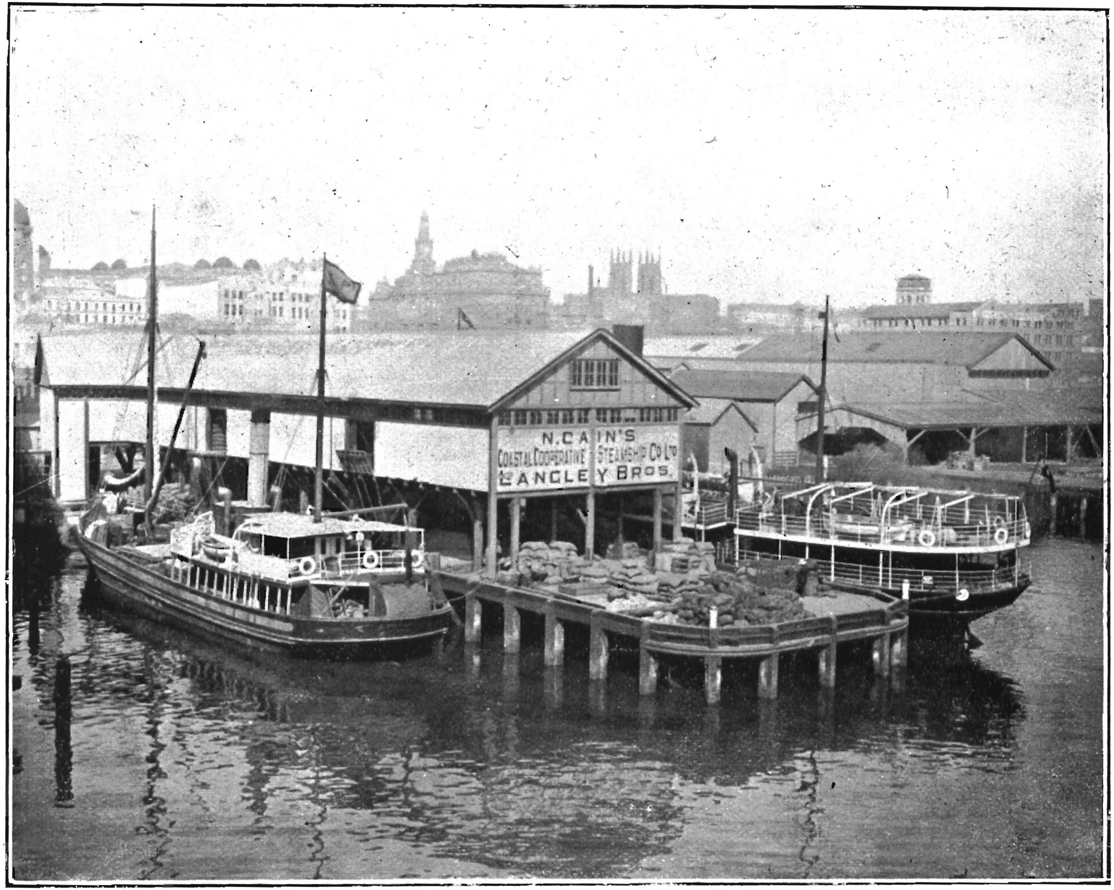


N. Cain & Co.'s Jetty, with Double Deck Shed, No. 29, Darling Harbour.

some 60 feet from the shore line. But with the growth of trade, it became necessary to provide better facilities. Timber wharves and jetties were then built in front of the Quay walls so that the vessels could come alongside.

In certain parts of Darling Harbour, the silt, being both soft and deep along the foreshore, sheet piling of turpentine was adopted in lieu of ballast and masonry for wharf backing. The piles were driven deep and in close contact, anchored back at the top with timber beams, and filled in with rubble and soil to wharf level. This sytem, while possessing certain advantages, especially as regards first cost and rapidity of construction, was not upon the whole successful. The piles were not sided to an even size on account of the objection to removal of the bark and sapwood, which forms a valuable protection against marine borers.

When the Sydney Harbour Trust was formed, a considerable amount of sea walling had been built in this way. The comparatively wide spaces between the piles, especially at the lower ends, allowed the wash of the sea to pass into the rubble and soil, with the result that continual settlement took place. Moreover, the wide interstices and the hollows that formed behind the piles became rat warrens.

