4000*l.* was offered by the legislature for the first and second iron steam-boats of not less than 40-horse power, and not more than 2 feet draught of water, which should succeed in navigating the Murray, from the Goolwa to at least the junction of the Darling.

This encouraging offer produced no effect until the year 1853, when in the month of July, Capt. Francis Cadell navigated round from Sydney a small steamer, which he had built there for the purpose, of 40-horse power. Waiting a favourable opportunity, this little vessel was pushed through the sea-mouth, and, a boat of about 100 tons capacity, having been previously built at the Goolwa to act as a lighter, the first freight-bearing vessels that had ever navigated the waters of the Murray, took their departure from Goolwa on the 25th August, 1853. Gannewarra, above Swan-hill, a distance of 1400 miles from the sea, was reached without accident on the 23rd September.

The following are the dimensions of the steamer, named the *Lady Augusta*, in honour of Lady Young:—Extreme length on deck 105 feet; extreme length of keel, 98 ft. 6 in.; depth of hold, 5 ft. 6 in.; breadth of beam, 12 feet; on the cross guards, 21 feet. She is built altogether on the American principle and model, and cost about 5000*l.* The engines, made at Sydney, are of 20-horse power each. Her total tonnage, including engines, which weigh 30 tons, is 91 tons. Her beams and planking are of New Zealand pine, her timbers are of honeysuckle. She draws 3 feet water when full, and 2 ft. 4 in. when light, and possesses accommodation for sixteen first-class passengers, and half as many second-class.

Encouraged by the success of this undertaking, a company has since been formed for the navigation of the river, to which a Charter of Incorporation has been granted by the local legislature, whereby the liability of the shareholders is limited to double the amount of their shares. Thirteen vessels of all kinds, belonging to this company, are now navigating the Murray, consisting of four paddle steamers of from 40 to 50-horse power, four wooden barges of from 120 to 150 tons, four iron barges from 50 to 150 tons, and a sailing schooner of 100 tons burthen.

PORT ELLIOTT AND GOOLWA RAILWAY, AND HARBOUR IMPROVEMENTS.

The first survey for these, the principal operations in the Murray navigation scheme, was made in 1849-50, by Mr. R. T. Hill, Surveyor to the Harbour Commission, who reported thereon to the commissioners in March 1850. His estimate for a single line of railway, 7 miles in length, with gradients suitable for locomotives, but designed to be worked at first by horses; also wooden jetties at the two termini, with a small breakwater for sheltering that at port Elliott, and moorings at the latter harbour, amounted to 21,100*l.* The line of country is favourable, presenting easy gradients with very light earthworks.

Operations were not commenced until the beginning of 1851.

At that time, the Harbour Commission was no longer in existence, and the engineer, Mr. Hill, who laid out the line, having left the colony, the author was called upon by the government to undertake the execution of these works.

Upon a careful examination of the line, together with the contemplated works, it was found that the sum which had been appropriated was much lower than what would allow of their being executed in so substantial a manner as might have been desirable. But, owing to the then unpopularity of the measure, the Lieut.-Governor was unwilling at that time to sanction any increased amount. This fact, together with the urgency for the early completion of the line, consequent on the government being in a manner pledged to its speedy performance, having already offered a premium for the river navigation, rendered it imperative to reject everything in the construction that would add needlessly to expense, or be a cause of delay in the completion.

The object to be gained was the speedy completion of such means of transit as the funds would allow of; it being judged expedient to leave to the future development of the resources which the opening of the line was calculated to promote, the means for remedying the want of substantiality in the first execution of the work.

The result has completely justified this view. Long before the line was finished, hundreds of acres of land in its vicinity which had been hitherto waste and uncultivated, were eagerly bought up, the price paid for which was sufficient to cover nearly the whole outlay upon the works themselves. Townships were laid out, and a busy and thriving population began to give life and activity to what was before an almost silent wilderness.

