Discussion.

The President. The PRESIDENT, in moving a vote of thanks to the Author for his very interesting Paper, remarked that the subject was of considerable importance at the present time, for events happening in the Far East would doubtless give great impetus to the construction of floating docks.

The Author. The AUTHOR exhibited a number of lantern-slides illustrating the construction and use of floating docks.

Mr. Harding. Mr. W. J. HARDING thought the Paper pointed the moral that the docks of one generation were not suited to the requirements of the next. Sir William White had recently stated that one important requisite for the improvement of ocean transit was that ships should be allowed to draw more water, and that naval architects and others had been appealing for years to dock- and harbour-authorities for deeper water for berthing vessels and over the sills of docks. Floating docks were a valuable means of meeting those requirements quickly. The development of floating docks, from a group of bladders or of gourds—such as at the present day a Chinese mother in a houseboat tied to the waist of her baby son to keep him afloat—to the cask, from the cask to the camel, and so on to the present floating dock, was an interesting subject of study. About 35 years ago a mail-boat was burned on the shores of Japan; she lay awash, and the Japanese warped her inshore by sinking bundles of bamboo around her and lightening her. He was not sufficiently versed in the matter to see where the great advantage of the pontoon dock as a whole lay over the old box dock, but he presumed there must be an advantage. With regard to the specification laid down for docks for the American Navy, in respect of longitudinal stiffness when a ship was docked centrally, the question arose whether those docks would stand what had been found necessary in docking damaged ships, namely, the removal of the whole of the blocks, and resting the ship on the dock until the holes in her could be patched. He presumed the floors of the docks were strong enough to carry the ship in that way. From the naval point of view, the possibility of moving the floating dock to any part of the harbour, out of the line of fire, and if necessary even sinking it below the surface of the water, provided there was sufficient depth, was a

Mr. Harding.

feature whose value might well be insisted on, when guns were sighted up to 7 miles or 7½ miles. He endorsed all that the Author claimed for the floating dock in respect of its advantages for the coating of ships; coating of the bottom was better done, and paint hardened much more rapidly in an open dock than in one in which the circulation of air was limited. But he could not subscribe to the opinion that steel rusted no more than iron. Steel plates would be better preserved throughout their whole life if the black oxide was removed at once by pickling; by such a course the exfoliation of the paint and the scale was avoided. The primary coat of paint should be white-lead. Time and again steel or iron plates coated with white-lead had been found to be, even after 15 or 20 years under water, as fresh as the day they were painted. Two or three coats of white-lead, well laid on pickled plates, would obviate a good deal of the scaling and deterioration mentioned by the Author. The Callao dock was to him quite an old friend. Built in 1864, it probably had iron plates and not steel, and it was said, after 40 years, to be fairly equal to its work. Why it was called a non-self-docking dock he did not know, as he had seen it several times ballasted down, and it appeared to him that the keel was above water; in fact, he had seen men working under the bottom of the dock. The fact that the dock was of iron spoke well for the material, because the harbour at Callao was simply the crater of an extinct volcano, and at times bubbles of sulphuretted hydrogen were continually rising through the water of the harbour. That phenomenon was called the "Callao painter," its effect being to turn white paint a drab colour, discolour all other paints, and rust ironwork. If steel docks could be made to last 40 years it would be a good thing. The Paper seemed to show that the life of a dock should be just one generation, or a generation and a half; that the granite docks left as legacies would be too small, or not wide enough at the entrance, or not deep enough, for the succeeding generation. He agreed with the President that out of the war in the East might arise a brisk demand for floating docks. For ships carrying four 12-inch guns and eight 10-inch guns, and having a displacement of 18,500 to 19,000 tons, very large docks would be required, and he thought those docks should be of steel, so as to be available for docking the ships speedily. He could not agree, however, with the Author's suggestion that battleships were becoming unwieldy. They were becoming rather heavy and also rather costly—for 1¾ million sterling was a great deal of money to put into a ship. His view was that too many

Mr. Harding. men were put into them. Engineers should strive, by using mechanical appliances wherever possible, to reduce the number of men carried in warships.

Sir William White. Sir WILLIAM WHITE, K.C.B., Past-President, mentioned that the Paper had been written at his request, and he had hoped that it would be read during his year of office as President. He thought it desirable to explain that the reason why the Paper apparently described only the work of the Author's firm was, that the Author, and those associated with him, had of late years been in the front of all improvements in floating docks, and in discussing recent progress the Author had to speak of his own work. He thought it would be agreed that the Paper displayed a generous spirit, in placing a vast amount of information at the disposal of all interested in the building of floating docks. It was true that details of scantlings did not appear; but by putting together the descriptions of the Author's methods of calculating strength and stability, and the full statements of the weights of docks of different dimensions given in the Appendix, it would not be difficult for any one interested in the subject to go far towards reconstructing the docks. No doubt the Author had views as to further improvements in docks which he kept to himself, as was natural and right; but that did not detract from the generosity he had displayed in the full statement of facts he had placed before the Institution. One essential point, to which, he thought, hardly sufficient prominence had been given in the Paper, was the necessity for a suitable, fairly sheltered berth for a floating dock. As the Author said, it must have ample depth of water, and for a modern ship drawing 30 to 33 feet when deep laden, the provision of such a berth involved under many circumstances heavy expense. That cost was not included in the figures given by the Author, but it had to be reckoned with by those who wished to use floating docks. Sometimes the provision of a berth was, in point of both time and money, a very serious matter. For example, it had been his duty to recommend to the Admiralty the adoption of a floating dock for Bermuda, because the coralline structure of that island, and the fissures in the coral, would have rendered it impossible, without very heavy expenditure—practically the construction of an artificial island—to have a graving-dock. Clearly, in those circumstances, the floating dock was the one to be adopted. It had many advantages, but in this instance the point was, that it was impossible to avoid a floating dock. A contract for that dock, to be delivered at Bermuda for a definite sum, had been made, and the dock was there. But the provision of the berth had been a work