As most of the timber sheet piling of this class was sound, it was decided to seal the front to a foot below low water mark with Monier plates to prevent the passage of rats. This plating is shown in Figure 5. The result was entirely successful, and the water front was vastly improved in appearance.

When building new wharves, the character of backing to be used became an important consideration, more particularly as the necessity for making it rat-proof became apparent. The system shown in Figures 6 and 7 is a common practice. Ballast is tipped to low water mark, and a foundation formed thereon, either of bagged concrete, or hand packed stone. Above this is reared either a mass-work concrete wall, or one of cut stone. But when the backing is filled in, considerable settlement takes place in the ballast, and such walls require to be built of unusual thickness to prevent failure. The concrete walls are divided into sections to prevent cracking, and even with a base width of 7 feet to a total height of 14 feet, i.e., 0.5 of the height, the movement, in some places, has been so great as to spoil the appearance of the wall. Where masonry has been used, more particularly where the balast was deep (over 30 feet), as in Dalgety's, a wharf at Miller's Point, the settlement caused many of the huge stones to break on the beds, and opened the joints considerably.

To overcome these difficulties, I decided to try a class of reinforced concrete construction locally known as the Trestle System. The first experiment of this kind was made at Miller's Point in 1907, at the wharf then being erected for the Messageries Maritimes Company. A timber wharf, 490 feet x 40 feet was built, as shown in Figure I., and ballast tipped in to low water mark. Upon this was erected every six feet, centre to centre, an "L" shaped trestle of reinforced concrete, connected with panel plates separately moulded, and resting against the flanges of the trestles. This wall was successful in that it was cheaply constructed, and possessed stability combined with flexibility sufficient to accommodate itself to the uneven settlement of the ballast foundation without rupture. It has proved rat-proof, and presents a good appearance, notwithstanding that the settlement of the filling amounted, in places, to as much as 10½ inches.

The method of erecting was as follows: After the reinforced concrete members had been allowed time to set, the ballast under the wharf was dressed off to a level berm, extending eight feet outside the line of the wall. Beds were then formed in the ballast for the foundation plate, shown in Figure 1, by ramming down a strong wooden template. The template was then removed, and the foundation plate laid in the recess thus formed. While this was being done, the ground was levelled for the base member and well dollied by hand. On to the foundation so prepared the trestles, weighing about three tons, were lifted by a travelling crane, the counterpoise plates placed in position and packed with stones to hold them. When the rising tide prevented the setting of more trestles, the plates were laid between and held with soft wood wedges. Sixty lineal feet were set up in one day.

The reclamation was carried out by tipping from the cart tail. No attempt was made to sort the materials, which consisted of sand, ballast, and clay in about equal proportions, and no injury was done to the concrete by the falling stones. Some 900 lineal feet of this class have since been put in hand and partly erected.

Following the success of this form of wall it was decided to try it upon a larger scale. The object was to build as little of the perishable timber work, and as much of the permanent reinforced concrete as possible. Instead of a wharf 40 feet wide, with a 14 feet wall behind, a wharf 20 feet and a wall 25 feet 6 inches high was fixed upon; thus, the cost of 20 feet width of timber work was put into the cost of additional height of the wall. See Figure 2.

As the ballast foundation could not be relied upon to carry a heavier load than two tons per square foot, a trestle and plate wall, which concentrated panel loads upon the trestles, was out of the question. The pressure, it was found, could be brought within the requisite limit by using trestles placed contiguously. The trestles were designed 21 feet 6 inches high, 15 feet long on the base and 3 feet 6 inches wide on the face. The base was tapered, as shown in the drawing, to allow adjustment for alignment, and to enable the filling to pack underneath when the pressure came on the filling. Each trestle weighed about nine tons.

The erection was as before, except that the top of the ballast was rammed all over with a large wooden dolly suspended from a pile frame. It was afterwards screeded level with small stone, and then the trestles were lowered into place by a crane. After the filling in had been carried out to the top of the trestle a dwarf concrete wall four feet high was built, and the filling completed. Altogether, 1380 lineal feet of this wall was erected at Nos. 2, 3 and 4 Berths, Miller's Point.

The only deep-sea gravity section wall so far built in Sydney is that at Darling Island (see Figure 5), designed by Mr. C. W. Darley when Engineer-in-Chief of the Public Works Department, and partly constructed before the Sydney Harmour Trust was formed. This was built of concrete blocks, weighing 30 tons each, set upon sloping beds. The foundation is upon rock, which was levelled up by mass concrete before the lowest tier of blocks was laid. The work is of a very substantial nature, and the cost amounted to £32 per foot run, the average height being 38 feet. The depth of water in front of this wall is 28 feet; but everything points to the necessity of providing at least 35 feet to meet future requirements.

