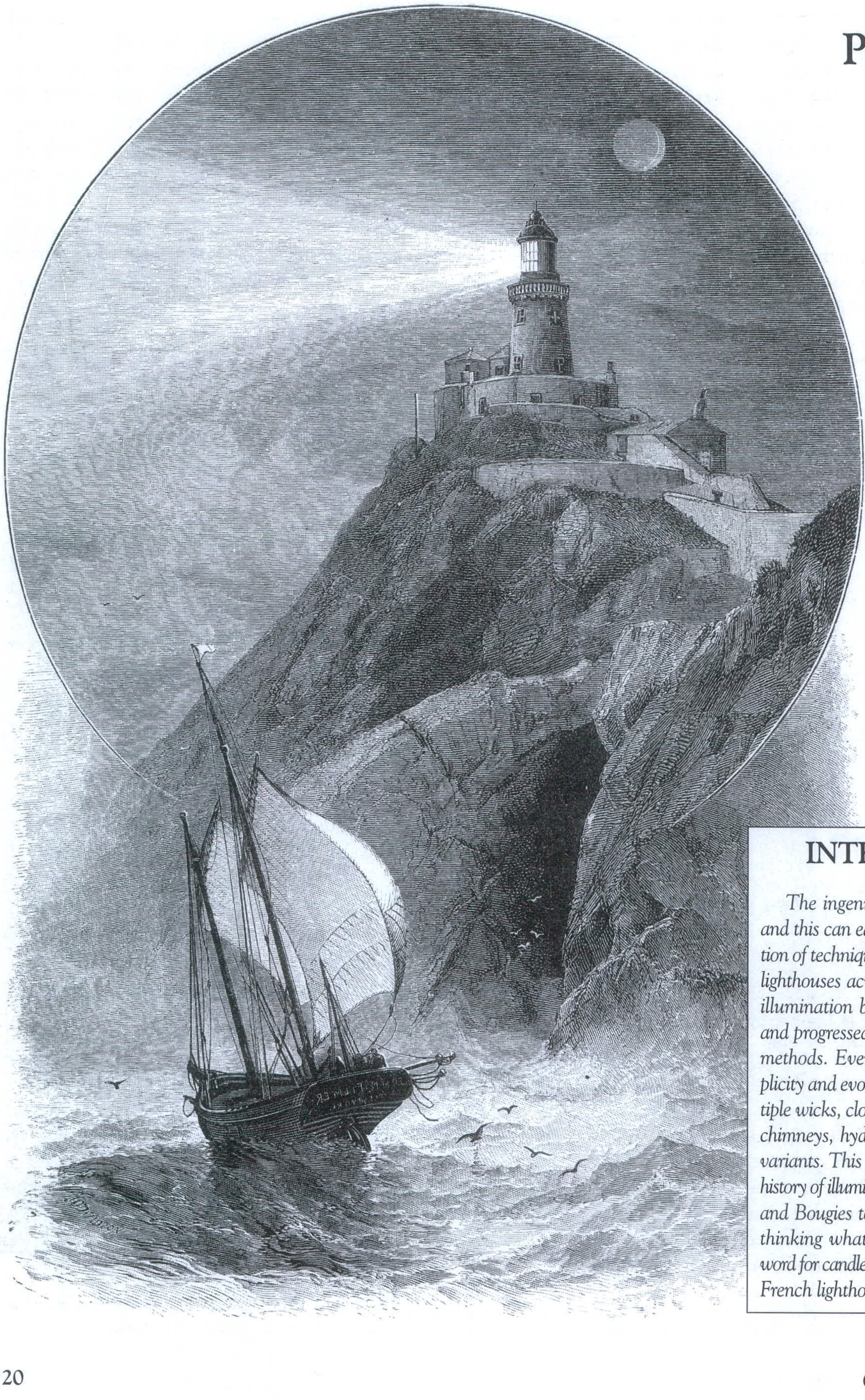
From Braziers and Bougies to Xenon

By Thomas A. Tag

PART II



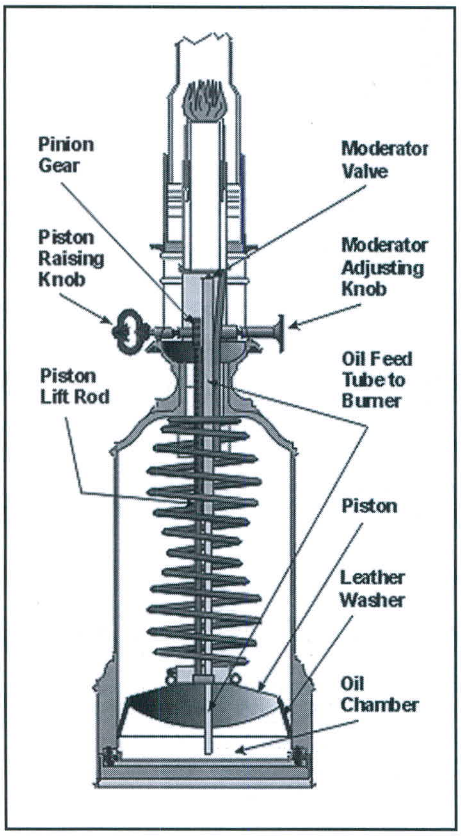
INTRODUCTION

The ingenuity of man is truly amazing and this can easily be seen in the odd collection of techniques used for the illumination of lighthouses across the centuries. Lighthouse illumination began with simple wood fires and progressed through generations of other methods. Even the oil lamp began in simplicity and evolved into a machine with multiple wicks, clockwork oil pumps, specialized chimneys, hydraulic, pneumatic, and other variants. This story will take you through the history of illumination methods, 'From Braziers and Bougies to Xenon.' Ok, I know you're thinking what's a Bougie; it is the French word for candle, and Bougies were used in early French lighthouses.

We are repeating the section on Franchot's spring operated moderator lamp in this installment because it wasn't illustrated in Part I.

Franchot's spring operated Moderator Lamp (1836)

In 1836, Monsieur Franchot invented the Moderator lamp where a spiral spring operated piston made oil flow to the wicks through a constricted valve known as the moderator. These lamps were used in most fixed lenses in France, and in America when Fresnel lenses were first installed during the 1850s. However, they were not used in American lighthouses after about 1865.



