what bird it is to the voice of which he is listening, for in the process, even if it be a long one, he will learn a good deal about the bird and its habits. But some learners are less gifted than others with a capacity for listening carefully, and have little or no musical ear, and a book like this may be of good service to these. Dr. Voigt's method is a very sensible one; he makes no great use of musical notation, but has invented a notation of his own which is likely to be much more useful to the ordinary observer. By a series of dots and dashes, inclining or curving up or down if necessary, he contrives to give a very fair idea of the character of the notes he wishes to represent, and also of their tendency to rise and fall. In some cases, *e.g.* in that of the swallow, he does not make use of either kind of notation, simply because neither would be any real help. His descriptions of the songs seem remarkably accurate. We have tested them in the case of many of the small warblers, which are among the most difficult to describe, and have invariably found them excellent, and the tendency of particular individuals of a species to vary the utterance is also duly noted. Thus of the marsh warbler (*Acrocephalus palustris*), Dr. Voigt says that it has troubled him more in the way of variation than any other species. In writing of this species he seems to have omitted the peculiar alarm-note uttered when an intruder is near the nest, but as a rule something is said of alarm- and call-notes. On the whole, we consider this book the most useful practical manual we have met.

W. W. F.

The Force of the Wind. By Prof. Herbert Chatley. Pp. viii+83; illustrated. (London: C. Griffin and Co., Ltd., 1909.) Price 3*s.* net.

PROF. CHATLEY has evidently devoted himself to a study of hydrodynamics and of its literature. He has attempted to boil down into an inordinately small compass, so as to be useful to engineers, an exposition of one of the most difficult and elusive subjects with which either the engineer or the mathematician has to deal. Explanation of principles which might be useful to a novice is replaced by a multiplicity of formulæ, which are flung at the reader with but little regard to dimensions or units. Numerical examples which, even in the case of clear exposition, always assist the student who wishes to apply a formula to any case in which he is interested are entirely absent. Much information is collected, and numerous authorities are cited, but the result can hardly be considered satisfactory.

LETTERS TO THE EDITOR.

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Stability of Aëroplanes.

I HAVE recently been occupied with a comparative study of the theories of stability of aëroplanes deduced by Prof. Bryan, Captain Ferber, and Mr. F. W. Lanchester, and have just noticed a parallelism between the formulæ of Ferber and Lanchester which is strongly corroborative of the practical application of both.

In Ferber's "Les Progrès de l'Aviation par le vol Plane" (*Revue d'Artillérie*, November, 1905) he deduces from an extension of Prof. Bryan's analysis a formula for the conditions of longitudinal stability

$$\frac{P^2 b}{2Bg^2kS} > 0{\cdot}8,$$

where P is the total mass of the machine, B is the moment of inertia about a transverse axis through the cg, S is the area of the supporting surfaces, b is the distance of the centre of pressure from the centre of area of the supporting surfaces, and K is an aërodynamic constant (0·7) kilometre-second system.

Lanchester's equation for longitudinal stability is

$$\Phi = \frac{4lH_n^2 \tan\gamma}{I\left(\frac{1}{K} + \frac{1}{\iota C\rho\alpha\beta}\right)} > 1,$$

where l is the distance from the centre of pressure on a tail plane to the Cg, H_n is the kinetic head of the machine corresponding to its normal velocity, γ is the normal gliding angle, I is the moment of inertia about a transverse axis through the Cg, $K = \frac{\text{weight}}{(\text{normal velocity})^2}$, and the denominator of the second term in the expression within brackets is the lift on the tail plane (ft.-lbs.-sec.-units) divided by the square of the velocity.

Now the mass varies as the lifting force, which again varies as the square of the velocity, so that $P^2 \propto H_n^2$.

The torque which restores the machine to equilibrium depends in the case of a machine without a tail plane on b, and with a tail plane on l, so that if Lanchester's form is to refer to a machine without a tail plane b must be substituted for l.

B and I are identical in kind.

K varies as the lift ÷ square of the normal velocity, and since the lift varies as the product of the area and the square of the velocity, $K \propto S$.

The term relating to the tail plane is peculiar to that type studied by Lanchester, so that it can be omitted from our comparison.

Tan γ is a constant for any one type of surface.

Hence it will be seen that the two formulæ are exactly of the same form, and it only remains exactly to determine the appropriate constants to discover if the two expressions can be made identical.

As has been pointed out by Prof. Bryan, everything (except for a machine with a tail) depends on b, and unless $db/d\alpha$, where α is the angle of attack, is negative, the torque will not produce equilibrium. The Government's committee is, I believe, giving this attention.

I would further point out that the variations in velocity leading to Lanchester's "phugoid oscillations," and the oscillations due to the variation of b with α, will serve to explain the two types of oscillation, respectively of long and short periods, observed by Prof. Bryan and Mr. W. E. Williams, and shown by the former to be deducible from the equations of motion.

HERBERT CHATLEY.

Imperial Railways of North China, Engineering and Mining College, August 24.

IT is dangerous to draw conclusions from half-finished investigations, and anything I may now say must be subject to confirmation or modification when I have completely disposed of the mathematical theory of stability, both longitudinal and lateral, as I hope to do in a very few months unless any further pressure of professorial duties necessitates again hanging the matter up indefinitely. But results which I have recently obtained seem rather to corroborate instead of contradicting Lanchester's equation as holding good, subject to suitable assumptions and for the types of machine to which such a formula is applicable. I may state that I have already obtained expressions for the conditions that the quick or slow small motions may be subsident or oscillatory, and for their coefficients of subsidence in the first case and their periods and moduli of decay in the second. This applies to longitudinal stability, and a similar investigation is in progress regarding lateral stability.

It will, I believe, be easy to explain also *why* Lanchester's method, which to a mathematician certainly appears wanting in rigour, may lead to a correct result. But the matter will, I hope, be cleared up very shortly.

In the meanwhile, Prof. Chatley's comparative studies appear to indicate that we are within measurable distance of obtaining consistent results from widely differing methods.

G. H. BRYAN.