Correspondence.

Mr. HERBERT E. ALLEN asked whether the repeated turning of the cement had been done by hand, or by tipping sections of the bin-floor allowing the cement to fall on to the floor below. As it was stated that generally the specified five turns were sufficient, Mr. Allen concluded that the number of turns up to five was covered by the general specification, and allowed for in the cost of the cement or concrete per cubic yard; but when seven turns or more were given to the cement, how had this been dealt with in regard to payment? It seemed evident that it would involve expense to the contractor, unless perhaps the Resident Engineer had had a special staff of men to test and deal with the cement before handing it over to the contractors for use. Again, would the Author say whether the heavy temporary work—staging, piling, overhead cranes, etc., had been met by a lump sum, or by an allowance through the schedule of prices, or whether the contractors' general prices for excavating, block-setting, etc., per cubic yard, had included all temporary work necessary to carry them out? A few details of the cost of the large concrete blocks would be of interest. Mr. Allen.

Mr. H. KELWAY BAMBER asked what had been the increase in bulk of the cement after the tenth and twenty-second time of turning. Had it been found that a bushel of this cement of increased bulk would make as much satisfactory concrete as a bushel of the original cement when not too quick-setting? Mr. H. K. Bamber.

Mr. JOHN S. BRODIE observed that the extensive and interesting tests of the cement showed the value of thoroughly aerating it before using, also the risk of adding gypsum to render a cement slow-setting. It was noticeable that the proportions of shingle to sand and gravel were not carefully gauged; the disadvantage of an ungauged aggregate was the probability of getting a porous concrete. The precautions taken for ensuring accurate work in block-setting under water appeared to have been very elaborate and well devised. It did not appear that the foundations carried into the greensand to a minimum of 2 feet would have been stable enough without the addition of the apron 13 feet in width. Probably a slightly greater depth of foundation would have obviated the necessity for an apron. It was not clear how the shuttering for the mass concrete could cause the blocks nearest the Mr. Brodie.

Mr. Brodie. centre-line of the pier to "creep" more quickly than the outer blocks. The method of jointing and bedding the blocks was exceedingly good, and showed that this important part of the work had received more than ordinary attention. Could not the strengthening of the root of the old pier have been carried out on the same principle as the widening of the old pier on the west side? That would have been more expeditious and cheaper than the block-work carried on steel-cylinder foundations.

Mr. Carron. Mr. F. G. Carron asked why circular pier-heads were almost invariably adopted: he thought it would be more economical to construct them square in plan with slightly rounded corners. The advantage of straight walls was evident where landing-steps were required at the head. With regard to the construction generally, it would be difficult to criticize any part adversely, with the exception of the method of renewing the face of the old pier. He thought it was a pity that there the construction could not have been of a nature which in permanence would have been more like the rest of the work. It must be assumed that lack of funds had been the principal factor in the choice of greenheart sheet-piling. It would have been preferable to drive reinforced-concrete piles at intervals and to form a mass-concrete wall between them in place of the chalk filling, the foundations of the wall being formed in short lengths, and the wall properly bonded with the old work. With regard to the concrete blocks used as wave-breakers, doubtless the 20-ton blocks were well suited for this position; but a few 60-ton concrete blocks recently used for a similar purpose at a breakwater with which Mr. Carron was acquainted had been moved by gales in a line parallel with the breakwater—two of them creeping along in this way as much as 40 and 50 feet. This proved that they were heavy enough to withstand the force of a wave exerted square to the breakwater, but not heavy enough to resist the resultant of a blow which struck the breakwater at an acute angle. For positions such as this, small rubble deposited as protection to a wall was of little or no use. Another point in regard to concrete blocks was suggested by that portion of the President's recent Address which referred to the use of reinforced concrete as a material for harbour-construction. In some positions great difficulty was experienced in launching blocks large enough for exposed situations without the use of very expensive plant, which it was not possible to provide where the number of blocks to be dealt with was small. In such a case Mr. Carron saw no reason why a reinforced-concrete shell should not be made on shore, launched and put in position, and then filled with concrete. This would be a great improvement on building blocks on the foreshore in ordinary timber moulds, as it would ensure a more perfect skin to the block, which was a very important point, and it would also avoid the excessive waste of cement due to tidal action on new concrete, as the shell would be practically water-tight. In this way a block of 100 tons weight could be made, whose shell alone would not weigh more than about 20 tons. Mr. Carron.

