Discussion.

The PRESIDENT, in moving a vote of thanks to the Authors, said he thought the members were to be congratulated upon receiving in Mr. Blyth's Paper an account of a work which was practically just finished, as everybody took a keener interest in a work when it was fresh in their minds. Mr. Cleaver's Paper was equally interesting, as showing a very large increase of trade created by a work carried out 13 years ago; and it also showed how, by adding to the old works in the excellent manner indicated by the two plans—one of the dock as it was originally and the other of the dock as it was at present—the increased traffic had been handled without in any way affecting the main features of the original design, a result upon which both the designer of the original work and the designer of the later extensions and improvements were to be congratulated. The President.

Mr. CLEAVER explained that in writing the Paper he had been actuated by the feeling that every member of The Institution should, whenever possible, submit to it the fruits of his experience. By so doing, he would benefit from hearing his colleagues' opinion of his work, and would often be saved the trouble involved in visiting works elsewhere. Mr. Cleaver.

Mr. B. HALL BLYTH, Vice-President, remarked that, as the author of Methil dock, although not of the Paper, he might say a few words to open the discussion. The original design of the sea-wall, which was nearly a mile in length, was much lighter than the design actually carried out. It was originally intended to build the wall of a considerably lighter section, in concrete backed with the rock excavated from the dock-site. The original section was to be about 11 feet thick, and was to have counterforts 30 feet apart. Bore-holes made there with diamond bores showed solid rock—the cores were still in existence; but when the rock was excavated it was found that as soon as it was exposed to the air it became quite useless as backing for the wall. He was not quite sure that that was not rather a blessing in disguise, because the section originally chosen, even if backed by the rock, would not have been sufficient to withstand such seas in the Forth as the wall now built had withstood. The whole question of this dock had been a serious problem. The original pier ran across the channel leading to the new dock. It was founded on the rock, but in building that wall he specified Mr. Blyth, Sen.

Mr. Blyth, Sen. that the rock was to be cut into about 2 feet and a level foundation secured. The pier was built very successfully, with admirable concrete, but after it had been in existence about 18 months the sea undermined a large part of it, and he thought he was right in saying that a portion of the pier 145 feet long by about 25 feet broad was standing with the rock scooped out underneath it and the concrete absolutely intact. He asked the directors of the North British Railway Company to allow him to consult the late Sir Benjamin Baker as to what should be done. They inspected the work together, and agreed that the best course would be to put in pell-mell concrete blocks in front. Sir Benjamin Baker in his report recommended 25-ton blocks; but he had never seen a storm at Methil, and as Mr. Blyth had, he suggested to the directors that it would be better to put in 50-ton blocks. He was quite satisfied that if 25-ton blocks had been put in they would have been moved. The 50-ton blocks had been completely successful; none of them had been moved, and the foundations of the pier had never been interfered with since they were put down. The whole length of the pier that was taken away had blocks in front of it, and they had to be removed. At the time he thought that would be sufficient for the new sea-wall, but after one of the early storms he found that it would be necessary to have many more blocks: these were put round the curve indicated on the plan (Fig. 2, Plate 1). After the storm of January, 1912, which did the very serious damage described in the Addendum to the Paper, he extended the 50-ton blocks along the whole length of the sea-wall, so that the wall was now protected from end to end by 50-ton pell-mell concrete blocks. It was very desirable that engineers should give more details of their failures than of their successes. In the storm in question nearly the whole length of what was called the east dock-wall, with a hoist partially erected on it, was completely knocked down. The wall, which was shown in Figs. 3, Plate 1, had been calculated to withstand the full hydraulic pressure with the dock empty. What happened was that the quay, which was about 175 feet wide, was not quite filled up to its full height with what came out of the dock—chiefly earth—and heavy seas, which, he was told, were something like 100 feet high, came over the wall and scooped out the soft filling at the back of the quay-wall. Having done this, they acted, as far as he could make out, like a battering-ram, and knocked the wall down. To give some idea of the strength of the work, he would mention that the foundations of the two coal-hoists Nos. 13 and 14 (Fig. 2) were put in simultaneously with the dock-wall itself in mass concrete, so that there was a thick mass of concrete extending from the front of the wall to the back of the hoist. Mr. Blyth, Sen. Notwithstanding that, the quay-wall was torn right off its foundations and thrown flat, and the hoist was half demolished, the front portion going with the wall, while the back part was left standing perfectly plumb. It was no good saying that the wall was strong enough theoretically, because it had turned out to be not strong enough actually. In order to overcome the difficulty he thickened the original section of the dock-wall, shown in Figs. 3, to the section which was eventually adopted; also, in order that there might be no scooping-out of the excavation behind it, the whole quay-space was covered with concrete 2 feet thick, in two layers of 1 foot each. There was one other point to which he wished to direct attention. When he began to design the sea-wall he decided to use bag-work, and the wall was designed to have bag-work carried right through across the foundation of the wall. The contractors at first thought they could make better foundations by having no bag-work; they preferred to clean the rock, put in mass concrete, and level it to form a foundation. He allowed them to try that plan, but they soon discovered that it would not answer. Thereupon they adopted his original plan of using bag-work, although they did not put it right through: as shown on the section, the bag-work was built in front and behind, and the space between was filled with mass concrete. That had made an absolutely satisfactory wall, which was almost perfectly watertight. As these remarks might perhaps be taken as a little derogatory to the contractors, he wished to say that no men could have done more to carry out the work that they had taken in hand than Messrs. McAlpine, the contractors. They had some trouble at first, but after they overcame that, nothing was left undone by them to carry out the contract in the best possible way.

Mr. C. S. Meik complimented the engineers and the contractors Mr. Meik. of the Methil dock on the way in which they had overcome the difficulties caused by the storm of January, 1912. The alarming accounts of that storm in the papers gave the impression that the whole of the works had been washed away; but the damage turned out to be nothing like so serious as that, and the manner in which it had been made good was extremely creditable, in regard to both the work done and the time occupied. He knew the site, as he had an intimate knowledge of the shores of the Firth of Forth, and he thought he was justified in saying that no worse site could have been chosen inside the Firth. True, it was largely sheltered from north-easterly gales, and possibly it was not quite so exposed as a situation right on the coast; but it was completely exposed on the

