THE SLOW SHEARING MOTION OF A LIQUID PAST A SEMI-INFINITE PLANE

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The problem of slow shearing motion of liquid past a semi-infinite plane, which was first attempted by Dean [1], is treated in a rather more straightforward manner, and a different type of solution is found. The stream-function is biharmonic and vanishes, together with its normal derivative, at all points of the fluid boundary and must be such as to yield uniform shearing at a great distance from the boundary. It has not been found possible to satisfy all boundary conditions exactly, but a solution, involving an infinite number of arbitrary constants, is obtained which satisfies most of the necessary conditions. These arbitrary constants, here restricted to eight as a first approximation, are chosen to give the best possible result. Expressions for the stream-function and fluid pressure are obtained for specific regions, verifying known results including those for shear flow, for flow between parallel planes and for flow at a sharp corner. Finally, a plane elastic state analogy is pointed out.

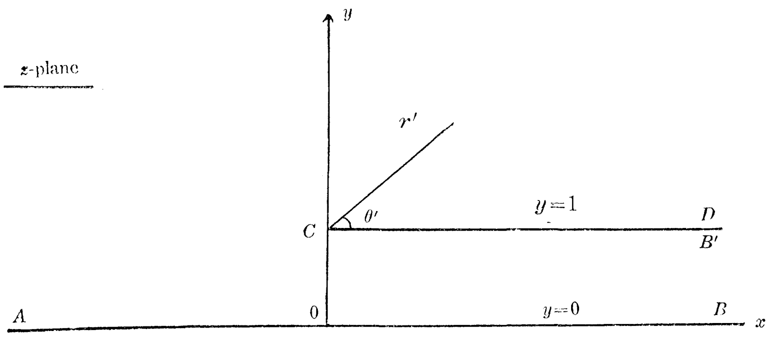

Fig. 1.

We shall here consider the slow two-dimensional flow of a viscous incompressible fluid bounded by the infinite plane AB, and the semi-infinite plane CD, as shown in Fig. 1. The motion at great distances from the planes is that of uniform shearing, and between the planes is that due to a uniform pressure gradient. W. R. Dean [1] has considered a similar type of boundary, but with the flow between the planes at great distance from the origin being due to a constant pressure, so that the type of motion produced here is fundamentally different, as is the method used to solve the problem.

We have to find a stream function satisfying the biharmonic equation

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