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7695 DISCUSSION

A high capacity container terminal

A. BECKETT & M. PUDDEN

Mr A. Beckett

It is over five years since the container terminal at Tilbury was completed, and since then many other parts of the world have had constructed for them purpose-made container terminals to be used exclusively for loading and unloading containers on to ships. It is interesting therefore to review some of the changes in design philosophy that have come about through experience of handling containers generally and in Tilbury in particular.

67. At Tilbury it was initially intended to use one berth only for loading and unloading of vessels designed to carry containers to and from Australia, and it was thought at the time of design that by careful organization and by stacking containers five high on the quayside, land space and cost could be kept to a minimum. In the event, the constraint on the movement of containers and the arrival of ships has been a major disadvantage which has only been remedied by the use of straddle carriers for supplementary stacking in the open.

68. When a new container terminal was under design for Singapore open stacking was adopted but limited to three high, and the concept of five high stacking in a building such as Tilbury was dropped altogether. The terminal operates entirely with straddle carriers fed by the heavy lift cranes operating on the quayside. There are no stack buildings.

69. Container berths have also been planned for Butterworth and Brunei. At Butterworth there is a large open space at the back for storing containers in the open using the trailer carrying system. At Brunei, the quay provides two berths, one for conventional general cargo and one intended for containers. In both cases the quay has a sufficiently strong construction to accept container cranes.

70. One might ask the question: has Tilbury been used to its design capacity? The latest records available show that throughput is 2 million tons/year, which is somewhat less than the design intention of 3 million tons. This is due, to some extent, to the difficulty of co-ordinating ship arrivals with internal movement of containers. The terminal itself has cost only a fraction of the price that has to be paid for a modern container ship, and it is important that ships should not be kept waiting. To this end it has been found better to build more terminals or reduce the number of ships using one, rather than operate a terminal at its maximum capacity. In effect a figure of about 65–70% usage of terminals for containers seems to be the optimum, and that is not far removed from the optimum found for general cargo handling.

Mr Pudden

When considering Berth 39 at Tilbury and its five high stacking system one must remember it was originally designed to cater for an 1100 container ship every ten days.

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Subsequent events increased the ships and ship capacities to 9×1300 containers; then with the development of the Australia Europe Container Service to 11×1500 containers at approximately 5 day intervals. At this stage it became necessary to develop the straddle carrier facilities to back up the stack system.

72. A number of lessons have been learnt from Berth 39 and its operation: these have been extensively applied throughout the world, by OCL, its associated companies, competitors and port authorities.

73. The principal problem, common to all terminals, is the failure of ships to maintain regular schedules. Ships have a tendency to bunch as a result of different services, bad weather, industrial troubles, breakdown and a host of other causes. This puts a strain on the terminal capacity for ships and land operations. Terminals can be, and have been, built to cater for such peaks. With few exceptions they are uneconomic. Berth 39 was designed as an economic unit of OCL's through transport system with ships calling on a regular, rather than random, basis.

Mr F. B. Shorrocks, Overseas Containers Ltd

The Paper is mainly concerned with operational matters at Tilbury. However, the building of Tilbury was a major construction exercise, and like all container terminals, it has experienced its problems, some of them very severe. I should like to cover two or three which may be common to other installations.

75. Tilbury has experienced major failures on every crane rail installation. The most significant was the failure of the main quay crane rail at Berth 39. It is significant because of the short life of the rail and the disruption caused to the operation. The failure of the water-side rail at Tilbury was first detected by transverse cracking of the rail, and a subsequent serpentine distortion. The trial excavations indicated that grout supporting the rail had failed. Operation was therefore transferred to the next berth, and a major exercise to rebuild the track was commenced.

76. Very few coherent lumps of concrete were excavated from underneath the rail, and a large amount of fines appeared in the excavated material. The rail trench was cast in the monolithic crane beam, the rail located by channel sleepers and the trench subsequently filled with Portland cement concrete. The rail itself was 144 lb/yd and the bearing flange underneath the rail only 6 in. wide. No intermediate support plates were used, and the channel sleepers, spaced at 5 ft intervals, provided very little support to the rail. The crane wheel loads were of the order of 40 tons, and the corner loads under operating conditions could in fact reach 200–250 tons.

77. The solution adopted was to increase the bearing area under the rail by welding in position bearing plates 1 in. thick and 15 in. wide, leaving the channel sleepers in position. This eliminated the task of relocating the rail and simplified construction. The bearing plates were bedded in sandfilled epoxy, a fairly standard procedure these days. In a similar installation in Hong Kong continuous bearer plates were used with clips to secure the rail. The clips are preferred in case the welding fails and the rail should shift. But at Tilbury it would have taken too long to do that operation. This sort of rail failure represents a catastrophe to the container operator. No amount of economy at the construction stage can compensate for costs of operational upsets arising from this sort of repair work.

