CONTAINER TERMINALS - PORT OF SYDNEY.

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Summary. - The trend to the use of cellular type container ships for the movement of general cargo on the international sea lanes has necessitated the construction of special port facilities at most major world ports. This paper describes the design and construction of the berths and the container handling equipment being provided at the Port of Sydney to meet this demand as well as indicating the general operational procedure being adopted. Further, it discusses the land transportation systems to be used for the transfer of the containers to and from the port area.

1. INTRODUCTION.

Advances in science and technology have in recent decades materially transformed the mode of human existence throughout the world in all but the most remote and undeveloped regions. Methods of transportation have not escaped their impact and, whilst it is not possible to speculate on the advances in the next 20 years, it is clear that the major technological development in sea-land transportation in this era is containerisation. The whole of the Australian maritime industry will eventually feel the impact of the changes which are now occurring in the techniques of handling general cargoes throughout the sea lanes of the world and this will have a marked effect on the ports of this country.

In the shipment of general cargoes, it has long been recognised that putting together of packages into the largest load possible for ease of handling offers the most efficient means of moving cargoes on and off vessels. However, it is only in recent years that the concept of an inter-modal through transport system has evolved and in this development the sea link is only one of the factors in moving cargo from consignor to consignee.

This change has emerged primarily due to the need to halt rising freight rates of sea-borne cargoes, but the modernising of general cargo handling methods is long overdue when one considers that until recently the procedures followed varied very little from those undertaken nearly 50 years ago. This is emphasised by the fact that a recent check by the Department of Trade on a major shipping line's vessels trading to Australia indicated that 44% of the total round time of a voyage was spent in port and 32% of the estimated total round voyage costs was accounted for by stevedoring expenditure. Whilst shipping companies have increased the size and speed of vessels to improve time between ports, there is obviously little advantage to be gained if such a large proportion of time is spent in port and the cost of handling cargoes on and off vessels so high.

In an endeavour to minimise this effect, shipping companies and port authorities have in recent years given considerable thought to the best means of meeting the above situation and there has been evolved the principle of containerisation which will eventually revolutionise the industry so providing a faster turn-round of vessels, better utilisation of berths, less road traffic, a door-to-door service for the customer, rationalisation of packing and a reduction in pilferage and damage to goods.

The purpose of this paper is to describe the design and construction of the facilities which are being provided at the Port of Sydney to meet the challenge of the container revolution and to outline broadly the operational procedures of this port complex.

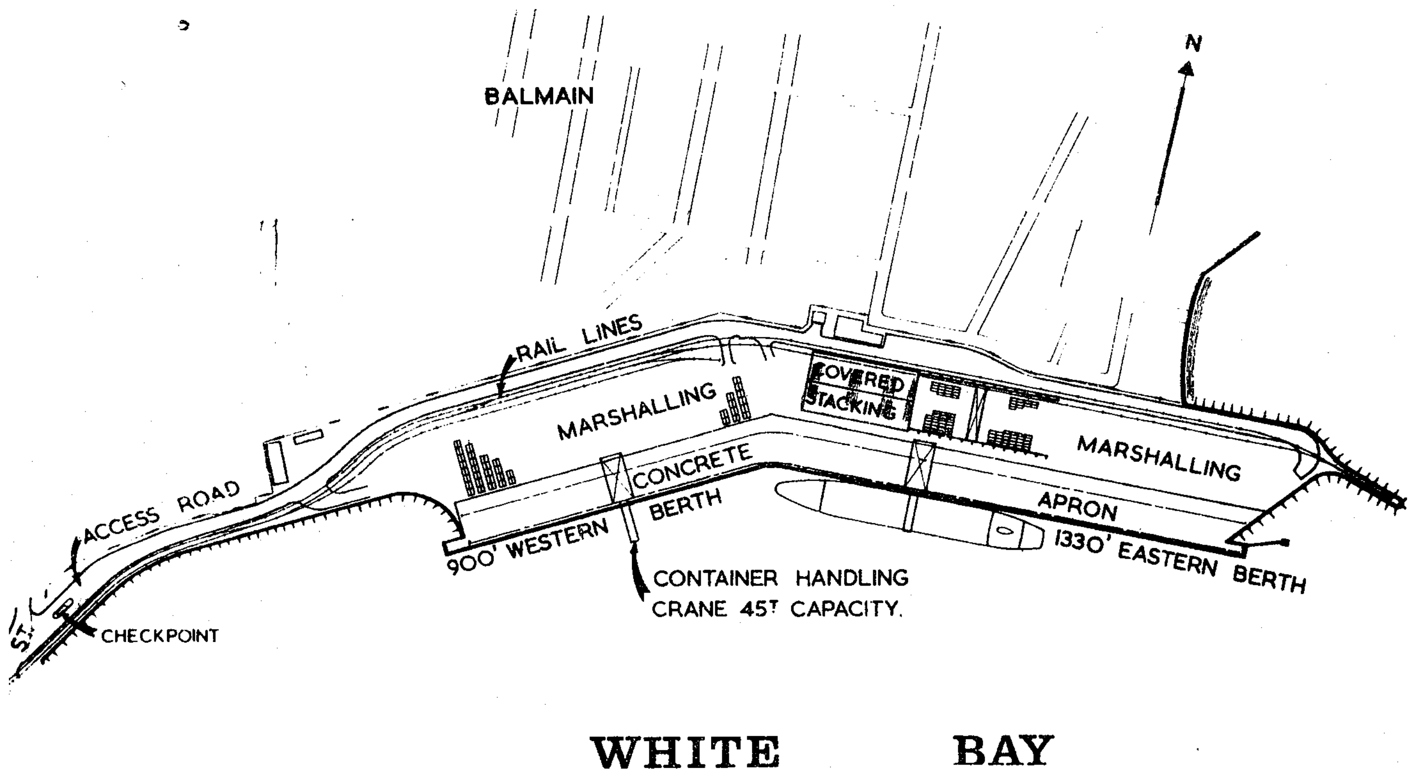

Fig. 1.—General Arrangement of Container Terminals at the Port of Sydney.