Mr. R. G. CLARK remarked that it was a well-known fact that aeration extended the setting-time, but his experience was that mixing the cement with the aggregate also had this effect. By this he suggested that although the neat cement might show a setting-time of, say, 1 hour, that of the concrete might be about 4 to 5 hours, thus giving ample time for mixing before it had begun to set. Again, the weather affected the cement, and it was of great importance to ascertain the proportion of water to use, as this fluctuated with the weather and with the aggregate used, such materials as crushed brick and hard ballast requiring different quantities of water. The aggregate, again, demanded more than passing attention, as he had found that by decreasing the sand and replacing it with stone he obtained results 50 per cent. higher in crushing strength. It was easily seen that if there was a large proportion of fine sand there was a large area for the cement to cover; and on the other hand, in a block with a fair proportion of stone the area was reduced and consequently the block was richer, although the amount of cement was the same. He felt sure that in many cases engineers might be assisted by the makers of the cement, and at least an interchange of ideas from two different points of view might be beneficial to both parties. With reference to the concrete cylinders, he suggested that reinforced concrete would have been suitable, as the reinforcement could be designed to take any tension that might be set up due to the cylinder canting. He was inclined to think it would be as cheap as the ordinary concrete, as it could be handled easily, and in his opinion was far preferable to the steel shells. Mr. Clark.

Mr. C. COLSON observed, with regard to the temporary repair of the old pier by the use of concrete in bags, that it might be interesting to note what was done in this connection during the construction of the Hamilton dock at Malta.[1] There the excavation of the dock was in rock which was badly fissured. Some of the fissures were in connection with the sea; they were of appreciable width, and in some parts widened out into cavities. In order to Mr. Colson.

[1] C. Colson and C. H. Colson, "Hamilton Graving-Dock, Malta." Minutes of Proceedings Inst. C.E., vol. cxv, p. 360.

Mr. Colson. check the great flow of water from the sea into the dock-excavation it was necessary for divers to stop some of the largest of the fissures and cavities under water. The course adopted was to clear out the fissure or cavity as far in as it was safe for the diver to go, and then to pack in small bags of concrete as closely and as regularly as possible. The bags varied in size according to circumstances, but were never larger than the diver could handle without undue exertion, and were never filled more than two-thirds; this ensured close and regular packing and consequently reduced the interstices to a *minimum*, and the inflow of water between the bags was correspondingly affected. With regard to the control of the setting-properties of Portland cement, in view of the present knowledge as to the ultimate effect of gypsum—or indeed of any other adulterating or controlling medium—on the soundness of the cement, all such additions should, in his opinion, be avoided until further experiment and observation removed the doubt which now attached to them. In the meantime, thorough aeration—whether ensured by the ordinary method of bulking and turning, which caused some delay and involved extensive storage, or by the more up-to-date mechanically aided method, which accelerated the process and saved time—would, if properly carried out, give the needed control. As to the soundness of concrete mixed dry and deposited under water in bags, he concurred in the view that soundness under such conditions was very problematical, except when bags of very small dimensions were used; and in any case, owing to the interstices not being so solidly filled by the dry sand and cement as would be the case were the concrete mixed in the ordinary way, the sand and cement would tend to settle, with the result that the lower part would be denser than the upper. Experiments made by him in this connection had not been altogether satisfactory, and had emphasized this tendency to settle. If the Author could give some details of the cost per unit of the chief sections of the work, such as the pier at the BB section (Fig. 5, Plate 1), the blockwork in the strengthening at the west side of the pier at the root, the cylinder foundations, etc., it would add to the value of the Paper.