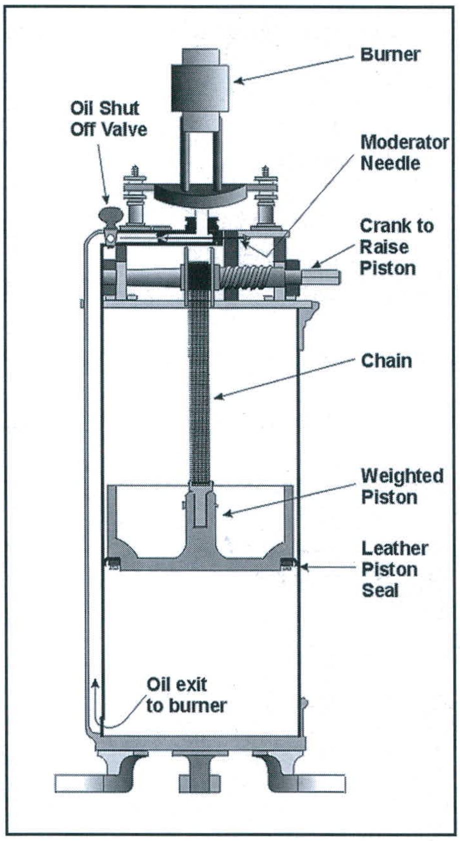
Franchot's Moderator Lamp, 1836. Drawing by the author from Lighthouse Board drawing.

The machinery placed in the reservoir of the lamp was formed by a spiral spring attached to a lightweight piston. The piston was made from a sheet-iron disk, fitted with a leather washer, and connected to a tube, which fed the burner. A square rod with gear teeth was connected to the piston, which served to raise the piston and compress the spring. The lamp was wound by turning a key fixed at the top of the burner, which operated a pinion gear meshed with the teeth of the square rod. It was necessary to windup the lamp before it was first lit each night, and it was necessary to rewind it at the end of about four hours' combustion. The piston, under pressure from the spring, pushed down on the oil, which forced it up the oil-feed tube to the moderator valve where it entered the base of the burner and fed the wick.

Franchot's moderator lamp was difficult to maintain because its spring drive was prone to getting stuck, its winding mechanism was easily jammed, and the moderator valve was difficult to properly maintain and provided only a very course fuel flow control.

Lepaute's Moderator Lamp (ca. 1845)

Henry Lepaute began to redesign the moderator lamp in the early 1840s. He replaced the drive spring with a much heavier piston and replaced the wind up gearing with a chain drive that allowed the heavy piston to be easily raised with a crank. The moderator valve was replaced with an easily adjusted needle valve that moved automatically as the piston was lowered. These changes significantly improved the reliability of Lepaute's moderator lamp. However, the piston was still prone to become stuck and its leather seal wore out rather quickly. Most of the world's lighthouses converted to this lamp starting around 1860.



Lepaute's Moderator Lamp, ca. 1845. Drawing by the author from Lighthouse Board drawing.

In this lamp the heavy piston pushed down on the oil only through its own weight and forced the oil up a tube on the side of the lamp body. The oil flowed up the tube into a chamber with a tiny hole located at the end toward the center of the lamp where the moderator needle was positioned. The moderator needle allowed a small and highly controlled flow of oil to pass into the burner at a steady rate.

PNEUMATIC LAMPS

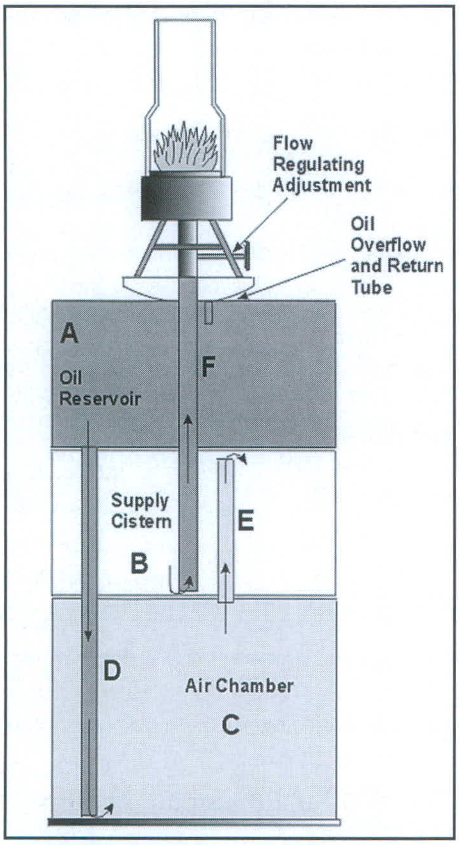
Pneumatic lamps operate through the use of air pressure to maintain a flow of oil or kerosene from the fuel reservoir below the burner up to the wicks.

The Wilkins Pneumatic Lamp (1837)

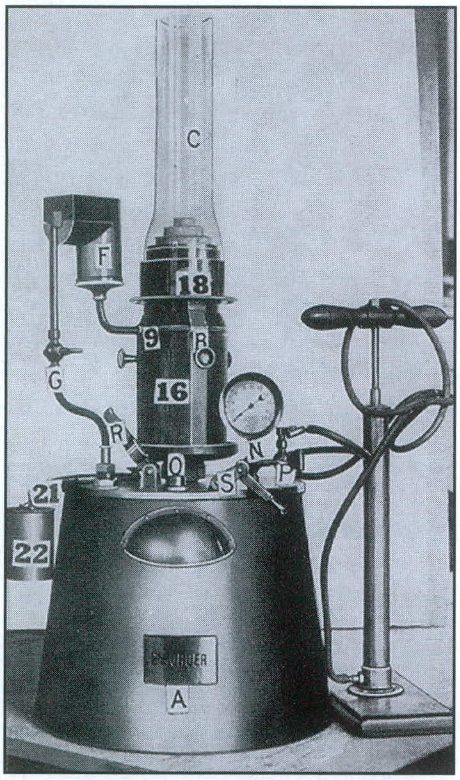
This lamp is composed of a Reservoir 'A', which is filled with oil, a Supply Cistern 'B' filled with oil, and an Air Chamber 'C'. There is a Tube 'D', which passes from the bottom of the Reservoir 'A' to the Air Chamber 'C' through which the oil passes into the Air Chamber 'C.' A Tube 'E' from the top of the Air Chamber 'C' passes up into the Supply Cistern 'B.' The main Tube 'F' leading to the burner passes from the center of the Supply Cistern 'B' up through the Reservoir 'A' to the burner. The pressure of the oil from the Reservoir 'A' into the Air Chamber 'C' will force the air into the Supply Cistern 'B', and cause the oil to flow to the burner, so long as there is any oil in the Reservoir 'A.'