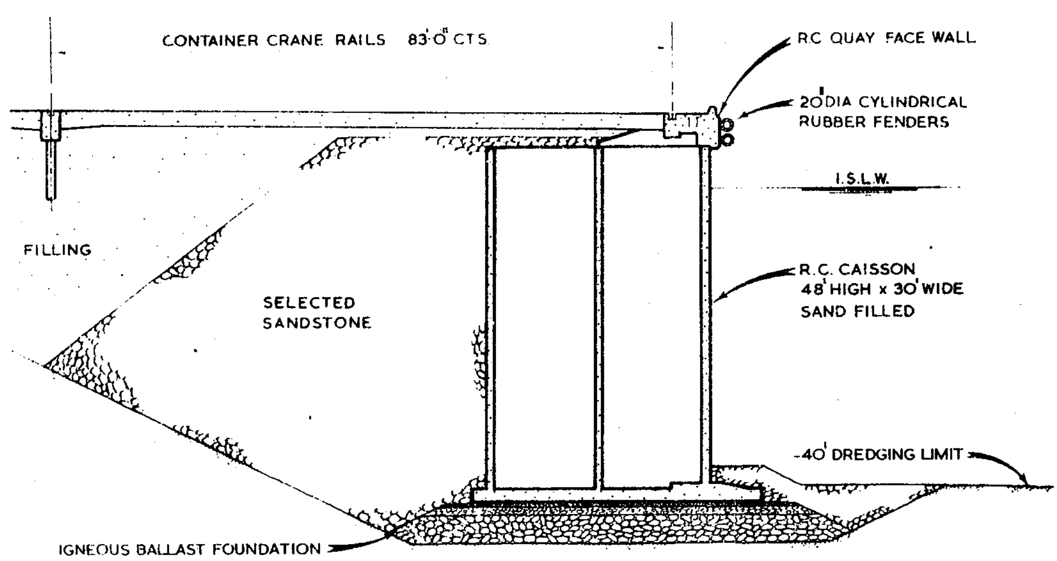

Fig. 2.—Typical Cross-Section of the Caisson Quay Wall.

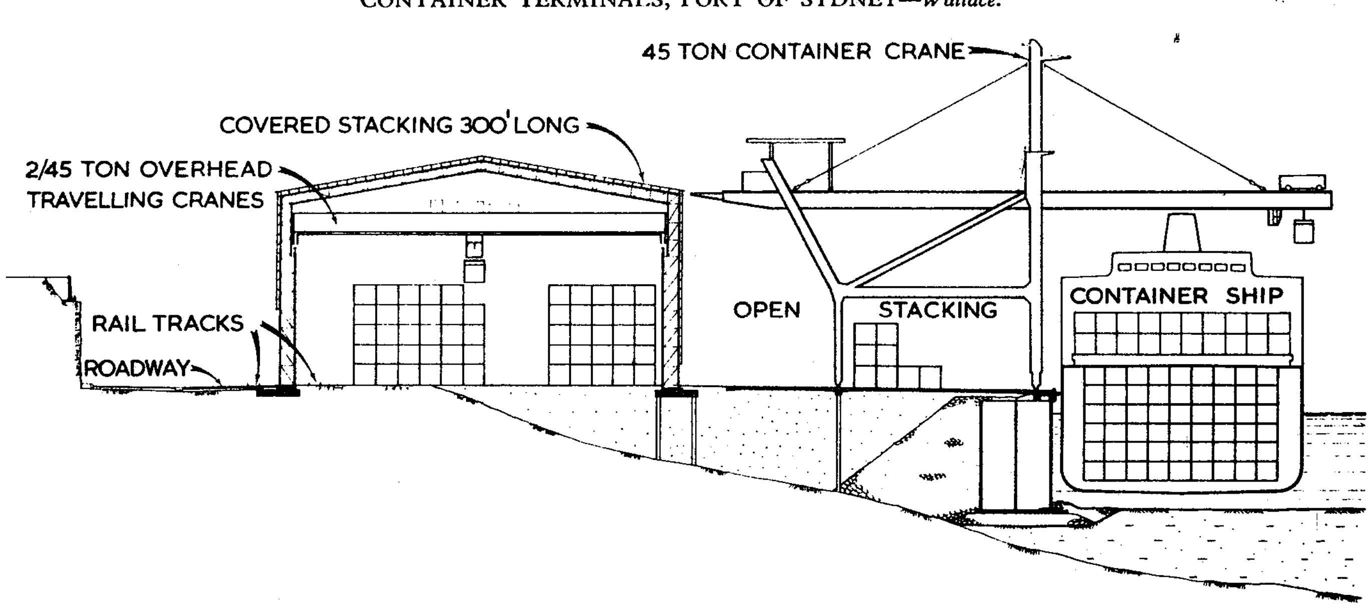

Fig. 3.—Cross-Section through the Eastern Berth showing a Typical Container Crane and the Multiple-Stacking Principle of Container Storage.

