Discussion.

Sir BENJAMIN BAKER, K.C.M.G., President, said the Author was personally known to many members of the Institution as an American engineer of great ability and energy. He was the right-hand man of Mr. Eads in the construction of the Mississippi jetties, works similar in character to those which were the subject of the Paper, but on a larger scale. That was a splendid school for any engineer to be brought up in, for Mr. Eads was a striking example of that remarkable type—the old-fashioned American engineer. He was not trained as an engineer, but he carried out the St. Louis bridge, which still remained the most remarkable arched steel bridge in the world; and, having completed that, he turned his attention to the Mississippi jetties, securing the Author as his resident engineer. At that time, there was no certainty that works of that character would prove successful under the given conditions; and it seemed a very bold thing for a self-made bridge-engineer to take a firm stand against the authority of all the United States Government hydraulic engineers, and to say that it would be a success. He well remembered Mr. Eads coming to him twenty or thirty years ago, on returning from a visit to the mouths of the Danube with Sir Charles Hartley, and telling him that on seeing at a distance the ball showing the depth of water on the bar, or in other words the practical realization of the theories which had been so contested in the States, he could not speak because of the great lump in his throat. The Author carried out the Mississippi jetties under Mr. Eads; and then, following the same plan, he succeeded in bringing the work described in the Paper to a successful conclusion. There were points of difference between the two works which were very instructive. The mattress work, for example, which was so largely used in the Mississippi, was effectual to a greater degree there than in the case of the Tampico harbour works, because of the remarkable silting up in the Mississippi. At the mouths of the Mississippi, the climate was very bad; but it was far better than the climate at the Isthmus of Tehuantepec, where the Author had carried out the railway; and it was not to be wondered at, under those circumstances, that his health had suffered much in the execution of his duty. He was sure the members would unite, not only in thanking the Author for the interest he had shown in the Institution by con-

Sir Benjamin
Baker.

Sir Benjamin Baker. tributing this valuable Paper to its Proceedings, but also in assuring him, on the part of British engineers, that they wished him a long life, and a continuance of energy to carry out the useful works which had hitherto distinguished his career.

Mr. Matthews. Mr. WILLIAM MATTHEWS, of Westminster, said the subject of the Author's excellent Paper was not one which lent itself to much discussion. A combination of Mr. Eads with the Author, naturally led to the works being well designed and efficiently executed. It was impossible not to be struck with the excellent results produced. From the diagram of the entrance, it might be concluded that an extension of the moles would be required at some future date, as there had been a considerable accretion to the south of the south jetty, which was no fault of the works. The moles had gone quite far enough to effect the present object; and when occasion

Fig. 12.

required, there would be no difficulty in prolonging them. It was evident, from the two cross-sections of the jetties, that as the slopes were 3 to 1, the structures could not be exposed to any great wave-stroke, as experienced in this country and in the colonies. If they had been exposed to heavy seas, he thought it would not have been advisable to carry them out on parallel lines. They were admirably suited to the conditions which prevailed; but where there was a

heavy sea running on to moles, he thought it preferable that the jetties should be curved as at the Sulina mouth. By carrying out the moles in the way shown in Fig. 12, two excellent wave-traps would be formed, so that undulations entering between the moles would be dissipated in the traps, instead of extending up the river. Two river entrances in New Zealand had been treated by Sir John Coode in this manner, with satisfactory results, the wave-traps on each side of the moles increasing the efficiency of the works, and preventing runs up the river. He observed that the Author had been troubled with the *teredo*, as others had been in many places. When Sir John Coode commenced the works at Colombo twenty years ago, he put up a temporary jetty to land materials. The Baltic fir timber was creosoted with 12 lbs. to 14 lbs. of oil per foot. This jetty was completely riddled with the *teredo* in two years, and had to be rebuilt. Creosote was

clearly not a preventive where the worm was very active, for in many of the holes, in some of which the finger could be put in and turned round, they could smell the creosote. His firm had found that there was no timber and no preservative that was proof against the ravages of the *teredo* in some tropical waters. Mr. Matthews.