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of great magnitude and difficulty, because it had to be a deep berth, and the dredging had entailed the provision of special appliances. It had been necessary to put the dock in the near neighbourhood of the dockyard, and to arrange for easy access to it from the dockyard workshops. All those requirements had entailed heavy expenditure, and in the total outlay on that dock the accessories constituted a large sum. Anyone who had to do with floating docks, would do well not to overlook that aspect of the question. The Bermuda dock had been constructed in accordance with the views of the Admiralty shipbuilding officers, who were accustomed to dock large battleships. It contained a great deal more weight than would be put into a dock of equal dimensions for mercantile vessels, because it had to deal with armoured vessels causing severe concentrated loads and stresses. As the Author observed, the support of armoured ships in dry docks could be greatly assisted by the use of docking-keels. The Americans had reverted to fitting side keels, which had been in use as long ago as the construction of the first armoured floating batteries built during the Russian war. The Americans had recourse to this construction because when they docked their first armoured battleship in the dock at Halifax they found that without such side supports the structure was not capable of withstanding the stresses. In his latest designs at the Admiralty for the "King Edward VII." class of battleship, he had adopted the same arrangement, because very great beam was required in those ships to fulfil other conditions. Anyone looking at the Table appended to the Paper might be struck with what appeared to be the excessive weight of the Bermuda dock, and it was only fair to the Author to say that his first proposal had been for a dock with a much lighter hull, and that the weight ultimately reached had been needed to fulfil additional requirements of the Admiralty, which, for Admiralty purposes, were quite justifiable. Besides demanding suitable sheltered berths and deep water, floating docks must, as the Author said, be capable of being thoroughly examined at comparatively frequent intervals. While a long period might safely elapse between successive examinations of the exterior if proper paints were used, the interior surfaces must be continuously examined, cleaned, and painted, especially in tropical climates. In the first dock at Bermuda this provision for external cleaning and painting, as the Author explained, had been met by Mr. Campbell, the designer, in a simple manner. The dock was approximately cylindrical in sectional shape, and could be heeled by admitting water-ballast, so that

Sir William White. any part of the bottom could be exposed for cleaning and painting. But unfortunately the necessary care of the interior had not been taken for many years, and the difficulty and expense ultimately incurred there had been in connection with the interior of the dock. Therefore it should not be taken for granted that the interior could be left untended for long periods. With all the appliances put into floating docks of recent design, ordinary cleaning and painting of the bottom of a ship was easily effected, as the dock was self-contained; but when dealing with large repairs the questions of the position of the dock in relation to the dockyard, of access from the dockyard workshops to the dock, and of dealing with the heavy weights which had to be taken out of and put into the ship during repairs, were matters of great importance, and required careful consideration when the design of the dock and its installation were being decided upon. They were features which involved considerable cost, and required to be taken into account when comparing the floating dock with the graving-dock. In some recent cases floating workshops had been associated with floating docks, no doubt with great advantage. That had been done in the dock built for Durban, which had a floating workshop attached to it; in fact, the workshop had been taken out to Durban on board the floating dock, although it had independent mobility when desired. In one of the designs which the Author had embodied in the Paper, for dealing with small vessels of the torpedo-destroyer class, the floating workshop was between the docks, forming a combination which no doubt did much to promote efficiency. Lifting-appliances on the docks themselves were also of great importance, and although the Author had not dealt in detail with that question, it had not been overlooked in the designs for which he had been responsible. There was one matter briefly alluded to in the Paper upon which he hoped the Author in his reply would give further information, namely, the use of what he called the "floating graving-dock," wherein the pontoon was made of much less depth than in other types, and the operation of lifting a ship consisted in first pumping out part of the water from the dock, then bringing gates into position at the end of the dock, and then pumping out the impounded water from around the vessels—a kind of combination of the principles of the dry dock and the floating dock. He would be glad if the Author would say something on that subject, because it appeared to be in many circumstances a valuable combination, enabling a moderate depth of water in the berth to suffice for lifting ships of considerable draught. Another interesting point was the rapid

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growth in the employment of floating docks in recent years, as indicated by the figures in the Appendix. It appeared that in the years 1887–90 six docks were built, the greatest lifting-power being 5,000 tons; in the years 1892–1900 fourteen docks were produced, the greatest lifting-power being 11,000 tons; while in the 4 years 1901–4 practically as many floating docks were produced as in all the preceding 23 years, and the greatest lifting-power rose to 18,000 tons. Many causes had tended to produce that result, but one deserved separate mention, namely, that ship-owners had begun to realize more than they formerly did that great economies in coal-consumption could be secured by more frequent docking and cleaning of the bottoms of steel ships—he said steel because iron ships were fast disappearing. It had therefore come about that, at distant stations and foreign ports where formerly no docking-accommodation could be had, it was now being provided; and no doubt its cost would be repaid to ship-owners by the saving in coal. The facilities afforded by floating docks for effecting repairs in distant parts of the world were very valuable, for they could be provided rapidly and at moderate cost in positions where graving-docks would be very difficult and costly to construct, even for accommodation suited to ordinary trade requirements. There were very many British-owned ships of the "tramp" class which remained abroad for long periods, and often passed long periods away from ports having provision for considerable repairs. Those vessels constituted one of the strongest branches of the English mercantile marine. They were marvellously economical in their working, as he had endeavoured to point out in his Presidential Address.[1] Nevertheless, those who carried on their business with such cargo-steamers were always endeavouring to find some new source of economy, some mode of cheapening transport, or improving the profit; and the existence of floating docks abroad would have a strong effect in that direction. He was disposed to concur with the Author in thinking that for such purposes, and for most kinds of merchant ships, the off-shore dock was the most satisfactory, taking into consideration its first cost and efficiency of working. But while he held that opinion in regard to ordinary cargo-steamers, even of large size, he certainly did not think it was desirable for armoured ships, or for the largest merchant ships, to dispense with the double wall; and he noticed that in the largest floating docks made in recent years that opinion had wisely been acted upon. With regard to the Author's

[1] Minutes of Proceedings Inst. C.E., vol. clv. p. 2.

