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Lighthouses and Lightships of the United States

by

George Rockwell Putnam

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PREFACE

THE lighthouse and the lightship appeal to the interest and better instinct of man because they are symbolic of never-ceasing watchfulness, of steadfast endurance in every exposure, of widespread helpfulness. The building and the keeping of the lights is a picturesque and humanitarian work of the nation. But this work is not all romance, as, unseen by the passing mariner, and back of the lighthouse and ship and buoy, there must be a great engineering and business machine with its endless contracts, plans, specifications, appointments, the routine of office and depot and ship and light-station. Scarcely a day passes, however, that there does not gleam in the mass of dry routine a fact of interest, an act of bravery, a risk cheerfully taken to aid another, a record of long and faithful service, an improvement of light or of fog signal, of vessel or of lighthouse, an historic record of the past, or a photograph of the present.

LIGHTHOUSES AND LIGHTSHIPS

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ILLUSTRATIONS

Most of the illustrations are from photographs in the Lighthouse Office, Washington. A number of them have appeared in the *National Geographic Magazine* and are reproduced through the courtesy of the National Geographic Society.

LIGHTHOUSES AND LIGHTSHIPS OF THE UNITED STATES

I

BOSTON LIGHT AND THE COLONIAL LIGHTS

The "Boston News Letter" of September 17, 1716, contained this item of news: —

Boston. By virtue of an Act of Assembly made in the First Year of His Majesty's Reign, For Building and Maintaining a Light House upon the Great Brewster (called Beacon-Island) at the Entrance of the Harbour of Boston, in order to prevent the loss of the Lives and Estates of His Majesty's Subjects; The said Light House has been built; and on Fryday last the 14th Currant the Light was kindled, which will be very useful for all Vessels going out and coming in to the Harbour of Boston, or any other Harbours in the Massachusetts Bay, for which all Masters shall pay to the Receiver of Impost, one Penny per Ton Inwards, and another Penny Outwards, except Coasters, who are to pay Two Shillings each, at their clearance Out, And all Fishing Vessels, Wood Sloops, etc. Five Shillings each by the Year.

This was the matter-of-fact announcement of an event the significance of which was hardly appreciated at the time, for the lighthouse at Boston was the first one built by any of the colonies in North America and probably the first on the American continents; and it was the first step in those numerous works for the protection of navigation and the safeguarding of life and property which now place the coasts of the United States among those best lighted and marked in the world. The year 1716 was an early date in modern lighthouse development, for the first Eddystone Light had been built only eighteen years, and the number of lighthouses then existing on the coasts of the British Islands was quite small.

At the time of the organization of the United States Government in 1789, ten lighthouses owned by the colonies were in operation. These were, with the years of their establishment: Boston Light, 1716; Brant Point Light, Nantucket Harbor, Massachusetts, 1746; New London Harbor Light, Connecticut, 1760; Beavertail Light, entrance to Narragansett Bay, 1761; Sandy Hook Light, New York Harbor, 1764; Cape Henlopen Light, Delaware, 1765; Charleston Light, South Carolina, 1767; Plymouth Light, on

Gurnet Point, Massachusetts, 1769; Nantucket Light, on Great Point, Nantucket Island, Massachusetts, 1784; and Portsmouth Harbor Light, New Hampshire, 1789. Five other lighthouses were built or undertaken by the colonies, but were not in operation at the organization of the Federal Government, these being Cape Ann Lights, Massachusetts, 1789; Newburyport Harbor Lights, Massachusetts, 1789; Portland Head Light, Maine, 1791; Tybee Light, entrance to Savannah River, Georgia, 1791; and Bald Head Light, at the entrance to Cape Fear River, North Carolina, 1796. In addition to these, Virginia had collected the materials for a lighthouse at Cape Henry, at the entrance to Chesapeake Bay, but construction had not been commenced. Of these sixteen colonial light-stations all are in operation at the present day excepting that, of the two lights at Portsmouth, one has been discontinued.

The original lighthouse structures at all of these stations have, however, been either destroyed or removed, excepting five, — those at Sandy Hook, Cape Henlopen, Portland Head, Tybee, and Cape Henry. The original masonry towers, built in 1764 at Sandy Hook and in 1765 at Cape Henlopen, are still standing and in use; those at Portland Head and Tybee have been increased in height; in the latter case the upper portion of the old tower was torn down. The original tower at Cape Henry is standing, but no longer lighted. The tower built at Boston in 1783 is still in use, but has been increased in height.

In 1713 a petition on behalf of the merchants of Boston was laid before the General Court of Massachusetts, "Proposing the Erecting of a Light Hous and Lanthorn on some Head Land at the Entrance of the Harbour of Boston for the Direction of Ships and Vessels in the Night Time bound into the said Harbour." A committee was appointed, which in March, 1713, reported to the Court, "That the Southernmost Part of the Great Brewster called Beacon Island is the most convenient Place for Erecting a Light House, which will be of great Use not only for the Preservation of the Lives and Estates of Persons designing for the Harbour of Boston and Charlestown but of any other Place within the Massachusetts Bay"; and the Court resolved "that the Projection will be of general publick Benefit and Service and is worthy to be encouraged."

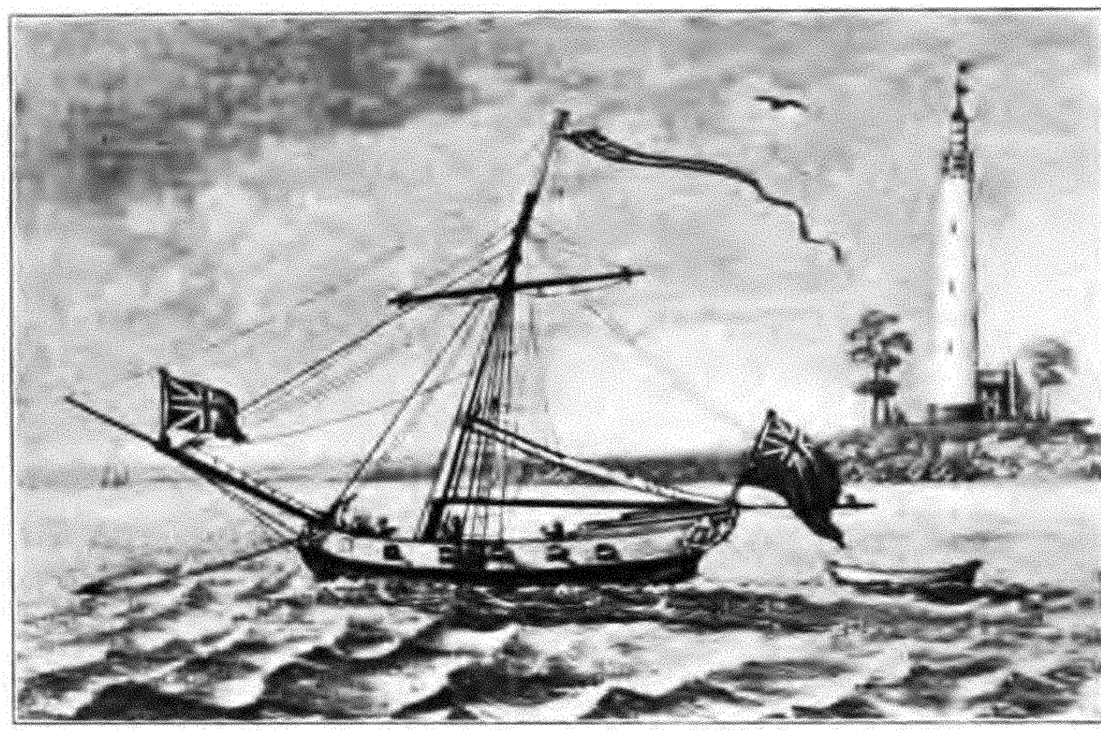
Meanwhile, at a meeting of freeholders and other inhabitants of Boston it was voted, "That the consideration of what is proper for the Town to do Abt. a Light-Hous be referred to the Select men"; and later the town asked the Court that Boston be given the preference in erecting and maintaining the lighthouse, "and being Intituled to the Proffits and Incomes thereof," the latter explaining the sudden interest of the town in the matter. The General Court, however, decided to build the lighthouse at the expense of the province, and on July 23, 1715, passed an act for building and maintaining it, giving as a reason that the want of such a lighthouse "hath been a great Discouragement to Navigation by the loss of the lives and Estates of several of His Majesties Subjects."

The work was accomplished at a total cost of £2385, 17*s*., 8*d*., and the light was first exhibited September 14 (25), 1716. The tower was built of stone, and an interesting mezzotint of 1729 shows it to have been a tall and stately structure.

In 1719 the keeper petitioned the General Court "that a great Gun be placed on Said Island to answer Ships in a Fog." The Court voted the gun, and it was probably the earliest fog signal established in this country. Though long since out of service for this purpose, this cannon is still at Boston Light Station; it bears the date 1700.

As stated, this lighthouse was supported by a special tax on shipping up to the time it was taken over by the Federal Government. It had various vicissitudes, suffering by fire, and otherwise. A writer in 1789 said that the building "was several times struck with lightning, and attempts were made to erect conductors; but this measure was opposed by several of the godly men of those days, who thought it vanity and irreligion for the arm of flesh to presume to avert the stroke of Heaven." However, after further damage from this cause it was thus protected.

Boston Light fared badly during the Revolution. After the British occupation of Boston, it was visited on July 20, 1775, by a party of Americans, who took the lamps and burned the wooden parts; an American eye-witness says he "saw the flames of the lighthouse ascending up to heaven like grateful incense." The British began the reconstruction of the lighthouse, but on July 31 an American expedition again landed on the island, overcame the guard, destroyed the works in progress, and departed with prisoners.



THE BOSTON LIGHT OF 1716

The British seem later to have restored and maintained the light, but when the fleet sailed from Boston in June, 1776, they left a train of gunpowder which blew up the light-tower about an hour later. Subsequently the "old top of the lighthouse," presumably the metal work of the lantern, was used by the Americans "to supply the cannon with ladles."

The first keeper of Boston Light, and hence the first lighthouse keeper in this country, was George Worthylake, who was allowed fifty pounds salary the first year. He with his wife and daughter were drowned November 3, 1718. This incident was the origin of a ballad, the "Lighthouse Tragedy," written by Benjamin Franklin, then a boy of thirteen, which he tells us in his "Autobiography" his brother induced him to print and sell on the streets of Boston, and which he says "sold wonderfully," the event being recent and "having made a great noise." No copy of this ballad is known, but its author says it was "wretched stuff."

The act for establishing Boston Light provided that the keeper "shall carefully and diligently attend to this Duty at all times in kindling the Lights from Sun-setting to Sun-rising, and placing them so as they may be most seen by vessels coming in or going out." The early keepers, however, had numerous duties, and evidently did not devote all their time to the light — they did much of the pilotage into Boston Harbor, enforced quarantine requirements, and rendered assistance to vessels in distress.

For about seven years after its destruction there was no lighthouse at the entrance to Boston Harbor, but after the close of the Revolution the Legislature directed that a lighthouse be built on the same island and of nearly the same dimensions as the former one, and this was done in 1783. This with various alterations is the present Boston Light. This tower was seventy-five feet high, including the lantern; it was raised to eighty-nine feet in 1859. It is of massive masonry construction, the lower portion of rubblestone and above that granite in courses; the walls are lined with brick and are nearly eight feet thick at the base. On account of cracks reported in 1809, there are six iron bands around the tower.

The Legislature of Massachusetts ceded to the United States, on June 10, 1790, Boston Light and five other lights belonging to the State; also four buoys at the mouth of the Merrimac River and "the beacon on the spit of sand near the light-house in the harbour of Boston." These apparently comprised all of the aids to navigation on the coast of Massachusetts at that time, except Brant Point Light at Nantucket, which was ceded in 1795.

The light was evidently not shown for a time during the War of 1812, for in January, 1814, the Marine Society of Boston petitioned for "having Boston Light lighted during the Winter months." The petitioners point out that to escape capture coasters must take advantage of the long nights to pass the most dangerous capes and some mark is absolutely necessary to guide them to a place of safety. "We presume the Lights are extinguished to prevent the Enemys availing himself of the security they afford."

Although candles and even coal fires were used in lighthouses in England to a much later date, Boston Light was probably illuminated from the first by oil lamps. In 1720 a fire occurred in the lighthouse, and the keeper "supposes the fire was occasioned by the Lamps dropping on the wooden benches and a snuff falling off." In 1789 the light was produced by sixteen lamps in groups of four. Argand lamps and crude reflectors were fitted in 1811, and also revolving mechanism, it having previously been a fixed light. In 1838 Boston Light is decribed as "a revolving light, consisting of 14 Argand lamps, with parabolic reflectors," the lamps being "of about the volume of similar lamps in family use." In 1839 large reflectors twenty-one inches in diameter were fitted to this light. Boston Light was provided with a revolving Fresnel lens in 1859, but within a few days the pilots of Boston petitioned that the old reflectors be replaced. This was never done. The light is now a flashing white light, giving a flash of 100,000 candle-power, every thirty seconds. Although it is still a primary coast light, its relative importance is diminished by Boston Lightship, six miles to the eastward, and the more powerful light on the Graves, two and one-half miles northeasterly.

For one hundred and thirty-two years the gun appears to have been the only fog signal at this station. A report in 1851 describes a "fog bell lately erected at the outer light" at Boston, stating that the bell weighs 1375 pounds, and is rung by machinery which runs six hours with one winding, striking every forty-seven seconds. In 1872 a fog trumpet was installed, and in 1887 the present steam siren, which is a powerful signal giving every minute two blasts in succession.

On the two hundredth anniversary of the first lighting of Boston Light, September 25, 1916, a tablet commemorative of the occasion, set in the masonry tower, was unveiled by the Secretary of Commerce, with appropriate exercises.

Sandy Hook Light, at the south point of the entrance to New York Harbor, is of interest among the colonial lighthouses because it is the oldest standing light-tower in the country. It was built at the instance of merchants of New York, and the Assembly in 1761 authorized a lottery to obtain the necessary funds. Twenty-six hundred pounds were raised by this lottery. Four acres of land on which to erect this lighthouse were purchased by trustees for New York in 1762; the deed has some curious provisions, including the "privilege of keeping and pasturing two cows on the lands" outside of the tract purchased, and an agreement "that no public house for the selling of strong liquors" shall be erected. The funds not being sufficient for the building of the tower, another lottery, held in 1763, was authorized by the Assembly, and a tonnage tax on ships was imposed for the maintenance of the light. The lighthouse was completed in 1764 and first lighted on June 11, as mentioned in the following account in the "New York Mercury" of June 18, 1764:—

> On Monday evening last the New York Light-house erected at Sandy Hook was lighted for the first time. The House is of an Octagon Figure, having eight equal Sides; the Diameter at the Base 29 Feet; and at the top of the Wall, 15 Feet. The Lanthorn is 7 feet high; the Circumference 33 feet. The whole Construction of the Lanthorn is Iron; the Top covered with Copper. There are 48 Oil Blazes. The Building from the Surface is Nine Stories; the whole from Bottom to Top 103 Feet.
>
> This structure was undertaken by Mr. Isaac Conro of this City, and was carried on with all the Expedition that the Difficulty attending to and fro on the Occasion could possibly admit of; and is judged to be masterly finished.

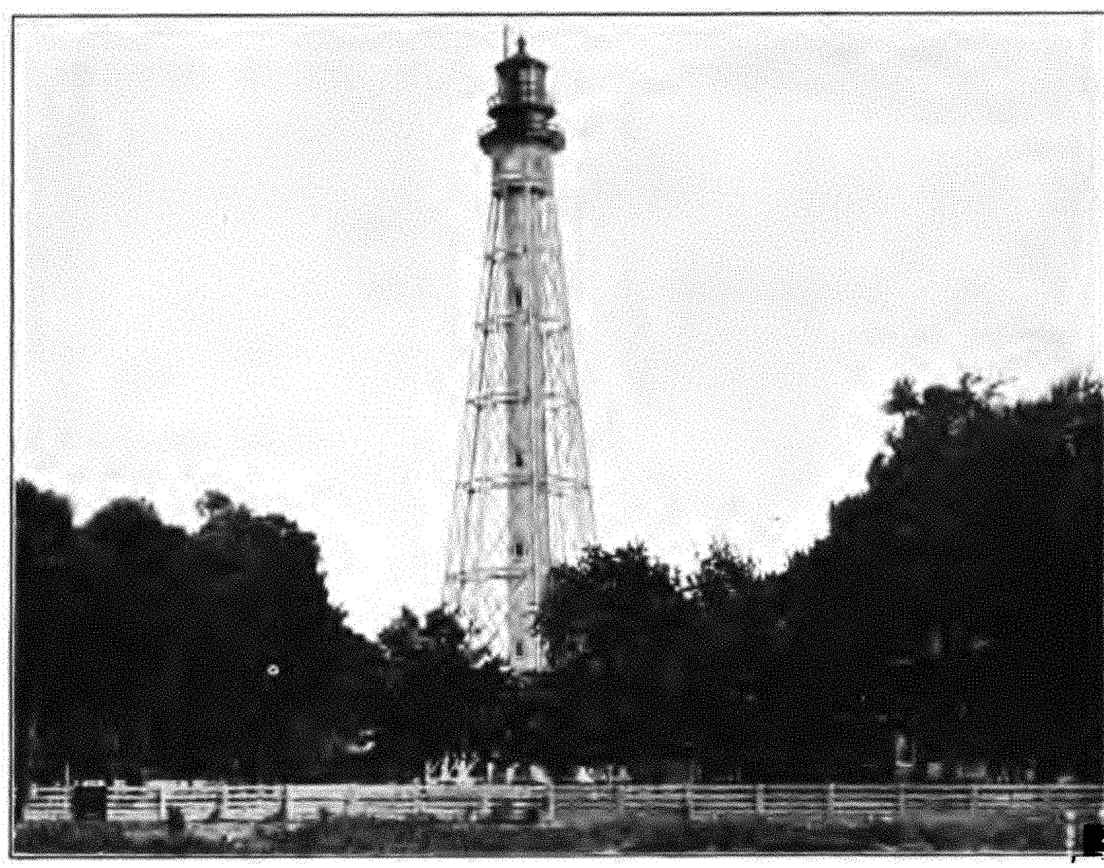
A letter of December 26, 1792, states that the "Wardens of port of New York had the management of the lighthouse on Sandy Hook. They had a tonnage of ships to defray all expenses and of course they spared no expense to make it complete . . . the lanthorn . . . gave a good light or a better one than any on the continent." Sandy Hook Lighthouse was also involved in the Revolutionary War. When the British fleet were gathering off New York in 1776, in order to embarrass them, the lighthouse was dismantled in March by a party of hardy American seamen. It was restored by the British, but on June 1 another expedition eluded the warships and bombarded the lighthouse with small field guns mounted in their boats, and retired, with the loss of several men, after damaging the tower. The lighthouse was ceded to the United States March 25, 1790; prior to this it had figured in the controversies between the States which preceded the adoption of the Federal Constitution. In 1787 New York enacted a law requiring all vessels from other States to be entered and cleared at the custom house, and this was particularly burdensome on small craft bringing supplies to the city from New Jersey. In retaliation the Legislature of that State thereupon levied a tax of thirty pounds a month on the lighthouse at Sandy Hook, which belonged to New York.

The original masonry tower is standing with apparently no exterior change. It is a dignified and massive structure, octagonal in form, the walls being seven feet thick at the base, of stone lined inside with brick.

In a report of 1852 it is mentioned as one of the three lighthouses of the country having the best masonry. The tower to the top of the lantern is eighty-five feet high; apparently the height given in the original account includes the foundation. The lighthouse is now five eighths of a mile from the northern extremity of Sandy Hook, but it is said to have been, when constructed, but five hundred feet from the point; its present distance is thus accounted for by a growth of the Hook to the northward of one half mile. New York Harbor now has a much more powerful light, Navesink, about four miles south, and a light vessel with a stronger light eight miles east, so that the Sandy Hook Light has become of secondary importance.

The fine old stone lighthouse tower on Cape Henlopen, at the entrance to Delaware Bay, was completed about 1767; there is evidence, however, that a light was shown earlier than this, as an item in the cost of the work is "expense of oil from the year 1765." It appears to have been built on the same plans as that at Sandy Hook, but is more imposing, as it stands on top of a great sand ridge about forty feet above the sea. The first mention of this lighthouse is an advertisement, in the "New York Mercury" of January 4,

LIGHTHOUSE AT CAPE HENLOPEN, DELAWARE



CAPE CHARLES LIGHT, VIRGINIA

1762, of a "Scheme of a Lottery for raising £3000 to be applied to erect a Lighthouse on Cape Henlopen and otherwise to facilitate the Navigation of the Delaware." There is a patent signed by John Penn granting two hundred acres of land to commissioners of the Province of Pennsylvania for erecting this lighthouse, although it was within the limits of Delaware. This lighthouse also suffered during the Revolution, being partially burned in 1777, but on the return of peace the damage was repaired and it was relighted in 1784.

This tower is veritably built upon the sands and from its early days has caused uneasiness as to its preservation. It is near the eastern end of a long ridge of sand dunes, from the top of which one may see on one side the living forest being buried in sand and on the other side the stripped trunks of trees of long ago emerging as the sand moves away. As far back as 1788 a committee of wardens reported to Benjamin Franklin, President of the Pennsylvania Council, that the land in the vicinity of this lighthouse "they observe to be so changeable from the strong currents of wind, that within these few years, where there have been deep ponds, there are now moles considerably high." In the following year the Master Warden says, "nor have we been without our fears on that account for the foundation of that Edifice." Measures have been taken at various times to protect the buildings from the encroachment or the cutting away of the sand. In 1863 a new dwelling for keepers was built, the "old one being threatened with speedy destruction by the steady progress in that direction of a remarkable sand hill, which has been moving inflexibly in a certain course at a constant rate of speed for many years." The sand driven by the wind cuts deeply into the wood framing of the keepers' dwellings, and soon grinds the window glass so that it is no longer transparent; but the lantern of the light is too high to be so affected. A still more serious menace to this historic lighthouse has arisen recently. Atlantic coast storms in the last few years have made considerable inroads in the beach east of the tower. At present the shore line is less than two hundred feet from the lighthouse, whereas it is said to have been about a mile away when the tower was built.

There are several quaint items in the old records about this lighthouse. A contract to "erect, sink and build a well for water," for $278, was approved in

1792 by President Washington with the reservation that if all the materials in the schedule "are not used in the work, a proportional deduction shall be made." In 1795 the keeper of the light asks for "an augmentation" of his salary, and says "it is known that the Necessaries of Life are one third higher than they were two years ago," which has a familiar sound.

The lighthouse at Charleston, South Carolina, was built in 1767, on Morris Island, and during the colonial days was the only coast light south of the Delaware capes. In 1861 the lighthouse was seized by the Confederate forces, and the tower and lens destroyed. The present tower was built in 1876, after delay on account of the unhealthfulness of the location. It is of brick one hundred and sixty-one feet high, on a grillage of timbers and concrete resting on piles in the marshy foundation. The great earthquake of 1886 threw the lens out of position and cracked the tower, but not dangerously. An interesting souvenir of the first Charleston Light is a copper plate taken from its corner-stone; it is inscribed in script, with many flourishes, "The First Stone of this Beacon was laid on the 30th of May 1767 in the seventh year of his Majesty's Reign, George The III," etc., followed by the names of the Governor, the commissioners, architect, engineer, and bricklayer.

A brick tower was built on Tybee Island in Georgia, at the mouth of the Savannah River, before 1755, as an act of the Provincial Assembly in March of that year provided for "an impost on shipping to defray the expenses of keeping the lighthouse on Tybee Island in repair." It is shown in a view of 1764, as a tall, beacon-like structure, pointed at the top, with no place for a light, although it is called "Tiby Lighthouse." It apparently was built to serve as a beacon rather than a lighthouse, for its top was not arranged for a light, and a letter of November 2, 1790, refers to "the alterations which are proposed for making it a Light House" and that "in order to erect the Cupola (according to the Draught) it will be necessary to take off seven feet of the top of the building." The light was in commission in 1791. Spermaceti candles were used in the lantern, because on account of its small diameter the smoke obscured the light when oil was used; this appears to be the only record of the employment of candles for lighthouse illumination in this country.

In November, 1792, the woodwork and lantern were destroyed by a fire of which there is a curious report by Jesse Tay, inspector of customs, who says he "lodged in the first loft and on the 8th about 2 o'clock in the morning the negro that trimed the lites went up to trim them and he discovered the lanthorn in flames he cry'd out the litehouse was on fier i jump'd up and run up Stairs . . . the glass and sinders was fawling so thick and it was so very hot i was not able to tarry half a moment and i saw it was in vain to attempt to save it."

There was a proposal in 1793 for rebuilding the woodwork of the lighthouse with "a hanging stair case for the sume of £160"; or "should a plain stair case be preferred," for £110, with the endorsement, "Approved with the plain stair case. G$^{o.}$ Washington."

In 1862, when the Confederates extinguished the light, they attempted to destroy the tower and lantern by fire, but a portion remained, and the lighthouse was rebuilt and lighted in 1867. The former tower was one hundred and three feet high and the new tower is one hundred and forty-five feet, of which about fifty feet of the base is the original tower.

The twin towers at Cape Ann, on Thatcher Island, were completed and lighted in 1789, having been built by Massachusetts and ceded to the United States. Two towers were built so that the two fixed lights shown would be distinguished from other light stations with a single fixed light; this was an expensive method sometimes employed before the introduction of modern apparatus for giving lights definite characteristics. The original towers were but forty-five feet high. These were torn down and replaced by two granite towers one hundred and twenty-four feet high and about three hundred yards apart, completed in 1861. Cape Ann is a primary seacoast light-station. There is here a diaphone fog signal.

The lighthouse at Cape Henry at the entrance to Chesapeake Bay was the first one built by the United States, the work being included in the first appropriation made by Congress for lighthouse purposes, on March 26, 1790. The project had, however, been undertaken by Virginia, as shown by a letter, dated December 18, 1789, from Governor Randolph of Virginia to President Washington, saying: "The State some years ago placed upon the shore at Cape Henry nearly a sufficient quantity of materials to complete such a lighthouse as was at that time thought convenient, which have been in the course of time

covered by sand. Measures are taking to extricate them from this situation"; and offering to sell the materials and cede the necessary land to the United States. An octagonal sandstone tower was built, and the light shown in 1792. The tower was constructed under contract for $15,200, and there is a curious supplementary contract with one Cornick to superintend the building of the lighthouse at a compensation of two dollars a week. During the Civil War the lantern was destroyed, but in 1863 the light was again in operation, protected by a military guard. In time a number of cracks appeared in the masonry tower and it was reported unsafe. A new lighthouse was completed in 1881, but the original tower is still standing back of it. The new structure is one hundred and sixty-five feet in height, built of cast-iron plates bolted together along their flanges. Cape Henry is one of the primary coast lights.

The remainder of the colonial lighthouses were of less relative importance, in some instances being harbor lights. They will be mentioned in the order of their establishment.

It was thirty years after Boston Light went into service before there was another within the limits of the present coast of this country. In January, 1746, the town of Nantucket, Massachusetts voted two hundred pounds to build a lighthouse, which was immediately constructed on Brant Point, on the western side of the entrance to Nantucket Harbor. The town built this lighthouse "in supposition that the owners of, or others concerned in, shipping will maintain a light therein"; but it appears that all the expenses of maintaining and rebuilding the lighthouse were defrayed by the town, until in 1774 the General Court of Massachusetts levied a tax on shipping to maintain the light which the act states "is absolutely necessary for all vessels coming in and going out of said harbor." The lighthouse was ceded by Massachusetts to the United States in 1795.

Besides being the second lighthouse of the country, this station is remarkable for the fact that seven successive lighthouses have been built on Brant Point, in 1746, 1758, 1774, 1786, 1825, 1856, and 1901. The earlier structures were of wood, and those built in 1746 and 1774 were burned. The second tower was blown down in March, 1774, and a news item of that time from Nantucket says they had "a most violent gust of wind that perhaps was ever known there," which in its progress blew down and totally destroyed the lighthouse, the loss of which "in every respect is considerable." The brick structure built in 1856 is still standing; it is about one hundred and thirty-five feet southerly from the site of the earlier lighthouses; the present tower is at the extremity of the point and about two hundred yards to the eastward of that of 1856.

A lighthouse was built on the west side of the entrance to New London Harbor about 1760. The original lighthouse was probably of masonry and appears to have been entirely removed when the present stone tower was built in 1801. A letter the following year recommends that the salary of the keeper be raised from two hundred dollars, at which it was fixed many years previously, "since which the Lighthouse has been made much higher, the light augmented, the machinery of the eclipser to be kept in order, his own dwelling house being contiguous to the light-house, the public have never been at any expense for that article." The more important lighthouse at New London Ledge, about a mile distant, was built in 1908.

Beavertail Lighthouse, on the south end of Conanicut Island at the entrance to Narragansett Bay, was built in 1761. In the early days it was referred to as "Newport Light" or "Conanicut Light." It was of rubble-stone and sixty-four feet high. It was replaced by a substantial granite tower in 1856. One of the early acts of President Washington regarding lighthouses was a letter to Secretary of the Treasury Hamilton, October 12, 1790, regarding the arrangements made relative to the lighthouses at Newport and Portland, and saying, "they are perfectly agreeable to me, and receive my approbation." This station has played an important part in the development of fog signals in this country. In 1829 a bell house was built near the base of the tower and a fog bell placed therein. In 1851 an air fog whistle and an air trumpet or reed horn were experimentally installed, the air compressor being operated by a horse. In 1857 a steam fog whistle was placed at Beavertail. In the two latter cases the installations were the first of their kind in this country. The present fog signal is an air siren.

A lighthouse at Plymouth, Massachusetts, on Gurnet Point, was built in 1769. It was burned in 1801, and two towers were built in 1803, and these again were replaced in 1843, the present and probably the former towers being of wood. At the time the lights were ceded by Massachusetts to the United States in 1790, the keeper was a woman, Mrs. Thomas. The act of cession mentions "the lighthouse situate on the Gurnet-head"; so there were not two towers until the rebuilding in 1803.

A report on these lights in 1838 says "they require to be double, to distinguish them from the single light of Barnstable." A serious difficulty with using this earlier method, however, is indicated by the following incident related in the same report: "It is but a few years since a vessel was lost to the northward of them, the captain protesting that but one tower was lighted, by which he was deceived. Both towers were lighted, but one concealed the other, so that but a single light appeared."

Nantucket, Great Point, Light was built by Massachusetts in 1784, on the northeast extremity of Nantucket Island, and was one of the lighthouses ceded by Massachusetts to the United States in 1790. This was a wooden structure, and was destroyed by fire in November, 1816. It was rebuilt by the United States in 1818 of stone, the masonry being sixty feet high, with light seventy feet above the sea. An inspection made in 1838 says there are fourteen lamps with reflectors, and "the keeper has removed seven lamps from the chandelier, and placed them on a shelf against the window, . . . the principal advantage he hopes to derive from this arrangement is the prevention of frost on the glass by the heat of the lamps." A lens was installed in 1857, and the tower lined with brick. This tower is still in service.

Portsmouth Harbor Light was built on the point at Newcastle, New Hampshire, in 1789. Another tower, of wood, was built in 1804, and in 1877 this was removed and a small cast-iron lighthouse was built about one thousand feet easterly. There is a curious contract dated November 18, 1790, by which Titus Salter agrees with Alexander Hamilton that Salter "will defray all the expence and charge that hath arisen for the support maintenance and repairs of the Light House situate on the Island of New Castle," and for future maintenance, from August 15, 1789, to July 1, 1791; "that he will by himself or some careful Person give proper attendance on said Light House and in the night time from the setting to the Rising of the Sun, keep the same constantly lighted," and will "make use of no other oil than

Spermaceti or Hakes Oil," and "said Salter doth also agree to cause all such repairs to be made on said Light House as shall be deemed necessary," for all of which he is to receive $555.99 and an allowance for repairs. Evidently the light was mostly entrusted to "some careful Person," for in an order regarding lightkeepers July 18, 1793, it is stated that "the President thinks it proper that the Keeper of the Light House at Portsmouth be informed, that he must reside on the spot where the Light House is, if he continues in that office, and that he will not be permitted to employ a deputy to take care of the Light House, unless upon some special occasion."

Newburyport Harbor Lights were built by Massachusetts in 1789 on Plum Island at the entrance to the Merrimac River. There were two small lighthouses the range of which marked the best channel into the river. They were rebuilt several times, and have from time to time been moved, sometimes considerable distances, as the channel shifted; on account of complete change in the direction of the channel the small range lights are at present on the north side of the river, and Newburyport Harbor Light is now a single tower, last rebuilt in 1898. In the early days of Congress an interesting petition was presented from the owners of the ship Friendship, lost at the Merrimac entrance by reason of one of the lights, which is a movable one, after a storm not being in the correct position for a leading mark into the harbor, the owners asking indemnification by the United States. A committee of the House of Representatives considered this petition and reported in 1796 that while there is "a duty, on the part of Government, to take, generally, such prudential measures as will embrace the object, yet it cannot be supposed that Government, while it was extending a convenience for the good of the citizens, ever contemplated it should be responsible for any losses that might accrue, in consequence of that convenience being incomplete in any instance arising from the neglect or omission of any of its agents, or from any other cause."

A lighthouse on Portland Head, at the entrance to Portland Harbor, Maine, was undertaken by Massachusetts and ceded to the United States in 1790, and was completed in 1791 under appropriations made by Congress, which authorized the Secretary of the Treasury "to cause the said lighthouse to be finished." The original tower, of rubble-stone, is stated to have been thirty feet in height; in 1865 the height of the tower was increased to eighty feet, retaining the old tower for the base. The buildings at this station are so close to military batteries that they have suffered materially in recent years from air concussion during gun practice. Particularly in the keeper's dwelling windows have been forced out, roof torn open, bricks forced from the mortar, and chimneys broken, so that after such practice it was necessary to examine all chimneys before making fires; recently means have been devised to avoid this damage.

A lighthouse was begun by North Carolina at Bald Head at the mouth of the Cape Fear River. This was completed by the United States in 1796. A contract was made with one Woodward, carpenter, to superintend the completing of the lighthouse for $4.66 a day. On the contract is an endorsement that the allowance "seems high, but as none have offered to execute the business so low, and a Superintendent of the building is necessary, the contract is approved by Go. Washington." Bald Head Lighthouse was rebuilt in 1818, and probably this was an entirely new structure. It was discontinued from 1866 to 1880, during which period the New Inlet into Cape Fear River was used and a light was maintained on Federal Point. On the closing of New Inlet by engineering works, the old tower at Bald Head was relighted. With the completion of a primary coast light in 1903 at the extremity of Cape Fear and two miles from Bald Head Light, the latter became of only local importance; it is now an unattended gas light, one of the aids for the entrance to the river.

II

THE LIGHTHOUSES UNDER THE UNITED STATES GOVERNMENT

Provision for the maintenance of the lighthouses was promptly made on the organization of the Federal Government. At the first session of Congress, an act was passed, approved on August 7, 1789, providing that all expenses "in the necessary support, maintenance and repairs of all lighthouses, beacons, buoys and public piers erected, placed, or sunk before the passing of this act, at the entrance of, or within any bay, inlet, harbor, or port of the United States, for rendering the navigation thereof easy and safe, shall be defrayed out of the Treasury of the United States." Thus the Lighthouse Service was one of the earliest public works established by the United States, though it has been conducted under several different forms of administration.

After the passage of the law for taking over the lighthouses no time was lost by some in calling on the Federal Government to pay the expenses; thus the next month the Wardens of the Port of Philadelphia remind the Secretary of the Treasury of the act, and observe that the lighthouses and buoys "on the Bay and River Delaware are numerous and very Expensive," and that the tonnage tax on shipping formerly used is now collected by the United States. On October 5, 1789, Alexander Hamilton wrote to the wardens of the ports where there were lighthouses asking them to continue to have them maintained as before, and saying that all expenses would be paid by the Federal Government. After considerable delay in some instances, the several States between 1789 and 1795 ceded to the United States the lighthouses which had been undertaken by them, some still unlighted as has been recounted.

Massachusetts, in ceding her lighthouses, showed her caution with respect to the new Government by providing "that if the United States shall at any time hereafter neglect to keep lighted, and in repair, any one or more of the lighthouses aforesaid, that then the grant of such lighthouse or lighthouses so neglected shall be void and of no effect"; and also, "that if the United States shall at any time hereafter make any compensation to any one of the United States for the cession of any lighthouse . . . like compensation be made to this Commonwealth by the United States, for the cession of the Light Houses aforesaid, in proportion to their respective values."

The maintenance of lighthouses, buoys, and other navigational aids was, at the organization of the Government, placed under the Treasury Department, and the details of lighthouse work were directed personally by the Secretary of the Treasury — Alexander Hamilton — by whom many of the earlier papers are signed. On May 22, 1792, Hamilton informed the Commissioner of the Revenue: "I have concluded to commit to you the general Superintendence of the Light Houses and other establishments relating to the security of Navigation." This duty remained with this officer up to 1820, except for the period from 1802 to 1813, during which the lighthouses were again personally supervised by the Secretary of the Treasury, then Albert Gallatin.

There are many interesting documents in the early archives of the service showing the attention given by high officers of the Government to matters of lighthouse detail. It was apparently considered that every contract, however small, must be approved by the President, as well as the appointment and salary of every light-keeper, and the papers show that often more than routine attention was given these matters. President Washington personally approved such contracts as these; for the purchase of spermaceti oil "immediately wanted for the use of the Light House on Cape Henry in Virginia," and for making "a mooring chain for one of the Floating Beacons of the Delaware Bay." On the last document appears the endorsement, all in Washington's hand-writing, "April 27th, 1793, Approved, so far as it respects the new chain; but is there an entire loss of the old one? G°. Washington."

There are some interesting and characteristic endorsements by President Jefferson. In a matter respecting the conduct of the keeper of Cape Henry Lighthouse he wrote:—

> I think the keepers of light houses should be dismissed for small degrees of remissness, because of the calamities which even these produce; and that the opinion of Col. Newton in this case is of sufficient authority for the removal of the present keeper.
>
> TH. JEFFERSON.
>
> *Dec.* 31, '06.

On a recommendation that Jared Hand be appointed as keeper of Montauk Point light to succeed his father, President Jefferson wrote this endorsement: —

I have constantly refused to give in to this method of making offices hereditary. Whenever this one becomes actually vacant, the claims of Jared Hand may be considered with those of other competitors.

THOMAS JEFFERSON.

The following document is of interest as showing the salaries then paid: —

UNITED STATES, *July* 18, 1793.

By the President's command T. Lear has the honor to inform the Secretary of the Treasury, that the President having duly considered the Representation of the Commissioner of the Revenue and the other documents relative to the compensations of the Keepers of the Light Houses, which were put into his hands by the Secretary, approves of the alterations of certain compensations as suggested by the Secretary:

1st. For the Keeper of the Light Houses on Thatcher's Island per annum, 266$\frac{2}{3}$ doll.

2. do. Boston Bay, 266$\frac{2}{3}$ doll.

3. do. Plymouth, 200 doll.

4. do. Portland Head, 160 doll.

5. do. Conanicut, 160 doll.

6. do. New London, 120 doll.

7. do. Sandy Hook, 266$\frac{2}{3}$ doll.

To commence from the 1st day of the present Month. . . .

TOBIAS LEAR,
Secretary to the President of the United States.

The pay of the keepers of Boston and Cape Ann Lights had previously been four hundred dollars each, and the reduction made in the above order was stated to be on account of the favorable conditions for living at those stations, and it is added, "the present incumbents it is presumed will perceive the perfect reasonableness and equity of this reform by the President."

The salaries of the light-keepers were fixed at a low rate even for those days, and there were many petitions for increase of pay.

In 1796 President Washington issued "An Act concerning the Compensations" of keepers and others, based on Congress having "encreased the fund for maintaining and repairing the Lighthouses," etc., but the highest pay for a keeper is fixed at $333.33, together with the use of the buildings and land at the station.

In connection with the salary of the keeper of Seguin Lighthouse having been fixed at two hundred dollars, the Commissioner of the Revenue in 1797 writes to the Secretary of the Treasury: —

> In the case of Major ——, there are the advantages of plenty of fuel, without expense, upon the public land, the opportunity to fish for his family use, or even for sale, a boat to fish in will be furnished for passing to the main, there is a little land for tillage and grass, and for a plentiful garden. The place is represented to be very healthy. . . . I have been thus particular because the salaries of keepers appear to have been subjected to some miscalculation on their parts from the unnecessary degree of former standing, which some of the candidates have had. It is plain at first view, that the above duties are not in their nature adapted to the standing of a field officer, or of a Major of Brigade.

On the general subject of increasing salaries there is this note of President Jefferson: —

> Th. J. to Mr. Gallatin. I have kept the papers on the subject of raising the salaries of certain lighthouse keepers longer than usual, because I know that the systematic pressure on every government for augmenting salaries requires serious consideration. However if the salaries at present are not properly proportioned among themselves, I think it will be just and expedient to make them so, once for all, and

hereafter to withstand individual solicitations for particular augmentations. Under this view I approve of the augmentations you propose. Affectionate salutations.

July 12, '06.

A recommendation of a person for appointment as keeper in 1809 stated that the applicant "being by occupation a mason will engage to keep the Light House white washed, should he receive the appointment, free from any expense to the Government as long as he is its Keeper."

This applicant was appointed by President Madison, and presumably he kept Sands Point Lighthouse well whitewashed — it is a white tower to this day.

In 1820 the "care and superintendence of the lighthouse establishment" was assigned by the Secretary of the Treasury to the Fifth Auditor of the Treasury, and this duty devolved upon Stephen Pleasonton, in this position, for nearly thirty-three years. It is a remarkable fact that for one hundred and twenty-one years the lighthouse work of this country was conducted by officials not appointed primarily for this duty, but assigned from other service or carrying on this work in connection with other duty, and this is true, not only at the headquarters of the Service in Washington, but in the district organization as well; during this long period no compensation was paid to any one for general lighthouse administration.

The collectors of customs were appointed superintendents of lighthouses for particular districts convenient to their ports; they had local supervision over the light stations and keepers, including repair and construction, recommendation of keepers for appointment, and disbursements, were expected to inspect the stations occasionally, and were allowed as extra compensation a small commission on the disbursements; in some cases this amounted to but a few dollars a year; as, for instance, $3.17 to the collector at Portsmouth, New Hampshire, in 1792, and the maximum amount was later fixed at four hundred dollars a year. In 1792 there were eleven such superintendents, and of course this number increased with the extension of the service. Of the seventeen superintendents in 1817 several had but one light each in their charge, while the superintendent at Boston had twenty-one lighthouses. In 1854 there were sixty-three collectors of customs acting as superintendents. George Bancroft, while Collector of the Port at

Boston from 1837 to 1841, served as Superintendent of Lighthouses, and during part of this period was charged with the purchase of all the oil for the Service. In 1880 the collectors ceased to make lighthouse disbursements and later their other duties in connection with lighthouses were transferred to the Lighthouse Board.

