DEPARTMENT OF COMMERCE
LIGHTHOUSE SERVICE

THE UNITED STATES LIGHTHOUSE SERVICE

1915

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GOVERNMENT PRINTING OFFICE
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Department of Commerce,
Bureau of Lighthouses,
Washington, December 1, 1915.

This pamphlet is published for the purpose of furnishing general information regarding the organization and operation of the United States Lighthouse Service, and to enable the Bureau to supply data asked for in inquiries frequently received. It has been compiled mainly by John S. Conway, Deputy Commissioner of Lighthouses.

George R. Putnam,
Commissioner.

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THE UNITED STATES LIGHTHOUSE SERVICE, 1915.

1. DUTIES AND ORGANIZATION.

The United States Lighthouse Service is charged with the establishment and maintenance of aids to navigation, and with all equipment and work incident thereto, on the coasts of the United States. The term "aids to navigation" comprises all land and sea marks established or adapted for the purpose of aiding the navigation of vessels, and includes light stations, light vessels, fog signals, buoys of all kinds, minor lights, and day beacons.

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 19 lighthouse districts, each of which is under the charge of a lighthouse inspector. In each district there is a central office at a location selected on account of either its maritime importance or 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, with a chief clerk and assistants, for the work of the district. The principal technical assistant to the inspector is the superintendent, and there are assistant superintendents and aids as required by the size of the district. 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 depots 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 to the various district depots, there is in the third lighthouse district, on Staten Island, New York Harbor, a general lighthouse depot, 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.

2. JURISDICTION.

The jurisdiction of the Lighthouse Service extends over the Atlantic, Gulf, Great Lakes, and Pacific coasts, the principal interior rivers, Alaska, Porto Rico, and Hawaii, and all other territory under the jurisdiction of the United States, with the exception of the Philippine Islands and Panama. In the Philippine Islands the lighthouse service is maintained by the insular government and supported entirely out of the revenues of the islands. At Panama the canal government has charge of the lighting of the canal and approaches under the general appropriations for the canal.

All the work of establishing and maintaining the aids to navigation under the jurisdiction of the Lighthouse Service is performed directly by that service through district organizations, with the exception of a few minor aids, which are maintained by contract, and the exception of the American Samoan Islands, the island of Guam, and Guantanamo, Cuba, where the aids are maintained under the supervision of the naval commandants under allotments made from the appropriations for the Lighthouse Service. The Lighthouse Service also has supervision over the establishment and maintenance of private aids to navigation and the lighting of bridges over navigable waters of the United States.

At the present time the United States assists in the maintenance of but one lighthouse outside of its territory, this being at Cape Spartel, Morocco. This light is maintained in accordance with the convention between Morocco and the United States, Austria, Belgium, Spain, France, Great Britain, Italy, Netherlands, Portugal, and Sweden, in force since March 12, 1867. The lighthouse was constructed at the expense of Morocco, but it is maintained by the other contracting powers. The annual appropriation by the United States for this purpose is $325, and it is not under the control of the Lighthouse Service.

The jurisdiction of the Lighthouse Service over rivers not included in tidewater navigation is restricted to such as are specifically named in the various acts of Congress. These now include practically all the important navigable rivers and lakes of the country.

3. COOPERATION.

In performing its duties, the Lighthouse Service cooperates actively with all other branches of the Government engaged in related work. Notices to mariners are issued jointly with the Coast and Geodetic Survey, and information affecting charts is supplied to that office for publication. Similar information is furnished the Lake Survey and other offices publishing charts. Cooperation is had with the Corps of Engineers, War Department, in connection with river and harbor improvements, as to special aids to navigation maintained for such works, information of improvements that will affect aids to navigation, the marking of river channels, lighting of wrecks, etc. Information as to deficiencies in aids is received from the Hydrographic Office and from naval vessels, and from other maritime services of the Government. The Public Health Service aids in matters of sanitation affecting lighthouse vessels and stations, the Bureau of Standards in the design of radio apparatus and in special tests, the Forest Service in the growing and management of timber on lighthouse reservations, the Steamboat-Inspection Service in the inspection of steam plants of vessels, etc. The Lighthouse Service supplies information respecting aids to navigation to all branches of the Government having need for this data and cooperates in the placing of buoys for special purposes.

Arrangements are in effect with the War Department for the assignment of lighthouse tenders from time to time for mine-planting practice, and in the event of necessity the Lighthouse Service is prepared to turn over to the Navy Department, with the approval of the President, such tenders as may be required in military operations.

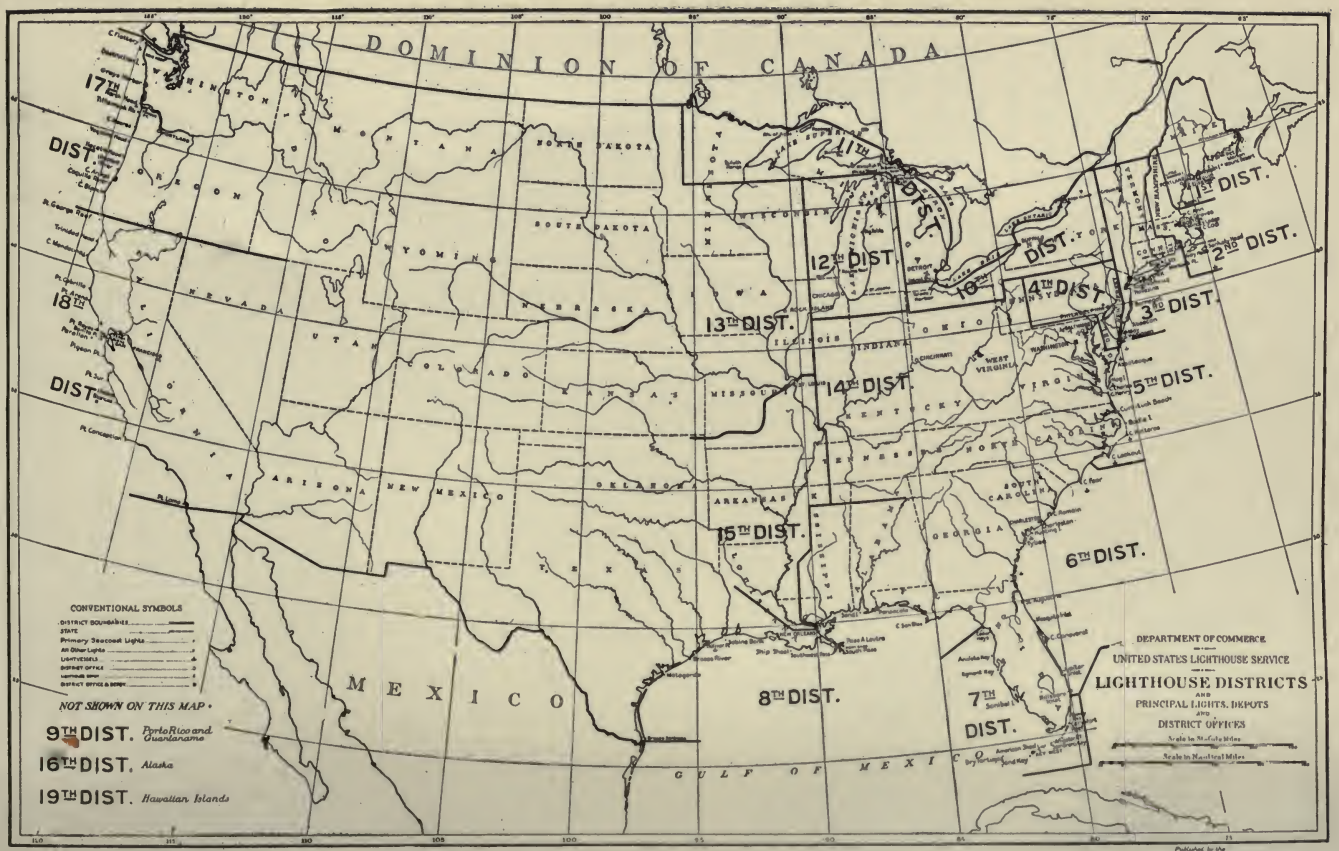
In addition to the foregoing special effort is made to consult the needs of merchant shipping as to aids to navigation. Applications from maritime interests for establishing or improving aids are carefully considered, and all matters involving extensive changes are taken up with such interests before action is decided upon.

Mariners and others interested are invited to give prompt information to the district lighthouse inspectors, or by direct communication to the Commissioner of Lighthouses, of all cases of injury to or unsatisfactory condition or incorrect position of any aid to navigation, or of the necessity for additional aids, or of any existing aid not needed, and of all cases where the lights are not exhibited punctually at sunset and extinguished at sunrise.

4. DISTRICT LIMITS AND OFFICES.

The limits of the lighthouse districts are as follows:

First district.—From the head of navigation on the St. Croix River, Me., the northeastern boundary of the United States, to and including Hampton Harbor, N. H. It embraces all aids to navigation on



General map of lighthouse districts.

the seacoast of Maine and New Hampshire, and on all tidal waters between the limits named.

Second district.—From Hampton Harbor, N. H., to Elisha Ledge, off Warren Point, R. I., but not including either the harbor or the ledge. It embraces all aids to navigation on the seacoast and tidal waters of Massachusetts, except on the Taunton River and that part of Mount Hope Bay lying within the State boundary.

Third district.—From Elisha Ledge, off Warren Point, R. I., to Cape May, on the coast of New Jersey, excepting Cape May Lighthouse, and to a point on the coast opposite Rehoboth, Del., excepting Cape Henlopen Lighthouse and Hen and Chickens Shoal. It embraces all aids to navigation on the coasts of Rhode Island, Connecticut, New York, and New Jersey northward of Cape May, including Northeast End, Five-Fathom Bank, and Overfalls light vessels, and McCries Shoal, and on all tidal waters tributary to the sea or Long Island Sound between the limits named, together with the aids on Whitehall Narrows, and on the United States waters of Lakes Champlain and Memphremagog.

Fourth district.—From and including Cape May Light Station, on the coast of New Jersey, to and including Fenwick Island Light Station on the coast of Delaware. It embraces all aids to navigation on the seacoast of New Jersey and Delaware between the points named, the entrance to Delaware Bay, Delaware Bay and River, and the waters tributary thereto, but does not include McCries Shoal, Overfalls Light Vessel, and the aids to navigation seaward thereof, nor the shoals seaward of Fenwick Island.

Fifth district.—From (but not including) Fenwick Island Light Station, on the coast of Delaware, to and including New River Inlet, N. C. It embraces all aids to navigation off the seacoast of Delaware seaward of Fenwick Island, on the seacoasts of Maryland, Virginia, and North Carolina between the limits named, all of Chesapeake Bay, the sounds of North Carolina, and tributary waters.

Sixth district.—From (but does not include) New River Inlet, N. C., to and including Hillsboro Inlet Light Station, Fla. It embraces all aids to navigation on the seacoasts, bays, sounds, harbors, rivers, and other tidal waters of North Carolina, South Carolina, Georgia, and Florida between the limits named.

Seventh district.—From a point just south of Hillsboro Inlet Light Station to and including Cedar Keys, Fla. It embraces all aids to navigation on the sea and Gulf coasts of Florida, Florida Keys, and on other waters tributary to the sea and Gulf between the limits named.

Eighth district.—From (but not including) Cedar Keys, Fla., to the southern boundary of Texas. It embraces all aids to navigation on the Gulf coast of the United States and tidal waters tributary to

the Gulf between the limits named, together with those on the Mississippi River below and including New Orleans, and on Grand Lake and Lake Chicot.

Ninth district.—The island of Porto Rico and the adjacent islands and other islands and stations ceded to the United States in the West Indies.

Tenth district.—From the mouth of the St. Regis River, St. Lawrence River, N. Y., to the mouth of the Detroit River. It embraces all aids to navigation on the United States shores and waters of Lakes Ontario and Erie and the upper part of the St. Lawrence River and the Niagara River, excepting aids to navigation at the mouth of the Detroit River.

Eleventh district.—From and including all aids to navigation at the mouth of the Detroit River, Mich., to the western end of Lake Superior. It embraces all aids to navigation on the United States shores and waters of Lakes St. Clair, Huron, and Superior, the Detroit River, including the mouth, the St. Clair and St. Marys rivers, and that part of the Straits of Mackinac lying to the eastward of a line drawn across the straits just to the eastward of Old Mackinac Point Light Station, Mich.

Twelfth district.—Includes all aids to navigation on Lake Michigan, Green Bay, and tributary waters lying west of a line drawn across the Straits of Mackinac just east of Old Mackinac Point Light Station, Mich.

Thirteenth district.—The Mississippi River from the head of navigation to the mouth of the Missouri River; the Minnesota River from the head of navigation to its mouth; the Illinois River from the head of navigation to its mouth; the Osage River from the head of navigation to its mouth; the Gasconade River from the head of navigation to its mouth; the Missouri River from the head of navigation to its mouth; St. Croix River and Lake; Lake Traverse; and includes all aids to navigation within these limits and navigable rivers tributary thereto.

Fourteenth district.—The Ohio River from Pittsburgh, Pa., to Cairo, Ill.; the Tennessee River from the head of navigation to its mouth; the Kanawha River from the head of navigation to its mouth; and embraces all aids to navigation within these limits and navigable rivers tributary thereto.

Fifteenth district.—The Mississippi River from and including the mouth of the Missouri River to New Orleans, La.; the Red River from the head of navigation to its mouth; and includes all aids to navigation within these limits and navigable rivers tributary thereto.

Sixteenth district.—From the boundary between Alaska and the Dominion of Canada to the boundary between Alaska and Siberia. It embraces all aids to navigation on the seacoast, bays, rivers, and other tidal waters of Alaska.

Seventeenth district.—From the boundary between California and Oregon to the northern boundary of the United States. It embraces all aids to navigation on the seacoast of Oregon and Washington, on the United States waters of the Strait of Juan de Fuca, Washington Sound, and the Strait of Georgia, and on the tidal waters tributary to the sea, straits, and sounds between the limits named.

Eighteenth district.—From the boundary between California and Mexico to the boundary between California and Oregon. It embraces all aids to navigation on the seacoast, bays, rivers, and other tidal waters of California. .

Nineteenth district.—Embraces the Hawaiian Islands, the Midway Islands, the island of Guam, and the American Samoan Islands, and includes all aids to navigation in the waters thereof.

The location of each district office, with the address of the lighthouse inspector, is given in the following table:

District.	Address.	District.	Address.
1st	Portland, Me., Y. M. C. A. Building.	11th	Detroit, Mich., Post Office Building.
2d	Boston, Mass., Customhouse.	12th	Milwaukee, Wis., Federal Building.
3d	Tompkinsville, N. Y.	13th	Rock Island, Ill., Federal Building.
4th	Philadelphia, Pa., Post Office Building.	14th	Cincinnati, Ohio, Customhouse.
5th	Baltimore, Md., New Customhouse.	15th	St. Louis, Mo., Customhouse.
6th	Charleston, S. C., Old Post Office Building.	16th	Ketchikan, Alaska.
7th	Key West, Fla.	17th	Portland, Oreg., Customhouse.
8th	New Orleans, La., Customhouse.	18th	San Francisco, Cal., Customhouse.
9th	San Juan, P. R.	19th	Honolulu, Hawaii, McCandless Building.
10th	Buffalo, N. Y., Federal Building.		

5. AIDS TO NAVIGATION.

The table following gives a summary of the 14,544 aids to navigation, under each principal class, in commission on June 30, 1915:

Lighted aids:	
Lights (other than minor lights)	1,662
Minor lights	2,837
Light-vessel stations	53
Gas buoys	479
Float lights	124
Total	5,155
Unlighted aids:	
Fog signals	527
Submarine signals	50
Whistling buoys, unlighted	86
Bell buoys, unlighted	237
Other buoys	6,488
Day beacons	2,001
Total	9,389
Grand total	14,544

Grouped according to the fixed or floating character of the aids, the following tabulation may be made:

Lighted fixed aids	4,499
Unlighted fixed aids	2,478
Total fixed aids	6,977
Lighted floating aids	656
Unlighted floating aids	6,911
Total floating aids	7,567
Grand total	14,544

The class described as "Lights (other than minor)" includes major lights classified under the Fresnel system of orders, which will be described more fully in another place, range lenses, reflectors, and lens lanterns. (See p. 31.) There are 744 stations with resident keepers, provided with dwellings, and in many cases these keepers have charge not only of the principal light but also such other lights in the vicinity as may be conveniently cared for from the same station.

The number of keepers varies from one to five, according to circumstances, and the number of stations having more than one keeper is shown in the following table:

Five-keeper stations	3
Four-keeper stations	28
Three-keeper stations	167
Two-keeper stations	238
Total stations with more than one keeper	436

The term "minor light" includes post lights and small lights generally not attended as a rule by resident keepers. These lights are usually cared for by persons living in the vicinity, who are not obliged to devote their entire time to the work and who sometimes have several lights, if conveniently located, in their charge. This type of light is commonly used on inland rivers and particularly on the Mississippi River and its tributaries.

Light vessels are used as a rule to mark offshore dangers, or the approaches to harbors or channels, where lighthouses would not be feasible or economical. They are more fully described on page 58.

Gas buoys are used to mark important channels or shoals or as general guides for navigation. Many improvements have been made in this type of aid, and they are considered among the most valuable of recent developments in modern coast lighting.

Float lights are usually small lights borne on a float or raft. They are employed for less important places where more convenient or economical than lighted buoys and where the expense of providing a foundation for a fixed structure would not be warranted.

Fog signals include various types of aerial sound-producing apparatus for use in foggy or thick weather. They embrace various types of

whistles, sirens, or horns, actuated by steam or compressed air, and bells, operated by machinery of various types or by hand.

Submarine signals are auxiliary fog signals consisting of bells operated under water. They are commonly a feature of light-vessel equipment, but are employed also at some light stations or attached to buoys.

Whistling and bell buoys, as the names imply, are buoys fitted with sound-producing apparatus operated by the motion of the buoy in the sea. Whistling buoys are more efficient in rough outside waters and bell buoys are more commonly used in harbors or inside waters. Further information in regard to both types appears on page 50.

Other buoys include cans, nuns, and spars of various types, and are the most extensively used of all aids. They are more frequently employed in channels and inside waters generally, and are described more fully on page 49.

Day beacons include minor fixed structures not bearing a light. They are of various types, the most common being a post or spindle bearing a target or some other object of a distinctive shape and color.

The number of light stations, light vessels, and fog signals of the world, as listed in the British Admiralty List of Lights for 1915, is approximately as given in the table below. The statistics do not include the Great Lakes of North America nor rivers above the limit of seagoing navigation, and the lights are given in greater completeness for some countries than for others.

Continents.	Light stations.	Light vessels.	Fog signals.
Europe	7,335	192	779
North America	2,913	49	645
Asia	1,355	36	116
Australia and Oceania	746	3	21
Africa	519	0	10
South America	358	10	15
Total	13,226	290	1,586

It is of interest to compare similar statistics of light stations for about 1888 (The Modern Lighthouse Service, Johnson).

Continents.	Light stations.	Continents.	Light stations.
Europe	3,309	Africa	219
North America	1,435	South America	167
Asia	476		
Oceania	319	Total	5,925

The lists for 1915 show that the United States Lighthouse Service has under its charge materially more lights and fog signals than any other organization, and this would be numerically increased if there were included the lights on the lakes and rivers, and if all aids to navigation were counted, including buoys and unlighted beacons.

6. HISTORY AND GROWTH OF THE LIGHTHOUSE SERVICE.

The history of lighthouses in the United States dates back to 1715–16, when the first lighthouse on this continent was built at the entrance to Boston Harbor by the Province of Massachusetts. This light was supported by light dues on all incoming and outgoing vessels, except coasters. Several other lighthouses were built by the colonies. Congress, by the act of August 7, 1789, authorized the maintenance of lighthouses and other aids to navigation at the expense of the United States. There were at that date eight lights in operation maintained by the colonies. These, together with others completed later, 13 in all, were ceded to the General Government by the States. The Lighthouse Service of the United States is supported entirely by appropriations out of the general revenues of the Government, and the United States lighthouses have been free to vessels of all nations from 1789 to the present time. There is no system of light dues, as is the case in a number of foreign maritime countries.

The maintenance of lighthouses, buoys, etc., was placed under the Treasury Department, and up to 1820 was directed personally by the Secretary of the Treasury, except for two intervals when supervision was assigned by him to the Commissioner of the Revenue. In 1820 the superintendence of the lights devolved upon the Fifth Auditor of the Treasury, who was popularly known as the General Superintendent of Lights and who continued in charge thereof until 1852, when the United States Lighthouse Board, consisting of officers of the Navy and Army and civilians, was organized, with the Secretary of the Treasury as ex officio president of the board. The board selected from its own number a member to act as chairman.

The Lighthouse Service was transferred to the Department of Commerce on July 1, 1903. On July 1, 1910, the Lighthouse Board was terminated and the present Bureau of Lighthouses established.

The eight colonial lights in the order of their establishment were:

Boston, on Little Brewster Island, Mass.	1716
Brant Point, on Nantucket Island, Mass.	1746
Beavertail, on Conanicut Island, R. I.	1761
Sandy Hook, N. J., entrance to New York Bay.	1764
Cape Henlopen, Del., entrance to Delaware Bay.	1764
Charleston, on Morris Island, S. C.	1767
Gurnet, near Plymouth, Mass.	1769
Portsmouth, N. H., entrance to harbor.	1789

All of these are still in existence, although with many improvements; at Sandy Hook and Cape Henlopen, however, the original towers are still in use.

The gradual increase in the number of aids to navigation from 1790 to 1910, by 10-year periods, and for each year since 1910, is shown in the following table:

Year.	Lighted aids.						Unlighted aids.							Grand total.
	Lights.	Minor lights.	Light vessels.	Lighted buoys.	Float lights.	Total lighted aids.	Fog signals.	Submarine bells.	Whistling buoys.	Bell buoys.	Other buoys.	Beacons.	Total unlighted aids.	
1790....	12	.....	.....	.....	.....	12	(a)	.....	.....	.....	(a)	(a)	(a)	(a)
1800....	23	.....	.....	.....	.....	23	2	.....	.....	.....	77	5	84	107
1810....	42	.....	.....	.....	.....	42	2	.....	.....	.....	117	22	141	183
1820....	59	.....	1	.....	.....	60	3	.....	.....	.....	156	30	189	249
1830....	137	.....	16	.....	.....	153	12	.....	.....	.....	350	60	422	575
1840....	234	.....	30	.....	.....	264	26	.....	.....	.....	800	90	916	1,180
1850....	297	.....	35	.....	.....	332	49	.....	.....	.....	1,034	121	1,204	1,536
1860....	425	.....	47	.....	.....	472	111	.....	.....	9	1,738	220	2,074	2,550
1870....	528	.....	32	.....	.....	560	117	.....	.....	9	2,446	324	2,892	3,456
1880....	661	819	31	.....	12	1,523	194	.....	25	9	3,115	355	3,694	5,221
1890....	833	1,550	26	7	34	2,450	254	.....	60	75	4,143	372	4,904	7,354
1900....	1,243	1,745	44	93	38	3,163	393	.....	70	120	4,749	496	5,828	8,991
1910....	1,397	2,256	54	225	60	3,992	457	42	89	178	5,783	1,120	7,669	11,661
1911....	1,424	2,362	51	287	87	4,211	506	40	88	189	5,821	1,295	7,939	12,150
1912....	1,475	2,552	51	346	92	4,516	510	43	84	205	5,992	1,474	8,308	12,824
1913....	1,531	2,666	53	388	101	4,739	520	46	84	216	6,174	1,655	8,695	13,434
1914....	1,590	2,791	52	453	118	5,004	519	48	86	233	6,330	1,978	9,194	14,198
1915....	1,662	2,837	53	479	124	5,155	527	50	86	237	6,488	2,001	9,389	14,544

a No definite information on record.

NOTES.—The information prior to 1850 should be considered approximate only, and the figures given may be regarded generally as somewhat less than the actual numbers.