The Heap Air-Pressure-Pneumatic Lamp (1899)

In 1899, David Heap began to study the significant maintenance problems with the hydraulic lamps then in use, and created the Air Pressure Lamp. This lamp used air pressure of 20 psi to push down on the kerosene and force it to flow to the lamp. The air pressure mechanism was very simple and very easy for the keeper to maintain. These lamps were first put into operation around 1900.



The Wilkins Pneumatic Lamp, 1837. Drawing by the author.



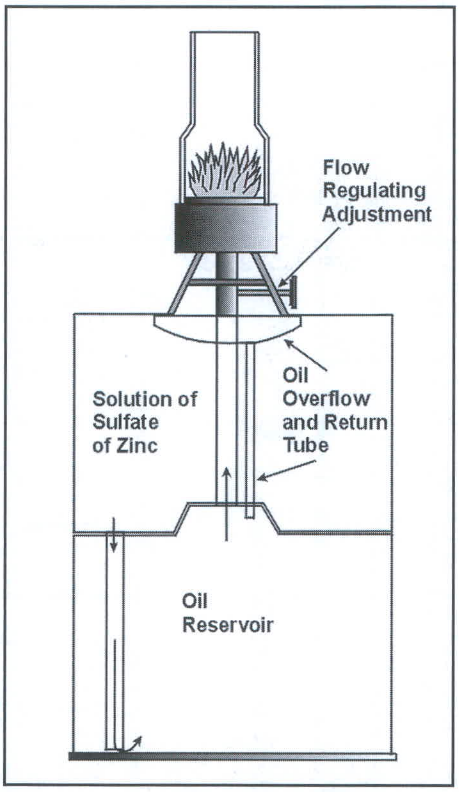
The air pressure lamp designed by D. P. Heap, which burned kerosene. Photo from *Instructions to Lighthouse Keepers.*

HYDROSTATIC LAMPS

The Hydrostatic lamp was the invention of Peter Kier in 1787. It used the weight of a liquid slightly heavier than the oil, which would flow below the oil and force it up a tube to the wicks. It was not used in lighthouses until it was significantly improved through the efforts of the French chemist Thilorier many years later.

Thilorier's Hydrostatic Lamp (ca. 1840)

Thilorier invented an improved Hydrostatic Lamp. This lamp required the use of dissolved sulfate of zinc and a test instrument called an 'Areometer' to test the density of the dissolved sulfate of zinc. Thilorier used the zinc sulfate in solution as the heavy liquid, which flowed down a tube below the oil. The oil actually floated on the zinc sulfate and was forced up a tube to the burner and on to the wicks. Any excess oil that overflowed the burner was collected and returned to the top of the oil tank by an overflow and return tube. The hydrostatic lamp was used to replace the early unreliable, clockwork driven, mechanical lamps in fixed lights where a reliable fountain or hydraulic style lamp could not be used due to its fountain and piping producing unacceptable shadows within the lens. The Scottish lighthouse service chose this lamp for use in all of their fixed lenses starting in the mid 1840s.

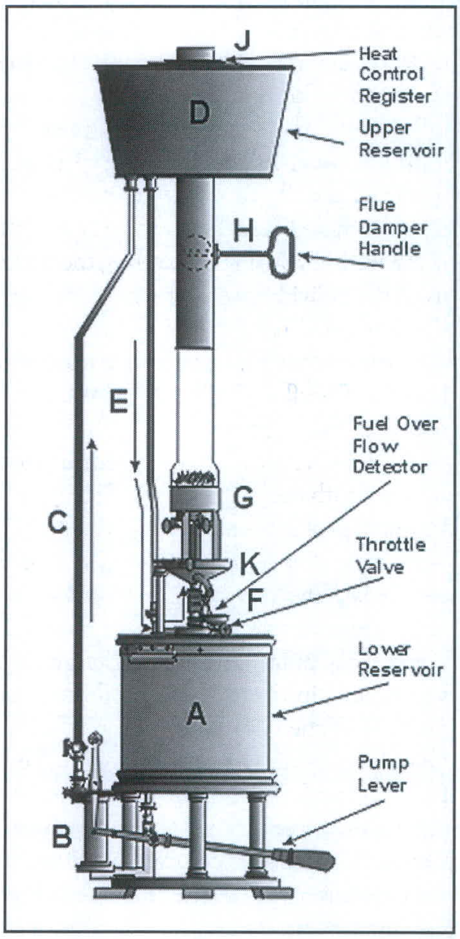


Thilorier's Hydrostatic Lamp, ca 1840. Drawing by the author.

The main drawback to the hydrostatic lamp was that it functioned based on the relatively minor difference in the density (specific gravity) of the zinc sulfate vs. that of the oil. If the density of the zinc sulfate solution was not exactly correct the oil would not flow at all or would flow much too quickly.

HYDRAULIC LAMPS

The hydraulic lamp was very similar to the fountain lamp and was used in all orders of lenses. It was based on gravity feed and consisted of a reservoir above the lens; another reservoir below the burner to contain the oil which overflowed the burner; a pump to raise the oil to the upper reservoir, and the burner.



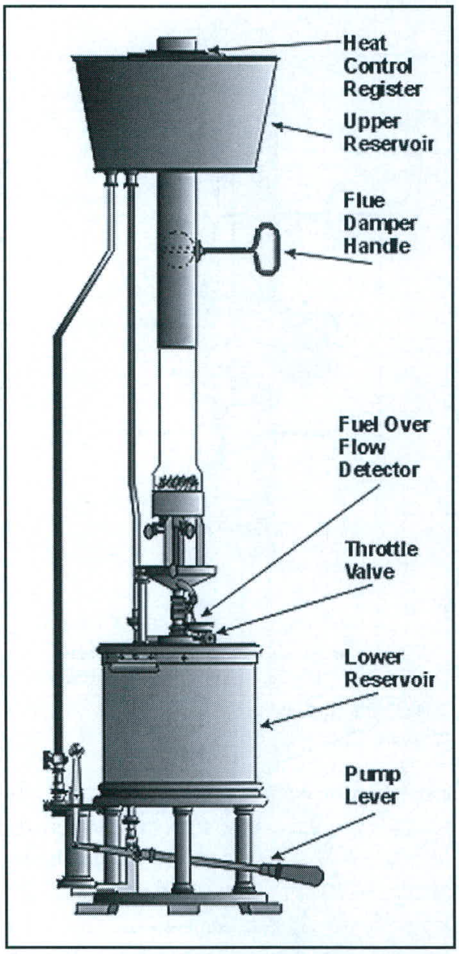
Hydraulic Lamp overview. Drawing by the author from Lighthouse Board drawing.

