DREDGING AND [illegible] WORK

7-2-59

PORT OF MELBOURNE.

J.B.O. HOSKING

I understand from a letter received last October by the Chairman of the Melbourne Harbour Trust from the Honorary Secretary of the Institution of Naval Architects (Australian Branch), Mr. Westhorpe, that this meeting is the inaugural gathering for your Institution in Melbourne. On this account his request that arrangements be made for one of the senior officers of the Trust to present a paper at this meeting dealing with problems of dredging in the Port of Melbourne, and any other aspects of Port development thought worth while, was replied to in the affirmative.

This desire to meet the wishes of your organisers has required me to take stock of the records and activities of the Trust to see what could be produced for your enlightenment and entertainment. It is realised that a paper cannot be presented which will be of technical worth to a gathering of Naval architects as the works of dredging and Port development are all more closely allied to civil engineering than Naval architecture. However, they have been carried out with the purpose of accommodating the ships produced by Naval architects.

Since the end of the last world war the Melbourne Harbour Trust has implemented a program of development without parallel among the major Australian ports and has spent in that period more than £1,000,000 annually in improving the accommodation and facilities in the Port, including deepening and widening dredged channels. During that period a reasonably good film library has accumulated and I have obtained from it a sufficient quantity of 16 mm. cini-colour film to illustrate the subjects chosen for this talk which include dredging, construction of new oil berth at Breakwater Pier, Williamstown, construction of three general cargo and two bulk handling berths at Appleton Dock, and provision of a mechanised steel handling berth at No. 21 South Wharf. I propose to show this film following a talk about these items illustrated with some appropriate slides.

As most of you know, the Port of Melbourne is situated at the head of Port Phillip Bay at a distance as the crow flies of about 30 miles from the open sea in Bass Strait. Two separate dredging problems are involved in providing a route for ships from Bass Strait to berths in the Port of Melbourne. The first is not carried out by the Melbourne Harbour Trust but by the Ports & Harbours Branch of the Public Works Department. Their work enables ships to navigate the channel at Port Phillip Heads, known as the Rip, and traverse the sand banks inside the Heads through two channels, the most important of these being known as the South Channel, which enables vessels to reach deep water in Port Phillip near the Hovel light not far from Rosebud. The other channel, known as the West Channel, provides a shorter route for smaller vessels capable of traversing a channel 19 feet deep at low water. The distance from the Port Phillip Heads to Gellibrand pile light is 30 miles by the West Channel and 40 miles by the South Channel.

Port Phillip has a water area of 725 square miles and the central portion of it has natural depths exceeding 10 fathoms. Although the tidal range in Bass Strait is about 6' it is only 2'6" average inside Port Phillip due to the throttling effect of the Rip channel forming a confined entrance to this large water area. This considerable reduction in the tidal range has an important bearing on the depths of channels which have to be provided in the Port of Melbourne and consequently on the volume of dredging work.

When the Melbourne Harbour Trust was formed in 1877 the southern boundary of the Port of Melbourne was defined by a line joining Breakwater Pier, Williamstown, and the end of the St. Kilda Pier, but as the size of ships increased it was necessary in 1915 to extend the dredged ship channel south of this line and the Trust boundary was amended to include the area to the Fawkner Beacon to provide for ships of 34 ft. draft.

It will be seen from the slide that in 1887 Hobson's Bay was shallow, with a general depth of about 20 feet, and that the rivers flowing into it were narrow and flanked by swamp land.

The Commissioners of the newly formed Trust appointed Sir John Coode, and eminent English Consulting Engineer, to advise them how to proceed with the development of the Port as there were several schemes supported by different factions. One of the main points then being discussed was whether the ship channel to bring ships from Hobson's Bay to Melbourne should be a straight cut from Port Melbourne to the entrance to Victoria Dock or whether it should be a curved channel following generally the course of the rivers. Sir John Coode advised that the latter course should be adopted and this decided for all time the general configuration of the Port. Humbug Reach was eliminated by excavation in the dry of Coode Canal and sinuosities in the river below Coode Canal were removed. Victoria Dock was commenced by excavation in the dry to 17 feet below low water to be finished later by dredging. Berths were then dredged with approaches to them to permit ships to moor alongside and eliminate the lightering of goods then necessary.

