# CORRESPONDENCE

Grove House,
Bodney Road,
Hackney Downs,
December 10, 1908.

SIR,—In answer to your invitation I take the opportunity of entering into the discussion of Mr. Lanchester's interesting and instructive paper on "A Comparison of the Wright and Voisin Flying Machines," although, since this paper is not to hand, I am not able to discuss it as fully as I should like.

Let us first consider the question of the propellers.

1.—A screw propeller derives its thrust by giving motion to the air, and since it is clear that it is more economical to give a large mass a small velocity rather than a small mass a high velocity it follows that a screw should be designed to engage as much air as possible. It is found with stationary two-bladed propellers suitable for driving aëroplanes in which the blades are of carefully and correctly shaped wood that

$$\text{horse power} = \frac{\text{thrust} \times \text{slip}}{33{,}000}$$

With such a propeller it is also found that the thrust does not very greatly fall off up to a speed of 70 per cent. of the slip speed. The Wright machine is undoubtedly much more efficient than the Voisin machine, and this appears to be in part due to the fact that the double propellers of the Wright machine engage between 6 and 7 times more air per horse power than the single propeller of the Voisin machine. Moreover, the propellers of the Wright machine are of wood and are perfectly smooth stream-line surfaces, while the propellers of the Voisin machine consist of metal paddles at the end of metal rods, and have wasteful humps on the back of the paddle or blade where the rod is welded to it.

2:—Placing two propellers axially behind one another and revolving in opposite directions, as Mr. Lanchester suggests, would have its advantages, but its great disadvantage would be in the fact—and this would outweigh all the advantages—that only half the quantity of air would be engaged. Hence one of the chief secrets of the superior efficiency of the Wright machine would be sacrificed.

3.—By placing the propellers behind the machine in the centre of maximum resistance it is found that some of the energy lost by the disturbance of the air caused by the passage of the aëroplane can be recovered by the propellers.

4.—The side by side disposition of the propellers of the Wright machine enables the maximum use to be made of this most important fact.

5.—The Wright machine also appears to be the more efficient type in that the framework of the aëroplane is covered in, thus making the aëroplanes smooth stream-line surfaces, whereas in the Voisin machine the framework of the aëroplanes is exposed on the back.

6.—Mr. Lanchester suggested in the course of his remarks that the behaviour of aëroplanes and propellers in air and in water is similar, subject to a correction for density.

7.—It must not be forgotten, however, that water wets a surface, air does not; water possesses viscosity and cohesion—the particles adhere together and resist separation—air has no measurable viscosity and the molecules are always doing their best to get as far away from one another as possible. The only loss that can occur in skin friction with a smooth stream-line body appears to be that due to exchange of momentum, such as would result if people jumped from a train going at one speed into another going at another speed. Sir Hiram Maxim found that a propeller of no pitch and with the blades carefully shaped required no appreciable torque, whereas a disc of smooth sheet tin of the same diameter and driven at the same speed gave an appreciable torque.

8.—An air propeller differs also from a marine propeller, in that the air is the equivalent of an elastic nut which hugs the surface of the blade on both sides. For these reasons one is compelled to agree with Mr. Wilbur Wright, Professor Langley, and Sir Hiram Maxim in the statement that the skin friction is a quantity so small that it may be neglected.

9.—The resistance of an aëroplane appears to be due, not so much to skin friction, as to eddies set up by the parts of the aëroplane which are not of stream-line formation, and to other parts of the machine in which the opening, or passage-way, is restricted so that the air has to be accelerated to pass through.

10.—Despite the superior efficiency of the Wright machine its efficiency could, apparently, be still further increased in various ways, as by improving the shapes of the frame and uprights, and by constructing a "cut wind" to the motor, operator, etc.

11.—The weight of the Farman machine is surprising (1540 lbs., if I understood Mr. Lanchester correctly). This is 400 lbs. more than was previously thought, and with the area given—535 sq. feet—gives the high lift of 2.9 lbs. per sq. foot. The highest lift which I have measured was 7 lbs. per sq. foot. This, however, was at nearly one hundred miles an hour and with a small angle.

