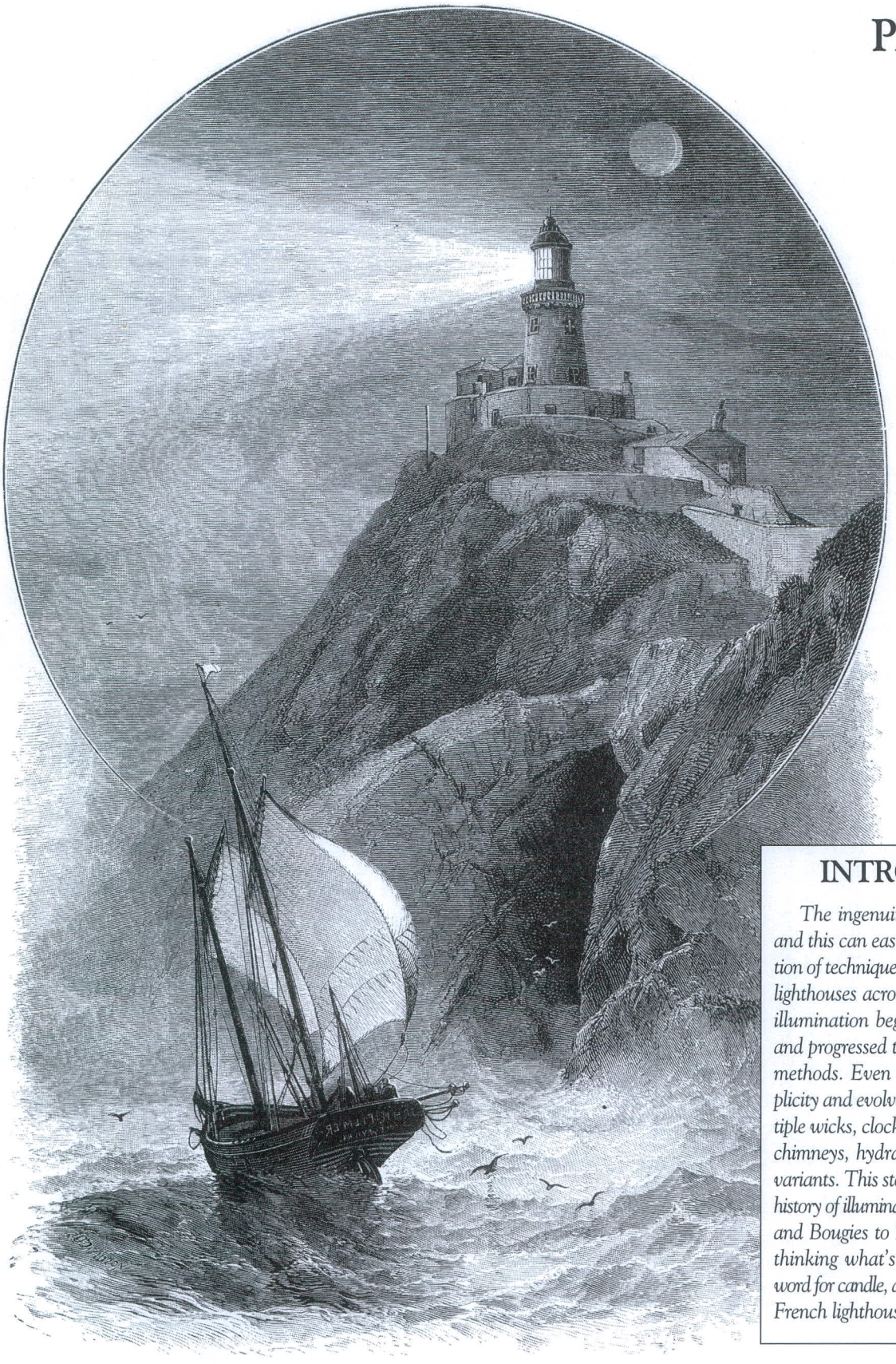
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From Braziers and Bougies to Xenon

By Thomas Tag

PART I



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.