Mr. Mann. Mr. I. J. MANN considered that some very useful information was derivable from the history of Folkestone Pier given by the Author, particularly as regarded the movement of loose material along the foreshore and the adjoining sea-bottom. In this case a solid structure had been projected across the line of drift, and the result, as might have been anticipated, was a temporary stoppage of the movement of the shingle, etc., in its normal direction, for the whole length of the old pier (about 600 feet). After the lapse of 11 years

Mr. Mann.

the loose material began to pass the seaward end of the old pier and to form a shoal at the entrance to the harbour. He would be glad if the Author would state the depth of water in which the old pier originally terminated. The Author referred to the accumulation of sand and shingle in the area dredged out for the reception of the apron-blocks, and it would be interesting to know if this movement of sand and shingle had occurred at or near the seaward end of the extension. That the effect of waves in current-less water of moderate depth was to produce a simple oscillation of any loose particle on the bottom, could readily be observed in clear water. After each forward oscillation, the particle returned to its original position. The amplitude of the oscillation, *ceteris paribus*, was no doubt directly proportional to the height of the wave, and inversely proportional to the depth of the water; but these proportions did not seem to have been practically determined, which was somewhat remarkable when their usefulness to harbour-engineers was considered. When a tidal current was present, and when the direction of the waves coincided more or less with that of the current, the forward oscillation of the loose particle was assisted, and the backward oscillation was retarded by the current, so that, instead of returning to its former position, the particle was carried back to a position in advance of that which it had before occupied, each successive wave producing a similar effect: in this way a drift or travel was produced in the direction of the prevailing waves which in its turn depended on the direction of the prevailing wind. As regarded the depth to which the disturbing action of waves could be propagated, there were so many conflicting opinions that a thoroughly practical and systematic investigation was extremely desirable, with a view to determine what relation existed between the height of a wave and the disturbance it was capable of producing at different depths, not only at low water when the current was generally at its minimum, but also shortly after half-tide when the current was usually at its maximum. The use of an apron or pavement of concrete blocks to protect the foundation of the pier from being undercut was neat and would fulfil its desired purpose, provided the pavement itself were not undercut. In deep water and where otherwise permissible, a low mound of loose rubble stones averaging 1 or 2 cwt. each had often been found to form a very effective protection against undercutting. The rubble adapted itself to the circumstances more readily than large concrete blocks, for as the sand was gradually scoured away it was immediately replaced by the rubble. In addition to its efficiency, this method had the advantage of being simple and inexpensive. The moderate weight

Mr. Mann. of the blocks used in the recent extension was judicious and economical, and an example that could be safely followed; at the same time, it should not be forgotten that the stability or immovability of any one block depended by no means entirely on its own weight, but was greatly increased by the weight of the superincumbent blocks. Having had considerable experience in the use of blocks of excessive weight (about 350 tons), and also of blocks of very moderate weight (about 10 tons), he had no hesitation in saying that excessively large blocks not only added very considerably and unnecessarily to the cost of the work, but also retarded progress, owing to the time and trouble involved in preparing a perfectly level surface of large area in the foundation for the reception of the block; the latter objection being accentuated when the work was in an exposed position, and rendering it necessary that every possible advantage should be taken of summer weather. If the Author would state the height of the waves met with during the course of the work, or the maximum height of the waves at the seaward end of the extension, he would further add to the interest of his Paper. Reference was made in the Paper to the tendency of the foundation-blocks to "creep" forward as they were set, which, if not checked, would have brought two vertical joints over one another. Even if this had occurred, however, it would have been of little consequence, and it would seldom happen. In the breakwater at Karachi all the vertical joints were over one another, which subsequently proved to be an advantage when unequal subsidence took place in the foundation. With reference to the tests employed to ascertain the quality of Portland cement, it was somewhat difficult to understand why the tensile strength of neat cement had ever been introduced; the cement was rarely, if ever, under tensile stress. It was well known that its cohesive strength greatly exceeded its adhesive strength, and no such test had ever been employed in testing any ordinary cementing material, such as ordinary glue or other cement. The cohesive test in the case of neat Portland cement was not only useless but also misleading, inasmuch as the cohesive strength of coarsely ground cement exceeded that of the very finely ground. It therefore seemed almost unaccountable why the comparatively useless test of cohesion should be persisted in, and the infinitely more practical and reliable test of adhesion neglected.

