

Mr. Buckton. charged against the job had proved very suitable in many other developments which were going on in the country and had been absorbed in a remarkable manner. Most of the cement used in the harbour work came from the local Jewish firm, the Nesher Cement Company, and was very good.

* * * The replies of Messrs. Frampton and Gray will be found at pp. 638 and 641 respectively.—SEC. INST. C.E.

Correspondence.

Mr. Deane.

Mr. H. J. DEANE observed that it was to be inferred from p. 599 of Mr. Gray's Paper that one reason for adopting the Navy Island site was that "facilities would be equally available to both the Canadian Pacific Railway and the Canadian National Railways," but how that was to be attained was not evident from an examination of Fig. 1, Plate 12. Some running powers might be possessed by the latter railway, and it would be of interest if Mr. Gray would explain the position.

Mr. Gray made no mention in the Paper of any borings or trial pits having been put down to ascertain the nature of the ground at the adopted site; had such information been obtained beforehand it would probably have been apparent that the method adopted by the contractor for damming the site would prove to be entirely unsuited to the materials he had to contend with; moreover, excavation of a large quantity of rock might have been avoided by constructing the pier on the site indicated in dotted lines under the words "Har. Comm. Elevator" in Fig. 1, Plate 12. That would have enabled the work to have been executed by cribs, as that method had apparently been successful in previous cases, or by monoliths or reinforced-concrete caissons. The dry dock had been constructed at a place where it might well have been expected that the material met with would be of a much firmer nature than that near Navy Island; indeed, it was admitted in the Paper that the latter proved to be extremely soft and that that was the principal cause of the failures experienced. The bold way in which wheelbarrows had been used for gauging concrete instead of the usual gauge-boxes or batch-mixers called for some comment; perhaps the barrows were of a different type from those usually met with in England, which were of such a form that to use them as measuring-boxes would be a most uncertain method. In any case, however, the use of barrows in connection with the 1-cubic-yard mixer seemed hard to justify, on account of its costliness. The greatest possible care seemed to have been taken in the measurement of the water, but that would appear to be a refinement entirely incommensurate

with the method of gauging the aggregate. Perhaps Mr. Gray^{Mr. Deane.} could throw some light on the subject. Mr. Deane presumed that the reason for adopting timber piles for the foundations of the elevator and the rear columns of the transit-sheds was their cheapness, but were they sufficiently well immersed to ensure the prevention of rot? As stringent economy did not seem to be of primary importance, would it not have been preferable to have used reinforced-concrete piles? It would be of interest to know the actual cost of the pier works, exclusive of sheds and equipment.

Mr. A. C. GARDNER observed that all three Papers contained^{Mr. Gardner.} special points of interest, and they illustrated the widely divergent features both of design and construction necessitated by the considerable differences of location, geological formation and tidal conditions obtaining in widely-separated parts of the world. In the case of Haifa, the several diagrams illustrating different projects relating to the establishment of a modern harbour, culminating in the general lay-out of the completed harbour, were of great interest. In the absence of previous information regarding such essential matters as wind, storms, wave-height, and coastal currents, the problem of determining the best form and lie of the breakwaters required to enclose the harbour was very formidable, but it would appear that its final location and lay-out had satisfied the prevailing conditions and its constructional form provided an economical solution. Not the smallest part of the problem was the choice of a quarry from which suitable stone for the rubble breakwater could be obtained, and the selection of the Athlit ridge at a comparatively short distance from the works made them economically possible. Credit was certainly due to the ancient Romans and to the Crusaders for having left works which now enabled the lasting qualities of the stone to be ascertained. The Author's observations on the suitability of a natural stone for a mound breakwater such as that at Haifa were interesting, and engineers would look forward to learning in due course the manner in which the specially-formed experimental precast blocks survived. In connection with the projected oil-dock, which would apparently enclose about 25 acres of water, the introduction of a fire-screen of reinforced concrete on the face of the jetty extending to a depth of 3 feet below mean sea-level was novel and interesting; together with the closing of the entrance by a floating boom, it should prove effective in preventing the escape of surface oil from the dock. He would like to know why specially-designed spring-buffers under the deck of the western jetty were to be provided. Were the conditions inside the lee breakwater at that point such as to require some special protection? Was Mr. Buckton aware of the suspended fenders which had been adopted with success

Mr. Gardner. by French engineers in connection with the construction of the new quay works at Le Verdon. The bumper-buoys in the main harbour proposed as an economical substitute for dolphins were novel, but their precise action was not quite clear, and Mr. Gardner would like a more detailed explanation of their operation within the compression distance of 6 feet mentioned in the Paper. It would be interesting to learn, if and when they were put into use, whether they proved to be effective.

