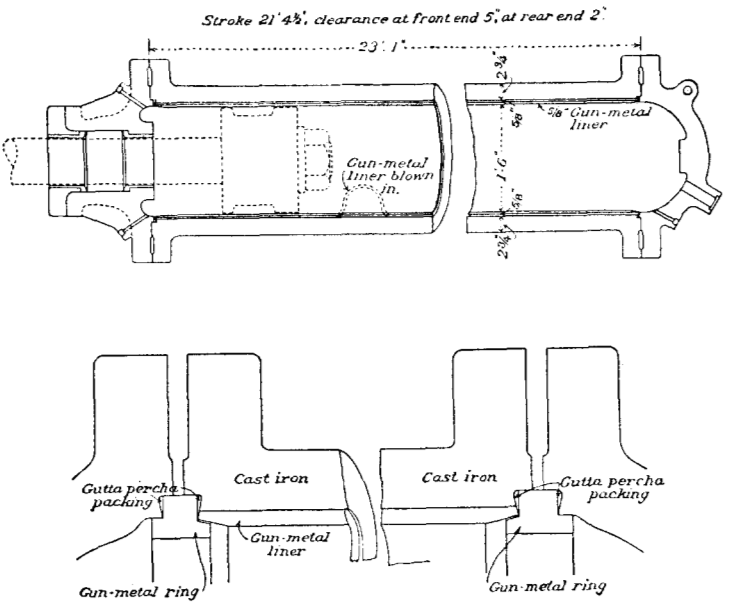
Discussion.

The Authors.

The AUTHORS showed a number of lantern-slides relating to the work. *Figs. 20* showed an accident to one of the lock-gate machines which happened when a ship was in the lock. It was due either to a porous place in the liner or to defective end-joints. Unfortunately

Figs. 20.



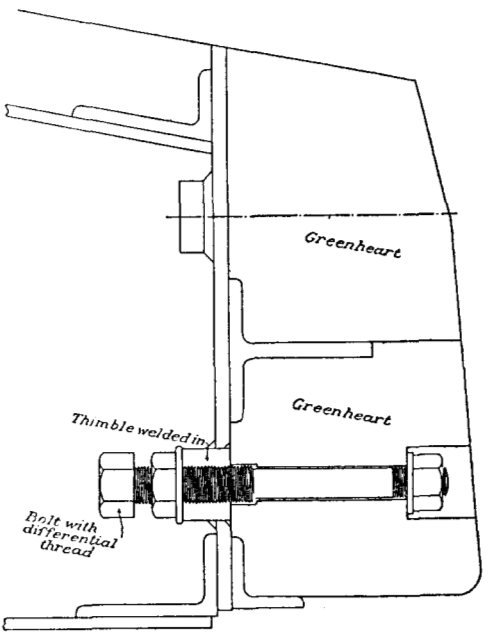
it took a considerable time to obtain a sufficiently sound casting to replace the liner. The gunmetal rings shown in the lower diagram were then fitted to all the gate-machines to strengthen the end-joints. *Fig. 21* showed an alternative method to that given in the Paper for fixing the mitre-post to the gate steelwork. The bolt had a differential thread which enabled the timbers to be tightened up inside the gate when immersed, and it was hoped to get watertight bolts without jamming the threads in the welded thimbles.

The tail-press to the heavy steel bridge, referred to on p. 310, was

designed with multiple cylinders in order to limit the working pressure to 700 lbs. per square inch, as there had been considerable trouble with another bridge using single cylinders working up to 2,400 lbs.; the leathers were always giving out. In both cases the tail-presses were fixed on girder grillage foundations, which had proved unsatisfactory, the punching action of the tail-press crushing the concrete beneath the girder flanges. Some of them had already been re-made in granite concrete without grillages. The

The Authors.

Fig. 21.



demolition of the walls of the old lock of the West India dock proved a great deal more costly to cut out than had been anticipated. Sir Frederick Palmer used to liken the job to putting new wine into old bottles; the phrase might not be quite appropriate, but it served one purpose in that it whitewashed some of those concerned for faulty estimating!

Mr. Asa Binns remarked that the works described in the Paper had cost approximately £4,500,000, out of a total capital expenditure by the Port Authority, during the 26 years of its existence, of £20,000,000. The works at the West India and Millwall docks had enabled a group of docks very largely over a century old—the West

Mr. Binns.