Minor lights and float lights originally covered only post lights on the Mississippi River and tributaries, first reported in 1875 (280 minor, 21 float).

Lighted buoys first reported in 1884 (4 buoys).

Early records of fog signals compiled from light lists and other sources and are somewhat indefinite. Whistles not regularly reported prior to 1872 (33 whistles); bells not prior to 1882 (115 bells).

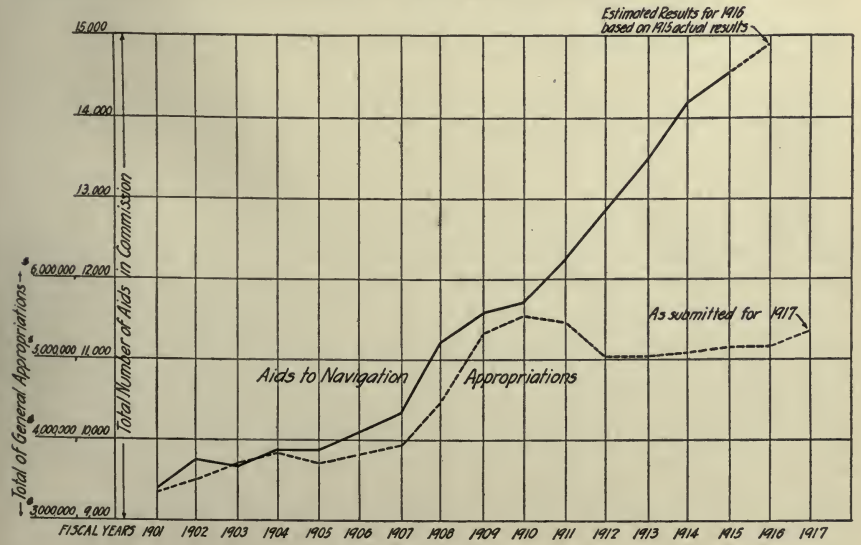
Submarine bells first reported in 1906 (5 bells).

Whistling buoys first reported in 1876 (4 buoys).

Bell buoys first reported regularly in 1881 (11 buoys). Bell buoys were introduced about 1855 (9 buoys). Bell boats, filling practically same purpose, were used at a much earlier date, although no definite records appear.

Buoy boats, consisting of a decked scow about 20 feet long by 7 feet beam, carrying a light mast or perch, were also in use in the early days.

The increase in the number of aids to navigation maintained by the United States Lighthouse Service is shown graphically for the last 15 years in the following diagram, as well as the range in general appropriations for maintenance during the same period.



U.S. Lighthouse Service
Number of Aids to Navigation and Annual Appropriations
1901–1917

7. DEVELOPMENT OF LIGHTHOUSE WORK IN ALASKA.

The first aids to navigation of the Lighthouse Service in Alaska were established in the spring of 1884 (14 iron buoys) and the first light in June, 1895. The following table gives the total number of aids to navigation at the end of the fiscal years named (June 30 in each case) illustrating the progress of the Service in the Territory:

Aids.	1890	1895	1900	1905	1910	1915
Lights	0	1	1	15	37	112
Fog signals	0	0	0	8	9	10
Buoys	27	57	57	68	84	167
Daymarks	15	26	25	30	30	49
Total	42	84	83	121	160	338

The 112 lights are of the following classes: 10 lighthouses with resident keepers, 62 unattended flashing acetylene lights, 34 minor lights, and 6 float lights, the use of the latter-named being confined to narrow channels or harbors where a small light answers all requirements of navigation.

Special attention has been given to increasing and improving the lights and buoys in Alaska, as shown by the table above, which indicates an increase of 203 per cent in the number of lights and 111 per cent in the total number of aids during the past five years.

There has been a considerable increase of shipping to this Territory with the rapid development there of the mining and other industries. The coast line, however, is of great extent in proportion to the amount of shipping. It is a difficult coast to navigate because of a number of causes in addition to the incompleteness of the system of aids to navigation. All the southern and more frequented portions of the Alaskan coast are subject, even in the summer months, to fog, rain, and storms; the coast is precipitous and rocky and hidden dangers are numerous; there is a great rise and fall of tide, resulting in strong tidal currents; the traffic is new and mainly restricted to only a part of the year, so that it is difficult for navigators to become thoroughly familiar with the region and conditions; much of the coast has not been completely surveyed and thorough surveys are rendered difficult by the nature of the bottom, and the coast is so abrupt and the depths so great that convenient and safe anchorages are not always available. On the other hand, 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. During the summer season, when traffic is heaviest, there is either daylight throughout the 24 hours or the time of darkness is short, thus materially aiding navigation, but the reverse condition exists in winter, because of the northern latitude. The immense coast line in proportion to the population and the amount of shipping, and

the uncertainty as to the permanency in routes of traffic, would not warrant the Government at this stage of development of the Territory in making the expenditures necessary to mark its coasts as elaborately as similar coasts in older and more settled portions of the United States.

The justice of the demands for additional aids to navigation in Alaska is, however, fully recognized. To meet these real needs, Alaska, which has formerly been under the charge of the district office at Portland, Oreg., was on August 1, 1910, made a separate lighthouse district, permitting the inspector in charge to give his entire attention to this important territory. A district office and depot have been established at Ketchikan and office and construction forces have been organized in the new district.

One of the largest tenders in the service, the *Kukui*, has been assigned to duty in Alaska, and a still larger vessel, the *Cedar*, is now being built for the same purpose. The new tender *Fern* has been constructed especially for work in the inside waters of southeastern Alaska.

Appropriations for special works in Alaska made in recent years include two appropriations of $60,000 each, made by the acts of March 4, 1911, and August 1, 1914, for aids to navigation in Alaska; $25,000 for rebuilding and improving Lincoln Rock Light and Fog Signal (act Mar. 4, 1911); and $115,000 for establishing Cape St. Elias Light and Fog Signal (act Oct. 22, 1913). In addition to these special works, the average expenditures from general appropriations for the support of the service in ordinary maintenance and betterments have averaged about $135,000 annually for the past two years.

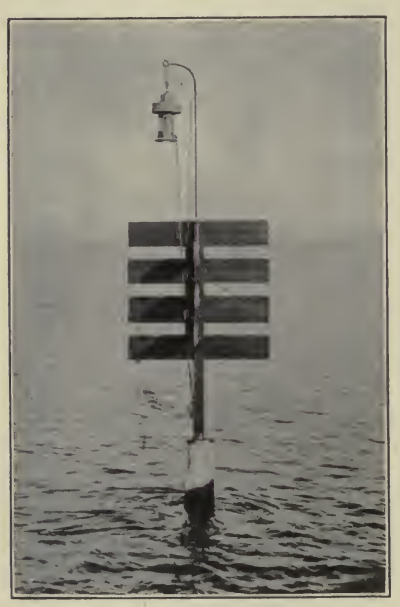
8. TYPES OF CONSTRUCTION OF LIGHTHOUSES.

The type of construction adopted in each case for lighthouse structures depends largely on the importance of the light and the foundation conditions. Brief descriptions of the various types more commonly employed are as follows:

Post lights are generally a single timber post, with a shelf or bracket for the lantern. In some cases ladders are attached, and to assist in identifying the aid by day, wooden wing boards for daymark purposes are frequently added. For similar construction in water, single piles, either timber or concrete, are used. A small service box for the lantern and supplies is often added.

Where the light is of more importance, framed timber towers have been used, generally built with four posts on proper foundations, battered and provided with the necessary framing and bracing, with a ladder and service box. Similar structures in water are generally of three or more piles, driven on a batter and forming a cluster at the top.

Recent improvements along this line include structural steel skeleton towers, also similar towers of iron pipe. Standard plans have been prepared for each of these types, both of which are useful when quickness of construction is desired. Each type is square in plan and strongly braced, with due provision allowed for corrosion in proportioning the sizes of the members. For similar structures in water, concrete pile foundation structures consisting of four, seven, or nine piles, with suitable cast-iron struts and structural bracing, have been developed and standard plans prepared for each type.



Sand Shoal Inlet Light, Va.

In addition to the foregoing types, which are principally adopted for nonattended lights, mention should be made of unlighted beacons, or daymarks. Some of these may be merely a pile or stake, occasionally with a pointer indicating the channel; others are timber structures of various designs, carrying a target or some other characteristic feature to attract attention; others are iron or steel spindles with a barrel or some form of cage work at the top, and some older types are monuments of stone. A type recently developed is that of strongly braced reinforced concrete tripods, to replace old wooden tripods destroyed by the sea. In some localities, particularly on rivers in California, where fog is prevalent part of the year, echo boards are used. These are rather long wall-like structures with projecting wings, to permit steamers obtaining an echo from their whistles in passing. These sometimes carry a post light on top of the board.

Petaluma Creek Light, Cal.

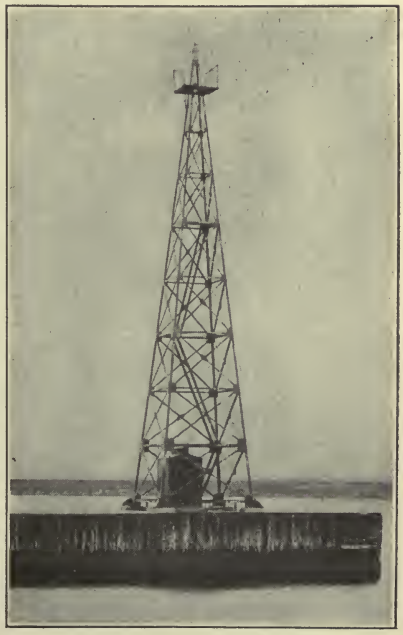
In case of attended lights where resident keepers are employed, which may be considered as lighthouses proper, there are also many types. A common form, frequently used for harbor or lake lights, is a combined tower and dwelling of timber or brick construction.

Sometimes the tower only is of masonry, while the dwelling is frame. For the more important lights, the tower is detached from the dwellings and as a rule is of fireproof construction. Most of the older towers of this type are built of brick or stone masonry, with stairways, lantern, and other appurtenances of cast iron. Others of a more recent type have a structural open framework of wrought iron or steel, usually with an inclosed stair well in the center. In still more recent years reinforced concrete towers have been used and will probably be more extensively adopted in the future.

Larchmont Breakwater Light, N. Y.

A completely equipped light station on a land site usually consists of the light tower, oil house, fog-signal building, keepers' dwellings, workshop, water supply and drainage systems, landing wharf, boathouse and ways, barn, and the usual outbuildings, roads, walks, and fences; although, owing to the restricted area of some sites, several of these purposes may be served by a single building. On submarine sites the whole station is frequently confined to one structure.

Where not built on rock, the foundation for towers on land sites is usually a single block of concrete resting upon the foundation soil, which has been previously excavated to the proper depth. Occasionally these blocks are placed upon a timber grillage supported by piles for sites upon low or marshy land, and in all cases the block is extended so as to bring the unit pressures within the bearing power of the foundation material.



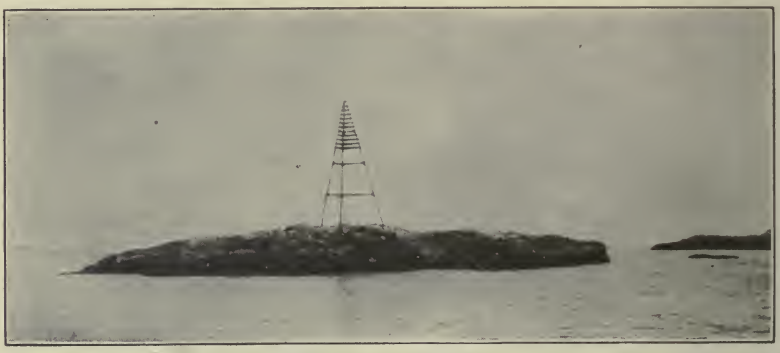
Fairport West Pier Light, Ohio.

Many lighthouses at the entrances to harbors are built on the ends of breakwaters or pierheads, utilizing, as a rule, such structures as the foundation. In such cases the problem is not essentially dif-

ferent from ordinary shore construction, although the weight of the superstructure must be considered carefully to avoid undue settlement of the foundation, providing at the same time a large margin of reserve strength to resist the impact of the waves and the vibrations caused thereby. Also, in such cases the necessary restrictions of available space require that the lighthouse be as compact as possible.

Berkeley Reef Beacon, Cal.

In the case of lighthouses on submerged sites the engineering features are important and often present great difficulties both in design and construction. Where the bottom is rocky or hard, the lighthouse is either built directly on the rock or on a pier. When placed on a ledge of rock, the latter is usually leveled or stepped as far as practicable and the structure heavily rag bolted to the rock. Two important lighthouses on the Great Lakes were built by constructing cofferdams, pumping out the water and leveling off the bed rock on which the lighthouse was built of cut stone, securely fastened. In other types, particularly on



Duck Rocks Tripod, Me.

the Great Lakes, cribs filled with stone are placed on the bottom and capped with concrete or other masonry.

Important wave-swept lighthouses, most of which are masonry structures founded on rocky ledges or hard bottom, include the following 20 stations:

First district:
- Saddleback Ledge, Me.
- Halfway Rock, Me.
- Ram Island Ledge, Me.
- Whaleback, Me.

Second district:
- The Graves, Mass.
- Minots Ledge, Mass.
- Bishop and Clerks, Mass.

Third district:
- Race Rock, N. Y.
- New London Ledge, Conn.
- Stratford Shoal, N. Y.

Tenth district:
- Toledo Harbor, Ohio.

Eleventh district:
- Port Austin Reef, Mich.
- Spectacle Reef, Mich.
- Stannard Rock, Mich.
- Rock of Ages, Mich.

Twelfth district:
- White Shoal, Mich.
- Racine Reef, Wis.

Seventeenth district:
- Tillamook Rock, Oreg.

Eighteenth district:
- St. George Reef, Cal.
- Mile Rocks, Cal.

Buffalo Light Station, N. Y.

Other severely exposed stations which are not given in the foregoing list include, in the seventh district, Fowey Rocks, Carysfort Reef, Alligator Reef, Sombrero Key, American Shoal, and Rebecca Shoal, Fla.; and, in the eighth district, Ship Shoal, Southwest Reef, and Sabine Bank, La. These stations appear in other lists on pages 25, 27, and 28.

Other stations not named in any of these lists, but which are noteworthy because of their unusual remoteness or isolation, include in part the following 34 locations:

First district:
- Libby Islands, Me.
- Petit Manan, Me.
- Great Duck Island, Me.
- Mount Desert Rock, Me.
- Matinicus Rock, Me.
- Boon Island, Me.
- Isles of Shoals, N. H.

Eighth district—Continued.
- Matagorda, Tex.

Ninth district:
- Mona Island, P. R.
- Culebrita Island, P. R.
- Muertos Island, P. R.

Sixteenth district:
- Cape Sarichef, Alaska.

Minots Ledge Light Station, Mass.

Third district:
- Falkner Island, Conn.

Fifth district:
- Cape Hatteras, N. C.
- Cape Lookout, N. C.

Sixth district:
- Cape Romain, S. C.
- Hunting Island, S. C.
- Cape Canaveral, Fla.

Seventh district:
- Dry Tortugas, Fla.

Eighth district:
- Cape San Blas, Fla.
- Sand Island, Ala.
- Timbalier, La.

- Scotch Cap, Alaska.
- Cape Hinchinbrook, Alaska.
- Lincoln Rock, Alaska.

Seventeenth district:
- Cape Flattery, Wash.
- Destruction Island, Wash.
- Cape Blanco, Oreg.

Eighteenth district:
- Punta Gorda, Cal.
- Farallon, Cal.
- Point Sur, Cal.

Nineteenth district:
- Makapuu Point, Hawaii.
- Molokai, Hawaii.
- Kilauea Point, Hawaii.

For submarine sites, where the bottom is sand, either a pile or caisson foundation is commonly employed. The screw pile, which was frequently employed some years ago, consists of a pile with a broad helicoidal flange on the foot, which is bored like an auger into the bottom, thereby greatly increasing the bearing power of the pile as well as anchoring it firmly. The caisson type usually consists of a cylinder from 21 to 35 feet in diameter, built up of cast-iron plates, and sunk by dredging or by the pneumatic process into the shoal until a firm

American Shoal Light Station, Fla.

bearing is attained, after which the interior is solidly filled with concrete. A few caissons have been placed on rocks or ledges. Both of these types are comparatively modern, the first screw-pile structure in the United States being at Brandywine Shoal, Delaware Bay, lighted in 1850, and the first pneumatic caisson structure being at Fourteen Foot Bank, Delaware Bay, completed in 1887. There are at the present time 76 attended lighthouses on piles, most of which are in Chesapeake Bay and the Carolina Sounds,

and 46 on caisson foundations, principally on the north and middle Atlantic coasts. The names and locations of such lighthouses are as follows:

ATTENDED LIGHTHOUSES ON PILES.

Second district:
*Narrows, Mass.
Third district:
*Long Beach Bar, N. Y.
*Bridgeport Harbor, Conn.

Fifth district—Continued.
Pages Rock, Va.
*Bells Rock, Va.
*Old Plantation Flats, Va.
*Cherrystone, Va.

Croatan Light Station, N. C.

Fourth district:
Mahon River, Del.
Fifth district:
*Killick Shoal, Va.
*Craney Island, Va.
Nansemond River, Va.
White Shoal, Va.
Point of Shoals, Va.
York Spit, Va.
*Deep Water Shoals, Va.
*Tue Marshes, Va.
*Stingray Point, Va.
*Bowlers Rock, Va.
*Windmill Point, Va.
*Tangier Sound, Va.
*James Island, Md.
Somers Cove, Md.
*Great Wicomico River, Va.
*Ragged Point, Md.
*Cobb Point Bar, Md.
Lower Cedar Point, Md.
*Mathias Point Shoal, Md.

*Indicates screw-pile structures (50).

Fifth district—Continued.
Upper Cedar Point, Md.
*Maryland Point, Md.
*Holland Island Bar, Md.
*Great Shoals, Md.
*Sharkfin Shoal, Md.
*Hooper Strait, Md.
*Drum Point, Md.
Choptank River, Md.
*Thomas Point Shoal, Md.
*Greenbury Point Shoal, Md.
Love Point, Md.

Fifth district—Continued.
*Harbor Island Bar, N. C.
*Brant Island Shoal, N. C.
*Pamlico Point, N. C.
*Neuse River, N. C.
Sixth district:
*Fort Ripley Shoal, S. C.
Seventh district:
Fowey Rocks, Fla.
Carysfort Reef, Fla.
Alligator Reef, Fla.
Sombrero Key, Fla.

Hog Island Shoal Light Station, R. I.

*Seven Foot Knoll, Md.
Hawkins Point, Md.
North River, N. C.
Wade Point, N. C.
*Laurel Point, N. C.
Roanoke River, N. C.
*Croatan, N. C.
Long Shoal, N. C.
*Hatteras Inlet, N. C.
*Gull Shoal, N. C.
*Bluff Shoal, N. C.
*Southwest Point Royal Shoal, N. C.

American Shoal, Fla.
*Sand Key, Fla.
Rebecca Shoal, Fla.
Eighth district:
Horn Island, Miss.
*Cat Island, Miss.
*Merrill Shell Bank, Miss.
*Lake Borgne, Miss.
*New Canal, La.
South Pass East Jetty, La.
Amite River, La.
*Ship Shoal, La.

* Indicates screw-pile structures (50).

Kilauea Point Light Station, Kauai, Hawaii.

Eighth district—Continued.
*Southwest Reef, La.
Oyster Bayou, La.

Seventeenth district:
Desdemona Sands, Oreg.
Willamette River, Oreg.

Cape Hatteras Light Station, N. C.

*Galveston Harbor, Tex.
*Red Fish Bar Cut, Tex.
*Half Moon Reef, Tex.
*Brazos Santiago, Tex.

Eighteenth district:
Oakland Harbor, Cal.
Southampton Shoal, Cal.
Roe Island, Cal.

* Indicates screw-pile structures (50).

ATTENDED LIGHTHOUSES ON CAISSONS.

First district:
- Lubec Channel, Me.
- Crabtree Ledge, Me.
- Goose Rocks, Me.
- Spring Point Ledge, Me.

Second district:
- Deer Island, Mass.
- Duxbury Pier, Mass.
- Butler Flats, Mass.

Third district:
- Sakonnet, R. I.
- Hog Island Shoal, R. I
- Borden Flats, Mass.
- Whale Rock, R. I.
- *Plum Beach, R. I.
- Conimicut, R. I.
- Latimer Reef, N. Y.
- Orient Point, N. Y.
- Saybrook Breakwater, Conn.
- Southwest Ledge, Conn.
- New Haven, Conn.
- Pecks Ledge, Conn.
- Greens Ledge, Conn.
- Cold Spring Harbor, N. Y.
- Stamford Harbor, Conn.
- West Bank, N. Y.
- Old Orchard Shoal, N. Y.

Third district—Continued.
- Romer Shoal, N. Y.
- Great Beds, N. J.
- Tarrytown, N. Y.
- Rockland Lake, N. Y.

Fourth district:
- Brandywine Shoal, Del.
- *Fourteen Foot Bank, Del.
- Miah Maull Shoal, N. J.
- *Elbow of Cross Ledge, N. J.
- Ship John Shoal, N. J.

Fifth district:
- *Thimble Shoal, Va.
- Newport News Middle Ground, Va.
- *Wolf Trap, Va.
- *Smith Point, Va.
- *Solomons Lump, Md.
- *Point No Point, Md.
- *Hooper Island, Md.
- Sharps Island, Md.
- Bloody Point Bar, Md.
- Sandy Point, Md.
- *Baltimore, Md.
- Craighill Channel Front, Md.

Eighth district:
- *Sabine Bank, La.

In designing lighthouse structures, particularly towers, it is customary to assume the wind, wave, current, ice, and other external pressures at the maximum in each instance, as lighthouses are commonly exposed to severe action from the elements. The usual procedure in determining the stability of a tower is to locate the common center of effort of all forces acting upon the structure to overturn it, and to proportion the weights (with due regard for the buoyancy of the water in the case of submarine work) so that the resultant of the active forces and the net weight falls properly within the outer edge of the base. In seeking this result the lateral resistance of the soil is considered, when the structure penetrates it for some distance, for the reason that it is often heavily compressed by a large deposit of riprap and offers good support. The superstructures are calculated in the manner commonly employed for chimneys and viaduct bents, with the exception that great stiffness and rigidity must be provided, as excessive vibrations are detrimental to the proper operation of the lamps and clocks of the illuminating apparatus.

* Indicates caissons sunk by pneumatic process (11).

Practically all the usual materials of construction are used in building lighthouses, as indicated in the foregoing paragraphs, such as stone masonry, brickwork, concrete (plain and reinforced), framed timber, and structural cast iron, wrought iron, and steel in various forms.

Cape Charles Light Station, Va.

