NOTE ON THE FLOW PAST A CIRCULAR CYLINDER

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Introduction

Buri's method of solution of the equations of turbulent motion in a boundary layer has been used extensively in a previous paper*. Since the results of that investigation have not been compared with experiment, nor has any other application of Buri's method been checked experimentally, it seems advisable to apply this method to a problem for which the experimental results are known.

The flow past a circular cylinder at high Reynolds numbers suggests itself. In this problem we use the experimentally measured pressure distribution to obtain the velocity distribution at the edge of the boundary layer. The difficulty that there is an appreciable scale effect on the form of the pressure curve limits the comparison to the particular Reynolds numbers at which the experiments were performed. The velocity distribution in the main stream at the edge of the boundary layer obtained from the experimental results of Fage and Falkner† is shown in Fig. 1. (η is the angular displacement from the forward stagnation point, and u the velocity of the fluid divided by the undisturbed velocity of the stream.) The Reynolds number of the flow was $2{\cdot}12 \times 10^5$. (The Reynolds number R is defined as $U_0 d/\nu$, where U_0 is the undisturbed velocity of the main stream, d is the diameter of the cylinder, and ν is the kinematic viscosity of the fluid.) Flachsbart‡ has made some measurements at the higher Reynolds number of $6{\cdot}7 \times 10^5$ and the corresponding velocity distribution is shown in Fig. 2. Eisner§ has also published some results, but since the pressure curve he gives shows no inflexion—a marked feature of the other curves—I have not used these results.

Results

We need say nothing of the application of the method since this is described fully in the previous paper.

I cannot find any mention of the experimental position of the points of transition or separation in the *Handbuch der Experimentalphysik*, wherein Flachsbart's experiments are recorded. On the assumption that transition takes place

* Howarth, "On the calculation of the lift coefficient for a thin elliptic cylinder", *Proc. Roy. Soc.* A, 149 (1935), 558–86.

† *Aeronautical Research Committee, Reports and Memoranda*, No. 1369 (1931).

‡ *Handbuch der Experimentalphysik*, 4, pt. 2, 316.

§ Eisner, *Zeitschr. f. angew. Math. u. Mech.* 5 (1925), 486–9.

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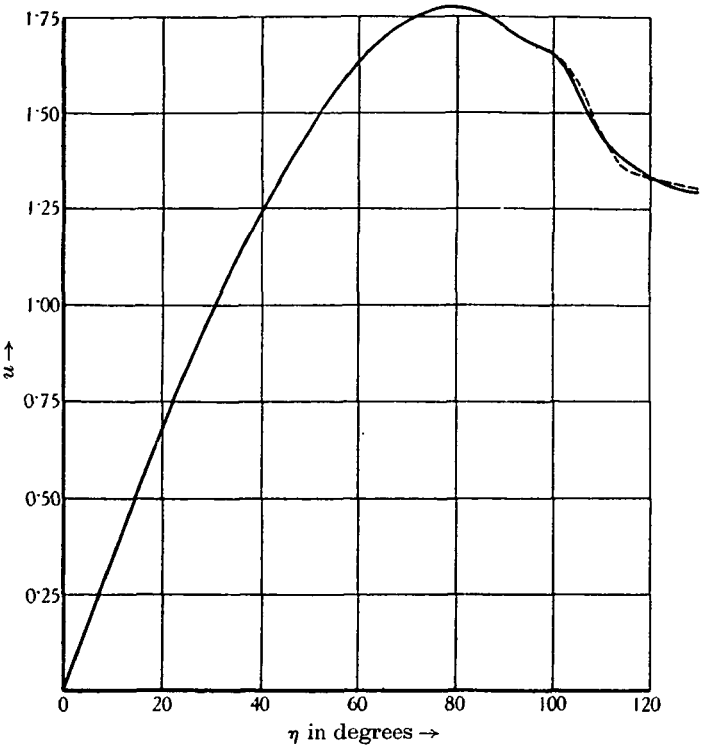


Fig. 1. Fage and Falkner's Measurements. $R=2{\cdot}12\times10^5$.