For many years the supply and even inspection of the lighthouses, as well as new construction, were performed mainly by contract. A broad contract, authorized by Congress, was made in 1812 for the purchase of a "patent-right to the plan of lighting light-houses by reflecting and magnifying lanterns," providing for placing this apparatus in all lighthouses of the United States, and for keeping it in repair for seven years and for furnishing supplies. This apparatus appears to have been substantially an introduction of the Argand lamp and parabolic reflector, which had been in use in Europe for some time, with the addition of a lens—one solid piece of glass—in front of the lamp. The first two features, whatever the merits of the question as to their originality, appear to have been an important improvement over the crude lamps before used, but the bull's-eye lens in this combination was worse than useless; it was, though not for some years, finally removed. These contracts were continued until 1828 and others for maintenance were made until 1842. The later contracts included the supply of oil, and also that the contractor "shall visit and inspect the several light-houses, at least once a year, and render a statement of their condition to the Fifth Auditor." An example of the discretion assumed under this contract system was the case of Mobile Point Light, which in 1835 the contractor changed from a fixed to a revolving light without previous instructions.

Beginning with 1827 Congress had begun to make very liberal appropriations for additional light-houses; at this time also important improvements in lighthouse illuminating apparatus were being made in Europe. After a few years, complaints began to be made as to the efficiency of the American light-houses, and questions raised as to the location and need of the new lighthouses authorized; the complaints were against the system and not against the head of the Service. A large amount of new light-house construction was done during these years, and at costs which seem small at the present time; it is true that many of these lighthouses were later rebuilt more substantially, yet the class of work done probably met at a moderate cost the immediate needs of a growing country.

Congress began to make restrictions, in part on itself; in 1837 it was provided that the new lighthouses for which it had made appropriations should not be commenced until examination of the projects had been made by the Board of Navy Commissioners, and the facts should be reported to Congress in cases where the "navigation is so inconsiderable as not to justify the proposed works." In 1838 Congress made appropriation for the importation of two sets of lens apparatus. In the same year inspections of a number of lighthouses were made by naval officers, who submitted reports and recommendations, as a result of which the construction was deferred of thirty-one lighthouses for which appropriations had been made. In 1843, under instructions of the Treasury Department, J. W. P. Lewis, a civil engineer, inspected and reported on most of the lighthouses on the New England coast; apparently this was the first instance in which an engineer had been employed in any important capacity in the Lighthouse Service. Congress by various provisions showed a growing feeling that some change in the system was desirable, and in 1842 a full report on the lighthouse system was made by a committee of the House of Representatives. In 1843 Congress required that the site for a lighthouse on Lake Michigan should be surveyed and selected by the Corps of Topographical Engineers, and in 1847 the construction of six lighthouses was placed under that corps. In 1845 two naval officers were sent to Europe by the Secretary of the Treasury, and made a report recommending changes in the lighthouses in this country.

Finally a board was appointed in 1851, to make a general investigation of the lighthouse problem; this preliminary board submitted an elaborate report of seven hundred and sixty pages, which led to the law creating the Lighthouse Board, which was organized October 9, 1852, and which administered the lighthouse work for nearly fifty-eight years. This Board was composed of two officers of the Navy, two officers of the Engineer Corps, and two civilians of high scientific attainments whose services were at the disposal of the President, and an officer of the Navy and of the Engineers as secretaries. It was empowered under the Secretary of the Treasury to "discharge all the administrative duties" relative to lighthouses and other aids to navigation. The Secretary of the Treasury was president of the Board, and it was authorized to elect a chairman and to divide the coast of the United States into twelve lighthouse districts, to each of which the President was to assign an army or navy officer as lighthouse inspector. None of the officers detailed to the Board or the districts received extra compensation.

Admiral William B. Shubrick was the first chairman of the Lighthouse Board, and, with a brief intermission, served in that capacity for nineteen years. Professor Joseph Henry was chairman for nearly seven years, and was the only civilian who acted as chairman. During his connection with the Board, Professor Henry made extensive investigations in connection with fog signals. Among the civilian members of the Board have been Bache, Pierce, Mendenhall, and Pritchett, Superintendents of the Coast Survey; and Morton, President of Stevens Institute; among members from the Navy have been Jenkins, Walker, Dewey, Evans, and Schley; and from the Engineers, Totten, Humphreys, Franklin, Poe, and Casey.

Several other officers who took leading parts in the Civil War served on lighthouse work during the decade preceding the war; Meade, later the Union commander at Gettysburg, was for more than four years engineer of various lighthouse districts and was actively identified with several of the important light structures on the Florida Reefs; he had charge of the completion of Sand Key Light and of the design of Sombrero Key Light. Semmes, later commander of the Alabama, served as lighthouse inspector and as naval secretary of the Lighthouse Board; he resigned from the Board February 15, 1861, and returned to Alabama, where he was for a short time made chief of a lighthouse bureau. Rosecrans was engineer of one of the districts, and Beauregard had special lighthouse duty.

The Lighthouse Board promptly took up its work and instituted important improvements in the methods and equipment of the lighthouse work. It carried out many of the notable and difficult lighthouse constructions of the country. In the early days, with much construction work to be done and the enthusiasm of a new organization, it proceeded effectively. But with time the obvious defects of a too complex plan appeared. The need of a more direct form of organization was pointed out by the Secretary of Commerce and Labor, and by officers of the Board itself, and was considered by committees of Congress. The main difficulties were the lack of an executive head with definite responsibility, the division of authority in each lighthouse district between the naval inspector, charged with the maintenance of the aids to navigation, and the engineer officer, charged with construction and repair and provided with office, personnel, and tenders quite independent from those of the inspector; and the fact that the responsible charge of the work was entirely in the hands of officers whom it had become customary to detail for but brief terms to this service.

The Board remained under the Treasury Department until July 1, 1903, when, with other activities having to do with navigation, it was transferred to the Department of Commerce and Labor (now the Department of Commerce).

Congress passed a law which took effect July 1, 1910, terminating the Lighthouse Board and substituting for it a simple bureau form of organization of which the following is an outline. There is an office in

Washington, known as the Bureau of Lighthouses, which is the executive center of the Service, under the Commissioner of Lighthouses and the Deputy Commissioner. There are in this office an engineering construction division, under the chief constructing engineer; a naval construction division, under the superintendent of naval construction; a hydrographic division, under an assistant engineer; and the general office force, under the chief clerk.

The Service outside of Washington is divided into nineteen lighthouse districts, each of which is under the charge of a lighthouse inspector. Illustrations of district division are these: the coast of Massachusetts is the second district; from there to Delaware Bay, the third; Porto Rico, the ninth; Lake Michigan, the twelfth; Ohio River, the fourteenth; Alaska, the sixteenth; California, the eighteenth; the Hawaiian Islands, the nineteenth. In each district there is a central office at a location selected on account either of its maritime importance or of its geographical position. Attached to each district office is a technical force for the construction and upkeep of both land structures and floating equipment, and also a clerical force. In the field are construction and repair parties under foremen, and in a number of districts there are mechanicians who attend to special repairs and installations of apparatus. All of this force is composed of civilians, except that in the three river districts officers of the Corps of Engineers who are in charge of river improvements act also as lighthouse inspectors.

One or more lighthouse dépôts are conveniently located in each district for carrying on the work of the district in the matter of storing and distributing supplies and apparatus. In addition there is on Staten Island, New York Harbor, a general lighthouse depot, established in 1863, where many of the supplies for the whole Service are purchased and stored and sent out for distribution, and where much of the special apparatus of the Service is manufactured or repaired, and where also there is carried on various technical work in the way of testing apparatus and supplies and designing or improving apparatus.

Each district is provided with one or more lighthouse tenders for the purpose of distributing supplies to the various stations and light vessels and for transportation of materials for construction or repair, for the placing and care of the buoyage system in the district, and for transporting the inspector and other officers of the Service on official inspections of stations and vessels and on other official duty.

The variety and wide geographic distribution of these operations are indicated by a few of the works recently completed or now in progress — a light and fog signal at Cape St. Elias, Alaska; a lighthouse on Navassa Island, West Indies; a lighthouse on Kauai Island, Hawaii; light and fog signal stations on submarine foundations in Delaware Bay and in Chesapeake Bay; and a system of lights and buoys for Livingstone Channel, Detroit River.

The seacoast line under the jurisdiction of the United States is 48,881 statute miles, measured in three-mile steps. The Federal Government provides lighthouses and other aids to navigation along all this coast, with the exception of the Philippine Islands, 11,511 miles, and Panama, where the marking of the coasts is maintained by the local governments. In addition, the United States provides lights along the American shores of the Great Lakes, 4020 miles, and on interior and coastal rivers, 5842 miles.

The United States Lighthouse Service thus maintains lights and other aids to navigation along 47,192 miles of coastline and river channels, a length equal to nearly twice the circumference of the earth. In this distance it has 14,947 aids to navigation of all classes, more than sufficient to place one every two miles around the Equator.

In respect to territory covered and aids maintained, it is much the most extensive service of its kind under a single management.

The annual maintenance cost of the entire Service is close to $5,000,000, and in addition in recent years there has been expended somewhat over $500,000 a year on new lighthouse works and vessels. Last year the total expenditure of the Service for repairs and improvements was $908,468, and for new works, $782,218, or a total of $1,690,686 for construction and repair, nearly one third of the total expenditures for the Service. This Service is supported by appropriations out of the general revenues, and no special light taxes are collected from shipping. Light dues are levied in some foreign countries, and have several times been suggested here, but the lighthouses of the United States have remained free to the ships of all lands.

About 5800 persons are required for the lighthouse work, of whom 270 are in the executive, engineering, and clerical force, 1783 are keepers of lights and depots, 1524 care for post lights, 1592 are on vessels, and 610 are in the construction and repair force.

The entire personnel is under the civil-service rules, and appointments and promotions are on a strictly merit system. This is of great importance for the maintenance of good organization and rigid discipline in a purely technical service, on the efficient conduct of which is directly dependent the safety of all the lives and all the property carried on the seas and the navigable waters of this country.

Light stations and vessels are inspected several times a year, and the districts and offices are themselves inspected from time to time by a general inspector and a traveling auditor.

An accurate cost-keeping system has recently been introduced for the entire Service, so that at the end of the year the principal items of cost for each feature can readily be ascertained and compared. The following are average annual costs of operating various features of the Service: large lighthouse tender, $43,000; light vessel on exposed station, $14,000; important light station, with fog signal, $5800; same without fog signal, $3400; river post light, $90; gas buoy, $85 to $200 according to size and type.

The growth of the lighthouse work of the United States is shown at intervals of thirty years by the numbers in the table below, including also the present year. The totals include minor aids not given in detail.

	1790	*1820*	*1850*	*1880*	*1910*	*1916*
Lights, other than minor.....	12	59	297	661	1397	1706
Light-vessels...............	0	1	35	31	54	53
Lighted buoys.............	0	0	0	0	225	512
Total lighted aids.....	12	60	332	1523	3992	5323
Fog signals	1	3	49	194	457	532
Bell and whistle buoys, not lighted..................	0	0	0	34	267	321
Other buoys...............	10(?)	156	1034	3115	5783	6659
Total aids to navigation...............	45(?)	249	1536	5221	11,661	14,947

In 1857 the Lighthouse Board expressed its belief "that but few additional aids to navigation of any kind can be reasonably asked for in any part of the Atlantic, Gulf, Lakes, or Pacific Coast of the United States"; and in 1860, "that the lighthouse establishment has about reached its maximum under our present limits." Notwithstanding that optimistic view, there are at the present time about four times as many aids to navigation within the same limits as there were then. There is a constant demand for more aids to navigation, and the average net increase during the past six years has been five hundred and forty a year. All needs cannot be filled. Some requests it is impracticable to meet; as, for instance, that made after the Titanic disaster, that flashing lights be placed on all large icebergs.

The improvement in the marking of channels and coasts, and the increase in the number of lights and buoys and other aids, has been brought about by the advance in water transportation, the introduction of the steam vessel and the increase in the speed of steamers, the growth in the size and draft of vessels, the greatly increased number of vessels, and the enormous expansion of the value of water-borne commerce, all demanding better-marked highways for the mariner; in addition, the development of more complete hydrographic surveys has shown the need of marks on hitherto unknown dangers, or of marks for better channels. The average loaded draft of the twenty largest steamships of the world increased between 1848 and 1903, from nineteen feet to thirty-two feet, and the average length of these vessels from 230 feet to 640 feet. Illustrative of the growth of water-borne traffic on the coasts of the United States are these facts: In 1789, on the organization of the Federal Government, the gross tonnage of American vessels was 201,000; in 1850 it was 3,535,000; in 1916 it was 8,469,000. The entries and clearances in the foreign trade of the United States were, in 1821, 1,834,000 net tons, and in 1916, 103,996,000 net tons. The character of the maritime traffic is shown by the fact that in 1850 fifteen per cent of the tonnage of American vessels was steam, while in 1916 seventy-two per cent was steam.

III

LIGHTS IN THE APPROACHES TO NEW YORK

On a voyage from Europe the weather had been such that the steamer had crossed the Atlantic without the officers obtaining an observation after leaving the Irish coast. A passenger came on deck on a misty evening and heard first faintly and then louder the blasts of a steam whistle at regular intervals of half a minute. Then through the thin fog shone a white light eclipsed every quarter of a minute, and there soon loomed out of the mist in the dusk a little vessel at anchor rolling heavily in the swell, with a red hull and N A N T U C K E T in large white letters on her side. The great liner swept close by and on toward her port, and her master had definite knowledge that he was two hundred miles east of New York Harbor. This lightship, anchored on one of the most exposed stations in the world, has given this message to many thousands of masters and has been the first signpost of America to millions of passengers.

Nantucket Lightship is anchored in thirty fathoms of water and forty-one miles from the nearest land, Nantucket Island. Her position is such as to guard the great area of shoals lying southeast of this island, one of the most dangerous parts of the United States coast, and most of the vessels approaching the Atlantic Coast lay their course directly for this vessel, so that they may pass safely to the southward of these shoals. The officers of the lightship say that large steamers often come very close out of the fog, sometimes almost grazing the sides. Although from the liner the vessel appears a small craft to be anchored in such a position, Nantucket Shoals ship belongs to the class of largest lightships, being one hundred and thirty-five feet long, with full propelling power, and a crew of fifteen persons. The vessel is fully equipped, having also a submarine bell which during fog strikes the number "66," and a radio service, by means of which vessels are reported, and storm-warning signals are displayed. A report to Congress in 1843 stated:—

There is another still more fatal spot [than Minots Ledge] upon the coast of Massachusetts, where many a brave heart and many a gallant ship lie buried in one common grave. The shoals of Nantucket are known and dreaded by every navigator on the Atlantic seaboard; and among the great number of "miss-

ing vessels" recorded at the insurance offices, there are doubtless many that have been swallowed up in these treacherous quicksands.

Congress did in 1849 make an appropriation for a screw-pile beacon, but it was never built.

In 1854 the Nantucket Shoals were first marked by a lightship placed about nineteen miles from Nantucket Island, near Davis South Shoal. This lightship broke adrift in 1855 and stranded near Montauk Point, Long Island, but was got off and repaired and now, as Light-Vessel No. 11, is doing duty as Scotland Lightship off New York, sixty-one years after her disaster. Within less than a year a new vessel was appropriated for, built, and stationed on Nantucket Shoals. This lightship was built of white oak and live-oak, at the Navy Yard at Kittery (Portsmouth), and was placed on station in January, 1856, and was finally removed from Nantucket Shoals in November, 1892. This vessel, but one hundred and three feet long and having no power but sails, occupied this exposed station for nearly thirty-seven years, and now, known as Light-Vessel No. 1, she is still doing duty, stationed on Martins Industry, north of the Savannah River entrance. During the last year of her service at Nantucket Shoals she parted her moorings twice, and drifted about, and could not come to anchor for nine days in one case, and fourteen days in the other. In 1892 the Nantucket Shoals vessel was moved about ten miles to the southward, and in 1896 she was again moved and placed on the present station, more than twice the original distance from the island.

Life on a lightship is somewhat dreary, but on such a station as this it is not without excitement. During every fog the crew on Nantucket ship know that many vessels are headed directly for them, and in a storm, anchored as they are in the open sea, they may be far from comfortable. Nevertheless, perhaps on account of the searoom and the more powerful signals, the instances of collision are relatively few on this station. The vessel has occasionally been driven from her position by parting her moorings in a gale; in a number of instances she has been able to regain the station unaided. In December, 1887, a British steamer foundered a few miles to the southward, and the officers and crew reached the lightship in their boats, but it was two weeks before the gale abated so that the lighthouse tender could take them off and replenish the provisions, which were running short. One of the few instances of the foundering of a lightship occurred on this station in 1905. On December 10, during a very heavy gale, a leak developed in Relief Light Vessel No. 58, then on Nantucket Station; all pumps and hand-bailing were used in an endeavor to keep the water down; the tender Azalea, notified by radio, came out from New Bedford notwithstanding the gale; it required several hours to get a hawser to the lightship, after which the tender headed back for New Bedford with the sinking ship in tow. The crew were finally forced to abandon the lightship and were taken off only ten minutes before she foundered.

Proceeding toward New York an incoming vessel passes two other lightships, Fire Island, thirty-four miles, and Ambrose Channel, five miles, from the entrance, and there are two tall lighthouses on the low south shore of Long Island, Shinnecock and Fire Island, and also Navesink Light on the New Jersey shore. A lightship was placed off Fire Island in 1896, partly as a result of the disaster to the steamer St. Paul which ran on to the New Jersey beach. An example of the dangers to which lightships are exposed is the fact that this vessel was collided with twice in 1916. On March 1, a few minutes after midnight, the steamer Eastern City struck the lightship head on, and on May 8 about daybreak, the steamship Philadelphian cut into the lightship to a depth of two feet and down to four feet below the water-line. The seaman on watch testified: "There were a lot of tows and other boats going by, but I could not tell which way they were going. At 4.45 A.M. I saw the Philadelphian coming. I thought she would clear. I could see little because of the fog. All lights were burning, submarine bell was going, everything was going. I was standing by on the starboard side listening. I noticed that she was coming pretty close. . . . I started ringing the bell. I got them all up, and had everything ready before she hit." By quick presence of mind the crew, by emptying tanks, shifting coal, and slinging out boats filled with water, were able to list the vessel so as to bring most of the damaged part above the water, and the lightship was kept free with her pumps and towed into New York.

A lightship was stationed off Sandy Hook in 1823, and was the first outside vessel placed off the coast of this country. This vessel cost $17,702. On the completion of the Navesink Lights this vessel was removed to another station in 1829 by order of Congress. Another ship was, however, moored off Sandy Hook in 1838. In 1891 a revolving light was installed on the Sandy Hook vessel, and in 1894 a vessel with electric light was placed on this station. On the opening of the Ambrose Channel a vessel with various improvements was placed on the station in 1908, and the name changed from Sandy Hook to Ambrose. This vessel now has a light of sixty thousand candle-power, eclipsed every fifteen seconds, visible thirteen miles, using electric arc light and a lens. This lightship is known to transatlantic passengers as the beginning or end of the "run" across the ocean.

Scotland Lightship is stationed three miles off the Sandy Hook shore. This vessel was placed in 1868 originally to mark the obstruction to navigation caused by the wreck of the steamship Scotland, long since removed.

Navesink Light, on the highlands immediately south of Sandy Hook, and the principal light for New York Harbor, is of interest in a number of ways. Two lights were established here in 1828, and the present brownstone, prison-like looking structure with two towers was built in 1862. A Fresnel lens imported from France was installed at Navesink in 1841, this being the first United States lighthouse so equipped; this lens is preserved, but not in service. In 1898 an electric arc lamp was installed in the south tower, with a bivalve lens of the new lightning type. This lens, weighing over seven tons, revolves in ten seconds, and gives a flash each five seconds, the flash lasting but one tenth second. This is the only primary lighthouse lighted by electricity in this country, and the only shore station having a plant for generating electricity. Its estimated candle-power is 25,000,000, making it the most powerful coast light in the United States. Although, on account of the curvature of the earth, the light itself cannot be seen more than twenty-two miles, its beam is reported to have been observed in the sky at a distance of seventy nautical miles. There is a brass plate below the lens with the inscription: "This apparatus, the greatest ever made according to the new principle of Lightning Lights, has been drawn and executed with the agreement of the French Lighthouse Board. . . . Paris, 1893." After the establishment of the electric flash light many complaints were made by residents of the neighborhood of great discomfort and annoyance caused by the brilliancy of the flash; this was obviated by darkening several of the lantern panels on the land side. The two great beams of this light sweeping around the horizon, rapidly and ceaselessly through the night, quite outshine New York's first light in the fine old tower four miles to the northward on Sandy Hook.

Ambrose Channel, the great cut through the shoals, two thousand feet wide and forty feet deep, leading into New York Harbor, is one of the best-marked of waterways. Marking the immediate approach to it is first the Ambrose Lightship, and then a great gas and whistle buoy with light twenty-eight feet above the water. Along the sides of the six miles of the channel there are eighteen gas buoys and eight tall, unlighted buoys; on the starboard side entering, the lights and the buoys are red; on the port side the lights are white and the buoys black; the lights on the buoys at each end of the cut and at the turns are flashing, the others fixed; the average interval between the buoys on each side is less than one half mile. In addition to the buoys, there are on shore two lights in range for the outer portion of the channel, and another range for the inner portion. Since the thorough lighting of this channel it has been possible for the largest steamers to pass in or out of the harbor at night.

A chart of New York Harbor in 1737 shows not a single aid to navigation there at that time. One may imagine the difficulties of Henry Hudson when in 1609 he sailed into New York Bay in the Halfmoon. The diary says: "We found it to have a very shoald barre before it, for we had but ten feet water"; and, again: "The mouth of that land hath many shoalds." Boats were repeatedly sent ahead for soundings as the Halfmoon worked her way into the harbor and river.

For New York Harbor and its immediate approaches alone, three hundred aids to navigation are now required, including forty-six shore lights, two light vessels, thirty-nine lighted buoys, and thirty-seven fog signals including sounding buoys.

There are a number of small but substantial lighthouses in the bay, standing in the water on caisson or pier foundations, those near the principal steamer track being Romer Shoal, West Bank, and Robbins Reef.

The following are some incidents of lighthouse history in New York Harbor. An attempt was made to build a lighthouse on Flynns Knoll, north of Sandy Hook, and was abandoned after the works were destroyed by storms in 1840. The Statue of Liberty was from 1886 to 1902 maintained by the Lighthouse Board as an aid to navigation, electric arc lights being placed in the torch. Hell Gate was illuminated in 1884 by a powerful electric light on an iron tower two hundred and fifty feet high, which it was stated "completely illuminated Hell Gate Channel, furnishing a light as strong and as useful certainly as moonlight, and sufficient to enable even sailing vessels to go through the Gate in safety." This was an attempt at the general illumination of a waterway somewhat similar to the idea of lighting city streets by powerful lights placed on towers, which prevailed in the early days of electric illumination. The first optimistic view was soon dispelled; complaints were made that the light dazzled the eyes of pilots, and made shadows so heavy as to appear as obstacles; and the light was removed within two years.

That great inside waterway to New York, Long Island Sound, is well marked. At the eastern approach are three important lights, Montauk Point, Block Island Southeast, and Point Judith, while Race Rock and Little Gull Island Lights mark the entrance proper at the Race. Well out in the Sound are Cornfield Point Lightship, Stratford Shoal Light, and Execution Rocks Light, and the important points and entrances on each shore are marked throughout the length of the Sound.

The lighthouse on Race Rock was built between 1872 and 1878 under great difficulties. It is constructed on a submerged ledge, covered at the site of the structure with from three to thirteen feet of water at low tide. The tidal currents sweep through the Race and over this ledge with great velocity. The foundation is of concrete built up from the rock, and above this a conical granite pier rises from the water. On the pier stands a granite dwelling surmounted by a light tower.

In recent years a large gas and whistle buoy and a bell buoy have been placed a mile south of Cornfield Lightship for the purpose of dividing the heavy traffic by encouraging vessels bound east to steer for the buoy and those bound west for the ship. Montauk Point Lighthouse, on the eastern end of Long Island, was the first for which Congress made appropriation aside from those taken over from the colonies; it was built in 1797, and the original tower is still in service. It is interesting that Congress, when it made this first new lighthouse appropriation, provided "that the number and disposition of the lights in the said lighthouse shall be such as may tend to distinguish it from others, and as far as is practicable, prevent mistakes."

IV

LIGHTS OF THE NEW ENGLAND COAST

APPROACHING from the Canadian provinces the first United States lighthouse is West Quoddy Head, standing on the easternmost point of land of the country. In the one hundred and sixty miles from there to Portland there are eight primary lighthouses, all on off-lying islands, well placed by nature for the stationing of guiding beacons; these eight are Libby Islands, Moose Peak, Petit Manan, Mount Desert, Matinicus Rock, Monhegan Island, Seguin, and Halfway Rock. Immediately to the southeastward of Portland are the Portland Lightship and Cape Elizabeth Lights, and passing southwestward are two more primary lights on off-lying islands, Boon Island and Isles of Shoals. All of the foregoing, save the last, are on the coast of Maine, a coast whose intricate and rocky outline, climatic conditions, and large water-borne traffic all demand an extensive system of aids to navigation. Along this two hundred miles of coast there are no less than twelve hundred and sixty-six aids on the outer coast and inland waters, or an average

THE PETIT MANAN LIGHTHOUSE, MAINE

A granite tower

of over six to the mile of general coast; these include ninety-nine lights, nine hundred and thirty-one buoys, and one hundred and forty-nine fog signals of all descriptions. The lights so overlap that a coasting vessel will always be in sight of one, and often of two or more primary lights. Petit Manan Lighthouse is a handsome, slender granite tower one hundred and nineteen feet in height. Mount Desert Light stands on a rocky islet twenty-two miles from the mainland, and is the most exposed light station on the Atlantic Coast. During severe gales the sea breaks entirely over the rock, and it is stated that a rock of seventy-five tons has been moved sixty feet during a storm. The light, which has a fifteen-second flash, is shown from a sturdy-looking tower, built with a broad base and thick walls, and fifty-eight feet high. The rock is frequented by many birds, especially gulls, which lay their eggs there.

Matinicus Rock, eighteen miles from the mainland, is a station only less exposed than Mount Desert. There is not a tree or shrub on the rock, and the nearest port is twenty-five miles away. Twin lights are shown from two granite towers sixty yards apart, one light being five feet higher than the other. In the storm of January 19, 1856, the sea made a complete breach over the rock, washing away every movable thing, including an old stone dwelling. The keeper was away and unable to return to the station. His daughter, Abbie Burgess, fourteen years old, wrote to a friend: "As the tide came, the sea rose higher and higher, till the only endurable places were the light towers. . . . For four weeks, owing to rough weather, no landing could be effected on the rock. During this time we were without the assistance of any male member of our family. Though at times greatly exhausted with my labors, not once did the lights fail." It appears that when her father left this station Abbie Burgess married the son of his successor and lived on this rock for nineteen years after the storm, and was the mother of four children there.

The light-keepers at Monhegan are more fortunate, as, although far from the mainland, the lighthouse is in the midst of a summer resort colony with regular communication; the island is much frequented by artists and the keeper's house is adorned with good works of art. Seguin is one of the earliest stations on this coast, the first lighthouse being built in 1795 at a cost of only $6300. At Cape Elizabeth also are twin lights, shown from two masonry towers over three hundred yards apart.

Boon Island has a granite tower one hundred and thirty-six feet high; as the island is low the tower appears to spring from the sea. Of this lighthouse Celia Thaxter, herself the daughter of the keeper of Isles of Shoals Light, wrote "The Watch of Boon Island": —

"Afar and cold on the horizon's rim
  Loomed the tall lighthouse, like a ghostly sign;
They sighed not as the shore behind grew dim, —
  A rose of joy they bore across the brine.

"They gained the barren rock, and made their home
  Among the wild waves and the sea-birds wild;
The wintry winds blew fierce across the foam,
  But in each other's eyes they looked and smiled.

"Aloft the lighthouse sent its warnings wide,
  Fed by their faithful hands; and ships in sight
With joy beheld it, and on land men cried,
  'Look, clear and steady burns Boon Island light!'

"And while they trimmed the lamp with busy hands,
  'Shine far and through the dark, sweet light,' they cried;
'Bring safely back the sailors from all lands
  To waiting love, — wife, mother, sister, bride!'"

The original lighthouse on the Isles of Shoals was a rubble-stone tower eighty-seven feet high, built in

1821. It was equipped with a revolving light of a patriotic character, as it showed alternate red, blue, and white flashes. The blue flash was, however, not long retained, probably because of the loss of light with this color. The present brick tower was built in 1859.

In the approaches to Boston are Cape Ann, the Graves, Boston and Minots Ledge lights, and Boston Lightship. Cape Ann and Boston were among the colonial lights and have been described. The dangerous ledges and rocks known as the Graves, lying immediately northeast of the entrance to Boston, were marked by a bell buoy in 1855. Between 1903 and 1905 a lighthouse was constructed on a rock but three feet above low water. The tower is built of 882 granite blocks, and is equipped with a powerful light showing, every six seconds, two flashes of 380,000 candle-power.

One of the most notable lighthouses of this country is that on Minots Ledge, six and one-half miles southeast from Boston entrance. A report in 1843 described the dangerous reefs extending two miles off Cohasset, "annually the scene of the most heart-rending disasters . . . causing the death of many a brave seaman and the loss of large amounts of property. Not a winter passes without one or more of these fearful accidents occurring." During the nine years to 1841, forty vessels were wrecked on Cohasset reefs and in the immediate vicinity, and on six of these all of the crew perished. An examination was made of the reefs and it was reported that it was feasible to build a lighthouse near the extremity. From 1847 to 1850 an iron-frame lighthouse was erected on the Outer Minot. At the site the rock was bare only at low water and then for but a small area. It was one and one-fourth miles offshore, and on the seaward side entirely exposed to the Atlantic, so that the drilling of the holes for the piles involved great difficulty, consuming the greater part of two seasons. The frame of the structure consisted of nine wrought-iron piles, wedged into holes drilled five feet into the rock, and braced above the pile frame was the living-room for the keepers, and the lantern, and the entire structure was seventy-five feet high. The base was only twenty-five feet in diameter, the deck was but thirty-six feet above high water, and the center of gravity was high, and these features undoubtedly had much to do with its fate. This construction was adopted for economical reasons, and the cost was only $39,000. The light was first shown January 1, 1850, and was the first lighthouse built in this country in a position directly exposed to the sweep of the open sea.

It stood but little over a year after its completion. There was a great gale in April, 1851, and this extract from the official report tells the story of one of the lighthouse tragedies: —

> The light on the Minot was last seen from Cohasset on Wednesday night at 10 o'clock. At 1 o'clock Thursday morning the 17th, the light-house bell was heard on shore, one and one half miles distant; and this being the hour of high water, or rather the turn of the tide, when from the opposition of the wind and the tide it is supposed that the sea was at its very highest mark; and it was at that hour, it is generally believed, that the light-house was destroyed; at daylight nothing of it was visible from shore, and hence it is most probable it was overthrown at or about the hour named.

Two keepers were in the tower and were lost.

Notwithstanding this disaster, steps were promptly taken for building another lighthouse on Minots Ledge, and in the meantime a lightship was stationed to guard the reef. The present massive stone lighthouse was built on the original site, and was commenced in 1855 and completed in 1860. "It ranks, by the engineering difficulties surrounding its erection and by the skill and science shown in the details of its construction, among the chief of the great sea-rock lighthouses of the world."

The site in some respects was more difficult than those of the Eddystone, Bell Rock, and Skerryvore. A good part of the foundation site was below low water, and landings on the ledge could be made only at low spring tides and with a smooth sea. Work was prosecuted for more than three years before a single stone could be laid, as the foundation rock had to be cut into proper shape. During the first year only one hundred and thirty working hours were obtained on the rock. The light was exhibited November 15, 1860, more than five years from the beginning of the work. No life was lost in its construction, nor was any one seriously injured. Among the precautions taken were these: no person was employed on the rock who could not swim; no landing from a boat was permitted without the company of a second boat; while the workmen were on the ledge a small boat with three men was stationed on the lee side to pick up men occasionally washed from the rock.

The focal plane of the light is eighty-five feet above high water. The tower is conical, thirty feet in diameter at the first full course, and is built of granite; the lower portion is solid for forty feet except for a central well. The stones are dovetailed in each course and connected vertically by bonding bolts; eight long iron posts pass through the lower courses and into holes in the ledge. There are 1079 cut stones in the tower. Dwellings for the keepers' families were built on shore, accommodations for the men only being provided in the tower. The total cost of the lighthouse and station was about $300,000.

The tower is entered through a door forty feet from its base, reached by a ladder. In storms the spray reaches the lantern, and in winter tends to cover the glass with ice. The project for the lighthouse was devised by General G. J. Totten, and the work of construction was directed by Captain B. S. Alexander, of the Corps of Engineers. The light shown is a group of flashes so arranged as to repeat the number "143" every thirty seconds; that is, there are one flash, four flashes, and three flashes, with brief intervals between.

Longfellow visited Minots Ledge in 1871, and

PRESENT STONE LIGHTHOUSE ON MINOTS LEDGE, MASSACHUSETTS

This structure ranks among the difficult lighthouse engineering works of the world

writes: "We find ourselves at the base of the lighthouse, rising sheer out of the sea like a huge stone cannon, mouth upward. We are hoisted up forty feet in a chair, some of us; others go up by an iron ladder." And again in a letter he says, "The lighthouse rises out of the sea like a beautiful stone cannon, mouth upward, belching forth only friendly fires."

Four miles south of Minots is the old tower long used as a lighthouse at the entrance to Scituate, and preserved by the town for its historical associations. Connected with this light is a pretty story of the strategy of two American girls. In September, 1814, an English warship was anchored off this town. Rebecca and Abigail Bates, twenty and fifteen years of age, the daughters of the lighthouse keeper, were alone at the light-station. From their position of vantage they saw two of the warship's boats, filled with men, putting off toward some craft lying in the harbor. The sisters snatched their father's fife and drum, hastened to the shore, and hiding behind a bluff near the lighthouse, lustily beat the drum and played the fife. The martial strains were carried to the crews of the barges, and they turned back to the man-of-war, and the vessels were unmolested.

Cape Cod Light is on the highlands on the northeast side of the Cape. It is a powerful light with a flash of 580,000 candle-power every five seconds. At Nauset Beach, on the east side of Cape Cod, there were formerly three small lighthouses in line, built before modern methods of distinguishing lighthouses were available; each had a fixed light. In 1911 a flashing light was installed in one of the towers and the other two were removed. The present light is nearly one hundred times more brilliant than one of the old lights, and has a characteristic which cannot be mistaken for another, — a triple flash every ten seconds. Sixty or more years ago Emerson visited Nauset, and he records that "Collins, the keeper, told us he found resistance to the project of building a lighthouse on this coast, as it would injure the wrecking business." On the east end of Nantucket Island is Sankaty Head Light, and on the west end of Marthas Vineyard Island is Gay Head Light, both standing near the edge of cliffs.

Nine light-vessels, or more than one sixth of the total number in this Service, are stationed along the passage through the shoals below Cape Cod and the Sounds as far as the entrance to Buzzards Bay. Four of these mark the passage through Pollock Rip Slue and into Nantucket Sound. This passage is difficult on account of its sharp turns with shoals on either side, and the extremely foggy conditions which prevail at some seasons; for instance, during a single month, July, 1916, there were three hundred and eighty-six hours of fog at Pollock Rip Slue Lightship, an average of twelve hours a day. The very heavy traffic through this passage, including many tows of barges, makes the maintenance of these and other aids of great importance, and also subjects the lightships and buoys to frequent damage from collision. In 1915 no less than 17,496 vessels — steamers, schooners, and barges, — passed Pollock Rip Lightship.

The lightships on Cross Rip Station, in the middle of Nantucket Sound, have a remarkable record. A lightship was first placed here in 1828, and for eighty-seven years thereafter the station was kept by but two ships except for an interval of two and one half years and for the usual relief. The first was driven ashore on Cape Poge and lost in 1864 after thirty-six years service on the station. Light-Vessel No. 5 was placed on Cross Rip January 11, 1867, and did duty there until October, 1915, a record of nearly half a century on one station. The vessel that filled the interval between these two met with disaster. After being damaged by a schooner in collision, she broke adrift in the gale of December 27, 1866. The following day, after parting from the second anchor, the crew set sail and stood out to sea, in order to keep off the shoals. They were not heard from for over a month, when the mate reported from New Orleans. The sails had been split one after another; the pumps were kept going until the 30th, when the crew were exhausted; signals of distress were made, and with great difficulty they were taken off by a vessel bound for New Orleans.

The risk of collision to which a lightship in these sounds is exposed is shown by the record of Cross Rip during the winter of 1901–02, the lightship being struck by a barge in tow, by a schooner, by another barge in tow, and again by a schooner. There are numerous reports of vessels colliding with the lightships in Pollock Rip Slue and the Sounds. In 1875 seven lightships — all of those off the Massachusetts coast, except Nantucket — were swept from their stations by the ice. In a gale in November, 1898, Pollock Rip Lightship parted her moorings and was driven over the easterly end of Stone Horse Shoal, striking three times, and drifted off to sea. The lightship was finally taken in tow and brought into Delaware Breakwater, three hundred miles from her station.

South from New York, after Navesink, the primary coast lighthouses are Barnegat, a white and red tower one hundred and sixty-one feet high; Absecon, a yellow and black tower of one hundred and seventy feet; Cape May, a gray tower of one hundred and seventy feet; Cape Henlopen, one of the colonial lights; Assateague, a red tower of one hundred and forty-two feet; and Hog Island, a black iron skeleton tower one hundred and ninety-one feet high. Absecon Lighthouse, owing to its location in the heart of Atlantic City, has the distinction of being the most visited lighthouse, there being as many as ten thousand visitors during the three summer months. Visitors are permitted at hours and under restrictions that avoid interference with the proper operation of the station. The present lighthouse at Cape May is the third to be built there.

Delaware Bay and River from the capes to Philadelphia are thoroughly marked with channel lights, range lights, and gas and other buoys. In the bay there are five substantial lighthouses built on caisson foundations close to the edge of the channel at dangerous shoals, and indicating by white and red sectors in the lights the limits of channel and shoals; these all stand in the water in depths of from seven to twenty-four feet. Above this for a distance of nearly fifty miles to Philadelphia there is an unusual series of powerful range lights, so that vessels are guided by two lights in line for every stretch of this winding waterway; there are also either gas buoys or adjacent lights at nearly every turn from one course to another. Some of the rear range lights are as much as three miles from the water, and furnish a rather novel sight standing in a farming district.

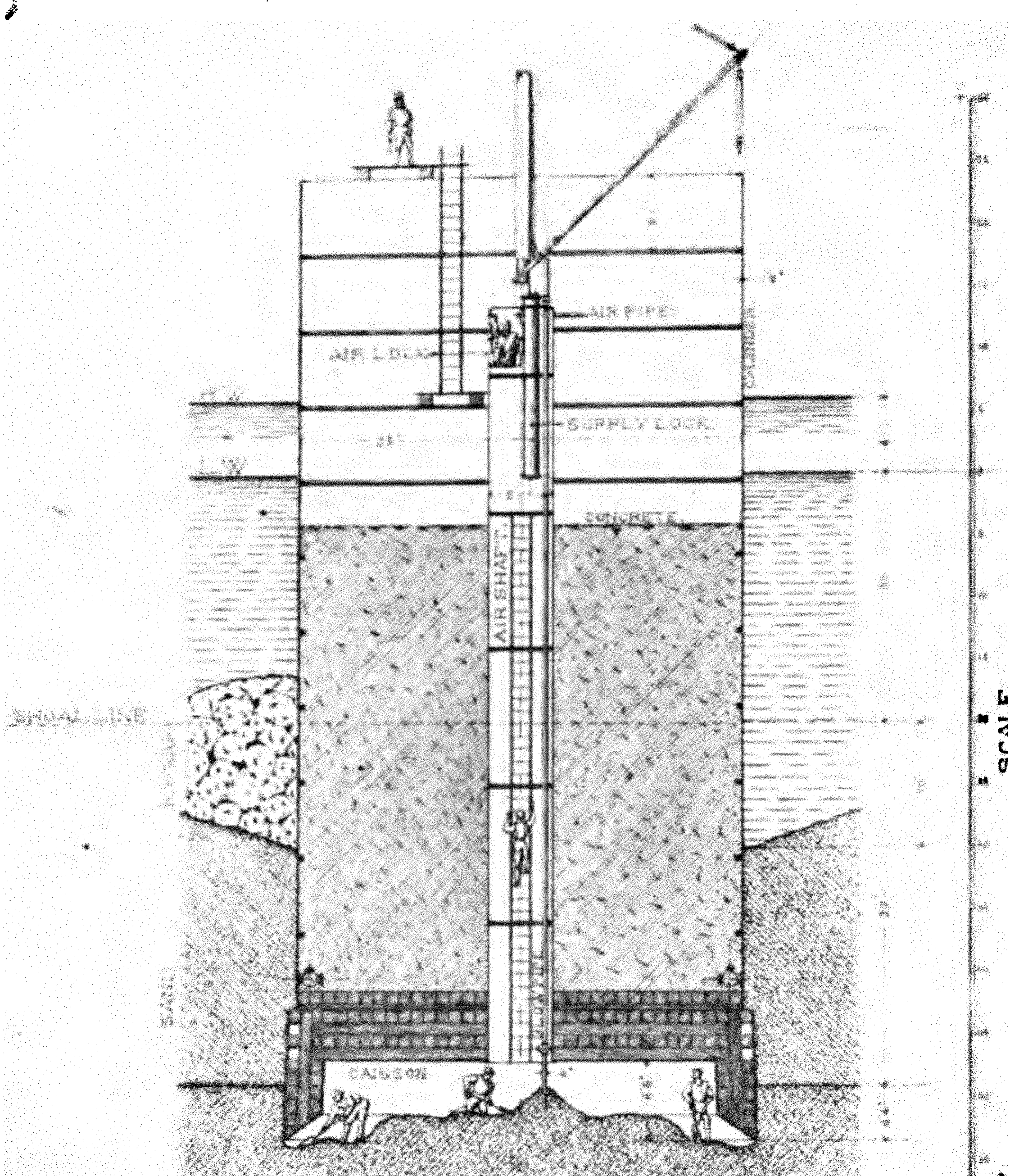
Two of the lower bay stations are notable in the history of lighthouse engineering. Brandywine Shoal is a dangerous and very shoal area lying near the center of Delaware Bay, eight miles from the entrance. A lightship was placed here in 1823. A lighthouse was first built on Brandywine in 1827, but was soon demolished by the sea, and the light-vessel was replaced. Some years later a project was prepared to place a light on an artificial island to be built on the shoal; but this and other plans were abandoned in favor of a screw-pile structure.