Since 1877 the Melbourne Harbour Trust has dredged more than 160 million barge yards of spoil and has deposited more than 130 million barge yards in Port Phillip south of a line joining Ricketts Point and Point Cook in a depth of not less than 10 fathoms at low water. The balance of about 30 million barge yards has been landed and deposited for reclamation along the banks of the river and on the adjoining swamp lands and also on the Elwood swamp. In the 19th century quite a considerable quantity of reclamation work was done with the aid of barrows, but subsequently it was accomplished by pumping. The Trust has expended about £11,000,000 on these dredging works and the present annual expenditure on dredging is about £500,000. These figures include both maintenance and and construction work. The average annual quantity of maintenance dredging over the past 5 years is about 850,000 cu. yards, equivalent to 1¼ million barge yards. The quantity of maintenance dredging varies from year to year, depending upon flood conditions. Removal of forests in the catchment area of the Yarra and Maribyrnong Rivers has been instrumental in increasing siltation in the dredged waters of the Port on account of the consequent increase in soil erosion. The rate of deposition of silt varies in different sections of the Port, being heaviest near the upper limits of dredging in the Yarra and Maribyrnong Rivers and lightest in the dredged channels at the southern end of the Port most remote from the influence of these streams. The area between Spencer Street Bridge and Queen's Bridge, which was formerly dredged by the Trust to a depth of 26 feet at low water, is now silted up to depths of less than 12 feet and following flood conditions many feet of siltation occurs immediately below Spencer Street. On the other hand, in the Port Melbourne Channel near the Fawkner Beacon, siltation amounts to only two to three inches a year.

As the Port of Melbourne is situated in a tidal estuary, a large proportion of the dredging is in alluvium, but it also includes sand and clay of varying degrees of stiffness, some being as hard as rock and containing nodules of limestone. Basaltic rocks at one time formed a barrier to navigation in the River Yarra and this was removed at Spencer Street with the aid of a Lobnitz rock breaker purchased in 1909 and using 15 ton needles. During the war, when it was found that a 40 ton floating crane was essential to the proper operation of the Port, the pontoon of the rock breaker became the central portion of a diesel electric floating crane designed by Trust's engineers and manufactured at the Trust's own workshops & Slipways. Many different types of dredging equipment have been employed by the Trust including bucket ladder dredges, usually of the centre well type (but in one case with a side cutting ladder) trailing and cutter suction dredges and grab dredges. The greater part of the work has, however, been accomlished with centre ladder dredges and spoil generally has been transported to the dump in self-propelled hopper barges. The position for depositing is marked by a spoil ground buoy which the transporting units are required to pass before opening their hopper doors. Observations of the bottom in the vicinity of the buoy are taken at regular intervals and the buoy is moved as required to ensure that the depths are not reduced to less than 50 feet at low water. This buoy is located in an area beyond the control of the Melbourne Harbour Trust and alterations in its position are carried out by the authority controlling that area, the Ports & Harbours branch of Public Works Dept.

Dredging is an operation which, on account of its submerged character, is difficult to supervise. With ordinary excavating machinery the results of work carried out can be seen and this makes supervision much easier.