Sir EDWARD CARBUTT, Bart., had visited New Orleans and several other places with the Author, and had seen the way of forming the mattress for carrying the stone. It was very effective at the Mississippi, and he thought, therefore, that it would also be very effective in the case described. He had not visited Tampico, but he had spent some time at San Luis Potosi, where, although everybody was anxious that the scheme should be a success, everyone said it was not likely to be so, since it was thought that, even if the jetties were got out, they would make up in time. He was glad to hear that the channel was likely to keep open, owing to the strength of the current; but he agreed with Mr. Matthews that the time would come when the jetties would have to be considerably extended. The same question had arisen in another case. The engineer of the Nicaragua Canal, Mr. Menocal, had discussed with him the various difficulties met with in that work, one of which was the entrance of the canal into the Gulf of Mexico. The conclusion at which Mr. Menocal had arrived was that he would have to keep on extending the piers. With regard to the *teredo*, at San Francisco nearly the whole of the harbour work was being gradually destroyed. The timber there could not last more than two or three years, and it had been decided to try iron piles. Sir Edward Carbutt.

Sir E. LEADER WILLIAMS agreed with Mr. Matthews that the jetties would have to be extended. The longitudinal section showed that the bar was diminishing in height and travelling seaward. There were 24 feet of water at present on the bar, but there were 30 feet to 36 feet nearer the town. The work was exceedingly interesting; but it should be remembered, in applying works of that character to other rivers, that the watershed was about 36,000 square miles, with a rainfall of 40 inches, between Tampico and the base of the mountains, providing enormous scouring power. No doubt there were long intervals of drought, but that was the case with tidal rivers in England. He had had a great deal to do with the Dee and other rivers where there was the same struggle with Nature. During periods of drought, there was a good deal of deposit; and then big winter floods came down, like those described in the Paper, and scoured it out. The confining of the channel greatly increased the scouring power. The cross-sections showed the gradual progress of the depth of the Sir Leader Williams.

Sir Leader Williams. channel, till at the bottom there was very little difference; so that in August in one year and January in another, the bed was almost exactly on the same lines. It was a proof of good engineering to maintain a channel so truly as that with varying conditions, with large floods coming down, with a heavy rainfall, with a great drainage area, and long droughts. He hardly thought that mattresses were absolutely necessary. In very rough weather they were no doubt an advantage, being the nucleus of the work, and in that sense they were useful. The question of constructing training-walls was an important one. The case of the Ribble was perhaps more interesting to English engineers than any other. There was a great struggle going on in the endeavour to get through the large delta at the mouth. In the case mentioned in the Paper there was no delta. There were varying changes outside, but nothing comparable with the great mass of sands which he had explored the previous week in the Ribble estuary. A commission of eminent men had struck out a straight channel; but unfortunately for Preston they had not a large backwater, as in the case of the Tampico harbour works. The tidal influence did not extend a long way above Preston, and there was no large area to contain the water required. Even the Dee was better off in that respect. An enormous area existed in the Mersey to empty through the narrows at Liverpool. Although it would be difficult to say what dredging might yet have to be done, he should like to bear his testimony to the great success of the dredging at the Mersey bar. The originators of the Manchester Ship Canal were almost as much interested in the depth of the bar at Liverpool as the Liverpool people themselves, except that at present they had not so large a trade. Years ago he was one of those who thought that dredging a channel through the bar at Liverpool, without some training-walls to support and maintain it, would be a failure; and he believed that the great bulk of the engineering profession were of the same opinion. There were some who adopted the other view, and they had proved to be right. Where there was not a great length of bar or delta to dredge through, with a great reservoir behind, which gave plenty of scouring power, if the channel was dredged, the hydraulic mean depth and power were so increased that, when once it was made, it would maintain itself. He had thought that at the Mersey bar, gales of wind would have brought the sand in, tending to close up the dredged channel. The sand-pumps proved of great value in the early part of the work; but with sand-pumps, it was necessary to have sand of good specific gravity to