The heights of towers vary according to the character of the shore and the importance of the light. On the Atlantic coast, where the beach as a rule is low and presents little relief, comparatively tall towers are required for the principal coast lights, while on the Pacific

coast, which is generally bold and high, a low tower erected on a prominent headland is generally sufficient. The tallest tower in the service is in the fifth district, at Cape Hatteras, N. C., and is 200 feet high. The names and locations of 20 towers with heights of 150 feet and over are as follows, in the order of height:

District.	Station.	Height, top of lantern above base.	District.	Station.	Height, top of lantern above base.
		Feet.			*Feet.*
5	Cape Hatteras, N. C	200	3	Barnegat, N. J	161
5	Hog Island, Va	191	6	St. Augustine, Fla	161
5	Cape Charles, Va	191	3	Shinnecock Bay, N. Y	161
8	Pensacola, Fla	171	5	Currituck Beach, N. C	161
3	Absecon, N. J	170	5	Cape Lookout, N. C	161
4	Cape May, N. J	170	5	Bodie Island, N. C	161
6	Mosquito Inlet, Fla	168	6	Charleston, S. C	161
6	Cape Fear, N. C	166	6	Cape Romain, S. C	161
3	Fire Island, N. Y	163	7	Dry Tortugas, Fla	157
5	Cape Henry, Va	163	7	Sombrero Key, Fla	153

9. LIGHTING APPARATUS AND ILLUMINANTS.

The earliest type of lighting apparatus consisted of an open coal or wood fire, with other inflammable materials, such as pitch, burned in a brazier, on top of the tower. When Boston Light was established, in 1716, the common oil burner of the period was used, inclosed in a lantern consisting of a cylinder of heavy wooden frames, holding small, thick panes of glass. The illuminant was fish or whale oil, burned in spider lamps with solid wicks and suspended by iron chains from the top of the lantern. Sperm oil was in general use about 1812, and was burned in a lamp constructed on the Argand principle, with a rough reflector and a so-called lens or magnifier. This apparatus was inclosed in a heavy wrought-iron lantern glazed with panes about 12 inches square. Improvements were gradually made in this apparatus, and by the year 1840 the useless bull's-eye "magnifiers" had been entirely removed, and the reflectors were made on correct optical principles, approaching the paraboloid in form, heavily silvered and properly placed. The lanterns were also improved by making the frames lighter, the panes larger, and by providing more adequate ventilation. To provide illumination all around the horizon, sets of from 8 to 20 lamps were used, placed side by side around the circumference of a circle. This arrangement, in its most complete form, is designated as the catoptric, or reflector system, and its relative merits as compared with the lenticular system originally devised by the French physicist Augustin Fresnel about 1822, was the source of much controversy in the years preceding the establishment of the Lighthouse Board in 1852. The first lens in the

United States was installed at Navesink Light, N. J., in 1841, and is still preserved by the Service. (See p. 91.)

The Fresnel apparatus consists of a polyzonal lens inclosing the lamp, which is placed at the central focus. The lens is built up of glass prisms in panels, the central portions of which are dioptric or refracting only, and the upper and lower portions are both reflecting

Point Reyes Light Station, Cal.

and refracting, described as "catadioptric." The advantages of this system lie in the greater brilliancy owing to the fact that a large proportion of the light given out by the source is concentrated by the prisms into beams useful to the mariner, and the consequent economy in the consumption of oil or other illuminant employed. The principal sizes of Fresnel lenses are classified according to their order, this depending upon the inside radius or focal distance of the lens—

that is, the distance from the center of the light to the inner surface of the lens—as given in the following table:

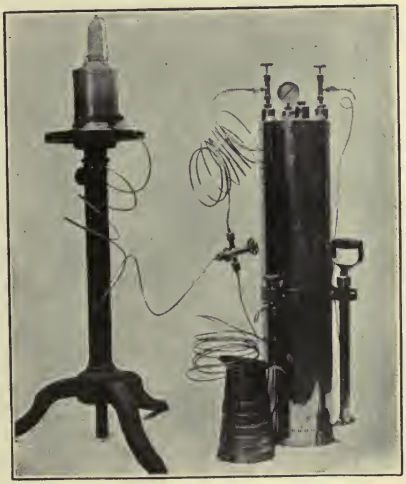
Order.	Millimeters.	Inches.
First	920	36.2
Second	700	27.6
Third	500	19.7
Three-and-a-half	375	14.7
Fourth	250	9.8
Fifth	187.5	7.4
Sixth	150	5.9

Pigeon Point Light Station, Cal.

One of the first steps taken by the Lighthouse Board in 1852 was to install lenses generally throughout the Service in place of reflectors, and this change was carried out as rapidly as possible, being practically completed in 1859. Lenses are in use at the present time at all important stations, with many subsequent improvements, however, in the design and arrangement of the panels. Improvements were also made from time to time in the lantern inclosing the lens, and the standard type now in use is of cast iron and bronze, with helical bars bent to the curvature of the lantern supporting lozenge-shaped panes of curved plate glass. These bars, crossing the beams of light diagonally, offer the least possible obscuration to the beams toward any point of the horizon. Suitable ventilators and flues to furnish the requisite draft and to carry off the products of combustion are

also provided, and the entire lantern is constructed in a number of sizes corresponding to the order of the lens which it accommodates.

The largest lens in use in the Lighthouse Service at present is that at Makapuu Point, Oahu, Hawaii, the landfall light for vessels bound from the States to the Hawaiian Islands. This is of the hyper-radiant order, a larger size than those regularly listed, and has a focal distance of 1,330 millimeters, or 52.4 inches; the inside diameter of the lens is therefore nearly 9 feet, and it is inclosed in a specially designed lantern of 16 feet inside diameter. It is the only one of its type in the Service. The number of other lenses, from the first to the sixth orders, inclusive, in commission on June 30, 1915, is as follows: 57 first order; 29 second order; 68 third order; 21 three-and-a-half order; 350 fourth order; 155 fifth order; and 86 sixth order; total, 766.

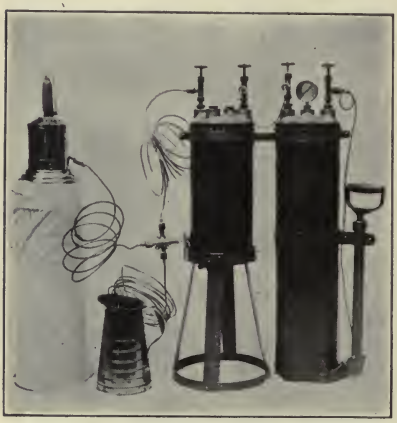


Incandescent oil-vapor lamp, 55-millimeter mantle, with single tank.

Reflectors are also in use, particularly for range lights, which are frequently employed to mark the axis or center line of a channel. For ranges two lights are necessary, and are placed a proper distance apart, usually with the rear light higher than the front, so that both lights show in line in the same vertical plane when the observer is in the center of the channel. Such reflectors are either silvered surfaces of metal in the form of a paraboloid, similar to head lights for locomotives or automobiles, or in improved forms of glass lenses with prismatic glass reflectors back of the light source. The latter are known as range lenses. On June 30, 1915, there were 100 reflectors and 41 range lenses in use in the Lighthouse Service.

During the transition period of lighthouse apparatus from reflectors to lenses sperm oil remained as the leading illuminant, but with the yearly diminution of the whale catch it gradually increased in price until its use became prohibitive. Colza oil was used in small quantities about 1862 and succeeding years, but during the period 1864–1867 lard oil was adopted as the standard illuminant, and was generally employed to 1878, when kerosene came into use. Its use was gradually extended, and by 1884 kerosene became the principal illuminant and so remains at the present time. The lamps used were also improved, passing through various styles to a special form of concentric wick, using five wicks for the largest sizes. The incan-

descent oil-vapor lamp, which is now generally employed for important lights, burns vaporized kerosene under an incandescent mantle, giving a much more powerful light with little or no increase in oil consumption. The kerosene is stored in a convenient size tank and is forced by compressed air, produced by operating a hand pump attached to either the oil tank or a separate air tank, into the vaporizer of the lamp. The air pressure varies from about 40 to 60 pounds per square inch and decreases so slowly during the operation of the light that a few strokes of the pump once or twice a night serves to maintain the required pressure. The kerosene is converted into vapor by a preheating torch when starting the lamp and subsequently by the heat of the mantle itself. The vapor issues from a minute nozzle, mixes with a proper supply of air, and ignites as a blue flame in a Bunsen burner under the mantle, which is thereby brought to a brilliant incandescence.



Incandescent oil-vapor lamp, 35-millimeter mantle, with double tanks.

Various other illuminants are now in use; oil gas is extensively used, particularly for lighted buoys; acetylene gas is used for lighted buoys and unattended lighted beacons; electric arc and incandescent lights and coal-gas lights are also used in special instances. Electric lights with distant control are employed in a number of cases where a reliable source of current may be obtained. Such lights may be on pierheads or structures built in the water, and can be easily operated by a switch on shore connected to the light by cable. A flashing characteristic may be arranged by means of an automatic make and break apparatus consisting of a small motor driving a clockwork and wheel with cams. The principal details as to illuminants used in the Service on June 30, 1915, are given in the following table:

	Lights.
Incandescent oil vapor	288
Kerosene wick	2,067
Acetylene	516
Oil gas	418
Coal gas	4
Electric incandescent	56
Electric arc	6

This table includes lighted buoys, but does not include the minor lights in the three river districts, of which there are 1,801, with kerosene wick lanterns.

All lights on the seacoast, with a few exceptions, are exhibited throughout the year, between sunset and sunrise. On the northern lakes and rivers lights are exhibited from sunset to sunrise at all seasons when vessels can enter the ports or are navigating in their vicinity. Some of these lights, notably on Lake Michigan, are maintained throughout the year. The closed time varies with the seasons, generally embracing a part of December, January, February, and a part or all of March. Gas buoys and light vessels in these localities are replaced by unlighted buoys in the fall when endangered by ice conditions, and again placed on their stations as early as practicable in the spring.

10. DISTINCTIVENESS AND CHARACTERISTICS OF LIGHTS.

In order to avoid the likelihood of confusion between lights, endeavor is made to give the lights distinct characteristics. As much of the coast was lighted before the introduction of modern lighthouse apparatus, the original lights were as a rule fixed, but at the more important of these stations apparatus has now been installed to make the lights flashing or occulting. This effect is produced in the case of flashing lights by revolving all or a part of the lens, which is specially constructed with panels of prisms for concentrating the rays into beams; and in the case of occulting lights by some form of traveling screen or shutter which obscures the light at intervals. In either case the motion is regulated by a clockwork generally actuated by weights wound over a drum and provided with the necessary governing mechanism so that the light and dark periods may occur in accurate sequence and produce the proper characteristic. The usual phases so attained are as follows: Fixed, showing a continuous steady light; flashing, showing a single flash at regular intervals; fixed and flashing, showing a fixed light varied at regular intervals by a single flash of greater brilliancy; group flashing, showing at regular intervals groups of flashes; occulting, showing a steady light suddenly and totally eclipsed at regular intervals; and group occulting, showing a steady light suddenly and totally eclipsed by a group of two or more eclipses at regular intervals. The foregoing refers only to lights which do not change color, commonly white, but further diversification is obtained by the use of red screens, changing the color from white to red in various combinations, such lights being known as alternating. In the case of gas or electric lights, the supply of gas or current is cut off at intervals by specially designed mechanisms whereby the characteristic may be adjusted as desired.

The terms "flashing" and "occulting" refer to the relative durations of light and darkness, a flash being an interval shorter than the duration of an eclipse, and an occultation being shorter than, or equal to, the duration of light. In approaching a light of varying intensity, such as fixed varied by flashes, or alternating red and white, due allowance must be made for the inferior brightness of the less powerful part of the light, which at a distance may show flashes only or white only, in the respective instances cited. Flashing lights may show a faint continuous light, due to reflection from the lantern, in clear weather and at short distances. White lights may have a reddish hue in some conditions of the atmosphere, and where lights change from white to red, by sectors or otherwise, there is a small amount of uncertain color on each side of the line of demarcation. Red sectors are produced by screens of colored glass; they are often employed to mark outlying dangers near the light, or the limits of channels, and are usually arranged so that the light shows white while a passing vessel is clear of such dangers, changing to red as the shoal or other obstruction is approached. Also, at the edge of a sector of visibility, the light is not cut off sharply, but gradually fades away.

To assist identification in daylight, towers are frequently distinguished by characteristic painting, in addition to peculiarities of form or outline. The effect of several colors, when combined in bold patterns of spirals, bands, or blocks, is quite striking in a number of important lighthouses.

The principal details of characteristics of lights in commission on June 30, 1915, are given in the following table:

	Lights.
Fixed white	1,316
Fixed red	864
Flashing or occulting	1,050
Fixed and flashing	69

The above table includes lighted buoys but does not include the 53 light vessels nor the 1,801 post lights on the Mississippi River and its tributaries, all of which are fixed. Of the light vessels, 29 have fixed white lights, 5 fixed red, 6 fixed white and red, and 13 flashing or occulting.

11. VISIBILITY AND CANDLEPOWER OF LIGHTS.

Under normal atmospheric conditions the visibility of a light depends upon its height and intensity; the distance due to the former being known as the geographic range, and to the latter as the luminous range. As a rule, for the principal lights the luminous range is greater than the geographic, and the distance from which the principal lights are visible is limited by the horizon only, and under some conditions of atmospheric refraction, the glare or loom of the light and occasionally the light itself may be visible far beyond the computed

geographic range of the light. On the other hand, and unfortunately more frequently the case, these distances may be greatly lessened by unfavorable weather conditions due to fog, rain, snow, haze, or smoke. Weak and colored lights are more easily obscured by such conditions. The distances of visibility in nautical miles for objects of various elevations in feet above sea level are given in the following table, which is employed in calculating the geographic range:

General lighting of Atlantic coast at entrances to Boston, New York, and Philadelphia.

Height, in feet.	Distance, in nautical miles.	Height, in feet.	Distance, in nautical miles.	Height, in feet.	Distance, in nautical miles.
5	2.55	60	8.85	130	13.03
10	3.61	65	9.21	140	13.52
15	4.43	70	9.56	150	14.00
20	5.11	75	9.90	200	16.16
25	5.71	80	10.22	250	18.07
30	6.26	85	10.54	300	19.80
35	6.76	90	10.84	350	21.38
40	7.23	95	11.14	400	22.86
45	7.67	100	11.43	450	24.24
50	8.08	110	11.99	500	25.56
55	8.48	120	12.52		

Distances corresponding to heights not included in the above table may be found approximately by the formula $D=\frac{8}{7}\sqrt{H}$, in which H = the elevation, or height, in feet, of the object above sea level, and D = the corresponding distance of visibility, in nautical miles. The formula is based on the mean curvature of the earth and is corrected for ordinary atmospheric refraction, and should be used only for moderate distances and elevations.

To make use of the above table in a practical way, it is necessary to add the distance corresponding to the height of the observer's eye above sea level, as illustrated in the following example:

A light 130 feet high is seen just at the horizon; what, under ordinary atmospheric conditions, is its distance from the observer?

	Nautical miles.
From table, distance corresponding to 130 feet height	13.03
Add distance corresponding to height of eye above sea level, say 15 feet	4.43
Distance of light	17.46

The highest light in the Service is at Cape Mendocino, Cal., the focal plane (or center of the light) of which is 422 feet above mean high water, thus giving it a geographic range of about 28 miles, under normal atmospheric conditions and with the observer's eye at a height of 15 feet. The following list gives the names and locations of 23 lights with focal plane heights of 200 feet and over, arranged in the order of height:

District.	Station.	Height of focal plane above mean high water.	District.	Station.	Height of focal plane above mean high water.
		Feet.			*Feet.*
18	Cape Mendocino, Cal	422	17	Cape Disappointment, Wash	233
19	Makapuu Point, Hawaii	420	9	Mona Island, P. R	231
18	Farallon, Cal	358	3	Staten Island, N. Y	231
9	Culebrita Island, P. R	305	3	Chapel Hill, N. J	221
9	Muertos Island, P. R	297	17	Cape Meares, Oreg	220
18	Point Reyes, Cal	294	19	Kilauea Point, Hawaii	216
18	Point Sur, Cal	270	18	Alcatraz, Cal	214
9	Cape San Juan, P. R	260	19	Molokai, Hawaii	213
17	Cape Blanco, Oreg	252	11	Grand Island, Mich	205
19	Aunuu Island, Samoa	250	17	Heceta Head, Oreg	204
3	Navesink, N. J	246	3	Block Island Southeast, R. I	201
16	Cape Hinchinbrook, Alaska	235			

The intensities of lights were formerly indicated merely by the order of the optical apparatus. So long as the lenses were similar in arrangement and the same type of lamp was used this gave a convenient basis of comparison, but with the introduction of more modern apparatus, with flash panels of great power and illuminating

apparatus of increased intensity, such distinctions became uncertain so far as indicating the relative brightness of lights. The statement of orders has now been generally superseded by a statement of the approximate candlepower in English candles. The actual determination of such candlepowers for large lenses is difficult, and it is in most cases estimated on the basis of accurate photometric measurements of small lights, proportioning the results so obtained to suit the elements of the lens under study, taking into account the intrinsic power of the light source, the horizontal and vertical angles of the various panels, the divergence of the rays at the source, the absorption or reflection of a percentage of the light by the prisms themselves, and such other factors as enter into consideration. Although only approximate, the final figures are, however, reasonably consistent, and from them the observer may judge of the relative brilliancy and power of the various lights.

Lens and diagram of Prisms, Kilauea Point.

The brightest light in the Service, and considered by some authorities as one of the brightest in the world, is at Navesink, N. J., on the highlands at the entrance to New York Bay, the candlepower of which is estimated at 25,000,000. The geographic range of this light is 22 miles, but its glare has been seen at a distance of 70 miles at sea under unusual conditions of the atmosphere. This great intensity is produced by a powerful electric arc inclosed in a modern lens of high magnification. The cost of maintenance is relatively large as compared with other stations, but is justified by the amount of commerce entering New York. The names and locations of 42 lights in the Service having candlepowers of 100,000 or greater are given in the following list in the order of brightness:

District.	Station.	Intensity of brightest part of light, in approximate English candles.	District.	Station.	Intensity of brightest part of light, in approximate English candles.
3	Navesink, N. J.	25,000,000	3	Fire Island, N. Y.	170,000
19	Molokai, Hawaii	620,000	6	Cape Romain, S. C.	170,000
2	Cape Cod, Mass.	580,000	6	Cape Canaveral, Fla.	170,000
4	Listons Range Rear, Del.	420,000	6	Jupiter Inlet, Fla.	170,000
6	Hillsboro Inlet, Fla.	420,000	17	Heceta Head, Oreg.	170,000
2	The Graves, Mass.	380,000	1	Monhegan Island, Me.	160,000
7	Dry Tortugas, Fla.	370,000	8	Ship Shoal, La.	160,000
12	White Shoal, Mich.	360,000	3	Montauk Point, N. Y.	130,000
3	Staten Island, N. Y.	300,000	4	Cape May, N. J.	130,000
18	Farallon, Cal.	280,000	5	Cape Charles, Va.	130,000
5	Hog Island, Va.	280,000	7	Carysfort Reef, Fla.	130,000
8	Pensacola, Fla.	280,000	8	Matagorda, Tex.	120,000
11	Whitefish Point, Mich.	270,000	1	Moose Peak, Me.	110,000
3	Shinnecock Bay, N. Y.	260,000	6	St. Augustine, Fla.	110,000
19	Kilauea Point, Hawaii	240,000	8	Cape San Blas, Fla.	110,000
18	Point Arena, Cal.	230,000	11	Stannard Rock, Mich.	110,000
11	Split Rock, Minn.	220,000	11	Outer Island, Wis.	110,000
17	Grays Harbor, Wash.	220,000	16	Cape Hinchinbrook, Alaska	110,000
11	Rock of Ages, Mich.	200,000	18	Point Cabrillo, Cal.	110,000
1	Petit Manan, Me.	180,000	2	Boston, Mass.	100,000
10	Buffalo, N. Y.	180,000	11	Manitou, Mich.	100,000

12. FOG SIGNALS.

The first fog signal in the United States was a cannon, installed at Boston Light in 1719, which was fired when necessary to answer the signals of ships in thick weather. Guns of various types were used at other lighthouses but have now been generally abandoned.

Bells were introduced at a comparatively early date, and at first were usually small and rung by hand to answer vessels. Larger bells were developed and striking machinery, governed by clockwork, devised for ringing a regular code or characteristic. Many bells are now in use, ranging from small hand bells up to 4,000 pounds in weight, and are of value for inside waters, harbors, etc., but are not sufficiently powerful for use on the seacoast.

Trumpets were the next improvement, and were first introduced about 1855. The original device consisted of a steel reed or tongue inclosed in a box with a large trumpet or resonator; the apparatus was sounded by means of compressed air produced by horsepower operating through suitable machinery. Although the sound was more penetrating than that of bells, the expense and inconvenience of the maintenance of a horse prevented its extended use. A modification was made, using an Ericsson hot-air engine instead of the horse as the motive power, and trumpets so equipped were established at a number of stations. A somewhat similar device, known now as a reed horn, is in use at a number of inside stations and is generally operated by compressed air, the compressors being driven by internal-combustion kerosene or gasoline engines. The sound is of moderate volume only and is not sufficiently loud for rough outside stations.

Steam whistles were investigated first in 1855, and an installation of a 5-inch whistle was made at Beavertail, R. I., in the fall of 1857, which was subsequently replaced about 1866 by a hot-air engine. The first station regularly equipped was at Cape Elizabeth, Me., where the installation was placed in commission on June 15, 1869. This consisted of a boiler and fittings with a 10-inch locomotive-type whistle, giving an 8-second blast every minute. This was the most powerful apparatus devised up to that time, and in point of volume and carrying power of the sound is still considered a very efficient aid. The rapid deterioration of the boilers, the expense of providing fresh water and fuel, the possibility of confusion with the whistle

Detroit River Light Station, Mich., showing fog signal.

of a passing vessel, and, above all, the time required to place the signal in operation in the event of sudden fog, are factors which have tended toward the nonuse or abandonment of this type of signal in practically all foreign lighthouse services, though it is still extensively employed in this country with whistles up to 12 inches in diameter.

Experiments with sirens were first made in 1867, and the first service installation was at Sandy Hook East Beacon on March 31, 1868. Originally this instrument consisted of a fixed disk, with a number of radial slits, back of which was a revolving plate with the same arrangement of slits, and a trumpet at the outer end. Steam at about 70 pounds pressure was driven through the apparatus,

and the escape and interruption of the jets through the openings in the disk and rotating plate produced the note. The apparatus has been modified and improved, and in its present form the revolving plate has been superseded by a cylinder with peripheral slots, known as the rotor, which is inclosed in a casing also with slots, leading to a horn or trumpet. The rotor is in some types driven by a separate auxiliary mechanism and in others automatically by the main supply of steam or air, this latter type being known as the automatic siren. Compressed air is generally employed as the sounding medium, though steam is used at a few places. The compressors are driven by internal-combustion engines. The principal advantages of the compressed-air siren are distinctiveness

Fog signal at Cape Henry Light Station, Va.

of note, which is entirely unlike the ordinary whistle, and quickness of starting, rarely over 10 minutes being required in any case, while some of the more recent installations may be sounded almost instantaneously.

A number of other signals have also been introduced, such as air whistles, in which the same type of plant as for an air siren is employed, except in regard to the sound-producing apparatus; also electrically operated bells and gongs, which do not differ essentially from those operated by clockwork.

Distant control is often used for electric fog signals, particularly when placed on the ends of jetties or breakwaters and other inaccessible places. The striking mechanism is usually driven by a motor incased in a storm-proof box or casing, with all gears running

in a bath of oil. A generally heavy and safe construction is adopted, and the striker is connected by submarine cable, if necessary, to the starting box, located on shore, where it is necessary only to throw a switch to start the apparatus.

Other types are the "sireno," an electrically driven blower siren, and the "diaphone," an instrument similar to the siren but having a reciprocating piston instead of a rotor. The diaphone is used quite extensively in the Canadian lighthouse service and a few installations have recently been made in this country. An experimental installation has also been made of an acetylene fog gun, which consists of an apparatus for firing an explosive mixture of air and acetylene gas by means of an electric spark.

Tests have been made with various shapes of resonators or trumpets for the most efficient propagation of the sound waves. A vertical mushroom trumpet has been found to give good results where an even distribution of the sound is desired at all points of the compass, as, for instance, in the case of light vessels. In other cases, particularly light stations marking important places, horizontal double-mouth horns have been found to give satisfactory results by effecting a wider and more even distribution of the sound.

Practically all fog signals as now installed are provided with a governing device for timing the strokes or blasts; this usually consists of a clockwork whereby the cycle is repeated every minute in order to facilitate identification.