General Operation of a Hydraulic Lamp

At the start of each day, the keeper removed all of the oil in the Lower Reservoir 'A'. He would then fill the Lower Reservoir 'A' with clean fresh oil and close the Throttle Valve 'F.' The keeper then used the Pump Lever connected to Pump 'B' and pumped the fresh oil from the Lower Reservoir 'A' up through pipe 'C' into the Upper Reservoir 'D,' which held enough fresh oil for operation during the longest night of the year with some oil left over. The fresh oil filled the Upper Reservoir 'D' and then flowed down pipe 'E' to the Throttle Valve 'F' where it could flow no further. Note: in the hydraulic lamp designed by George Meade it was also possible to pump oil from a storage tank kept in the room below the lantern room instead of from the Lower Reservoir 'A.'

In the evening the lamp was lit by opening the Throttle Valve 'F,' which allowed the oil to flow up a central tube passing through the oil Overflow Collector 'K' and into the Burner 'G' where it flowed through and over the wicks. The keeper lit the oil at the wicks and regulated the flow of oil by adjusting the Throttle Valve 'F' and by adjusting the height of the wicks by raising or lowering the wicks using the individual wick adjusting knobs on the Burner 'G.' The overflow of the oil passed over the concentric wicks and back down into the Overflow Collector 'K' and out a small tube into a Sensor Cup, which was a part of the Fuel Overflow Detector. An alarm bell was used with the lamps in Fresnel lens lights. It consisted of a lever that was pivoted like a teeter-totter. One end of the lever was raised and blocked the alarm mechanism. The other end of the lever held a small Sensor Cup with a small hole in its bottom. The Sensor Cup was located in the flow of the oil from the overflow of the burner. As long as oil overflowed the burner, the Sensor Cup was kept full of oil and the alarm lever was held in place. If the overflow of oil stopped, the Sensor Cup would cease to be filled and the oil within it would flow out through the small hole in its bottom. When this happened the alarm lever was no longer held in the up position and the end blocking the alarm mechanism lowered and the alarm would sound. The alarm usually consisted of a bell located in the tower or keeper's quarters. After passing through the Sensor Cup the overflow oil was passed into the top of the Lower Reservoir 'A' through a small wire mesh strainer.

The air flow through the burner and chimney was regulated by hand adjusting the Flue Damper Handle 'H.' The Upper Reservoir 'D' had a cylindrical hole through its center. Through this hole a sheet-iron chimney passed down to the glass chimney. In the upper cover of the Upper Reservoir 'D' was a Heat Control Register 'J', which surrounded the sheet-iron chimney. When the register was open, the heated air passed through between the chimney and the reservoir, producing little effect upon the temperature of the oil. When it was closed, the heated air was obstructed and the oil was heated by it, so that in cold weather the oil was kept fluid enough to flow easily through the pipes.



George G. Meade's Hydraulic Lamp, 1853. Drawing by the author from Lighthouse Board drawing.

The Wilkins Hydraulic Lamp (ca. 1839)

This lamp was composed of a reservoir to hold the required quantity of oil for use during one night, a supply cistern, and a burner. From the bottom of the reservoir a tube connected to the supply cistern. In the end of this tube was a movable stop, to which was attached a hollow metallic ball, which served, as the oil in the cistern rose or fell, to regulate the flow of oil in the cistern, and to the burner. The oil was fed from the supply cistern through a tube from the bottom of the cistern to the burner, and up to the concentric wicks. The overflow of oil flowed into the overflow cistern.

Meade's Hydraulic Lamp (1853)

This lamp was designed by then Lieutenant George G. Meade, of the United States Corps of Topographical Engineers, and erected by him first at the Sand Key Lighthouse in Florida, and later at other locations. It should be noted that this was the same George G. Meade that would become the General leading the Union troops in the battle of Gettysburg, during the Civil War.

Meade's lamp was intended to take the place of the French mechanical lamps of the Fresnel-Arago and Lepaute patterns, and do away with the pumps and clockwork machinery. This lamp was previously described in the section 'General Operation of a Hydraulic Lamp.'

Franklin Hydraulic Lamp (1863) - for Fourth, Fifth, and Sixth Order Lights

This lamp was designed by Captain William B. Franklin, United Stated Corps Topographical Engineers, and Engineer Secretary of the Lighthouse Board. It consisted of four principal parts:

1. An airtight reservoir, with supply tube attached, resting on the upper ring of lens.
2. The burner, with reception tube and oil level control.
3. A bracket, with a drip-cup fastened to the bottom ring of the lens.
4. An oil level control air chamber opening into the reception tube.

Joseph Funck created an almost identical lamp for use with fourth, fifth and sixth order lenses in 1869, that also used his float valve design to replace the oil level control chamber of the Franklin hydraulic lamp.

Funck's Hydraulic-Float Lamp (1869)

The major successor to the French mechanical lamp, in America, was a lamp designed by Mr. Joseph Funck, the foreman of the American Lighthouse Service workshops at the depot on Staten Island, New York.

Funck's hydraulic float lamp had a pump, operated by hand, that raised the oil from the Lower Reservoir to the Upper Reservoir through Pipe 'A.' The oil then flowed down from the Upper Reservoir through Pipe 'B' into the Float Chamber. The Float 'C' was donut shaped and floated upon the surface of the oil in the glass chamber. In the center of the Float 'C' a small needle was fixed that pointed upward into a specially shaped restriction in the oil inlet Pipe 'B' and when the Float Chamber was full of oil, the needle in Float 'C' blocked further flow of oil from Pipe 'B' into the Float Chamber. The oil flowed to the wick after passing through the Float Chamber. As the oil flowed into and over the wicks, some of it being burned, the oil in the Float Chamber lowered and the Float 'C' lowered allowing more oil to enter the chamber. The Float 'C' was adjusted so as to rise and close the oil inlet as soon as the oil reached the proper height to just overflow the wick, thus maintaining the oil always at the same level. The overflow oil passed down through an Overflow Collector 'D' into the top of the Lower Reservoir.