settle quickly. Having got through the surface of the bar of the Mersey, strata of a muddy character was encountered, which took longer to settle. A sand-pump had been tried on the Ship Canal at Manchester, where there was a good deal of sewage, silt, or light deposit. The surface water had to flow over the sides of the vessel into the river, and nearly all the mud flowed over with it. After keeping the sand-pump at work about a day, very little stuff was found at the bottom of the hoppers; but in cases like the Mersey, the Dee, or other rivers where there was sand of a heavy character, sand-pumps might be used with great advantage. Training-walls, however, were the cheapest plan, as, when well constructed, they maintained the channel without cost. If they could be carried out economically, if there was stone and other material handy, no better means could be employed for improving a river than those so successfully adopted by the Author.

Sir Leader Williams.

Mr. J. WOLFE BARRY, C.B., Vice-President, felt sure the Institution would congratulate the Author on his brilliant success as a harbour engineer. The Paper was eminently practical, and appealed to a large class of engineers who were engaged in important harbour works like those described. Although Papers on theoretical subjects were gladly received, yet a Paper like the present was specially welcome, as it gave all the arguments and reasons, both theoretical and practical, that had induced an engineer to adopt a particular mode of construction. All would admit that the works in question had been laid out on the best scientific principles. There might be some little matters for criticism, such as that to which Mr. Matthews had alluded in regard to converging moles instead of parallel piers; but, like Mr. Matthews, he thought the Author had all the circumstances well in his mind when he designed the parallel piers. Probably he considered that the waves entering the end of the harbour of Tampico could not be very heavy. Mr. Matthews' surmise in that respect was presumably right, and if so, the provision of a wave-trap was not necessary. When they observed the great care with which the works were designed, following the investigation of littoral currents, the floods, the transporting power of the river, and all the various circumstances to be dealt with, they might feel assured that this matter relating to the piers had not escaped the Author's notice. Owing to the prevailing winds in that locality, it was found that there was a well-developed littoral current, and also that, owing to the large amount of back-water from the river, there was no difficulty, if the scour of the back-water was directed upon the bar, in deepening the bar by pushing forward

Mr. Wolfe Barry.

Mr. Wolfe the eroded material into such a strong littoral current as would sweep it away and keep the entrance open. Something might be said against Sir Edward Carbutt's and Mr. Matthews' view as to the necessity for the prolongation of the piers. It must be a matter of balance of power which could not, he thought, yet be predicated, whether the littoral current would be sufficient under the new circumstances to take away the deposits brought down by the river. He should rather incline to the hope that the balance of power would be in favour of the strong stream which issued from the river, and would keep the channel open. That, however, could not be considered as in any way settled. A short time ago, the valuable services which Sir Charles Hartley rendered to the scheme for the improvement of the Mississippi, so ably carried out by Mr. Eads, had been brought before him, in the correspondence between Sir Charles Hartley and Mr. Eads and some of the promoters of the Mississippi scheme under Mr. Eads' direction. At the time when Mr. Eads stood almost alone in contesting the views of the Government engineers, Sir Charles Hartley came to his aid with most apposite suggestions, and with extremely valuable information gained at the mouth of the Danube. He pointed out how, contrary to the definite assertions of the Government engineers on the subject, there was probably a well-developed littoral current at no great distance from the shore-line, amply sufficient to maintain the outlet channel of the Mississippi if it could be developed by jetties projecting into the sea. Observations were, accordingly, made, and the anticipated current was found to exist. He had seen a letter from Mr. Eads to Sir Charles Hartley, expressing the warmest thanks for the yeoman service rendered in reference to that very uphill fight. Mr. Eads might perhaps have been able, unaided, to convince his fellow-countrymen; but his task of converting them was rendered immensely easier by the extraordinarily able report which Sir Charles Hartley made. As English engineers, they ought to be cognizant of that important fact; and nobody recognized it more thoroughly than Mr. Eads himself. The Paper under discussion presented an example of a good littoral current with practically no tidal action. In this case, a current was developed by prevailing winds; and it was to be specially noted, after the recent discussion on littoral drift, that here was one of those littoral currents which were so valuable to engineers in the construction of harbour works, without the action of great tides, which had been invoked as the only practical means of maintaining a littoral travel. He should like to know what opinion the Author had formed after experience

