## Discussion

**Mr J. H. Jellett** referred to the statement made on p. 428 that, in the timber-depot quays, no fixed fendering had been provided; apart from reference to the 12-inch-by-12-inch timber coping beam, no other mention had been made of fendering. Was some form of floating dummy provided?

How was the bituminous paint on the steelwork for the sawn timber sheds behaving? Experience had shown that the behaviour of that type of paint could be very patchy and a record of how it had lasted in the conditions in Takoradi would be of interest.

It was unusual to berth ships in what was, after all, the open sea when special unloading or loading plant (such as that at the bauxite berth) had to be provided. Were sea conditions ever experienced at those berths which made it impossible to operate the loading plant? In the description of the construction of the berths, there was reference to the fact that the face of the breakwater had been drawn down to some extent by sea action, which indicated that conditions of calm did not always obtain in that part of the harbour.

Turning to the reclamation, which was described on p. 435, Mr Jellett asked if the cost of blanketing the shale filling over the whole of the reclamation was considered to be justified. So far as could be seen from the Paper, no immediate purpose was envisaged for a large part of the reclamation area, and even though it had been made as large as possible, some of the surplus material had had to be taken to sea. In those circumstances, would it not have been more economical to allow the shale over the unwanted part of the reclamation area to disintegrate, which presumably would have made room for that extra volume of material which had to be taken to sea? It might be that there was something undesirable in allowing such a large volume of shale to disintegrate in the vicinity of the harbour, but the point had not been brought out and it was interesting.

Finally, information on some of the timbers mentioned in the end of the Paper would be of great value. Nowadays people were offered a large variety of timbers from various parts of the world to take the place of some of the better-known qualities and species which were not so plentiful as in the past, and information about the behaviour of the new timbers was not always readily forthcoming.

**Mr A. J. Hill** said that he could comment on certain matters from the contractor's point of view, particularly on the background in West Africa which accompanied the work and the many important circumstances which had had to be taken into account before the work was undertaken.

The job was tendered for in 1949, which was in what one might describe as the early part of the post-war period when many things were uncertain. It was in a country where there had not been a vast amount of civil engineering practice in previous years, mostly because of the war, and where there was a developing political situation—a situation which, during the course of the work, saw a change in the form of government. There was also the fact that the community at Takoradi was of such a size that the work would have a great impact upon it. There were about 600 Europeans at Takoradi and about 15,000 Africans. The advent of harbour extensions, therefore, meant a 10-per-cent increase in the number of people there, so that not only was there the impingement of the work on the harbour itself but there was also a question of its effect locally in social and other types of contact.

Lastly, there was the circumstance of the great difficulty with materials, especially those which had to be imported into the country. All those factors had been reviewed and some deliberate policy decisions had been taken so as to get the best out of the work.

Those policy decisions included, first of all, a determination to utilize Africans to the utmost on the work in all its phases so as to minimize the number of Europeans who had to be sent from England. That had involved training, teaching, and encouraging Africans to do work of which previously they had had little or no experience.

To accompany that decision, it had been decided to move very much in the direction of the mechanization of operations. The mechanization which had been embarked upon was, he believed, far ahead of what had been expected by people who had seen previous work in the Colony.

Considerable attention had been given to the personnel side of the work, both with Europeans and Africans, and some specific arrangements had been made about the housing, welfare, and health of the people. Lastly, it had been decided that in view of the shortage of materials and that that was one of the first post-war major overseas contracts, at least on a firm price, service from the United Kingdom would have to be faultless and that extra trouble would have to be taken to see that the people on the job were served.

The average African labour force on the job had been about 1,600 men, rising to a peak of a little less than 2,000. During the course of the job, the wage of the African had radically changed. The labourer's wage had risen from 2*s*. 9*d*. a day to 4*s*. 6*d*. a day—a 64-per-cent increase—and the wage of a typical operator, doing a skilled job, had risen from 5*s*. a day to 9*s*. a day. The introduction of mechanization had been a great buffer against the impingement of extra labour cost on the work. Among the Africans there had been the usual number of tradesmen such as carpenters, masons, riggers—but a lot was done—and it needed a good deal of determination and patience on the part of the Europeans concerned —to train and encourage men to do other skilled jobs. There had been twenty electricians and welders on the job, most of whom had been brought on during the course of the work. Eventually, fifteen men, entirely without previous experience, had become divers. Forty fitters and other men had been employed on the servicing of plant and, in all, there had been about a hundred plant operators. Mr Hill did not claim that the quality of the labour so trained had been equal to that obtainable in Great Britain, but a lot had been done to help the Africans to play a bigger part in the work.