Sir William White. method of computing the strength of floating docks, he thought that, as the Author said, the assumptions made erred considerably on the safe side; and that was borne out by experience. When in America he had been told by a naval constructor who had charge of the repair of the Havana dock, which had now been bought by the United States Government, that that dock had actually broken in two, as the result of accident. He hoped the Author would furnish some information as to whether that accident was due to mismanagement, or to any imperfection in the structural strength. He had heard of cases in which there had been warping of the structure—where the pontoons, which should have maintained a plane surface on the floor, had ceased to do so. If that had actually happened, perhaps the Author would say whether it had been a frequent accident, and whether it had been due to bad treatment on the part of those in charge, or to defective design. Allusion was made in the Paper to self-propelling docks. He was happy to see present Mr. George B. Rennie, who had done such valuable work in the design and construction of floating docks long ago, and whose interest in the subject still continued. Some years ago Mr. Rennie had put forward a design for a self-propelling dock, which he considered to be perfectly practicable; but the Author, after looking into the matter, had come to the conclusion that, under present circumstances, he would not be prepared to undertake the construction of such a dock. He hoped Mr. Rennie would state how it was that he had come to the contrary conclusion, and had been prepared to construct such a vessel, if he could have secured an order for it. Whether a self-propelling dock was desirable, was another matter; he was only speaking of its practicability. For his own part, he was disposed to think that the idea of a dock accompanying a fleet at sea was not one which would be found of much value in practice. For the small vessels of the fleet, the torpedo flotilla, etc., it might be feasible, but on a larger scale he doubted it. Any comparison of the merits of floating docks and graving-docks must be largely a matter of opinion; and no doubt every one who could express an opinion upon it—not excluding the Author—would have his views tinged by personal considerations. Nowhere in the Paper was the Author's enthusiasm for floating docks more apparent than in the section which compared the floating dock with the graving-dock; and naturally, one who had done so much to develop the floating dock had a right to urge the relative advantages which it possessed. At the Düsseldorf Maritime Congress in 1902, a long discussion had occurred on the relative merits of graving-docks and floating docks, the conclusion arrived at being that if the docks were to serve for the general benefit of navigation, graving-docks were almost always preferable, as they possessed greater durability and secured greater safety; but if the docks were to be regarded as an investment of private capital—as a money-earning concern—then commercially floating docks would prove the most advantageous, because of their smaller first cost, greater rapidity of construction, and less expense in working. In other words, the Düsseldorf Congress practically endorsed the action of those who had to deal with the matter on a large scale. For example, the United States Naval authorities had authorized the construction of the largest floating dock mentioned in the Paper, with a lifting-power of 18,000 tons, for a particular station in the Southern States, near New Orleans. But subsequently they had committed themselves to the construction of graving-docks of the largest size; and at Newport News he had seen a graving-dock built by a private individual—Mr. Huntington, who founded the great port and dockyard there; and that timber graving-dock, built some years ago, would, he believed, be capable of taking the new Cunard steamships when they were completed. That, he thought, showed wise judgment on the part of those responsible for the United States Navy in adopting floating docks where they were likely to prove of greater utility, but using graving-docks as a rule. In the Royal Navy the same thing had been done. Floating docks had been adopted where special difficulties would occur in making graving-docks, but as a rule, graving-docks had been preferred. There was much to be said, under the special conditions of a Naval arsenal, for having graving-docks. He thought the Author had dealt rather hardly with the supposed Admiralty policy of building for eternity. At the St. Louis Engineering Congress an address on that subject had been given by a Dutch engineer, who said he had been greatly struck with the temporary character of much American engineering work. In Holland large engineering works had been begun hundreds of years before any United States of America existed, and some of them were still standing. But he also said he believed the time would come when engineers in the United States would do the same, although they might find it necessary at present to have regard to what they could afford, rather than to what they would like to have. Sir William White thought that was true of docks as well as of other things, and he would give an example to illustrate the point. In the docks at Portsmouth, England's great naval arsenal, anyone acquainted

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Sir William White. with the history of British shipping could see epitomized the argument he had been using. Soon after entering the yard at Portsmouth the visitor found himself in what had been a complete dockyard not much more than 100 years ago, with its docks opening from basins. They now seemed toys compared with the most modern docks. Walking through the docks, the visitor came to larger and larger basins and docks. Were the docks in which the ships of the Nelson period were docked of no service now because they were small relatively to the size of the largest ships of the present day? Quite the contrary. The docks formerly used for line-of-battle ships—and in one of which he had seen Nelson's "Victory" docked—were now used for torpedo-vessels; so that in a great arsenal it did not follow that building in a durable fashion did not pay. As the fleet had been enlarged, certain classes of vessels had grown in size, but the smaller docks still served a very useful purpose; and he did not think there were too many docks at Portsmouth at the present time for the requirements of the fleet. England had been going ahead in the matter of the size of ships, both for war and for commerce, and graving-docks had been rather left behind; but what that really pointed to was, that it was necessary to have a good margin of dimensions in all docks, whether dry or floating; and while it was true that there were not the same limitations of length in a floating dock as in a graving-dock, it was also true that in the matter of width, which was becoming the determining dimension in connection with docks, the floating dock suitable for the largest ships, with double walls, needed just as much to be made with a good margin as did a graving-dock. No reasonable person could doubt that the great expansion in the use of floating docks which was indicated in the Paper, and to which the Author and his firm had so largely contributed, would go further. On the other hand, he did not in the least anticipate that, however perfect might be the design of the floating dock, and however simple its construction, it would entirely supersede the graving-dock. He thought there would always be room for both kinds of dock, for whatever use they were employed. Finally, he wished to say that he thought the Author, in once more introducing the subject to the notice of the Institution after an interval of nearly 30 years since it was last discussed, had put the members under considerable obligation.

Mr. Rennie. Mr. George B. Rennie stated that the Carthagena dock was the first iron floating dock built, though, owing to some delay due to difficulties over which his firm had no control, two other docks built on the same principle, and practically made from the same designs, were launched first, one for Callao and the other for Alexandria, the former being built for the Pacific Steam Navigation Company and the latter for the Société Maritime of Marseilles. Those three docks, built on the principle of a continuous pontoon, with walls in one piece, were the most durable docks yet constructed; and he thought one reason for that was that they were not divided into numerous pontoons. If he understood the Paper correctly, the Havana dock was built in three pieces. No doubt three pieces were better than five, or six, or ten, and less liable to get damaged when being towed; but he thought that both for strength and for durability there was nothing like a dock in one piece. He had considered whether it would not be possible to make a navigable dock more in the shape of a ship, in such a way that when one side was full it might be heeled over like the Bermuda dock, to enable the under-water portions to be cleaned when necessary; and he had proposed to use hydraulic pumps for propulsion, five on each side. The hydraulic propeller was not as good as the screw propeller; but taking everything into consideration, it had seemed to him to be the most serviceable and convenient means of propelling such vessels. He had not intended that the dock should attain a speed of 15 or 16 knots per hour in order to keep company with a fleet; it would be built to travel at only a low speed, such as 5 or 6 knots, to enable it to be taken somewhere near the fleet. He did not think it would be practicable to get a floating dock to cruise with a fleet. The navigable dock was to be like that of Carthagena, and divided into compartments, except that the form of the cross section was semi-cylindrical instead of rectangular: each water-tight compartment was to be fitted with a steam-engine to drive a centrifugal pump, to be used for propelling the dock or for pumping out water in order to raise the dock and ship. One name in connection with floating docks which he thought should be mentioned was that of Mr. John Gilbert, of the United States, who had made several floating docks of wood for the different arsenals in America, and who had afterwards been called to Venice to make a wooden floating dock of the same kind. Wood was a bad material for such a structure, and therefore Mr. Rennie had proposed a somewhat similar dock in iron, in which the water had not to be pumped up into the side walls, as in Mr. Gilbert's docks, which had to be weighted to make them go down. He was glad to see that the Author had been so successful in the building of his docks, but he did not think the division into pontoons was satisfactory. The Carthagena form of dock was Mr. Rennie.