Mr. Tait. Mr. W. A. TAIT could not help thinking that the value of the Paper would be greatly enhanced if the Author could see his way to give some particulars of the cost of the whole of the recently constructed work, as well as of several of the more important items. The cost from the commencement must no doubt have been considerable, but, on the other hand, account should be taken of the value to the railway-company of the large area of land which had practically reclaimed itself, and which probably would be free from any complications in regard to title. The Author was also to be congratulated on the very elaborate and continuing series of cement-tests described in the Paper. His remarks on the increase of volume of the cement due to aeration were of great interest. In the case of the Talla waterworks, lately described,[1] the practice had been to pay contractors upon the tonnage of cement delivered, and in this case, of course, the contractor got no benefit from the increase in the bulk of the cement due to its being repeatedly turned over in the sheds. The Author had drawn attention to a noteworthy point on p. 76, where he referred to the continuous sheeting having the effect of raising gauge-piles already driven. This had some resemblance to the disturbance of ground, fencing, culverts, etc., which was occasionally observed a considerable distance away from the leading end of a high railway-embankment in course of formation. He would be glad if the Author could supplement the Paper with some further information as to the rate at which the piles were driven from the commencement to the finish; and he might also add explanatory sketches showing at what time the movement of the gauge-pile was first noticed, and how near the sheet-piling was to it when the movement took place. It was, of course, common knowledge that wet sand was an extremely troublesome material in which to drive ordinary piles. The Author's remarks on the use of concrete cylinders in ground which was not homogeneous quite bore out Mr. Tait's own experience in the sinking of somewhat similar cylinders on the Clyde at the Broomielaw, and it would seem that cylinders of such a type were unsuitable for use in ground containing boulders, old masonry, or timber-work. The Author did not mention what plant was provided for maintaining the air-pressure, referred to on p. 72, when dealing with the agitation of the green-sand; and it would be of interest to learn whether the sand was sufficiently homogeneous and compact to prevent the air from getting away suddenly, and so causing a corresponding reduction in the pressure. The actual pressure near the nozzle might also be stated. No doubt, from the fact that two divers were necessary to control the nozzle, there could not have been great loss of pressure between the receiver and the nozzle. Mr. Tait.

[1] W. A. P. Tait, "The Talla Works for the Water-supply of Edinburgh." Minutes of Proceedings Inst. C.E., vol. clxvii, p. 102.

Mr. Thompson. Mr. J. HANNAY THOMPSON was very much interested in the information given by the Author with regard to the addition of gypsum to cement. About 7 years ago he made tests of cement which, having been first analysed and certified to be free from gypsum, had quantities of gypsum varying from $\frac{1}{4}$ per cent. to 3 per cent. added to it. The results of the neat tensile tests showed that at 7 days and 28 days there was an increase of strength over the unadulterated cement of about 100 lbs. per square inch, which gradually increased until at 9 months the strength of the adulterated cement was about 150 lbs. per square inch higher than that of the unadulterated cement. At 12 months there was a fall in strength of 50 lbs. to 150 lbs. per square inch. The results of similar tests made with 3-to-1 standard sand showed that cement to which $\frac{1}{4}$ to 1 per cent. of gypsum had been added did not give such high tensile results as the unadulterated cement at 7 days to 12 months, but cement to which $1\frac{1}{2}$ to 3 per cent. of gypsum had been added gave results about 50 lbs. per square inch higher than the unadulterated cement. The following Table showed the results of some tests of the final time of setting of cement to which different percentages of gypsum had been added, the tests being made at intervals of 3 days, after the gypsum had been added.