Before proceeding to discuss any of the plant units now used in dredging in Melbourne, it is proposed to describe the system that has been evolved to ensure that they are properly employed. A survey party equipped with a 30 ft. motor launch with echo sounder and Kitchen rudder for general sounding work and with a small motor boat equipped with wires on reels, lead lines and poles for berth soundings survey the Port on a basis that every section of the Port should be sounded every six months. This ensures that the depths of water areas are not allowed to become less than those indicated on charts as the guaranteed depths. When an area has been found which is not more than I foot deeper than the guaranteed depth a dredging instruction is prepared showing the area concerned and directing that it be redredged to a depth 4 feet deeper than the guaranteed depth. This directs the Dredging Department to the proper areas for effective work and ensures that the dredgers will not be working on an insufficient depth of face to enable them to fill their buckets and carry out effective work. It also provides a sufficient margin for siltation to ensure that redredging will not be required for a considerable period. The survey party at weekly intervals checks the progress of dredgers carrying out these instructions and provides weekly reports of work which ensure that the unseen dredging is being satisfactorily performed. When the work covered by a particular dredging instruction is completed a re-survey of the whole area is made and from this and the survey data prior to dredging a calculation is made of the actual number of cubic yards dredged. The cubic yard in situ gives the only true index of the work actually performed. In quoting particulars concerning the quantity of dredging work carried out by the Trust, the units used were barge yards. The barge yard, however, bears no direct relation to the number of cubic yards in situ, being the number of cubic yards of mixed material and water transported from the dredge by hopper barges. The figure obtained by dividing the number of cubic yards in situ and the number of barge yards is called the "barge yard factor" and this is influenced by the character of the material and the skill with which the dredging plant is employed on the work allotted. An average figure today for the barge yard factor is I½, but in the past this figure has been as high as 3, showing that for some reason hopper barges have carried an unusual proportion of water into their spoil.

An important function of the Hydrographic Surveyor is to supervise the precautions taken by Dredge Masters to compensate for variations in water level due to the tide. On each bucket dredge is a gauge on which, if the dials are set to read the amount of tide shown by a normal tide gauge, a correction is made in the cutting depth of the buckets which ensures that a level bottom will be formed at the required depth below low water. The Surveyor at the beginning of a job sets the ladder and this gauge so that the Master of the dredge, if he maintains the gauge to the tide reading from time to time, provides the dredged bottom at the required depth. All the floating plant units are equipped with radio-telephones so that the Master can obtain the true tide readings from time to time as required.

The barge yard factor previously referred to becomes increasingly difficult to maintain at a low figure when dealing with soft silt; the product of recent siltation is when this material is deposited into water it readily mixes with it and cannot be returned to a reasonably solid state. When the Trust ordered a new steam hopper barge in 1954 from Scotland, an endeavour was made to improve its load carrying capacity by specifying that its doors be sealed with rubber and that it be provided with a de-watering pump to permit the hoppers to be pumped out between the dump and the dredging site. This enables the dredge to start loading into a virtually dry hopper and in this way assists to reduce the barge yard factor. This vessel, which is the latest addition to the Trust's dredging fleet, is 199 feet long by 36 feet beam. It has a capacity of 900 barge yards and a speed of 10 to 10½ knots. It was first ordered in 1950 but when being delivered by the Contractor it was lost on the coast of Western Australia North of Fremantle. The Builders consequently had to build a second vessel, but this also sustained considerable damage when driven ashore at Milford Haven during a 100 mph gale. It had to be returned to Glasgow for hull reconstruction. Not withstanding this ill use, the de-watering arrangements operated satisfactorily when the vessel was delivered, but some difficulty has occurred in practice due to damage caused to structural members when the hydraulically operated door closing mechanism forces doors against obstructions on these members.

