Discussion.

Mr. Preece. Mr. W. H. PREECE, C.B., F.R.S., President, said his first duty was to propose a vote of thanks to the Author for the care, industry, and clearness with which he had brought before the Institution the great work of which engineers were all so proud. They were proud to see work of that kind conducted in other parts of the world. Those who had travelled over the world could go nowhere without finding illustrations of the prowess and skill of the British engineer. Perhaps the most charming part of the Paper was the very graceful tribute that the Author had paid to those great minds which were the springs of that magnificent work.

Mr. Hawkshaw. Mr. J. C. HAWKSHAW regretted that the Author, being on his way to Buenos Ayres, was unable to be present; but he was glad of the opportunity of saying how much credit was due to him for the able way in which he had superintended the carrying out of the works, often under conditions of great difficulty, requiring much tact and consideration on his part. It was also a matter of regret that so many of those who were concerned at the beginning with the works had not lived to see them completed. He alluded more especially to Don Eduardo Madero, the concessionnaire; Mr. T. A. Walker, the contractor; Mr. Hayter and Sir John Hawkshaw, the engineers. The harbour had been known as the Madero port, and he hoped that the name of Madero would always be associated with it, because he felt sure that to his ability, his energy, and his foresight, the works owed their existence. Taking into consideration the size of the work—the work covering much ground—and having taken so many years to complete, the Paper had very few mishaps to relate, and it lacked some of the interest which was usually attached to a good account of a failure during construction. He attributed the freedom from accidents in a great measure to the good material which was met with throughout for the foundations; but he thought that credit was also due to the contractor for the careful way in which he had carried on his work, and for the abundance and excellence of the plant which he had put on it. The late Mr. T. A. Walker was never wont to stint the amount of plant he put on any work he had to do, and his nephew, Mr. Charles Walker, who had carried on the work since his uncle's death, had followed his example in that respect, and he

hoped for his own sake he would always continue to do so. The material met with in the foundations was commonly called Tosca. It extended over a very large area in Argentina. It was the only formation met with over thousands of square miles south and west of the River Plate, immediately below the surface soil. It was a calcareous marl formed in an old estuary, probably from the drainage of an area very similar to that drained by the rivers which now fell into the estuary of the River Plate. Looked at from the point of view of an engineer who wished to make docks it had admirable qualities. It was easy to work and it would stand with a vertical face of 20 feet or more without any timbering for an indefinite length of time. With regard to the provision of locks, Mr. Révy, he believed, was the first observer who determined that there was a regular lunar tide in the River Plate. During the whole time in which he was engaged in the survey of the rivers Paraguay and Uruguay, and the estuary of the Plate, for the late Mr. Bateman, he took systematic observations of the tides. He gave the deductions arrived at from those observations, but not the observations themselves, in a great work which he published on the rivers Parana and Uruguay and the estuary of the River Plate, which he called "The Hydraulics of Great Rivers." Soon after the harbour works were begun, a self-recording tide-gauge was provided, and a regular record was kept of the tides from that time onwards. The Author had given a summary of those records in a tabular form in the Appendix. There it would be seen that the range of tide was 2 feet 7·4 inches, but the level of the water varied very much with the wind. When a strong wind prevailed for any length of time, and acted on the wide expanse of shallow water in the estuary, the tide rose far above and—what was more important for the docks—fell much below the normal height. It was the knowledge that that would be the case which determined the provision of locks. On the 2nd May, 1890, shortly after the south lock was open, the water fell to a level of 8·2 feet below zero, leaving only 13 feet 7 inches on the dock sill. The channel to provide access from the deep water in the river to the North Basin was the most difficult problem to be decided in connection with the work. There were many who thought such a channel could not be made, and if made could not be maintained. The late Mr. Bateman, however, was not one of those, and he was sure that the members would feel satisfaction that an engineer of his eminence should have also recommended a channel very much in the direction it now occupied, which channel had been made since and maintained.

Mr. Hawkshaw.

Mr. Hawkshaw.

The full depth and width had been completed from the North Basin to its junction with the Riachuelo Channel. It was most unfortunate that the Government had not yet decided on the extension of that channel to deep water. There could be no doubt that it ought to be extended in a direct line to the deep water at the bar anchorage. Until the channel was completed to deep water, to the "bar anchorage," the works were so far incomplete. At the same time he could not help thinking that though the sum which the docks had cost was very large, it had been money well spent by the Government. The Government would get a handsome revenue from the docks provided with such a large amount of warehouse and shed space. There was no doubt that that was the paying part of the dock. In addition to that they would have the land which had been reclaimed, and which would go far when sold to recoup them for a large part of the capital expenditure. There was besides a large indirect saving to the country in the diminished cost of landing the goods from ships. It was reckoned that before ships could enter the docks the average cost of landing a ton of goods from ships in the "bar anchorage," and bringing them to the town, averaged about 10*s.* a ton. He could not say what the present cost was, but it was nothing like that amount, and there was a large indirect saving on that account.

The Hon. R. C. Parsons.

The Hon. R. CLERE PARSONS had read the Paper with much interest as he had been frequently in Buenos Ayres, and when he first landed there he had the experience, which was so graphically told in the Paper, of the manner of landing before the docks were built. He had also an additional adventure over and above what was described. When he got into the cart the horse became restive and insisted upon dragging it over an obstacle in the bottom of the river, and very nearly projected him into the water. Still, he landed safely. He thought it was the general opinion that the docks had been, and would be, of the very greatest benefit to the city of Buenos Ayres in the way of facilitating the trade of that port; but, besides this, they would be, and were now, of very great advantage from a sanitary point of view, in that they had covered the sandbanks in front of Buenos Ayres, which, when exposed at low tide, were extremely offensive. He noticed in the Paper that the Author drew attention to a paragraph which appeared in a Paper Mr. Parsons had prepared for the Institution some years ago upon the sanitary improvements of Buenos Ayres, with which he was connected. He wished it to be clearly understood that anything he said in

