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“The Karori Rock Beacon, Cook Strait, New Zealand.”

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(Abridged.)

COOK Strait, named after the great English navigator, separates the two principal islands of New Zealand, and forms the most important sea highway in the Dominion (*Fig. 1*). Though no formidable dangers to navigation exist in the strait, the heavy tidal currents and frequent gales of wind often drive vessels considerably off their courses, and this, in thick weather, is a matter of grave concern. The tidal stream may, during springs, attain a velocity of 5 knots and upwards, and when running against a heavy gale may cause an overfalling sea, dangerous even to large vessels.

While the entrances to the strait are well marked by lights, the stretch from Pencarrow Head northward, through the narrow and most dangerous part, has hitherto been unlighted. The wreck of the S.S. “Penguin” in 1909, with the loss of some seventy lives, brought about an agitation which resulted in the decision to erect an unwatched lighted beacon on Karori Rock. This rock stands about $\frac{1}{2}$ mile from shore, and, although a pinnacle rock, is surrounded by reefs and foul ground, but only for a short distance outside. It consists of hard greywacke, and at its highest point is about 35 feet above low water. The prevailing winds are almost constantly westerly, but cyclones of large diameter, revolving clockwise, and travelling always from west to east, pass over the strait and cause winds which commence with startling suddenness, particularly from the south, the transition from a state of calm to a storm taking place in a few seconds.

Several designs for the beacon were considered; but, in view of the presence of suitable material on the spot, it was finally decided to erect a structure in monolithic reinforced concrete. The pedestal carrying the lantern, and forming the room in which the gas-cylinders are placed, is made of cast-iron plates

bolted together, the outside being painted with Hartmann white paint. On the summit of the beacon is placed an automatic light apparatus, on the Dalen system, with a lens 800 millimetres in diameter, carried on a cast-iron pedestal. Compressed acetylene

Fig. 1.

gas, dissolved in acetone, is used for illumination, and steel bottles of the usual type are employed for storage. The bottles provide a sufficient supply for 80 days, varying, however, according to season through the use of a sun valve. The characteristic of the light is

$\frac{1}{2}$ second light followed by $3\frac{1}{2}$ seconds darkness. The gas consumption of about 90,000 litres per annum is charged in eighteen bottles, and costs at the factory £26 11s., which, with freight to and from Wellington to Napier, makes the total annual cost about £32. A sun valve is installed to cut off the gas-supply to the main light during daylight, but two pilot-lights, which together consume 20 litres per 24 hours, burn continuously. By this means a saving in gas, averaging about 30 per cent., is effected.

Sand found in patches, and excellent shingle from the beach in the vicinity, were used for the concrete, and conveyed to the rock by a 8-HP. benzine-engine launch 25 feet in length, with $7\frac{1}{2}$ feet beam. The engine was placed aft, so as to leave the forward part free for cargo. The boat, when not in use, was drawn up on the beach over hauling plank-ways by means of a 10-HP. Anderson oil-engine of New Zealand manufacture. This engine served also to drive the concrete-mixer and to convey the shingle up an incline to the bins.

For water-storage purposes a small reservoir, contained within a concrete dam, was constructed in a gully in the hills near by, at an elevation of about 50 feet. The cement was made in New Zealand to the British Standard specification. The proportions adopted for the concrete were 5 shingle, 2 sand, and 1 cement throughout, which yielded a perfectly sound material, with a solid face everywhere when the forms were removed. A few "plums" were incorporated in the mixture in the lower part of the structure. A small jetty, built on wrought-iron-pipe piles, $2\frac{1}{2}$ inches in diameter, facilitated the work of bringing the concrete from the mixer to the boat, and enabled the boat to remain afloat while it was being loaded.

The concrete was placed in buckets, at first made to a special design, each with a capacity of $\frac{1}{3}$ cubic yard, in order to be conveyed to the rock; but later 10-gallon oil-drums, suitably strengthened and fitted to tip, were used with complete success. It required twenty of these drums to contain 1 cubic yard, and in a smooth sea the launch would carry fifteen at a time.