The traffic on the railway within the first year after it was opened, was nearly sufficient to pay its working expenses. The line was first opened throughout in May 1854, and the tonnage conveyed along it from that time to March 1855 was 2371 tons, in wheat, flour, stores, and different goods, besides 3780 bales of wool. The receipts during this period were 1000*l.* 11*s.* 7*d.* for goods, and 160*l.* 5*s.* for passengers and parcels. The line is worked by horses. The total cost of the working establishment, as provided in the colonial estimates for the year 1855, is 1622*l.* 4*s.* 6*d.* per annum, consisting of the following items:—

Superintendent .... Salary	£300	0	0
Bookkeeper .... do.	160	0	0
Two Warehousemen and one Breaksman, each 313 days, at 9*s.* 6*d.*	446	0	6
One Teamster (cottage and) 365 days, at 8*s.*	146	0	0
One Labourer, 313 days, at 8*s.*	125	4	0
Increase under Clerk's Salary Act	20	0	0
Incidental expenses	25	0	0
Materials and extra labour for maintenance of line	100	0	0
Forage for horses, repairs to harness, and sundries	300	0	0
Total	£1622	4	6

The execution of this little railway, which has the honour of being the first opened for traffic in the Australian colonies, has justified the assumption on which some lines have been undertaken in the old country, namely, that a railway will make its own traffic. It has done more than this, and more than any English railway could ever have the opportunity of doing; it has not only created traffic, but it has created population—has gathered in its immediate vicinity a thriving community, where was before but an aboriginal waste, and initiated the development of vast lines of internal water communication, whose limits at the present time can scarcely be estimated, but which cannot fail to give a powerful stimulus to the progress of civilisation over the whole of that immense area of country watered by the Murray and its tributaries.

Until the discovery of this navigable river, the occupation of country westward and northward of Sydney and Port Philip, found its limit when the expense of the long and difficult land carriage over the mountainous tracts to these ports became such as to make the settlers' employment cease to be profitable. Thus a large interior tract of country remained unoccupied, not because of any inherent deficiency in natural productiveness, but because of its practical inaccessibility. The opening of the Murray, by giving a western outlet to the sea, has become the means of removing this practical boundary to profitable enterprise, and has at once opened up a new and extensive area for colonisation.

Construction of Railway.

At the time of the commencement of this undertaking, there was in the colony no contractor possessing the means of carrying it out in its entirety. Accordingly the government became in a sense their own contractors, purchasing all the necessary materials and employing a staff of workmen under the control of a resident superintendent. This course, which necessarily involved a greater amount of labour and responsibility on those entrusted with the management of the undertaking, was yet found to possess many advantages. In executing for the first time a work of this nature in a new country, it was anticipated that, in many instances, a departure might be advantageously made from the routine established in a country very differently situated in respect of natural features and material progress. It was convenient, therefore, not to be bound by the strict terms of a pre-arranged contract, but to be able to make such modifications in the mode of carrying out the work as experience should from time to time suggest. For the same reason, a far greater economy could be secured than would have resulted had the whole been let to a contractor, who, to cover the risks attendant on a new work, and the fluctuation in price of labour and materials, must have allowed a considerable margin for profits. A satisfactory proof of this was afterwards given. When the work was considerably advanced, a contractor came forward and offered to complete the whole on certain terms. His offer, on examination, was rejected, because his prices were in general nearly 50 per cent. higher than those at which the work was being actually executed.

Orders were sent to England, through the Agent-General for H.M. Crown Colonies, for the rails, turntables, truck-wheels and axles, and such like materials as could only be procured there. Both the price of iron and freights were at the time favourable to the desired economy, rails being purchased at 5*l.* 1*s.* 3*d.* per ton, and shipped to Port Adelaide for 1*l.* But 2*l.* per ton had to be paid for re-shipping by a coasting vessel from Port Adelaide to Port Elliott, not more than two days' sail.

Fig. 1. Section of Railway—(Scale, 4 feet to 1 inch.)