While good transporting units are necessary they are of little use without an efficient dredger and with this in mind the Trust obtained (from Lobnitz Pty. Ltd.) a modern bucket dredger, the "A.D. Mackenzie" with length 178 feet and breadth 36 feet. It is powered with a high speed triple expansion engine driving a bucket band of 44 No. 28 cubic feet buckets through belt drives with a speed of 18 buckets per minute. Actually a lower speed of 14 buckets per minute was provided through different sized pulleys in the belt drives, but it has been found unnecessary to use lower speed in any materials encountered in Melbourne. This dredge proved much more efficient than any dredge previously used by the Trust, particularly in the stiff clays encountered. Even so, it had its teething troubles, particularly in the bucket band. In this band, buckets are connected with 4 links in parallel operating on rotating manganese pins. When dredging in hard clay these pins started to fail with less than 2000 hours service and on two occasions dropped the band on the bottom. The pins that failed showed signs of circumferential fatigue failure. Correspondence with the U.S. Corps of Engineers showed that they had had similar troubles with rotating pins so steps were taken to prevent the pins from rotating. However, as the pins were replaced with new pins forged in our own workshops all trouble disappeared. It was eventually ascertained that the trouble was in great part due to faulty heat treatment by the English makers of the pins. This trouble caused a discussion regarding the merits of double links as supplied by Lobnitz and heavy single links which have been used on previous dredgers employed by the Trust. The double links have theadvantage of being lighter, but as the bucket bushes spread under the hammering effect of work, there is a tendency to deform the washers retaining the pins and shear the cotters. With the double links the laterial swelling of the bushes is absorbed by the structures of the bucket so that the trouble previously mentioned with washers and cotters disappears. An additional 10 buckets required to complete spares for this dredge were made on the basis of heavy single links so that eventually a comparison will be available between the merits of single and double links in the bucket band of this dredge.

One of the operations that controls the rate of advance of a bucket ladder dredge working in an open channel such as the Port Melbourne Channel is the handling of moorings. The Lobnitz dredge has wire head and stern moorings which can be readily dealt with but the quarter and bow moorings are of chains which have to be underrun by a tug with a special underrunning block. Considerable time could be saved if these side moorings were of wire as in the case of the head and stern moorings. The chain has some advantage when working in confined waterways trafficked by shipping, but it is doubtful if this precaution is necessary even under such conditions. As the winches on the Lobnitz dredge are provided with drums for handling chain, it is not possible to instal side wires without extensive alterations to the equipment, but when working in the Bay some of the advantages of wires are obtained by using only sufficient lengthof chain to enable the dredge to work across the width of the cut, approximately 300 feet, the balance of the side moorings to the anchors being then of wire.

Centre ladder dredges will not effectively provide the necessary depth of water along the side of a wharf structure and for this purpose the Trust previously used a side ladder dredger called the "Latrobe". This, however, was not very satisfactory as the considerable weight of the ladder on the side of the pontoon caused it to heel or tilt to a considerable extent when the end of the ladder was not resting on the bottom. This eventually was instrumental in causing the dredge to sink at its moorings in a storm, and as it was then 70 years old it was written off. It has been replaced in service by a diesel driven Priestman grab dredge with a 6½ ton crane equipped with grabs suitable for handling rock, clay and silt, the silt grab containing approximately 3 cubic yards of material. This type of equipment can operate in berths occupied by ships with less trouble thanthe side ladder dredge for two reasons; (I) greater mobility, and (2) better method of dealing with wires and other rubbish which ships dump into the dredged waters. The bucket dredge lower tumbler became wound up chocka block with these old wires and had to be burnt out periodically. Even then, it did not pick them up properly but pressed them into the bottom. When grabs were first employed, particularly at berths used in Victoria Docks for discharge of steel cargo, it was necessary to engage motor lorries to remove the rubbish which included steel sections picked up by the grabs.

Until recently the draft of ships used in Australian ports has been limited by the draft available in the Suez Canal and a 34 ft. laden draft has been the maximum provided for, but with the advent of the oil refinery at Altona and the desire of the oil companies to use larger and larger tankers, increased depths in channels providing access to the crude oil discharging berth at Breakwater Pier, Williamstown, have hadd to be provided. Consequently, the Trust is now engaged in dredging the Port Melbourne Channel from Fawkner Beacon to No. 7 Buoy to provide a 37 ft. minimum depth at low water. For this purpose the plant of the Australian Dredging & General Works Pty. Ltd. is being employed in addition to the Trust's own bucket ladder dredge attended by three self-propelled hopper barges. The Trust's equipment operates three shifts with a total of I20 hours per week while the Contractor's plant operates five I0 hour days, or 50 hours per week.