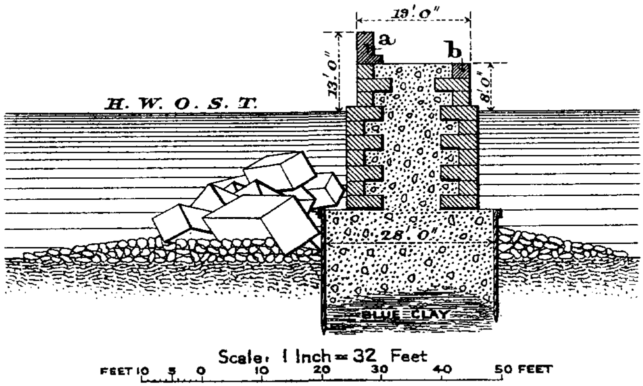
Mr. Meik. south-east. For that reason he believed a vertical sea-wall was not quite suitable, and that view was borne out by the fact that the heavy seas of January, 1912, swept over the wall, excavated the material at the back, and damaged the east dock-wall. The engineers had dealt with the matter very ably by putting pell-mell blocks outside, and he thought those blocks would be the salvation of the sea-wall. Experience would show whether they were sufficient in number; but they would certainly save the sea-wall from further serious damage. On account of the exposure, the work had been, as was to be expected, somewhat expensive, the figures given in the Paper showing that the dock had cost £42,500 per acre. That was costly, especially for a coal-dock. The east dock at Burntisland, designed by the firm of Thomas Meik and Sons, cost £31,000 per acre, the difference being accounted for solely by the fact that the site was more sheltered. The cost of the new King's dock at Swansea worked out at £25,000 per acre. He did not give those figures as suggesting that the engineers were in any way responsible for the heavy cost; that was due to the site. The collieries immediately adjoining the dock were to be congratulated on getting such a good dock so close at hand, as it would save them a very large amount in railway-charges. Coal shipped from the East Fife district ought to be put on board more cheaply than any other coal in the country. It was not often a railway-company was so liberal as the North British Railway had been in providing facilities for coal in such a situation. The foundation of the sea-wall on bag-work was, in his opinion, rather a questionable proceeding, because bag-work always gave trouble; the sea got into the interstices, and eventually caused the disintegration of the work. The pell-mell blocks—which it would be well to show on the Figures in Plate 1—would no doubt protect it to a large extent, but bag-work should not be adopted for exposed situations if it could possibly be avoided. He noticed that the hoists—and he presumed all the machinery—around the docks were to be worked by hydraulic power; yet very large provision had been made for electric power, accommodation for 1,000 kilowatts having been provided in the power-house. All that could not be required for lighting, and perhaps the Author would kindly explain whether the working of any of the machinery by electric power was contemplated. It was not unusual to have both hydraulic and electric cranes and hoists at modern docks.

The Paper that interested him more intimately was that on the Port Talbot docks, and he must ask the indulgence of the members, because it would be necessary for him to make what was to a certain extent a personal explanation. The statement that Fig. 1, Plate 2, Mr. Meik.

showed Port Talbot docks in 1899, at the time when it was handed over to the Company, was hardly correct, because the docks had been in the possession of the Company since 1894, when they obtained their new Act, and the traffic was always worked to a small extent during the construction of the new outer dock. The engineers who designed and constructed it were his brother, Mr. P. W. Meik, Mr. T. Forster Brown, and Mr. James McConnochie, MM. Inst. C.E., all of whom were now dead. His own connection with Port Talbot began in 1895; he was intimately concerned in the designing of the works throughout, and before their completion he was appointed joint engineer. The works were carried out by Messrs. S. Pearson and Sons and were handed over to the company in instalments. The Author also said that certain features of the original design had been subsequently found unsuitable and either abolished or modified by those responsible for the maintenance of the works. He was obliged to the Author for pointing out what, possibly, he considered defects, and he was sure other members of The Institution would also be very glad if maintenance-engineers would come forward and indicate where improvements could be made in works; but at the same time he thought the Author had rather overlooked the fact that constructional engineers, especially those who had to deal with new companies, were rather handicapped. For instance—and he was not referring to Port Talbot alone, for the same thing applied in other cases—matters arrived at this position: the limited capital was nearly expended, the contractors had exceeded their time, the directors were getting impatient, and the works had to be opened by a given date. Under such circumstances engineers very often had to give way on points about which they ought to stand firm, and at the last, as a matter of expediency, work was often done in a way in which it would not be done under normal conditions. The drains mentioned on p. 116 formed a case in point. He knew perfectly well when those drains were put in that they would give trouble; but the conditions under which they were built were just such as he had described. That point should not be lost sight of in criticizing work of that kind. Again, in the original design the moorings were intended to be of concrete. In all the docks he had had to do with he had invariably put in, when working in the dry, concrete moorings with chain cables or stirrups built in; and such moorings were contemplated at Port Talbot. Unfortunately, the water having to be let in suddenly, the moorings had to be put in when the dock was full, and the contractor elected, under those circumstances, to put in screw-pile moorings as being the cheapest and most expeditious.

Mr. Meik. He might mention that the contract was let for a lump sum. The moorings were thought to be sufficient at the time, and most people would have agreed with that view; but unfortunately the clay at Port Talbot—known locally as "bungum"—was afterwards found not to be the best kind of clay for moorings of that description. When the water got into it, it became soft, and in the case under discussion the screw-pile moorings were drawn out. The concrete-block moorings in the original design were intended to weigh 50 tons, which was sufficient at that time for the vessels frequenting the port. Those at Swansea, which were designed for a larger class of vessel and weighed 82 tons, had been put in practically to the same design as the original design for Port Talbot, and they were quite satisfactory. Trouble from the River Avon had always been expected. When the works were completed there was a dam higher up the river, which practically collected all the silt, but in the course of time the river above this dam was filled up, and the silt came over into the channel. The Author had acted wisely in recommending the Board to build the additional dam, which would check the material for a considerable time. With regard to the lock-gates, the Author expressed surprise that check-chains had not been fitted. The question was considered at the time, and the conclusion come to was that check-chains were of so little real value that they were not worth the extra cost of altering the masonry to take them. When a vessel had any way on her a check-chain was of little use; she would go right through it into the gates, or whatever else happened to be in her road. Those who had seen the effects of collision with a masonry dock-head by a vessel going dead slow could understand the force in a steamer of any considerable size. It was a little hazardous to lay and join up a hydraulic main under water, and if the Author had tested the submerged hydraulic main described in the Paper, it would be of advantage to know the results of the pressure-tests made after it was completed. With regard to the damage done to the south breakwater by the storm of the 16th December, 1910—which he was fortunate enough to see on the following day—that storm caused much damage all over the South Wales district, not only on account of its violence but also because it occurred on the date of a high spring-tide, which, owing to the wind, rose 3 to 4 feet higher than had been predicted. *Fig. 1* was a section of the breakwater where the damage occurred. The heavy seas, falling over the parapet *a*, fell on the coping or curb *b*, loosened it, and eventually washed it off the pier; subsequently the parapet itself was overthrown for a length of about 300 feet. The Figure showed the structure of the breakwater for a length of 360 feet from its inner end, where it offered the greatest resistance to the south-west gales owing to the direction in which it was placed. Farther seaward the method of construction was altered, and sloping concrete blocks were adopted, the reason for the altered form of construction being the difficulty experienced in founding the mass concrete satisfactorily on the clay inside the timber sheet-piling forming the pockets. That portion of the parapet situated above the sloping blocks was not injured, neither were the blocks themselves affected in any way. It was apparent that had the parapet *a* not been on the breakwater, the coping *b* would not have suffered, as the sea would then have washed in an unbroken mass over the upper surface of the breakwater. Therefore, in his opinion, the parapet Mr. Meik.

