

The Romance of Lighthouse Building.

BY RAY STANNARD BAKER.



LARGE proportion of the lighthouses, which are by far the most important Governmental works for the protection of the mariner, are built on land well above the wash of the sea, where they require only the ordinary skill of the carpenter, the mason, and the iron-worker.

The small remaining residue, the off-shore lights, built in the most difficult and dangerous locations that can be selected, have cost more, both in construction and in subsequent maintenance, than all the others put together. The true sea-builder speaks with something akin to contempt for the ordinary shore-light. He must have tides, breakers, ice-packs, wrecks, fierce currents, and wind-storms to test his mettle and to show what he can do. Not only must he be a skilled engineer and a trained builder, but he has need of the mysterious human elements of courage, executive foresight, resourcefulness in the face of danger, and indomitable perseverance in surmounting obstacles. His work is a constant warfare, and his foe is always vigilant, always cruel and implacable, and in the long stretch of years always victorious. It is with this warfare and with some of the men who have been its heroes that this article has to deal.

In lighthouse-building the stone-tower light easily takes precedence both in age and in the difficulties and dangers which attend its construction. A little more than 140 years ago John Smeaton, maker of odd and intricate philosophical instruments and dabbler in mechanical engineering, was called upon to place a light on the bold reefs of Eddystone, near Plymouth, and it is to him that the world owes the idea of building a lighthouse in the form of a solid stone tower. Twice before the rocks of Eddystone had been marked with a light. The first structure, built by the Winstanley of song and story, was bowled over one night in a storm, and the builder and his keepers were carried to their deaths; the second, the work of John Rudyerd, was burned to the water's edge, and one of the keepers died from the effects of melting lead which fell from the roof and

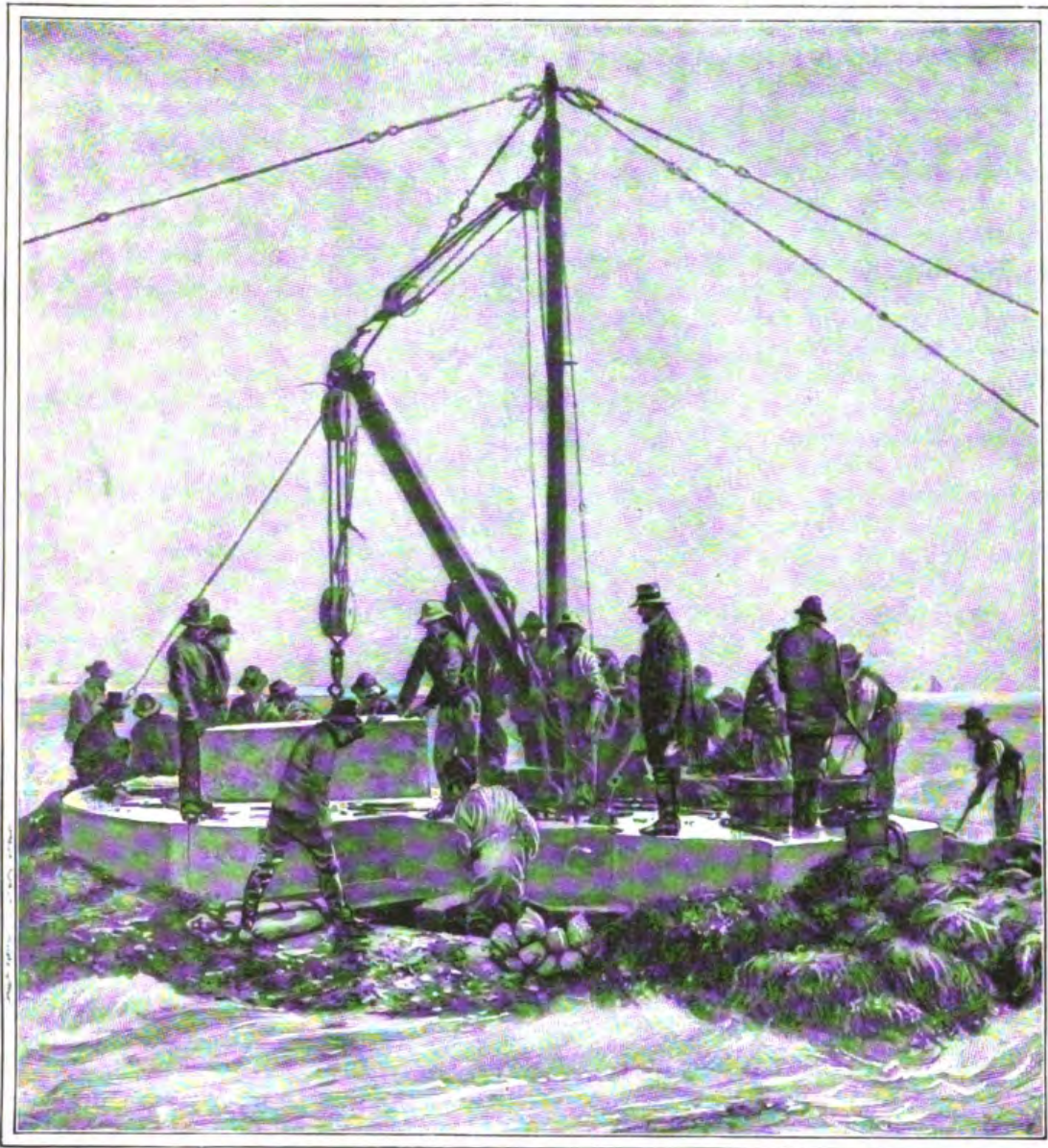
entered his open mouth as he gazed upward. Both of these lighthouses were of wood, the first being ornamented with fantastic balconies and bay windows, which furnished ready leverage for wind and wave.

John Smeaton, profiting by the disasters which befell his predecessors, laid down the principle that the weight of a lighthouse should be as great as possible in proportion to its mass; that it should be built of stone to avoid the possibility of fire; and that the stones should be so fastened together that the tower would resist the force of the waves with a degree of stability equal to that of a monolith. For a suitable model of form Smeaton went back to Nature. In his memoirs he tells with delicious quaintness how he observed the strength with which an oak tree bore its great weight of leaves and branches; and when he built his lighthouse it was wide and flaring at the base, like the oak, and deeply rooted into the sea-rock with wedges of wood and iron. The waist was tapering and cylindrical in section, bearing the weight of the keeper's quarters and the lantern as firmly and jauntily as the oak bears its branches.

With Smeaton as the pioneer, other engineers have dared all manner of difficult tasks, although they have since discarded the flaring base for the straight-sided frustum of a cone. In England the famous lighthouses of Bell Rock, Skerryvore, and Wolf Rock are all stone towers, and in America Minot's Ledge, off Boston Harbour, more difficult of construction than any of them, and Spectacle Reef Light, in Lake Huron, are good examples of this method of building.