Brandywine Shoal was the first lighthouse in the United States erected by this method, which had been used in England in 1838 for Maplin Lighthouse in the Thames estuary. The iron piles, nine in number, were fitted with broad-bladed screws three feet in diameter, and by turning were bored into the sand of the shoal to a depth of about six feet. The broad screws furnish additional bearing surface, as well as a means to force the piles into the sand. An iron frame structure, with house and lantern, was erected on the pile foundation. The lighthouse stood in six feet of water and was completed in 1850. It was surrounded by an ice breaker, built with screw piles in a similar manner, but entirely separate from the lighthouse.

On account of deterioration due to the great ice movements in Delaware Bay, and to corrosion, a new lighthouse has been erected near by. This lighthouse, completed in 1914, is also the first of its type of construction in this country. It is built of reinforced concrete, and the foundation is an unprotected cylindrical pier thirty-five feet in diameter, resting in eight feet of water upon the heads of seventy-four pine piles, which were jetted into the shoal so that their heads were one foot above it. The reinforced-concrete pier, weighing 225 tons, was built on shore, and was launched, floated to the site, and sunk in position. It was secured upon the wooden piles by twelve reinforced-concrete piles, each weighing four and one half tons, which pass through pockets in the outer shell of the pier. Above this pier is a concrete dwelling, circular in plan, surmounted by the lantern.

Fourteen-Foot Bank lies above Brandywine Shoal, about in the center of Delaware Bay, and was marked for ten years by a lightship. This vessel was often forced from her station by the heavy ice of the Delaware. In 1887 the first lighthouse in the United States built on a submarine foundation, with a caisson sunk in the sand bottom by the pneumatic process, was completed on Fourteen-Foot Bank. A timber working-chamber forty feet square, and with sides seven feet deep, was built on shore and launched. On this were placed three courses of an iron cylinder thirty-five feet in diameter, built up of cast-iron plates bolted together on their flanges. The caisson was then towed by two tugs to the site, where it was sunk in position, in a depth of twenty feet, by admitting water to the cylinder. Through the center of the cylinder rose an air-shaft, with lock, through which men passed to the working-chamber, where, working in an air pressure sufficient to keep out the water, they dug out the sand, which was blown out by air-pressure through an iron pipe. There were three gangs of eight men each, working in the caisson in four-hour shifts. In this manner the caisson was sunk at the rate of about one and one half feet per day, until it penetrated the shoal thirty-three feet. As the caisson descended, the cylinder was built higher, keeping it above the water, and was filled with concrete. The completed cylinder is seventy-three feet high. On this cylinder stands the keepers' dwelling, surmounted by the light tower. The current produced considerable scour, and at times the cylinder was twelve degrees out of plumb; about six thousand tons of riprap were placed around the cylinder to prevent scour.

From off Delaware Bay to Chesapeake Bay there are five light-vessels stationed, all well offshore, being from seven to sixteen miles out, and known as Northeast End, Five-Fathom Bank, Fenwick Island Shoal, Winter-Quarter Shoal, and Cape Charles. Light-Vessel No. 37 foundered on Five-Fathom Bank



THE FOURTEEN-FOOT BANK LIGHTHOUSE, DELAWARE

The first lighthouse in this country the foundation of which was placed by pneumatic process Completed in 1887. The diagram shows men working in the caisson under air pressure removing the sand, which is blown out

Station in a hurricane in August, 1893; of the crew of six, two were rescued after being in the water sixteen hours.

A new lightship, with propelling power, has recently been placed on Cape Charles Station; the previous station ships, provided only with sail power, have several times been driven from the station and into dangerous positions near the coast. Two years ago the tender Orchid, with great skill and daring on the part of her officers, reached the lightship when she was about two hundred yards from the beach, both vessels being in the breakers, and the Orchid towed the lightship off.

Guarding the entrance to Chesapeake Bay are Cape Charles and Cape Henry Lights, the latter one of the colonial lighthouses already mentioned. Lighthouses are sometimes undermined by the sea, and from this cause three successive towers have been built at Cape Charles, Virginia. The first was constructed in 1827, seven hundred feet from the then shore line. It was attacked by a party of guerrillas in 1863, who completely destroyed the light. A new tower was then already in course of construction on account of the cutting-away of the beach, and the first site has now been washed into the sea. The second lighthouse was completed in 1864, also about seven hundred feet from the shore; but the sea has continued to encroach until this now stands on the edge of the water.

The present lighthouse was built in 1895, about thirty-six hundred feet from the shore, and is an iron cylinder nine feet in diameter, surrounded and braced by an iron skeleton tower. This light flashes "45" every minute, — four flashes in succession, followed by an eclipse, and then five flashes.

Birds are attracted by the brilliant light, and sometimes are killed by striking against the heavy plate glass of the lanterns, and fall to the ground. At Cape Charles Light the keeper has seen ducks fly directly through the lantern and fall to the floor cut and torn by the broken glass. Some lighthouses are fitted with bird-protecting screens around the lantern, as for instance at Mayo Beach Light on Cape Cod. When Sabine Bank Light, in the Gulf of Mexico, was increased in brilliancy by installing an oil vapor lamp a bird-guard was found necessary because of the birds flying for the lantern, attracted by the more brilliant light.

Many changes in the positions of lighthouses have

been made necessary by changes in coast line, usually the cutting-away of the shore as in the case of Cape Charles. A remarkable instance of the opposite kind is Fishing Point, on the outer coast of Maryland, north of Cape Charles. When surveyed in 1849 Fishing Point was but a bend in the shore line. Since then there has formed a long tongue of land extending to the southward and westward, the point having moved about three miles in this interval, or an average of about eight inches a day. The light has had to be shifted on account of the extension of the point, and is now three-quarters of a mile from its position of a few years ago.

The very extensive navigable waters of Chesapeake Bay and its tributary rivers are marked by no less than three hundred lighted aids to navigation. The main bay has lighthouses at the extremities of shoals and points, many of these standing in the water. Originally a number of these were on screw piles, and they were sometimes damaged by heavy movements of ice; for instance, in 1893 three of these lighthouses were swept away or wrecked by the ice. An instance of heroism is recorded on the part of the keepers of Sharps Island Lighthouse. The structure was lifted from its foundation by a heavy run of ice in February, 1881, thrown over on its side, and carried away. The keepers, although they had a boat, clung to the floating house, and drifted for sixteen hours without food or fire, always in danger from the ice; they did not leave the wreck until it grounded on an island, and they were able to save the lens and much of the property.

Another of these water lighthouses in Chesapeake Bay has experienced repeated disasters. One of the first lightships established in this country was that placed off Willoughby Spit, at the southern end of the bay, to mark the passage through the shoals into Hampton Roads. In 1872 a screw-pile lighthouse was built on the opposite side of the passage, to mark the dangerous shoal, the Thimble, off Old Point Comfort, and to replace the lightship. This lighthouse has been twice destroyed by fire, and it has a number of times been rammed and badly injured by vessels and tows. In 1914 it was replaced by a substantial structure, with caisson foundation, a cast-iron pier filled with concrete. Vessels will be more careful in future of colliding with it.

Baltimore Light Station stands on a pier in twenty-three feet of water at the entrance to the channel leading to Baltimore. The caisson for this foundation, after being floated to the site and sunk in position, tilted over because of heavy seas and other conditions, and finally in a severe storm turned flat on its side. To right this great weight was a serious task, but this was finally accomplished by suspending one hundred and twenty tons of lead from cables secured to the structure and led over long lever arms. The lighthouse was completed in 1908 after much delay.

The long dredged channel leading to Baltimore is marked by gas buoys at all turns and at intervals throughout its length, and for the greater portion by range lights, as well as by other buoys and several lighthouses. The dredged channel into Norfolk is marked by gas buoys and other aids to navigation, including a small lightship with fog bell.

VI

LIGHTS OF THE SOUTH ATLANTIC COAST

THE coast south of the Chesapeake is all low, and consequently, in order to get sufficient range of visibility, tall towers have been built to carry the main coast lights. Currituck Beach and Bodie Island Lighthouses are each one hundred and sixty-three feet high. Cape Hatteras Light is on the most projecting point on the Atlantic Coast, a narrow sand island.

Cape Hatteras, with the Diamond Shoals extending eight miles to seaward, constitutes one of the greatest dangers to shipping on the coasts of the United States, and no point on the coast has received more earnest consideration as to the best method of providing safeguards against disaster.

Alexander Hamilton, in a report to the Senate in 1794, referred to "having for a long time entertained an opinion that a lighthouse on some part of Cape Hatteras would be an establishment of very general utility to the navigation of the United States"; and he advises Congress "to erect a lighthouse of the first rate." As a result a stone tower ninety feet high was

built at Cape Hatteras in 1798. The present brick tower with granite base was completed in 1870, in a position six hundred feet northerly from the preceding. It is one hundred and ninety-three feet high, the tallest light tower of this country, and is painted with broad black and white bands spirally. It is equipped with a first-order lens having twenty-four panels, giving a flash each six seconds as this large lens slowly revolves. It is a beautiful sight from near the tower to see these twenty-four beams of clear light sweeping around the horizon.

It was soon evident that a light on the Cape was not sufficient. A lightship was built and placed on Diamond Shoals off Cape Hatteras in 1824. After a few months this vessel broke from her moorings, and after being driven a great distance to sea, succeeded in gaining the port of Norfolk. The vessel was replaced several times, but finally in 1827 was driven ashore near Ocracoke Inlet and wrecked. It was seventy years before another lightship was placed on Diamond Shoals. In a report made in 1851, Lieutenant D. D. Porter, U.S.N., urged that "there is much required off the Point of Hatteras shoal a fog bell that can be heard at some distance"; and in the same year Congress made appropriation for "a floating bell beacon on Cape Hatteras, outer shoal." In 1852 a bell boat was moored nine miles and a buoy three and one half miles from the lighthouse, but within four months both had disappeared; the absence of further mention indicates that the attempt was abandoned for the time. A whistling buoy was placed off the shoals in 1883. In 1884 a gas buoy was moored off Cape Hatteras, but a later report states that it "remained in position but a few months and has since been drifting about the Atlantic"; and remarks, "It is evident that such a buoy cannot be maintained at this point."

After considerable discussion, Congress in 1889 authorized the construction of a lighthouse by contract on Outer Diamond Shoal at a cost not to exceed $500,000. The contractors built at Norfolk a caisson fifty-four feet in diameter and forty-five feet high. The caisson was towed to the site by three powerful tugs and grounded in water twenty-two to twenty-five feet deep on July 1, 1891. The scour of the currents caused the caisson to sink out of level, and also as a whole, so that only a few feet remained out of the water. The sea soon prevented work, the storm of

July 8 carried away the machinery and the upper part of the caisson, and the contractors abandoned the work. In 1894 the Lighthouse Board again undertook the project of a lighthouse on the shoals, and as a preliminary measure a skeleton iron frame supported by wrought-iron piles with large disks at their lower ends was built, floated to the site on pontoons, and successfully placed in position; from this, borings of one hundred and five feet into the shoal were obtained to determine the character of the foundation. This frame was still standing in 1895. A project was then proposed of a skeleton iron structure supported on heavy iron piles, to be driven by the water jet.

In 1896 Congress directed the building of a light-vessel for Diamond Shoals instead of the lighthouse, and Lightship No. 69 was built, and first displayed lights on the station September 30, 1897. Since that date a light-vessel has been continuously maintained at this difficult position, except for brief intervals when carried away by storm. In 1904 and 1905 Congress authorized the construction of a lighthouse on Diamond Shoals by private individuals, to be paid for under certain conditions, but the law lapsed through failure to commence construction.

Diamond Shoal lightship occupies one of the most exposed stations for such a vessel in the world. The ship is moored in thirty fathoms of water, in the Atlantic Ocean, thirteen miles off Cape Hatteras and five miles outside of the outer limit of the shoals, so that a vessel may safely lay her course to pass close to the lightship, which she could not do in the case of a lighthouse on the shoals.

The present station ship is Lightship No. 71, a vessel one hundred and twenty-two feet in length, with propelling machinery and steam fog signal, and equipped with radio. Because of the dangerous position, the ships on this station have had various vicissitudes. Lightship No. 69 was used for a lighthouse tender for a while during the Spanish War of 1898, when some of the tenders were used in the naval service. Later this vessel was driven from her anchorage off Diamond Shoals in the hurricane of August, 1899, and was stranded on the beach near Cape Hatteras; the vessel was, however, got off the next month and repaired, and is still on duty as a lightship, now stationed at the Overfalls in the entrance to Delaware Bay. The Diamond Shoal Lightship is subjected to unusual danger both from

STRANDING OF DIAMOND SHOAL LIGHTSHIP

TOWING A LIGHTKEEPER'S DWELLING ACROSS WINYAH BAY,

storm and collision, as the records show each year. One report of the master reads: "All day yesterday and all last night we had the heaviest S.E. gale that I have experienced here. About midnight she was breaking all over the ship"; the storm did much damage to the vessel, "but we managed to keep on the station and the light and fog signals going all night. Everything that we are able to will be put in order. All is well on board." At another time the master reports that a schooner going at nine knots struck the lightship and did much damage to upper works and carried away all the rigging of the main-mast. The lightship "being light on the water was doing all kinds of acrobatic stunts," which kept the mainmast swinging and swaying. "The six seamen and also the cook worked manfully all night in trying to save the mainmast," and succeeded, as also in fitting up the wireless aerial so that a message could be sent. The report ends by stating that the light has "been kept burning as usual, and the ship kept in right position, and unless very severe weather sets in the vessel will stay here until relieved."

For a number of years the Diamond Shoal ship showed experimentally a searchlight beam directed southeastward midway between the horizon and the zenith; this was discontinued in 1908, it being effective only when cloud conditions were favorable.

Between Cape Hatteras and Charleston are the tall lighthouses on Cape Lookout, Cape Fear, and Cape Romain, nearly equidistant and each marking a prominent point, with dangerous shoals extending far off shore. Cape Lookout Shoals Lightship and Frying-Pan Shoals Lightship, each eighteen miles from the coast, guard the extremities of the shoals off the first two capes. Cape Lookout tower is distinguished by its unusual marking, alternate black and white lozenge shapes. Cape Lookout showed a fixed white light up to February, 1914, when it was changed to occulting, with two eclipses each ten seconds. The importance of a distinguishing characteristic is well illustrated in this case. In the two and one fourth years before the change five wrecks were reported, in which the cause was stated to be the mistaking of Cape Lookout Light for some other light. In the same interval since the change there has been no report of a wreck from this cause.

The Cape Fear River leading to Wilmington, North

Carolina, is lighted with thirty-three lights, most of which are range lights; all of these are cared for by two keepers.

The one hundred and sixty-one-foot tower at Cape Romain is appreciably out of plumb, due to character of soil and foundation. The original lighthouse built in 1827 is still standing near by. At Winyah Bay, just north of Cape Romain, it recently became desirable to move a light-keeper's dwelling across the bay to the Georgetown Light Station. The dwelling, with chimneys and porches intact, and the keeper's family still living in it, was skidded on to two lighters, towed across the bay, and safely placed in position.

Charleston Lighthouse is one of the colonial lights already described. One of the range lights for the entrance channel is on historic Fort Sumter. For twenty-two years, the rear light for this range was located in the beautiful spire of St. Philips Church in Charleston, but this light was recently changed to a site more useful to shipping.

The first incident of the Civil War affecting the Lighthouse Service occurred at Charleston. On December 18, 1860, the lighthouse inspector at Charleston reported as to the probable seizure of lighthouse property there. On December 20, 1860, Commander R. Semmes, then Secretary of the Lighthouse Board, wrote to the Secretary of the Treasury that he would not recommend that the coast of South Carolina "be lighted by the Federal Government against her will." On December 24 the Secretary of the Treasury declined to issue instructions in the matter. On December 30 the lighthouse inspector informed the Lighthouse Board that "the Governor of the State of South Carolina has requested me to leave the State. I am informed that forcible possession has been taken of the lights, buoys, etc., of this harbor, and that similar measures will be adopted in regard to all the lights in the State." Early in January the Rattlesnake Shoal Lightship was towed into Charleston and the lighthouse tenders were seized. By the latter part of April, 1861, practically all lights were extinguished, lightships removed, and other aids removed or destroyed, from the Chesapeake to the Rio Grande, with the exception of some of the lights on the Florida coast and reefs. In all one hundred and sixty-four lights were forcibly discontinued on the Southern coasts. These were relighted from time to time, and by 1866 the greater part had been restored. The

Charleston channel was re-marked promptly on the occupation of the city in February, 1865.

Midway between Charleston and Savannah is Hunting Island Lighthouse, which was undermined and thrown down during the Civil War. In 1875 a new lighthouse was completed, built of cast-iron plates. On account of unhealthiness of the climate, the work of construction was carried on only half of the year. The tower was placed about one fourth mile from the coast and there was some criticism of its being so far from the shore. But it was not far enough, for on account of the sea cutting away the end of the island, its position became unsafe, and in 1889 the lighthouse was taken down and reerected on a new site one and one fourth miles distant. The possibility of removal was considered in the selection of this type of construction.

The Tybee Light at the entrance to Savannah River was one of the colonial lighthouses already mentioned, though first lighted by the United States. This river is well marked to Savannah with range lights and other aids. Somewhat more than halfway up, at a little light-station on Elba Island, lives "the waving girl of the Savannah River," the sister of the light-keeper; for years past she is said to have greeted every passing vessel, waving a flag by day and a lantern by night.

Between the Savannah River and the Florida Keys, the primary lights are Sapelo, St. Simon, St. Augustine, Mosquito Inlet, Cape Canaveral, Jupiter Inlet, and Hillsboro Inlet. The present St. Augustine Lighthouse is a black and white spirally banded tower, one hundred and sixty-one feet in height. The first lighthouse was built in 1824 and used for fifty years, though the site is now washed away. It was a massive square tower rather after the mission style. The first mention of it in the laws is an appropriation of March 3, 1823, "for finishing the lighthouse near St. Augustine," $5000. From this it appears probable that the lighthouse tower had been under construction by the Spanish authorities. The official reports note that in November, 1874, at St. Augustine Lighthouse "a flock of wild ducks flew against the lantern, breaking three panes of glass and slightly damaging the lens-apparatus."

In 1868 an iron-plate lighthouse, one hundred and forty-five feet in height, was built at Cape Canaveral to replace an earlier light, and in 1894 this was taken down on account of encroachment of the sea, and reerected in the present position, one and one fourth miles westward of the former site. Hillsboro Inlet Lighthouse is of iron skeleton construction.

There are extensive navigable inland waters south from the Chesapeake, including Albemarle and Pamlico Sounds, and connecting rivers and channels, which with canals and cuts form a nearly continuous inside route for small vessels from Chesapeake Bay to Florida. In addition, therefore, to the great coast lights and the system of aids for the various harbor entrances, a large number of lights, beacons, and buoys are placed to mark these inside waters, and there is in reality a double line of aids to navigation along much of the South Atlantic Coast. The same is true of a portion of the Gulf Coast, and these inside routes are being extended and are increasing in importance.

VII

LIGHTS OF THE FLORIDA REEFS AND THE GULF COAST

On the transfer of Florida to the United States in 1821, the first provision of Congress for lights was an appropriation in 1822 for lighthouses on Cape Florida and Dry Tortugas. Cape Florida Lighthouse, in Biscayne Bay, was partially burned in 1836 by the Indians in the Seminole War. A new tower was built in 1846; the illuminating apparatus was destroyed in 1861. The station was discontinued in 1878 on the completion of Fowey Rocks Light, but the old tower is still standing, about six miles northwesterly from Fowey Rocks.

The following story is told of the attack on the tower by the Indians in 1836. The keepers had been warned and the head keeper had taken the families to a place of safety, leaving the lighthouse in the care of the assistant, with a negro to assist him. On the approach of the Indians they barricaded themselves in, and went up to the watch-room. The Indians tried to go up the steps of the tower, but the keepers fired at them. The Indians then filled the base of the tower with dry wood and set it on fire. The tower acted as a chimney and the heat and smoke drove the occupants on to the balcony, crawling flat on their faces. When the fire burned out and the Indians were quiet the negro peered over and was shot. The assistant keeper was wounded, and suffering from thirst, lying in the tropical sun, had given up hope when a government cutter arrived and drove the Indians away. A cord was shot over the tower, and the assistant keeper hauled up a rope and made it fast; a sailor boy climbed up, and the assistant keeper was finally rescued. The Indian war prevented the rebuilding of Cape Florida Light, as well as any additional lights on the Atlantic Coast of Florida, for a number of years.

Marking the Florida Reefs from Fowey Rocks to Sand Key is a remarkable group of six tall skeleton iron lighthouses, at an average distance apart of about twenty-five miles. On account of the convex curvature of the line of these reefs with respect to the channel in the Straits of Florida, the abruptness of the edge of the reefs and the proximity to the Gulf Stream, the Florida Reefs have always been a serious menace to shipping. For the years 1831 to 1844 the salvage of the wreckers of Key West amounted to over one million dollars, and the wrecking trade was sufficient to sustain a fleet of fifty wreckers' vessels. The wreckers even took possession of the first lightship built for this coast, which sailed from New York in June, 1825, and on its passage was blown on the Florida coast and abandoned by the crew; the contractors for the vessel were obliged to ransom it from the wreckers. Congress had made an appropriation in 1824 for a lightship at Carysfort Reef, nearly due east of the southern end of the Florida peninsula. This vessel was placed on station in 1825, and although an aid to navigation of only moderate effectiveness, it was for twenty-seven years the only light marking the one hundred and thirty miles of the Florida Reefs between the lights at Cape Florida and Key West, and for much of this time it was the only light between St. Augustine and Key West. In June, 1837, the captain of Carysfort Reef Lightship and one of his men were killed by the Indians.

The first of the tall towers on the Florida Reefs was that built on Carysfort Reef to replace this lightship. Congress in 1837 made an appropriation for a lighthouse on this reef. The following year a civil engineer, J. W. P. Lewis, examined the site, and his report was favorable to the erection of a lighthouse on the reef. He also pointed out the necessity "of the erection of five new lighthouses on various parts of the reef, at distances from twenty-five to thirty miles apart." The construction of the lighthouse was postponed on account of the Seminole War, but was finally begun in 1848. The lighthouse was designed by Mr. Lewis. It was constructed under the direction of officers of the Topographical Bureau and was first lighted March 10, 1852. Carysfort Lighthouse is an iron openwork structure, pyramidal in shape, standing in three feet of water about three hundred yards from the edge of the reef. At the site there is a hard exterior coral crust over a softer material below, so that it was considered that screw piles would not have sufficient bearing to support the tower, which weighed four hundred and fifty tons. Therefore large cast-iron disks or foot plates, six feet in diameter, were used to spread the pressure over the coral surface. The tower is supported on nine eight-inch iron piles, forming an octagon, with one central pile, all passing through center eyes in the disks and driven ten feet into the reef until shoulders on the piles rest on the disks. The tower is one hundred and seventeen feet high above the reef, with a base fifty feet in diameter, and the light is one hundred feet above the sea. Two stories enclosed within the structure form a lodging-place for the keepers, thirty-three feet above the water, and leading from this to the lantern is a cylinder enclosing a winding stairway. The entire structure was built and set up for test in Philadelphia. To facilitate work at the isolated site, the lighthouse was built entirely by men and with equipment and materials sent by schooner from Philadelphia.

The second of the tall reef lighthouses was completed the following year, on Sand Key, seven miles southwesterly from Key West. A brick lighthouse sixty feet high and a dwelling had been built here in 1826, but the sand on which they stood was washed away in a hurricane in 1846, and the buildings were undermined and fell, burying the inmates. Sand Key Lighthouse, built in 1853, is an openwork iron structure one hundred and twenty-one feet high, similar in general character to Carysfort, except that it is supported by screw piles without disks; a modified form of screw, two feet in diameter, was used, which cut its way through the coral with slow motion. It has a broad base, fifty feet square, and rests on seventeen iron piles bored fourteen feet into the reef. It rises from the center of a small low white sandy key, and is the only one of the six reef towers which does not stand in the water. At the time of the completion of this lighthouse the engineer officer charged with its supervision was Lieutenant G. G. Meade; the Sand Key Light was lighted in July, 1853, and just ten years later Meade was commander at the battle of Gettysburg. While this lighthouse has stood firmly now for well over a half century, the keepers have not always been so sure of the island beneath them, for in a gale in 1856 the island with all on it was washed away and the water rose six feet around the tower, but it suffered no injury. In October, 1865, a hurricane again took away the island and everything on it except the lighthouse.

In 1858 the tallest of the reef lighthouses was completed on Sombrero Key, thirty-eight miles east of Key West. This is a graceful iron tower, fifty-six feet in diameter at the base, one hundred and sixty feet high, with light one hundred and forty-two feet above the sea. It stands in five feet of water and is supported by nine wrought-iron piles, twelve inches in diameter, resting on cast-iron disks eight feet in diameter, through which the piles are driven into the as at Carysfort. The keepers live in quarters ca within the skeleton tower on a platform thirty-s feet above the water. The report and plan for construction of this lighthouse were prepared Lieutenant Meade, but he was transferred to ot duty early in its construction. The structure a illuminating apparatus cost about $120,000.

The other three of the tall reef lighthouses, Al gator Reef, nearly midway of the extent of the ree Fowey Rocks, at the northern extremity, and Ame can Shoal, fifteen miles east of Key West, were com pleted from 1873 to 1880. All of these are of the sam type as Carysfort Reef Lighthouse, and stand in th water near the edge of the reef, supported on iron piles driven through disks. Alligator Reef Lighthouse is said to be "one of the finest iron sea-swept light-house structures in the world." The tower is practically the same height as that at Sombrero Key, but the light is six feet lower. The cost of Alligator Reef Lighthouse was $185,000.

At Dry Tortugas, on Loggerhead Key, the most westerly key of the Florida Reefs, is a tall brick light-house, one hundred and fifty-seven feet in height.

eter, through which the piles are driven into the reef, as at Carysfort. The keepers live in quarters carried within the skeleton tower on a platform thirty-seven feet above the water. The report and plan for the construction of this lighthouse were prepared by Lieutenant Meade, but he was transferred to other duty early in its construction. The structure and illuminating apparatus cost about $120,000.

The other three of the tall reef lighthouses, Alligator Reef, nearly midway of the extent of the reefs, Fowey Rocks, at the northern extremity, and American Shoal, fifteen miles east of Key West, were completed from 1873 to 1880. All of these are of the same type as Carysfort Reef Lighthouse, and stand in the water near the edge of the reef, supported on iron piles driven through disks. Alligator Reef Lighthouse is said to be "one of the finest iron sea-swept lighthouse structures in the world." The tower is practically the same height as that at Sombrero Key, but the light is six feet lower. The cost of Alligator Reef Lighthouse was $185,000.

At Dry Tortugas, on Loggerhead Key, the most westerly key of the Florida Reefs, is a tall brick lighthouse, one hundred and fifty-seven feet in height,

SOMBRERO KEY LIGHT, FLORIDA

A pyramidal iron skeleton tower, supported on iron piles driven into the coral reef. The keepers live in the enclosed house

built in 1858. The Dry Tortugas Light of 1826 was on Garden Key, about three miles east, where a harbor light is still maintained. In 1858 also was built the tall brick lighthouse at Pensacola, one hundred and seventy-one feet in height.

The history of no lighthouse in the country is more filled with struggle than is that of Sand Island Light at the entrance to Mobile Bay, and thirty miles from Mobile. A lighthouse fifty-five feet in height was built here in 1838, and this was replaced in 1858 by a fine tower of one hundred and fifty feet, and a first-order lens. In 1861, three years after its completion, this tower was blown up by the Confederate forces. In 1867 a light was shown from a temporary frame tower. The present handsome brick tower with granite trimmings was completed in 1873. It is one hundred and thirty-two feet in height, and its foundation consists of one hundred and seventy-eight piles overlaid with sill timbers and twelve feet of concrete. In 1873 Sand Island is described as "merely a bank of sand, about four hundred acres in extent, constantly changing its outline." The earlier light had been twice moved back from the water on account of the encroachment of the sea, and the temporary frame tower was then in danger of destruction from this cause. The tower of 1873 was located six hundred and seventy feet northwest of the one destroyed, and on what appeared to be the most stable part of the island, but by 1885 the sea had cut the island away so that it was necessary to build jetties to protect the station. Since that time there has been continuous effort, by means of jetty and riprap protection, to save this important lighthouse from destruction by the sea. The outer edge of Sand Island has in sixty years moved northwesterly more than one half mile, and had by 1908 left the lighthouse standing in the water a quarter of a mile away; the island has now entirely disappeared. Most of the small island then remaining around the lighthouse was swept away by the hurricane of September, 1906, which carried disaster along the Gulf Coast; at that time this telegram was received from the lighthouse inspector: "Sand Island Light out, island washed away, dwelling gone, keepers not to be found." The tower remained, and one keeper had, fortunately, gone ashore, but the other keeper and his wife perished. During the recent hurricane of July 5, 1916, which did much damage in Mobile Bay, the keepers at Sand

Island maintained the light continuously, although the vibration of the tower was so great as to throw half the water out of a bucket in the watch-room, and to require the substitution of a wick lamp in place of the oil vapor lamp which could not be kept burning.

There are many cases of contest with the sea along the low and sandy coasts of the Gulf and South Atlantic. Horn Island Light marks the entrance to Mississippi Sound, and a report in 1882 says that "a little more than a year ago this station was moved about three hundred feet across the island, so as to be on its northern side, within the waters of the Mississippi Sound, but the island has again worked over and built up to the northward of the lighthouse, and the station is now again in the Gulf." The disastrous storm of 1906, already mentioned, washed away a considerable section of the easterly end of Horn Island, destroying the light and other buildings; the keeper and his wife and daughter were drowned.

Louisiana was transferred to the United States in 1803, and the next year Congress made appropriation "for building a lighthouse at the mouth of the river Mississippi," but due to difficulties of site and construction and interruption by war, it was 1820 before the first lighthouse was built at the mouth of the river, though there appears to have been a temporary light on the blockhouse at Balize about 1817.

This light of 1820 was built on Franks Island and marked the entrance known as Northeast Pass, a passage no longer used, and next south of Pass-a-Loutre. On account of settlement this tower was rebuilt in 1822, and is still standing, though not lighted since the building of Pass-a-Loutre Lighthouse in 1855.

The first light in the vicinity of New Orleans appears to have been that on Lake Ponchartrain to mark the entrance to Bayou St. John, placed in 1811 on the petition of the Port Wardens.

There was a lightship off the mouth of the Mississippi from about 1821 to 1825. Lights were placed in 1831 at the South and Southwest Passes, and at both stations there are now tall pyramidal skeleton iron towers. That at Southwest Pass was built in 1873, replacing a brick tower which had sunk several feet into the soft ground and inclined three or four feet from the perpendicular, but which is still standing. This brick lighthouse was built in 1839, after the original tower had been undermined by the river. The soft alluvial formation of the Mississippi delta rendered it difficult to secure a suitable foundation for the iron tower, which is one hundred and thirty-seven feet high. It stands on one hundred and eighty-five piles thirty-three feet long; the tops of the piles are one foot below low water and are capped by timbers and a concrete block. This lighthouse is in the midst of a marsh. In line with this tower, to form a range for entering the Southwest Pass, is a small front light, which is unusual in the fact that the structure is movable, being mounted on a track running on a dike at the river-bank, so that, as the channel changes, the position of the light may be shifted, to show the best water across the bar at the entrance to the Pass. A lightship was stationed off the South Pass of the Mississippi in 1894; it has since been moved and its present position is in seventeen fathoms of water, one and one fourth miles from the entrance to Southwest Pass. Semmes in his account says that while lying at the Head of the Passes in June, 1861, he "dispatched an officer to the different lighthouses, to stave the oil-casks, and bring away the lighting apparatus, to prevent the enemy's shipping from using the lights," which were of great use to the blockading ships, but not to the blockade-runners, which could not enter the Mississippi.

The small light at Timbalier Pass, on the Louisiana coast south of New Orleans, has several times been demolished by hurricanes. Early in 1867 Timbalier Island had been cut away by the sea so that the lighthouse was surrounded by water. As the tower was in danger of falling, the lens was removed and a beacon light placed on top of the keepers' dwelling. In "March following, during a hurricane, the dwelling, together with the tower, and everything about the station, was leveled to the ground, and covered with from three to six feet of water. Everything belonging to the lighthouse, as well as the private property of the keepers, was lost"; the keepers "faithfully performed their duty, barely escaping with their lives, and living for some days in an iron can buoy."

On Ship Shoal, in the Gulf of Mexico, ten miles off the Louisiana coast, in thirteen feet of water, is one of the most exposed of the screw-pile lighthouses. This was built in 1859, and replaced a lightship which had marked this shoal for ten years. This is a pyramidal skeleton iron tower similar to those on the Florida Reefs.

Midway between the Mississippi delta and Galveston lies the dangerous Trinity Shoal, extending twenty-three miles out from the coast. There was a lightship on Trinity Shoal from 1881 to 1894, when the vessel was moved to South Pass. This station is now marked by a large gas and whistle buoy, twenty-five miles from land. In 1873 an attempt was made to construct a screw-pile lighthouse on this shoal. A working platform was successfully erected at the site, and in November the tenders Pharos and Guthrie, both schooners, had arrived with the ironwork of the foundation. On the 15th a severe storm commenced, and

During the night of the 16th the tender Guthrie having struck heavily on the shoal, put to sea, her master hoping to keep her clear with the pumps, but without success. Filling rapidly, she was headed for the shoal, on which she sunk in eleven feet of water, becoming a total wreck, her crew being picked up by the lighthouse tender Pharos. The wind moderated in the afternoon of the 17th, but commenced blowing hard again during the night, shifting to northwest and north-northwest, and again making a heavy sea which broke on nearly every part of the shoal; this continued during the 18th. At about 1.30 P.M. of that day, when the storm was at its height, the waves nearly reaching the top of the platform, which was about fifteen feet above mean low water, the entire platform was swept away, carrying with it all the ironwork of the structure on it at the time, the quarters of the working party, and the entire working-force, consisting of some sixteen persons. Through the exertions of the master of the Pharos, all the persons on the platform at the time of the disaster were rescued, the superintendent of the works and the master of the lost schooner Guthrie being carried out to sea. They were in the water some three hours, clinging to the floating timber, before they were picked up, in an almost exhausted condition.

The only lighthouse of this country in the open sea, built on a caisson sunk in the sand by the pneumatic process, is that on Sabine Bank, fifteen miles offshore, lying in the Gulf of Mexico east of Galveston. The caisson of cast-iron plates was built at Sabine, Texas, towed sixteen miles to the site, and sunk by the process used at Fourteen-Foot Bank, as described. This lighthouse was completed in 1904, and stands in eighteen feet of water.

The remaining primary lights on the Gulf Coast are Bolivar Point, a lighthouse one hundred and sixteen feet high, built of cast-iron plates, and located on the north side of the entrance to Galveston Bay, and Brazos River and Matagorda Lights, and a lightship on Heald Bank, twenty-eight miles southeasterly from Galveston entrance. The last lighthouse on the Texas coast is a small structure on piles at Brazos Santiago, seven miles north of the Rio Grande mouth.

The keeper of Bolivar Point Lighthouse has a most creditable record in the two great storms which passed over Galveston, September 8, 1900, and August 16–17, 1915. The inspector's report states that in the 1900 storm, through the keeper's "efforts, the lives of one hundred and twenty-five people were saved, and to my personal knowledge he harbored and fed a large number of them for a considerable period." In doing this the keeper exhausted the month's store of provisions for himself and family. He also furnished the sufferers with clothing and bedding until his own supply and that of his family were gone; he and his family also lost heavily of their personal property. In the 1915 storm, during which the wind velocity reached one hundred and twenty miles an hour, the keeper's dwelling was washed from its foundation. Except this and the tower everything else about the station, including the assistant's house, was completely destroyed. Fifty people took refuge in the light tower for two nights, sitting two each on alternate iron steps of the stair. The vibration of the tower was so great that it was impossible to keep the lens rotating; the water rose around the tower and the sea burst open the door, and the surging of the water in the base of the lighthouse and the battering of the waves outside added to the alarm of the refugees. The light was kept burning throughout the night of the storm, and until the supply of oil gave out.

The September, 1915, storm played some strange freaks. The lantern of the Long Point Light, an unattended light on Lake Borgne, was found in the marsh, two miles from the station. At a light station on the Louisiana coast a pig disappeared in the storm; the water level rose about eight feet and the marshes were covered for ten miles; about a month after the storm the pig returned to the station of his own volition; his experiences in the mean time will never be known.

VIII

LIGHTS OF THE PACIFIC COAST AND ALASKA

THE first provision for aids to navigation on the present Pacific Coast of the United States was made by Congress in 1848, when appropriations were made for lighthouses at Cape Disappointment at the mouth of the Columbia River, and at New Dungeness at the entrance to Puget Sound, and for buoys from the Columbia mouth to Astoria. The sum provided, $15,000, was, however, totally inadequate, and nothing was accomplished. In 1850 Congress was more liberal, and appropriated $143,000 for nine lighthouses, a fog signal and some buoys on the California and Oregon coasts. Due to difficulties resulting from the then remoteness of the region, the first of these was not established until 1854. This was Alcatraz Light, on an island in San Francisco Bay. There does not appear to have been any light on the California coast during the Spanish or Mexican ownership. Lights were added in 1854 at Point Pinos; in 1855 at Point Loma, Point Conception, Farallon, Bonita Point, Fort Point; in 1856 at Santa Barbara, Humboldt, Crescent City, Cape Hancock; and in 1857 at Umpqua, Cape Flattery, and New Dungeness. Alcatraz Lighthouse and the other principal Pacific Coast lights were equipped from the first with Fresnel lenses; the old third-order lens used at Alcatraz, the first to be installed on the Pacific Coast, and which was used until 1902, was recently shown at the San Francisco Exposition.

The lighthouse work on the Pacific Coast was first organized in 1853 under an officer of the Corps of Engineers as inspector. At that time the towers at Alcatraz, Farallon, Point Pinos, and Fort Point had been completed, and were awaiting apparatus. In those days it sometimes took over two months for a letter to go from Washington to San Francisco, the mail being dispatched by way of Panama or Nicaragua; a letter from Umpqua Bay, where a lighthouse was being built, to San Francisco, a distance of three hundred and sixty miles, was thirty-eight days in transit. There were many other difficulties in carrying on the work on the California and Oregon coasts at that time. In 1853 the bark Oriole was wrecked on the Columbia River bar, after waiting for eight days to enter; this vessel had on board the construc-

tion materials for five lighthouses, which were all lost. All costs were exorbitant; a bid to make one first-class iron can buoy was \$3250, about sixteen times the present normal cost; in 1855 the lighthouse engineer recommended "that hereafter all estimates for the Pacific Coast be four times higher than for like work on the Atlantic."

There was great difficulty in securing, at the rates of pay allowed, suitable men for lighthouse keepers, and there were many complaints from the keepers. In nine months there were seven different keepers and assistants at Bonita Point Lighthouse. The keeper of this lighthouse in 1855 thus describes conditions:—

> There are no inhabitants within five miles of this point . . . from San Francisco to Point Bonita there is no direct communication but by chance, a sail boat may be procured at an expense of \$5, and from \$2 to \$5 per barrel freight . . . my first assistant would only take the appointment by my agreeing to make our salaries equal, even then would only remain 4 months.

The keeper of Point Conception Light writes in the same year: —

> Point Conception lies some sixty-five miles by land from the little village of Santa Barbara, the nearest

point at which supplies can be obtained, the road to which place is only passable at very low water and that in consequence of the difficulty of transportation, the freight on goods amounts to nearly the actual cost at Santa Barbara, which is one hundred per cent over San Francisco rates.

And again: —

How to convey my wood and water here I know not, the former being five or six miles off, and the latter about six hundred yards. That my situation here is truly distressing admits not of any doubt, cut off as I am from all communications and without means to live on.

The last probably refers to the difficulty in getting the pay to the keepers; the keepers of Cape Hancock Light complain that they have not received a dollar of salary in seven months "and we are annoyed very much by those we owe."

On the northern coast there were difficulties on account of the Indians. In 1856 it was not considered safe to commence the construction of the lights at Cape Flattery, New Dungeness, and Smith Island on account of the relations between the whites and the Indians in Washington Territory. For the Cape Flattery Light a blockhouse was built on Tatoosh

Island before commencing the lighthouse, and twenty muskets with ammunition were furnished for protection against Indians from the British Columbia side. Even friendly Indians were troublesome, as a letter from Umpqua, during the construction of the lighthouse, says there are many friendly Indians "and I have to watch them very closely to keep them from stealing." The lighthouse at Cape Flattery was finally completed and the light first shown December 28, 1857. In the following June there were two hundred and fifty Indians and four white men on Tatoosh Island, and the keepers resigned because of annoyance from the Indians, who used the island as a fishing and whaling station, and called the whites "Bostons."

The first fog signal on the Pacific Coast was a cannon transferred from Benecia Arsenal and placed at Bonita Point Light Station, at the entrance to San Francisco Bay. A former army sergeant was employed specially to fire this gun, and these are the instructions to Sergeant Malony, August 6, 1855:—

You are charged with the firing of the 24-pounder gun placed at Point Bonita as a fog signal, and will proceed thither to-morrow with the powder purchased for same. . . . In the performance of your duties you will be governed by the following directions: To fire the gun every half-hour during fogs at the entrance of the Bay, whether they occur at night or in the day — the firing being made at the hours and half-hours of San Francisco mean time.

But Malony found he had no sinecure, as one may imagine who knows the fogs of the Golden Gate; two months later he writes: —

I cannot find any person here to relieve me not five minutes; I have been up three days and nights, had only two hours rest. . . . I was nearly used up. All the rest I would require in the twenty-four hours is two if I only could get it.

This gun remained in use until 1857, when it was discontinued as being too expensive and not effective. The annual cost of powder alone at the prices then prevailing in San Francisco was nearly two thousand dollars. The gun is still at Bonita Point Light Station. In 1856 three fog bells were established, all in the vicinity of San Francisco, at Bonita Point, Fort Point, and Alcatraz, and in 1857 there were fog bells struck by machinery at nine stations on the Pacific Coast. In 1858 a bell boat was placed off the San

Francisco entrance, but it does not appear to have been successful.

