Mr. Brunlees said the only explanation he had to offer was in respect of the cost of the two piers. It would have been noticed that the cost of one pier was almost double that of the other, although the designs in both cases were similar, and the difference in cost ought not to have been more than about £2,000. In explanation he stated that New Ferry Pier was built for one proprietor; and in that case Mr. Brunlees was permitted to appoint his own Resident Engineer, and was fortunate in having a good contractor. The New Brighton Pier was under the superintendence of a Board, who appointed their own Resident Engineer, and were very unfortunate in their contractor.

Mr. Haughton thought it might add to the interest of the subject if he referred to a disastrous event which occurred to the New Brighton Pier in the autumn of 1867, and which he witnessed. While fully appreciating the great ingenuity of the design, and the extreme simplicity of the whole structure, it seemed to him, previous to the event alluded to, that the landing-stage was in a very unprotected state. One day while waiting for the ferry-boat to Liverpool, he noticed a screw steamer, the 'Galileo,' coming down the river, apparently outward bound. After a time her helm was put a-starboard, and an endeavour was made to anchor her in the centre of the river, by wheeling in a semicircle so as to place her head to the tide. A strong south-east wind was blowing, and in making this manœuvre, the pilot miscalculated the force of the wind, and the vessel would have gone ashore to the northward of the pier, had the pilot not placed her alongside the landing-stage—the best thing under the circumstances that could be done to insure the safety of the ship, which was ultimately accomplished. It struck Mr. Haughton that the bridge was in serious peril. The pilot then put the vessel ahead under full steam; but she had not proceeded more than about 50 yards from the landing stage, when the strong wind, catching the ship on the port bow, blew her across the head of the stage, and after a time the pressure became so great, that the moorings yielded, the bridge curled up in the air like a sapling, and fell in three fragments into the water. The landward end of the bridge was torn from its connection; but the riverward end retained its attachment to the arch by means of the chains, until some one on the landing-stage cut it loose with a chisel and let it go 'by the board.' The bridge had since been renewed, and now rested on the landing stage on a series of rollers set in a frame.

Mr. Bramwell said, with regard to the accident that befell one of these structures, it had not been suggested that anything ought to have been done by the Engineer which had not been done. A very large steamer, such as was never intended even to come alongside, to avoid being driven on shore, not only came alongside, but actually into collision. Mr. Bramwell did not think, from what he had heard, that the designer of this pier would have been justified in providing means for resisting an extraordinary occurrence of that kind; and in corroboration it appeared that those who reconstructed the work had not taken any extra precautions against a similar accident. It seemed that the connections of the bridge were more than sufficient for all ordinary purposes, and that they were not even injured by the collision. Mr. Brunlees, therefore, might be congratulated on having made an efficient, but inexpensive pier; and probably the captain of the steamer, revolving in his mind the value of his vessel, in comparison with that of a pier which should have cost only £10,000, did the best thing he could in running into something cheap.

Mr. Bazalgette said it was satisfactory to him to observe that, in their general features, these works were much the same as he had adopted in the construction of the landing stages of the Thames Embankment. The main difference appeared to be that the pontoons of the New Ferry and the New Brighton landing stages were carried out from the shore into deep water, and were so arranged that vessels could come alongside; while in his case the Embankment had been carried into deep water, and the object was to construct the piers so as not to project, or in any way to impede the navigation of the river. Consequently, in those now constructed on the Thames, the bridges, instead of being at right angles to the shore, were parallel to the roadway, and were masked behind a wall. Again, the pontoons were placed in recesses, and kept in position by iron guides fixed in the masonry. In adopting that mode of construction, it had occurred to him as possible, that deposit might take place under the pontoons. To obviate that, arches had been built under the Embankment, into which the tide was allowed to flow at high water, and within which it was retained by means of penstocks; so that on the penstocks being raised at low water, the bed of the recess was flushed out, and the deposit which had accumulated under the pontoons was cleared away. He was not prepared to compare the size and cost of the Embankment pontoons with those described in the Paper. In the arrangement he had adopted, the bridges were necessarily placed upon one side of the pontoon; the effect of this was to cast the pontoon over towards the shore, and in consequence it had been necessary to load the pontoons on the other side, to make them balance. He thought it would be advisable in future, under similar circumstances, to construct the bridges of steel, rather than of iron, and thus to make them much lighter. The pontoons were reduced in cost by utilizing the caissons which had been previously used to form the coffer-dam in the construction of the Embankment. These caissons were the ground-work of the pontoons; and by that means considerable economy had been effected.