Number of Days after Addition of Gypsum.	No Gypsum.	0·5 per Cent. Gypsum added.	1 per Cent. Gypsum added.	2 per Cent. Gypsum added.	3 per Cent. Gypsum added.	Temperature ° F.
3	10 minutes	20 minutes	$4\frac{3}{4}$ hours	8 hours	10 hours	73
6	20 ,,	27 ,,	43 minutes	48 minutes	8 ,,	74
9	20 ,,	19 ,,	25 ,,	4 hours	7 ,,	72
12	11 ,,	36 ,,	35 ,,	4 ,,	$4\frac{1}{2}$,,	73
15	10 ,,	1 hour	1 hour	5 ,,	7 ,,	72
18	10 ,,	2 hours	$3\frac{1}{2}$ hours	$6\frac{1}{2}$,,	$6\frac{3}{4}$,,	70
21	10 ,,	$2\frac{1}{2}$,,	$3\frac{1}{2}$,,	$5\frac{1}{2}$,,	5 ,,	71
24	10 ,,	$2\frac{1}{2}$,,	$3\frac{3}{4}$,,	5 ,,	5 ,,	72
27	10 ,,	$4\frac{1}{4}$,,	$4\frac{1}{2}$,,	5 ,,	$5\frac{1}{4}$,,	73
30	10 ,,	$4\frac{1}{4}$,,	$4\frac{1}{2}$,,	5 ,,	6 ,,	70

It would be noticed that, with an addition of 1 per cent. of gypsum, the time of setting, 3 days after mixing, was $4\frac{3}{4}$ hours, and that at 9 days the time of setting was reduced to 25 minutes; while corresponding results were shown with an addition of 2 per cent. and 3 per cent. of gypsum. Generally the results of the tests appeared to show that the addition of $\frac{1}{2}$ per cent. of gypsum, 27 days after mixing, had practically the same effect as the addition of 1, 2, or 3 per cent. Pat-tests were also made, the cement being gauged with fresh water. Some of the pats were put into fresh water, and others in salt water, both before and after setting. The unadulterated cement was sound under all the tests, but pats made from the cement to which ½ to 3 per cent. of gypsum had been added all failed to pass these tests. The pats to which 1½ to 3 per cent. of gypsum had been added were very badly cracked in all cases, were quite soft, and had a scale on the top; and there was a white deposit both on the cement and on the glass. These tests were made immediately on the cement being received on the works, and after it was bulked. The tests were repeated after the cement had been aerated for 5 weeks. The same percentage of gypsum was added in each case, and all the pats stood this series of tests quite satisfactorily. Boiling-tests were made of cement adulterated in the same way. The tests were made 2 days, 4 days, 7 days, and 28 days after gauging, and in every case the adulterated cement stood the boiling-test, although it had failed under the water-pat tests. Cement often stood the pat tests in water, but failed under the boiling-test. In the above case, however, the addition of gypsum caused the reverse to happen. Mr. Thompson.

Mr. Voisin, of Boulogne-sur-Mer, considered that the Paper was the more worthy of attention in that it accentuated again one of the most noticeable characteristics of English sea-works, which consisted not only in the care given to the arrangement of the work-yards, but above all in the selection of plant of sufficient size and strength to enable the works to be carried out with the minimum delay through the action of the natural forces such as winds, currents, waves, tides, etc., with which it was necessary to reckon. It was on these lines that the work at Folkestone had been carried out, and it was thus that work was being carried out, though on a larger scale, with equal success at Dover. Undoubtedly this method of construction necessarily entailed higher costs than had been usual in similar French works until latterly, when the tendency had been towards an improvement; but a large portion of the extra cost must be repaid by the safety and the rapidity with which the works were executed. It would be interesting to know if, in the end, the English practice, which offered at least the marked advantage of speed, was more or less advantageous from the point of view of economy than the French practice. He was inclined to think that it was less; but it was so difficult to make a comparison between works, no matter how similar, that it was impossible to answer the question definitely; and, as the Paper made no mention of the financial aspect, there was Mr. Voisin.