Amongst other classes of construction may be mentioned the reinforced concrete sheet piled wall (shown in Figure 4) and the counterfeit and plate wall. As regards the former, a length of 150 feet was built at the foot of Market Street in 1903. The piles are increased in strength towards the point of greatest bending moment, and taper towards the top and bottom. The lower ends are stepped into a chase cut in the rock and grouted up with concrete. The heads are held back by forked steel land ties surrounded by concrete. There is, however, a practical limit to the height of a wall of this construction, on account of the heavy transversal loading.

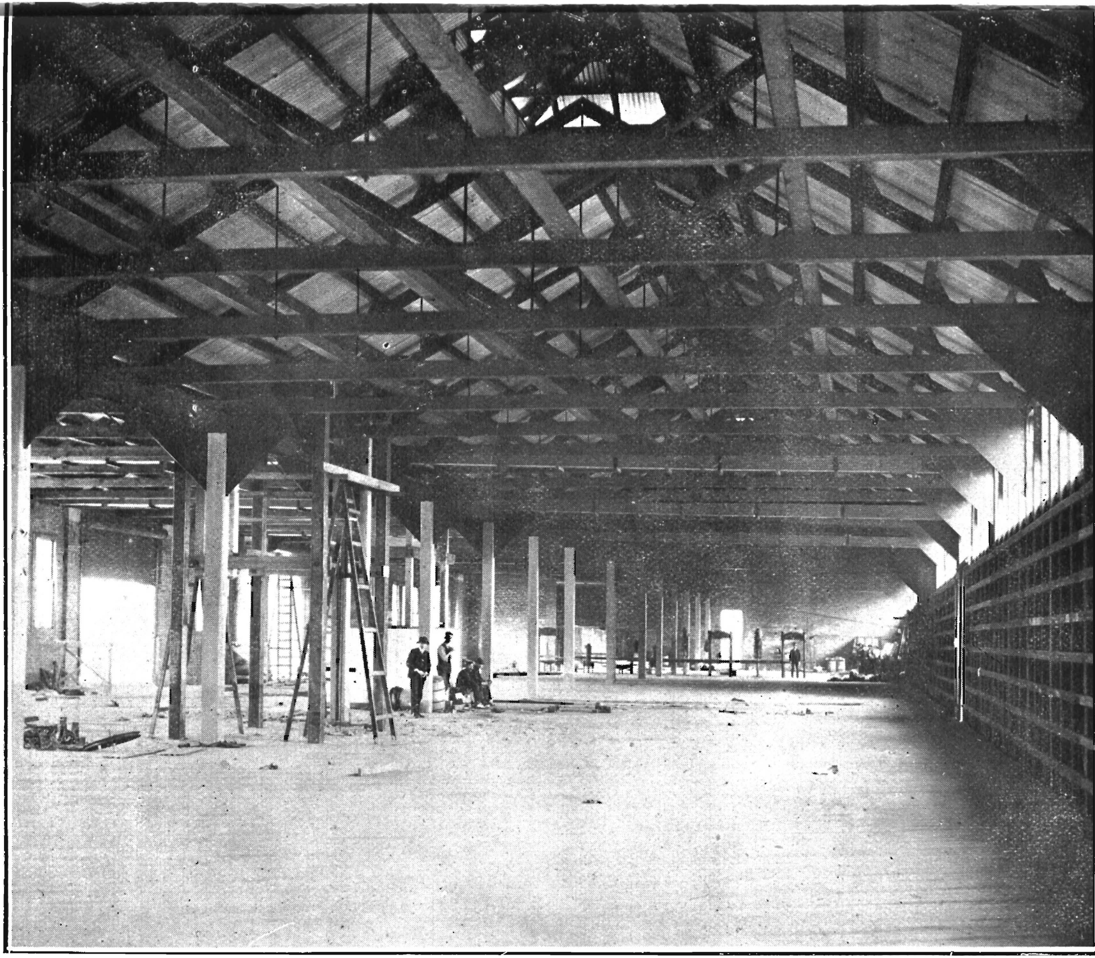
The counterfort and plate wall consists of monolithic concrete buttresses, built in situ, the intervening spaces being closed by reinforced concrete slabs resting on the rear of the counterfort. On a suitable foundation this class of wall should prove economical.