The works at Saint John Harbour, New Brunswick, were particularly interesting, as it was always profitable to learn of failures which had attended the execution of important works. Considering the high tidal range of 28 feet at New Brunswick, the decision to carry out the works within a cofferdam was undoubtedly wise, and with the successful experience which had attended the use of a timber sheet-pile cofferdam during the construction of the dry dock in 1920, the contractor, upon whom the onus of success or failure was placed, no doubt felt justified in taking the risk of using the same construction on the larger works. Without desiring to be unduly critical, and in the absence of knowledge which the contractor no doubt obtained regarding the nature of the strata likely to be encountered, the adoption of the same method would appear to have been unduly hazardous, as the sites of the earlier and later works were nearly 2 miles apart. A dam of exceptional strength and stability was undoubtedly called for to withstand the hydrostatic head of 65 feet, with a northern exposure to the sea. Two successive failures of the cofferdam would seem to indicate that financial considerations had operated too severely on the contractor, inducing him to take an excessive risk. From the cross sections of the main cofferdam as finally constructed, it would appear that its weight alone was effective in resisting its tendency to slide under the severe external pressure and in so treacherous a soil. Perhaps Mr. Gray would state the estimated and actual costs of the cofferdam. The decision to locate the extension works near Navy Island, rather than near Negro Point, appeared to have been wise, and the methods adopted in the construction of the main 700-foot pier, where the walls were carried partly upon the protruding rock and partly beyond it, seemed to have provided a very satisfactory and economical design. It might, however, be asked whether, by reducing the width of the sheds to some extent and reducing the number of tracks between them from five to three (if that were possible), it might not have been more economical to have constructed both walls on the rock outcrop shown on the cross sections. The improvement in the currents at the entrance to the pier and quay brought about by the closing of the Buttermilk Channel, rendered necessary by the reclamation-works

and the extension of the cofferdam there, was of great interest. In Mr. Gardner, the greatly extended times now available for docking, that improvement appeared to have afforded considerable compensation for the additional expenditure incurred as a result of the failures referred to. Had that improvement been foreseen? If so, it reflected great credit on the engineers.

In the port of Beira, as at New Brunswick, the tidal range was considerable; although the magnitude of the work at Beira was not as great as that of the two previous examples, the adoption of screw-piling in the soft ground dealt with was undoubtedly the best solution of a difficult problem, and the rate of progress exceptionally good. Would Mr. Frampton state what were the estimated working loads on each of the piles in the finished conditions of the work?

Mr. R. F. HINDMARSH observed that Mr. Buckton had stated Mr. Hindmarsh, that for a mound breakwater there was no better block than a natural homogeneous stone. Perhaps, however, he would agree that for a breakwater in a position subject to heavy seas it would usually be impracticable to obtain blocks of natural stone of the required weight and size, and that, therefore, heavy pre-cast blocks would have to be used. Furthermore, large rectangular blocks had the advantage of providing large cavities in a mound or pell-mell wavebreaker in which waves were swallowed up and dispersed, and they could be more cheaply made than the types suggested by Mr. Buckton. Had any provision been made for the maintenance of the breakwaters? It was stated that the cranes had been withdrawn, and the absence of means of quickly carrying out any necessary maintenance-work appeared to involve some risk of extensive damage.

With regard to the bollards on the main breakwater, would it have been possible to place large mooring-rings on concrete slabs on the top of the breakwater, and attach them by means of chains or rods to blocks placed at about mean sea-level on the seaward slope? Such anchorages would have offered more resistance to movement than the concrete blocks actually used. The arrangement of bumper buoys was novel, and it would be interesting to hear whether they had been entirely successful in actual use, and whether any damage had occurred through bilge-keels fouling the mooring chains when tightened up. It would appear that difficulties might arise in bad weather owing to the lack of head and stern moorings, and also in coming alongside when the wind was from the bumpers to the vessel. On what considerations did Mr. Buckton decide to use them in preference to a single or double tier of ordinary buoy moorings, which would have been much less costly?