In stone-tower lights, as in all other kinds, the first and greatest difficulty which the builder has to meet lies in placing the foundation. For instance, when Captain Alexander began work on Minot's Ledge, in 1855, he had an apparently impossible problem to solve. A bold, black knob of rock lay in the sea just off the south-eastern chop of the bay. At high tide the waters covered it entirely and its place was indicated by a few restless breakers; or, if the water was very calm, by a smooth, oily, treacherous eddy. At the lowest tide it reached a glistening head, laced around with a collar

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LAYING THE LOWEST STONE IN THE STRUCTURE, MINOT'S LEDGE LIGHTHOUSE, BOSTON HARBOUR.
From a Photograph in the possession of the Lighthouse Board, taken at sunrise, Sunday morning, July 4, 1858, three years
after the work was started.

of surf, a few feet above the surface of the water. In thirty years' time forty-three vessels had been dashed to pieces upon it, twenty-seven of which were totally lost, together with their crews. A small light propped on wrought-iron piles already had occupied the rock, but on a stormy night in April, 1851, while the bell in the tower was ringing furiously, the waves and the wind twisted it from its moorings, and hurled it over 100ft. into the sea, carrying its keepers with it.

Upon this ill-fated rock Captain Alexander agreed to build a stone tower 106ft. high and 30ft. in diameter at the base. On his first visit to the reef it was so slippery with sea-moss, and the waves dashed over it so

fiercely, that he could not maintain his footing. Part of the ledge was always covered with water and the remainder, even at low tide, was never bare more than three or four hours at a time.

Captain Alexander sent a crew of men to the rock to scrape it clear of weeds and to cut level steps on which they could maintain a firm footing. They worked with desperate energy. When a great wave came rolling in from the sea the foreman shouted and they all fell on their faces, clinging together, and held their breath until the rock was bare again. Sometimes, when a storm blew up suddenly and the boats dared not approach near enough to effect a landing, the boatswain was accustomed to cast out a line. One

of the workmen would seize it, make it fast to his wrist, and plunge boldly into the sea. Then the sailors would pull him in like a great, clumsy cod. Working in instant danger of their lives, and continually drenched and suffering from the smarting of salt-water sores, Captain Alexander's men were able to cut only four or five little holes in the rock during the whole of the first season. And yet they could console themselves with the fact that it took Winstanley, of the first Eddystone light, four years to drill twelve foundation-holes and fit them with iron rods.

In the second year the workmen succeeded in building an iron platform 20ft. above low water. Ropes were stretched between the piles on which it rested, and when the waves were high the men clung to them to prevent being washed into the sea. The next winter a big coast-wise bark, driven in by a storm, swept away the platform, crushed the face of the rock, and ruined two years of hard work in a single night. In the third year the workmen succeeded in laying four foundation-stones, and in the fifth year the six lower courses of the tower were completed. The work of fitting the stones in place was full of excitement. Stout bags of sand were swung on a crane from a boat to the rock. While they were pitching and tossing in the air the men caught them and piled them up in the form of a small pen and rammed them firmly together. Sometimes it took three or four staggering men, each clinging with one hand to the life-ropes, to handle a single bag. The inside of this primitive coffer-dam was then baled out



MINOT'S LEDGE LIGHTHOUSE AS IT NOW APPEARS.

and wiped dry with a sponge. Meantime the men on the boat had prepared the stone by laying it on a piece of thin muslin covered with mortar, like a mustard plaster. The edges of the muslin were then drawn up around the top of the stone and it was lowered into the coffer-dam. Each stone was dovetailed so that it fitted closely into the stone next adjoining it in the course. The difficulty of fitting a stone held aloft on a swinging crane with the waves dashing around the workmen's legs can well be imagined. Quantities of sledges and drills were swept from the rock and lost. One of the more inventive workmen conceived the idea of wearing a life-belt and fastening his sledge to his wrist. This scheme was generally adopted, and it worked admirably until a breaker washed one of the men off the rock. Owing to the weight on his wrist his head went down, and only his legs were left sprawling above the surface of the water. He was rescued with the greatest difficulty.

In five years' time the light was finished, "rising sheer out of the sea," as Longfellow described it, "like a huge stone

cannon, mouth upward." It cost the Government \$300,000.

The devotion and the loyalty of the lighthouse builder approach the enthusiasm of the soldier in the heat of battle. When the first of the Stephensons was building the Bell Rock Light on the famous Inch-Cape Reef, his Scotchmen worked with the desperation of despair. Only two could remain on the rock at a time, but they stuck there with the tenacity of leeches, the cold water of the north seas bearing down every few

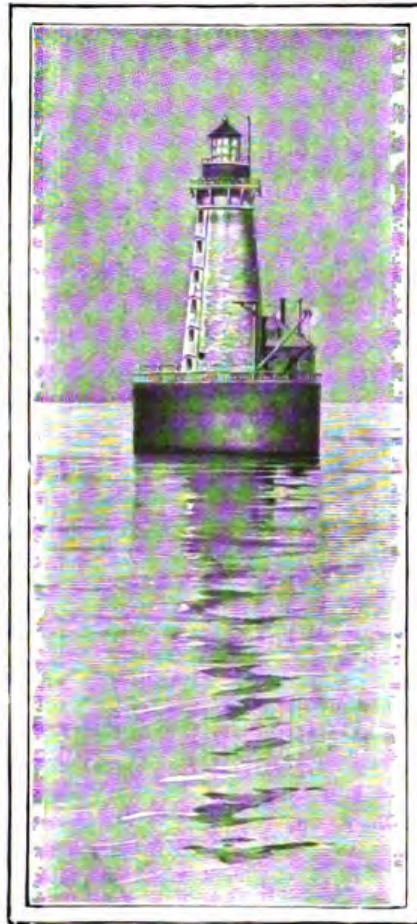
minutes and whipping entirely over them. In describing the progress of the work Stephenson tells with quaint humour how the drenched workers were cheered by a sailor on board the work ship, who played sweetly on a German flute. Iron rods were fastened into the reef to hold the courses of the tower. When the first stone was at last swung out on the tipsy crane the Scottish workmen, ragged and chilled and worn with the awful struggle, clung to the iron rods and cheered madly, like soldiers just over the crest of an enemy's fort.