Mr. Rennie. most advantageous, so far as cleaning was concerned, because it enabled the dock to be taken to the basin and cleaned whenever desired. That dock had been cleaned every 2 years, and was in as good a condition as ever.

Mr. Brereton. Mr. CUTHBERT A. BRERETON remarked that the floating dock was a very useful appliance, as where difficulties in regard to foundations were likely to be met with they could often be avoided by its use; in fact, in some cases it was practically the only form of dock that could be adopted. It had also the great merit that it could be built and put in position in a very short time. On the other hand, where circumstances permitted a more permanent kind of graving-dock to be adopted, the general opinion was that that course should be followed. For instance, where there was sufficient rise and fall of tide to enable the emptying of the dock to be done largely by natural means, the fixed dock had a decided advantage over the floating dock, which must at any state of the tide be lifted by pumping to the full weight of the vessel. Again, the fixed dock, which was now usually considered to be an essential adjunct to any large system of docks, could have permanent workshops and railway-sidings adjoining it; and the facilities for executing extensive repairs, and dealing with heavy machinery were far greater than they could be with a floating dock. The costs of the two kinds of dock could hardly be compared, because the local circumstances varied so much. After all, it was really the commercial side of the question which had to be looked at. The floating dock might perhaps pay the best dividend; but, a graving-dock, being an essential adjunct to any large system of docks, indirectly paid the dock-undertaking as a whole, even if it merely paid its way without yielding any profit, because vessels would go where they knew they could find facilities for dry-dock accommodation, and would not go where they were debarred from those facilities. The revenue from a graving-dock therefore should not always be measured by the amount taken in dues from the vessels using it. Another important element in the question was the shipowner's view. He had had to consider on several occasions whether a permanent or a floating dock should be adopted, and he had naturally had to take into consideration the views of those who were likely to use it. He had invariably found that shipowners much preferred sending their ships into a solid dock rather than into a floating dock. Whether that opinion was right or wrong, it was one which engineers had to take into consideration. The fact that at Liverpool, for instance, there were about fourteen fixed graving-docks might be regarded as some evidence that in the midst of the shipping world solid graving-docks were preferred; and there was a strong feeling on the part of many naval architects and shipowners that they would like to see their vessels put on a solid bottom. No doubt in many docks, in the course of time, it might be necessary for the development of the port to displace a fixed dock or to build another in some other position. In that respect the floating dock had an advantage: but he considered that the general impression in England was that, where circumstances were favourable, the permanent dock was the one to be adopted. Mr. Brereton.

Mr. DRUITT HALPIN remarked that the point urged by Sir William White, that the cost of the dock alone was only a part of the total expenditure incurred in installing a floating dock for use, and that large sums had often to be spent on the berth, had struck him forcibly when at Barrow, where the floating dock lay inside a wet dock, in which it took up a large amount of room. Provision had to be made not only for the room the floating dock occupied, but also for a passage to get ships into and out of it. At Cardiff there was a lifting-dock outside; and, all things considered, it was a question whether the dock might not have been put outside with advantage at Barrow. An example of a combined dock, in which the pontoon was lifted partially by extraneous means, and the balance of flotation was obtained by pumping, was afforded by the Victoria graving-docks.[1] The first system in use there, initiated by the Author's uncle, the late Mr. Edwin Clark, was a hydraulic lift consisting of thirty-two presses. These presses carried sixteen pairs of girders. A shallow pontoon, open at the top, was used, which was floated between the rows of presses; valves were then opened and the pontoon sank with the girders to the bottom of the lift-pit. The ship was then drawn in over it, and both ship and pontoon were raised out of the water by the presses, the water in the pontoon running away through valves which then were closed. Then the pontoon was lowered to float on the water, carrying the vessel. That system worked successfully for 27 years, but by that time the size of the ships had outgrown its capabilities, and it was decided to build a floating dock. The dock was constructed with large side walls; one end was closed permanently, and the other was provided with a pair of gates. The dock was brought over the hydraulic lift and sunk by opening the end gates. The ship was then floated into the dock, the end gates were Mr. Halpin.

[1] C. Elwin, "On a Floating Dock upon an improved system at the Victoria Graving Docks." Proceedings Inst. Mechanical Engineers, 1878, p. 139.

Mr. Halpin closed, and the ship and dock were lifted until the tops of the side walls were about 1 foot out of the water. The rest of the lifting was effected by pumping out water from the dock. The stability of the whole structure was controlled by the side walls when afloat, and by the lifting-girders when the dock was submerged. Mr. Edwin Clark's original arrangement of pontoons was absolutely flexible. When Mr. Clark designed it there were none but wooden ships in use, which bent and buckled in every conceivable manner. In designing the Victoria floating dock, Mr. Halpin had departed altogether from those arrangements. Ships of all kinds had to be dealt with, and in order to reduce the pumping and the stresses on the whole structure, buoyancy was provided over the whole of the midship part of the dock where the heavy sections of the ship rested; but in the ends of the dock, the flotation was destroyed so that the displacement of the dock tapered off from the middle towards the ends. With regard to navigable floating docks, he had designed such a dock, and had placed it before the Admiralty. One of the chief objects was that it should not only be able to dry-dock ships, but also be capable of picking up ships sunk at a depth of 120 to 150 feet. The dock consisted of two complete ships, with propellers, connected by an extremely strong deck of lattice-girders, plated over. The important part of the design was that without wetting a man's hand a mechanical hold could be obtained on a ship of 10,000 tons in 150 feet of water, a depth at which it was useless to expect divers to work. The whole system was carried out automatically, the necessary attachments to the vessel being completely carried out by means of a floating tower which could be sunk so as to make the required holes in the side of the wreck, into which steel wire ropes were inserted, and locked in position by means of toggles. These wire ropes were passed up through hawse-pipes in the deck of the floating dock, which was brought over the wreck; the dock was then sunk to within about 1 foot of the tops of the side walls, when the ropes were made fast, and the lifting of the wreck was effected by the rise of the tide, if any, and by the flotation produced by pumping out the dock. The dock then carried the wreck inshore, where the process was repeated in shallow water, the ropes being shortened at each lift until the deck of the wreck was as close as possible to the bottom of the dock. The ship was then in a position where she could be temporarily repaired and floated, when the dock was sunk under her and she was dry-docked in the usual way. Working models of the whole of the apparatus were in the South Kensington Museum, and all the operations were described in a

Mr. Halpin.