I do not think that the last word in sea-wall construction has yet been said. There is still plenty of room for the display of ability and resourcefulness in this connection. The enormous developments in shipping must be kept pace with by the marine engineer, and it is clear to me that the engineers of the fuutre will have great and difficult problems to solve.

General Design of Sydney Wharves.—The trade of the port of Sydney may be divided into three classes, viz., the over-sea, the inter-State and the coastal, and special berthing and shed accommodation has to be provided to meet the requirements of each class. At the present time, the inter-State trade is provided for chiefly at wharves and jetties in Darling Harbour between the Gas Works and Druitt Street—these structures having, during the last ten years, been reconstructed and enlarged so far as the space available would permit; but, owing to the large increase which is taking place in the tonnage of the steamers in this trade it is inevitable that in the near future more extensive jetties and more shed room will have to be provided, and this will necessitate a considerable reduction in the number of the existing berths at this place. The general design of these jetties is similar to that of most of our Sydney wharves, viz., piles from 40 to 60 feet long, spaced 10 feet apart, caps 14 inches x 14 inches, girders 12 inches x 12 inches, spaced 5 feet, centres and decking 4 inches thick, with guard logs, fenders, etc., deck level from 8 feet 6 inches to 10 feet above low water ordinary spring tide. No bracing is used in any of our wharves or jetties, raking piles (driven with a batter of one in six) every 30 feet, fitted and bolted to the front pile and to the cap being found much more effective. Owing to the small range of tide, it is impossible to fix braces at such an angle as would give much stiffness to the structure, and an examination of the bracing on jetties erected years ago showed that, in nearly every case, the ends below high water were eaten away or split at the bolts which originally fastened them to the piles.

In order to provide adequate accommodation for the ever increasing over-sea trade, extensive wharfage schemes have been prepared, and a brief description of some of the work at present in hand may be of interest. No. 4, north of the Gas Works, a jetty 500 feet long by 100 feet wide, on which is erected a double-decked shed, 500 feet by 60 feet, with double-decked shore shed 300 feet long by 75 feet wide, the upper deck of which is approached from an overhead bridge over Hickson's Road, is nearly ready for occupation. The jetty is of the usual construction already described, but with the deck level 14 feet above low water spring tide. Groups of extra piles were driven to carry the upper structure. In order to give as much free space

Sheds being erected for McIllraith, McEacharn & Co., No. 4 Jetty, Darling Harbour.



Upper Floor, Store Shed, No. 3 Jetty, Darling Harbour.

as possible on the lower deck, only one row of posts were placed down the centre, thus rendering trussed girders necessary to carry the upper load. The upper floor consists of three inch decking covered with malthoid and sheathed with two inch Powellised planks planed on each edge and fitted as close as possible, the object being to make this floor water-tight. The upper floor of the shore shed is similarly constructed. To facilitate the discharge of cargo from ships into the upper deck of shed, travelling platforms 20 feet wide are provided; these can be shifted along the wharf to accommodate the ships' hatches. The cargo will be landed on these and trucked into the shed in the usual way. Lifting gear can be attached to these platforms for loading cargo into carts on the lower deck. The shore shed is provided with lifts, schutes, and other appliances for the handling of cargo. The floor of this shed is four feet above the roadway, so that cargo can be loaded into drays without lifting. The adjoining jetty, No. 3, completed a few months ago, is of similar design, with this exception, that, for the present, the jetty shed has no upper deck. The shore shed, is, however, fitted with an extensive wool dumping plant, the presses being fixed on the upper floor and the engine room, gas producer plant, etc., on the ground floor. North of this jetty, at No. 2, another large two-decked store has been erected, making a total length of handsome brick front from Munn Street to the Gas Works of 873 feet. Along this front is constructed a reinforced concrete roadway 30 feet wide and 24 feet above the level of Hickson Road, connected with High Street by an iron and concrete bridge, also 30 feet wide, to give access to the upper floors of these sheds.

