DISCUSSION.

Mr. Poole, remarked :—The importance to the people of N. S. Wales of a careful and earnest consideration of the best methods, both scientifically and financially, of permanently improving the bar harbours along our coast, could not in his opinion be over estimated. Therefore, any thoughtful and well directed discussion upon this subject was a national gain, the more so when it was remembered that the bar entrances, at all times intricate and sometimes exceedingly dangerous, were the means, and sometimes the only means, of access to some of the richest agricultural and mineral districts in the world. Unfortunately the gravity and importance of this subject had been considerably weakened in its hold upon the public mind, by propositions more or less earnest, to construct coast railways in order to transport the produce of the coast districts to Sydney. Now, without troubling the Association with a tabulated statement, contrasting railway and coasting steamship rates for transport, and without accepting absolutely the conclusions of Mr. A. W. H. Bailey that a ton of goods could be sent a distance of 2000 miles by water at a cost equal to that of 100 miles by land, still the advantage of water over land transit was so obvious as to need no further illustration. Then what must be said of the proposals to construct coast railways, which from the very nature of the position, had a greater mileage than the transit by water. He would take two cases as an example of the whole. First, from Sydney to Newcastle by water was at the outside only 70 miles, by rail via Homebush and Waratah 104 miles, difference in favour of water carriage, 34 miles. Second, from Grafton to the Tweed by water 100 miles, by surveyed railway line, 165 miles, difference in favour of water carriage, 65 miles. Surely these two examples were sufficient to show the unwisdom, financially at least, of constructing coast lines of railway to compete with shorter water carriage ; and conversely the wisdom of earnestly considering the best way to facilitate the transit of produce by water by deepening and protecting the entrances to our bar harbours. To effect this desirable result, the engineer would be called upon to deal with and master some of the most difficult and complex problems to be found within the whole range of the profession, and although the success and failures of the past might be, and indeed ought to be, as guides and beacons for the future, still no ready cut and dried rule could be laid down to meet any particular case. The engineer who aspired to be something more than a mere copyist, must study for himself, thoroughly and carefully, the whole of the vast natural forces surrounding each particular position, and the play of these forces upon each other. It would, be thought, be readily admitted that he ought, first, to make himself acquainted with the configuration, even to the most minute details of the site of the proposed works; second, the maximum velocity and force of the waves; third, the strength and direction of the littoral current, and the consequent movement, if any, of the shingle and sand along the beach; fourth, the range of the tides; fifth, the angle at the point of intersection of the river and sea; sixth, the maximum and minimum discharge of the river; seventh, the nature of the base upon which the works are to rest, and eighth, what effect his works would have upon any or the whole of the forces just mentioned, and of these forces upon his work. Moreover, it was not enough that a temporary improvement only was obtained; permanent improvement should be the only aim; and without entering into the merits of the various methods of breakwater construction, so ably dealt with by the author of the paper we were now considering; or the suitability of any one of these methods for any particular breakwater for the protection and improvement of any river entrance along our coast, he might, however, venture to say that no permanent improvement would be obtained in any case unless the works were carried sufficiently seaward, so as to bring the outlet or point of discharge within the reach of the littoral current, otherwise a new bar would, in all probability, be formed just beyond the head of the work, and then it might be found exceedingly difficult to extend the works on the old lines and effectually maintain the nozzle action on the new bar.