The first lighthouse tender on the Pacific Coast, and the first steam tender in the Lighthouse Service, was the Shubrick, a side-wheel steamer built at the Philadelphia Navy Yard in 1857 and constructed of live-oak and white oak, one hundred and forty feet long, twenty-two feet beam, and nine feet draft. This vessel sailed from Philadelphia December 23, 1857, passed through the Straits of Magellan, and arrived at San Francisco May 27, 1858. An hour after leaving Rio Janeiro yellow fever broke out on board; there were eight cases, and one of these, an assistant engineer, died. In the Straits of Magellan head winds and boisterous weather were encountered, nearly all of the coal was consumed, and it was necessary to cut a considerable quantity of wood in order to make the port of Valparaiso. The Shubrick carried several guns, for besides lighthouse work she was "also, in case of incursions of the Indians from the British dominions in the Straits of Fuca and vicinity, to protect the keepers and citizens in that quarter against their attacks." The Shubrick remained in service until January, 1886, performed much useful work, and had an eventful career. She was used as a revenue cutter from 1861 to January, 1867. After being returned to lighthouse duty, the tender, loaded with materials for the lighthouse on Cape Mendocino, was driven ashore thirty miles south of the cape in a fog, striking a sunken boulder with such force as to fix it in the port bow so firmly that, to remove it, blasting had to be resorted to. The vessel was hauled on the beach for temporary repairs, and later taken to San Francisco and rebuilt. Until 1880 the Shubrick cared for the lighthouse work on all of the Pacific Coast, but in 1880, on the arrival of the first Manzanita at San Francisco, the Shubrick's work was confined to the Oregon and Washington coasts. Six years later, after it had been reported that "she is unable to make steam enough to tow a first-class whistling buoy into position," the Shubrick was sold, and burned to get the metal from her fastenings.

The Pacific Coast of the United States has a comparatively simple outline, with few off-lying islands or extensive indentations. The number of sea-marks required is therefore less, in proportion to the length of ocean front, than on much of the Atlantic Coast. There are primary lights on all the salient points, and from Cape Mendocino to Cape Flattery the arcs of the principal lights overlap except for three short intervals; south of Cape Mendocino the primary lights do not cover a number of the deeper embayments.

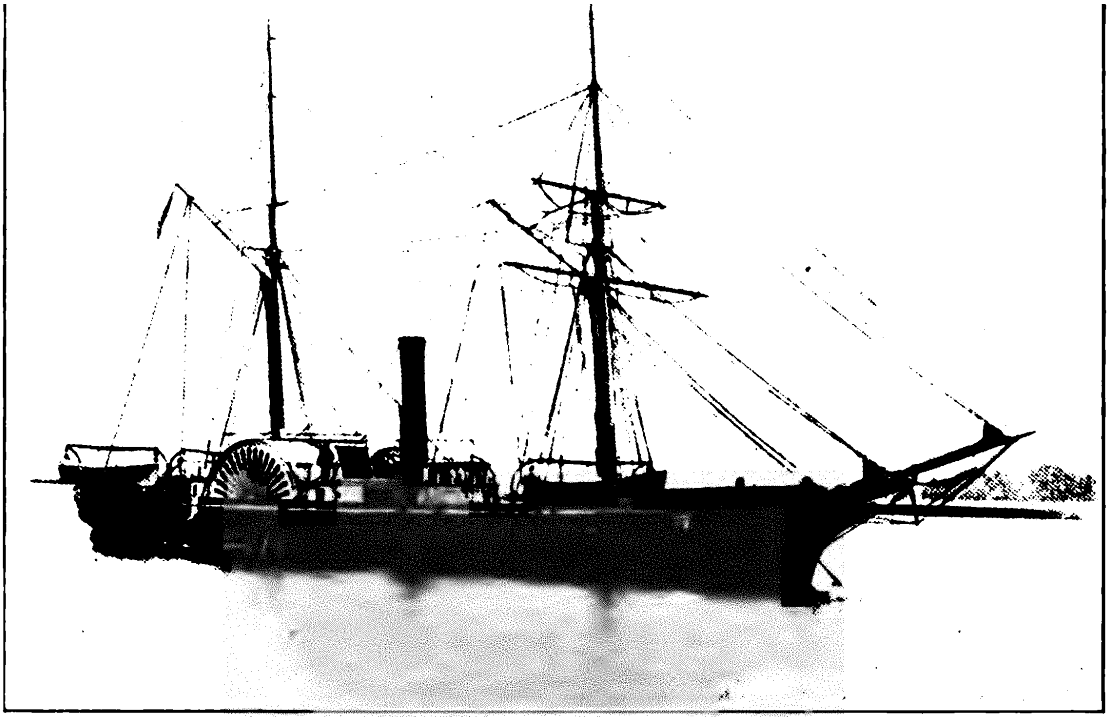
The precipitous and mountainous character of the Pacific Coast has rendered tall light towers unnecessary, and there are but four lighthouses which exceed one hundred feet in height,—St. George Reef, Pigeon Point, Point Arena, and Grays Harbor. In some instances the difficulty has rather been to keep the light from being too high above the sea. An instance of this was the original lighthouse at San Diego, which was built on top of the ridge at Point Loma in 1855. The light was four hundred and sixty-two feet above the sea, the highest at that time in the United States, but it was often obscured by high fogs while the coast line was plainly visible. This light was abandoned in 1891 on the completion of an iron skeleton tower on the extremity of the Point, with the light shown only eighty-eight feet above the sea.

Although very high towers are lacking, there are some notable structures and unusual light stations on the Pacific Coast. Two lighthouses involving great difficulties have been built on rocky islets off the coast, Tillamook Rock and St. George Reef.

Tillamook is a high, precipitous rock nineteen miles south of Columbia River entrance and one mile from the coast. The rock is surrounded by water over one hundred feet deep, and is exposed to the sweep of the Pacific Ocean. Landing on Tillamook was very dangerous, and the construction foreman was drowned when landing to examine the rock. Later men and supplies were landed by a traveler running on a cable from the vessel to the rock. This entry in the journal of the construction superintendent shows that difficulties arose even with this method:—

Tried to land a quarryman (Gruber), but found the man was too big for the breeches buoy. I told Denny to lash him on top of it, but he (Gruber) did not like the idea, so I told Denny to get a cork life-belt in Astoria and land Gruber next time.

Gruber was finally landed "without wetting the soles of his boots, the first man that landed dry on the rock." In the construction, materials were landed by a derrick, within the reach of whose boom the loaded schooner was brought, and this method is still ordinarily used in landing men and supplies from boats.



LIGHTHOUSE TENDER SHUBRICK

First lighthouse vessel on the Pacific coast, and first steam lighthouse tender

There was serious difficulty in providing protection for the workmen, as in heavy storms the waves broke over the rock. Temporary shelter was obtained by canvas lashed to ring-bolts in the rock, until a strong timber barracks was erected in the most sheltered spot that could be found, high up on the north side. Of the first rude canvas shelter the superintendent's journal says after a storm: —

It was rather disagreeable in our tent, it being but six by sixteen feet with a horizontal ridge-pole about four feet six inches from the ground. The tent just holds ten men. We always do our cooking on the lee side, shifting according to the direction of the wind.

Mr. Ballantyne, the superintendent of construction, and his hardy little party of quarrymen remained at the site during the winter of 1879–80, blasting off the top of the rock from its original height of one hundred and twelve feet to make sufficient room for the lighthouse, at a level of eighty-three feet above the sea. In a storm in January the waves were carried by the wind over the rock continuously for many days, washing away the supply house, but the men escaped disaster. During the height of this storm an English bark was driven on the coast not a mile from the rock, and all on board lost. A warning bonfire had been built on the rock.

A one-story stone dwelling, forty-five by forty-eight feet, was built on top of the rock, with an extension for the fog sirens, and a stone tower sixteen feet square rises from the center of the dwelling, the top of the lantern being sixty-two feet above the foundation. A light, flashing every five seconds, is shown one hundred and thirty-three feet above the water, and the siren fog signal gives a blast, lasting five seconds, each forty-five seconds. The light was first shown January 21, 1881. There are five light-keepers at this station, because of its isolated location.

The extremely exposed position of this lighthouse, and the severe conditions to which it has been subjected in time of storm, are shown in many reports. During a storm in January, 1883, stones were thrown by the waves on to the fog-signal building, and many holes broken in the iron roof. In December, 1886, a mass of concrete "filling weighing half a ton was thrown over the fence into the enclosure," at a level of eighty-three feet above the sea. In a storm in December, 1887, the keepers reported that the seas broke over the building, some going above the tower, lantern panes (one hundred and thirty-three feet above the sea) were broken, and other damage done.

On December 9, 1894, a severe storm occurred, with a very high sea that broke over the whole station, destroying thirteen lights of glass in the lantern, and the seas, with dislodged fragments of rocks, broke in the roofs of the dwelling and fog-signal station and flooded the premises. Much stronger roofs were built in 1898. There was telephone cable connection with Tillamook for two years, but the cable was broken in a storm in 1897. Here is the keeper's report of a storm in October, 1912, at Tillamook Light. The lighthouse tender, on account of weather conditions, was not able to reach the rock for seven weeks after this storm:—

I regret to state that on the evening of the 18th, or morning of the 19th, we lost a portion of the west end of the Rock, water and rocks coming over with so much noise we could not tell when, and did not know it had departed before next morning when the sea went down so that we could go outside.

At 12.35 A.M. on the 19th the sea came up and broke one pane in of the middle section of the lantern which also put the light out and flooded the watch-room, as well as downstairs. To add to it all the soot and ashes came out of the stove in the kitchen.

At 12.50 A.M. we had the light burning and storm pane in for the rest of the night.

Siren was running until the crash came, but making no regular blast on account of the water filling the trumpet too fast. After getting the light burning we closed down the fog signal, as the wind hauled to westward and cleared the atmosphere somewhat. Shortly afterward when taking siren out to clear it I found it filled partly full with rocks; therefore the water could not get out of it (siren horns are about one hundred feet above the sea).

Will also state that every one under my charge worked hard and faithfully, regardless of water and glass, everybody being drenched to the skin.

During a storm in November, 1913, the keeper reports that a shift of the wind to the southwest brought ugly cross-seas, and at 8.15 A.M. two panes of plate glass in the lantern were broken in; "by that time there were tons upon tons of water coming with each wave, we expecting it would take the whole side of the lantern out. This kept up until 5 P.M., fourteen and one half hours in all."

Before the location of the lighthouse, this rock had been a favorite resort for thousands of sea lions, who completely covered its slopes; these at first were hostile and disposed to object to other use of the rock, but finally retired to other haunts.

St. George Reef Lighthouse is built on a rock lying six miles off the northern coast of California, midway between Capes Mendocino and Blanco. A lighthouse could have been constructed economically on Point St. George, but as vessels on account of the off-lying reefs must here give the coast a berth of ten miles in thick weather, even a powerful light would often not be seen in the haze which is prevalent, and a fog signal would have been practically useless at this distance. It was therefore decided to place the lighthouse on the outermost danger, which was a rock three hundred feet in diameter, and with its highest point fifty-four feet above the water. The rock is so exposed and swept by the seas that workmen could not safely live upon it, as had been done at Tillamook Rock, and it was necessary to moor a schooner near the rock to provide quarters for the men, who when necessary were transported back and forth in a cage, suspended from a traveler on a cable, one end of which was made fast to the rock and the other to the mast of the schooner. A quick means of getting off the rock was necessary, as heavy waves, resulting from offshore winds, would begin breaking on the rock without any local warning, and the sea would rise so suddenly that in three or four hours from a dead calm the crest of the rock would be swept by the waves,. and no one could live on it. The schooner was moored with four very heavy moorings.

At the first examination of the rock in 1882 it was possible to make but three landings in four weeks. The construction of the lighthouse was commenced in 1883; when the rock was first reached on April 3 the sea was found breaking completely over it. The schooner which was to provide quarters for the workmen was moored near the rock with a 12,000-pound anchor. The tender returning twelve days later found no signs of the schooner, and it took a number of days to find the vessel, which had been torn from her moorings during a furious gale.

The foundation of the structure is a pier, an irregular oval in plan, eighty-six feet in longest diameter, faced with cut granite and filled with concrete, except for service rooms. Horizontal terraces were cut in the rock for the footing of the pier, and in order to obtain sufficient area for the structure. The top of the pier is seventy feet above the water, and above this is a square granite tower, with projecting stair cylinder, the top of the lantern being one hundred and thirty-four feet above the base of the pier. The light is shown one hundred and forty-six feet above the sea. The stone was quarried from granite boulders found on Mad River near Humboldt Bay, nearly one hundred miles from the site. In the face of the tower were used 1339 dressed granite blocks averaging two and one half tons each; these were so finished and placed that the last stone of each course slipped into place with joints each side three-sixteenths inch, as required. The blocks were landed in rope nets so that none were chipped. The station was first lighted October 20, 1892, ten years after it was begun, and the total cost was $702,000, making it one of the most costly lighthouses. Both the excessive time and cost were in considerable measure due to the appropriations being made in amounts too small at one time, and at irregular intervals.

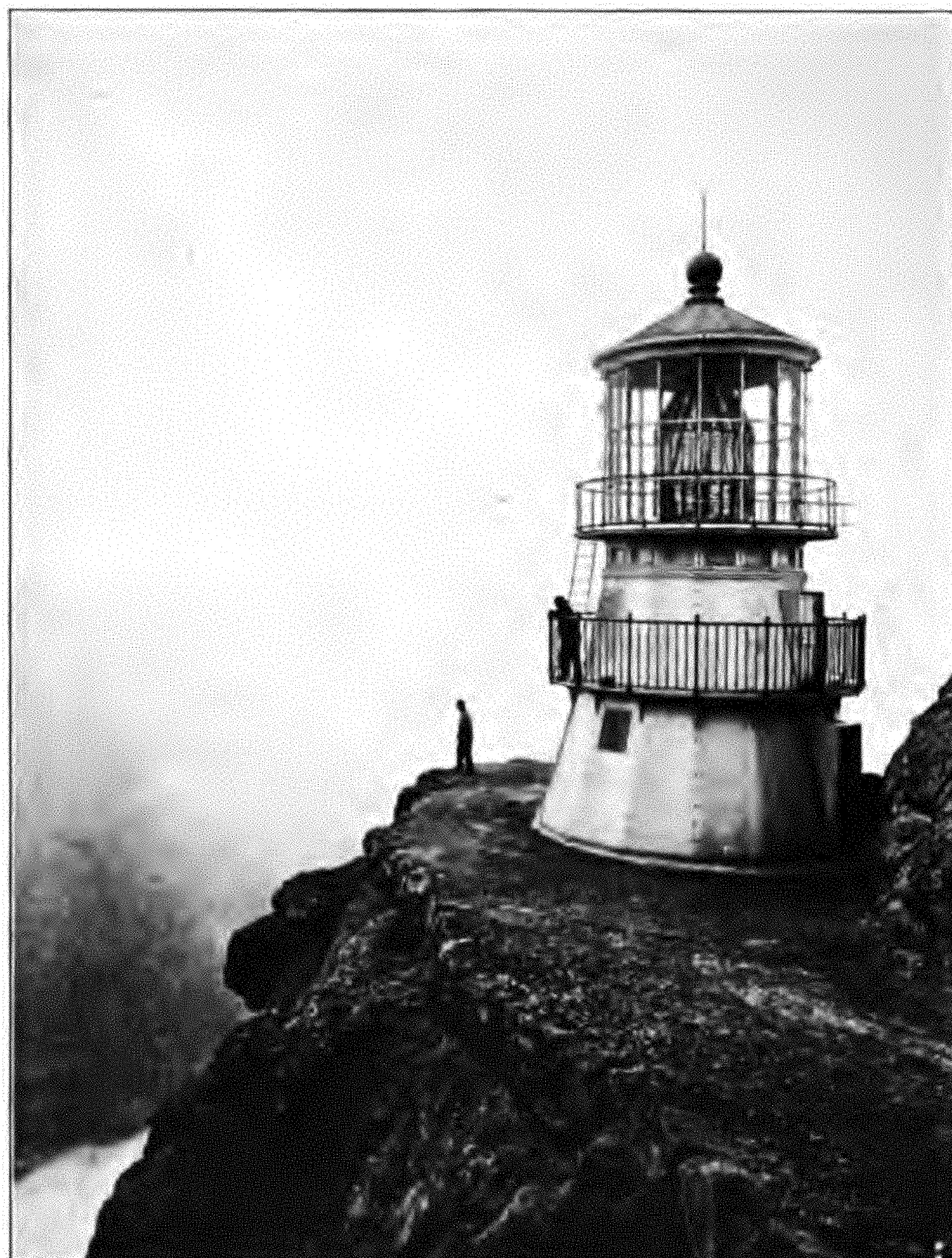
The southernmost of the United States lighthouses on the Pacific Coast is that at Point Loma, already mentioned. A large gas and whistling buoy is stationed nearly west of this, well out in the Pacific, eighty-eight miles from the mainland and forty-one miles from the nearest land at San Clemente Island. This buoy guards the Cortes Bank, which has on it a rock with only fifteen feet of water; it is the loneliest buoy, being the most distant from land of any buoy of this country. On the extremity of the new breakwater at Los Angeles Harbor a new lighthouse has recently been built, a covered structural steel building. The present lighthouse at Point Fermin will be discontinued when that projected at Point Vincente is built. The lighthouses at Point Hueneme and Point Conception mark the two ends of the Santa Barbara Channel. The latter was originally built in 1855 with the light two hundred and fifty feet above the water; it was rebuilt at a lower point in 1882, and the elevation of the light is now one hundred and thirty-three feet.

At the west extremity of the Santa Barbara Islands and directly south of Point Conception, is Richardson Rock, a bare and wave-swept rock rising abruptly fifty feet above the water from depths of two hundred feet around. An unattended automatic acetylene light was placed on this rock in 1912. The light is on a steel tower and is one hundred and twenty feet above the sea, and the total cost was $3800. This light will operate for half a year on one charge of gas; it flashes every three seconds. A similar station is the light on Redding Rock, four and one half miles off the northern coast of California. At this rock the six men who were completing the structure were marooned by bad weather and had to spend the night on the rock; the following day they were taken off by throwing them ropes which they tied around their waists. The men then leaped into the sea and were drawn into the boat.

Between Point Conception and San Francisco there are primary lights at Point Arguello, San Luis Obispo, Piedras Blancas, Point Sur, Point Pinos, and Pigeon Point. South of the last-named is a secondary light on Año Nuevo Island. This small island is a favorite resort for sea lions, and the light-keeper has for neighbors about two thousand who form the sea-lion colony at Año Nuevo.

The Farallon Light is twenty-three miles off the Golden Gate, on the highest peak of the rugged Farallones Islands. The light tower is but forty-one feet high, but the light is three hundred and fifty-eight feet above the sea. The first tower on this peak was built by carrying all the materials up by laborers, one man carrying a load of five bricks with great fatigue. This tower was too small for the lens, and had to be reconstructed before it was used. The present lighthouse was built in 1855, and mules were used to get the materials to the summit. There is a remarkable amount of bird life on this island.

San Francisco Lightship is stationed three miles outside the bar, and in the entrance to San Francisco are several lights of local importance: Bonita Point, at the north point of the entrance, built in 1855 at an elevation of three hundred and six feet, and rebuilt in 1877 much lower down, one hundred and twenty-four feet above the sea, to avoid being so often obscured by haze or fog; Mile Rocks, on the opposite side of the entrance, built on an exposed rock, the substructure consisting of a pier of concrete enclosed within steel plates; and Lime Rock and Fort Point, on the north and south shores respectively, at the narrower part of the entrance. The steamer Rio Janeiro was wrecked in 1901 in a fog, with a loss of one hundred lives, near Fort Point; the Lighthouse Board had for several years called attention to the inadequacy of the fog signal at Fort Point, and a new fog signal was



POINT REYES LIGHT, CALIFORNIA

placed there later. Alcatraz, the first light established on the coast, is on an island just within San Francisco Bay; fifty-five years after its first construction a new lighthouse had to be built, because of the erection of a prison building which would have obscured the light from seaward.

At Point Reyes, an important point on the coast north of San Francisco, is a light and a diaphone fog signal. The next prominent headland, Point Arena, has a tower one hundred and fifteen feet high and a light of 380,000 candle-power, in both respects the maximum for this coast. Of the light-stations on the Pacific Coast Point Arena suffered most in the earthquake of April, 1906. The brick light-tower and the first-order lens were wrecked. The lighthouse was rebuilt in 1908, of reinforced concrete, the first lighthouse of that type of construction in this country. Several other lighthouses were severely shaken by the earthquake; the tower at Point Pinos was so badly injured that it had to be torn down; it also was rebuilt of reinforced concrete.

From Point Arena there are primary lights on the prominent points to the Columbia River, as follows: Point Cabrillo, Cape Mendocino, Table Bluff, Trinidad Head, St. George Reef, Cape Blanco, Cape Arago, Umpqua River, Heceta Head, Yaquina Head, Cape Meares, and Tillamook Rock. The lighthouse at Cape Mendocino is but forty-three feet high, but it stands on the edge of a cliff so that the light is four hundred and twenty-two feet above the sea, and it is the highest in the United States. Great difficulty was experienced in building this light on account of all supplies having to be landed through the surf on the beach.

Four miles off Cape Mendocino is the Blunts Reef Lightship, on a very exposed station, and there is another lightship three miles off the Columbia River Bar. The first light-vessel on the Pacific Coast was placed off the Columbia entrance in 1892; this lightship, No. 50, was built in San Francisco, and had no propelling power but sails. In November, 1899, Columbia River Lightship parted her moorings in a gale and tremendous sea, and was stranded near Cape Disappointment, at the mouth of the Columbia River. After lying for sixteen months where she struck the shore, and after it was found that she could not be got off into the sea, the vessel was hauled seven hundred yards across the land through the woods, and launched into the Columbia River. After this unusual overland journey No. 50 was repaired and replaced on her station and remained in service until 1909.

The light at Trinidad Head is one hundred and ninety-six feet above the water, and the tower stands on a cliff about one hundred and seventy-five feet high. This is the keeper's report of a storm at this station in December, 1913:—

At 4.40 P.M. I was in the tower and had just set the lens in operation and turned to wipe the lantern windows when I observed a sea of unusual height, then about two hundred yards distant, approaching. I watched it as it came in. When it struck the bluff the jar was very heavy, and the sea shot up the face of the bluff and over it, until the solid sea seemed to me to be on a level with where I stood in the lantern. Then it commenced to recede and the spray went twenty-five feet or more higher. The sea itself fell over onto the top of the bluff and struck the tower about on a level with the balcony, making a terrible jar. The whole point between the tower and the bluff was buried in water. The lens immediately stopped revolving and the tower was shivering from the impact for several seconds. Whether the lens was thrown off level by the jar on the bluff or the sea striking the tower I could not say. Either one would have been enough. However, I had it leveled and running in half an hour.

The primary lights north from the Columbia are North Head on Cape Disappointment, Grays Harbor, Destruction Island, and Cape Flattery Light on Tatoosh Island. Cape Flattery Lighthouse is an exposed station, the difficulties of building which have been given. The supply of such a station also presents serious problems. A few years back it took the tender Heather ten days to land the winter's supply of coal for the four keepers and the Weather Bureau observer. On three different dates but one small boatload could be landed in a day. Time after time the boat was swamped on the beach, and all hands worked waist-deep in the icy waters of the Pacific.

Umatilla Reef Lightship is fourteen miles south of Cape Flattery, and Swiftsure Bank Lightship is the same distance northwest. The latter vessel was placed in 1909, directly off the entrance to the Straits of Fuca, to guide vessels into the Straits. What this lightship means to the sea captain is shown by this recent letter: —

Year after year on making the Straits nine times out of ten it is foggy, especially in the summer, — at least that is my experience, — but my one great beacon of hope, when having many hundreds of lives on board, is that I need not approach the dangerous coast line to locate myself but can safely sound my way to get the sound of the good old Swiftsure lightship's fog whistle, and when I get it I have no hesitation, no matter how thick it is, night or day, I feel safe in entering the Straits on my usual course.

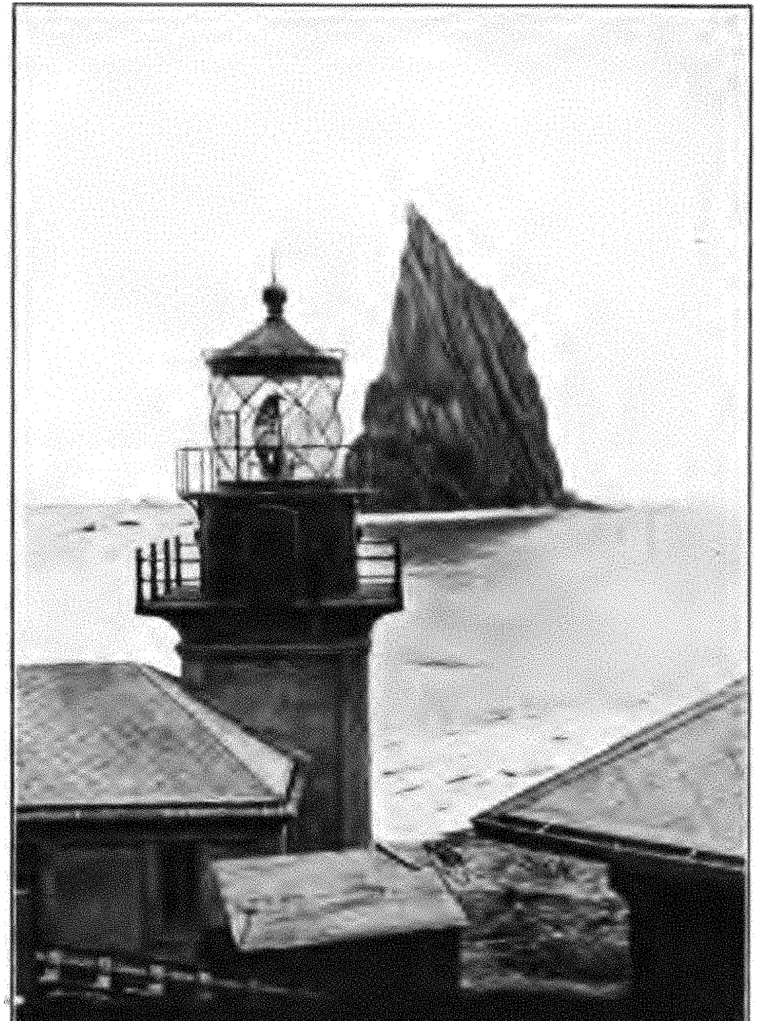
Until recently, most of the vessels required for lighthouse service on the Pacific Coast had to be built on the Atlantic Coast, and sent around South America, through the Straits of Magellan. The voyage of the first of these vessels, the tender Shubrick, has already been described. In 1908 a fleet of six vessels, the tenders Sequoia, Manzanita, and Kukui, and Lightships Nos. 88, 92, and 93, were sent out, making the voyage from New York to San Francisco in one hundred and twenty-four days.

Alaska has a general coast line, measured in thirty mile steps, of 7300 miles, as compared with a total of 4884 miles for the Atlantic, Gulf, and Pacific Coasts of the United States. This enormous extent of coast, with a very sparsely settled interior, the precipitous, rocky, and intricate character of much of the coast, the high latitude with little darkness in the summer and long nights in winter, and, for the portions most frequented, the great amount of rain and fog and the extreme tides with strong currents, all make special problems in lighthouse engineering. A considerable portion of Alaska is an Arctic region with shore free from ice but a short time each year, and other extensive stretches of the coast are not visited by ships or seldom visited; as a consequence there are at present no aids to navigation on more than three-fourths of the Alaska coast. But in the portions frequented by shipping there has been a great increase in recent years in the lights and other aids. The importance of the lighthouse problem was recognized by making Alaska a separate district in 1910, with office and depot at Ketchikan, and by stationing lighthouse tenders continuously in Alaskan waters.

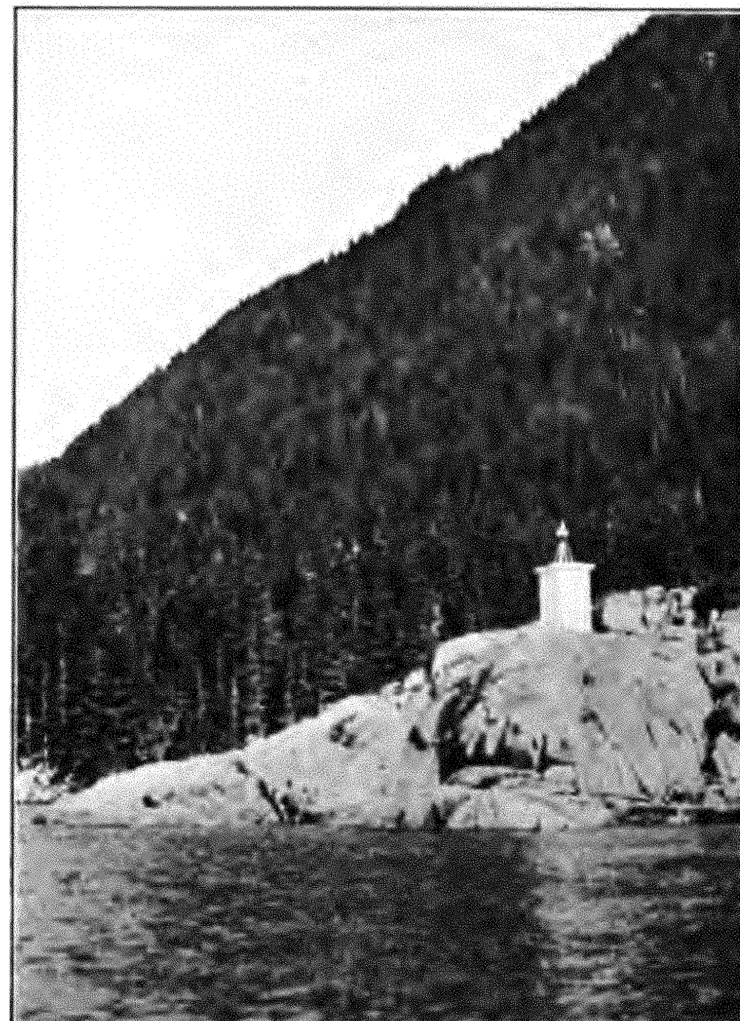
Alaska was purchased from Russia in 1867. The Russian Government had maintained a small light at Sitka, but apparently this was not kept up by the United States, as in 1895 a beacon light was established at Sitka, which is stated to have been the first light placed by the United States on the Alaskan coast. The first aids to navigation in Alaskan waters placed by the United States were fourteen iron buoys, in the spring of 1884. The first regular light stations were established March 1, 1902, at Southeast Five Finger Island and at Sentinel Island, both on the main inside passage between Wrangell Strait and Skagway. In all seven such stations on this passage, each provided with fog signal, were built in the years 1902 to 1905. These stations were comparatively expensive both to build and maintain, and since that time the marking of this passage has been greatly extended by less expensive means, and no more stations of this character have been built on the inside passages. There are now in Alaska one hundred and forty-seven lights, and a total of three hundred and eighty-eight aids to navigation of all classes. The rapid increase of recent years in the number of lights has been due largely to the facility with which flashing gas lights, unattended, may be established in that region, where it would be difficult and expensive to maintain keepers. At stations, however, where there are fog signals, keepers must be stationed, as there is not yet available a practical automatic fog signal for land use. Some navigators required a little time to get used to the quick-flashing lights; one said they were so quick that he could not tell whether he was approaching or leaving the light; but they have greatly improved the facilities for navigation in Alaska.

Southeastern Alaska has a remarkable network of well-protected inside channels in large part sufficiently wide and deep for any class of vessels, and has numerous small harbors. The main route is that between Seattle and Skagway, nine hundred and seventy-five miles, of which three hundred and seventy miles are through Alaskan waters. This important and much-traveled steamship route is continuously marked, having in Alaska sixty-two lights, including nine float lights and gas buoys, and seven fog signals, thus permitting the navigation at night of this long and intricate channel, the most remarkable inside salt-water passage in the world. The other main channels in southeastern Alaska are lighted and there are small lights at the principal entrances from the outside. There are a number of lights in Cook Inlet and Prince William Sound, including a primary light station with fog signal at the entrance to the latter, Cape Hinchinbrook.

There are two primary lighthouses, Scotch Cap and Cape Sarichef, marking Unimak Pass, the principal passage through the Aleutian Islands into Bering Sea



LIGHTHOUSE AND PINNACLE ROCK,
CAPE ST. ELIAS, ALASKA



AN UNATTENDED AUTOMATIC FLASHING LIGHT,
AT LOW POINT, IN TH SIDE PASSAGE, ALASKA

from the Pacific. The station at Cape Sarichef was completed in 1904 and is the most isolated in the Lighthouse Service; it is the only lighthouse on the entire shore line of Bering Sea, though there are some small lights maintained in the summer season near St. Michael and the Yukon mouth. When the keepers at Cape Sarichef received the mail in June, 1913, it was the first they had had since August, 1912. Their only neighbor is a trapper, ten miles away.

An important primary-light station has recently (September, 1916) been completed at Cape St. Elias, a very prominent point eastward of Prince William Sound. This will be an important landfall light for this section of the Alaska coast. The tower and buildings are of reinforced concrete. Work had to be done at this very inaccessible site under difficulties; as the location was far from any settlement or ordinary means of communication a special radio station was maintained to facilitate construction. At these remote stations quarters are furnished for the keepers only, and not for their families.

The difficulties of carrying on the lighthouse work in Alaska are considerable. The distances are great, the tender must go fourteen hundred miles from the depot at Ketchikan to the lighthouses at Unimak Pass, the season suitable for construction work is short and broken by stormy intervals, and it is hard to retain reliable keepers. For these reasons a large proportion of the lights in Alaska are automatic acetylene beacons, which can operate nearly five months on one charge of gas. The average cost of establishing these lights is about eighteen hundred dollars, so it is possible to install a number of such aids for the cost of one first-class attended lighthouse.

IX

LIGHTS OF THE GREAT LAKES AND THE RIVERS

THE total net tonnage of vessels passing through the Sault Ste. Marie Canals in 1916 was over 69,000,000, making this one of the most used waterways in the world, with several times the traffic of the Suez Canal, and more than double the total tonnage of vessels in the foreign trade entering and clearing from New York. Lake navigation is exceptional in a number of ways. The distances are considerable, — as, for instance, from Duluth to Buffalo is one thousand statute miles, — but large portions of most Lake voyages are through intricate passages, such as the St. Marys River and the Detroit River. The maximum draft is controlled by these river passages and by the depths in many of the important harbors, and this compels the construction of special types of vessels of less draft than would be used for the same capacity vessel on the ocean. The Lakes are subject to much fog in the spring and fall, and to sudden storms of great violence, and near the close of navigation there is always impending sudden difficulty with ice and winter gales.

The importance of navigation on the Great Lakes has led to an extensive system of lights and other marks. There are six hundred and ninety-eight lights and nine hundred and sixty-one other aids to navigation on the United States shores of the Lakes and the rivers connected therewith, and the Canadian Government has marked the Canadian shores with thoroughness.

The first provision for lighthouses on the Lakes was made by Congress in 1810 for two lights on Lake Erie. There was probably delay because of international relations, and the first lights appear to have been established in 1818 at Buffalo, the "junction of Buffalo Creek and Lake Erie," and at Erie, Pennsylvania, on "Presque Isle, entrance of Presque Bay." Lights were established at Galloo Island, east end of Lake Ontario, in 1820; at Sandusky on Lake Erie in 1821; at Oswego and at Genesee River on Lake Ontario in 1822; and at Fort Niagara in 1823. The first light at Cleveland was in 1829 and at Chicago in 1832; the latter was on the south bank of the Chicago River, and was a fixed light eighty feet above the lake, on a tower forty feet high. This light, then mentioned as the "old light-tower in the town," was discontinued in 1859 on the completion of a lighthouse at the end of the north pier.

A lighthouse was built at Fort Gratiot at the outlet of Lake Huron in 1825, and this was the first light marking the passage through the St. Clair and Detroit Rivers. The first light at Detroit was that built in 1837 at Windmill Point at the outlet of Lake St. Clair; the following year a lighthouse was built near the mouth of the Detroit River at Gibraltar, west of the channels now used; in 1829 a light had been established at Otter Creek Point at the west end of Lake Erie, about midway between the mouths of the Detroit and Maumee Rivers. In 1837 there was a floating light at the junction of Lakes Huron and Michigan, and this was the first of the twelve lightships now stationed on the Lakes.

In 1867 the first steam lighthouse tender on the Lakes was purchased, replacing two sailing tenders; previous to this one sailing vessel had attempted to do all the lighthouse work above Detroit, including Lakes Huron, Superior, and Michigan.

Most of the lighthouses on the Great Lakes are closed during the winter months, when general navigation ceases on these waters. It is necessary to keep the lightships and gas buoys on station as late as possible to help the last ships to make port, but it is also necessary that the lightships and gas buoys be brought in, and the keepers taken off the isolated stations before the ice becomes a serious menace; and consequently there is risk to men and vessels in the severe conditions, and rush work required, at the close of navigation. In order to prolong the time of closing some of the isolated lights, automatic lights are now left burning at certain of the stations when the keepers are taken off about December 10, with sufficient gas supply so that the lights will burn two weeks.

There are a number of notable lighthouses on the Great Lakes. Two of these, on Spectacle Reef and Stannard Rock, are structures similar to that on Minots Ledge; in construction, however, they differ in the important respect that while they stand in eleven feet of water they are not exposed to the sweep of the open ocean as is Minots Ledge, but they are subjected to very heavy ice action. Spectacle Reef Lighthouse, a notable engineering work, stands on a limestone reef at the northern end of Lake Huron, near the Straits of Mackinac, ten statute miles from land. Two vessels had been wrecked on this reef at one time in 1868. Work on the lighthouse was commenced in 1870 and the light was first shown June 1, 1874. The tower is built of limestone and is conical in shape, thirty-two feet in diameter at the base and eighteen feet below the cornice; the masonry tower is ninety-three feet high from the base, and is solid to a height of thirty-four feet; above this it is hollow and divided into five stories. The stones in the solid portion are cut to interlock with one another in each course, and the courses are bolted together with wrought-iron bolts wedged and cemented, and the lower course is similarly secured to the ledge. Above the solid portion a projecting ribbon on each course fits into a corresponding recess in the course above. To erect this structure a coffer-dam was built around the site. First a large timber protection pier, ninety-two feet square and twelve feet high, was built ashore, towed to the reef by two tugs, and sunk in position; the wreck of a schooner with a cargo of iron ore had to be removed to make way for the lighthouse. Very ingenious methods were used to fit this pier to the reef and get it into the correct position; to hold it eighteen hundred tons of rock were quickly loaded into it, and it was then built up to fourteen feet above the water.

Within this pier, which formed a working platform as well as a protection pier, was a central opening forty-eight feet across, in which was placed the coffer-dam, a hollow cylinder forty-one feet in diameter, built of wooden staves fifteen feet long and hooped with iron. It was put together at the surface and then lowered into position, and when it reached the bottom each stave was driven down to fit the rock as closely as possible, and the openings between the lower edge and the rock closed by cement and ropes. The coffer-dam was then pumped out and kept clear of water, the ledge was leveled off, and the masonry tower built up within the cylinder of the coffer-dam. The coffer-dam was designed by Colonel W. E. Raynolds and the tower was planned and built by Lieutenant-Colonel O. M. Poe, of the Engineer Corps. The total cost was $375,000. The strength of the lighthouse was well tested within a year of its completion. When the keepers returned to the tower in the spring of 1875, they found the ice piled against it to a height of thirty feet, or seven feet higher than the doorway, and they had to cut their way through the ice to enter. The original protection pier used in the construction of the lighthouse had been retained and repaired, and it was finally made permanent by replacing the timber and stone of the outer crib by concrete, and filling inside with stone, thus affording a large pier around the foundation of the lighthouse proper. This work was completed in 1906.

Stannard Rock Light, twenty-four statute miles from the nearest land and marking a very dangerous reef in Lake Superior, is the most distant from shore of any lighthouse in this country. A stone beacon was built at the southerly edge of the reef in 1868, and is still standing. The lighthouse was commenced in 1877 and completed in 1882, and was constructed within a protection pier, similar to the plan used at Spectacle Reef, and it stands in the same depth of water, eleven feet. The foundation pier, however, is a wrought-iron cylinder, sixty-two feet in diameter and thirty-five feet high, filled with concrete, and on this is built the stone lighthouse. The light is one hundred and two feet above the lake. The cost of the station was $300,000.

A beautiful lighthouse is that on the Rock of Ages, west of Isle Royal in the northern part of Lake Superior. Its foundation is a massive concrete pier, within a steel cylinder, built upon the rock at about water level. On this pier was built the light-tower of brick, one hundred and thirty feet high. It was completed in 1908. This is a station difficult to reach in stormy seasons, and one year, at the close of navigation when the tender took off the four keepers, the only food they had left was one can of tomatoes. Careful provision by regulation as to reserve supplies of food is now made against such contingencies.

White Shoal, a dangerous spot in Lake Michigan, at the entrance to the Straits of Mackinac, was marked for eighteen years by a light vessel anchored over it. On account of the ice, this vessel could not be kept on the station during a portion of the season of navigation in the spring and fall. As the unmarked shoal was a serious menace to navigation at these seasons, an appropriation was made for building a lighthouse, and this was completed in 1910 at a cost of $225,000.

A timber crib seventy-two feet square and eighteen feet high was built on shore and floated out to the site, where the depth of water was twenty-two feet. The

STANNARD ROCK LIGHTHOUSE, MICHIGAN; IN LAKE SUPERIOF, 24 MILES FROM THE NEAREST LAND

A POST LIGHT ON THE MISSISSIPPI RIVER

bottom, which is of coarse gravel, was covered with two feet of rock, and the crib was filled with stone and sunk. Above this was built a concrete pier, which supports the lighthouse. The light is one hundred and twenty-five feet above the lake, and is white, flashing every eight seconds, and of 360,000 candle-power. In addition to the compressed air fog whistle there is a submarine bell signal, located in sixty feet of water three quarters of a mile from the station. This bell is supported on a tripod standing on the bottom of the lake, is operated by electric power transmitted through a cable from the light station, and strikes "23."

There is an enormous traffic through the Detroit River, the average number of vessels passing through being about thirty-five thousand a year. The important Livingstone Channel recently cut in the Detroit River below Detroit has been marked with gas beacons and buoys throughout its length of six and one half miles, the lights being placed opposite each other and at intervals of about one half a mile, and with spar buoys intermediate between the gas buoys. The beacons consist of concrete piers twenty-two by thirty-five feet in plan, with their ice breakers, protected by steel plating, pointed upstream. In the construction of the beacons advantage was taken of the coffer-dam a mile in length which was built for the purpose of taking out the principal rock cut. The solid concrete foundations of six of the beacons were built in place in the dry before the coffer-dam was removed. Four other piers are reinforced-concrete caissons, built within the coffer-dam when it was dry, floated out after the water was admitted, and sunk in twelve to fourteen feet of water on their sites, which had previously been dredged clean to rock and covered with small stone to give an even and level bearing; the interior of the cribs was then filled with concrete. Two additional beacons in deeper water rest on timber cribs capped with concrete blocks. On account of the heavy traffic and large size of vessels, they are now required to pass through this channel with a time interval of not less than five minutes between ships. Semaphore signals are placed at two of the light-stations at the upper end of the channel, to signal to vessels whether the channel is clear and the required time interval is maintained.

