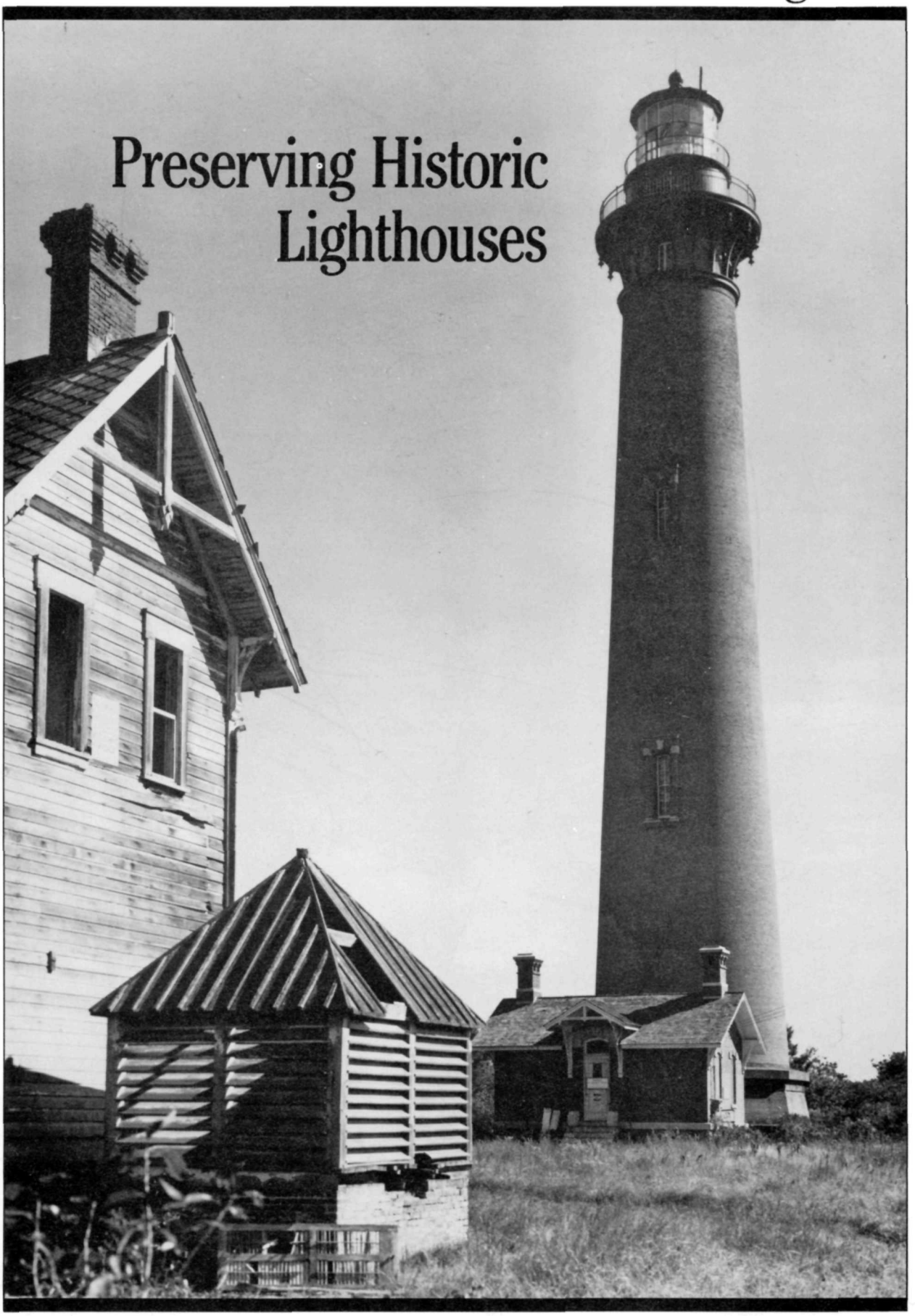
NPS Reading List

Preserving Historic Lighthouses



U.S. Department of the Interior National Park Service Preservation Assistance Division

Cover Photograph: Currituck Lighthouse, Currituck, NC. This brick lighthouse tower (1875), owned by the State, is only one part of a grouping of buildings. In preserving America's lighthouses, we must also consider the complex and its related setting. Photo: Randall Page, North Carolina, Division of Archives and History.

Preserving Historic Lighthouses

An Annotated Bibliography

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U.S. Department of the Interior
National Park Service
Preservation Assistance Division
Washington, D.C.

1989

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This technical preservation bibilography was prepared to assist owners, architects and administrative officials with the planning, review, and implementation of preservation work on historic lighthouses. The authors wish to acknowledge the contributions of the following individuals who provided technical comments on the manuscript: Ross Holland; Lieutenant Commander Robert Garrett, and Dr. Robert Scheina, U.S. Coast Guard; Ken Black, Shore Village Museum; Wayne Wheeler, U.S. Lighthouse Society; Kirk Mohney, Maine Historic Preservation Commission; Dick Moehl, Great Lakes Lighthouse Keepers Association; and James P. Delgado and Kevin J. Foster, National Park Service. Special thanks go to Michael Auer and Theresa Robinson, of the Preservation Assistance Division of the National Park Service, and Linda G. Willett of the Northeast region of the National Trust for Historic Preservation for her bibliographic contribution.

Reading lists have been published by the National Park Service, Preservation Assistance Division, since 1975. Most are selected bibliographies, that is, not intended to be a comprehensive overview of the subject; some are annotated. The Reading Lists are periodically updated. Comments on the usefulness of this information should be sent to Lee H. Nelson, FAIA, Chief, Preservation Assistance Division, National Park Service, P.O. Box 20013-7127.

FOREWORD

To commemorate the 200th anniversary of the Federal Lighthouse Program, Congress appropriated two million dollars for a Bicentennial Lighthouse Fund (to be administered through the Historic Preservation Fund Program) to assist in the preservation of historically significant lighthouses and related complexes. Through Public Laws 100-202 and 100-446 in Fiscal Year 1987 and 1988, monies have been made available for matching grants-in-aid to the States, to fund a variety of activities, including the preparation of National Register nominations, inventories of historic lighthouses, historic structure reports, and actual "bricks and mortar" preservation work.

The lighthouses on our coastal landscapes and lake shores are a distinctive part of the nation's heritage. There are few historic structures that evoke romantic images like a lighthouse. They have been an integral part of the seagoing traditions of this country for two centuries, and we admire the effective and long lasting technologies that produced these historic lighthouses, their lenses and equipment.

The maintenance and repair of these lighthouses and related structures such as keeper's houses have always been difficult because of their harsh marine environment. Now, with the era of manned lighthouses coming to an end, the preservation challenges for this entire class of buildings is even greater. If these historic treasures are to be preserved as part of our cultural heritage, they must be properly protected.

This technical preservation bibliography has been developed to assist owners, architects and administrative officials with the planning, review, and implementation of preservation work on historic lighthouses. Preservation work funded by the Bicentennial Lighthouse Fund must meet the Secretary of the Interior's Standards for Historic Preservation Projects, which require that the historic character and materials be preserved. It is, therefore, important that those planning the work on these lighthouses and related structures be aware of how they were built, what materials they contain and how these materials and features should be preserved.

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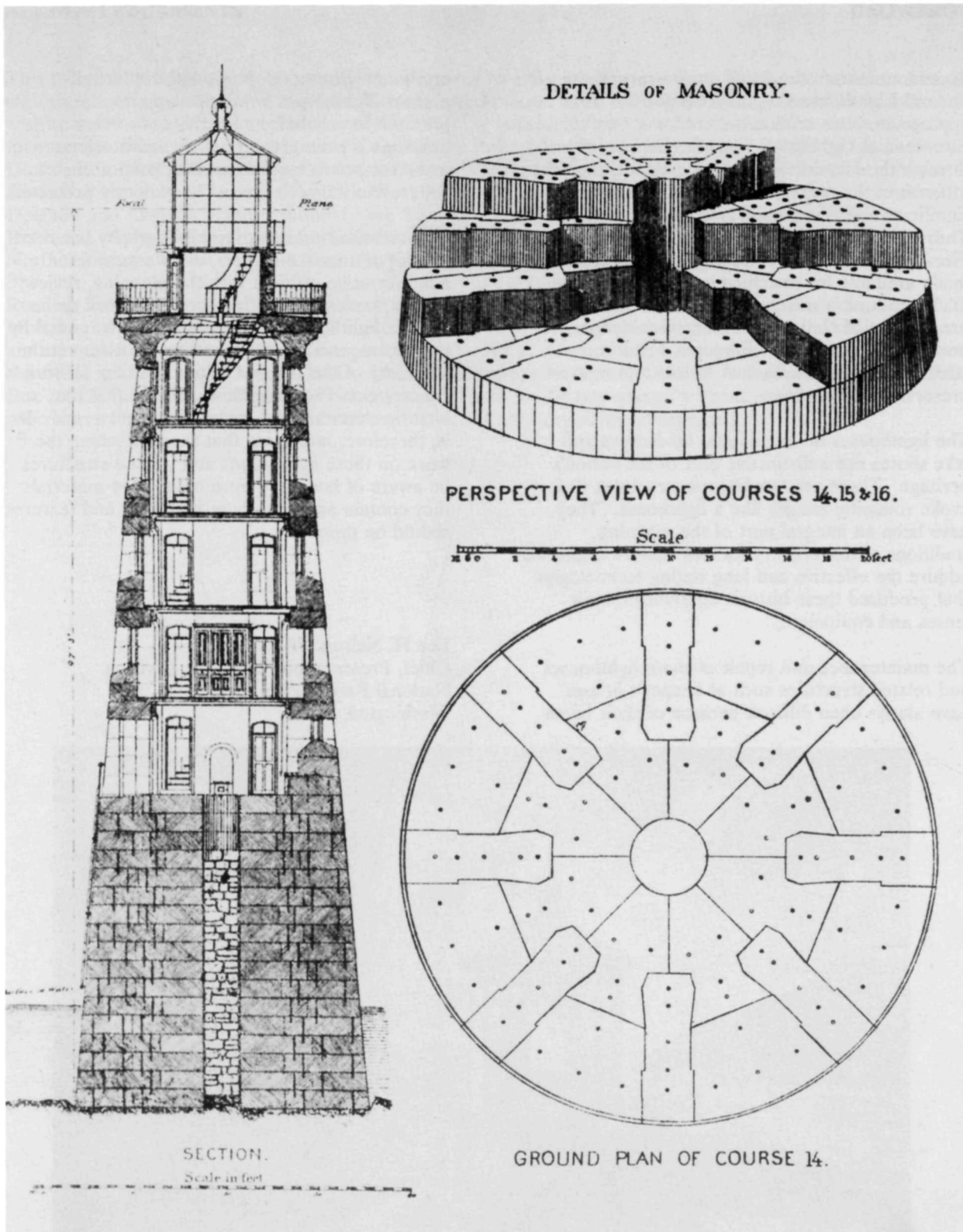
Heceta Head Lighthouse, Heceta Head, OR. This rare first order lens, installed in 1893 at the time of construction of this U.S. Coast Guard owned lighthouse, was manufactured by the Chance Brothers, England. Now automated, this million candlepower light can be seen 21 miles off shore. Photo: Lee H. Nelson, FAIA.



Spectacle Reef Lighthouse, Lake Huron, MI. A wealth of technical information can be found in early histories of lighthouse construction. This illustration is from The Modern Lighthouse Service, *written by Arnold Burges Johnson, head of the U.S. Lighthouse Board in 1890. To combat the crushing blows of ice floes often found in the Great Lakes, the horizontally interlocking masonry blocks were further reinforced with 2 foot long vertical iron bolts.*

PREFACE

In the United States, there are over 850 light stations which remain standing, over half of which are owned by the U.S. Coast Guard and other Federal agencies. The remaining light stations are owned by States, maritime museums, or private individuals, many of whom have adaptively reused them. In some cases, historic lighthouses have been "mothballed" awaiting reuse. A large number of these structures are listed, or have been determined to meet the criteria for listing, in the National Register of Historic Places.

Little has been written on the technical aspects of preserving historic lighthouses, and few case studies or inventories of individual lighthouses have been published or made available to the public. Books and articles selected for inclusion in this bibliography, therefore, either describe early construction technology or have a direct applicability to the technical preservation of lighthouses and related structures. Therefore, the more general kind of picture books typically found under the heading of "lighthouses" in library card catalogs have not been included in this bibliography.

The listings here include a variety of publications found at the Library of Congress, the National Archives, the libraries of the U.S. Coast Guard, American Institute of Architects, various universities, and also at several lighthouse organizations. There are a number of official documents from the U.S. Lighthouse Service, some rare but excellent early descriptions of building technology, specific case studies regarding preservation of historic lighthouses, as well as preservation, rehabilitation and maintenance information. Wherever possible, the bibliographic entry includes the Library of Congress number or an asterisk (*) followed by a publication number if the publication can be ordered (see **Appendix A**).

The publications dealing with repair or actual preservation work, particularly the case studies, may or may not reflect appropriate treatments for future lighthouse preservation projects. The reader is reminded that each historic resource is unique, and that each treatment should preserve the historic character and materials of the resource to the maximum extent possible. Because preservation technology is ongoing, some of the architectural treatments described in early case studies may not be appropriate for projects today.

Publications are grouped into four basic categories:

1. OFFICIAL DOCUMENTS OF THE U.S. LIGHTHOUSE SERVICE includes the annual reports, light lists, instructions to keepers, and other administrative documents that describe the construction and operation of lighthouses. In addition, there are a number of articles about the U.S. Lighthouse Service and its activities over the last 200 years. Pages 1-3.

2. GENERAL HISTORY AND CONSTRUCTION includes inventories and narratives of the construction of individual lighthouses, groupings of lighthouses, or navigational aids. Pages 5-10.

3. PRESERVATION, REPAIR, AND MAINTENANCE includes the preservation approach to planning, recording and implementing the actual "bricks and mortar" work undertaken on historic properties. Pages 11-17.

4. LIGHTHOUSE PRESERVATION CASE STUDIES includes descriptions of restoration or repair work undertaken on specific lighthouses or related structures. Pages 19-22.

This publication also contains five appendices:

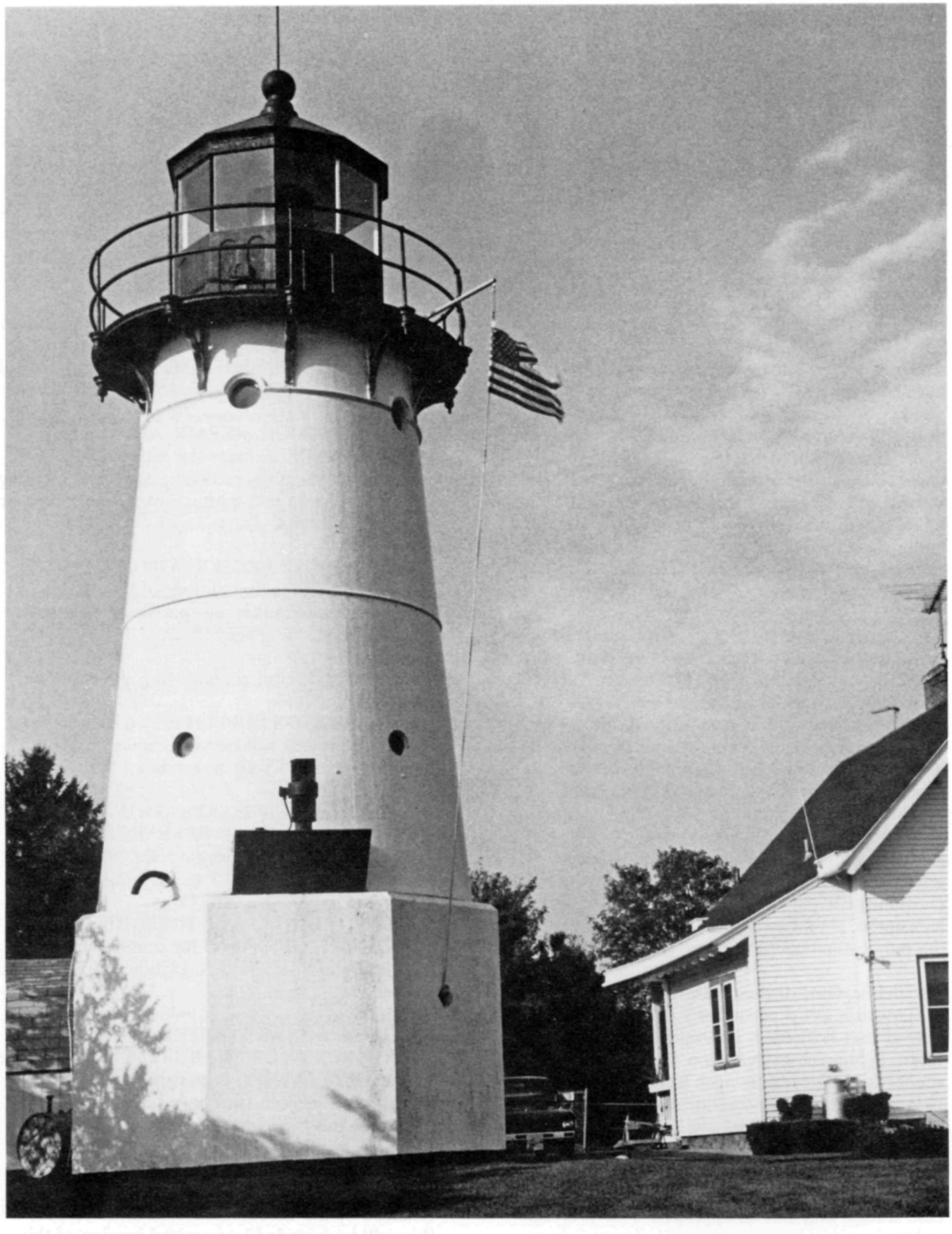
A. PUBLICATION SUPPLIERS: a list of organizations that will provide copies of the publications noted with an asterisk (*). Page 23.

B. LIGHTHOUSE PRESERVATION ORGANIZATIONS AND RESEARCH SOURCES: organizations involved with lighthouse preservation. Pages 24-25.