The average number of Europeans on the job had been forty-two, rising to a peak of forty-nine, of whom fifteen had been employed on management and supervisory work, eleven on technical work, eleven on supervising mechanical servicing, seven as divers, and five on clerical duties. During the course of the work, twenty men had had the company of their wives and there had been eight children living at Takoradi.

During the work, eight pupil engineers had been sent (in pairs) to Takoradi as part of their indentured training under the scheme between the Institution and the Federation. Their tours had lasted about 9 months; they had all thoroughly enjoyed it and most had been reluctant to return home to make way for others.

In the mechanization, every effort had been made to use African operators on the powered units, and at no time were Europeans regularly driving any machine. The Europeans instructed the Africans, and after that the Africans drove the machines. There were 120 powered units on the job, ranging from the largest crane to smaller items weighing ½ cwt. Some benefit had been derived from the background of the mining industry in West Africa, and from that it had been possible to build a greater ability in the Africans to work machines.

One point in the Paper reflected rather unfavourably on the excavation. On p. 436, the average rate of digging was stated as 40,000 cubic yards per month. That included any time which those machines spent on crane work, pile-driving, and so on. Mr Hill's records showed that normally, when digging was at its peak, the average rate was 100,000 cubic yards per month. Altogether, 80 per cent of the time had been spent in working, 6 per cent in mechanical breakdowns, and 14 per cent in standing due to various causes, weather being one. The machines had achieved a very creditable output, with an average throughout the digging work of 70 cubic yards per hour per cubic yard of bucket capacity—a good performance in Britain or anywhere else.

The measure of the degree of mechanization was one powered unit for every 150 Africans; but Mr Hill said that if the job had had to be done again mechanization would have been developed even further.

There were one or two points on the subject of welfare which might be of interest to those who had been to, or contemplated going to, similar places. First of all, there existed a local hospital, with facilities both for Europeans and for Africans, and nothing special had been provided in the contract. The Europeans voluntarily had 3-monthly examinations to clear their bills of health and to make them feel confident and happy—

an essential for good work. On the contractors' staff there had been altogether fifty-one hospital cases, which worked out at one case per 44 man-months on the job (which meant that on the average each person went to hospital once during the currency of the contract). The average duration of hospitalization was about 7 days, but that was more precautionary than anything else and there had been no serious illness. There had been malaria cases, skin disorders, and intestinal troubles, but they had all been of fairly short duration.

There had been no fatalities among Europeans on the work, but unfortunately one of the resident engineer's staff had died from poliomyelitis at Takoradi. Two others of the staff (a man and his son) had also contracted the same disease and had been sent home.

The contractors had had very little to do with medical care or housing of the Africans; the housing of the Takoradi community under the Government had been arranged independently of the contract.

Two fatalities had occurred among the Africans, which was a ratio of one fatality to every 45,000 man-months on the site.

Mr Hill said that there had been a great deal of trouble in getting plant and materials from the United Kingdom in the prevailing conditions of universal shortage. Weekly schedules had been prepared in the fullest detail for all equipment and materials being shipped to Takoradi so that the people on the site had known exactly where everything was and there had been no doubt about what was happening.

One of the great difficulties had been the time taken to get something from England to West Africa. The average time had been from 10 to 13 weeks. The transit time, by boat, to West Africa was 3 or, at most, 4 weeks, and the remainder of the time was occupied in delays in the United Kingdom in getting a boat—for boats had been generally very full at that time— or in incredible delays at the other end. Only those with experience of the frustrations of the quay-side in Africa would recognize what he meant.

Those delays had produced one benefit: they had made people look ahead, and that was important to any industry.

