Augustin Fresnel and his Magic Lantern

by Wayne Wheeler

For thousands of years man has been putting to sea using that surface of the world to transport people and goods and to take food from beneath its surface. Early mariners were guided by local familiar landmarks during the day. Perhaps open fires on the beach were man's first stab at providing a guide at night. During the third century B.C. the Egyptians constructed the mammoth Pharos of Alexandria (Keepers LOG Vol. 1, #1). Over the ensuing years the Romans constructed lighthouse towers throughout their empire and the rest of the civilized world followed suit.

During the first two thousand years "lighthouses" were merely towers (some rather tall and complex) with an open lantern room where the Keepers tended coal or wood fires. Occasionally bales of oakum and pitch were used as an illuminate. The fires were open to the elements and often produced a great deal more smoke than light.

At the end of the 17th century the English lighthouse at Eddystone employed a closed lantern with glass storm panes. The illuminate consisted of 60 one pound candles set in a candelier. A few other lighthouses of this period also used candles.

Augustin-Jean Fresnel. Photo from Smithsonian Institution #66625

In the 1730's parabolic reflectors were installed in a Swedish lighthouse. Throughout the 18th century numerous people in several nations experimented with reflectors. The Englishman Hutchison's design consisted of a wooden bowl with small pieces of glass affixed to the interior. Most, however, were metal adaptations. The reflectors were fastened to metal frames and placed vertical to the horizon. An oil lamp was placed in front of each reflector. In 1782 the Swiss Scientist Aime Argand perfected the lamp that radically altered the illuminate used in lighthouses. Prior to this all oil lamps used in lighthouses required trimming several times during the night and gave out smoke which deposited soot on the parabolic mirrors and the panes of the lantern room.

Argand discovered a cure for this trouble by inventing a relatively smokeless oil lamp which gave a steady flame and a more intense light than was previously possible. The special feature of his lamp was the use of two concentric tubes of thin brass, about 1″ in diameter and slightly separated. The space between the tubes held a cylindrical cotton wick. Air passed through the

inner and the outer tube and this double air current on each side of the wick caused an even temperature and good combuston of oil. He further improved the apparatus by adding a circular glass chimney which closely surrounded the outer tube and wick. Later one of Argand's rivals improved the chimney by constricting the glass just above the wick. This drove the air current into the flame and produced an even more intense light.

Towards the end of the 18th century a means to rotate large banks of parabolic reflectors was devised. This allowed lighthouses to display a flashing characteristic or signature, if you will.

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However, the most revolutionary improvement to the science of Pharology (study of optics and lighthouses) was the development of the lenticular lens by Augustine-Jean Fresnel (pronounced Frey nel). A man of extraordinary talent he was to discover, correct and refine every fact we know about the nature of light.

Fresnel was born in France in 1788. He was a frail boy and was plagued by ill health throughout his short life. He died of consumption at the age of 39. His teachers considered him rather slow-witted. He had difficulty reading his native tongue at the age of eight and never learned English or Latin, which were considered the scientific languages of his time.

During his secondary schooling Fresnel showed such remarkable abilities in mathematics that he won an annual competition to enter the celebrated Ecole Polytechnique. Although he barely passed some test subjects, he astounded his teachers in graphic arts and geometry when he was barely 16.

Because of the Napoleonic era in France during Fresnel's schooling most of the courses during his final years dealt with artillery and military matters. Those students, including Fresnel, who were not strong enough or suited for the military were designated civil servants and engineers. Augustin finished his training at the school of bridges and highways. The Department of Bridges and Highways even today controls the vast network of rivers and canals that lace the French countryside.

Fresnel, as a graduate engineer, was assigned to repair highways. This was a mission to which he was not suited and one that wasted his genius. "There is nothing I loathe more than having to lead men," he once said. However, he worked hard at his assignments and was regularly promoted. He also continued to pursue scientific research. He corresponded with his uncle, Leonor Merimee, concerning several scientific formulas. The men traded formulas for India ink and glues. At one point Fresnel developed a new process for manufacturing soda. His uncle was so impressed that he consulted several leading chemists of the day. Fresnel's intellectual development had begun.