C. and D. REPRINTS OF HISTORIC SPECIFICATIONS: two 19th century specifications from the U.S. Lighthouse Board are reproduced. Pages 26-38.

E. THE SECRETARY OF THE INTERIOR'S STANDARDS FOR REHABILITATION. Because this set of 10 standards is central to any preservation project, they have been reproduced as part of this bibliography. Page 39.

As new sources of preservation information are published, hopefully as a result of the work financed by the Bicentennial Lighthouse Fund, they will be included in a revised version of this bibliography.



Warwick Lighthouse, Warwick, RI. This lighthouse (1932), owned by the U.S. Coast Guard which is the largest single owner of American lighthouses, was constructed of cast iron pre-fabricated components in use since the 1880s and described in the documents of the U.S. Lighthouse Service. Photo: Eugene Wick York, Rhode Island Historic Preservation Commission.

1. OFFICIAL DOCUMENTS OF THE U.S. LIGHTHOUSE SERVICE

The Lighthouse Service was established in 1789 by the Federal government, and over the last 200 years, there have been a number of name changes. This makes locating documents difficult. The U.S. Lighthouse Service has been under the jurisdiction of several agencies, including the U.S. Department of Treasury, U.S. Department of Commerce, and the U.S. Coast Guard. Official documents can be found under the following headings: The Lighthouse Service, U.S. Bureau of Lighthouses, U.S. Coast Guard, U.S. Light-House Board, U.S. Lighthouse Board, U.S. Lighthouse Establishment, and U.S. Lighthouse Service.

The documents that comprise this record of the history of the Lighthouse Service are rich with descriptions of the construction, operation and maintenance of these historic structures. There were **Annual Reports** to Congress, **Bulletins** to the various lighthouse keepers, **Light Lists** which identified types of lighthouses and construction materials, **Instructions to Keepers** which outlined the duties and responsibilities of the keepers to operate and maintain their properties, as well as construction plans and specifications.

Appendices C and D include two of the specifications of the Lighthouse Service. They have been reproduced as examples of the types of resources that may be helpful in researching original materials and construction details of historic lighthouses and related structures.

U.S. Bureau of Lighthouses, *Annual Reports*. Washington, D.C.: U.S. Department of Commerce; issued annually from the mid-19th century. Library of Congress: VK1023.A2, 1910-1913.

These invaluable reports include information on the construction or modifications of all the active lighthouses under the jurisdiction of the U.S. Bureau of Lighthouses. These annual reports, part of a larger publication of reports to the Secretary of Commerce and to the United States Congress, were never bound as a unit. Some libraries and maritime museums have a varied assortment. The U.S. Coast Guard Library, and the Historian for the U.S. Coast Guard may have the most complete set. For the serious researcher, they are important documents to consult.

U.S. Bureau of Lighthouses, *Lighthouse Service Bulletin*. Washington, D.C.: U.S. Department of Commerce; Volume 2, 1918-1923. Library of Congress: VK1023.A23. 1918-1923.

This compilation of monthly bulletins (approx. 8 pages each), contains valuable information, including construction, maintenance information, reports from individual lighthouse keepers, etc. A very helpful index is included for Volume 2.

U.S. Bureau of Lighthouses, *List of Beacons, Buoys, Stokes and other Day-Marks in the First (and up to Eighteenth) Light-House District*. Washington, D.C.: U.S. Government Printing Office, various years, from 1840. Library of Congress: VK1243. U5, or U6, or U7 depending on district.

These lists provide a comprehensive inventory of all the lighthouse towers, beacons, buoys and other navigational aids in the 18 Coast Guard districts nationwide. Included is the actual height of the beacon, which may assist in identifying what type of light was used at this time. Foundation materials, colors of features, and other specific information are also included. These annual lists were supplemented by the Notice to Mariners, which came out periodically. These lists can also be found in the Historian's Office, U.S. Coast Guard Headquarters, Washington, D.C.

U.S. Lighthouse Board. *Comparative Papers on the Catoptric and Dioptric or Catadioptric Systems of Lighthouse Illumination*. Washington D.C.: Government Printing Office, 1861.

This is an excellent volume of information, compiled from British, French and U.S. sources. Contributions from noted figures in lighthouse construction, history and illumination include letters from Thomas Stevenson and Sir David Brewster. Overall, the source provides a comparison of the relative merits of the first illuminating system, that of the catoptric lens (reflective mirrors), and the dioptric or Fresnel system (glass prism). Particularly informative

is an entry by Alexander Mitchell and Sons, entitled "Screw Pile Foundations for Lighthouses and Screw Moorings for Buoys."

U.S. Lighthouse Board. "Lighthouse Papers," *Documents Relating to Lighthouses 1789-1871 Record Group No. 26.* National Archives, Washington, D.C.; also Historian's Office, Coast Guard Headquarters, Washington, D.C.

This is a compilation of invaluable documents from the U.S. Lighthouse Board as well as related papers from a variety of lighthouses. Of particular note are the original plans and specifications of many of the lighthouses and technical descriptions of lens apparatuses.

U.S. Lighthouse Establishment (by authority of the U.S. Lighthouse Board). *Instructions to Light Keepers*. Washington, D.C.: Government Printing Office, 1870, 1871, 1881, (various years). Library of Congress: VK1023.A5.

These instructions to keepers are full of useful maintenance information. In the 1871 edition, there is a chapter on mixing paints and preparing caustic potash lye for removing oil paint from iron.

U.S. Lighthouse Establishment. *Rules, Regulations and General Instructions*. Washington, D.C.: Government Printing Office, 1870 (and other years). Library of Congress: VK1023.A5.

These manuals are similar to the *Instructions to Light Keepers* and described in detail the duties of the light keepers. Included is technical information on the operation and maintenance of the various types of lens, clocks and structures. Included is a generous appendix with drawings of lenses, oil pumps, and related mechanisms.

U.S. Lighthouse Service. *Book of References and Standards*, Washington, D.C., 1937.

This is a compilation of plans, sections, elevations and details for constructing lighthouse towers in the 1920s-1934. It was put together as a working document for the U.S. Coast Guard to illustrate current standards of practice. A copy is available at the Historian's Office, United States Coast Guard Headquarters, but Coast Guard district offices may have copies.

The following **SPECIFICATIONS** by the U.S. Lighthouse Board (also called the Lighthouse Establishment in later publications) offer a wealth of details concerning materials and specifications for all aspects of construction. Included is only a small fraction of what was printed. Library of Congress: TC375.U4 or VK1023.A5. A few University Engineering Libraries that were in existence in the 19th century may well have copies of U.S. Lighthouse Board publications. Each Coast Guard district office will have some copies. The most complete set is in the U.S. Coast Guard Academy Library.

U.S. Lighthouse Board. *Documents Relating to Lighthouses, 1789-1871*. Washington, D.C., 1871.

U.S. Lighthouse Board. *Specifications for a Dwelling for the Keepers of First Order Lights*. Washington, D.C., 1862.

U.S. Lighthouse Board. *Specifications for a First Order Lighthouse, Brick Tower*. Washington, D.C., 1861. (see **Appendix C**).

U.S. Lighthouse Board. *Specifications for an Iron Light-House for Lake Superior*. Washington, D.C., 1860. (see **Appendix D**).

U.S. Lighthouse Board. *Specifications for an Iron Pile Lighthouse at the Southwest Pass of the Mississippi River*. Washington, D.C., 1861.

U.S. Lighthouse Board. *Specifications for a Third Order Lantern*. Washington, D.C., 1862.

U.S. Lighthouse Board. *Specifications for a Third Order Lighthouse, Brick Tower*. Washington, D.C., 1864.

U.S. Lighthouse Board. *Specifications for Love Point Lighthouse, Chesapeake Bay, Maryland*. Washington, D.C., 1858.

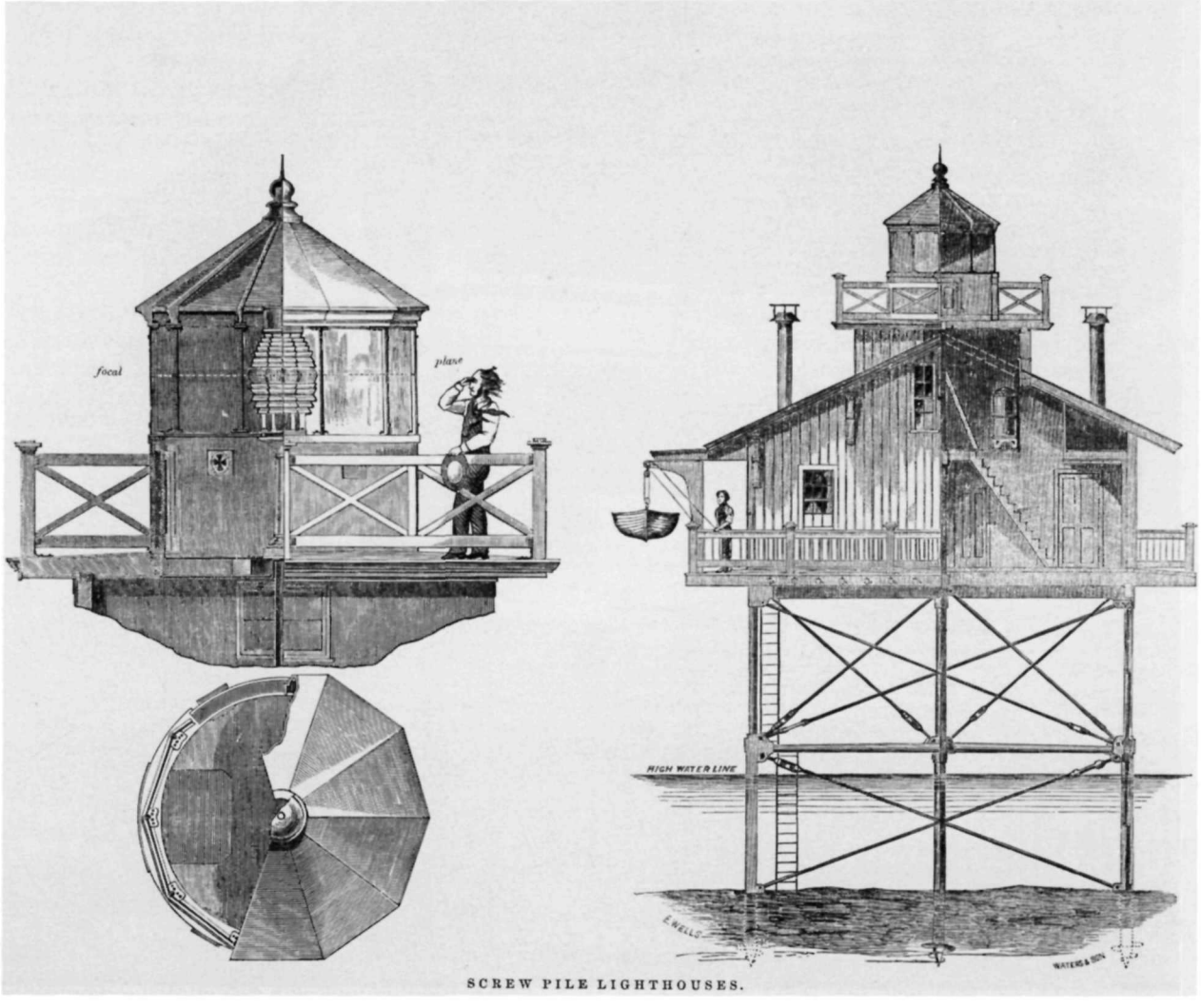
U.S. Lighthouse Establishment. *Specifications and Contract for Dwelling for Two Keepers at Staaten Island Light Station, Richmond, New York*. Washington, D.C., 1911.

U.S. Lighthouse Establishment. *Specifications and Contract for Dwelling For Keeper of Waackaack Light Station, Keansburg, New Jersey.* Washington, D.C., 1908.

U.S. Lighthouse Establishment. *Specifications and Contract for Landing and Approach Substructure and Superstructures for Carquinez Strait Light Station in Carquinez, California.* Washington, D.C., 1908.

U.S. Lighthouse Establishment. *Specifications and Contract for Metal Work for Tower at Makapuu Point Light Station, Oahu, Territory of Hawaii.* Washington, D.C., 1908.

U.S. Lighthouse Establishment. *Specifications and Contract for Metal Work for Tower at Reedy Island Range Rear Light Station, Delaware.* Washington, D.C., 1909.



Nineteenth Century Screw Pile Lighthouse, U.S. Lighthouse Board. Illustrations, such as these, often accompanied Specifications or other official documents of the U.S. Lighthouse Board, and clearly reveal details, materials, and dimensions of historic lighthouses. These screw piles were often found in coastal waters and in temperate climate zone, where neither rough currents nor ice floes would damage them.

Point Fermin Lighthouse, San Pedro, CA. This wooden lighthouse (1870) was one of a series of wooden lights constructed from San Francisco to San Diego. As seen in this 1920 view, the lighthouse was unchanged. After W.W. II, a new beacon was constructed beachside and the light tower was converted to a viewing platform. This lighthouse, now part of a public park, will be included in the California survey of historic lighthouses being funded by a grant from the Bicentennial Lighthouse Fund. Photo: San Pedro News-Pilot.

2. GENERAL HISTORY AND CONSTRUCTION OF LIGHTHOUSES

The history of the construction of lighthouses closely follows the evolution of construction technology in North America. In the tapered shape typical of the early load-bearing masonry towers, the elegant skeletal frames of iron towers, and the solid, reinforced, seismically-designed concrete towers lies a rich history of engineering and functional design. While there are certain regional variations in materials and types of lighthouses, a simplified chronology of the development of lighthouses begins with the colonial coastal lighthouses made of wood. Because they used an open flame for the lamps, many were destroyed by fire. They generally were replaced with stone lighthouses; the earliest to survive from this period is the stone lighthouse (1764) at Sandy Hook, New Jersey.

From 1820-1852, when the Fifth Auditor of the Treasury Department was responsible for lighthouses, there was great fiscal restraint in construction and maintenance. However, the emerging technology of wrought iron and cast iron for foundations was used, which made possible off shore screw pile lighthouses.

The greatest expansion of the number and types of lighthouses occurred after 1852 when the Lighthouse Service was reorganized and the U.S. Lighthouse Board was created. This was an age of industrial technology and expanding international shipping. As taller and stronger towers were needed, or as lights moved further off shore, wood piling and cribbage systems were replaced with sunken cast iron caissons; brick towers exceeded 160 feet in height; pre-fabricated cast iron units made towers more cost effective; available technology produced skeletal iron and steel towers.

At the beginning of the 20th century, concrete towers and later reinforced concrete towers, capable of withstanding earthquakes and hurricane strength winds, were constructed, many on the west coast or north Atlantic.

The publications listed in this section include information on the history of construction technology of lighthouses, inventories of historic lighthouses, some specific histories of well documented lighthouses and data on early lenses. The reader should also check official U.S. Lighthouse Service records if specific plans and specifications are being researched.

Note: Publications identified with an asterisk (*) are available from organizations listed in **Appendix A.**

Adams, William Henry Davenport. *Lighthouses and Lightships: A descriptive and historical account of their mode of construction and organization.* London, New York: T. Nelson and Sons, 1871. Library of Congress: TC375.A21.

This publication is narrative in tone, but contains descriptions of building materials, construction and possible alterations to lighthouses throughout time. It is abundantly illustrated.

Alexander, B.S. "Minot's Ledge Lighthouse." *Transactions of The American Society of Civil Engineers.* Vol. 8, 1879, p. 83. Library of Congress: TA1.A5.V8.

This article provides a thorough account of the preparation of the site for the laying of the foundation for Minot's Ledge Lighthouse, it also includes explanations of the use of coffer dams and the method used to secure wet vertical mortar joints to prevent their disintegration as the masonry was lowered into water.

Barnard, J. G. "Lighthouse Engineering as Displayed at the Centennial Exhibition." *Transactions of the American Society of Civil Engineers.* Vol. 8, 1879, p. 55. Library of Congress: TA1.A5.V.8.

This excellent article features mostly American lighthouses distinguished as engineering feats. It includes detailed information on the preparation of sites to receive foundations, the laying of stones and brick, and characteristics of screw-pile construction.

Benjamin, Park, ed. *Appletons' Cyclopaedia of Applied Mechanics: A Dictionary of Mechanical Engineering and the Mechanical Arts*; New York: D. Appleton and Company,

1880. Volume II "Lighthouses; construction of." p. 293.

This entry gives a history of the various types of construction technology prevalent in England and applicable to the United States. A number of lighthouses are described with specific information regarding dimensions, features, and materials.

Brees, S.C. *The Illustrated Glossary of Practical Architecture and Civil Engineering.* London: J.O. Clarke, Printer, 1853, pp. 249-252.

This well-illustrated chapter gives construction information on lighthouses and includes references to numerous public works in England. The Eddystone Lighthouse in the English Chanel is featured.

Brees, S.C. and C.E. *A Glossary of Civil Engineering.* London: Henry G. Bohn, 1864, pp. 140-143.

The chapter on lighthouses discusses the Eddystone Lighthouse, the most celebrated lighthouse of the time. It aptly describes with illustrations the construction of this famous lighthouse and includes references to numerous public works in England.

Chance, James Frederick. *The Lighthouse Work of Sir James Chance.* London: Smith, Elder and Co., 1902.

The technical aspects of the construction, lens molding and proper reflector placement for lighthouse illumination are described in this history by the lens specialist, James Chance. The comparative merits of the dioptric (prism reflection or Fresnel lens) and the catoptric method (mirror reflection) of illumination are also described in some detail.

Chance Brothers and Company, Ltd. *A Few Notes on Modern Lighthouse Practice.* London, 1910.

A sales catalogue of the Chance Brothers suppliers for lighthouse construction. Included are numerous plates of cast iron sections, lens apparatus and hardware.

Cipra, David L. *Lighthouses and Lightships of the Northern Gulf of Mexico.* Washington, D.C.: U.S. Department of Transportation, 1976.