Fog signals, though of the greatest value to the mariner, are subject to a number of aberrations, so that they can not be relied upon implicitly. Every endeavor is made to start fog signals as soon as signs of fog have been observed at the station, but such signals should be regarded by mariners as auxiliary aids only and soundings should be taken in all conditions of doubt. A fog often creeps imperceptibly toward the land and a vessel may have been in it some time before it is observed at the signal. Sound is conveyed irregularly through the atmosphere and mariners can not place dependence on judging their distance from the fog signal by the power of the sound. Under certain conditions of the atmosphere the sound may be lost a short distance from the signal, as there may be silent areas or zones; or the sound may carry much farther in one direction than in another, and these conditions may vary in the same locality within short intervals of time.

It is often observed that in any given direction from a fog signal, and near its limit of audibility, the sound may become extremely faint, and at a greater distance it may again become quite distinct. It should never therefore be assumed that fog signals are not in operation because the sound is not heard, even when in close proximity. Frequently noises in the ship may interfere with the hearing

from the deck or bridge, especially with the engines running. In such cases it is well to stop the ship and listen in a quiet position. Whistling and bell buoys are sounded only by the action of the sea; therefore in calm weather they are less effective or may not sound.

However, by due caution in navigation and the prudent use of the lead, sufficient warning of danger is generally obtained. In order to guard against the possibility of breakdowns, all modern fog-signal installations are in duplicate, so the second signal may be started at once in event of accident to the first. Care is taken to give each signal an equal amount of use, as far as practicable. These precautions are taken owing to the difficulty of making quick repairs at the station.

Submarine signals, which have been introduced in recent years, have as a rule a more effective and constant range of audibility than signals sounded in air. Such a signal consists essentially of a specially designed bell, submerged sufficiently to avoid wave disturbance, with some form of striking mechanism. On light vessels the bell is usually swung over the ship's side on a chain attached to a davit, and the striking device is operated pneumatically to ring a certain set of blows at prescribed intervals. At light stations the bell is usually supported on a tripod, placed on the sea bottom, a short distance away from the light, and the striking mechanism operated electrically through a cable, with characteristic number of blows at regular intervals. When attached to buoys a swinging vane is provided, which is forced up and down as the buoy surges in the sea. The motion of the vane causes a spring to stretch, which is released at a sufficient tension, striking a blow on the bell. The blows are of equal intensity, being due to the elongation of the spring, although the interval between them varies with the condition of the sea, and no regular code of blows is therefore practicable.

In order to obtain the best results with submarine bells, a receiving apparatus, somewhat similar to a telephone, has been devised for attachment to a vessel. This is apparently more effective in vessels of deep draft, and a ship so equipped may determine the approximate bearing of the signal. The sound may be heard also on vessels not equipped with receiving apparatus, by observers below the water line, and particularly in iron or steel ships, but the bearing of the signal can not then be readily determined.

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 residents in the vicinity of the signal.

The numbers and types of the 578 fog signals in use on June 30, 1915 (not including sounding buoys), are shown in the following table:

Steam (112):	
Whistle	108
Siren	4
Air (150):	
Whistle	13
Siren	82
Diaphone	3
Sireno (electric)	6
Reed horn	46
Bell (261):	
Clockwork	231
Electric	13
Engine	1
Hand	16
Horn (4): Hand	4
Gun (1): Acetylene	1
Submarine bells (50):	
On light vessels, operated by compressed air	38
On bottom, operated by electricity	3
On buoys, operated by the sea	9
Total	578

Since 1885 systematic records have been kept of the number of hours of fog or thick weather observed per year at each fog-signal station. These figures present interesting statistics, and are of some value in approximating the prevalence of fog at various localities when proposed new signals are under consideration. A summary of the principal results is given in the subjoined table.

District.[a]	Number of stations.	Mean hours per year for district.	Maximum observed.			Highest annual average.		
			Station.	Hours.	Year.	Station.	Average.	Years.
1	56	874	Seguin	2,734	1907	Petit Manan	1,691	31
2	36	680	Great Round Shoal Light Vessel.	1,727	1907	Pollock Rip Slue Light Vessel.	1,175	14
3	100	463	New London Harbor	1,809	1885	Block Island SE	831	31
4	12	363	Delaware Breakwater	912	1887	Delaware Breakwater	525	30
5	85	218	Cape Henry	902	1904	Baltimore	426	7
6	7	135	Martins Industry Light Vessel.	320	1898	Brunswick Light Vessel.	183	8
7	1	112	Egmont Key	128	1913	Egmont Key	112	3
8	16	281	Cubits Gap	819	1907	Cubits Gap	562	10
10	15	228	Cleveland Breakwater	1,224	1915	Buffalo Breakwater	524	22
11	47	310	Thunder Bay Island	1,085	1909	Middle Island	541	11
12	54	359	Calumet Harbor	2,269	1913	Calumet Harbor	1,196	9
16	10	278	Scotch Cap	1,144	1915	Cape Hinchinbrook	555	5
17	29	439	Swiftsure Bank Light Vessel.	1,770	1912	Swiftsure Bank Light Vessel.	1,203	9
18	40	606	San Francisco Light Vessel.	2,145	1915	Point Reyes	1,337	31

[a] No fog-signal stations in the ninth, thirteenth, fourteenth, fifteenth, and nineteenth districts.

The absolute maximum record is that at Seguin, Me., 2,734 hours in 1907, equivalent to about 30 per cent of the entire year (8,760 hours). The maximum observed on the Great Lakes was at Calumet

Harbor, near Chicago, Ill., where 2,269 hours of fog occurred in 1913, amounting to about 26 per cent of the year. This and other stations near large cities are affected somewhat by smoke in the vicinity. The highest Pacific coast record was observed in 1915 on San Francisco Light Vessel, Cal., being 2,145 hours, or about 24 per cent of the year.

Fog is more generally prevalent throughout the first district than any other, as shown by the following table, from which it will be seen that out of 29 stations in the entire service averaging over 1,000 hours of fog per year 14, or practically one-half, are in that locality:

District.	Station.	Average hours of fog per year.	Years of record.	Percentage of fog based on entire period.
1	Petit Manan, Me	1,691	31	19
1	Whitehead, Me	1,544	31	18
1	Libby Islands, Me	1,536	31	17
1	Matinicus Rock, Me	1,399	31	16
1	Great Duck Island, Me	1,384	25	16
1	West Quoddy Head, Me	1,372	31	16
1	Moose Peak, Me	1,356	3	15
1	Egg Rock, Me	1,341	11	15
18	Point Reyes, Cal	1,337	31	15
1	Seguin, Me	1,331	31	15
1	Mount Desert, Me	1,304	24	15
1	Little River, Me	1,219	10	14
1	The Cuckolds, Me	1,208	23	14
17	Swiftsure Bank Light Vessel, Wash	1,203	9	14
12	Calumet Harbor, Ill	1,196	9	14
2	Pollock Rip Slue Light Vessel, Mass	1,175	14	13
18	Bonita Point, Cal	1,143	31	13
1	Manana Island, Me	1,116	31	13
18	Point Arena, Cal	1,076	31	12
18	Blunts Reef Light Vessel, Cal	1,065	10	12
2	Great Round Shoal Light Vessel, Mass	1,064	23	12
1	Nash Island, Me	1,063	10	12
2	Pollock Rip Light Vessel, Mass	1,061	31	12
18	Point Cabrillo, Cal	1,045	7	12
18	Humboldt, Cal	1,037	7	12
18	San Luis Obispo, Cal	1,027	25	12
2	Nantucket Shoals Light Vessel, Mass	1,005	23	11
18	San Francisco Light Vessel, Cal	1,004	18	11
2	Gloucester Breakwater, Mass	1,002	4	11

13. BUOYS.

Buoys are, as a rule, employed to mark shoals or other obstructions, to indicate the approaches to and limits of channels or the fairway passage through a channel, and in some cases to define anchorage grounds. There were some buoys in service at the time of the transfer of the lighthouses to the Federal Government in 1789. Buoys originally were either solid wooden spars or built up in various shapes of wooden staves, like barrels. Wooden spars are still extensively used, particularly in inside waters; but built-up buoys are now constructed of iron or steel plates.

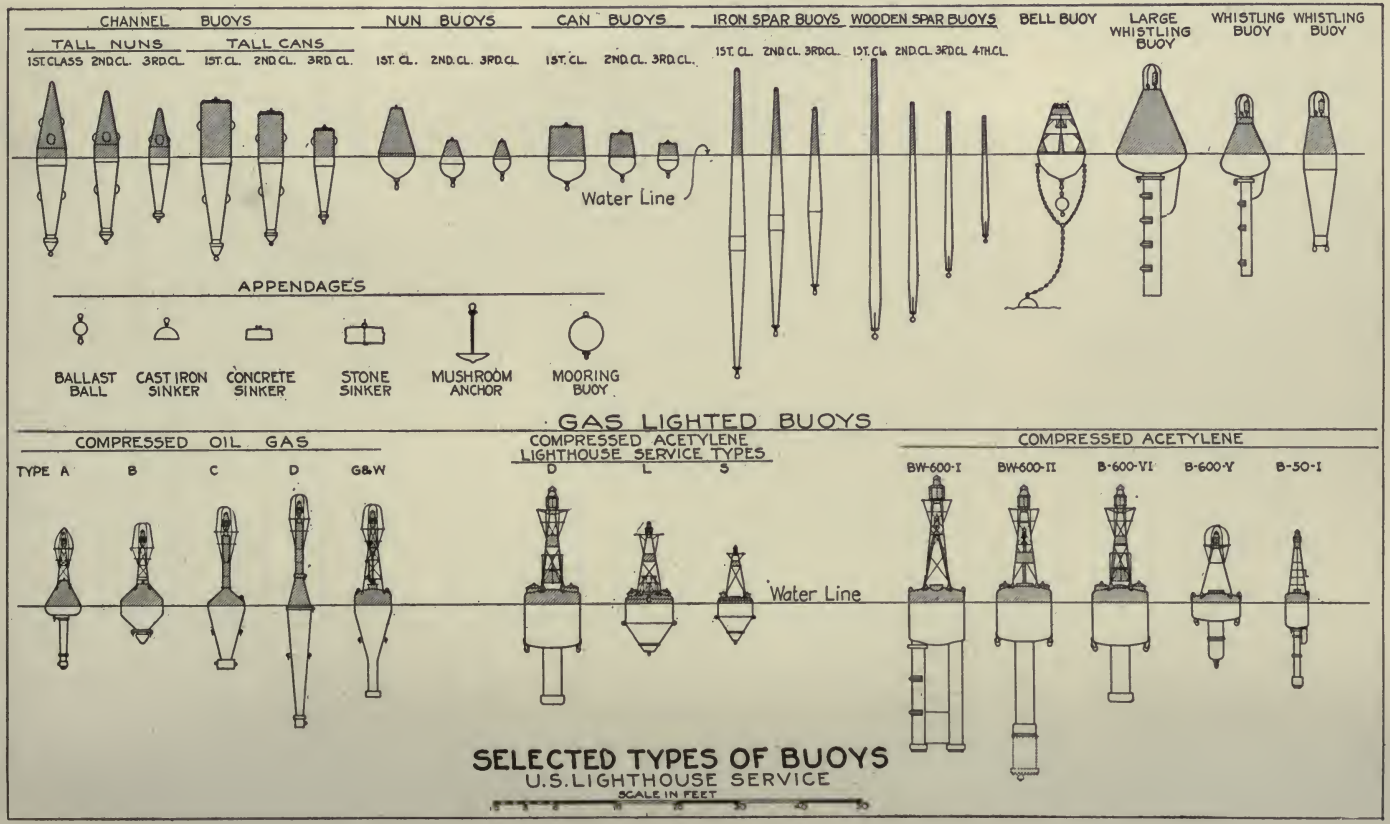
In order to give the proper distinctiveness, buoys are given certain characteristic colors and numbers; and following the uniform practice of maritime nations generally, Congress by the act of September 28, 1850, prescribed that all buoys along the coast or in bays, harbors,

sounds, or channels shall be colored and numbered so that passing up the coast or sound or entering the bay, harbor, or channel, red buoys with even numbers shall be passed on the starboard or right hand; black buoys with odd numbers on the port or left hand; buoys with red and black horizontal stripes without numbers shall be passed on either hand, and indicate rocks, shoals, or other obstructions, with channels on either side of them; and buoys in channel ways shall be colored with black and white perpendicular stripes, without numbers, and may be passed close-to, indicating mid-channels. Buoys to mark abrupt turning points in channels or obstructions requiring unusual prominence, are fitted with perches or staves surmounted by balls, cages, or other distinctive marks.

Buoys marking light-vessel stations are placed in close proximity to the light vessel, are colored in a similar manner, and bear the letters LV with the initials of the station they mark. Buoys defining anchorage grounds are painted white, except those used for such purposes at a quarantine station, in which case they are painted yellow.

To assist further in distinguishing buoys, the ordinary unlighted types are made in two principal shapes in the portion showing above the water line: Nun buoys, conical in pattern with pointed tops, and can buoys, cylinder shaped with flat tops. When placed on the sides of channels, nun buoys, properly colored and numbered, are placed on the starboard or right-hand side going in from sea, and can buoys on the port or left-hand side. The numbers and letters placed on all buoys are formed by standard stencils, to insure uniformity, and the largest size practicable is used so that these may show as prominently as possible. White characters are painted on black buoys and black characters on red buoys.

Buoys are anchored in their positions by various types of moorings, depending on the character of the bottom and the size and importance of the buoy. They are placed in position and cared for by the lighthouse tenders, which are provided with specially designed derricks and lifting gear for handling them. It is customary to relieve all buoys at least once a year for overhauling, repairing, cleaning, and painting, and oftener when circumstances render it necessary. Although among the most useful of aids to navigation, buoys are liable to be carried away, dragged, capsized, or sunk, as a result of ice or storm action, collision, and other accidents, and therefore may not be regarded as absolutely reliable at all times. Great effort is made, however, by the Service to maintain them on station in an efficient condition, which frequently requires strenuous and hazardous exertions on the part of the vessels charged with this duty. It is necessary to keep an ample supply of spare or relief buoys, with the necessary appendages, always on hand to provide for emergencies, and the systematic relieving of buoys on station.


CHANNEL BUOYS
TALL NUNS
1ST CLASS 2ND CL. 3RD CL.
TALL CANS
1ST. CL. 2ND CL. 3RD CL.
NUN BUOYS
1ST. CL. 2ND CL. 3RD CL.
CAN BUOYS
1ST. CL. 2ND CL. 3RD CL.
IRON SPAR BUOYS
1ST. CL. 2ND CL. 3RD CL.
WOODEN SPAR BUOYS
1ST. CL. 2ND CL. 3RD CL. 4TH CL.
BELL BUOY
LARGE WHISTLING BUOY
WHISTLING BUOY
WHISTLING BUOY
Water Line
APPENDAGES
BALLAST BALL
CAST IRON SINKER
CONCRETE SINKER
STONE SINKER
MUSHROOM ANCHOR
MOORING BUOY
GAS LIGHTED BUOYS
COMPRESSED OIL GAS
TYPE A
B
C
D
G&W
COMPRESSED ACETYLENE LIGHTHOUSE SERVICE TYPES
D
L
S
Water Line
COMPRESSED ACETYLENE
BW-600-I
BW-600-II
B-600-VI
B-600-V
B-50-I
SELECTED TYPES OF BUOYS
U.S. LIGHTHOUSE SERVICE
SCALE IN FEET
0 5 10 15 20 25 30 35 40 45 50

Buoys may be divided broadly into two general classes, lighted and unlighted, of which the latter are in the great majority. Unlighted buoys comprise spars, both wooden and iron, can, nun, bell, and whistling buoys, with a few other types for special purposes. Lighted buoys are provided with some form of gas apparatus and a lantern; frequently a bell or whistle is also attached, in which case they are known as combination buoys. A brief description of each kind follows.

Wooden spar buoys are usually cedar, juniper, or spruce logs, trimmed, shaped, and provided with an iron strap and band at the lower end for attaching the mooring, which is as a rule a heavy stone or concrete block, or iron sinker, sometimes shackled directly to the buoy, or to a short piece of chain, as required by the depth. Such buoys are among the most economical and generally used of all aids, and are particularly employed in rivers and harbors. They are, however, easily damaged by ice or collision, and in some waters suffer greatly from the attacks of the teredo and other marine borers, although this may be reduced by special paints or other protective treatment when not unduly expensive. Four sizes or classes are in use, varying in length from 50 to 20 feet over all, to conform properly to the depth of water at the position of the buoy. The weights of such buoys vary from 1,500 to 350 pounds each.

Iron spar buoys are built up of iron or steel plates in the form of wooden spars, and are particularly valuable where severe ice conditions exist, or where the teredo is unusually active. They are naturally more expensive and heavier to handle, thus restricting their use to special localities. They are made in three classes, in lengths of from 50 to 30 feet over all, weighing from 4,000 to 2,000 pounds, respectively.

Cans and nuns, as already noted, are built of iron or steel plates, the former showing a cylindrical and the latter a conical top, and are the most extensively used of metal buoys. The interior of the buoy is divided into two or more compartments, by bulkheads or diaphragms, to prevent sinking when damaged. Each kind is built in three classes or sizes, and in addition two general types are in use, the ordinary type and the tall type, or channel buoys; the latter being a modern development of a larger and more prominent buoy for use in deeper water. These buoys weigh from 8,300 to 700 pounds each, according to size, and are generally moored by means of a stone or concrete block, or a specially designed hemispherical cast iron sinker, shackled on a length of chain about two or three times the depth of water in which the buoy is placed. The ordinary type buoys commonly require a cast-iron ballast ball attached directly below the buoy, the mooring chain being shackled in turn to the

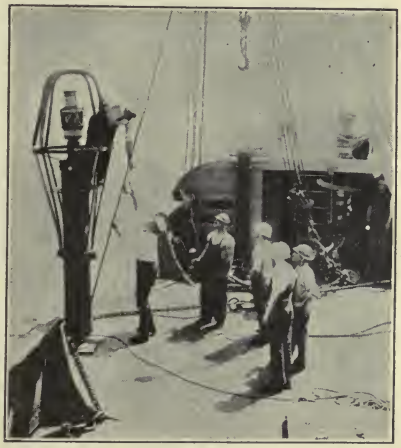
lower end of the ballast ball; this is necessary to assist the buoy in maintaining an upright position, regardless of tidal or other currents. The ballast ball is not needed with the tall type buoy, which has more stability, due to its greater draft and to a fixed counterweight of cast iron bolted on its lower end. To prevent kinking or twisting of the chain, a swivel is occasionally placed in the mooring chain for all types.

Bell buoys have a hemispherical-shaped hull, built of steel plates, with flat deck, and carry a structural-steel superstructure which supports a bronze bell and usually four iron clappers. The motion of the buoy in the sea causes these clappers to strike the bell, so that the action is entirely automatic. Although the buoy is quite sensitive and responds to even a very slight motion of the waves, the sound may be faint or absent in unusual calms. This type of buoy is especially efficient in harbors or inside waters for marking points where a sound signal is desired. Bell buoys weigh about 6,900 pounds each, complete, and are moored by means of a bridle of chain attached to lugs on the opposite sides of the hull near the water line, the main mooring being shackled to the middle and lowermost part of the bridle and extending in the customary scope of chain with a swivel to a heavy cast-iron sinker on the bottom. A large-sized ballast ball is shackled to a mooring eye at the bottom of the buoy, and the whole effect of this arrangement is to assist in the pendular motion necessary for ringing the bell.

Whistling buoys are built of steel plates, and consist of a pear-shaped body with the smaller end uppermost, with a long open tube on the lower end. This tube extends throughout the length of the buoy, and is closed at the upper end by a headplate on which is mounted a check valve and a whistle on the superstructure of the buoy. The sound is produced by the air in the upper portion of the tube being compressed by the falling of the buoy in the waves, its means of escape being through the whistle. A fresh supply of air is drawn through the check valve as the buoy rises again. Like the bell buoy, the sound is automatic, depending solely on the motion of the waves, and therefore the whistle may be silent when the sea is very smooth. The whistling buoy is most efficient in rough outside waters, where a ground swell exists, and is employed for important points where a sound signal is considered desirable. It is generally moored with a single chain of the proper scope and a heavy iron sinker. The weight of the buoy is about 6,500 pounds. For great depths, where the necessary quantity of chain impedes the flotation of the ordinary size of this buoy, a special and larger size is in use similar to the regular size in design and operation but weighing about 11,000 pounds.

Lighted buoys are a modern invention, having come into use within about the last 30 years, and are considered by mariners generally as among the most valuable of recent developments in coast lighting. The first buoy of this kind was a gas buoy established experimentally by its manufacturers in 1881 near Scotland Lightship, entrance to New York Bay; it was officially taken over by the Lighthouse Service in April, 1884. Electric buoys, operated by a cable from shore, were established in Gedney Channel, New York Bay, in November, 1888, and were discontinued in 1903, after many mishaps, due chiefly to breaking of the cable. The operating expense was high, and in the final year of service these buoys were extinguished through accident on 120 nights.

All of the lighted buoys now in service use compressed gas, either oil gas or acetylene. Various types of self-generating acetylene buoys have been in use, operating on the carbide-to-water and water-to-carbide principles, but have been abandoned on account of uncertainty of length of run difficulty of cleaning, and danger of explosion.



Testing pressure in gas buoy, New York Bay.

In the types now in use the gas, at a pressure of about 12 atmospheres, is contained either directly in the body of the buoy or in tanks fitted into compartments of the body, and is piped to the lantern at the top of the superstructure. If the light is flashing, as is commonly the case, a small pilot light burns continuously and ignites the main burner as gas is admitted from the flashing chamber, which is a regulating compartment in the base of the lantern provided with a flexible diaphragm and valves for cutting off and opening the flow of gas at intervals, the operation being due to the pressure of the gas in the reservoirs. The length of the light and dark periods may be adjusted to produce the desired characteristic, such as five seconds light, five seconds dark, etc. Some types burn the gas as an ordinary flat flame, while others make use of an incandescent mantle, which is, however, not wholly satisfactory in rough water on account of breakage.

Gas buoys are made in a number of different sizes, weighing from 2,800 to 34,500 pounds each, depending on the importance of the location, and burn continuously by night and day for intervals of a month to a year without recharging. The apparatus is patented by

the various makers and has been brought by them to a considerable degree of perfection, so that considering the rough usage to which such buoys are subjected by the elements, gas buoys are generally satisfactory within the limits of reliability to be expected from such aids. They should not, however, be relied upon implicitly, as they may become extinguished or dragged from their proper positions, or the apparatus may be out of order and some time may elapse before the buoy can be reached to repair or relight it. Gas buoys furnish valuable marks for approaching entrances, defining channels, and marking dangers, and at times may obviate the necessity for light vessels or lighthouses on submerged sites, either of which would be many times more expensive. There is a constant demand among mariners for more gas buoys and for buoys with more brilliant lights.

Gas and whistling buoy, entrance to New York Bay.

Many gas buoys are provided with some automatic form of sound-producing device, such as a bell or whistle, and in a few cases have both a whistle and a submarine bell. These operate in the manner heretofore described (see pp. 44 and 50), and are of especial value in fog or thick weather, or in case of accidental extinguishment of the light.

The numbers and types of the 7,290 buoys in the Lighthouse Service in commission on June 30, 1915, were as follows:

Unlighted buoys (6,811):	
Wooden spars	4,516
Iron spars, cans, and nuns	1,972
Bell buoys	237
Whistling buoys	86
Lighted buoys (479):	
Gas buoys	335
Gas and bell buoys	81
Gas and whistling buoys	55
Gas, whistling, and submarine bell buoys	8
Total	7,290

14. RIVER LIGHTING.

The lighting of nontidal rivers is limited to those which have been specifically authorized by law; these, however, now embrace nearly all the important streams of the country. In the Lighthouse Service three districts, the thirteenth, fourteenth, and fifteenth, are engaged entirely in the lighting of the Mississippi River and its principal tributaries. The lighting of these streams began in 1874 and has since been continued. The problem presented by these districts differs considerably from that found in the coast and lake districts. As noted in a previous chapter (p. 5), the inspectors in charge of these districts are officers of the Corps of Engineers, United States Army and are usually those in charge at the same time of the river improvement work of the War Department proceeding in the vicinity.