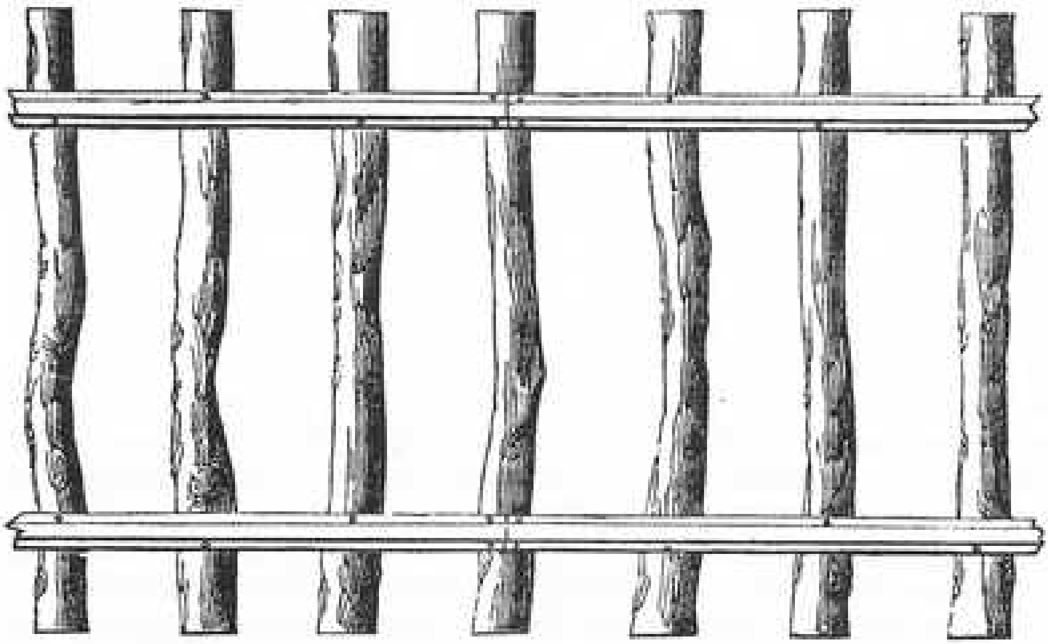


Fig. 2. Plan of Railway—(Scale, 4 feet to 1 inch.)

The weight of rails is 40 lb. to the yard, *foot-rail* section, as shown by the illustration (fig. 1). It was at first intended that the permanent way should be formed by screwing these rails to longitudinal bearers of sawn timber 8 inches by 6 inches, laid edgewise, the narrow face upwards, and supported by cross sleepers of rough timber placed at every 3 feet. On attempting to negotiate for the supply of the sawn timber, difficulties were met with; sawyers were scarce in the colony, and independent in proportion to the smallness of their number. The only way of procuring the required timber was to agree with these men, at a certain price, to go into the *Tiers*—the colonial term for forest country—and fell and saw, and with others for the hire of bullocks and timber wagons for carriage to the works. Little dependance could be placed on the constancy of either of these classes of men; this, and the difficulty and distance of the land carriage over trackless hills and woods, led to the abandonment of the use of longitudinals, with the exception of a few hundred yards of way at the terminal stations, where there would be greater wear and tear.

The price at first paid for sawing was 17*s*. per 100 feet, *colonial measurement*, a peculiar system, according to which the quantity is ascertained by multiplying together the dimensions of two sides of the sawn piece; thus in a scantling 8 by 6, 8 multiplied by 6 = 48, which divided by 12 is 4, this size is then said to contain four measurements; consequently 25 feet lineal would be 100 feet measurement. At this rate, 17*s*. per hundred would be about 2*s*. per cubic foot. The cost of cartage varies with the distance, but the average price per cubic foot delivered was from 2*s*. 6*d*. to 3*s*. The prime cost of the timber was an inconsiderable item, 5*l*. per annum only being paid for the license to cut any quantity on unsold land.

The prices afterwards advanced upwards of 50 per cent. in consequence of the rise in wages which followed the gold discoveries.

The permanent way thus constructed has been found to stand remarkably well, and has hitherto remained untouched by the white ant.