2. PLANNING OF PORT FACILITIES.

Comprehensive long term planning for port facilities requires the assembly of data which casts light on probable and future trends in trade in a metropolitan region as well as the proper inter-relation of all forms of sea, road and rail transportation. Specifically, in planning for future port development for the Sydney region, because of topographical considerations, it is not only necessary to estimate the numbers of berths which will be required for the region but to evaluate the impact of the proposed waterfront facilities on urban development as well as any probable changes in the forms of land transportation linking the port with the interior. Questions of decentralisation, the general movement of population and employment are also relevant as are the future trade trends in relation to import destination and the origin of exports.

Studies of this nature have been undertaken in considerable depth to evaluate these relevant factors but, notwithstanding conclusions from these investigations, paramount consideration must be given to the natural assets with which nature has endowed the City of Sydney by way of Port Jackson and Botany Bay to ensure that the degree of shelter provided by each is used to the best advantage for vessels trading to this City.

In this regard when evaluating the factors which determine the siting of container facilities, it is important to consider both the maritime and regional planning components. A maritime aspect which is particularly significant at a container terminal is the ability of vessels to load or unload in all weather conditions in order that the economics and speed of operation of the vessels can be maintained. This necessitates the port being free of the influence of swell or surge because the cell guide tolerance is such that when handling containers the movement of the vessel due to these factors must be negligible.

The need to produce berths which would meet this requirement within the two year period before container vessels arrived in early 1969, whilst having due regard for the overall economics of port operation as well as transportation and other requirements outlined above, set the basic conditions for locating the initial container terminals at White Bay, Port Jackson, adjacent to existing wharfage and on land which for many years had been zoned for port purposes.

3. THE CONTAINER TERMINALS.

3.1 General :

To appreciate fully the design of the container facilities at White Bay, it is important to realise that they are to be used as transit areas only for the marshalling of containers associated with the loading and unloading of vessels and that no packing or unpacking of containers will be undertaken in the area.

This concept, which is common to most ports in the U.K./Aust. trade, varies from the established American practice where containers which cannot be received or delivered full are generally packed or unpacked at depots adjacent to the berth. In effect, the American practice demands sufficient area for both a terminal and a depot at the port whereas the procedure to be adopted in Sydney by the British consortia operating in the U.K./Aust. trade is to establish inland depots, under control of Customs, at centres of production and consumption and only use the port for terminal facilities. In Sydney the depot operations are to be undertaken at Chullora and Villawood some 12 and 13.8 miles, respectively, from the port and each depot will be rail served to permit a shuttle service of containers to and from the port area.

It is estimated that the rail service will handle up to 60% of all containers to and from the depots and the remaining 40% will be delivered by road directly to or from the consignee's or consignor's premises. The value of locating a depot away from the port is emphasised by the fact that a recent cargo origin and destination study for Sydney has indicated that, for the U.K./Aust. trade, approximately 65% of all depot cargo will originate from or be destined to locations within a five mile radius of Chullora. A further 33% lies within 5-10 miles and the remaining 2% within 10-15 miles. Distribution from Chullora will be on less congested roadways than if the depot was at White Bay where only 40% of the depot cargo is within a 5-mile radius, 50% within 5-10 miles and 10% within 10-15 miles. The operations at the U.K./Aust. terminals will further vary from the existing American practices by the use of the multiple stacking operation which is a system pioneeded in Australia for inter-state trade in 1964. The principle of stacking containers up to 5 high on the terminal in lieu of 1 or 2 high in the American trailer park or straddle carrier system will be explained more fully later in this paper but for the present it is sufficient to say that the areas required for the proposed form of operation are substantially less than the American terminal/depot concept.

3.2 Terminal Site :

The berths at White Bay have a total length of wharfage of 2,230 feet and are designed to accommodate the high uniformly distributed loads, etc., associated with container operations. In this regard, it is possible, when containers are stacked four high as is currently proposed by one of the terminal operators, to have loads of up to 80 tons distributed over an area of 18 in. square. Similarly large fork lift trucks when used to handle 20-ton containers produce axle loads in the vicinity of 45 tons and, as it was found more economical at this site to accommodate these loads on a solid fill type of wharf, the use of concrete caissons to retain the reclamation was selected as being the most suitable form of construction for the berth.

Fig. 1 shows the general arrangement of the container complex which covers a total area of some 27 acres. This area is apportioned approximately into 12.5 acres for the eastern berth, 8.5 acres for the western berth and 6 acres for offices, road, and rail access.

Whilst the majority of the land used for the berths had been occupied by individual port industries for many years, a considerable portion was up to 60 ft. above the final port level and excavation of this section produced some 310,000 cu. yd.s. of sandstone fill. The ballast so obtained, in addition to a further 500,000 cu. yd. imported onto the site from other sources, was used for reclamation behind the caisson wall as in some areas its alignment is 260 ft. beyond the original shoreline.

3.3 Concrete Caisson Construction :

The reinforced concrete caissons are 51 ft. long, 30 ft. wide and have an overall height of 48.67 ft. Additionally, each caisson is divided into 6 cells to assist in strengthening external walls and to maintain stability during towing operations.

