Discussion.

The PRESIDENT, in proposing a vote of thanks to the Author for his Paper, which described a very successful commercial work well carried out, mentioned that the Author was in China, but Mr. John T. Wood, one of the engineers of the work, was present and was prepared to afford any further information required by members in regard to the work. The President.

Mr. JOHN T. WOOD observed that since the writing of the Paper some modifications had been made, although not of a very important character. When the Paper was written the Tranmere Bay Development Company had 60 acres of the foreshore available for works; since then another 15 acres, extending right up to the southern boundary, had been added; that was, they had exercised their option of taking the whole of the land. The extra 15 acres gave an additional frontage of 300 feet to the river, and slipways were now in process of construction. There had also been an alteration in the inclination of the launchways, which were originally designed to have a slope towards the river of $\frac{5}{8}$ inch per foot. The north slipway, nearest the outer basin, had been constructed in that way, but it had been thought desirable in all the others to construct the first 50 feet from the river-wall with $\frac{5}{8}$ inch per foot slope, making the remainder of the slope $\frac{1}{2}$ inch per foot. The Author drew attention to the forward movement of the south wall of the outer basin, at a point between the 150-ton crane and the south-west corner. During the last 4 months there had not been the slightest alteration in that wall; and $11\frac{3}{4}$ inches was the total advance. It was not expected that the wall would move again; it was thought now to have settled into its natural position. In slipway No. 1 there were 450 piles covered by a blanket of concrete 4 feet 6 inches in depth and 44 feet in width, the concrete being reinforced with steel rails. He had placed on the wall two diagrams (*Figs. 7* and *8*) of a scheme which had considerably interested him; they were designs made by the late Mr. James Abernethy in 1862, for the utilization of the same site for docks. The Tranmere Bay Company occupied only 75 acres of the shore available between Birkenhead and Rockferry, but Mr. Abernethy planned the utilization of the whole area of 175 acres. To students of the advance that had been Mr. Wood.

Mr. Wood.