In laying the remainder of the line, transverse sleepers alone were used. Fig. 2 shows the permanent way thus constructed. The rails are screwed to the sleepers by ½-inch coach screws 5 inches long. The sleepers are of native wood, chiefly the eucalyptus, which is hard and durable and not readily attacked by the white ant, though not quite free from the ravages of this destructive insect. They are unhewn, being merely cross cut from the stems of small trees and the branches of larger ones, 8 feet long and averaging 7 inches diameter in the clear of the bark, which is stripped off. They are laid at distances of 2 feet from centre to centre, the largest being selected for the rail junctions. They are slightly adzed at the point where the rail lies upon them, to form a bed for it. The labour in cutting and delivering these sleepers was paid for by piece work; their average cost was rather less than 1*s*. each.

Workmen having experience in plate-laying could not be procured, but a few handy country carpenters were obtained, who soon became tolerably expert; one of whom, with a gang of labourers, could lay about 200 yards of permanent way in a week, at a cost of 1*s*. 9*d*. per lineal yard, including trimming the sleepers.

The earthworks were very light, the country being favourable; the line generally nearly follows the surface. The ruling gradient of one in a hundred, adopted in the original survey, was increased to one in sixty-six for the sake of economy, and as being very well suited to animal traffic. The only cuttings of any consequence are two, situated near the two termini, one is about 170 yards long and 15 feet in the deepest part; the other, 370 yards and 23 feet at the deepest. The ground in both was easy for working; after cutting through 2 or 3 feet of the crust, which consists of the peculiar surface limestone described in a former part of this paper, the remainder was a compact sandy loam.

The earthworks were let piecework to gangs of labourers, the wagons and temporary rails and cattle being supplied them. The two deep cuttings were done at a cost of 1*s.* 3*d.* per cubic yard, the lead averaging a quarter of a mile.

The material used for ballast was the soft siliceous limestone, of which a sufficient quantity was got from the cuttings to supply the whole line. This was broken down small, and very soon became consolidated into a compact substance, in which the sleepers were imbedded, and which formed a firm and hard track for the horses. Common roads have been in some instances made with this material alone, which, as long as the traffic is light, is very durable, while, used for horse traffic alone (no wheels passing over it, and kept well drained), it will stand without sensible wear for years.

The line was not fenced: that was left to be done by the proprietors of lands adjoining the railway, the boundary line being defined by the side ditches. Although the line is laid single, sufficient width of land is taken for a double line.

There is one bridge to carry an accommodation road over the line across the cutting at the Port Elliott terminus. The other public roads cross on the level. No permanent water-courses cross the line, but several considerable waterways had to be left to carry off the land drainage in the wet season.

A commodious building for storing goods is erected at each terminus, together with workshops and a residence and office for the superintendent of the line. The line is laid double at the terminal stations, with turntables to connect them, and cross lines communicating with the stores. There are two intermediate sidings for passing places at about equal distances from the termini. The rolling stock consists of eleven goods trucks and one passenger carriage.

At the Goolwa terminus the rails are carried direct to the water's edge, where a small wharf front is built, affording space for one of the river boats or barges to lie alongside in 12 feet water, and provided with a crane. At the Port Elliott terminus the line is continued to the head of a wooden jetty running 100 feet into the harbour, with 6 feet of water at low tide, provided also with a crane. At this end there is also a weighbridge.

The rise of tide in the harbour is from 4 to 6 feet, but is extremely variable; sometimes in the winter season it will keep nearly up to the high-water mark for weeks together. The effect of the tide is scarcely felt in the lake, the height of water at Goolwa seldom varying so much as 2 feet.

Water Works.

In the immediate locality of the town of Port Elliott there is an absence of water, but at the base of a range of hills lying from one to two miles from the shore some good springs are found. The execution of works for the conveyance of this water to the town and harbour was therefore determined on, for the double purpose of supplying the shipping and the inhabitants.