78. Oil contamination of paving is a serious problem at all container terminals employing straddle carriers. These machines use mineral oil for hydraulic services and engine lubrication and have the propensity for distributing this oil indiscriminately over the terminal. The straddle carrier illustrated in Fig. 8 is a fully hydrostatic drive type, although mechanical drive forms are almost as bad.

79. The majority of terminals employ bituminous asphalt surfacing since it gives the best compromise of strength and flexibility on reclaimed land. Oil on this type of surface softens the binder, and in wet weather the oil leaches out of the binder no matter what method of cleaning is employed. The resultant slippery surfaces are already receiving the critical attention of the berth labour and an adequate solution

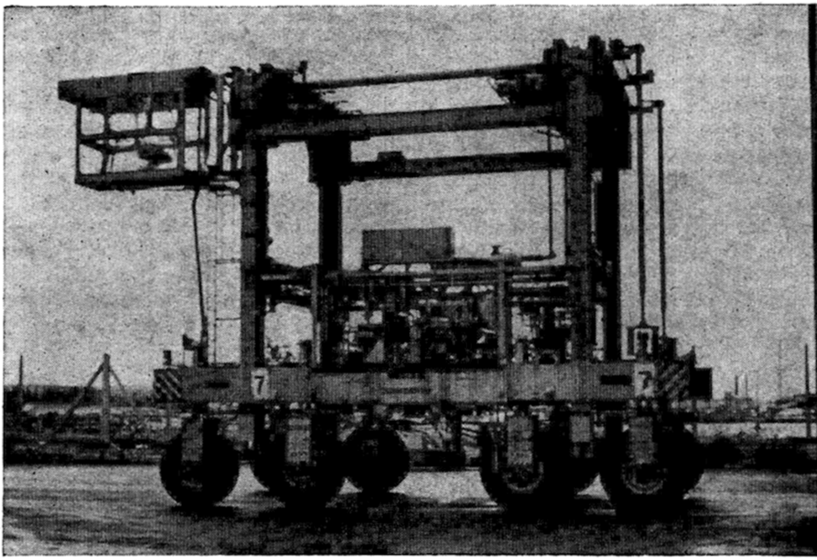

Fig. 8. Fully hydrostatic model straddle carrier

must be found if escalation of labour problems is to be avoided. There are several proprietary surfacing materials, but so far they have not proved satisfactory. There is a machine for removing oil contaminated material from the surface of the paving. It has the advantage of scrubbing in a detergent and sucking this up in a sludge so that chemicals are not washed into the drains, thereby upsetting the local authorities.

80. The greatest possible care must be taken in the design and construction of a container terminal to remove all possible obstructions to the free movement of handling machinery and vehicles. In the container yard and all access ways, anything higher than a white line painted on the paving is bound to be demolished. Where mobile handling machinery is employed the terminal must be designed with the largest possible unobstructed paved area, with all buildings, substations, lighting towers, etc., located well away from the operating area, and preferably on the terminal perimeter.

Mr P. Sampson, Overseas Containers Ltd

The points which I should like to raise particularly refer to the five high stack at Tilbury. First of all it is necessary to appreciate why the five high stack was used at Tilbury in the first place. What emerges from the Paper is that this concept was in fact designed for one customer and one service, namely OCL.

82. The second point is the economic use of space, and at Tilbury space is at a premium. Another point which has not been mentioned in the Paper is that five high stacking demands a crane operation, and cranes are not unreliable. For these reasons I believe that the overall concept was very sound. However, the decision was taken to put straddle carriers on the park. This was because OCL was getting into AECS, a consortium of continental operators using continental ports as well as Tilbury. At a later date it would have been necessary, when in fact Canadian Pacific came on the scene.

83. Another factor which affects this variation from the original concept is the

increasing road traffic through the terminal. Originally the basic concept was that the majority of containers would be freighted to and from regions using rail track. In fact 70% of traffic to the regions is by rail and 20% by road. However, this is to major distribution points outside the southern region: within the southern region 50% of traffic is by road and 50% by rail. This means there has been a tremendous increase in containers into the terminal which are not scheduled as they would be when arriving by rail.

84. Another factor which affected the variation from the original concept is that, in an endeavour to give satisfactory customer service, indiscriminate importing and exporting facilities are allowed. This is the price the company is prepared to pay. Yet another variation from the original concept was 'heavy lifts'. There are certain types of cargo which cannot be containerized. Notable cases have been giraffes and double decker buses, and since a heavy lift takes anything up to an hour to load or unload, using slings and straps, this slows down the operation.