Mr. Wolfe
Barry.

of the construction of mattresses; it seemed to him that it was open to question whether any advantage was gained by the use of mattresses in these works. In other places mattresses might be very beneficial; but he doubted whether, if the Author's work had to be done again, they would be used at Tampico. It rather appeared they were adopted when the Author thought they would be more easily built and compressed, and would not be so expensive as they turned out to be. As in so many other cases, that seemed to be one of the circumstances to be dealt with and judged of by local conditions. The cost of the large stone appeared to be as high as 9s. 3d. per cubic yard; of the small stone 7s. 5½d.; and of the concrete blocks £2 1s. 8d. He could well believe that mattresses might have been introduced for the sake of cheapness, when stone had to be brought from such a great distance as 78 miles at such a heavy expense. Mattresses were no doubt useful in some positions for resisting the scour which attacked the toe of embankments and endangered the whole structure; but he did not gather that that was altogether the case with the Tampico harbour works, although it was right to notice that the Author gave very high velocities of the stream in times of flood. Still such a stream could only attack the mole in course of construction, and before the stonework surrounding the mattresses was finished. To that extent perhaps mattresses might be desirable during the progress of the works; but looking at the fact that the sand seemed to have been hard and solid, he could not help thinking that, but for the idea of economy, mattresses would not have been adopted. Another point was the great importance of selecting, as the Author had selected, stone of heavy specific gravity for sea-work, a matter which had not been adequately considered. The Author had stated that the limestone was selected largely on account of its being as heavy as granite. In the construction of any sea-work, it was an enormous advantage to have a stone of high specific gravity. He remembered, many years ago, having been struck by a device adopted by Mr. Messent, at the piers at the mouth of the Tyne, of mixing mill cinder from ironworks with concrete in order to obtain, by the admixture of the heavy iron ingredient, a high specific gravity for the concrete blocks which protected the break-water. As English engineers, they highly appreciated the courtesy shown by the Author to the Institution in contributing a Paper which was not only valuable in itself, but was a record of an extremely successful work that was a credit to the engineering world.

Mr. EDWARD JACKSON said one feature in the Author's work which had contributed greatly to its success was in making provision

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Barry.

Mr. Jackson.

Mr. Jackson. for a rapid method of execution. He did not refer merely to the details of the appliances adopted and the mode of carrying on the work, but also to the provision made for the materials being brought to the ground over-night; so that during the working-hours of the day, there was no waiting or loss of time. On a sandy shore of that kind, it was of importance, when the work was once commenced, that it should be pushed forward rapidly, otherwise troubles would arise such as those to which Mr. Barry had alluded, the littoral drift becoming arrested, and causing a vast amount of expense and extra work. As it was, it was carried out before any material obstacles had come in the way. It appeared from the price given for the mattresses, namely, 6s. 2d. a cubic yard, that their cost exceeded the cost of the stone by about 1s. a cubic yard. Taking the average cost of large and small stone, namely, 8s. 4½d. a cubic yard, the cost of the mattress—which was 50 per cent. more than was estimated, through unlooked-for consolidation—was really more than that of the stone. The question then arose whether it was worth while to use these with their intricacies and contingent arrangements necessary for sinking them, together with the risk of their being damaged or carried away by the sea, instead of filling up the hearting with a mixture of different-sized stones. Another point was the steep slopes at which the channel stood, or would eventually stand. The borings indicated a depth of 20 feet or more of sand in the bed of the channel; and he imagined that it must be fine or silty sand, because the Author had stated that it was not suitable for making concrete. It remained to be seen in the future whether the remarkable enlargement of the channel between the jetties, which had taken place since the work was in progress, would, owing to increased scour due to increased depth or exceptional floods, still further widen the channel, and encroach upon the sides, and so undermine the slopes, especially along the south jetty, to an extent sufficient to cause the jetties to settle, or slip into the channel. The works, however, had been finished more than three years, and had, up to the present, been most successful, as shown by the plan and sections of the channel; so that perhaps such forebodings were not warranted.

