9th June, 1887.

W. D. CRUICKSHANK, President, in the Chair.

The following Paper was read by Mr H. W. Kerle :—

OCEAN JETTY.

For the North Illawarra Coal Mining Company, North Bulli.

By H. W. Kerle.

This is the latest of a number of jetties constructed on the coast, for the purpose of loading coal from the various mines situated on the seaboard of New South Wales. It may not be here amiss to state, briefly, the various works of this class that have been erected up to this time. The first was at Bellamby, between Bulli and Wollongong, over thirty years since; it was of a very temporary character, and, owing to the great difficulty of getting alongside with a sailing vessel, it fell into disuse, and eventually, through decay and damage by storms, it washed away. Precisely the same fate overtook a similar jetty constructed about the same time at Catherine Hill Bay. Only about 120 feet of this is now standing (or falling), but there is one point of interest in it which the author considers worthy of notice. On examining the piles he found that they principally consisted of ti-tree, and were in apparently a sound condition; they did not seem to be affected in any way by the cobra or other sea worm; this state of preservation, after a period of immersion of fully thirty years, appears to him remarkable; but the rock formation being a conglomorate highly charged with iron pyrites, may to a great extent account for it.

Next in order come the Bulli, Coal Cliff, and Kembla jetties; these have now been in use for some years, that at Bulli being a well known landmark familiar to many travelling by sea.

The work forming the subject of this paper was commenced in April, 1886; it has been in use since January of this year, and is now on the point of completion.

It begins at the junction of the lines of railway from Nos. 1 and 2 mine, and is carried out across a small indent in the coast, known as Hick's Bay (Plate 5), in an easterly direction, being partially sheltered from the effect of a southerly gale by a headland and a low lying reef of rocks, but exposed to all weather from the S.E., E., and N.E.

The bottom consists of a shale rock, generally soft and easy to work, but having patches of a hard nature. Overlying the rock is a shifting bed of sand, which varies greatly according to the state of the weather; this has caused considerable obstruction in the carrying out of the work.

From the commencement outwards, about 250 feet, the reef falls very gradually, being immersed at high tide. From this point it drops quickly into deep water through broken rocks and boulders, and falls gradually outwards.

The general dimensions are:—Total length, 870 feet; width, 30 feet from the outer end to 620 feet inshore, thence 42 feet to 180 feet inwards, from which it branches off in two wings to Nos. 1 and 2 mine, at a width of 23 feet each; height from reef to deck at inshore end, 30 feet, and at outer end, 56 feet. Depth of water varies from 22 to 25 feet, according to the state of the sand.

The construction of the work is shewn in elevation and plan, plate No. 6, and in sections, plate No. 7. The deck load it is designed to carry is that equal to a 12-ton locomotive and train on the double line. The piers of the wings carrying the superstructure are formed in the manner shewn in the section AA. The piles are not less than 15 inches diameter at the smaller end, and 20 inches at the butt, the larger end being placed downwards. The butt is adzed round a distance of 2 feet 6 inches and to 18 inches diameter, on which two wrought-iron rings, 4 inches x 1 inch, are shrunk on, one at the upper end, the other close to the base. In the centre of the pile a hole is bored to receive a dowell-pin, 3 inches diameter.