Paper[1] read by Mr. Halpin before the Royal United Service Institution in 1879. On p. 32 it was stated that the Barrow dock had lifted a vessel with an overhang of 107 feet at each end. He did not doubt that that was a fact, but he congratulated the Barrow Company on their broad-minded charity in allowing ships to be docked in that way. As they were docking only half the ship they should charge only half the docking dues. The Author also mentioned that the Barrow dock, which had a width of pontoon of only 54 feet, had lifted a paddle steamer of 68 feet beam. If that was the beam of the vessel, allowing 1 foot for a fender, the keel would not be much more than about 4 feet from the edge of the pontoon. It seemed to him risky to dock a ship under those conditions.

Mr. Matthews.

Mr. WM. MATTHEWS (of Westminster) wished to touch upon two or three salient points in connection with the subject of the Paper. First, in regard to the relative advantages of graving-docks as compared with floating docks, he supposed he was biased to some extent in favour of graving-docks, and presumably the Author was in a measure biased in the other direction. He had had to consider the matter in considerable detail on several occasions, notably when serving as the engineer member of Mr. Gibson Bowles's Gibraltar Committee some years ago, in which some public interest was taken at the time. One of the points which had arisen in the course of the inquiry was the desirability of providing a floating dock in a harbour on the east side of the Rock at Gibraltar, if such a harbour were constructed, as compared with placing a graving-dock there. The Committee had had the advantage of hearing valuable evidence from well-known authorities, such as Sir William White, K.C.B., Sir Henry Pilkington, K.C.B., Colonel Raban, C.B., the Master Attendant at Gibraltar, and others; and after very careful consideration a majority of the Committee had decided in favour of a graving-dock, as being the most suitable under all the conditions. Again, in the case of Colombo—where a graving-dock was now being built 700 feet long on the floor, with 32 feet of water over the sill, and with an entrance 85 feet wide—before deciding to construct this graving-dock, the question of the provision of a floating dock instead had been very carefully considered. One important point was that raised by Mr. Halpin. In a harbour like Colombo the sheltered space was of extreme value, and if a

[1] "On an Economical Means of Raising Ironclads sunk in Deep Water," Journal of the Royal United Service Institution, vol. xxiii. p. 21.

Mr. Matthews. floating dock occupied space in such a sheltered anchorage, that fact told in favour of having a graving-dock. In the many cases with which he had had to deal it had generally been found, after careful investigation, that the balance of advantage lay in favour of the provision of a graving-dock. An instance on the other side was mentioned in the Paper, namely, the floating dock at Bermuda. There could be no doubt that, having regard to the conditions there, a graving-dock was impracticable, and therefore it had been necessary to provide a floating dock. He had had an opportunity of witnessing the trial of that excellent dock, made, under the Author's direction, at Sheerness. By a wise provision of the contract, it had been arranged that the dock was to be thoroughly tested at Sheerness before it was sent to Bermuda. The dock had gone admirably through the trial, which was a severe one, and had apparently fulfilled the conditions laid down. In one or two cases of that kind his firm had recommended a floating dock rather than a graving-dock; but such cases were in the minority. He believed that Sir William White's remark, that there was room for both systems, really summed up the position. There were many places for which floating docks were admirably adapted, and no doubt their use would be extended; but as an old believer in the graving-dock, he had no fear that its mission was altogether ended, and he believed engineers would yet have many such docks to construct in all parts of the world. The use of older graving-docks for smaller craft, referred to by Sir William White in connection with Portsmouth, was what actually took place in many ports, especially where there were numerous docks. He knew of a port in the East, with three or four docks, where the docks were being extended and modernized, at no great cost, to adapt them to present day requirements.

Mr. Stileman. Mr. Frank Stileman thought Mr. Halpin did not quite grasp the circumstances which had led the engineers to construct a depositing dock at Barrow. The dock was situated in the Devonshire Dock, whose length was 2,500 feet, and width 530 feet. A clear passage-way of 250 feet was left for vessels, which must be considered ample room specially in still water. It had a gridiron twice the length of the depositing dock, to which were attached repairing-shops, engineering shops, and shipbuilding yards, which at that time belonged to the Barrow Shipbuilding Company, passed later to the Naval Construction and Armaments Company, and now belonged to Messrs. Vickers, Sons and Maxim. The Barrow depositing dock was one of the first floating docks built in England. The only other similar dock then in existence had been that at Nicolaieff which

Mr. Stileman.

he had been deputed to visit. Admiral Popoff and Captain Goulaeff, who had been responsible for the design and construction of that dock, had informed him that the main reason for building a floating dock at Nicolaieff had been the want of stone; and that the floating dock had proved of great service. At that time there was trouble between Russia and Turkey, and they were able to lift a cruiser, the "Rossia," clean her bottom, paint her, and send her to sea in very short time. The Barrow dock was far enough away from the gridiron to allow a vessel with a beam of 60 to 80 feet to lie between it and the gridiron, if required. The question of finance had been carefully considered. The Dock Company had thought they saw their way to a large repairing business with the Barrow Shipbuilding Company, and they had felt that it would be very expensive to take ships into a graving-dock from the fitting-out yard of the Company. The depositing dock had cost about £54,000, including dredging, etc.—considerably more than a graving-dock of equal length; but he was of opinion that the depositing dock, plus two gridirons of similar length, had cost less than a graving-dock would have cost, if capable of taking vessels three times the length of that dock. The gridirons themselves had cost between £7,000 and £8,000 each, and they had proved very serviceable for certain work. Soon after the dock was built, a paddle-steamer, then known as the "Duchess of Edinburgh," which plied between Folkestone and Boulogne, was put on it, cut in three, and lengthened, at comparatively small expense. The floating dock at Barrow, with a gridiron twice the length of the dock, gave accommodation for three vessels; or if room were wanted only for two, they could be put on the gridiron, the dock being then used for painting, cleaning or sighting the bottoms of other vessels, which could be done more quickly in this way than in a graving-dock. With regard to a paddle-steamer being lifted on the depositing dock at Barrow, the beam of the paddle-steamer, 68 feet, was taken over the sponsons, and the width of the pontoon was 54 feet. A graving-dock at least 70 feet wide would have been required for a vessel of that kind. The lifting of the "Empress of China," 456 feet long, on the Barrow dock, which was 242 feet long, had been done under exceptional circumstances; and while entailing a certain amount of risk, the operation had saved heavy expense. In going down Walney Channel in a gale of wind the vessel had hit a timber pier, which was supposed to have drawn a propeller-shaft. She was docked at the next tide, and it was decided to lift her on the Barrow dock, because otherwise she would have had to be taken to Belfast, Glasgow or