The Detroit River Lighthouse, near the channel in the mouth of the river, stands in twenty-two feet of water. Its foundation is a wooden crib ninety feet long, forty-five feet wide, and eighteen feet high, its top thus being four feet below the water. The crib is filled with concrete, and above it is built a pier fifteen feet high of cut stone backed with concrete. The lighthouse, standing on the pier, was built of cast iron, and completed in 1885.

A memorial lighthouse has been built at Crown Point, New York, on Lake Champlain. A light was placed here in 1858 to mark a turn in the channel. With the permission of the United States, the States of Vermont and New York, as a part of the commemoration of the three hundredth anniversary of the discovery of Lake Champlain by Samuel de Champlain, removed the old tower and built in its stead an ornamental cylindrical tower of cut granite blocks, surrounded by eight Doric columns; on the pedestal is a heroic group in bronze with Champlain as the central figure, presented by the Republic of France.

Racine Reef, on the west shore of Lake Michigan, is one of the lake lighthouses which is maintained throughout the year. The keeper reported that in a severe storm in February, 1915, "the station was covered with one continuous cloud of spray, which flooded all the north and east rooms. Lantern glass was covered with ice to a thickness of eight inches on east and northeast sides. The building vibrated to such an extent that furniture was moved across the rooms." The vibration has been largely remedied by placing heavy riprap around the pier.

The important engineering improvements made in the harbors of the Great Lakes have necessitated the rebuilding or moving of a number of lighthouses and fog signals. A recent instance is at Superior Entry, Wisconsin, where the main light and the fog signal are on the outer end of the new south breakwater. The new lighthouse is on a concrete block at the end of the breakwater, and is built of reinforced concrete. At Sheboygan, Wisconsin, it was recently necessary, from a similar cause, to rearrange the lights. An interesting feature of this was the removal of an entire cylindrical steel light-tower from the old north pier and the replacing of it on a concrete foundation on the new breakwater. This tower weighs about thirty tons, and was jacked up and placed on a large scow, to which it was well secured, and then towed across the harbor.

An instance of changes sometimes required in light-towers is the lighthouse at North Point, Milwaukee, Wisconsin, where, on account of the growth of park trees, the light became obscured from some directions and it was necessary to raise the focal plane thirty-two feet. This was recently accomplished by taking down the original tower, which was of cast iron lined with brick, and erecting on a new foundation a steel-frame subtower, encased in steel plates. On top of this the cast-iron shell of the old tower and the old lantern were reërected.

The outer brickwork of some of the earlier lighthouse towers erected on the Great Lakes has disintegrated to such an extent as to require repair. In several cases these brick towers have been protected by encasing them with steel plates riveted together and filled in with concrete. Recently the brick lighthouse at Evanston, Illinois, Grossepoint, has been repaired by covering the tower with concrete and cement mortar, over steel reinforcement.

There are twelve lightships on the Lakes, five of which mark the intricate waters at the northern ends of Lakes Michigan and Huron in the general vicinity of the Straits of Mackinac. A tragedy of the light-vessels of the Great Lakes was the loss of Buffalo Lightship No. 82, with the six men comprising her crew, in the great storm of November, 1913, so disastrous to Lake shipping. The vessel sank about two miles from her station, in the eastern end of Lake Erie, in sixty-three feet of water, and the wreck was located, after much search, by the use of a wire drag. The vessel was successfully raised by passing chains under the hull, attached to submerged pontoons which were later pumped out and filled with air.

All the important navigable rivers of the country are lighted, a total of nearly six thousand miles of river channel. The first lights maintained by the United States on the Western rivers were lights at Jefferson Barracks, near St. Louis, and at Twin Hollows, Missouri, in December, 1874, and later in the same month on the Ohio River. The first section of the Mississippi lighted was that from St. Louis to Cairo. All lanterns on the rivers were supplied with mineral oil. There were at that time on the Mississippi and tributaries eleven hundred steamboats besides other craft, and the total value of cargoes carried was estimated at $400,000,000 annually. Although since that time the rivers have been thoroughly lighted and marked, as well as otherwise improved, it is regrettable that the number of boats and the traffic is much less than when there were no lights.

At present there are 1798 lights and 861 buoys and beacons marking 4226 miles of the Mississippi and Ohio Rivers and tributaries. The lights on these rivers are of simple character, but are effective, for the moderate distances that they are required to be seen, to indicate the crossings and bends in the channel. They are known as "post" lights, and consist either of a flat wick lamp in a small pressed-glass lens, or of an ordinary hand lantern, enclosed in a triangular tin case with glass sides. These lights are usually shown from posts set on the river-bank, with large wings so painted as to make a good day mark; occasionally a tree may furnish the lamp support. The river lights are cared for by persons living in the neighborhood. The work requires but a part of their time, and they are paid small amounts per month for tending the lights, and are supplied with the necessary oil and outfit; in some cases a number of lights are cared for by one person, who usually uses a boat to reach them.

On some portions of these rivers the channel is fairly permanent in position, but in other sections it shifts in unexpected ways, making necessary many changes in the positions of the post lights. For example, last year, during a flood on the Missouri, the river cut across a bend, shortening the channel seven miles, and leaving several of the aids to navigation about four miles inland. The story is told that years ago it was found that several beacon lights were being regularly maintained in Louisiana, although the channel they were supposed to mark had completely silted up and was dry.

The careful lighting and marking of many of the coastal rivers is very important, and extensive systems of lights and other aids are maintained to the head of navigation on such rivers as the Hudson, Delaware, Potomac, James, Cape Fear, Savannah, St. Johns, Mississippi and Columbia. On some of these are regular lighthouses, fog signals, and range lights.

A specially designed post lantern is used in the coast districts. It has an eight-inch pressed-glass lens, and a burner with two flat wicks using kerosene. Great pains have been taken to make the lantern wind-proof, and still have ventilation for a good light; the present lantern will burn in gales of considerable violence. A post lantern that will burn eight days is in use at stations that cannot with certainty be visited daily; this is similar to the one-day lantern, with the addition at the upper part of an oil reservoir, containing sufficient kerosene for eight days. The oil is automatically fed to the lamp below, a floating piston cutting off the supply as soon as the oil in the lamp is at the desired height.

X

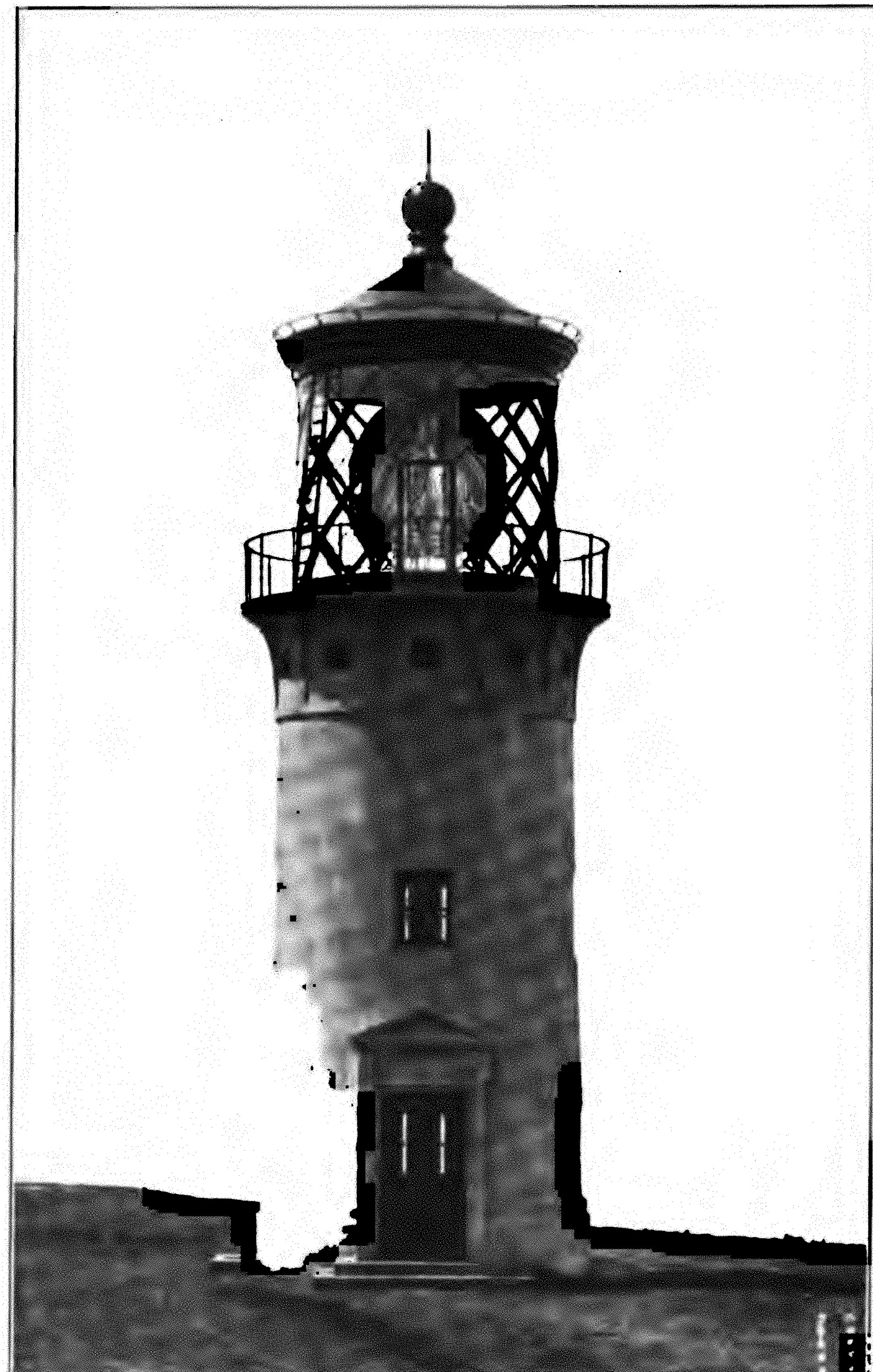
LIGHTING THE ISLANDS AND THE PANAMA CANAL

The lighthouses of the United States not only mark the long coasts of the main country and Alaska, but they light the distant islands, Porto Rico, Hawaii, Guam, and Samoa. In Porto Rico the Spanish had built thirteen lighthouses, the first of these, on the old fort known as Morro Castle, at the entrance to San Juan Harbor, having been established in 1853. Two others which were under construction were completed after the American occupation. The Lighthouse Board took charge of the Porto Rico lights May 1, 1900. The lighthouses of the island are mostly substantial masonry or iron structures of moderate height, as the bold coast line makes high towers unnecessary. Because of the absence of fog there are no fog signals. The lightkeepers are natives of the island. On Mona Island, lying to the west of Porto Rico, the Spanish Government had deposited the material for a steel lighthouse and keepers' dwellings. This station was completed in 1900 by the Americans with considerable difficulty because of the inaccessibility of the site and the deterioration of the materials. Mona Island is uninhabited and without a harbor; vessels coming here for phosphate anchor in the open roadstead, and when storms arise from the eastward it is said the crews leave the vessels with both anchors and all chain out, and take to the boats and go ashore; in too many cases the vessels follow them. This lighthouse marks the Mona Passage through the West Indies.

The necessary lights and buoys have been maintained by the United States at the Island of Guam, at the American Samoan Islands in the Pacific Ocean, and at the naval station at Guantanamo, Cuba, since the transfer of these territories to the United States. Since 1904 the lighthouses of the Hawaiian Islands have been maintained by the United States. Eighteen lights had been established and kept in operation by the Hawaiian Government, and there were seventeen maintained by private corporations. At present the United States has forty-nine lights in service in the islands, including six gas buoys, and there are nineteen privately maintained lights.

A landfall light for vessels bound from the States was established in 1909 on Makapuu Point, the eastern extremity of Oahu Island. All the commerce from the west coast of North America bound to Honolulu passes Makapuu, and previously there was "not a single light on the whole northern coast of the Hawaiian Islands to guide ships or warn them of their approach to land, after a voyage of several thousand miles." The largest lens in this service is that at Makapuu. The inside diameter of this lens is eight and three-fourths feet. Although the tower is only forty-six feet high, this light is four hundred and twenty feet above the sea, and is visible twenty-eight miles.

Another very important landfall light was built in 1913 at Kilauea Point, the north point of Kauai Island. This provides a landfall for ships bound to Honolulu from the Orient. The light-tower is of reinforced concrete and is but fifty-two feet high, but it stands near the edge of a cliff so that the light is two hundred and sixteen feet above the water. The lens is composed of two groups of two panels each. The moving part weighs nearly four tons and turns on a mercury float, making a complete revolution every twenty seconds, and giving each ten seconds a



KILAUEA POINT LIGHT, KAUAI, HAWAIIAN ISLANDS

double flash of 240,000 candle-power. The lens was built in France and cost about $12,000, including duty.

Molokai Lighthouse, on the prominent point on the north coast of the island of the same name, was built in 1909. It is a tower one hundred and thirty-two feet high, and the light of 620,000 candle-power is two hundred and thirteen feet above the sea. This station is close to the leper settlement of the Hawaiian Islands, and special precautions are taken for the protection of the keepers.

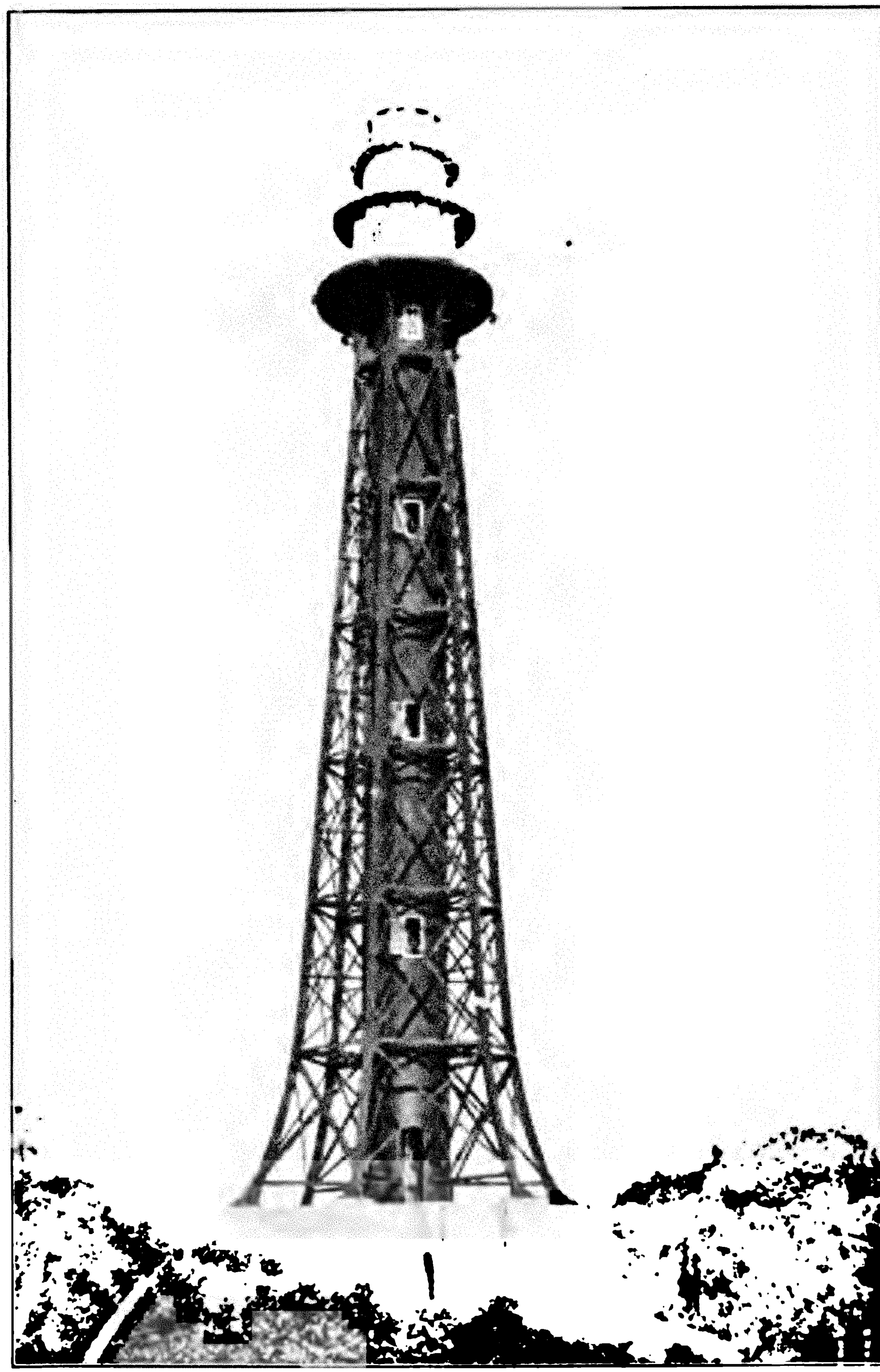
In recent years a number of automatic acetylene lights have been established in the Hawaiian Islands. One of these, Molokini Light, on an islet in the channel southwest of Maui Island, recently completed a record of burning every night for five years without having been extinguished; this light flashes every three seconds, so that this record means that about 25,000,000 night flashes were sent out automatically without failure.

An unusual lighthouse is that now being built by the United States on Navassa Island, which lies between Cuba, Jamaica, and Haiti, in the main passage to Panama. This is an uninhabited island two miles in length, and was at one time worked for phosphate rock by an American company, by reason of which it belongs to this country. The greater part of the island is a rough plateau, and the lighthouse is being built near its highest point, two hundred and fifty feet above sea level. The lighthouse is of reinforced concrete, the concrete tower being one hundred and forty-seven feet high. The focal plane of the light will be four hundred and two feet above sea level. The tall tower is necessary not to get the light so high above the sea, but so that it will be seen over the edge of the plateau all around the horizon, as otherwise the light would be hidden from view for vessels in the close vicinity of the island. The island is a most desolate place, without harbor, or good landing, or water, and with a very rough surface full of pit-holes. It has been necessary to take to the island nearly every material used in construction, including even sand and water. To facilitate communication a radio station is maintained on the island. Recently, after the schooner carrying supplies was damaged in a hurricane and put back to Jamaica, the radio was very useful in getting food to Navassa. This was the reassuring report from the island as to food: —

The last flour was used for making bread on Friday. There were sufficient rations on hand to last through Sunday, and with goats, wild pigeons, fish, etc., together with a pig, and a number of chickens which are kept here, we were in no serious predicament.

The Panama Canal authorities have very thoroughly lighted and marked that great waterway. The general scheme of marking the Canal includes the use of range lights in the longest reaches, and lighted buoys and beacons along the sides. There is a double range for each long reach, a head and a back range, so that a vessel going in either direction will have two lights in line ahead. The towers are white cylindrical concrete structures, set a little to starboard of the axis of the Canal, so that if vessels going in opposite directions keep on their respective head ranges, they will have ample room to pass. Lighted buoys and beacons, showing red lights on one side and white on the other, are placed along both sides of the Canal and across Gatun Lake at intervals of a little less than one mile, and at all turns, and spar buoys are placed between the gas buoys. There are no buoys in Gaillard Cut. The range lights are white, the front fixed and the rear flashing. The gas buoys use acetylene gas, and the beacons and range lights are lighted with electricity or acetylene, as most convenient for the different sections of the Canal. The Canal authorities have also established several lights to mark the approach to the Canal on the Pacific side. The Canal has about two hundred and fifty aids to navigation in its forty-four miles of length.

Few regions in the world depend more completely on water transportation than do the Philippine Islands, both for communication with the rest of the world and between the islands. With an area less than that of New Mexico, the Philippines consist of some three thousand islands and islets, and cover an extent of about one thousand miles from north to south, and six hundred miles from east to west. At the time of the transfer to the United States, there were in serviceable condition in the islands twenty-nine lighthouses and minor lights. There were five large first-order lights on massive masonry towers, of excellent but expensive construction, built by the Spanish engineers, using prison labor. These were the lighthouses at Cape Engano, Cape Bojeador, Capones, Cabra, and Cape Melville. The lighting system has been greatly increased in recent years



APO REEF LIGHTHOUSE, PHILIPPINE ISLANDS

until there are now in the islands more than one hundred and fifty lights of all classes. A special problem in lighthouse construction in the Philippines is stability against typhoon winds, which have reached a recorded velocity of one hundred and twenty miles an hour.

XI

LIGHTHOUSE CONSTRUCTION AND APPARATUS

"Nothing indicates the liberality, prosperity, or intelligence of a nation more clearly than the facilities which it affords for the safe approach of the mariner to its shores." The ideal marking of a coast would require that the primary lights be so placed that their arcs of visibility overlap, with one at least always visible from any point near the coast, and that every danger and channel and approach be marked sufficiently to render navigation safe so far as can be done by aids to navigation. Of course this is limited in application by the resources available. Considering this limitation, the desirable distribution of lights and other aids along a coast depends on its maritime development and its physical characteristics, and on the prevailing meteorological conditions, and the problem varies greatly on different portions of the coast of the United States. The North Atlantic Coast has, for instance, both a large transoceanic commerce and a large coasting trade, and several of its harbors rank among the world's great seaports. On the other hand, there are considerable stretches of the western and northern Alaska coast which are approached by very little shipping. The coasts of New England and of southern Alaska are rockbound and rugged, and very intricate, with indentations, islands, rocks, and reefs; most of the Pacific Coast is precipitous and rocky, but of simple outline; much of the South Atlantic and Gulf Coast is low and sandy, of simple contour, but with extensive inside navigable waters.

On the Atlantic Coast north of Cape Hatteras, with slight exceptions, the main lights are so placed that their arcs of visibility overlap. The American shores of the Great Lakes are nearly continuously lighted, as are the South Atlantic Coast from Cape Romain to the end of the Florida Reefs, and about half of the Pacific Coast. On the balance of the Atlantic, Gulf, and Pacific Coasts there are unlighted stretches between the lights which stand on the projecting headlands. Along the enormous coast line of Alaska there are as yet only a few general coast lights, but the principal inland channel is nearly continuously lighted.

Among the lighthouses of the country may be found examples of great engineering skill and of dignified and simple design. Some of the tall lighthouse structures are of beautiful architecture, suited to the purpose, and set off by picturesque location on headland or rock overlooking the sea.

Many types of structure have been used for the lighthouses of the United States, and various materials employed, including stone, brick, cast iron, wrought iron, steel, plain concrete, reinforced concrete, and wood. The latter was used in the earlier work in some portions of the country because of economy and facility of construction, but now endeavor is made to eliminate perishable materials so far as practicable, and to erect all structures in a permanent manner, so as to avoid or greatly lessen future expense of repair.

The distance at which a light may be seen in clear weather depends not only on its illuminating power, but on the curvature of the earth, and most of the more brilliant lights would be visible from a greater distance if it were not that they are cut off from view by the intervening rounding surface of the earth. The curvature increases as the square of the distance, so that while it is slight for moderate distances, it increases rapidly at greater distances; thus, at four miles it is about twelve feet, but at eight miles it is forty-nine feet, as the voyager notes by the rapid disappearance of the hulls of large vessels at sea as the distance increases. An observer on a vessel, with his eye fifteen feet above the water, can see a light one hundred feet above the sea at a distance of fifteen and three-fourths miles, but a light elevated two hundred feet can be seen only four and three-fourths miles farther, or at about twenty and one-half miles. The relation of height and visibility is expressed roughly by the equation

$$\text{Distance (in nautical miles)} = \frac{8}{7}\sqrt{\text{Height}}\ \text{(in feet)}.$$

An important feature of lighthouse construction, height of the tower, is controlled by this element of the effect of curvature on visibility, and lighthouse towers on low-lying coasts have generally been limited to a height not much exceeding two hundred feet, because beyond that the gain in distance seen is not sufficient to warrant the added expense of construction, and also because the range of visibility of twenty miles meets most practical needs.

Lighthouse construction on the land is usually comparatively simple, except when there is difficulty of access to the site. But often it is important for the protection of shipping that lighthouses be erected either on rocks or reefs exposed to the sea, or actually in the water, on sand or rock bottom. Such work in some instances has called forth the greatest skill of engineers.

A large number of lighthouses have been built on wholly or partially submerged sites, in order to place the light in the most useful position. A number of types of construction have been employed for these. Timber cribs or iron piers, filled with concrete or rock, have sometimes been used, placed directly on the bottom, or on riprap foundations. At important locations, where the site is exposed even at the lowest tides, masonry towers have, in some cases with great labor and danger, been fitted to the bed-rock, which has been leveled or cut in steps to receive them. Masonry towers have in a few instances been built within coffer-dams placed around a submerged site. Where the bottom is sand, gravel, or coral, the structure has been erected on iron piles driven, screwed, or jetted into the shoal, or on caissons floated to the site and set on the bottom, or sunk deeper by the pneumatic process, or on cribs or piers as above mentioned.

The most notable of the wave-swept lighthouses have been described, Minots Ledge near Boston, Tillamook Rock and St. George Reef on the Pacific Coast, Spectacle Reef and Stannard Rock in the Great Lakes, the tall iron lighthouses on the Florida Reefs, and Sabine Bank off the Gulf Coast. The screw pile was formerly much employed, there being fifty lighthouses of this type in the United States. This is an iron pile with a large screw flange at the base, which is bored into the sand bottom, increasing the bearing and anchorage of the pile, the first use in this country being at Brandywine Shoal as described. There are many attended lighthouses built on piles, in Chesapeake Bay and the Carolina Sounds.

Eleven lighthouses in the United States have been built on submarine sites by the use of caissons sunk into the sand foundation by the pneumatic process, the first being that at Fourteen-Foot Bank, in connection with which the method is described. Of others standing in the water thirty-five have been built on cylindrical piers of cast-iron plates, sunk on a prepared bottom and filled with concrete; this is a familiar type in some of the North Atlantic bays and sounds.

The greater portion of the earlier lighthouses built on the land are substantial towers of stone or brick masonry. A few towers have been built of cast-iron plates, bolted along their flanges. Later wrought-iron or steel open framework towers have been used for a number of lighthouses, and more recently reinforced concrete has been employed at a few stations. Because lighthouses are usually exposed to the strongest action of the elements, attention is given in their design to the maximum effect of wind, waves, current, and ice, as may be applicable in each case, and the stability of the tower is carefully computed to bring it within safe limits under the most severe conditions.

A fully equipped light-station on a land site usually consists of light-tower, fog-signal building, keepers' dwellings, oil-house, boat-house, landing-wharf, etc. The tower is surmounted by the lantern for the protection of the illuminating apparatus; the lantern is reached by a winding iron stairway. At some of the land stations, especially of less importance, the tower and dwelling are combined in one building, and on submarine sites the whole station is generally confined to one building. Quarters for the families of keepers are usually provided at land stations unless very remote or exposed, but not at the water stations.

Shore-line erosion must be contended with in the maintenance of lighthouses on certain portions of the coast, and presents serious problems, often requiring prompt and vigorous action to prevent the destruction of valuable property. In some instances the original lighthouse has been undermined and destroyed or endangered, rendering necessary the construction of a new tower. Thus, as already described, three successive towers have been built at Cape Charles at the entrance to Chesapeake Bay. This is only one of many instances where it has been necessary to remove lighthouses to save them from the sea, or to build new towers to replace those abandoned to the waves, and at some stations a fight has been kept up for years to save the lighthouse from the sea.

Minor lights on the coasts are placed on small framed structures of steel, iron pipe, concrete, or wood, or on a cluster of piles of wood or reinforced concrete. A new type of cast-iron mast for unattended automatic gas lights has been developed and installed on the Point Judith breakwaters, which in times of storm are sometimes swept by the sea to a depth of ten feet. Each light structure is made up of a hollow cast-iron column thirty-three feet long and ten inches outside diameter, made in three sections. The columns are set nine feet into the breakwater and embedded in concrete. Around the top section, twenty feet above high water, is a steel tank-house four feet in diameter for holding gas tanks. The acetylene lantern is mounted above this tank house. The columns are filled with concrete with reinforcing rods. The columns offer but a small surface to resist the waves and the tank-house is above their reach; the structures have withstood severe storms.

"Safety is only to be found in certainty, and anything which does not secure the latter condition is a foe rather than a friend to the mariner," is a maxim of Trinity House, and an early report of the Lighthouse Board says: —

> One maxim should ever be observed, namely, perfect regularity of exhibition of every signal from night to night and from year to year. A light, for example, which has been regularly visible from a tower, it may be for years, cannot be suffered to fail for a single hour, without danger of casualties of the most serious character.

In order to increase the reliability and efficiency of lights and other aids to navigation the highest technical skill has been called upon in recent years. Although lighthouses are known to have been used to aid the mariner for more than two thousand years, most of the progress in illuminating apparatus has been made during the last hundred years; lighthouses were for many centuries lighted only by wood fires burned in open grates on the tops of the towers. Coal was used at a Swedish lighthouse in 1560, and up to 1816, a century ago, a coal fire was still burned at the important Isle of May Light in the approach to the Firth of Forth, Scotland. The famous Eddystone Lighthouse was lighted with twenty-four tallow candles down to 1811.

Oil lamps were early used in this country, if not from the first lighting of Boston Light. Fish oil, sperm oil, colza oil, lard oil, and kerosene were in turn burned, increasing expense in each case compelling a change. Sperm oil, for many years the standard illuminant, had increased in cost to $2.43 a gallon in 1863, and in consequence colza or rapeseed oil was at that time being introduced. By 1867, however, lard oil had been substituted for sperm oil, using colza oil in the smaller lamps in cold weather. Kerosene oil was long considered too dangerous; in 1864 a Lake Michigan lightkeeper on his own responsibility used a kerosene lamp in his light, but after several nights an explosion scattered oil over the keeper, and a second violent explosion blew the whole lantern from the tower and destroyed the lens. In 1875 the Lighthouse Board hesitated "to endanger lives of employees and valuable property by placing mineral oil at . . . points from which keepers could not escape in case of accident." However, two years later kerosene was being introduced at the smaller lights, and by 1885 was generally used in the lighthouses in this country. Cylindrical wick lamps, with a central current of air, were invented by Argand about 1782, and such lamps were introduced in lighthouses of this country in 1812. At the present time lamps with from one to five concentric wicks, and burning a high grade of kerosene oil, are in service in a majority of lighthouses. Over six hundred thousand gallons of kerosene are used each year at the light stations of the United States, more than half of which is burned for lighthouse illumination.

An important advance was made by the introduction of the incandescent oil vapor lamp at a French lighthouse in 1898. In 1904 this lamp was installed at North Hook beacon, Sandy Hook, New Jersey, and it is now in use at three hundred and six light-stations of this country, including most of the primary coast lights. In this lamp the kerosene, forced into the vaporizer by air pressure, is heated and vaporized, and is burned mixed with air under a mantle, which is thus brought to a brilliant incandescence. This lamp gives a much more powerful light than the wick lamp, with a smaller consumption of oil, and has been greatly appreciated by mariners because of its superior brilliancy. The illuminating power from a given quantity of oil is in some cases increased as much as eight times as compared with the wick lamp. With the oil vapor lamp about three-fourths gallon of kerosene a year is consumed for each candle-power of the bare lamp, as against six gallons a year per candle-power for the Argand lamp. When the oil vapor lamp was introduced at Cape Hatteras Lighthouse the power of the light was increased from 27,000 to 80,000 candles, while the consumption of oil was reduced from 2280 to 1300 gallons a year. Where a still more powerful light is required a lamp is provided with three burners and a cluster of three mantles, such as is now installed at Cape Lookout Lighthouse.

Electricity was adopted as the illuminant at Dungeness Lighthouse on the coast of England in 1862, but was later abandoned at this station. Its first use in this country for lighthouse purposes appears to have been the placing of an arc light in the Statue of Liberty, in 1886. Two years later six electrically lighted buoys were used to mark Gedney Channel, and in 1889 an incandescent electric lamp was placed in Sandy Hook Beacon, all of these installations being in New York Harbor. Electric lights are, however, used at comparatively few light-stations, as the expense is too great to warrant their wide employment, particularly as the oil vapor mantle lamp now furnishes a brilliant light at moderate cost. The only primary lighthouse using electricity in this country is that at Navesink on the highlands just south of New York Harbor, already described. For some harbor lights, however, electricity can be used to great advantage by taking current from a local source of supply, and an effective light can thus be maintained in an exposed position and controlled from a distant point on the shore. By convenient automatic devices such lights are made occulting, and one lamp is automatically substituted for another lamp burned out.

Gas made from rosin was used at a light-station on the Delaware in 1841, and ten years later four stations in that vicinity were so lighted. As early as 1838, a light on Lake Erie, at Portland, New York, was being lighted by natural gas. There are at present but three coal-gas harbor lights, supplied from local sources. There has in recent years been a large use of compressed acetylene and compressed oil gas as illuminants for minor lights, such as unattended lighted beacons and lighted buoys; this extended use is due to the facility with which the gas may be stored and transported. Oil gas was first used in this country for a lighted buoy in 1881, and for lighted beacons in Currituck Sound the same year. It is readily transported in tanks, as the gas may be compressed to one hundred atmospheres or about fifteen hundred pounds per square inch. A beacon equipped with a generator for producing acetylene gas from calcium carbide was placed on the Mobile Channel in 1902, this being the first Service use of acetylene gas, and a limited number of beacons are now illuminated with acetylene gas generated at the station. Compressed acetylene dissolved in acetone was first used at Jones Rocks Beacon, Connecticut, and South Hook Beacon, Sandy Hook, New Jersey, in 1903. In this system the gas is compressed into cylinders filled with a porous substance, and with acetone, a liquid having the remarkable power of absorbing at atmospheric pressure twenty-four times its own volume of acetylene gas; its power to absorb the gas increases in proportion to the pressure, so that at a pressure of ten atmospheres it will dissolve two hundred and forty times its own volume of acetylene gas. There are now in use a number of acetylene gas-lighted beacons on this principle, supplied by tanks of gas of sufficient capacity to maintain without replenishing a quick-flashing light for several months. This method of storing acetylene gas is the invention of French chemists, and the apparatus for using it in automatic lights was developed by a Swedish physicist. Some of the acetylene beacons are provided with a sun valve, which saves gas by automatically cutting off the gas supply during the time the sun shines.

When candles and lamps were first used in lighthouses they were enclosed in a lantern with heavy metal frame and small glass panes. Such a lantern

COLUMBIA RIVER LIGHTSHIP BEING HAULED THROUGH THE WOODS

acted simply as a protection against the weather, and the greater part of the feeble light was lost in directions not useful to the mariner. The only light helpful to the navigator is that which is thrown out near the horizon, and in order to give him the greatest benefit from a light the rays must be concentrated in this useful plane. It is further often desirable to direct the light in certain directions in the horizontal plane, either to avoid the waste of light on the land side or to indicate the limits of danger, or to bring the light into one or more horizontal beams in a powerful flashing light. To effect these objects, reflectors, lenses, and prisms are used, and the apparatus depends on the reflection of light, the catoptric system, or the refraction of light, the dioptric system, or the combination of the two, the catadioptric system.

Parabolic reflectors were used in some English lights about 1763. Crude reflectors were introduced in lighthouses in this country in 1812, together with a useless solid lens in front of the lamp. The lens was later discarded and subsequently more perfect parabolic reflectors were imported. In order to make the light more powerful and to show around the horizon, it was necessary to mount on a chandelier a number of lamps each with its own reflector. Thus in 1828 there were at Boston Lighthouse fourteen lamps; at Sandy Hook, eighteen lamps; and at Franks Island, Louisiana, twenty-eight lamps.

Lenses were used as early as 1790 at an English lighthouse. The French physicist, Augustin Fresnel, beginning in 1822, revolutionized lighthouse practice by developing a built-up annular lens comprised of a central spherical lens surrounded by rings of glass prisms, the central portions of which refract and the outer portions both reflect and refract in the desired direction the light from a single lamp placed at the central focus. Various forms of lenses designed on these principles, with further improvements, are now very widely used in lighthouse work, varying from the simple lens lantern, with a singular annular lens, to the great first-order lens, built of many pieces of beautifully cut and polished glass. Of such a lens the distinguished Scotch lighthouse engineer, Alan Stevenson, wrote:—

Nothing can be more beautiful than an entire apparatus for a fixed light of the first order. It consists of a central belt of refractors, forming a hollow cylinder six feet in diameter and thirty inches high; below it are six triangular rings of glass, ranged in a cylindrical form, and above a crown of thirteen rings of glass, forming by their union a hollow cage, composed of polished glass, ten feet high and six feet in diameter. I know of no work of art more beautifully creditable to the boldness, ardor, intelligence, and zeal of the artist.

With the most complete lenses about sixty per cent of the light is rendered useful, the balance being lost at the top and bottom and by absorption of the glass of the lens and the lantern.

The first Fresnel lens in the United States was installed at Navesink Light in 1841, but up to 1853 only five stations were equipped with lenses. After the organization of the Lighthouse Board lenticular apparatus was rapidly introduced and by 1859 had been installed in practically all the lighthouses of this country. There resulted a large saving in the consumption of oil, as in 1853, before the change, there were 3093 lamps for 331 lighthouses.

The order of a light depends on the focal length of the lens, — that is, the distance from the center of the light to the inner surface of the lens; for instance, a first-order lens has thirty-six inches focal length or six feet total inside diameter, and a third-order lens twenty inches focal length or forty inches diameter. As the power of lights does not depend only on the order of the lens, it is customary now to describe lights by stating the candle-power rather than the order.

Marine disasters have occurred from the mistaking of one lighthouse for another, and it is evidently important that lights be so distinguished that the navigator may recognize with certainty the light he sees. To this end lights are known by their number, color, intensity, or time of visibility. Before the introduction of flashing or occulting lights, in a few cases two or three light towers were built close together to give a distinctive combination, an example being the two lighthouses at Cape Ann. This is an expensive method not now employed for new lighthouse work. For lights to be seen at close range, two lights are sometimes shown, one vertically above the other. Color distinctions, especially the use of red, have been widely used, but an objection is the great loss of power with the use of colored glass; with the best color, red, the loss is about sixty per cent. However, red is considerably used for minor lights; as, for instance, in a harbor to distinguish from city lights, and for buoys on one side of a channel; and there are a number of lighthouses flashing alternately white and red, and others fitted with red sectors to guard dangerous waters.

Much the most effective method of distinguishing lights is by making them flashing or occulting. With the systems now available it is possible to obtain a sufficient variety of positive characteristics. Cordouan light in France was made a revolving light in 1791, but the first light of this character was installed in Sweden in 1768. As early as 1797 there is reference to ordering from Europe "eclipsers" for the Cape Cod Light, Massachusetts, and stating that "there is great difficulty in making this unknown machinery here." Boston Light was fitted as a revolving light in 1811, and others at about that time. Sandy Hook Light is described in 1817 as "a revolving light with eighteen lamps and reflectors, on a triangular frame, performing a revolution every five minutes; the utmost power of light will appear three times in each revolution." The lenses were carried on wheels and revolved slowly, actuated by a weight working through clockwork. The long intervals of darkness between the flashes were a decided objection to this system of slow-revolving lenses, as they interfered with the full usefulness of the light to the mariner. A most important development in lighthouse apparatus was the invention, by Bourdelles in 1890, of the mercury float for the rapid revolution of heavy lenses, and the introduction the same year in France of quick-flashing lights. The weight of the rotating parts is carried by mercury in an annular trough, and a lens weighing with mounting as much as seven tons may thus smoothly make a complete revolution in thirty seconds. For rapidly revolving smaller lenses ball bearings are used.

Lenses for flashing lights are divided into as many panels as there are to be flashes for each revolution, and the prisms of each panel are so designed as to concentrate all the light falling on the panel from the lamp into one horizontal beam, which appears as a flash as it sweeps past the observer. On account of slow revolution the earlier lenses were divided into numerous panels; for instance, the lens at Boston Light, revolving once in six minutes, has twelve panels giving a flash each thirty seconds. For the quick-flashing light the number of panels is reduced to a minimum to give the desired characteristic; thus, the lens recently installed at Kilauea Lighthouse, Hawaii, has, as stated two double panels, and makes a complete revolution in twenty seconds, giving a double flash every ten seconds.

The speeding-up in revolving a lens has permitted this reduction in the number of panels into which it is divided, with concentration of a greater proportion of the light in the beam from each panel, so that a smaller lens with few panels, revolving rapidly, may give a more brilliant light, and at as short intervals, as a larger lens divided into many panels and revolving slowly. The following comparison illustrates this point, as well as the relatively low efficiency of a fixed light. The first three are earlier, and the last three more recent installations. Seguin, Maine, fixed light, 22,000 candle-power, lens seventy-two inches diameter; American Shoal, Florida, flashing every five seconds, 80,000 candles, twenty-four panel lens, seventy-two inches diameter, revolves in one hundred and twenty seconds; Heceta Head, Oregon, flashing each sixty seconds, 170,000 candles, eight panel lens, seventy-two inches diameter, revolves in eight minutes; Molokai, Hawaii, flashing each ten seconds, 620,000 candles, two-panel lens, fifty-five inches diameter, revolves in twenty seconds; Split Rock, Minnesota, flashing each ten seconds, 220,000 candles, two-panel lens, thirty-nine inches diameter, revolves in twenty seconds; and Los Angeles Harbor, California, flashing each fifteen seconds, 67,000 candles, two-panel lens, twenty inches diameter, revolves in thirty seconds. The introduction of quick-flashing lights and of more powerful illuminants and more effective lamps has made unnecessary in future the installation of the largest sizes of lenses, which are very expensive. The astonishing efficiency of the modern quick-flashing lens and the oil vapor lamp is shown by the fact that a light, giving a flash of 620,000 candle-power, with two-panel lens of the second order, consumes only about nine hundred gallons of kerosene a year. At the present value of kerosene this amounts to a cost of about one hundredth of a cent for one candle-power for a year's service.

There are a number of lighthouses showing a fixed light with a flash of greater intensity at regular intervals; this is obtained by revolving a single panel around a fixed lens. Red flashes alternating with white, or lights showing red flashes in certain directions, are produced by interposing red glass, either moving with the lens or fixed, as the case may be. The tendency is gradually to eliminate arrangements such as these in which the power of the light is not constant, as they introduce a possibility of the characteristic not appearing the same at a distance. Occulting lights are less efficient, as the light is not concentrated into beams, and is lost when the light is obscured. The effect is obtained by some form of moving screen or shutter or by blank panels in a revolving lens. These arrangements have been of great advantage in giving to the earlier established fixed lights a characteristic by which they can be recognized with certainty. With gas or electric lights, flashes or occultations are obtained by automatically cutting off the supply of gas or current at intervals, by suitable mechanism adjusted for the desired characteristic.