Funck's 8-Day Lamp (1885)

In the early 1880s, there was a great need for lanterns that could be used as beacon lights on small piers and as post lamps, functioning as the warning lights for obstacles on the major inland rivers. The problem with the lamps, in use at the time, was their need for constant attention. In 1885, Joseph Funck developed the idea of adding a large circular tank for oil around the top of the lamp, giving it the capacity to operate for up to 8 days without attention. This design worked quite well, but the lamp itself was the old-fashioned flat wick variety and the lens was made of pressed glass of rather poor quality. The lamp was also susceptible to being blown out by strong winds.

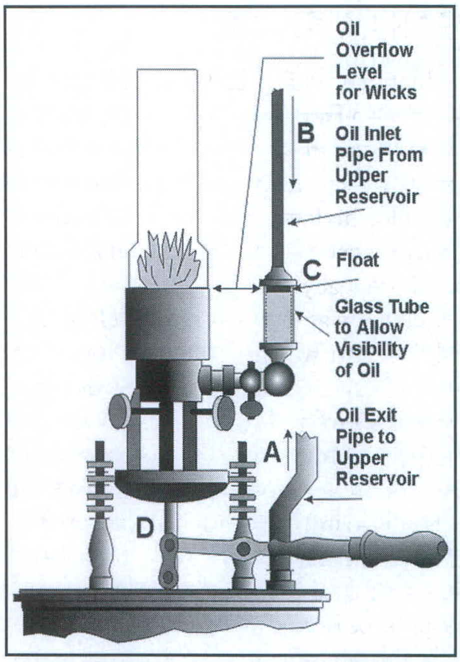
Heap's 5 and 8-Day Lamps (1889)

In 1889, David Heap developed a further improved design for the American 8-day lantern and invented a new 5-day lantern. He described his thoughts in a report to the Lighthouse Board as follows:

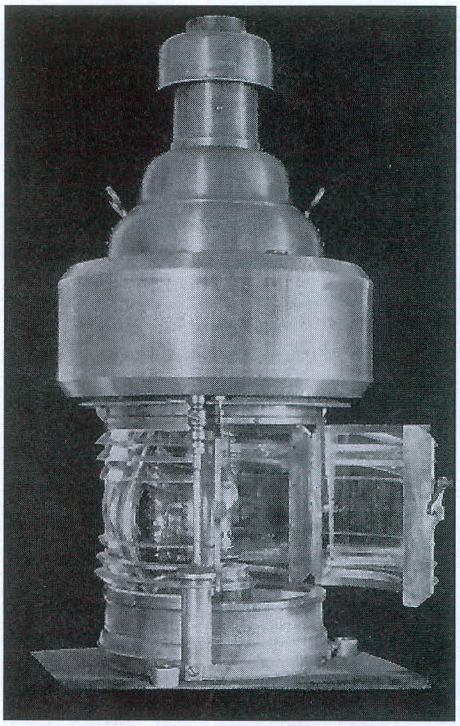
"The eight-day tubular lens-lanterns having proved quite successful so far as maintaining a light without attention during that length of time, I believed that it would be advisable to apply the same principle to a lantern with cut-glass prisms, using a lamp with a circular burner and a chimney, and thus obtain a much more powerful light."

The Benson-Lee Automatic Lamp (1895)

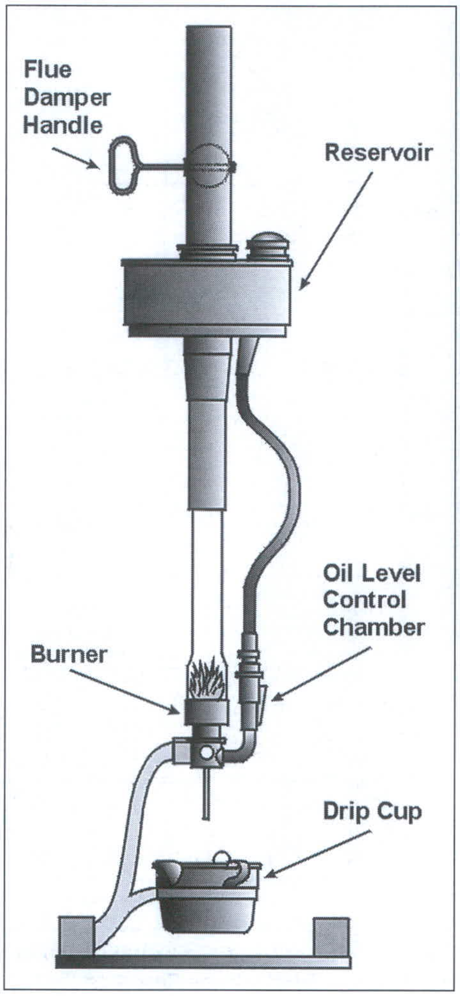
By 1895 in Europe, the Benson–Lee automatic lamp was beginning to be used in beacons. It had special wicks that were tipped with carbon from tar and it required no trimming for four or five days of operation. It was chosen for all new installations in Scotland and acted like the American 8-day lamp. The Benson-Lee lamp replaced the earlier Trotter-Lindberg lamp developed in Sweden, which required significantly more technical knowledge to maintain.



Detail of the float. Drawing by the author from Lighthouse Board drawing.



The five-day Lens Lantern developed and improved by David Heap. Photo from the author's collection.



Left – Franklin's Hydraulic Lamp. Drawing by the author from Lighthouse Board drawing.

GAS BURNERS

Monsieur Phillip Le Bond d'Hambersin was given a French patent for producing illuminating gas from wood in 1799, which was made by carbonizing wood in a closed retort. He called his invention the Thermo Lamp, which was first used in the Le Havre lighthouse in France that year.

Oil gas was first used at the Holyhead lighthouse in Wales in 1820, and from 1819 to 1827 Fresnel and Arago experimented with the use of gas burners for use within the Fresnel lenses, however, they chose to continue with the use of their multi-wick oil lamps. Also in 1823, Pintsch gas was tried at the South Foreland lighthouse in England. All of these early experiments with gas used simple tube or multiple tube burners.