Mr. ERNEST LATHAM remarked that the bumper buoys described Mr. Latham, by Mr. Buckton were of great interest, though he gathered that they

Mr. Latham. had not yet been constructed, but had been designed with a view to economizing by dispensing with a costly deep-water berth. As he had recently been responsible for the construction of several deep-water berths in the Thames estuary capable of taking oil-tankers of the largest size, any practical substitute for such costly structures was very appealing. He did not quite understand the description of the buoy in contact with the ship swivelling until the whole length of its fender was in contact with the ship's side, and hoped that Mr. Buckton would amplify it. The idea of using the up-thrust of a submerging buoy to take the shock of a berthing ship was most ingenious. The greatest variation in sea-level at Haifa appeared to be 3 feet 6 inches. Allowing for wind, weather and tide, a range of 22 feet was sometimes reached in the Thames estuary, and he would like to know whether such a range would debar the introduction of bumper buoys; also, had Mr. Buckton taken out any estimates as to the total costs of a berth constructed with a series of bumper buoys instead of a fendered wharf?

Mr. Frampton's valuable Paper outlined many novel features of the work at Beira. The 3-foot diameter cylinders with 7-foot screws, which formed the main foundations of the deep-water wharf, would appear to be very heavy, as they were of cast iron $1\frac{3}{8}$ inch thick; what objections would there have been to a design including columns constructed in mild-steel plating suitably stiffened and sunk by means of the usual cutting edges? He was glad to see that no underwater bracings were included in the design, as he believed that they were always unsatisfactory. In view of the large size of the screws, it would be of interest if Mr. Frampton could give a diagram of one of them, together with some information as to the rate of rotation during screwing.

The most interesting feature in Mr. Gray's Paper was the difficulty experienced in withdrawing the steel sheet-piling used in the construction of the cofferdam. He had experienced similar difficulties on a much smaller scale in the withdrawal of interlocked steel piling which had become distorted. Had Mr. Gray considered or tried the withdrawal of any of the piling by means of floating craft? Apparently the gravel and rock fill was removed to a level of 6 feet above low water, leaving an effective available tidal pull of 22 feet. Mr. Gray gave no indication of the actual maximum pull required to extract the piles; it would admittedly be less under the vibratory conditions caused by the McKiernan-Terry hammer than the steady static pull which would have to be exerted by lighters lying alongside the piling, utilizing their buoyancy as the tide rose to extract the pile. Some idea of the maximum extracting force could be obtained by studying the pulling rig (Fig. 13, Plate 12), which was used

apparently without failure. The 5-inch chrome-nickel-steel cotter-pin would presumably have failed at about 2,000 tons under double shear. The static pull necessary to withdraw the piles would probably be twice that amount, but with the large rise and fall of tide it did appear to him that that method might have been tried. However, Mr. Gray had no doubt considered it, and his reasons for its non-employment would be of interest.

Mr. JAMES MITCHELL remarked, with reference to Mr. Buckton's Paper, that the statements on p. 555 regarding the relative values of natural and cast blocks for the clothing of a mound breakwater were interesting and suggestive. Referring to the former, the opinion was expressed that "on tipping, they bed themselves comparatively well, this bedding being much improved when the breakwater is subjected to heavy wave-action." In the next paragraph, however, it was stated that "The general settlement resulting from storm-action is comparatively moderate," a result which is considered to be due to the fact that "contact is usually over a surface, rather than a point." The large percentage of voids in a body of tipped rubble-stone was evidence that the bedding was far from good. A study of the effect of heavy rolling on a mass of rubble showed that the reduction of volume produced in it was due chiefly to the crushing which took place at point-contacts, and that the contacts were all, to a greater or less degree, of that nature. With respect to cast blocks, the truncation, to some extent, of the corners, as in Type A of *Figs. 5*, seemed a good idea, as those corners generally suffered severely in practice during the bedding into place of the block. Type B, by approximating to the spherical form, was likely to be more easily moved than Type A; furthermore, the percentage of voids in a mass of Type B blocks would be smaller, which would be a drawback from the point of view of the action of the mound in dissipating the energy of the wave-masses—an action likely to be helped by a large percentage of voids. The experimental strip of cast blocks would afford valuable information as to the balancing, in practice, of the various pros and cons. With reference to the statement made regarding precast concrete blocks of the ordinary form, that "it is common for them to break in two," it might be suggested that that was not very likely to happen with good concrete. The arrangement of bumper-buoys shown in *Figs. 11*, Plate 10, appeared to be well adapted to its purpose, and would provide, at a reasonable cost, a degree of elasticity unattainable by any practicable form of piled dolphin.