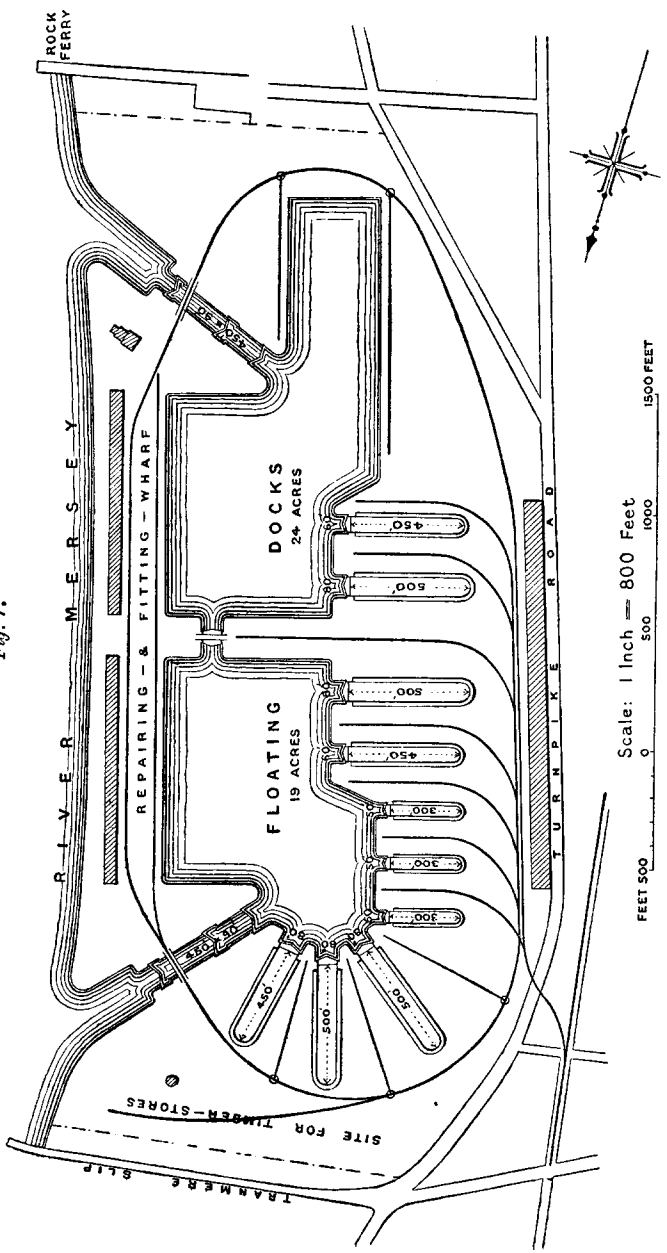
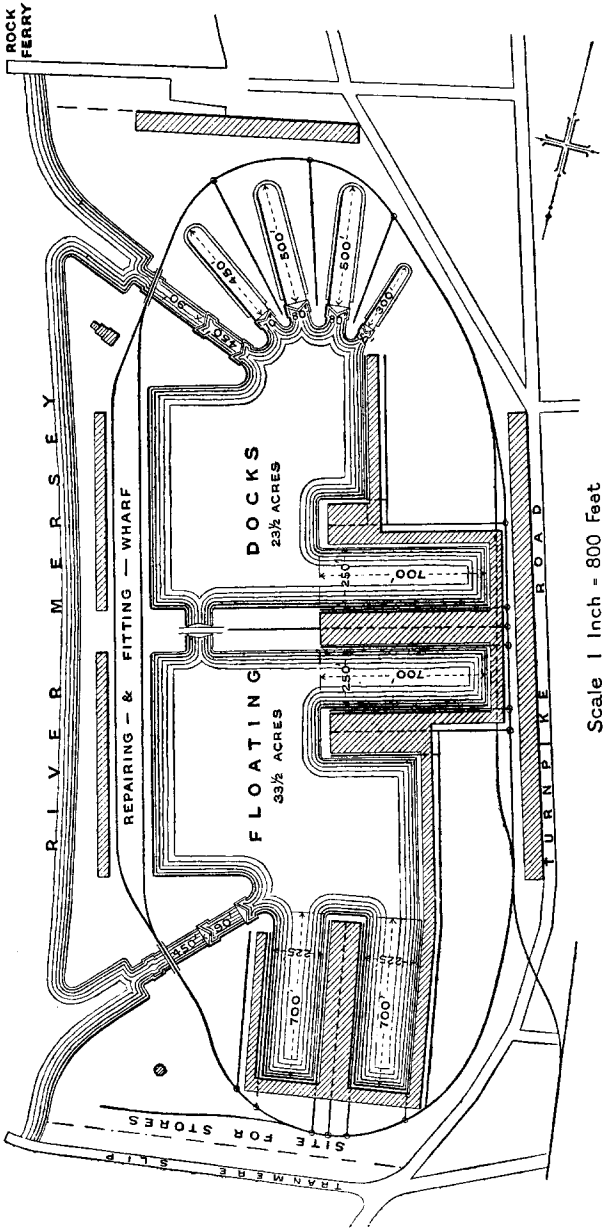


Fig. 7.

MR. JAMES ABERNETHY'S PLAN FOR DOCKS FOR WARSHIPS AT TRANMERE BAY, 1862.

Fig. 8.



Mr. James Abernethy's Plan for Commercial Docks at Tranmere Bay, 1862.

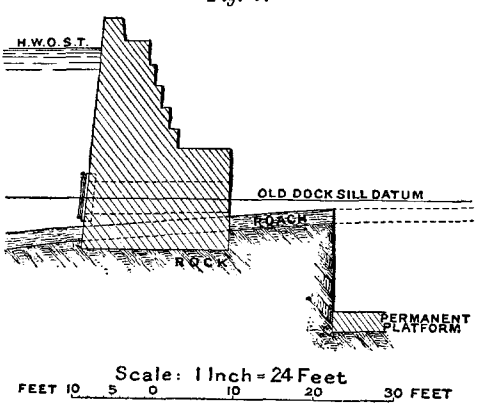
Mr. Wood. made in the building of ships, both for war and for commercial purposes, the diagrams were of considerable interest as showing what were considered 45 years ago to be up-to-date high-class works. *Fig. 7* showed the intended provision for warships and other large vessels. There were to be ten graving-docks, the largest of which were 500 feet long, with entrances 80 feet in width, and the smallest 300 feet long with 50-foot entrances. There was to be ample accommodation in the wet docks, which were to be approached by entrances having locks 450 feet in length. There were to be quays between the graving-docks, all the quays being supplied with railways for getting material to and from the vessels. As a matter of fact, an arrangement of that character, although designed in 1862, would put some of the docks in Liverpool, now held by the Mersey Docks and Harbour Board, very much in the shade as regarded railway-facilities and accommodation.

Sir Wm. White. Sir WILLIAM WHITE asked what was the intended depth of water.