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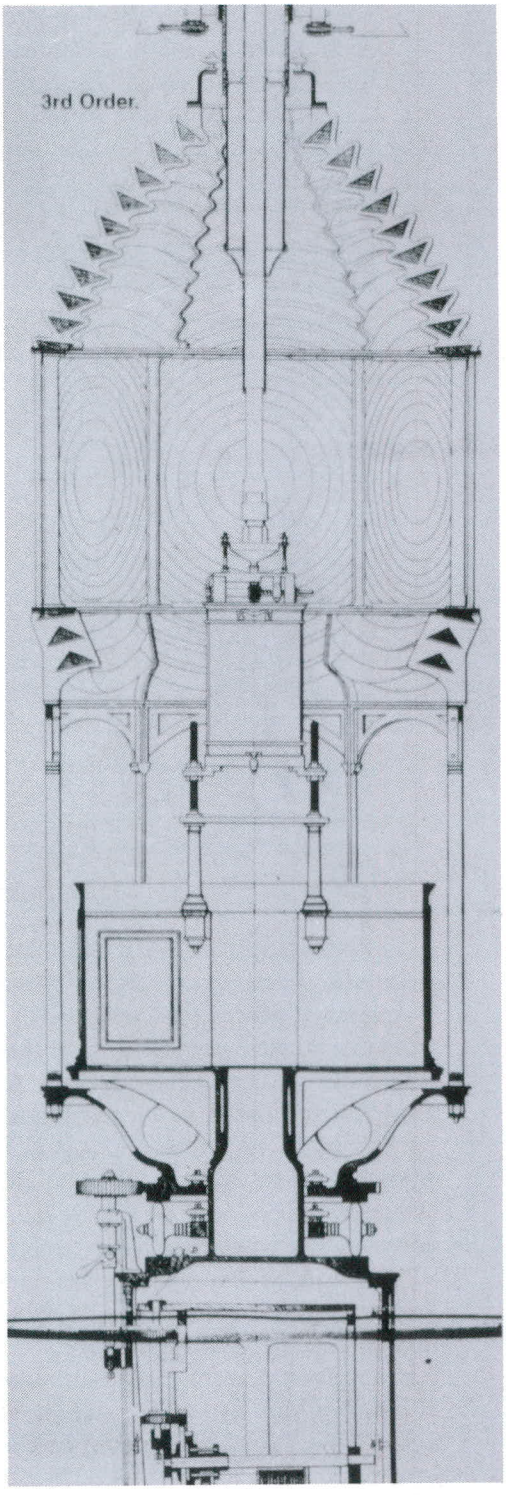
At the time Augustine Fresnel was beginning his experiments with light and optics the general scientific community agreed with the theories postulated by Isaac Newton over 150 years previously. Newton had stated that light consisted of a swarm of "corpuscles" moving through the "ether," as Aristotle had called the substance filling space and which he imagined made up the heavens. Newton also thought that each light "corpuscle" had a different mass that varied according to its color. He stated that some corpuscles allowed themselves to be refracted, some reflected and some just did as they pleased. He was rather vague about the whole theory. Because Newton was so entrenched in the scientific mind of the era his



theories proved a formidable obstacle to Fresnel's quest for scientific truth.

In 1815 Fresnel was assigned to road projects in the south of France. Although he hated every minute of it, he worked diligently at the task. He also continued to work on his theories concerning optics and light. During this period he managed to get the attention of the well known scientist Ampere (from whom we get the electrical term). This contact, and his notions which differed so much from the accepted theories of light, eventually brought Fresnel to the attention of the scientific community in Paris.

At this time Fresnel was 27 years old with but eight years to work and 12 years of life remaining. He was still completely ignorant of the most fundamental information about the science of physical optics which he was to discover in the next few years.

In the spring of 1815 Napoleon returned from exile and Fresnel, along with others who opposed Napoleon's return, were fired from their positions with the government. Actually this proved to be a god-send as the time off allowed Fresnel to spend a great deal of effort on his theories which lead to the development of his wondrous lens. In June of 1815 Fresnel traveled to Paris and visited the famous French scientist Arago. Fresnel spoke excitedly about his discoveries only to be cautioned by Arago that he was "rushing at open doors." Arago suggested further study.

