Discussion.

Mr. HURTZIG. Mr. HURTZIG wished to add a few words on the question of expedition. The works at the dock were carried on with almost unparalleled vigour; but a loss of several weeks would have occurred if it had been necessary to wait for the completion of the gates and various other inner works before removing the cofferdam. That contingency was anticipated by the Engineer and provided against. By the Act of 1881-2 the Company had power to build another dock to the eastward, which was to communicate with the Alexandra Dock by means of a canal having an entrance on the east side. Provision was made for a caisson stop to be placed between the cofferdam and the outer gates; and a floating steel caisson was built to enable the cofferdam to be removed while the erection of the lock-gates and the remainder of the inner works were being completed. That clearly effected a saving of several weeks. The caisson consisted of framing and plates of steel of the usual kind. It was 95 feet wide at the coping level and 88 feet at the bottom. A double keel of green-heart was passed round the caisson, which being dressed very smooth made a water-tight joint with the granite masonry. The caisson was completed in December, 1884, when the erection of the lock-gates was commenced. During the whole of the remaining six months the Contractors had ample time to remove the cofferdam, while the inner works were going on with ease. The caisson served two or three other purposes, one of them being to close the entrance to the canal to which he had referred. In the canal entrance there was also a caisson stop, and when the new dock was made, instead of having to go to the expense of building a big cofferdam the caisson would take its place. It was also available for excluding the tide in case of accident or otherwise when work was being done in the dock at a low level. Very few docks in the country were so wide as 1,000 feet. A ship 550 feet long could go across on entering without interrupting operations at the opposite quay. Although it was said by some persons that there was little difficulty in manipulating ships in a narrow dock, there was still less difficulty in manipulating them in a wide dock.

Mr. Vernon-
Harcourt.

Mr. L. F. VERNON-HARCOURT said that the Paper had recalled to his mind his earlier experience with regard to dock construction on the foreshore of the Humber about twenty-four years ago. In reading the Paper he observed many points of similarity. He

believed that no other place could now be found at Hull for making docks except the foreshore of the Humber. In the Albert Dock, on which he was engaged for some time, very similar arrangements were provided for carrying out the work. There was the reclamation bank in front, with a toe of chalk; there were cross banks where certain portions had to be reclaimed first; there was naturally a removal of a great deal of stuff from the banks by erosion during the progress of the works; and (as had been stated in Mr. Hawkshaw's Paper on the Albert Dock¹) a difficulty had been encountered from the blows that had occurred at the lock. Another difficulty occurring on the foreshore was that as soon as the foreshore was enclosed at all, there followed a large accumulation of the mud with which the Humber was so densely charged; so that there was more work to do in the excavation than appeared upon the sections at first. That made it somewhat difficult to settle what the contract price should be. There was also, on that muddy foreshore, considerable difficulty in the foundations. In some of the wall foundations at the Albert Dock, sheet-piling of whole timbers was driven upon both sides, and the lower portion of the dock wall constructed in the trench excavated between; and in other cases the wall was built upon bearing piles. As far as he could judge, more difficulties had been encountered in constructing the Alexandra Dock than in the Albert Dock. It was more exposed to the sea, being farther down the Humber; it extended farther out on the foreshore, and the running quicksand was met with at a higher level. It had been stated that it was necessary to enclose a certain portion of the site of the dock before proceeding with the walls; but in the case of a dock which he had seen abroad (the ninth dock at Havre), that course was not adopted. Before the reclamation of a portion of the site of the dock from the foreshore of the Seine was finished, masonry wells, filled up afterwards with concrete, were sunk for forming the walls of the dock.² He saw the work in progress on two or three occasions. As in the case of the Humber, there was a great silting up on the partially reclaimed foreshore. Well-foundations were resorted to in that instance to expedite the work, as it was important to open the extension as soon as possible; but he doubted the economy of the system. The use of hydraulic machinery in the preliminary operations of constructing a dock was new to him, but he should think that it was a decidedly

Mr. Vernon-Harcourt.