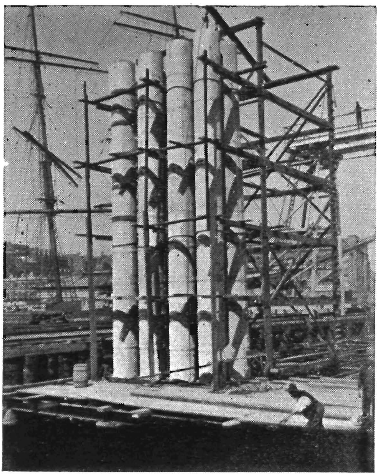
Another large jetty of somewhat similar design is in course of construction, east of Miller's Point. In this case, the jetty is 130 feet wide, and the double-decked shed 90 feet wide, the shore shed will be three storeys high, with 342 feet 6 inches frontage to Hickson Road, and provided with wool dumping plant, lifts, etc. The wharf shed is being fitted with a 15-ton traveller across the shed, and some 2200 feet of runway hoists wool conveyor, a three-ton lifting crane, travelling platforms, etc. An overhead bridge is to be erected over Hickson Road, giving access to the second storey from Windmill Street.

A long shore wharf, 540 feet in length and 50 feet wide, is nearly completed at Dawes' Point. Considerable difficulty was experienced in constructing this wharf, owing to the steep slope of the rock foreshore, which, in places, was dry at low water at the back of the wharf, and dipped to 40 feet at the front row of piles. All the piles were planted in holes drilled from four feet to six feet into the rock, and heavy raking piles placed every thirty feet. In ramming the ballast at back to receive the reinforced trestle work (as described above), the stone showed a tendency to slip down the rock face, and thus throw undue pressure on the piles. To obviate this, large blocks of stone were placed between the first and second row of piles, and extra land ties were fixed to prevent any forward movement of the wharf. Two double-decked sheds, 200 feet and 190 feet x 70 feet, will be erected in connection with this wharf. The upper deck will be connected with George Street North by a bridge over Hickson Road. The berth will be provided with travelling platforms, electric cranes and other appliances for the rapid handling of cargo.

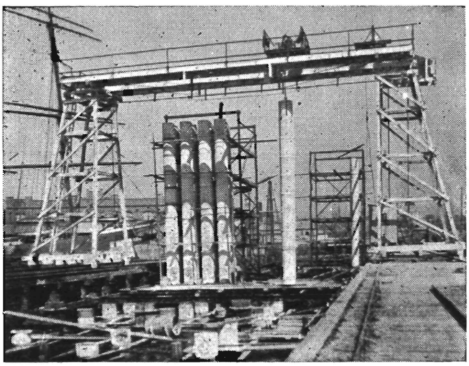
Perhaps the most extensive and interesting work at present in hand is the jetty now in course of construction in Woolloomooloo Bay. This jetty will have a total length of 1200 feet and a width of 208 feet. A centre roadway 53 feet wide and four feet below the wharf level runs for the full length of the jetty. The wharves at each side are divided into two berths of approximately 600 feet each, thus providing four extra oversea berths. Double-decked sheds, fitted with three-ton electric travellers, are being erected for the full length of each side of the roadway. Travelling platforms and electric traversing cranes are being provided at each berth, and ramps are constructed to give access to the wharf from the centre roadway where required.

The wharf work is of similar construction to those already described, and consist of turpentine piles, 10 feet centres, with hewn ironbark (14 inches x 14 inches) headstocks and (12 inches x 12 inches) girders. The decking of open portion consists of 9 inches x 4 inches brush box laid diagonally, to ensure cart wheels bearing on more than one plank at a time. Decking for shed portion is of blackbutt (9 inches x 4 inches) laid across girders with 9 inches x 2 inches sheeting (laid diagonally) on top ,to take the wear of cargo, trucks, etc., and can be replaced when required. The roadway is of novel construction and permanent nature. Ironbark piles are driven 20 feet into the clay bottom with the large end down, and over each pier a hollow cylinder of reinforced concrete pipes 2 feet 6 inches diameter is placed. The thickness of the pipes is 2½ in. and a double spiral of 10 gauge steel wire reinforcement is embedded ½ inch under inside and outside surfaces. The pipes are obtained in lengths of 3 feet 7 inches each and joined together on the job in columns of 10 pipes, making a total length of approximately 37 feet. The method of jointing consists of two lengths of 2½ inches x ⅜ inch flat iron, carried up the inside of pipes and opposite to one another. The bottom of each length has a hook on it which embraces the thickness of bottom pipe. Holes are punched in these iron flats corresponding to holes bored in the pipes, to

No. 6 Jetty, Woolloomooloo.



Framework for Assembling Re-Inforced Concrete Cylinders.



Lowering Cylinder Over Pile.