The caissons were constructed by the Contractor to a height of 18.17 ft. at the Maritime Services Board's depot in Rozelle Bay where two slipways exist for this purpose and after launching at this height they were towed to a temporary berth for pouring of a further 6 concrete pours bringing the overall height to 48.67 ft. To maintain stability during construction the cells were progressively filled with salt water as the height of the walls of the caisson increased.

For the caissons as well as the in-situ quay face wall, the Board elected to provide the ready mixed concrete from its central mixing plant so ensuring the use of low heat cement for all concrete exposed to marine conditions. A basic mix of 3,500 lb. per sq. in. design strength, containing 650 lb. of low heat cement per cu. yd. (0.50 W/C ratio), was used. Where the concrete was to be exposed to weathering in the seawater intertidal zone, the cement content was increased to 725 lb. per cu. yd. With graded crushed river gravel of ¾ in. maximum size, Nepean River sand and air entrainment to 3.5%, the concrete had a unit weight of 148 lb. per cu. ft.

3.4 Dredging :

Dredging at the site consisted broadly of two phases, the removal of silt overburden from the whole of the area to be reclaimed and the trench dredging for the founding of the caissons. Trench dredging was undertaken mainly in sandy clay to a level of 48 ft. below I.S.L.W. although for a 240 ft. section at the eastern end of the berth it was necessary to dredge to 65 ft. below I.S.L.W. before a suitable stratum was reached. In all some 485,000 cu. yd. of silt, sand, and clay were removed as well as 11,000 cu. yd. of sandstone from a section of the trench where rock was encountered.

Two grab dredgers were used by the Contractor and each had a maximum lifting capacity of 25 tons and bucket sizes of up to 12 cu. yd. The average production per dredger in the silt, sand and clay was 94 cu. yd. per working hour.

In the case of the rock dredging, the Contractor originally intended to use compressed air rock breakers but it was found necessary to drill and blast because of the uneven nature of the sloping rock surface and the difficulty of cleaning out clay pockets from the irregular surface.

Because of the relative closeness of residential areas and industry, the Contractor was limited by specification to a maximum allowable instantaneous underwater charge of 100 lb. and in this case the distance to the nearest building had to be 300 ft. or over. Further, with this charge the maximum vibration was limited to 0.75 in. per sec. but in practice it was found satisfactory breakage could be obtained using an instantaneous charge of 50 lb. which produced vibrations in the range of 0.3 to 0.5 in. per sec. at 300 ft.

Rock drilling equipment was located on a 60 ft. by 60 ft. by 10 ft. deep steel pontoon fitted with two 1 ft. dia. spuds to improve its stability against horizontal and vertical movement. The drilling pattern was at 4 to 5 ft. centres longitudinally and at 8 ft. centres transversely to avoid instantaneous detonation and the holes were carried down to 10 ft. below the theoretical dredged level to ensure satisfactory overbreak. Prior to removal of the steel drill casing, plastic tubing was inserted through the casing to permit the ready placing of explosives. The explosive used was Anzite yellow at a rate of 3½ to 4 lb. per cu. yd. of paid rock.

Dredging of the broken rock was effected by grab dredger using a Stockton Clamshell Bucket Series 500 power arm type grab having a 5 cu. yd. capacity and weighing 16 tons. The output of the dredger using this bucket was 51 cu. yd. per working hour. Production fell below this level when removing rock at the bottom of the dredged trench.

3.5 Caisson Foundations :

Fig. 2 indicates the three layers of crushed igneous rock used for the caisson foundations.

The base course, which consists of 6 to 12 in. spalls, was progressively placed by filling a bottom dumping barge with the necessary quantity of rock required for the 4 ft. thickness. After dumping, soundings were taken so that the next load could be placed in such a manner as to ensure as near as possible continuity of the base course level. The blinding course, consisting of crushed rock graded from 2 to 6 in., was used to increase the regularity of the top of the base course and the screeding course of 1½ in. stone provided the final surface upon which the caisson was founded. The blinding and screeding courses have a combined depth of 1 ft. and this was deposited through a floating hopper with a telescopic shute. The rock was placed in the hopper by a pontoon mounted grab crane obtaining the material from a barge moored alongside.

To maintain accuracy in the final founding of caissons, it was necessary to achieve a tolerance of screeding approximating 1 in. and the Contractor was able to satisfy this condition by accurately placing longitudinal screed rails just outside the alignment of the caisson base. These rails were adjusted in height by placing them on regulating boxes each of which had four levelling screws in the base so permitting any necessary vertical adjustment. Once the rails were checked for accuracy of alignment and level, the screeding course was placed in small quantities through the telescopic shute and a heavy screed board, consisting of a section of sheet piling reinforced with a heavy R.S.J., was winched along the rails so levelling the igneous rock. A diver checked this operation continuously to ensure that the base was completely filled with rock.

On progressive completion of the foundation bed, caissons were floated over the site, and, after interlocking with the previous caisson, were sunk into position by filling each of the six cells simultaneously with salt water. Approximately 200 ft. of caisson foundation bed was completed monthly using the above equipment and a diver and this permitted the caissons to be founded at an average rate of four per month over the period that these operations were in progress.