Fig. 1.



was either not high enough and of sufficient strength, or was not required at all. In any such structure utilized for traffic where vessels had to be berthed alongside, a parapet of sufficient height and strength was a necessity; but where this was not the case the parapet should be dispensed with, as it was invariably a source of weakness to the main structure, opposing as it did a large surface to the force of the sea at the most unfavourable place, namely, the point of greatest leverage from the base. He had come to the conclusion that parapets were not advisable on breakwaters built solely for the protection of an outer harbour. It might be said that access to the lighthouse was required; but he understood it was now quite possible to equip a lighthouse with compressed gas which would last for 2 or 3 months without attention, and under those conditions the charging of the reservoir could

Mr. Meik. be done when the weather was calm. In conclusion, he wished to express his appreciation of the Author's complete account of the demolition of the old accumulator-tower. The description of the Cordeaux fuse was a revelation to most engineers, and he would be very glad to see the fuse adopted more widely.

Mr. Cruttwell. Mr. E. CRUTTWELL remarked that the first point that had occurred to him on reading the Paper on the Methil dock was that, with so good a depth of water at low tide as 17½ feet, a lock should have been provided instead of the entrance shown on the plan, which admitted vessels practically at the time of high water only. With 17½ feet at low water of spring-tides most vessels of moderate draught could approach the dock at half-tide, and small vessels even at low water; and it occurred to him—though he was not aware of the actual character of the trade carried on—that it might be a great advantage if vessels could get in at any state of the tide, as they could have done had a lock been provided. Keeping the inner gates in their present position, it would not have added very much to the expense if a lock with outer gates had been placed somewhere opposite the passage between docks Nos. 1 and 2, and it would have shortened the very long entrance-channel. That channel was about 1,800 feet long and only 120 feet wide, and he thought vessels entering and leaving the dock would find it rather awkward to navigate. The lock-entrance, being 80 feet wide, would admit vessels of 70 feet beam, but such a vessel could not pass another of the same size in the channel. A wider channel might have been obtained by running the sea-wall in a straight line from the elbow opposite the entrance to its present site opposite the middle of dock No. 3, instead of making the east side of the entrance parallel with the west side. This wider entrance would also have acted in the same way as the wave-basins. If a lock had been built, and just outside the lock the entrance-channel had widened out, there would have been plenty of room for vessels to pass to and from the lock, and the outer basin would have been very useful as a lay-by for vessels, supposing the lock were not ready to receive them when they wished to enter. So far as he could judge from the plan, he concluded that the depth of the sea-wall, if carried along a straight line as suggested, would not have been much more, and would have entailed little extra expense—though the advantages would have been well worth moderate extra expense. With regard to the sea-wall, the 50-ton pell-mell blocks no doubt broke the sea to a large extent, but it seemed rather extravagant to use good solid blocks in that way, and he would rather have built them into the wall itself. Had the engineers considered the question of spending a little more on the wall and a little less on protective blocks? He would also like to know whether any sluices were provided in the entrance-gates. According to Figs. 4, Plate 1, in the sluicing-culverts there appeared to be only a single hydraulic sluice. In all dock-works with which he had been connected he had provided on one side of the hydraulic sluice a hand-sluice for use in case of a breakdown in the hydraulic appliances, and on the other side a groove in which a temporary timber dam could be inserted, so that if anything went wrong at any time with the hydraulic main sluice a dam could be put on each side to enable repairs to be effected. Such appliances were highly necessary, and he would like to know whether anything of the sort was provided at Methil. Mr. Hall Blyth, senior, had suggested that the section of the west quay-wall of the dock was sufficiently strong according to calculation, but Mr. Cruttwell was bound to say that the first thing that had occurred to him on looking at the diagram was that the wall was too weak, and on reading the Paper he saw that it had actually proved to be so. The ratio of the height to the thickness just about the footings was $2\frac{3}{4}$ to 1, which meant a thin wall. On dock-walls with which he had had to do he had aimed, as a rule, at a ratio of certainly not less than $2\frac{1}{4}$ to 1, and in many cases 2 to 1, or even thicker. Of course he did not mean that the thickness was settled by taking it in that ratio; the actual pressures on the wall were worked out, and the thickness necessary was governed also by the nature of the material at the back: but as a general rule, after making the calculations, he had never built a wall so thin as $2\frac{3}{4}$ to 1. With regard to the hoists, he would like to know what radius of action the swivelling shoot gave to the spout where the two fixed coal-hoists were side by side. The two hoists were 100 feet apart from centre to centre, and it was stated in the Paper that with the help of the swivelling shoots it was possible to fill the fore and aft holds of a vessel simultaneously. In most cases where he had had to arrange for loading two hatches simultaneously there was one fixed hoist and, alongside of it, a movable hoist which could be adjusted to suit the hatchways. Mr. Cruttwell.

Turning to the Paper on the Port Talbot docks, he thought the arrangement of the moorings shown in Fig. 7, Plate 2, was a very good one. He had used something similar at Immingham dock, which was opened quite recently, but, instead of bearing-piles being driven, concrete blocks were put in. A large number of vessels had been hanging on to these moorings in strong winds, and there had not been the least movement. The blocks were 10-foot cubes, as compared with the blocks at Port Talbot, which were 12 feet square by 5 feet deep, and it appeared to him that sufficient strength would

Mr. Cruttwell. have been obtained if the depth at Port Talbot had been made a little more and the piles, which were rather expensive, had been omitted. Perhaps the Author would say whether he had considered the question of doing without the piles.

Mr. Wentworth-Sheilds. Mr. F. E. WENTWORTH-SHEILDS remarked that the Papers were exceedingly interesting to dock-engineers, and there were one or two questions he wished to ask about them. In the Paper on the Methil dock, the Author mentioned that he had carried out the difficult operation of sinking a foundation through sand to rock by timbering under water. It would be of value to have some detailed information as to how that timbering had been carried out. At Southampton trenches had been sunk through clay under water, by submarine work, to a depth of 20 feet: that was effected by first driving sheet-piling along both sides of the trench and then excavating between the rows of piling with grabs. When a depth of 6 to 7 feet had been reached, walings and struts were put in, just as in an ordinary dry trench, except that the struts, instead of being tightened by means of wedges, as in a trench, were tightened by a special screwed head which could easily be worked by a diver. By working in that way it had been possible to get down to a depth of 20 feet quite easily with only two rows of struts. The side pressure on the timbering was not nearly as great under water as it was when working in the dry, so that the timbering need not be so close or so heavy. He noticed that at Methil the timbering had been sunk in a rough sea, through sand which was described as taking up a natural slope of about 9 to 1, and the difficulties of sinking through that to the rock must have called for much ingenuity on the part of the engineers and contractors. It was also interesting to notice how those responsible for the work had tried bag-work and blocks, and had gone from one to the other, which meant that neither method had proved easy to carry out. Perhaps the Author after his experience could say which was the more successful. Probably blocks were the more satisfactory if they could be put in position, and bags were easier to lay; but bag-work was loose and porous and liable to give trouble after it was put in. He also noticed with interest that the concrete used, not only in the bags but also in the mass-work deposited from boxes with bottom doors, had been of what might be called a very coarse character. It was a 1 : 2 : 4 mixture, and the stone was broken to pass through a 2½-inch ring, which meant that it was fairly large. At Southampton it had been found that the best mass concrete for depositing under water was obtained by using a fine stone; if the stone were all passed through a 1-inch