¹ Minutes of Proceedings Inst. C.E. vol. xli. p. 98.

² "Harbours and Docks," Plate 14, Fig. 23.

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good method; and it would be interesting to know to what extent it had cheapened the cost of the works at Hull. As to the question of width of lock, the widest lock at Hull before the construction of the Alexandra Dock was 80 feet; and there was no lock in the port of London that had a greater width than that. At Liverpool and Havre there were locks 100 feet in width, this provision having been made for large paddle-wheel steamers, which had become obsolete; and the latest entrance constructed at Liverpool was only 65 feet wide; whilst the width proposed for the Panama Canal locks was 59 feet. He therefore inferred that a width of 85 feet was rather more than necessary; at any rate, it was more than was considered necessary either at London or Liverpool at the present time. As to the depth, which was greater than that of any other sill at Hull, 34 feet as compared with $28\frac{1}{2}$ feet below high-water of ordinary spring-tides, he thought that was a wise precaution. At Tilbury there was a deeper sill than anywhere else in the port of London; and he thought it was wise to have it as deep as convenient, because there was always a tendency in vessels to increase in draught, and it was well to provide beforehand for it. It was also an advantage for a vessel to be able to enter at any state of the tide. It appeared that green-heart gates had been used at the Alexandra Dock; and he should be glad to know their cost as compared with iron gates. There was only one disadvantage connected with them, namely, that in opening a lock for locking up, when the tide was rather low, there was a greater weight on the gates than there would be upon balanced iron gates. Iron gates without rollers had recently been substituted for the wooden gates across the 100-foot wide lock at Havre. The fresh-water supply brought in from Holderness seemed to be a very good arrangement, especially as it combined improved drainage with the exclusion of muddy water from the docks; the only objection to it being that the vessels would have to be locked in and out, instead of, as was done in London, making the levels in the basins and river the same near the time of high-water, which enabled the work to be done more quickly. A similar provision had been made at the Bristol Channel ports of Swansea, Cardiff, and Newport. The form of the dock with its jetties he considered to be remarkably good. He agreed with the Author that if a wide dock could be afforded it was better than a narrow one. But what he particularly liked was the projection of the jetties into the dock, affording a much greater length of quay, and enabling the vessels to be handled more easily. The equipment also seemed to be good. It was a great mistake not to equip docks thoroughly.

He remembered that when the Millwall Docks were first opened there was not a railway to them, there were no cranes, and no warehouses or even sheds, and the consequence was that for some time the shipping in the docks simply consisted of old vessels which had nothing to do. The Author had said nothing about the cost of the works. There were only two slight references to the subject, one being a statement that the works had been stopped for a time by financial difficulties, and the other that the dock wall made in concrete cost the same sum per lineal yard as that formerly designed. It would be interesting to know what the exact cost was; and as dock walls varied so much in thickness and height, it would be well to know the cost per cubic yard. He thought that a detailed statement of cost added greatly to the value of a Paper, much more so than a mere statement of amount of work done, to which an Appendix had been devoted. On the subject of tonnage, he lately had occasion to get out the tonnage of vessels entering various ports, and he observed that Hull had not much increased within the ten years from 1873 to 1883. Perhaps the Author would state whether the tonnage given as entering the dock in the year ending the 30th of June, 1887 (628,738 tons) really represented an increase in the trade of Hull, due to the opening of the Hull and Barnsley Railway, thereby destroying the monopoly of the North-Eastern Railway Company, or whether it was only taken off the traffic from the other Hull docks.

Mr. Vernon-Harcourt.

Mr. J. CLARKE HAWKSHAW remarked that the same difficulty appeared to have been encountered in the foundations of the Alexandra Dock as had to be contended with in the case of the Albert Dock, and it had apparently arisen from the same cause, there being a similarity in the strata met with. The intention was in both cases to found the walls of the lock on a bed of stiff clay. Below the clay there was a bed of running sand charged with water from the chalk underneath. The chalk rose to a great height in the neighbourhood of Hull; the water, gravitating towards the river, was penned below the bed of clay, and the moment the clay was pierced the water came through it. At the Albert Dock entrance there ought not to have been any trouble with the water, because there was a great thickness of clay there, 30 or 40 feet. The only cause of its getting up into the foundations was the existence of some old bore-holes. One of the bore-holes into the foundations had been found; it was a clean round hole in the chocolate-coloured clay, and it was filled with small rounded pieces of chalk. Before the morning the water had found its way through it, and half filled the foundation with sand. In the foundation of the

Mr. Hawkshaw.