Levels were taken to a spot one mile distant from the harbour, where several small springs exist. Wells were sunk in three different places, to a depth of about 8 feet, and steined in dry brickwork. The water stood in all of them to the level of the surface. These wells were connected together by covered brick channels, puddled to keep out the surface water, which is slightly brackish. A spot was then selected on the high ground immediately overlooking the harbour, at the same level as the wells at the springs. Here a covered tank was built, 24 feet long, 8 feet wide and 8 feet deep, excavated in the ground and cased with brickwork, the bottom and sides being 9 inches thick, with two cross walls for supporting the sides, the whole laid in mortar. A foot of puddled clay is laid outside the brickwork, which makes the tank effectually water-tight, although the ground in which it is built is entirely sand. The top is covered with 4-inch gum planking, and 2 feet of earth laid over all. By this means the water is preserved at an agreeable temperature in all seasons.

The inhabitants draw their supply of water from the tank by means of a pump placed there for the purpose. An overflow pipe leads from the tank to the level of the railway below, conducting the superfluous water, which is always flowing in a stream, into an open trough for the use of horses and for general purposes.

The shipping is supplied by 2-inch cast-iron pipes leading from the tank to the jetty-head, whence the water is drawn by a hose pipe and stop-cock, direct into the ships' water-casks, which are brought alongside in boats.

Between the springs and the tank, a distance of one mile, the ground dips slightly, the greatest difference of level being about 20 feet. The water is conducted from the springs by a 4-inch pipe. Cast-iron piping not being procurable in the colony at a less price than 40*s*. per cwt., the necessary economy precluded its use, accordingly galvanised tinned iron was used. To compensate as much as possible for the want of durability in this material when laid underground, the pipe was carefully bedded throughout in fine concrete of a thickness of 4 inches all round it. Thus, should the pipe ultimately even entirely corrode away, a clear and indestructible channel would remain in the hardened concrete, the pressure from the head of water not being too great for this material to stand.

Owing to the general dearth of good spring water throughout the colony, particularly in the dry season, it is a common practice to have somewhat similar underground tanks to that here described attached to dwelling houses. The rain water collected from the roofs during the wet season, and stored in these tanks, furnishes a supply during the dry season for all purposes. Rain water so collected and stored, keeps very sweet and good, and is scarcely distinguishable in taste from good spring water.

The clearance and cultivation of the land in this country, although of so recent a date, appears to have already a remarkable effect in the development of permanent land water, where none before existed. In many localities, and particularly on the sloping foot of ranges of hills, numerous springs have from time to time burst forth, forming little perennial streams. A remarkable instance of this occurred during the summer of 1852-3. A new spring suddenly made its appearance not far those whence the water supply for Port Elliott is drawn; over a space of more than an acre the soil was slowly upheaved bodily to a height of about 5 feet above the surrounding level, from all parts of which water oozed out, standing in pools on the top and overflowing in a continuous stream.

Harbour Works.

Besides the jetty already mentioned, at Port Elliott, two moorings have been laid down in the harbour, capable of holding vessels of large size. These are placed under the lee of the small island called Lipson's breakwater. In this situation three or four vessels can ride in perfect safety in any weather, the island forming complete shelter against the south-west winds, which are the prevailing ones. This anchorage is open to the south-east; but little inconvenience is to be apprehended from a heavy sea from that quarter, on account of the shelter afforded by the sweep of the bay in that direction.

A heavy swell almost continually sets in from the south-west between Lipson's breakwater and Freeman's knob. The jetty, however, is well protected from this by the projecting headland of the knob. Goods can be landed at it in almost all weathers; the practice is at present to do this by boats and lighters from the vessels which lie at the moorings. There is seldom sufficient surf in the harbour to prevent this being done.