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regard to the matter was in no way finding fault with the construction of the docks, but simply as to the suitability of those works to meet the local requirements. The late Mr. Bateman, as was probably well known, had prepared an extensive dock scheme for Buenos Ayres, and his idea was that the docks should not be enclosed with gates, but that they should consist of a basin open to the inflow and outflow of the tide. His views were based upon the lengthy experiments which were carried out by Mr. Révy, whom Mr. Hawkshaw had referred to. Those experiments clearly showed that the rise and fall of the tide, except under abnormal circumstances, was only about 3 feet, and that was confirmed in the Appendix to the Paper. The depth of the river also from Buenos Ayres for 40 miles did not exceed, curiously enough, 21 or 22 feet, and Mr. Bateman argued that if those abnormal falls in the tide took place, and vessels took the ground, they might as well ground in the docks where the bottom had been made level and soft, as in what was called the deep water, where the bottom was uneven and not of uniform hardness; and the saving which would be effected in the cost of the docks by dispensing with the use of dock gates would be very considerable. The Paper showed clearly that it was absolutely necessary to keep the water of the Riachuelo out of the docks, because the water of that river, in consequence of having slaughter-houses and factories of various kinds on its banks, the refuse of which was discharged into it, was an extremely offensive fluid. Mr. Bateman provided in his scheme that there should be gates which would merely prevent the entrance of that water into the docks, but which would not be capable of supporting any considerable water pressure. Those gates would be of comparatively small cost. His scheme provided for the construction of a large basin parallel to the outer wall shown on the plan instead of being parallel to the town, as the docks had been constructed. There was to be an entrance into it nearly opposite the Customs House, and the channel was to run in practically the same direction as that adopted, and the water of the River Plate would flow into the large basin and out again. Inasmuch as the rise and fall of the tide was 3 feet per day and the dock 21 feet deep, the whole of the water in that dock would practically be changed twice every week. The estimate for that large basin, he need hardly say, was very much less than the cost of the docks as constructed, and he could not help thinking that it would have answered all practical purposes, and the results would have been as good as those of the costly docks which had been

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constructed. Mr. Bateman, in addition, with the view of changing the water in the docks, which was of great importance, suggested in his report that the storm-waters which fell over a large area of that great city should flow into the basin, and in that way assist materially in changing the water. It was seldom understood in this country what a large amount of water fell in Buenos Ayres during storms. The storm-conduits which were under that city were more like railway tunnels than conduits—most of them were 14 feet by 12 feet—and they were to discharge into the basin. The amount of water which would flow during a storm down those conduits into the basin would be 127 cubic metres per second, or, in other words, there would be 457,000 cubic metres of water per hour flowing into the basin, which was no trifling amount. During one storm, three-eighths of the total volume of water in the docks would be changed. That was a very considerable advantage, and might be obtained by the use of that storm-water; but the principal reason why it was proposed that the storm-water should be taken into the basin was to save the enormous expense of carrying it into the river outside the basin. That point had been entirely omitted from the Paper. The cost of the storm-water conduit shown in the plan was about three-quarters of a million sterling, and about half of it had already been constructed. Three-quarters of a million sterling would more than pay for all the sewers throughout Buenos Ayres, and that was one of the most potent reasons why it was proposed that the storm-water should be discharged direct into the basin. At the time this was proposed the Argentine Government were very short of funds, and it was important that the money should be saved. The construction of the docks was, however, proceeded with without any decision being arrived at, and it was not until they were almost completed that the intercepting storm-water conduit was commenced. Another interesting point with reference to the cost of these works, which amounted to seven millions sterling, was the enormous outlay on the reclamation of land. It was stated in the Paper that certain offers had been made for the purchase of that land which amounted to four millions sterling; but he would say that those offers were made at a time when everybody in Buenos Ayres was excited about the value of land. It was in the prosperous times, when everybody thought that land would rapidly increase in value. Everybody believed that they had only to speculate in land to treble their money annually, and many people told him what a fool he was not to bring out any capital he possessed and treble it annually in Buenos Ayres.

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That boom lasted for about 2 years, and then came the collapse, and since that time land upon which that enormous expenditure had been made for reclamation had been practically unsaleable. It had been put up to auction again and again, and small lots had been sold at about 12 to 14 gold dollars per square metre. The cost of filling up the land came to nearly 4 gold dollars, and that was after the deduction was made for the cost of dredging out the channel and depositing the material in a suitable position, so that it would not be washed into the channel again. That expenditure of capital was lying dead, and it was a question how long it would remain so, because to cover that reclaimed area with buildings would take years, and in the meantime it was doubtful whether the expenditure was warranted. That led to the point, should not the area of the docks be similar to the area of land to be reclaimed, and was any land gained from the river beyond that of the nature of a land speculation? In point of fact the works described were to a great extent a land speculation which had not been very successful. The Southern Basin, as would be seen on the plan, was a basin with a timber wharf constructed of pitch-pine, at which a very large amount of trade was carried on. Vessels did not mind in the least grounding there when the abnormally low tides took place, and it was a question whether the docks, if they had been constructed of timber—not pitch pine, but Quebracho Colorado, a native wood, the life of which was practically unknown, as it lasted so long—would not have answered as well. Many of the wharves on the Riachuelo were constructed of that timber, and alongside of those wharves a very large amount of trade was carried on. The cost of a wharf of that description was about 257 gold dollars per lineal metre, while the cost of the concrete wall was 600 gold dollars per lineal metre. Not long since he was consulted by the Great Southern Railway of Buenos Ayres with reference to the construction of a large dock on the south side of the Riachuelo. He had carefully investigated the matter, and it appeared to him perfectly clear that a dock with wharves constructed of that native timber would come to about one-third of the cost per lineal metre of those described in the Paper. That dock was now being carried out by the railway company, and he believed it would pay far better and be more easily accessible for shipping than the docks referred to. He would very much like to have the views of the Author on the points to which he had alluded, as, doubtless, they had been carefully considered, and were matters of considerable

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interest and importance, not only to Buenos Ayres, but to other places. Before he sat down he should like to congratulate the Author upon a remarkable intervention of Providence, to which allusion had been made. He must say that all the time he was in Buenos Ayres he was never favoured in the way the Author had been. Many a time he had wished that some providential way of getting out of his difficulties would arise, but he was sorry to say he always had to wriggle out of them as best he could unassisted by any similar occurrence.

Mr. Baggallay.