Mr. Hawkshaw. Alexandra Dock the clay seemed to have been thinner, and the water appeared to have found its way from the sand into the foundation without the assistance of the bore-holes, as the clay thinned out in some places to only 2 feet. The lesson to be learned from such difficulties was that if, in some cases, the engineers of the day contented themselves with the foundation on bearing piles which the older engineers so often relied upon, and were not so anxious to take the masonry and concrete so low down, they would often save themselves a great deal of trouble and anxiety, and get quite as good a foundation in the end.

Mr. Giles, M.P. Mr. A. GILES, M.P., thought that the Author had rendered the Institution great service by the details which he had given, and by his account of the difficulties and anxieties of the Engineer in the work described. He could not help saying, judging from his own experience, and also from the experience at Hull, that engineers as a rule were not careful enough as to borings. He had a case in point at Southampton, where he had had borings taken for the dock walls every 50 feet in length. He had wished to avoid the special difficulty mentioned by Mr. Clarke Hawkshaw, of having bore-holes immediately under the wall, and he took care that the borings should be 10 or 20 feet in front. The bore-holes showed practically no sand in front of the wall, but on excavating the trenches he found a depth of 5 or 6 feet of quicksand under the wall, and he had considerable difficulty in getting rid of it by excavating down to the solid ground. When a large dock was commenced everybody was in a hurry to get it completed as soon as possible, and instead of waiting until the great bulk of the excavation was out, and then putting in the walls by ordinary means, trenches were generally resorted to for the last 20 or 25 feet. On reaching the bottom of the 20-foot trench, and when all was ready for the foundations, it was not pleasant to find a blow-hole in the middle of the site of the wall, and in the blow-hole 5 or 6 feet of quicksand. That was a difficulty which he had had to encounter, and he therefore cautioned engineers not to trust too much to bore-holes not exactly in the line of the work. The Paper was very complete in all its details, but he should be glad to have a little more information as to the cost of the dock walls, the cost of excavation, and the cost of the gates per foot. He thought that a width of 85 feet for gates at the present day was unnecessary, and that 80 feet, or even 70 feet, was wide enough. An ironclad was only 72 or 73 feet beam, and 80 feet would certainly be more than ample for the commercial marine. He was surprised to hear that vessels had been admitted

drawing $26\frac{3}{4}$ feet, which was an unprecedented depth, the depth of Mr. Giles, M.P. mercantile vessels rarely exceeding 25 feet or 26 feet. That showed, however, the necessity for deep sills; but it was well known that when there were deep sills, particularly in such a muddy estuary as the Humber, there was a great deal of trouble in keeping them clear. He congratulated the designer of the dock upon having adopted gates instead of caissons for the dry-dock. He had himself never put in caissons unless they were absolutely ordered. Mr. Abernethy would excuse him if he criticised the shape of the dock. He assumed that had it not been for the shape of the area to be dealt with he would never have designed the dock in the way described. The lock was 550 feet long, and projected 400 feet into the dock; therefore the remaining space to turn a ship out of the lock between the end of the lock and the opposite wall was only 600 feet. It would be observed, in looking at the shape of the dock and entrance, how difficult it was to berth a vessel at any one of the quay walls. At Southampton he was not adopting the old-fashioned plan of making a square dock. He had so designed the dock, that vessels coming in could berth themselves at every quay very easily. There was a width of 800 feet across the dock at its widest part, and any vessel from any quay could turn round without interfering with other vessels. The dock was being dug 26 feet below low-water of spring-tides. The great advantage possessed by vessels coming into Southampton was the rapidity with which they could run in, discharge, load, and run out again. There was also an advantage in the connection with the railway sidings. No turn-tables were needed, the curves being very easy; He wished to ask Mr. Abernethy if, with his present experience, he had to make the dock again, he would make the entrance square with the channel, or pointing down the channel? He should also like to know whether any advantage had been found from the plums, or large stones, with which the Portland cement was studded. As a matter of economy he had no doubt they were desirable; and it would be interesting to know whether there was any disadvantage connected with them.