The caissons were initially founded at a level higher than the final design height and leaning landwards to allow for both the immediate settlement of the igneous rock foundation and the long term settlement of the underlying strata. These allowances varied along the berths to suit the different types of foundation conditions and it was found from a careful monitoring of the movement, from the time of founding, that the average settlement approximated 4½ in. and the top of the caisson initially moved 4 in. landwards when filled with sand. Approximately 3 in. of this movement was recovered as the top moved seawards after the reclamation behind the wall was completed.

3.6 Wharf Apron :

After founding and filling of the caissons, reclamation behind the caissons with selected sandstone rubble commenced. As a specification requirement, the in-situ quay face wall was not commenced for a minimum of two months after back filling to permit settlement of the caisson to occur, and in practice it was found that this period was generally sufficient to allow movement to cease. The quay face wall is braced by buttresses to the caisson cross walls and within the wall is incorporated a service duct for electrical and water supply outlets as well as valve pits for oil bunkering lines.

A reinforced concrete beam spans the transverse walls of the caisson to carry the front wheels of the container cranes and the rear wheels are supported on a beam and pile structure 83 ft. behind the front rail. The concrete apron slab behind the quay wall is 138 ft. wide and consists of an 18 in. reinforced concrete slab poured on to a 6 in. layer of firmly compacted, well graded, fine crushed rock (see Fig. 3). The design of the slab followed airport pavement design practice and the loadings were based on the following :-

(a) the containers would be 20 ft. x 8 ft. x 8 ft. with the maximum weight of each container being 20 tons, which is the International Standards Organisation's (I.S.O.) recommended standard.

(b) containers would be stacked 4 high, close together, and at random on the slab and would have 7 in. by 7 in. corner bearing plates.

With these conditions of loading and the maximum crane loadings, the toe pressure under the caisson is 3.10 tons per sq. ft. and the heel pressure 0.35 tons per sq. ft.

The fendering system adopted consists of pairs of 20 in. dia. cylindrical rubber units 5 ft. 6 in. long suspended by chains from the concrete quay face wall at approximately 16 ft. centres. The rubber fenders have been designed to absorb 50% of the energy of a vessel displacing 35,000 tons and berthing at a velocity of ½ ft. per sec. assuming that the impact from the vessel is distributed over a maximum of a 50 ft. length of wharf face.

3.7 Provision of Rail and Road Facilities :

The operation of the container terminals is closely linked with the rail movement of containers to and from the inland depots and a new rail link from the Department of Railways' Rozelle goods yard has been provided for the purpose. In all, this has involved the construction of some 3¼ miles of rail track which includes sidings at the rear of the container facilities as shown in Fig. 1. All rail tracks within the port area are flush with the road or stacking area pavement to facilitate ease of movement of other forms of transport or mobile equipment.

Whilst it is not anticipated that, at least initially,the movement of containers by road from the terminals will be a dominant mode of transportation, it was essential that, in addition to an adequate road system within the container complex, satisfactory road ingress and egress be provided from the port boundary to the nearest existing highway. The municipal road adjoining the only entrance to the port facilities is Robert Street, Balmain, portion of which the Board had some years previously widened to a minimum carriageway of 60 ft. The remaining section has now been widened to 60 ft. by the construction of approximately 850 ft. of piled concrete bridging over a stormwater channel which runs parallel to the roadway. This ensures that Robert Street with its low traffic density has adequate carriageway from the port boundary to Main Road No. 165 (Victoria Rd.) to cater for any increased vehicle movement.

Within the container complex itself, approximately 4,000 linear ft. of 40 ft. nominal width access roadway has been constructed to ensure that all vehicles operating in the area have an uninterrupted traffic flow. Designed as a flexible pavement suitable for axle loads of up to 100,000 lb. the roadway consists of 12 in. of crushed rock base course of selected grading and a 3 in. asphaltic concrete surface course.

3.8 Cranes :

Two 45 ton capacity container handling cranes have been provided on the berths of the container complex. The first is for the eastern berthing face and has been installed by Seatainer Terminals Ltd., the lessees of the berth, and the crane will be limited in travel to the 1,330 ft. of this berth. The second crane has been provided by the Maritime Services Board of N.S.W. and is for use primarily on the western berth but it is capable of negotiating the curve in the berthing face and operating also on the eastern berth.

The Board's crane was manufactured by A.S.E.A. Electric (Aust.) Pty. Ltd., and that of Seatainer Terminals Ltd., by Vickers Hoskins Pty. Ltd., which manufactures in Australia under licence from "PACECO". The cranes, although they are being supplied by different companies, are virtually identical in operational characteristics, and each is capable of twin lifting two 20 ft. long containers or single lifting one 30 ft. long or one 40 ft. long container between wharf and ship's deck or hold. The containers are lifted and set down automatically by spreaders attached to the hoisting ropes of the crane.

In the case of the crane supplied by A.S.E.A. Electric (Aust.) Pty. Ltd., the hoisting mechanism is carried on a powered trolley which, with the operator's cabin, travels along a horizontal boom over the ship and the wharf deck enabling the containers to be set down anywhere between the crane legs and also at the rear. The seaward portion of the boom can be luffed to clear ship's superstructure. The crane is capable of operating at a distance of approximately 100 ft. beyond the wharf face and inshore a distance of approximately 122 ft. and is able to handle containers within this span to a depth of 40 ft. below and to a height of 71 ft. above wharf level. To facilitate the crane's movement around the curve between berths swivelling bogies together with hinged legs on the landward side are provided.