Mr. Wood. Mr. WOOD could not say, as he had not seen any sections.

Mr. Brodie. Mr. ROBERT BRODIE wished briefly to supplement the information given by the Author with regard to the dam. The concrete wall adopted at the north end (*Fig. 9*), where the foundation was on rock above low-water level, was probably more expensive than a timber

Fig. 9.



dam would have been, not only in construction, but also in removal, after which the materials were of no value; but the advantages of adopting this construction were, first, greater stability at the most exposed part of the dam, secondly, no struts were required and therefore the dam could be kept closer to the wall, and thirdly, and

Mr. Brodie.

chiefly, the necessary sluices could be much more satisfactorily provided through concrete than through timber and clay puddle. One of the lower sluices with the timber flap was shown in *Fig. 9*. The construction of the strutting of the timber and puddle portion of the dam had been carried out under considerable difficulty, as the whole of the foundation was either at or below low-water level, and was in silt of a very objectionable character. Before commencing to deposit the clay between the sheet-piles of the dam, he attempted to remove that silt by pumping, but it came in almost as quickly as it was cleared out: he decided therefore to trust to the weight of the clay forcing the bulk of it out, and accordingly commenced filling from both ends of the dam and allowed the toe of the slope to keep in advance of the closing-piles, so that the silt might escape. As the dam was filled and the closing-piles were driven, clay was deposited on the outside of the dam, and that no doubt settled well down into the silt and prevented what was a real danger, namely, the bursting through of

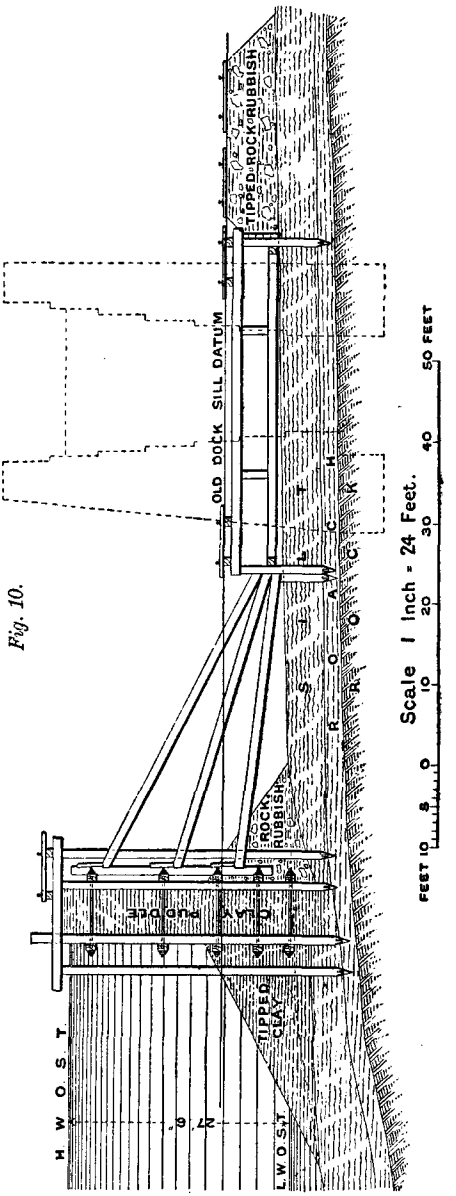


Fig. 10.

Mr. Brodie. the water between the points of the piles and the rock, as the piles penetrated the "roach," but could not as a rule reach the solid rock. Rock rubbish was also deposited against the inner side of the dam (*Fig. 10*). The short piles which took the thrust of the rakers were also driven in the silt and had therefore no practical effect, so that it was necessary to transmit the thrust by struts to another row of similar piles backed by a rubble bank, which besides supporting those piles served as a foundation for two roads which were utilized for excavating the foundation of the permanent wall. Those roads were connected by a road inclined at about 1 in 30, running up the inner slope of the southern embankment shown in Fig. 2, Plate 2. The inner white strip there shown should have come down to the rubble bank; the outer white strip was the top of the bank, on which the roads were laid at about coping-level, and continued over the top of the dam. They were used for concreting the permanent wall and for unloading cargoes of gravel, cement, granite, etc. The cost of the coffer-dam had been approximately £12 per foot for the concrete portion, and £24 per foot for the timber and puddle portion, including erection, maintenance, and removal, and crediting the value of the material removed. The maintenance was not a heavy item, but it was considered advisable to have a man constantly in attendance for about 3 hours before and 3 hours after high-water at every tide during the 2 years the dam was in use. During all that time there was not the slightest leakage under the dam. At first there was slight leakage in places through the clay, chiefly at the bolt-holes, but after the clay had fairly settled down there was practically no leakage, unless at high spring-tides, when there was a certain amount of leakage under the caps. That, however, was easily dealt with by two 9-inch, belt-driven, centrifugal pumps, one placed at the mouth of No. 2 graving-dock and the other at the south-east corner of the outer basin. Those two pumps easily dealt with the drainage-water of the whole area, except on the night of the 26th November, 1905, when there occurred the highest tide ever recorded in the Mersey. It rose about 3 feet above extraordinary high-water mark, and as there was a considerable swell, every wave for nearly an hour swept over the whole length of the dam, making a waterfall about 900 feet long and 30 feet high, the beauty of which he was unable to appreciate. No damage was done, however, the rock bank behind the dam proving an excellent receptacle for the falling water. He noticed in connection with the southern embankment that the Author referred to the outer slope as being pitched. That was rather misleading, as the outer portion was formed of rock excavation, simply deposited from