A comprehensive history of the lighthouses from Florida to Texas along the Gulf of Mexico. It includes original construction drawings, descriptions of materials, interesting photographs taken in 1890 during the pouring of the foundation, and a glossary.

Description of Funck's Hydraulic Lamp Float, with directions for using. Washington, D.C.: Government Printing Office, 1869.

One of several methods for burning oil to light lighthouse lanterns was the Funck's float lamp. Correct operation of the float and instructions for filling the oil reservoir are given.

Dean, Love. *Reef lights; Seaswept Lighthouses of the Florida Keys.* Key West: The Historic Key West Preservation Board, 1982. Library of Congress: 82-083206.

This is an excellent history of the construction of the six iron pile lighthouses of the Florida Keys. The original documents used to research these lighthouses are carefully footnoted at the end of each lighthouse chapter.

Franklin Institute. *Report on the Dioptric System of August Fresnel for the Illumination of Lighthouses.* Philadelphia: Grattan and McLean, 1850.

Although the Fresnel system had been used in Europe for many years, it was not until the middle of the nineteenth century that the optical system became the standard apparatus in the United States. This report describes the operating principles of the Fresnel system and advocates the adoption of the lenses for use in American lights.

"The Fresnel Lens, of Dia-Cataoptric Illuminating Apparatus for Light Houses." *New York Exhibition Illustrated*. New York: 1853. Library of Congress: TC379.F83.

This is a period discussion of the operation of the Fresnel Lens, which later became the standard lens for American lighthouses.

Hague, Douglas B. and Rosemary Christie. *Lighthouses: Their Architecture, History and Archaeology*. Llandysul, Wales: Gomer Press, 1975. Library of Congress: VK1013.H33.

This source is devoted to lighthouses of the British Isles, but the section on general design and construction may have relevance for their American counterparts. Most useful is the section on the development of reinforced concrete, and cast iron screw-pile construction, which improved upon the more conventional methods of pile construction.

Heap, David Porter. *Ancient and Modern Lighthouses*. Boston: Ticknor and Co., 1889. Library of Congress: TC375.H43.

This publication has a thorough description of the construction of a select number of American lighthouses, including lighting, lenses, and painting of lighthouses. The text is often accompanied by useful structural diagrams.

Holland, F. Ross. *America's Lighthouses*. Brattleboro, VT: Greene Press, 1972. Library of Congress: VK1023.H65.

The role of the U.S. Lighthouse Service and all significant and technological achievements in the history of American lighthouse construction are presented in this thorough study. The book is prefaced by a worldwide account of the earliest lighthouses, and features excellent photographic illustrations.

Holland, F. Ross. *A History of the Bodie Island Light Station, North Carolina*. Washington, D.C.: National Park Service, Division of History, 1967. *CRM BIBNUM: 002294.

This historic essay on the Bodie Island Light and early failed attempts to establish a lighthouse on this site provides a historical account of the lens apparatus and its original mode of operation.

Holland, F. Ross. *The Old Point Loma Lighthouse: Symbol of the Pacific Coast's First Lighthouses*. San Diego: Cabrillo Historical Association, 1968, reprinted 1978.

This report documents the history, construction, lens apparatus and tending duties related to the Old Point Loma Lighthouse. Some construction specifications are given, although the author notes that little factual information on construction activity is available for this structure. Unlike many sources on lighthouse construction and engineering, this booklet clearly explains the terminology used for lens construction and lens classification.

Johnson, Arnold B. *The Modern Lighthouse Service*. Washington, D.C.: 1890. Library of Congress: VK1010.J6.

Information on the cost and construction of lighthouses, light vessels, buoys and light signals is presented in this general history of the Lighthouse Service. Information on the lens system; original operation of the lantern and types and characteristics of illuminants are included. Johnson was the longtime Chief Clerk for The Lighthouse Board and later was a district superintendent.

Lockwood, D.W. "Coast Lighting in the United States." *Transactions of the American Society of Civil Engineers*. Vol. 54 - Part B, 1905, p. 43. Library of Congress: TA1.A5.V54.

This paper is from the International Engineering Congress of 1904 and provides an excellent discussion of lighthouses in the United States. There are details of concrete and cast iron structures as well as photographs of the Dungeness Lighthouse of 1898 under construction.

Matthews, Thomas. "Coast Lighting in Great Britain." *Transactions of the American Society of Civil Engineers.* Vol 54 - Part B, 1905, p. 25. Library of Congress: TA1.A5.V54.

This paper is from the International Engineering Congress of 1904 and provides an excellent discussion of lighthouses in Great Britain.

National Maritime Initiative. "Inventory of Aids to Navigation." Washington, D.C.: National Park Service, forthcoming 1989.

This computerized list identifies all the standing lighthouses, light ships and other aids to navigation in the United States. It lists the owners of the property, the construction materials, markings, dates of construction, types of lenses, number of associated structures on the site, and other facts of interest. This listing will be available through the National Maritime Initiative program of the National Park Service (see **Appendix B**).

Peck, R. M. "The Incidence of False Windows in Two Early Newfoundland Lighthouses." *Association for Preservation Technology Bulletin.* Vol. IX, No. 1, 1977, pp. 4-10.

Photographic research and structural investigation confirmed that several lighthouse windows were intended as false windows. Illustrations of the false window type used on the structure are included.

Putnam, George Rockwell. *Lighthouses and Lightships of the United States.* Boston: Houghton Mifflin Co., 1933. Library of Congress: VK1023.P8.

This source provides a layman's discussion of basic lighthouse construction. Lighthouse histories and general notes of construction are provided in regional chapters. An engineer, Putnam was the commissioner of the Bureau of Lighthouses between 1910 and 1939.

Reynaud, M. Leonce. *Memoir Upon the Illumination and Beaconage of the Coast of France.* Washington, D.C.: Government Printing Office, 1876 (English Translation of an 1864 French publication).

This fascinating account of the history of lighthouse construction and the science of illumination was translated and printed for the use of the U.S. Lighthouse Board. Includes fold out plates of cast iron lighthouses, demountable wooden beacons, plans and sections of a variety of lighthouses and apparatus.

Ribiere, C. "Lighting the Coast of France," *Transactions of the American Society of Civil Engineers*, Vol 54 - Part B, 1905, p. 3. Library of Congress: TA1.A5.V.54.

This paper is from the International Engineering Congress of 1904, and includes an excellent discussion of the lighthouses in France.

Schodek, Daniel L. *Landmarks in American Civil Engineering.* Cambridge: Massachusetts Institute of Technology, 1987, pp. 337, 342-344. Library of Congress; TA23,S36.

This publication includes a brief history of early American lighthouses, as well as detailed information on the history, type of construction and costs of construction for the old and new Minot's Ledge Lighthouses.

Sheina, Robert L. "Lighthouses, Then and Now." Supplement to *Commandant's Bulletin.* Washington, D.C.: U.S. Coast Guard, 1987.

This bulletin offers a general overview of the history of Federal administration of the lighthouses and of the major technological advancements reflected in the design and construction of U.S. lighthouses. (To request copies write: Commandant (GBPA-H), U.S. Coast Guard, 2100 2nd Street SW, Washington, D.C. 20593-0001).

Sheina, Robert L. "Minot's Ledge." *The Keepers Log.* Spring 1985, pp. 3-5.

Minot's Ledge, off the coast of Massachusetts, was one of the most difficult construction sites

of all American lighthouses. Details of the construction of the granite foundation are given in this article.

Small, Nora Pat. "Lighthouses of the National Park Service." Washington, D.C.: 1980.

This list identifies approximately 58 lighthouses in and around National Park Service sites. It is intended that there will be more lighthouses included in future years. There is a description of each lighthouse, its type of lens, and where additional information can be found. Available through the National Maritime Initiative of the National Park Service (see **Appendix B**).

Stevenson, David Alan. *The World's Lighthouses Before 1820*. London, New York: Oxford Univ. Press, 1839. Library of Congress: VK1015.S7.

This book gives a worldwide regional history of lighthouses and their evolution to 1820. There are occasional construction details such as a diagram of a template which dictated the configuration and laying of stone courses in a foundation. The section on North American lighthouses may be worthwhile for those wishing to document the original site of lighthouses that were later replaced.

Stevenson, Robert L. *Records of a Family of Engineers*. London: Chatto & Windus, 1912.

The first section of this book describes the history of the Stevenson family renowned as engineers. The second half of the book provides a comprehensive history of their work on the Scottish Northern Lights lighthouses. Construction plans and other illustrations are provided for Bell Rock, one of the Scottish lighthouses.

Stevenson, Thomas. *Lighthouse Illumination: a description of the holophotal system, and of azimuthal-condensing, and apparent lights*. London: 1880.

A technical description by one of the early engineers of British and Scottish lighthouses.

Talbot, Frederick. *Lightships and Lighthouses*. Philadelphia: J.B. Lippincott Co., 1913. Library of Congress: TC375.T3.

This source gives a mostly narrative, non-technical treatment of lighthouses but includes a number of period photographs which may suggest preservation issues.

United States Coast Guard. *Aids to Navigation*, CG-127. Washington, D.C.: U.S. Government Printing Office, 1945.

This publication shows the development of aids to navigation in the United States from colonial times to 1941, just prior to the entry of the U.S. into World War II. Included are physical descriptions and operations of lighthouses, buoys, and lightships. A copy is available in the Historian's Office, U.S. Coast Guard Headquarters, (see Appendix B).

United States Coast Guard. *Historically Famous Lighthouses*. Washington, D.C.: U.S. Coast Guard, Public Information Division, 1972. Library of Congress: VK1023.A25. 1972.

This review of lighthouse styles illustrates examples of American lighthouses with photographs and brief notes on the history, construction methods and the range of materials used.

Updike, Richard W. "A. Fresnel and His Lighthouse Lenses." *Log of Mystic Seaport*. Vol. 19, No. 12, 1967.

The history of Augustin Jean Fresnel and his invention of the lens that became the standard lens for all lighthouses. The basic operating principles of the lens are discussed along with an explanation of lens classifications.

Weiss, George. *The Lighthouse Service, Its History, Activities and Organization*. Baltimore: The Johns Hopkins Press, 1926. Library of Congress: VK1023.W4, Reprinted New York: AMS Press, 1974.

This is a history of the Lighthouse Service as an administrative unit of the U.S. Government. The source profiles the Colonial lights and operations prior to the act of 1789, which placed the care and superintendence of the Lighthouse Establishment under the Treasury Department. Various technologies along with discussions of the Fresnel lens and different illuminants (oils) that were gradually adopted in the U.S. are included.

Wheeler, Wayne. "Alcatraz and the First West Coast Lighthouses." *The Keepers Log of the U.S. Lighthouse Preservation Society.* Winter 1985, p. 2.

This article chronicles the history and construction of the Alcatraz lighthouses. The original structure built in 1857, was damaged by the San Francisco earthquake, and the present light tower, built of reinforced concrete, replaced it in 1909.

Wheeler, Wayne. "The Eddystone: Part IV the Douglas Tower." *The Keeper's Log of the U.S. Lighthouse Preservation Society.* Spring 1986, p. 23.

This is a description of the construction of the 1882 masonry lighthouse on the English Channel outcropping known as the Eddystone. Of particular interest is the engineering of the structure with dovetailed and interlocking (both horizontally and vertically) granite blocks. A particularly revealing section through the lighthouse shows the eight rooms stacked vertically in the tower.

White, Walter. "Lighthouse Memories." *The Keepers Log of the U.S. Lighthouse Preservation Society.* Summer 1985, p. 6.

The San Francisco earthquake of 1906 damaged many California coastal lighthouses. The Point Arena lighthouse built in 1907 was the first such structure to employ earthquake resistant concrete reinforcements. The account given describes the hand feeding and threading of reinforced iron to the top of the tower.

Saugerties Lighthouse, Hudson River, Saugerties, NY. This brick lighthouse (1869), owned by the Saugerties Lighthouse Conservancy, is a combination house and light tower and has received a grant from the Bicentennial Lighthouse Fund for masonry repair and preservation of the structure. Photo: National Park Service files.

3. PRESERVATION, REPAIR AND MAINTENANCE

The publications in this section are intended to aid in the overall physical protection of lighthouses by discussing methods of investigation, evaluation and preservation of historic materials. Before any repair or restoration work is to be done on a historic resource, it is important that the entire resource be studied. A comprehensive plan should be developed to ensure that the significant character-defining features of the resource as well as the historic materials are preserved. Once the structures or buildings are in good repair, then development of a routine maintenance plan is essential. Because the Coast Guard is responsible for the greatest number of lighthouses, some of the publications, including maintenance manuals, have been developed by and for the Coast Guard.

The materials and structural systems used for each lighthouse, keeper's house, river light or other navigational aid varied by region and time of construction. As such, each structure is unique and will require a separate analysis and preservation plan. One of the components of any preservation plan, be it repair or maintenance, will involve looking at specific materials, structural systems, and, in the cases of lighthouses, the types of light systems.

While few lighthouses are made of wood, there are a number clad with shingles and there are numerous clapboard keeper's houses and related structures. In addition, there are structural components subject to rot or animal infestation. Brick, masonry and concrete structures share similar problems of spalling and materials deterioration due to moist environments. Cast iron is found not only as the exterior material for entire lighthouses, but also as components such as balcony railings, staircases, window and lantern frames, etc. Miscellaneous metals includes such items as copper roofs, domes and ventilators, bronze lanterns and brass hardware. As paintings and coatings are an important component of exterior protection of lighthouses, they have also been included.

Information on preservation work associated with specific lighthouse properties is included in Section 4, **LIGHTHOUSE PRESERVATION CASE STUDIES.**

Publications identified with an asterisk (*) are available from organizations listed in Appendix A.

Aldrich, Harl P., Jr. "Preserving the Foundations of Older Buildings: The Importance of Groundwater Levels." *Technology and Conservation*. Summer, 1979, pp. 32-34.

The issue of new construction and excavation near older historic buildings is addressed in this article. The question of water table stabilization is particularly germane to the issue of lighthouse preservation. Case studies in Mexico City and Boston are illustrated as examples of severe settlement.

Atwood, W.G. and A.A. Johnson, "The Disintegration of Cement in Sea Water." *Transactions of the American Society of Civil Engineers*. Vol. 87, 1924, pp. 204-230.

This is a highly technical discussion of cement breakdown in marine structures. The article is prefaced with an account of John Smeaton's early attempt at perfecting a decay-resistant cement mortar for the Eddystone lighthouse. The proposed strategy calls for the addition of a siliceous material to the cement--an action which produces an insoluble bind with the setting cement thus making it resistant to the attack of sulfates present in sea water.

Bryant, Terry. "Protecting Exterior Masonry From Water Damage." *Technology and Conservation*. Spring 1978, pp. 38-42.

This article presents a concise review of the action of water on masonry surfaces. The sources of moisture problems can be identified and located using various types of chemical surface treatments.

Burns, John A. *Recording Historic Structures*. Washington, D.C.: National Park Service HABS/HAER Division with the American Institute of Architects, forthcoming Winter/Spring 1989.

As part of a thorough restoration, it may be necessary to produce accurate measured

drawings of the lighthouse or related structures. The book outlines standards and guidelines for producing documentation acceptable to the Historic American Buildings Survey or the Historic American Engineering Record.

Chambers, J. Henry, AIA. *Cyclical Maintenance for Historic Buildings*. Washington, D.C.: National Park Service, Technical Preservation Services, 1976. *NTIS: PB87-118659.

This book provides a step-by-step process for building managers, architects, and others involved in the routine maintenance of historic properties.

Chambers, J. Henry, FAIA. *Using Photogrammetry to Monitor Materials Deterioration and Structural Problems on Historic Buildings: Dorchester Heights Monument, A Case Study*. Washington, D.C.: Department of the Interior, Technical Preservation Services, 1985. *NTIS: PB87-232146.

This case study discusses the use of close-range photogrammetry in monitoring the condition of historic masonry structures, particularly when more conventional methods of inspection are impracticable.

Coney, William B. "Preservation of Historic Concrete: Problems and General Approaches." *Preservation Briefs 15*. Washington, D.C.: National Park Service, Technical Preservation Services, 1987. *GPO stock number: 024- 005-01027-1.

The brief focuses on reinforced concrete (cast-in-place or reinforced) and is useful for anyone undertaking repair or limited replacement. The guidance addresses the causes of concrete deterioration, the signs of deterioration, and actual concrete repair.

Davis, Deborah, ed. *Keeping the Light: A Handbook for Adaptive Re-use of Island Lighthouse Stations*. Rockland, ME: Island Institute, 1987.

Featured in this source are sections explaining the determination of National Register eligibility for lighthouses, case studies of management and restoration strategies and the various licensing procedures for the acquisition of a Coast guard-owned lighthouse. It should be cautioned that the booklet states, incorrectly, that National Register status protects Federally-owned lights from demolition.

Delgado, James P. and Kevin J. Foster. *Nominating Historic Lighthouses and Other Aids to Navigation to the National Register of Historic Places: Bulletin 34*. Washington, D.C.: National Park Service. 1989.

This bulletin provides guidance on identifying, evaluating, and nominating historic lighthouses and other aids to navigation to the National Register of Historic Places. It features illustrations and a bibliography. Copies will be available from the History Division, National Park Service, when printed. (See Appendix B).

Drisko, Richard W. *Painting of Facilities, A Training Manual--For the Air Force Engineering and Services Center*. Naval Civil Engineering Laboratory, Port Hueneme, CA, 93043: 1983.

This is probably the most comprehensive treatment of the subject of exterior paints and coatings in marine environments. The handbook addresses problems for most exterior lighthouse surfaces including concrete, stone, wood, iron and steel. Especially relevant are sections regarding the painting of concrete and masonry surfaces and remedies for mildew attack.

Fearn, James E. *The Effects of Herbicides on Masonry*. Washington, D.C.: Department of Commerce, National Technical Information Service, 1978. *NTIS: PB261563.

This literature survey outlines possible effects of herbicides on masonry.

Gayle, Margot, and David W. Look. *Metals in America's Historic Buildings: Uses and*

Preservation Treatments. Washington, D.C.: National Park Service, Technical Preservation Services, 1980. *GPO stock number: 025-005-00872-1.