Mr. Binns. India docks were 130 years old—to be brought up to modern requirements. They were in a splendid geographical position relative to the City, and with the fine entrance-lock and communicating passages which had been provided there was no reason why they should not see at least another century of excellent service. The work at Tilbury was in a different category. The new entrance-lock, dry dock and landing-stage could not in themselves prove remunerative until the time, which it was to be hoped was not far distant, when the length of quay would be greatly increased by the extension of the dock in a northerly direction. The landing-stage, however, had removed a long-standing reproach which used to apply to the Port of London. Those who had had the misery of landing by tender from a steamer anchored in midstream and getting through the Customs, and who had also had the privilege of landing at the new stage, would realize that the improvement had been essential. When the late Sir Frederick Palmer, Past-President Inst. C.E., had been appointed the first Chief Engineer to the Port of London Authority in 1909, he had been faced with a very great task. The financial difficulties of the old dock companies had resulted in a state of stagnation in the matter of port improvements which had lasted from the opening of Tilbury docks in 1887, for a period of over 20 years, during which time the mercantile marine throughout the world was developing at perhaps the most rapid pace that it had ever achieved. Sir Frederick had been called upon to formulate proposals for the modernization of the Port of London, Sir Cyril Kirkpatrick, Past President Inst. C.E., being appointed as his first assistant. In December 1910, after 18 months' study of the problem, Sir Frederick produced a report recommending improvements which were to cost in the aggregate something like £14½ millions. £11½ millions had now been spent on those works, and the expenditure of an additional £1½ million in the immediate future was contemplated. Prices, of course, had increased, and much remained to be done. He could quite conceive that in another 25 years his successors would be carrying out the North Albert dock or the Tilbury extension on the lines proposed by Sir Frederick Palmer in 1910. The various docks of the Port of London were shown in *Figs. 22* and *22a*. The St. Katharine dock, built in 1828 by Telford, the illustrious founder of The Institution, had scarcely been touched, but Sir Frederick in his report in 1910 proposed to bring the London docks up to date by giving access for short-seas traders and barges, so that the fine warehouse accommodation could be put to better use ; about £400,000 had been spent on that group of docks. At the Isle of Dogs over £2,000,000 had been spent on various works, including some which the present Authors had

Mr. Binns.

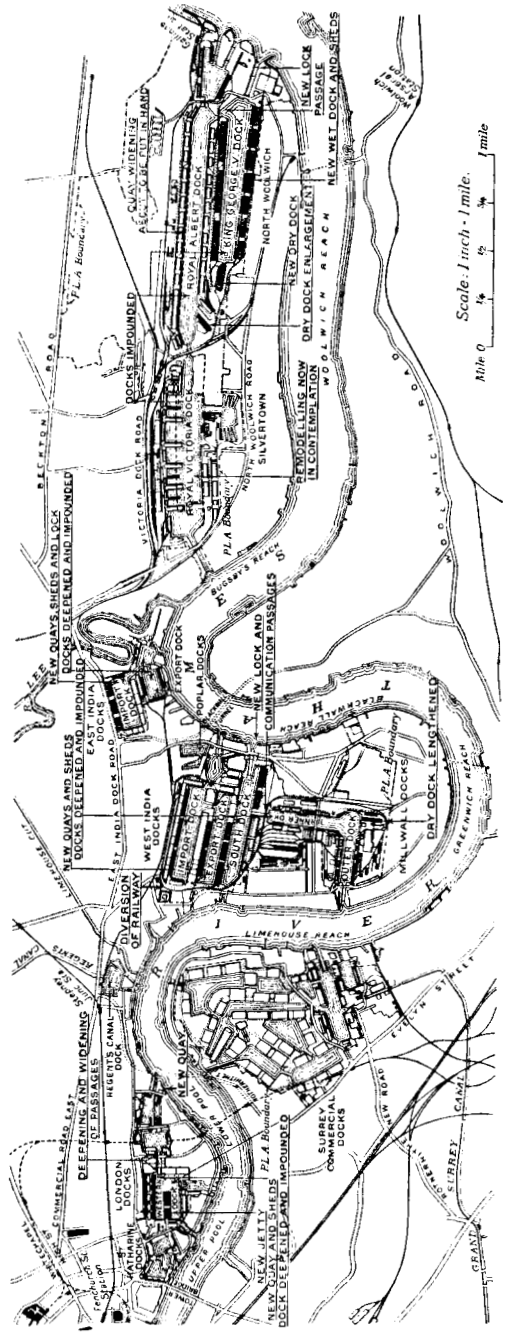
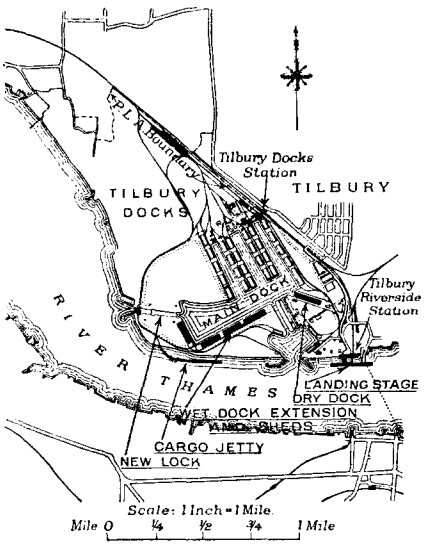


Fig. 22.