side-tip wagons to protect clay from the wash of the water. There was only one point in the Paper on which he would like to express a difference of opinion, namely, the Author's statement that great economy had been effected by leaving in the rock sides and bottom of the graving-docks. In fixing an all-round price for that rock excavation, it had been necessary to consider the extra cost entailed owing to the careful manner in which the work had to be carried out. If permission had been given to take the rock out roughly, making provision for a thin lining of concrete, he thought it would have been almost, if not quite, as cheap; and there was no doubt that concrete altars and floors would have been more satisfactory than sandstone rock. Mr. Brodie.

Mr. ARTHUR MUSKER did not intend to discuss or criticize the Paper, but wished to add a few particulars in reference to the machinery for closing and opening the dock-gates. Seeing that there had been, and still was, considerable controversy as to the merits of electrical machinery *versus* hydraulic, it occurred to him it might be interesting to the profession to know the result of the working of electrical machinery in the present case. The construction of the machinery had been entrusted to him partly by the Mersey Docks and Harbour Board and partly by the Tranmere Bay Development Company. The Docks Board in the first place specified, and had fitted, hand-worked machinery only, but this was afterwards converted into electrically worked machinery by the Tranmere Bay Company. The hand-worked machinery was of an ordinary type, having opening- and closing-chains wound on barrels driven by spur-gearing, which in their turn were worked by capstan-bars. The gates were 91 feet wide and the chains were $1\frac{1}{2}$ inch in diameter. These were outer gates or storm-gates, and considerable shocks came upon them, as would be realized when he mentioned that the chains had been broken. The machinery was specified to be stronger than the chains, and therefore received practically no damage. Afterwards, when it was converted to electrically driven machinery, spur- and worm-gear was added with motors, a slipping clutch being placed between the motor and the gear so that the motor should not be overloaded in any way. The worm-gear was added solely on account of want of space. This was therefore an instance of ordinary machinery, driven electrically, working under circumstances in which shocks were very severe; and it worked very satisfactorily, although personally he thought hydraulic machines were more adapted to rough work of that kind. Certain improvements had suggested themselves in the case of electrical machines of that type, namely, mechanical buffers Mr. Musker.

Mr. Musker. of some kind between the gear and the shocks. He thought there would be no difficulty in working them, any more than there would be with hydraulic gear. He did not know of any other electrically worked machines for dock-gates of that size, and if there were any he would be glad to hear of them. The power of the motors for working the 90-foot gates was only 15 to 20 HP., and the time of opening was 3 to 4 minutes.

Mr. Hudleston. Mr. F. HUDLESTON had listened to the Paper with some interest because, as an old pupil of the late Mr. G. F. Lyster, he knew the class of work that was done in Liverpool, and it was interesting to see the differences between the more modern graving-docks and appliances and those which were built 15 years ago. First of all, the cross section of the graving-docks at Tranmere Bay seemed to him to be rather too steep in the sides to give proper light and air to the bottom of the graving-dock. When he was at Liverpool the favourite dock of the time had a much flatter slope; and although he believed that in some of the newer docks the sides had had to be made steeper, it should be remembered that some of the older docks in Liverpool were nearly as steep in the sides, and they had gone out of fashion in favour of the flatter slope, which, giving much more light and air, enabled a ship to dry better, and consequently enabled work in the bottom of the dock to be carried out more satisfactorily. The next point he wished to refer to was what was described as the movement in the south wall at the west end. As far as he could make out, the rest of the wall between the river and the crane was founded on rock. The inner part was on bearing-piles and moved outwards about 11 inches as a maximum. It was said that the wall did not cant over at all but slid at the bottom. That was interesting because in older practice there used to be a regular habit of building a long straight wall with a definite inward camber to allow for any movement that might take place in the settlement of the toe and the general pushing out of the wall, and thus to mask the ugly appearance of such movement. In the present case the whole wall appeared to have slipped out, and that seemed to him to be chiefly consequent upon the use of the bearing-piles. The diagrams (Figs. 4, Plate 2) showed three together without much rake, two towards the toe and one at the back. It appeared to him that it would have been rather a better design to have the front two closer together, because the mass of concrete could easily bridge the distance between, and all the pressure was on the toe. At that depth of excavation it was not easy to drive piles with a rake. It was not altogether to be wondered at that when the filling