Mr. Wentworth-Sheilds.

ring the quality of the mass-work was much improved. With regard to the use of stationary mixers, his experience had been such that if he were starting work again he would not, if he could avoid it, use stationary mixers for concrete to be simply deposited under water without protection of any kind. He had found that if concrete had to travel some distance from the mixer to the place where it was to be deposited, the shaking on the journey tended to consolidate it to such an extent that instead of running freely from the box it seemed to hang together in a hard lump: nor did it mix readily with the concrete around it. With regard to the section of the quay-wall, there was certainly a great difference between the wall as rebuilt and the original wall, the former being about twice as thick; but he was not at all sure that he agreed with Mr. Cruttwell's view that the original wall was too thin. A great deal would depend upon the nature of the backing and the foundation, and to judge from the Paper the foundation was almost as good as rock, in which case he thought there would be no risk of the wall sliding forward. The danger of a thin wall was that it might possibly overturn, but he had never yet come across a dock-wall that had overturned, although he knew of many which had slipped on their foundations, sometimes perhaps owing to the fact that the material underneath the toe of the wall was not strong enough to bear it, but more often because the coefficient of friction between the wall itself and the clay, or whatever it might be, on which the wall stood was not high enough to afford sufficient resistance to the lateral pressure of the backing. But in a wall such as was shown in Figs. 3, Plate 1, with practically a rock backing and a rock foundation, there did not seem to be much danger of the wall ever sliding or overturning. The wall on the other side of the dock, which, of course, would not be exposed to heavy seas such as those which overturned the east wall, would be amply safe.

The Author of the second Paper put down the cost of a screw-pile mooring at about £200, and that figure was certainly a warning to engineers not to use such moorings. He could quite believe, however, that the driving of a single timber-pile would give almost as good a hold, and certainly the cost in that case would not be anything like £200. The Author's remarks about strengthening bollards were also interesting to maintenance-engineers. He gathered from the Paper that what happened was that the bollard was liable to be pulled out bodily, with the block of concrete in which it was embedded, by the pull of a large ship. His experience had been that the casting itself was liable to break. The old-fashioned bollard consisted merely of a tube, as it were, of cast iron, Mr. Went-worth-Sheilds. which it would be found by calculation would only stand safely a pull of about 20 tons. Modern vessels put a great deal more pull on a bollard than that. At Southampton, bollards built to take the "Olympic," the largest ship afloat, had been designed to take safely a pull of 50 tons; and considering that it had been estimated that a quite possible wind would produce a pressure of about 500 tons on the broadside of the ship, it would readily be seen that a strength of 50 tons per bollard was none too much for safety; in fact, some special bollards were being designed for a pull of as much as 100 tons, where many hawsers were likely to be fastened to them. Cast-iron bollards of the old type were used, reinforced inside either with old rails or box girders, the hollow space left inside them being filled with concrete. In that case the steel and concrete came to the assistance of the casting. The Author's remarks about maintenance would appeal to all. Those who had had maintenance work to do would appreciate how necessary it was that all engineers should have experience in that class of work; really it should be part of the training of an engineer, if possible. Certainly no engineer should lose any opportunity of examining closely work that had been built for a number of years, in order to note both its weak and its strong points. He would often be surprised to find that things about which he might have felt doubtful had stood very well, while things which he would have thought quite strong had proved to be weak. In that connection it was interesting to see that the Author had not hesitated to take up reinforced concrete. Many people, and certainly many engineers, were nervous about the life of reinforced concrete, but he had noticed that maintenance-engineers were not so nervous as constructional engineers. He was inclined to agree with the Author's view that there was nothing specially to be feared about the life of reinforced concrete in marine works. His own experience showed that there were circumstances in which it was liable to deterioration, but he did not think it was liable to any special deterioration on account of being used in the sea or in salt water. About 10 years ago, when the use of reinforced concrete was begun at Southampton, a good deal of misgiving was felt as to the fate of those portions of the structures —reinforced-concrete jetties—which were built under water; but it had been found that, although in some structures deterioration had set in, no deterioration was taking place below the water-level. The oldest of the structures built at Southampton under or close to the water was a jetty which was in perfect condition. In some of the other structures deterioration had taken place to a certain extent, which was undoubtedly due to electrolysis. In one

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jetty in particular, in which an electric wire was earthed to the jetty and a distinct amount of current had passed constantly through the structure to the sea at a pressure of about 7 volts—although it was supposed to be a neutral wire—there had been distinct deterioration above the water-level during the past 10 years. But the parts below water were as good as at first, as far as any action of sea-water was concerned; that was to say, sea-water did not seem to have produced any chemical or other deteriorative action. On the other hand, reinforced concrete would not bear being knocked about by heavy ships; and where a structure was subject to severe blows of that sort, it was not easy to find anything better than timber. But there was no doubt in his mind that, used at the right time and in the right place, reinforced concrete was a very valuable material for the dock designer as well as for every other engineer.

Mr. Brodie.

Mr. R. Brodie was specially interested in the Paper on the Methil dock because he knew the district very well, having visited all the docks during their construction and having prepared, for Mr. Nott, a tender for the new dock. At the time that tender was prepared he made certain notes, from which he found that the following problems, among others, had had to be considered: (1) Was the outer wall strong enough to withstand unsupported a storm during construction? (2) Was it possible to back the wall without having the backing washed away by the storm? and (3) Could the work be completed within the specified time—which he thought was 3 or $3\frac{1}{2}$ years? Consideration of those questions undoubtedly led to a substantial increase in the price quoted, and it would be instructive to know the amounts of the various tenders for the work, especially those of contractors who had carried out similar work elsewhere. As Mr. McAlpine had done somewhat similar work at Peterhead, his courage in taking the work at the lowest price would readily be admitted. Mr. Nott had intended, in the event of his obtaining the contract, to suggest to the engineers that at the price quoted the outer wall should be widened and the counterforts abandoned, as they were undesirable features for under-water work; and it was interesting to find that as the result of experience that course was eventually adopted. His firm came to the conclusion that the work could not be completed in less than 4 years at least, and they made their calculations accordingly. The directors of the North British Railway were very anxious to get the docks finished as soon as possible; when he was there seven or eight vessels lying at anchor outside, waiting to come into the dock, were pointed out to him. But Father Neptune was no respecter of persons, and he thought it would have been better had it been recognized at the time that