Sir JOHN COODE, K.C.M.G., said he too should be glad to have a Sir John Coode. little more information as to the cost of the works, divided under the usual heads, the cost of the graving-docks, the entrance, and the quay walls.

Mr. W. SHELFORD said he believed that the shape of this dock Mr. Shelford. was very much influenced by its site. The Alexandra Dock at Hull had been working for two years; it was well supplied with water-space and with quays, and no doubt the Author would be

Mr. Shelford. able to say whether the want of water-space or the want of quay-length was likely to limit the capacity of the dock. He did not ask the question from any desire to disparage or criticise the work, but because he thought the information would be useful to other engineers in designing docks. He should be glad to know also why a width of 85 feet for the lock entrance had been adopted. In the larger gravings-dock at the Alexandra Dock, which was intended to accommodate the largest vessels, the entrance was only 65 feet in width. Possibly the great width adopted by the designer was to enable vessels of ordinary size to enter side by side, so that there might be a saving in lockage. A method which was intended to meet that difficulty had been carried out in a lock in America. It was at the foot of Lake Superior, was built by the United States Government, and was undoubtedly a fine piece of work. The lock was 80 feet wide, but the entrances were only 60 feet. The intention was to pass through it two vessels at a time. Of course, in that way, economy in the construction of the gates was obtained. He thought that the Alexandra Dock compared favourably in its design with other docks which he had examined both in England and abroad. He had seen it constantly during construction, and he unhesitatingly said that in every detail it bore the evidence of a master hand. The best proof that it was a good work was that the trade entering it was increasing by leaps and bounds. Allusion had been made to the Hull and Barnsley Railway, which was an adjunct to the dock, or perhaps he ought to say that the dock was an adjunct to the railway. The capital cost of the railway was about double that of the dock. The length of the line was 57 miles, besides 10 miles of branches and junctions, and it might be compared, both in character and length, to the main line from London to Brighton. The object of the railway was to connect the great coal-fields of Yorkshire and the wealthy districts of the West Riding with the port of Hull. As the coals were worked out to the westward the depth of the collieries increased. The maximum depth was reached at South Kirby. This was the newest pit and was 634 yards deep, and there was there a magnificent bed of Barnsley coal. The bed was level at that point, and it had been proved by borings and sinkings that it rose slightly to the eastward, so that there was a regular coal-basin. The eastward half was overlapped by magnesian limestone. The railway, therefore, crossed what might be called a virgin coal-field for the greater part of its length. In order to carry out the object he had mentioned there was a large depot at Cudworth, adjoining the main line, where the traffic was collected from the different

collieries and districts served by the Midland, the Manchester, Mr. Shelford. Sheffield and Lincolnshire, and the Hull and Barnsley railways, and the trains made up there ran to the Alexandra Dock at Hull, in the neighbourhood of which gravitation sorting-sidings had been provided. The line was graded against the load throughout for export traffic 1 in 264, except where it crossed the Wolds, where the gradient was 1 in 150. It had often struck him that an immense amount of anxiety and thought was consumed in the carrying out of works of that character, and yet, when they were completed, there appeared to be little to say about them. Some of the anxiety might be spared if there was more co-operation amongst engineers. In America there were road-masters' and other associations, and they appointed committees to discuss points of detail, who settled standards for general adoption, and thus saved constant repetition of the same work. In England generally there was too much exclusiveness, but in The Institution of Civil Engineers opportunities were afforded for discussing those matters in such a way as would benefit the whole profession, and he thought that the less the members kept their knowledge to themselves, and the more they ventilated it, the better it would be for the members individually, and for the profession as a body.