came in at the back of the wall there was a pushing-out generally and the wall, as it were, swung over on the piles, and bulged out into the dock. Mr. Musker's remarks about the machinery for the gates were very interesting. In common with many men who had been brought up in docks, he himself would prefer distinctly to have hydraulic machinery for gates, but he thought in the present case, where the large gates were seldom used —probably they were only opened very seldom, certainly not on every tide—it was not necessary to adopt expensive hydraulic machinery, because electrical machinery was distinctly cheaper; and moreover it was probably so made that hand-power could be applied at any time in the event of failure of the electric plant. He noticed caissons in the graving-docks, from which he gathered that the docks were not intended to be used very frequently. In Liverpool, in his own time, graving-docks invariably had gates, and they were especially used for painting vessels. Probably the Tranmere Bay graving-docks were used more for heavy repairs, when it did not matter whether 10 minutes were lost in getting the caissons set after vessels had come in or gone out. Mr. Hudleston.

Sir WILLIAM WHITE, K.C.B., Past-President, observed that for him the Paper possessed great interest, because he believed he was right in saying that the works had been undertaken largely to give to the old-established firm of Laird at Birkenhead the power of dealing with modern ships both in building and in repair—ships which could not be accommodated in the historic yard where so much valuable work had been done since the commencement of iron shipbuilding. He was not aware of the conditions that had been laid down for the guidance of those designing the works, as to the scale of operations. So far as he could make out, from measurements on the plan, the utmost length provided for in building-slipways, clear of buildings, was about 700 feet, and he noticed that the entrance to the finishing-basin or repairing-basin was 91 feet 6 inches wide, and the effective width of the largest dock at the level of the sill was about 90 feet. Those dimensions, of course, were sufficient for anything in existence at the present time; but, for permanent works of such a nature, it appeared to him that the margin was rather small, when it was remembered that the new Cunard steamships were 88 feet in beam and that their design had been practically determined upon at the time the works at Tranmere were begun. Of course, it might have been decided that such vessels must be regarded as exceptional, and that it was wiser to keep to a more modest programme on the site in question and to allow the building of very large vessels to go elsewhere. The works were undoubtedly Sir William White.

Sir William White. very well proportioned: they all went together, the finishing-basin, the building-slips, and the docks; and it would be possible no doubt to lengthen the building-slips without much inconvenience, if it were so decided. He noticed that the depth of water provided at the outer ends of the launching-ways was about 7 feet 10 inches—and he thought it would be difficult, so far as he could judge from the drawings, to carry the launching-ways beyond the river-front without expensive work. When he had to settle points of a similar nature in connection with the design of the warship building-yard at Elswick in 1883, he did not hesitate so to pitch the ground or launching-ways—which he could place as he liked, because the original foreshore was under water at high tide, and it was necessary to make the ground—as to get 14 feet of water on the way-ends. In the working of that yard since, that depth had been found to be a great advantage in launching heavy armoured ships. It might be that to have secured such a depth as that in the Tranmere yard would have involved very much greater expense, because he noticed that with the 7 feet 10 inches the water appeared to come up the launchway about 150 feet at high water of spring-tides. There could be no doubt that the creation of such an important shipbuilding- and repairing-yard in the port of Liverpool ought to be of very great advantage, and he was sure the members of The Institution would wish every success to those who had had the courage to create that great establishment. In respect of repairs there was a very good opening in the port of Liverpool, with its vast increase of trade, for an establishment of such a nature; and with the modern equipment that would be there he was sure the old firm of Laird, which was now associated with the great Sheffield firm of Cammell, would be ensured a future which would be quite worthy of their historic past.