All operations are electrically powered with main operating speeds as follows :-

Main hoist - 120 ft. per min.
Trolley traverse - 500 ft. per min.
Long travel - 150 ft. per min.

Additionally in its leased area, Seatainer Terminals Ltd., has provided two overhead travelling cranes to enable containers to be stacked up to five high and so make maximum use of the stacking area in accordance with the multi-stack principle being adopted for the U.K./Aust. trade. These cranes are also rated at 45 tons excluding the spreader load and are capable of twin lifting two 20 ft. containers. The span of each crane is 154 ft. and they can operate over a length of 690 ft. behind the berth at this stage, with a potential length of 1,260 ft. if required in the future. To enable containers to be stacked five high with allowance for one container to be passed over the top of the stack has necessitated a height of spreader above ground level of 52 ft. The operating characteristics equate approximately to that of the wharf crane except in respect of the long travel motion which is higher at 450 ft. per min.

The Company has also roofed over 300 ft. of the gantry track and partially covered in the sides and western end to provide weather protection for operating personnel assembling small containers into modules of standard 20 ft. units and for stacking of open topped containers. (See Fig. 3.)

3.9 Development Expenditure :

The Maritime Services Board of N.S.W. will have incurred an overall expenditure of approximately $12.00 million to provide the container facilities at White Bay when construction is completed at the end of 1969. The work represented by this expenditure includes the construction of the berths, access roadways, rail facilities, amenities, paving and the provision of a container crane. Further, Seatainer Terminals Ltd., has expended approximately $2.70 million for its container crane, two overhead travelling cranes and buildings making the total expenditure on the whole complex $14.70 million.

The most interesting engineering unit cost in the project is that of the caisson quay wall as for most of the other sections such as roadworks, drainage, paving, buildings, structural steel, piling, etc., the general unit rates are well known. The cost of the caisson quay wall was $1,450 per linear ft. which included the supply of the caissons, dredging of the foundation trench as well as the underwater rock excavation described earlier, foundations, selected backfill, and the construction of the in situ concrete quay face wall.

The prime contractor for the civil engineering work on the site was Citra Australia which was responsible for the caisson quay wall, site excavation, backfilling and the apron slab, etc. The other major civil engineering contractors associated with the project were John Holland (Constructions) Pty. Ltd., which undertook construction of the pre-cast concrete seawall for the approach road and rail access as well as the bridging of the stormwater canal for the widening of Robert Street, and Road Constructors Pty. Ltd., which built the access roadways within the port complex.

The development work associated with the eastern berth, which was the responsibility of Seatainer Terminals Ltd., was undertaken by Paynter and Dixon Pty. Ltd.

4. TERMINAL OPERATIONS.

4.1 General :

The alignment of wharfage at the White Bay container complex permits of its subdivision into two distinct areas as shown in Fig. 1 and these are referred to generally as the eastern and western terminals. The eastern terminal has a berthing face of 1,330 ft. which is capable of accommodating simultaneously two container vessels and the western complex is suitable for berthing one vessel along the 900 ft. frontage.

The eastern terminal which has an annual capacity of 1.0 million freight tons has been leased by the Board, with appropriate safeguards as to throughput, to Seatainer Terminals Ltd. (A freight ton equals 2,240 lb. or 40 cu. ft. whichever is greater.) This Company is the terminal operator for the two consortia of British shipping companies, Overseas Containers Ltd. and Associated Containers Transportation Ltd., which carry the majority of the U.K./Aust. general cargo and additionally it will act in the same capacity for the Australian interstate shipping company, Associated Steamships Pty. Ltd., which will be providing the sea feeder service to interstate ports not visited by the overseas container vessels.

The western terminal is to be used as a common user berth for those shipping companies operating container vessels to the port which, by virtue of the quantity of cargo handled annually, cannot justify the exclusive use of a berth. The specialised equipment for this berth including the container crane is being provided and operated by the Board.

The two British shipping consortia commenced operating to Australia with the new container vessels early in 1969 and it is anticipated that, once all the nine vessels are in service, overseas container ships carrying cargo from the U.K. to Australia will make regular visits to Sydney, of approximately 36 hours duration, every seven days. It is expected that some 500 containers will be unloaded and a similar number loaded each trip. Typical of the cellular type vessels in the trade is the "Encounter Bay", the first of the six ordered by Overseas Containers Ltd., which has an overall length of 745 ft., a breadth of 100 ft. and a maximum draft of 35 ft. It has a gross tonnage of 27,000 tons, a service speed of 21.5 knots and a peak container capacity of 1,300 units each 20 ft. by 8 ft. by 8 ft. Of this number, 304 will be refrigerated. The containers will be stowed longitudinally in the vessel 9 units across and 6 in each tier or cell. A bay or hatch consists of two containers longitudinally because of the twin lift system, 9 across and 6 high or a total of 108 containers. Depending on the actual loading in the vessel, containers up to 2 or 3 high may be stacked on deck. In the case of two high stacking on deck, the number of containers carried by the vessel is 1,152.