The lights used are simple in character and are generally known as post lights. In some cases these consist of an ordinary 14-inch hand lantern, inclosed in a square or triangular tin case with plain glazed sides; and in other types a specially designed post lantern, with a 1-inch flat wick and pressed glass lens about 8 inches in diameter, is used inside a small triangular case, with glass on two or three sides as the location requires. A wire screen is fitted to the top of the lantern to prevent the entrance of insects. These lights burn kerosene and as a rule are fixed white in character, although some are fitted with red globes or shades.

The channel of these rivers generally follows the concave banks, with crossings where the concavity shifts from one side of the river to the other, and the lights are located so as to show the general shapes of the bends and the positions of the crossings. The lights are usually placed on the banks of the river and the crossings marked by two range lights, one ahead, the other astern. Where the crossing is crooked it is sometimes necessary to have a series of range lights and during low water some of the lights are placed on sand bars or on small floats or rafts, these latter being known as float lights.

The most complete type of structure on which post lights are placed consists of a post with braces and steps, with the lantern on top. Wings are attached to make a better daymark, and are set in oblique positions with a view to catching the sunlight in various directions and thus assist the pilots in locating it. The wings are perforated to diminish wind action, and the stations are further designated by numbers placed conspicuously above them. It is necessary to shift the position of many of these lights from time to time, on account of changes in the channel, caving banks, and other reasons. For this reason some of these structures are of a more temporary character than the type just described; in emergencies the light may even be attached to a tree.

Where the channel is narrow or crooked, or the ends of wing dams are to be marked, buoys have been found desirable, and a special type has been developed. It was found that the buoy best adapted to fulfill the conditions peculiar to these waters is one having but a slight reserve buoyancy, in order that drift and other floating objects coming in contact with it will pass over the buoy, submerging but not displacing it. One type in use is a built-up spar consisting of a central barrel-shaped section fitted with galvanized sheet-iron cones or hoods at each end. A slide for a hand lantern is provided at the upper end, and the buoy is moored by a light wire cable attached to the lower end, with an iron weight for a sinker. Another type is composed of two galvanized sheet-iron cones placed base to base;

Mississippi River Post Light.

the upper cone is a right cone, but the lower is oblique in order that the buoy may not spin in the current and untwist the light wire anchor cable.

The river lights are attended by persons living in the vicinity, known as laborers in charge, and in some cases a group of several lights may be in charge of the same person when they may be conveniently cared for in that manner. These laborers are not required to devote their entire time to the Service, as in the case of regularly appointed keepers. The supplies for the lights are delivered by the lighthouse tender or Engineer Department vessels, and such vessels also patrol the river and make the changes in location as required. Captains and pilots of river steamers are supplied with franked postal cards on which they are requested to report to the inspector's office whenever a light is found not burning properly.

Of the 2,961 aids in commission on June 30, 1915, classed as minor lights and float lights, 1,801, or about 61 per cent, were in the three river districts. In the remaining districts the systems of river lighting are naturally not so extensive, although the aggregate number of such lights in rivers like the Connecticut, Hudson, Delaware, and St. Johns on the Atlantic coast, and the Columbia and Willamette on the Pacific coast, together with many other shorter streams, constitutes no small part of the activities of many districts. A specially designed post lantern is manufactured by the Lighthouse Service for this work in the coast districts. It is constructed of brass, with an outside protecting cage, and contains a pressed glass lens of 200 millimeters (approximately 8 inches) diameter, with a burner of two 1-inch flat wicks, using kerosene. Great pains were taken to make the lantern wind proof, and at the same time to provide proper ventilation and a reasonably bright light. The type now in use has been found satisfactory, even in gales of considerable violence. The lights are carried on various types of simple structures, ranging from single posts on shore to pile clusters for use in the water. They are attended by laborers, as in the case of the river districts, or sometimes by the keepers of some adjacent light station.

15. LIGHTHOUSE DEPOTS.

An important feature of lighthouse work consists of the lighthouse depot, which is used as a base of supplies and repairs and a base station for vessels. There are 44 such depots in the various districts, as given in the following list. The principal depot of the district is indicated by the larger type.

First district:
- Bear Island, Me.
- Little Diamond Island, Me.

Second district:
- Lovells Island, Boston, Mass.
- Woods Hole, Mass.

Third district:
- Goat Island, R. I.
- Juniper Island, Vt.
- New London, Conn.
- Tompkinsville, Staten Island, N. Y.
- Tucker Beach, N. J.

Fourth district:
- Edgemoor, Del.
- Lewes, Del.

Fifth district:
- Annapolis, Md.
- Chincoteague, Va.
- Lazaretto Point, Md.
- Point Lookout, Md.

Fifth district—Continued.
- Portsmouth, Va.
- Washington Wharf, D. C.
- Washington, North Carolina.

Sixth district:
- Castle Pinckney, Charleston, S. C.

Seventh district:
- Egmont Key, Fla.
- Key West, Fla.

Eighth district:
- Fort San Jacinto, Galveston, Tex.
- Mobile, Ala.
- Port Eads, La.

Ninth district:
- Culebrita Island, P. R.
- Guantanamo Bay, Cuba.
- San Juan, P. R.

Tenth district:
- Buffalo, N. Y.
- Erie, Pa.

Tenth district—Continued.
Maumee Bay, Ohio.
Rock Island, N. Y.
Sandusky Bay (Cedar Point), Ohio.
Eleventh district:
Detroit, Mich.
Minnesota Point, Minn.
St. Marys River, Mich.
Twelfth district:
Charlevoix, Mich.
Milwaukee, Wis.
Twelfth district—Continued.
St. Joseph, Mich.
Sixteenth district:
Ketchikan, Alaska.
Seventeenth district:
Ediz Hook, Wash.
Tongue Point, Oreg.
Eighteenth district:
Goat Island, Cal.
Nineteenth district:
Honolulu, Hawaii.

To be of the greatest efficiency depots should be central in location with reference to the district, adjacent to important mercantile centers for facilitating purchases, and easily accessible by teams, rail, and water. Many of the depots in the service were originally intended only for the storage of relief or spare buoys, and were often located on islands or other remote places; hence not fulfilling the ideal conditions just outlined. Constant effort is made, however, to improve such conditions as available funds permit, and, as an instance, the case of the sixth district may be cited, in which a new depot on the mainland, on the Ashley River side of Charleston, S. C., is being made ready in place of the old depot on an island in the harbor.

The principal features of a depot are a dock and a storehouse; to these other structures, such as isolated oil houses for inflammable articles, lamp, machine, carpenter and blacksmith's shops, cement houses, buoy, lumber, and coal sheds, offices, keepers' dwellings, derricks and other lifting gear, tramways, and similar appurtenances, are added as may be required by the extent and character of the work in the respective districts.

The principal work at a lighthouse depot consists in caring for the articles in stock and the filling of approved requisitions for the use of such articles in the work of the Service, also in the cleaning, painting, and overhauling of the buoys and appendages. Tools and equipment for working parties on stations and vessels are also stored at the depots when not in active use; damaged and worn-out articles are brought to the depot from the vessels and stations for repair or survey and condemnation, as their condition warrants. The depots are headquarters for the vessels of the Lighthouse Service, both for the routine work of the tenders and for examination and sometimes repair of tenders and light vessels.

The general depot at Tompkinsville, N. Y., which is much larger than the customary district depot, has already been mentioned on page 5. This depot fills the double purpose of being headquarters for the third district as well as a central supply station, repair shop, and purchasing agency for the entire Service. Proposals for annual supplies are issued from this depot for articles to be delivered on

Wharves at General Lighthouse Depot, Tompkinsville, N. Y.

contract; these are then issued to other districts on the basis of requisitions made by the inspectors and approved by the Commissioner. The various shops at this depot are employed chiefly in the manufacture and repair of special apparatus used by the Service, much of which can not be obtained from regular dealers at an economical price; and a considerable amount of repair work to vessels is also performed. A small laboratory is also maintained for the analysis and testing of articles used in the Service; and a large amount of experimental work is done on various light and sound producing devices, either submitted by the makers for test or designed by the technical force of the Service. About 210 persons are engaged at this depot; this number including also those who are directly concerned in the work of the third district.

16. LIGHT VESSELS.

The Lighthouse Service maintains light vessels on 53 stations, and has for this purpose 66 light vessels, of which 13 are relief vessels; all figures being those of June 30, 1915. They are generally employed for marking dangers at sea, approaches or entrances to harbors, or important points in the courses of vessels, where a lighthouse would not be feasible or economical, and are of particular value in providing both a light and a fog signal which may be approached close-to, thus enabling mariners to fix their position at sea with reasonable certainty. In this respect light vessels are superior to lighthouses, as in the case of the latter, in the majority of instances, due allowance must be made for a safe distance in passing. A valuable secondary advantage is the fact that light vessels may be shifted to meet varying conditions of traffic, such as changes in shoals or channels, use of deeper draft vessels, and similar contingencies.

The first light vessel established in this Service was in the summer of 1820, at Willoughby Spit, Hampton Roads, Chesapeake Bay, Va., but proved too small for the station and was moved to Craney Island, Elizabeth River, Va. A larger vessel was stationed on Willoughby Spit in 1821. The first outside vessel was placed 7 miles off Sandy Hook, N. J., in 1823. The idea of lightboats, as they were then called, became popular, and by 1839 there were 30 in service, most of them being small craft in inside waters. The largest vessel was that on the Sandy Hook station, which had a tonnage of 230.

By the year 1852, when the Lighthouse Board was established, there were 38 light vessels in service, of which number 26 were in bays or sounds. The maximum number of men employed on each was 10 for the most exposed stations, varying down to 4 for those least exposed. The type of vessel used at that time was evidently not wholly suitable for the purpose, as there were often complaints that the vessels were frequently blown from their moorings, and that the

expense of maintenance and repair was excessive, considering also the comparative feebleness of the lights.

The early activities of the board were directed toward the replacement of many inside light vessels by lighthouses, screw-pile foundations being used extensively for the latter; and more careful attention was given to the design of vessels suitable for exposed outside stations. Wooden construction was the rule up to the year 1882, when the first iron light vessel, *No. 44*, was built, for station on the seacoast of New Jersey. About the same time several vessels of the composite type, with steel frames and wooden sheathing, were constructed; but the modern tendency has been toward all-steel construction. Another practical feature of design which has greatly increased the efficiency

San Francisco Light Vessel No. 70, Cal.

of light vessels is the use of propelling machinery, thus enabling them to proceed to and from their stations under their own power and to assist them in maintaining their positions in heavy weather. The first light vessels in this Service so equipped were *Nos. 55*, *56*, and *57*, built in 1891 for service on the Great Lakes.

The question of the proper form of the hull of a light vessel presents many interesting and complex problems in naval architecture. Steadiness and ease of motion are the chief requirements for the general efficiency of the light, as well as for the comfort of those on board. In order to obtain this desired result recent practice is to design the hull so that the wedges of immersion and emersion in transverse rolling are approximately equal, thus avoiding the usual impulse of excess buoyancy, while the metacentric height has been reduced to a minimum of 12 inches. The lines are quite full fore

and aft, thereby increasing the displacement rapidly as the vessel pitches into a sea, while bilge keels and ballast are both employed when necessary to insure steadiness; the whole idea being to make use of all elements tending to control both rolling and pitching. The scantling throughout is much heavier than ordinarily required in vessels of similar size, for the double purpose of providing great excess strength as well as guarding against the injurious effects of corrosion. An ample number of water-tight bulkheads is provided below the main deck, to increase the stiffness and safety of the vessel, and especial care is taken in the design of the mooring gear, which consists essentially of a large central hawse pipe, protected by a water-tight breakwater, with chain compressors, springs, and a powerful double windlass, usually operated by steam. The main mooring chain is, as a rule, composed of links made of the best double-refined wrought iron, 1⅝ inches in diameter, with cast-iron studs, in accordance with rigid specifications, and tested to a proof strain of over 80,000 pounds. The chain is carefully inspected during all stages of manufacture, and is made up into cables of suitable lengths, with the necessary shackles and swivels. Such chain weighs approximately 160 pounds per fathom (6 feet), so that the entire weight of a standard 120 fathom cable is about 9 tons. Specially designed cast-steel mushroom anchors, in weights up to 7,000 pounds, are used for mooring to the bottom, and in the case of vessels in severely exposed positions in deep water a spherical mooring buoy strongly braced to resist collapsing pressures, is shackled into the submerged portion of the chain, tending to carry a portion of the weight, and forming a double catenary which is of value in avoiding injurious strains on the vessel as it surges in rough weather.

The standard type of propelling machinery now in use consists of one vertical, inverted, direct-acting, surface-condensing, fore-and-aft compound engine of a size suitable to the dimensions and duty of the vessel, driving a cast-iron propeller and supplied with steam from two Scotch boilers; the engine and boiler space being located amidships. Some of the more recent vessels are provided with internal-combustion kerosene engines, which it is believed will be more economical than steam, particularly in avoiding the expense and difficulty due to keeping light vessels supplied with coal and fresh water, as well as avoiding the deterioration of boilers.

Much progress has been made in the interior arrangements of light vessels, particularly in the way of accommodations for the crew. The early lightships were single-deck vessels, with the quarters generally below the water line. A forecastle head was then added, which was gradually extended in height and length, until an entire spar deck had been developed. The latest vessels are flush-decked

throughout, with all quarters on the main deck well above the water line, thereby also conducing greatly to the stability and safety of the vessel when seas are shipped in heavy weather. The details of the interior of the present types of light vessels are also worked out with care; comfortable staterooms and berths are provided, the vessels are steam heated throughout, sanitary plumbing systems with baths, toilets and drainage attachments are fitted, and in some cases electric lights are also installed.

The complement of a first-class light vessel is generally 4 officers and 10 men, which is varied in the case of smaller and less exposed vessels as conditions justify, down to a minimum of 3 men all told,

Buffalo Light Vessel No. 98, N. Y.

for the smallest size of inside lightships. Liberal provision is made for shore liberty, as will be taken up in greater detail in another chapter. (See p. 73.)

The illuminating and fog-signal apparatus on board light vessels has undergone many improvements. Ordinary ship's lanterns served for lights on the early vessels, while the fog signal was a hand bell or horn. When reflector lights were introduced, each light was composed of eight lamps with reflectors 12 inches in diameter, set upon a ring which encircled the mast, the whole apparatus being inclosed in a lantern with large panes of glass to protect the light from the wind. When not in use the lanterns were kept in a small house

with a hinged roof at the base of the mast, and were lighted and hoisted to the masthead at night. This arrangement is still in use on some of the older vessels. Sometimes such lights are shown on two masts. White lights are commonly employed, red being used occasionally when necessary to give distinctiveness.

The next development was the substitution of a group of three-lens lanterns instead of the reflectors, placed in gimbals on a ring around the mast and operated similarly to the reflector lanterns. In recent years a tubular steel mast, of diameter sufficient to contain a ladder, has been installed. This is surmounted by a helical bar lantern of the type used in lighthouses on shore, containing a regular lighthouse lens. Access to the lantern is through the interior of the mast, and the lantern is surrounded by a gallery reached from the interior to permit cleaning the glass, and serving also as a distinguishing daymark. Any illuminant may be employed in such a lantern, such as electric light, incandescent oil vapor, acetylene, or oil gas, as desired.

Corresponding improvements have also been made in fog signals on board light vessels, but these installations are essentially the same as have already been described. (See p. 40.) The 12-inch steam whistle is still used on many light vessels as the main signal, and a pneumatically operated submarine bell is frequently added as an auxiliary.

Four of the most important light vessels on the Atlantic and Gulf coasts, those on Nantucket Shoals, Diamond Shoal (Cape Hatteras), and Frying Pan Shoals, and the relief vessels for these stations, also the vessel on Heald Bank, are equipped with radio, at present operated by the Navy Department in connection with their coast radio system. These installations have been found of considerable value, and it is expected that the number will be increased.

Light vessels are distinguishable in the daytime by their unusual shape and rig, including generally some form of cagework as a daymark at the mastheads, and by their characteristic painting and lettering. The hull is often painted red or straw color, although many other colors or combinations of color are employed to make adjacent vessels as different as possible, and a short station name is painted on the sides of the vessel in the largest size letters practicable. From 1867 to 1913 light vessels also exhibited a number, painted at first on the stern, and afterwards on each bow and quarter. These numbers were solely for identification of the ship, regardless of the station occupied, and hence formed a possible source of confusion when vessels were transferred. The numbers are still retained as part of the official designation of the vessel for service purposes, but are no longer prominently displayed. Light vessels on seacoast stations are also assigned international code-signal letter flags, identify-

ing the geographical locality, which they display to passing vessels when it is necessary to warn them.

Light vessels are brought in from station at regular intervals for docking, overhauling, and repair, and during the interim a relief light vessel is placed on the station. Care is taken when practicable to have the relief ships so equipped that they can show the identical light of the station ship at night, and during fog the identical fog signal; also sounding the same code number on the submarine bell, and displaying the international signal flags described above of the vessel relieved. Relief vessels are commonly painted red, with the middle third of the hull white, bearing thereon the word "Relief"

Relief Light Vessel No. 92, seventeenth district.

in large black letters. They also exhibit an oval daymark on the spring stay, midway between the two masts, when two are provided.

To avoid confusion when light vessels are off their stations while proceeding to or from port, or during stress of weather, they fly under such circumstances the signal letters QE, a square yellow flag over a triangular flag with vertical bands of red, white, and blue, meaning in the international code "Lightship is not at anchor on her station."

The average life of a light vessel is estimated at 30 years, and in order to maintain the present number of light vessels it is necessary to build on an average two new light vessels annually.

The principal facts relating to light vessels in commission during the fiscal year 1915 are shown in the table on the following page:

Light Vessels in Commission During the Fiscal Year 1915.

Number.	Station.	International code signal.	District.	Tonnage. Gross.	Tonnage. Net.	When built.	Material of hull.	Dimensions. Length over all.	Dimensions. Breadth.	Dimensions. Depth.	Indicated horsepower (self-propelling).	Regular complement. Officers.	Regular complement. Crew.	Fog signal.	Illuminant.	Cost of repairs made during fiscal year.	Cost of maintenance during fiscal year.	Original cost.	On station. Months.	On station. Days.
								Ft. in.	*Ft. in.*	*Ft. in.*										
74	Portland, Me.	BALV	1	[a] 495	.....	1902	Wood.	129 9	28 6	13 0	380	4	8	12" steam whistle [b]	Acet.	$4,278	$10,641	$88,896	8	3
3	Shovelful Shoal, Mass	BAEP	2	140	.....	1852	...do...	[c] 69 4	23 0	10 0	.....	2	5	Bell or horn	Oil.	273	4,618	12,000	12	----
4	Handkerchief, Mass	BAEM	2	104	.....	1855	...do...	[c] 77 0	20 0	10 0	.....	2	5	...do	...do...	829	4,998	.....	12	----
5	Cross Rip, Mass	BAES	2	104	.....	1864	...do...	[c] 80 6	21 6	9 0	.....	2	6	8" air whistle	...do...	581	6,254	.....	12	----
6	Relief	.....	2	120	.....	.....	...do...	[c] 80 0	24 0	10 0	.....	1	----	Bell	...do...	2,016	1,821	.....	2	29
9	Hedge Fence, Mass	BAET	2	104	.....	1857	...do...	[c] 81 2	28 2	9 6	.....	2	5	8" air whistle	...do...	2,718	3,044	19,883	9	7
41	Vineyard Sound, Mass	BACI	2	387	.....	1876	...do...	120 6	26 9	11 0	.....	2	6	First-class air siren [b]	...do...	216	6,285	33,000	11	25
42	Hen and Chickens, Mass	AZXT	2	410	.....	1877	...do...	121 7	26 6	10 6	.....	3	7	10" air whistle	...do...	5,614	10,439	40,796	8	11
47	Pollock Rip, Mass	BAFN	2	[a] 470	.....	1891	Comp.	120 10	26 6	11 0	.....	4	6	12" stm. chime wh. [b]	...do...	835	8,879	60,000	9	----
54	Boston, Mass	BAGY	2	310	.....	1892	Steel.	118 10	26 0	11 0	150	4	7	First-class air siren [b]	Inc. o.v.	41,659	9,565	62,030	----	3
66	Relief [d]	.....	2	[a] 590	.....	1896	Comp.	123 0	28 6	13 0	350	2	6	12" stm. chime wh. [b]	E. i. or o.	32	7,816	69,282	10	28
73	Pollock Rip Slue, Mass	BAEK	2	[a] 538	.....	1901	Steel.	123 9	28 6	12 9	400	4	8	.....do. [b]	Oil.	1,048	10,395	79,872	11	9
85	Nantucket Shoals, Mass [d]	BAFE	2	[a] 683	246	1907	...do...	135 5	29 0	13 0	380	5	10	12" steam whistle [b]	El. inc.	4,248	15,462	99,000	9	12
86	Great Round Shoal, Mass	BAFK	2	[a] 683	246	1907	...do...	135 5	29 0	13 0	380	4	8	.....do. [b]	Oil.	278	11,015	99,000	12	----
90	Relief	.....	2	[a] 685	225	1908	...do...	135 5	29 6	13 0	400	2	6	12" stm. chime wh. [b]	...do...	982	10,729	107,213	10	26
11	Scotland, N. J.	AZNB	3	320	.....	1853	Wood.	[c] 104 0	24 8	11 6	.....	2	6	Bell	Oil gas.	1,238	5,693	13,462	10	3
13	Bartlett Reef, Conn	AZTP	3	155	.....	1854	...do...	[c] 79 8	21 8	10 4	.....	2	5	.....do	Oil.	1,539	4,741	12,000	9	15
16	Relief	.....	3	250	.....	1854	...do...	[c] 103 6	22 6	11 0	.....	0	1	First-class air siren, 6" whistle. [b]	...do...	864	1,202	28,084	5	6
20	.....do	.....	3	165	.....	1867	...do...	[c] 81 6	21 6	10 0	.....	0	1	Bell	...do...	.....	822	25,040	1	---- 28
23	Ram Island Reef, N. Y	AZUB	3	186	.....	1857	...do...	[c] 94 2	24 0	9 0	.....	2	5	.....do	...do...	168	484	7,500	10	3
39	Brenton Reef, R. I.	AZXK	3	387	.....	1875	...do...	119 6	26 9	13 0	.....	4	6	12" and 6" stm. wh. [b]	...do...	46	8,711	42,200	12	----
44	Northeast End, N. J.	AZHQ	3	197	.....	1882	Iron...	115 6	25 0	10 6	.....	4	7	First-cl. stm. siren [b]	Acet.	1,441	9,279	50,000	10	24
48	Cornfield Point, Conn	AZTO	3	[a] 470	.....	1891	Comp.	120 10	27 8	12 0	.....	3	7	First-class air siren [b]	...do...	569	8,290	52,780	11	9
51	Relief	.....	3	283	.....	1892	Steel.	118 10	26 9	11 0	135	2	5	12" steam whistle [b]	El. inc.	3,284	8,252	53,325	5	25
68	Fire Island, N. Y	AZMS	3	[a] 590	204	1897	Comp.	122 10	28 6	12 6	350	4	10	12" stm. chime wh. [b]	...do...	1,801	12,714	74,750	9	29
69	Overfalls, Del	AZHT	3	[a] 590	204	1897	...do...	122 10	29 6	13 0	350	4	10	.....do. [b]	...do...	1,143	12,789	79,500	9	8
79	Five-Fathom Bank, N. J.	AZHP	3	[a] 668	188	1904	Steel.	129 0	28 6	12 6	325	4	8	.....do. [b]	Oil.	328	10,725	89,000	11	22
87	Ambrose Channel, N. Y	AZMY	3	[a] 683	246	1907	...do...	135 5	29 0	13 0	325	4	10	12" steam whistle [b]	El. arc.	1,597	13,000	99,000	10	8
78	Relief	.....	3	[a] 668	188	1904	...do...	129 0	28 6	12 6	325	2	5	.....do. [b]	Ac. or o.	6,261	7,179	89,030	7	11
2	....do	.....	5	210	.....	1849	Wood.	[c] 98 0	25 0	9 0	.....	1	2	Bell	...do...	112	2,577	12,402	4	20
45	Thirty-Five Foot Channel, Va.	AYUX	5	[a] 401	285	1887	Steel [e]	124 6	27 6	12 0	.....	2	6	8" air chime whistle [b]	...do...	4,298	5,008	58,500	7	10