At the head the piles are tenoned into an ironbark headstock, 14 inches x 14 inches, and secured each with double anchor bolts. The centre pile is vertical, and the other piles have each a batter of 1 in 5. They are braced with double whalings, notched into and bolted to the piles; the diagonal bracing being 9 inches x 5 inches, toed into the whalings and bolted to piles and headstocks respectively. At the junction of the two wings, and for the next eight bays, the piers are constructed with four piles, these are the same size as those before mentioned, and are finished at head and butt in a similar manner. They are braced as shewn in section CC, above H.W.M., with 12 inches x 6 inches double whalings, and 9 inches x 5 inches braces, notched in and bolted. At the termination of the four pile work, which completes the widening out of the deck for the purpose of sidings, crossings, &c., the piers are constructed for a further distance of 180 feet in the manner shewn in section BB. The whole of the work in this portion is similar to that previously described, with the exception of the chain bracing below water, which is substituted for wood to avoid the strain which would inevitably occur by the action of the waves upon it, and thereby be a source of weakness instead of strength. These chains, which are $\frac{3}{4}$ inch diameter, are secured to the butt of each outside pile by means of a heavy bolt passing through them, the head being forged into an eye to which the shackle of the chain is fixed. Immediately under the longitudinal whalings similar bolts are fitted, to these a shackle and bolt are fitted, which work into a hoop secured to the end of the chain. They are thus, after fitting, all hauled up taut and made fast at their intersection with the centre pile by a suitable staple. Up to this point, or 420 feet from shore, the piers are set 20 feet apart, and from hence they are spaced 15 feet apart, and are constructed in the manner shewn in section CC, to within 30 feet of the termination of the jetty. As will be seen the work here throughout is of a similar character to that previously described. The two outer piers are constructed in cast-iron columns, there being two to each pier. They are cast in sections 5 feet 6 inches long, 3 feet internal diameter, thickness of metal 1 inch, flanges $1\frac{3}{8}$ inch. Each section is cast with spigot and faucet, which are accurately turned to fit and made interchangeable. Internal flanges, $1\frac{3}{8}$ inch thick, are provided to secure one to the other, the bolts being $1\frac{1}{8}$ inch, $4\frac{1}{2}$ inch pitch. In the positions shewn on elevation DD, there are cast pockets for the purpose of receiving and securing the ends of the struts, which are formed of 12 inches x 6 inches rolled girders. These struts are made fast with one pin in each end, 2 inches diameter, passing through the sides of the pocket and webb respectively. The top sections are formed in a similar manner generally to the others, but there are intermediate flanges 16 inches below the level, and the sides of the cylinders are cut down to allow the girders forming the struts and carrying the deck to finish flush with the cap. The transverse girders, viz., those carrying the longitudinal wooden girders to which the deck is spiked, are built; they are 16 inches deep, 12 inches wide, and of the length shewn in section; they run across the whole width of the cylinder, and are thoroughly bolted to the flanges before mentioned. The longitudinal girders are rolled joists 15 inches x 6 inches, with cover-plates top and bottom, 9 inches wide x $\frac{1}{2}$ inch thick; they rest on and are secured to the flange at head, and are butted and strapped to the transverse girders. Below these girders, in the position shewn, are two diagonal struts of 12 inches x 6 inches rolled iron, the ends of which are received into and secured to pockets cast on the sections in a manner similar to those below. On both sides and ends the columns are braced vertically as shewn, the tie-rods being 2 inches diameter in the body. The end of each rod is hooped to pin passing through pocket, the other being screwed up taut to ring in the centre. These cylinders are filled with blue metal concrete to the top for the purpose of giving additional strength and weight, and to prevent the corrosion on the inside which would otherwise more quickly occur.

From the inner columns, and extending to the commencement of the wings, a thorough system of horizontal bracing has been introduced, for the purpose of distributing the strain on the piles at this, their weakest, point, and to knit the whole together. For this purpose, beneath the horizontal cross whalings and at 8 feet above high water, longitudinal whalings have been run through to the point shewn on Elevation Plate. These are scarfed and bolted on the piles, and fitted with chock underneath. Notched into these, and secured to intermediate piles, are double horizontal diagonal braces of 9 inches x 5 inches, as shewn on body plan, Plate 6. The whole of this work is scarfed, bolted, and knocked-in in an exceptionally strong manner.