There was still another matter of great importance, that was the judicious selection of the material to be used in breakwater construction, and upon this subject he quoted from the Treatise on Civil Engineering, by Henry Law, C.E. At page 122, he said :—"A very important branch of the science of hydraulic engineering, as applied to the construction of seaworks, is that connected with the chemical action of the salt water upon materials immersed in it. Some stones and mortars not only when immersed, but also when exposed to the sea air, may often be noticed to decompose and to become covered by an efflorescence of the carbonate of soda, resulting from the action of the hydro-chloride of soda in suspension in the atmosphere, or in combination with the water upon the carbonate of lime. The hydro-chlorides of magnesia present in sea water act in a very peculiar manner upon some stones and mortars, for when the former exist in the state of proto-carbonates of lime, the magnesia enters into combination with it, and as during that process a new crystalline arrangement takes place, it is frequently the case the stone disintegrates. With the argillo-calcareous stones, however, this action does not take place, and it would appear that the combination of the lime with the alumina is sufficiently energetic to enable the stones in which that state prevails to resist the decomposition of the sea water. The same remarks apply to mortars and cements, for it is fcund that unless the mortars made with ordinary limes are perfectly carbonized before being immersed, or unless the cements be obtained from natural argillo-calcareous rocks, or if artificial, unless the lime and alumina have been made to combine intimately by the effects of fusion, however well they may appear to resist in the commencement, they will eventually be certain to disintegrate. At Algiers, Brest, Cherbourg and the Ile de Rhé, some mortars were employed for the formation of large blocks of concrete, and were composed of moderately hydraulic limes mixed with artificial puzzalanos, prepared in accordance with Vicat's suggestion, merely by exposing clays to a low heat, in such a manner as to allow free access of air to all the parts in incandescence. The concretes thus made resisted satisfactorily for some time, but at the expiration of two or three years, they fell to powder; whilst in all cases where the natural puzzolanos have been employed they have not yielded. It appears, therefore, that there are certain changes produced in the alumina by the action of intense heat which render it more capable of combining with lime, and it is probably in this manner that we may account for the admirable result obtained by the application of the Portland cement." "The most important observation to be made with respect to the employment of metals in sea water is, that under no circumstances should any two different kinds be employed in contact with one another. In such cases a galvanic action takes place, by the intervention of the salt waters, which produces very rapid and important chemical decomposition."

Mr. Laing said the subject of Mr. Shellshear's paper on Breakwaters and Training Jetties, was a very important one, and must interest, not only the members of this association but the public generally, for it affected more or less the material interests not only of N.S. Wales but of the whole of Australia, and the great amount of information he had collected and laid before us, with lithographs of various works referred to, deserved from the members the careful study and time necessary for a clear conception of the work, and an intelligent discussion of the various methods adopted to carry out such works to a successful issue, and dealing as he had done with the subject, under two seperate headings, we were enabled to examine better in detail the parts of most importance to ourselves at present.

Speaking of breakwaters, Mr. Shellshear gave the preference to the monolithic system, and as he said, we learn most from failures, he gave us two examples of failures in that system, and although the improvement of cement and other requirements of concrete works had changed the character of such works, and also the time and money requisite to carry them out, the two failures mentioned, Wick and Madras,* go to show that the importance of sound foundations still holds good. Before leaving this portion of the subject for the present, he would remark that Plymouth breakwater was commenced in 1812, and finished in 1841. It was formed to protect the exposed face of a natural harbour, and cost £1,500,000 sterling.

Cherbourg, on the French coast, was an artificial harbour (said to be the greatest and most costly work of its kind) was finished about 1856, was over 70 years building, and cost over £2,500,000. It was the first of our modern marine works in which cement was used to a large extent.

With respect to Dover, a Commission, which sat in 1844, recommended that £2,500,000 should be expended in forming an artificial harbour of refuge at Dover, and the works now being carried on, as described by Mr. Shellshear, were the result of that recommendation.

These three harbours showed the time and money devoted by England and France to such works, and we had now, young as the colony was, commenced preparations for our first harbour of refuge. At Trial Bay the buildings for housing prisoners to be employed on the works had been completed, and the first batch of prisoners had been sent there about three weeks ago.

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*The breakwaters at Wick and Madras are referred to in the paper as examples of the second system, namely, breakwaters founded upon a rubble base with a solid masonry superstructure, and are not examples of the monolithic system as stated by Mr. Laing.—Ed.