This sourcebook provides information on historic architectural metals, such as lead, tin, zinc, bronze, copper, iron, nickel, steel, and aluminum. Part I focuses on the identification and historic uses of architectural metals; Part II provides indepth information on repair and preservation methods, discussing each metal individually.

Glassgold, I. Leon. "Repair of Seawater Structures - An Overview." *Concrete International: Design and Construction*. March 1982, p. 56.

Although lighthouses are not specifically mentioned, the article presents the range of deterioration problems associated with many marine structures. The history of marine concrete use and appropriate treatments for repairing submerged and exposed concrete construction are included.

Grimmer, Anne E. "Dangers of Abrasive Cleaning to Historic Buildings." *Preservation Briefs 6*. Washington, D.C.: National Park Service, Technical Preservation Services, 1979. *GPO stock number: 024-005-00882-9.

This publication cautions against the use of sandblasting to clean various buildings and suggests measures to mitigate the effects of improper cleaning. It explains the limited circumstances under which abrasive cleaning may be appropriate.

Grimmer, Anne E. *A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments*. Washington: National Park Service, Technical Preservation Services, 1984. *GPO stock number: 024-005-00870-1.

This booklet is generously illustrated and provides information on 22 common masonry deterioration problems and their known treatments. The source is intended for use both as a general reference tool and as an on-site interpretive guide in the maintenance and preservation of historic structures.

Grimmer, Anne E. *Keeping it Clean: Removing Dirt, Paint, Stains, and Graffiti from Historic Exterior Masonry*. Washington, D.C.: National Park Service, Technical Preservation Services, 1988. *GPO stock number: 024-005-01035-1.

The author covers virtually every aspect of a cleaning project--identifying building materials to be cleaned and those that might be affected by cleaning; scheduling cleaning around other work; what to ask for in cleaning "specs," and what kind of test cleaning procedures to use. A useful chart summarizes cleaners and techniques.

Hart, David M. *X-Ray Examination of Historic Structures*. Washington, D.C.: National Park Service, Technical Preservation Services, 1975. *NTIS: PB85-180800.

This technical report explains a method for nondestructive probing of historic buildings that permits investigation of components normally hidden from view. Intended for architects, conservators, and other professionals.

Knofel, Dietbert, translated by R.M.E. Diamant. *Corrosion of Building Materials*. New York: Van Nostrand Reinhold Co., 1975, pp. 41-59.

These pages describe the corrosion potential of metals in or near sea water. The discussion of the chemical and electrochemical reactions between metals is particularly important for repairs or restorations where different metals may collide in context of a building. It is useful for selecting appropriate and compatible metals to be used in roofing, gutters, flashing etc.

Mack, Robert C., AIA. "The Cleaning and Waterproof Coating of Masonry Buildings." *Preservation Briefs 1*. Washington, D.C.: National Park Service, Technical Preservation Services, 1975. *GPO stock number: 024-005-00877-2.

This information offers guidance on the techniques of cleaning and waterproofing and

explains the consequences of inappropriate use.

Mack, Robert C., AIA. "Repointing Mortar Joints in Historic Brick Buildings." *Preservation Briefs 2*. Washington, D.C.: National Park Service, Technical Preservation Services, 1980. *GPO stock number: 024-005-00878-1.

Information on appropriate materials and methods for repointing historic brick buildings is provided in this brief.

Mehta, P. Kumar and Ben C. Gerwick, Jr. "Cracking-Corrosion Interaction in Concrete Exposed to Marine Environment." *Concrete International: Design and Construction*. October 1982, pp. 45-51.

This highly technical discussion of the cracking-corrosion phenomenon of steel-reinforced concrete in a marine environment may be useful for the identification of problems in steel-reinforced concrete lighthouses.

Minnery, Catherine, Donald Minnery, and the Technical Staff. "Repairing Stucco/More About Stucco." *The Old House Journal*. July, 1979, pp. 73, 77-79.

The article discussed how to analyze various stucco types, match textures, and repair the material. Methods of applications are also discussed.

Myers, John H. "The Repair of Historic Wooden Windows." *Preservation Briefs 9*. Washington, D.C.: National Park Service, Technical Preservation Services, 1981. *GPO stock number: 024-005-00884-5.

Emphasizing the practical methods for homeowners or developers, this brief provides useful information on evaluating and repairing historic wooden windows found in typical rehabilitation projects.

National Park Service. *The Secretary of the Interior's Standards for Rehabilitation with Guidelines for Rehabilitating Historic Buildings (rev. 1983)*. Washington: Superintendent of Documents, Government Printing Office. *GPO stock number: 024-005-01003-3.

The Standards are used to determine whether the historic character of a building has been preserved in the process of rehabilitation. All projects that owners wish to be certified for purposes of Federal tax incentives are reviewed and evaluated in accordance with the ten Standards for Rehabilitation. These standards are listed in **Appendix E** in this bibliography. The accompanying guidelines, intended to assist in applying the Standards, recommend responsible methods and approaches and also list those treatments that should be avoided.

National Park Service. *HABS Field Instructions for Measured Drawings*. Washington, D.C.: National Park Service, 1981.

This guide directs production of measured drawings of historic buildings according to the standards of the Historic American Buildings Survey (HABS).

National Park Service. *HABS Historian's Procedures Manual*. Washington, D.C.: National Park Service, 1983.

This manual provides guidelines for producing written data on historic buildings that are acceptable to HABS standards.

O'Bright, Alan. "Paint Removal from Wood Siding." *Preservation Tech Note, Exterior Woodwork Number 2*. Washington, D.C.: National Park Service, Technical Preservation Services, 1986. *NTIS: PB88-192257.

When thick accumulations of paint layers are failing, there are several options for their removal prior to the repainting or the restoration of original paints and finishes. In this case study the preferred removal method was a heat gun, preceded by testing and investigation of the structural condition of the building.

Ozol, Michael A. "Direct tensile test for bond strength between cement paste and rock or mineral surfaces." *Decay and Preservation of Stone*. Geological Society of America, Engineering/Geology Division. Boulder, Colorado: Geological Society of America, 1978, p. 31.

This discusses the procedure for determining the compatibility and durability of a Portland cement plaster applied to stone. It may be relevant for stone lighthouse plasters (stuccos) that require patching or reapplication.

"Painting: Iron and Steel." *Building Defects and Maintenance*. London: Construction Press, Ltd., 1977, pp. 167-173. Smithsonian Libraries: Th.441.B847.

This article is part of a digest meant to serve as a short guide to the painting of iron and steel in buildings. Relevant subheadings include, methods of surface preparation and primers, and a section defining the characteristics and performance of various pigments and binders on iron and steel. Especially useful is a chart specifying appropriate paint treatments for environmental conditions such as areas affected by severe salt spray.

Park, Sharon C., AIA. "The Repair and Thermal Upgrading of Historic Steel Windows." *Preservation Briefs 13*. Washington, D.C.: National Park Service, Technical Preservation Services, 1984. *GPO stock number: 024-005-00868-3.

This brief presents a historical background on the development, use, and styles of rolled steel windows popular in the first half of the 20th century. Many lighthouses utilized steel windows which must be kept painted. This brief explains steps for cleaning and repairing damaged steel windows and provides information on appropriate methods of thermal upgrading.

Park, Sharon C., AIA. "Proper Painting and Surface Preparation." *Preservation Tech Note, Exterior Woodwork Number 1*. Washington, D.C.: National Park Service, Technical Preservation Services, 1986. *NTIS: PB88-192257.

In order to correct the moisture-related paint failures of a newly repainted tongue and groove-sided building the exteriors were stripped, primed, caulked and repainted. The correct use and sequence of treatments is outlined, along with procedures for the selective replacement of damaged columns, sills, and siding.

Park, Sharon C., AIA. "The Use of Substitute Materials on Historic Building Exteriors." *Preservation Briefs 16*. Washington, D.C.: National Park Service, Technical Preservation Services, 1988. *GPO stock number: 024-005-01037.

Some masonry lighthouses have selectively used substitute materials such as cast stone for sandstone replacement. This brief discusses when to use substitute materials, cautions regarding their expected performance, and describes their advantages and disadvantages. Summary charts of various materials are included.

Philips, Morgan W. and Judith E. Selwyn. *Epoxies for Wood Repairs in Historic Buildings*. Washington, D.C.: National Park Service, Technical Preservation Services, 1987. *NTIS: PB85-180834.

This information presents research findings on the use of epoxies to preserve historic wood features rather than replace them. The discussion of low-viscosity epoxy consolidants that can be soaked into rotted wood in order to restore its solidity and epoxy pastes for filling holes and cracks in historic woodwork concludes with useful case-study applications, suggested formulations, and lists of suppliers.

Sabnis, Gajanan, ed. *Rehabilitation, Renovation, and Preservation of Concrete and Masonry Structures*. Detroit: American Concrete Institute, 1985.

Although this compilation of concrete and masonry restoration case studies does not address the issue of repair of these materials in a marine environment, certain chapters have general relevance: nondestructive evaluation of

concrete and masonry (including recommendations in chart form), investigation and renovation of historic and reinforced brick and masonry structures and the repair of reinforced concrete columns.

Scheffel, Carl W. "Repair of Piles Using Fiber Reinforced Jackets." *Concrete International: Design and Construction*. March 1982, p. 39.

The deterioration of concrete piles that are intermittently exposed to sea water is discussed. The proposed method of repair involves the placement of a fiber reinforced jacket with a moisture-intensive epoxy mortar (or cementitious mortar) around the base of deteriorated piles.

Scott, Gary. "Historic Concrete Preservation Problems at Fort Washington, Maryland." *Association for Preservation Technology Bulletin*. Vol. X, No. 2 (1978), pp. 123-132.

This is a conditions report for a concrete gun battlement along a coastal waterway. Because the physical environment of this structure is similar to that of lighthouses, the range of deterioration problems and possible remedies may be relevant. Both in photographs and text, the article isolates typical forms of decay and deterioration associated with concrete in a marine environment and offers solutions.

Sleater, Gerald A. *A Review of Natural Stone Preservation*. Washington, D.C.: Department of Commerce, National Technical Information Service, 1973. *NTIS: PB74-10548.

This report reviews the causes of stone decay, various materials that have been used to preserve stone, and methods for evaluating stone preservatives.

Smith, Baird M. *Moisture Problems in Historic Masonry Walls: Diagnosis and Treatment*. Washington, D.C.: National Park Service, Technical Preservation Services, 1984. *GPO stock number: 024-005-00872-1.

This publication discusses problems caused by excessive moisture in historic masonry walls and outlines a methodology for diagnosing such problems and selecting appropriate treatments.

Sweetser, Sarah M. "Roofing for Historic Buildings." *Preservation Briefs 4*. Washington, D.C.: National Park Service, Technical Preservation Services, 1978. *GPO stock number: 024-005-00880-2.

This brief provides a history of roofing materials in America. The sound preservation approach to roof repair, replacement, and the use of alternative roofing materials may be useful for the rehabilitation of lighthouse keepers dwellings.

"Technology Trends: Protecting the Protectors." *Technology and Conservation*. Spring 1983, pp. 9-14.

Efforts to clean and prepare cast iron and deteriorated masonry for repainting were undertaken at South Carolina's Hunting Island State Park Lighthouse, and at the Loraine, Ohio, Lighthouse. The successful application of several commercial corrosion-resistant paints and sealants to both exterior metals and masonry is examined.

Timmons, Sharon, ed. *Preservation and Conservation: Principles and Practices. Proceedings of the North American International Regional Conference, Williamsburg, Virginia, and Philadelphia, Pennsylvania, September 10-16, 1972*. Washington D.C.: The Preservation Press, 1976.

Many aspects of conservation technology are covered in a comprehensive presentation--together with the role of professionals in the field and various philosophies of approaches to conservation.

United States Coast Guard. *Fixed Aids to Navigation Maintenance*. Cleveland, Ohio: U.S.C.G., Department of Transportation, May 1984. No. CCGNNINEINST MI6500.2.

This manual provides technical guidance for Coast Guard units performing maintenance on fixed aids to navigation in the 9th District (upper Midwest and Northeast). Text on masonry treatments, painting and coatings, weatherproofing, and ventilation systems are often accompanied by simplified diagrams.

United States Coast Guard. *Aids to Navigation Manual, CG-222*. Washington, D.C.: Treasury Department, 1964. pp. 4-1 to 4-22.

A valuable source organized in glossary style, these pages define the various types of lighthouse construction. Featured is a section on foundations, which includes reinforced concrete piles, multiple wood piles, screwpile foundations, iron pile in coral, caisson and stone foundations.

Warnock, Robert A., Lila Fendrick, Barbara E. Hightower, and Terry Denise Tatum. *Vegetative Threats to Historic Sites and Structures*. Washington, D.C.: Department of Commerce, National Technical Information Service, 1983. *NTIS: PB83-250373.

The crucial point at which vegetation threatens to overwhelm and damage the integrity of historic resources is examined.

Weeks, Kay D. and David W. Look. "Exterior Paint Problems on Historic Woodwork." *Preservation Briefs 10*. Washington, D.C.: National Park Service, Technical Preservation Services, 1982. *GPO stock number: 024-005-00885-3.

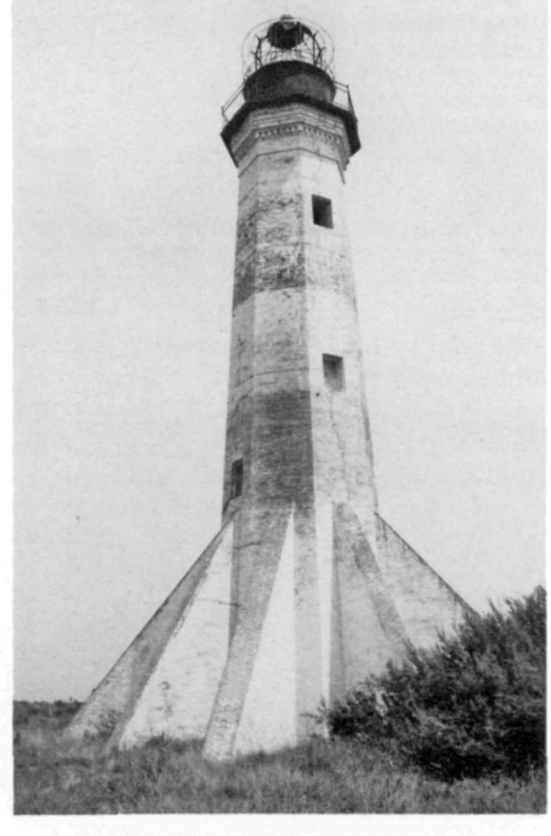
The report identifies and describes common types of paint surface conditions and failures and provides guidance on preparing historic woodwork for repainting, including limited and total paint removal. This may be particularly useful for wooden structures that are part of a lighthouse complex.

Weiss, Norman R. "Cleaning of Building Exteriors: Problems and Procedures of Dirt Removal." *Technology and Conservation*. Fall 1976, pp. 8-13.

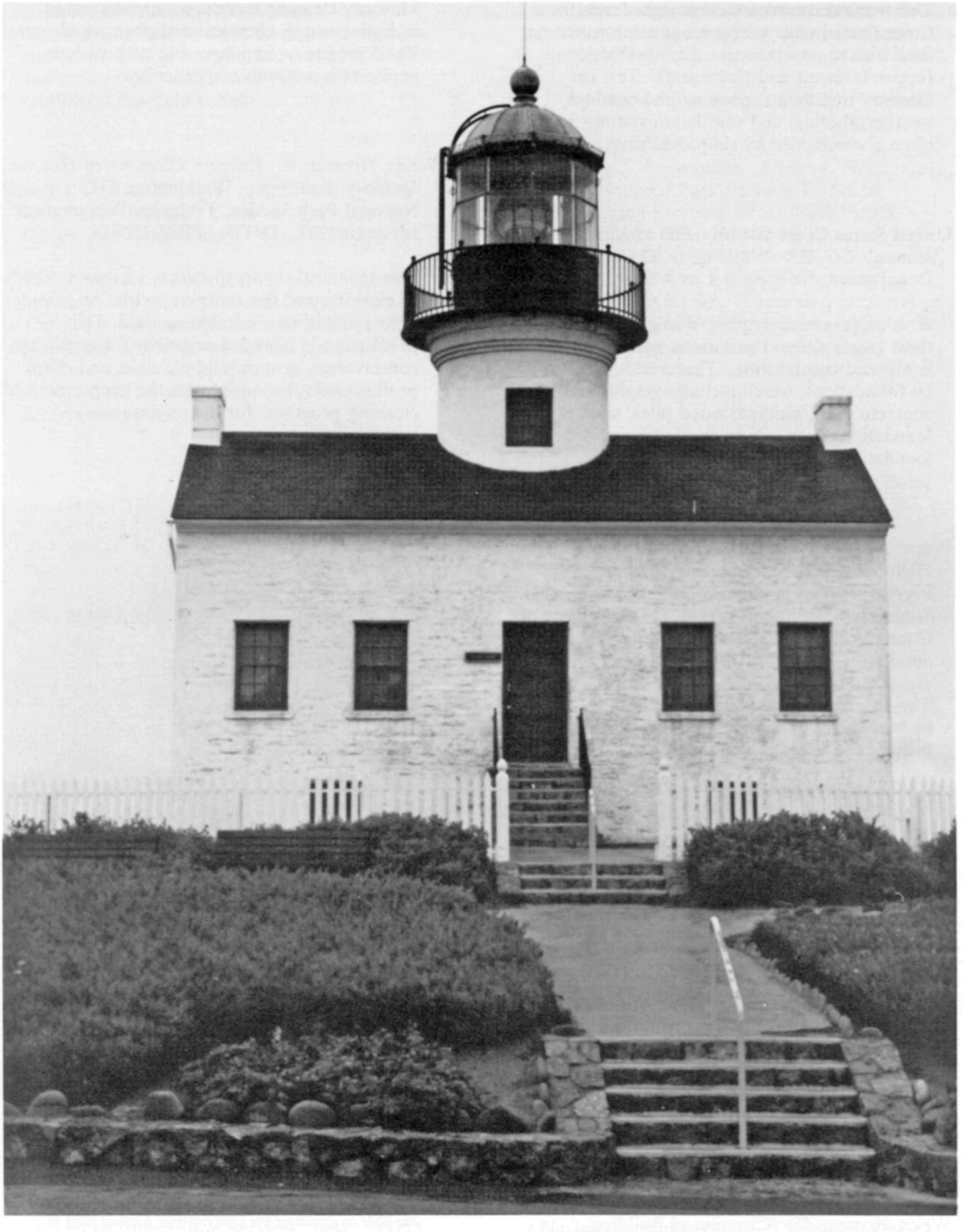
Masonry cleaning techniques are discussed including water, chemical and abrasive cleaning. Their proper or improper use with various application methods are described.