Mr. Deacon. Mr. G. F. DEACON thought some injustice had been unintentionally done to the Author, from the fact that the survey from which Fig. 9, Plate 4, was compiled, was evidently made before the last part of the Paper was written. After describing everything up to the date of the survey, the Author stated that a flood took place in August 1894, which reduced the depth immediately in front of the jetties to 19 feet of water, increased to

21½ feet at the end of the month; and the survey of January 1895, Mr. Deacon. Fig. 9, Plate 4, showed a clear, but somewhat tortuous channel of 24 feet. No later chart was given with the Paper; but the Author added that in August 1895, there was 24 feet of water, and before February 1896, the littoral current had swept away the whole of that deposit; and from December 1895 to February 1896, a navigable channel with a minimum depth of 27½ feet was maintained at the end of the jetties. The tidal diagram was given for a whole year, during eight months of which the tide was almost wholly below the zero level, which he assumed to be the mean-tide level. In one month only, namely in June, the tide had a range of double that which occurred in any other month; and about half that range was above zero, and half below. It was a condition of things he had never seen elsewhere, and he thought it should be explained more fully.

Mr. W. SHELFORD said, with regard to the mattress work, it Mr. Shelford. appeared to him that, as the piers were founded upon sand, the Author very properly took the precaution of using mattresses, in order that he might not lose the foundation of his piers as soon as he commenced to throw in the stone. He had himself, in the Fen district, used mattresses, copying the Dutch practice to some extent. The most trying case was where he had to put a weir across a tidal channel with a bottom of silt and sand of unknown depth, where the bed was easily scoured by the tide which ebbed and flowed over the weir, and submerged it even at low water. He began the work by forming several mattresses, and placing them on rafts in position, one after the other; and at the turn of the tide at high water, he lowered them rapidly in their places with stones upon them. The result was that when the tide began to ebb, the current increased from 4 miles an hour up to 10 miles. Nevertheless, that weir was raised by a succession of mattresses to the desired height above the river bottom, and stood until it had to be taken up for reasons irrespective of the weir itself, when great difficulty was found in removing it. All the mattress work in the Fens consisted of fascines or faggots, carefully made, and costly. He did not gather that the brushwood used in the Author's work was first of all made into fascines; if so, it would not have compressed so much as stated. The cost was not very clearly described in the Paper. "The final estimate to the contractor"—whatever that might mean—"made on the 1st January 1893, was £293,989;" whilst the final cost, which apparently included all expenses, general, incidental, engineering, maintenance, etc., came to £617,543. There was a very wide dis-

Mr. Shelford. crepancy between the two. The one might possibly mean the first cost of the works, and the other the cost of maintenance for a few years, which might properly be included in it. He, however, thought that not much had been saved directly by the use of faggots; and it was possible they were only used as hearting, and not carried to the toe of the stage. In that case, a very large quantity of stone might have gone into the sand at the foot of the slopes beyond what was shown in the sections. That was almost certain to have been the case if it were a sand bottom as described, and would account for the apparently heavy cost charged to maintenance.