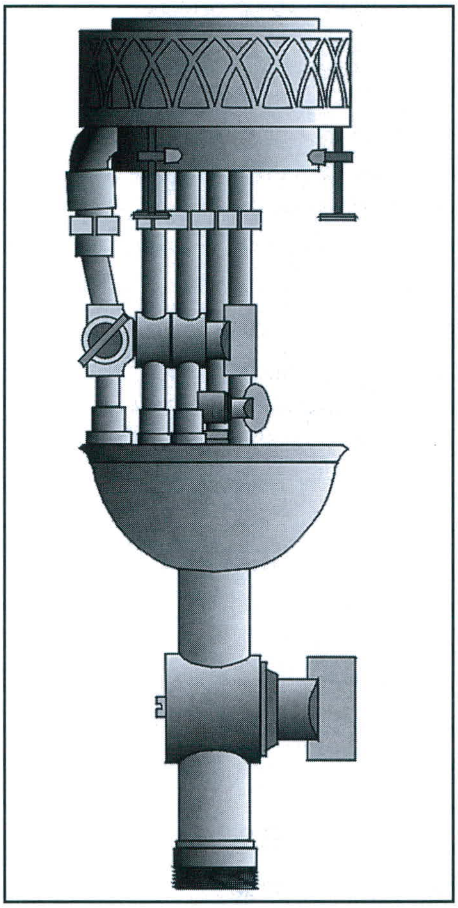
A lighthouse built in 1829, known as the Barcelona light, and sometimes called the Portland light located on Lake Erie, was unique because of its fuel source. The nearby town of Fredonia, New York was the first site in North America to commercially use Natural gas, starting in 1821. The Barcelona lighthouse was located 18 miles west of Fredonia and for part of its life, it used a nearby 'spring' of Natural gas carried a distance of two miles in pipes to the tower to light its lamps. Unfortunately, the Natural gas gave out in 1838, and the gas lamps were removed.

An effort was made in 1841 to use another form of Wood gas known as Rosin gas at the Christina Creek light station, near Wilmington, Delaware. Rosin gas was made through the heating of pinesap (rosin) or pine logs in an enclosed retort. After about a year of trial, the effort at Christina Creek was abandoned as impractical.

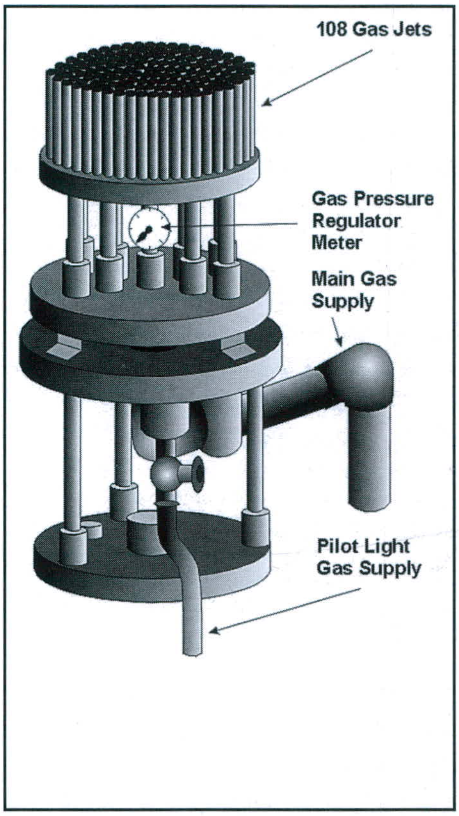
Gas was later used in lighthouses in a number of countries. However, its production, delivery, and excessive heat restricted its use to a relatively small number of lighthouse locations. The major drawback was the need for the building and operation of a gas production plant next to each lighthouse where it was to be used.

Wigham's Crocus Gas Burner (1865)

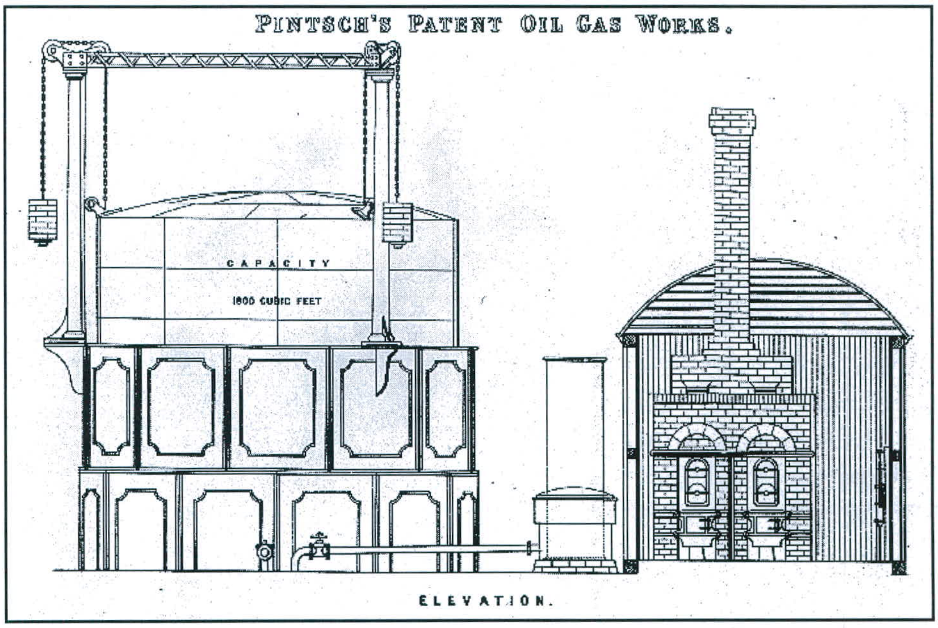
John R. Wigham developed many forms of lamps for use with coal gas in Ireland starting in 1865. His designs were the first that could be used reliably and which could be sized based on the size of the lens. Wigham's designs ranged from 28 to 108 gas jets and several still larger numbers of jets were experimented with. Wigham's gas lamps were used extensively in Ireland.



The Fresnel-Arago Gas Burner, 1824 Drawing by the author from drawing in *Oeuvres de Fresnel*.



John R. Wigham's 108-jet Crocus Gas Burner, 1856. Drawing by the author.