With reference to Mr. Gray's Paper, the particulars given of the methods adopted for the extraction of the steel piles of the cofferdam, and the results attained, gave a graphic picture of the great difficulty

Mr. Mitchell. of such work. Mr. Mitchell had had experience of the drawing of some hundreds of steel piles, driven 40 feet into undisturbed ground, consisting mainly of gravel and silty sand, but for the lower 3 or 4 feet of hard boulder-clay, which distorted the piles very considerably. The extractor-tackle used was similar in type to that shown by Fig. 13, Plate 12, except that the yoke consisted of a massive hollow steel forging, containing two sliding steel wedges, the opposed faces of which were serrated. When attaching the tackle to the head of the pile to be pulled, the wedges were first lifted sufficiently to allow the web of the pile to pass between their serrated surfaces. The tackle was then lowered sufficiently to afford a good grip on the pile-head, and the wedges were tapped down by a hand-hammer. The upward pull on the tackle then embedded the serrations in the pile, sometimes to such an extent as to make it difficult to release the wedges after a pile had been withdrawn, notwithstanding the thorough lubrication of their outer sides. A 30-ton sheave-block tackle, hung from an A-frame 43 feet high, was used for the suspension of the extractor, a helical spring being interposed between the extractor and the hook of the lower sheave-block. In view of the fact that the piles had to be afterwards withdrawn, the interlocks were coated before driving with a mixture of grease and graphite. In spite of that, however, the withdrawal was a tedious and heartbreaking operation.

Mr. Monk. Mr. J. E. MONK was interested in the screwing of the 3-foot cylinders at Beira, and in the means adopted to steady the piles at the commencement of screwing. His own experience of such work had been in connection with the screwing of sixty piles of 3 feet to 4 feet 6 inches in diameter and of design similar to those used at Beira. The piles were in groups of five for bridge piers in a strongly tidal river, with depths of from 20 to 30 feet, and they were screwed 60 to 70 feet into the bed from two pontoons braced together and with overhead gantries carrying lifting-gear. An attempt was made to carry out the screwing by two deck-pattern steam-winchs hauling on a 10-foot diameter capstan-head bolted on to the piles, and one pier was with some difficulty completed by that method. In screwing the first pile of the next pier, however, when the pile had nearly reached its finished depth, and at high water, when about 40 feet of the pile was above the river bed, the driver of one winch failed to notice the stop signal and the unbalanced pull of that winch with about 40 feet of leverage broke the pile off at about 8 feet below river-bed level. The risk involved in synchronizing and balancing the pulls of two steam-winchs was recognized, and the remainder of the piles were screwed by the Braithwaite electric capstan, which, with its continuous anti-rotation rope, made it impossible for a pile to be subjected to an unbalanced pull.

He, like Mr. Frampton, had met with great difficulty in getting Mr. Monk. piles to keep their position at the commencement of screwing, though he had not had to deal with sites with a 2-to-1 slope. The river-bed in his case consisted of a fine and very compact sand which, while it scoured easily, offered great resistance to the screw. As soon as the pile rested on the bed an irregular scour crater began to form; immediately screwing was started and the leading edge of the screw met the sand the pile began to rotate about that point, and would be thrown as much as 2 feet out of position in half a turn. He had overcome that difficulty by sinking the pile to a depth of about 8 feet by means of a water-jet and air-lift before commencing screwing. The sand inside the pile was excavated by water-jet and air-lift below the pile, the water-level inside the pile being kept a little higher than the tide; the water-jet was then stopped and the water-level inside lowered, causing a blow which carried the pile down 6 inches to 1 foot at a time with little disturbance in position. At a depth of 8 feet the screw and about 4 feet of the pile above it were well bedded in the sand, and screwing could then be started. Any correction of position required at that stage was made by putting down a 2-inch water-jet outside the screw and on the side to which it was required to draw the pile; great care had, however, to be taken with that method of correction, as it was found that the effect of jetting lasted some time after the water had been cut off, with the result that the pile might seriously overrun the correction required. He would have welcomed Mr. Frampton's temporary extension to the cylinder, which was well worth remembering by anyone who might have to deal with similar work.