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BRAZIERS

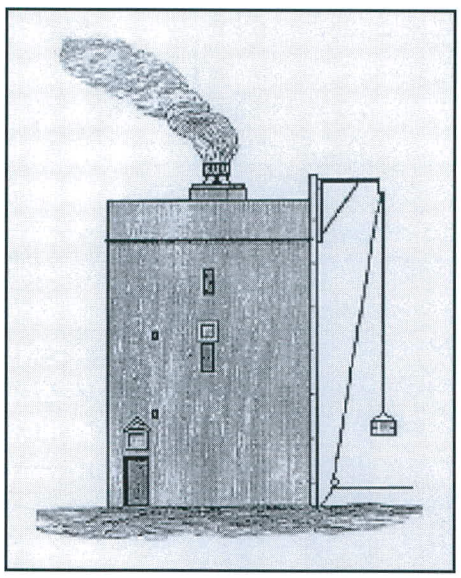
Coal and Wood Fires

The early mariner's warning lights consisted chiefly of open fires and later of fire beacons maintained on a grate or in an iron basket known as a brazier and shown from an elevated location or platform near the coast. They were often unreliable because of the variability between burning well, with lots of flame and therefore light, or burning poorly with little flame or much smoke obscuring the light. These beacons were maintained both by public and private enterprises. Patents were granted to certain individuals for the upkeep of beacons in England and Scotland. While in other countries, the governments accepted the total responsibility for building and maintaining the warning lights.

The first English lighthouse to use mined coal was Dungeness in 1616, and its coal-fired brazier consumed as many as 400 tons of coal per year. The quality of the light from brazier coal fires varied considerably with weather conditions. When a strong wind blew off the land toward the sea, the light on the seaside became quite bright, but when the wind came from off the water the side of the fire facing the sea would be quite dark, while the land side of the fire was bright, yet useless. This was a great problem, because it was precisely when the wind was blowing toward shore that the most brilliant light was needed, and the most danger to shipping was present.

At first these fires were burnt in the open, but later they were enclosed by a lantern provided with a ventilating flue in an attempt to carry away the smoke, which would form around the fire and frequently obscure the light. The lanterns were not always a success as the glazing became blackened, and in a number of cases they were removed. One of the earliest known coal-fire towers to be fitted with a lantern is to be found on the island of St. Agnes in the Isles of Scilly in England. It was built in 1680, and the brazier, in which the fire was burnt, is still in existence.

The Isle of May, in Scotland, was the location of an old lighthouse established in the year 1636. The original lighthouse consisted of a stone tower with a large brazier for the burning of coal at its' top. The coal was set alight each night and burned an average of a little over one ton of coal per night. The coal fire was exhibited every night from the lighthouse's opening in 1636 until February 4, 1816, when it was replaced by a new lighthouse using reflectors, each with an Argand style oil lamp. A primitive block and tackle was used to raise the coal to the brazier on the top of the tower by the three men who were assigned to the stoking of the fire. The old coal fires survived in England until 1822, and there were examples of such lights in service in the Baltic region until 1850.

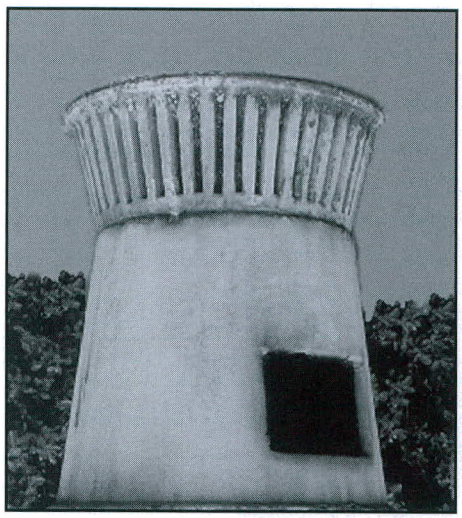


Old Isle of May lighthouse. Drawing by the author from an old manuscript.