On the top of the headstocks, and forming the lower portion of the superstructure, and under the girders are corbels of ironbark 14 x 12, and 14 x 9, respectively, those on the piers spaced 20 feet apart, being 8 feet long, whilst those on the 15 feet bays are 6 feet; they are all notched into and bolted to the headstocks. The deck is carried by four ironbark girders, 14 x 12, and two of the same material 14 x 9, at the sides. The large girders are placed immediately under the rails, to take the strain of the traffic direct; they are bolted and butted to the corbels. The deck is 9 x 3, hardwood, laid slightly open, and secured to the girders with 8-inch x ½-inch spikes. The kerb is 9 inches x 6 inches, scarfed off for 2 inches on the inner edge, and bolted to girder. The rails are laid on continuous sleepers of 12 x 6 hardwood, which is bolted to the girders.

There are three sets of fender piles constructed, as shewn on section CC. Each set is formed of three vertical piles, pinned into the rock in a similar manner to the bearing piles, and having two diagonal strut piles toed into the rock, and secured with vertical dowel. The head is secured to cross strut, which is notched into the uprights.

These fenders are distinct, and clear of the jetty in every way, and, in the event of their being carried away by the roll of a vessel upon them, no damage or strain would result to the main portion of the work.

In the position shewn on Plate, 400 feet from the outer end of the jetty, a landing stage and steps are erected. The stage is constructed about 9 feet above high water mark, and is carried up by means of an extention of the horizontal cross whalings. It is 20 feet long, 4 feet wide, and formed of 6 x 4 hardwood, laid on edge, there being a space of 4 inches between each piece, and they are each secured by through bolts at each end. Leading from low water mark to the stage is a wrought-iron landing stairs, the top end being hinged on to the stage, the bottom being swung with a substantial chain. From the stage to the deck a substantial set of steps is fitted: it is constructed of 12 x 4 stringers and 9 x 3 treads. A neat handrail of wrought-iron standards and wire rope encloses the outer side.

Sixty feet from the end of the jetty the apparatus for loading is erected. The trucks in use all open with bottom doors. Between the rails on the up line at this point a hatchway is cut, which communicates with the shoot below. The shoot is formed in two pieces, the upper portion being fitted round and enclosing the hatchway, and secured to the girders with strong angle-iron, the lower end being carried up by straps secured to the outer girders. The lower portion of the shoot is movable; when not in use it rests upon a staging constructed for the purpose, with two piers of two piles each, having headstocks, girders, and planking similar to that used in the jetty. This staging is 10 feet below the level of the deck. On the bottom sides of this shoot are fixed four wheels, and at the back of the stage a small winch is provided to run it in and out. Erected on and above the kerb is a substantial jibbet constructed of 9-inch x 9-inch posts, and well stayed back on to the main girders with 2-inch x 2-inch square wrought-iron rods. In the centre of the jibbet a set of 3 x 2 blocks are fixed, and on the deck a double powered winch is fitted.

When in use the shoot is lowered and held in position by the fall of the rope from the blocks overhead round winch barrel, and the small winch tackle on the lower stage; whilst in case of danger, or when not required, it is hauled up to the large winch and run home by the smaller on to the stage. It is thus completely under control, may be held in any position required, or lifted clear of danger in a very short time. The moorings in use are situated on the port, starboard-quarter and stern of the jetty, as shewn in the local sketch, Plate 3. The first three are held in position by large anchors dropped into the best available holding ground. Each buoy is connected to the anchor stocks with 125 fathom of stud cable $1\frac{1}{8}$-inch diameter. The stern mooring is pinned to the solid rock on the shore. From these moorings the vessel, when loading, rides, and does not at any time touch the jetty, and, if properly handled, but seldom the fender piles.

The Company, having a large amount of timber on the estate, together with an efficient saw mill and workshop adjacent to the jetty, considered it advisable to undertake the work and risks incidental thereto themselves, under the management and charge of a resident engineer, rather than let it by contract. The whole of the timber for decking, braces and whalings was obtained from the estate, and sawn as required. The girders and headstocks being of ironbark, and, as this was not obtainable in the district, it had to be brought from the Manning River and landed at Wollongong, and hauled to the site. The piles, being of turpentine, were obtained on the property. The large amount of timber required entailed much hard work in its selection to maintain its quality.

