REMARKS ON THE IMPROVEMENT OF TIDAL RIVERS

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IMPROVEMENT OF TIDAL RIVERS.

BY

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READ BEFORE THE ROYAL SOCIETY OF EDINBURGH, AT THE MEETING OF 17TH MARCH 1845.

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REMARKS, &c.

THOUGH the writings of Philosophers, and the reports of Engineers, from an early period, contain much valuable information regarding the improvement of inland navigation, yet the various theories, and even the practical opinions that have been advanced, are not a little discordant; and, hence, we find that authors, both of early and recent date, concur in expressing their conviction of the small degree of success by which both the theoretical and practical investigation of the subject, has hitherto been attended.

Professor Robison, for example, in his Treatise on the Theory of Rivers, makes the following observations:— "Such," says he, "having been our incessant occupation with moving waters, we should expect that the professional engineer would be daily acting from established principle, and be seldom disappointed in his expectations. Unfortunately, the reverse of this is nearly the true state of the case. Each Engineer is obliged to collect the greatest part of his knowledge from his own experience, and, by many dear-bought lessons, to direct his future operations, in which he still proceeds with anxiety and hesitation; for

we have not yet acquired principles of theory; and experiments have not yet been collected and published, by which an empirical practice might be safely formed. Many experiments of inestimable value are daily made; but they remain with their authors, who seldom have either leisure, ability, or generosity, to add them to the public stock."* And, again, Mr George Rennie, in his able Reports to the British Association on the State of our Knowledge of Hydraulics as a branch of Engineering, in alluding to the laws of rivers, says, "it is the office of science to unravel these mysteries; but although the attention of Philosophers has been directed to the attainment of a true theory, from the time of Galileo to the present, our knowledge of the laws which govern the motion of rivers is as yet very imperfect. The little success with which they have been investigated may be attributed to the difficulty of making correct observations, and to the local obstructions which generally exist in most rivers; and until we can ascertain those points correctly, by means of a series of careful experiments, we can only arrive at approximate results."†

Such was the state of our knowledge in this department of Engineering at the close of the last century, when Robison wrote, and such may still be said to be our information at the present day. And, in order to avoid misconception, it is necessary for me to state, that this communi-

* System of Mechanical Philosophy, by John Robison, LL.D., vol. ii. p. 389.

† Report on the Progress and Present State of our Knowledge of Hydraulics, as a branch of Engineering, by George Rennie, Esq., C.E. Transactions of British Association for 1834, p. 426.

cation has not for its object the advancement of any new *theory* or *principle* (a task which would, more naturally, fall within the province of the philosophical inquirer, than of the practical Engineer), but simply an exposition of the views by which I have been guided in designing different navigation improvements; and a statement of instances in which the works executed in accordance with these views have produced beneficial results.

I had occasion, in my Treatise on the Application of Marine Surveying and Hydrometry to the Practice of Civil Engineering, to refer, in illustration of the subject, to the tidal phenomena and physical characteristics of various Rivers and Firths with which I have been professionally connected.* But in that work I did not enlarge on the facts brought forward, or, indeed, do more than refer strictly to the means of acquiring the data necessary to enable the Engineer to form an opinion as to the practicability and probable expense of effecting desired improvements. In the present communication I have, therefore, availed myself, not only of the information contained in that Treatise, in so far as it is applicable, but also of that which is given in several professional Reports, which have from time to time been made; and I feel persuaded that this more extended view of the subject will not be considered out of place in this Society, as it may be interesting, and in some degree instructive, to the profession; while, in a purely theoretical point of view, ideas may perhaps be suggested, calculated to facilitate the determination of the

* Treatise on the Application of Marine Surveying and Hydrometry to the Practice of Civil Engineering. Edinburgh, 1842.

laws which regulate the motion of rivers; and thus to lead to the introduction of more definite and acknowledged principles for our guidance in conducting improvements on inland navigation.

The influx of the tidal wave through Firths or Bays, and the modification it receives in its passage up the inclined beds of rivers, produce two physical boundaries, which are found to exist in all rivers, when viewed in connection with the sea. These boundaries, again, produce three sections or compartments, to the improvement of only one of which the practical remarks I have now to offer refer, but it is necessary that they should be clearly defined, before proceeding to what has been sketched out as the special subject of observation. The seaward, or lowest of these sections, I have elsewhere termed the "sea proper;" the next, or intermediate one, into which the sea ascends, and from which it again withdraws itself, I termed the "tidal compartment of the river;" and the highest, or that which is above the influence of the sea, the "river proper." Their relative extent, in different situations, is influenced, not only by the circumstances under which the great tidal wave of the ocean enters the river, but by the size of its stream, the configuration and the slope of its bed, and, in short, by every natural or artificial obstruction which is presented to the free flow of the tidal currents along its channel.

These three compartments possess very different physical characteristics, and a totally different class of works is required for effecting improvements on them; and I shall endeavour to point out as distinctly, and, at the

same time, as briefly as possible, wherein these differences consist.

The presence of *unimpaired tidal phenomena* in the lowest; the *modified flow of the tide* produced by the inclination of the river's bed in the intermediate; and *the absence of all tidal influence* in the highest compartment, may be shortly stated as the physical characteristics by which these spaces are recognised. The tidal wave in the "sea proper" compartment, for example (although the place of observation be several miles embayed from what, in strictness, could be called the "sea" or "ocean"), is found, as regards both the amount of its range and its form, to be, practically speaking, identical with that of the adjoining seas; while the identity between the tidal phenomena is farther strikingly exemplified by the practically level line preserved by the low water mark, and by the shortness of the time which elapses between the cessation of ebbing and the commencement of flowing; or, in other words, the absence of any protracted period of low water, during which the sea appears to remain stationary at the same level. In ascending into the intermediate compartment, however, the level of the low water is no longer the same, the range of tide, excepting in peculiar cases, becomes less, and is gradually decreased, as the bed of the river rises; and, at length, a point is reached where its influence is not perceptible. In this intermediate section, the phenomena of *ebbing* and *flowing*, and the consequent reversal of the direction of the currents, take place; but the times of ebb and flood do not remain constant; that of ebb gradually gaining the

ascendancy; and the continuance of low water being gradually protracted as we proceed upwards, until the existence of tide is unknown. This forms the boundary line of the upper compartment, the characteristic of which is, the total absence of ebbing and flowing, the river at all times pursuing its downward course in an uninterrupted stream. In the investigation of these different characteristics, the variable nature of the elements to be dealt with must be kept in view;—the river, for example, is liable to be affected by floods, and the state of the tides by winds and other causes; and, therefore, a great degree of precision in defining these spaces cannot, in all cases, be expected, nor, indeed, is such necessary for the purpose of the present inquiry. But it is satisfactory to know that the termination of the low water level at the separation of the seaward and intermediate spaces, as laid down by Marine Surveyors, simply from observation of the tidal phenomena, has, in several situations, been found to agree exactly with the position of that boundary, as determined by Engineers, by means of accurate levelling, combined with careful tidal observation.*

The remedial means which call for the Engineer's consideration are, as I have already hinted, not less distinct than the physical characteristics which I have endeavoured to describe. The seaward compartment embraces all works connected with the removal or improvement of bars. The tidal compartment embraces a more varied range, including the straightening, widening, or deepening, of the

* The Rivers Mersey and Ribble, and the Firths of Cromarty and Dornoch, may be stated as examples.