Mr. H. C. BAGGALLAY had been in Buenos Ayres two or three times during the last few years, and had had opportunities of seeing this great work under construction. He had never seen any work more thoroughly carried out than that work had been by Messrs. Walker; it was magnificent, but he agreed with the Author that less costly works would probably have answered the purpose. The first question he would have liked to have asked the Author had he been present was, what was the reason for having lock-entrances at each end? The docks, as arranged, were, he would not say parallel to the shore, but they more or less took up the whole frontage. To his mind the disadvantage was that half of the traffic must, of necessity, cross swing-bridges to get to the other side of the dock. That, of course, was the case in most English docks, because it could not be helped; circumstances had made it necessary to construct the docks in that particular way. For instance, the West India docks comprised three parallel docks, and beyond them again there were the Millwall docks, all crossed by swing-bridges, and the inconvenience to traffic was very considerable. In a case like Buenos Ayres there was nothing to tie the design in any way, and it would have been perfectly feasible to design docks on any particular plan. He presumed that that particular position was more or less compulsory and beyond the control of the engineers. It was known that with South American Governments, if the Minister said a dock was to be in a particular place it had to be put there. He did not quite see why docks of more or less the same size should not have been constructed about parallel to the South Basin. In fact, it might be said that the approach to the dock was something like the passage in a Pullman car as compared with that in a corridor carriage. He looked upon the work as a Pullman car with a passage down the middle. The docks might have been slewed round and the approaches made from one end, and then all the rails would have gone down on either side of those docks; and

for the same amount of accommodation the water area might then have been half the width, and there would have been no crossing swing-bridges. He looked upon the docks simply as the beginning of a much greater system. They happened to be of almost the same size as the Victoria and Albert docks in London; they were not quite so long, but they were exactly the same width, and he calculated they would accommodate nearly the same amount of trade. Referring to Appendix III, headed "Ocean steamers that entered the docks and basins during the years 1892–7 inclusive," he presumed that it meant the Buenos Ayres docks. Mr. Baggallay.

Mr. HAWKSHAW observed that the Author meant the Buenos Ayres docks. Mr. Hawkshaw.

Mr. BAGGALLAY said it was a curious fact that in 1897 in the Victoria and Albert docks 877 ships entered, with the registered tonnage of 2,160,000. In the Buenos Ayres docks, which were practically of the same size and very much the same in shape, 900 ships (almost exactly the same number) with a tonnage of 2,350,000 entered. That being the case he presumed the docks were full, because it was found that more work could not be done in the Victoria and Albert docks. That led him to the question of bridges and cranes. It was found at the Victoria and Albert docks, where there were five engines of a total I.HP. of 1,000 to work the hydraulic power, that sometimes the power failed. The docks at Buenos Ayres were provided with only two engines of 450 I.HP. each. That was easily added to, but what he wanted to point out was that that great power of 900 I.HP. was divided between only two engines. He found practically that it was necessary to have always at least three units. With two units, when one engine was out of repair, only half the power was available; whereas, if the power was divided into three there was not more than one-third out of gear at one time. He presumed the engines could be worked in halves, so that the inconvenience might not be quite as bad as might appear at first sight; but even then it was very often necessary to stop an entire engine, although the halves could be worked independently. Therefore he thought it would be necessary before long to add hydraulic power for a large number of cranes as well as for hydraulic bridges. When the docks were extended, as marked on the plan, more docks would be made parallel to those now existing, and then the inconvenience of the railway traffic over the swing bridges would be greater. There was another reason why he should have suggested putting the docks in the other position, and that was that a lock at either end added very much to the working Mr. Baggallay.

Mr. Baggallay. expenses of the dock-masters and the men connected with the locking. Had both the locks been at one end, one supervision would have been sufficient for both. With regard to the question of getting a current of water through, he thought that might just as easily have been got over by a small canal which might have had permanent bridges over it approaching from the north side, if both of the locks had been put on the south. He could not quite understand from the Paper the real reason for making the northern channel. It was stated that with this direction of the channel it was much easier to keep clear of silt. That was apparent, but it appeared to him that it was absolutely necessary to keep the south channel clear whether it cost much or little, because that was the only approach to a very large docking arrangement on the Riachuelo and its branches. Therefore it would be absolutely necessary to maintain the south channel. It did not seem that there was much economy in making a better channel which could be kept clear at a cheaper rate than the south one, if both had to be kept clear. He might be mistaken on that point, and it might be the intention to allow the south channel to silt up and to make another approach. With regard to the length of the locks, he noticed that the main lock on the south side was only 443 feet long, whereas the other lock was 508. It seemed to him that those lengths were very short for the present day, when it was found that Liverpool, Barry, and nearly all the Dock Companies in England, were lengthening the locks up to between 600 and 900 feet. The entrances at the Victoria and Albert docks were 550 feet long, and ships now had to be sent to Tilbury, where the entrances were 700 feet in length, because they could not get through the Victoria and Albert locks. It was under the serious consideration of the Committee whether they would not have to make a new lock. At the West India dock, some years ago, a new lock had to be put in, because the dimensions of ships were growing so fast. It could not be said that the ships which traded in the River Plate would of necessity be shorter than those which came to London; for he found, on working out the number of ships at Buenos Ayres in 1897, with their tonnage, that they averaged actually 100 tons more than the ships which came into the Victoria and Albert docks. Therefore the ships were larger. It was known they could not be deeper, because the river at the present moment was only 21 feet deep. The ships which came into the Victoria and Albert Docks drew as much as 26 feet; therefore it must be taken out in length or in beam. Then he noticed the southern lock was only

65 feet wide, whereas it was found necessary now in England to make most of the locks much wider than that. In fact, all the new locks were being made 80 feet, and even more. Mr. Baggallay.

Mr. HAWKSHAW pointed out that the north lock was 82 feet wide. Mr. Hawkshaw.