46	Tail of the Horsehoe, Va...	AYUW	5	a 401	.....	1887	...do...	124	6	27	6	12	0	.....	4	6	12" steam whistle b..	...do....	2,039	8,676	60,000	12	....
49	Cape Charles, Va.....	AZGP	5	a 470	.....	1890	Comp.	120	10	27	0	14	0	.....	4	6	.....do.b.....	...do....	2,398	8,224	57,900	12	....
52	Fenwick Island Shoal, Del.	AZHJ	5	a 416	.....	1892	Steel..	118	10	26	6	12	0	180	4	8	First-class air siren b..	...do....	11,384	8,398	62,000	4	....
71	Diamond Shoal, N.C.d....	AYTB	5	a 590	204	1897	Comp.	122	10	28	6	13	0	350	5	10	12" stm. chime wh.b..	El. inc.	924	12,472	70,700	9	17
72	Relief d.....	.....	5	a 693	.....	1900	Steel..	123	6	28	6	14	0	350	2	6	.....do.b.....	...do....	301	10,850	89,000	9	22
80	Cape Lookout Shoals, N.C.	AYQT	5	a 668	188	1904	...do...	129	0	28	6	12	6	500	4	9	.....do.b.....	Oil.....	5,047	11,531	85,000	9	13
91	Winter-Quarter Shoals, Va.	AZED	5	a 685	225	1908	...do...	135	5	29	0	13	0	400	4	8	8" stm. chime wh.b..	Acet....	4,870	9,583	107,213	9	13
97	Bush Bluff, Va.....	AYVC	5	87	.....	1876	Comp.	80	6	19	5	12	0	.....	1	2	Bell.....	Oil gas.	23	1,662	.....	9	1
29	Relief.....	.....	5	232	150	1864	Wood.	101	0	23	6	10	6	.....	1	2	.....do.....	Oil.....	.....	2,054	.....	2	29
1	Martins Industry, S. C....	AYNL	6	275	.....	1855	...do...	c103	0	24	0	13	0	.....	2	8	12" steam whistle b..	...do....	9,414	7,960	.....	9	28
34	Charleston, S. C.....	AYOQ	6	150	.....	1864	...do...	101	10	23	0	10	0	.....	2	6	8" air chime whistle..	...do....	69	5,789	48,000	9	22
53	Relief d.....	.....	6	310	.....	1892	Steel..	119	0	26	6	11	0	135	3	5	12" steam whistle b..	Acet....	1,499	3,052	61,538	6	21
84	Brunswick, Ga.....	AYKV	6	a 583	246	1907	...do...	135	5	29	0	13	0	325	4	8	.....do.b.....	Oil.....	1,942	11,059	99,000	10	17
94	Frying Pan Shoals, N. C.d.	AYQR	6	a 670	229	1911	...do...	135	6	29	0	13	0	363	4	10	12" stm. chime wh.b..	Inc. o.v.	1,904	12,402	104,604	11	2
43	Southwest Pass, La.....	AXBF	8	191	110	1881	Comp.	118	0	25	0	12	0	.....	4	6	12" steam whistle b..	Oil.....	3,506	7,705	50,000	6	13
81	Lead Bank, Tex.....	AWVH	8	a 685	188	1904	Steel..	129	0	28	6	12	6	325	4	8	.....do.b.....	...do....	2,022	10,500	90,000	7	17
98	Buffalo, N. Y.....	.....	10	f 195	.....	1915	...do...	101	0	23	6	11	5	100	4	2	First-class air siren..	El. inc.	17	2,697	87,025	....	19
61	Lake Huron, Mich.....	.....	11	105	101	1893	Wood.	87	2	21	0	9	0	.....	3	3	6" steam whistle b...	Oil.....	225	4,410	14,098	7	21
62	Bar Point Shoal, Mich....	.....	11	105	101	1893	...do...	87	2	21	6	8	0	.....	3	3	.....do.b.....	...do....	533	4,507	14,098	7	22
75	Lake St. Clair, Mich.....	.....	11	160	.....	1902	Steel..	83	9	24	0	4	9	.....	2	2	Bell.....	...do....	245	2,971	14,983	7	23
89	Martin Reef, Mich.....	.....	11	f 205	76	1908	...do...	88	3	21	0	10	0	90	4	2	6" steam whistle....	...do....	383	5,559	37,500	7	11
96	Poe Reef, Mich.....	.....	11	f 170	.....	1914	...do...	101	0	23	6	11	5	.....	3	3	First-class air siren b..	...do....	360	4,027	71,292	2	6
55	Lansing Shoal, Mich.....	.....	12	129	100	1891	Wood.	102	8	20	0	9	0	100	4	2	6" steam whistle b....	...do....	2,686	5,350	13,600	7	20
56	North Manitou Shoal, Mich.	.....	12	130	101	1891	...do...	102	8	20	0	8	10	100	4	2	.....do.b.....	...do....	3,915	5,796	13,600	7	19
57	Grays Reef, Mich.....	.....	12	130	101	1891	...do...	102	8	20	0	8	10	100	4	2	.....do.b.....	...do....	2,824	5,295	13,600	7	19
60	Eleven-Foot Shoal, Mich..	.....	12	105	101	1893	...do...	87	2	21	6	8	6	.....	3	3	.....do.b.....	...do....	1,637	5,014	13,990	7	16
77	Peshtigo Reef, Wis.....	.....	12	f 155	.....	1906	Steel..	75	0	21	6	4	0	.....	2	3	8" air chime whistle..	...do....	14	3,655	13,950	7	4
95	Milwaukee, Wis.....	.....	12	f 368	156	1912	...do...	108	5	23	0	10	2	200	4	5	12" steam whistle....	...do....	577	8,263	74,558	10	9
67	Umatilla Reef, Wash.....	AUCK	17	450	364	1897	Comp.	122	7	28	6	13	0	200	4	10	12" stm. chime wh.b..	...do....	20,305	1,282	69,750	4	19
88	Columbia River, Oreg.....	AUCY	17	a 683	246	1907	Steel..	135	5	29	0	13	0	325	4	10	12" steam whistle b..	...do....	1,593	14,489	99,000	11	14
92	Relief.....	.....	17	a 685	225	1908	...do...	135	5	29	0	13	0	400	2	5	.....do.b.....	...do....	.....	15,839	107,213	10	1
93	Swiftsure Bank, Wash....	ATXJ	17	a 685	225	1908	...do...	135	5	29	0	13	0	400	4	11	.....do.b.....	...do....	2,326	15,172	107,213	9	29
70	San Francisco, Cal.....	AUGE	18	a 590	.....	1897	Comp.	122	10	28	6	13	0	300	4	11	.....do.b.....	El. inc.	2,232	15,987	79,000	8	2
76	Relief.....	.....	18	a 578	169	1904	Steel..	129	6	28	8	12	0	400	2	5	.....do.b.....	Oil.....	207	13,659	90,000	7	26
83	Blunts Reef, Cal.....	AUFL	18	a 668	188	1904	...do...	129	0	28	6	13	0	380	4	10	.....do.b.....	...do....	4,601	13,278	90,000	8	15

a Displacement (salt water).
b Submarine signal.
c Length between perpendiculars.
d Equipped with radio.
e Wood sheathed.
f Displacement (fresh water).

17. LIGHTHOUSE TENDERS.

The work of these vessels is to attend to the buoyage, to supply the light vessels and isolated light stations both with the ordinary articles for maintenance and materials for construction or repair, and also for inspection purposes when necessary. The 47 vessels which were in commission during the year ended June 30, 1915, steamed a total of about 469,000 nautical miles in the performance of their duties.

The original tenders were sailing vessels and the first in use was the former revenue cutter *Rush*, transferred to the Lighthouse Service in May, 1840, and thereafter used in New York Bay and vicinity; prior to that time and for a considerable period thereafter much of the buoy work and other duty now devolving on tenders was performed by contract. The first steam tender was the *Shubrick*, built at the navy

Lighthouse tender "Lilac," third district.

yard in Philadelphia in 1857 and first used on the Pacific coast in 1858. In 1865 six small steamers, used in the war, were transferred to the Lighthouse Service from the Navy Department for service on the Atlantic coast, and these formed the nucleus of the present fleet, although none of the original vessels are now in the Service. The early steam tenders, like other steamers of that period, were side-wheelers, and frequently carried sail as well.

The first propeller ship used as a lighthouse tender on the seacoast of this country was the former *Fern*, built in 1871, and turned over to the Navy Department in 1891. With a few exceptions, all of the tenders now in service are screw vessels. The old sailing tenders were disposed of as rapidly as replacement could be made, and by 1882 only two remained, the *Pharos* and the *Mignonette*, both schooners. The latter was lost in a hurricane off the Texas coast in 1887, while the *Pharos* was in service as late as 1908, when she was condemned and sold.

The essential features of a lighthouse tender, in which it differs from the ordinary vessel of similar size, are the low forward deck and the buoy-handling gear, whereby the foremast is rigged as a derrick, with a boom and falls for reaching over the side. The construction of the hull, the framing of the deck and all parts of the superstructure, also all mechanical appliances, are designed with a large reserve of strength, and are made as simple and sturdy as possible. As these vessels are frequently required to take and keep the sea even in the face of the most violent storms, a high degree of seaworthiness is essential; and as the nature of their duty requires them to be handled around shoals, rocks, and other obstructions in the placing and relief of buoys, their economic maximum draft is proportionally limited, and unusually strong hulls are required to prevent damage from accidental grounding which such work frequently entails.

Lighthouse tender "Fern," sixteenth district.

It is the policy of the Service in the design of lighthouse tenders to plan working boats as effective as possible for placing and tending buoys and for other lighthouse duties, and to provide suitable and sanitary quarters for the officers and crews of the vessels. As opportunity offers in connection with the overhaul of older vessels improvements along these lines are effected.

As the average life of a lighthouse tender is estimated at 25 years, it is necessary on an average to build from one to two new tenders a year in order to maintain the present number of vessels in service.

To provide for frequent overhaul, cleaning, and painting of the underwater body, it is customary to dock tenders in exclusively salt-water districts every six months; in districts having a reasonable amount of or all fresh water, once a year is deemed sufficient. A standard style of painting is prescribed, using red lead and approved antifouling paints for the underwater body, black for the exposed

outside of the hull and funnel, and white for the top-sides and deck houses. White is also given the preference for the larger portion of the interior painting, while the lower deck is painted metallic brown and the upper deck light lead.

Since 1867 it has been the custom to give botanical names to tenders, generally of some plant, flower, or tree indigenous to the district wherein they are assigned. This name appears commonly on the stern; brass miniature lighthouses are also fitted on each side of the bow.

The typical arrangements of a number of tenders are along the following general lines, although in a number of instances variations have been made. The anchor windlass is forward on the main deck; this is often protected by a forecastle head. Below this the chain

Lighthouse tender "Anemone," second district.

lockers, tanks, and crew's quarters are located. The open portion of the main deck is devoted to space for carrying and handling buoys; a large hatch gives access to the fore hold, which is the principal freight-carrying space. The foremast is fitted with a boom, falls, and lifting gear as a derrick for handling buoys and heavy articles. The hoisting engine for the derrick is sometimes on the main deck, just aft of the foremast or in the hold directly below and operated from the deck by levers. The officers' quarters, wardroom, galley, and entrances to the upper engine room and drum room are usually on the main deck, the gangways of which are as a rule inclosed. There is generally an open space aft with towing bitts and a hawser rack. The amidships portion of the hold is given over to the engine, boiler, and bunker space, while the after space contains petty officers' quarters, ship's stores, and tanks.

The upper or spar deck generally extends from just abaft the foremast to the stern; here may be found the wheelhouse and master's quarters, the small boats, generally three in number, a launch, a whaleboat or cutter, and a dinghy, and quarters for the inspector or other official passengers. The mainmast appearing above this deck is used for the display of the customary range light, officials' flags, and for the support of the antennæ yard when the vessel is fitted with radio. At the present time three tenders are so equipped, and further installations will be made as funds permit.

In addition to the national ensign, which is displayed at the flagstaff while under way in daylight, tenders may fly the Lighthouse Service flag. This flag was first used in 1869, and is triangular in shape, with a red border, and bears a blue lighthouse on a white field. While working on buoys in channels or other frequented waters, tenders may display a red flag and a black ball at the foremast head, as a warning to other vessels to slow down in passing.

The largest tender of the Service will be the *Cedar*, now under construction at Long Beach, Cal., for use in Alaskan waters. This vessel will be 200 feet 8 inches over all, 36 feet molded beam, and of approximately 1,750 tons displacement at 13 feet draft. The smallest regular tenders are the *Snowdrop* and *Waterlily*, gasoline-propelled vessels about 65 feet long, 11 feet beam, and 3 feet 6 inches draft.

General information concerning tenders in commission during the fiscal year 1915 will be found in the table on the following page.

Name.	District.	Displacement.		When built.	Description.	Material of hull.	Dimensions.			Mean draft.				Indicated horsepower.	Regular complement.		Miles steamed.	Coal consumed for all purposes.	Cost of repairs.	Cost of maintenance.	Original cost.
		Light.[a]	Loaded.[b]				Length over all.	Breadth.	Depth.	Light.[a]		Loaded.[b]			Officers.	Crew.					
		Tons.	*Tons.*				*Feet.*	*Feet.*	*Feet.*	*Ft.*	*in.*	*Ft.*	*in.*					*Tons.*			
Hibiscus	1	803	1,053	1908	Steamer, screw	Steel	190	30	16	10	10	13	0	1,000	6	23	13,366	1,762	$1,868	$35,301	$184,643
Zizania	1	575	643	1888	do	do	161	27	12	8	9	9	6	650	6	19	9,240	1,363	4,021	29,851	48,739
Lilac	1	464	643	1892	do*	do	155	27	15	10	0	12	3	800	5	19	12,259	1,223	2,305	29,826	92,125
Anemone	2	803	1,053	1908	do	do	190	30	16	10	10	13	0	1,000	7	23	14,114	2,127	2,149	37,435	191,999
Azalea	2	330	516	1891	do*	do	154	25	12	6	6	9	0	400	5	19	11,514	833	1,487	26,717	79,792
Mayflower	2	593	668	1897	do	do	164	30	12	7	4	8	1	650	5	22	9,471	1,357	9,325	29,919	74,872
Daisy	3	61	84	1892	do*	Wood	80	14	5	4	0	5	0	60	2	4	9,100	153	310	7,046	6,500
Gardenia	3	217	245	1879	do*	do	c 117	20	9	6	0	6	6	200	4	11	8,728	488	1,003	15,948	11,000
John Rodgers	3	455	571	1883	Steamer, side-wheel	Iron	160	27	9	6	6	7	9	260	4	16	7,268	734	1,669	20,859	59,987
Larkspur	3	738	888	1903	Steamer, screw	Steel	169	30	14	9	1	10	6	750	6	22	13,687	2,120	1,086	30,960	123,259
Mistletoe	3	455	476	1872	Steamer, side-wheel	Wood	160	26	9	6	9	7	0	370	4	16	7,692	692	1,545	18,868	45,833
Pansy	3	431	454	1878	Steamer, screw	Iron	152	25	11	7	7	7	11	250	4	17	18	62	10,787	14,685	48,739
Tulip	3	803	1,053	1908	do	Steel	190	30	16	10	10	13	0	1,000	7	24	16,483	2,216	4,020	36,526	191,658
Iris	4	519	606	1897	do*	do	153	30	10	8	7	9	6	800	4	19	11,873	1,367	3,094	26,202	84,407
Woodbine	4	85	107	1913	Oil, screw*	Wood	95	16	7	5	2	5	11	125	2	4	11,654	d 18	1,889	8,502	24,728
Holly	5	431	499	1881	Steamer, side-wheel	Comp	176	24	10	7	0	8	6	400	4	16	9,955	732	1,075	20,667	41,911
Ivy	5	736	916	1904	Steamer, screw	Steel	173	30	13	7	11	9	6	700	5	22	10,419	1,833	6,540	30,414	123,860
Jessamine	5	369	427	1881	Steamer, side-wheel	Iron	156	24	10	7	3	8	1	350	4	16	8,062	753	3,363	20,150	41,911
Juniper	5	125	146	1903	Steamer, screw	Steel	95	18	8	4	6	5	0	220	2	5	11,305	578	563	9,238	29,425
Laurel	5	218	233	1915	do*	Wood	105	22	9	6	1	6	4	160	4	8	385	9	115	2,762	55,502
Maple	5	567	799	1893	do	Steel	164	30	12	7	3	9	5	650	6	22	13,397	1,333	3,106	29,625	93,889
Orchid	5	803	1,053	1908	do	do	190	30	16	10	10	13	0	1,000	6	23	14,373	1,760	1,199	31,858	186,151
Cypress e	6	803	1,053	1908	do	do	190	30	16	10	10	13	0	1,000	7	23	20,285	2,605	4,069	38,238	191,633
Mangrove	6	593	668	1897	do	do	164	30	12	7	4	8	1	550	6	22	14,150	1,554	4,714	32,988	74,998
Snowdrop	6	30	41	1896	Gasoline, screw	Wood	69	11	5	2	11	3	7	32	2	2	9,281	f 6,255	943	5,215	9,700
Water Lily	6	29	39	1895	do	do	64	11	5	2	11	3	8	36	2	2	5,674	f 3,535	312	4,725	9,261

Arbutus	7	398	545	1879	Steamer, screw	...do..	153	25	11	7	1	9	0	360	6	19	9,550	1,087	101	29,727	49,769
Camellia	8	276	377	1911	.....do	Steel..	117	24	10	5	10	7	7	280	4	12	4,999	476	1,271	18,464	57,412
Magnolia	8	736	916	1904	.....do	...do..	173	30	13	7	11	9	6	700	5	22	10,872	1,518	4,962	23,142	124,874
Sunflower	8	728	986	1907	.....do	...do..	174	31	15	9	8	12	1	900	7	22	12,895	1,863	2,227	35,609	124,958
Myrtle	9	435	542	1872	.....do*	Wood.	140	25	11	9	6	11	0	225	4	17	8,177	748	242	24,886	44,500
Crocus	10	g 542	g 836	1904	.....do	Steel..	165	29	14	8	0	10	11	700	6	22	7,884	1,429	6,083	30,635	119,718
Amaranth	11	g 597	g 975	1892	.....do*	...do..	166	28	14	8	6	12	6	672	5	19	10,341	1,496	4,006	30,539	74,994
Aspen	11	g 353	g 415	1906	.....do*	...do..	126	25	12	7	3	8	3	440	4	10	7,880	622	2,608	16,238	70,573
Clover	11	g 163	g 205	1899	.....do*	Wood.	93	22	7	5	4	6	4	140	4	8	9,836	368	758	13,555	.....
Marigold	11	g 477	g 696	1890	.....do*	Iron...	160	27	12	8	7	11	3	550	5	19	11,823	990	671	25,071	84,871
Hyacinth	12	g 493	g 914	1903	.....do*	Steel..	165	28	14	7	0	11	6	878	5	19	10,030	1,388	3,460	26,710	115,000
Sumac	12	g 600	g 887	1903	.....do	...do..	169	30	13	8	10	11	9	700	6	22	11,638	1,612	2,748	32,393	114,992
Goldenrod	13, 14	g 194	g 283	1888	Steamer, stern-wheel	...do..	169	27	4	2	5	3	4	152	3	15	3,328	448	1,319	9,354	33,221
Oleander	15	g 418	g 494	1903	.....do	...do..	189	34	7	3	6	4	1	600	3	15	13,549	2,107	4,159	23,300	60,000
Kukui [e]	16, 19	803	1,053	1908	Steamer, screw	...do..	190	30	16	10	10	13	0	1,000	7	22	7,547	1,353	11,705	46,331	213,880
Fern [h]	16	253	317	1915	.....do*	Wood.	112	22	10	7	3	8	6	330	4	8	.....	.....	.....	.....	62,100
Heather	17	631	831	1903	.....do*	...do..	179	28	15	9	6	11	6	685	6	19	8,078	1,152	11,527	31,391	118,568
Manzanita	17	803	1,053	1908	.....do	...do..	190	30	16	10	10	13	0	1,000	6	23	13,087	1,909	1,941	39,419	211,817
Madrono	18	654	806	1885	.....do*	Iron...	180	27	15	9	9	11	6	750	6	19	10,744	1,385	2,729	42,118	87,872
Sequoia	18	803	1,053	1908	.....do	Steel..	190	30	16	10	10	13	0	1,000	6	23	9,760	1,155	344	36,615	213,499
Columbine [e]	19, 16	464	643	1892	.....do*	...do..	155	27	15	10	0	12	3	800	6	19	13,139	1,168	8,300	4,322	93,993

[a] Light=without cargo and deck loads, and a minimum supply of stores, provisions, water, and coal.
[b] Loaded=bunkers full of coal; all tanks, including trimming tanks, full of water; full stores and provisions, and an average maximum cargo and deck load.
[c] Length between perpendiculars.
[d] Also 9,868 gallons gasoline and 7,757 gallons kerosene.
[e] Equipped with radio.
[f] Gallons gasoline.
[g] Displacement (fresh water).
[h] Completed and placed in commission June 25, 1915.
* Single screw, others twin screw.

18. PERSONNEL AND CIVIL-SERVICE SYSTEMS.

All positions in the Lighthouse Service are governed by the civil-service rules, which were extended to this Service by President Cleveland, May 6, 1896, and all appointments and promotions are made on a strictly merit basis; this is of great importance in maintaining a good organization and rigid discipline in a purely technical service, on the efficient conduct of which is directly dependent the safety of lives and property. The Service is justly proud of its long and honorable record in fulfilling an important public duty, and it is only by close adherence to those worthy traditions that its ideals may be perpetuated.

The technical and clerical positions in the Lighthouse Service, such as inspectors, superintendents, draftsmen, aids, and clerks of all grades, also cadets on tenders, are in the educational class of classified competitive positions; all original appointments are therefore made from rosters of eligibles established as a result of educational examinations conducted by the Civil Service Commission. Registers of eligibles for all noneducational positions peculiar to the Lighthouse Service, such as officers of vessels, except cadets, keepers of lights, etc., are established and maintained by the district civil-service boards. Applicants for such positions are rated by these boards from answers made in their application forms, and if an eligible rating is obtained their names are entered on the register and they are given due consideration for appointment from time to time as vacancies occur, in accordance with civil-service rules. Original appointment is usually in the lowest grade, the more responsible positions being filled whenever practicable by transfer and promotion of employees in less important positions who have earned such consideration by reason of efficiency and length of service.

In the case of officers of vessels, the possession of a proper license from the Steamboat-Inspection Service is a condition precedent to placing upon an eligible register the name of an applicant for appointment; and in general similar licenses are required on self-propelled vessels of the Lighthouse Service to those required in the merchant marine for vessels of similar service and tonnage, so far as may be practicable.

The duties of all positions of keepers require that the lights be given the necessary care and attention in cleaning, filling, and lighting, and generally that the incumbents possess ability to handle a boat; in many cases knowledge of operating machinery is required, in view of the fog-signal and revolving-light mechanisms at a number of stations. The same requirements apply in a less degree to the positions of laborers in charge of minor lights, in which the incumbents work but a portion of their time each day. Selection for

these positions is made with sole reference to the ability and fitness of the applicants, the proximity of the applicant's home to the lights, and facilities possessed by them, such as the ownership of a suitable boat when needed, etc.

Trades and skilled positions, such as machinists, carpenters, blacksmiths, etc., are also in the classified competitive civil service, and employment in such positions is made by selection from registers based on the physical ability, training, experience, and fitness of the applicants for the employment desired.