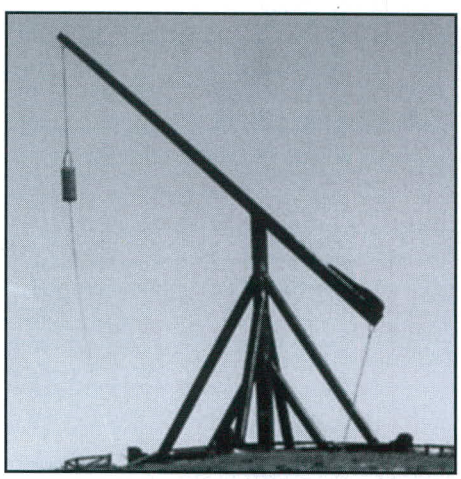
VIPPEFYRS

In Denmark, Jens Pedersen Groves designed the Vippefyr in 1624, which utilized the lever principle to raise a fire into the air. He drove one end of a large square beam in the ground strengthened by several additional diagonal supports. Pivoted from the main beam was a balanced cross member, or lever. One end of the lever was attached by a chain to a large fire basket, while the other end was weighted to facilitate raising the fire basket some 14 to 30 feet into the air. The long end of the lever, with the fire basket, was usually covered with metal sheathing as a protection against fire. The fire basket could be lowered when the keepers needed to fill it with coal or wood or to stoke the fire. It was then raised again to show the signal. One of the last Vippefyrs to be used was as a small local light on the island of Gothland, in Denmark, in 1905

In England a similar device known as the Swape was used. The coal or wood fire was made in a metal basket, which could be easily tended on the ground and then elevated by means of the Swape, or fire lever. The great English Civil Engineer, John Smeaton visited Spurn Point in 1767 and decided to use a Swape there. He designed an improved version of the Swape with a small umbrella to protect the control rope from falling cinders.



St. Agnes Brazier ca. 1680-1809. Photo from the author's collection.



The Vippefyr at Skagen, Denmark ca. 1624. Photo from the Egbert Koch Collection.

BOUGIES AND CANDLES

The first use of candles consisted of a simple lantern shown at a window by a hermit or a monk. It was only when the enclosed lantern room was developed that the use of candles was made possible for use in lighthouses. The light from individual candles was rather feeble, however, when a number of candles were placed in a candelabra, and protected from the wind by the lantern windows, the light was a significant improvement over

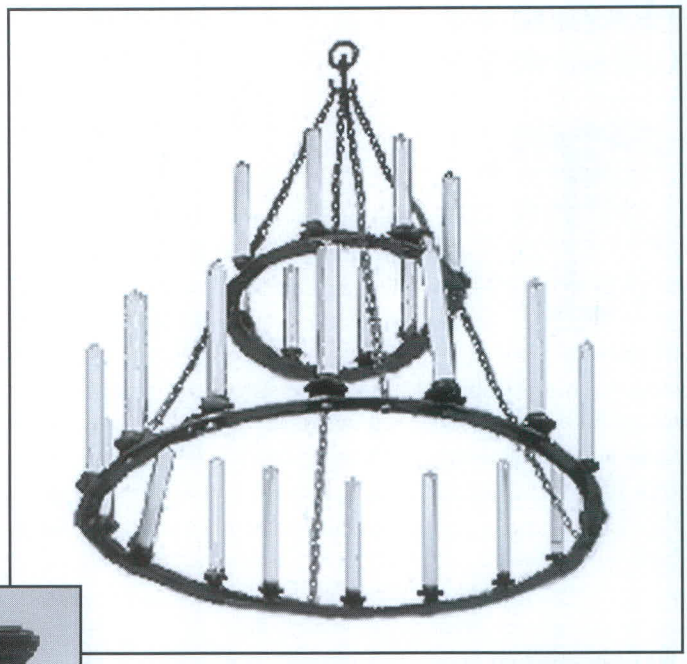
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that from the coal fires. Candles were used in many lighthouses in Europe in the 1500s and were first used in England at the North Shields lighthouse in 1540. In France the name for candles was Bougies, which were made from tallow and used in their earliest lighthouses. The first lighthouse illumination in America came also from tallow candles, which were used for several years in the first Boston lighthouse and in most other early 18th century American lights. The keepers usually made the candles on site, because commercially produced candles were virtually nonexistent. Wax candles were used, but were very expensive; tallow candles were cheaper, but smoky and bad smelling.