Mr. G. H. Phipps asked whether, in this mode of construction, any weakness was found to result from the twisting action of the separate pontoons, caused by the action of the waves at each end of the pontoon?

Mr. Brunlees replied, that this was provided against by strong keelsons running from one end to the other of the pontoons.

Mr. Grover wished to ask one or two questions, as he had found some difficulties in carrying out works of a similar character. In the first place he would inquire if any of the piles had been broken in the process of screwing into the ground, and if any observations had been made as to the effect of salt water upon iron piles in general. He believed that considerable difference of opinion still existed, as to whether it was advisable to use cast or wrought iron. In a pier he was executing on the Thames, at Woolwich Arsenal, he decided to use wrought-iron cylinders in preference to cast-iron columns. He believed the iron, whether wrought or cast, usually failed at those points where the bolts passed through the flanges. Galvanic action he presumed took place at those points, and rapid decay of both bolts and flanges followed; so that, practically, the durability of the structure was to be measured by the durability of the bolts. He should like to be informed, whether any protecting material was used for preventing the action of the water upon the piles in the Mersey, and whether the interior was filled up. In the Clevedon pier he had filled the piles with a solution of coal-tar, lime, and sand, poured in at the top. In the work which he was carrying out at Woolwich Arsenal the wrought-iron cylinders were coated with a solution of coal-tar, naphtha, and resin. This he considered should be done just before immersion, for if rust was once allowed to set in, neither coal-tar nor any other application would be of any avail. The cylinders were afterwards filled in with concrete.

Mr. Beardmore remarked, with regard to the piers at Liverpool, that there was always a gentle rolling movement, with a strong breeze and a counter-tide in the Mersey, and in heavy weather it was very sensible; but the longitudinal keelsons kept the pontoons together, so as to a great extent to distribute the effects of the waves. The most troublesome thing hitherto on the Thames had been the ice, which, in severe winters, accumulated beneath the pontoons to such an extent as to endanger their safety. He much feared that the new landing stages on the Thames would be in some peril from the same cause, from the peculiar recesses in the Embankment within which the pontoons were placed. With regard to the question of the decay of iron in works of this kind, there was nothing to be feared, under ordinary circumstances when reasonable care was taken. There had recently come under his notice, the case of a sea lock, which had existed for thirty five years at the head of a ship canal containing very soft water. When pumped out for repairs, it was found that all the cast and wrought iron portions of the gates, &c., were equally destroyed. Even the spikes of the platform planking were perished, though the timber was perfectly sound. He attributed that intense action of the water upon the iron to the mixture of fresh and salt water, to which the lock was peculiarly subjected, as the soft water was 'locked' down direct into the saltest of sea water. Cast and wrought iron similarly exposed, and for the same length of time, in the Thames would be scarcely affected, probably from the absence of the mixture of salt water.

Mr. Hemans inquired whether any inconvenience was found in having the pontoons which supported the landing stages at right angles to the current. It appeared to him that if thick ice or floating timber got lodged between the pontoons considerable inconvenience might result. It would be a simple matter to connect the ends of the pontoons, so as to make a flush side, like that of a ship, along which the water would flow without interruption.