Sir Guilford Molesworth. Sir GUILFORD MOLESWORTH could confirm what Mr. Matthews had said with regard to the action of the *teredo*. He had put down some jarrah in a temporary jetty at Colombo, and found that in less than two years it was thoroughly honey-combed. Jarrah was said to be a timber which withstood the action of that insect, and in some localities it might do so. In other places, the action of that insect might be much more intense; and possibly on the coast of Australia, where it was said to have withstood that action, it was due to the fact of the insect being less active. It had often been said that a wave did not move loose stones at a depth of more than 12 or 14 feet. In Madras harbour, which he had inspected for the Government of India after the accident which happened to it, he descended in a diving dress and found that large lumps of laterite, nearly a cubic foot in size, had been moved by the cyclonic wave. He was able to put his hands almost as far as he could reach, underneath where the loose blocks of laterite, forming the rubble base, at a depth of 24 feet, had been washed away from under the great concrete blocks composing the superstructure.

Dr. Corthell. Dr. E. L. CORTHELL, in reply to the Discussion, wished at the outset to express his high appreciation of the general approval of his Paper, and of the works described, and especially of the very kind remarks in regard to himself. The prediction made by Mr. Matthews as to the need of an extension of the jetties, owing to the advance of the foreshore, would probably not have been made, had it been possible to have presented a longitudinal profile of the channel through the bar, and of the sea slope, in November or December 1895. It would be noticed, in *Fig. 7*, showing the depths in the jetty channel, that the last date was January 1895, as no complete survey was available subsequently to that date to compare with these longitudinal sections. Partial surveys, however, made at different times and subsequently, from which a model of the channel was made in December 1895, showed

that there had been a marked deepening in front of the works, Dr. Corthell. and that if the present section was drawn, the line would probably fall below that of May 1890, on the outer slope of the bar in the sea. The model of December 1892, which was made subsequently to the discharge of a large amount of heavy material eroded by the river from the channel during its formation, showed an extension of the foreshore immediately in front of the jetties. The model of November 1895, showed that this had been entirely swept away by the action of the currents across the sea ends of the jetties. The current that had performed this work was not the true littoral current of the Gulf Stream, but a much stronger current flowing in the opposite direction, caused by the persistent "northers" referred to in the Paper. He was of opinion, from a careful study of this current in front of the jetties, that no extension of the works would be required for many years. The accretions south of the south jetty had not advanced towards the end of the jetty, beyond the position shown on the chart, for the last two or three years. The reef which was the result of this accretion had become stable, and no further advance of it was expected; and the reef also, or shore-line, on the north side of the north jetty, had not advanced during the last two or three years, and had evidently become stable. The reef on the south side, and all the immense deposits which had occurred in that vicinity, were largely produced by the discharge of sedimentary matters, either from the river itself, or from the channel during the development of the channel. The reef upon the north side of the north jetty was caused by the littoral drift of sand along the shore towards the jetty.

The remarks made by Mr. Matthews and others, in regard to the *teredo*, had no great bearing upon the main question of the permanency of the works, because, as stated by him on pages 251 and 252, "The amount of creosote in the piles was 12 lbs. per cubic foot, which was found to be sufficient, as it was only necessary to preserve them during the construction of the work, or about three years." It might be added that the piles of the trestle outside those under the rails were not creosoted, and yet very few of them were eaten to such an extent by the *teredo* as to require renewal. The presence of fresh water, specially muddy water, in this and other sediment-bearing rivers of the Gulf of Mexico, made the ravages of the *teredo* much less than at points where such conditions did not exist; and at such exposed points, a charge of 16 to 18 lbs. per cubic foot, had been found generally sufficient to extend the life of the timber from about two years to an average of fifteen years.