Mr. Brodie. storms were to be expected, which would interfere seriously with the work during the winter months, from October to March, more especially in those two months and in December and January. Provision should have been made so that as little of the temporary staging as possible was exposed during the winter. He had had charge at Wick, Fraserburgh, and Peterhead, where there was absolutely no shelter whatever; and experience showed that in exposed situations it was not advisable to attempt to do any work at all in the winter months. He did not think the conditions at Methil were quite so bad, but no doubt the site was exposed to very severe storms, and therefore provision should have been made by the middle of October to have everything as snug as possible and to go slowly during the winter months so as to lessen the sea-risks. Mr. Hall Blyth's statement that during the storm of January, 1912, waves came over the sea-wall 100 feet high seemed to have been scarcely credited by some members, but he could assure the meeting that it was not exaggerated at all. He had frequently seen waves, which outside would not be more than 20 or 25 feet high, rise to a height of more than 100 feet on striking a wall, and dash down on the inside of it. At Peterhead he had had a short coffer-dam across the Port Henry entrance, and during winter storms the waves dashed over the dam and scooped out a hole 4 feet deep in the granite at the back. The storm of January, 1912, was undoubtedly the heaviest that could be remembered on the east coast of Scotland, a large amount of damage being done all along the coast. At Wick a breach was made in the south breakwater, which had stood the heavy winter gales for more than half a century. He could not help being struck with the adaptiveness of both engineers and contractors; there seemed to have been no hard and fast line of procedure, and where circumstances had shown that improvements could be introduced, there had been no hesitation in adopting them. The conditions had certainly been abnormal, but the lessons taught by experience had not been neglected He noticed, for instance, that a great improvement was made, during the course of the work, in the method of depositing the bags of concrete, and the engineers and contractors were to be congratulated on carrying so difficult a job to a successful conclusion. It would be interesting to know why salt water had been used for the concrete in the outer walls and fresh water for the dock-walls. His own experience was that salt water was quite satisfactory if taken from the open sea, although, in a river such as the Thames or the Mersey, the quality of the water was not satisfactory. There was an old joke in the Liverpool and Manchester district that the quality of Mersey was not strained!

Mr. A. Scott had been surprised to hear that seas 100 feet high came rolling over at Methil, but he took it that what was meant was really broken water and spray. He had never heard of a sea 100 feet high anywhere near the coast. It would be interesting to know whether the engineer had made any observations of the heights of the seas in the Firth or near the site of the works, as they would be of great value. According to the chart, he found the depths at the entrance to the Firth were 5, 6, 12, up to 26 fathoms, and no doubt, with such depths of water, very heavy seas could come in. Mr. Scott.

Mr. Gerald FitzGibbon agreed with Mr. Meik that it was questionable whether a solid sea-wall was the proper form of protection to adopt. During the last 10 or 15 years many important harbour-works had been carried out in the British Isles, and in nearly all of them the works had been executed on ground reclaimed from the sea. Some of the most important were those at Heysham, with which he had been connected as resident engineer, Avonmouth, Swansea, Cardiff, and the joint dock at Hull. In every one of those cases a sea-embankment, and not a solid concrete wall, had been adopted as a protection to the reclaimed area. He quite agreed with Mr. Cruttwell that it might have been better to build the sea-wall in a straight line instead of a curve. If that had been done, any difficulty in the way of forming a sea-embankment due to the narrowness of the site would have been overcome. At most of the places he had mentioned the sites were exposed to very heavy seas, but the works had been carried out with very little difficulty and with complete success. The difficulties met with in the construction of the sea-wall at Methil would have been avoided if an embankment had been constructed. Perhaps the Author might be able to mention some special reason why the sea-wall had been preferred to an embankment. With regard to the use of bag-work, he was not an advocate of concrete bag-work under water, nor was he in favour of depositing loose mass concrete through water in any form whatever. He preferred to use concrete blocks matured on land and properly set on a bed prepared for them in the sea. He had seen so many cases of bad concrete as the result of depositing concrete through or in water, that he would carefully avoid that method in any work with which he had to do. He congratulated the officials of the North British Railway Company on the very high duty they obtained from their coal-shipping appliances at Methil. Some years ago he had occasion to visit many of the largest coal-loading ports in the kingdom, among them the principal ports of South Wales, especially for the purpose of examining the arrangements for shipment of coal. He found that the Mr. Fitz-Gibbon.

Mr. Fitz-Gibbon. quantity of coal shipped per annum per appliance at the ports visited ranged from 125,000 to 350,000 tons, taking the average for the whole of the appliances throughout the year. At Cardiff, with sixty appliances of various kinds, about 7½ million tons of coal was shipped in the year, which worked out at 125,000 tons per annum per appliance. Grangemouth at that time came out better than any of the other coal-shipping ports visited, namely, 350,000 tons per annum per appliance. According to the Author, in 1910 nearly 3 million tons of coal was shipped at Methil, and that seemed to have been done with six coal-hoists and one coaling-crane. That worked out at 418,000 tons per appliance per annum, which was far in advance of any other port with which he was acquainted.

Mr. MacAlpine. Mr. W. H. MacAlpine, as the member of the contractors' firm in charge of the works at Methil, wished to say a few words on the Paper describing that work. The building of the sea-wall was really the most vital and interesting part of the work. The idea at starting was to work on staging from the entrance-channel at the end of the sea-wall, and on that staging sufficient plant was put to complete the work within the contract time. When his firm took the contract they fully intended to do that, and they were quite certain they could do it in the time; but after making a start they found not only a difficulty with the sand, but also very great difficulty in removing the sand, because of huge boulders with which the sand-pump could not deal, and which had to be moved by means of grabs. The quantity of sand to be dealt with was so large that they required some other place in which to deposit it: otherwise in sinking the trench a bank was raised. With regard to the timbering under water, he thought Mr. Wentworth-Sheilds had misunderstood some part of the Paper. There had been little attempt to timber under water, the whole of the sand having been dealt with in the way he had described, namely, by removing first all the heavy stones, and then pumping with a sand-pump all the material that could be dealt with in that way. For that reason progress was slow, and during the first winter it was realized that the speed would be less than had been anticipated. By the end of that winter, in March, the whole of the staging had been very badly damaged, and the contractors had come to the conclusion that it would be necessary to adopt some other method and start from the other end. Accordingly the work was begun in the spring from the other end, and made fair progress. By that time it was becoming quite evident that the completion of the works would be far behind the contract date. Several stagings were used with derricks, which dealt with the ground much more satisfactorily. At the end of that season another storm occurred and brought the third season's work to an end without a scrap of plant left. The contractors were greatly indebted to Mr. Hall Blyth for the sympathetic help he gave them. He was not discouraged by the mishaps: the dock had to be made, and he was satisfied the contractors were doing well, and therefore he encouraged them to go on. They prepared to face the work again, and came to the conclusion that they might as well have a thorough smash or get the dock made. Fortune favoured them and the dock was made. With regard to bag-work, it would be seen from the plan that for the purpose of the inner works the outer wall had to act really as a coffer-dam. It was therefore as essential to the contractors to have a watertight and sound wall as it was to the engineer to get the work carried out as he wanted it. At the beginning there was great difficulty in setting the bags to please either the Author or the contractors, but the result of using the apparatus shown in Figs. 5, Plate 1, was that the bags were laid in a manner that, from a practical point of view, gave an even better result than block-work, because on withdrawing the box the weight of the bag pressed it hard against the other bags. Each bag was saturated with cement, and when examined afterwards the work really formed monolithic concrete, the bags adhering one to the other. Except a small piece at one end, done before a proper system of laying the bags was arrived at, the work was actually watertight, there being no leakage at all through the bag-work. If there had been any hollows between the bags the mass-work would have been affected. With regard to concrete-mixers, with a mixer at each of the working-points it would be found that the interval between the time when the concrete left the mixer and the time when it was put in the wall was too short to allow the concrete to set in the boxes. That had really been one of the most difficult things to manage. Considering the quantities dealt with and the points at which the work was being carried on, and remembering that the work was all tidal work, it would be realized that it was no small feat to put in the concrete in the time. The success achieved was due not only to the contractor's staff, but also to the engineer's staff and the contractor's staff working together harmoniously: no one was a critic and everyone was a worker. Mr. MacAlpine.