Mr. Voisin. no means of discussing the point further. The statement of the total cost (exclusive of railways, lighthouse-installation, landings, etc.) for sections of pier founded respectively between 6 and 12 feet, between 12 and 18 feet, and below, would perhaps have enabled interesting comparisons to be made with, for instance, the Carnot sea-wall at Boulogne, a structure of wholly different type. Another point for notice was that the action of sea-worms upon timber varied greatly in accordance with local circumstances, which were very ill-defined. Thus at Folkestone the action was very rapid; it was rapid, but less so at Calais; and was relatively slow at Boulogne. One of the points most worthy of study was the question of Portland cement. The finely ground condition of the Portland cement used at Folkestone was evidently one of the reasons for the setting being so rapid as to interfere with the gauging. He would like to point out that for some years it had been thought desirable in French sea-works to return to comparatively coarsely ground cements, as, when mixed with ordinary sand, they were generally less inclined to deteriorate than those which were more finely ground; at all events, the speed of setting had never presented the least inconvenience. It was also surprising that, notwithstanding the steps very wisely taken to aerate the fresh cement, its speed of setting was still so high; but it was difficult to account for this fact, the degree of fineness not being stated. Under the circumstances, the question whether the addition of a suitable quantity of gypsum was good or bad did not arise in connection with the French harbours, and although it seemed to follow from numerous experiments made, notably at the Laboratoire des Ponts et Chaussées at Boulogne, by Mr. Feret, that the addition of less than 1 per cent. of gypsum, either unburnt or burnt, was of little importance as regarded the holding-power of the mortar in the sea, such addition was prohibited. These experiments showed also that unburnt gypsum added in small proportion retarded the setting, and that the addition in large quantity of this same gypsum slightly accelerated it; while the substitution of plaster of Paris (burnt gypsum) in large proportion accelerated it in a marked degree. At all events, however, a mixture of cement with 10 per cent of gypsum, whether burnt or otherwise, was regarded as extremely dangerous to the holding-power of the mortar, not only in sea-water, but also in fresh water. The incorporation with cement of a small percentage of gypsum rendered the boiling-water test less stringent to such an extent that it lost its value. The Author raised the question whether, in the event of the addition of 1 per cent. of gypsum to Portland cement being acknowledged to be without danger, this practice should be regarded as preferable to that of adhering to cement unmixed with extraneous material, even if the setting was too quick; but he did not answer the question. It followed from the foregoing that in French sea-works no hesitation would be shown in adopting the second practice if the case arose, which, however, as already stated, it did not. An interesting detail to remember was the use, for the purpose of protecting the mortar against the wash of the sea, of a mixture of about equal parts of Portland cement and plaster of Paris. There was no doubt that this mixture solved the difficulty. But, as it might happen that it was only partially possible to remove the protective bed, or even impossible to remove it at all, its use involved serious danger of leaving—if not in the masonry, at least in the facing—mortar which would decompose very rapidly and very completely. This was not the case with the quick-setting cement which was used regularly in French harbours under similar circumstances, and which, notably at the Carnot sea-wall at Boulogne, had been able to resist the action of the sea perfectly during 10 to 15 years. It would be useful to know what was the mean annual accretion over the area dredged. In conclusion, the works described had not only been well designed, but had entirely succeeded in fulfilling their purpose. Mr. Voisin.

Mr. W. H. Wheeler considered that what had occurred at Folkestone in regard to the movement of the shingle along the coast appeared to bear out the correctness of one of the propositions laid down in his Paper on Littoral Drift.[1] It was there contended that the quantity of drift travelling along a coast was limited, and might be cut off entirely, and that its movement could be controlled. This appeared to be borne out by what had occurred at Folkestone. After the west pier of the harbour was constructed in 1856 there ensued a large accumulation of shingle at the back of the wall, due to the drift along the shore, which finally worked round the end of the pier into the harbour. The pier was then extended into 15 feet at low water. The accumulation still continuing, a large area of beach was raised above tide-level, and below this a fine stretch of beach extended westward up to the pavilion. On the raised area of shingle thus accumulated by the harbour-wall, a wide road or drive with pleasure-gardens had been constructed. Further westward, and along the coast past Sandgate and Hythe, groynes had been constructed, and the erosion of the cliffs, which were the Mr. Wheeler.