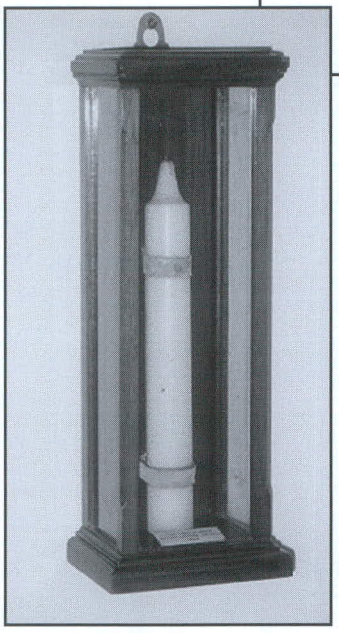
In the original Winstanley Eddystone lighthouse, 60 one-pound candles were used when it was first lit in 1698. In Smeaton's Eddystone lighthouse in 1759, the first light exhibited was from 24 candles, which produced a rather feeble light, although, it is said that the light could be seen by telescope from Plymouth Hoe, 12 miles away. The candles Smeaton used at Eddystone weighted 2/5 of a pound each and the 24 candles had to be replaced about once every 3 hours.

OIL LAMPS OVERVIEW

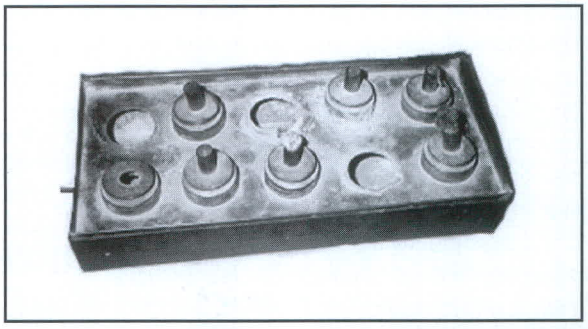
The Cresset was one of the earliest forms of oil lamp used in a lighthouse. It consisted of a bowl hollowed out of stone, which was filled with fish oil, with one or more small rope wicks. As the years passed, several other types of oil lamps began to be used. The lamps, were usually made by local artisans, and began to be used as early as 1500. At this time, there were no standard types of lamps in use; however, most lamps had solid-rope wicks made of loosely braided cotton and a rather small common oil reservoir that fed one or more wicks. These lamps initially burned fish oil, seal oil, and later whale oil. They used no chimneys or reflectors, and produced a very poor light with much smoke and acrid fumes. Small tin lamps were tried, but failed due to their lack of a sufficient oil supply and poor flame qualities. The solid wicks had very poor combustion of the oil on the wick, producing large quantities of smoke. Later improvements were made by flattening the wicks to allow the ambient air to better reach both sides. While this produced a better flame, some smoke and soot was still produced, and portions of the oil remained unconsumed by the flame.



A replica of the candelabra originally installed in the Eddystone lighthouse, 1759. Tom Tag collection.



Left, An actual candle from the Eddystone Lighthouse, 1759. Tom Tag collection.



A typical Pan Lamp with ten 'blazes,' 1760. Shore Village Museum photo.

Spider Lamps

By the 1760s, a form of Spider Lamp known as the Pan Lamp replaced the other early oil lamps in some lighthouses. The Sandy Hook light, in New Jersey, built in 1764, is reported to have used two Pan Lamps with a total of 48 oil blazes, hung from the lantern room ceiling by chains. Pan Lamps came in several forms. There were circular and rectangular pans, and a donut shaped Pan Lamp was used in the early lightships. Pan Lamps with a circular form were also known as Compass Lamps.

The Pan Lamp solved the problem of a limited oil supply and could operate for twelve or more hours on one fill of oil. The Pan Lamp had multiple rope wicks. The number of wicks varied from two too as many as twenty-four, with eight to ten wicks being very common. The Pan Lamp produced more light than the other early oil lamps because individual large diameter wicks were placed nearly side by side across the surface of the metal pan, and the flames could all be seen at the same time. Its main drawbacks were its relatively low light output, its massive consumption of oil, and the smoke and fumes produced within the lantern room, which at times became almost intolerable.

Pan Lamps were used for a very long time. The early light lists show a Compass Lamp with 8 wicks still in use at the Vermilion beacon light, in Ohio, in 1849. Compass Pan Lamps were the only style of lamp in use on American lightships until the mid 1850s.

