there was a great difference of opinion as to the merits of the three principal branches or mouths, all the technical authorities who had studied the question on the ground, agreed in recommending that whichever mouth was chosen, the system of improvement should be that of guiding the river water across the bar by means of piers projected from the most advanced dry angles of the mouth, so as to concentrate the strength of the river current on the bottom of the proposed improved channel by an artificial prolongation of the river banks into deep water." After giving the description of works quoted by Mr. Shellshear, Mr. Hartley went on saying, "In April, 1858, when the works were commenced, there was a navigable channel only 9 feet deep over the long shoal forming the Sulina bar. In November, 1859, when the works had been brought to a close for the winter, the north pier had advanced 3000 feet, and the south pier 500 feet, and there the depth on the bar was 10 feet, which was increased to 14 feet by the following April, although the works had remained stationary. Hopes were consequently entertained that the action of the north pier would in itself be sufficient to maintain an improvement; but these expectations were disappointed, as in August, when the north pier had reached a length of 4600 feet, the depth on the bar had diminished to $9\frac{1}{4}$ feet. Every exertion was then made to bring the opposite pier into play. Accordingly, during the next three months the south pier was advanced 1500 feet, and as it was within 600 feet of the north pier the good effect of concentrating the whole force of the river current on the bar became at once apparent, thus on the 30th of November, 1860, there was a navigable channel of 12 feet, and on the 28th February, 1861, of 16 feet. Then came the breaking up of the ice in the river, and the furious descent of the extraordinary high floods which caused so much damage at Galatz and submerged the whole delta; but this time, instead of the depth on the bar being diminished, the swollen waters confined between the two piers, and directed in a proper line, fairly swept away the remains of the bar on to the south bank and into deep water." It would be seen from these quotations that these shoals were formed by the river waters, and removed by the concentration of the discharge of the river waters, they, the floods, being the prime factors in both cases. Mr. Shellshear informs us that after 10 years the piers were lengthened 1100 feet. He contended they would require to be lengthened periodically, the time might be longer or shorter, in proportion to the depth of the sea when the river water was discharged, and the surface area of the bottom over which the alluvial detritus was spread by the action of winds and current, but 600,000 cubic yards of matter, or even 15,000 cubic yards per day could not be discharged in one place day after day for years without forming a shoal in the place of deposit.

The question now remaining to be dealt with was, how can the Richmond River be made a highway for trade, safe and open at all times in all weathers ?

The matter could be dealt with, he thought, in two ways, viz., by canal joining it to the Clarence River, or by training walls, breakwater, and dredging, to contract and clear the entrance.

The entrance of the Richmond was one mile wide, and it was on a dead lee-shore to all our storm winds and waves, as he said before, with the north head standing out nearly 5000 feet to the eastward, intercepting the sand carried along our coast by the storm, to all of which it was open, and by which it is blocked with this sand. A remark made by Sir John Coode in a report on the Timaru breakwater in New Zealand, was very appropriate in this place, it was as follows : "In order to be successful the travel of the shingle northward must not be interfered with." There were scattered rocks outside the north head, and also a large rock with 9 feet of water on it, termed middle ground ; it was about 1500 feet south-east of the north head, and it seemed to him that if the entrance was to be rendered accessible in all weathers, it would have to be done on the principle so successfully adopted for Newcastle Harbour, viz., with inside training wall on north side, say from pilot station to the south end of rock termed middle ground, this wall would be 4000 feet long, and on the south side a training wall and breakwater from the upper end of Mangrove Flat to the south spit breakwater, from there past the north training wall, leaving a passage 1500 feet wide, trending round in a north-easterly direction until it came in line with the north head to divert the sand past the north head and outlying rocks, and prevent the storm waves dashing vessels on the lee-shore. This training wall and breakwater on south side would be 2½ miles long. One half of it would be in deep water, and the entrance would not be so well protected as the entrance to Newcastle, for even with the length stated there would be troubled waters at north head in an easterly gale. The cost of this breakwater he would scarcely like to say. The last 1650 feet of breakwater outside of Nobbys, at Newcastle, cost about £60,000, rather over £36 per foot run.