Mr. J. WOLFE BARRY asked if any chemical analysis had been Mr. Barry. made of the Portland cement used for the concrete in the dock walls, and whether any deterioration had been noticed in the concrete since it was placed *in situ*? In several cases it was stated that when concrete had been exposed to sea-water there had been a deterioration, but he imagined that in most of those cases the concrete had been alternately wet and dry, which, he gathered, was not generally the case in the Alexandra Dock. With regard to the width of the lock, he wished to point out that, although the lock was 85 feet wide at the coping, owing to the batter of the walls, it was not 85 feet wide at the level of the bilge of vessels, which now-a-days were built with very upright sides; it was there probably only about 80 feet wide.

Mr. J. ABERNETHY, Past-President, said that the shape of the dock Mr. Abernethy. at Hull was, of course, determined by the site, and by the formation of the foreshore. If he were ever driven to deal with a site like that described by Mr. Giles, he should probably construct a dock of something like the same form; but he did not see how any commercial advantage could be gained by a dock of that kind at Hull. If jetties were projected from any one of the walls, the facility of vessels running in and taking their berths without interruption would be destroyed. Such a dock might

Mr. Abernethy. be well adapted for steamers going in and out in limited numbers, but he should never adopt a form of that kind, if he could avoid it, for a commercial dock. With regard to the width of the gates, it was quite true that there were very few vessels of 80 feet beam, though there were ironclads of 70 or 75 feet beam. The object of having a width of 85 feet was that vessels of upwards of 1,000 tons might come in and berth side by side. In the Alexandra Dock, at Newport, he had made the lock 65 feet wide; it was found, after long experience, that it would have been much more advantageous to have had it of a width of 80 or 85 feet, so as to enable two large vessels to lie side by side. The object was to save water required for lockage, and the construction of additional locks. He had been asked whether, if he had to construct the dock again, he would place the lock in the position shown on the plan, or have it pointing up or down the stream? Neither one nor the other. He adhered to the form he had chosen, namely, a trumpet-mouthed embayment free from tidal currents, which enabled vessels to pass in and out and get to the lock with facility either up-stream or down-stream. In practice, steamers came in on the flood-tide, steaming gently into the lock, and they left in the same way on the ebb. The Harbour-master had repeatedly expressed his great approbation of the facility with which vessels were able to go in and out. With regard to the material of which the gates were made, he had for many years objected to iron gates, owing to the unequal pressures they were subject to, and the strains in opening and shutting, rendering it very difficult to keep them watertight. The life of a timber gate was much longer than that of an iron gate. He had seen timber gates (good English oak) eighty years old taken out of a canal quite as fresh as on the day when they were put in. His impression was that a century hence the green-heart gates of the Alexandra Dock would be perfectly sound. Some questions had been asked with reference to the cost of the dock, and the Author would no doubt be able to give particulars.

Mr. Hurtzig. Mr. HURTZIG, in reply, stated that the accumulation of mud on the foreshore, of the Humber was always a serious question in works carried on at Hull. The last dock built by the Hull Dock Company was closed by a cofferdam, part of which, on the occasion of one very high spring-tide, gave way, so that the water got into the dock before it was completed. He had been previously engaged with the Dock Company on that dock, and had an opportunity of fully observing the effects of the inward and outward flow of the tide to and from the basin. The walls had been carried nearly