The earlier lighthouses all had fixed lights, but there has been steady progress in changing the more important lights to show a distinctive characteristic. At present of the sixty-five primary lights on the Atlantic and Gulf Coasts, forty-seven are flashing or occulting, and of the thirty-four on the Pacific Coast all but two are flashing or occulting.

Reflectors are still in use, mainly for range lights, employed to mark the center line of a channel. Such reflectors are either silvered surfaces of metal of parabolic form, or prismatic glass reflectors back of the lamp used in connection with glass lenses.

The changes in channels, harbors, and coast line, due either to storms, currents, or other natural causes, or to the works of man, the every-varying needs of maritime commerce, and the necessity for introducing improvements, cause a considerable number of changes in the lights and other aids each year, recently averaging sixteen hundred annually, and these are published promptly for the information of mariners; accidents to important aids are broadcasted by radio so as to reach at once vessels upon the seas.

XII

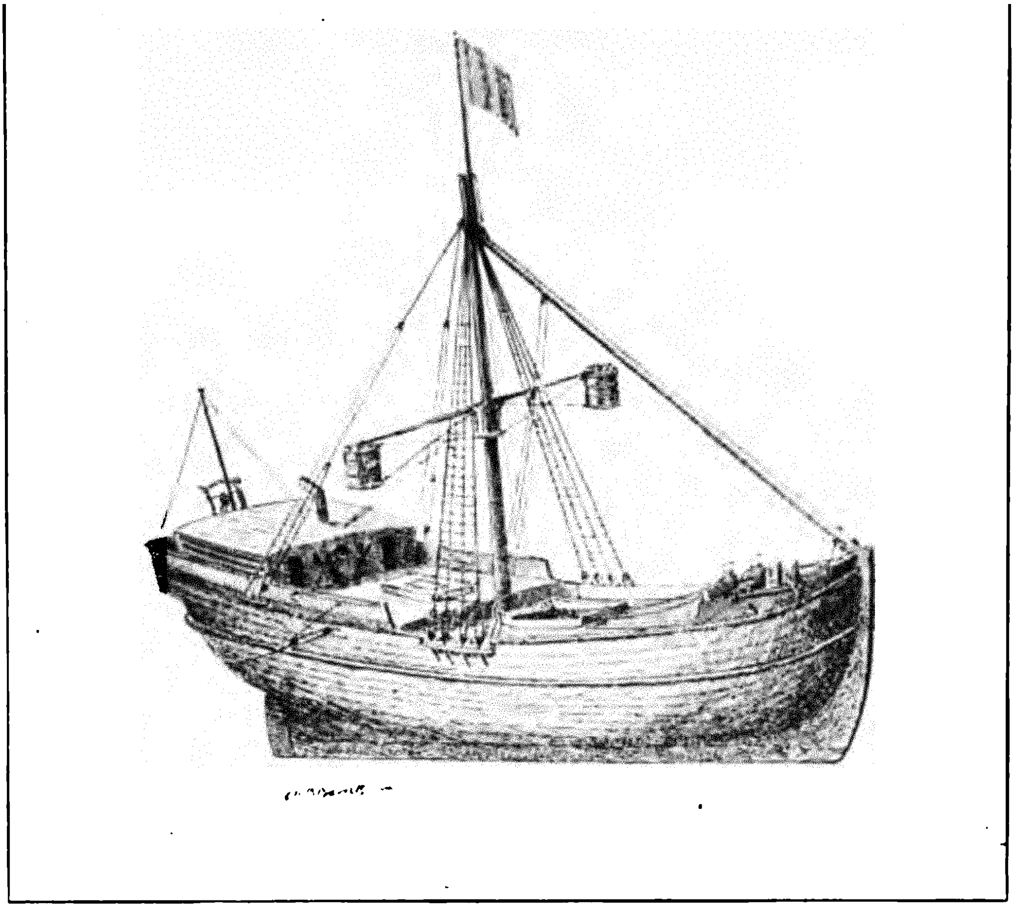
LIGHTSHIPS AND LIGHTHOUSE TENDERS

Lightships are placed in locations off the coast, where it would be impracticable or needlessly expensive to build a lighthouse, and they usually mark the approach to a port or bay or the outer limit of an off-lying danger. They are also sometimes used in inside waters. They may be moored in the channel or close to it, and they have the advantage over most lighthouses that they provide both a light and fog signal for which a vessel may without danger steer directly so long as collision with the light-vessel is avoided, and also that they may be moved, and moored in another position, when change of conditions or necessity requires. On the other hand, a light-vessel is more expensive to maintain, and there is the possibility of its being driven from its station, though this is reduced in recent years by improved vessels and moorings.

The first lightship, the Nore, was established in England in 1732, at the mouth of the Thames. The first in this country was stationed in 1820 in Chesapeake Bay, off Craney Island, at the entrance to the

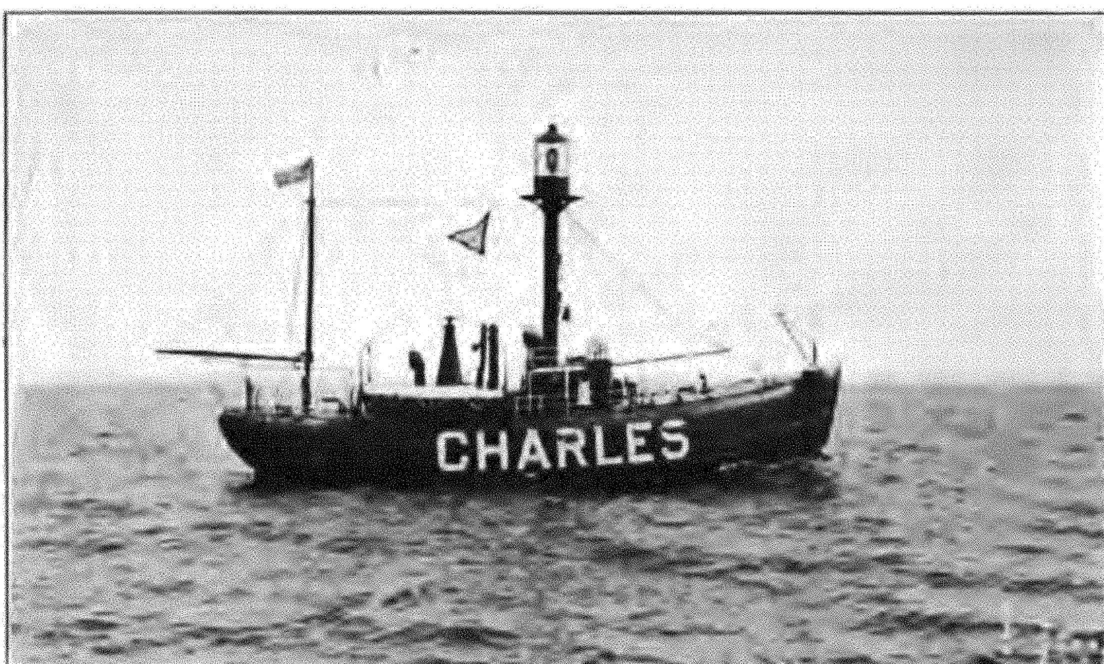
Elizabeth River, near Norfolk. Four other lightships were placed in Chesapeake Bay in the following year, including one off Willoughby Spit, at the entrance to Hampton Roads. The first outside vessel was moored seven miles off Sandy Hook, at the entrance to New York, in 1823. The number of lightboats or floating lights, as they were then called, quickly increased; in 1825 there were ten. In 1839 there were thirty in service, mostly small craft in inside waters; the largest was that on Sandy Hook Station, with a tonnage of two hundred and thirty, and there were only three on outside stations, Sandy Hook, Five-Fathom Bank, and Carysfort Reef, Florida.

In 1858 there were forty-eight station lightships, but by 1885 this number had been reduced to twenty-two, owing to the replacement of many of the small vessels on inside stations by lighthouses built in the water. For instance in one year, 1867, eight lightships in the sounds of North Carolina and Chesapeake Bay were replaced by screw-pile lighthouses. The United States at present maintains lightships on fifty-three stations, and there are a number of relief ships, so that the regular station vessels may be brought in for repairs. A fog bell is mentioned in



THE FIRST LIGHTSHIP

From a model in Trinity House Museum



1819 as a desirable feature for the lightship then being planned, and it is probable that such fog signals were early provided for the lightships. In 1835 there was an appropriation "for lightboat, with a bell to be attached to the same and anchored at Bartletts Reef, $5000." In 1840 the master of the lightship in the Northwest Passage, Key West, was forbidden to act as a pilot, it appearing that he had been taking "every vessel that comes that way" to the detriment of other pilots. Up to about 1877 the lightships were built of white oak and live-oak, and twelve of these small vessels over fifty years old are still in service, one being sixty-seven years old. After Lightship No. 3 had completed more than sixty years of service the master said she was good for sixty years more. An "iron boat" of four hundred tons with one lamp was placed on Merrills Shell Bank, Louisiana, in 1847, but it was not until 1882, beginning with No. 44, that lightships were regularly built of iron or steel.

In 1891 lightships were first built with self-propelling power, and more than half of them are now so provided. All the lightships on the more exposed and important stations have propelling power, thus assisting them to maintain or regain their positions in heavy weather, and enabling them unaided to proceed to and from their stations.

Reflector lights were early used on lightships, and are still the source of illumination on some older vessels. Each light is composed of eight lamps with reflectors twelve inches in diameter, set upon a ring which encircles the mast, the whole enclosed in a lantern with large panes of glass as protection from the weather. The lantern is kept in a small house, with opening roof, on deck at the base of the mast, where the lamps are lighted at night and the whole is hoisted to the masthead.

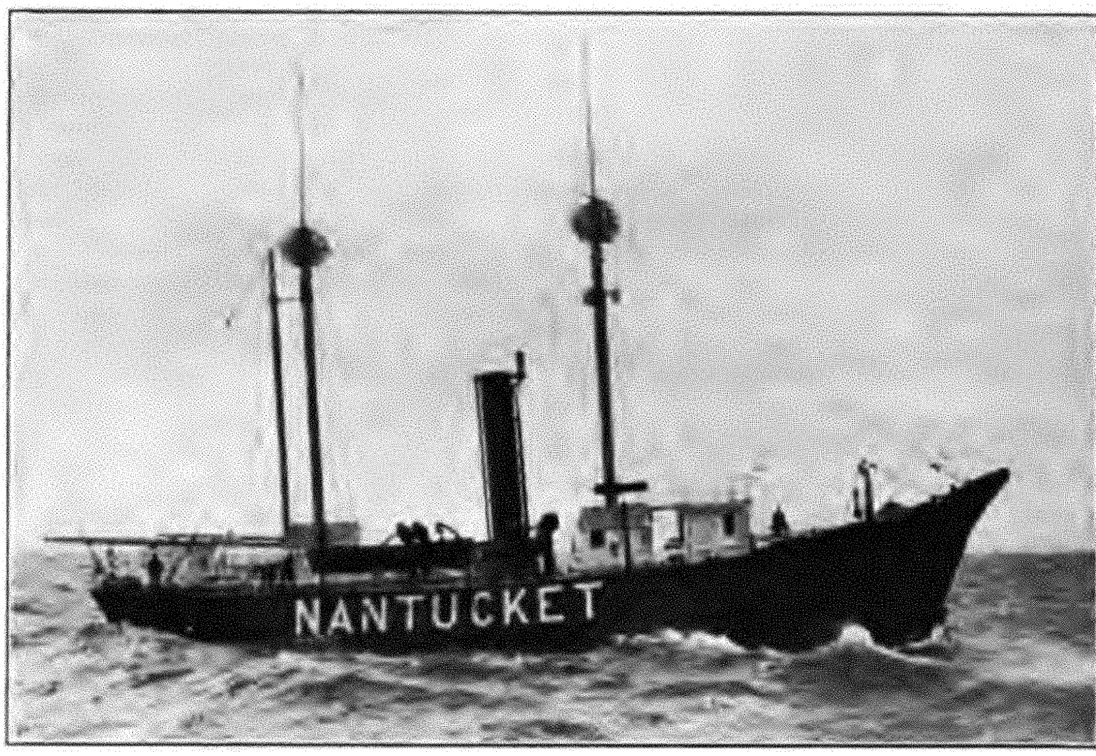
The next improvement was the use of a group of three lens lanterns swung in gimbals on a ring around the mast, and operated in the same manner as the reflector lanterns. Electric incandescent lamps were first applied to a lightship in 1892, on No. 51 at Cornfield Point. Since then various other illuminants have been installed, and there are now two lightships using incandescent oil vapor lamps, five compressed acetylene gas, three oil gas with mantle, one electric arc, and eight electric incandescent lamps.

A mechanism for revolving the lamps about the mast, so as to obtain a flashing light, was installed on a lightship in 1891, but its use was discontinued on account of difficulties in operation. The majority of lightships still have fixed lights, though many of these are made distinctive by showing two lights, one on each masthead. The lightships with illuminants other than oil lamps all show flashing or occulting lights. Several recent lightships are built with a single tubular mast of diameter sufficient to contain a ladder, which is surmounted by a lantern similar to those on lighthouses on shore; the lantern is of sufficient size to install a lens or other illuminating apparatus.

Lightships are easily recognized in the daytime, as they differ from other vessels in their unusual rig and shape, with cagework at the mastheads as a day mark, and characteristic painting, generally red or straw color, with the name of the station in very large letters on each side. Each individual vessel is known in the Service by a number, regardless of the station occupied. Lightships must be brought in at regular intervals for overhaul, and at such times are replaced by a relief vessel with so far as practicable the same light and fog-signal characteristics.

The design of lightships presents interesting problems in naval architecture, as steadiness and ease of motion are requisite for the efficiency of the light and the comfort of the crew. The lines are designed to control both rolling and pitching. The framing is heavy, and ample water-tight bulkheads are provided. The largest light-vessels in this service have an overall length of but one hundred and thirty-five feet, and the smaller vessels placed on the more protected stations on the Great Lakes and sounds and bays are from eighty to one hundred feet in length. Vessels are moored with mushroom anchors up to seventy-eight hundred pounds in weight on the most exposed stations, and with wrought-iron mooring-chain made under most rigid specifications. Diamond Shoal Lightship is moored with a chain one hundred and fifty fathoms or nine hundred feet in length, and weighing approximately twenty-three thousand pounds, so that anchor and chain together weigh fourteen tons. Lightships anchored in the more exposed positions are subjected to most severe treatment by the combination of gales and cross-currents, and every precaution is taken to secure their safety and their being maintained on their stations. Very long scope is given to mooring-chains, and the strain is relieved by judicious use of the propelling machinery. At some stations a spherical mooring-buoy is shackled to a submerged portion of the chain to carry a portion of the weight and ease the strains due to the vessel surging. The most exposed lightships have a complement of fifteen officers and men, and from this the size of the crew varies down to three men on the smallest inside lightship. The lightships are provided with fog signals similar to those at lighthouses of corresponding importance, and those on the open stations have submarine bells. Radio communication was experimentally established with Nantucket Lightship in 1901; at the present time four of the more exposed lightships on the Atlantic Coast are regular radio stations of the Navy. The Lighthouse Service has three tenders equipped for radio communication, and others of the seagoing tenders will be equipped.

One lightship took part in a polar expedition. Lightship No. 8, a steam brig of one hundred and twenty-five tons, was built at the Philadelphia Navy Yard in 1855, and before being placed on station was fitted out under the name of the Arctic as a part of the rescue expedition of that year to find Dr. Elisha Kent Kane. This vessel is referred to in his book, as having, "in addition to her steam-motive power, the qualities of a good weatherly, moderate-sailing vessel," and as "our invaluable little Arctic," and she and the bark Release "were pretty severely nipped and chafed by the ice." The Arctic went north to latitude 78°, and the two little ships were successful and returned the same year with Dr. Kane and his party. But the adventures of the Arctic were not over. Her engines were taken out, this being long before the day of using propelling engines in lightships, and she was sent to Rattlesnake Shoal, off Charleston, South Carolina, as a relief light-vessel. On the breaking-out of the war she was seized by the Confederates and sunk in the Cape Fear River. At the close of hostilities she was raised, repaired, towed north, and stationed on Hen and Chickens Shoal, Massachusetts, where she did duty until 1879. Another lightship, No. 31, was a vessel taken at the end of the war, which had previously been used for one year by the Confederates as a gunboat, being named the Lady Davis. Another, No. 35, was seized by the Confederates and sunk in the Savannah River in 1861.



THE NANTUCKET SHOALS LIGHTSHIP

LIGHTHOUSE TENDER COLUMBINE, IN ALASKA

A lightship off her station or dragged from her position or not showing her announced signals may mean disaster to some unsuspecting mariner, so that every effort, both in design and equipment of vessel and in discipline of crew, is made to maintain the station continuously. Owing to danger of storm and collision this is done often in the face of great difficulties. In case of accident a relief ship or a tender is hurried to the station and the news broadcasted by radio to vessels at sea. Unless relieved a lightship is not allowed to leave her station on any pretext except under absolute necessity, and the records of the Service show many instances of damaged vessels holding on against great odds. As early as 1829 the master of a lightship was instructed "not to slip or cut the cable, or suffer it to be done, in any event, and if the vessel should be likely to founder, to abandon her with the crew."

During the stormy seasons all of the crew are required to remain on the vessel, but at other times they are in turn allowed liberal liberty ashore. There are often serious difficulties in getting coal and provisions to the ships on exposed stations, and they are therefore provided with ample supplies to last over stormy periods. In the records of the lightships there are many reports of danger cheerfully met, of endurance and resourcefulness. These are typical reports from lightship masters after times of stress: "Everybody did his full share of work cheerfully"; "I desire to state that the crew behaved fine and ready to give a hand at all times"; "They did what they could to keep things fast and shelter themselves as best they could during the worst of the gale."

The lighthouse tenders are a very busy part of the Service, placing and tending the buoys, and supplying the lightships and isolated stations. One of these vessels steamed nearly twenty thousand miles during the past year. There are forty-seven tenders, of various sizes and types, specially designed for the lighthouse duty on the coasts or inland waters, with powerful hoisting-gear and open deck space for handling buoys. The largest of these tenders, the Cedar, now being built for service in Alaska, will be a vessel two hundred feet in length, and of seventeen hundred and fifty tons displacement. The smallest regular tenders are but sixty-five feet long and of three and one-half feet draft.

The first tender of the Lighthouse Service was a sailing vessel, the former revenue cutter Rush, transferred in 1840. Previous to that time the buoy work and supply of lighthouses was done by contract, or by charter of vessels, or with the assistance of other government vessels, and this was true also of much of the work for some time later. Prior to 1840 two thousand dollars a year was paid to the pilots of New York for taking up and mooring the buoys of that harbor. In 1824 the captain of the revenue cutter at Norfolk presented a bill for extra services in mooring floating lights in Chesapeake Bay, getting them offshore, dragging for their anchors, and "attending to them in many other respects." The buoys were thus cared for down to 1842, when extra payment to these officers was stopped by law. Beginning about 1852 a number of lighthouse tenders were purchased or built. These were at first all sailing vessels, and as late as 1855 there is a recommendation that "for lighthouse purposes steam should only be used on occasion, in emergencies, when sails avail nothing." The first steam tender was the Shubrick, built at the navy yard in Philadelphia in 1857 and first used on the Pacific Coast in 1858. In 1859 there were twenty-one tenders, all sailing vessels but one. In 1865, at the close of the war, six small steamers were transferred by the Navy Department for use as tenders, and these replaced a number of the sailing vessels. The early steam tenders were side-wheelers, and there are still four of this type in service. The first steam propeller tender appears to have been the Iris, purchased in 1865. The last of the sailing tenders were the Mignonette, which in a hurricane in 1887 was swept from her moorings off the coast of Texas, and neither vessel nor crew ever heard from, and the Pharos, which remained in service until 1908.

Since about 1865 it has been the custom to name the tenders after flowers, trees, or plants, and now with one exception they are all so named; four of the tenders purchased from the Navy in 1865 were thus named Iris, Cactus, Geranium, and Heliotrope

In addition to the national ensign, the tenders display the Lighthouse Service flag, which was adopted in 1869; it is triangular in shape, with a red border, and bears a blue lighthouse on a white field.

The lighthouse tenders are available for use in times of national need. In the war in 1898 four tenders, the Mayflower (Suwanee), Maple, Mangrove, and Armeria, were transferred to the Navy Depart-

ment and rendered valuable service. The tenders also gave important help in planting and protecting submarine mine fields; in this work they have regular drill. In that war additional telephone or telegraph connections were made with seventy-eight stations. No seacoast lights were extinguished or lightships removed, but changes in lights and buoys, rendered necessary by mine fields, were made at a number of harbors.

Speaking of the work of the lighthouse tenders, a member of the Cabinet recently said: —

The Government has a fleet of vessels in its service whose duty it is to go where no other vessels are allowed to go, and who, through storm, darkness, and sunshine, do their work for humanity without any boasting, without any advertising, with none to trumpet their praises and with only their own sense of duty to guide them. The story of the Service is full of brave deeds, and I honor the men who have done and are doing these things.

XIII

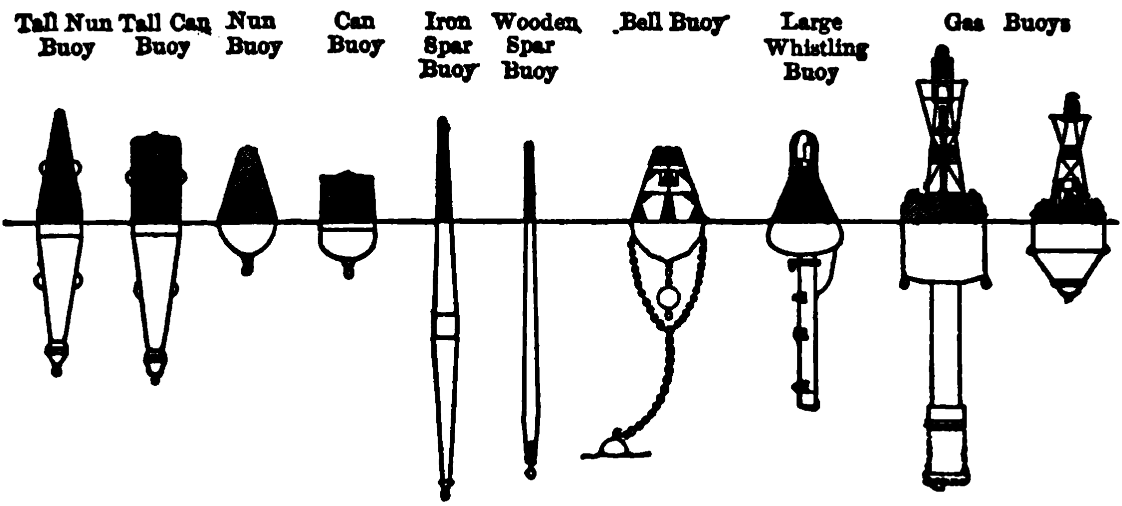
BUOYS AND DAY MARKS

I DIP and I surge and I swing
  In the rip of the racing tide,
By the gates of doom I sing,
  On the horns of death I ride.
  A ship-length overside,
Between the course and the sand,
  Fretted and bound I bide
        Peril whereof I cry.
  Would I change with my brother a league inland?
(Shoal! 'Ware shoal!) Not I!

(RUDYARD KIPLING: *The Bell Buoy.*)

MORE than half of the aids to navigation maintained by the Lighthouse Service are floating on the water, moored in position. Buoys are extremely useful aids, as they may be readily placed in critical positions to mark shoals or the limits of channels, or the middle of a channel, where it would be impracticable to place a fixed beacon or light. They are, however, subject to the disadvantage that they may be torn from their moorings, dragged out of position, or sunk on their stations.

Buoys are mentioned in connection with the building of Cape Henlopen Lighthouse by Pennsylvania, the statement of expense about 1767 showing that two sets of buoys in the Delaware River cost £1143. Massachusetts ceded to the Federal Government with her lighthouses four buoys at the mouth of the Merrimac River; and a letter from the Port Warden



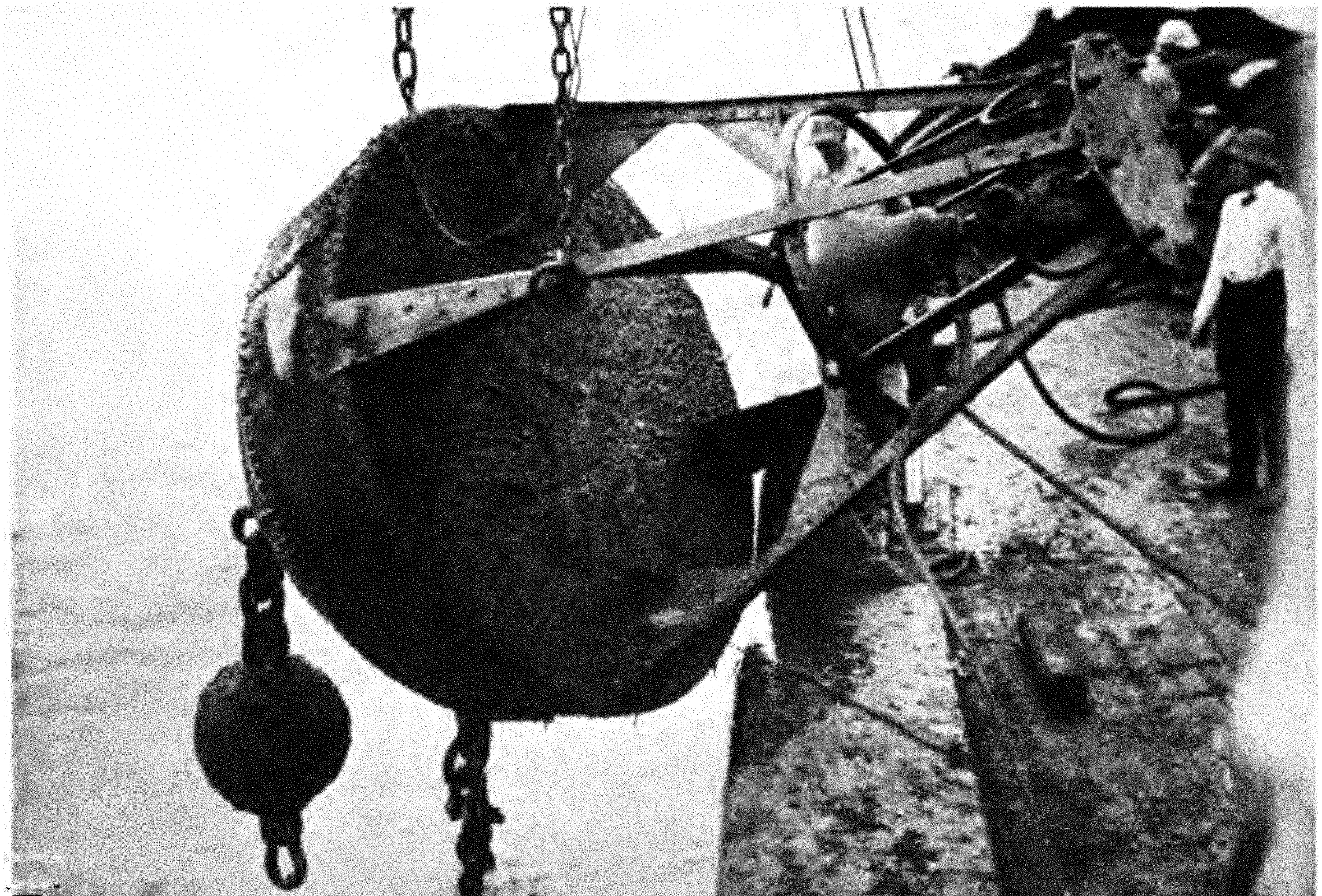
VARIOUS TYPES OF BUOYS

of Philadelphia in September, 1789, describes the floating aids in the Delaware transferred by Pennsylvania:—

There are in the Bay three floating beacons moored at the following shoals, to say one on the Brown, one on the Brandywine, and one on the Cross Ledge, these are small vessels with masts erected therein, on which are fixed a kind of cages placed in different orders so as to distinguish them from each other, thereby pointing out with certainty the situations of danger, they are moored with chains to heavy sinkers. . . . They require to be attended at least once in a month to examine their moorings, and pump them out. . . . There are also three Buoys stationed at moorings in like manner, one of them on the shoal called the flat ground of the Fourteen Feet Bank, one on the shoal called the Middle and one on Red Bank bar in the river, which are also subject to be driven from their stations by storms. . . . There have been other buoys stationed on shoals nearer the mouth of the Bay, but as they never could be kept in their stations, were generally lost, and the design of maintaining them in those places relinquished. Neither the floating beacons or the large summer buoys are permitted to remain in time of ice, as they would thereby be entirely destroyed, but buoys of a different construction suitable to the season called ice buoys are placed for the relief of the whole during that period, which shows at once the necessity of having a double set and entire exchange of the whole twice every year. . . . The value of each floating beacon with their moorings, is about one hundred pounds and of each summer buoy about fifty pounds, of each of the ice buoys about forty-five pounds.

In 1793 President Washington approved a contract for a floating beacon with two masts and cages complete, for the Delaware, for $264.

Three floating beacons are mentioned as in Chesapeake Bay in 1792, on Willoughby Spit, the Horseshoe, and the Middle Ground; an act of 1797 provides for sixteen buoys in or near Boston Harbor. The early buoys were either solid wooden spars or they were built up, barrel fashion, of wooden staves. A letter from Boston in 1808 describes buoys as made of staves, five feet long, four feet in diameter at the large head, and one and one half feet at small end, hooped with eight hoops of iron, strapped with iron, with chain fastened at small end, and moored with twenty-five hundred pound sinker. About 1820 spar buoys were substituted for these barrel buoys, as experience proved them more reliable, and they were much less expensive. In 1843 the buoys on the Maine and Massachusetts coasts are described as being all spar buoys except two can buoys, and it is stated that they were painted black, white, or red without any system. Congress by law in 1850 prescribed that buoys should be colored and numbered so that in entering from seaward red buoys with even numbers should be on the starboard or right hand; black buoys with odd numbers on the port or left hand; buoys with red and black horizontal stripes should indicate shoals with channels on either side; and buoys in channel ways should be colored with black and white perpendicular stripes. An appropriation in 1850 provided for an iron can buoy at Little Egg Harbor, New Jersey, and it is probable that iron buoys were introduced at about this time. In 1851 buoy boats are mentioned, and were probably in use to some extent in exposed positions; they were stoutly timbered boats about twenty feet long and seven feet beam, with mast twelve feet high carrying some sort of day mark. Buoys now in use are nun or can buoys of iron, or wooden spars. The iron buoys are placed at the more important points on account of their superior visibility, and the portion above water is made in two different shapes further to distinguish the position of the buoy; red nun buoys are conical in shape with pointed tops; and black can buoys are cylinder shaped with flat tops. By this system the position of the buoy with respect to the channel can be determined even if the color or number cannot be distinguished. In 1900 the tall-type can and nun buoys were introduced for use in important positions, the buoys being designed to stand much higher out of the water and thus furnish a mark easier to pick up, as well as much better resisting displacement by running ice. The metal buoys are built of iron or steel



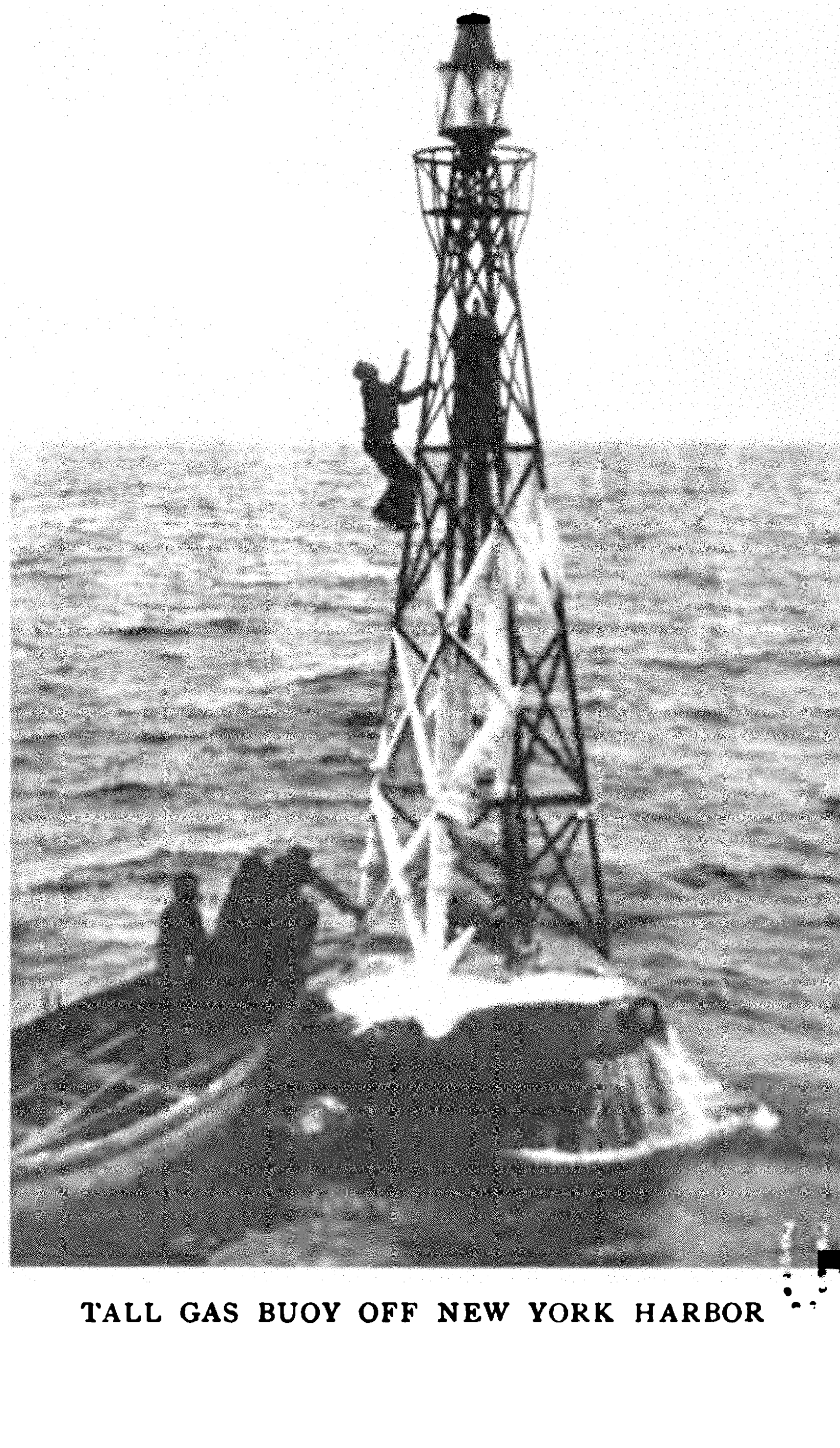
A BELL BUOY TAKEN ON BOARD A LIGHTHOUSE TENDER

Shows marine growth and the necessity for periodic cleaning and painting of buoys

plates, and the interior is divided into compartments to prevent sinking if damaged.

For warning in fog or mist, buoys are fitted with bells, whistles, and submarine bells, all actuated by the motion of the sea. Bell buoys were introduced about 1855; bell boats appear to have been used earlier than that, but were found expensive and not satisfactory. The present type of bell buoy is very sensitive to slight motion of the waves, but the sound may be faint or absent in unusual calms. Whistling buoys were invented in the United States by J. M. Courtenay and first used in 1876. This buoy has a long tube open at the lower end; a supply of air is drawn into this tube when the buoy rises with the motion of the sea, and this air is compressed and expelled through the whistle as the buoy falls in the waves, producing a peculiar mournful note; it is an efficient signal in outside waters where there is sufficient swell or sea.

Gas-lighted buoys are a recent development and have proved a most valuable addition to the aids to navigation. The first in this country was an oil gas buoy placed for trial near Scotland Lightship in 1881. This buoy was stationed in 1882 to mark the wreck of the Nankin in lower New York Bay, and was taken over by the Lighthouse Board in 1884. The use of this type of gas buoy was extended and many are in service at present. The body of the buoy itself serves as a gas tank and the gas is compressed therein under about twelve atmospheres pressure. From 1888 to 1903 an attempt was made to maintain buoys lighted by electricity to mark the Gedney Channel into New York Harbor. These buoys were connected by cable and supplied by current from a special power station at Sandy Hook, but great difficulty was experienced in maintaining the cable connection, the plant was expensive, and the system was replaced with gas buoys. In 1904 tests were made of an acetylene gas buoy, in which the gas was generated in the buoy body by the action of water on calcium carbide. Two buoys of this type were placed in service in 1906, and later others of this and another design; but the use of buoys of the self-generating type has now been suspended owing to various difficulties and danger in operation. In 1910 a buoy operated by compressed acetylene gas dissolved in acetone was placed at Ambrose Channel Entrance, New York. This buoy is arranged with pockets to carry gas tanks of convenient



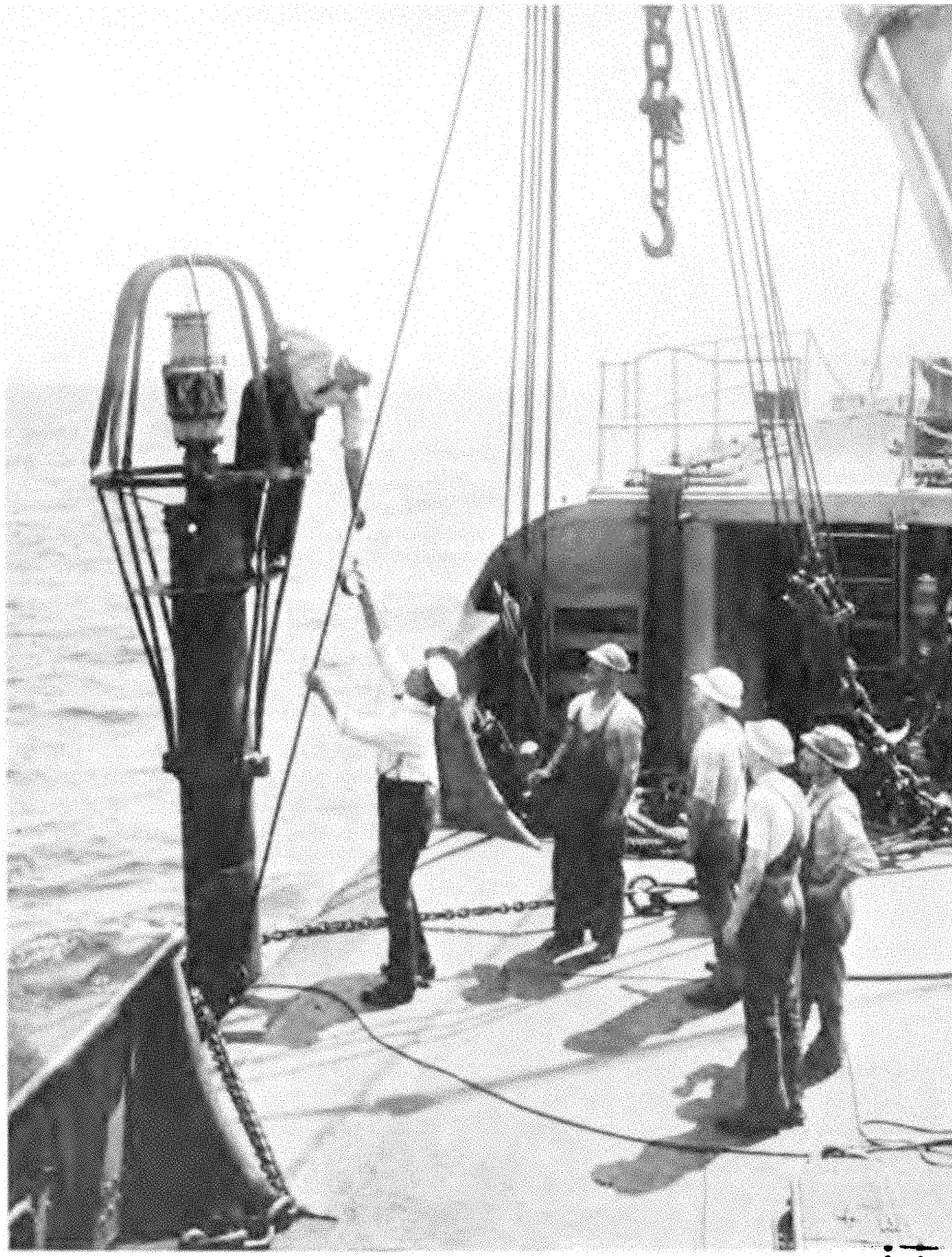
TALL GAS BUOY OFF NEW YORK HARBOR

size. A number of buoys of this type have been installed and are now in use.

In all gas buoys the gas is piped from the container in the buoy body to the lantern mounted above the buoy. They are operated as flashing or occulting lights in order both to prolong the supply of gas and to give the buoy a distinctive characteristic. The flash is obtained by a diaphragm and valve mechanism operated automatically by the gas pressure itself, by which at intervals a definite quantity of gas goes from a flashing chamber to the burner where it is ignited by a small pilot flame which burns continuously. Incandescent mantles are sometimes used over the burners of oil gas buoys, in order to get a more satisfactory candle-power, but they are subject to the difficulty of breakage of the frail mantles in such service, and the inconvenience of renewing them. Some of the gas buoys are provided also with bell or whistle, or with both whistle and submarine bell.

The largest gas buoys in service are the two off Ambrose Channel and Point Judith. Each is nearly sixty feet long, weighs over seventeen tons, and shows a light twenty-eight feet above the water, occulting every ten seconds; the buoy off Ambrose Channel has a light of seven hundred candle-power visible eleven miles. The Peaked Hill Bar gas and whistle buoy off Cape Cod, on one charge of compressed acetylene gas burned from April 22, 1913, to October 8, 1914,—very nearly one and one-half years,—without being extinguished during this period. It has a light of three hundred and ninety candle-power, and is reported to have been seen twenty miles.