The compensation of all positions in the Service not fixed by law is based so far as practicable on similar requirements in the commercial world; thus, the entrance salary for draftsmen and other technical employees is, as a rule, from $100 to $125 per month, for clerks $75 per month, for junior officers of vessels from $50 to $80 per month, for assistant keepers of lighthouses $35 to $40 per month, the latter two grades receiving also a subsistence allowance while on duty. It should be observed that these are the average rates only and that the compensation varies according to the character and location of the work. The pay of laborers in charge of minor lights is based upon the number of lights cared for, distance necessary to be traveled, and conditions met, averaging roughly about $8 per month for each light in the river districts. The pay of trades and skilled positions is generally governed by the prevailing rates in the locality.

All appointed employees in offices, at depots, on tenders, and in the field force at monthly rates of pay, who have been in the Service for a considerable period of time, may be granted leave when properly approved, not exceeding 30 days each of annual and sick leave in any one calendar year.

Special rules are in effect regarding leave and shore liberty on light vessels and at isolated light stations. These rules provide for a rotative system, so that all may have an equitable amount, without interfering with the proper conduct of work on the station or vessel, and fix a maximum of 90 days per year in the case of light vessels and 72 days per year at isolated light stations where families do not reside or where the location is unusually remote or unhealthful.

Careful attention is paid to the welfare of employees in all cases in which remedial measures are authorized by law. All persons in hazardous employment in the Service are entitled to the benefits of the act of May 30, 1908, providing for compensation for injury or death sustained in the line of duty. In addition, expenses of medical or surgical attendance, or of burial, are allowed in special cases under proper authority and restrictions. The benefits of the Public Health Service are extended to various classes of employees, those on vessels being cared for without charge, while other employees

may receive care and treatment under the same rates as fixed for the Army and Navy. The Public Health Service also gives information and advice, when called upon, in regard to medical questions and matters of sanitation affecting the Lighthouse Service, and provides for the free vaccination of certain classes of employees against smallpox and typhoid fever. That Service has also cooperated in the preparation of a Medical Handbook for the use of lighthouse vessels and stations on the prevention of disease and care of the sick and injured, with special reference to first aid to the injured. Medicine chests, containing such articles as may be needed for isolated vessels or stations in emergency cases, with directions for use, are also furnished by the Lighthouse Service.

Libraries are furnished all light vessels and inaccessible offshore light stations, with proper arrangements for their exchange at intervals. These libraries were first introduced in the Service in 1876, and are carefully selected from books of a good standard appropriate to the persons who will use them; while largely fiction, other classes of literature are included in reasonable proportions. In the matter of educational facilities at stations not accessible to schools and where there are children of school age, inquiry is made from time to time into the education of the children and any course which will lead to their suitable education is encouraged; and, other things being equal, preference is given to employees having children between the ages of 5 and 16 years in filling vacancies by transfer at stations convenient to schools. Consultation is had with State and local educational authorities and in some localities, notably in the State of Maine, good results have been achieved through traveling teachers provided by the State, who are transported by lighthouse tenders in making their visits.

There is great need for provision by law for the retirement of employees of the Lighthouse Service who after long service have lost their ability for active duty by reason of age or disability incident to their work. This is essential to full efficiency in the administration of the Service. A pension system is in force with favorable results in the lighthouse services of most of the other important maritime countries.

All male employees on vessels and at light stations are required, when on duty, to wear a uniform as prescribed for their respective grades. Laborers in charge of minor lights are not required to wear uniforms. These uniforms must conform to the regulations issued on the subject, which cover all details for each class or rank. Such regulations were first issued in 1883. The standard material for the clothing is dark navy-blue cloth or serge, except in hot weather, when white duck is allowed. The standard cap bears in the middle of the front a gold embroidered wreath inclosing a silver embroidered light-

house. Officers of tenders wear a single-breasted coat shaped to the figure with a fly front and standing collar, trimmed with braid. Other employees wear a double-breasted sack coat with gilt buttons embossed with a lighthouse. Deck officers of vessels wear an anchor on the collar, while engineer officers wear a propeller. The relative rank of such officers is indicated by sleeve stripes of braid near the cuff of the coat. Keepers of lighthouses wear within a loop on the collar the letters K, 1, 2, etc., as the case may be, indicating respectively keeper, first assistant, second assistant, etc., and do not wear sleeve ornaments. Petty officers of tenders wear ornaments on the sleeves only, midway between the shoulder and elbow; a white steering wheel for quartermasters, and a red propeller for machinists.

In order to insure uniformity in the practical operations of the Service, one of the first acts of the Lighthouse Board was to issue a a set of rules and regulations for the government of employees, with detailed instructions concerning the routine of their duties. Such regulations were first issued October 22, 1852, and have been since revised and amended from time to time. These regulations are authorized by the law governing the Lighthouse Service, and the latest edition went into effect October 1, 1914, comprising a volume of about 180 pages, with chapters appropriate to the various activities of the Service. The Regulations are supplemented by Instructions to Employees, the latest edition of which took effect July 15, 1915. This is a book of about 100 pages, with chapters dealing with the duties of different grades of employees, such as keepers of lighthouses, officers of tenders, etc., with general chapters on disciplinary and professional matters applicable to all. All employees are required to familiarize themselves with the instructions and to be governed thereby. The lighthouse is and should be a common synonym for absolute reliability. Strict rules for the government of the Service must be made and observed, and this has been the policy from its earliest days. President Thomas Jefferson, in approving the dismissal of a keeper in a case referred to him for decision, made the following remarks in his own handwriting, dated December 31, 1806: "I think the keepers of lighthouses should be dismissed for small degrees of remissness, because of the calamities which even these produce."

On the other hand, devotion to duty is always praised and rewarded. Keepers in charge of stations who attain a high efficiency, as shown by inspections made during the year, are entitled to wear the inspector's efficiency star, and those who win this star for three successive years are entitled to wear in lieu thereof the Commissioner's star. Whenever employees render service to endangered persons or property, or otherwise perform their duty under hazardous or trying conditions, including any special act of unselfish or unusual service of any kind, either in the office or the field, in a manner to

merit commendation, a special report is made and a commendatory letter, signed by the Secretary of Commerce, is addressed to such person and the fact noted on the official records of the Service. Also, the light station in each district attaining the highest general efficiency during the year is entitled to fly the "efficiency flag," being the regulation service flag, for the succeeding year.

As a means of attaining the ends sought by the Regulations and Instructions, systematic inspections are made of all branches of the Service by its officers. Each light station and depot is inspected at least twice a year; each tender and light vessel at least three times a year, at such times as will secure the most efficient service, and not at regular intervals that may be anticipated. Inspection of non-attended lights, buoys, and unlighted beacons is made at least once a year. Additional inspections are made whenever rendered necessary by unusual conditions. Such inspections are made by the district officers, who fill out a form provided for the purpose at the time of making the inspection, and in case it appears that a bad state of repair or other unsatisfactory condition exists, the Commissioner is promptly notified.

Such inspections are supplemented by traveling officers of the Service; a general inspector, who attends particularly to the technical features, such as the condition of vessels and stations from the engineering standpoint; and an examiner, whose activities are more particularly addressed to business methods and fiscal matters, such as accounts, reports, etc. The officers of the Bureau also make inspections from time to time, as opportunity permits, in order to obtain information at first hand regarding the operations of the Service.

On June 30, 1915, there were 5,792 authorized positions in the Lighthouse Service, divided into the following principal classes:

Executive and technical employees	123
Clerical employees	145
Depot keepers and assistants	71
Light keepers and assistants	1,471
Laborers in charge of minor lights	1,782
Custodians of reservations	12
Officers and crews of vessels	1,605
Construction and repair force	583
Total	5,792

19. LIGHT KEEPERS' QUARTERS.

On account of the comparative isolation of many lighthouses, and to insure immediate attention at all times, it is the practice of the Service to furnish quarters for keepers at all attended lights. Dwellings for keepers and their families are provided for nearly all important lights located on shore, while in the case of offshore stations,

Fort Pickering, Mass.

Cape Hatteras, N. C.

Point Conception, Cal.

Barbers Point, Oahu, Hawaii.

Fort Point, Cal.

Pointe aux Barques, Mich.

DWELLINGS FOR LIGHT KEEPERS.

where women and children are not permitted to reside on account of the hazard in making a landing and the restricted space, quarters for the keepers only are allowed. Eight hundred and fifty-seven dwellings are now provided for lighthouse and depot keepers.

There is no standard type or design of keepers' dwellings, by reason of many different local conditions which have to be met, embracing all kinds of climate from the exposed coasts of Maine, Alaska, and the Great Lakes to the semi-tropical conditions of Porto Rico and Hawaii. Attempt is made to have such buildings conform to the prevailing local styles and customs, and at the same time to harmonize them architectually so far as practicable with the light station and its surroundings. Consideration must also be given to the kind of materials most available in the vicinity, for economical reasons, as the limit of cost for such dwellings is fixed by law at not to exceed $6,500, exclusive of the site. While this is ample under ordinary conditions, the great difficulties of transportation frequently make the costs much higher than would prevail in localities close to markets for materials and sources of skilled labor. Unnecessary or elaborate ornamentation is avoided, and care is taken to use simple and substantial designs appropriate to the purpose. In recent years preference has been given to fireproof construction, when funds permit, and the use of perishable materials has been eliminated when feasible to avoid or lessen future repairs. In all new dwellings hot water or steam heat is provided in climates requiring it, as well as sanitary plumbing with water-supply and sewerage systems; these features are also being added to older dwellings not so equipped, as circumstances allow.

In some cases double or triple dwellings have been built at stations with more than one keeper, but recent practice favors detached houses, as insuring greater privacy, and giving the opportunity for individual gardens or yards. Many reservations have areas of tillable soil, on which keepers are permitted and encouraged to grow vegetables, etc., for household consumption.

Where quarters are furnished by the Government, a fuel allowance is made for heating and cooking, and each station to which a Government power boat is assigned is also granted an allowance of gasoline or other fuel, based on the reasonable official requirements of the station.

In order to avoid any possible interference to the work, persons outside the Service are not permitted to occupy any premises belonging the the Lighthouse Service; no traffic or trade is allowed to be carried on within any lighthouse reservation, nor may articles be exposed for sale on the premises. Visitors must be received with courtesy and may be admitted in limited numbers to lighthouses at prescribed hours not conflicting with the regular duties of the keepers.

A placard entitled "Rules for visitors" is posted in convenient places where it may be seen by such persons. Probably more visitors are received at Absecon Light Station, Atlantic City, N. J., than any other in the United States, about 10,000 persons visiting this lighthouse in July, August, and September of each year.

20. SAVING OF LIFE AND PROPERTY.

While the business of the Service is primarily concerned with the maintenance of aids to navigation, it frequently happens that opportunity presents itself to give assistance to persons or vessels in distress, and in such cases it is the duty of light keepers and their assistants, and of officers and crews of lighthouse vessels, to give or summon aid to vessels in distress, whether public or private, and to assist in saving life and property from perils of the sea whenever it is practicable to do so. The records of the Service are replete with many heroic incidents of this character, and it is customary to include a brief statement of this work in the Commissioner's annual report, giving the name of the vessel or employee rendering this service, the object or person aided, and the nature of the assistance performed. Commendatory letters signed by the Secretary of Commerce are addressed to such employees, and in specially meritorious cases involving great personal danger recommendation may be made to the Secretary of the Treasury for the award of life-saving medals.

In the annual report for 1914 mention is made of 124 occasions on which services in saving of life or property were rendered by employees of the Lighthouse Service, and the report of 1915 includes 143 similar incidents. These latter may be grouped into the following general classes:

	Cases.
Towing disabled small boats to safety	59
Towing larger vessels to safety	30
Furnishing food, clothing, and shelter	24
Rescuing persons overboard	20
Recovering property	5
Recovering bodies	2
Miscellaneous	3
Total	143

21. LIGHTING OF BRIDGES.

One of the duties of the Lighthouse Service incidental to its general work is the supervision of the lighting of bridges over navigable waters of the United States, also of lights on sheer booms, piers, dams, and similar obstructions to navigation. All parties owning, occupying, or operating bridges over any navigable river are required by the act of August 7, 1882, to maintain at their own expense, from sunset to sunrise, throughout the year, such lights on their bridges

as may be required by the Commissioner of Lighthouses; failure to do so may subject the offender to a fine of not exceeding $100 for each offense, and each day during which such violation continues is considered as a new offense.

Special regulations are issued on the subject, the latest edition being dated June 25, 1915, intended for the guidance of shipmasters, pilots, and bridge owners. They prescribe standard methods for marking the piers and waterways of bridges with various combinations of red and green lights for different classes of bridges, illustrated by diagrams or plates showing the proper arrangements. The red lights indicate danger, while the fairway is marked by green lights. In the case of draw or swing bridges, mechanism must be provided for changing the color from red to green and vice versa as the draw is opened or closed. All lights are required to be securely attached and of sufficient intensity to be visible on a dark night with a clear atmosphere not less than 1 nautical mile. Provision is made for exempting bridges infrequently used from the more detailed requirements of these regulations, so long as such lights as are necessary for the security of navigation are maintained in each case.

On June 30, 1915, there were 1,183 bridges lighted in accordance with the regulations. The bridges are inspected at intervals and any deficiency in lights is called to the attention of the owners.

22. PRIVATE AIDS TO NAVIGATION.

It is unlawful for anyone to establish or maintain any light or other aid to navigation similar to those maintained by the Lighthouse Service without first obtaining permission to do so from the Commissioner of Lighthouses in accordance with regulations established by the Secretary of Commerce; violation of these provisions may subject the offender to a fine of not exceeding $100 per day.

In accordance with the law, those desiring to establish a private aid may apply for authority, on a blank provided for the purpose, to the Commissioner through the proper lighthouse inspector. This application must contain the material facts relating to the proposed aid, such as whether a light, fog signal, buoy, with its exact location, color, and other descriptive items, in order that it may be properly ascertained that no conflict will exist between this and any neighboring Government aid. An annual report is also required from those authorized to maintain a private aid, stating its condition, and inspections of such aids are made at intervals by representatives of the Service. Private aids authorized under the rules cover a useful purpose in marking privately dredged channels or localities where special service is required. Such aids are usually under the control of municipalities, corporations, yacht clubs, or other organizations. Light and fog signals on ferry slips and on piers, used only by certain ves-

sels, and stakes, bushes, and barrel buoys marking shallow and little-used channels, are not affected by these regulations. Information regarding lawfully maintained private aids is printed in the customary publications of the Service, the same as for Government aids, and they are also entitled to the same protection of law as is afforded aids maintained by the Lighthouse Service. On June 30, 1915, there were 660 authorized private aids in commission, comprising 211 lights, 23 lighted buoys, 267 unlighted buoys, 134 other unlighted aids, and 25 fog signals.

23. LAWS FOR PROTECTION OF AIDS.

Heavy penalties are prescribed by law for obstruction to or interference with any aid to navigation. Exhibiting a false light, or extinguishing a true light, with intent to bring any vessel into danger, is a felony punishable by imprisonment of not less than 10 years, or for life. Any person who obstructs or interferes with any aid to navigation maintained by the Lighthouse Service, or who anchors a vessel so as to obstruct range lights, may be subject to a fine of $500 for each offense, and each day during which the violation continues may be considered as a separate offense. By a recent act of Congress these provisions apply also to any lawfully maintained private aid, as noted in the previous chapter.

In addition to the Federal statutes on the subject, various States and Porto Rico have passed laws providing penalties to be imposed on persons interfering in any manner with aids to navigation maintained by the Lighthouse Service, as follows: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Florida, Alabama, Texas, Porto Rico, Ohio, Michigan, Minnesota, Wisconsin, Washington, Oregon, and California.

The Lighthouse Service takes the position, inasmuch as the aids to navigation are established and maintained at heavy expense for the sole purpose of safeguarding maritime interests and the lives and property intrusted to their care, that it is therefore the obvious duty of masters and pilots, in their own interests, as well as those of the public welfare, to exercise special care to avoid collisions with these aids to navigation. Failure to do so renders persons in charge and the owners of offending vessels liable for the full amount of damages to aids and subjects them to the penalties prescribed by law. It is a part of the duty of the Lighthouse Service to prosecute all such offenders vigorously.

Making fast any vessel or boat to a buoy or beacon is an interference with an aid to navigation of a serious nature, and any person committing this offense is liable to prosecution.

Masters of towboats should exercise special care to avoid barges in tow striking and injuring buoys, beacons, or light vessels.

24. PUBLICATIONS.

The principal publications of the Lighthouse Service are light lists, buoy lists, and notices to mariners, all of which are distributed gratuitously to shipmasters or pilots for their information and guidance. There are three important light lists, each revised annually, containing information regarding lighthouses, lighted beacons, light vessels, lighted buoys, and fog signals, giving in tabular form and in geographical sequence the name of each aid, the character and period of the light, the location of the structure, with the latitude and longitude of more important outside aids, the height in feet of the light above high water, the distance in miles at which the light may be seen in clear weather, and the approximate candlepower. Other columns give a brief description of the structure, vessel, or buoy, with the height of towers in feet, the characteristic blasts or strokes of the fog signal, if any, and such additional explanatory remarks as may be necessary in any case. The three lists mentioned are devoted respectively to the Atlantic and Gulf coasts, the Great Lakes, and the Pacific coast, in separate octavo volumes, with the following number of pages each for the 1915 editions: Atlantic list, 357 pages; Lake List, 271 pages; and Pacific List, 148 pages. These light lists aim to give all the important information as to lights and fog signals in a convenient manner for the purpose of mariners engaged in coastwise or transoceanic navigation. Effort is made to publish the Atlantic and Pacific Lists on January 1, or as soon after the first of the calendar year as possible, and the Lake List on April 1, immediately prior to the opening of the season of navigation.

In addition, the Service publishes separately for each lighthouse district a buoy list, which gives a list of all the buoys in the district, both lighted and unlighted, as well as all the other aids. This is issued rather for the use of local authorities and pilots and for the Lighthouse Service. As far as the location of buoys is concerned, the larger scale charts published by the United States Coast and Geodetic Survey are preferable sources of information, as such charts show at a glance the location and character of all buoys and aids with reference to their surroundings, and are, moreover, corrected to the date of issue; while the lists can only be brought up to date when a new edition is published, about every two years. The present series of buoy lists forms a set of 16 octavo volumes, ranging from about 125 to 20 pages each, depending on the size of the district.

Announcement of all changes in aids to navigation, information of dangers, changes in shoals and channels, facts of interest affecting charts and coast pilots, corrections to published lists, and similar items affecting navigable waters under the jurisdiction of the United States, are published weekly in a Notice to Mariners, prepared jointly

by the Coast and Geodetic Survey and the Lighthouse Service. For important changes in seacoast lights and lightships used by vessels in foreign trade, a supplementary poster notice is also issued for prominent display to mariners. A Notice to Mariners covering all navigable waters of the world is published weekly by the Hydrographic Office, Navy Department.

Light lists are also issued for each of the three river districts, comprising the Mississippi River and its tributaries, covering broadly the upper Mississippi, the Ohio, and the lower Mississippi, respectively. These are small volumes published annually in vest-pocket size and contain simply the number and name of the aid, the distance from some starting point, the side of the channel, and the color of the aid.

A special publication of the Service is a small quarto pamphlet of about 20 pages, including diagrams, containing the Regulations for Lighting Bridges, to which reference has already been made on page 80. This publication is issued only when a new edition is necessary.

The Service publication of chief interest to the general public is the Annual Report of the Commissioner of Lighthouses to the Secretary of Commerce, which is available for distribution after the convening of Congress in regular session in December of each year, and covers the work of the Service for the fiscal year ended on the preceding June 30, as required by law. In its present form, this is an octavo volume of about 100 pages, and gives a general description of the operations and cost of the Service during the year, with recommendations for new legislation and estimates for appropriations for the second next following year, supplemented by detailed statistics of various classes of aids to navigation and fuller details of many subjects mentioned in the report proper, along with brief technical descriptions of important works of construction or repair completed during the year.

Other publications of the Service are of a routine character, printed in limited editions, and intended more particularly for its internal government and administration. A number of these have been referred to in the preceding pages. They embrace the Regulations, the Instructions to Employees, the Medical Handbook, the Lighthouse Service Bulletin (a monthly leaflet, commenced in January, 1912, containing items of interest to the Service), the Regulations for Uniforms, the Civil-Service Regulations, and the various forms, blanks, record books, etc., needed in the work of the Service.

Mention should also be made of the various printed specifications and proposal forms issued by the Service from time to time covering new vessels, lighthouses, annual supplies, and other large purchases for which contract with bond is required. These are distributed to prospective bidders in response to their inquiries as a result of public advertisements in newspapers and other periodicals.

25. ENGINEERING AND FISCAL MATTERS.

Careful supervision is exercised over all technical and administrative work of the Service, the desire being to attain a high professional standard in modern methods of design and construction, with due regard to the economical expenditure of funds.

Surveys are made with especial care, with bearings given from the true meridian, and the distances well checked, to insure great accuracy. Each corner where practicable is permanently marked by a substantial monument and at the conclusion of the survey maps are prepared showing the information obtained. All notebooks and other records are preserved, and in connection with each important new structure a complete record is kept of the engineering elements, such as computations, stress, analyses, weights, and estimated cost. These principles apply to the design of vessels as well as shore structures, full details of the form characteristics of vessels being worked out by curves of displacements, centers of buoyancy, coefficients, metacenters, centers of gravity with varying conditions of load, etc., in order that complete stability and seaworthiness may be assured.

Plans and specifications are prepared for all important works. Standard sizes of drawings are prescribed, being based on multiples of the dimensions of customary letter-size sheets 8 by 10½ inches in size. Each drawing bears a standard title giving information regarding the subject, the scale, date, and the persons responsible for its preparation. A standard form of advertisement, proposal, instructions to bidders, general conditions, and contract is used throughout the Service, and a number of standard plans and specifications covering materials, articles, and structures have been prepared for Service use, as a guide to designing wherever practicable and economical.

All works of construction and repair are supervised closely in order to make certain that the plans and specifications are followed, and persons charged with such duty are required to keep proper construction records and to make regular reports of progress. In the case of work performed by the field forces of the Service, written work orders are issued showing the work to be done and the authorized amount of expenditure. When the inspection of supplies or material under purchase can be more conveniently handled by a district office near the location of the contractor's shop or plant, inspectors cooperate with each other by forwarding the plans, specifications, and other necessary information to the office assigned this additional duty.

Progress photographs are also taken from time to time to show the development of work under way, and record photographs are kept of all light stations and vessels, with descriptions of the construction, equipment, and similar information. About 8,000 photographs of

various lighthouse objects are on file in the Commissioner's office, covering practically every phase of the activities of the Service.

The administration of fiscal matters pertaining to the Lighthouse Service forms one of its most interesting problems. A rigid economy is enforced in this direction, and no expenditure is authorized or permitted which is not necessary to render the aids to navigation efficient.

The appropriations made by Congress for the Lighthouse Service may be divided into two broad classes, general and special. General appropriations are those providing for the payment of salaries, and the other ordinary expenses of maintenance, operation, and betterment, and are limited to the fiscal year for which appropriated, while special appropriations are those designated for some specific purpose—usually new construction or extensive rebuilding, such as new lighthouses, vessels, etc., and are available until expended. The total amount of special appropriations varies from time to time with the needs of the Service and the action of Congress. The estimates for such appropriations usually aggregate about $1,000,000 annually, and the average sums so appropriated for the 10 fiscal years 1905 to 1914, inclusive, amounted to $946,247. For the fiscal year 1915 the total appropriations for special works were $136,000 and for 1916 the amount was $250,000.