LONDON DOCKS, SHOWING IMPROVEMENTS SINCE 1910.

Mr. Binns.

Fig. 22a.



TILBURY DOCKS, SHOWING IMPROVEMENTS SINCE 1910.

described. At the biggest group of docks, the Victoria and Albert and the King George docks, over £5,000,000 had been spent. On the west was the Victoria dock, which it was proposed to modernize, and a Bill would shortly be before Parliament for that purpose. The new Silvertown Way, which had converted Silvertown from an inaccessible island into a peninsula served by one of the finest roads in London, was also shown. To the north of that group of docks an area was marked which, as a result of the report of 1910, was acquired for a future North Albert dock, and to the east were the Tilbury docks (*Fig. 22a*), where another area was available there for future extensions.

In considering the various alternative positions for the Tilbury entrance, shown by dotted lines on *Fig. 1*, p. 260, Sir Frederick entered into discussion with all possible authorities—representing shipowners, ships' captains, pilots, port-masters, harbour-masters and so on—and they expressed most diverse opinions. Sir Frederick, however, with his wonderful appreciation of the main features of a problem, proposed the alignment which was ultimately adopted, and also succeeded in persuading each of the different warring authorities that its own particular opinion had considerably influenced the final decision.

Mr. Binns.

The works described could not have been carried through successfully without the co-operation of the capable contractors named at the end of the Paper, and the thanks of the Port Authority were due to them one and all for the excellent way in which the work had been done. Sir Frederick always taught his staff that, provided the work contracted for was carried out at the agreed price, it was their duty to help the contractor in every possible way. Furthermore, as it was not stated in the Paper, he would like to mention that they had had the assistance of excellent quantity-surveyors, who had helped very much to make things run smoothly.

With regard to the details of the Paper, time permitted only a brief reference to one or two innovations. In the lock-gates rollers and roller-paths had been omitted, and, after 5 years' experience, he could say that no disadvantages had been discovered. He would like to congratulate Mr. Davis on his invention of the leading-in girder. Those who had had the privilege of seeing a ship enter the dry dock and had seen the way in which that girder engaged the stem of the ship and led it along the dock, keeping it central over the keel-blocks, would realize that it greatly expedited the safe dry-docking of ships.

There had now been 5 years' experience of the running and maintenance of the works described, and he was able to say that there had been no difficulties whatever. They had come up to expectations in all respects, and he had every reason to believe that the works would see a century's useful life in the Port. He was certain that, had Sir Frederick Palmer been present, he would have wished to pay a tribute not only to the Authors but to his partner, Mr. Buckton, and to Mr. A. T. Best, of his own staff, who were particularly associated with the work.

Sir Frederick Palmer found the Port of London almost moribund; he transformed it, largely by his own efforts, into the premier port of the Empire. Those who came in contact with him would treasure grateful memories of his strong but generous personality. He loved The Institution and added lustre to its fame. His portrait was at the moment obscured by the cartoons representing some of the great works he carried out; but, looking at the cartoons, one would like to say of him, in words applied to another great artist, "Si monumentum requiris, circumspice."

Sir Cyril Kirkpatrick.

Sir CYRIL KIRKPATRICK, Past-President, said that the scheme prepared by the late Sir Frederick Palmer in 1910, and carried out firstly under the Chairmanship of the late Lord Devonport and later under that of Lord Ritchie, was perhaps the boldest and most successful that any engineer had seen brought to a successful issue in the short space of 25 years. He proposed to make a few com-

Sir Cyril Kirkpatrick.