Mr. BAGGALLAY said he was referring to the southern one. On the north side the lock was longer, 508 feet long, 82 feet wide and 22 feet deep. The one on the south side was 443 feet by 65 feet and 21 feet 9 inches deep. It would be interesting to know why the basin on the north side which approached the larger lock was made 2 feet 6 inches shallower than the docks themselves. At Ensanada la Plata the docks were dug down deeper, because there were no lock-gates, and when the river became low the ships dropped as into a hole, and it was not necessary to have the approach as deep as where the ships were lying; but at Buenos Ayres the water was kept up with lock-gates. He did not quite understand why the basin was made only 21 feet deep. He saw that a part of the channel was already dredged to over 22 feet, and he was perfectly certain that before many years Buenos Ayres would not be content with an approach of only 21 feet. If it was impossible, as it might be, to maintain a channel to sea deeper than 21 feet, then he was pretty certain that before many years they would have a ship-canal to Buenos Ayres. A place which was practically the only large port for an enormous country which was doubling and trebling its trade every few years, would not be content with ships that only drew 20 feet of water. With regard to the increase of ships, he noticed in the Port of London during the last 10 years that the average size of ships had increased 24 per cent. —that was taking all the ships coming into the London docks increased 28 per cent. in 10 years. It was hardly likely that the people of Argentina, who were very advanced in many of their views, would be content to allow only 21 feet as the approach to their capital, for if they did not improve it, they knew that the trade would have to go down to Bahia Blanca and to other places where there was plenty of deep water. Even the docks themselves, he thought, might with advantage have been made a little deeper. He had worked out the details given in the Paper, and he found that for every foot in depth the cost would be £70,000. When £7,000,000 were being spent on docks the spending of another £70,000 or £150,000 in making them 2 feet or 3 feet deeper would be money well spent, because after the docks were once made the additional cost of deepening them was very serious. Even in the West India docks, where there Mr. Baggallay.

Mr. Baggallay. was 25 feet of water, they were putting out false quays in order to get deeper water. He should like to ask one question with regard to the dredging in the channel. It was stated that the estimate was about 800,000 metres to keep the channel clear. He took a metre to be about 2 tons—say 1,600,000 tons. Of course, in the Tyne about $2\frac{3}{4}$ million tons were dredged, and in the Clyde $2\frac{3}{4}$ million tons, and in the London docks a good deal more than $\frac{1}{2}$ million tons were taken out of the docks in addition to what was removed from the river. Therefore it did not seem to him a very large expenditure, compared with the magnitude of the work, to have to dredge $1\frac{1}{2}$ million tons to keep the channel clear. If that would keep the channel clear a little more dredging would deepen it. It seemed to him that the first consideration would be to get a better approach up the river, either by deepening or by making a ship-canal, as the land on the side of the river was very low and of an alluvial character, which could easily be excavated. The cost would not be great.

Mr. Meldrum. Mr. S. J. MELDRUM thought that in the allocation of praise it might be well to remember that before Messrs. Hawkshaw and Hayter, before even Mr. Bateman had approached the question, there was a design prepared by Messrs. Bell and Miller, of Glasgow and Westminster, at the request of the Argentine authorities, which design was to a very large extent adopted by Mr. Bateman. In addition to the abstract statement in the Paper that the design was settled after considering the various previous schemes, he thought it ought to be put on record that the original design for these docks was that by Messrs. Bell and Miller, in whose office he had received his early training, about 25 years ago. He remembered Mr. Bell telling him that his original design had shown what was now described as the north channel, but after due consideration he had concluded that it was economically impossible to keep open such a channel, and he therefore resolved that the only possible economical channel was the one leading to the Riachuelo. It had been mentioned that the cost of keeping open the northern channel was not so very great, but he fancied if any attempt was made to deepen it to the requirements of modern ships the difficulty would be much increased. He was in Buenos Ayres during the period of exceptionally low tide mentioned in the Paper as having occurred in 1890, when for more than 24 hours the water was several miles distant from the town, and when the area exposed was used as a promenade by thousands of people. Serious damage was, he believed, at that time done to vessels lying in the channel

entrance and also to some of the temporary work. It would be interesting to know whether the level of the water in the docks was well maintained during this period. Mr. Meldrum.

Mr. L. F. VERNON-HARCOURT congratulated Mr. Hawkshaw upon the completion of the work in which he had been most intimately concerned from the very commencement. The Author had stated that the whole of the water could be changed in the docks by directing the tidal current through them. The whole of the water, however, could not be thus changed, because the water was kept up to a certain low-water level; but no doubt there would be a great advantage in that current going through the docks for scouring the passages at locks and renewing the water. The Author had stated as the result of some float experiments, that the current through the docks was a good deal better than had been expected. The velocity obtained depended very much on what kind of floats were used, and where those currents were observed. In the docks themselves the current could not be very great; but in the passages and through the locks it would be considerable. It was to be regretted that if a lock of 82 feet was considered necessary, which probably it would be in the present day, the passages between the docks were not also made of the same width, because a vessel that required an 82-feet lock would be only able to get into the northern dock, and not into the others. Only the upper portion of the dock wall was given on the Plate in the Paper. The section of the dock wall was an important matter, because that made a large difference in the cost of the docks. The Author must be congratulated on the way that he got over a difficulty in putting in the foundations of one of the sills of the northern lock, namely, his use of a cylinder which he sunk to the lower stratum of tosca, by which he was able to pump above the running sand, and therefore without displacing it. Everyone who had had to do with docks, or almost any other engineering works connected with water, knew that if running sand were pumped up, it was impossible to tell how much one might be undermining foundations at a distance. Another thing worthy of notice was the subway which was put underneath the north lock; and certainly if a watertight subway could be arranged in that way, he thought it was preferable to the usual plan of having a groove down the side of the lock, across the invert, and up the other side. Where possible it would be certainly more convenient, although it might be more expensive, to have a subway for the various pipes which had to go across a lock severing property from the mainland. Thus at the West India docks, where he had superintended the con- Mr. Vernon-Harcourt.

Mr. Vernon-Harcourt.

struction of docks, grooves were provided in the outer lock for the gas- and water-pipes, because there were locks at each end cutting off the Isle of Dogs. In the Paper most of the quantities were given in metres, and he thought it would have been advisable, as most of the figures in the Minutes were in feet, to make it clear in the Plate that water-levels were in metres. The arrangement made by the contractors with regard to the dredging was another point worthy of notice. It was generally supposed that if a contractor arranged to dredge a channel of a certain size, it would suffice to measure that channel in place, to ascertain that the contractor had done his work; but at Buenos Ayres they were more fortunate, because the dredging was not measured in place, but measured by what was actually brought up, assumed to be reduced in bulk as if it was in place; and certainly that was measuring the material to the greatest advantage, for all material dredged which was not deposited in the barges was excluded, although the determination of the actual bulk of the dredged material in place seemed to have given rise to a great deal of difficulty. It was unfortunate that the sills were not made rather deeper, because 22 feet was given as the depth of the sill below low water in the north lock; and adding to that the small tidal rise, which seemed to average about 2 feet 6 inches, with a maximum of 5 feet, there was only 27 feet as the depth over the sill. That seemed to be rather small as a maximum during spring tides, and he thought it would be an advantage if the North Basin could be carried down at least as low as the sill of the north lock.