One of the most difficult of all stone-tower lighthouses to build was the Spectacle Reef Light, in the northern end of Lake Huron, near the Straits of Mackinac. Here the problem dealt not with tides or heavy seas, but with the crushing force of the ice-packs that came down out of the north and moved with all the mighty power of a glacier. Moreover, the tower must be placed on a lone rock lying over ten miles from land and 11 ft. under the surface of the water. At first the engineers declared the feat impossible of accomplishment, but the wreck of a number of valuable vessels on the reef spurred them to attempt the task. The plans were drawn by General O. M. Poe, who was Sherman's chief engineer on the famous march to the sea. An enormous wooden crib, 92 ft. square, 24 ft. high, and having a space within 68 ft. square, was built at a harbour twelve miles away, and towed out to the site of the proposed lighthouse. Here it was sunk to the bottom and weighted with stone, thereby forming a quiet pond in which the work could be prosecuted. A great bottomless tub, 36 ft. in diameter, and having staves 14 ft. long, was now built and suspended exactly over the site of the tower. A rope of oakum was tacked to its lower edge, and a diver having cleaned off the rock foundation the tub was lowered into the water. Where the lake bottom was irregular

the staves were mauled down until each of them pressed close down on the rock. Then the divers, toiling in the icy water, filled all the openings around the bottom of the tub with hay and Portland cement. A huge pump sucked all the water out of the tub, and the rock lay clean and bare, ready for the workmen.

Owing to the approach of winter great haste was necessary to secure the preliminary work, so that it would not be affected by the

ice. Not infrequently the men were called out at three o'clock in the morning, and they were allowed only a few minutes for meals during a day's work that often lasted from eighteen to twenty-one hours. During the last days of the season snow and sleet fell almost constantly, and the waves frequently dashed over the breakwater, keeping the men drenched. The next summer the work was continued with renewed zeal. For the first 34 ft. the tower was built of solid masonry 32 ft. in diameter, the stones all dovetailed firmly together, and the courses attached one to another with heavy iron rods. As in all other lighthouses, the builders used Portland cement, which possesses the remarkable property of becoming as hard as the hardest rock, whether used under the water, or outside of it like ordinary mortar. By mixing Portland cement with sand and gravel the



THE LIGHTHOUSE ON SPECTACLE REEF,
LAKE HURON.

builder produces concrete, without which modern lighthouse building would be almost an impossibility. In effect, therefore, the Spectacle Reef light for 34 ft. of its height became a single massive rock, capable of enormous resistance. In the top of the tower five keepers' rooms were built one above the other and connected with spiral stairways. Far up at the pinnacle stands the cylindrical box of iron and glass which protects the light. The cost of the Spectacle Reef tower was \$375,000. In the spring after it was finished the work of the builders was given a remarkable test. The keepers, returning

to their sturdy charge, found the hitherto irresistible ice-pack piled to a depth of more than 30ft. around the tower, so that they had to cut their way in to the door.

Following General Poe's plans a similar lighthouse was afterwards constructed on Stannard's Rock, in Lake Superior.

Even more terrible difficulties and dangers were encountered in building Tillamook Lighthouse, off the coast of Oregon. While

expedition was headed by an experienced English lighthouse builder named Trewavas. When he reached the rock it was edged with surf, although the sea outside was almost wholly calm. When the boat was swept up close to the rock he and one of the sailors leaped for shore. Trewavas stumbled, and was carried out to sea and drowned in sight of his boat's crew.

One of the earliest and oddest difficulties



A STORM AT THE TILLAMOOK ROCK LIGHTHOUSE, OREGON.

its foundation is not submerged, by virtue of its exposed position in the ocean, it belongs properly among the off-shore lights. The island rock on which it rests rises a sheer 80ft. above a brawling sea and resembles a great, bushy lion's head. It is only a mile from the mainland, but the nearest harbour, owing to the precipitous shores, is twenty miles away at the mouth of the Columbia River. So violent are the waves that break around the ragged edges of the island that it was only with the utmost difficulty that the surveyors made their first landings. One

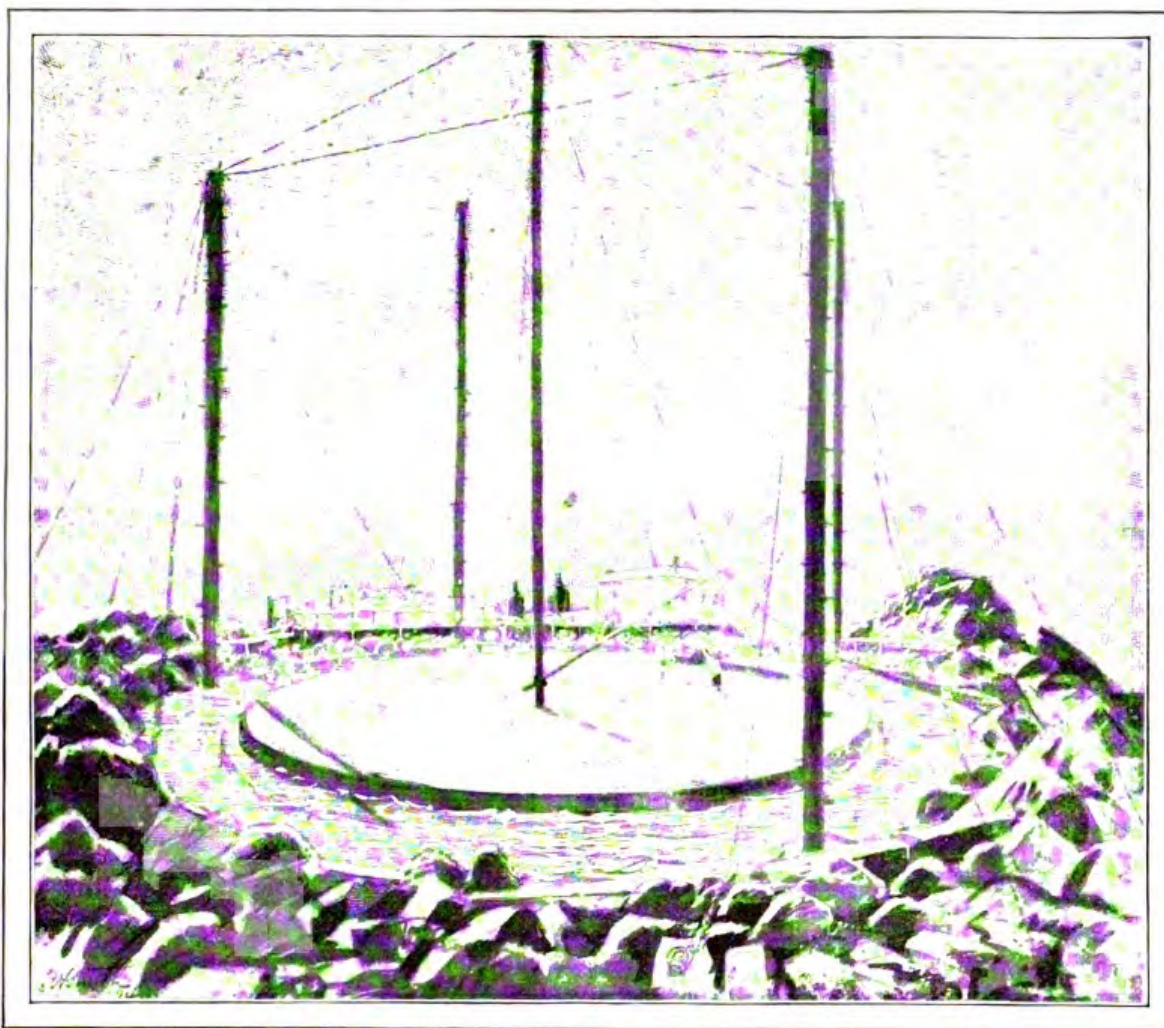
with which the Tillamook builders had to contend was an immense herd of sea-lions which defended their ancient citadel with persistent valour. Before the workmen were allowed undisputed possession they were compelled to arm themselves and drive the herd repeatedly into the sea.