ments on the lay-out generally. The Authors had referred to the difficult ebb currents which existed near the Tilbury entrance as constructed. He, in his time as Chief Engineer, had had to consider the location of the entrance, and had decided that in spite of those currents it would be necessary to adopt that position, which had been previously proposed by Sir Frederick Palmer. An entrance-lock from Northfleet Hope, running north and south, had also been considered; but, as the Authors pointed out, the huge expense that would have been involved rendered it out of the question. Another proposal which came into prominence was for the entrance to be made through the tidal basin, near to the existing lock. The late Lord Devonport had been definitely of the opinion that that was the right place, and had been determined that the entrance should go there. Sir Cyril Kirkpatrick gave his own views on the matter perhaps equally strongly. Later on, when Sir Frederick Palmer took charge of all the new works, he had been rather surprised to find Sir Frederick seriously considering the position favoured by Lord Devonport. He felt that the choice of that position would have been a fatal mistake, as, apart from the reduction in length and the congestion that would have arisen, the tidal basin was a most expensive part of the Port to maintain, owing to the silt settling in the still water, so that it had to be dredged almost continuously to maintain the depth. He had been delighted to hear later that Sir Frederick Palmer, after weighing up the whole position, had come back to his old love and constructed the entrance almost exactly in the position which he had selected in 1910. Sir Frederick had originally proposed to put the dry dock nearly parallel to the existing entrance-lock, but he had changed that plan and put it at the eastern end of the main dock, near to the existing dry docks. That was a very good decision, as it enabled all the ship-refitting and all the pumping arrangements to be concentrated round about the existing dry docks.

With regard to the Tilbury landing-stage, when he had been Chief Engineer he had been instructed to make the stage 2,200 feet long, to allow of two berths of 300 feet at the downstream end for the L. M. & S. Railway. The Port Authority subsequently decided, perhaps wisely, that instead of two berths they would in the first instance make one; but he did not think it would be long before the second was constructed. The Port Authority had, however, succeeded in postponing considerable expenditure for some years.

Sir Frederick Palmer had made drastic alterations in his original scheme for the West India and Millwall docks. No doubt he had had good reasons for doing so, but Sir Cyril was not acquainted with them all. Sir Frederick's original idea had been to make the entrance pointing from the south-west to the north-east, and he believed that

land had been acquired for that purpose, but there had been grave difficulties in the way. His own subsequent idea had been to make an entrance-lock 625 or 650 feet by 80 feet by 41 feet 3 inches, to divert the railway over the river-side of the entrance, and to make a large turning basin at the eastern end of the Import, Export and South docks, on the site of the railway as then existing, with a cut to the Millwall dock, so as to permit vessels to enter any of the group of docks by the new entrance. The size of the proposed entrance had, however, been cut down, he believed to 550 feet, and the sill also made of less depth. One of the reasons given was the existence of the Blackwall tunnel, but he himself considered that it would have been safe for big ships to come up so as to fill the 625-foot entrance. That scheme had been inspired by a proposal by one of the biggest of the shipping companies in the Port of London to use that group of docks, particularly the South dock, but the shipping company had subsequently changed its ideas, and the whole scheme had been revised. Sir Frederick Palmer decided to make the cuts and a new entrance, having one great advantage in considering the matter which he himself had not enjoyed, inasmuch as the railway line which was in his own time a passenger line to North Greenwich station could be diverted, passenger traffic having ceased owing to omnibus competition. He himself still hankered after the full scheme, but no doubt Sir Frederick had been told that economy was necessary, and his scheme was probably cheaper. It had certainly proved an admirable one.

Sir Cyril Kirkpatrick.

The group of docks in question had become exceedingly busy. Mr. Binns had referred to the fact that they were 130 years old, but he would like to read a short extract from Joseph Conrad's book "The Mirror of the Sea," written, he believed, about 1880, which was interesting in view of the present Paper, and in which reference was made to the New South dock (which, as a matter of fact, was one of the oldest of them all) :—

"This New South Dock (it was its official name), round which my earlier professional memories are centred, belongs to the group of West India Docks, together with two smaller and much older basins called Import and Export respectively, both with the greatness of their trade departed from them already. Picturesque and clean as docks go, these twin basins spread side by side the dark lustre of their glassy water sparsely peopled by a few ships laid up on buoys or tucked far away from each other at the end of sheds in the corners of empty quays, where they seemed to slumber quietly remote, untouched by the bustle of men's affairs—in retreat rather than in activity. They were quaint and sympathetic, those two homely basins, unfurnished and silent, with no aggressive display of cranes, no apparatus of hurry and work on their narrow shores. No railway-lines cumbered them. The knots of labourers trooping in clumsily round the corners of cargo sheds to eat their food in peace out of red cotton handkerchiefs had the air of picnicking by the side of a lonely

Sir Cyril Kirkpatrick.

mountain pool. They were restful (and I should say very unprofitable) those basins, where the chief officer of one of the ships involved in the harassing, strenuous, noisy activity of the New South Dock only a few yards away could escape in the dinner hour to stroll, unhampered by men and affairs, meditating (*if he chose*) on the vanity of all things human."