**Mr H. R. Boyce** said that it should be borne in mind that Takoradi was not a terminal port but a port of call. Very few ships discharged more than 600–2,000 tons. Ships were coming and going the whole time, proceeding to other ports on the West Coast of Africa, and the only goods which were handled in bulk at Takoradi were manganese and bauxite (ships on charter entered light and departed fully laden); the shipment of bauxite was intermittent because the demand was also met from other parts of the world. The only cargo imported in bulk was coal, which was required for the Gold Coast railways, who were almost the sole importers of coal. Some Diesel train sets were on order.

On p. 430 mention was made of the extra width obtained during the war of the quay or wharf at berth No. 2. At that time there had been large shipments of crated aircraft arriving from America, ultimately to be flown to Cairo and other parts of the Middle East. Additional space had been required. With more cars and lorries being shipped into the country, that space had proved very valuable. The small cased goods had gone straight into the transit sheds. Cars had been off-loaded and parked anywhere on the roads in the neighbourhood of the transit sheds, causing congestion.

A glance at berth No. 5 (Figs 1, Plate 1) would show that there was a space between sheds Nos 4 and 6. In view of the bulky goods which came into the harbour, Mr Boyce felt that that was a very useful space. It was not big enough for a full berth, but a ship coming in with a lot of bulky goods would be able to berth there and discharge the goods on to the large paved area between those two sheds.

The major buildings were mentioned in the Paper, but there were also a number of small buildings—substations, small stores for inflammable goods such as carbide, and some small workshops. The walls of those small buildings were of blockwork. The substations had concrete roofs; the small stores and workshops had local timber-made trusses. The trusses had metal connectors, such as were used in Great Britain.

Referring to the railway yard, Mr Boyce said that at one time it was to have been sited rather inland from its present position, and the old marshalling yard (to the north of the locomotive shed), on the extreme right of Figs 1, Plate 1, was to have been retained in use. After the works had started, the Railway Administration had given further thought to the matter and had decided to have the marshalling yard brought in as close as possible to the harbour. That meant that the lay-out had had to be fitted behind the cargo platforms shown in Figs 1, Plate 1. The lay-out had certain disadvantages, but the Railway Administration had considered that having all the shunting locomotives and operations within the harbour area was a great advantage which outweighed the disadvantage of the cramped working.

Commenting on the underwater concrete, he said that the aggregate was of crushed granite, which was not so good as a rounded aggregate. The concreting equipment for the underwater work had all been operated from floating craft—large barges equipped with two mixers and swing weigh-batchers. The batchers had been a constant source of trouble to the contractor. They had seemed frail, and as soon as a labourer threw a shovel full of stone into the batcher the whole set-up had shuddered; it was not long before the batchers had been thrown out of adjustment. Frequent repairs had been necessary.

Two methods of concreting had been used in the timber depot. At first it had been done by constructing a number of piers and then concreting from pier to pier—the pier-and-panel method. Later, when the water became deeper, the " end-on " method had been used. Mr Boyce believed that the pier-and-panel method had the greater advantages.

There was greater flexibility for the contractor and the general work was better than in the deeper sections where the " end-on " method had been used. Underwater concrete was deposited and screeded to form the foundation for the main blockwork wall, and it was also used in the piers for the bauxite and oil berths. The concrete, generally, had a good finish and the amount of poor work was small. The placing and spotting of the skips had to be watched and individual spotting had been essential.

**Mr P. A. Scott** had made several visits to Takoradi in another connexion and, through the courtesy of the engineers, he had recently been able to see round the works described in the Paper. He thought it remarkable that the increase on the original estimate of £2¼ million was only £½ million in view of the fantastic way in which costs had risen in the Gold Coast during the past 5 years. The contract was on a bill of quantities—it was not a " cost-plus " contract—and he wondered whether that was why the cost was so close to the estimate.

Anybody who had seen the works would have received two particular impressions. The first was the magnificence of the provisions made for the timber—covered sheds for sawn timber and fine handling appliances. The port authorities, who had authorized that provision, had been extremely generous to the timber considering the treatment which the original timber merchants or the forest owners gave their own timber and the treatment which the timber received when it reached Europe. Neither at source nor at destination was it given the care which it received at Takoradi harbour.