Weiss, Norman R. *Exterior Cleaning of Historic Masonry Buildings*. Washington, D.C.: National Park Service, Technical Preservation Services, 1977. *NTIS: PB85-180818.

This technical report discusses various methods of cleaning and the complex factors to consider before selecting a suitable method. This publication is intended primarily for architects, conservators, government officials, and other professionals responsible for the preparation of cleaning programs for historic masonry buildings.



Sabine Pass Lighthouse, Cameron Parish, LA. This octagonal brick lighthouse tower (1856), owned by the State, was constructed with flared buttresses at the base to distribute the concentrated bearing load in this predominantly marshy, unstable soil. The State has received a grant from the Bicentennial Lighthouse Fund for stabilization of all exterior metal work. Photo: Louisiana Division of Historic Preservation.



Old Point Loma Lighthouse, Cabrillo National Monument, San Diego, CA. This Cape Cod style masonry lighthouse (1854), owned by the National Park Service, was one of the first eight lighthouses constructed on the West Coast, and may be the sole remaining lighthouse of that type and vintage. It has been preserved by the National Park Service as a museum interpreting the life of 19th century lighthouse keepers and their families. Photo: Camille M. Martone.

4. LIGHTHOUSE PRESERVATION CASE STUDIES

A number of historic lighthouses have been preserved, but it is difficult to have public access to these construction documents or preservation plans. There are, however, historic structure reports (HSRs), preservation plans, and technical articles that have been prepared for a limited audience. These reports are being made available, some for the first time, by a few organizations identified in **APPENDIX A**. Any articles marked by an asterisk (*) in the bibliographic entry may be ordered.

The reader is cautioned that the information contained in the case studies will be specific to that project and the work outlined may not be appropriate for other historic resources. As technology changes, and as systems are re-evaluated, there may be instances where techniques once thought appropriate will prove to have been ineffective or damaging. As with any historic resource, it is important to preserve the historic materials and the historic character as sensitively as possible.

Information on the preservation of specific materials or on the maintenance of structures once preserved or repaired can be found in Section **3, PRESERVATION, REPAIR AND MAINTENANCE.**

Clarke, Eric T. "Radiography of the Cape Hatteras Lighthouse." *Technology and Conservation*. Spring 1980, pp. 20-25.

This article describes the process of radiography, (radiation photography) used to probe the substrate for cracks in the iron brackets around the lantern. The advantage is that this method is easily deployed because the equipment is small and lightweight relative to other X-Ray techniques. In addition, the process does not disturb the building material or structure.

Fowler, John W. "Construction of the Chesapeake Light Station." *Transactions of the American Society of Civil Engineers*. Vol. 131, 1966, pp. 650-651.

The design and prefabricated construction of a modern replacement light is featured. Most relevant may be the discussion of contemporary approaches to pile construction for free-standing lights.

Green, P. "Coast Guard Gets Brand New 1818 Lighthouse." *Engineering News-Record*. July 3, 1986, p. 33 (single page article).

The Great Point Lighthouse, Nantucket Island, Massachusetts, was destroyed in a storm in 1984. The Coast Guard's proposal to replace the 166-year old structure with a fiberglass tower prompted Islanders to rally for an authentic reconstruction of the original. A bill introduced into Congress made possible the reconstruction of a reinforced concrete tower, cast in four parts, with overlay of granite ashlar salvaged from the original.

Holland, F. Ross. *Old Point Loma Lighthouse, San Diego, Historic Structure Report*. Washington, D.C.: National Park Service, 1964. *NTIS: 82265513/PCA08/MFA01.

As a companion to the historical essay on Old Point Loma Lighthouse by the same author, this study provides technical documentation and features period photographs and construction data for all aspects of the structure. The final section is devoted to precise recommendations for both interior and exterior restoration procedures, and makes reference to previous treatments and restoration work.

Holland, F. Ross. *A History of the Cape Hatteras Light Station, Cape Light Station, Cape Hatteras National Seashore, North Carolina*. Washington, D.C.: Office of Archaeology and Historic Preservation, Division of History, National Park Service, 30 September 1968. vii, pp. 146, illus, maps, notes. *CRM BIBNUM: 002291.

This is a mostly historical profile of the many attempts to establish a permanent light at this site. There is some discussion of the 1873 paint

scheme which gave the structure its distinctive spiral stripes. A description of the stone foundation work and an account of the construction are featured.

Holland, F. Ross and Henry G. Law. *Old Point Loma Lighthouse, Cabrillo National Monument, Historic Structure Report*. Denver, Colorado: National Park Service, 1981. *CRM BIBNUM: 011328.

This document is an update of the 1964 Historic Structure Report and provides more explicit information regarding restoration and maintenance procedures than the earlier report. Recommended treatments are qualified with alternative methods and determination of adverse effect/no adverse effect. It is well illustrated with photographs and line drawings.

Holland, F. Ross and Archie W. Franzen. *Historic Structure Report--Part I Administrative Data Section, Keepers Dwelling, Cape Hatteras National Seashore*. Washington, D.C.: National Park Service, 1968. *DSCTIC: 603D 35, *CRM BIBNUM: 002290.

This short report includes a description of the original structure and concludes with brief recommendations for restoration and estimates for proposed work.

Hurd, M.K. "Structural Rehabilitation of a Concrete Lighthouse." *Concrete Construction*. July 1988, Vol. XXXIII, No. 7, pp. 659-662.

Restoration work undertaken at the Brandywine Shoal Lighthouse is summarized in this article. A more thorough review of the project is given in the bibliographic entry by Michael Johannes Paul.

Kunkel, Ray and John Ochman. *Completion Report, Stabilization of the Raspberry Light Station, Apostle Islands National Lakeshore*. Washington, D.C.: National Park Service: 1977. *CRM BIBNUM: 014068.

This report includes specifications and cost details for improvements made to the footings and basement of the clapboard structure. Maintenance and repair work was confined to the exterior and involved the painting, roofing and repair of the outbuildings, boathouse and dock.

Kunkel, Ray and John Ochman. *Completion Report, Stabilization of South Mantou Lighthouse Complex, Apostle Islands National Lakeshore*. Washington, D.C.: National Park Service, 1978. *CRM BIBNUM: 014071.

Exterior repairs and repainting are outlined in list form. Specifications for commercial paints, epoxies and primers are given along with a mortar recipe for repointing work.

Lisle, Lorance D. "Foundation for the Cape Hatteras Lighthouse." *Shore and Beach*. April 1985, pp. 38-39.

In view of the erosion activity along the Cape Hatteras shore, the National Park Service began investigations of the foundation of the lighthouse on this site. Early specifications for this structure do not indicate the level of the foundation with respect to the low water line. This article discusses the need to probe the depth and condition of the timber grillage lying beneath the granite foundation in order to propose preservation strategies.

Milner, John and Associates. *Testing of the Masonry Cleaning, Caulking and Repointing of Perry's Victory and Peace Memorial*. Washington, D.C.: National Park Service, 1979. *CRM BIBNUM: 010651 9G1.

A concise report on the cleaning and repair of deteriorated mortar for this memorial/aid to navigation is given. Hydro-silica blasting was the chosen method for cleaning the discolored stone, and although grit-blasting of any kind is not recommended by the National Park Service, the technique was judged to be harmless to the highly stable and durable granite sheath. Sealants and caulking agents were selected for their superior expansion/contraction properties.

Milner, John and Associates. *Structural, Architectural, Mechanical and Electrical Rehabilitation of Perry's Victory and Peace Memorial, Title I Services-Design Analysis.* Washington, D.C.: National Park Service, 1978. *CRM BIBNUM: 010652.

This is a comprehensive assessment of the structural and cosmetic condition of the monument with recommendations for the observation gallery, penthouse, bronze lantern, steps, heating/dehumidification, plumbing and draining and paint restoration. Cost estimates for all proposed work are listed.

Milner, John and Associates. *Structural, Architectural, Mechanical and Electrical Rehabilitation of Perry's Victory and Peace Memorial, Title II Services-Construction.* Washington, D.C.: National Park Service, 1978. *CRM BIBNUM: 010652.

This companion to the Design Analysis Report provides more specific information regarding types of repair/restoration materials and treatments and their exact recommended application.

"Mobile Bay Lighthouse Saved." *The Keepers Log of the U.S. Lighthouse Society.* Spring 1986, pp. 16-18, (reprint from "Port of Mobile" magazine, courtesy of the Alabama State Docks Department).

The short article gives little mention to actual restoration procedures, but chronicles the series of community volunteer efforts which made the Mobile Bay project possible. General improvements to specific features of the lighthouse are outlined.

National Academy Press. *Saving Cape Hatteras Lighthouse from the Sea, Options and Policy Implications.* Washington D.C.: National Academy Press, 1988.

The pending destruction of Cape Hatteras lighthouse by severe coastal erosion has prompted a study of viable preservation options. This report is an overview of various solutions including the incremental relocation of the structure and the protection of the lighthouse *in situ*.

National Park Service. *Lantern Restoration and Preservation. Project A.D. Point Reyes National Seashore.* National Park Service, San Francisco: Western Regional Office, 1982/1983. *CRM BIBNUM: 010694 10B2.

The report supplies specifications, photographic documentation and costs for work completed in the restoration of the lighthouse lantern at Point Reyes.

National Park Service. *Completion Report, Stabilization of the Michigan Island Light Station.* National Park Service, Washington D.C.: 1975. *CRM BIBNUM: 011109.

Efforts were made to improve drainage systems, repoint deteriorated masonry and to clear excessive plant growth away from the buildings. Similar procedures were undertaken on other buildings within the lighthouse complex.

National Park Service. *Old Point Loma Lighthouse, Cabrillo National Monument.* National Park Service, San Francisco: Western Regional Office, 1965. *CRM BIBNUM: 003639 2B3.

Proposals for visitor use, new construction and general recommendations for both interior and exterior restoration of the lighthouse dwelling and tower are given. Brief technical description of materials and construction are provided.

National Park Service. *Old Point Loma Lighthouse Preservation, Package 123-Project Manual.* National Park Service, Denver: Denver Service Center, 1978. *No CRM BIBNUM (copy may be obtained from the Old Point Loma Lighthouse).

Included are contract specifications for maintenance and restoration for such issues as minor structural excavation, underdrains, carpentry and millwork, damp-proofing, flashing and sheet metal.

New York State Hudson River Valley Commission. *The Hudson River Lighthouses.* Albany, New York, 1967.

This booklet provides a summary of preservation objectives recommended for the five lighthouses remaining along the Hudson River. Potential difficulties in the conversion of the lighthouses to other uses are discussed. There are also immediate recommendations for urgent maintenance that could prevent future serious deterioration.

Paul, Michael Johannes. "Brandywine Shoal Lighthouse--Evaluation and design for an historic concrete lighthouse." *Concrete International: Design and Construction.* July 1987.

Severe deterioration of the concrete caisson and lighthouse structure was remedied with a variety of concrete replacement materials. Repair work was preceded by site review, structural inspection and evaluation and laboratory analysis. Findings and location of characteristic deterioration problems are organized in chart form.

Raithel, Kenneth Jr. *Emergency Restoration of Point Loma Lighthouse Lantern--Task Directive Package 134.* National Park Service, San Francisco: Western Regional Office, 1982. No CRM BIBNUM.

This is a short report on the inevitable structural failure of the lantern and the urgent need for safety precautions to protect visitors. Proposed treatments for the masonry and metal construction are specified with a list of consultants and the time schedule.

Ruffin, J.V. "Steel Offshore Towers Replace Lightships." *Transactions of the American Society of Civil Engineers.* Vol. 131, 1966, pp. 645-646.

Although the article profiles the construction of modern navigational lights, there is useful information about contemporary pile construction for fixed marine structures. Such an approach may be applicable for free-standing historic lights facing the replacement or repair of deteriorated piles.

Slaton, Deborah, Harry Hunderman, and Jerry G. Stockbridge. "The Cape Hatteras Lighthouse--Diagnostics and Preservation." *Bulletin of the Association for Preservation Technology.* Vol. XIX, No. 2 (1984) pp. 52-60.

A thorough examination of the physical condition of the Cape Hatteras lighthouse is outlined in this article. Diagnostic testing was performed with special consideration to soil stability, wind resistance, solar radiation, humidity and moisture levels and cracking of cast iron features.

Whitehouse, F. E. *Field Investigation of Cape Hatteras Lighthouse.* Washington, D.C.: National Park Service: 1937. *CRM BIBNUM: 002293.

This report provides concise information about the lighthouse construction, and the author identifies chronic deterioration problems at this site which may be relevant for restoration work at any time.

Marblehead Light, Marblehead, MA. This iron skeletal tower (1895), owned by the U.S. Coast Guard, represents an important phase in technology as lighter weight structures reached greater heights. Photo: Massachusetts Historical Commission.

APPENDIX A

PUBLICATION SUPPLIERS

Several agencies can supply technical publications listed in this bibliography. The order numbers are included in the bibliographic entries and are preceded with an asterisk (*). Prices available upon request.

CRM (Cultural Resource Management) publications of the National Park Service are available on microfiche with a CRM Bibliography Number (**CRM BIBNUM**) through:

NPS Cultural Resource Bibliography
Chadwyck-Healey Inc.
1101 King Street
Alexandria, VA 22314
Tel: (703) 683-4890

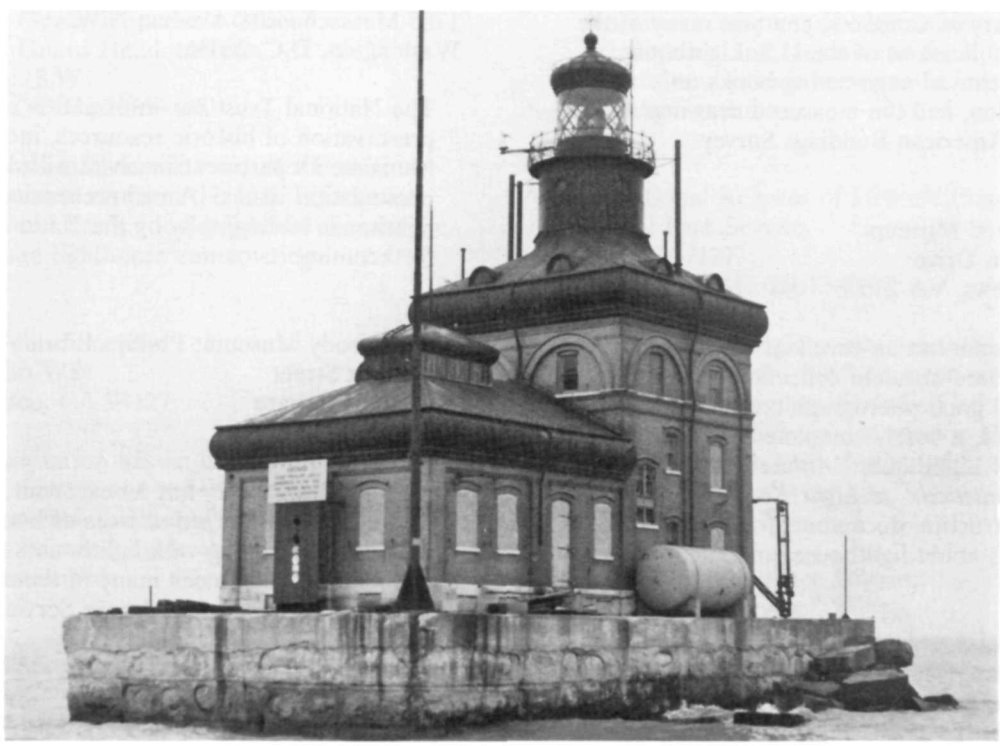
DSCTIC (Denver Service Center Technical Information Center)
May be ordered from the Denver Service Center,

Denver Service Center
Technical Information Center
12795 West Alameda Parkway
P.O. Box 25287
Denver, CO 80225
Tel: (303) 969-2100
FTS: 327-2100

GPO (Government Printing Office) publications, currently in print, are available for purchase from:

The Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402-9325

NTIS (National Technical Information Service)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
Tel: (703) 487-4650
FTS: 737-4650



Toledo Harbor Lighthouse, Toledo, OH. This buff-colored brick Lighthouse (1904), owned by the U.S. Coast Guard, was important in the development of Toledo as a port. The structural steel frame of the lighthouse sits on a concrete superstructure anchored onto a stone and gravel cribbage foundation. The original 3 1/2-order Fresnel lens is still in use and the lighthouse remains relatively unchanged since its construction. Photo: Carol Poh Miller.

APPENDIX B

LIGHTHOUSE PRESERVATION ORGANIZATIONS AND RESEARCH SOURCES

The following organizations, museums and libraries are included for their involvement in lighthouse preservation or for their specialized collections in maritime history and architecture. Only a select number of the organizations and libraries have been listed. The researcher should not overlook local historical societies, regional museums, and State Historic Preservation Offices.

Great Lakes Lighthouse Keepers Association
P.O. Box 580
Allen Park, MI 48101

This regional lighthouse organization publishes the **Beacon**, a newsletter about lighthouses in the Great Lakes area.

The Library of Congress
First and Independence Avenues
Washington, D.C. 20540

The Library of Congress, contains many of the official publications of the U.S. Lighthouse Board, technical engineering books on construction, and the measured drawings of the Historic American Buildings Survey.