Had Sir Frederick been present, he would have been interested to hear that paragraph in view of the marvellous change which he had made in that group of docks.

In conclusion, he would like to congratulate the Authors and all the engineers and contractors concerned in the great works which had been successfully concluded. Had Sir Frederick been alive, he would have asked him also to accept his congratulations on his splendid achievement. He would like to endorse every word that Mr. Binns had said regarding the greatness of Sir Frederick's conception, and his marvellous character and ability to see things carried through.

Mr. Du-Plat. Taylor.

Mr. F. M. G. DU-PLAT-TAYLOR said he had read the Paper with very great interest and with a feeling of deep regret that his old chief and friend Sir Frederick Palmer was no longer alive to join in the discussion. His own interest in Tilbury docks dated from their original construction between 1882 and 1886, for his father, who was at that time a director of the East and West India Dock Company, had been chiefly responsible for those docks being built at Tilbury and not higher up the river. The most important docks on the Thames at that time had been owned by that company, and by the London and St. Katharine's Dock Company, and there had been great competition between the two. The London and St. Katharine's Dock Company had opened in 1880 the Royal Albert Dock, then the largest dock on the Thames, and the East and West India Dock Company were contemplating the construction of a dock of equal or greater size. The Board were divided as to whether that dock should be built within the London cartage area and lighterage limits at a site which they had acquired on the south side of the river opposite the Royal Albert dock, or whether they should go boldly down to a site much nearer the mouth of the river, where the channel was much deeper and where consequently very much larger ships than had up to that time been constructed could in future be accommodated. His father had been the chief protagonist of the latter scheme, and proposed a dock with a depth of 38 feet instead of the 27 feet of the Royal Albert dock, and with a lock-entrance with a length of 700 feet instead of 550 feet. That view prevailed, and the construction of the dock had been commenced in 1882, the opening taking place on the 17th April, 1886. The dock was much ahead of its time, there were difficulties with regard to lighterage, and rail haulage to

London proved a more serious drawback than had been anticipated, so that for many years less than half of its berths were occupied. It revived at about the time that the Port of London Authority was constituted, and it was pleasant to learn that the shipowners and merchants were now unanimously in favour of extending the Tilbury docks rather than going up the river. Mr. Du-Plat-Taylor.

With regard to the activities of the dock companies, the original Port of London Bill, drafted in 1903, had laid down the conditions under which the docks were to be taken over, and therefore the dock companies knew that any expenditure that they made after that date would be practically money thrown away, because they would get no more for the docks as improved by them than if they had left them as they were. The original Port of London Bill was thrown out, and its successor, of a different form, was not passed until 4 years later, so that the docks were by that time in bad condition.

The adoption of hydraulic power for the gates and capstans at the new lock was wise, and the all-electric capstans afforded extra security, as they could be employed for closing the gates by means of blocks and wire ropes in the event of hydraulic breakdown. The monoliths differed very little from those used in the first extension of the Tilbury dock in 1912, except that the size of the blocks had been doubled. In the original monoliths the contractors had only been able to employ a 5-ton crane, so that the blocks were limited to that size and therefore there were eighteen blocks in each course. In the present case there were nine, as Scotch derrick-cranes were used instead of gantry-cranes. Thames ballast was used for all the concrete; it was a very good aggregate, though rather deficient in sand, and in his opinion was very much better than the land ballast used in the work of 1912.

The Authors stated that the dry dock at Tilbury had been so placed that its diagonal direction in relation to the wet dock gave sufficient room to dock vessels up to 950 feet in length, the longest that could be admitted through the entrance-lock. He would have expected that a ship longer than 950 feet could be got into the lock, as its length between mitres was 1,000 feet, and he would not have thought that as much as 50 feet clearance would be required. He thought that mechanically-operated bilge-blocks had not previously been used in Great Britain. There were evidently two schools of thought on the subject of bilge-blocks, as for the new dry dock at Southampton the ordinary cast-steel wedge pattern with softwood caps and without any mechanical adjustment had been adopted. In a large dry dock built some years ago at Havre mechanically-operated blocks were not employed, but hydraulically-operated

Mr. Du-Plat-Taylor.

carriages were used to pick up the blocks and run them into position mechanically, which saved a good deal of expense.

Sir Leopold Savile.