[1] "Littoral drift: in its relation to the Outfalls of Rivers, and to the Construction and Maintenance of Harbours on Sandy Coasts." Minutes of Proceedings Inst. C.E., vol. cxxv, p. 2.

Mr. Wheeler. source from which the shingle was derived, had been stopped. Consequently, as stated in the Paper, the shingle had ceased to collect, and no apprehension now existed of any further detriment to the harbour from the drift.

The Author. The AUTHOR, in reply, welcomed the particulars given by Mr. Thompson of his tests made with cement adulterated with gypsum, and desired to emphasize the importance of the results obtained. It was made clear that the use of gypsum-adulterated cement on harbour- or other works, where it was probable that concrete-in-mass would be deposited under water, was decidedly dangerous. Cement so treated, if used for concrete which was to set in air, and thereafter to be deposited in water, might—though in the Author's opinion it was by no means certain—be capable of producing sound work; but the adulteration with gypsum of cement to be used in concrete designed to set under water would in all probability lead to disastrous results. The turning of the cement, referred to by Mr. Allen, had all been done by hand without any mechanical contrivance, and no cement had been turned over more than five times unless it was found, either that the increase in bulk more than paid for the cost of turning, or that extra turns were required in order that the boiling-test might be passed. The whole of the testing had been done by one man. The answer to Mr. H. K. Bamber's first question, regarding the increase in bulk of the cement, was given in the Author's reply to the discussion. With regard to the strength of the cement of increased bulk, the Author was unable to say from direct experiment whether, bushel for bushel, the cement of increased bulk would produce work as satisfactory as the original cement; but since the tests made, both of neat cement and of 3-to-1 mortar from the cement of increased bulk, had given better results than tests made from the original cement, the Author considered it safe to infer that the former would produce better work than the original cement. Mr. Brodie's suggestion, that by carrying the foundations to a greater depth into the greensand the apron might have been dispensed with, was not wise. In the first place, the cost of the apron would not have paid for deepening the foundations of the pier by even 6 inches; and in the second place, the foundations, even if carried to a considerably greater depth, would not have been secured against undermining without a protecting apron along the toe of the wall. Mr. Mann also referred to the apron, and advocated the use of a low mound of loose rubble instead of apron blocks. The behaviour of the latter in the event of any scour taking place was exactly the same as that of the rubble described by Mr. Mann. The blocks subsided and cut off further sea-action; whereas with a rubble mound the tendency was for the sea to flatten the slope and scatter the rubble over a large area, and to a considerable distance from the pier. The cylinder foundation at the root of the pier, referred to by Mr. Brodie, was necessary owing to the depth of cover overlying the greensand, and the proximity of the old buttresses and their apron. An open trench similar to that on the widening of the west face, as Mr. Brodie suggested, was out of the question. The inside slope would have undercut the existing old work which was already in a precarious condition. Mr. Clark's suggestion that reinforced-concrete cylinders would have been preferable to the steel cylinders, was made without due regard to the exposed site of this portion of the work, or to the nature of the material to be pierced. The cylinders, if built in one length of reinforced concrete, would have been too large and too heavy for the capabilities of the plant available. If built in situ, the state of affairs after some hours of a rough sea acting on the shuttering and rods might be better imagined than described. The Author thought that the best and most economical method of obtaining a good foundation in similar conditions was to sink steel cylinders by means of compressed air, so that as obstructions were met they could be removed with comparative ease by men who could see what they were doing. In sinking a concrete cylinder, whether reinforced or not, the obstructions had to be dealt with by men encumbered with the diving-dress and groping about in dark, dirty water. The Author fully agreed with Mr. Carron that it would have been preferable if the renewal of the east face of the old pier had been of a permanent character to correspond with the rest of the work; but owing to the necessity for minimizing the break in the line of the pier, it had been quite impossible to construct a wall of sufficient thickness, and piling had been adopted in lieu thereof. The decision to use greenheart piling was arrived at only after many other methods, including reinforced concrete, had been carefully considered and judged unsuitable. The suggestion that a mass concrete wall should have been built between the piles and the old pier did not commend itself to the Author. The space generally was so narrow that the wall would have been no more than a veneer of concrete, of a quality rendered very doubtful owing to the tide rising and falling through its small volume; and the Author failed to see what compensating advantage would have been gained for the extra expense incurred. Mr. Wheeler, referring to the coast past Sandgate and Hythe, assumed that the erosion of the cliffs on one portion of the coast-line produced an accumulation of shingle along that portion. That this was not the case was evident from the fact