The Bucket Lamp, another form of Spider

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Lamp, had been available for many years and began to be used in lighthouses in the latter part of the 1700s, mainly in the smaller lighthouses, beacon, and pier-head lights. The Bucket Lamp was made of sheet metal and was cylindrical in shape, with two or four spouts protruding from its sides. Each spout carried a large diameter rope wick that extended down inside the body of the lamp into the oil. Below each spout was a similarly shaped drip catcher. The Bucket Lamp held up to an eight-quart oil supply and could operate for twelve or more hours on one fill of oil. Its main drawbacks were still the very poor light produced, the smoke and fumes, and the problem that some of the flames were hidden from view behind the bucket, when it was viewed from specific directions. The Cape Henry light used this style lamp in 1792 and burned fish oil probably from Herring. The use of Bucket Lamps lasted a long time and four were recorded as being in use in 1845, at the Cunningham Creek Beacon light in Ohio.

FOUNTAIN LAMPS

Fountain lamps use a closed container of fuel with a small valve at its lower end. The valve is set at a height slightly below the top of the wick in the lamp burner. As fuel is burned, the valve in the fountain opens slightly to admit additional oil into the tube going to the burner. The fountain lamp maintains the fuel at a constant level at the burner. Fountain lamps function through capillary attraction and do not overflow the wicks.

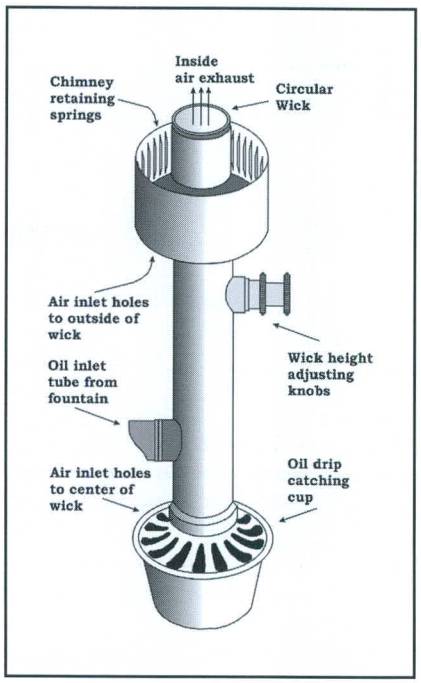
Argand's Lamp

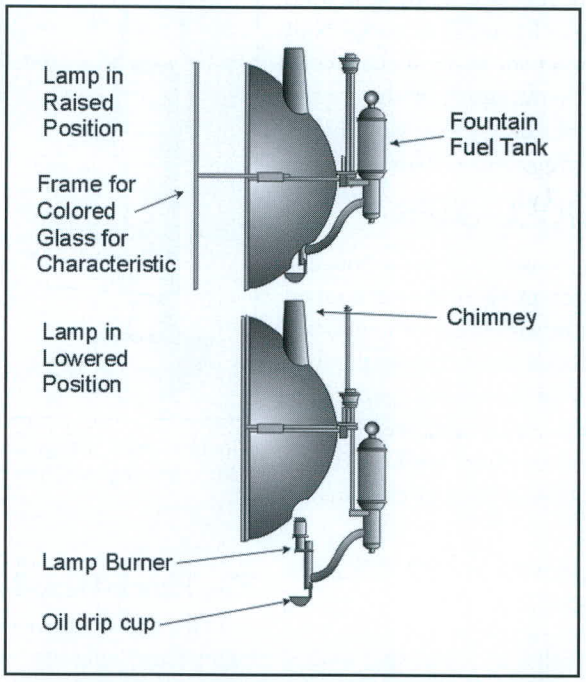
In 1782, François -Pierre Ami Argand (1750-1803), a Swiss born physicist living in France, invented the double draft burner, which became known as the Argand oil lamp. Argand's design used two thin metal tubes with one set inside the other. The wick was placed between these tubes and was thus formed into a long hollow cylinder. Air was allowed to enter the center of the wick through holes placed in the oil drip-cup attached to the bottom of the wick tubes. Air was also allowed to enter around the outside of the outer wick tube, through holes in the bottom of the chimney holder. Argand's design provided much more oxygen to the flame, more efficient fuel combustion, and a much brighter light. Argand also invented the use of a chimney, which helped to provide additional airflow over the wick and protected the flame from outside air currents, which could make it flicker.