A definition of the nature of tosca, which had an important bearing on the security of the foundations, and some indication of the regimen of the River Plate in respect of the sediment it brought down, would assist in elucidating the Paper. The proportion of 67 lineal yards of quay per acre of water area in the Buenos Ayres docks, was similar to that of the East and West India, and the Victoria and Albert docks in London; but the proportion of quay was considerably larger at Liverpool, Hull, and several other English ports. The high water-level of a "Santa Rosa," reaching 8 feet 3 inches above high water of spring-tides, was evidently caused by the heaping up of the waters of the out-flowing river by a strong southerly wind; and the very low water-level of 8 feet 2 inches below low water of spring-tides must be attributed to the reverse action of high northerly winds, driving the river water out to sea. Accordingly, instead of stating "that the level of the tides varies considerably, owing chiefly to the effect of the

wind" (p. 191), it would appear more correct to say that strong winds blowing up or down the river had much more influence on the level of the River Plate than the small tidal oscillations on that coast. Mr. Vernon-Harcourt.

Mr. J. C. HAWKSHAW remarked, with regard to the provision of locks, that a vessel grounding in the River Plate, where the bottom was perfectly soft, was a very different thing from a vessel grounding in a dock with a very hard bottom, when the ship was perhaps half-loaded or just unloading. He did not think it would be safe to ground in the docks with a hard bottom. There was really a good current through the docks now from the North Basin to the South Basin, and the gates, he believed, were not shut regularly. The gates were there as a provision in case of any sudden fall in the water, so as to enable the water to be held up in the docks. He looked upon the land as something to the good, beyond the revenue from the docks which ought to pay a very good interest on the expenditure. When the works were half finished, the Chairman of the Harbour Trust made a statement at the Annual Meeting that the return to the Government from port dues and other charges produced a gross income equal to 3·84 per cent. on the total expenditure to the end of 1892 of $3\frac{1}{2}$ millions sterling, and at that time only a portion of the warehouses had been constructed. It was the warehouses and sheds that really paid the interest on cost, and there was no doubt when they were all in working order a very good revenue would be obtained. With regard to the lock-entrances at both ends, when the docks were designed the Government insisted that access should be made from the Riachuelo channel. When the question of channels came to be looked into, it was considered that the Riachuelo channel was not the best direction for a channel, but that one ought to be made in the line of the present north channel, which was more in the line of the current in the river. The Riachuelo channel had never been dredged or maintained to the full depth—it had really never been completed, whereas the other channel had been completed through the most difficult part—the shallow part—and there ought to be much less difficulty about the other end of it, because there was very little dredging to do there. The water was deeper, and if the one end could be maintained, there ought to be no difficulty in maintaining the other. With regard to the dimensions of the docks, it must be remembered that the date of the first report was 15 years ago, and it was during the progress of the works, before the north lock had been begun, that it was thought desirable to increase its Mr. Hawkshaw.

Mr. Hawkshaw. width. Possibly if the work was to be commenced now, a still further increase would be recommended in the South lock. He thought it should be borne in mind that the widths were settled 15 years ago. With regard to the depth of the channel, at the present moment there was not 21 feet of water at the entrance to the River Plate opposite Monte Video, and so there would be very little use in making the channels deeper until something was done to what was practically the bar of the estuary. Opposite Monte Video one had often to steam through the mud for an hour or two together.

Mr. Dobson. Mr. J. M. DOBSON, in a written reply to the Discussion, remarked that from the plan of the late Mr. Bateman, *Fig. 16*, it would be seen that the scheme proposed was, as stated in the Paper, very different in many great and important points from the one which had been carried out. With reference to the range of tide at Buenos Ayres, in order to avoid any misunderstanding which might arise regarding the figures given in Appendix I—they being average levels—he had prepared a diagram showing the actual variations during the month of December 1894. From *Fig. 17* it would be seen that the tidal axis itself experienced extraordinary variations, so that high water on one day was frequently lower than low water on the following, and *vice versâ*. This variation greatly facilitated the navigation of the River Plate so far as the depth of water was concerned, although it was a factor which could not be depended upon as to time. As to the statement that Mr. Bateman's reason for preferring an open basin was because he considered that if vessels grounded in the outer roads they might as well ground in the docks, he could only say that he was exceedingly glad that such a scheme was never carried out; since for large steamers to ground in the bar anchorage, where the mud in most cases was very soft, was quite different to ships grounding on the hard tosca in the docks. Referring to the Riachuelo, Mr. Parsons had stated that the Paper clearly showed that it was absolutely necessary to keep the water of this river out of the docks, and had referred to some gates suggested by Mr. Bateman which were not merely to prevent the entrance of the stream into the docks, but would be capable of supporting any resistance. It was difficult to understand to what Mr. Parsons referred, as it almost seemed as if he thought the outer or flood gates of the south lock were continually closed, and were not of sufficient strength to stand the small amount of pressure against them, there being nothing to prevent the water from entering the docks at the north end. In the Paper it was stated that the flood gates