In 1879, Sir John Coode reporting on the Belfast harbour works at the entrance of the river Moyne flowing into Port Fairy as reported in *Australian Engineering and Building News*, 1st September, 1879, said: "The construction of a work nearly, if not quite, 3000 feet in length would involve an expenditure of not less than £450,000 or £500,000," this would give a cost of about £166 per foot run, and would be a nearer proximate of the cost of an effective breakwater at Richmond River entrance, than that of the breakwater at Newcastle would be.

The other method which could perhaps be adopted would be to cut a canal joining the two rivers, Clarence and Richmond. The Clarence entrance was more easily dealt with, and bringing the waters of both rivers into one channel, and concentrating expenditure on one entrance, a better port might be got for less cost. This, of course, could only be determined after a careful survey, not only for the best place of cutting and the cost of a canal, but also as to the effect the flow of the Richmond into the Clarence would have on the fertility of the district below the junction of the canal. The Richmond River being a very winding river watered a large space in its course, the distance from Ballina to Lismore being 70 miles by river and 20 or 22 miles by land; and no doubt the river had a great influence on the fertility and value of the country through which it passed.

He now wished to show what had been done at the entrance to the Hunter River. Having a southern headland at entrance, and the change caused by training walls and good breakwaters carrying the storm water and sand past the entrance, and by judicious dredging, one plan would show the condition of the place in 1816, when the greater portion of it was sand flats, the second plan was one showing the condition of the port in 1883, with a city built on its banks and accommodation in the harbour for from 50,000 to 60,000 tons of shipping. Exclusive of coasters, in 1883, 656,906 tons of shipping came into, and 926,596 tons left Newcastle.

He closed his remarks by reading a report, dated 16th June, 1882, from the Harbour Master at Newcastle to the President of the Marine Board, Sydney, taken from a return laid before Parliament in 1883.

The Harbour Master, Newcastle, to the President, Marine Board.

Harbour Office, Newcastle, 16th June, 1882.

SIR,

I have the honor to forward for your information copies of soundings in the fairway of this harbour, taken under favourable circumstances, 27/4/81 and '82, which shows a steady increase in the depth of water over those taken in 1880. This serves to confirm my opinion expressed in letter on that subject, dated 30/4/80. The increased depth of water is owing to the very large amount of dredging done in the harbour, thereby admitting a large volume of water, which has greatly increased the scouring influence, between the southern breakwater and the northern retaining wall (or breakwater). The latter has had the effect of removing a large sand-spit, which was partly above water, running out from Scott's Point, and caused a very dangerous eddy that does not now exist. Where it was dry, there is now 8 feet of water at low tide, and I have no doubt that, if the retaining wall is kept in repair, there will soon be 20 feet, thus giving about 150 feet more width in the narrowest and most intricate part of the harbour.

The North Channel still continues to increase in depth through the same influence. I may note that the much dreaded Oyster Bank, abreast of Nobby's, is now a thing of the past; where there was only 7 feet there is now 19. All these increased depths in the fairway and North Channel, where the dredges have never been employed, must be the result of extensive dredging in the harbour, which has caused a great scour in the fairway, as already expressed.

I have also forwarded copies of soundings taken across the harbour in 1860, with those taken on the same lines of bearings, in May, 1882; which must be interesting to all concerned, as they show the enormous quantity of silt that has been removed, to obtain the present accommodation. You will observe the position of the red buoy on the south elbow of the Horse-shoe, where there was only 4½ feet, there is now 20 feet at low-water; also, the white buoy on the north arm of the Horse-shoe, where there was 10 feet there is now 21 feet at low-water. Both of these buoys have been removed, being no longer required. The deep water extends a considerable distance to the westward beyond what is shown on the chart, until the end of the high level coal staiths comes in line with cathedral.

Within a short distance off the wharf, there is not less than 23 feet across the harbour, over a sand-bank that formerly dried at low water (see chart enclosed); but, notwithstanding all that has been done, a great deal more space is required to meet the requirements of the large ships and steamers now visiting this port.