Sir Whately Eliot. Sir WHATELY ELIOT thought the docks and basins had been designed to take the fullest advantage of the materials at hand. The rock came up at the north end in a convenient way to receive the two graving-docks; in fact, the graving-docks were carved out of the solid rock. It was a pity the rock did not come up to the bottoms of the walls round the outer basin, which would have avoided the necessity of the piling, because he noticed the piling had already given evidence of being a weak point. Although it was hoped there would be no further movement of the walls, it was well known that in time the weakness was forgotten, heavy weights were put on the back of the quay-walls, and there was always a tendency for them to slip forward again. He hoped, however, that that would not occur. It had been interesting to hear the remark

made by Mr. Brodie about the shaping of the rock. Judging from his own experience he would say it was very tedious work and unsatisfactory. It was almost impossible to work rock, especially red sandstone rock, to a smooth and even face, and the patching it had received could not add much to the beauty of the work. He thought it would be interesting to know what were the actual proportions specified to the contractor for the concrete: it was said that it worked out afterwards at 1 part of cement to 8 parts of finished concrete. He had never been accustomed to state the proportions of concrete from the finished work in that way. The proportions given from experiments on the shingle as 1 of cement to 2·64 of sand and 6·32 of rough shingle must have been decided after the shingle was delivered on the spot, and those two proportions of sand and shingle mixed together would be nearer $8\frac{1}{2}$ than 8. In the usual way it would have been called $8\frac{1}{2}$-to-1 concrete instead of 8-to-1. The concrete piles seemed to afford a very advantageous way of getting over the difficulty of piling in ground where timber would not last any time. He had himself had difficulty in made ground overlying hard ground or compressed mud, in which piles would rot as fast as they were driven. The course he had had to adopt was to sink a shaft down to the top of the mud, drive piles and completely bury them, and carry out the rest in concrete. The Simplex method of piling overcame that difficulty by enabling the pile to be driven from the surface. Sir Whately Eliot.

Mr. CUTHBERT A. BRERETON remarked that he had a recollection of the sandstone rock in the Tranmere district when the "Great Eastern" was on the gridiron at Rock Ferry in 1862, and he had had experience in another place of a graving-dock cut in sandstone rock, where it was found, after some years of use, that the fact of the face of the rock becoming alternately wet and dry caused the surface to disintegrate by degrees and rendered it very difficult to secure the shores satisfactorily. He would be very glad to know whether anything of that sort had occurred at Tranmere. The cost of cutting the rock to the exact shape required must have been heavy, and he thought it would have been better to face the rock with either concrete or thin slabs of stone. Another point he wished to ask was whether much water had been met with in the graving-docks—water that had had to be dealt with by pumping. In some places sandstone contained a great deal of water, but at Tranmere there might not be much, as the water from the back of the wall seemed to have been cut off, and consequently there was probably not much pressure upon it. As to the bearing-piles for the buildings, the system of driving a hollow pile no Mr. Brereton.

Mr. Brereton. doubt had its advantages where the ground was soft, and where dependence was placed on skin-friction more than upon direct bearing-power, because when the "form" was drawn up in anything like loose ground there would be a tendency for the ground to fall in and a less satisfactory bearing-point would be obtained than when the pile itself was driven down to the solid. He desired to know whether any case had occurred of inequality of settlement, although perhaps there had not been an opportunity of ascertaining that, as the heads of the piles were buried in a kind of platform of concrete. Still, there might have been isolated cases where such experience had been obtained. With regard to the movement of the wall, similar movements had occurred in other places, where a good foundation was left for a bad one. It certainly appeared as though the bearing-piles were hardly equal to their work, particularly in regard to the rake or batter given to them. When once a wall began to come forward the piles leant over with the motion and tended to send the wall over farther still. He would like to know why it had not been carried down a little deeper, so as to get a bigger footing to resist any forward motion. The general section of the wall was the same as that founded on the solid rock, whereas it was customary to have a greater thickness at the base when on a soft foundation or on bearing-piles.