In September of 1815 Fresnel wrote to Arago stating "I believe I have found the explanation and the laws of the colored fringes one is able to discern in the shadows thrown by opaque bodies illuminated by a bright point (light) source..." It was a letter of importance of which only Arago and a few other scientists could appreciate.

Napoleon was returned to exile and Fresnel to his mundane roadwork in Brittany. It was here that he began conducting further experiments which proved to be incredibly accurate. His only light source was the sun and his single instrument, a micrometer fashioned from wires and cardboard. He fashioned a small lens by placing a drop of honey over a small hole in a piece of cardboard. That Fresnel could conduct such accurate experiments with such crude equipment is a marvel. In due time he succeeded in convincing certain scientists in Paris that he was on the track of a breakthrough in the theory of optics and light. He was occasionally excused from his highway duties and invited to Paris where he was able to work with state-of-the-art instruments. One unfortunate setback of this period of his life was the submission of a paper contradicting the theories of Newton. To scientists of the time the mere suggestion that Newton could be wrong was sacrilege and Fresnel was labeled an illusionistic renegade. Nevertheless he proved many of his ideas and even devised an experiment used by scientists today called "Fresnel's mirrors."

Some of his theories were accepted in 1818, but then he was transferred to Rennes, over 200 miles from Paris and placed in charge of a workhouse for loafers. After several months his new friend Arago managed to have him transferred closer to Paris. In 1819 and 1821 Fresnel had two classical papers published. The latter succeeded in convincing most of his skeptics and he was appointed Secretary to the Commission for Lighthouses. Although he was still to solve problems of the Bridge and Highway Administration he was where he wanted to be and able to make vast inroads in the development of the Fresnel lens.

After a brief battle with the bureaucracy his lenses were installed in most of the major seacoast lighthouses of France. The first Fresnel lens (1st Order) was placed in the famous lighthouse at Cordouan at the mouth of the Gironde River in 1822.

The head of lighthouses in this country thought Fresnel's System too expensive.

Mariners spread the word of the excellence of the French coastal lighthouses and soon all European lighthouses employed the Fresnel lens in their structures. However, the United States did not purchase the Fresnel Lens (with the exception of a few for experiments) until 1852. The head of lighthouses in this country thought Fresnel's system too expensive.

Perhaps befitting a famous Frenchman, Augustine Fresnel died on Bastille Day, 1827. He was 39 years old. He certainly could have advanced science further had his life not been wasted patching the roads of France and solving canal problems. Although he did see his systems of lenses placed in French and other European lighthouses, his papers were ignored and not published until many years after his death. He has since been praised as a geometrician, engineer, philosopher, inventor and, without question, a pioneer in the theory of optics.

Augustine Fresnel once said, "All the compliments that I have ever received never gave me so much pleasure as the discovery of a theoretic truth, or the confirmation of a calculation by experiment." Truly, a man who dreamed impossible dreams and reached unreachable stars.

"Wickie" in a 3rd Order Fresnel Lens Circa 1930. Photo by Irving Corklin

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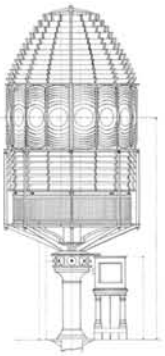

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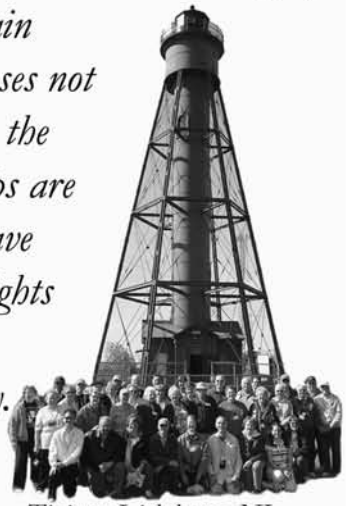

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