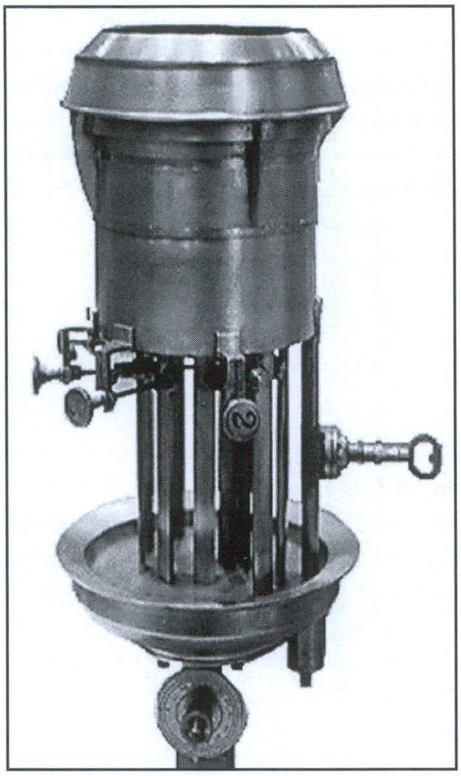
A typical gas generation facility that had to be co-located with each lighthouse using gas. Drawing from *Trinity House Report on the Relative Merits of Electricity, Gas and Oil, 1885.*

KEROSENE BURNERS

Doty's Kerosene Burner (1868)

An American ship captain, Henry Harrison Doty, thought he could solve the problems related to the use of kerosene in lighthouse burners. He described his efforts as follows:

In 1866, the idea occurred to me that if paraffin (Ed: kerosene) as now manufactured, with a large specific gravity and safety standard, could be employed in Lighthouse Illumination, a great reform in the economy and intensity of coast lights would be attained. I accordingly set myself resolutely to the solution of the problem, how this could be effected, not only for the one wick burner, but for lamps having concentric wicks. After more than two years unremitting study and experiment, I was successful in discovering the means of doing this for all the different orders of burners, and that too, without causing any structural re-arrangement of the apparatus or lamp at present in use."



French Five-Wick Lamp based on Doty's patent, ca. 1873. Photo from the author's collection.

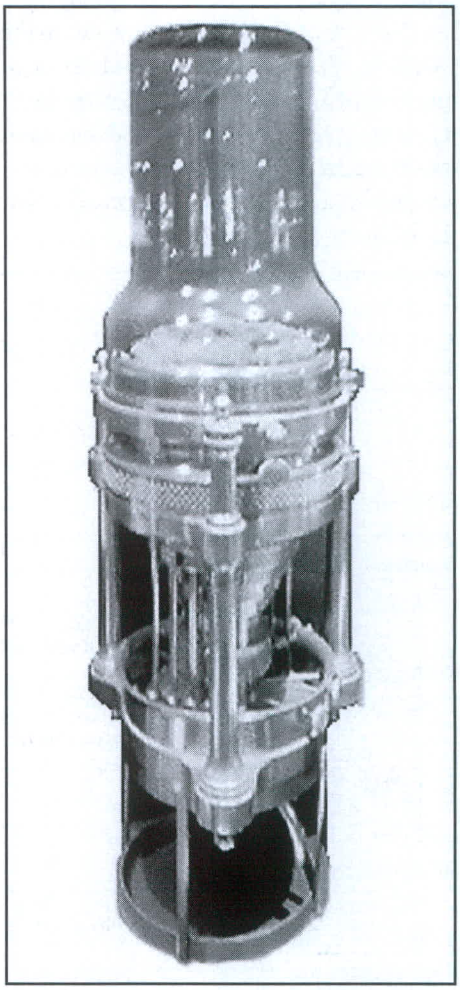
Doty mentioned the specific gravity of the kerosene because the heavier the kerosene the less volatile it was, and therefore the safer it was to use.

The French Lighthouse Service had long been considered the leader in technical innovation and quality. Captain Doty took samples of his latest burners and went to Emperor Napoleon III in November 1868, convincing him of their advantage and requesting that France put them on trial. Doty's request was granted and a trial within the French Lighthouse Service was begun in December 1868 and completed successfully in January 1869. A number of French lighthouses were then converted to kerosene as a fuel, with the Doty burner modifications. The French did not use the Doty burner directly. Instead, they bought the rights to use Doty's design principals in their own burner designs.

Funck's Kerosene Lamps (1876)

Early in 1874, Joseph Funck, the foreman of the Lamp Shop at the Tompkinsville New York Depot, was assigned to begin analyzing any changes necessary in the design of burners for the use of kerosene. Joseph Funck was given a patent for his version of the kerosene burner for lighthouses on November 28, 1876. Captain Doty was continuing to further describe his design and on March 28, 1877, he asked for a second reissue of his patent to describe some additional features of his original design that he felt Funck was infringing upon, and began a lawsuit against the Lighthouse Board and Funck. On December 5, 1878 there was a final decision of the Supreme Court of the District of Columbia. In this decision Funck and the Government won every point and Funck's multi-wick design was declared to be free of any patent infringement related to H. H. Doty or anyone else. The Lighthouse Board now had the right to deploy Funck's multi-wick kerosene burners throughout the system.

Joseph Funck's Four-Wick Lamp, 1883. This lamp is of the moderator type. Photo from the author's collection.



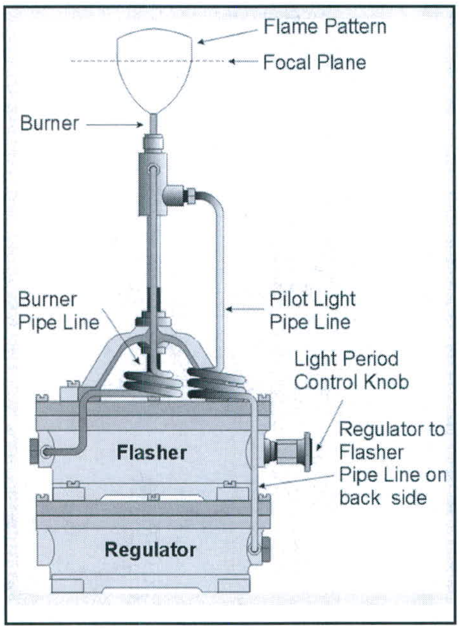
The French Ten-Wick Kerosene Burner. Photo from the author's collection.

ACETYLENE

The Acetylene process was invented by a Canadian, Thomas Leopold Willson in 1892. Willson also invented the idea of generating Acetylene inside a buoy in 1904. Acetylene is also sometimes called Dalen gas. When Acetylene is employed in lighthouse work, the gas is either supplied in cylinders, or is generated on the spot.

In 1896, two Frenchmen, George Claude and Albert Hess developed a method to store compressed Acetylene by dissolving it in Acetone held in steel cylinders. In this system the gas is compressed into cylinders filled with a porous substance, and with acetone, a liquid having the remarkable power of absorbing at atmospheric pressure twenty-four times its own volume of acetylene gas. Its power to absorb the gas increases in proportion to the pressure, so that at a pressure of ten atmospheres it will dissolve two hundred and forty times its own volume of acetylene gas.