Mr. Baterden. Mr. J. R. BATERDEN noticed that the coffer-dam, as was usually the case, had been made with a double row of piling, and he wished to know whether the engineers had had any experience with a single-pile dam. He had had to do with seven or eight graving-docks, and in only one case had a double row of piles been put in; and curiously enough that had been the only case in which there was the slightest difficulty with the coffer-dams. A weak point of double coffer-dams was the impossibility of knowing what was going on inside. The clay settled, and the water travelled along the bolts; whereas with a single-pile dam a leak was easily seen. It appeared to him to be wholly a question of strutting. He was particularly surprised at seeing that the rock altars had been left in their natural condition. He had had to do with similar work in hard shale, but the altars and also the flooring were faced with a thin layer of concrete. He was afraid that when the Tranmere graving-docks came to be used the soft sandstone would be found to wear away soon. Anyone who was acquainted with the work of graving-docks, and knew the damp condition of the floor, would feel quite certain that the sandstone in time would weather, and with men walking about on it and dragging plates and material over it, it would quickly deteriorate. The extra labour in dressing

altars to the exact face would have been fairly counterbalanced, and it would have cost very little, if any, more to put in a facing of concrete. Mr. Hudleston had referred to the width of the graving-docks at the top. Mr. Baterden's own experience had always been that ship-repairers did not like wide-topped docks. They were undoubtedly of advantage in drying the ships, but they caused a little more difficulty in shoring. In passing a graving-dock on the north-east coast recently he noticed a ship jammed against the top altar, only about 3 feet from the coping, so that it must have been rather dark down below. He wished to know whether there was any particular reason why caissons had been fitted instead of gates for the graving-docks. It might have been necessary to put a short gate and a long gate, but his own experience of caissons had been that they were a great trouble in a waterway, bobbing up and down and seriously inconveniencing shipping. The most serious objection to them was that the dock could not be used so quickly with caissons as with gates. The Paper said that the caissons would be floated to clear the grooves when there was 23 feet on the sill. It seemed to him there was only a few inches more than 23 feet on the sill of one of the docks at neap-tides, so that, unless he was mistaken, it was quite possible there might be an exceptionally low neap-tide, when great difficulty would be experienced. It was possible to open gates as soon as the water inside was level, but that was not the case with caissons. One advantage they had was that a line of railway could be taken over them, but that was the only advantage, and as a rule they were not cheaper than gates. The Simplex system of piling was interesting and novel. He was surprised to find it worked out so cheaply. In getting prices he had found that it could not hold its own against ordinary piling; in fact, he knew of one case where it could not hold its own even against greenheart piling. Mr. Baterden.

Mr. C. H. COLSON noticed in the Paper a statement that the cement delivered on the works was not turned; apparently it was used just as it came from the manufacturer. That was not the usual practice on works of the kind, and if no ill effect on the concrete had resulted it tended to show that turning and aeration were to some extent unnecessary. He would be glad to know if any cracks or other signs of deterioration had been seen in the concrete. Mr. Colson.

Mr. DRUITT HALPIN asked whether it would not have been possible to reverse the arrangement shown in Fig. 1, Plate 2. The docks seemed to be chiefly for repairs, and where such large masses of material had to be moved about, it might have been worth consideration whether a great deal of carriage could not have been saved. All the material that came to the graving-dock probably had to be put into barges Mr. Druitt Halpin.

Mr. Druitt Halpin. and ferried across the dock and unloaded, whereas if the graving-docks had been put at the south side next to the shop, a great deal of useless transport might have been saved. With regard to the steepness of the walls in the graving-docks, he certainly thought there was a disadvantage on account of the absence of light and air, which was essential to iron ships of the present day. In painting and cleaning, light and air were of the greatest possible value. With regard to the disadvantage of having wide docks, he did not see any advantage in docking with long shores. He had docked over a thousand ships without using a shore at all, and he did not see why it should not be done in the docks under discussion.

Mr. Wood. Mr. JOHN T. WOOD observed that, while he would like the Author to reply to the criticisms, he might offer some remarks on one or two points. Mr. Brodie had disagreed with the Author on the question of concrete in the graving-docks, and his own opinion was and always had been Mr. Brodie's opinion. Owing to the laminated character of the rock in No. 1 graving-dock, since the Paper was written further excavation had been made and a concrete floor had been put in. In his own view there was not much objection to the altar-courses being in sandstone. He had had considerable experience for many years in the adjoining yard of Messrs. Laird Brothers, where the altar-courses in all the old docks, of probably 50 or 60 years' standing, were sandstone, and they were still good and sound. The works under discussion were, of course, a commercial undertaking, not carried out with public money but built as a paying concern, and naturally it had been necessary to study economy. The economy of constructing graving-docks in sandstone was very great, and the dressing of the altar-courses in sandstone was not expensive. With regard to appearance, where it was necessary to cut out decayed sandstone here and there, or to block up fissures, in a ship-yard, he did not think a few blue bricks would make any difference 5 or 6 years hence. The object had been to provide a good sound job for commercial purposes. The reason why the graving-docks had been placed as shown was partly on account of the suitability of the subsoil, the rock, but more because they were in close proximity to the existing works of Messrs. Laird and to the workshops and machinery. With reference to Sir William White's remarks as to the length of the launchways, those at present constructed could be used up to 700 feet, but 1,000 feet would be available on the new extension of 15 acres. As to the width of the entrances, when it was first proposed to have two wide entrances in the outer basin he advocated that one of them should be 80 feet and the other 100 feet, and when it came to one entrance he advised 100 feet but failed