From the section of the screw-cylinder wharf it appeared that the front line of cylinders was unbraced for a height of about 40 feet. Had Mr. Frampton considered the effect on that front line of cylinders of impact from the bilge of a listed steamer coming alongside? He considered that the provision of two struts distributing the impact over the first three rows of cylinders would have been money well spent as insurance against possible damage from such shocks, which were a daily experience in the berthing of ships in tidal waters. It would be interesting to know what consideration had influenced Mr. Frampton in his adoption of cast-iron cylinders. For instance, on the Hooghly and at Chittagong in India there were some miles of wharves and jetties on ordinary steel screw-piles in situations similar to those at Beira, which had for many years been used by steamers up to 10,000 tons; although the piles in places were slightly bent they still stood up to their work, and he did not think that that would have been the case with cast-iron cylinders.

Mr. BUCKTON, in reply, stated that the spring buffers were provided Mr. Buckton.

Mr. Buckton. in the west jetty of the oil-dock, not on account of rough water, but to minimize the effect on the reinforced-concrete jetty of a blow from a ship coming alongside.

With regard to the bumper buoys, as a ship came alongside it would push the buoy over slightly until all four chains became taut. Further movement of the ship towards the buoy would force the rear buoyancy-chamber downwards. The horizontal force to depress the buoyancy-chamber gradually increased in proportion to the amount of submersion, and reached a maximum of some 200 tons on total submersion. In that condition the buoy would have moved through the first 6 feet. No bumper buoys had yet been installed, but as designed it would be impossible, under ordinary working conditions, for the mooring chains to foul the bilge-keels. Each buoy would have a single-point mooring on the harbour-bed, and as all four mooring chains would be attached to the same point, each buoy would be free to swivel and would swivel as a ship came alongside and touched it. In the case of a row of buoys, the buoys would swivel and adjust themselves to the shape of the vessel. The bumper buoys were not to be used as mooring buoys, head-and-stern moorings being adopted. The site of the liner-berth was off the lee shore, and large ships would not use stem-and-stern moorings without bumper buoys or dolphins. Although bumper buoys could be used in certain tidal waters, tidal waters were less favourable than non-tidal waters.

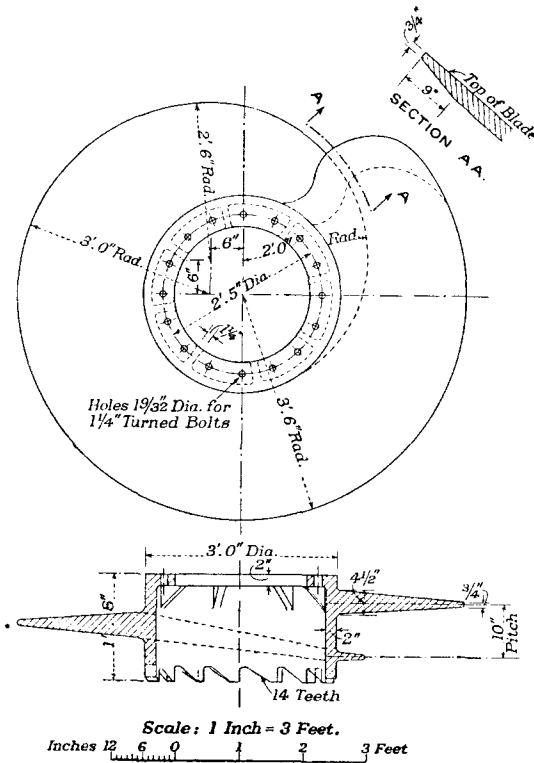
Provision had been made for the maintenance of the breakwater by mounting a 15-ton construction-derrick on three construction-lighters which had been formed into a single floating unit by means of a specially-designed steel frame. That improvised floating derrick was only intended for maintenance-work, but actually there had been considerable demand for it for ordinary commercial purposes. One of the quarry-faces had been left equipped for the supply of stone for maintenance-purposes.