In 1787, another Frenchman, Monsieur Lange, invented the constricted chimney, which Argand quickly added to his design. The constricted chimney forced the outside air closer to the flame. This action further improved the combustion of the fuel, giving a still brighter flame, which was measured at about 7 candlepower.

Robert Stevenson's Lamp

From 1803 to 1810, Robert Stevenson worked to improve the design of Scotland's copper parabolic reflectors and lamps. He chose an improved Argand lamp with a fountain fuel tank set in a true parabolic reflector with a heavy cladding of silver. By 1809, he had succeeded in developing a design where the lamp was able to be released from the focus of the reflector by turning a locking ring, that let the lamp assembly slide down, allowing easy wick replacement or trimming, and allowing easy polishing of the inside of the reflector. When the work was completed, the keeper raised the lamp back into its preset position, in the reflector's focus, and locked it with the ring. Stevenson's new lamps were first installed in the Bell Rock lighthouse in 1811.





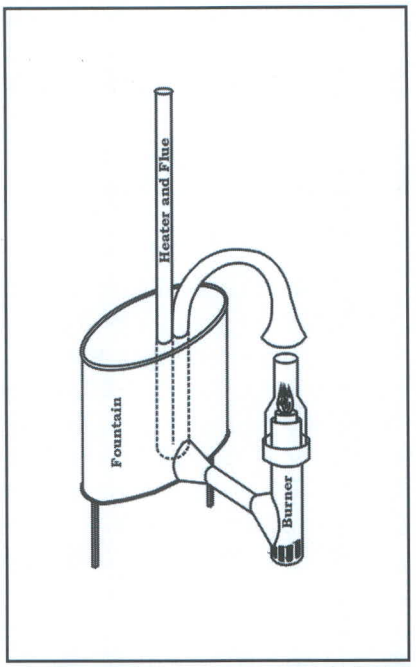
Robert Stevenson's retractable lamp with reflector (1811). Drawing by author from drawing in *Lighthouse Illumination* 1859.

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Winslow Lewis' Lamps

Winslow Lewis, an American ship captain, created a crude lamp design, but he succeeded in impressing the government through actual trials of the lamp's performance and low oil consumption, which were held at the Boston lighthouse. In 1812, U.S. Government paid Lewis over $ 20,000 for his invention.

The lamp in Lewis' design was a rough copy of an Argand style lamp with a three-quarter inch burner. The original lamp also used a short glass chimney and a simple woven-cotton lamp wick, which was poorly made, and resulted in inefficient fuel usage. Nearly all of the American lighthouses from 1812 to 1840 used the Winslow Lewis reflector and lamp design, and most continued to use the design until about 1858.



Winslow Lewis lamp patent 2901-X. (1818) Drawing by author from patent drawing.



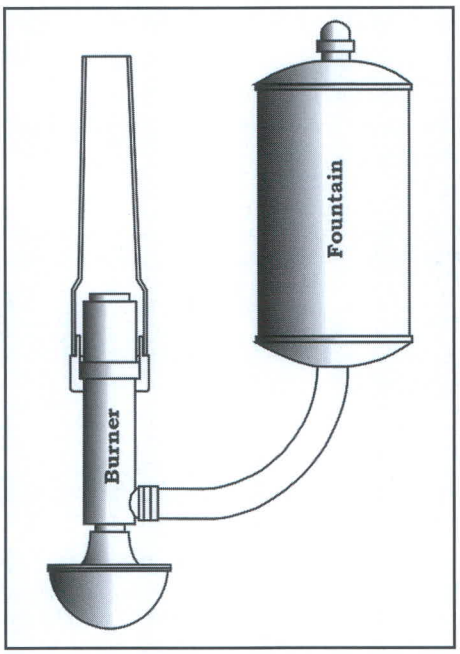
The Funck – Heap fourth-order lamp. Photo from author's collection.