Before commencing the erection, a suitable crane, running on wheels and having a jib 28 feet long, was constructed, which was made movable horizontally but was otherwise fixed.

The first portion of the work for 250 feet was comparatively easy to erect, the rock being generally uncovered at low water. After the curves of the wings were struck, the positions of the piles in the piers were marked off, and the holes for the dowels on the ends of the piles were drilled with augur and drill in the usual way to the required depth. The rock on which the butt of the piles rested on was then dressed off and the pin driven home. The piles forming the first pier were then each lifted on to the pins, the heads cut off, and headstock, corbels, and girders fitted and permanently fixed, the deck being laid loosely. The crane was then run out, and lifted the next pier into position together with the other necessary timbers; in this way the work proceeded to its completion. Immediately each pier was erected, it was treated in this manner, the other portions, viz., braces, whalings, &c., being brought forward at the same time, or as soon after as possible, and completed. Very little temporary work was used or required, and the liability of damage by sudden storm was reduced to a minimum. In fact, the whole of this work was completed without a single stick being washed away; and this in the face of some of the heaviest weather that has been known on the coast for years, and especially of the storm in November, 1886, which was quoted at the time as the worst experienced for the last 40 years, when the jetty was at that time advanced to 700 feet from shore. Careful management and foresight, a constant stock of the required material, together with an efficient staff of first-rate men was absolutely necessary for the carrying out of the work in this manner. Beyond low water outwards considerable difficulty was experienced—in the first place owing to the wash and boulders, and latterly in the accumulation of sand, which had to be removed before boring the holes for the dowels and to clean off the surface of the rock for the seat of the piles. The boulders were broken up by blasting and removed. Movable boxes were constructed encircling the pile to be erected; the divers then removed the sand and held the drill in position while the hole was being pierced from on deck. The pin was then inserted in the hole and the pile driven on to it, any sand being removed from underneath. The centre of each pier was taken from the centre of the jetty; temporary girders were run out for the purpose of lowering a staging for drilling the holes from the upper whalings, and the exact depth being found, the hole was marked off from above and driven with the requisite batter to suit the pile. As each pile was erected, it was fitted with a temporary brace until the whole number forming the pier were up, when the heads were cut off and the headstocks put on, &c.

The work of erecting the cast-iron cylinders has been of a laborious character. The base of each column has been sunk into the rock a distance of five feet. Sinking these holes in the exposed position has been a difficult undertaking, more especially so as the weather during the whole of the time (some four months) has been most unsettled, considerably more than half of the time it being impossible for the divers to work, and frequently, no sooner had the debris been removed from the hole being sunk and the work recommenced, than they were again compelled to stop. The method of sinking consisted in drilling a number of holes 3in. diameter round the circumference of the hole, which was slightly larger than the required size ; after these holes were completed, one was in a similar manner put down about the centre, into which a dynamite charge was inserted and fired by a battery from on deck. This had the effect of loosening the core, after which it was removed, the sides being cleaned off and the bottom dressed perfectly level. On the four holes being completed the bottom sections were lowered and secured into position with concrete. The levels of each section were then taken, and the matching pieces ordered so as to bring the intermediate struts and cylinders horizontal and level on completion. An unavoidable delay occurred during the time these final sections were being cast and turned, during which time (three weeks) beautiful weather prevailed, but when forthcoming nothing could be done towards fixing them for another ten days on account of heavy weather. As soon as practicable, the remaining sections were lowered and bolted up securely up to the first set of horizontal struts ; matching pieces were then lowered, the holes marked in the flanges, taken up again, bored, replaced, and the struts and braces fixed in position. The next sections were then lowered up to the second set of struts and braces, when the work had to be discontinued owing again to bad weather. The author hoped, on commencing this paper, to have been able to say that the whole of the work was completed, and without accident of any kind, and such would undoubtedly have been the case had the weather held favourable for another four days, but, unfortunately, when within sight and confidential expectation of a satisfactory ending, an unforseen and somewhat serious accident happened.