85. OCL still likes the five high stacks at Tilbury, but it is the change in operation for the causes mentioned above which has detracted from its efficiency. It was these variations which brought about the introduction of the straddle carrier and it is well worth considering some of their advantages, particularly as many people are still considering what type of terminal is the best. Without doubt the major advantage of the straddle carrier is its flexibility. With a stack which is five high by two boxes wide there are 60 boxes: with an overhead crane only one can be moved. With sufficient straddle carriers, containers can be moved from any place. A further advantage is the way in which straddle carriers are used on an adjacent berth by the PLA, who use them to lift boxes out and put them directly under the quay crane. However, there is one disadvantage as far as OCL is concerned: the quay cranes at Tilbury are twin lift, and it becomes impractical to do a twin lift operation using the straddle carrier because it is difficult to place two boxes so accurately side by side that the crane can pick them up simultaneously.

86. A major disadvantage of some types of straddle carriers is oil contamination of the terminal. However, a more serious disadvantage is the poor maintenance ratio of this kind of machine. Many hours are spent keeping them operational: 50 h/week operation per machine may require 50–60 h maintenance, taking a tremendous amount of expertise, particularly in the case of hydrostatic machines.

87. If the distance from the park to the crane is short, then obviously without internal movement vehicles to move the containers to the crane, the straddle operation requires one less lift, and the operation is therefore faster. However, bearing in mind that the straddle carrier was designed as a lifting device, a break point is reached where it is quicker to put the box on an internal movement vehicle and move it fast under the crane.

88. I should now briefly like to mention the advantages and disadvantages of twin lift crane systems. The twin lift system provided it is well controlled is extremely fast. With the dual cycle routine it is possible to lift two boxes on to a ship and in the same cycle to lift two boxes off. At Tilbury 70 containers per hour are moved, but this cannot be maintained without good planning, control and back-up facilities. The other advantage is that if one hoist is lost there is another to provide a lifting capability. Additionally it is worth noting that the single lift crane will lift a nominal 35 tons, whereas the capacity of the twin lift crane at Tilbury is 45 tons, and under a class 2 lift the capacity is 58 tons.

89. The Paper gives an excellent description of the refrigeration and this equipment is considered an outstanding success. Disregarding the problem associated with the five high stacking, the method of refrigeration using a remote refrigeration unit serving 360 containers is extremely efficient and easy to monitor using the data logger. For the whole time it has been in operation not one container has been lost. The major problems have been associated with prevention of cross taint between different types of cargo.

90. With any terminal, a good operation depends on good control of containers, wherever they are—on a terminal, at distribution and collection points, or at sea. In a containerized through transport system the speed at which containers are turned round is a measure of the system's efficiency. The other point is that it is an industry with heavy capital investment. OCL was a pioneer of containerization in the UK and in some respects learned the hard way: it bought heavy capital investment machinery and did not appreciate the need to provide back-up services. These factors have been rapidly corrected. This kind of operation needs large workshop facilities and also the technical ability of skilled maintenance personnel capable of keeping the plant operational after the designers have left the site. Lastly there must be—and is—excellent industrial relations at shop floor level to operate efficiently in this kind of environment.

Mr W. Jamieson, Director, C. G. Chantrill & Partners Ltd

It appears that at Tilbury the Authors have a unique opportunity of comparing three different systems of handling containers: (*a*) the five high stack, gantry crane, transport by trailer to the ship's side; (*b*) the container stacks three high handled by gantry crane and transported by trailers to the ship; and (*c*) the straddle carrier operation. It would would interesting if they could give some economic comparisons of these three systems, apart from the operational advantages and disadvantages.

92. So far as the five high stack is concerned, would it be true to say that some of the difficulties associated with these are the assembling of containers in the correct order for ship loading when export containers are arriving in random order and, similarly, selecting import containers from stock to supply consignees' vehicles, again arriving in random order, where the main disadvantages of selectivity arise. Would it be wrong to conclude from subsequent development of Tilbury that the five high silos are really to be considered only where there is great constraint on space on the site?

93. Secondly, could the Authors give some logistic details which might influence future design of container berths? For example, how many container spaces are required to marshal ships' loading, and to accommodate import containers until the loading of the export containers can begin? Further, what is the pattern of arrival and collection of containers associated with the ship, that is, the minimum and maximum number of days, on average, when containers are likely to be on the port from both the import and export point of view?