The Mariners' Museum
100 Museum Drive
Newport News, VA 23606

This museum has an excellent research library and maritime museum collection. The library includes a good photographic collection of lighthouses, a nearly complete set of the U.S. Bureau of Lighthouses' *Annual Reports* and some *Instructions to Light Keepers*. There are also construction documents for lighthouses, and books about lighthouse construction.

The National Archives
8th and Pennsylvania Avenue, N.W.
Washington, D.C. 20408

Record Group 26 is a compilation of information on American lighthouses and light stations. Included are copies of official U.S. Lighthouse Board documents, correspondence from lighthouse keepers and original plans and construction documents for lighthouses.

The National Conference of State Historic Preservation Offices
Suite 332 Hall of States
444 North Capitol Street, N.W.
Washington, D.C. 20001-1512

The National Conference can provide information on the activities of the State Historic Preservation offices involved with the Bicentennial Lighthouse Preservation Fund.

The National Park Service
(For preservation programs see listing at the end of this appendix)

The National Trust for Historic Preservation
1785 Massachusetts Avenue, N.W.
Washington, D.C. 20036

The National Trust has information on the preservation of historic resources, including a Maritime Department involved with lighthouse preservation issues. A comprehensive lighthouse bibliography by the National Trust is forthcoming.

The Peabody Museum; Phillips Library
161 Essex Street
East India Square
Salem, MA 01970

The Phillips Library has an excellent research library with many rare sources of books and manuscripts dealing with lighthouses. The collection also includes many of the annual reports of the U.S. Lighthouse Service.

J. Porter Shaw Library
San Francisco Maritime National Historical Park
Building E 3rd Floor
Fort Mason
San Francisco, CA 94123

This maritime library has a large collection of modern and historical information on lighthouses including *Annual Reports* and *Light Lists* of the U.S. Lighthouse Board, and also has a good photographic collection.

Shore Village Museum
104 Limerock Street
Rockland, Maine 04841

This museum has the largest collection of lenses in the United States as well as extensive artifacts associated with lighthouses. The curators are very knowledgeable about lighthouses in the Northeast.

U.S. Coast Guard Academy Library
New London, CT 06320

The greatest collection of the records of the U.S. Lighthouse Service are housed at the academy library. This includes the *Annual Reports, Light Lists,* and *Instructions to Keepers*. Unique in the country is the microfilm collection of official lighthouse plans.

U.S. Coast Guard Historian's Office
U.S. Coast Guard Headquarters
2100 2nd St. S.W.
Washington, D.C., 20593-0001

This office has obtained many of the original official documents from the U.S. Lighthouse Service , and has a good collection of maritime history, and lighthouse construction.

U.S. Lighthouse Society
130 St. Elmo Way
San Francisco, CA 94127

This organization has an extensive library of maritime history and publishes the **Keepers Log**, a quarterly journal of the society. The society is knowledgeable about preservation activity nationwide.

U.S. Lighthouse Preservation Society
P.O. Box 736
Rockport, MA 019666

This organization has been active in the funding, preservation and the documentation of endangered lighthouses. It publishes quarterly the **Lighthouse Letter**, which profiles the preservation activities nationwide.

National Park Service Programs:

Historic American Buildings Survey (HABS)
Historic American Engineering Record (HAER)
National Park Service
P.O. Box 37127
Washington, D.C. 20013-7127

HABS/HAER has developed standards for recording historic buildings and structures in addition to having measured, photographed and produced recorded drawings for a number of lighthouses. Records are kept at the Library of Congress.

The National Maritime Program
History Division
National Park Service
P.O. Box 37127
Washington, D.C. 20013-7127

In 1984, Congress issued a Directive to the National Park Service to survey historic maritime resources, develop standards for their preservation and recommend the appropriate Federal and private sector roles in preservation of these resources.

The National Register of Historic Places
National Park Service
P.O. Box 37127
Washington, D.C. 20013-7127

The National Register maintains the list of historic structures that have been entered into the National Register, including lighthouses. The nomination forms for specific lighthouses includes descriptions, photographs, and listings of sources for information.

Preservation Assistance Division
National Park Service
P.O. Box 37127
Washington, D.C. 20013-7127

The Preservation Assistance Division provides technical publications and guidance on preserving historic structures to Federal, State and local preservation organizations and to private owners of historic properties.

APPENDIX C

Following is a reprint of the specifications for a brick lighthouse, 1861, prepared for the U.S. Light-House Board. This specification is typical of those produced for the Light-House Board and is included as an example of the variety of construction information found in these documents. This specification came from the library at the Smithsonian Institution; other copies can be found at the Library of Congress, the National Archives, the Coast Guard Academy Library, and other repositories of maritime documents.

SPECIFICATIONS

FOR A

FIRST ORDER LIGHT-HOUSE,

(BRICK TOWER,)

PREPARED AT THE OFFICE OF THE LIGHT-HOUSE BOARD.

OCTOBER, 1861.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1861.

SPECIFICATIONS

FOR A

FIRST ORDER LIGHT-HOUSE,

(BRICK TOWER.)

The dimensions, general arrangements, and details to be as shown on plates 85, 85 I, 85 II, 85 III, and 85 IV, of the U. S. Light-house Portfolio. **Drawings.**

The shape of the tower is a frustrum of a cone. There are two shells of brickwork, the inner one being cylindrical, and connected to the outer one with six radial walls. The inner and outer walls will decrease in thickness as they approach the top, by offsets at intervals, as shown on the drawing. **General description.**

The tower is surmounted with a stone cornice, and a lantern for a first order Fresnel lens.

Attached to the tower is a small brick structure containing work and oil rooms.

The main spiral stairway, extending from the lower part of tower to the watch-room, is of iron, and built in the brickwork of cylinder.

From the level of ground to the focal plane of lantern the height is one hundred and fifty (150) feet. The outside diameter of the frustrum, just above the plinth, is twenty-eight (28) feet, and immediately under the cornice, fifteen (15) feet. The difference between the radii of the upper and lower parts of frustrum being seventy-eight (78) inches, and the height of the frustrum being 126.81 feet, the bâtir, or inclination per foot of vertical height, is consequently $\frac{78}{126.81} = .615''$ **Principal dimensions.**

The thickness of the outer shell, at the base, is 3′ 9″, and at the top, 1′ 10½″. The inner shell has an internal diameter of ten feet six inches (10′ 6″); thickness at the base 18″, decreasing to 9″ near the upper part, where it merges into the outer shell. The radial walls are uniformly the length of two bricks in thickness.

The walls of oil and work rooms to be built hollow, as shown on plate 85 IV.

If the ground on which the tower is to be built is good and solid, the foundation pit must be excavated to the depth of ten (10) feet, and suitably levelled for the bed of concrete, which must be from two to three feet in thickness. But if, in the judgment of the Superintendent, **Excavation.**

the ground be not sufficiently firm to build directly upon, then it must be closely piled, and covered with a grillage of heavy timbers, say 12″ × 12″. The upper side of grillage to come within eight feet of the surface of ground.

All excavated material to be graded around the premises, as may be directed. When the foundation is completed, the earth must be well rammed about it.

Foundation. The foundation to be of good rubble masonry, in random courses, with level beds. The extreme diameter of the lowest course to be forty (40) feet. The largest stones obtainable must be used for this course.

Plinth. The two courses forming the plinth of tower to have square beds and builds; the faces to have chisel draughts 1½″ wide all around; the intermediate surface to be dressed off roughly with a pick.

Concrete, or Béton. When concrete is used in the foundation, it must be made as follows: one barrel of cement, two barrels of clean, sharp, fresh water sand, and one cubic yard of stone, will make a batch of concrete. The stone must be hard and sound, and broken to pass through a 2½″ ring. The materials must all be measured. The broken stone having been spread on a bed of plank, the mortar must be spread evenly over it, and the whole mass turned over and thoroughly mixed with a hoe or shovel. When deposited in the foundation pit it must be carefully rammed.

Mortar. The mortar for the foundation and all other parts of tower must be made with hydraulic cement, of the best quality, freshly burned, perfectly ground, securely put up, and kept dry until used. The sand to be clean, free from salt, and sharp gritted. The mortar to be mixed as it is used. The time from the first wetting of the cement until used in masonry must not exceed one half hour.

Brickwork. The brick used throughout must be of the best quality, firm in texture, hard burned, and laid in the most solid manner, with full beds of mortar. The dimensions of all the walls are fully shown on the drawings.

Lead flashings to be inserted where necessary.

In the lower part of inside shell there must be left six holes for ventilating the compartments between the radial walls. Each hole to be 4″ square. At the upper part of the outer shell copper ventilators will be inserted, as hereafter described.

The following must be built in the brickwork during the erection: the landing-plates, girders, watch-room and lantern decks; the steps of stairways, window frames, lintels and sills.

Solid cornice. The cornice of tower to be of stone, of the form and dimensions shown on plate 85 III. The upper surface to be patent hammered. All other surfaces, including beds and builds, to be rough hammered.

Cornice may be built with brackets. Provided the general dimensions (as diameter, height, &c.) are retained, the cornice may be built with stone brackets, as in the second order light-house. There must not be less than twelve (12) brackets, with a thickness of not less than ten (10) inches each. Whichever cornice is decided upon, the stonework must be thoroughly tied together with wrought-iron cramps and anchors.

Parapet. The parapet for the lantern will be a hollow brick wall. External diameter 13′ 6″; thickness 18″.

The iron door and frame shown on plate 20 VII, together with the lantern ventilators, must be built in the brickwork.

Lantern furnished complete. The lantern will be furnished, complete, at ————. The contractor must erect it in an accurate and substantial manner.

Work and oil rooms. The foundation for the work and oil rooms to be of rubble masonry 18″ thick, and extending 3 feet below the surface of ground, and 3 feet above it. The stone may be in irregular courses, but must have square beds and builds.

The outer walls will be hollow, and 14″ thick. The partition walls will be the length of a brick in thickness.

Chimney. The chimney flue will be 12″ × 12″, properly pargetted on the inside, and capped with an Emerson ventilator made of galvanized iron.

Earthen thimbles. There must be inserted in the flue two earthenware thimbles 5½″ diameter, one in the first and one in the second story, each 30″ below the ceiling.

A small fireplace must be constructed on the first floor.

Paving of oil rooms and passages. The oil rooms will be paved with hard brick, laid on edge.

The passages to, and floor of tower must be paved with encaustic tiles, blue and buff, solidly laid in cement.

Stone shelves for oil butts. Fine hammered stone shelves, built on brick piers, must be provided for the oil butts. Shelves to be not less than 4″ thick by 24″ wide. The upper side to be 18″ above the floor.

METAL WORK.

Main stairway. The steps for main stairway to be of cast iron, of the form and dimensions shown on plate 85 I. The total number actually required for the stairway is 181. There must be furnished, in addition to this number, six (6) extra steps.

Surfaces of contact faced. The upper and lower surfaces of the hubs forming the central column of stairway must be turned, and the height of the steps must be made to an uniform gauge of eight (8) inches, U. S. standard measure.

Each flight of steps to be temporarily erected and fitted

together at the workshop; and each step must be marked or numbered with a chisel, according to its position.

Stairway railing. The wrought-iron railing for the stairway must be made in portions convenient for shipment, having suitable scarfs in the rail. The standards will be turned at the lower part, and neatly fitted to the steps. The rail must be of round iron, one (1) inch diameter, in place of the arrangement shown on the drawing. At the commencement and termination of each flight, the rail must be neatly turned down in the form of a scroll.

The arrangement of main stairway is shown on plate 85. Each step has a rise of 8″ and is placed $\frac{1}{24}$ of a circle in advance of its neighbor. The dotted semi-circles on the vertical section represent the relative positions of the landings.

Landings. Each landing is formed of two cast-iron plates one inch thick, partly bedded in the brick work and partly resting on a cast-iron girder, whose ends are also secured in the brickwork of cylinder.

Stirling's toughened iron. All the girders in the light-house must be made of Stirling's toughened iron—that is, of cast iron, with an admixture of about 20 per cent. of wrought iron turnings or scraps.

Base plate of stairway. The base plate of stairway to be of cast iron of the size shown on the drawing. It must be turned to fit the hub of lower step.

The watch-room deck to be of cast iron one inch thick arranged as shown on plate 85 III.

Head of main stairway. The arrangement for covering in the head of main stairway, and preventing injurious draughts reaching the lantern, is shown on plate 85 III.

Plate-iron work. It consists of a casing formed of plate iron one-eighth ($\frac{1}{8}$) of an inch thick; a door of like material, and a covering of steps and risers of cast iron; which latter lead to the lantern.

The casing must be secured to the flange on the watch-room deck with rivets $\frac{3}{8}$″ diameter, not exceeding 3 apart from centre to centre, sperical headed and driven hot. The joints of the casing to be flush, and covered with battens 3″×$\frac{1}{8}$″, secured as above. The door and door frame will be stiffened with bar iron of the sizes shown on the drawing, extending all around the door and around the top and sides forming the frame, secured with rivets not over 3″ apart.

The door must be hung with two pairs of brass butt hinges of 4″×4″, secured with screws $\frac{3}{8}$″ diameter. A brass lock of suitable size must be fitted to the door.

Watchroom stairway. Each cast-iron riser must be secured to the casing with four wrought-iron bolts $\frac{1}{2}$″ diameter. Bolts to be tool finished. The cast-iron treads to be checked or roughened on

the upper side to the depth of $\frac{1}{16}$″ to prevent the feet from slipping.

The back of the tread enters a groove formed in the riser next above it, while the front underside of tread forms a groove for the reception of the riser next below it. The stairway railing to be of wrought iron, of the sizes shown.

The standards to be tool finished, and secured to the steps with hexagonal nuts.

Lantern deck. The lantern-deck consists of a cast-iron plate one inch thick, made in three parts, an opening being formed in it for the watch-room stairway.

The part opposite the hatchway to be a quadrant; the remainder of plate to be in two equal segments.

The periphery of plate is bedded in the brickwork of parapet; the inner part rests on a girder, which is also bedded in the wall at both ends. The stone seats for the girder ends must be fine hammered, and a sheet of lead $\frac{1}{8}$″ thick to be laid thereon.

Girder. The girder is provided in the centre with an opening for the socket of lens pedestal. The section beyond the centre is that known as "Hodgkinson's," the lower flange being much in excess of the upper in area.

This, as well as the girders for the landings, must be made of Stirling's toughened cast iron, described above.

Socket for lens pedestal. The socket for lens pedestal to be of cast iron. The upper flange to be $1\frac{1}{4}$″ thick, and to have in addition eight (8) radial chipping pieces 1″ wide by $\frac{1}{4}$″ deep (on the underside.) The upper and under sides to be faced. The tube projecting downwards into the girder to be bored to the sizes marked. The socket and deck will be bolted together with eight (8) wrought-iron bolts 1″ diameter, heads and nuts six sided and finished.

Railing around parapet. The railing around the parapet to be of wrought iron. The standards to be $1\frac{1}{2}$″×$1\frac{1}{2}$″; the lower part is bent inward 12″, and then downward 9″, and secured in the stonework of cornice with melted brimstone, the upper surface being flush with the surface of stone.

The bottom rail, which is $\frac{3}{4}$″×$1\frac{1}{2}$″, is turned up at the ends, and is secured to the standards with wrought-iron bolts $\frac{5}{8}$″ diameter. Bolts to be tool finished.

The upper rail, which is $\frac{3}{4}$″×2″, has scarf joints at the ends of the segments, the standards pass through these, and both are secured together with brass ball nuts. The vertical rods are formed of $\frac{5}{8}$″ round iron, rivetted to the rails at both ends.

Parapet door. The doorway in parapet is shown on plate 20 VII. The outer folding doors are of cast iron, the inner doors of wood. The jambs, cap and sill are of cast iron. The rebates for the doors, and the upper and lower flanges of

the jambs must be planed. Those parts of the cap and sill which form surfaces of contact with the jambs must be planed. The cap and sill will each be secured to the jambs with four wrought-iron bolts $\frac{3}{4}''$ diameter.

The door frame thus formed will be built in the wall of parapet. The top, bottom, and sides of the outer doors must be planed, and will be secured to the jambs with strong composition hinges $3\frac{1}{2}''$ by $3\frac{1}{2}''$, fastened with gun-metal screws $\frac{3}{8}''$ diameter. In addition to the wrought-iron catch at the bottom of the door, (as shown on the drawing,) there must be provided two strong composition bolts (9 of copper to 1 of tin) at the upper part on the inside; also a composition hook and eye must be fitted to each fold, or to the jambs, to keep the doors open when desired.

Hinges.

Inner wooden doors.

The inner doors will be $1\frac{1}{2}''$ thick, made of the best sash stuff, hung with strong composition hinges, and provided with a composition lock; also two bolts, and hooks and eyes (all of composition) for retaining the doors open. The lock to have mineral knobs. The joints of the doors to be well plied with white lead. The doors to be grained in imitation of oak, and varnished.

Lantern.

For particulars of lantern, and the steps leading to lantern gallery, see specifications for a first order lantern.

The metal windows of tower are shown on plate 85 II. The lintels and window stools are to be of cast iron, of constant width and thickness, but in varying lengths, to suit the thickness of tower at different heights. The plans of these are shown on plate 85 I, where the number of ribs required in each case is noted. The projections on the lintels and stools enter corresponding recesses in the window frames, and thus retain them in position. The window frames are to be of cast iron, made quite fair and true. The rebates for the sash must be planed, or chipped, or filed, as may be convenient.

Gun-metal sashes.

The window sashes to be of gun-metal (9 of copper to 1 of tin). The sides and front next the frame must be planed. The glass will be retained in place with strips of sheet brass one-sixteenth ($\frac{1}{16}$) of an inch thick, secured with brass screws $\frac{3}{16}''$ diameter, 24 for each sash of two lights.

In addition to the catch at the bottom of each window, (which must be of gun-metal instead of wrought iron, as marked on the drawing,) there must be fitted at the top of each window a plate spring bolt of brass.

The hinges of windows to be neatly fitted; the pins to be of gun-metal $\frac{1}{4}''$ diameter. Sash knobs to be of brass, (instead of wrought iron, as marked on the drawing).