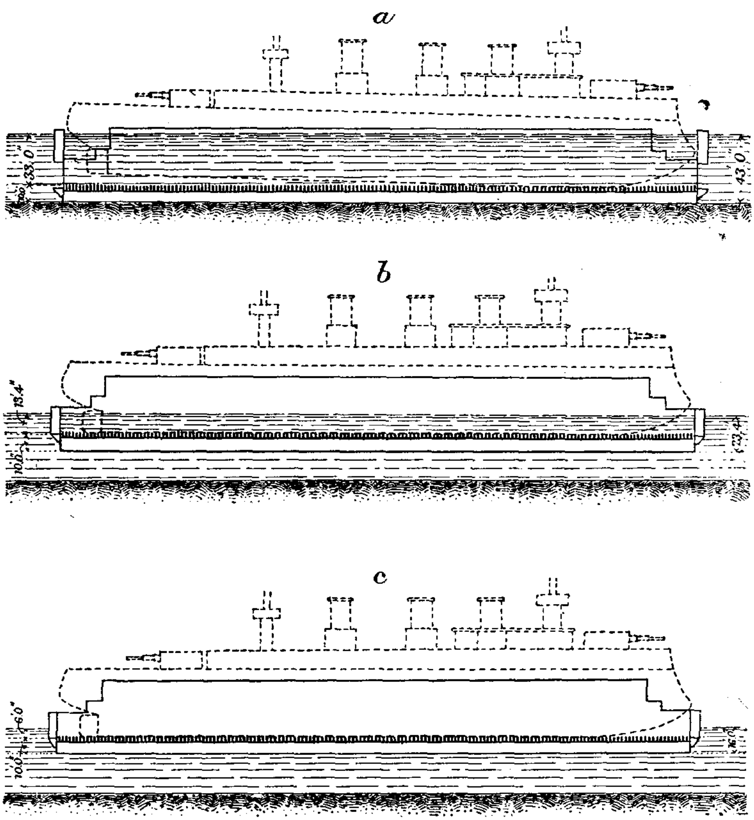
Mr. Stileman. Birkenhead, which would have been a source of serious expense. About a week later, after taking various sights on her, the vessel was lifted far enough to enable the propeller-shaft to be drawn, and the damage to be determined. There was certainly a slight movement of the ship, but when she was lowered back into the water the sights came back quite truly. That was a risk, in a case of emergency, which the Company were willing to take: in a national emergency such a risk would probably be undertaken under better conditions. The Cardiff dock was an off-shore dock for a general work, and the only thing about it which need be mentioned was that commercially it was very successful. The floating dock need not be as long as the ship it lifted. For instance, the length of the "Oceanic" was about 750 feet, but the bearing length of her keel was only 560 feet.

Mr. Pretty. Mr. W. H. PRETTY observed that while the Author mentioned that with a small vessel in a graving-dock a large quantity of water had to be pumped out, he did not refer to the other side of the question, namely, that with a very large vessel on the blocks there was comparatively little water to be pumped. As to the size of the pumping-plant, it seemed to be the custom to make the plant for floating docks as small as possible, and for graving-docks larger than was necessary. He thought a comparison of the pumping-power at present in use for floating docks and graving-docks, for vessels of about the same displacement, would show that there was not so great a difference as was indicated by the Paper. The pumping-plant of a floating dock had to be designed to lift the maximum load, including the dock itself, whereas in the case of a graving-dock the pumps were usually designed to empty the dock in a specified time, irrespective of the size of the ship to be docked, no ship being on the blocks during this test. The fairest way of comparing the behaviour of a floating dock and a graving-dock was to make a comparison of the *horse-power-hours* actually required to raise a ship and the dock in the case of a floating dock until the pontoon deck was awash, and to pump out the water from a graving-dock in which the same ship was docked, the ship being a maximum size for each. He thought that for a floating dock the horse-power of the plant would be about 75 per cent. of that now used in a graving-dock of about the same docking-capacity. It would be an advantage if some particulars were given of the leakage pumps for the Devonport docks mentioned on p. 36; they must be exceedingly large. One advantage of having three lines of keel-blocks on floating docks, was the saving of time in shoring. He thought no one who had had to do with a floating dock, and who had watched shoring-operations in a choppy sea would hesitate to adopt three lines of keel-blocks. Quite as much time seemed to be expended in shoring up a ship as in pumping, when only a single line of keel-blocks were used. A point greatly in favour of the graving-dock as compared with the floating dock was the space available around the dock itself for keeping tackle, repair-outfit, machinery, etc., and for bringing materials and other things up to the ship as required. He had not altogether pleasant recollections of the small amount of room available at times on the deck of a floating dock when docking ships; the whole available deck was occupied by tackle, ropes, etc. Large graving-docks could be subdivided, and very small craft could be accommodated in large graving-docks on platforms, when it was unnecessary to pump out the whole of the water. The mobility of floating docks rendered them of immense value both in peace and in war, and their seaworthy qualities had been fully demonstrated. For sea-going docks the pumping machinery necessarily included boilers, steam-engines, and pumps; for river purposes, however, floating power-stations, delivering electrical energy to motors directly connected with pumps on the docks, would have many advantages, both for graving-docks and for floating docks of the off-shore type, auxiliary machinery being used as usual for other purposes. Such a floating power-station could serve many docks and be available for other purposes as required. Mr. Pretty.

The AUTHOR, in reply, pointed out that dredging was not required everywhere. In England it was customary, in constructing a harbour or port, to cut back into the land; abroad, the engineer frequently built out into the sea, and as a rule the depth of water obtained was more than was required. His firm was at present constructing a floating dock for a Mediterranean port where there was 100 feet of water, and they would rather it were only 50 feet. Still, dredging was required in many places, and that was some drawback to the more general adoption of the floating dock. In large docks it might become a very serious factor. A floating dock capable of lifting a present-day battleship of 18,000 tons must, if the lifting-power was obtained solely by the displacement of the dock itself, have pontoons about 19 feet deep; and with 33 feet as the possible draught of a damaged vessel, a depth of water was required which would not be obtained by ordinary dredging-appliances. At Bermuda, the hole requiring to be dredged was only 50 feet deep, which certainly did not seem to be a very terrible task in a coral formation. But the fact remained that in dealing with heavy vessels want of water was a drawback, though not an insuperable one. At the beginning of the Paper it The Author.

