taken into account when measuring the forces on an aerofoil in a wind channel. The difficulty arises, however, when an endeavour is made to estimate the magnitude of the inflow velocity, which when used in conjunction with the aerodynamic data of aerofoils of sections similar to those of the blade, would enable the performance of an airscrew to be calculated with good accuracy.

An investigation at the National Physical Laboratory on the distribution of pressure over the entire surface of an airscrew blade has supplied experimental data which will greatly advance the theory of airscrew design. It is proposed to publish shortly the first three parts of this investigation, which are—

(1) An investigation of the distribution of pressure over the entire surface of an airscrew blade.

(2) Measurement of the aerodynamic data of aerofoils of sections similar to those of the airscrew blade.

(3) An analysis of the preceding experimental data with a view to an advancement of airscrew theory.

In part 3 an endeavour has been made to evolve a theory of general applicability, which will take into consideration the interference on a blade element of the neighbouring parts of a blade and also calculate the inflow velocity at each blade element.

It is suggested that pending further investigation, which is now in hand, the analysis and conclusions of Part 3 should not be taken as final.

At present the general conclusions of the investigation are:—

(*a*) The magnitude of the inflow velocity to be used with the aerodynamic data of aerofoils is less than that calculated from the Momentum Theory of Froude.

Incidentally it should be mentioned that an experimental investigation by the writer and his colleague, Mr. Howard, has established the soundness of the underlying conception of the Froude Momentum Theory.

(*b*) The inflow velocity varies along the blade and is probably negative at the tip.

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(c) At any blade element, the magnitude of the inflow velocity to be used with the aerodynamic data of aerofoils is a function of the number of blades and the thrust, forward speed and diameter of the airscrew.

It is perhaps of special interest to mention that with a blade element at a radial distance 0.7 R and the airscrew working at an average value of the thrust coefficient, the values of the ratio of the inflow velocity needed with aerofoil data—as calculated from the data of Part 3—to the Froude inflow velocity are 0.45 with a two-bladed airscrew and 0.70 with a four-bladed airscrew. These values are in close agreement with those measured by Drzewiecki, namely, 0.40 and 0.65 respectively—see Fig. 6 of Mr. Watts' note.

In conclusion, with reference to Mr. Watts' opening remarks, I and my colleague Mr. Collins plead guilty to having presented to the A.C.A., in September, 1916, an empirical airscrew theory which was an endeavour to combine a momentum theory with an aerofoil theory. I venture to suggest that at that time, when the importance of inflow velocity was just being fully realised, this theory in spite of its shortcomings was a decided advance from the ordinary aerofoil theory which did not take into account inflow velocity. Since that time our knowledge of airscrew theory has increased and will undoubtedly continue to increase, so that the "combined" theory may now be regarded as a stepping stone, which has been useful, in the climb of progress.

Yours, etc.,

A. FAGE.

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