The second impression gained was the very fine workmanship in the passenger shed, shown in Fig. 9, Plate 2. The entire 400-foot length of one upper storey of one transit shed was given over to passenger accommodation, which must be equal to the best in Great Britain, with the possible exception of that at Southampton. It was certainly of a very high standard, and Mr Scott was curious about the fact that those sheds would be used for only a short period—about 3 hours a week—when the mail boat arrived. It had not been arranged that they should have other uses during the remainder of the period. In other ports in countries which were perhaps not so wealthy, the passenger had his luggage examined and his passport checked in a shed which could be converted, later, into a cargo shed.

Turning to Fig. 6, Plate 1, he said the inner crane rail seemed to present a foundation problem, because the outer crane rail was resting on the sea-wall. Piles could not be driven into the rubble bed; the normal fill above the rubble was class 2 or class 1, which apparently would accept piles, but apparently piles could not be driven there either, so it looked as though the rubble backing to the wall had had to be extended upwards to support the rail beam. Was he correct in that assumption?

The anchor for the hold-off moorings (*Fig. 12*), described on p. 433, was interesting. The Authors had not said very much about the way in which that interesting mooring had been sunk into the rock and concreted in. It looked as though they had had to make holes, to set the moorings in the holes, and to concrete them in. Was that so ?

He endorsed the views on mechanization expressed by Mr Hill. The time of the shilling-a-day African labourer had disappeared long ago. Even in those times, it was not cheap labour. With present prices for labour, mechanization was as important in Africa as in any other part of the world. The work done at Takoradi had undoubtedly been a great benefit to the Gold Coast, because the country had a very big development programme in hand and many of the men trained to handle machines at Takoradi were at present being used in other parts of the country to drive heavy machines in the Gold Coast development programme. In all that they were thinking and planning in the Gold Coast today, it was generally agreed that all heavy civil engineering, to be economical, must be based on the fullest possible mechanization. That was from the financial point of view as well as because there was a certain labour shortage.

**Mr G. A. Wilson** approved the provision of such excellent passenger accommodation but he certainly did not agree with the suggestion that anything would do for the present-day shipping passenger. Airfields had set a high standard. For what volume of passenger traffic had the accommodation at Takoradi been designed ? There were two grades—deck passengers and cabin passengers.

He had seen some figures recently which suggested that fast Far Eastern passenger liners had increased their draught by 4 feet in the past 20 years. The draught of cargo vessels was said to have been static at about 30 feet for about 30 years, but it was known that there was a tendency for the displacement of cargo vessels to increase from 8,000 to 10,000 tons, and also for their speed to increase. The Suez Canal was 34 feet, but at the annual general meeting of the Company it had been announced that dredging was to be done to pass vessels of 36 feet draught. For some years it had been forecast that beam was the most likely dimension to increase but, from the preceding figures, there now appeared to be a tendency to increase draught, which presented a more difficult problem.

From the Paper, it would seem that the draught of berths Nos 4, 5, and 6 ranged from 27 feet through 30 feet to what looked like 35 feet. Probably " squat " did not matter very much when a ship was moving slowly into harbour ; allowance had to be made, however, for pitching or rolling,and since there seemed to be a certain amount of swell in the harbour, perhaps 2 feet would be needed. A further 2 feet might be allowed for list, so that for the average cargo ship with a draught of 30 feet, it could be argued that 36 feet of water would not be excessive. It seemed that berths Nos 4, 5, and 6 had not quite enough water to provide for the future ; on the other hand, if the harbour was to be further extended, the deeper berths could be made in the future.

Similar remarks regarding draught applied to the oil berths. The depths ranged from 33 feet to 38 feet, whereas he understood that the Americans were considering 40-foot depths. The berth was on the seaward side of the arm, where there seemed likely to be a certain amount of movement requiring some clearance under the ships. The ore carrier was the most difficult craft of all, for there was a tendency to build those ships with mechanical unloading devices, which would lead to bigger ships.