It was only a few days ago that 50,000 tons of shipping were safely moored in this port (which proves its capabilities), that a few years ago was a mass of sand-banks forming dangerous eddies and intricate navigation. Such is the result of judicious engineering, which has made this once dreaded harbour to be perfectly secure and safe to enter or leave by day or night.

I have, &c.,

D. T. ALLEN,
Harbour Master.

Mr. Shellshear, in reply, remarked that the danger of the bar re-forming in front of works at river entrances was confined to the case of shallow seas where the depth was small for a long distance from the shore, but in the case of our rivers the depth increased so rapidly sea-ward that there was no probability of any trouble on that score if the bar was once removed.

No doubt great care would have to be exercised in the selection of cement for sea works, but at the present time there was no difficulty in getting cement of suitable quality with proper supervision.

The question of the time taken to construct sea works was not of so much importance in the case of breakwaters as it was with training jetties, for, as a rule, breakwaters were built on sites which are, so to speak, permanent, but training jetties were erected where the nature of the bottom is constantly varying, and therefore if training jetties were not pushed forward with dispatch great additional expenditure would be incurred.

Reference had been made in the paper to the Mississippi and Danube works, and some little misunderstanding had arisen as some of the speakers had confused the question of the constructive details of the works with the action that training jetties produced. In the case of a river flowing through a delta into a tideless sea, training jetties protected the entrance from the action of the waves, and concentrated the flow of the river in a definite channel, and as far as the action of the waves was concerned, the works performed the same function whether there was a tide or not. It had been stated that with our small range of tide it would not be possible to get a sufficient velocity over the bars to remove the sand, but the question of velocity was one that depended upon the proportion that existed between the tidal capacity of the river and the width of the entrance, and by contracting or expanding the width of entrance, the velocity of tide could be regulated to any required extent. Sir John Coode reccommended works somewhat similar to those at the Danube for the improvement works at the entrance to the Gippsland Lakes, and these works were now in progress. This entrance was quite as exposed as the river entrances on our coast.

Referring to the extension of the piers at the Sulina mouth of the Danube, it should have been stated that the piers, as originally carried out, did not both extend the same distance seaward, and it was found necessary to extend the south pier out the same distance as the north. There was also a cutting back action at the shore end of the north pier which necessitated that pier being extended landwards for some distance; but no extension has been found necessary in addition to the original length of the north pier seawards.

The works going on in America were designed to give the current a sufficient velocity to clear the channels without dredging. Reference had been made to Newcastle; there could be no doubt that Newcastle had been greatly improved, but at that place the harbour had been improved by protecting it with a breakwater, which enabled dredging to be carried out under the protection of the works; over 6,000,000 tons had been dredged from that harbour, so the improvement could not be looked upon wholly as the result of improved tidal scour. If our smaller rivers were to be improved at any reasonable cost, the only system upon which this could be done, was by the induced tidal scour produced by the construction of training jetties, as the expense of constructing protecting breakwaters, and then dredging a channel would be too great to come within the means of the districts through which the rivers flow.

Port Fairy (Belfast, Victoria), was referred to by one of the speakers. The works recommended by Sir John Coode in 1879 were for the formation of an outer harbour, and not for the improvement of the river.

The velocity of tide through the Dublin entrance was $3\frac{1}{2}$ miles per hour, and had been found sufficient to maintain the entrance and remove the bar.

The following table, founded on those given by Du Buat and Beardmore, shows the approximate velocities at which water will move various material

Velocities.			Material.
Feet per Second.	Feet per Minute.	Miles per Hour.	
0·50	30	0·34	Will just move fine sand.
0·70	42	0·49	,, ,, ,, coarse sand.
1·00	60	0·68	,, ,, ,, fine gravel.
2·25	135	1·53	,, ,, ,, pebbles 1 inch diameter.
3·34	200	2·25	,, ,, ,, ,, $1\frac{1}{2}$ inch diameter.
4·00	240	2·72	,, ,, ,, heavy shingle.