Sir LEOPOLD SAVILE said that the modernization of old docks was a most important engineering question; he thought it was right to say that the Port of London had led the way in the matter, and the vast improvements which had been carried out under the original schemes proposed by Sir Frederick Palmer would serve later as examples for many other ports which had had to defer their improvements for financial reasons. He had no criticism to make of the work that had been done under Sir Frederick Palmer's scheme. The fact that Mr. Binns was able, after 5 years' working, to say that if it were to be redesigned he would not alter it at all was the best compliment which could be paid to it. But, whatever the difficulties encountered in laying out the scheme, he thought the people who had to carry it out had as great if not greater difficulties with which to contend. A straightforward new job was comparatively easy, but when those concerned had dealt successfully with all the unforeseen difficulties which arose where the construction was carried on in the midst of the old buildings and works of an existing dock he thought that they deserved as much credit as those who were responsible for the design.

He would like to ask one or two questions of detail on engineering matters, confining his remarks principally to the Tilbury dock. Reference was made in the Paper to the concreting of the floor of the dry dock. In the case of the Singapore dry dock, and also, he believed, at Southampton, the method had been adopted of carrying up the whole depth of the floor in voussoirs in one lift, the reason being that most of the failures that occurred in regard to the floors of docks and locks were due to horizontal construction-joints, which were avoided by that method. He was glad to know that no trouble had been experienced from that cause at Tilbury, as the floors of one or two docks, for whose maintenance he had been responsible, had lifted and had been very difficult to rectify. Had the method he referred to been adopted at Tilbury? On p. 272 reference was made to timber-slides. Twenty or thirty years ago when making a dry dock he had omitted timber-slides because he had been told that they were no use, and he was rather surprised that they had been put in at Tilbury; he would like to know what purpose they served. On p. 273 the Authors said that it had been anticipated that after the fine-axing of the granite stones for the gate-sills was completed only a final rubbing-down would be necessary. Some engineers went still further and polished the stone, but he himself had never gone further than fine-axing with a ten-blade axe, and he was certain that that gave as

smooth a surface as was wanted in contact with the greenheart sills. It was mentioned that the gates were made of steel. In the past engineers had always endeavoured to use wrought-iron plating for the outside of the gates, as it was thought that wrought iron did not deteriorate so fast in sea-water as steel. It was now difficult to get wrought-iron plates, although they had been used until quite recently. It was stated that the dry dock could be emptied in $2\frac{1}{2}$ hours, but for a dock of that size he would have thought that 3 hours was sufficiently fast, as it would take that time for the men working on the cleaning down at the sides of the ship to finish. Reference was made on p. 286 to the elaborate precautions taken to ensure that the keel-blocks should work. He would like to hear whether they had been satisfactory. The old dry docks at Bombay were fitted with sliding keel-blocks with the wedge-shaped arrangement, and he was told that they always rusted and seized up, and it was necessary to cut out the timber top to remove them. For the new dry dock at Bombay, therefore, instead of spending a great deal of money on such blocks—for they were expensive—he had adopted plain cast-iron keel-blocks; when one or more had to be removed the softwood top was simply cut out. He wondered whether the provision of a caisson-stop in the centre of the dock had been considered. That was very often done, and saved a large amount of pumping when docking a small ship. It was very interesting to know that the leading-in girder worked so well, and presumably justified its cost. Mr. Binns said he had never regretted not having rollers in the gates. He himself thought rollers were useful in case of accidents; where they were used nowadays they generally took no weight except in an emergency. In conclusion, he would like to ask whether it would not have been more convenient to have the rolling bridge in one span instead of two. Sir Leopold Savile.

Mr. E. J. BUCKTON observed that it was now 5 years since the works had been completed, but the Paper carried his memory back to many points of interest, a few of which he would mention. The first was the question of contract documents. Diagrams of assumed methods of construction and schemes of operation were prepared to furnish a basis for the measurement for the quantities. Included in the quantities were items for earth dams, sheet-piling and similar major temporary works, the cost of which would otherwise have been spread over the contractors' items. The tolerances allowed for the monoliths were 1 per cent. vertical tilt on the face and 2 per cent. on the side, and it was interesting to note that they proved to be reasonable. The arrangement for the monolith-blocks shown in *Figs. 4* (p. 266) was the outcome of a friendly competition, and although simple it was the result of much consideration. The monolith was Mr. Buckton.

Mr. Buckton. a light one, and heavy kentledge was essential; 6,000 tons of kentledge were therefore scheduled and paid for direct. Another item was the trenching in " bungum," the difficult formation which had to be dealt with at Tilbury; the bottom tended to spew up and make trenching very difficult. Sheet-piling, close framing, and loaded trench-bottoms helped to overcome the trouble. Among the items of interest was the two-point anchorage of the lock-gates shown in *Figs. 8.* Usually such anchorages had three points, of which only two could be effective. The gates were described as buoyancy gates; there were no rollers, spear-rods or roller-paths. He remembered that Mr. Binns had at first been anxious over that, but he was glad that Mr. Binns was now satisfied with the design. The anchorage and pintle had in any case to be designed to carry the dead weight of the gate, and they might as well be trusted to do the work continuously instead of adding a roller and not knowing which was going to carry the load. The dry-dock keel- and bilge-blocks and the leading-in girder were of an interesting design mechanically and represented a great deal of detailed thought. The leading-in girder was a particular favourite of Mr. Davis, and he believed it was very satisfactory.