He was interested in Mr Boyce's remarks about the middle section in the lay-out of the quays—1,400 feet with two sheds and an open space. He did not like the idea of half-berth ; if it were occupied, a ship could not be left in either of the others, and if it were not occupied it was wasted. He thought it was for practical purposes a two-berth lay-out with a space in between, and in that case the argument for a little more depth was strengthened.

The passenger accommodation was in No. 4 shed, and if in future a service of fast passenger liners was anticipated, that berth might require the greater draught at an earlier date than the others.

Mr Scott had suggested that timber received better treatment at Takoradi than elsewhere. Mr Wilson felt that possibly he had not recently seen the timber storage at the London Surrey Commercial Docks.

**Mr D. H. Little** referred to the north lights in the roof trusses. They actually faced north, but he assumed that that did not matter in that part of the world—they had simply to be vertical. If that were so, he would have thought that in Fig. 6, Plate 1, the light was coming from the north and that the northlight roof would throw light only on to part of the shed which already had windows and not into the middle of the shed.

In any case, why were north lights needed ? Was it to keep the heat of the sun out or to keep the daylight out ? The roof of the building was not very well insulated—corrugated iron, painted black. If it was necessary to keep the sun out, had the Authors considered using ply-glass with an ordinary pitched roof, because the northlight roof was 20-per-cent dearer than the pitched-roof type of construction ?

Mr Little next mentioned the settlement of filling. From Fig. 6, Plate 1, it appeared that there was nearly 45 feet of filling, and he thought that would settle as much as 2 feet in 30 years. Presumably the floor of the transit sheds would have to be made up to suit in the course of time. Reference had been made to the crane track partly on solid wall and partly on filling. What happened when the rear leg settled ? He had seen bigger crane tracks laid on sleepers on filling, with the intention of packing the sleepers up as settlement took place, but he did not see how they could readily be packed up in the case in point. Had there been much evidence of settlement yet ?

He assumed that the shale was what was known in Devon as " shillet." The whole of the Devonport dockyard had been filled in that way, about 1900, and by 1937 there had generally been at least 2 feet settlement.

One vexed question concerned the block walls. All walls built by British engineers in the tropics seemed to be mass gravity walls. They might have been all right hitherto, but previous speakers had already mentioned that labour costs were getting higher and higher in the tropics. That sort of wall had gone out of favour in Great Britain; the last ones built were the big monolith walls at Southampton and they had proved very expensive. All British consulting engineers used such walls in the tropics, but were they the right answer and how much longer was that use to be continued ?

It had been made clear that the sea-bed at Takoradi was rock, but what type of rock was it—granite or shale ? Steel piles could be driven into shale and even into a stiff chalk bed, and it seemed that the embankment with the piled platform going over it, as had been used on the bauxite wharves, might be the type of wharf which engineers would soon be compelled to use. If they must hold the earth up—although why they deliberately set out to hold the earth up he did not know—he thought the Continental development of the steel sheet-piling, also used in Britain, was a cheaper alternative. That question of design in Britain for the tropics was very important, and he thought the time would come when gravity walls would become less popular. The maintenance people were probably delighted to have gravity walls, but in Britain they cost at least three times as much as the sheet-pile wall, and even in Takoradi, if they cost £400 or £500 a linear foot, an open wharf could be provided for half that money.

Those who had quoted costs had declared that the days of the 1*s*.-a-day labourer were a thing of the past. From that arose the most important issue in the Paper.

**Mr B. F. Saurin** said that a good many years ago, when all oil berths had been very flimsy affairs, hold-off moorings had usually been provided to prevent the full weight of the ship bearing against whatever staging or pontoon was provided for the oil-pipes. Nowadays substantial alongside berths were usually provided. A good example was given in the Paper. It would be of interest to know whether the hold-off moorings were a traditional survival from the older system or whether there was some special circumstance in the sea conditions which made them desirable.

He noted with interest that the fendering provided at the two ends of the oil berth took the form of rubber blocks in compression. Could the Authors state what energy capacity was provided in each of those assemblies of rubber blocks ?

There had been mention of the use of hot-applied coal-tar enamel. Perhaps when considering the other question regarding the success or otherwise of the bituminous material, the Authors could say how the coal-tar enamel, applied hot, was enduring.