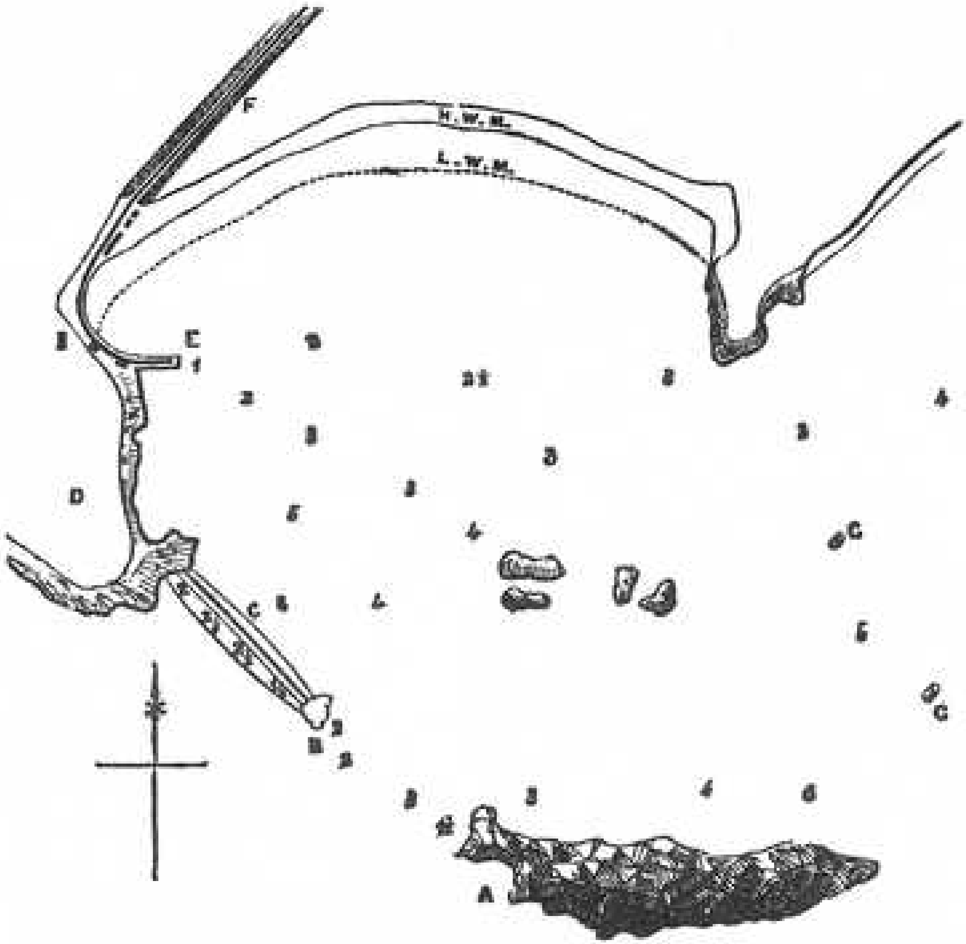
The only work at present executed in the river, besides the small wharf at Goolwa, is the buoying out of the channel from that point across the lake to point Pomond where the Murray enters it.

Cost of Works.

The total cost of the whole of these works connected with the river Murray navigation, including engineering and superintendence, has been 31,000*l.*, of which the railway alone was a little less than 20,000*l.*, being at the rate of about 2857*l.* per mile. There were no parliamentary expenses whatever, and scarcely any for land, as the whole was crown land, with the exception of 12 or 14 acres which had to be purchased, at prices varying from 10*l.* to 20*l.* per acre.

Every circumstance that could tend to reduce the expense of this undertaking was availed of by the government. By executing the works in detail, contractors' profits were saved; the expense of superintendence was confined to the pay of one officer, which was at first four guineas a week, afterwards raised to 4*l.* 16*s.*: the engineering, management, and responsibility of the whole undertaking being borne by the Supervisor of Public Works, who receives a fixed salary in his capacity of head of the Public Works Department.

PORT ELLIOTT HARBOUR.



A, Lipson's Breakwater.—B, Sunken Rock.—C, Breakwater.—D, Freeman's Nob.
E, Jetty.—F, Port Elliott and Goolwa Railway.—G, G', Moorings.

Regarded as the sea outlet for the river Murray navigation, the harbour of port Elliott, though the best that nature had provided, is certainly, in its natural state, not all that could be desired.