to the finished level. In the three months, during which the tide Mr. Hurtzig flowed in, a depth of 12 feet of mud had accumulated in the basin, the place having proved a regular trap. On the foreshore, at the site of the Alexandra Dock, within the reclamations, in some cases there had been an accumulation of 8 or 9 or 10 feet; but there was always a certain amount of wash which kept the mud from being finally deposited to a very great thickness. Of course the deposit had to be taken out, and it was a matter of arrangement with the contractors and engineer how it should be paid for, there being no rule about it. The Alexandra Dock was a little more exposed than the Albert Dock. It would be seen from the plan that the dock was near the last bend of the river, and there was a fetch of 14 miles, and with a south-easterly gale, there were consequently heavy seas in front of the dock. With regard to the enclosure of the walls, the question of expedition was the ruling one. The contractors wanted an area where a large force of men could be set to work. The first protection banks were put up in a week or two, a thousand men or so working on them, and when they were finished the whole force was set to work on the excavation and masonry. Sinking wells for the walls of the Alexandra Dock, would not, he believed, have been a more suitable method. He thought that there had been no appreciable effect on the cost by the use of hydraulic plant, for the excavation or for other parts of the works. The cost was very much the same whether steam was used or hydraulic plant. With regard to the width of the lock, he might mention, in addition to what Mr. Abernethy had stated, that Hull was a port at which centred a large number of inland waterways from the Lancashire and Yorkshire manufacturing districts. There was an enormous traffic by lighters, keels and small barges which could not be dealt with by a small lock. He had seen the lock crammed with lighters from end to end. The keels brought goods from the Aire and Calder and other navigations down to the dock for export to America and elsewhere. The goods were all transhipped in the docks. It was a great advantage to have a wide lock for that purpose, apart from the consideration of admitting two big ships together, and he thought local conditions, as well as shipping conditions, determined the question. Green-heart gates undoubtedly would be heavier than iron, but he did not think the effect would be appreciable in working the lock. No disadvantage had been found in working the Alexandra Dock lock. The gates were 40 feet high, and they were worked when there was a depth of 20 feet of water on the sill. With regard to the tonnage of Hull, it did not increase between

Mr. Hurtzig. 1873 and 1883 at the previous rate; indeed, between 1883 and 1884 it was decreasing, the tonnage for 1884 being 75,000 tons less than for 1883. But since the opening of the dock there had been a great addition to the tonnage of the port, though there had not been any great increase in the trade of the country generally. Last year the tonnage was greater than in any previous year, and it was still growing largely. Taking the decade 1877 to 1887, and dividing it into two periods, it appeared that from 1877 to 1884, being the period prior to the opening of the Alexandra Dock, the average annual increase in the tonnage of Hull was 15,122. From 1884 to 1887, being the period subsequent to the opening of the Alexandra Dock, the average annual increase had been 133,048 tons. There was, at the present time, something like 60 per cent. more tonnage this year entering the Alexandra Dock than in the corresponding period of last year. A great deal of the increased tonnage arose from new trades being established, and old ones extended, in consequence of the existence of the Alexandra Dock. In answer to Mr. Hawkshaw's question about bore-holes, he might state that there were no bore-holes at the site of the Alexandra Dock. Only one bore-hole was put down at the commencement. A trial pit was sunk in the centre of the dock, and it was continued by boring to ascertain the general nature of the material. No old bore-holes were encountered as in the case of the Albert Dock excavations. With regard to the system of founding masonry work on piles, and not having the foundations so low, that might apply in some cases, but not to a case like that of the Alexandra Dock lock. If the clay had been found 10 feet higher than it was, it would still have been necessary to carry the work down to the levels shown. The hydrostatic pressure under the chambers of the locks was so great that it had to be resisted by a suitable weight of masonry, and a suitable form of construction. He agreed that borings as a rule were no criterion of what would be found in the foreshore where docks were being built. They might be good at certain places, but under conditions like those of Hull it was impossible to depend upon them for information, except at the exact spot where they were sunk. The object of the graving-dock gates being 65 feet wide was to provide accommodation for ships of large size, which only went in one at a time. As to the entrance, the sills were very deep, and necessarily so, for the accommodation of the large ships that had been built at Hull for the American trade. The last ship of Messrs. Thomas Wilson, Sons & Co., was figured to draw 29 feet, the