On the subject of corrosion the Authors had said that the waters were very aggressive and corrosive. Was concrete subject to corrosion in those parts, and had that been a factor in the selection of the type of main wall ? So far as Mr Little's remarks were concerned, Mr Saurin agreed that perhaps the blockwork wall was indeed a little unusual for a modern piece of work. The answer might be that reinforced concrete would be too liable to attack from sea water.

Mr Little had suggested the alternative of the sheet-pile wall in steel piling. He would himself suggest that if, instead of being an English job, it had been an Italian or French job, it would probably have been done by building reinforced-concrete caissons in the harbour, floating them to the site, sinking them, and filling them up afterwards with whatever material best suited the circumstances.

**The Authors,** in reply, said there was no fixed fendering in the timber-depot quays except the hardwood coping which had been mentioned. Three of the quays were used only for putting logs overside into the water and the timber coping was to prevent damage to the quay-edge when handling the logs. In the water the logs were their own fenders so to speak. At the quays of the sawn-timber sheds there might be some reason for fendering, but the water was reasonably calm, the finish of the concrete very smooth, and the lighters which worked in the dock were provided with timber rubbing strakes. Conditions for the lighters were better than when lying alongside ships and so far there had been no complaints.

Regarding reclamation and filling, no filling had been taken to sea ; it had all been deposited in the reclamation. It was difficult to say what extra expense had been involved in separating the fill into two classes instead of using it as it came from the hill, for there was an all-in rate for disposing of it in the manner described. The decision to blanket the shale fill had been based upon experience obtained during the original harbour construction ; there was a great demand for level sites near the harbour and the blanketing would enable the reclamation area to be brought into use earlier than would otherwise have been possible. The so-called first-class fill had not been altogether first class. It looked like laterite but in fact contained a high proportion of clay. The only really first-class fill on the job was the sand used in the timber depot, which, being deposited into water, was excellently consolidated.

Bituminous paint on the steelwork had proved rather disappointing. The steelwork had been flame-cleaned and given one shop coat of bituminous paint but during shipment and while lying at Takoradi the coating had started to fail. The steelwork, therefore, had become badly rusted and all of it had had to be cleaned off and reprimed. It was too early to say what lasting protection would be derived from the finished bituminous painting, but in the timber depot sheds the steelwork was protected from exposure by the sheeted walls.

Mr Jellett had asked about the timbers mentioned at the end of the Paper. Kussia had been chosen for underwater fendering timber mainly as a result of the Sea Action Committee report on tests carried out at

Takoradi, and appeared to be standing up very well. Local experience had shown the other timbers to be suitable for the purposes for which they had been used, although mahogany, sapele, and iroko would be considered too expensive for ordinary building work in the United Kingdom. Wawa (obeche), which was light in weight, inexpensive, and easily worked, was sold in the United Kingdom for common joinery work and mouldings.

Mr Scott had thought that rather too good a job had been made of looking after the sawn timber. In Britain, probably the sides of the timber sheds would not have been sheeted, but a good deal of salt-water spray came over off the reef and timber exporters had pressed for complete protection from weather. Most of the sawn timber was quite valuable furniture wood, which shipped at about 10*s*. a cubic foot.

The timber exporters had given an assurance, as had the railways, that the wood would be brought down in closed wagons to the port and the handling methods had been designed on that assumption, but in fact most of it had arrived in open trucks.

The crane-rail beam, to which both Mr Scott and Mr Little had referred, had been a rather troublesome problem. Originally, in the belief that the first-class filling would be laterite gravel, it had been proposed to put the beam on a timber grillage of longitudinal and cross-sleepers ; it had been reckoned that it would be packed up when it settled. The material, however, had proved more clayey than anticipated, and so under the crane rail it had had to be dug out and replaced with rubble stone, and quarry waste, down to the level of the top of the rubble backing of the wall. Then the weight on the rubble filling had been spread by a wide reinforced-concrete beam. There was almost certain to be some settlement, and at sometime or other the rail would have to be raised and packed up.