12.—The use of vertical planes in connection with the rear aëroplanes in the Voisin machine appears to be a good feature in that it enables the machine to adjust itself to meet

side currents which would upset it. A slight *cross* current of air causes the lift on one side of an aëroplane to be more than on the other. In the case of Sir Hiram's large machine a cross current of only 4 miles an hour caused the machine to lift a ton more on one side of the track than on the other. A cross current therefore causes an aëroplane to be subjected to a considerable upsetting torque. This may be obviated by twisting the planes, as in the Wright machine, by forming all the planes with vertical planes so as to assure the machine drifting with any unexpected cross current, as in Santos Dumont's first machine, "The Bird of Prey," or with one vertical plane, as in Mr. Cody's machine, or by forming the rear planes only with vertical planes so that a cross current will tend to turn the machine round to meet it, as in the Voisin machine. This feature of the Voisin machine appears to be of great importance and to give this machine more automatic stability than that possessed by the Wright machine.

13.—Will Mr. Lanchester be good enough to give further information with regard to the diagram of the lines of motion of the air about two superposed planes which he threw on to the screen? This diagram, it seemed to me, appeared to show *the air rising up to meet the aëroplane* as if the plane or curve had some cohesive or other attraction for it. This is contrary to what I should have expected from experiments which I have seen.

14.—With regard to the minimum horse power required for flight, Mr. Wilbur Wright recently said: "Two years ago, with a motor of only 14-h.p., I drove an aëroplane weighing $11\frac{3}{4}$ cwt., and carried one passenger with me. I deem it impossible ever to do better."

In conclusion, I would warmly thank Mr. Lanchester for his interesting paper.

Yours faithfully,

ALBERT P. THURSTON.

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## Answer to Communication of Mr. A. P. Thurston

On reading through the communication of Mr. Thurston I first observed that it embodied fallacies (to which further reference is made) apparently taken direct from Sir Hiram Maxim's book on flight. I next observed that Mr. Thurston is the kind friend to whom Sir Hiram in his preface acknowledges his indebtedness for reading his proofs; consequently I take Thurston to be Maxim in disguise, or the mechanical equivalent thereof.

I have numbered the paragraphs in Mr. Thurston's communication, and in the following reply these numbers are used to facilitate references.

1.—The first portion of this paragraph is a statement of the Newtonian principle applied to the screw propeller by Rankine and Froude. I have given a summary of this in my "Aërodynamics," 198 *et seq.* The latter part gives Maxim's result that with certain propellers used by him under stationary running conditions the influence of skin-friction is inappreciable. I do not dispute this fact, but I say definitely that it in no wise proves that skin-friction as a factor in flight resistance or in propeller design is negligible, the conditions of a propeller under running conditions is very different. Certain analogous phenomena are known in the behaviour of an inclined aëroplane, for a plane making a considerable angle to its direction of motion, skin-friction is an unimportant part of the total resistance.

I do not understand how Mr. Thurston makes out that the Wright propellers engage 6 or 7 times as much air as the Voisin; I fear his arithmetic is at fault, the actual figure is nearer $2\frac{1}{2}$ times. Evidently Mr. Thurston has not seen the Wright propellers except on paper, for they are not "perfectly smooth," and are but a poor apology for stream-line form. As to the disparaging remarks made on the design of the Voisin propeller, also based on Maxim's book, p. 106, I could show Mr. Thurston experiments that indicate that the resistance due to a rib on the rarefaction face of an aëroplane is far less than he and Sir Hiram seem to think. The drawing (p. 106) in Sir Hiram's book is plausible, but it does not represent the facts. The whole of this paragraph seems to imply that I have not allowed sufficient credit to the Wright propeller on the score of efficiency, but all the facts mentioned by Mr. Thurston that are pertinent have received due consideration.

2.—It is quite true that if two propellers are placed tandem, unless (as they should be) they are made of larger diameter, there is some loss of efficiency on the score named. There are, however, certain advantages that to some extent compensate for this loss, as is found to be the case in the Whitehead Torpedo, in which this arrangement is adopted.

3.—Of what is this paragraph *apropos?* The whole question here raised is thoroughly treated in pages 199, 200 and 201 of my "Aërodynamics," but what bearing Mr. Thurston's remarks have on the subject of my present paper I do not know. The Voisin disposition appears to me to be as good as, or better than, the Wright in this respect, except in the Goupy type, and this has been already pointed out in my paper.

5.—The framework of the Voisin machine is covered in also. This is pointed out in my paper and was illustrated on the black-board in the course of the reading.

6.—This is true. I believe that the be-