It would have been possible to have had moorings of a different type on the main breakwater, but it was considered best to place the bollards as described, and to use coir mooring-springs for the stern-on moorings. They had been found to be satisfactory.

Mr. Frampton. Mr. FRAMPTON, in reply to the Discussion and Correspondence, stated that *Fig. 3* showed the design of screw used for the cylinders, as requested by Sir Cyril Kirkpatrick, and the Table on p. 640 gave the amperages recorded in the screwing of certain typical cylinders, chosen at random, with the corresponding penetrations obtained. The test-loads on screw-piles and screw-cylinders were not strictly comparable, as the skin-friction was approximately $4\frac{1}{2}$ times greater on the latter than on the former. In reply to Mr. Du-Plat-Taylor,

the cylinders were screwed by means of a capstan, which was held Mr. Frampton in position on the head of the cylinder by an endless wire-rope, passing through the head of the capstan and securely held by anchorages fore and aft. No mandrel was used for screwing, but a sleeve was projected beneath the screw during the initial phase of screwing to ensure perpendicular penetration into the sloping

Fig. 3.



mud-bank, the sleeve being withdrawn as soon as the screw itself had got a firm grip. The amount of skin-friction was never actually measured during the progress of the work. A test-load was applied at frequent intervals, and, if the pile subsided under the test, it was screwed farther and re-tested till the necessary bearing capacity was obtained. It should be remembered that the resistance of the pile was due to a combination of bearing- and skin-resistance, the former being apt to vary considerably with the type of soil encountered, so that it was necessary to resort to fairly frequent tests; it was doubtful whether any system of measuring the skin-

Mr. Frampton, friction would have eliminated any of those tests. No slip occurred in the screwing of the piles after the introduction of the sleeve described above.

It was evident that Mr. W. R. G. Taylor was experienced in local conditions around Beira. Mr. Frampton had also found that *mzimbiti* timber was the finest obtainable for resisting the deprecations of the *Teredo*; it was, in fact, still being used for replacing piles in the old timber lighter-wharves, but was unfortunately not to be found in the quantities and dimensions which would have been

MAIN WHARF—SECTION "B" CYLINDER-SCREWING AMPERAGES RECORDED.

Penetration: feet.	Cylinder No.					
	14	46	53	65	74	101
2	18	16	12	12	18	12
4	18	18	20	18	18	12
6	20	20	24	20	18	20
8	20	22	20	22	20	22
10	22	22	40	30	30	30
12	26	26	48	28	50	32
14	30	32	70	50	40	36
16	35	44	24	40	90	70
18	42	38	40	26	60	20
20	68	70	50	28	50	32
22	70	26	30	28	46	30
24	38	80	24	30	42	26
26	36	32	28	24	36	22
28	26	26	30	26	36	20
30	26	28	28	32	34	24
32	28	26	28	36	—	—
34	—	26	—	—	—	—

required for the work described. It had been his experience that unprotected pitch-pine lasted 18 months or less in the water at Beira, whereas *mzimbiti* had in some cases stood over 10 years. The splice referred to in the composite piles had been made when the end of the timber was still above mud-level, and the piles had subsequently been driven further until the splices were completely buried. It had not been found that the timber had been attacked through the very thin layers of sand that occurred under the *matopi*; no indication of such attack had been found in the case of test piles which had been driven and subsequently withdrawn. Regarding the two former attempts at the construction of deep-water wharves, the first, known as the Railway Jetty, was built by the contractors, Messrs. Pauling & Co., to unload their materials for the construction of the Beira Railway, and, as far as he was aware, had served its purpose satisfactorily. However, the rate of erosion at that jetty, as measured before the commencement of the new works, amounted to

8 feet per annum, so that eventually the screw-piles of the jetty failed Mr. Frampton. to support it. The second jetty, known as the B.C.C. Pier, had never been completed, but considerable erosion had already taken place round the cylinders that had been sunk, and, when he had had to remove them to clear the site for the new wharves, he found that some had already fallen over from that cause. That erosion had been checked in the new works by means of the stone-pitching of the slopes underneath.