94. It appears at present that ships arrive on an average every nine days. They are perhaps loaded and have a turn-around time of three days, which gives a six-day apparent under-utilization of the berth. Can the Authors say what they think would be the maximum potential of the Tilbury Dock; what additional container parking and storage facilities would be likely to be required to realise this potential, and what form should they take? For example, would it be economically viable to have a back-up container park several miles away from the dock in order to support the full operation of the dock facility?

Mr R. F. Smeardon, formerly Port of London Authority, Tilbury Dock

In § 16 the Authors give details of roads constructed of 3½ in. tar macadam on 9 in. lean mix concrete laid on rolled hardcore which, despite settlement, have been easily repaired without interrupting the heavy traffic. On Berth 43 the 13½ acre container stacking area was constructed of 3½ in. hot rolled asphalt on 10 in. dry lean concrete base. The sub-base was Thames ballast hydraulically placed. This form of construction has also proved to be satisfactory under local conditions, and has withstood seven years of use. It would be of interest to hear from the representatives of other ports of their experience of various types of paving for container berths, including the use of Stelcon rafts.

96. Reference is made in § 7 to the protection of cargoes against weather and pilferage. Have there been any problems with damage to cargo in containers stowed on deck, and would the Authors comment on incidents of pilfering?

97. Referring to §§ 9 and 50, it would be interesting to know more about the types of cargoes in the Australia trade susceptible to taint. Are there any firm plans for extensions to the OCL terminal for stacking five high in an additional shed as indicated in Fig. 3 or for additional areas for straddle carrier stacking.

98. In §§ 12 and 21 reference is made to container ships carrying 1300 and 1522 containers. Has the total number of 9 ships changed? Are larger container ships planned for this service, and have any serious delays occurred due to locking in and out at Tilbury compared with direct berthing at continental and Australian ports?

Mr F. A. Page, Port of London Authority

I would first draw attention to the reference to the impounding station on the berth layouts in Figs 2 and 3. Output from the station is about 1200 cusecs; the water passes down the hollow front cells of the monolith quay and is discharged into the dock beneath the general level of the dock bottom. It was obviously important that berthed ships should not be disturbed by this discharge; when the arrangement was designed in 1964 the modern container ship had not been developed and the criterion adopted was that the energy of discharge should not be more than that generated by a 20 mile/h wind upon the superstructure of the largest passenger vessel then using the dock. A discharge velocity of 2·5 ft/s equated to this condition and was used for design. I understand that there is no problem regarding disturbance of berthed ships and the criterion appears to have been satisfactory. The impounding station was also carefully designed to take in the cleanest river water available, and as little or no siltation has been experienced in or around the berth this aspect has also proved satisfactory.

100. The quay apron shown on the layout drawings was in fact designed by the Port of London Authority (PLA) to the Client's requirements and leased to them. Vertical movement such as could arise from settlement was limited to about $\frac{1}{8}$ in., necessitating a piled foundation, although the PLA is prepared to accept normal settlement on common user berths and is satisfied with normal paving.

101. As the stacking area of the apron is about 35 000 sq. ft a completely piled reinforced concrete slab capable of taking container stacks three high at random throughout would have been very expensive. In the final design a series of longitudinal beams on piles was adopted to accommodate random stacking of containers longitudinally along the quay but fixed as to transverse station. In fact, seven longitudinal beams were required, not three as indicated. The space between was paved with a series of heavy-duty Stelcon rafts supported on self-draining fill with a network of subsoil drains. Initial settlement of the slabs may have been fairly high but it is thought by now the settlement would be of the order of $\frac{1}{2}$ in./year and probably substantially less. As the berth was not operational for about 18 months, some of the rafts would probably have required relaying before they had ever been used.

102. Regarding container operation, this has been studied in depth over a long period by the PLA, and more recently a study group was set up with operational research, dock operating and plant engineering representation. Its main purpose was to decide, when the new seaport was developed at Maplin, whether the PLA should continue with a van carrier orientated system or adopt alternatives. While a credible alternative has yet to be found, the problems associated with the present van carrier operations are now known in considerable detail. A computer simulation program has been developed and a great deal of field data accumulated on the various operations which can now be simulated, enabling varying situations to be studied.

103. The remarks which have been made about straddle carriers are wholly endorsed; they are very expensive, they have a fairly short life, their operational downtime can be as high as 40%, and they add considerably to the box handling charge.

Competitors on the Continent operating common user terminals have similar problems but still rely upon van carriers. One Rotterdam operator claims to have found part of the answer—his van carriers are used more or less as mobile cranes, horizontal transportation being done by tractors and trailers.