The Tilbury landing-stage, he thought, deserved a Paper to itself; there had been a somewhat similar stage at Liverpool many years ago, but he had not been able to find any particulars of it. The outstanding feature of the Tilbury landing-stage was its flexibility, allowing for the rising and falling tide, its ebb and flow, the greatly varying live loads, the bumps and pulls of ocean liners, and the loads on the bridges and beams. The varying depth and length of the pontoons and the concrete kentledge adjustment were not referred to in the Paper, but there was a good deal of kentledge used as ballast at different points in the stage. The adjustment was the outcome of very full buoyancy diagrams. The mooring cables were shown in *Fig. 12* (p. 292). Each 3-inch cable had a 1-inch stud-link cable for easy adjustment.

The works as a whole were all well done by the contractors, the central blockyard at Tilbury being notable. The construction time of 3 years for Tilbury and 2 years for the other works spoke for itself. He looked back with pleasure on his 5 years' close association with a large group of engineers and contractors who collectively brought the works described to completion. Sir Frederick Palmer visualized those works 25 years ago and lived to see them completed and in use, and Sir Frederick was as proud of them as the members of The Institution were proud of him.

Mr. Mitchell. Mr. H. H. G. MITCHELL remarked that square monoliths had been used in many places, and he understood that there had been some

difficulty in keeping them upright. His own experience was that an oblong monolith was much more easily handled than a round or square one; the length was of great assistance in sinking monoliths which had to be true to line, and for controlling the monolith in the direction of its width it was better to pile up the spoil on the side to which the monolith was leaning rather than to grab it from the high side. As sinking progressed, the monolith gradually came up to the vertical, and if there was any tendency to go beyond that spoil could be excavated on that side again. If it were attempted to right it by excavating under the foot on the high side it might swing right over to the other side. The monoliths of which he was speaking were 50 feet by 28 feet, so that they were comparable to those referred to in the Paper, and he sank them to a depth of 60 feet. With regard to plugging the monoliths, from *Fig. 7* (p. 272) it appeared that the ground had been levelled under the monolith before the concrete plug had been put in; on the other hand, it seemed from the section at bridge AA in Figs. 2, Plate 1, that the concrete had been filled in to the curved bottom left by the grabbing. The Authors would be able to say which was the case. He had always been taught that the bottom should be levelled up with a firm substance similar to the stratum at foundation level, and he thought that that point ought to be watched. It was also important that the concrete in the plugs should be put in by divers. He was not referring to a well such as a bridge well, but to monoliths such as those used in quay-walls, where there was more pressure on one side than on the other and a consequent tendency to tilt. Mr. Mitchell.

Mr. W. H. McAlpine remarked that at the beginning of the contract he had felt a little fearful of the fact that they were working for an engineer for whom they had a great admiration but that the work was being carried out actually under the supervision of the engineers of the Port of London Authority, and, having a little experience of human nature, he found it rather difficult to assume that those engineers would deal with Sir Frederick's plans altogether without criticism. His fears on that subject, however, were groundless, as he soon discovered. At the very beginning his firm took their estimating and preliminary lay-out down to the ground and set to work to prepare their final lay-out and programme of work, and he asked Mr. MacKenzie if he would mind helping them with his experience. Mr. MacKenzie willingly came with them, and they were greatly indebted to him for his help; he was a party to the lay-out and to the planning of the whole job, which worked most satisfactorily. Mr. McAlpine.

Not only at the beginning but throughout the work he found that it was not a matter of trying to serve two masters, but that there

Mr. McAlpine. was a very fine team of men pooling their brains with one object only, namely, to make a success of Tilbury dock. Their success was evident, as the work was done in considerably less than the contract time, and in the ultimate settlement the money paid was considerably less than the contract sum accepted.