Owing to the great difficulty in making landings most of the workmen were sent to the rock in a breeches-buoy. A thick hawser was stretched from the summit of the island to the mast of a ship lying 300ft. away in calm water. Along this travelled the buoy,

which consisted of a life-preserver fastened to a stout pair of breeches cut off at the knees. Sometimes when the water was a trifle rough, giving the ship a rolling motion, the hawser would slacken suddenly, let the buoy and its passenger drop with sickening velocity into the sea, and then snatch him out, and hurl him fiercely a hundred feet in the air. Only men of seasoned pluck could be persuaded to make this trip at all. A large crew were finally landed with supplies enough to last them several months, and at the coming of winter and rough weather the ship was compelled to leave them to their fate. One night in January a tornado drove the waves entirely over the rock, crushing the tent in which the men slept and washing away most of their provisions and nearly all their tools, clothing, and equipment. For days at a time in the coldest weather of a northern winter they were compelled to lie clinging to the slippery rock, drenched with icy water, covered with

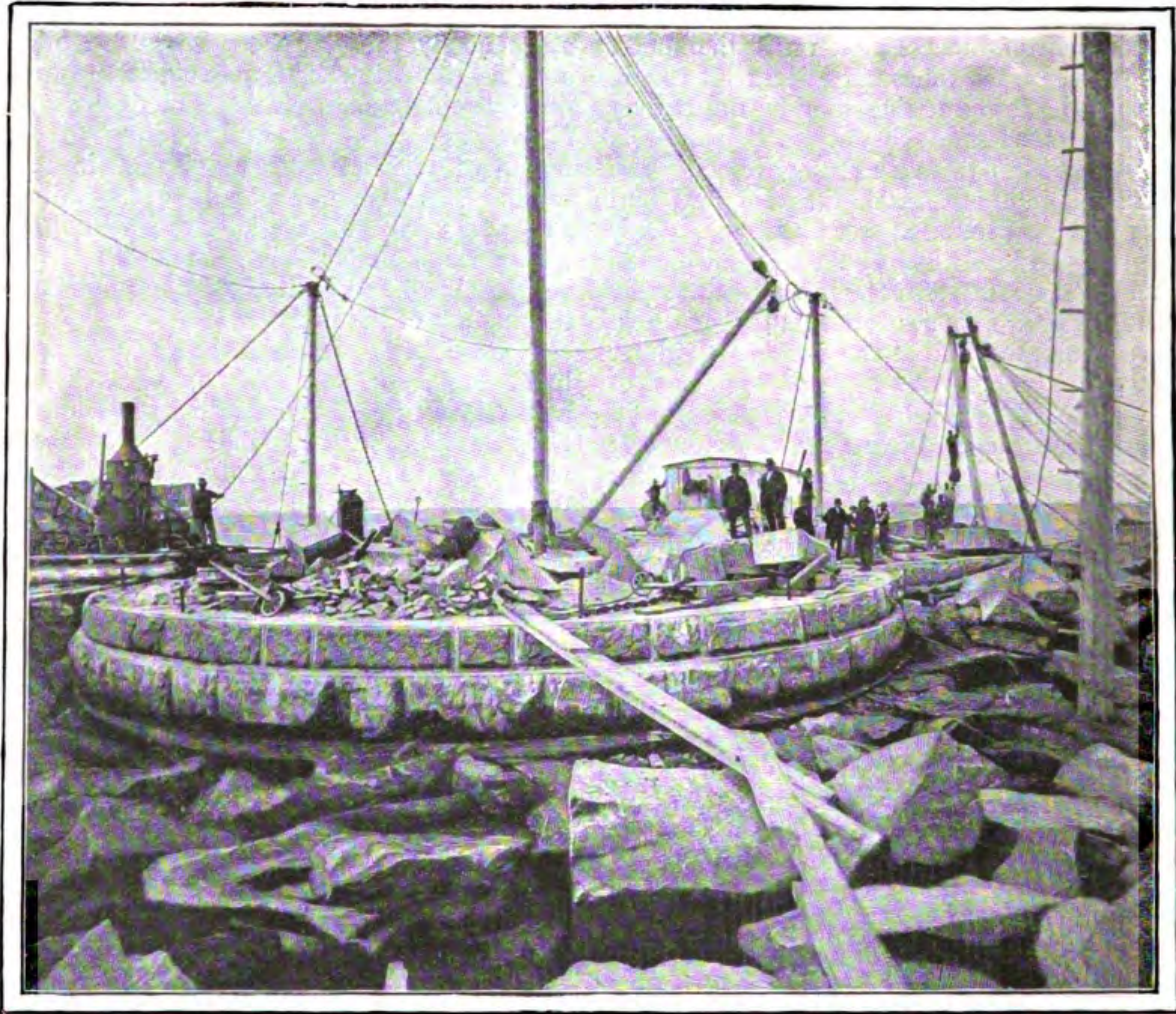
swiftly succeeding storms of snow and sleet, and cut by the sharp sea-winds. During all this time they had no sufficient means of warming themselves, practically no fresh water to drink, and nothing to eat but hard tack and bacon, soaked in sea-water. Few Arctic explorers ever had to suffer the perils of privations to which these lighthouse builders were subjected. And yet they lived and built a great lighthouse on the summit of the rock.

Colonel G. L. Gillespie, the engineer who had charge of this great work, tells an amusing story of the difficulties of the lighthouse establishment in finding a cook who was willing to live on the rock, cut off wholly for months at a time from communication with the outside world. Finally a portly, good-natured German named Greuber agreed to accept the position. He was promptly sent down to Tillamook, but when he saw the tossing breeches-buoy in which he was



CONSTRUCTION OF THE RACE ROCK LIGHTHOUSE, LONG ISLAND SOUND.

This picture, showing the state of the foundation on September 5, 1874, is from a Sketch by Mr. F. Hopkinson Smith, the constructing engineer.



CONSTRUCTION OF THE RACE ROCK LIGHTHOUSE.

This picture, from a Photograph lent by Mr. F. Hopkinson Smith, shows the progress made in the construction on September 15, 1874. (See picture on preceding page.)

expected to make the passage to the rock he held fast to the rail of the ship.

"I am too fat," he explained.