104. If one investigates container handling in depth, stacking height and retrieval become very important. Some figures produced by Mr Hill, the engineer in the Authority's study group, serve to indicate the problem. If containers are stacked one box high, only one movement is required for random access; if the stack is two high, 1·25 movements are required, whereas for three high the number increases to 1·90. Clearly if the stack is much higher, random access becomes impossible and the system presupposes a high degree of control of container stacking and retrieval. If this does not work out, very heavy handling penalties are involved.

105. The container crane rail detail, which has been severely criticized by Mr Shorrocks, evolved only after considerable thought and was certainly not adopted for reasons of economy. Previous experience with similar heavy dry dock cranes was drawn upon. This had shown that bedding in grout or a rich mortar produced shrinkage gaps beneath the rail, encouraged vibration, leading to progressive pulverization and eventual failure. Although provision made for rail expansion in the past had proved ineffective, no problems had arisen, and in consequence it was decided that no allowance need be made for expansion, the rails being concreted in solid. The detail adopted provided rail supports by cross-channel bearers at 5 ft intervals, which were also used for alignment prior to final concreting. The design mix for the concrete bed was $\frac{3}{8}$ in. maximum aggregate of low water/cement ratio, it being specified that this was to be placed on one side of the rail and vibrated until it rose up on the other.

106. In the PLA's view, this detail was reasonably successful; of a total of 5000 lin ft of rail in use on the Authority's container berths, 800 ft had to be taken up and replaced over a period of 5–7 years. Such failures as have occurred have not been due to breakdown of the concrete rail bed, which is considered to have performed satisfactorily, but possibly to some points of weakness which have arisen around the bedding of the channel supports. It has to be emphasized that with heavy wheel loads of this kind, crane track is likely to develop faults whatever the detail used. Any weakness which occurs must be treated early, as progressive deterioration is quite rapid, leading eventually to the total breakdown described by Mr Shorrocks. If the operations are such that it is impossible to carry out minor repairs to crane rail track, there is a danger that wholesale repair may eventually become necessary, as occurred at this OCL berth after four years of intensive operation.

Mr J. E. O. Palmer, Consultant, Rendel, Palmer & Tritton

The most fundamental question is 'Will anyone ever again go in for this type of stacking?' The area available is important. An old rule is that there should be three acres behind the berth for every 100 ft length of berth. The 840 ft at Tilbury would therefore need 25¼ acres and if there are only 23¼ I wonder if this is enough. If more area is needed at Berth 39, there is no physical difficulty in moving the river wall 50 yd south into the river. The only possibility is that it might mean a little more maintenance dredging. No doubt there will be 945 ft container vessels soon, and I hope they can get into Tilbury. It was a stroke of genius to take over Berth 37.

108. I have one leading and perhaps awkward question to put to Mr Pudden. All things considered, is Berth 39 at Tilbury a better place to handle containers than the container terminal at Greenock?

109. I would also like to thank both Authors for the unforgettable statement in § 37: 'During the sea passage from Australia a high percentage of the cargo changes destination'. No wonder shipowners and container ship operators always seem bankrupt!

110. Finally, with regard to output, I have done some quick calculations: 70

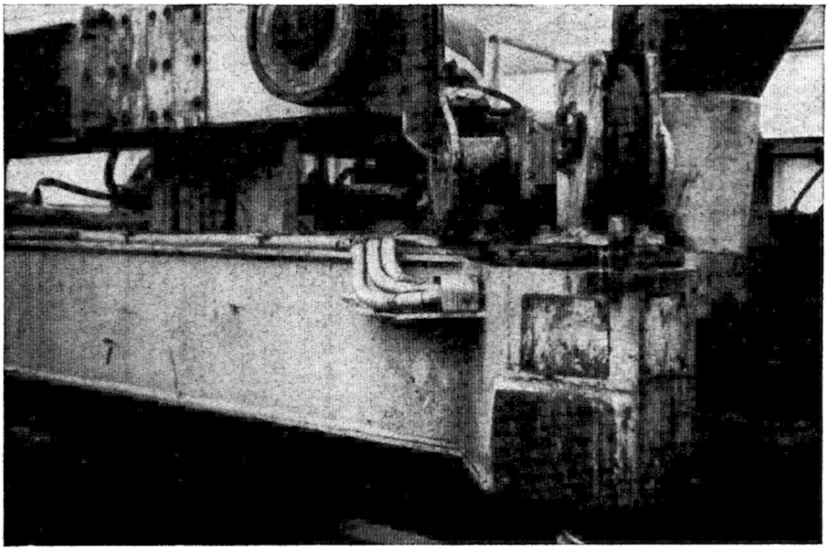

Fig. 9. Early design of lifting spreader beam showing inaccessible twist locks and exposed electrical connexions

containers/h means 750 ton/h, which approaches 15 000 ton/day. This would mean 2 million ton/year is unloaded in something like 135–140 days. Is this right?