He would like to join with others in paying a tribute to the late Sir Frederick Palmer. Only those who carried out the work could realize the marvellous engineering skill which Sir Frederick showed in designing it to meet the very difficult conditions of the site. Furthermore, Sir Frederick was not the type of man to say " I have arranged this, and your job is to carry it out " ; he considered every practical suggestion which was made to meet the difficulties encountered, and adopted it if it was for the benefit of the work. In the early part of the work the steel shoes which should have been fitted to the monoliths were held up by a strike, so that it looked as if the whole scheme would be delayed. When he realized the position he asked Mr. MacKenzie whether they could not design a reinforced-concrete shoe, and he was overjoyed when he found that Mr. MacKenzie agreed with him and told him that they had actually improvised one on a previous occasion under somewhat similar conditions. Strengthened by that, he at once went to Sir Frederick, who immediately said " I think the idea is sound ; produce your design, and if I approve of it we will adopt it." He gave that as only one instance of the attitude which prevailed throughout the work. One thing of which he was very proud was that when he had made the preliminary lay-out with Mr. MacKenzie, he presented it to Sir Frederick and pointed out that the time looked very optimistic, but that was the result which appeared probable and it was hoped to stick to it. Actually, although there had been variations in detail, the work had been accomplished according to the original lay-out.

The Authors. The AUTHORS, in reply, thanked the Members for the very good discussion that they had given to the Paper, and were particularly grateful to Mr. Binns and Sir Cyril Kirkpatrick for adding a good deal of interesting information which it had not been possible to include in the Paper. There had in the past been many Papers on dock work in the river Thames, and the discussions on those Papers had been extremely useful to engineers ; in fact, one Paper in 1859 had been the only reliable record of the construction of the Victoria dock which the Port Authority was now about to remodel.

Mr. Du-Plat-Taylor in his remarks suggested that a vessel longer than 950 feet could be locked through a 1,000 feet entrance, but, allowing for the space required for the swinging of the gates, it was unlikely that a smaller clearance would be risked.

Replying to the questions raised by Sir Leopold Savile, the inverts of the lock and dry dock were formed in convenient-sized blocks to the full depth of the inverts, the concrete in each block being deposited without interruption. The Authors.

Provision of the timber-slides, which were used chiefly for lowering paint-drums and small gear on to the floor, was pressed for by users of the dry dock, no doubt in order to reduce craneage-charges.

The setting of granite masonry with the watertight faces already dressed, in order to eliminate dressing in situ, more often than not resulted in disappointment, particularly in the case of stones with vertical faces, since, apart from the time and the extreme care required in setting, instances had occurred where movements in the walls, due either to contraction, temperature-changes or slight settlements, had upset the accuracy in the setting of the masonry. The rubbing-down of hollow quoins, in addition to improving the watertightness, reduced the wear on the heel-posts which so often proved to be the determining factor necessitating the removal of lock-gates for repair.

With reference to the time required for unwatering the dry dock, the period of $2\frac{1}{2}$ hours was a measure of what the pumps could do; it was obtained by the use of the unwatering pumps in conjunction with the impounding pumps, the latter for so long as the head was such that they were not less efficient than the former. Although that was quicker than required when scrubbing-down of the vessel was taking place, the faster pumping was a great advantage at other times so as to allow work to start as soon as possible on the bottom of the vessel, and also when the dock was being pumped out without any vessel in it for sighting the blocks.

Referring to the comment on the care which had been taken in designing the wedge keel-blocks to ensure that the blocks could be removed by striking the wedges, the ship-repairing firms attached considerable importance to the provision of blocks which could be struck, so as to save the expense and loss of time in splitting-out the caps which they were incurring elsewhere to release the blocks, even though they were of the wedge type. That led to the adoption of the two-wedge keel-blocks of suitable inclination for striking under heavy loading, and the blocks so designed had proved satisfactory, being readily struck by the use of a small portable jack, tension-rods and strongback, referred to on p. 287, in cases where manhandled battering-rams were not sufficient.

The use made of sub-divided dry docks had not in the past justified the additional capital and maintenance costs involved.

A one-span rolling lift bridge, apart from the greater windage and concentration of weight to be provided for, would, at Tilbury, have

The Authors. necessitated additional monolith-foundations and would also have been slower in operation.

For oblong monoliths with a single row of wells, the method advocated by Mr. Mitchell of loading the ground on either side to correct tilt or drift during sinking would be a useful expedient, if applied in time. It was doubtful, however, whether the conditions appertaining to the sinking of monoliths for the quays at Tilbury would have permitted advantage being taken of that method to any considerable extent. In the Authors' experience, two rows of wells in monoliths gave all the control necessary. The concrete plugs were deposited on the curved bottom of the well-excavation as left by the grab, after final cleaning-out. With the four-well monolith on a gravel foundation, there seemed to be no substantial objection to the concrete filling. Any method that could be devised of depositing concrete under water without the aid of divers would be preferable.