Mr. B. Hall Blyth, Vice-President, observed that many of the interesting points raised by the various speakers would no doubt be dealt with by the Author, but there were several matters in regard to the engineering of the dock, the laying-out, and the method of construction, with which he would like to deal. The Mr. Blyth, Sen.

Mr. Blyth, Sen. question whether or not there should be a lock leading into the dock was very carefully considered, and it was thought by all concerned—not only the engineers but also those responsible for the working of the dock—that the extra cost of a lock was not worth the extra accommodation that it would give. With regard to Mr. Cruttwell's point that by building a lock the entrance-channel would have been shortened, that was the very thing the engineers did not want to do, because although the prevailing wind was south-east, very heavy seas came from the south-west; so heavy were they that in the existing entrance-channel the storm-gates when first put up were sucked open by receding waves, and were continually chattering until special appliances were put in to keep them fixed. It was the desire of all, in designing the dock, to have the new storm-gates removed as far as possible from the action of the south-west wind. In order to help to moderate the effect of the seas the whole of the sea-wall along the channel was recessed at intervals. He had been rather surprised at Mr. Cruttwell's suggestion that the sea-wall should have been put about 200 feet seaward. Mr. Cruttwell could never have seen the place, and could have no idea of the depth of water and the difficulty that would have been incurred had any such plan been adopted. If the wall had been put in the position suggested by Mr. Cruttwell and Mr. FitzGibbon, he very much doubted whether it could have been constructed—at all events except at enormously greater cost. Another criticism of Mr. Cruttwell's was that the 50-ton blocks would have been much better embedded in the wall, to add to its thickness. Even if the thickness of that sea-wall had been doubled he did not think it would have stood satisfactorily without a protection such as was afforded to it by the 50-ton blocks. There was no fear of that wall being overturned, but many things might happen to it which the 50-ton blocks would prevent. As he had pointed out already, the older pier had been undermined by the sea, the rock being of such a nature that the waves against the foot of the pier cut into it, taking away the rock and leaving the pier standing. Since the 50-ton blocks were deposited nothing of that sort had happened. It was with a view to protect the wall and break the seas, and thus prevent huge masses of water from being carried over the quays and into the docks, as happened in January last, that the 50-ton blocks were put there, and he was satisfied that nothing better had been done for the preservation of the wall. Again, Mr. Cruttwell had said that he was satisfied the dock-walls were too weak and had referred to some method of calculation with which Mr. Blyth was not familiar. Using the ordinary method of calculating the strength of a dock-wall, Mr. Cruttwell would find that the dock-walls were strong enough to stand. The two spurs and the west wall were of precisely the same section as the wall that was knocked over, and they had stood satisfactorily. In designing the dock-walls the object was to avoid wasting money by making them unnecessarily thick. They would never now have to withstand pressure to any great extent. As long as the dock was full, the pressure of the water at the back of the wall was balanced, and therefore the pressure which the wall itself had to withstand was comparatively trifling. In his opinion an engineer ought to design dock-walls so as to make them strong enough when they were finished, and ought not to waste unnecessary money on them during their construction. The position of the twin hoists had been arranged after very careful consideration. The distance of the two hoists apart had been settled in consultation with the dock-authorities and after measuring all the vessels that frequented not only the port of Methil, but the whole Firth of Forth. It was fixed at 100 feet, because by means of a swivelling shoot it was then possible to command both the fore and after holds. The movement of the coal-shoot was 7 feet 6 inches in each direction, so that it moved through an arc of 15 feet, which would enable the four hatchways of a vessel to be coaled without her moving a foot. He did not think Mr. Meik's comparison of the cost of the Methil dock with the cost of Burntisland dock was quite a fair one. In the first place, included in the £42,000 per acre which Mr. Meik had reckoned as the cost of the Methil dock was the cost of entire rearrangement of all the sidings down to the existing hoists. They had been laid out from time to time, and at present they involved a great deal of back shunting, but as soon as the traffic was diverted to the new dock they would be rearranged so that the coal would come from the pits to all the hoists in a continuous flow, without any back shunting. The levels would be raised so that an engine would push the trucks to somewhere about the middle of the sidings shown in Figs. 2, Plate 1, whence they would run down towards the hoists. That alone would cost £100,000, which reduced Mr. Meik's estimate by £6,000 per acre. In addition, the cost of the railway by which the new dock was to be fed was included. It was about 1¼ mile long, and cost about £30,000, which took another £2,000 off Mr. Meik's average cost per acre. Moreover, the dock at Methil was deeper than the dock at Burntisland, and was much more exposed to the sea. In fact, the latter was almost an inland dock. The Methil dock-gates were 80 feet wide, while he believed those at Burntisland were only Mr. Blyth, Sen.

Mr. Blyth, Sen. 60 feet. The coal-hoists were larger and heavier, and were designed to lift trucks weighing 25 tons to a height of 55 feet. The whole thing was on a larger scale than the dock at Burntisland, and he did not think the comparison made by Mr. Meik was justified. He was not sufficiently acquainted with Swansea to enter into a comparison of those docks with Methil; but, if he went to Swansea, he might find very good reasons why the docks there had cost so much less. He had listened to Mr. Wentworth-Sheilds's admirable remarks with great pleasure. On several points the Author would, no doubt, be able to give some further information, but he himself would like to say a word on the subject of the concrete. Mr. Sheilds thought a smaller size of stone than would pass through a $2\frac{1}{2}$-inch ring made a better concrete for under-water work. That depended very largely on the quality of the stone used. He had made numerous experiments on concrete made with stones of many kinds and sizes, and had come to the conclusions that freestone was the best stone to use; that the proportions should be as nearly as possible 1 of cement, 2 of sand, and 4 of freestone; and that the freestone should be broken to pass through a $2\frac{1}{2}$-inch ring. If Mr. Sheilds would do him the honour of coming to see him in Edinburgh he would be able to convince him that that had turned out the best kind of concrete that could be made. The only other remark he had to make was on the suggestion Mr. FitzGibbon had put forward as to a sea-embankment. Any attempt to put a sea-embankment at Methil, as had been done at Rosyth, would have been futile; and there were no seas at Avonmouth or at Cardiff which approached those found at Methil. Had Mr. FitzGibbon known the site and seen the seas, he would have abandoned at once the idea of a sea-embankment.