Mr F. B. Shorrocks

The original container lifting spreader supplied to Tilbury was one of the earliest manufactured in the world. It has a number of interesting features (Fig. 9). Exposed on the front face are cables (a ridiculous place to put electric connexions) and above the corners are guide rollers which assist the container and the spreader to enter the cell guides. Experience showed that damage to these guide rollers was enormous, and they are better located in the mass of the corner where they are better able to withstand the impact loads. Subsequent experience has also shown that guide arms are very frequently damaged. Later designs employ split plummer blocks and two-part guide arms to facilitate speedy replacement.

112. The new design of spreader (Fig. 10) incorporates good access to the twist-lock. There is no need to enclose a twist-lock provided there is a massive steel bulkhead to protect it from damage. This particular spreader has a quick release pin fixing on the twist-lock for simple replacement. The guide roller is now sunk into the bulk of the spreader. Limit switches and wiring are also located behind the twist-lock and bulkhead, protected but accessible.

113. Figure 11 shows the result of operating a terminal using tractor/trailer units with elevating fifth wheels. It is difficult to train drivers to drop the fifth wheel on to the base supports of the tractor, and they will insist on driving with the fifth wheel lifted, so there is no roll stiffness at the king-pin point. The fifth wheel has to be completely flexible to avoid undue stresses in the elevating rams.

Mr D. H. Little, Walter C. Andrews & Partners

I should like to ask Mr Beckett what his brief was. Was he required to design the

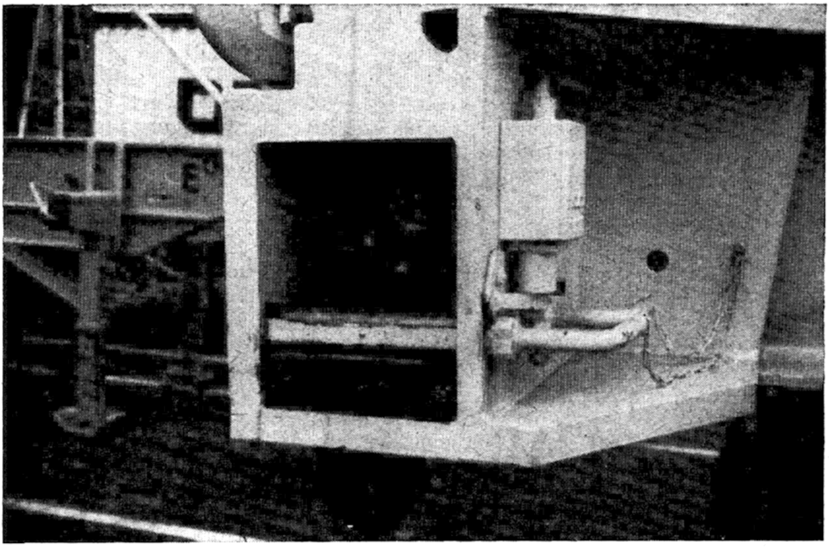

Fig. 10. Recent design of lifting spreader beam showing easy access and quick release twist locks

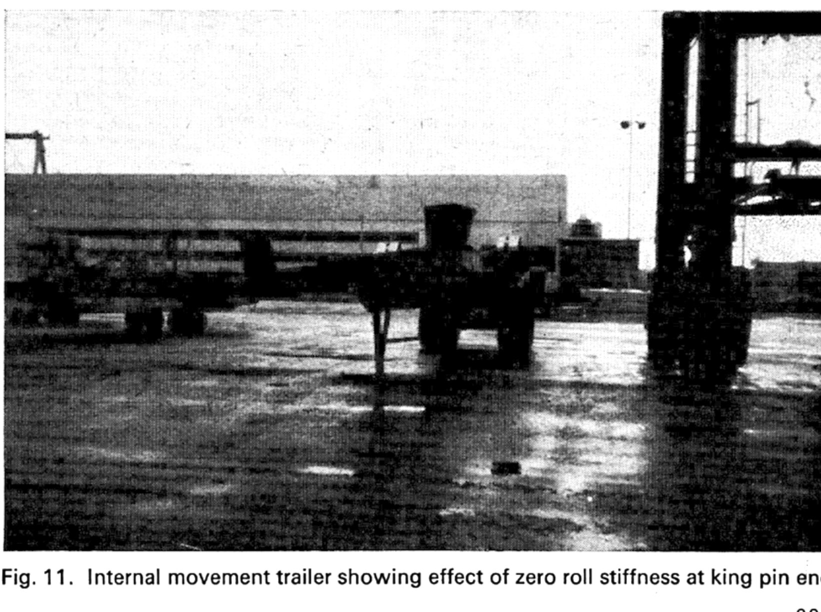

Fig. 11. Internal movement trailer showing effect of zero roll stiffness at king pin end