Dr. Corthell. In reply to Sir Edward Carbutt, the engineer of the Nicaragua Canal, in reference to his own work at Nicaragua, would no doubt have to continue extending the piers, but not particularly on account of the *teredo*, although the *teredo* had already practically devoured the work there, but on account of the rapid advance of the littoral drift seaward. As to the use of mattresses, to which reference had been made by several speakers, he would frankly say that if he had to do the work again, now that he was acquainted with the character of the brushwood, he would not use it, except for laying a flat foundation for the superimposed stonework, as the cost of it was fully as great as that of the stonework itself, on account of the extraordinary compression which followed the loading of it with stone. He was decidedly of opinion that nothing but permanent, parallel jetties would have removed the changeable sandy bar in front of the entrance of the Pánuco River; and he further considered that could this bar have been removed by a number of powerful dredgers, so as to form the present channel, the first flood would have refilled the channel; and the lateral action of the winds upon the shoal and movable bar on either side would have assisted in filling up the channel, and so would have obliterated the expensive dredging work. The very appreciative remarks of Mr. Barry, rendered it unnecessary for him to reply to some criticisms made by others. Mr. Jackson spoke of the "steep slopes at which the channel stood." These slopes were not so great as they appeared to be from the cross-sections, in which the vertical scale was greatly exaggerated in order to bring out the irregularities of the channel; but with a natural scale, the slopes would have appeared more stable. Mr. Deacon assumed that the zero level was the mean-tide level; but the zero for all depths of profiles and sections in the Paper was mean high-tide, or average flood-tide, as stated at the foot of the tidal diagram, *Fig. 2*. The fluctuations in this tidal diagram were due in part to the varying conditions of the tides, but also to certain extraordinary conditions which prevailed during the year they were taken. On pages 257 and 258, he had said that, "During one of the floods in 1892, the river at Tampico was raised 2 feet above the level which would have been reached by a similar flood before the jetties were built," for the purpose of showing how the jetties, in connection with the still unremoved bar, backed up the waters in times of flood. The automatic tide-gauge was at the original mouth of the river. In *Fig. 11* the slope of the river during the flood of July and August was plainly indicated; and it would be seen that, at that time, the reading on the automatic tide-gauge

showed an elevation of the water surface of more than 2 feet above the level of the gulf outside the jetties. This flood, as stated below *Fig. 11*, removed the bar entirely, and gave the river the freedom of discharge which its normal conditions required, preventing further abnormal elevations of the water surface in times of flood.

The rapidly increasing commerce of the Port of Tampico had led the Government to enter into a contract, in August 1895, with the Mexican Central Railway Company, to erect a new fire-proof Custom House, wharf, and other facilities for the despatch of business at Tampico. The buildings were to be of substantial construction, with all the improved devices for handling goods; and the estimated cost was about \$1,250,000. The Custom House was to be 984 feet by 121 feet, and the wharf 1,148 feet long and 49 feet wide, extending out into the river, so that vessels of 24 feet draught could be moored alongside.

Mr. Shelford considered the estimates of the cost of the work required some explanation. The final estimate to the contractor, made on the 1st of January 1893, included all the construction work covered by the materials, and the prices of the same given on page 254, and certain extra amounts for some additional work. The following statement embraced a summary of items of what might be called extraordinary outside expenses, which rounded up the total cost of construction two years after the works were completed. The cost was given in United States currency, or gold, of the Tampico Harbour Works and property to the 31st of December 1894, and related to the construction at the time of the completion of the works, there being very little in the amounts in the way of maintenance or repairs.

	\$
Preliminary expenses	3,299·38
General expenses	62,529·36
Engineering	77,132·34
Construction of jetties	2,049,187·31
Office and headquarters buildings	13,487·42
Wrecking and dredging	101,066·70
Real estate	44,098·18
Railroad extension to La Barra	215,971·80
Tracks at Doña Cecilia	23,783·51
Wharves and docks	51,779·90
Bond interest	357,101·85
Subsidy expenses	1,822·80
	<hr/>
	3,001,260·55
Less credit balance of miscellaneous interest account	171,192·57
	<hr/>
	\$2,830,067·98
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