The Author. was pointed out that the first form of floating dock was of the enclosed or "pound" type, and consisted of a box, which was closed by a gate at either or both ends, and from which the water was removed when the ship had been docked. This was now called a "graving-dock," which was generally understood to mean a sunk or excavated dock; and while the use of the term in that restricted sense was, in his opinion, open to exception, he would retain it in his reply as meaning an excavated masonry dock. The earliest box docks had been, to a large extent, graving-docks, because the underwater body was extremely thin and had no buoyancy whatever. They had not been pontoon docks, supporting the vessel by their displacement. The practice of using end gates had been continued, and they were used in connection with floating docks in the United States. At Portland, Maine, there was a dock which was a floating dock to a certain extent, but which had gates at the ends, by means of which the vessel was enclosed and the water in the pound was pumped out. His firm had used the same system in order to gain a little more lifting-power in the case of the Havana dock, and also, in a less degree, in the case of the Stettin dock, where the pound was formed simply by raising a bulwark round the deck as high as the top of the keel-blocks. The water was pumped out after the edge of the bulwark was brought above water. Quite recently, however, his firm had had to consider how to deal with ironclads of 15,000 tons displacement, which might have a draught of 33 feet, in a port which had but a small depth of water. They had therefore gone back to the Havana type, but starting with the graving principle as the main point in the design. They had set themselves to ascertain to what extent the depth of the pontoon could be reduced, without going to extreme forms, and without loading the top and bottom booms in any way, but simply using the dock as an ordinary box dock. It was found quite possible to reduce the depth of the pontoon to 8 feet. The 33-foot draught of ship which had to be allowed for was not the normal draught; it was only likely to be met with in case of an accident, when the ship was holed. On such an occasion it would be permissible to lift the ship on keel-blocks of less height than usual; for instance, 2 feet would be quite sufficient to get the ship into dock and patch her for the first lift. Therefore with 2-foot keel-blocks and 8-foot pontoons, the depth required was a little over 10 feet in excess of the draught of the vessel, which was a reasonable amount, and would be obtainable in almost any port where vessels were allowed to move freely (*Figs. 21, a*). In a dock of that sort the first portion of the lift was done on the ordinary floating-dock principle: the interior compartments of the pontoons were emptied, which raised the vessel considerably. In the case in point it was found that the draught of the ship was reduced from 33 feet to slightly over 13 feet (*Figs. 21, b*). Then the gates were placed in position, the pound was emptied, and by the removal of that water The Author.

Figs. 21.



the dock as a whole vessel floated lighter, so that at the end of the lift the head on the gates was reduced to 6 feet (*Figs. 21, c*). What really had been done was that, instead of loading the walls and the invert of a graving-dock in order to keep it down and prevent it from rising, use had been made of the displacement of the mass to lighten the pressure on the invert and on the gates. The gates

The Author. in the diagram were performing exactly the same function as in an ordinary graving-dock, but instead of having a head of 33 feet against them the maximum head was 6 feet. Further, the caissons were automatic in their action and required no pumping; they were floated into position at any time, and as the dock rose it lifted the gate on to its seating. A dock of that kind had the disadvantage of a graving-dock, in that the length of the pontoon between the gates must be greater than that of the vessel. In many cases a slight overhang might be allowed, but generally speaking the dock required to be longer than the vessel, which was not the case in the floating dock. On the other hand, it was satisfactory to know that a dock of that kind could be built with the same or even less material than a floating dock pure and simple. The dock in question, 440 feet long and of 15,000 tons lifting-power, would require about 5,000 tons of plates and angles including rivets in the hull. He might also mention that it had specially strengthened sides for the purpose of supporting the armour-belts. It was not a commercial dock, but was for ironclads. In the illustration it was shown only as a dock for a particular class of vessel. It could, of course, be made longer, and the gates might be fitted anywhere on the dock to suit short or long vessels: for the sill to take a gate with that small head against it was a very small matter indeed. As only about 600 HP. would be required for its pumping-plant, the expense would be so small, compared with the value of the vessels lifted, that it would almost be justifiable to build such a dock for a single ship, and certainly for a class of ships. With regard to Mr. Harding's remarks, the Author could quite understand that his statement that steel did not rust more than iron should be challenged; but, before making it, he had obtained the opinion of many users of steel docks, and had found that they were unanimous in stating that according to their experience there was no difference, or at most very little, between the behaviour of iron and steel docks. He ascribed this to the fact that, unlike a ship, a floating dock required but very little external cleaning, so that those surfaces which were protected with paint in the first instance did not get scraped clean again; whilst those portions which had missed the original paint soon became covered with a vegetable or shell growth, which in itself acted as a preservative, and prevented any continuous rusting action of the water. He learned with interest that the Callao dock could be heeled for the purpose of cleaning, although he could hardly imagine that a dock of that section could be tipped sufficiently to bring the centre-line out of water. It was, however, as

Sir William White had pointed out, not the external portion, but the internal portions of a dock which suffered most, and these latter were of course independent of any self-docking of the dock itself. He desired to thank Sir William White for his kind remarks as to the work done by the Author's firm. He must of course admit that where preparation of the site of a floating dock was necessary, its cost should be added to that of the dock, and likewise the position of the dock with regard to workshops in connection with it had to be considered. But he did not consider that the floating dock was always at a disadvantage in respect of this latter point. It was manifestly impossible in a large establishment to have a dock so placed that it was close to all the different departments in the yard; and it therefore became necessary to transport the material from the dock, say to the engine-shop, or to the armour-plate shop, or to the shipbuilding side. Therefore it was merely a question whether it was better to lift a heavy weight—such as a tail-shaft or stern-post—from the bottom of a graving-dock, and put it on trollies and carry it to the necessary shop, or simply to slide it along the deck of the pontoon, pick it off with a floating crane, and transfer it to its destination. The question was clearly determinable only for each particular site; but on the face of it, there could not be much difference either one way or the other. He quite agreed with Sir William that in dealing with large vessels, it was necessary to have a dock of U section, for, as pointed out in the Paper, it was difficult to obtain sufficient rigidity with the L-shaped dock when of large lifting-power. The accident to the Havana dock had occurred when the United States authorities were self-docking the two end pontoons. The operation had been performed before when the dock was in the possession of the Spaniards, but that was some 5 years earlier. It appeared that in lifting the end pontoons, the valves which were provided in the bottom to enable the water to drain off as the pontoon was lifted out of the water had become set, and the man in charge was lifting these pontoons with a certain amount of water in them, intending to cut out a rivet and let it run out when the pontoons were raised. Of course, the extra weight thus raised on the ends of the dock had produced an appreciable bending-moment on the walls, which had been somewhat accentuated by the fact that the three central pontoons were all pumped dry instead of, as should have been the case, only the two nearest to the lifted pontoons being utilized for lifting. Even with these stresses, if the dock had been in good condition, it would seem impossible, if calculations could be relied upon, for any rupture

The Author.