On Thursday 2nd inst, a strong wind and heavy sea sprang up, causing work to be discontinued. This was at a period when the two outer cylinders were about thirty-five feet high, the inner cylinders being up to the second strut, or forty feet high. Before stopping the work everything was secured, so far as the unfinished nature of the work would permit ; the whole of the cylinders being completed, as shown on elevation DD, and they were temporarily braced back on to the jetty. During the night the sea increased to a gale, and coming from the N.E., it, as may be seen on the local sketch, struck the jetty in the worst possible position. The quarter buoy having snapped the mooring chain, broke loose and rode on the hawser (twelve-inch), one end of which was fixed to the northern side of the jetty; it then washed into the bay, outside the outer cylinders, carrying the hawser with it, and owing to the strain thus induced by the buoy being driven by the sea, it acted as a lever of about six to one on the top sections of the cylinders, and by also taking them in a diagonal direction to the jetty it literally dragged them over. The flanges in the bottom sections were ripped out, and both cylinders fell, breaking off the shoes holding the struts in position. The inner cylinders owing to their being stayed back on to the jetty remained secure. Had the cylinders been coupled, or had even the second set of struts been fixed, the accident could not have occured, as the whole would have been secured and braced on to the jetty, and the action of the rope on the buoy would have been reduced to a minium, as the strain would have been that of a simple pull, and the point taken above the portion acted upon instead of at the fulcrum on the flange at the rock. The author does not under-estimate the force of the sea itself acting on the cylinders independently of the above cause, but he feels confident that the force of the water acting on the round surface of the cylinders was not nearly sufficient to have caused the damage of itself, although he has no doubt, that it materialy assisted in the result. Whether it was one, or both that caused the accident, it undoubtedly occured during the most critical period of the work, and was such that it was impossible to calculate on, or provide for. When these cylinders are erected and completed with the girders secured in position at the head, and the horizontal and diagonal struts, and vertical diagonal braces in position, they will form a hollow column or pier, having a base to be acted upon of thirty-four feet by thirty-four feet, and the author thinks that there is no sea capable of acting upon it with sufficient force to overturn or destroy it, whatever may have occured lately, and also that they will, as designed, greatly add to the strength and stability of the whole structure, by providing a tie to the jetty at the outer end far stronger than it is possible to obtain by piles or any other means.

On referring to the local sketch it will be seen that the jetty is very greatly exposed, in fact, far more so than any other on the coast. It is protected partially from the south by the headland and by the low long reef; this latter is sufficient to break the full force of the water, yet a large amount is felt, and the breakers over it are very heavy during a gale. From the S.E. to the N.E. it is completely exposed and receives the full force of the sea. The gales which occurred whilst it has been in construction have been numerous and heavy, the waves have risen some feet over the horizontal whalings, and on one occasion the spray reached the deck. During these trying times the works resisted he strains put upon them remarkably well; a sea could be felt striking the end of the jetty, and the strain transmitted through the whole structure to the shore, thus proving the immense value of the longitudinal whalings and diagonal bracing. In designing this work great care was taken not to expose more material to the action of the sea than was absolutely necessary for its safety and durability, it being thoroughly recognised that in this instance an excess of strength (apparent) was virtually an element of weakness; nothing, therefore, has been done more than has been considered absolutely essential to carry out the above object, and what has been done has been completed in the strongest and best possible manner; whether the best means have been adopted to secure the desired end remains to be further proved by the best judge, viz., time. The cost of the work when completed will probably not exceed £12,000. This work has been designed and carried out by the author in conjunction with his brother, Mr. Walter Kerle, who has been, and is, the resident engineer, and who has had the direct charge and management of the whole, great praise being undoubtedly due to him for the manner in which it has been pushed on, and so near completed. Mr. James Coulter has acted during the whole time as foreman of works in a thoroughly efficient manner.