The passenger landing station in No. 4 transit shed occupied 256 feet of the total length of the upper floor and provided accommodation for 250 deck passengers and 150 cabin passengers. Whether the passenger accommodation was really necessary was a matter for the port authority. Probably Mr Jellett had a lot to answer for. When people saw what had been provided at Southampton they expected something of the sort in Takoradi. Rather similar accommodation had recently been provided at Sierra Leone.

Regarding depths of water available at the various shipping berths, it should be remembered that the original harbour had been constructed on a rock bottom with the breakwaters going out far enough to obtain 38 feet at the entrance. The depth aimed at for the new berths on the main wharf was a minimum of 30 feet and some rock dredging was being done departmentally to obtain that depth at No. 4 Berth.

The latest Elder Dempster mail steamers drew 25½ feet, the permissible draught being at present controlled by available depths at Lagos, but there would be no difficulty, apart from expense, in deepening the berths at Takoradi. The bauxite berth had a depth of 32 feet (rock level was about

35 feet) but so far the vessels chartered for that trade had not exceeded 26¼ feet draught. At the oil berth 33 feet was provided to suit tankers of 12,000 tons drawing 29 feet. The oil companies would have liked to bring in larger tankers of greater draught but the amount of additional rock excavation in the berth and the approaches would have made it very expensive.

Mr Wilson had used the expression "half-berth," but in the Paper, the Authors had described the 1,400-foot extension of the main wharf as providing three short berths or two long ones. The open space on the quayside between the two transit sheds was occupied by the railway connexion considered to be necessary from the front of the end berth to the lines at the back of the sheds. That end berth would be used for bulk import of cement and it would cause congestion to have that amount of railway traffic passing along the front of the other cargo wharfs.

Replying to questions regarding the northlight roofs of the timber sheds, the Authors considered that so long as the building was north of the Equator the vertical glass should be put on the north side. That had the effect of keeping out most of the direct rays of the sun whilst letting in the light from the sky. Also, the vertical glazing faced away from the weather and would be much less likely to give trouble than glazed lights in a pitched roof. If pitched roofs had been adopted the Authors would probably have used corrugated Perspex sheets as in the locomotive shed.

In the original harbour all the quay walls, both the shallow ones and the deep water quays, were made of reinforced concrete, in the form of a beam-and-slab deck construction carried on cylinders. About 5 years after they had been finished, quite a lot of defects had developed, and they had all had to be gunited. Corrosion was very active in tropical sea exposures and the most trouble-free type of wall, when foundation conditions were good, was a gravity wall of masonry.

The cost had not been so very much in excess of a steel wall or a reinforced-concrete wall. After all, it was right in principle, to make use of local materials, and for a concrete blockwork wall, the only imported material was the cement. A steel sheet-pile wall with sulphur-shale filling at the back of it and the tie rods buried in that material would have been a very doubtful proposition, apart from the difficulty of constructing it before or while the filling was put in.

Mr Saurin had asked about the hold-off moorings at the oil berth. Although the oil berth was outside the harbour—the same remarks applied to the bauxite berth—it was on the lee side of the lee breakwater and therefore generally fairly calm. Occasionally there would be a choppy sea when the "tornadoes" blew from the north off the land but except for a few days in the year there was no great trouble. The oil companies had asked for only 3½ feet extra draught to be allowed below the bottom of the ship, on account of scend, etc. The hold-off moorings added to the safety of the oil and bauxite berths when strong winds blew from the north, but they had not been asked for by the oil companies. The British Aluminium Company asked for them at the bauxite berth, where the structure was not designed to carry bollards, and then the Marine Department of the Harbour Authority had asked for them at the oil berth also, although that jetty was very substantial and was equipped with bollards.

The special anchors for the hold-off moorings had been concreted into plug-shaped holes cut in the rock bottom by divers using pneumatic tools. The holes had been slightly undercut to give a better grip for the concrete.

In reply to Mr Saurin's question about the energy capacity of the oil-berth fenders, each fender was provided with eight Goodyear rubber blocks having a total energy capacity of 530 inch-tons for 10 inches compression.

It was too early yet to say how the coal-tar enamel, to which Mr Saurin had referred, was standing up.

The closing date for Correspondence on the foregoing Paper has now passed without the receipt of any communication.—SEC. I.C.E.