It will be appreciated, because of the high capital cost of building specially designed vessels, cranes, containers, etc., that it is quite uneconomic for vessels to make lengthy calls at numerous ports to load and discharge. Therefore, as far as the U.K./Aust. trade is concerned, the vessels operated by the two consortia will only visit Sydney, Melbourne and Fremantle, and cargoes for other ports will be transhipped by smaller coastal container vessels or by road or rail. The coastwise shipping service to be provided by Associated Steamships Pty. Ltd., will use two new container vessels, the "Kanimbla" and "Manoora". These vessels are 415 ft. long, 72 ft. wide, have a design draft of 24 ft., and a service speed of 17.5 knots. The gross tonnage is 12,500 tons and each vessel can carry the equivalent of 418 containers 20 ft. by 8 ft. by 8 ft.

4.2 The Stacking System :

The multiple stacking system used by Seatainer Terminals Ltd. at the eastern berth is such that it is well able to incorporate the "put and take" technique of shiploading and discharge which was originally used so successfully by the American operators between the west coast of America and Hawaii.

The basic concept of the Company's system is to lay out the marshalling area of the terminal as a mirror image of the stow in the ship's cells and to initiate an exchange of containers between the import container on the vessel and the export container ashore. Any imbalance between full export and full import containers will generally be made up with empties to preserve this flow and also to make sure that no more containers are needed in the system than is absolutely necessary. For instance, Sydney generally has a surplus of import over export containers and Melbourne is opposite so that excess import containers in Sydney will be carried empty to Melbourne and taken off at that port to correct the imbalance. Necessarily, therefore, the vessels of both consortia will be programmed to Sydney before Melbourne.

After the stacking area of the terminal has been laid out to a mirror image of the ship's stow the exchange can commence. This entails the crane removing the deck containers over a hatch, one cell of this hatch being progressively emptied, and the containers being taken two at a time to the stacking area by an internal transfer trailer. These vehicles consist of a heavy duty tractor towing a trailer unit which is capable of carrying two containers.

When this first cell is emptied the trailers commence bringing containers from the stacking area two at a time to the ship for loading into the empty cell. The crane after placing the first two export containers into the empty cell then lifts two import containers from the top of the adjacent cell and these are then placed on the trailer for movement to the stacking area. This "put and take" between ship and terminal is continuous until the whole of the nine cells across the width of the vessel are emptied and refilled with export containers. It is then necessary to recommence the operation in a new hatch by emptying the first cell again and then resuming the exchange operations.

The twin lift wharf container crane has a cycle time of 3 to 4 minutes and, with the two containers on and two off principle, a theoretical capability of handling 60 containers per hour can be achieved. Depending on the actual weight in each container, a maximum combined loading and discharge rate of approximately 900 to to 1,000 tons per hour is possible, although to date this rate has only been achieved for short periods of operation. However, as the operation of the system generally improves, the above rates should be achieved over the whole of the vessels operations. In the stacking area each overhead travelling crane has comparable performance to the wharf crane so that one only is used for the ship exchange operation leaving the other free to receive or deliver containers either from road or rail.

At the western berth, where the Board will operate the terminal, the 45 ton twin-lift container crane has the same capabilities as that on the eastern berth and a similar exchange system between ship and terminal will apply. However, it is unlikely that it will be necessary to stack containers more than two high at the berth and as such mobile gantry cranes will be used for stacking.

4.3 <u>The Control System</u> :

As it is necessary to receive and deliver containers during the period when the ship exchange is in operation, it is essential that at both berths rigid control of all container movements in the terminal be maintained. This necessitates the central control buildings being connected to the wharf container cranes, stacking cranes, and mobile equipment by radio-telephone and direct inter-office communication between the central control buildings and the entry gate. Further a pneumatic tube or similar system to handle documents quickly from the entry gate to the general offices is essential.

Programming and control of the arrival and departure of road vehicles by liaison with various customers is possible in this type of terminal operation which will permit traffic flow to be spread over the whole of the 24 hour working day so minimising vehicle movements at peak periods.

A further important advantage which flows from a container service is the ability to reduce the extensive documentation which has at present to be completed by international shippers. Additionally, to assist in this regard, the Department of Customs and Excise has arranged new streamlined customs procedures for containerised shipments which is reducing to a minimum the delays and inconvenience associated with the clearance of goods.

To ensure that every advantage is gained from the speedier movement of cargo and to exercise precise control on the movement of containers the two shipping consortia have both established computer communication links between their U.K. and Aust. offices. A typical example of how computers will be used by these companies is best illustrated by briefly tracing the movement of say an export cargo from Australia.

On receipt of a booking for the shipment of a commodity from an exporter, the Company stores this information in the computer which at required intervals is programmed to produce lists of provisional and confirmed bookings and a breakdown of the numbers of containers of varying types required to accommodate the exports. After the cargo is packed into containers full details of the actual cargo received are then recorded by the computer.

On a date prior to the departure of the vessel bookings close and the computer is then able to produce the export manifest and other associated documentation required by the various statutory authorities. All the required export information is transferred to a magnetic tape which is then air freighted to the port of destination. The information on the magnetic tape is also used to produce stowage plans showing the location of each container in the vessel, sequence sheets giving the order in which containers will be discharged and cargo summaries for the purpose of calculating when each consignment will be available for collection by or delivery to the consignee. Notifications to the consignee will also be produced by the computer giving details of the cargo and after the availability date is added these will be posted to the consignee with the request for a reply confirming the date on which they wish to collect or receive their cargo.

4.4 The Transport System :

The total annual cargo capacity of the White Bay container complex including both the eastern and western berths is approximately 2.0 million freight tons although it is unlikely to reach this capacity for some years.