detailed method of operating the facility? Normally the only brief I get is that a client wants 1000 ft of wharf, 45 ft of water. He does not want any buildings, but he wants 45 acres of land: he can do with 25 to begin with, so long as another 20 follow soon. He does not say how many miles of railway he wants, he will not use straddle carriers, but will have forklift trucks with 100 ton axle loads on the front, and he wants to use them anywhere on the 45 acres. He does not want to start operating 18 months after the berth has opened, but 18 months before it has opened! Finally, all the land has been reclaimed, but he does not want to go to the expense of surfacing it.

115. I have the impression that at Tilbury cargo is not now being handled the way Mr Becket intended.

116. The other point that interested me was the reference to trouble with the crane rails. When I joined the Admiralty 40 years ago shipbuilding cranes lifting 50 tons on a 75 ft radius were fairly common. These cranes had four wheel bogies, the minimum load per wheel being 50 tons. In Gibraltar some were carried on sleeper tracks which were packed to level whenever necessary, just as are ordinary rail tracks. All the tracks I have designed have been on piles but I have not heard of any trouble in the Admiralty concerning failure of crane rails whether piled or not. I have seen at a private port instances where at the joints the rails dipped down and were giving trouble.

117. At Sheerness there was some trouble with one length of 30 ft which was not grouted properly. Ordinary cement and sand which had an expanding agent was used in it, but a specialist called in to pump grout in the repaired section refused to use any expanding agent which he considered unnecessary.

118. There were complaints from the client that the crane rails were not accurate in level and line and that the cranes were rocking a little. They were laid to the specification I had always found satisfactory. I made enquiries of Admiralty friends and a colleague at Portsmouth said he had trouble in 1969. He had laid a length of rail with departmental labour and the manager of the engineering department complained that the crane rocked in use. So it was lifted and relaid with extra special care but to no avail. One more relaying was done, but still the crane rocked. My colleague said he could not lay the rail any more accurately than it was, and that the fault must lie in the rigidity of the crane. The solution was for the crane manufacturers to insert some plastic pads under the four legs of the crane to make it more resilient in itself. Eventually at Sheerness it was accepted that the rocking was due to rigidity in the crane structures and not to inaccuracies in rail laying. Apart from one length of grouting at Sheerness, in 30 or 40 years I have never experienced any trouble, and I wonder if the trouble at Tilbury was due to heavier wheel loadings, or perhaps to poor grouting.

Mr Beckett and Mr Pudden

Mr Shorrocks mentioned failure of the crane rails and the troubles resulting from their short life and need for extensive maintenance work. Since we had only one crane at Berth 39 and this could disrupt the service if it were to fail, it was hoped that by arrangement with the PLA in the event of failure, OCL might be able to borrow one of the PLA cranes from the adjacent common user berths. This of course required that the quay rails on Berth 39 could accept the crane. Rails to suit the single lift PLA cranes had already been installed and standardized and the crane wheels permitted no increase in rail size. We therefore had no alternative but to design twin-lift cranes to operate on rails more suitable for single lift cranes. To carry the extra crane weight, more wheels were introduced on the simple theory that one could thereby spread the load. For rapid movement, increased horsepower was applied to the OCL crane and this has proved incompatible with long rail life. The right answer would have been to put down rails throughout which were strong enough for the OCL twin-lift crane and modify the PLA crane wheels to suit, but liaison difficulties could not be overcome in time.

120. **Mr Jamieson** raised a question concerning the comparison between the 2000 container stack five high, the 480 container stack three high and 1230 container stack two high, each lifted by a different method. It is impossible at Berth 39 to measure the three different methods effectively as they operate concurrently. For example, containers could be arriving at the ship side from the five high stack at the same time as containers are being fed, via internal movement vehicles, from straddle carriers The next container could be lifted directly on to the ship from the back reach of the quay crane.

121. The next question referred to the problems of operating the five high silo, first in assembling containers in the correct order for ship loading with export containers arriving in an random pattern. That is not too much of a problem. Most of the container ships have ample stability, and for ship loading purposes containers are segregated by port of discharge into, and by, three weight categories, light (under 10 tons), medium (10–15 tons) and heavy (over 15 tons). Blocks of containers are then allocated a ship stowage and transported sequentially when loading commences. There is a problem with hazardous containers and their segregation within the ship. In the Australian trade some 10% of export containers have a hazardous classification. These have to be stowed according to the 'Regulations for carriage of dangerous goods in ships', which causes operational problems in stacking and planning, but these problems are well known to the terminal management and appropriate allowances are made in the overall operational plan.