The Author. to occur, as the stresses set up were small; but there was no doubt that the dock had been considerably neglected; and the Havana waters being most deleterious in their action on iron, it was quite possible that the walls of the dock had been considerably weakened, so that under the extra strain of the loaded pontoons they broke practically in two. The pontoons themselves, however, were not damaged; the dock did not sink; and it was eventually towed in two separate pieces to Pensacola, where it was repaired. He believed it was now in use again. He had not seen the report of the Düsseldorf Maritime Congress, and although to a certain extent he could agree with the conclusions there arrived at, he still thought that the main condition which determined whether floating docks or graving-docks should be used was one of situation. It was impossible to ignore the fact that the port of Hamburg had fifteen floating docks, aggregating nearly 75,000 tons in lifting-power, as against one small graving-dock; and the only possible conclusion was that the floating dock had been universally adopted there because of its efficiency and the fact that the site was essentially suitable. He must also uphold his opinion that the Admiralty policy of building for eternity was wrong. In a Paper read before the Institution of Naval Architects in 1896, he had drawn attention to the fact that at that time the United Kingdom did not possess a single graving-dock which could deal with her large ironclads if they were in a damaged condition. That was nearly 10 years ago; and it was only now that the new docks, which were even then contemplated if not commenced, and which did allow of the largest vessel being docked, were becoming available. Fortunately the intervening 9 years had been times of peace at sea, enabling British vessels to be put into trim before going into dock, and the most suitable time for docking to be selected, so that no breakdown had occurred. No one, however, could foresee when a war might break out, and the policy which he condemned was that which allowed of the construction of docks requiring 7 or 8 years for building. He considered that the Admiralty, more than anybody else, should adopt a type of dock which could be built as rapidly as the ships which it was designed to accommodate, whether the dock they used were a graving-dock or a floating dock. He was of course aware that the old stone docks at Portsmouth were used for torpedo-craft; but at what expense! These old docks must contain more than 8,000 tons of water, and the whole of this had to be pumped out against a mean head of 10 feet for the purpose of docking a small craft weighing say 300 to 400 tons, and drawing perhaps 8 to 10 feet. It would have been a better and more economical policy to build these docks of such a form that they might be scrapped when they became useless for the purpose for which they were designed, and new and suitable modern docks be built in their place. He could not allow Mr. Pretty's remarks with regard to the pumping-plant of docks to pass unchallenged. It was well known that no docking-appliance was so rapid in its action as the floating dock. He had himself designed small docks which would lift trawlers in 15 to 20 minutes, larger ones lifting 3,000-ton "tramps" in 30 minutes, or 5,000 tons in 45 minutes; and in the largest docks, lifting as much as 10,000 tons, the duration of lift was as short as 1½ hour. He was not aware that these speeds were in any way approached in existing graving-docks. He also thought that Mr. Pretty had hardly gone into the question of the amount of work to be done in pumping out an ordinary graving-dock. The No. 14 and No. 15 docks at Portsmouth, which corresponded very closely with the Bermuda floating dock in dimensions, contained nearly 57,000 tons of water; so that whether they were empty or contained a 15,000-ton ironclad, there was still a large amount of water to be removed. But it must also be remembered that, for each time a ship was docked, the dock itself had to be emptied, to prepare the berth; and if the work done in emptying the dock once to prepare the berth, and once for lifting the maximum ship, was compared with the work done on the Bermuda dock for similar operations, it would be found that the horse-power required was nearly four times as large in the case of the graving-dock as in that of the floating dock. With regard to the Devonport drainage-pumps, he had always understood that they were of 490 HP., while the entire pumping-plant of the Bermuda dock was only 600 HP. In conclusion, he thanked the members for the kind manner in which they had received his communication. The design of a floating dock lay certainly more within the province of the naval architect than in that of the constructing engineer; but he was not sanguine enough to imagine, as some of the speakers would seem to imply, that the naval architect was in any way going to oust the engineer. On the contrary, he was quite in agreement with Mr. Matthews and other speakers in recognizing that there were many sites which from various causes were quite unsuitable for a floating dock. At the same time, he quite believed with Sir William White that the use of the floating dock would become more general in the future. Steel was gradually replacing The Author.

The Author. bricks and mortar in every direction and he quite expected to see it do the same in the case of graving-docks; and he looked forward to an early date when the chain-reinforced invert of Sir Benjamin Baker developed into an armoured concrete graving-dock, and possibly in some situations even into a completely plated-in steel basin, somewhat on the lines of the floating graving-dock described at the beginning of his reply. He hoped he had shown that the floating dock was now a thoroughly reliable appliance, largely used, which, if the first cost should justify it, might be freely used by the engineer in places where difficulties were met with in the construction of the ordinary masonry or excavated dock; and he would ask engineers to look on the steel floating dock as a useful tool offered them by the naval architect in the same way as the mechanical engineer offered them improved machinery.

Correspondence.

Mr. Baterden. Mr. J. R. BATERDEN was well acquainted with the site of the floating dock at Sunderland and the two docks at North Shields, particularly the latter, having supervised, on behalf of Messrs. Sandeman and Moncrieff, MM. Inst. C.E., the preparation of plans for and the construction of the quays and jetties around them, as well as the necessary excavation and dredging. The site of the floating docks at North Shields was a narrow strip of land parallel to the River Tyne, in a situation where it would have been impossible to construct two ordinary dry docks capable of dealing with vessels of the same size. Even one dry dock as long as the larger floating dock could not have been constructed on this site without so cutting up the land as to detract seriously from the value of the yard. Hence, for such a situation the floating dock was specially suitable, although it should be noticed, in comparing it with a dry dock, that the surrounding quays, which were a considerable item in the cost of the former, would not come into the cost of the latter. He estimated that in ordinary ground, assuming the ground-level at 5 feet above high water, a floating dock of the section shown in Fig. 12, Plate 1, would require about double the amount of excavation or dredging needed for a dry dock of equal capacity; and he considered that, taking the Author's estimate of £10 per ton of lifting-power, on a suitable site and in similar ground, a dry dock equal in capacity to the No. 2 floating