The general appropriations for the maintenance of the Service for the fiscal year 1916 were $5,164,030, subdivided as follows:

Salaries, Bureau of Lighthouses	$64,030
Salaries, lighthouse keepers	940,000
Salaries, lighthouse vessels	1,010,000
Salaries, Lighthouse Service	375,000
General expenses, Lighthouse Service	2,775,000
Total	5,164,030

The names of the first three of these appropriations indicate their respective objects; the appropriation "Salaries, Lighthouse Service," is for the compensation of technical and clerical employees in the field service, while the appropriation "General expenses" covers all items of supplies, repairs, maintenance, and incidental expenses required in the Lighthouse Service, including the wages of laborers attending post lights and pay of mechanics and laborers in the field force. The law requires that these appropriations shall be so apportioned by allotments as to prevent expenditures which may necessitate deficiency or additional appropriations to complete the service of the year; careful accounts are therefore kept and monthly reports made by each district, showing under each appropriation the total allotments, deductions, advances, repayments, vouchers paid or forwarded for payment, and available balances. On account of the casualties to which the property and equipment of the Service is frequently subjected by reason of storm damage and other accidents,

a close scrutiny of available funds is a highly necessary feature in the management of the Service finances. Allotments under the various general appropriations are made to the lighthouse inspectors in charge of districts at the beginning of each fiscal year for operation of their district during that year; all requisitions for supplies made by each district, or other expenses incurred by them, are charged against this allotment. This has been found advantageous in placing definite responsibility for the judicious expenditure of funds and increasing economy and efficiency. It is necessary when making allotments to keep a small reserve to provide for storm damage or other emergencies.

All purchases, except in cases of unusual emergency, are required to be procured by public contracts after public advertisement for proposals with the lowest and best bidder therefor. Every effort is made to obtain the widest possible competition in all cases. Vouchers and pay rolls are required to be checked as to quantities, prices, extensions, and totals, and signed certificates of performance are required on all bills, covering the receipt of the articles and the correctness of the quantity and quality. Payments on approved vouchers are generally made by checks issued by duly bonded special disbursing agents; in a few cases cash payments for services are made to employees.

Property records are kept in all offices, depots, stations, and vessels; such lists are verified and audited from time to time by inspectors or by traveling representatives of the Commissioner, and an annual inventory is taken. When changes are made in the personnel having custody of property an additional inventory is required. Property is divided into seven general classes, as follows:

Class 1. Issuable or expendable materials or supplies.
Class 2. Working equipment, fixtures, and fittings.
Class 3. Working tools for construction and repair.
Class 4. Buoys and appendages.
Class 5. Condemned articles.
Class 6. Shipments in transit.
Class 7. Office furniture and equipment.

A stock and stores account is kept of all expendable supplies and issue is made only on approved requisitions. An invoice accompanies each shipment, a copy of which must be receipted and returned to the issuing office or depot. The information obtained from this stock-keeping system forms a basis for keeping an accurate cost of every important feature of the work of the Lighthouse Service. The results thus obtained are of value in preparing estimates, in planning work, and in comparing the efficiency of different districts, vessels, apparatus, methods, etc. The system used is made as simple as practicable in order to save clerical expense and to avoid obscuring

the important facts. Separate costs are kept only of the more important features and classes of expenditures; general operating costs, such as tender service and administration, are not distributed, and liabilities are generally not charged.

Expenditures of materials, supplies, and labor are charged the same as expenditures of money. Each principal object in the Service is classed as a feature, such as district offices, depots, tenders, light vessels, light and fog-signal stations, etc., and a set of account numbers, ranging from 10 to 24, assigned to each feature. These account numbers are arranged in continuous order, and certain blank numbers are allowed each feature to provide for future extensions; thus numbers 1 to 19 are assigned the Commissioner's office, while only 15 are in use; numbers 20 to 49 to district offices, while only up to No. 34 are live numbers. The numbers are of course purely arbitrary and are used merely for convenience and abbreviation, each number referring to some particular item of cost; for example, under the Commissioner's office No. 1 stands for administrative salaries, No. 2 for technical salaries, No. 3 for clerical salaries, No. 4 for transportation of persons, No. 5 for freight, express, and cartage, and so on, the intention being to charge each item of expenditure to an appropriate number. In all cases the numbers are so arranged as to divide the costs into two main headings—maintenance and betterments. The cost of maintenance includes what may be considered fixed expenses, such as salaries, rations, fuel, and general expendable supplies. The item of betterments includes repairs, improvements, and new construction and is further subdivided to show the cost of labor and materials separately for each principal object. Cost reports are submitted annually by all the districts, and these are consolidated in the Commissioner's office to show the results for the entire Service. Such statements are checked with the money accounts by taking into consideration the actual cash expenditures and the difference in the value of supplies on hand at the beginning and end of the year. A generalized summary of costs for the fiscal year ended June 30, 1915, as derived from this cost-keeping system appears on pages 88 to 90.

Summary of Costs, Lighthouse Service, Fiscal Year Ended June 30, 1915.

TOTAL COSTS OF PRINCIPAL FEATURES.

Feature.	Maintenance expenses.					Betterment expenses.				Grand total.	Per cent.
	Salaries.	Subsistence.	General supplies.	Incidental expenses.	Total.	Repairs and improvements.		New works.	Total.		
						Labor.	Materials and supplies.				
Administration [a]	$334,535	.....	$53,760	$2,549	$390,844	.....	.....	.....	.....	$390,844	7
Distributive charges [b]	816,400	$201,879	436,455	33,068	1,487,802	$117,758	$117,879	$138,445	$374,082	1,861,884	34
Aids to navigation [c]	1,482,894	251,491	381,732	22,808	2,138,901	249,048	484,656	422,671	1,156,377	3,295,300	59
Total	2,633,829	453,370	871,947	58,425	4,017,547	366,806	602,535	561,116	1,530,459	5,548,028	100

TOTAL COSTS OF DETAILED FEATURES.

Offices	$334,535	.....	$84,373	$2,549	$421,457	.....	.....	.....	.....	$421,457	8
Depots	165,097	.....	64,039	22,005	251,141	$39,079	$39,107	$73,477	$151,753	402,894	8
Tenders:											
Large	179,770	$53,178	107,864	2,138	342,950	19,412	19,413	653	39,478	382,428	7
Medium	415,077	130,098	205,103	7,799	758,077	52,155	52,156	64,315	168,626	926,703	16
Small	56,456	18,603	28,836	1,126	105,018	7,112	7,113	.....	14,225	119,243	2
Total	651,303	201,879	341,803	11,063	1,206,045	78,679	78,682	64,968	222,329	1,428,374	25
Light vessels:											
Exposed	161,052	38,823	42,573	1,985	244,433	36,935	36,936	.....	73,871	318,304	6
Moderately exposed	93,927	25,861	20,653	218	140,662	39,736	39,737	1,486	80,959	221,621	4
Relief	59,113	14,813	17,596	461	91,978	7,500	7,501	209	15,210	107,188	2
Lakes	38,094	11,064	7,564	989	57,711	6,233	6,234	38,759	51,226	108,937	2
Total	352,186	90,561	88,386	3,653	534,784	90,404	90,408	40,454	221,266	756,050	14

Light stations:											
First order	115,256	20,751	30,220	1,328	167,553	17,536	20,958	1,587	40,081	207,634	4
Second order	46,337	8,426	16,480	187	71,425	6,984	10,506	3,361	20,851	92,276	2
Third order	94,790	19,835	36,491	1,295	152,411	22,307	20,438	41,704	84,449	236,860	4
Three and one-half order	21,212	4,085	5,077	78	30,449	7,098	5,223	106	12,427	42,876	1
Fourth order	324,682	64,197	91,199	2,657	482,730	47,135	56,572	114,376	218,083	700,813	12
Total	602,277	117,294	179,467	5,545	904,568	101,060	113,697	161,134	375,891	1,280,459	23
Minor fixed aids:											
Fifth order	90,924	18,687	18,162	101	127,869	6,335	7,537	87	13,959	141,828	3
Sixth order	49,037	9,143	8,160	183	66,522	4,115	10,214	368	14,697	81,219	1
Lens lanterns	72,003	8,088	12,806	165	93,064	7,358	4,285	13,948	25,593	118,657	2
Post lights	220,913	.....	17,064	1,021	238,999	2,804	6,785	4,464	14,053	253,052	5
Other lights	92,842	7,718	35,892	4,373	140,821	23,583	55,350	142,273	221,206	362,027	6
Daymarks, etc	.....	.....	1,301	498	1,799	2,842	2,257	2,275	7,374	9,173	.....
Total	525,719	43,636	93,385	6,341	669,074	47,037	86,428	163,415	296,882	965,956	17
Buoys:											
Lighted	2,712	.....	19,252	2,383	24,347	2,364	121,800	57,668	181,832	206,179	4
Unlighted	.....	.....	1,242	4,886	6,128	8,183	72,323	.....	80,506	86,634	1
Total	2,712	.....	20,494	7,269	30,475	10,547	194,123	57,668	262,338	292,813	5
Grand total	2,633,829	453,370	871,947	58,245	4,017,547	366,806	602,535	561,116	1,530,459	5,548,028	100

[a] Includes offices, except expenses of publications and general freight accounts.
[b] Includes depots and tenders; also items excepted above, charged to supplies.
[c] Includes light vessels, light stations, minor fixed aids, and buoys.

SUMMARY OF COSTS, LIGHTHOUSE SERVICE, FISCAL YEAR ENDED JUNE 30, 1915—Continued.

AVERAGE OPERATING COSTS OF SELECTED FEATURES.

Average cost of—	Salaries.	Subsistence.	Illuminants.	Fuel.	Other supplies.	Incidentals.	Total maintenance.	Repairs and improvements.	Total.
District office, exclusive of third	$12,252	.....	.....	.....	$2,025	$131	$14,408	.....	$14,408
District depot, exclusive of third	6,831	.....	.....	.....	2,624	922	10,377	$4,616	14,993
Large tender, Pacific	22,612	$5,945	.....	$9,724	4,055	286	42,622	5,458	48,087
Large tender, Atlantic	18,655	5,800	.....	8,025	3,063	213	35,846	3,740	39,587
Medium tender	14,740	4,604	.....	4,865	2,399	277	26,885	3,721	30,606
Exposed light vessel	8,053	1,941	$77	1,197	854	99	12,221	3,693	15,914
Moderately exposed light vessel	4,473	1,231	82	280	622	10	6,698	3,784	10,482
Lake light vessel	3,323	950	105	300	292	22	4,992	1,218	6,210
First-order light stations with powerful fog signals	2,465	430	135	277	248	23	3,578	1,032	4,610
First-order light stations without fog signals	1,800	330	147	110	208	24	2,619	515	3,134
Fourth-order light stations with powerful fog signal	1,430	287	65	272	195	17	2,226	632	2,898
Fourth-order light stations without fog signal	658	131	34	44	99	6	974	295	1,269
Lens lantern	189	21	18	5	11	.....	245	a 31	276
Minor light, river districts	90	.....	2	.....	3	.....	95	a 1	96
Minor light, other districts	121	.....	11	.....	5	1	138	a 14	152
High-pressure acetylene light	36	3	30	2	8	4	83	a 157	240
High-pressure acetylene buoy	.....	.....	36	.....	b 51	1	88	a 15	c 103
Low-pressure acetylene buoy	.....	.....	130	.....	b 22	.....	152	a 22	c 174
Oil-gas buoy	.....	.....	32	.....	b 21	1	54	a 7	c 61

a Figures do not include cost of establishment of new aids.
b Figures include transportation charges of all kinds, such as freight on new buoys, etc.
c Figures do not include renewal of appendages.

With reference to the cost of establishing new aids, so much depends upon the local conditions that little definite information can be given. The following approximate statements, however, furnish some idea of the prevailing range. Minor lights cost from about $100 to $10,000 each; lighthouses with quarters, and fog signal where necessary, from $40,000 to $200,000 and over per station. The light and fog signal at St. George Reef, Cal., the most expensive lighthouse thus far constructed in this country, cost nearly $800,000; it is on Northwest Seal Rock, 6½ miles off the northern coast of California, in the Pacific Ocean; construction was commenced in 1883, and the light first exhibited in October, 1892. Lighthouse tenders cost from $20,000 to $250,000 each, depending on their size and duty; the average medium-sized tender will cost now about $150,000. A first-class self-propelling light vessel will cost about $130,000; smaller and less powerful vessels may be built for down to about $70,000. Lighted buoys cost from about $800 to $5,000 each, the larger and more expensive sizes being needed for outside stations. Whistling buoys cost about $500 each, and bell buoys about $400 each, cans and nuns, including also iron spars, range from about $50 to $300 each, depending on size, while first-class wooden spars are about $35 each, with corresponding reductions for smaller classes. The cost of moorings

for buoys is not included in any type mentioned; this will vary from a few dollars to $500 and over per buoy, depending on the location and depth of water.

26. EXHIBITS OF THE LIGHTHOUSE SERVICE.

It has been the custom of the Lighthouse Service for many years to participate in various national expositions and similar occasions, by a display of various articles and equipment used in its work, illustrating some of the progress made, the apparatus or methods employed, and the results so obtained. As a part of the collective exhibit of the Department of Commerce, similar steps were taken in connection with the Panama-Pacific International Exhibition, held at San Francisco during the current year.

The Lighthouse Service was allotted approximately 3,300 square feet of space in the north end of the Machinery Building, and the sum of $4,750 from the appropriation for the Government's exhibit as a whole. It was planned to make the exhibit of interest from both a historical and practical point of view.

The historic features included a collection of water colors, painted in 1859, of early light stations on the Pacific; the old 10-pounder cannon used from 1855 to 1857 at Point Bonita, Cal., being the first fog signal on the Pacific coast; the first Fresnel lens imported into this country in 1841 for use at Navesink, N. J., as well as the first lens used on the Pacific coast at Alcatraz, Cal., in 1854; also a collection of old lamps used for burning sperm oil, lard oil, and early plunger and air-pressure lamps for kerosene.

From a practical standpoint, the exhibit included 50 enlarged photographs of important lighthouse objects, with models to scale of a number of important light stations and vessels. A modern flashing lens and lantern, also improved forms of fog-bell strikers and a recent type of compressed-air fog-signal, using a 6-inch siren were shown. An unusual and striking feature was the inclusion of a portion of the illuminating and fog-signal apparatus for the new lighthouse now under construction at Cape St. Elias, Alaska, embracing, among other equipment, the complete parapet deck, watch room, and helical bar lantern, a massive metal structure standing 29 feet high above the floor level and weighing approximately 44,000 pounds. Present practice in lamps was illustrated by incandescent oil-vapor outfits of 35 and 55 millimeter mantles, along with smaller sizes of lens and post lanterns. Typical sizes and types of buoys, such as whistling, bell, cans, and nuns, with ballast balls, sinkers, and anchors were also shown.

The attendants on duty were experienced lighthouse keepers, selected from the Pacific coast districts for details of about three weeks each, who were present in uniform to care for and explain the apparatus.

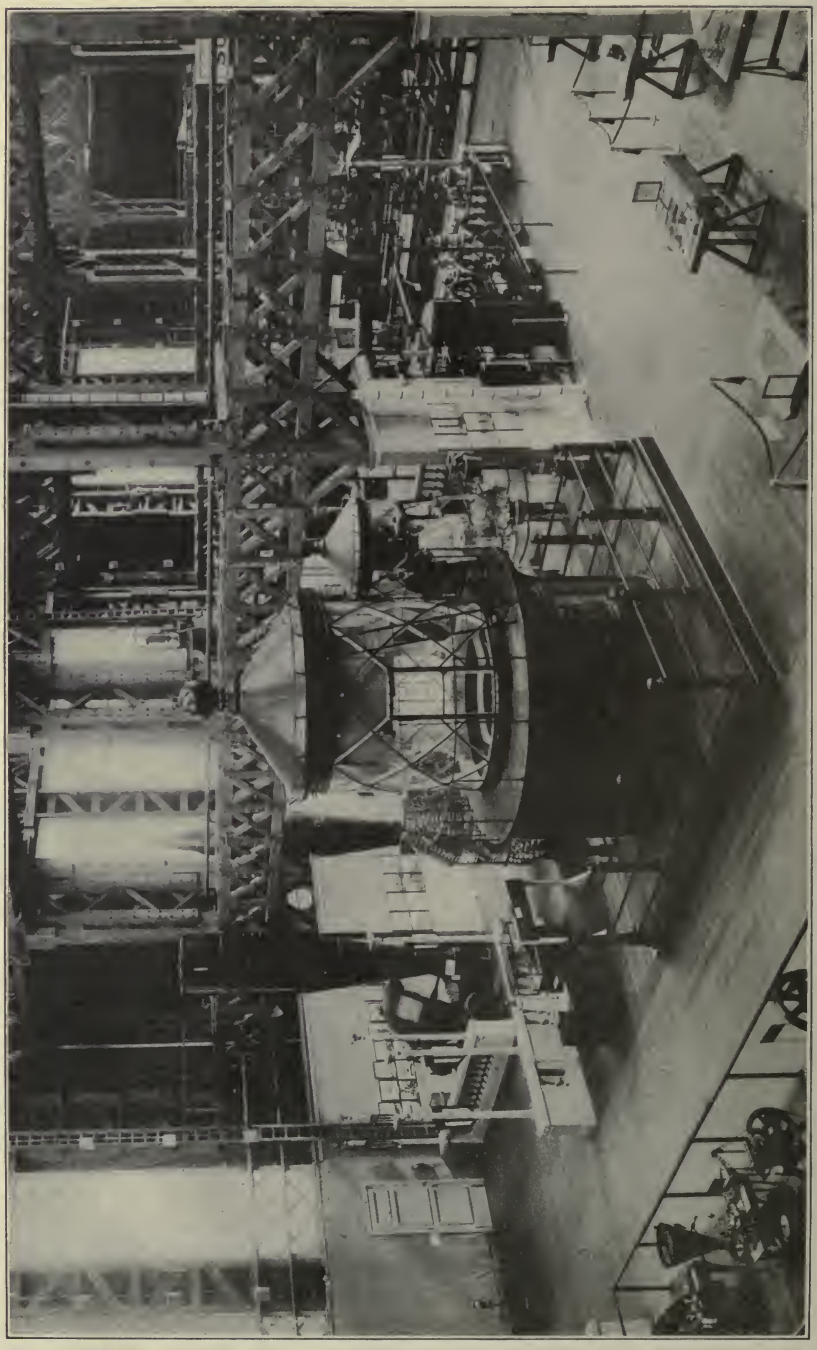


Exhibit of Lighthouse Service at Panama-Pacific International Exposition, San Francisco, Cal.

A medal of honor was awarded the exhibit by the exposition authorities, and silver medals were awarded to those officers of the Service who collaborated in the preparation of the exhibit. Similar awards and tokens have been granted to previous exhibits made by the Lighthouse Service in past years at other expositions, among which may be mentioned the International Exposition at Vienna in 1873, the Centennial Exhibition at Philadelphia in 1876, the Third International Geographic Congress at Venice in 1881, the International Fisheries Exhibition at London in 1883, the Industrial Exhibition at Cincinnati in 1884, the World's Columbian Exhibition at Chicago in 1893, the Trans-Mississippi Exposition at Omaha in 1898, the Pan-American Exposition at Buffalo in 1901, and the Louisiana Purchase Exposition at St. Louis in 1904.

27. PAST AND PRESENT OFFICERS OF THE SERVICE.

The names of officers in direct charge of the operations of the Lighthouse Service, from the time of the establishment of the Federal Government to the present, with their respective dates of service, are given in the table below. In colonial days the management of the lights was in the hands of the local authorities of the various colonies and provinces. It should be observed that up to 1820 many matters, involving even routine business, were approved personally by the President.

Name.	From—	To—
PRIOR TO THE LIGHTHOUSE BOARD.		
Alexander Hamilton, Secretary of the Treasury	Aug. 7, 1789	May 8, 1792
Tench Coxe, Commissioner of the Revenue	May 9, 1792	Jan. 21, 1798
William Miller, jr., Commissioner of the Revenue	Jan. 22, 1798	Apr. 6, 1802
Albert Gallatin, Secretary of the Treasury	Apr. 7, 1802	July 24, 1813
Samuel H. Smith, Commissioner of the Revenue	July 31, 1813	Dec. 31, 1819
Stephen Pleasonton, Fifth Auditor of the Treasury	Jan. 7, 1820	Oct. 8, 1852
CHAIRMEN OF LIGHTHOUSE BOARD.		
William B. Shubrick, captain, U. S. Navy	Oct. 9, 1852	Feb. 7, 1859
Lawrence Kearney, captain, U. S. Navy	Feb. 7, 1859	June 6, 1859
William B. Shubrick, rear admiral, U. S. Navy	June 6, 1859	Oct. 30, 1871
Prof. Joseph Henry, LL. D. (Secretary of the Smithsonian Institution)	Oct. 30, 1871	May 13, 1878
John Rodgers, rear admiral, U. S. Navy	June 23, 1878	May 5, 1882
Robert H. Wyman, rear admiral, U. S. Navy	June 5, 1882	Dec. 2, 1882
Stephen C. Rowan, vice admiral, U. S. Navy	Jan. 18, 1883	Feb. 26, 1889
David P. Harmony, rear admiral, U. S. Navy	Feb. 27, 1889	May 29, 1891
James M. Greer, rear admiral, U. S. Navy	June 1, 1891	Dec. 1, 1894
John G. Walker, rear admiral, U. S. Navy	Dec. 4, 1894	Mar. 23, 1897
Winfield S. Schley, commodore, U. S. Navy	Apr. 5, 1897	Mar. 25, 1898
F. V. McNair, rear admiral, U. S. Navy	Apr. 4, 1898	July 5, 1898
Rush R. Wallace, commodore, U. S. Navy	July 11, 1898	Oct. 3, 1898
Francis J. Higginson, commodore, U. S. Navy	Oct. 3, 1898	Apr. 22, 1901
Norman H. Farquhar, rear admiral, U. S. Navy	May 2, 1901	May 6, 1902
George C. Remey, rear admiral, U. S. Navy	May 6, 1902	Aug. 8, 1903
John J. Read, rear admiral, U. S. Navy	Aug. 8, 1903	June 17, 1904
Robley D. Evans, rear admiral, U. S. Navy	June 20, 1904	Jan. 5, 1905
Benjamin P. Lamberton, rear admiral, U. S. Navy	Jan. 6, 1905	Feb. 25, 1906
George C. Reiter, rear admiral, U. S. Navy	Feb. 25, 1906	Dec. 31, 1907
A. Marix, rear admiral, U. S. Navy	Jan. 6, 1908	June 30, 1910
COMMISSIONER OF LIGHTHOUSES.		
George R. Putnam	July 1, 1910	.....

The present principal officers of the Service are George R. Putnam, M. Am. Soc. C. E., Commissioner of Lighthouses; John S. Conway, M. Am. Soc. C. E., Deputy Commissioner; H. B. Bowerman, M. Am. Soc. C. E., chief constructing engineer; and Edward C. Gillette, superintendent of naval construction.

The lighthouse inspectors, with the duty or district assigned to each, were as follows on December 1, 1915:

District.	Inspector.	District.	Inspector.
General duty	Everett M. Trott.	Twelfth	Lewis M. Stoddard.
First	Carl E. Sherman.	Thirteenth	Maj. George M. Hoffman, Corps of Engineers, U. S. Army.
Second	Ralph H. Goddard.	Fourteenth	Col. Lansing H. Beach, Corps of Engineers, U. S. Army; M. Am. Soc. C. E.
Third	Joseph T. Yates.		
Fourth	Thomas J. Rout.		
Fifth	Harold D. King.		
Sixth	Henry L. Beck.	Fifteenth	Maj. Wildurr Willing, Corps of Engineers, U. S. Army.
Seventh	Wm. W. Demeritt.		
Eighth	Benj. B. Dorry.	Sixteenth	Walter C. Dibrell.
Ninth	Camille A. Lamy.	Seventeenth	Robert Warrack.
Tenth	Roscoe House.	Eighteenth	Harry W. Rhodes.
Eleventh	Edward L. Woodruff, M. Am. Soc. C. E.	Nineteenth	Arthur E. Arledge, Assoc. M. Am. Soc. C. E.