OIL AND KEROSENE LAMPS FOR USE IN FRESNEL LENSES

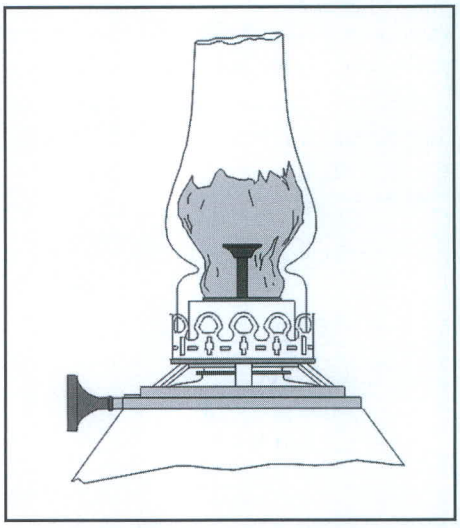
A number of styles of lamps were used within the Fresnel lenses. They varied both by the operating principals of their construction and by the order, or size, of the Fresnel lens in which they were placed. The main styles of lamps were as follows:

CAPILLARY LAMPS

Capillary lamps are based on the principle of capillary attraction where the fuel is raised to the flame by the wick itself. In these lamps the fuel is stored below the burner and the fibers of the wick soak up the fuel and raise it from the fuel reservoir to the top of the wick through capillary action within the fibers. These lamps were used in the fourth-order and smaller lenses.



Winslow Lewis / Benjamin Hemmenway Lamp (1844). Drawing by author from patent drawing.



Improved Funck – Heap fifth and sixth-order burner. Drawing by Author from *Annual Report of the Lighthouse Board.*

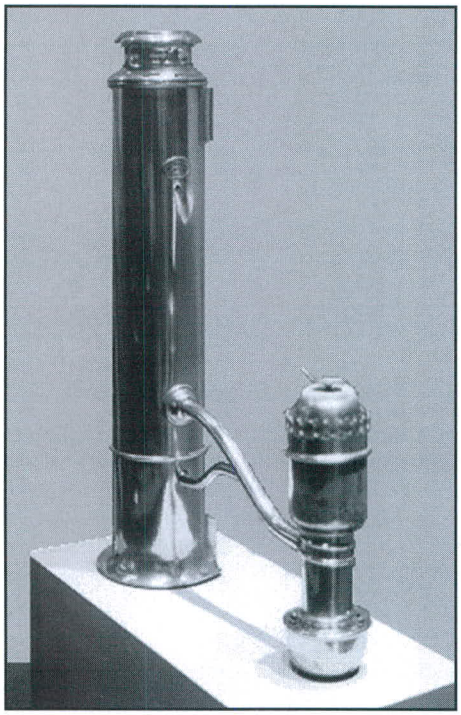
Funck's Improved Fourth-Order Lamp (1888)

In 1888, Joseph Funck was able to dramatically improve the lamps used in the fourth-order lenses in America. Funck redesigned the old fourth-order lamp and produced the 'improved-fourth-order lamp,' which had a new flame spreader and a number of airflow adjustments.

The Funck-Heap Lamp (1892)

In the smaller lighthouses a lamp called the Funck-Heap lamp was introduced in 1892. It was a standard Argand lamp with a single one and one-eighth-inch wick. There was a flame-spreading button in the center of the flame that got red-hot and helped to keep the flame a constant size and shape. The feeding of the wick was accomplished by a screw thread on the wick carrying tube. The Funck-Heap lamp became the standard lamp used in all fourth-order lenses in the American Lighthouse Service and was refitted into all of the lighthouses using a fourth-order lens as quickly as it could be manufactured. The same design with slight variations in the flame spreader and chimney was developed for the fifth and sixth-order lamps.

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American constant level lamp. Photo from author's collection.

Funck's Constant Level Fountain Lamp (1876)