As indicated earlier in the paper, the terminal operators of the eastern berth estimate that 40% of all import cargo will move directly to the clients' premises by road in full container loads and the remainder will be taken by rail to the inland depots at Chullora and Villawood. These depots are for packing and unpacking containers and provide a service for those clients who, by virtue of not having sufficient cargo to fill a container, cannot avail themselves of a full container load.

The Depot-Terminal rail link is being provided by the N.S.W. Government Railways and the Department has indicated that, if required, a shuttle service at hourly intervals can be provided. This is well in excess of the capacity required to move cargo to and from the terminals as a train load consists of 17 specially designed waggons each carrying two containers.

On the question of road movement it will be appreciated that virtually all of the 2.0 million freight tons of general cargo, expected to ultimately move through the terminals, is at present transported to and from the existing berths by road vehicle. All types of vehicles are involved carrying heavy loads to small packages and it is estimated that the average truck load under present distribution methods is about 5 to 6 freight tons. Surveys indicate that the track movements to handle the 2.0 million freight tons to and from the present conventional berths would be in the order of 330,000 per annum.

Whilst it is not possible to speculate on what proportion of the 2.0 million freight tons capacity of the container terminals will ultimately be handled to and from the facility by road or rail because of the many variable factors involved, it is considered that the 60% rail 40% road represents a reasonable estimate. Using these figures as a basis 800,000 freight tons per annum would be expected to move to and from the terminal via Robert Street and Victoria Road (Main Road 165). On present indications the average cargo in a 20 ft. container will be approximately 20 freight tons and on this basis a total of 80,000 vehicle movements per year would be produced or for a 5 day week and 40 weeks operation per annum a total of 400 vehicle trips per day. Even assuming this is eventually increased to 500 vehicle movements per day, because of the smaller capacity interstate containers, the additional daily flow in Victoria Road in the vicinity of the Robert Street intersection would be less than 1% and, as indicated above, the vehicle movement associated with port traffic in other parts of the city will be substantially reduced. However, because the type of vehicle to be used for container cargoes may possibly create a little more concentration of traffic at intersections, this question is under review by the responsible State Authority, the Department of Main Roads, New South Wales.

It is evident from the above analysis and studies made by other Port Authorities that if the general road system is adequate for normal industrial, commercial and amenity needs it will be adequate for port traffic. Further the advent of highly developed container terminals will not place demands on roads which are proportional to the increase in berth throughput.

5. CONCLUSION.

The container terminals at the Port of Sydney represent a highly developed concept of container handling equal to any in other world ports and these facilities together with the installations provided at other Australian ports will ensure that adequate modern terminals are available for the introduction of full scale international container operations on the Australian maritime scene.

Additionally, the Maritime Services Board of N.S.W. has completed studies of other sites capable of being developed when the container trade has demonstrated a need beyond the facilities now being provided and in this regard the City of Sydney is fortunate to have been so richly endowed by nature in Port Jackson and equally by having nearby an expansive waterway such as Botany Bay, with its potential port and industrial areas. Having these assets and with a future programme which is characterised by its flexibility to meet changes, the Board is confident, notwithstanding the present fluidity in modes of sea transportation, that it is in an excellent position to meet any future challenge.

"CONTAINER TERMINALS - PORT OF SYDNEY."
DISCUSSION.

Mr. J.M. Wallace.
19th November, 1969.

MR. K. FISHER, University of Sydney:
Is there any concern over the reliability of the cranes when there is only one per berth?

MR. J.M. WALLACE:
Yes. There is concern in this regard. I think the situation is met adequately as far as the eastern berths are concerned by the fact that the Board's crane which is normally located on the western berth can travel onto the eastern berth. This in effect gives the eastern berth the potential of two cranes. As far as the Board's berth is concerned, there is only potentially one crane and we do feel that this does present a link that could be a little weak but in this regard the particular crane we have selected is a most sophisticated and well-engineered piece of equipment and we feel confident that any problem which might occur as regards reliability has been satisfactorily covered.

MR. K. FISHER:
Who finances the construction of the container terminals and over how long a period is the write-off for these facilities?

MR. J.M. WALLACE:
This question would probably take a little longer time than I am able to give at present, but very briefly the Board finances all the container facilities up to deck level and this includes the roads, rail tracks and berths, etc. As regards equipment, the eastern berth has been leased to Seatainer Terminals Ltd., and this Company has provided its own wharf cranes, gantry cranes, office accommodation, etc. At the western berth which is operated as a common user container terminal by the Board, all the cranes, office accommodation and other container handling equipment is provided by the Board.

As far as writing off is concerned, this is the function of the companies' general policy and I cannot help you with this aspect. As far as our own operation is concerned, the Board does not make this type of information generally available.

MR. R.J. TUFT, University of N.S.W.:
What minimum clearance do you generally allow in future planning at a berth between the bottom of a ship and the harbour bed.

MR. J.M. WALLACE:
The normal clearance is two feet between the ship and the dredged bottom. We endeavour to get more than this if we can but two feet is the minimum requirement. For example, if there is a forty feet depth of water alongside the berth, the ship could have a draft of thirty-eight feet and be satisfactory.

MR. TUFT:

So that there is a continuing need to keep the actual harbour bed at the prescribed level.

MR. J.M. WALLACE:

Yes. This is correct. In Sydney, it presents no problem because we do not have siltation but in other ports it does present a problem and we do, in fact, have to undertake continual maintenance dredging.