Spring catches, for retaining the outer sashes open, to

be of steel, suitably tempered, and secured to the window stool with two brass screws $\frac{1}{16}''$ diameter.

The inner sashes to be retained open with brass hooks and eyes.

The window sills to be either blue stone, limestone, or granite, as may be most readily obtained.

Stone sills.

Lintels over the passages 1st & 2d floors.

The cast-iron lintels, for covering the passages in tower, to be $\frac{3}{4}''$ thick, with deep ribs on the upper side $1''$ thick at the root, and $\frac{7}{8}''$ at the top. Each lintel will be made in seven pieces, as indicated on plates 85 and 85 I. Both ends will have a bearing of six inches on the brickwork.

Ventilators for cells of tower.

There will be required six (6) ventilators at the upper part of tower, to be inserted in the outer shell, 13 feet below the watch-room deck; one to be in each of the compartments formed by the radial walls. They are to be of sheet copper $\frac{1}{16}''$ thick. The form will be a plain cylinder, five (5) inches outside diameter, by 2 feet in length. The outer end will project $3''$ beyond the brickwork, and is to be furnished with a conical cowl, base $10''$ diameter, height $5''$. The base to be in the same plane with the end of the tube, to which it is to be secured with four strips of copper $\frac{3}{4}''$ wide rivetted to cone and tube. This arrangement is designed to exclude the driving rains.

The tubes will be built in the brickwork, with the outer ends $2''$ lower than the inner ends.

Doors in the passages.

The door frames in the passages to be of yellow pine, $3'' \times 5''$, built in the brickwork. Rebates for the doors, $\frac{3}{4}'' \times 1\frac{3}{4}''$. Each door to be made in two folds, of the best sash stuff; thickness of stiles and rails $1\frac{3}{4}''$; ditto of panels $\frac{3}{4}''$. There are to be three panels to each fold; the upper panel to be glazed with a $9'' \times 12''$ light. All the joints to be well plied with white lead. Each fold must be hung with two pairs of $3\frac{1}{2}'' \times 3\frac{1}{2}''$ brass butt hinges. The locks and bolts for the doors must be of brass, strongly made. Locks to have mineral knobs. Provide brass hooks and eyes for retaining the doors open.

Windows of the workroom, &c.

The windows in the work and oil rooms are to have double sets of sashes, made of clear stuff, suitably hung with cast-iron weights, brass axle pullies, and copper wire sash cords.

Provide stone sills, and cast-iron lintels, of the sizes shown on the drawings. The glass for the windows must be of extra thickness, well bedded, and back puttied.

Main entrance door.

The entrance door is shown on plate 85 IV. The lintel, cornice, consoles, sill and steps to be of stone; faces to be fine hammered; beds and builds to be dressed off fair, having square joints.

The door, frame and dressings to be of clear stuff, well fitted; joints to be plied with white lead. There will be a head light over the door; glass to be not less than $\frac{1}{16}''$

thick. Sash must be well secured to the door frame. Each fold of the door to be hung with two pairs brass butt hinges 4″ × 4″, secured with 1¾″ brass screws. Brass plate bolts must be fitted at the upper and lower parts of door. Provide a six-inch mortise rebate lock, with porcelain knobs.

2d floor. The joists for the 2d floor (workroom floor) to be of spruce pine 3″ × 12″. The flooring boards to be of yellow heart pine, one inch thick, not over four inches wide, tongued, grooved, dressed, and well nailed to the joists. The washboard around the 1st and 2d floors to be 6 inches high, and beaded.

Roof. The ceiling joists and wall plates of workroom to be of spruce pine 3″ × 10″. The joists to extend to the outer edge of brickwork.

3″ × 4″ scantling will be notched in the joists, near the ends of the latter, for attaching the rafters of roof, as shown on plate 85 IV. The rafters and ridge pole to be of spruce pine; the former 3″ × 5″, the latter 3″ × 12″.

The finish of cornice to be as shown on the drawings. Brackets to be 4″ thick, and well secured.

Slating. The rafters to be sheathed with one inch boards, and covered with the best quality of ladies slate, securely fixed with zinc nails, two to each slate. The ridge to be covered with ridge tiles. The underside of the slating to be well pointed with lime and hair mortar.

Flashings. At the juncture of roof and tower, lead flashings must be inserted in the brickwork. Use milled lead, weighing not less than six lbs. per square foot.

Plastering. All the walls and ceilings in the work and oil rooms and the passages in the tower, to receive two coats of brown mortar, containing a suitable amount of hair, and one coat of white hard finish.

Painting. All the iron work of structure must be painted with two coats of white lead in oil, at the workshop; and when fixed in the tower, to receive two additional coats of green paint and one coat of varnish.

All the woodwork of structure to have three coats of white zinc paint. The doors must be grained in imitation of oak, and have two coats of varnish. The interior brickwork of tower must be painted with three coats of white lead in oil, well laid on.

MISCELLANEOUS ITEMS.

Oil room doors. A four-paneled door 1½″ thick, must be fitted at the entrance of each oil room. Frame to be the depth of the wall, and to have mouldings on each side not less than 4½″ wide. The hinges and locks to be of brass. The above doors and frames are not shown on the drawings.

Lightning rod. A lightning rod, not less than ¾″ diameter, made of copper wire rope, must be provided. It must be fastened to the tower with copper fastenings, and is to extend from the foot of the lantern pinnacle to some point of the ground, not less than 40 feet from the centre of tower; then to descend vertically 10 feet, or further if the ground is too dry at that depth. A barrel of powdered charcoal must be rammed around the lower end of rod.

Iron castings. All iron castings must be made from remelted iron. All castings which are honeycombed, or otherwise imperfect, *will be rejected.*

All parts of the iron work that have been planed, turned or finished, must be well smeared with a mixture of white lead and tallow, to prevent rusting.

Finally, the structure to be completed in a faithful and workmanlike manner, whether herein particularly specified or not.

All the materials used to be of the best quality of their several kinds.

TREASURY DEPARTMENT,

Light-house Board,

Washington city.

APPENDIX D

Following is a reprint of the specifications for an iron lighthouse, 1860, prepared for the U.S. Light-House Board. This specification is typical of those produced for the Light-House Board and is included as an example of the variety of construction information found in these documents. This specification came from the library at the Smithsonian Institution; other copies can be found at the Library of Congress, the National Archives, the Coast Guard Academy Library, and other repositories of maritime documents.

SPECIFICATIONS

FOR AN

IRON LIGHT-HOUSE

FOR

LAKE SUPERIOR.

PREPARED AT THE OFFICE OF THE LIGHT-HOUSE BOARD,
(TREASURY DEPARTMENT, SOUTH WING.)

WASHINGTON:
GEO. W. BOWMAN, PUBLIC PRINTER.
1860.

SPECIFICATIONS

FOR

MATERIALS AND LABOR

FOR CONSTRUCTING AN

IRON PILE LIGHT-HOUSE

FOR

LAKE SUPERIOR.

The foundation is formed of five (5) wrought iron piles, one placed at each angle and one in the centre of a square. The lower ends of these piles pass through cast iron disks and enter into solid masonry to a depth of two feet, (see sheet No. 1.) From the heads of the piles the superstructure rises in the form of a truncated pyramid, surmounted with a cornice and lantern for the illuminating apparatus. The general elevation and section are shown on sheet No. 1; the details from Nos. 1 to 16 inclusive. General description.

The principal dimensions of the structure are as follows: The length of a side of the square at the base, or the distance from centre to centre of the foundation piles, is twenty-six (26) feet. The vertical height from the under side of the disks to the point where the axes of piles and inclined columns intersect is seventeen feet six inches, (17′ 6″.) From the point of intersection of axes of piles and inclined columns to the top of lantern deck the vertical height is forty-two feet six inches, (42′ 6″.) From the top of lantern deck to the focal plane the height is ten feet one and a half inches, (10′ 1½″.) From the lower ends of foundation piles to the focal plane the vertical height is seventy-two feet one and a half inches, (72′ 1½″.) Principal dimensions.

IRON WORK.

Cast iron disks, of the form and dimensions shown on sheet No. 4, are to be bored out and neatly fitted on the lower part of the foundation piles. Disks on foundation piles.

These disks are firmly held down by wrought iron bolts 1¼ inch diameter and 4½ feet long, furnished at their lower Foundation bolts.

ends with $\frac{3}{8}$-inch boiler plate washers 12 inches square, which, with the bolts, are built in the masonry. Suitable nuts and washers are to be provided for the upper ends of the bolts.

Foundation struts. Into the sockets of the disks are to be fitted the foundation struts, and there secured by wrought iron gibs and keys, (see sheet No. 4.) The struts to be of rolled iron, four and a half ($4\frac{1}{2}$) inches diameter, with the ends formed as shown on sheet No. 4.

Holes, $1\frac{3}{4}$ inch diameter, to be drilled in the heads of the gibs to receive the tension bolts.

Foundation piles. The foundation piles to be of the best quality wrought iron six (6) inches in diameter. The ends will be turned to the form and dimensions indicated on sheet No. 2.

Sockets at base of pyramid. The corner cap sockets of piles to be of cast iron, made in dry sand, and of the form and dimensions shown on sheet No. 3.

Centre cap socket. The cap socket for the centre pile to be of cast iron, of the form and dimensions shown on sheet No. 4, and to be made in dry sand.

Lugs are provided, as shown, for attaching the tension braces to. In all the sockets those surfaces in contact with the piles and inclined columns must be bored and faced. All holes for tension bolts must be bored.

The upper ends of the piles must neatly fit their respective sockets; the lower ends to fit the foundation disks.

Columns of pyramid. The inclined columns to be of the best rolled iron. The first series five and a half ($5\frac{1}{2}$) inches diameter. The second series five (5) inches diameter. The third series four and a half ($4\frac{1}{2}$) inches diameter. The ends to be turned to the form and dimensions shown on sheet No. 2.

Rolled iron girders. Four 12-inch girders (each sixteen feet nine and five-eighths inches 16′ $9\frac{5}{8}$″ long) form radial struts from the centre pile—one extending to each corner pile. They are secured with wrought iron bolts and nuts to the flanges of the cap sockets, as shown on sheet No. 4, and on them rests the cylinder enclosing the main spiral stairway. The girders to be similar to those made by the "Phœnix Iron Company," Philadelphia, Pa.

Boiler plate struts. The side struts at the heads of piles are to be made of $\frac{5}{16}$-inch boiler-plate, and of the form and dimensions shown on sheet No. 5. To each end of these struts is to be riveted a square flange of cast iron, for bolting to the corner pile cap sockets. The holes in the casting, for the tension bolts, must be bored out.

Along the upper side of the interior of the strut, to within $6\frac{1}{2}$ inches of each end, extends a bar of 4″ × 4″ × $\frac{1}{2}$″ T iron, secured by rivets not exceeding 3 inches apart from centre to centre. All the rivets used in making these struts are to be $\frac{5}{8}$ inch diameter, spherical headed and driven hot.

If the strut cannot conveniently be riveted in three (3) parts, the contractor may have it made in five (5) parts, provided the joints are similar to those already indicated on the drawing.

Angle sockets of pyramid. The first and second angle sockets, for the columns of pyramid, are to be of cast iron, of the form and dimensions shown on sheets Nos. 7 and 9. The surfaces in contact with the columns to be bored and faced. Lugs are formed for the attachment of the braces, and recesses for the horizontal struts and braces to the cylinder.

Struts for the pyramid. The struts for the pyramid to be forged as shown on sheet No. 9. The ends to be secured to the sockets by wrought iron bolts and nuts. All the surfaces in contact with the several sockets to be turned and faced to the sizes marked on the drawings.

Tension braces. The tension braces to be arranged as indicated on sheet No. 1, and all to be made of wrought iron.

Below the pyramid, a number of them extend diagonally from the centre to the corner piles; the balance of them are arranged at the sides of the square. These braces are not furnished with turnbuckles, but are tightened by means of a nut and screw between the links at their upper ends, (as shown on sheets Nos. 1 and 5.)

Four (4) pairs of the links A A, with the washers a a on the inside, attach to the centre cap socket. Four (4) pairs modified, as represented by the washers B B, (which are raised on the outside instead of inside,) attach to the inside of the corner cap sockets, under the bearings for the rolled girders. Eight (8) pairs, with the modification C C, embrace the plate iron side struts at the heads of corner piles.

Tension braces for pyramid. The tension braces for the pyramid and their accompanying turnbuckles to be of wrought iron, and of the form and dimensions shown on sheet No. 7. There are also two sets of horizontal braces extending radially inward from the first and second angle sockets of pyramid to the cylinder; these have palms forged on their inner ends, each palm to be secured by ten (10) rivets $\frac{5}{8}$ inch diameter. The outer ends to be secured by wrought iron bolts. Suitable screws to be cut in the turnbuckles and on the enlarged ends of braces.

Tension bolts. All the tension bolts to be of wrought iron, of the form and dimensions shown on sheet No. 9. The ends to be perforated with conical holes, and fitted with split-pins of wrought iron—all to be tool finished.

Wrought iron washers, $\frac{3}{8}$ inch thick, 3 inches diameter, to be provided under the pins of the bolts for foundation braces.

Wrought iron platform. Resting on one of the side struts is a platform (shown in sheets Nos. 1, 2, and 6) leading to the entrance door of the cylinder. It is formed of a sheet of $\frac{5}{16}$-inch boiler iron, four (4) feet wide and ten feet six inches (10′ 6″) long.

On each side it is stiffened with a lattice railing formed of $2'' \times 2'' \times \frac{1}{4}''$ angle iron and bar iron $1\frac{1}{2}'' \times \frac{1}{2}''$.

The platform is stiffened transversely with $2'' \times 2'' \times \frac{1}{4}''$ angle iron, secured to its under side by $\frac{5}{8}$-inch rivets, placed not more than three inches apart from centre to centre, and having their heads countersunk on the upper side of the sheet. Details of the platform and its railing are shown on sheet No. 6.

Base plate of cylinder.

The base plate of cylinder must be of boiler iron $\frac{1}{4}$ inch thick, made in quadrants, and secured to the angle iron on the cylinder with $\frac{5}{8}$-inch rivets, not over 4 inches apart from centre to centre, and to the rolled girders with wrought iron strips as shown, (two sets to each beam.)

An opening in the centre of the base plate, 12 inches diameter, permits the hub of the steps to enter the cap socket on the centre pile.

The periphery of the base plate is stiffened with angle iron $3'' \times 3'' \times \frac{3}{8}''$, secured with rivets $\frac{5}{8}$ inch diameter, and not over 3 inches apart from centre to centre.

Cylinder of boiler iron.

The cylinder which encloses the main stairway extends from the base plate to the cap segments which surmount the columns. It has an uniform exterior diameter of six (6) feet, and is composed of regular courses of boiler plate, as shown on sheet No. 8. The lower course is 2 feet $5\frac{3}{4}$ inches high; above this are six courses, each six (6) feet high. The cylinder terminates with a course 2 feet $9\frac{1}{4}$ inches high, which enters four (4) inches into the cap segments, where it is secured by a double row of rivets, staggered, $\frac{5}{8}$ inch diameter, and not exceeding 3 inches apart from centre to centre. The plates and battens to be $\frac{1}{4}$ inch thick, secured with $\frac{5}{8}$-inch rivets placed not more than $2\frac{1}{2}$ inches from centre to centre.

Around the base of cylinder (both on the inside and outside) angle iron, $3'' \times 3'' \times \frac{3}{8}''$, will be riveted, by which it will be secured to the base plate with rivets placed not more than 4″ from centre to centre; $\frac{5}{8}$-inch rivets to be used through both flanges of the angle iron.

The bottom of the opening cut in the cylinder for the entrance door is 6 inches above the base.

Cylinder to be stayed.

The cylinder is stayed by the horizontal braces extending from the first and second sockets of pyramid.

Windows in the cylinder.

In the two windows for the cylinder, the sash will be of cast iron, the fastenings of wrought iron. In each sash strips of gutta percha to be laid around the edges of the glass, and retained by a wrought iron rim, secured with eight (8) tap screws suitably distributed.

Steps for main stairway.

The steps for the main spiral stairway to be of cast iron of the form and dimensions shown on sheet No. 2. By inspection of the drawing it will be seen that they are so formed that each step may fit successively in the one beneath it, thus forming a continuous central column with

their sockets. The upper and under edges which will be in contact with the steps above and beneath them to be faced. The outer ends of steps to be secured to the cylinder by wrought iron bolts and nuts $\frac{5}{8}$ inch diameter. The rise of each step is nine inches, the tread is one-twentieth ($\frac{1}{20}$) of a circle.

The arrangement of the several flights of stairs may be understood by reference to sheets Nos. 1 and 9. It will be necessary in construction to put the landing plates and steps progressively in their positions before the surrounding sheets composing the cylinder are riveted, otherwise they may not clear the rivet heads which project from the cylinder.

Landing plates.

The landing plates to be of cast iron, of the form and dimensions shown on sheet No. 10. The segments to be secured together with wrought iron bolts $\frac{3}{4}$ inch diameter, and to the cylinder with wrought iron bolts $\frac{5}{8}$ inch diameter. The joints to be neatly fitted. On the under side of the plates projections are formed which enter corresponding recesses in the steps immediately beneath them; recesses are formed in the upper sides into which the steps above enter. The upper and under edges which come in contact with the steps are to be faced.

Lantern deck.

The lantern deck to be of cast iron, of the form and dimensions shown on sheet No. 10. It is formed in two segments, which must be neatly fitted together and secured by wrought iron bolts $\frac{3}{4}$ inch diameter. The socket for the lens pedestal on the upper side to be bored to the given sizes; the flange to be faced; said flange to be modified, as regards size, as the agent of the Light-house Board may direct.

Trap door.

In one of the segments of the lantern deck, there is formed an opening communicating with stairway. It will be covered with a door of boiler plate three-sixteenths ($\frac{3}{16}$) of an inch thick; suitable handles for opening and closing to be provided.

Torsional spring.

The torsional spring for this door to be three-eighths ($\frac{3}{8}$) of an inch in diameter, of the best steel suitable for the purpose. The ends to be made square, and secured in the steel spring holders at the ends.