net registered tonnage being about 3,000. It was absolutely necessary to accommodate such a firm as far as possible. The sill was at a depth of 34 feet; at high-water that would take 29 feet, but at neap-tides only 28 feet 6 inches. The deepest ship that had ever been taken out was 26 feet 9 inches. At one tide a large American liner of about 2,500 tons net register, called the "Martello," came in at high-water, and immediately afterwards the "Buffalo," a New York liner of 3,000 tons net register went out, and about two hours after high-water of the same tide a ship with 4,000 tons of coal went out, drawing about 25 feet. If ships of that kind could go in and out two hours after high-water, he thought the accommodation must be very good. To enable them to do that the entrance undoubtedly ought to be trumpet-shaped. A ship, two hours after ebb had commenced, could not come into an entrance which pointed up-stream, but could come into an entrance pointing down-stream; and in a similar way a ship approaching two hours before high-water could not conveniently enter into an opening pointing down-stream. No doubt plums in the concrete were economical, and he thought they made quite as good a foundation, if not better, than concrete without large stones. Nothing, however, had occurred to enable an accurate judgment to be formed on the point. Since the failure at Aberdeen, he had had the whole face of the walls carefully examined by a diver, and there was no indication of the concrete perishing. The walls were constantly in contact with sea-water, and were liable so far to the conditions prevailing at Aberdeen. There was also at Hull a graving-dock, built by the Hull Dock Company of Portland-cement concrete, which was opened in 1881, and it had not shown the slightest sign of perishing. It was sometimes full and sometimes empty, and therefore suffered from the effect of that condition, whatever it might be. There had been no chemical analysis made of the cement at the Alexandra Dock. The cost of the Alexandra Dock at Hull, he thought, compared favourably with the cost of other docks in the kingdom, the rate per acre being considerably lower than an average of other docks. The gross cost of the works was £1,355,392, or £29,147 per acre, including two graving-docks and equipment. Without equipment the cost was £21,450 per acre, which he did not consider an out-of-the-way figure. Anything under £30,000 an acre was generally reckoned cheap. The total cost of the walls, including certain foundations for coal-hoisting, and all the subsidiary works round the walls, had been £312,224, or about £28 per lineal foot, and as the walls were sometimes 62 feet high, he thought that that sum

Mr. Hurtzig. would not be considered excessive by engineers. The gates were expensive; green-heart was dear, and the members would not be surprised to hear that the price of the gates was higher than usual for iron, pitch-pine, or other material. The cost per foot super of the lock-gates, which were 40 feet high and 50 feet wide, was 48s. The price of gates varied from 25s. to 45s. at various sites. The cost of the two graving-docks, including the pumping-station and pumps, which, however, were designed to perform in addition another duty, was £130,800. The cost of the lock-entrance, excluding gates, was £138,200, but this amount included all the cost of the "blow."

Correspondence.

Mr. Cay. MR. W. DYCE CAY was of opinion that many of the difficulties encountered, and much of the expense incurred, in carrying out these works, might have been saved by trusting from the beginning to piles for forming the foundation, instead of trying to carry down solid concrete foundations to the clay stratum, which itself was not very secure. In his experience of reclamation embankments, he had found it a good plan to carry a row of round tree piles along the toe of the outer slope, their heads being cut off about $1\frac{1}{2}$ foot above low-water ordinary spring-tides, or at the foot of the pitching, and in front of them to place a sloping deposit of rubble. This piling held up the pitched slope above it, in case of any undermining of the toe of the bank by dredging or scour, until the rubble deposit in front was replaced. The strength and security it afforded enabled such a heavy bank of rubble and clay as was used on these works to be dispensed with. In the foundation of the dock walls, of which a length of 2 miles had been constructed, instead of the base of concrete, 9 feet deep by 20 feet broad, containing nearly 7 cubic yards of concrete to the lineal foot of wall, and involving the excavation of a deep trench 11 feet below the dock-bottom, with timbering and pumping, he should have thought it better to have carried a row of sheet-piling along under the toe of the wall (Fig. 2), and to have driven additional bearing-piles, spread over the rest of the foundation of the wall, cut off say 2 feet below the dock-bottom, where he should have covered the foundation and pile-heads with jute canvas, and deposited on it a bed of concrete on which to carry up the wall. In reference to the "blows" or bursts of water and silt, described in the Paper as overpowering the pumps, and causing considerable trouble, time,