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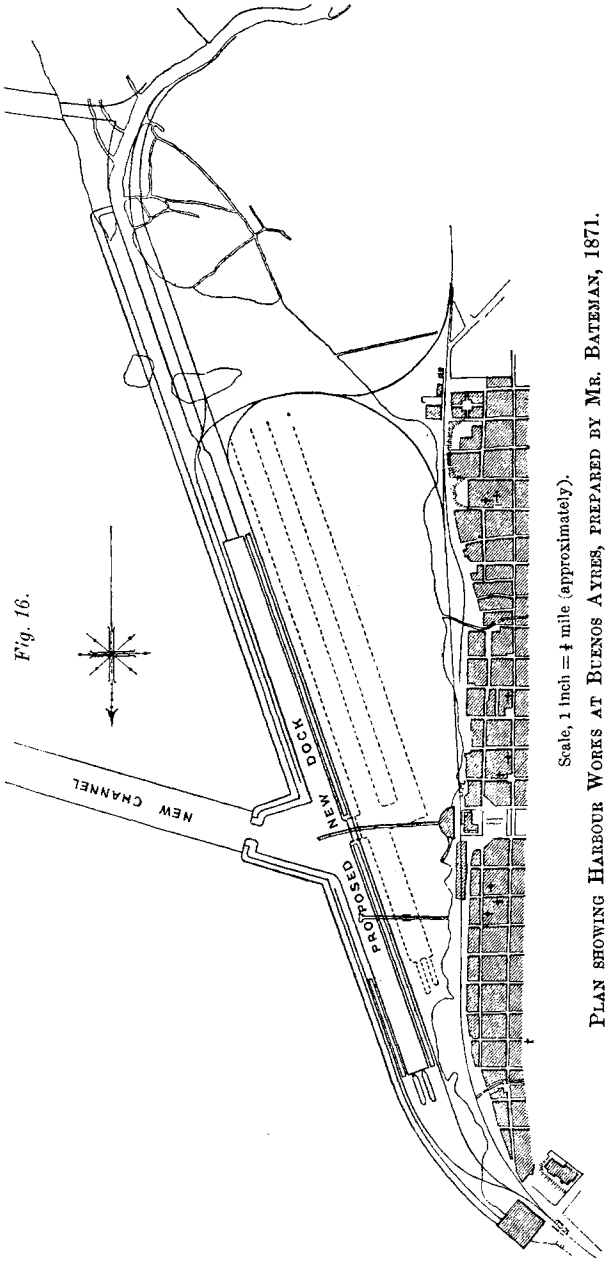

Fig. 16.

PLAN SHOWING HARBOUR WORKS AT BUENOS AYRES, PREPARED BY MR. BATEMAN, 1871.

Scale, 1 inch = ¼ mile (approximately).

Mr. Dobson. at the south lock were used to prevent the water of the Riachuelo from entering the docks when in a turbid state. This occurred when the tide was very high and accompanied by heavy rains. The water of the Riachuelo then became backed up, and ran with the water from the River Plate up the South Basin. As a rule, however, the water of the Riachuelo did not run into the docks, but into the River Plate through the south channel. The gates in the north and south locks were only closed when the water fell to zero, by which means a depth of 23 feet 9 inches was always retained in the docks, and consequently vessels were always kept afloat. Respecting the cost of Mr. Bateman's proposed scheme, it was only necessary to study the plan and section. As a scheme, it was naturally a costly one to construct, more especially the outer wall, and it would in no way compare with the docks,

Fig. 17.

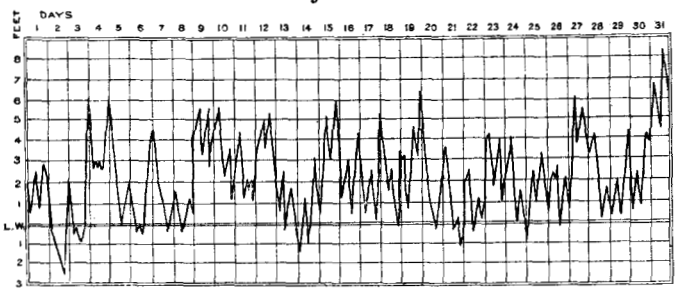

DIAGRAM OF TIDES DURING DECEMBER, 1894.

warehouses, and graving-docks as built. The section of Mr. Bateman's basin, *Figs. 18* and *19*, showed stone walls, and not timber, as would be inferred from Mr. Parsons' remarks, and a pitched slope, which, in section, was shown to be 21 feet 4 inches below low water, while the depth of the dock was only 20 feet below low water, and not 23 feet 9 inches, which was the case in the docks now constructed. As to the storm-water conduits which were intended to be discharged into the proposed basin, and which discharge it was estimated would amount to some 457,000 cubic metres of water per hour, the late Sir John Hawkshaw and Mr. Hayter were strongly opposed to the storm-water drains being discharged into the docks, on account of the large amount of sewage and other material which came down those drains. At the conduit at Calle Garay there was always over 18 inches of sewage for a great distance in the open cut during the whole

time the Author was in that district, while opposite the intercepting storm-water conduit, which had now just been completed, as far as Calle Cangallo, there was at present a long bank of material some 18 inches thick — let it be called what it may — of a most offensive character, and dangerous to the health of the city. The Author felt sure Mr. Parsons could not realize what came down these drains, or he never would have advocated discharging them into the docks. It had also been stated that the docks were constructed and the progress of the construction was continued without any consideration as to the storm-water conduit being commenced. Everything was done by Sir John Hawkshaw and Mr. Hawkshaw, before and after the commencement of the works, to show the necessity of at once constructing the storm-water conduits. The government instructions distinctly were that the dock engineers should not make any provision for drainage, as that was in other hands; but Mr. Hawkshaw, knowing that the works would block some of the main outlets, brought the matter in 1885 before Mr. Bateman's representative in Buenos Ayres; and it was perfectly easy, had it been thought advisable, to have raised any objection to the proposed dock plans during the 12 months they were under discussion; while in the memorial to government which Don Eduardo Madero sent when the plans were presented, dated 14th December, 1885, appeared the following: "Culverts. Several of these for discharging rain-water exist along the shore, fronting the area of land to be reclaimed from the river. A permanent tunnel that will take these waters to the river by the northern

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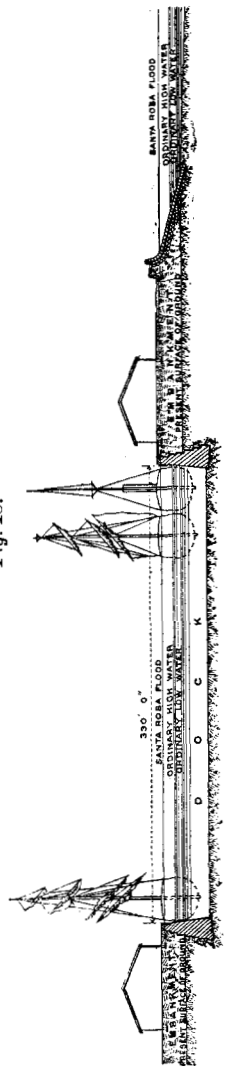


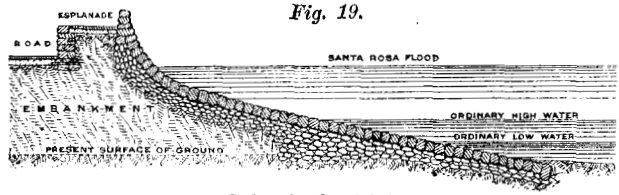
Fig. 18.