One spring holder to be secured to the deck and the other to the door. The spring will pass through and form the axis of the hinges. The holders to be so arranged, that when the door is vertical, or at right angles to the deck, there will be no strain on the rod; in the act of closing, the rod will then be strained, and thus serve to some extent in counterbalancing the weight of the door.

Cap segments.

The cap segments fitting on the tops of the inclined columns, to be of cast iron, made in dry sand, and of the form and dimensions shown on sheet No. 7.

NOTE.—The sizes of these segments have been increased

as marked on the lithograph, and the contractor will make the castings to correspond with the altered dimensions.

All surfaces in contact with the columns to be bored and faced. Lugs are provided for securing the tension braces.

From a note on sheet No.7 it will be seen that the pattern for the cap segments may be modified and made to answer for the intermediate segments.

Chipping pieces are cast on all the segments, so that the joints may be neatly fitted.

The segments will be secured together with wrought iron bolts and nuts, thereby forming a firm figure; the perimeter of which will be an octagon.

As the sockets on the tops of the columns do not descend vertically while being fitted to their places, the intermediate segments, and the plate iron work of the cylinder in the vicinity, should not be fixed until the former are in position.

Octagonal railing around lantern.

The octagonal railing around the lantern to be of the form and dimensions shown on sheet No. 15. The top and bottom rails, the standards and rods, to be of wrought iron. The rods to be riveted to the rails. The sockets and balls which fit on the standards to be of cast iron, and bored to fit them. The rails to be secured to the castings by wrought iron bolts $\frac{1}{2}$ inch diameter. The sockets on the lower ends of standards to be planed or faced on the under side, and neatly fitted or secured to the deck with wrought iron bolts $\frac{3}{4}$ inch diameter.

Wall of lantern of cast iron.

The panels forming the decagonal wall of lantern to be of cast iron, of the form and dimensions shown on sheet No 14. The tops, bottoms, and sides, forming surfaces of contact, to be planed. The panels to be secured to each other by wrought iron bolts $\frac{3}{4}$ inch diameter. The wall of lantern and the deck plate will be secured to the cap segments by wrought iron bolts one inch diameter, one passing through the lower flange of each panel. Countersunk holes to be drilled where indicated on the drawings for screws $\frac{3}{8}$ inch diameter for securing the furring of the wood-work. In nine (9) of the panels, air registers will be formed; the remaining one to be modified so as to accommodate the doors. The recesses for the astragals of lantern to be planed.

Stairway inside of lantern.

The winding stairway inside of the lantern to be of the form and dimensions shown on sheet No. 15. The stringers to be of wrought iron, secured at both ends by wrought iron bolts. The steps to be cast iron, secured to the stringers by wrought iron tap bolts.

Ladder outside of lantern.

The ladder for the outside of lantern to be of wrought iron; form, &c., as per sheet 15. To be secured at its upper end to the gallery plates with wrought iron bolts. The rounds to be riveted to the stringers.

Gallery around the glazing of lantern.

The segments of gallery plate to be of cast iron, of the form and dimensions as per sheet No. 14. Chipping pieces are provided on their edges and under sides, so that neat joints may be made with each other and with the panels. They are to be secured to each other by wrought iron bolts $\frac{1}{2}$ inch diameter, and to the panels beneath by bolts $\frac{3}{4}$ inch diameter. As will be seen by the drawings, two of the segments are so modified that they may afford an opening on the inside for a stairway, and on the outside for a ladder. A socket is formed in each panel for a railing standard.

Opening for stairs and ladder.

Railing around glazing.

The rail and standards for the gallery of lantern to be of wrought iron, neatly fitted and secured, and of the form and dimensions as shown on sheet No. 9.

Astragals of lantern.

The astragals of lantern to be of wrought iron, of the form and dimensions shown on sheet No. 13. They may be formed of flat rolled iron $3\frac{1}{4}''$ by $1\frac{1}{4}''$.

The grooves for the reception of the glass to be planed, also that part of astragal in contact with the glass stop.

The lower ends of astragals must be accurately fitted in the sockets provided for their reception between the panels, and secured by wrought iron bolts $\frac{3}{4}$ inch diameter. The upper ends to be secured in a similar manner to the cornice of lantern.

Mullions.

The mullions to be of gun metal (0.9 copper, 0.1 tin) of the form and dimensions per sheet No. 13. They must be accurately fitted to the astragals, and secured by wrought iron bolts $\frac{5}{8}$ inch diameter. The recesses for the glass to be planed.

Cornice of lantern.

The segments of cornice of lantern to be of brass, of the form and size per sheet 13; to be accurately fitted to each other, and to the astragals, and secured by wrought iron bolts $\frac{3}{4}$ inch diameter. The recesses for the glass and glass stops to be planed.

Glass stops.

All the glass stops for the lantern to be of gun metal; to be planed on the sides towards the glass, and secured to the astragals, cornice, and mullions, by wrought iron tap screws $\frac{5}{16}$ inch diameter.

Draining the water from roof of lantern.

The moulding on the cornice forms a gutter which receives the water from the dome. It is drained by means of five (5) short tubes or pipes of copper, attached as shown on the drawing of lantern, one directly in front of every other astragal.

The ribs of dome.

The ribs of dome to be of wrought iron, of the form and dimensions shown on sheets Nos. 11, 12, 13, and 16. The lower ends, shown on sheet 13, to be secured to the cornice by wrought iron tap bolts $\frac{1}{2}$ inch diameter. Each upper end of rib to be secured, as shown on sheet No. 16, by a wrought iron tap bolt $\frac{1}{2}$ inch diameter.

Stays.

For stiffening the frame-work of dome, wrought iron stays, as shown on sheet No. 16, are secured to the ribs by wrought iron bolts $\frac{3}{8}$ inch diameter.

Tie and supension rods.

The tie and supension rods to be of wrought iron, of the form and dimensions as per sheet No. 16. Suitable screws to be cut where indicated.

Turnbuckles.

The turnbuckles for the suspension rods to be of wrought iron. "Right and left" screws to be cut in them.

Adjusting apparatus for axis of lens.

The ring in which the ends of the tie rods are secured, and the adjusting apparatus for the axis of lens, to be of brass, of the form and dimensions shown on sheet No. 16. To be neatly fitted and finished.

The crown piece of dome to be of cast iron; the form and size as per sheet 16.

Copper roof of lantern.

The dome of lantern to be covered with sheet copper one-sixteenth ($\frac{1}{16}$) of an inch thick; to be secured to the cornice by copper rivets one-eighth ($\frac{1}{8}$) of an inch diameter, placed not exceeding six (6) inches apart from centre to centre.

The joints of the plates to be made as indicated on sheet No. 16.

Ventilating pipe, spherical cowl, and moulding.

The ventilator and adjoining parts to be of the same material and thickness as the dome. The form and dimensions are shown on sheets 11 and 12. They must be well secured to each other and to the roof by copper rivets suitably distributed. The ventilator pipe at its lower end to be riveted to crown piece of dome.

Zinc lining of dome.

The interior of the dome of lantern to be lined with sheet zinc one thirty-second ($\frac{1}{32}$) of an inch thick, secured to the ribs by wrought iron tap screws $\frac{3}{16}$ inch diameter, not exceeding six inches apart from centre to centre.

Tin hood for lens apparatus.

In the lantern there must be provided for sheltering the lens from water arising from leakage or condensation of moisture, a conical hood formed of X X tin, of the form and dimensions shown on sheet No. 9; to be neatly fitted around the suspension rods, its base resting on the tie rods.

WOOD WORK.

The contractor for the light-house must furnish all the required wood work.

The interior of the cylinder to be sheathed with well seasoned boards $\frac{1}{2}''$ thick (when dressed,) not over three inches wide, tongued, grooved, dressed on the exposed side and well secured to the furring.

A double door, of the form and dimensions shown on sheet No. 8, to be made of the best sash stuff, the joints to be well plied with white lead.

Door at third landing.

A door (not shown on the drawings) is to be placed at the termination of the third flight of steps; to be $1\frac{1}{2}$ inch thick, 2 feet 3 inches wide, and 6 feet 9 inches high, formed with not less than two panels. The under sides and backs

of steps in the vicinity and space above door to be covered, it being intended to prevent injurious drafts to the lantern.

Lining of lantern.

The interior of lantern to be lined as shown on sheets 11 and 12. The furring to be of white pine, secured to the wall plates of lantern by wrought iron screws $\frac{3}{8}$ inch diameter, at such places as are indicated on sheet No. 14. The sheathing to be of white pine boards not over 4 inches wide, tongued, grooved, dressed on the exposed side, and well secured to the furring.

Doors in lantern.

At one of the panels, there well be two double doors, of the form and dimensions shown on sheets 11, 12, and 14.

All the doors to be hung with brass butt hinges $3\frac{1}{2}''$ $\times$ $3\frac{1}{2}''$, and furnished with brass locks and mineral knobs of suitable size. *Defective wood work will be rejected.*

MISCELLANEOUS ITEMS.

All parts of iron work that have been "finished," or form surfaces of contact, must be well smeared with white lead as a protection against rust; and all the remaining parts of iron work must be painted with two coats of white lead, in oil, at the workshop (*after inspection*) for the same purpose.

The amount of riveting the contractor will be required to perform.

The contractor will be required to perform about one half of the total amount of riveting herein before specified, and all of the drilling, punching, and fitting. He must also furnish all the rivets required, and the temporary bolts necessary to be used during the erection.

The riveting will be performed at such places as will not prevent shipment; or at such places as may be designated by the agent of the department.

Drawings only show finishing sizes.

The contractor will please observe that on all the drawings the dimensions shown or marked are finishing sizes, that is, the exact measurements when the work shall have been completed; consequently, for whatever parts are to be planed, turned, &c., such extra allowance of material must be made as he may deem necessary, and no reductions from the dimensions shown will be allowed.

Iron work to be erected at workshop.

ALL OF THE METAL WORK must be fitted together and erected at the workshop, and inspected and approved by the agent of the Light-house Board, before it will be received. All castings which are honey-combed, or otherwise imperfect, *will be rejected.*

Marking.

All parts of the iron work must be chisel-marked according to an uniform system, and a set of drawings also marked to correspond.

Boxing.

All bolts and nuts, the upper part of the lantern above the gallery plates, the lantern steps and ladder, and such small parts as are liable to be lost or mislaid, must be substantially boxed, and lists of contents furnished the Light-house Board.

All the wood work must be primed with one coat of white lead in oil.

FINALLY.

The entire structure must be completed in a faithful and workmanlike manner; all the materials to be of the best quality of their several kinds.

No advantage is to be taken of any omission of details in the drawings, or in this specification, as full explanations and complete detail drawings will be given to the contractor for any part of the work not sufficiently shown or understood.

APPENDIX E

THE SECRETARY OF THE INTERIOR'S STANDARDS FOR REHABILITATION

Following is a reprint of the Secretary of the Interior's Standards for Rehabilitation. This set of ten standards and their accompanying Guidelines is available from the Government Printing Office as well as each State Historic Preservation Office. Other specific standards for historic preservation projects can be obtained from the Preservation Assistance Division of the National Park Service. They are Standards for: Acquisition, Protection, Stabilization, Preservation, Restoration, and Reconstruction.

1. Every reasonable effort shall be made to provide a compatible use for a property which requires minimal alteration of the building, structure, or site and its environment, or to use a property for its originally intended purpose.

2. The distinguishing original qualities or character of a building, structure, or site and its environment shall not be destroyed. The removal or alteration of any historic material or distinctive architectural features should be avoided when possible.

3. All buildings, structures, and sites shall be recognized as products of their own time. Alterations that have no historical basis and which seek to create an earlier appearance shall be discouraged.

4. Changes which may have taken place in the course of time are evidence of the history and development of a building, structure, or site and its environment. These changes may have acquired significance in their own right, and this significance shall be recognized and respected.

5. Distinctive stylistic features or examples of skilled craftsmanship which characterize a building, structure, or site shall be treated with sensitivity.

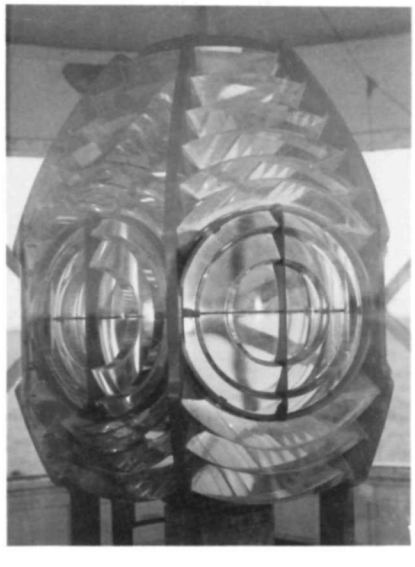
6. Deteriorated architectural features shall be repaired rather than replaced, wherever possible. In the event replacement is necessary, the new material should match the material being replaced in composition, design, color, texture, and other visual qualities. Repair or replacement of missing architectural features should be based on accurate duplications of features, substantiated by historic, physical, or pictorial evidence rather than on conjectural designs or the availability of different architectural elements from other buildings or structures.

7. The surface cleaning of structures shall be undertaken with the gentlest means possible. Sandblasting and other cleaning methods that will damage the historic building materials shall not be undertaken.

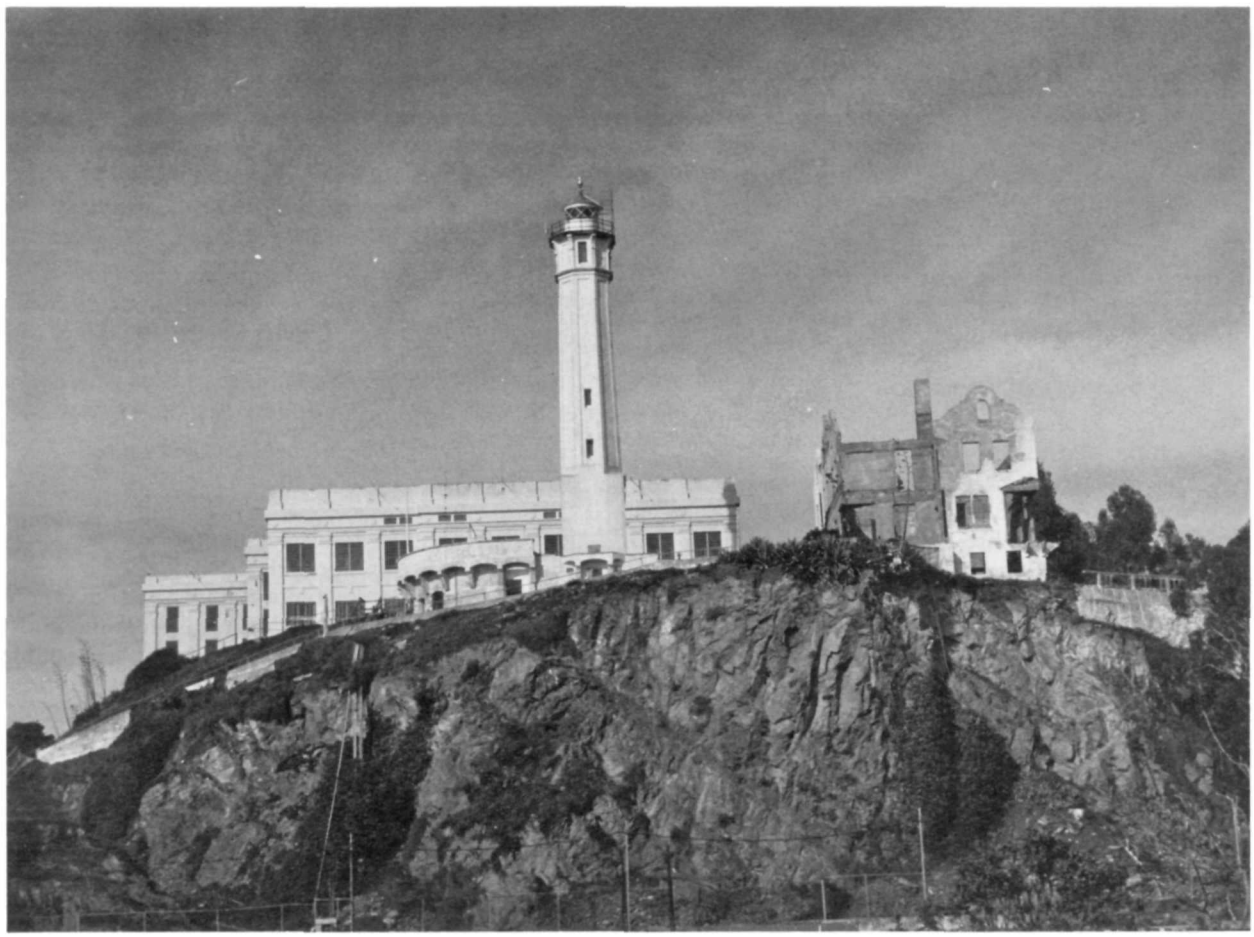
8. Every reasonable effort shall be made to protect and preserve archeological resources affected by, or adjacent to any project.

9. Contemporary design for alterations and additions to existing properties shall not be discouraged when such alterations and additions do not destroy significant historical, architectural or cultural material, and such design is compatible with the size, scale, color, material, and character of the property, neighborhood or environment.

10. Wherever possible, new additions or alterations to structures shall be done in such a manner that if such additions or alterations were to be removed in the future, the essential form and integrity of the structure would be unimpaired.



Fresnel Lens, 1896, manufactured in Paris, France. This 3 1/2 order Fresnel lens is from the Ashtabula Harbor Light, Ohio, owned by the U.S. Coast Guard. These bull's eye glass prism lenses were introduced into American lighthouses in the late 19th century. Photo: U.S. Coast Guard.



Alcatraz Lighthouse, San Francisco, CA. This reinforced concrete lighthouse (1909), a six-sided tower, is located on Alcatraz Island, and is part of the Golden Gate National Recreation Area, a unit of the National Park System. It was built near the site of the first U.S. lighthouse on the West Coast, which was demolished in 1909. Photo: National Park Service files.