One of the first acetylene gas buoys in the world was designed by David P. Heap, engineer of the Third District depot, in 1897. Heap's buoy used three tanks of compressed acetylene gas to supply a lens lantern, and was used in an experiment conducted in New York harbor.



Acetylene Regulator Flasher Lamp. Drawing by the author.

An acetylene gas lamp was installed at the Cloch lighthouse, in Scotland around 1900, and the acetylene was used to operate everything from the domestic lighting, fog signals and the engine house to the lighthouse lamp itself. In America, a beacon equipped with a generator for producing acetylene gas from calcium carbide was placed in the Mobile Channel in 1902, and this was the first official use of acetylene gas by the American Lighthouse Service. Compressed acetylene was first officially used at Jones Rocks Beacon, Connecticut, and South Hook Beacon, Sandy Hook, New Jersey, in 1903.

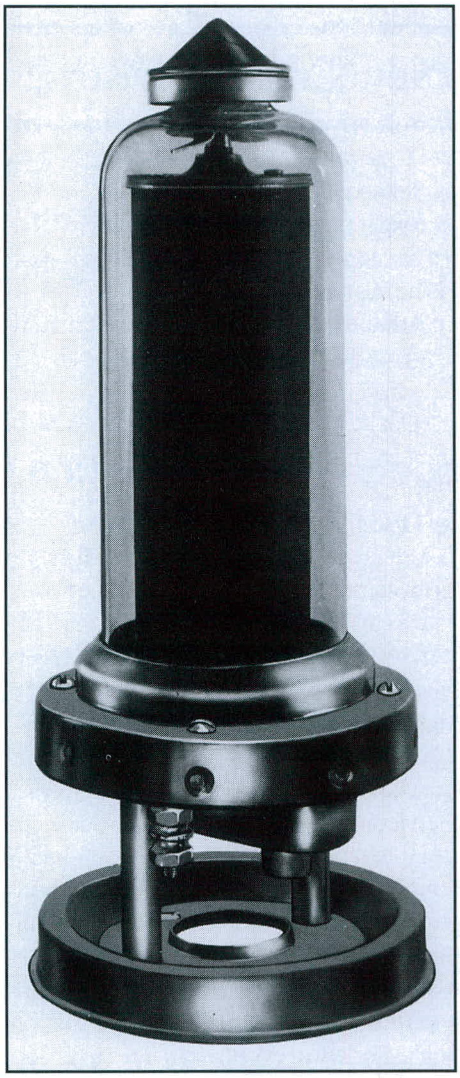
In 1904, the development of dissolved acetylene was improved when John Höjer approached the Gasaccumulator Company (later known as the AGA Company), requesting them to redesign the current apparatus. Mr. Gustaf Dalen of Stockholm, Sweden solved the problem with his development of the AGA compound for storing the gas in cylinders. He also invented the acetylene flasher in 1905, which drastically reduced the amount of gas used. An experimental buoy of the Swedish Pilotage Board, was installed at Kalmarsund, showing a fixed acetylene light in 1905. In the following year the buoy was first fitted with the Dalen flasher. The Dalen flasher reduced the amount of gas consumed and was proven to need little maintenance.

The American Lighthouse Service chose the Willson carbide-water buoy design rather than the pressurized acetone cylinder type. In the Willson buoy the gas was made on the spot by sliding solid calcium carbide through a canvas chute into a fuel chamber in what was known as the 'charging process'. This process was very dangerous and in 1913 an explosion occurred when refilling such an acetylene chamber in a buoy on the tender Hibiscus. Later, America abandoned the Willson design and began using pressurized cylinders throughout the American Lighthouse Service.

Sun Valve

The invention of the sun valve became critical to the expanded use of acetylene in lighthouses. Dalen invented the Sun-Valve in 1907 to still further increase the time between gas cylinder replacements. The Sun-Valve consisted of an arrangement of reflective gold-plated copper bars supporting a suspended absorbent black rod. The central black rod absorbs heat from the sunlight and expands closing a small valve at its base and shutting off the supply of gas to the burner (a pilot light is always maintained). When darkness approaches the heat is reduced and the black rod contracts opening the valve and allowing full flow of gas to the burner. The central black rod can be adjusted, by means of a screw, and the entire sun-valve is enclosed in a heavy glass cylinder. The first sun-valve was put into operation in the little Furuholmen lighthouse near Stockholm in 1907. Later sun-valve designs eliminated the reflective gold-plated bars to reduce the cost of the sun-valve assembly.

In England, Sir Thomas Matthews created a special clockwork mechanism that was able to time the flash cycles and the turn-on and turn-off times of unattended lights using acetylene fuel. The clockwork was wound automatically by the same mechanism that powered the lens rotation. While its intention was to function similarly to the sun valve, it could not react to storms as the sun valve could, nor was it able to be placed in the open or on buoys.



Sun valve. U. S. Lighthouse Society photo.

Part III of Tom Tag's article on lighting apparatus will conclude in the Spring issue of *The Keeper's Log.*

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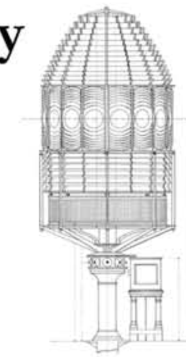

Restoration & Preservation

Thomas Point Shoal Lighthouse, MD

The U.S. Lighthouse Society has donated to many lighthouse preservation projects throughout the U.S. Most recently we were honored by being presented with the Preserve America Stewardship Award from The White House for our restoration work at Thomas Point Shoal Lighthouse.

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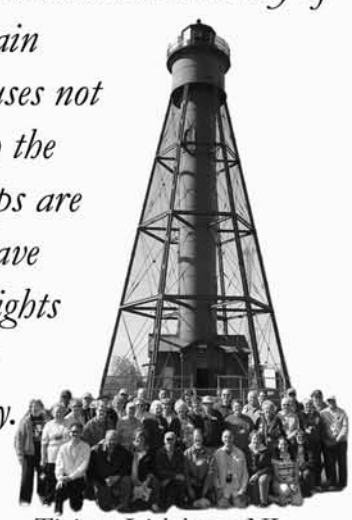
The Society organizes domestic and international lighthouse tours. Many of our excursions gain access to lighthouses not normally open to the public. These trips are a great way to have fun, see lots of lights and learn about lighthouse history.



Tinicum Lighthouse, NJ