The beacon, illustrated in *Figs. 2 and 3*, consists of a solid reinforced-concrete pillar, vertical on the sides and seaward face, but sloping landward to increase the base and, therefore, the stability in the required direction. The base, in plan, is thus a parallel straight-sided figure, with semi-circular ends. The back slope eliminates the parallel sides, making the summit circular in plan. Steps are formed up the sloping back, with a copper hand-rail on each side. The summit of the beacon is slightly enlarged to increase the

Fig. 2.

platform area, and to prevent, as far as possible, the spray from running up the seaward face and over the top. A heavy parapet built round the top serves to shelter the light. The decision to make the front and sides vertical was governed by the size of the

Fig. 3.

rock, and the necessity of simplifying the boxing required to form the concrete. The casing was designed so as to confine to the straight sides the alteration required at each lift, due to the sloping back. The iron casing was given 3 or 4 inches lap on the lower course of concrete; this formed its only support. On reaching the place where the top splays out, timber casing, first fitted ashore, was used, and the top angle-ring of the iron casing was employed as a foundation for the timber casing, to which it was bolted.

After removing all shaken pieces in the rock and trimming it to a suitable shape for the foundation, holes were drilled, by means of hand-hammer rock-drills, to a depth of 2 feet to 3 feet, to receive mild-steel bars 2 inches in diameter and 8 feet in length, which served as dowels to connect the pedestal with the rock (*Fig. 3*). These, to the number of fifteen, were cemented in place in selected positions. As the surface of the rock was very uneven, rising on one side to a height of 18 feet, and forming a cliff-like face, a number of 1-inch reinforcing rods were driven into the rock, spaced about 2 feet 6 inches apart in each direction (*Fig. 2*). The boxing for the first part of the bottom of the foundation was built of timber, 6-inch by 6-inch corner studs, with 6-inch by 3-inch intermediates, spaced at 18-inch centres, and 8-inch by 1-inch planking to a height of 7 feet, the planking being fixed as the concrete rose. The boxing was secured by lewis bolts cemented into the rock.

On the highest part of the rock a skeleton stage was erected to carry a winch driven by a 5-HP. oil-engine, operated by a friction-clutch. A short derrick jib was also erected, and these facilitated the landing of concrete and other materials. The stage, formed of 3-inch wrought-iron pipe, braced together with 2-inch by 2-inch by $\frac{1}{4}$ -inch angle-bars, with 4-inch by 4-inch by $\frac{1}{2}$ -inch angle-bars at the top, to carry the timber platform on which the winch was placed, was raised from time to time as the work proceeded. The lightness of its construction proved its salvation, as although the rock was often swept by seas during storms, the stage never suffered damage.

The decision to establish a light was arrived at on the 10th December, 1912, and work on the rock, which was commenced on the 19th November, 1913, was completed shortly after the light was first shown, on the 20th October, 1915. The preparation of the rock for the foundation occupied about 4 months. The foundation was completed in 5 months, and the pedestal needed 16 months; the rest of the time was required for fixing the apparatus, crane, and handrails, and generally finishing off the work. The cost of

the beacon, rather increased by boisterous weather, amounted to £4,000, made up as follows:—

	£
Apparatus	1,115
Launch	180
Plant, general, expended	328
Plant, hired—rent	100
Steel reinforcement	268
Cement	217
Labour	1,615
Provisions for workmen	265
Miscellaneous expenses	40
	<hr/>
	£4,128
Deduct value of launch at end of work	128
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Net cost	£4,000

A few of the leading dimensions of the beacon are as follows:—

	Ft.	Ins.
Height from low-water mark to bottom of base	12	6
From bottom of base to top of coping	62	0
From top of coping to focal plane	3	9
	<hr/>	
Total	78	3
Height from top of coping to top of dome	8	8
„ „ low water to top of foundation	30	0
Area of rock at low water	2,928 square feet.	
Total length of rock at low water	122 feet.	
Average width „ „ „	24	„
Height of highest part of rock above low water	30	„
Total volume of concrete	293 cubic yards.	
Maximum quantity of concrete placed in 1 day	8	„ „

The general design was prepared by the Author, the details and drawings being furnished by Mr. J. D. Holmes, Assoc. M. Inst. C.E. The construction was entrusted to Mr. W. A. Fraser under the general direction of the Author.

The Paper is accompanied by five sheets of tracings, from which the Figures in the text have been prepared.