Let us now look at the second part, namely, training jetties. Mr. Shellshear said in page 111 "There are few countries in the world where works of this class are more urgently needed than in New South Wales," and further on in the same page, he says :— "The objects to be attained by the construction of training jetties are to confine the inlet and exit of *tidal* and upland waters within definite limits, and to obstruct the progress of sand, as it tends to force its way across the entrance of a river by the action of the waves." and in page 92 he said: "Recent investigations tend to the conclusion, which is in accordance with observation, that every wave is more or less a 'wave of translation,' setting down each particle of water, or of matter suspended in water, a little in advance of where it picked up that particle, and thus by degrees producing that heaping up of waves which gather on a lee-shore during storm. This property of waves accounts for the facts that, although they tend to undermine and demolish steep cliffs, they heap up sand, gravel, shingle, or such materials as they are able to sweep along, upon every flat or sloping beach against which they directly roll, that they carry such materials into bays and estuaries, and that when they advance obliquely along the coast they make the materials of the beach travel along the coast in the same direction,"—and in the next paragraph he said : "The extent to which waves acting obliquely along a coast cause the materials of the beach to travel is well illustrated along the coast of New South Wales, where at almost every inlet sandspits are found forcing their way across the entrance by this action." These quotations formed, he thought, a clear statement of Mr. Shellshear's case, that the entrances of our rivers on the east coast were filled up by deposit from the sea ; this there could be no doubt was correct, and it was also true that the coast presented an oblique lee-shore to all our storm winds, and also that all the rivers having, like "Richmond" river, a north headland at the entrance, present not only an oblique, but also a *dead lee-shore to all* our storm winds.

Having now looked at the cause of the deposit which closed the entrances to our rivers, we would look at the proposed remedy, which, although an estimate of cost was given, was not clearly stated in the paper, and we could only, as the American says, "guess" the method by the examples quoted, and which were said to be applicable in treating our rivers, We could not, therefore, judge the proposed treatment on its merits without plans. We could only enquire and judge whether the conditions of the coast where these examples occur were the same, the cause of deposit the same, and whether the means which remove the obstructions formed by the deposits were also available on our rivers.

In page 111, Mr. Shellshear said: "Within the last few years the Americans have made great advances in the science of constructing training jetties, as along their extended seaboard they have many rivers obstructed by shifting sand bars, under circumstances much less favourable for successful treatment than is the case with the rivers on our coast; for, although the rise and fall of the tide is about the same, the distance to which the shallow water extends is much greater on the coast of America than it is with us." And after describing the works at Charleston on page 114, he goes on to say, "There are many other works now in progress on the American coast, including the great works at the mouth of the Mississippi, where a depth of about 40 feet was secured, against a former depth of only 8 or 9 feet;" and further on in the same page he remarked, "The American system of construction could no doubt be applied with advantage in treating the rivers of New South Wales, although there might be some difficulty in the manufacture of the fascines, as there is not the same abundance of suitable material available." We could observe by these passages that he was very favourably impressed with the conviction that the American mode of treatment would apply to our rivers, but as he was still more favourably impressed in favour of works on the Danube, and he intended to confine his remarks on the comparative condition of our coast and rivers to that of the Danube and Black Sea, into which it falls, he wished before leaving the American works to state what the Mississippi was, for the works on it were identically the same in principle as the works on the Danube.

The Mississippi from its entrance to the source of the Missouri, which falls into it, was over 4,000 miles in length, and, with its many branches, drained a basin of 1,250,000 square miles, which was four times the total area of New South Wales. The *Scientific American* of the 15th May, 1880, said: "The 33 navigable rivers of the Mississippi system comprise 14,000 miles of navigable waters, intersecting or bordering on 18 states and two territories, and up to 1878 18,500,000 dollars (equal to £3,700,000) had been spent in improvements."

It had annual periodical floods, which rose as much as 40 feet at the head of the plain and 20 feet at New Orleans, and thousands of acres of land with their growth of timber on the banks were annually carried away by the current, and formed into shoals at the mouth, and in 1882 a disastrous flood took place, which left 75,000 persons destitute.

