

the objection to the width between the piers being too great. A small channel is apt to form at A ; this is chiefly kept open by the flood tide which, towards high water, sets across the main channel with great velocity.

When it is desired to improve a tidal river, every obstacle which checks the flow of the tide up the river should, first, be removed, and such places as Jarrow Slake, on the Tyne, should be enclosed. A small extent of beaching ground, within the entrance, is generally necessary, that the wind-waves entering, may expend their force upon it, and not proceed up the river to disturb the shipping ; but when the entrance is artificial, this object may be sometimes better attained, by land-locking it.

In arranging the lines for the channel of the river intended to be maintained, advantage may, occasionally, be taken of the different action of the water, when forced during the flood and running freely on the ebb. In the former case, the velocity being greatest over the shallows and least over the deep, and in the latter, the reverse.

All curves in the course of the channel diminish the velocity of the flood tide, some of its momentum being constantly expended in changing the direction ; the process seems to be, that the water is heaped up against the concave side, which accumulation generates a wave, more, or less, across the channel. (Figs. 34 and 35.) Curves are, therefore, to be avoided, and when necessary, should be of as large a radius as possible ; they should, when reversed, be passed gently from one to the other, without any intermediate straight line, which is objectionable for reasons mentioned before. Where it is necessary to join a curve into a straight line, the curve should become, gradually, of larger radius downwards.

It is not pretended, that this Paper thoroughly explains the action of the flood and ebb tide, in all rivers and estuaries ; each presents peculiarities and many anomalies, some of which will, probably, be raised as objections to the whole theory. The observations are presented to the Institution as an approximation to the solution of the interesting subject treated of, and with the hope, that they may lead to discussion and to a further collection of facts, upon which alone any sound theory can be founded.

The Paper is illustrated by a series of diagrams, from which Plate 9 is compiled.

Mr. SCOTT RUSSELL was glad to receive a confirmation of the correctness of his experiments, when applied to the theory of tidal rivers and running streams. He agreed with the Author, that the phenomena attendant upon the standing wave had much to do with

the formation of bars, as in the cases of the Clyde, the Tyne, &c. ; but he thought, that a too limited idea had been taken of the action of water. It was impossible to obtain one simple action ; there were always several others coincident with and consequent upon it ; for instance, continual friction was going on between the particles of water in motion, producing a kind of pendulous action throughout. By erecting groynes, or scouring the channels of rivers, certain desired effects might be obtained ; but frequently, these operations were also attended with unforeseen and embarrassing results, such as obstructions in the course of the river, or the formation of bars. Running water, meeting with a shoal in the bed of the stream, increased its velocity, in order to pass the same volume through a less space, but the power was afterwards expended in excavating a deep, immediately beyond the obstruction, and heaping up the material removed, to a lower part of the river, and the continued repetition of these phenomena led, eventually, to the formation of either outer bars, or inner bars, according to the peculiar local circumstances. When a lateral strangulation occurred in a channel, the water from one side was reflected towards the other, scooping out a hollow immediately below, after which it diverged to either side of the enlarged channel, leaving a deposit in the centre of the two currents. This reflection of the water was the main cause of the formation of deltoids. In the River Dee he had uniformly found these effects below every strangulation, the water suddenly diminishing from 9 feet, to as many inches.

In all operations for the improvement of rivers, care should be taken not to attempt to cure an evil by a purely local remedy, for it would rarely be effectual. Every effort should be made to give one symmetrical contour, to form gradual curves, and to obtain an uniform depth, avoiding all causes of sudden check to the free passage of the water.

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After the Meeting, Mr. F. A. Carrington exhibited in the Library a model, in relief, of portions of the counties of Lancashire, Yorkshire, Cheshire, Nottinghamshire, and Derbyshire, extending from Manchester, on the west, to Lincoln and the Humber, on the east ; and from Leeds and Bradford on the north, to Chetsworth Park on the south. These models showed, at one view, the whole physical geography of the district, and were admirably calculated for projecting works of both civil and military engineering ; and if they were more frequently made use of, when designing works for the sanitary improvements of towns, the progress would be more certain, and less costly.

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