Mr. Mallet remarked, as to the amount of movement of the large landing stages on the Mersey, that several years ago, during a strong winter gale, when the waves were probably from 5 feet to 6 feet in height in the estuary, he had ascertained, from rough personal observation, that the twisting or buckling of the floor of the St. George's Pier landing stage, which had been constructed from the designs of the late Sir W. Cubitt, was about 5 inches. The general question of the durability of iron was a very important one, and he could not then venture to enlarge upon the subject of the corrosion of iron, to which he had devoted a good deal of attention. Briefly, he would say that the result of observation induced him to consider wrought iron was, upon the whole, a more durable material than cast iron. It was true that some wrought iron corroded faster, but only a little faster, than some cast iron; but the amount of decay, and the rate of weakening, could be ascertained by measurement in the former, whereas in cast iron the nature of the corrosion was entirely different, and the mass of the material suffered a molecular and chemical change to a considerable and uncertain depth. In sea water, especially if mixed occasionally with well aërated fresh water, there was the maximum rapidity of corrosion, both of wrought and of cast iron, except that producible by the admixture with sewage water, which often contained matter that corroded iron almost as fast as diluted vitriol. The protection produced by even a thin film of mud, covering up immersed iron, so as to screen it from fresh supplies of water unexhausted of its combined air, had a marvellous effect in preserving it. With regard to artificial modes of preservation by various coatings, in his opinion there was nothing equal to coal tar, well boiled, with a mixture of finely-powdered dry caustic lime. The iron to be coated should be previously heated to about 600° or 700° Fahrenheit, and be dipped into the mixture. It was useless merely to pay over cold iron with coal-tar, as was often done; the iron must be heated almost to a black red, be immersed for some time in the hot tar, which then perfectly dried upon it, and produced a varnish almost as persistent as the japan on a tea-tray. If the iron were previously painted with oil-paint, the coal-tar would not adhere, nor become hard and dry upon it.

Mr. Redman mentioned, with reference to the decay of iron structures exposed to the action of salt or brackish water, that in the estuary of the Thames, there were several works which had been completed from twenty to twenty five years, where the pillars were of cast iron, and which yet remained intact at the present time. The pier at Milton-on-Thames, below Gravesend, designed and carried out by him in 1842-44, was supported on cast-iron columns, 3 feet in diameter, the metal being $1\frac{1}{2}$ inch thick, and these were unaffected by such action. The Gravesend Town Pier, by the late Mr. Tierney Clark, M. Inst. C.E., was on similar supports, the metal being $1\frac{1}{4}$ inch thick; and these too, though about thirty years old, were similarly unaffected. The cast-iron columns of the Maplin Sand Lighthouse, erected about the same time, likewise remained sound, although the metal was only $\frac{3}{4}$ inch thick.

Mr. Brunlees said, in reply to the observations as to the unprotected state of the pontoon at New Brighton, that in the original design he proposed to construct dolphins at each end for the protection of the pontoons; but Admiral Evans, the Conservator of the River Mersey, would not allow this to be done. Hence the alleged unprotected state of the pontoons. In reference to the durability of cast iron in salt water, so far as these piers were concerned, the time had been too short to form any opinion upon it. But he might state, with regard to the viaducts which had existed in Morecambe Bay for fifteen or sixteen years, that there was not at this time any sensible decay in the iron columns there. The whole of the cast iron work in these structures was protected with a preparation of tar and asphalte. The tar was heated in a large tank, and each piece of ironwork was boiled in that preparation for half an hour; this he believed was the best protection for cast iron. With reference to the interior of the piles, his practice had been to fill them in simply with clean sand, and by that means he found the water was excluded from the inside of the piles. If the water were not excluded, in frosty weather the columns would be apt to burst. As to the anchors, those used were so large and efficacious that hitherto none of them had dragged. There was not the slightest risk of ice, or other material, getting into the spaces between the pontoons, because a rubbing piece was placed at the water-level all round the stage. He could not agree in the opinion that wrought iron was preferable to cast iron for use in sea-water, inasmuch as in order to bring down the cost to the same as cast iron, it would be necessary to employ wrought iron so thin that it might be more liable to waste away and to be affected by mechanical injury. He believed the decay of cast iron was not so rapid as that of wrought iron, and that it was a safer and more reliable material.

Mr. Mallet explained, that he did not say anything as to the choice between wrought and cast iron as applied to piers in water, or other like structures; nor did he wish it to be inferred, that in all such cases he preferred wrought iron to cast iron. He referred simply to the relative durability of the two materials in respect to aqueous corrosion, and to the character of that change in each. But many other considerations besides corrosion must enter into the engineer's consideration as to the material for piles, piers, &c., in or out of water. And so far from being prepared indiscriminately to employ wrought iron, he should, until it could be manufactured into hollow piles, in forms much cheaper than were at present possible, endorse the use of cast iron, as adopted by Mr. Brunlees. The question of durability in cast iron resolved itself, as regarded cost, into one of so much increased thickness at the outset as amply to allow for it in reference to a predetermined period of endurance.