Dredging in this location is difficult on account of exposure and variable weather conditions and the nature of the bottom which is of very tough yellow clay with some inclusions of limestone. At the present time the limiting draft declared for Port Phillip entrance is 36 ft., but it is hoped that when dredging in the approaches to Breakwater Pier is completed within a few months, this limit will be correspondingly increased.

The Breakwater Pier oil berth is of particular interest on account of the method which had to be adopted to provide a sufficient length of berthage for the tankers projected at the time of construction of the Altona refinery. At that time 30,000 ton tankers were proposed with a limit of length of 700 feet. Breakwater Pier was first constructed partly by convict labour about I00 years ago and used as a railway berth for ships handling wheat. Some 25 years ago, on account of its condition and changed trade requirements, it was placed out of commission. It was called Breakwater Pier, but apart from its rock filled shore approach contained no efficient breakwater, being merely a pile structure with a line of close piling on the seaward side. Its outer end finished in such a position that only about 500 lin. feet of berthage space was available for deep draft shipping beyond the basalt formation at the inner end of the pier. It was therefore necessary to extend the outer end about 200 feet, but unfortunately the clay foundation of the pier there dipped to a depth of about 90 feet below low water and the bottom became silt in the course of an old river channel. As a smooth water berth was required for the tankers a rubble mound was built on the clay bottom to the outer end of the previously existing pier and the pier was altered and reconditioned to accommodate the deep draft vessels anticipated. A rubble mound breakwater was impracticable for the 200 feet further extension required and moorings and protection for tankers were obtained by constructing two concrete caissons each 80 feet by 35 feet to a height of 16 feet in a floating dock and then at Gellibrand Pier, building them up to a height of 45 feet. The site of the proposed extension of Breakwater Pier was dredged to approximately 55 feet below low water, using Lobnitz dredger with the ladder in its lower position and the hole so formed was filled with sand obtained by a dredger from the floor of Hobson's Bay. This provided a mattress on which the caisson was sunk. Approximately 144 piles were then driven through the bottom of each caisson and through the sand and underlying silt into the clay bottom and the bottom of the caissons were filled with tremie and reinforced concrete. Filling was completed with sand, the total weight of each caisson when filled being about 4000 tons. The deck was then concreted and provided with special bollards each capable of withstanding a pull of 150 tons. Opposite the caissons a 16 pile dolphin was constructed in a sand pocket provided in the silt bottom to absorb energy from tankers and prevent them from contacting the concrete breakwater. Energy absorption of tankers berthed against the reconstructed pier was provided through 100 feet long floating fenders cushioned on each side with 8" dia. rubber cylinders. Ends of fenders were step tapered to ensure that berthing loads were distributed over several piles in the face of the structure. Steps were also taken to ensure that berthing speeds perpendicular to face of structure did not exceed 6" per second.

While these works were proceeding at Williamstown other equally important works were in progress elsewhere, such as:-

(1) The River Entrance Docks where more than 4,000,000 cubic yards of silt were dredged under contract by the Australian Dredging & General Works Pty. Ltd. as a site for berths for large overseas liners. It is now being used as a convenient site for the special vessels being provided by the Australian National Line for the Tasmanian trade.

(2) Appleton Dock where three general cargo berths and two bulk handling berths have been provided at a cost of more than £3,000,000 and

(3) Mechanised steel handling berth at No. 21 South Wharf.

(4) Berth for Bass Strait Ferry.