122. Selecting import containers from a stack to supply the consignee's vehicles arriving at random is a problem. There is no total answer. By close liaison with users' transport organizations every effort is made to minimize the random arrival pattern. Some importers use their own vehicles instead of the transport services of the container operators. To cater for their requirements 'shuffling' and secondary lifting is necessary.

123. The design of the five high stack was, to a large degree, associated with refrigeration commitments. There is no other trade operating to a single port with such an intense refrigeration requirement. Future developments must consider this factor as well as the availability of space. As to how many container storage spaces are required, a rule of thumb measure is one and a half times the average weekly throughput, e.g. for 2000 containers a week 3000 container spaces are needed, or the nearest possible figure taking into consideration land availability and associated costs. Export container arrival patterns are such that little moves to the port on Monday, Tuesday and Wednesday. Production lines and manufacturing processes are geared to the normal five day week. Therefore the biggest demand for movement to the port is at the end of the week. This produces a pattern, for a ship sailing on a Sunday, of some 30% Monday–Wednesday, 70% Thursday–Saturday. There are obvious variations to the pattern when mid-week sailings are involved.

124. Import container duration varies depending on whether the customer wants his cargo or is stockpiling. It also depends on whether the container operator is charging a demurrage rate equal to the warehouse charges which the consignee pays outside the port environment. Obviously every terminal operator wants import containers out as soon as possible and tariffs are constructed with that end in mind. Averages are misleading, but generally speaking most import containers move out of the terminal in five days, those that remain doing so for from 5 to 30 days.

125. On the question of ship arrival pattern, when the Paper was written there was one ship arriving each week at Berth 39 and the ship stay in port was, on average, 2½ to 3 days. In theory with one berth, three ships each staying two days could be handled. However, there is then the problem of ship schedules running awry, the possibility of ship delay and the high costs resulting from that delay. At present Berth 39 handles a ship every 4 or 5 days.

126. **Mr Smeardon** referred to the protection of cargos against weather and pilfering. This matter has been discussed with interested parties and so far as containers stowed on deck are concerned, during 1974 (and last winter was one of the worst on record for weather in the North Atlantic) CP ships had 8 damaged containers in the 20 000 that were carried on deck. On the question of pilferage, insurance claims for damage and general pilferage of cargo in containers are said to be running at something under 10% of the level which existed when conventional ships carried the same tonnage of cargo. With containers a new form of theft has come about, namely, hi-jacking—loss of whole containers taking place on land before or after they reach the port. Fortunately this is an infrequent occurrence. The taint problem is present in the Australian trade when fruit and meat are carried and imported at the same time of the year.

127. **Mr Page**'s comments on the Continental common use terminals are interesting. Some Continental operators have introduced a system of stacking underneath transtainers. In visits to a fair cross-section of the world's container terminals, it appears that transtainers with three high, as opposed to five high stacking, seem to be becoming increasingly popular: 1½ high stacking with straddle carriers to provide access with minimum unproductive movement is the aim of all such terminal operators. It does not yet seem to work for prolonged periods because of the uneven ship and container arrival and departure pattern at the terminals concerned.

128. **Mr Palmer** mentioned the question of land space, and referred to 3 acres for a 100 ft quay. That is a good rule, but if one bases the layout on the use of straddle carriers with two-tier stacking, one needs more land.

129. The answer to Mr Palmer's question concerning Greenock is fairly simple. Some 40% of the Australian trade exports and imports originate in or are destined for the southern part of the United Kingdom. Inland costs, therefore, dictate the use of London in this one UK port operation. Added to which is the need to call at a port which fits in as a natural part of a total North European port rotation, e.g. Hamburg, Bremerhaven, Rotterdam, Zeebrugge, Flushing, etc. As to the calculation of the rate of unloading the ship, the reference to 70 containers/h was in connexion with dual cycling. In effect only some 40% of the average container ship can be dual cycled. The destination referred to in § 37 does, of course, mean the 'inland' destination.

130. **Mr Little** asked whether the consultants had a brief which could be viewed in retrospect as having been accurate with regard to performance. Generally speaking, they were required to undertake the civil engineering design in close collaboration with the Research and Development Department of the OCL organization. This organization was strong in talent and thought up a new idea almost every day, yet in retrospect the brief worked well.