SECTION OF PROPOSED DOCKS AND RIVER-WALL.

Scale, 1 inch = 64 feet.

Mr. Dobson. end of the works must therefore be constructed. As there would not be time to construct this tunnel before the building of the docks begins, the constructors for these will have to form a temporary drain for the water that flows between Brazil and Venezuela streets. But in order to finish the harbour works within the time stated in the specification, it is indispensable that the forementioned permanent tunnel be finished within 2 years after the approval of the plans. On this point my engineers have spoken with the director of the sewerage works, the matter offering no difficulty." Surely in no way, therefore, were the dock engineers to blame, because the tunnel or conduit was not constructed during the execution of the port works, and remained uncompleted to-day, when the port works were finished. Mr. Parsons further referred to what he termed "a rather interesting point with reference to the cost of these works, which amounted to £7,000,000 sterling, which was the enormous outlay

Fig. 19.



Scale, 1 inch = 16 feet.

SECTION OF RIVER-WALL.

on the reclamation of land," and he went on to say that the land had been put up to auction again and again, and small lots had been sold at about 12 gold dollars to 14 gold dollars per square metre, and that the cost of filling up the land came to nearly 4 gold dollars, after the deduction was made for the dredging. These statements were misleading, and the cost for making up the land totally incorrect. In the first place, it was of great importance that all work carried out by engineers should show some result; and the principle so common in Holland, of carrying out works in the construction of which valuable land was reclaimed, land which, in many cases, represented the cost of these works, was a principle it would be well always, when possible, to keep in view. It was needless to say that on every count it would be seen that Mr. Parsons was in error. In the first case, had the land cost 4 gold dollars, or 16*s.* per square metre to make up, and all been sold for $12 to $14, or £2 7*s.* 7*d.* to £2 15*s.* 6*d.* per square metre, that would have left £1 11*s.* 7*d.*

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to £1 19*s.* 6*d.* per square metre; and taking the 296·5 acres or 1,200,000 square metres filled at even £1 11*s.* 7*d.*, the lower price, it would equal £1,895,000. But the land did not cost $4 to make up; on the contrary, as stated, "the land was filled with dredged material," each square metre of land requiring about 5 cubic metres of material to bring it up to quay level. As the difference of price to bring this material ashore, instead of depositing it in the river, amounted to 0·3107 gold dollar, or 1*s.* 3*d.* per cubic metre, therefore the cost of filling up each square metre of land was $\$0{\cdot}3107 \times 5 =$ say 1·55 gold dollars, or 6*s.* 3*d.*; this deducted from £2 7*s.* 7*d.* or £2 15*s.* 6*d.* gave £2 1*s.* 4*d.* and £2 9*s.* 3*d.* respectively, or a total of £2,480,000 and £2,955,000. It must be borne in mind that the government only sold the land at the price of 12 gold dollars to 14 gold dollars because they were urgently in want of money. Moreover, at the present time a large area of land had been let on the east or river side of the docks for 1 gold dollar, or 4*s.* per square metre per annum, and this was considerably better than selling it for 14 gold dollars per square metre. Mr. Parsons had further stated that this enormous capital was lying dead, and that it was a question whether that expenditure was wanted at all. To prove the fallacy of such an argument, the outer wall was required for the works, and was not necessitated on account of the filling; and surely to bring material ashore at a cost of 0·3107 gold dollar, making up land which, selling even at 12 gold dollars to 14 gold dollars per square metre, gave a profit of from 2·09 gold dollars to 2·49 gold dollars per cubic metre, was infinitely better than throwing it into the river, which the contractors were compelled to do at present, because there was no place to deposit it. Moreover, it might be well to notice that in Mr. Bateman's scheme referred to, a large area of about 750 acres was enclosed, and the excavation from the docks could never have filled the land proposed to be reclaimed. With reference to the South Basin, Mr. Parsons had stated that he thought it was a question whether the docks, if they had been constructed of timber, not pitch pine (hardwood, no doubt, was meant)—the life of which was practically not known, it lasted so long—would not have answered as well. If the docks had been built of hardwood timber, the works would not have been half finished at the present time. The fact of building the South Basin wharfing of pitch pine arose from the difficulty in obtaining hardwood of suitable sizes within the time fixed for the completion, which was very short; considering that the South Basin was commenced in July, 1887, and opened in

Mr. Dobson. January, 1889, the length of wharfing completed being 1,135 yards—while the completion of this section also necessitated the construction of 1,732 metres of timber wharfing in the river-wall. There was no doubt whatever that, when admissible, works such as the South Basin wharfing had much better be built of stone, because the life of pitch pine was very short in this country, elm rotted almost as quickly, and quebracho, while difficult to obtain in suitable sizes, cracked and twisted with the sun; so much so that the Author was exceedingly glad when the government agreed, after much discussion, to alter the construction of the outside river-wall from timber to stone. The large dock on the other side of the Riachuelo was not to be carried out in timber, it having been decided to be unsuitable. In reply to the remarks made by Mr. Baggallay, the Author desired to state that, owing to the conditions existing at the time the contract was made, it was necessary that the works should be commenced at the south end, and none of the docks could have been used until all had been finished, if there had not been a lock at the south end. It was not considered that the south channel was laid down in a line that would serve the docks when completed to the best advantage; and as long ago as 1885 Mr. Hawkshaw had reported that he did not consider two deep-water channels were necessary. At the same time it was thought that, from the intersection to the Boca, a shallow channel would always be needed to serve the shipping in the Riachuelo, consequently the line of the north channel was laid down as considered best, and the engineers stated that to make two deep-water channels would be throwing money away. The government decided as follows:—Art. 3. "That the director of the engineers of the nation having stated in his report to the President, dated 26th August, 1881, that although at first sight the opening of a northern channel appears unnecessary, since the Riachuelo one can be used, still it is convenient to have two to expedite traffic, avoid useless goings and comings, and in the possible but improbable case that one of the channels become obstructed by the sinking of any ship, the other would be available, as is generally accepted in the construction of works of this nature, which was also taken into consideration in the cabinet meeting of 4th December, 1884; and, further, the dredging of the northern channel having been proposed by the engineers of the works, of whose competency the government has the highest official testimonials, the executive agrees with the statements made herein." Further, it was always understood that, when