All the buoys must be relieved at least once a year, freshly painted buoys taking the place of the old, and the moorings must be renewed. To do this for the seventy-six hundred buoys of the Service and keep them in good order and on their proper positions, and replace those damaged or sunk or dragged or blown from their stations, is a heavy work and is one of the principal duties of the lighthouse tenders, and in this way forms one of the heavy expenses of lighthouse work. In Northern waters, where there is much ice, some of the gas buoys must be removed in winter and replaced by spar buoys over which the ice may pass without serious damage to the buoy. In channels of special importance, however, such as those leading into New York, the gas buoys are maintained on station throughout the winter, and with severe ice

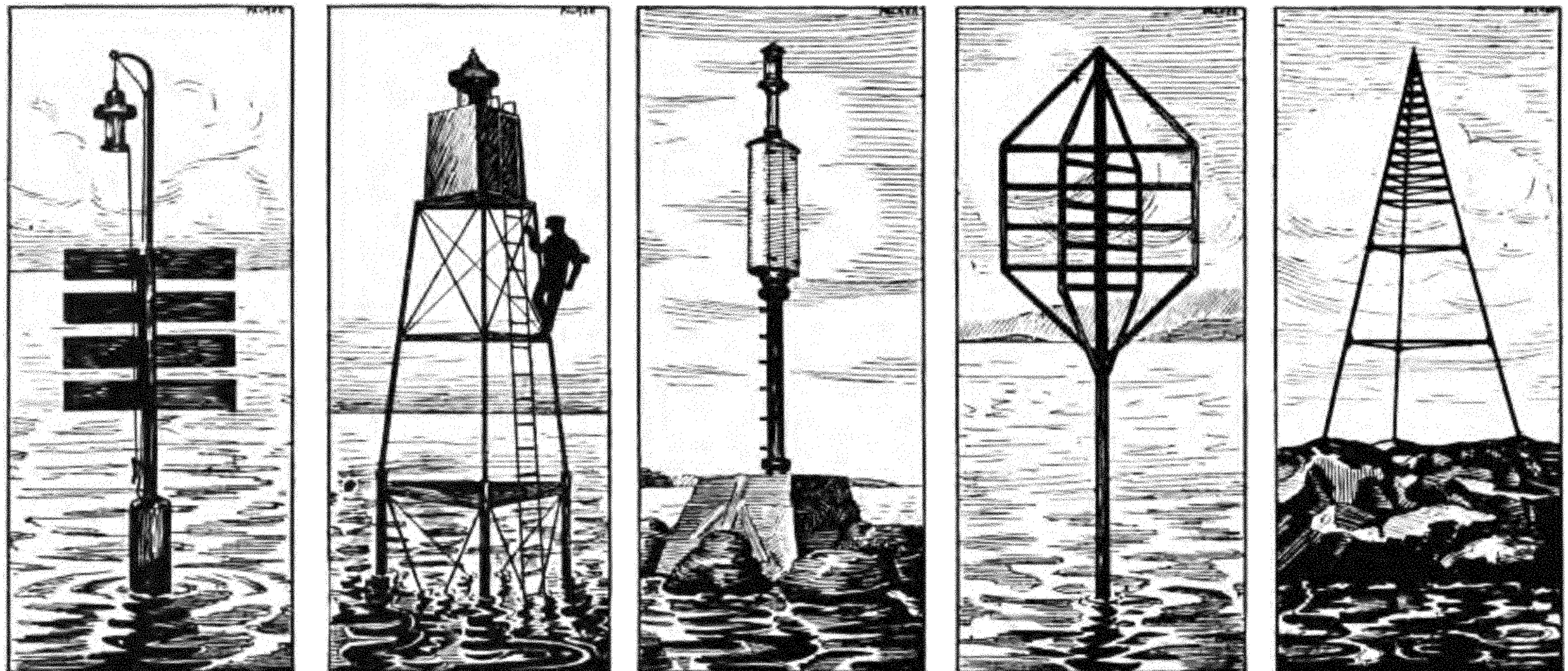


GAS BUOY BEING CHARGED WITH GAS

conditions to do this requires strenuous and dangerous work on the part of the tenders. The spray freezes to bell buoys sometimes until the weight of the ice overturns them. In severe winters there have been occasions when moving fields of ice have carried away every iron buoy in a harbor. There is often a heavy marine growth on the buoys, which if not removed seriously lessens their usefulness: an astonishing mass of seaweed and barnacles sometimes comes up with the buoy and chain. This mass tends to make it float low in the water, or causes a whistling buoy to be so logy it will scarcely move. A peck of oysters has been brought up on a single sinker. A considerable amount of mooring-gear is unavoidably lost each year. While a large part of this is later recovered, yet for use in mooring buoys and light vessels there must be purchased annually about fifteen thousand fathoms of chain, a length equal to seventeen statute miles.

Two buoys from the Atlantic Coast of the United States have been picked up on the coast of Ireland, having drifted about three thousand miles; one of these was found there six weeks after it was carried away from its station in New York Harbor. Another buoy which went adrift from its station off San Francisco Bay was picked up seventeen months later off the coast of Maui, Hawaii, nineteen hundred miles away. Recently a hurricane broke from its station the gas buoy near Rebecca Shoal, Florida Reefs, and for eighteen days this buoy, still burning, was carried by currents and winds in an erratic course about the reefs and was reported in widely different localities.

A gas buoy disappeared from its station off the Southwest Pass of the Mississippi during a hurricane in 1915, and was not seen for two months, when it came to the surface again one hundred yards from the lightship. A few years ago an iron buoy was missed from its station on the coast of Maine. Later a surveying party, dragging for rocks, reported the finding of a sharp pinnacle in deep water in the vicinity, and a buoy was placed to mark this pinnacle. After a while this buoy failed to watch properly and the tender was sent to relieve it. As the buoy was hauled up, the mate sang out, "The ledge is coming too, sir." And the supposed pinnacle rock did come up, for it was the long-lost iron buoy which had been dragged by the ice into deep water and held submerged by its



Sand Shoal Inlet Light, Va. — Petaluma Creek Light, Cal. — Larchmont Breakwater Light, N.Y. — Berkeley Reef Beacon, Cal. — Duck Rock Tripod, Me.

TYPES OF DAY MARKS AND SMALL LIGHTS IN SHELTERED WATERS

sinker, and which the mooring-chain of the second buoy had fouled.

All the lighted aids to navigation, lighthouses, lightships, and buoys, also serve as guiding marks by day, and for this reason are given distinctive shapes and colors so they may be recognized with certainty. In addition there are a large number of unlighted beacons or day marks; these may be iron spindles set in a sunken ledge, with a cage at the top, or wooden or concrete piles, with slats or targets, or structures framed with iron pipe, or a single pipe, or simple stakes, or even bushes stuck in the edge of the channel. One beacon is mentioned in the act ceding the lighthouses by Massachusetts, and contracts were made in 1791 for "stakage" of inland sounds and rivers of the Middle Atlantic Coast, where numerous aids of this character are still required.

XIV

FOG SIGNALS

The most powerful coast lights may be rendered of little or no use to the mariner by thick fog or rain; they fail to serve him at the very time assistance is most needed. To aid vessels under such conditions fog signals have been established only in recent times. Coast fog signals, except for occasional bells and guns, were practically unknown until the middle of the nineteenth century, and their development has been much behind that of lighthouse illumination, not only in point of time, but also in present effectiveness. This is due to dependence thus far for fog-signal purposes on the transmission of sound, so much less efficient and certain than the transmission of light in clear weather.

The conditions as to fog differ greatly on various parts of the coasts of the United States. The North Atlantic Coast and portions of the Pacific and Alaska Coasts are extremely foggy, while on the South Atlantic and Gulf Coasts and in Porto Rico and the Hawaiian Islands there is little fog. The average number of hours of fog in a year decreases from 874 hours on the coast of Maine to 165 hours on the South Atlantic and Gulf Coasts. There is a moderate amount of fog on the Great Lakes, the average of 116 stations being 332 hours a year. The highest record of fog for a year at any station is 2734 hours (thirty-one per cent of the total time) at Seguin Light Station, Maine, and there is a record of 2221 hours of fog in a year at San Francisco Lightship. At Moose Peak Light, on the coast of Maine, there were seven and one-half days of continuous fog in July, 1916, requiring the operation of the fog signal from 2.15 A.M. on July 20 to 3.30 P.M. on July 27, or 181 hours without cessation.

The distribution of fog signals along the coasts has of course conformed to the needs imposed by these fog conditions. On the Atlantic Coast from Cape Lookout northward there are 629 fog signals of all kinds, including sounding buoys, while on more than double this extent of coast south of Cape Lookout and along the Gulf Coast there are 107 fog signals. If sounding buoys are not included, there are along the Atlantic Coast from Cape Lookout northward 334 fog signals, or considerably more than half of the total of 586 maintained by the United States, while there are 78 on the Pacific Coast and 131 on the Great Lakes. There are no fog signals in Porto Rico or Hawaii, where fog is rare.

The first fog signal in the United States was the cannon placed at Boston Light in 1719, and fired to answer the signals of ships in thick weather. Fog bells at lighthouses in this country are first mentioned about 1820, in which year an appropriation was made "for placing a bell near the lighthouse on West Quoddy Head," Maine. There is mention of a fog bell in connection with the construction of Isles of Shoals Light, built in 1821. An act of Congress of 1827 provided that "the keeper of Quoddy Head Lighthouse, in the State of Maine, shall be allowed, in addition to his present salary, the sum of sixty dollars annually, for ringing the bell connected with said lighthouse, from the time he commenced ringing said bell." In 1838 a fog bell operated by the tide was installed at Whitehead Light Station, Maine; a float through tidal motion wound up a weight which drove the striking mechanism. This "perpetual fog bell" was in service several years. In 1843 there were only four fog bells on the coast of Maine. The first bells were small and rung by hand. Fog bells rung mechanically were introduced about 1860, being operated first by small engines, and later by a striking mechanism governed by clockwork. Many bells are now in use for harbors and inside waters. The smaller bells are rung by hand, and the larger, up to four thousand pounds, have hammers actuated by a falling weight, and governed by clockwork, the strokes being timed according to a definite characteristic.

In 1851 an experimental installation was made, at Beavertail Lighthouse, Rhode Island, of an air whistle and also of an air trumpet, both operated by compressed air, the compressor being driven by horse-power. In the air trumpet the sound was produced by the vibrations of a steel tongue or reed set in motion by a blast of air from the air reservoir; the reed is enclosed in a box attached to a large horn. Both air whistles and reed horns are still in use to a limited extent, the latter at inside stations only. But the horse did not long supply the power; the last mention of horse-power is in 1852, for the air whistles at Beavertail and at Little Gull Island, New York. At a later period hot-air engines were used to drive the air compressors, and these have now been displaced by internal combustion kerosene or gasoline engines.

The use of steam whistles as fog signals was investigated in 1855. A five-inch whistle was placed at Beavertail, Rhode Island, in 1857, but this was not very successful and was replaced by a reed horn and hot-air engine about nine years later. The first stations regularly equipped with steam whistles were West Quoddy Head, Maine, and Cape Elizabeth, Maine, in 1869, the plant consisting of a boiler and an eight- or ten-inch locomotive type whistle, giving each minute a blast of eight seconds duration. This was the most powerful type of fog signal devised to that time, and in point of volume and carrying power is still considered very efficient. Many steam whistles, up to twelve inches in diameter, are still in use as fog signals in this country both at lighthouses and on lightships, though not used in foreign lighthouse services. Because of the time required to place the signal in operation and the expense of maintenance, a number of the steam fog signals have been replaced by other apparatus.

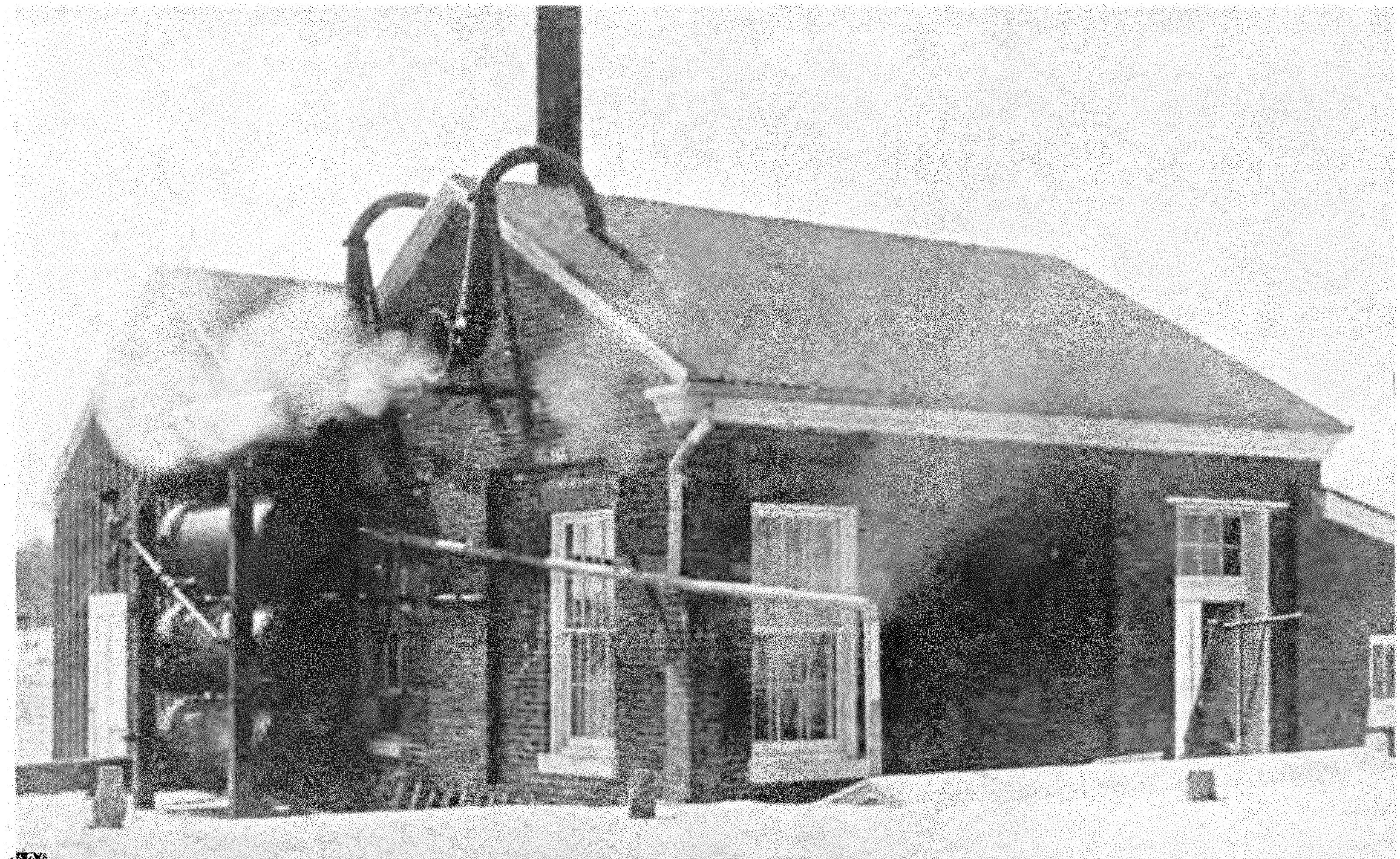
After experiments in 1867, the first siren fog signal was installed at Sandy Hook East Beacon in 1868.

The siren as a fog signal was first developed in the United States. Originally this instrument consisted of a fixed disk with radial slits, back of which was a revolving plate with similar slits, and a trumpet at the outer end; steam at about seventy pounds pressure was driven through the apparatus and the escape and interruption of the jets through the slits set up a vibration of the air and produced the note. In the form of siren now used, a hollow cylinder or rotor with peripheral slots is revolved in a casing with similar slots, leading to a horn or trumpet. The rotor is revolved either automatically by the steam or air, or by a separate mechanism. Steam is still used at a few places, but sirens are now generally sounded by compressed air. The air compressors are driven by internal-combustion engines. The siren has a distinctive note, and a fog signal of this class can be started very quickly on the approach of fog. The development of the internal-combustion engine has greatly facilitated the introduction of more efficient fog signals. At a few stations compressed air is used with whistles.

Diaphones have been installed at several fog-signal stations in this country. This type of signal has been used extensively in Canada, and is an instrument similar to the siren but having a reciprocating piston instead of a rotor. There are several sirenos in operation as fog signals; this is a small siren in which the air is supplied by a blower driven by electricity. An acetylene fog gun has been installed experimentally. Experimental tests are in progress of the possible use of radio signals as fog signals, and of a vessel obtaining its bearings by radio.

There are in service a number of fog bells and sirens which are operated and controlled electrically from a distance. This permits the placing of the actual fog signal in an exposed position, as at the end of a breakwater, and its control by the keeper at his station, in some cases one or two miles distant. Fog signals on buoys, bells, whistles and submarine bells, all operated by the movement of the buoy due to the sea, have already been mentioned. Echo boards are placed along some of the rivers in California, where fog is prevalent. These permit a steamer in passing to get its position by an echo from its whistle, as is frequently done with natural cliffs where the shores are favorable.

Fog signals, excepting those on buoys and a few



CAPE HENRY FOG SIGNAL, VIRGINIA

This fog signal is an air siren driven by oil engines. The trumpets are curved downward to prevent sand drifting into the sirens

hand bells, are through suitable controlling mechanism operated to sound a characteristic signal so that they may be distinguished, there being a succession of blasts or groups of blasts or strokes at regular time intervals, which are known for each station, just as a distinguishing characteristic is given to a light. Even adjacent buoys are differentiated by the alternate use of whistles and bells on the buoys and by variation of tone.

A first-class fog-signal station requires powerful and expensive machinery and skilled attendance. Such a station may have engines of twenty horsepower, and the signal may consume one hundred cubic feet of free air per minute. To guard against the possibility of breakdown the entire plant is in duplicate. While aerial fog signals furnish a very valuable aid to navigation under weather conditions when assistance is most needed, yet they are subject to a number of aberrations so that they cannot be implicitly relied upon. A signal is sometimes lost at much less than its normal range, and not infrequently a signal may be lost and at a greater distance again heard distinctly. These phenomena are associated with the refraction and reflection of sound waves.

Sound travels faster with the wind than against it; while the direct effect is small, as the velocity of the wind is but a small percentage of that of sound, the differential effect may be important, as the velocity of the wind ordinarily increases considerably with altitude above the earth. In such case the sound waves moving against the wind will be deflected up, over the head of the observer, and moving with the wind will be deflected down towards the earth. If the surface and higher winds are in different or opposite directions, the effects become more complex. Sound also travels faster in a heated atmosphere than in a cooler one, and therefore when the strata of air near the earth's surface are more heated than those above there will be a tendency to tilt the sound waves upward.

Submarine bells were first regularly employed as fog signals in the United States in 1906. The bell is suspended in the water from a light-vessel to a depth of twenty-five to thirty feet and is operated by compressed air, or the bell is mounted on a tripod on the bottom and worked by electric power transmitted from the shore through a cable, or it is suspended from a buoy and actuated by the motion of the sea, which moves a vane and winds a spring. Sound from submarine bells is transmitted through the water more uniformly and effectively than it is through the air from an aerial signal. The efficient use of submarine bells requires that vessels be equipped with suitable receiving apparatus attached to the hull on each bow and telephonically connected with the wheel-house; by comparing the loudness on the two sides the direction of the signal may be obtained. Submarine bells have been heard through the water at distances of fifteen miles and more. Except those on buoys, the submarine bells sound a definite characteristic, — a given number of strokes repeated at fixed time intervals, — so that the particular bell that is heard may be known with certainty.

Keepers of fog-signal stations are required to maintain a continuous watch, night and day, as the signal must be started promptly on the approach of fog. In order to keep a record of the sounding of the fog signal, recording gauges are now installed at the more important stations.

There is sometimes an unfortunate conflict of interest between the need of a loud and distinctive sound to aid the mariner in a fog and the quiet and comfort of seashore residents in whose midst the fog-signal station may be located. Even the mournful note of the whistling buoy may bring complaints from the near-by shore residents. In some cases it has been possible to lessen the difficulty by installing a deflector on the land side of a shore fog signal. Regarding protests against a disturbing fog signal a newspaper writer recently put it this way: —

Russian Hill should put to sea of a foggy night in a fisherman's boat or a three-master. It should see the skipper at the helm, holding his boat to an uncertain course through the blackness of space, while the wet sails drip in endless patter on the deck. There would be minutes of suspense and apprehension; then out of the night would come the siren, so friendly and intimate and reassuring — almost beautiful. Then Russian Hill could go back and sleep in peace; the siren would have a sweeter tone ever after.

Fog signals attached to buoys have been described under that head; they are an important addition to the available means of giving warning in fog, though unfortunately lacking in desirable uniformity of effectiveness.

XV

THE LIGHT-KEEPERS

Although the pay is small and the life often lonely, the work of the Lighthouse Service attracts as a rule an excellent class of faithful men, willing to take large risks in doing their duty, and in helping others in distress.

The entire personnel of the Lighthouse Service is under the civil service rules, and appointments and promotions are on a strictly merit system. This is of great importance for the maintenance of good organization and rigid discipline in a purely technical service, on the efficient conduct of which is directly dependent the safety of all the lives and all the property carried on the seas and navigable waters of this country. The old reports show that, unfortunately, this was not always the case. For a long time the light-keepers were nominated by the collectors of customs. A report in 1843 says, "another, and by no means the lesser evil, is the appointment or dismissal of keepers on the grounds of political faith or heresy"; and in 1873 it is stated that efficient and faithful light-keepers have in many cases been changed by collectors of customs for no other reason than to give place to some political favorite. The Lighthouse Board protested against this, saying that "on the intelligence, fidelity, and experience of the keepers depend the thousands of lives and millions of property which are nightly approaching, leaving, or sailing along our eight thousand miles of sea, gulf, and lake coast." On May 6, 1896, President Cleveland placed the Lighthouse Service within the classified civil service. No part of the entire government is now conducted more strictly on a merit system.

The average pay of the light-keepers was fixed by law in 1867 at not to exceed six hundred dollars, and the law has not been changed since. The keepers are provided at most stations with living quarters for themselves and families, and they receive a small subsistence allowance, and are provided with fuel and some other things, depending on the location of the station. The maximum pay at difficult offshore stations is about one thousand dollars a year. For the care of a post light along the rivers eight to ten dollars a month is paid; but this requires only a small amount of work each day.

At present there is no provision in this country for the retirement of light-keepers on account of age, long service, or disability resulting from their work. A committee of the Senate, in favorably reporting a bill for this purpose in 1916, stated that "the service of the light-keeper is one of great isolation for themselves and for their families, and in many instances of a most hazardous character. It calls for the highest degree of faithfulness and attention, and not only involves the giving of warnings by lights and other aids to navigation, but oftentimes involves the saving of lives and wrecks of ships."

In 1916 there were in the entire Lighthouse Service ninety-two persons over seventy years of age, and twenty-four persons who had served over forty years.

A high degree of discipline is maintained, as is essential in a service so directly charged with safeguarding human life. While devotion to duty is commended and rewarded, any infraction of the regulations is promptly punished.

At all important light-stations there are from two to five keepers, who maintain a continuous watch of the light at night and of the approach of fog at all times. Alarm bells are now being installed at stations where there is but a single keeper; a thermostat or other device is placed over the lamp and so adjusted that if the lamp burns too high or too low the keeper is notified by the bell ringing. Keepers are granted leave under suitable arrangements, those at isolated stations where families cannot live being allowed seventy-two days a year. Many provisions are made for their welfare: those injured in the Service are entitled to compensation; keepers can receive medical treatment from the Public Health Service; remote stations are supplied with medicine chests and medical handbooks, and there is sanitary inspection of stations; isolated stations are furnished libraries, and the endeavor is made to transfer keepers with children of school age to stations near school facilities; keepers with a high record of efficiency are entitled to wear an efficiency star, and the station in each district with the best record to fly an efficiency pennant.

The following letters show something of the life of a lightkeeper a century ago.

The keeper of Gayhead lighthouse in 1805 made this petition for an increase of salary: —

GAYHEAD *October 25, 1805*

SIR: Clay and Oker of different colours from which this place derived its name ascend in a Sheet of wind pened by the high Clifts and catch on the light House Glass, which often requires cleaning on the outside — tedious service in cold weather, and additional to what is necessary in any other part of the Massachusetts.

The Spring of water in the edge of the Clift is not sufficient. I have carted almost the whole of the water used in my family during the last Summer and until this Month commenced, from nearly one mile distant.

These Impediments were neither known nor under Consideration at the time of fixing my Salary.

I humbly pray you to think of me, and (if it shall be consistent with your wisdom) increase my Salary.

And in duty bound I am your's to Command

EBENEZER SKIFF,
Keeper of Gayhead Light House.

ALBERT GALLATIN ESQUIRE
Secretary of the Treasury.

In consequence of this letter President Jefferson approved of increasing his salary by fifty dollars to two hundred and fifty dollars per annum.

Ten years later the same Ebenezer Skiff petitions for an increase of salary on these grounds, some of which have a familiar ring, although the spelling has somewhat changed.

To Samuel Smith Esquire Commissioner of the Revenue

SIR: Clay ochre and earth of various colours from which this place derived its name ascend in a sheet of wind from the high clifts and catch on the glass of the light-house, which glass requires to be often cleaned on the outside:—Tedious service in cold weather and not so commonly necessary in any other place in the Massachusetts, nor in any of the New England States.

The Spring of water in the edge of the clifts, by means of their late caving has become useless. I cart the water used in my family more than half a mile, necessarily keep a draught horse and carriage for that purpose and frequently have to travel in a hilly common extending five miles to find the horse. Truely I catch some rain water and it is as true that many times I empty it coloured as red as blood with oker blown from the clifts.

My firewood is brought from the Mainland and, there being neither harbor nor wharf here, is more expensive than in seaports. Keepers in some places get their wood with little cost; but here the native Indians watch the shores to take all drifts.

The lately constructed light with a stone revolves by a clock which is to be stopped every time anything is done to the fire, which, in cold weather, must be kindled the sun an hour high, or sooner, and recruited until eleven o'clock, or after, when I have to trim the lamps and wind up the weights of the clock and can go into bed at nearly midnight until which a fire is kept in the dwelling-house consuming more wood than when I tended the former light.

It is about eight miles from here to a gristmill and in the common way of passing are creeks not fordable at all seasons.

The business respecting the light is, mostly, done by me in person, yet I occasionally leave home to procure wood and many other necessaries; previous to which I have to agree with and instruct some trusty white person to tend the light in my absence: If my salary would admit I would hire some person to live constantly with me lest I should be sick — I have no neighbors here but Indians or people of colour.

Tending the former light might be deemed a simple business if compar'd with the tendance of the present complicated works and machinery, which requires much time care &c.

Almost any man or lad under my wife's care could light the former lamp and do the business a short time: but the case is not so now.

When I hire an Indian to work I usually give him a dollar per day when the days are long and seventy-five cents a day when the days are short and give him three meals: Now supposing the meals worth twenty-five cents each they amount to seventy-five cents which is seven cents more than the wages for my service both a day and night (while I board myself) only sixty-eight cents, computing my Salary (as it now is) at two hundred and fifty dollars a year and the year to consist of three hundred and sixty-five days.

I have the use of two acres of land intersected with buildings, the use of a small dwelling-house and a small barn.

I refer you to Capt. Winslow Lewis Superintendent of the Lamps &c. for the truth respecting all of the above particulars that he is acquainted with — and before I forward this Application shall lay before the Selectmen of Chilmark, which adjoins Gay Head, for their inspection; And in duty bound I humbly pray you to take this Matter into your wise consideration and afford me relief by granting an increase to my Salary.

Gay Head 2nd November 1815.

I am sir with all possible respect yours to command

EBENEZER SKIFF.

As a result of this letter, President Madison approved of a further increase of fifty dollars in his salary.

Robert Louis Stevenson, in sketching the life of his grandfather Robert Stevenson, the distinguished

Scotch lighthouse engineer, gives some pen-pictures of Scotch light-keepers. These are doubtless tinged somewhat by national characteristics, but human nature is much the same the world over; incidentally they show the care for detail of one of the world's great engineers: —

The lightkeeper occupies a position apart among men. In sea-towers the complement has always been three since the deplorable business in the Eddystone(?), when one keeper died, and the survivor, signaling in vain for relief, was compelled to live for days with the dead body. These usually pass their time by the pleasant human expedient of quarreling; and sometimes, I am assured, not one of the three is on speaking terms with any other. On shore stations, which on the Scottish coast are sometimes hardly less isolated, the usual number is two, a principal and an assistant. The principal is dissatisfied with the assistant, or perhaps the assistant keeps pigeons, and the principal wants the water from the roof. Their wives and families are with them, living cheek by jowl. The children quarrel; Jockie hits Jimsie in the eye, and the mothers make haste to mingle in the dissension. Perhaps there is trouble about a broken dish; perhaps Mrs. Assistant is more highly born than Mrs. Principal and gives herself airs; and the men are drawn in and the servants presently follow. "Church privileges have been denied the keeper's and the assistant's servants," I read in one case, and the eminently Scots periphrasis means neither more nor less than excommunication, "on account of the discordant and quarrelsome state of the families. The cause, when inquired into, proves to be *tittle-tattle* on both sides."

I find in my grandfather's diary the following pregnant entry: "The Lightkeepers, agreeing ill, keep one another to their duty."

I must tell here an anecdote that illustrates the difficulties of inspection. In the days of my uncle David and my father there was a station which they regarded with jealousy. The two engineers compared notes and were agreed. The tower was always clean, but seemed always to bear traces of a hasty cleansing, as though the keepers had been suddenly forwarned. On inquiry, it proved that such was the case, and that a wandering fiddler was the unfailing harbinger of the engineer. At last my father was storm-stayed one Sunday in a port at the other side of the island. The visit was quite overdue, and as he walked across upon the Monday morning he promised himself that he should at last take the keepers unprepared. They were both waiting for him in uniform at the gate; the fiddler had been there on Saturday!

From Robert Stevenson's diary:—

I hold it as a fixed maxim that, when a man or a family put on a slovenly appearance in their houses, stairs, and lanterns, I always find their reflectors, burners, windows, and light in general, ill attended to; and, therefore, I must insist on cleanliness throughout.

Robert Stevenson sends word to one of the light-keepers: —

Let him attend his duty to the Lighthouse and his family concerns, and give less heed to Tale-bearers.

To this the comment is added: —

There is the great word out. Tales and Tale-bearing, always with the emphatic capitals, run continually in his correspondence.

From Robert Stevenson's diary: —

Object to the keeper keeping a Bull-Terrier dog of ferocious appearance. It is dangerous, as we land at all times of the night. . . . The furniture of both houses wants much rubbing. Mrs. ——'s carpets are absurd beyond anything I have seen.

A keeper of Skerryvore light in Scotland thus describes life on the rock: —

I have been taught in the school of loneliness, I have known the distracted feeling of leaving a loving wife and romping child behind, have known what a "relief" means on one of the wildest wave-swept rocks, in being ofttimes trailed through the surf, and washed off the landing stage, have known what it is to live in a beacon, where each compartment was in absolute darkness (except for the use of artificial light) during sunny hours for those on shore, have been closed up for weeks hearing nothing but the incessant thunder of the Atlantic's mighty waves crash against and over our bottle-like edifice, and the screams of the sea-gulls, as if taunting us in our lonely plight.

Many facts or incidents, unusual or characteristic, arise in such a service.

The keeper of a lighthouse on Buzzard's Bay asked the inspector to use felt slippers over his shoes in going up into the tower, to keep the stairs clean.

The keeper of an island light station on the coast of Maine had seventeen children, many born at the island, and all well reared; a few years ago he with his family was transferred to another station. Another keeper raised a family of twelve children at Isle Royal Lighthouse, on a lonely rock on the north side of Lake Superior. This man had helped build the lighthouse and applied for the position of keeper, being then a bachelor. The inspector told him he wanted a married man for keeper, so he went to the mainland and was promptly married.

The keeper of a minor light on the upper Hudson River died recently at the age of ninety-three years, having tended this light for fifty-two years. His son had had an ambition to succeed the father in the care of this light, and he did so at the age of sixty-five.

The keeper of some river lights in South Carolina reported a few years ago that when his assistant was ascending a beacon and "nearly at the top he heard just above his head a terrific buzzing sound that caused him to hurriedly descend. Peering around for the cause, he was amazed to discover a huge rattlesnake that had coiled itself just under the light box. Arming himself with an oar he succeeded in making it plunge overboard by thrusts of the oar; when to his amazement, as well as discomfiture, the now thoroughly angered reptile, instead of making off, swam back to the beacon, and proceeded to ascend, weaving his body in and out between the steps. Fortunately he managed to give it another well-directed blow with the oar, which caused it to drop back into the water and float off apparently dying." It is said to be not an infrequent occurrence to find moccasins, and sometimes rattlesnakes, on post lights which stand in the water, especially on the St. Johns River.

A light-keeper in the Hawaiian Islands who had been discharged for inefficiency addressed the inspector thus:—

With blessing and thankful thoughts I dropping this few remarks to you, and given you my farewell thanks and aloha nui. Off cause it is my fault and I can not blame this to no body.

The lighthouse inspector at Staten Island in 1912 received this letter:—

I am writing to you for a position as keeper in a lighthouse anywhere from New York to Portland, Maine. I am the daughter of a barge captain, and know much about the Sound and I also have a pal and we both are willing to do hard work and I know I would enjoy that lonesome life keeping the light a burning. I know how to row and run an engine and steer a boat. . . . I am afraid we will not get this position on account of us being girls but we shall wear trousers instead of skirts. . . . I think that two strong girls like us could manage a lighthouse and keep a good log, and trusting that Uncle Sam will only be kind to us.

The location of the lighthouses and lightships in such prominent positions, and the continuous patrol of the coastal waters maintained by the tenders present frequent opportunity to keepers and crews to give

or summon aid to vessels or persons in distress, and to assist in saving life and property. The fact that the Service is primarily concerned with other duties, and that employees do not receive any additional compensation for this work, makes the risks and hardships voluntarily taken the more commendable. The records of the Service are full of heroic incidents of this character; in 1916 there were reported one hundred and sixty-one cases of the saving of life and property and of acts of heroism by members of the Lighthouse Service.

In 1885 a gold medal was awarded by the Government to the keeper of Cape Elizabeth Light "for signal heroism involving great peril to his life." In a severe gale, with heavy snow and temperature ten degrees below zero, this keeper, much of the time alone, got two men ashore, who were nearly frozen in the rigging of a schooner stranded near the Cape. The keeper working on the rocks at the edge of the surf threw a line across the schooner. In the previous year gold medals were awarded to two persons in the Lighthouse Service for saving lives at the imminent risk of their own.

In October, 1892, the keeper of Pilot Island Lighthouse, between Lake Michigan and Green Bay, rescued the entire crews of two schooners which were driven on the island by gales. The keeper in the dark and storm waded out from the island, picking his way through the surf and along a ledge of rocks which came nearly to the surface close to the wrecks. He made himself heard above the storm and called on the men to jump. They leaped one by one into the water and the keeper seized them as they came to the surface and pulled them on to the ledge where he stood. He carried a woman and then an aged man ashore, with a heavy sea running and difficulty in maintaining a footing.

In 1914 the keeper of Whitefish Point Lighthouse, with the aid of two fishermen, rescued eleven men from a launch which had capsized in Lake Superior.

In February, 1913, the keeper of St. Helena Light, in the Straits of Mackinac, saved the lives of two men who were lost on the ice in a blizzard while attempting to cross the Straits; he went out with a hand sled and brought in the exhausted men.

In 1916 the tender Columbine in the Hawaiian Islands rescued a British bark of four times her size after fifty-six hours of continuous work. "Nothing short of valor, heroism, and determination" enabled the officers and crew of the Columbine to save the imperiled vessel. This action received the commendation of the President.

During the Charleston hurricane of July, 1916, the tender Cypress did courageous work in removing vessels and persons from positions of peril and finally in rescuing twenty-two people from a wrecked collier under conditions requiring the highest courage and seamanship.

In August, 1893, Martins Industry Lightship was driven from the station in a hurricane. The ship lost all her boats and the master had three ribs broken, and the vessel dragged until nearly in the breakers; but the mate worked her back almost exactly to the regular position, using sail power alone.

In 1881 a lighthouse inspector was drowned while attempting to land at Cape Mendocino Light Station, California, and the following year another inspector died of yellow fever at his post of duty, Key West.

There are a number of women light-keepers. One of these, the keeper of Angel Island Light in San Francisco Bay, reported that after the machinery of the fog signal was disabled on July 2, 1906, she "had struck the bell by hand for 20 hours and 35 minutes, until the fog lifted," and that on July 4, when the machinery was further disabled, she "stood all night on the platform outside and struck the bell with a nail hammer with all my might. The fog was dense."

Another woman, keeper of the New Canal Light on Lake Ponchartrain, stuck to her post the night of the great hurricane which passed over New Orleans September 28, 1915. She was alone at the station, and maintained the light by securing the lens and hanging a lantern in the tower, although the storm did great damage around the station.

A widely known woman light-keeper was Ida Lewis, who died several years ago. She lived at Lime Rock Lighthouse, on a ledge in Newport Harbor, for fifty-seven years, her father having been appointed keeper when she was twelve years old. She was keeper of the light for thirty-two years. There are reports of her having rescued thirteen persons from drowning. On one occasion, it is said, she saved three men who had swamped while attempting to pick up a sheep, and then she rescued the sheep also.

The lighthouses and lightships and tenders have often furnished havens of refuge to shipwrecked persons. In June, 1916, one hundred and fifty-five persons from the wrecked steamer Bear were taken aboard Blunts Reef Lightship, California, and cared for until taken off. In 1915 Fenwick Island Lightship took on board thirty-nine shipwrecked men from the steamship Washingtonian. On a number of occasions Columbia River Lightship has furnished a refuge to shipwrecked crews, as it is sometimes safer to reach the lightship than it is to cross the bar. In the Charleston earthquake of 1886 many persons were given shelter on the lighthouse tender Wistaria. Nantucket Lightship has on several occasions cared for the shipwrecked.

In October, 1916, South Pass Lighthouse gave shelter in the rooms of the tower, to seventy-five people throughout the night of the hurricane. At Ocracoke, North Carolina, twenty-seven people took refuge in the light-tower, when their dwellings were destroyed in the storm of September, 1913. The repeated aid of Bolivar Point Lighthouse to the shelterless has been mentioned.

There are many cases of faithful service and brave devotion to duty, some of which have already been recounted. The hurricane of September, 1906, did serious damage to lighthouse property along the Gulf Coast and a number of lives were lost at Sand Island and at Horn Island Light Stations. Twenty-three lights were destroyed by this storm. On October 3 the inspector of the eighth district made this report: —

The employees of the Lighthouse Service have, as was to be expected, maintained its credit. I have heard stories of gallant actions, and I have witnessed the uncomplaining manner in which they and their families have taken their great losses and deprivations, also their cheerfulness in beginning all over again.

The keeper of post lights on the St. Johns River, Florida, after being severely injured, went on with his work, as he tells in this report, in May, 1912: —

I arrived at the light at 9.30 A.M. I took the lamp out, and as I went to blow it out it exploded and knocked me off the light (twenty-two feet), and I did not know anything until 12M. When I came to I found the lamp gone. I crawled back to the boat two hundred and fifty feet, got another lamp and put it on the beacon and lit it. Then came home (eight miles). Injury: broken leg just above the ankle and severe bruised shin and bruised arm and lick on head.

A light-keeper on the Columbia River, Oregon, has taken only two days' leave in twenty-three years, and one of these two days was for the purpose of being married.

At Brazos River Lighthouse, during the storm of August, 1915, when the vibration of the tower threw the mercury out of the trough and put the clockwork out of order, the keepers maintained the characteristic of the light by hand, and this has been done on several occasions at other light stations.

The keeper of a lighthouse on the Hudson River a few years ago, when a bolt of lightning struck the tower, was knocked out of his chair and his side temporarily paralyzed, but he remained on duty until daybreak.

On the Delaware River is a light-keeper who is seventy-two years of age, and who has been in the Lighthouse Service over forty years. He has had charge of a range light during the past nine years and in that time has never been absent from the station a night or a part of a night; he has used the same lamp chimney on the service lamp every night for the past five years.

An Indian keeper of a post light on the Upper Mississippi always brings his entire outfit in a box whenever the tender comes; on a recent supply trip he refused to take the customary allowance of oil, as he said he had enough for the rest of the season.

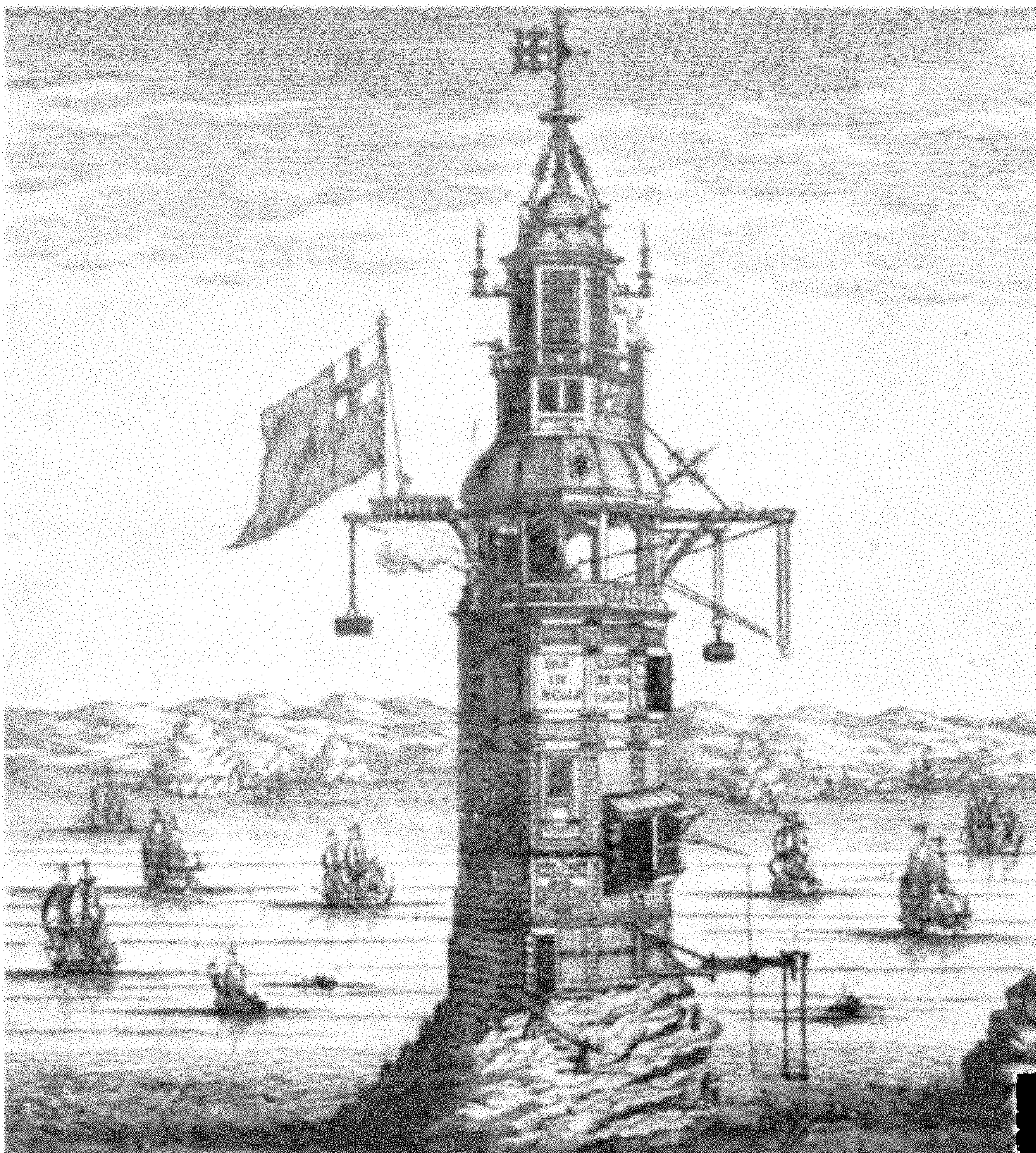
There is a pathetic story of the keeper of Key West Light, who after thirty-five years of service became so absorbed in his duty that he would not leave his task, even for a short vacation, laboring under the delusion that no one but himself could properly care for the light. On a certain very stormy night a ship was wrecked near the fort at Key West. The keeper, then nearly seventy years of age, excited by the storm and the prolonged whistle blasts of the unfortunate vessel, insisted that the wreck was due to the front-range light being out, although it had just been examined by his son and found burning properly. In spite of his feeble condition he procured a lantern and, resisting efforts to detain him, went on foot in the storm to the range light and satisfied himself that it was really burning. He died not long afterward.