to get it, and he was sorry to say the 91 feet 6 inches had been adopted. It was intended that the docks should be for constructive purposes or for the repair of large vessels. Messrs. Laird Brothers had six or seven other graving-docks in their present yard, where no doubt repairs would be done, leaving the new works to be used chiefly for the construction of new vessels. Hence the use of caissons instead of gates for the two graving-docks. With reference to the concrete, the specification was 8 to 1 for the bulk of the concrete, and 4 to 1 for the facing work. Up to the present time no settlement whatever had been noticed. Mr. Wood.

The AUTHOR, in reply, desired to acknowledge his indebtedness to Mr. Wood for supplementing the information contained in the Paper as to the general scheme of the work, and to Mr. Brodie for the valuable details which he had contributed regarding the coffer-dam. With reference to the question of facing the rock floor and walls of the graving-docks with concrete or masonry, it was purely from considerations of economy that this had not been done; and the Author agreed with Mr. Wood that for the floor of the docks and the treads of the altars some form of facing would have been desirable. The face of the walls, on the other hand, had been dressed very cheaply, appeared to be durable, and was not rendered particularly unsightly by the patchwork found necessary. With reference to Mr. Hudleston's remarks, the profile of the graving-dock walls was nearly the same as in the latest Liverpool graving-docks, though somewhat steeper than, for instance, that at Avonmouth. Considerable light and air was admitted by the small altars at the top falling away in a flatter slope than the rest. With reference to the movement of the south wall of the basin, only a length of 200 feet at the end nearer the river was founded on rock, the remaining portion between that and the crane being on hard clay, where, also, no movement had taken place. The Author imagined that, in the length founded on sand, not only the wall itself moved forward, but also the stratum immediately underneath it, pushed forward by the weight of the filling behind the wall. No settlement of the wall took place, and no perceptible canting, so that it did not seem as if an increase in the number of bearing-piles, or a concentration of them near the toe, would have prevented the movement. With regard to Mr. Brereton's criticism of the section of the wall—the whole of the wall was designed as for a soft foundation, only one-fifth of its length being on rock. It had not been considered advisable to carry down the foundations any lower, owing to the quickly increasing quantity of water which was met with as excavation proceeded into the bed of sand. No doubt if the wall The Author.

The Author. had been laid out in the first place with an inward camber, the unsightly effect of the forward movement would have been minimized. Judging also from the way in which the wall by the crane-foundation had remained firm, it would seem as if substantial counterforts, spaced, say, 50 feet apart, might prevent any general movement. With reference to the proportions of the concrete, this for the mass work was gauged by measure at 1 part of cement to 8 parts of gravel. The proportions of 2·64 parts of sand and 6·32 of shingle were those obtained (as an average) by a series of experiments, from 8 parts of the gravel used. As to the possible effects of shores on the unfaced sandstone altars of the graving-docks, the Author would point out that in the case of ships of the size which would chiefly be docked at Tranmere, the ends of the shores would rest on the small altars at the top, which were formed in concrete throughout. The inflow of water into the graving-docks was generally very slight indeed, consisting of almost imperceptible weeps through beds in the sandstone, except in the case of the north wall of No. 1 dock, to the back of which tidal water had access on certain days of the month. Weep-holes were provided here, to prevent pressure on the back of the wall, and for a short time at high-water of spring-tides they ran freely. The total amount of inflow was, however, never more than the drainage-pump could deal with easily. Caissons had been provided instead of gates, in order that, if necessary, water might be held up in the graving-docks so as to keep a vessel floating at low tide. These docks being purely for repairing purposes, a little time lost in getting the caisson in place was not of first importance. Turning and aerating the cement had not been considered necessary except in the case of two cargoes which failed at first to satisfy the usual tests for soundness, but which after aeration proved satisfactory. All the rest had been used after 3 weeks' storage on the site; and no ill effects had been discernible from the customary turning being omitted.