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the north channel was completed, all the large steamers would enter the docks at that end, land their passengers in the North Basin, and use docks Nos. 4 and 3 for loading and unloading cargo, as naturally they would not run the risk of grounding if there were an exceptionally low tide. For this reason it was decided by the government to make the north lock 82 feet wide, although really 65 feet 7 inches was ample for any ships now coming, or likely to come for many years, to the River Plate. When the South Basin was opened in January, 1889, the M.M.S. "Orenoque" came up the south channel, as stated in the Paper. This channel was in the same condition then as it was to-day; the steamer grounded on the bank, and there was great difficulty in getting her off. The Royal Mail Company, the Veloce Company, and the Messageries Maritimes Company were waiting for the north channel to be completed in a direct line to deep water before they would allow their large steamers to come up to Buenos Ayres, and all this strongly supported the north channel having been laid down in the right direction. No inconvenience whatever arose from the locks and passages themselves, the only trouble occurred when the steamers endeavoured to pass through the locks and passages, with their own machinery, and at a rate which was quite prohibitive, instead of being warped through or tugged, as was done in any other port. There was no doubt that the docks were the beginning of a much greater system, as Mr. Baggallay had remarked, but any extension of the docks, in the Author's opinion, would not be at the south, but at the north end. The manner in which the basins and docks had been constructed had answered admirably, because, as soon as the South Basin was completed and opened, it brought in a revenue, and so on consecutively with docks 1, 2, 3. Docks constructed as proposed by Mr. Baggallay, with one entrance, never could have been flushed in the same manner as the docks of the capital, which could be dealt with so easily, as described in the Paper. With regard to the hydraulic power, the Author agreed with Mr. Baggallay's statement respecting the advisability of having one lay-by engine; but when the contract was framed it was not intended to carry the pipes down the South Basin, nor to have anything like the number of cranes, etc., that had been erected; for instance, in the nine new warehouses there were no less than 36 cranes and 36 hydraulic lifts, which were not contemplated. Had the Author been present at the Institution he would have further explained that the government had another hydraulic engine-house on the Riachuelo lying

Mr. Dobson. unused and falling to pieces, and a number of cranes which had hardly been worked at all; and when it was found that more hydraulic power would be required, the Author proposed that the engine there should be put in order, and the cranes taken down, altered and re-erected on the South Basin. In consequence the hydraulic power had been thus increased. The engines of the port of the capital form practically four separate units; but even now, such had been the increase of the trade, the power was insufficient; consequently the Government were going to erect another pair of engines at the north end of the works. The fact of having additional power and cranes would therefore explain the difference between the Victoria and Albert docks and the docks of the capital, because the power of the Riachuelo engine was 125 H.P., making with the two engines of 450 H.P. each, a total of 1,025 H.P. With regard to the length of the locks, Mr. Baggallay had overlooked the fact that, when it was necessary to close the lock-gates on account of the water being below zero, no large vessels could come up or go down the channel, and when they could come up the locks were always open. Only vessels that could pass down the channel when the water was below zero were locked in or out, hence there was no necessity for having locks of very great length; the only advantage in having a long lock being that more than one small steamer could be taken in or out at the same time. As to the remark that if the docks had been put at one end and only one lock built, it would have saved working expenses, this matter was not lost sight of when the docks were planned; but many evident advantages had to be set aside in favour of the all-important point of providing the best possible entrance to the port. With regard to the depth of the North and South Basins, which was 21 feet 3 inches below zero, there was really no object in making these basins deeper than the channel, which was maintained at 21 feet; and the reason that the docks were made 2 feet 6 inches deeper was in order that the vessels should be kept afloat when the river fell to zero. With regard to the channel being down to 22 feet below zero on a length of 10 kilometres, it would be impossible to keep a channel down to 21 feet throughout its entire length unless it were dredged to a greater depth; and the instructions which the Author had given to the constructors were, that they should dredge not less than to a depth of 22 feet, nor more than 23 feet, and by this means it was possible to keep the channel down always to 21 feet. Should the north channel ever be maintained to 23 feet, it would involve a large amount of dredging between the bar

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anchorage and Montevideo, as there was at present in many parts of the course, and in front of Montevideo, as stated by Mr. Hawkshaw, only 21 feet below zero. With reference to Mr. Meldrum's question as to the level of the water in the docks in 1890, on the date to which he referred, the level of the water should have been zero or low water, giving 23 feet 9 inches in dock No. 1, which was the only dock opened; and this proved the advantage of having lock-gates, as the level of the water in the river, as stated in the Paper, was 8 feet 2 inches below zero, consequently all the steamers in the South Basin, which was tidal, were aground. Replying to the remarks made by Mr. L. F. Vernon-Harcourt, the whole of the water could be changed, as stated in the Paper, because, although the water was not allowed to fall below zero, the gates were left open sometimes for days together, and only closed when the necessity arose, either for sluicing purposes or for retaining the water at the zero level, when a low tide was expected. With regard to the floats referred to, it would be hardly necessary for the Author to state that proper floats were used to find the rate of the current; they each consisted of a flat piece of wood, to which a line 15 feet in length was attached, having at its lower end a sack filled with shavings, and loaded with sufficient stone to sink it to the proper depth, so that the float was controlled by the lower current, and not appreciably affected by the wind or surface current. The current was naturally greater through the passages than in the docks. The floats were tried at almost every time of tide. The current through the docks was such that the bottom of the lock sills at both ends, the bottom of the passages, and the docks down the centre, were perfectly free from silt. As to the depth of the sills in the north lock, to this the Author had already replied, but it might be as well to add that the tendency to-day was to build larger ships, but drawing less water, for the navigation of the River Plate.