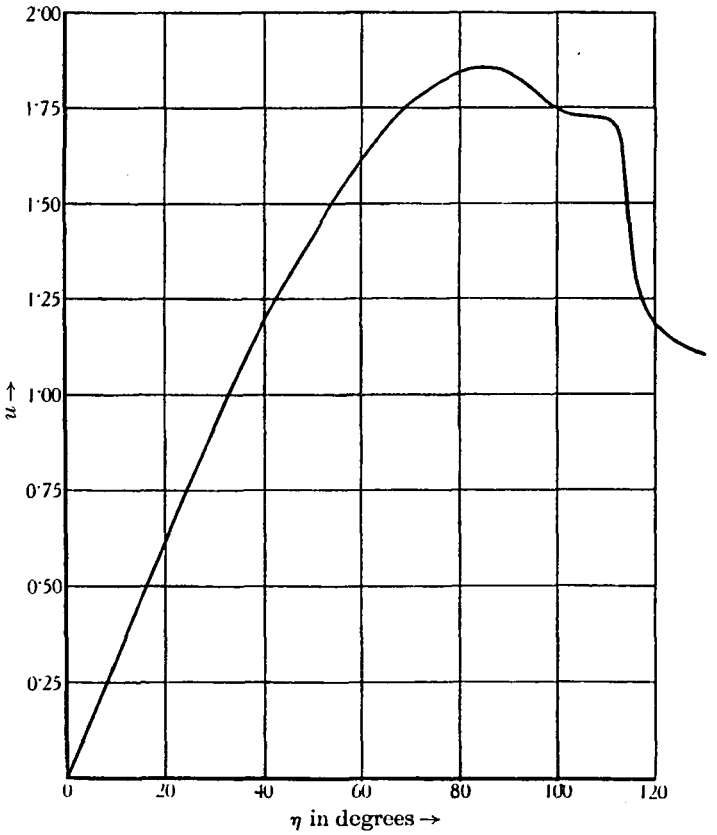


Fig. 2. Flachsbart's Measurements. $R=6{\cdot}7\times10^5$.

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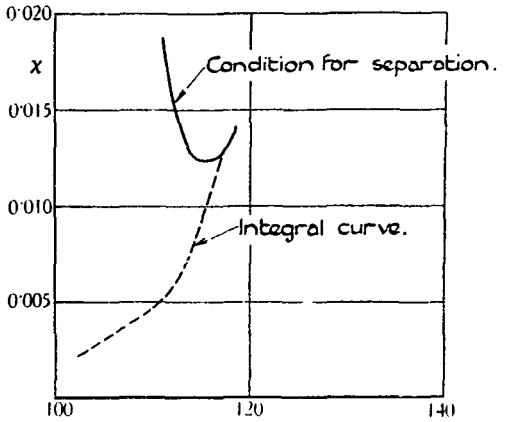


Fig. 3.

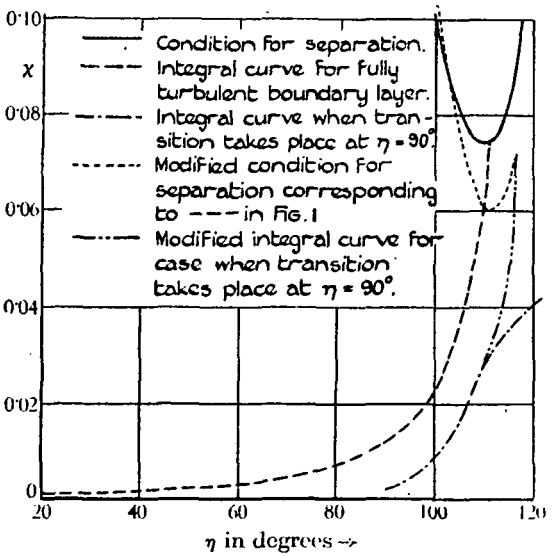


Fig. 4.

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at the point of inflexion in the velocity curve—the result given by Fage and Falkner—separation occurs at $\eta = 117°$ using Flachsbart's results (the integral curve is given in Fig. 3: χ is defined as $2R^{1/4}\, d^{-5/4}\left[\int_0^\delta (1-u)\, u\, dy\right]^{5/4}$, where the integral is taken through the boundary layer). Indeed it is clear from Fig. 2 that separation, if it occurs at all, occurs in the range

$$112° < \eta < 117°.$$

We do not gain any confirmation for the use of Buri's method from this comparison beyond the fact that the method does give a separation at a likely place.

Using Fage and Falkner's results, and taking transition to occur at the point of inflexion, we do not find any separation. The condition for separation is shown by the full line in Fig. 4 and the corresponding integral curve is shown –·–. The two do not meet. The integral curve, assuming the boundary layer turbulent right from the forward stagnation point, is shown – – – and gives separation at $\eta = 111°$.

I am indebted to Mr Fage for the interest he has taken in this comparison. He tells me that in his opinion in the turbulent region it is justifiable to take any smooth curve which lies close to, but not necessarily right through, the observed points. If we use the curve shown – – – in Fig. 1 instead of the curve through all the observed points we get the condition for separation shown ----- and the integral curve shown –··–·· in Fig. 4, and find separation at $\eta = 116°$. Mr Fage considers that the experimental results lead to the conclusion that separation takes place throughout the region $122° < \eta < 130°$, and that it is better to speak of a region of separation than of a point of separation.

It should be stressed here that the position of the point of separation, as given by this method of calculation, is very insensitive to the form of these slight variations of the pressure curve given by Fage and Falkner, provided that these variations are sufficient to produce separation.

We are not able to draw any very definite conclusions from these comparisons of Buri's method and experiment. Although the experimental results do not fully substantiate the use of this method, they do not condemn it. More comparisons seem to be desirable.

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