The area and depth of water are doubtless sufficient for the accommodation of a large trade, could the whole of that area be made available. The most useful part of it, being that most accessible to the shore, is the portion lying between the jetty and the headland on the eastern side; but this is exposed to the constant set of the sea from the south-west through the opening between Freeman's knob and the island. Could this opening be closed, or even partially closed, the inner part of the harbour would be at once rendered available, and shipping might even lie alongside of wharves on its western side, where there would be direct communication with the railway.

Impressed with the importance of effecting some improvements in this harbour, the Executive in 1852 appropriated 10,000*l.* from the Land Fund for the commencement of a breakwater to be run out from Freeman's knob.

PORT ELLIOTT BREAKWATER.

In the instructions which the author received for carrying out this work, it was directed that the most simple and inexpensive method of construction should be adopted, in order to effect as much as possible with the fund provided.

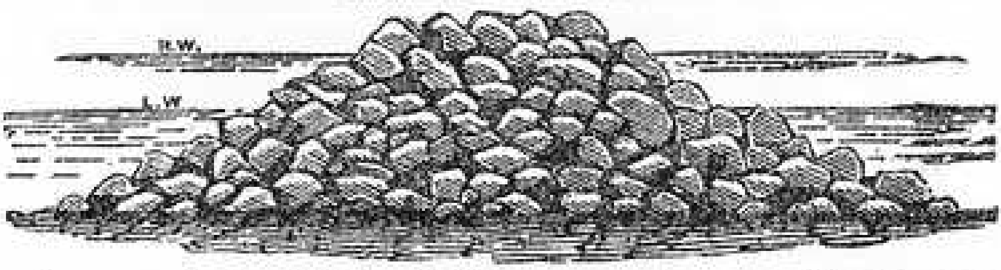
The headland being a mass of fine granite, rising abruptly from the sea to a height of upwards of 100 feet, it was at once determined that this material should be used. The depth of water across the opening varies from 1½ to 3 fathoms at low water, the rise of tide being about 5 feet. About midway there is a sunken rock barely visible at low water. The naval officer of the colony, Capt. Thomas Lipson, R.N., in reporting on this proposed work, recommended that it should be carried only as far as this rock, giving it as his opinion that sufficient shelter would thus be afforded to the harbour, because the swell entering beyond that point would be met by the detached rocks lying within the harbour. He considered it further desirable not to close the opening entirely, because, though vessels generally enter the harbour on its eastern side, it might be convenient sometimes to use this western entrance, there being 3 fathoms water in the middle of it.

The bottom is rocky, and is indeed a sort of reef, the water being deep outside and deepening again immediately within, as will be seen by the soundings.

The whole of this coast is at all times exposed to a very heavy swell; which, on meeting this reef, occasionally rises to something formidable, always breaking across it in heavy weather.

An accurate observation was once taken, during the progress of the works, of the height which a wave sometimes reaches at this place. The level line of the top of the breakwater being taken as a guide, the top of a wave was seen to rise 8 feet above the average water level. It is by no means certain that the trough of a sea is as much below the average level as the crest is above it, but on a moderate calculation the whole perpendicular lift of this wave could not have been less than from 13 to 14 feet.

SECTION OF BREAKWATER.



Any work to withstand this sea must necessarily be very substantial. The following simple method of construction was tried, and has been found perfectly successful. Granite was quarried in large blocks, and at once tipped, after the manner of a railway embankment, in the direction chosen for the work. The top of the breakwater is 21 feet wide and 5 feet above high-water mark. No attempt was made to give any particular slope to the sides, that which they assumed was about two horizontal to one vertical. It was anticipated that, by this method of formation, and by the use of very large blocks, the slope which they at first assumed would suffer no further alteration by the action of the sea; because, by the work being tipped at once to its full height, the lower stones were no sooner dropped than they were at once covered by those above them, being, in addition to their own intrinsic weight, thus held down by the superincumbent mass. The shape of the stones being very angular, they would become so interlocked that it would be scarcely possible for the sea to displace any of them, except perhaps those which lay exposed at the top.