On his return to Astoria his friends made so much fun of him that he declared he would go to the rock if it killed him. He turned as white as chalk when the buoy was strapped around him, but he made the trip without even wetting his feet. After that, however, nothing would persuade him to venture again in the perilous buoy, and he died recently on the rock after nearly sixteen years of steady service.

In the construction of Race Rock Light, in Long Island Sound, the builders also found themselves confronted by great difficulties and dangers. The foundation-rock is just off Fisher's Island Sound at the mouth of the Race, where the water rushes both ways, according to the tide, with great violence and force. A quantity of stone riprap was thrown into the swift water, where it

was arranged by divers and then covered with a circular mass of concrete, on which a tower of solid granite was constructed.

A stone-tower lighthouse bears much the same relation to an iron-pile lighthouse that a sturdy oak bears to a willow twig. One meets the fury of wind and wave by stern resistance, opposing force to force; the other conquers its difficulties by avoiding them. The principles of construction of the two are entirely different, and the builder of the screw-pile or disc-pile light is confronted by his own peculiar problems and dangers.

A completed iron-pile lighthouse has the odd appearance of a huge, ugly spider standing knee-deep in the sea. Its squat body is the home of the keeper, with a single bright eye of light at the top, and its long, spindly legs are the iron piles on which the structure rests. Thirty years ago lighthouse builders were much enamoured with the ease and apparent durability of the pile light. An

Englishman named Mitchell had invented an iron pile having at the end a screw not unlike the point of a large auger. By boring a number of these piles deep into the sand and using them as the foundation for a light but durable iron building, he was enabled to construct a lighthouse in a considerable depth of water at a small expense. Later builders have used ordinary iron piles which are driven into the sand with heavy sledges. Waves and tides play readily through the open work of the foundation, the legs of the spider, without disturbing the building overhead. For southern waters, where there is no danger of moving ice-packs, lighthouses of this type have been found very useful, although the action of the salt water on the iron piling necessitates frequent repairs. More than eighty lights of this description dot the shoals of Florida and adjoining States. Some of the oldest ones still remain in use in the north, notably the one on Brandywine Shoal, in Delaware Bay, but it has been found necessary to surround them with strongly built ice-breakers.

Two magnificent iron-pile lights are found on Fowey Rocks and American Shoals, off the coast of Florida, the first of which was built with much difficulty.

Fowey Reef lies five miles from the low coral island of Soldier Key. Northern storms sweeping down the Atlantic rush in wild breakers over the reef and out upon the little Key, often burying it entirely under a torrent of water. Even in calm weather the sea is rarely quiet enough to make it safe for a vessel of any size to approach the reef. The builders erected a stout elevated wharf and store-house on the Key, and brought their men and tools to await the opportunity to dart out when the sea was at rest and begin the work of making the reef. Before shipment the lighthouse, which was built in

the north, was set up complete from foundation to pinnacle and thoroughly tested.

At length the workmen were able to stay on the reef long enough to build a strong working platform 12ft. above the surface of the water and set on iron-shod mangrove piles. Having established this base of operations in the enemy's domain, a heavy iron disc was lowered to the reef, and the first pile was driven through the hole at its centre. Elaborate tests were made after each blow of

the sledge, and the slightest deviation from the vertical was promptly rectified with block and tackle. In two months' time nine piles were driven 10ft. into the coral rock, the workmen toiling long hours under a blistering sun. When the time came to erect the superstructure the sea suddenly awakened, and storm followed storm, so that for weeks together no one dared venture out to the reef. The men rusted and grumbled on the narrow docks of the Key, and work was finally suspended for an entire winter. At the first attempt to make a landing in the spring a tornado drove the vessels far out of their course. But a crew was finally placed on the working platform with enough food to last them several weeks, and there they stayed suspended between the sea and the



THE FOWEY ROCKS LIGHTHOUSE, FLORIDA.

sky until the structure was complete. This lighthouse cost \$175,000.

The famous Bug Light of Boston and Thimble Light of Hampton Roads, Virginia, are both good examples of the screw-pile lighthouse.

Another class of lighthouse, quite different from either of those already described, consists of a solid iron tower with a core of concrete, in the construction of which the sea-builder touches the pinnacle of his art. Here is a sandy shoal marked only by a white-fringed breaker. The water rushes over it in swift and constantly varying cur-

rents, and if there is a capful of wind anywhere on the sea it becomes an instant menace to the mariner. The shore may be ten or twenty miles away—so far, that a land light would only lure the seaman into peril instead of guiding him safely on his way. A lightship is always uncertain: the first great storm may drive it from its moorings, and leave the coast unprotected when protection is most necessary. Upon such a shoal, often covered from 10ft. to 20ft. with water, the builder is called upon to construct a lighthouse, laying his foundation in shifting sand, and placing upon it a building strong enough to withstand any storm, or the crushing weight of wrecks or ice-packs. Such is the problem that has been successfully solved at many dangerous shoals along the American coast.

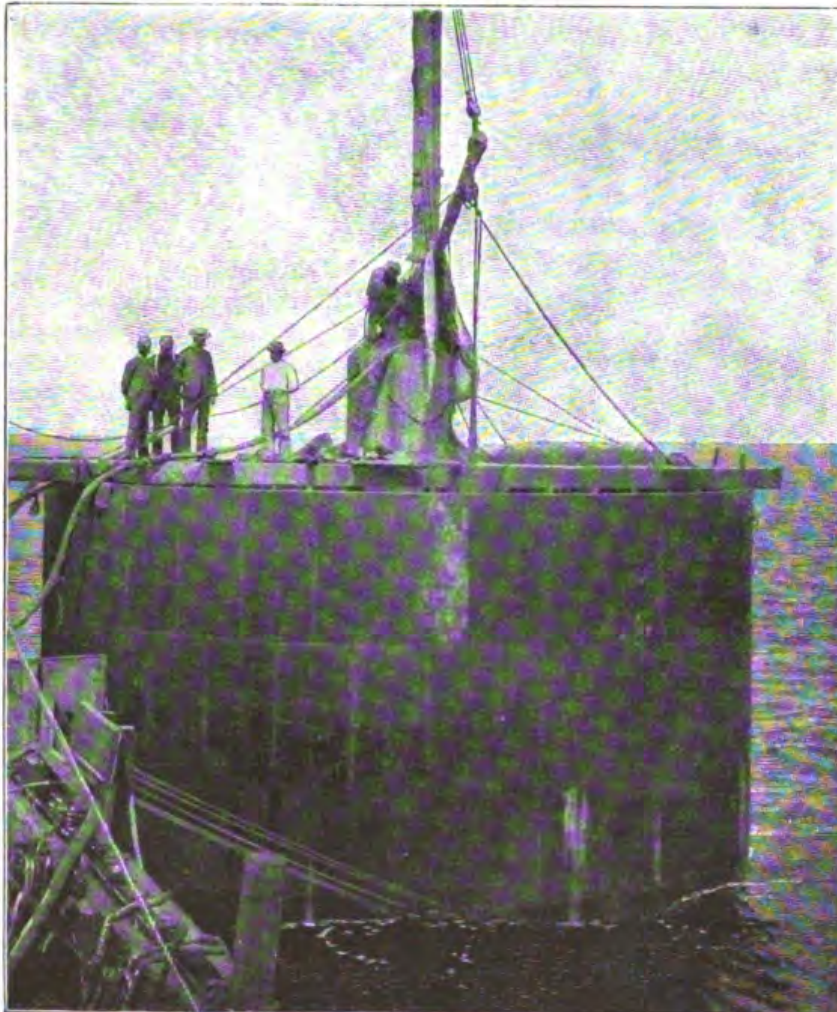
It was less than twenty years ago that the sea-builders first ventured to grapple with the difficulties presented by these off-shore shoals. In 1881 Germany built the first cylinder iron lighthouse at Rothersand, near