Mr. Blyth, Jun. Mr. B. Hall Blyth, jun., in reply, remarked that Mr. Blyth, senior, had practically answered almost every question that had been asked. The electric power-house had been built to accommodate four engines, capable of generating about 1,000 kilowatts. So far only two engines had been erected, each of which drove a generator giving 270 kilowatts at normal load. The electrical equipment was primarily for the purpose of lighting, and at present was to be used solely for that purpose, though it was possible that a motor load might be added. The whole electric equipment had been carried out under the charge of Professor Baily of the Heriot-Watt College, Edinburgh. A length of about 250 feet of timbering under water had been carried out during the construction of the sea-wall in order to keep back the sand. This was done where the wall was built of mass concrete from the bottom, and also where the blocks

Mr. Blyth, Jun. were used instead of bag-work. The depth through the sand was 5 to 8 feet. The width of the wall was divided into three, and a length of about 30 feet was taken each time. To the main piles of the goliath staging, which was already built, were attached longitudinally heavy beams or girders at the level of the surface of the sand, and the sheet piling was driven by divers down to the hard on the inside of this girder. Owing to the fineness of the sand the timbering had to be very close, and in some cases jute sheeting had to be attached to the front before the sand was kept out entirely. With regard to the height of the waves, Mr. Hall Blyth, senior, had never intended to convey that there was 100 feet of solid water; it was 100 feet of broken water and spray, which was quite bad enough. As to the bag-work, the little block-work that had been done was very good, but certainly was no better than the bag-work as finished. The wall was absolutely tight from end to end, except in one short length of 100 feet opposite the dock-gates, where it was built in mass concrete from the bottom. There were no sluices in the dock-gates, but after the gates were finished sluices were cut in the mitres of the gates. The main sluices were single sluices. With regard to Mr. FitzGibbon's statement that the output of coal per appliance per annum at Methil was 418,000 tons, during 1911 altogether 3,012,000 tons of coal were shipped at Methil. The travelling coaling-crane had never been used, and one of the hoists was used only for a limited period, owing to the quay around it having to be used for the unloading of timber; but, even allowing the full six hoists, the quantity per appliance per annum should be 502,000 tons.

Mr. Cleaver. Mr. Cleaver, in reply, remarked that he fully realized the position of engineers and their staff on construction works, and that the special conditions often met with materially influenced the decisions arrived at; he also appreciated highly the kind way in which Mr. Meik had accepted and criticized the Paper, particularly as he and the late Mr. P. W. Meik were the Consulting Engineers when the Port Talbot Docks were constructed. Mr. Meik was quite right in stating that the old docks and channel, etc., were in actual use by the Company in and before 1899, and what Mr. Cleaver meant was that in that year the entire works were handed over to the sole maintenance of the Company, as having been to all intents and purposes finally completed. The Paper applied only to what transpired after that date. Although he understood that the majority of the screw-pile moorings were put in after the water had been let into the dock, he had been unaware that the original intention was to put in mass-

Mr. Cleaver. concrete blocks. He was still of opinion, however, that even concrete blocks of the size generally favoured at that time would not have proved absolutely reliable under present-day conditions. He could not help differing from Mr. Meik as to check-chains. Granting that a rigid cable or wire would be unsatisfactory, owing to the fact that a suddenly-applied resistance from anything (other than a too unwieldy cable) would have little effect in retarding the way of a heavy steamer, this could not be said of suitable apparatus, designed, like all efficient brakes, to apply a gradually-increasing resistance. If any device could be fitted to lock-gates, so as to offer a gradually-increasing resistance to a steamer whose momentum could not be checked otherwise, it must reduce very materially the damage due to collision, even if it did not prevent it. It was, therefore, for those responsible to continue to experiment until some effective means of coping with the difficulty was discovered. Damage to check-chains, booms, etc., was of no consequence if it prevented, or even reduced, damage to such important structures as lock-gates; and every provision for such appliances that could be made in lock-walls when they were built would be found of service at some later date, and therefore should be provided. The fender-chain now on trial at Port Talbot was that of the Stopall Fender Chain and Resistance Unit Co., of Westminster. The effect of gradually-increasing resistance could of course be secured by using coiled or other steel springs, but as the chain would only come into use in rare cases of emergency, the springs would inevitably deteriorate, and when called upon suddenly for duty would probably prove ineffective; whereas the timber core of the chain now being tried was likely, with ordinary care, to keep good for years. The submerged mains at Port Talbot had been tested in the following manner before being brought into use:—Each set of pipes, after being laid and connected with the preceding set, was closed at the end by means of an ordinary blank flange. An ordinary hydraulic-pressure hand-pump was then connected with the shore end, and the main was tested to a minimum pressure of 1,500 lbs. per square inch; in fact, most of the joints withstood a pressure of 2,000 lbs. without a leak. The entire length of main when completed was again tested throughout with the same pressure, before the valves were opened to the main circuit. The return-mains were similarly tested to a pressure of 600 lbs. per square inch. No leak or other defect had yet been experienced at any of the joints since the main was brought into use. The main has been damaged once by a ship-pilot carelessly allowing a heavy anchor to foul it, but the damaged lengths had been replaced and tested, and no further trouble had been experienced. He quite agreed with Mr. Meik that the breakwater itself would probably be less liable to damage if the parapet could be omitted altogether, but damage to the breakwater was not the primary consideration, either at Port Talbot or in the majority of cases where a breakwater was necessary. In such a storm as the one mentioned in the Paper, when large waves generated by a severe gale occurred at an exceptionally high spring-tide, the deck or coping of the breakwater was almost level with the surface of the sea, and if the parapet had been omitted, as suggested by Mr. Meik, the destructive waves experienced that night would have rolled almost unimpeded over the top of the breakwater, and continued their course up the channel to the lock-gates, etc., causing probably very serious damage. As it was, the parapet, presenting an additional height of 5 feet 6 inches, caused the waves to mount that height and fall on to the hard concrete surface of the deck on the other side, practically nullifying its action so far as the channel and dock-entrance were concerned. Of course, in doing so, the parapet ultimately gave way (for reasons stated in the Paper), as also did the coping over a certain length; but the principle as to the wisdom of erecting the parapet still held good. Had it not been for certain local circumstances governing the original design, the parapet would probably have been effective in breaking the force of the waves, and yet would not have been destroyed. As would be noticed on the plan, the inner end of the new south breakwater was at a different angle from the outer end. The prevailing gales and storm-waves at Port Talbot were from the south-west, and the resulting angle of incidence of the waves with the outer portion of the new breakwater was an acute one, whereas it was almost a right angle in the case of the inner portion. But for the necessity of constructing the inner portion in that form, so as to provide a wave-trap, the parapet would have held as constructed, as on the outer portion it was not damaged at all, the waves striking there at an acute angle and sliding off without causing any damage. This showed the necessity of strengthening the parapet by reinforcement or otherwise, as suggested in the Paper; but the parapet must still be provided if damage elsewhere was to be prevented. The damage to the breakwater, serious as it was, did not affect the working of the dock, and the repairs were without inconvenience left over until the weather was favourable; whereas the repair of damage higher up the channel would have meant serious delay to traffic. Mr. Meik's remarks as to lighting the end of the breakwater with compressed gas had, no doubt, been made with the old occulting light in mind, which was fitted with an oil-lamp.