In reply to Mr. A. C. Gardner, the estimated working loads on the cylinders were 90 tons, on the screw-piles 28 tons, and on the composite piles 16 tons. The reasons for not using steel cylinders, as suggested by Mr. Latham, were that the thickness would have had to be excessive in order to resist the screwing torque, and that cast-iron seemed to be more impervious than steel to the chemical action of salt water. If the cylinders had been sunk by means of the usual cutting edges, the diameters would have had to be increased in order to accommodate the grab within them.

The struts mentioned by Mr. Monk had not been found to be necessary, though the structure had already experienced more than one severe shock during berthing operations. The first part of the deep-water wharf at Beira had been constructed of the ordinary screw-piles, and the consideration which resulted in the remainder being constructed of cylinders was that they made it possible to eliminate all underwater bracing, which had always been a constant source of worry to engineers and contractors alike.

Mr. GRAY, in reply to the Discussion and Correspondence, Mr. Gray. remarked that it would possibly have been more economical to remove the cofferdam by dredging, as suggested by Mr. Du-Plat-Taylor, but that would not have overcome the difficulty encountered in extracting the piling, as it had been driven to a considerable depth below grade.

With regard to Mr. Latham's suggestion that the buoyancy of lighters on a rising tide might have been utilized to pull the piling, that method had been tried with a steel scow, as mentioned on p. 613. In that case the buoyancy of the scow, in combination with the inverted No. 7 hammer, had been used. The operation had proved very cumbersome and slow, and had only been used for a section that had been left by the land plant.

The reason for using a land operation was that a very large amount of filling was required, both in the pier and in the area required for trackage. The material in the cofferdam was mostly gravel, and consequently it was decided that it would be more economical to use the gravel from the cofferdam than to obtain it by other means.

When the scheme for the development was first considered, it was intended that a joint railway and vehicular bridge should cross the

Mr. Gray.

harbour in the vicinity of Navy Island and link up with the present railway trackage. No further progress had been made in promoting the bridge scheme. All traffic for the terminals was handled by the Canadian Pacific Railway Company, the Canadian National Railway's traffic being handed to the former railway at a transfer-point.

With reference to Mr. Deane's suggestion that rock-excavation might have been avoided by constructing the pier on the site indicated by the dotted lines in Fig. 1, Plate 12, that area was occupied by a ferry-landing and railway-terminus. The proposed bridge referred to above was intended to replace that ferry. To provide accommodation for the ferry and railway-trackage at some other place would have entailed considerable expense, in addition to delaying the construction. The sites of the works as constructed were available, and no time was lost in proceeding with the work. Furthermore, the site shown in the dotted lines was intended for further extension of the scheme.

Mr. A. C. Gardner suggested that the width of the sheds, and also the number of tracks between the sheds, might have been somewhat reduced. Transatlantic vessels using the pier and quay-wall were usually in port for 5 or 6 days. During that time, they discharged an average of 5,000 or 6,000 tons of cargo, and loaded for export an average of 7,500 tons of cargo. The Port of Saint John was a transfer between vessel and railway, and a very small proportion of the overseas traffic emanated from the city and surrounding area. The transit-sheds consequently had to be of sufficient capacity to handle the cargo, both outward and inward, with the least amount of congestion. An ordinary cargo of 7,500 tons required about four hundred and fifty freight-cars. To reduce the number of tracks would mean that considerable shunting would require to be done during working hours, which would considerably increase the cost of loading and unloading, on account of more frequent movement of the freight-cars at the sheds.

With regard to the use of wheelbarrows for handling the aggregate, very close inspection was given to that work. There was a total calculated quantity of 84,000 cubic yards of aggregate, and the method used checked within 1 per cent. The extra cost per cubic yard of concrete placed during winter and protected by live steam was governed by the daily output and the yardage of concrete in the work. The extra cost for the work under discussion was 27 cents per cubic yard.

The actual cost of the pier work, exclusive of sheds and equipment, was \$2,400,000.

Past experience in other works in the port indicated that timber piles, at the levels at which they were cut off under the elevator and transit-sheds, were well protected against rot.