the mouth of the Weser River, and three years later the Lighthouse Establishment of the United States planted a similar tower on Fourteen Foot Banks, over three miles from the shores of Delaware Bay, in 20ft. of water. Since then many hitherto dangerous shoals have been marked by new lighthouses of this type.

When a builder begins a stone-tower light on some lonely sea rock, he says to the sea, "Do your worst. I am going to stick here until this light is built, if it takes a hundred years." And his men are always on hand in fair weather or foul, dropping one stone to-day and another to-morrow, and succeeding by virtue of steady grit and patience. The builder of the iron cylinder light pursues an exactly opposite course. His warfare is more spirited, more modern. He stakes his whole success on a single desperate throw. If he fails, he loses everything; if he wins, he may throw again. His lighthouse is built from foundation caisson to lantern a hundred or a thousand miles away.

It is simply an enormous cast-iron tube made in sections or courses, each about 6ft. high, not unlike the standpipe of a village water-works. The builder must set up this tube on the shoal, sink it deep into the sandy bottom, and fill it with concrete so that it will not tip over. At first sight such a feat would seem absolutely impossible, but the sea-builder has his own methods of fighting. With all the material necessary to his work, he creeps up on the shoal and lies quietly in some secluded harbour until the sea is calmly at rest, suspecting no attack. Then he darts out with his whole fleet, plants his foundation, and before the waves and the wind wake up he has established his out-works on the shoal.

Last year W. H. Flaherty, of New York,



THE FOUNDATION CYLINDER.

built such a lighthouse at Smith's Point, in Chesapeake Bay. At the mouth of the Potomac River the opposing tides and currents have built up shoals of sand extending eight or ten miles out into the bay. Here the waves, sweeping in from the open Atlantic, sometimes drown the side-lights of the big Boston steamers. The point has a grim story of wrecks and loss of life; last year alone four sea-craft were driven in and swamped on the shoals. The Lighthouse Establishment planned to set up the light just at the edge of the channel, about eight miles from shore, and 120 miles south of Baltimore.

Eighty thousand dollars were appropriated for doing the work. In August, 1896, the contractors formally agreed to build the lighthouse for \$56,000, and, more than that, to have the lantern burning within a single year.

By the last of September a huge, unwieldy foundation caisson was framing in a Baltimore ship-yard. It was made in the form of a bottomless box 32ft. square and 12ft. high, with the top nearly as thick as the height of a man, so that it would easily sustain the weight of the great iron cylinder soon to be placed upon it. It was lined and caulked, painted inside and out, to make it air-tight, and then dragged out into the bay, together with half an acre of mud and dock timbers. Here the workmen crowned it with the first two courses of the iron cylinder—a collar 30ft. in diameter and about 12ft. high. Inside of this a second cylinder, a steel air-shaft, 5ft. in diameter, rose from a hole in the centre of the caisson, thus providing a means of entrance and exit when the structure should reach the shoal.

Upon the addition of this vast weight of iron and steel, the wooden caisson, although it weighed nearly a hundred tons, disappeared completely under the water, leaving in view only the great black rim of the iron cylinder and the top of the air-shaft.

On April 7th of the next year the fleet was ready to start on its voyage of conquest. The whole country had contributed to the expedition. Cleveland, Ohio, furnished the iron plates for the tower; Pittsburg sent steel and machinery; South Carolina supplied the enormous yellow pine timbers for the caisson; Washington provided two great barge-loads of stone; and New York City contributed hundreds of tons of Portland cement and sand and gravel, it being cheaper to bring even such supplies from the north than to gather them on the shores of the bay.

Everything necessary to the completion of the lighthouse and the maintenance of eighty-eight men was loaded aboard ship; and quite a fleet it made as it lay on the bay in the warm spring sunshine. The flag-ship was a big double-deck steamer, 200ft. over all, once used in the coastwise trade. She was loaded close down to her white lines, and men lay over her rails in double rows. She led the fleet down the bay, and the two tugs and seven barges followed in her wake like a flock of ducklings. The steamer towed the caisson at the head of a long hawser. It had an unwieldy, top-heavy swagger, like a tipsy Dutchman.

In three days the fleet reached the lighthouse site. During all this time the sea had been calm, with only occasional puffs of wind, and the builders planned, somewhat exultantly, to drop the caisson the moment they arrived.

But before they were well in sight of the point the sea awakened suddenly, as if conscious of the planned surprise. A storm blew up in the north, and at sunset, on the 10th of April, the waves were washing over the top of the iron cylinder and slapping it about like a boy's craft. A few tons of water inside the structure would sink it entirely, and the builder would lose months of work and thousands of dollars.

From a rude platform on top of the cylinder two men were working at the pumps to keep the water out. When the edge of the great iron rim heaved up with the waves they pumped and shouted, and when it went down they struggled and clung for their lives.

The builder saw the necessity of immediate assistance. Twelve men scrambled into a lifeboat, and three waves later they were dashed against the rim of the cylinder. Here half of the number, clinging like cats to the iron plates, spread out a sail canvas and drew it over the windward half of the cylinder, while the other men pulled it down with their hands and teeth and lashed it firmly into place. In this way the cylinder shed most of the wash, although the larger waves still scuttled down within its iron sides. Half of the crew were now hurried down the rope ladders inside of the cylinder, where the water was nearly 3ft. deep and swashing about like a whirlpool. They all knew that one more than ordinarily large wave would send the whole structure to the bottom, but they dipped swiftly and passed up the water without a word. It was nothing short of a battle for life. They must keep the water down or drown like rats in a

hole. They began to work at sunset, and at sunrise the next morning, when the fury of the storm was somewhat abated, they were still at work, and the cylinder was saved.

