DISCUSSION.

Mr. Bramson : I listened to Captain Sayers with very great interest, and it is very remarkable that this paper should be the first public exposition in this country dealing with this particular theory of aerofoils, the Prandtl theory. I believe that Mr. Lanchester did write on this subject, but I think that Prandtl was the first one to put it before the designer in a comprehensible form. I tried to read Prandtl's book, but I am now understanding very much more about it than I managed to do then.

Now, there are one or two points about the vortices which are a little difficult to visualize. I do understand that the total behaviour of the air may be resolved into a circulation round the wing with a rectilinear flow superimposed upon it, but a sheet of vortices turning into two trailing vortices, I cannot grasp. I cannot quite visualize how the one merges into the other, and would like a word on that subject from Captain Sayers.

Major A. R. Low : It gives me very great pleasure to be present at this exposition of the rather difficult and advanced theory of aerofoils. I have lately been asked to work out deductions for the R.A.F., and I am going to use Captain Sayers' figures, without giving any reference whatever to that gentleman, for which I hope he will pardon me. Really, the subject is by now becoming exhausted and familiar, and as to go into any more minute details would be dry, even to experts, I feel I cannot say anything further.

With regard to this question of getting into the air with this theory, it is very interesting. I picture the air as a whole thing over the surface of the earth and under an aeroplane, and as the span either moves up or moves down, it shows how to consider the pressure of the air on the surface of the earth. What I mean is this—if you could have an aeroplane suspended by a piece of string in the air, and then let it go, and have a barometer on the ground, you would find that as the aeroplane dropped the barometer would rise slowly, and as the aeroplane passed would rise again. If it were possible to have an aeroplane 100 feet up you would be able to record the differences of pressure.

And I see the trailing vortices pressing on the earth and know that it is this action and reaction that retains the action of flight and makes flying possible. The strength of the induced drag balancing the plane over the earth. And there is a feeling of satisfaction in not only seeing it fly, but in knowing how it flies.

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CAPTAIN SAYERS'S REPLY TO THE DISCUSSION:

Mr. Bramson raises the question of why or how a sheet of little vortices along the trailing edge turns into a couple of trailing vortices, and does not know whether it does or does not.

Actually the idea of a sheet of vortices leaving the trailing edge along the whole span gives a more accurate picture of what really happens, but such a sheet of vorticity will produce at any point along the span a down-wash which would be equally produced by a pair of single wing tip vortices. Therefore, it is considered permissible, when discussing the theory in general terms, to refer to the equivalent pair of vortices for the sake of simplicity.

As a matter of fact, vortices of the same hand attract each other, and tend to rotate round each other, so that a little behind the wing a sheet of vortices has formed into a pair of vortex "ropes," as shown in a drawing in Lanchester's "Aerodynamics."

The correct values for change of drag and of incidence with change of span can be calculated from the momentum theory, provided that the appropriate values are taken for the cross section of air dealt with by the wing and for the downward acceleration imparted to it. From the vortex theory it can be computated that in the condition for minimum induced drag (elliptical loading) the momentum theory gives correct results if it is assumed that a cylinder of air of diameter equal to span is given uniform downward acceleration, and these assumptions may be used with satisfactory results. They do not, however, accurately represent what happens, for the real wing does not uniformly accelerate a finite section of air, but creates a varying disturbance extending to the limits of the fluid in which it works.

I am glad to hear Major Low thinks my figures will be useful. These figures are in no sense original, they are merely the standard expressions reduced to the practical units which have to be used in the drawing office, and I hope that they will prove generally useful.

CHAIRMAN: We have had a most fascinating lecture, and considering the tremendous work in preparing it, Captain Sayers is to be congratulated upon the very great amount of time he must have spent on it. He has set an example for other lecturers to follow; he is a very busy man, and that usually deters people from coming forward, but with this example before them they will not be likely to hesitate in the future. He has explained his diagrams with extreme lucidity, and also pointed out the microscopic errors in his paper, and I ask you to give him a hearty vote of thanks for reading us this paper to-night.

The vote of thanks was carried with acclamation, and after Captain Sayers had briefly responded the meeting closed.

NOTE.

Captain Sayers has been awarded the Taylor Medal of the Institution for his paper, as being the most valuable paper read during the Session 1925-1926.