Nothing more will be said about the first of these items as it entailed only bucket dredging, already referred to in some detail. However, some of these operations will be seen in a film to be shown later. The Appleton Dock job was of particular interest from the dredging viewpoint as it involved the removal of about 3,000,000 cubic yards of material to form the dock basin. Of this about 50% was silt which could not be used as filling unless excavated in the dry. About half a million cubic yards of this material was excavated with a 2 cu. yard Ruston-Burgess dragline excavator and deposited on swamp lands north of the Footscray Road. The remaining million cubic yards of silt were removed by bucket dredges and hoppers to the spoil ground in Port Phillip. The balance of 1½ million cubic yards, consisting of sand and clay, was pumped ashore by the cutter suction dredge G.F.H. This unit deserves special mention as it is the largest suction dredge in the southern hemisphere. It has a suction pipe 45" in diameter and a discharge line 42" in diameter. The cutter engine which drives a cutter about 12' in diameter is of 400 H.P. and the pump engine which drives a pump 14' diameter is of 4000 H.P. It is a self-propelled vessel and has carried out work in Wyalla and other Ports of the Commonwealth. It can dredge to a depth of 70' and pump to a distance of one mile. On account of the size of the pipelines the whole of the discharge line must be located on trestle supports inside the impounded reclamation area with sufficient spillway to deal with 115 cusecs before dredging work is commenced. The pipeline requires a sufficient combination of discharge points to permit the whole reclamation area to be filled merely by operating fixed valves and bleeder pipe lines.

The 3500 lin. feet of berthage provided by these works at Appleton Dock is intersected by the old course of the River Yarra and south of this point the foundations are of sand while north of it they are of silt. Therefore, two types of structures were required. The sand enables shed floors to be supported without piling other than for the structures themselves and on this section transit sheds are being erected. When completed, they will be the largest cargo sheds in Australia. The wharf apron at these three berths will be 70 ft. wide, equipped with wharf cranes and railway tracks.

On the silt foundations two berths have been established for handling bulk cargo such as coal and phosphatic rock. These materials can be discharged with 7½ ton grabbing cranes behind the 12 ft. high concrete wall for handling from a concrete surface with overloaders into vehicles or direct from the grabbing cranes into railway trucks on the wharf apron where 70 ton hoppers with hydraulically operated doors are being provided to ensure minimum delays for cranes due to truck movements.

To provide for most efficient handling of iron and steel in the Port the Trust have constructed a completely mechanised steel handling berth at No. 21 South Wharf. This berth, the most modern of its kind in Australia, has been specially designed for Victoria's growing steel trade. It was designed primarily for the most efficient handling of structural steel sections, but it can also be used for handling pig iron and scrap when available from its original purpose. Four 6 ton electric level luffing wharf cranes are provided on the wharf apron. Running on tracks within the specially designed shed are travelling overhead bridge cranes in 6 of the 7 bays and each of the cranes is also of 6 ton capacity. A unique feature of the shed design is that the cranes run transversely across the shed and not longitudinally as is the usual practice with overhead shed cranes. The bridge cranes serve a dual purpose of receiving iron and steel from the wharf cranes and loading motor trucks and semi-trailers at the roadside at the rear of the shed. Two of the wharf cranes have single hoisting wires and the other two double hoisting wires, the double wires being installed to facilitate the handling of steel in lengths longer than the opening of the ships hatch. When two hooks are used on the one crane they are attached to the steel bars in the ship's hull at some distance apart and can be operated independently of each other to lift the pre-slung bars which may be 45 feet or more in length into an approximately vertical position so that it can be lifted easily through the hatch. The sling load can then be lowered into a horizontal position to be placed on the wharf. The 4 wharf cranes have been equipped with gear enabling electro-magnets weighing 4 tons each and 65" in dia. to be attached to the hoist wire to be used to handle pig iron and scrap steel. Four of the bridge cranes have also been similarly equipped.

The pattern of discharge from a ship is by wharf crane from ship to wharf transferred to the hooks or magnet of the overhead shed crane for conveyance, sorting within the shed and then direct to road transport again by overhead crane. The shed has been so dimensioned and designed that a newly arrived ship may use it for discharge while steel from a previous shipment is still being cleared.