The swells were now too high to think of planting the caisson, and the fleet ran into the mouth of the great Wicomico River to await a more favourable opportunity. Here the builders lay for a week. To keep the men busy some of them were employed in mixing concrete, adding another course of iron to the cylinder, and in other tasks of preparation. The crew was composed largely of Americans and Irishmen, with a few Norwegians, the ordinary Italian or Bohemian labourer not taking kindly to the risks and terrors of such an expedition. Their number included carpenters, masons, ironworkers, bricklayers, caisson men, sailors, and a host of common shovellers. The pay varied from twenty to fifty cents an hour for time actually worked, and the builders furnished meals of unlimited ham, bread, and coffee.

On April 17th, the weather being calmer, the fleet ventured out stealthily. A buoy marked the spot where the lighthouse was to stand. When the cylinder was exactly over the chosen site the valves of two of the compartments into which it was divided were quickly opened, and the water poured in. The moment the lower edge of the caisson, borne downward by the weight of the water, touched the shoal, the men began working with feverish haste.

Large stones were rolled from the barges around the outside of the caisson to prevent the water from eating away the sand and tipping the structure over. In the meantime a crew of twenty men had taken their places in the compartments of the cylinder still unfilled with water. A chute from the steamer vomited a steady stream of dusty concrete down upon their heads. A pump drenched them with an unceasing cataract of salt water. In this terrible hole they wallowed and struggled, shovelling the concrete mortar into place and ramming it down. Every man on the expedition, even the cooks and the stokers, were called upon at this supreme moment to take part in the work. Unless the structure could be sufficiently ballasted while the water was calm, the first wave



"THE SKY HAD TURNED BLACK AND THE WAVES RAN HIGH."

would brush it over and pound it to pieces on the shoals.

After two hours of this exhausting labour the captain of the steamer suddenly shouted the command to cast away.

The sky had turned black and the waves ran high. All the cranes were whipped in, and up from the cylinder poured the shovellers, looking as if they had been freshly rolled in a mortar-bed. There was a confused babel of voices and a wild flight for the steamer. In the midst of the excitement one of the barges snapped a hawser, and being lightened of its load it all but turned over in a trough of the sea. The men aboard her went down on their faces, clung fast and shouted for help, and it was only with difficulty that they were rescued. One of the lifeboats, venturing too near the iron cylinder, was crushed like an egg-shell, but a tug was ready to pick up the men who manned it.

So terrified were the workmen by the dangers and difficulties of the task that twelve of them ran away that night without asking for their pay.

On the following morning the builder was appalled to see that the cylinder was inclined more than 4ft. from the perpendicular. In spite of the stone piled around the caisson, the water had washed the sand from under one edge of it, and it had tipped part way over. Now was the pivotal point of the whole enterprise. A little lack of courage or skill, and the work was doomed.

The waves still ran high, and the freshet currents from the Potomac River poured past the shoals at the rate of six or seven miles an hour. And yet one of the tugs ran out daringly, dragging a large barge-load of stone. It was made fast, and although it pitched up and down so that every wave threatened to swamp it, and every man aboard was sea-sick, they managed to throw off two hundred tons more of stone around the base of the caisson on the side toward which it was inclined. In this way further tipping in that direction was prevented, and the action of the water on the sand under the opposite side soon righted the structure.

Beginning on the morning of April 21st the entire crew worked steadily for forty-eight hours, without sleeping or stopping for meals more than fifteen minutes at a time. When at last they were relieved they came up out of the cylinder shouting and cheering, because the foundation was at last secure.

The structure was now about 30ft. high, and filled nearly to the top with concrete.

The next step was to force it down 15½ft. into the hard sand at the bottom of the bay, thus securing it for ever against the power of the waves and the tide. An air-lock, which is a strongly-built steel chamber about the size of a hogshead, was placed on the top of the air-shaft, the water in the big box-like caisson at the bottom of the cylinder was forced out with compressed air, and the men prepared to enter the caisson.

No toil can compare in its severity and danger with that of a caisson-worker. He is first sent into the air-lock and the air-pressure is gradually increased around him until it equals that of the caisson below, then he may descend. New men often shout and beg pitifully to be liberated from the torture. Frequently they bleed at the ears and nose, a terrible clutching comes at the throat, and for a time their heads throb as if about to burst open.

In a few minutes these pains pass away, the workers crawl down the long ladder of the air-shaft, and begin to dig away the sand of the sea bottom. It is washed high around the bottom of a 4in. pipe, which leads up the air-shaft and reaches out over the sea. A valve in the pipe is opened, and the sand and stones are driven upward by the compressed air of the caisson and blown out into the water with tremendous force. As the sand is mined away the great tower above it slowly sinks downwards, while the subterranean toilers grow sallow-faced, yellow-eyed, become half deaf, and lose their appetites.

When Smith's Point Light was within 2ft. of being deep enough the workmen had a strange and terrible adventure.

Thirty-five men were in the caisson at the time. They noticed that the candles stuck along the wall were burning a lambent green. Black streaks, that widened swiftly, formed along the white-painted walls. One man after another began staggering dizzily, with eyes blinded and a terrible burning in the throat. Orders were instantly given to ascend, and the crew, with the help of ropes, succeeded in escaping. All that night the men lay moaning and sleepless in their bunks. In the morning only a few of them could open their eyes, and they all experienced the keenest torture in the presence of light. Bags were fitted over their heads and they were led out to their meals.

That afternoon Major E. H. Ruffner, of Baltimore, the Government inspector for the district, appeared with two physicians. An examination of the caisson showed that the

men had struck a vein of sulphuretted hydrogen gas. When the air-lock was opened the stench became almost unendurable, even at a steamer's length from the cylinder.

Here was a new difficulty—a difficulty never before encountered in lighthouse construction. When the builder found he could not rid the caisson of gas even by repeated flooding, he laid the case before the inspector. In consideration of the fact that an apparently insurmountable obstacle had been encountered, would not the United States Government permit the foundation to remain where it was? The tower had been sunk nearly 14ft. into the sand of the shoal, where nothing could ever disturb it. But the inspector had no power to grant such permission, even if he had desired to do so. A Government is a hard master. It has its contract, and it is protected by the bond of the builder. The lighthouse must comply with the specifications, or it will not be accepted.

For three days the force lay idle. There seemed no way of completing the foundation. On the fourth day, after another flooding of the caisson, Mr. Flaherty called for volunteers to go down the air-shaft, agreeing to accompany them himself—all this in the face of the spectacle of thirty-five men moaning in their bunks, with their eyes burning and blinded and their throats raw. And yet fourteen men stepped forward and offered to "see the work through."

Upon reaching the bottom of the tower they found that the flow of gas was less rapid, and they worked with almost frantic energy, expecting every moment to feel the gas gripping in their throats. In half an hour another shift came on, and before night the lighthouse was within an inch or two of its final resting-place.