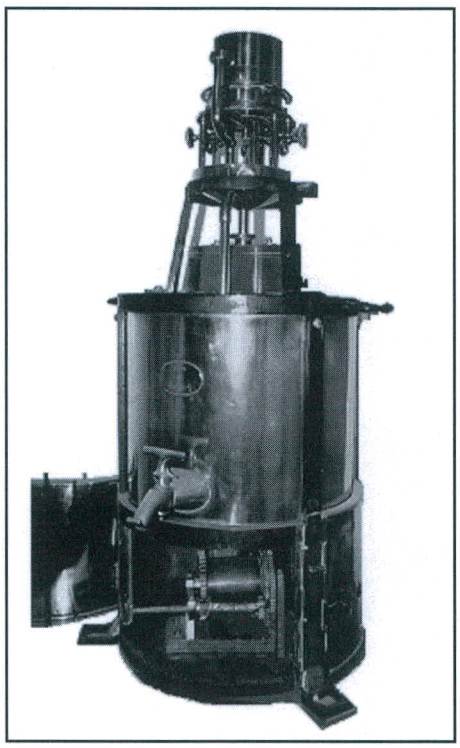
The constant level lamp was used in what was known as a projector light. Projector lights were used as range lights using the constant level lamp backed by a parabolic reflector. Constant level lamps were also used with a single small Fresnel bulls-eye lens in front of the lamp as range lights.

MECHANICAL OVERFLOW LAMPS

Fresnel-Arago Clockwork-Concentric-Wick Lamps (1819)

Augustin Fresnel and François Arago used the ideas of Count Rumford and the Guyton de Morveau to design new Argand style lamps, and made a series of trials of lamps with various numbers of concentric wicks, in late 1819. It was found that a standard Argand lamp, even with multiple concentric wicks, would not perform as required, because the multiple wicks caused such great heat that the burner would melt and the wicks would quickly char. After many trials it was found that the Argand style lamp invented by Monsieur Bertrand Carcel in 1800, could be used with multiple concentric wicks.

The Carcel lamp had a double-piston-mechanical pump operated by clockwork that forced excess oil through a tube to the wick, overflowing the wick and cooling the entire burner. By December 1819, Fresnel and Arago had created a multiple-concentric-wick lamp using the Carcel cooling principal and the first triple-wick burner was operational in their laboratory. Within a few months, they also developed a quadruple-wick burner and proposed its use within the first, first-order lens that was manufactured.



An early Fresnel-Arago lamp with a Carcel pump clockwork shown in the base (1823). Photo from author's collection.

The Lepaute Escapement Lamp (ca.1830)

In the 1830s, Henry Lepaute developed the escapement lamp using metal pistons instead of the leather ones used in the original Fresnel-Arago lamps, and two groups of dual alternating pumps versus the two simple pumps in the original Fresnel-Arago lamp. It was run by clockwork through a toothed wheel known as an escapement, which allowed the pump drive mechanism to operate in only one direction. However, many technical difficulties remained in the Lepaute escapement lamp and it was not used except in trials until about 1845, when Monsieur Wagner improved its design.

The Wagner Pump Lamp (1845)

In 1845, Wagner, who was an engineer working for Augustin's brother Leonor Fresnel, improved the design of Lepaute's escapement lamp. His design significantly strengthened the pump drive mechanism and simplified its operation. He also added a simple screw to each pump, designed to regulate the flow of the oil to the burner by reducing the opening left for the passage of oil.

Franchot's spring operated Moderator Lamp (1836)

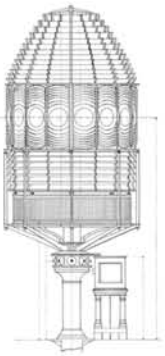
In 1836, Monsieur Franchot invented the Moderator lamp where a spiral spring operated piston made oil flow to the wicks through a constricted valve known as the moderator. These lamps were used in most fixed lenses in France, and in America when Fresnel lenses were first installed during the 1850s. However,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

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.

Part II of this article will appear in the winter edition of *The Keeper's Log* with a discussion of moderator, pneumatic and hydrostatic lamps developed for lighthouse use. Author Tom Tag is the Society's technical expert.

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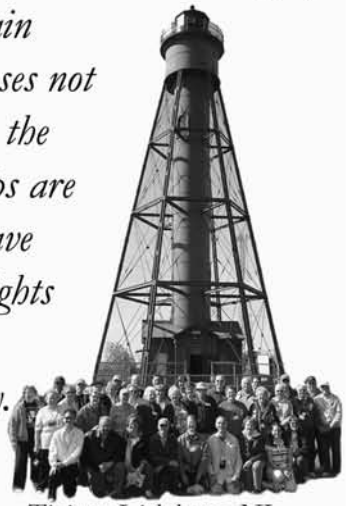
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