It would be appropriate to state here, for reference, the length of some of our own rivers, as stated in an essay on New South Wales by G. H. Reid, Esq., M.P. The length of the Hawkesbury was 330 miles, Hunter 300 miles, Manning 100 miles, Macleay 190 miles, Clarence 240 miles. The length of the Richmond was not given. It had two arms, but measuring the branch on which Lismore was situated, the distance on the map in a straight line from the mouth to the source at Mt. Lindsay was from 60 to 65 miles. Of course it was a winding river, and the actual length was much greater. Lismore was distant from Ballina 70 miles by river, but only 20 miles by land. All of these rivers were subject to floods after a heavy rainfall, but none of our east coast rivers had annual or periodical floods. The Manning River he was not acquainted with, but the Hunter, Macleay, Clarence, and Richmond rivers had all large storage for tidal waters in proportion to their lengths, but it should be borne in mind that the small tidal range on our coast, which as Mr. Shellshear said, "reduces the difficulties of construction," reduced also the rapidity of tidal scour. Let us now look at the river Danube. In page 114 of Mr. Shellshear's paper he said, "Another system of constructing works, and one that is eminently suitable for the successful treatment of our rivers, is the most ingenious plan adopted in the case of the now famous works at the Sulina mouth of the Danube. These works are among the most economical and successful works that have ever been carried out, and having stood the test of nearly 30 years contest with the elements, a somewhat lengthy account of their construction, maintenance, and consolidation should be of special interest." He quite agreed with the favourable opinion of the works expressed in the above quotation, but as to whether they were "suitable for the successful treatment of our rivers," that was a different question, and required further inquiry, and information in answer to the following questions: First, were the shoals at the mouth of the Danube formed by deposit from the rivers or from the sea? Second, were these shoals removed by scour derived from tidal waters or by the concentrated force of the annual flood waters of the river? The second might be answered by simply stating that the Danube falls into the Black Sea, which has *no tide,* and the river has annual periodical floods caused by the melting of the snow and ice formed in the winter months, but, from its important bearing in the treatment of bar harbours, the second question, as well as the first, would be better answered by a quotation from Sir C. A. Hartley's paper, from which Mr. Shellshear had taken the description of the works. The paper was read by Sir Charles (then Mr. Hartley) before the Institution of Civil Engineers, March 11th, 1862, and published in the *Artizan* the following month. Mr. Hartley said : "The Danube, after a course of 1700 miles, during which it received more than 400 tributaries and drained 300,000 square miles, passed in a single channel 1,700 feet wide and 50 feet deep, the Bulgarian town of Wakeha. . . . . . During high floods the inclination of the surface waters of the Sulina has 3 inches per mile, while during extreme low water it did not exceed one inch per mile. At times of ordinary high waters, when the current had obtained the velocity of from $2\frac{1}{2}$ to 3 miles an hour, the Danube before it divided at Ishmail Chatal delivered a volume of water equal to nineteen and a half million cubic feet per minute, while in the dry season, when the current was reduced to one mile per hour, the flow did not exceed seven and a half million cubic feet per minute. At times of extraordinary floods, such as that which occurred in March, 1861, the velocity was increased to 5 miles per hour, and the volume of water then delivered amounted to sixty million cubic feet per minute, or eight times the quantity discharged at ordinary low water. It was stated, as the result of careful observation, that when the waters were most surcharged, they carried to sea at the rate of 1 cubic inch of sedimentary matter, supposing it to be solidified into coherent earth per cubic foot of water, and that not more than one-fortieth part of this proportion was transported when the floods had subsided. Thus, at the former period, upwards of 600,000 cubic yards of alluvial detritus passed into the sea by the several mouths of the rivers in twenty-four hours, and at the latter not more than 15,000 cubic yards. The results of these investigations accounted in a great degree for the changes which took place from time to time in the positions and extent of the sand banks forming the bars across the several mouths."

The second question was, were these shoals removed by the scour of tidal waters, or by the concentrated force of the annual flood waters? As he said before the Black Sea had no tide, therefore there could be no tidal scour, and labour was not interrupted or increased in cost by tidal range. With respect to the flood waters Mr. Hartley said: "Although