The Author.

The Author. that from Folkestone to Hythe there was no cliff or foreshore of chalk, and that the geological formation was that of the Lower Greensand, from which no shingle was derived. It was not because of the erosion of that portion of the coast being stopped that the shingle was not accumulating at Folkestone at the same rate as hitherto, but because the groyning to the west, which had been greatly increased of late years, had had the effect of trapping the shingle on its way to the east before it reached Folkestone.

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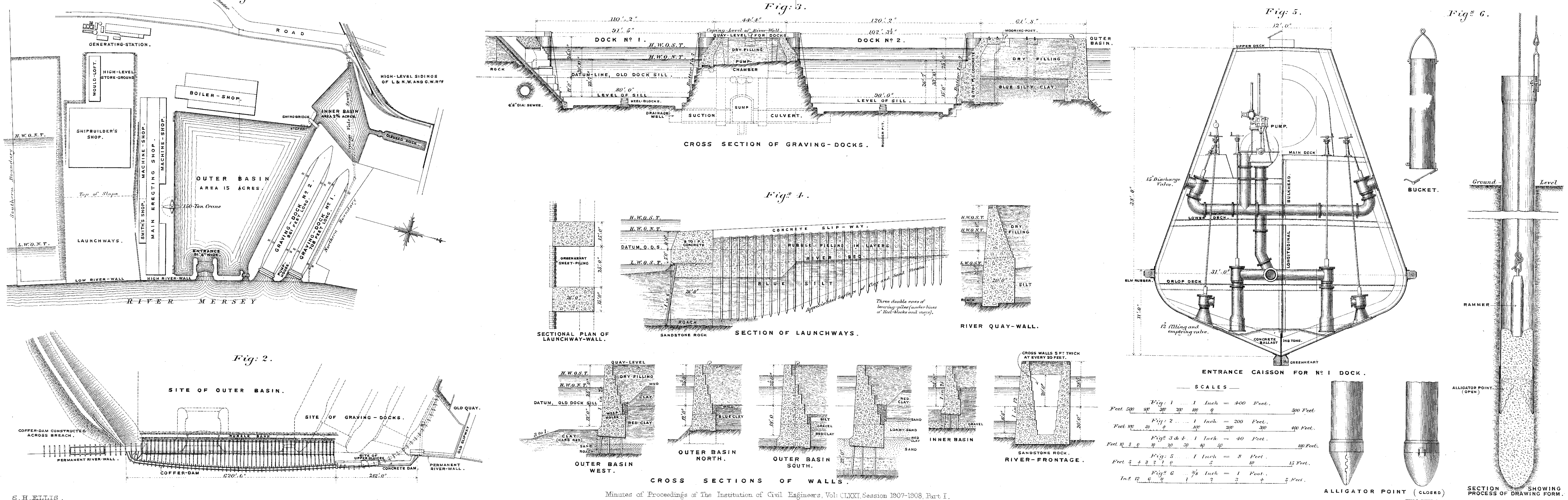
19 November, 1907.

Sir WILLIAM MATTHEWS, K.C.M.G., President, in the Chair.

The discussion on Mr. H. T. Ker's Paper on "The Extension, Widening, and Strengthening of Folkestone Pier" occupied the evening.

TRANMERE BAY DEVELOPMENT WORKS.



S. H. ELLIS.

THOS KELL & SON, LITH. 40 KING ST COVENT GARDEN.