A commencement was made of the work in April 1853. The stones, being quarried, were removed in wagons upon a line of rails laid down and continued along the top of the breakwater, as it progressed. In this manner a length of about 40 yards was first completed. Some little inconvenience was felt at times by the sea, which in bad weather broke quite over, disturbing the line of rails; but not sufficient to make it advisable to go to the expense of a raised staging.

This portion of the work was completed during the winter of 1853, and remained thus without any further additions during the ensuing winter. The exposure which it had during that time to many violent storms, gave satisfactory evidence of the correctness of the principle observed in its construction, not a single stone having been in any way disturbed.

The work was resumed in the summer of 1854, the same method of operations being pursued, but this time in a more systematic manner. A steam engine of six-horse power was first erected, with machinery for hoisting and moving the stones, also smiths' forges, with other conveniences for making and repairing tools; and a double line of rails was laid down upon the breakwater, with branches into the quarry. In a report to the government, dated November 17, 1854, the total cost of the breakwater to reach the midchannel rock, being a length of 211 yards, was estimated at 21,000*l*. This estimate was based on the following data.

Working Establishment.	£	*s.*	*d.*
30 Men blasting and quarrying, at per day 10*s.*	15	0	0
14 Men moving and tipping stones, at per day 9*s.* 6*d.*	6	13	0
4 Blacksmiths and Hammermen....	4	16	0
1 Carpenter	0	14	0
1 Man and boy attending engine....	1	0	0
1 Working Foreman	0	16	0
2 Boys, at per day 4*s.*	0	8	0
2 Boys, at per day 7*s.* 6*d.*	0	15	0
Powder, iron, coals, wood, rope, &c.	11	1	0
Total working expenditure, per day ...	£41	3	0

From previous experience it was reckoned that, with this establishment, an average of 72 cubic yards of stone per day could be deposited. The total quantity of stone in the breakwater when completed, would be 29,596 cubic yards; the quantity at this time remaining to be deposited was 28,028 cubic yards, consequently the estimated time required for completion was 389 working days, which, at the above daily rate of expenditure,

	£	s.	d.
would amount to	£15,955	3	0
The outlay for plant was	2,323	3	10
For stone previously deposited	1,798	16	1
Allowance for contingencies	922	17	1
Estimated total	£21,000	0	0

This is equal to an average of 14*s.* 3*d.* per cubic yard of stone, measured in the breakwater, and of course including interstices.

At the beginning of February 1855, 97 lineal yards of the work was completed, at a cost somewhat *less* than had been estimated. At this time the work, though exposed to much heavy weather, had stood perfectly well.

The sizes of the blocks run about as follows: out of one hundred fifty contain from 60 to 90 cubic feet each; twenty-five from 30 to 60 cubic feet; and twenty-five smaller sizes.

A ton and a-half of powder was used to quarry 6300 cubic yards, or about 8½ ounces to a cubic yard, measured in the breakwater.

Costly as this work may appear when compared with English prices, there is no doubt it was done as cheaply as possible under the circumstances. A contractor, who was quite competent to the undertaking, made an offer to do the whole for 25*s.* per cubic yard, provided the government would incur the necessary outlay for plant. It is needless to say that this offer was not accepted.

Sand tamping was occasionally used in the blasting; it answered very well when the charge was fired by the galvanic battery, but with the patent fuse was apt to blow out.

The following method of blasting was found to answer very well in breaking up small blocks. A cartridge was made containing the requisite quantity of powder, having a small steel wire in the middle of it, with a percussion cap at each end, placed in such a manner that when in the hole, one cap rested on the bottom against the stone, and the other appeared at the top of the cartridge. To fire it, a rod of iron, fitting the hole accurately, was placed upon the cartridge; a sudden blow being given to this, by letting fall a hammer by means of a trigger, the percussion caps immediately exploded and ignited the powder. The blast acted well this way, splitting the stone, but in no case driving out the iron rod. *Two* percussion caps were used merely as a precaution in case one should miss fire.

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