Mr. Cleaver.

Mr. Cleaver. This, however, had been superseded by an electric port-light on a steel lattice tower 40 feet high. The new light was fitted with a metallic-filament lamp of 1,000 candle-power at 220 volts, and with a revolving clockwork shutter occulting at 10 seconds light and 5 seconds dark. The light showed white seaward and red to cover shore and all sandbanks, etc. The effective range of the white light in clear weather was about 12 miles, and of the red light 9 miles. The lighthouse was fitted also with a fog-bell for use when the docking-signals could not be seen. This bell, which was 14½ inches in diameter, was rung by means of a small motor fixed inside it, and also worked at 220 volts continuous current. Both the light and the bell were controlled by switches fixed in the cabin near the lock-gates. With regard to the moorings, he had thought of using large concrete blocks, similar to those at Immingham mentioned by Mr. Cruttwell, but he found that it was almost impracticable to adopt them at Port Talbot under existing conditions. He believed that the 10-foot-cube mooring-blocks at Immingham had been built in the dry, which, of course, was a simple matter, and under those circumstances they ought to be quite effective and as cheap a method as any that could be provided. Mr. Cruttwell, however, appeared to have overlooked the fact that the new moorings at Port Talbot had been, and were being, constructed in water at a permanent depth of 32 feet, the surface of the dock-bottom being dredged to this depth before any mooring was commenced. This was 4 to 5 feet deeper than in the case of the old screw-pile moorings. The removal of this amount to allow for the deeper draught of vessels reduced the depth of clay to about a foot or two, and below that was hard boulder gravel. A hole 4 to 5 feet deep was about the deepest that could be excavated with an ordinary grab in hard gravel, and would be altogether insufficient for a mass-concrete block, leaving out of consideration the question of the doubtful advisability of depending entirely on concrete laid in situ under water at such a depth. Hence he had felt compelled to resort to pile-driving, which the result had amply warranted, especially as the extra cost was comparatively small. The concrete was intended primarily to act simply as a protective covering to the piles and braces, and incidentally it bonded the whole work and added weight. Great care in the mixing, laying, etc., of the concrete was therefore not as necessary as it would be in the case of mass-concrete blocks. Knowing Mr. Wentworth-Sheilds's exceptional experience in both the maintenance and construction of docks, he had naturally been pleased to hear many of his views concurred in by Mr. Sheilds, especially as in some respects he believed the natural conditions at Southampton and elsewhere on the south coast were quite dissimilar to those at Port Talbot. He could quite understand Mr. Sheilds thinking that £200 for one screw-pile mooring-appliance was an excessive estimate, but it would not appear so when it was considered that suitable plant would have to come from a long distance, and that the quantity and size of the spear-rods, capstan-heads, etc., would have to be much in excess of those used in the past, as it would be no use replacing any drawn and ineffective screw-pile with one of the same size and depth. A screw-pile mooring put down now would have to be much larger and stronger than previous ones. Again, only at certain times would it be convenient to construct each mooring in the midst of traffic in a busy dock, so that the plant and barges would be standing idle for considerable periods; and if they were on hire, as would probably be the case, the estimate of £200 for each screw-pile would probably in the end prove rather a modest one. He knew of an instance in another South Wales dock where a screw-pile driven to 16 feet below dock-bottom was drawn in actual use. The repeated alternating stresses caused the blade to rock, and a cavity was formed around it, with the inevitable result. Lately a screw-pile mooring had been drawn out at Port Talbot during a very severe gale. Three large sailing ships were moored to it. When the mooring was afterwards examined on shore everything was found in perfect condition, except that a portion of the screw blade was broken off. This, however, might have been done recently or during previous use, or even when the pile was screwed into the ground. In this instance the screw-pile was fixed in good hard ground, the blade showing evidence of having been driven through the clay into gravel. Mr. Sheilds was quite right in assuming that the mooring-posts and blocks on the dock-side, mentioned as having been strengthened, had been found to be shaken by heavy pulls; fortunately none of the cast-iron bollard-posts at Port Talbot had ever broken. Most of them were amply thick enough to withstand the pulls exerted on them. There was only one instance in his recollection of a cast-iron bollard, of the standard adopted at Port Talbot, breaking in use, and that was found to be due, not to any weakness in the dimensions, but to a hidden defect in the casting: this had evidently been poured in two feeds, and a slight "cold shot" had occurred at their junction, constituting a serious flaw. He quite agreed with Mr. Sheilds, however, that the additional precaution of reinforcing the bollards was very necessary to meet existing requirements; and he had admired the method adopted at South-

Mr. Cleaver.

Mr. Cleaver. ampton when on a visit there in the summer of 1911. Experience at Port Talbot confirmed Mr. Sheilds's statement as to the insufficiency of the older estimates of the amount of pull on a bollard. In all specifications for wharves, jetties, etc., Mr. Cleaver always specified a maximum pull of 100 tons. With regard to reinforced concrete, timber fenders were fixed in front of all concrete wharves, etc., at Port Talbot, as a certain amount of wear and tear on the face of such structures was inevitable, and it was naturally much easier to repair timber fenders than concrete piles. He also adopted timber piles for fenders in each instance, so as to avoid the necessity of making attachments between the fenders and the concrete piles except at coping-level, which, of course, was an easy matter. Any fender damaged or moved, therefore, did not carry any portion of the concrete structure with it—at all events not under water. Timber dolphins, etc., were also placed at the ends of structures where a vessel was liable to collide with them, for the same reason that it was easier to repair timber than concrete. The ratio of the timber involved in these precautionary measures to the concrete was still so small that it did not affect the claims made in favour of using concrete for the permanent primary structures.

Correspondence.

Mr. Binns. Mr. ASA BINNS observed that the construction of the new dock at Methil had apparently occupied about 5 years, at a total cost of about £700,000. No doubt the comparatively slow progress of the work was due to its inherent difficulties, such as the exposed situation and the unexpectedly bad foundations, which had caused serious delays and changes in design. These delays were probably unfortunate from the point of view of the railway-company, who would otherwise have had the full benefit of the new works considerably earlier, during a period of great commercial prosperity. Judging from the general plan, and without knowledge of local conditions, it seemed possible that the great advantages to be derived from a lock entrance would have gone far to justify the additional capital cost. With regard to the design of the dock-walls, it might have been preferable to keep a vertical face, and to shorten the radius of the toe. The batter on the wall was certainly very slight, but it must be remembered that ships could not count