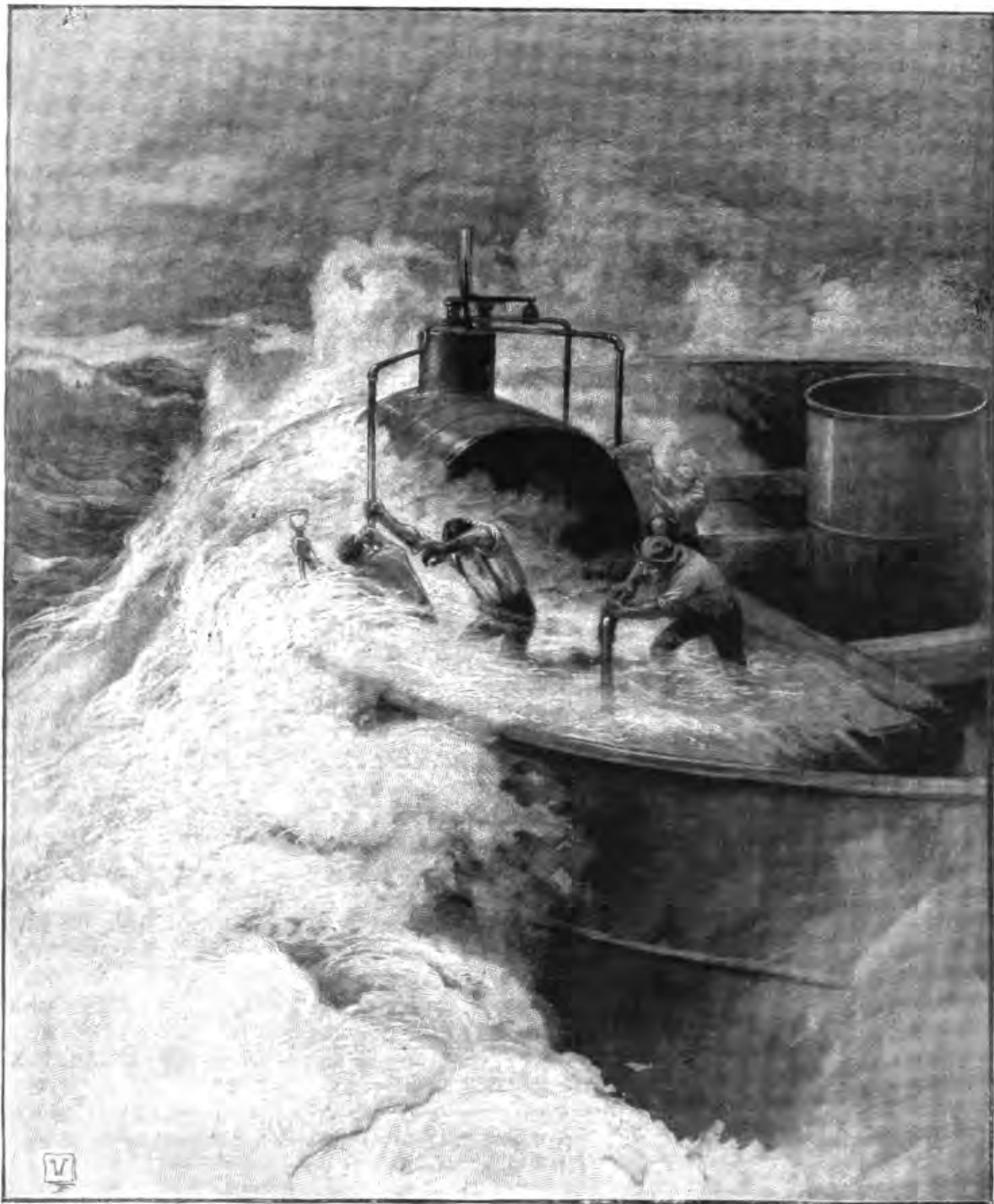
The last shift was headed by an old caisson man named Griffin, who bore the record of having stood seventy-five pounds of air pressure in the famous Long Island gas-tunnel. Just as the men were ready to leave the caisson the gas suddenly burst up again with something of explosive violence. Instantly the workmen threw down their tools and made a dash for the air-shaft. Here a terrible struggle followed. Only one man could go up the ladder at a time, and they scrambled and fought, pulling down by main force every man who succeeded in reaching the rounds. A moment later they began to stagger apart, blinded by the gas, some of them even striking at the solid walls of the caisson with their bare fists.

Then, one after another, they dropped in the sand unconscious. A few of the stronger ones scrambled up the ladder. Griffin, remaining below, had signalled for a rope. When it came down he groped for the nearest workman, fastening it around his body, and sent him aloft. Then he crawled around and pulled the unconscious workmen together under the air-shaft. One by one he sent them up. The last was a powerfully-built Irishman named Howard. Griffin's eyes were blinded, and he was so dizzy that he reeled like a drunken man, but he managed to get the rope around Howard's body and start him up. At the 18in. door of the lock the unconscious Irishman wedged fast, and those outside could not pull him through. Griffin climbed painfully up the 30ft. of ladder, and pushed and pulled until Howard's limp body went through. Griffin tried to follow him, but his numbed fingers slipped on the steel rim, and he slid backward into the death-hole below. They dropped the rope again, but there was no response. One of the men called Griffin by name. The half-conscious caisson man aroused himself and managed to tie the rope under his arms. Then he, too, was hoisted aloft, and when he was dragged from the caisson, more dead than alive, the half-blinded men on the steamer's deck set up a shout of applause—all the credit he ever received.

Two of the men prostrated by the gas were sent to an hospital in New York, where they were months in recovering. Another went insane. Griffin was blind for six weeks. Four other caisson men came out of the work with the painful malady known as "bends," which attacks those who work long under high air pressure. A victim of the "bends" cannot straighten his back, and often his legs and arms are cramped and contorted.

Nor were the men who ran the engine and air-compressor on the top of the cylinder exempt from peril. Twice while the work was in progress great waves dashed entirely over them, so that they had to cling for their lives to the air-pipes. These sudden inundations of cold water also had the effect of cooling the boiler and reducing steam so that the air-compressor barely moved. If the pressure once failed entirely the men below would go to instant death; and the stokers and engine-man were compelled to make fire when they could hardly keep their places on the boiler platform.

Having sunk the caisson deep enough the



"GREAT WAVES DASHED ENTIRELY OVER THEM."

workmen filled it full of concrete and sealed the top of the air-shaft.

In the meantime a storm had come up, and before the steamer could free itself from its moorings the waves drove it bodily against the cylinder. Eight of the heavy iron plates in the sixth course, each of which was over an inch thick and weighed a ton, were crushed in like so many panes of window-glass. For three weeks in May and June

the men lay idle again, awaiting the coming of new plates. It seemed impossible that the tower could be completed within the year, and yet, so thoroughly had the builder prepared for emergencies, that within twenty-four days after the new plates were in place the lightkeeper's home had been completed and the lantern was ready for lighting. Three days within the contract year the tower was formally turned over to the Government.