Truly, the light-keeper "stands his vigils for all humanity, asking no questions as to the nationality or purpose of him whom he directs to safety."

XVI

LIGHTHOUSES OF OTHER COUNTRIES AND OF ANTIQUITY

The most famous lighthouse is the Eddystone, a sea-swept lighthouse off the south coast of England, fourteen miles from Plymouth. Four successive towers have been built on this ledge, the first three by private enterprise. Each has been a work of great difficulty, as the rock is submerged at high tide and lies in an exposed position. The first tower, built of timber and of rather fantastic design, was completed in 1699, after four years of work; during the first year all that was accomplished was drilling twelve holes in the rock and fastening irons in them. In 1697, during the progress of this work, Winstanley, the designer, and his men were taken off the rock by a French privateer, but the story is that their release was ordered by Louis XIV, who remarked that he was at war with England, but not with humanity. Winstanley was so confident of the lighthouse that he had wished to be in it "in the greatest storm that ever blew under the face of heaven." In November, 1703, he went to the tower with workmen to make some repairs; a great storm on November 26 completely demolished the lighthouse and Winstanley and the keepers and workmen perished. The need of a lighthouse on the Eddystone was soon proved by the wreck of a man-of-war on the rock, and the loss of most of her crew. Another lighthouse of timber and of simple outline was finished in 1709, designed by Rudyerd, and stood until destroyed by fire in 1755. A lightship was placed off the rock the following year, and a tower built entirely of stone was commenced in 1756 and completed in 1759. Smeaton, the engineer, used, for the first time in a lighthouse, dovetailed joints for the stones, which averaged over one ton in weight. Owing to insufficient height and the undermining of the rock another stone tower, of much larger dimensions, was completed in 1882, designed by Sir James N. Douglass. This lighthouse differs in design from preceding sea-swept towers in an important respect: the base is vertical, and above this rises the tower of incurving profile, instead of the curved outline beginning at the foundation as in the Smeaton's Eddystone, the Bell Rock, and other noted lighthouses. The base of the



THE FIRST EDDYSTONE LIGHT, OFF THE SOUTH COAST OF ENGLAND

The Eddystone is the most famous lighthouse in the world. Four towers

present Eddystone is a massive solid cylinder forty-four feet in diameter and twenty-two feet high, and this form has been found effective in breaking up the seas, so that only the spray ascends to the height of the lantern, whereas with the previous Eddystone tower there was a tendency for the waves to run up the surface. The light is one hundred and thirty-three feet above high water, and there are two lenses, one mounted above the other. Smeaton in the tower built in 1759 used for illumination a chandelier carrying twenty-four tallow candles giving an aggregate illumination of sixty-seven candle-power. With the present oil vapor lamp and lenses Eddystone Light has 292,000 candle-power.

Another of the many notable lighthouses of the British Isles is that on Bell Rock, built by Robert Stevenson in the years 1807 to 1811. This dangerous reef, lying off the east coast of Scotland, eighteen miles east of Dundee, in the track of vessels bound to the Firths of Tay and Forth, was long a terror to mariners, and is the subject of Southey's well-known ballad, "The Inchcape Rock." Some of the early lights and buoys in England were maintained by religious men. The ballad is founded on a tradition of such a philanthropy, and Bell Rock derived its name from this buoy.

"No stir in the air, no stir in the sea,
The ship was still as she could be,
Her sails from heaven received no motion,
Her keel was steady in the ocean.

"Without either sign or sound of their shock
The waves flow'd over the Inchcape Rock;
So little they rose, so little they fell,
They did not move the Inchcape Bell.

"The Abbot of Aberbrothok
Had placed that bell on the Inchcape Rock;
On a buoy in the storm it floated and swung,
And over the waves its warning rung.

"When the rock was hid by the surge's swell,
The mariners heard the warning bell;
And then they knew the perilous Rock,
And blest the Abbot of Aberbrothok.

"The sun in heaven was shining gay,
All things were joyful on that day;
The sea-birds scream'd as they wheel'd round,
And there was joyaunce in their sound.

"The buoy of the Inchcape Bell was seen
A darker speck on the ocean green;
Sir Ralph the Rover walk'd his deck,
And he fixed his eye on the darker speck.

"He felt the cheering power of spring,
It made him whistle, it made him sing;
His heart was mirthful to excess,
But the Rover's mirth was wickedness.

"His eye was on the Inchcape float;
Quoth he, 'My men, put out the boat,
And row me to the Inchcape Rock,
And I'll plague the Abbot of Aberbrothok.'

"The boat is lower'd, the boatmen row,
And to the Inchcape Rock they go;
Sir Ralph bent over from the boat,
And he cut the Bell from the Inchcape float.

"Down sunk the Bell with a gurgling sound;
The bubbles rose and burst around;
Quoth Sir Ralph, 'The next who comes to the Rock
Won't bless the Abbot of Aberbrothok.'

"Sir Ralph the Rover sail'd away,
He scour'd the seas for many a day;
And now grown rich with plunder'd store,
He steers his course for Scotland's shore.

"So thick a haze o'erspreads the sky
They cannot see the Sun on high;
The wind hath blown a gale all day,
At evening it hath died away.

"On the deck the Rover takes his stand,
So dark it is they see no land.

Quoth Sir Ralph, 'It will be lighter soon,
For there is the dawn of the rising Moon.'

"'Canst hear,' said one, 'the breakers roar?
For methinks we should be near the shore.'
'Now where we are I cannot tell,
But I wish I could hear the Inchcape Bell.'

"They hear no sound, the swell is strong;
Though the wind hath fallen they drift along,
Till the vessel strikes with a shivering shock,—
'Oh Christ! it is the Inchcape Rock!'

"Sir Ralph the Rover tore his hair;
He curst himself in his despair;
The waves rush in on every side,
The ship is sinking beneath the tide.

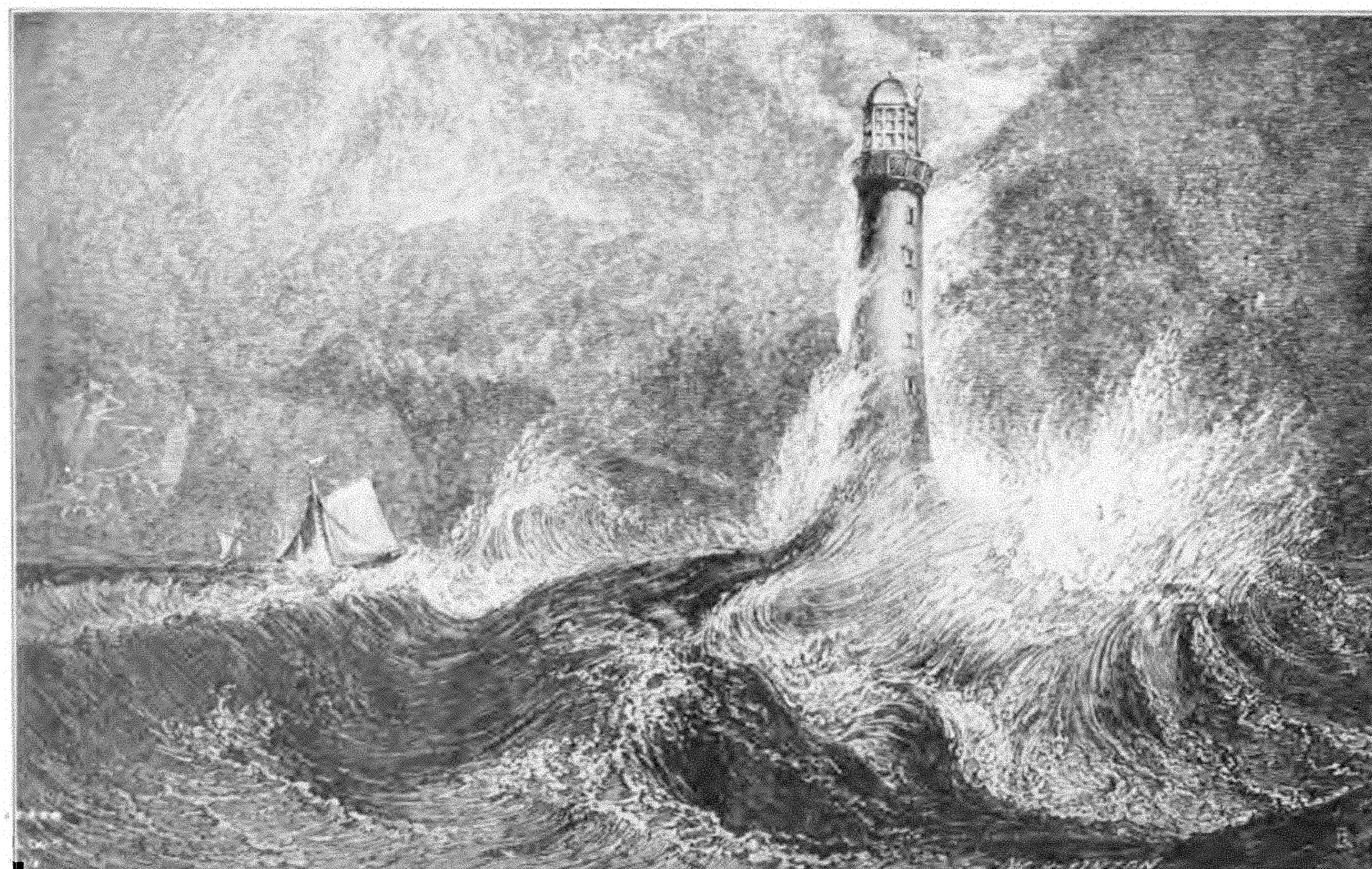
"But even in his dying fear
One dreadful sound could the Rover hear,
A sound as if with the Inchcape Bell,
The Devil below was ringing his knell."

The difficult problem at Bell Rock was to build a tower on a rock ten miles from land, and covered to a depth of twelve feet at every tide; the rock being accessible for but a short time between the ebbing and rising tide. Over a year elapsed from the time excavation commenced on the rock, before the first stone was laid. Many articles from ships were found on the reef, showing the extent to which it had been the cause of wrecks. The tower of cut stone is one hundred feet in height. The drawing by J. M. W. Turner of "Bell Rock Lighthouse during a storm from the northeast," showing the waves running up the whole height of the tower, is said to be no exaggeration of the actual conditions. Sir Walter Scott visited the lighthouse in 1814, and wrote these lines in the visitor's book:—

> "*Pharos loquitur.*—
> Far in the bosom of the deep,
> O'er these wild shelves my watch I keep,
> A ruddy gem of changeful light,
> Bound on the dusky brow of Night,
> The seaman bids my lustre hail,
> And scorns to strike his timorous sail."

Off the middle of the west coast of Scotland, on a rock ten miles from the nearest island, and exposed to the full sweep of the Atlantic, stands the Skerryvore Lighthouse. The Skerryvore Rocks had long been a terror to mariners and had been the scene of many known shipwrecks, and probably were the cause of the disappearance of other vessels of fate unknown. The neighboring islanders made regular trips after storms to the rocks, to gather wreckage. A noble lighthouse, perhaps the finest example for elegance of outline of any extant sea-rock tower, was built here between 1838 and 1844. The Skerryvore tower proper is one hundred and thirty-eight feet high, forty-two feet in diameter at the base and sixteen feet at the top, and contains upwards of forty-three hundred tons of granite. The base is only slightly above high water; the light one hundred and fifty feet above the sea, and it is one of the highest of the wave-swept lighthouses. This tower was designed by Alan Stevenson, like his father, the builder of Bell Rock, a noted lighthouse engineer. Stevenson personally supervised the construction. After the first seasons the men lived in a temporary wooden barrack, a framed pyramidal structure secured to the rock with three enclosed decks at the top, modeled after that used by Robert Stevenson at Bell Rock, and the engineer thus describes experiences there:—

Perched forty feet above the wave-beaten rock, in this singular abode, the writer with a goodly company of thirty men, has spent many a weary day and night at those times when the sea prevented any one going down to the rock, anxiously looking for supplies from



BELL ROCK LIGHTHOUSE, DURING A STORM FROM THE NORTHEAST

From a woodcut after a drawing by J. M. W. Turner

the shore, and earnestly longing for a change of weather favorable to the recommencement of the works. For miles around nothing could be seen but white foaming breakers, and nothing heard but howling winds and lashing waves. . . . Our slumbers were at times fearfully interrupted by the sudden pouring of the sea over the roof, the rocking of the house on its pillars, and the spurting of water through the seams of the doors and windows, symptoms which, to one suddenly aroused from sound sleep, recalled the appalling fate of the former barrack, which had been engulfed in the foam not twenty yards from our dwelling, and for a moment seemed to summon us to a similar fate. On two occasions, in particular, these sensations were so vivid as to cause almost every one to spring out of bed; and some of the men fled from the barrack by a temporary gangway, to the more stable but less comfortable shelter afforded by the bare wall of the lighthouse tower, then unfinished, where they spent the remainder of the night in the darkness and the cold.

In the equipment of the Skerryvore, Alan Stevenson introduced important improvements in the Fresnel system of lenses.

Bishop Rock Lighthouse is on the outermost rock of the Scilly Islands off the southwest coast of England, in a most exposed position. The first lighthouse on this rock, a cast- and wrought-iron openwork structure, was destroyed by the great storm of February, 1850, before it had been put into service. This was replaced by a granite tower completed in 1858. This structure was found not sufficient for the severe conditions on this rock. In 1887 a protection of the original tower was completed, by encasing it with granite blocks securely dovetailed; the elevation of the tower was also increased, raising the light to one hundred and forty-six feet above the sea.

These four famous British rock lighthouses, the Eddystone, Skerryvore, Bell Rock, and Bishop Rock, have been described as "the most perfect specimens of modern architecture. Tall and graceful as the minarets of an Eastern mosque, they possess far more solidity and beauty of construction, while, in addition, their form is as appropriate to the purpose for which they are designed as anything ever built by the Greeks."

The most northerly lighthouse in Great Britain, the North Unst, is remarkable from its location, as it stands on top of a bare and precipitous rock rising nearly two hundred feet from the sea, off the northern extremity of the Shetland Islands; the buildings occupy nearly the whole available area of the rock, and are accessible by stone steps cut in the rock.

Fastnet Lighthouse, on a rock, off the southwest coast of Ireland, is the point for which a large part of the eastbound vessels across the Atlantic steer. A new and handsome lighthouse was completed here in 1904.

Off the east coast of England near the Scottish border lie the Farne Islands and on the outermost rock stands Longstone Lighthouse. It was here that Grace Darling lived with her father who was keeper of the light, as had been his father before him. On September 7, 1838, the steamer Forfarshire was wrecked on the rocks not far from the lighthouse, and most of her company were lost. Keeper Darling, who was alone with his wife and daughter at the light, saw that a few survivors had found refuge on a rock. He launched a coble and rowed to the wreck with the help of his daughter, knowing that it would be impossible to return to the lighthouse without the aid of some of the people from the ship. Four men and one woman were successfully taken off by the keeper and his daughter and were landed at the lighthouse, and later Darling and the rescued men brought off the four other survivors. Grace Darling was then twenty-two years old and this brave deed made both her and her father famous, and brought them generous recognition. She died four years later and her tomb in her native town bears this inscription, "Pious and pure, modest and yet so brave; though young, so wise; though weak, so resolute."

The Isle of May Light, in the entrance to the Firth of Forth, is believed to have been the first lighthouse in Scotland, and was constructed about 1635 by private individuals under a patent granted by Charles I. Up to 1816 the illuminant here was an open fire in a grate on the tower; it is stated that in 1786 the light was improved by enlarging the *chauffer* to a square of three feet; the light then burned four hundred tons of coal a year, and had double the coal capacity of any light in England. On account of wrecks of vessels, particularly of two British frigates in December, 1810, the light was purchased by Parliament in 1814, from its then owner, the Duke of Portland, for sixty thousand pounds, and a new lighthouse was built, being completed and oil reflector lights exhibited in 1816, after an open fire had been the illuminant here for one hundred and eighty-one years. The last coal light, that at St. Bees on the northwest coast of England, was extinguished only in 1823.

The lighthouse service of England is under the charge of Trinity House, which also has certain supervisory powers over the Scottish and Irish lights, which are under the direct charge respectively of the Commissioners of Northern Lighthouses and the Commissioners of Irish Lights. The Trinity House is a body of great historic interest, and received a charter from King Henry VIII in 1514. Trinity House was first charged with lighthouse duties during the reign of Queen Elizabeth, by the Act of 1565, which recites that "the Master, Wardens, and Assistants of the Trinity House of Deptford Strond, being a Company of the chiefest and most expert masters and governors of ships," are empowered to "make, erect, and set up such and so many beacons, marks, and signs for the sea in such place or places of the seashores, and uplands near the sea coasts, or forelands of the sea, only for seamarks, as to them shall seem most meet, needful, and requisite whereby the dangers may be avoided and escaped, and ships the better come into their ports without peril." This was the first English statute relating to aids to navigation, and the preamble explains that by reason of the destruction of "steeples, woods, and other marks standing on the main shores" which had served "as beacons and marks of ancient time accustomed to seafaring men," divers ships in sailing from foreign ports to England "have, by the lack of such marks, of late years been miscarried, perished, and lost in the sea, to the great detriment and hurt of the common weal, and the perishing of no small number of people."

The corporation of Trinity House now consists of a master, a deputy master, and twenty-two elder brethren, of whom a number are honorary. It is a body of great distinction, and occupies a building, adjoining the Tower of London, containing most interesting models and pictures illustrating the history and progress of lighthouses and light-vessels, and numerous portraits of distinguished men of England who have been members of the corporation. Among the masters have been William Pitt and the Duke of Wellington. Sir James N. Douglass, the builder of the present Eddystone, Bishop Rock, Smalls, and other lighthouses, was for many years engineer-in-chief to the Trinity House, and among its scientific advisers have been Dr. Tyndall, Professor Faraday, and Lord

Rayleigh. Trinity House has important duties of a nautical character other than those connected with lighthouse administration, and in addition is in fact the Guild of Mariners of England.

Many of the early lighthouses of England were in the hands of private individuals, who, under leases or patents from the Crown, Parliament, or Trinity House, built and maintained the lights, paying a rental and having the right to collect toll from vessels that passed the light. An act of 1836 vested all light-houses and sea-marks on the coast of England in Trinity House, and authorized the purchase of the ten coast lighthouses that were then held by individuals. This purchase was not completed until 1842, condemnation proceedings being necessary in some cases. The total amount paid for these ten light-houses was £1,182,546, an amount far greater than their original cost, this being due to the fact that the rights under which they were held, permitting the collection of dues from vessels passing, were in some cases very valuable. The most remarkable case was that of the lighthouse marking the dangerous group of rocks known as the Skerries, projecting into the Irish Sea in the approach to Liverpool. The owner of the islets built a lighthouse here in 1714, at a cost of three thousand pounds, but was unable to collect from ships the dues which his patent authorized him to collect, and died a ruined man. The rights were then sold for a nominal sum, but finally became so valuable that in 1840 the net revenue which the owner derived from Skerries Lighthouse was no less than £20,042 a year, and in the condemnation proceedings the award of the jury as the value of this lighthouse was £444,985 which enormous amount was paid by Trinity House to take it over.

These purchases included all the general coast lights then remaining in private hands. The lighthouses of the British Islands are now supported by light dues levied on shipping using British ports, and this money is applied directly to the support and construction of lighthouses. As an increase in the cost of the lighthouse service would result in an increase in the light dues levied on shipping, the effect is to make maritime interests scrutinize closely and sometimes object to projects for new lighthouses, an economical attitude which is wholly absent where lighthouse expenses are paid out of the general treasury.

Among other notable wave-swept lighthouses on the coasts of Great Britain are the Smalls, Wolf, Dubh Artach, and Beachy Head Lights, all built after the general plan of which Smeaton's Eddystone was the first. The Smalls Lighthouse is located on one of a group of rocks lying off the westernmost point of Wales. It was built in 1776 by a wealthy merchant of Liverpool who said it was a work which should be "a great and holy good to serve and save humanity." Nevertheless, when Trinity House bought the rights from his heirs £170,000 had to be paid for the lighthouse, a strange, wooden-legged affair designed by a musical-instrument maker. The present lighthouse is a masonry tower one hundred and fourteen feet in height, completed in 1861. It was at the old Smalls Light in 1802 that the tragic incident occurred of the death of one of the two keepers at the lighthouse during a spell of stormy weather which prevented communication with the land for four months. During the latter part of the time no light was shown because of the supply of oil having been exhausted. When the lighthouse was finally reached the two keepers were brought off, one emaciated and the other a corpse; one of the keepers had been dead three weeks, and the survivor had feared to bury him in the sea.

Standing on Lands End and looking out toward the sea a lighthouse appears to rise out of the midst of the waters. It is the Wolf on a much-exposed rock covered to a depth of six feet at high water. It is a stone tower one hundred and seventeen feet high; the lower courses are in steps with vertical faces, in order to break up the sea. Off the west coast of Scotland, southeast of Skerryvore and twelve miles from the nearest land, Dubh Artach Lighthouse stands on an exposed rock thirty-five feet above high water. It is a granite tower one hundred and twenty-six feet in height, and was built by David and Thomas Stevenson, two others of that family of lighthouse engineers. On the coast nearly south of London, at Beachy Head, a granite lighthouse was completed in 1902, on a site at the edge of low tide. The light is one hundred and three feet high, and takes the place of a former lighthouse on the cliff, two hundred and eighty-four feet above the sea, which was often obscured by mist or fog.

The first lightship was placed in 1732 at the east end of the Nore Sands in the entrance to the Thames

River. This lightship was placed as a private enterprise under a lease from Trinity House, the owner paying one hundred pounds a year and collecting tolls. The early lightships were small and carried small and primitive lanterns suspended from the ends of the yardarms. The British Islands are now well supplied with lightships, there being eighty-three, or more than a fourth of the total number in the world; none of these are self-propelling. There are no less than seventeen lightships in the entrance and approaches to the river Thames. The Trinity House now has in service two unattended lightboats, the Lune in Morecambe Bay, north of Liverpool, and the Mid-Barrow in the entrance to the Thames. These boats are equipped with gas lights and revolving lenses, and with an automatic regulating clock for turning on the gas at sunset and shutting it off at sunrise. They have fog bells rung by the motion of the vessel. The Barrow lightboat has a light of seven thousand candle-power showing a triple flash every twenty seconds, and also has a submarine bell, operated by the sea. The whole apparatus is automatic and there is no crew on either vessel. The clock mechanism for turning on and off the gas is also used for automatic beacons ashore and for gas buoys; the clock is wound by the gas, which later is burned in the light, and the clock automatically changes the hours of gas supply with the season of the year.

The most complete automatic unattended light and fog-signal station is that built in 1910 by the English lighthouse authorities on Platte Fougere, an isolated rock, submerged except at extreme low tides, lying off the island of Guernsey and near the French coast. The illuminant is compressed acetylene gas, which is turned off at sunrise and on at sunset by clockwork. The air for the siren fog signal is supplied by compressors driven by electric motors connected by a cable with the shore, a mile distant, where is a dwelling for two keepers. The cost of the station was $42,500, about one-seventh of the estimated cost of a complete lighthouse built on the rock.

It seems almost incredible to find, only three centuries ago, powerful opposition to the establishment of lighthouses. In 1619 a heroic Cornish gentleman, Sir John Killegrew, petitioned the king for permission to build a lighthouse on the Lizard, the southernmost point of England, where there is now an electric light whose powerful beam sweeps around the horizon.

The nautical board to whom was referred the petition advised the king that it was not "necessarie nor convenient on the Lizard to erect a light, but, *per contra* inconvenient, both in regard of pirates, or foreign enemys; for the light would serve them as a pilot to conduct and lead them to safe places of landinge; the danger and perill whereof we leave to your majesty's absolute and profound wisdom." Notwithstanding the flattery, James I granted the petition.

Next the local Cornish people opposed the work, as thus told by Killegrew: "The inabytants neer by think they suffer by this erection. They affirme I take away God's grace from them. Their English meaning is that now they shall receive no more benefitt by shipwreck, for this will prevent yt. They have been so long used to repe profitt by the callamyties of the ruin of shipping, that they clayme it heredytarye, and heavely complayne on me." The light was, however, completed and the fire kindled, which, wrote Killegrew, "I presume speaks for yt selfe to the most part of Christendom." But it was impossible to obtain, for supporting it, the "voluntary contributions" from shipping which the king's grant authorized. Finally the corporation of the town of Plymouth pulled down the lighthouse, which the shipowners considered "burthernsome to all ye countrie," and there was no light at the Lizard for one hundred and thirty-two years thereafter.

The present lighthouse on the Lizard was built under lease from Trinity House and completed in 1752. Originally coal fires enclosed in glass were maintained in each of the four towers. The present single electric light was installed in 1903; it is one of the most powerful lights on the English coast, and has an exceedingly short period, flashing every three seconds; its loom in the sky has been reported far beyond its ordinary range of visibility.

In telling of the building of the lighthouse on Start Point, on the island of Sanday, in the Orkneys, Robert Stevenson illustrates the attitude of some of the coast people toward wrecks and lighthouses:—

It had become proverbial with some of the inhabitants to observe that "if wrecks were to happen, they might as well be sent to the poor island of Sanday as anywhere else." On this and the neighboring islands, the inhabitants have certainly had their share of wrecked goods.

On complaining to one of the pilots of the badness of his boat's sails, he replied with some degree of pleasantry, "Had it been His (God's) will that you came na here wi' these lights, we might a' had better sails to our boats and more o' other things."

In the leasing of farms, a location with a greater probability of shipwreck on the shore brought a much higher rent.

The earliest example now existing of a sea-swept lighthouse, is the beautiful tower of Cordouan, built in 1584 to 1611, on a rock in the sea at the mouth of the Gironde, on the west coast of France. This lighthouse has since been altered and raised in height. The original structure was elaborately decorated, and one floor was occupied by a chapel which still remains. The lighthouse stands upon a rock covered with ten feet of water at high tide. The tower rises two hundred and sixteen feet above the rock, and the light is one hundred and ninety-seven feet above high water. The tower stands on a pier about one hundred and thirty feet in diameter, and around the base of the tower is a circular building containing the keepers' quarters. Cordouan was provided with reflector lights in 1782, replacing the coal fire previously used. Although there were no less than eighty lamps, each with a reflector, the apparatus was so crude and the light so poor that mariners earnestly requested a return to the coal fire. One of the earliest revolving lights was installed at Cordouan in 1791. In 1823 the first revolving lens constructed from Fresnel's design was placed at Cordouan.

France has not only excelled in the development of lighthouse apparatus, but has built many notable lighthouses on her coasts. Among these are Heaux-de-Brehat Light, on the north coast of Brittany, a tower of one hundred and fifty-six feet on a reef submerged at high water, and Ar'men Light off the west coast of Finistere, built on a rock of small area barely uncovered at low water. This light was fifteen years in course of construction, and was designed by Reynaud, as was also the preceding. There are a number of powerful quick-flashing electric lights located on the principal points of the coasts of France. One of these is at the point of Creac'h, the northwest extremity of France; it is a light giving, each ten seconds, two flashes of 30,000,000 candle-power, and is typical of the others. In this vicinity, on account of the dangerous off-lying reefs and the large commerce passing, it was later considered necessary to place a light and fog signal on the reefs themselves. This

handsome tower, the Jument Light, was completed in 1911, and has a special interest for the reason that money for its construction was bequeathed by a French traveler, though the Government had to add as much more.

The Phare d'Eckmuhl, at the point of Penmarc'h, not far south of the above lighthouses, was also built largely by means of a private bequest. This is a magnificent granite tower two hundred and three feet in height, with powerful electric light. On the north coast, eastward of Creac'h is the Phare de l'île Vierge, a cylindrical granite tower built in 1902. This lighthouse is two hundred and sixty-two feet high from the ground to the top of the lantern, and is probably the tallest lighthouse structure in the world. All of the six lighthouses just mentioned are grouped around the northwest extremity of France.

Canada has been energetic and progressive in developing an extensive and efficient lighthouse service, and the frequented portions of her great coast line are marked by some eighty-six hundred aids to navigation. The gas buoy was early and widely used, as well as a new type of fog signal. A number of recent light-towers are of reinforced concrete, some with flying buttresses. The St. Lawrence River has over three hundred and fifty lights and lighted buoys below Montreal; those in the river channel are on massive foundations to withstand the ice pressure. Many of the Canadian lighthouses are on exposed and remote stations; as, the two lighthouses marking the extremities of Sable Island, that former graveyard of the sea lying a hundred miles out in the Atlantic; the lights on the north and south ends of Belle Isle; on Cape Race and Cape Bauld, two of the points of Newfoundland; along the northern shores of Lake Superior; and on the exposed western coast of British Columbia.

The first lighthouse built in the sea distant from the land and not on a rock foundation was the Rothersand. This notable engineering work stands in twenty feet of water, on a sand foundation, in the North Sea, ten miles from the German coast, in the approach to the river Weser and Bremen.

The first attempt to place a lighthouse in this position resulted in failure, but a structure was finally completed in 1885. A caisson of boiler iron thirty-seven feet wide, forty-seven feet long, and sixty-two feet deep was built in port. This caisson was towed to the site and sunk in position. Eight feet above the lower or cutting edge of the caisson was a diaphragm, forming a working chamber, from the center of which rose a cylindrical shaft with an airlock. The caisson was sunk by the pneumatic process to a depth of seventy-three feet below low water, the sides being raised by adding iron plates as the caisson sank. The sand was removed from the working chamber by suction. The caisson was filled with concrete and masonry and the light-tower erected on this foundation. The total height of the structure from the base of the caisson to the top of the lantern is one hundred and seventy-two feet.

The most powerful light on the German coast is that on the island of Helgoland, reported to be of 38,000,000 candle-power. Three arc lights are used, each in the focus of a parabolic mirror of glass, silvered on the back. These three searchlights are mounted one hundred and twenty degrees apart, and the group is rotated so as to give a brilliant flash every five seconds. The light is two hundred and sixty-nine feet above the sea; it is necessarily expensive to maintain.

The intricate coast of Norway is lighted with twelve hundred lights, numerically more than any other country save the United States. A large part of these are minor lights.

In view of the very rapid progress in lighthouse engineering in the last century, it is interesting to go back into history and find that a great lighthouse, in dimensions probably the greatest that has been built, was constructed in Egypt twenty-two centuries ago. The famous Pharos of Alexandria, the earliest lighthouse of which there is definite historical information, was regarded by the ancients as one of the seven wonders of the world, and its name has become a general term for all lighthouses.

Alexander the Great, on his occupation of Egypt, founded in 332 B.C. the city of Alexandria, as a Greek center in Egypt. It was located near the western extremity of the delta of the Nile, partly on the mainland and partly on the island of Pharos, which was joined to the mainland by a mole. The city grew rapidly in importance and for some centuries was second only to Rome. It was the seat of government of the Ptolemies, the Macedonian kings who ruled Egypt after the death of Alexander. Not long after the founding of Alexandria, the great tower, named

Pharos after the island at whose eastern extremity it stood, was undertaken. It was commenced about 300 B.C. under Ptolemy I and completed about 280 B.C. under Ptolemy II, thus taking about twenty years to build. The tower was built by the engineer or architect Sostratus. While there is no definite description of the Pharos, study of the evidence indicates that the tower was nearly four hundred feet in total height, including the statue by which it was surmounted.

The Greek geographer Strabo, who visited Egypt in 24 B.C., in his work on geography, says that "Pharos is a small oblong island," and that its eastern extremity "is a rock washed by the sea on all sides, with a tower upon it of the same name as the island, admirably constructed of white marble, with several stories. Sostratus of Cnidus, a friend of the kings, erected it for the safety of mariners, as the inscription imports. For as the coast on each side is low and without harbors, with reefs and shallows, an elevated and conspicuous mark was required to enable navigators coming in from the open sea to direct their course exactly to the entrance of the harbor." Cæsar, who went to Alexandria in 48 B.C., describes the Pharos as a "tower of great height, of wonderful construction." Pliny in his "Natural History" (77 A.D.) describes the celebrated tower; and says, "the purpose of this is to show a fire for the course of ships at night, in order to forewarn of the shoals and the harbor entrance." He mentions similar fires lighted at Ostia, the port of ancient Rome, and at Ravenna on the Adriatic coast of present Italy.

The Pharos was probably used as a lighthouse for much over a thousand years, for Edrisi, the Arab geographer, thus describes it in a work of 1154:—

> This structure is singularly remarkable, as much because of its height as of its solidity; it is very useful, as it is illuminated by fire night and day, to serve as a signal for navigators during their voyages. . . . During the night it appears as a star, and during the day it is distinguished by the smoke.

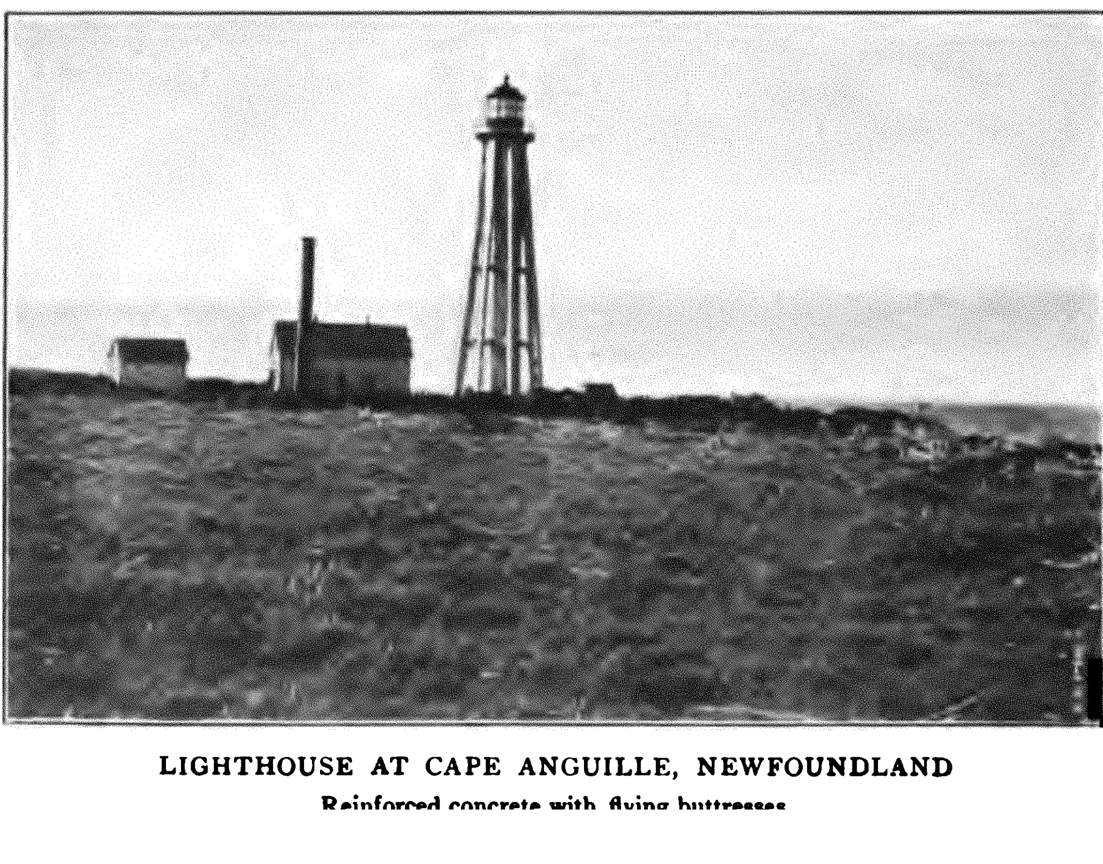
In 1349 the Pharos was found in ruins. The present principal lighthouse at Alexandria, Ras el Tin, is about one and three-fourths miles from the fort which now occupies the site of the Pharos tower, and at the southwestern or opposite end of the ancient Pharos island, now a peninsula joined to the mainland.

There are various references by writers of antiquity from which it has been inferred that there were lighthouses long before the Pharos, but these are rather indefinite in character. There appear, however, to have been, as early as the fifth century B.C., pillars on which fires burned for the use of ships, as the two marking the entrance to Piræus, the port of Athens. It is significant that the "Periplus" of Scylax, a full description in the fourth century B.C. of the entire coast line of the Mediterranean Sea, for the use of navigators, does not mention any lighthouse. There were several ancient lighthouses marking the passage from the Mediterranean to the Black Sea. Following the Pharos a number of lighthouses were built by the Romans, among which were those at Messina, Ostia, and Ravenna. It has been estimated that seventeen of the ancient towers which are known can with some certainty be considered to have been used as lighthouses.

One of these is still standing at Coruña on the northwest coast of Spain, and is known as the Tower of Hercules. This was a square stone tower of about one hundred and thirty feet in height, and had an unusual ascending way winding a number of times around its exterior. It is described in writings of the fourth century A.D., but is believed to have been built much earlier. The Spanish Government has restored the tower and encased it in granite. It has been again put to service as a lighthouse, after having been dark for many centuries. It is the oldest light-tower at present in use, and is the only lighthouse of antiquity which has survived. Another ancient lighthouse, the Tour d'Ordre at Boulogne on the north coast of France, stood until 1644. It was built by the Romans about 40 A.D., and restored by Charlemagne in 811, and was a massive structure, at times used as a fort.

The seafaring Italian republics were the first to restore the use of lighthouses to modern Europe. Pisa constructed a lighthouse on the near-by island of Meloria in 1157 and another near Leghorn in 1163; a tower at Genoa was built in 1139, but not lighted until 1326; and a light was established at Venice about 1312. The progress in lighthouse building was slow, and five and one half centuries later, at the time of the building of Boston Light in 1716, it is estimated that there were but seventy lighthouses in the world. And for a century after the lighting of Boston Light, — that is, up to a hundred years ago, — the increase in

LIGHTHOUSE IN THE ST. LAWRENCE RIVER AT MONTREAL, NEAR ISLE STE.-HÉLÈNE



LIGHTHOUSE AT CAPE ANGUILLE, NEWFOUNDLAND

Reinforced concrete with flying buttresses

aids to navigation was still slow, the means of illumination remained crude, and fog signals except of the most primitive character were wholly lacking. Thus the great advance in placing artificial aids to guide the mariner, both numerically and in perfection of apparatus, has been made within the last one hundred years, and is a direct result of the remarkable progress during this period in navigation and ships, and in the extent of intercourse upon the sea. All modern maritime nations have actively cooperated in the great work of safeguarding the seas and coasts, and in this the work as well as the influence of Great Britain, impelled by her maritime interests, in increasing the lighthouse facilities of the world, as well as in improving the charting of the coasts of the world, has been a most important contribution to intercourse among the nations.

As of the surface of the earth 51,886,000 square statute miles is land, as compared with 145,054,000 square miles of water, it is evident that a large part of the commerce of the world will always be carried on this great water area. Lights and buoys and fog signals are essential to safeguard the ships as they approach the continents and follow the coasts, and these or other suitable guides will be needed for aerial traffic, should it ever develop.

There is a great difference to-day in the manner in which the shores of different seas are lighted. The official British lists for 1915 give a total of thirteen thousand five hundred light-stations and light-vessels for the whole world, not including the Great Lakes or interior rivers. Of these ten thousand are on the coasts of Europe, the United States, and Canada, while Asia, Africa, Australia, South America, and the balance of North America have together about thirty-five hundred. South America has but three hundred and seventy light-stations for its immense shore line, and Africa but five hundred and twenty.

The Caribbean Sea, the West Indies, and Central America constitute an area which is badly lighted and marked. This is a region of interest to our shipping. For example, the large island of Haiti has no lighthouses at either of its two prominent western extremities, and the small light at the eastern cape is marked in the list as unreliable, as are several of the few harbor lights of Haiti. A number of the lighthouses on the Central American coast are maintained by an enterprising steamship company.

An example of international coöperation is the lighthouse on Cape Spartel, Africa, at the entrance to the Mediterranean, which is maintained jointly by the contributions of eleven nations, including the United States.

The proper lighting and marking of the coasts is an obligation assumed by all modern maritime nations. The lights protect not only the ships of the country maintaining them, but the vessels of other nations as well. The lighthouse, for instance, at Cape Maysi, on the east end of Cuba, is of great value to many ships which never call at a Cuban port. The brilliant lights on either side of the Straits of Dover guide many vessels not bound to a French or English port.

Longfellow, in his beautiful poem, shows the spirit of the lighthouses and their work for humanity:—

"The rocky ledge runs far into the sea,
And on its outer point, some miles away,
The Lighthouse lifts its massive masonry,
A pillar of fire by night, of cloud by day.

. . . .

"And as the evening darkens, lo! how bright,
Through the deep purple of the twilight air,
Beams forth the sudden radiance of its light
With strange, unearthly splendor in the glare!

"Not one alone; from each projecting cape
And perilous reef along the ocean's verge,
Starts into life a dim, gigantic shape,
Holding its lantern o'er the restless surge.

. . . .

"Steadfast, serene, immovable, the same
Year after year, through all the silent night
Burns on forevermore that quenchless flame,
Shines on that inextinguishable light!

. . . .

"The startled waves leap over it; the storm
Smites it with all the scourges of the rain,
And steadily against its solid form
Press the great shoulders of the hurricane.

"The sea-bird wheeling round it, with the din
Of wings and winds and solitary cries,
Blinded and maddened by the light within,
Dashes himself against the glare, and dies.

. . . .

"'Sail on!' it says, 'sail on, ye stately ships!
And with your floating bridge the ocean span;
Be mine to guard this light from all eclipse,
Be yours to bring man nearer unto man!'"

THE END

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