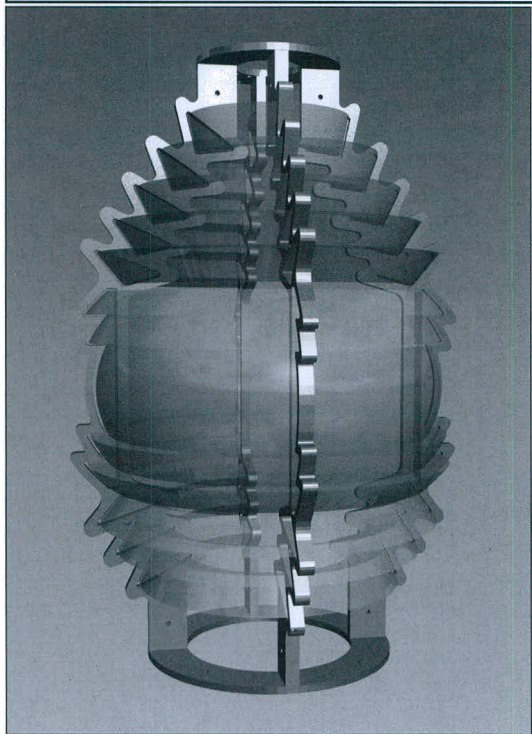


THE ART OF MANUFACTURING FRESNEL LENSES

By Dan Spinella



Computer model of Fresnel lens used to manufacture prisms and framework. Courtesy Artworks Florida.

Historic Fresnel lenses are probably one of the most valued and admired artifacts in the lighthouse community. Mostly built in the 1800s, they are not only engineering marvels but also works of art. The industry faded away in the early 1900s, and even with today's technology, building a Fresnel lens is a challenge.

During the lighthouse boom, factories were in place with the tooling for casting the glass prisms and manufacturing bronze frames. Machinery was designed for the meticulous shaping and polishing process of the prisms and lenses. Because Fresnel lens manufacturing is no longer a large industry, it is not feasible for companies to tool up to this level. But there have been a number of successful projects around the country using both glass and acrylic replacement prisms to restore historic Fresnel lenses. And most recently, complete full-size replicas have been constructed.

The success of manufacturing Fresnel lens replicas has been a delight to lighthouse organizations requesting a historic-

style Fresnel lens for an interpretive museum display, or even to be exhibited in the lantern room of their lighthouse. Though glass reproduction is possible, most prefer acrylic prisms due to the more affordable price and the ability to tint the prisms to match the greenish hue of historic lenses.

Design

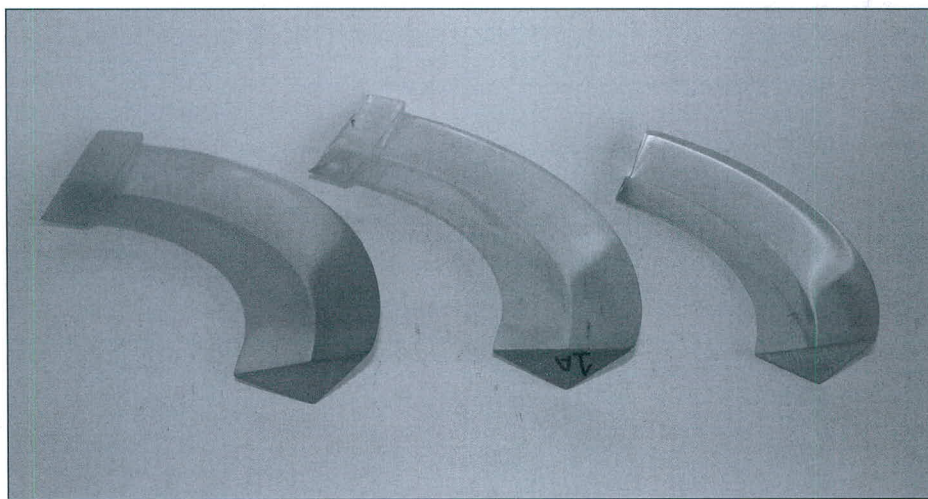
With today's replicas there are several steps required in the manufacturing process. The first step is the design and engineering. Augustin Fresnel's original formulas are used along with computer-aided design tools. The shape of each prism is adjusted slightly to compensate for the acrylic material being used, versus the original crown glass. Once the prisms' shapes are calculated, a 3-D computer model is created for manufacturing purposes.

Prism Manufacturing

One of the most difficult tasks in manufacturing a Fresnel lens is to replicate the prisms. In the 1800s the original prisms were manufactured by pouring molten glass into cast-iron molds to acquire the basic shape. They were then fixed to a large table lathe for the meticulous grinding and polishing process.

Today a new process is being used to replicate acrylic prisms. First, a computerized 3-D model of each prism shape is used to create a master. The master is made through a new process called "rapid prototyping," which is basically a machine that does 3-D printing. The master prism is essentially grown out of an opaque plastic material. Next a mold is made from the master. The mold is simply a reverse of the master, or a cavity in which the liquid acrylic is poured. The acrylic material is a mixture of liquid polymer, resin powder, and a pigment to add color. The mold filled with liquid acrylic is placed in an autoclave where it is pressurized and heated at specific settings to assure a flawless part. After the prism is cured, the annealing process takes place. This process heats the prism and ramps down the temperature at a certain rate to improve material qualities. And finally, there is the polishing process.

This is a lengthy process but has many advantages. The computerized model assures a dimensionally accurate prism shape, which is important for not only the bending of the light but also the fit into the brass frames. The casting allows for an integral color to be added, which makes the prism look more authentic. Also, color matching of existing prisms is an option when restoring an original lens. And finally, the annealing process improves the UV characteristics and helps

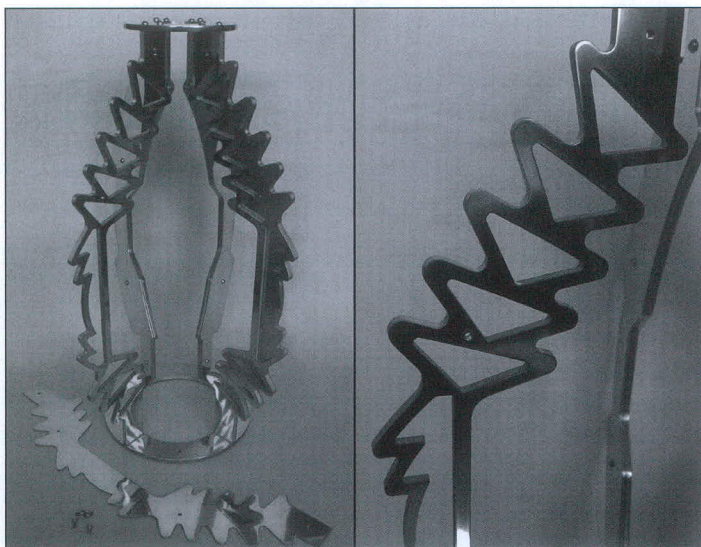


Left: rapid prototype prism; center: as-cast acrylic prism; right: finished prism. Courtesy Artworks Florida.

prevent crazing (tiny cracks) of the acrylic. There is no machining in this process. Machining creates stress in the material and can cause crazing over time.

Frame Construction

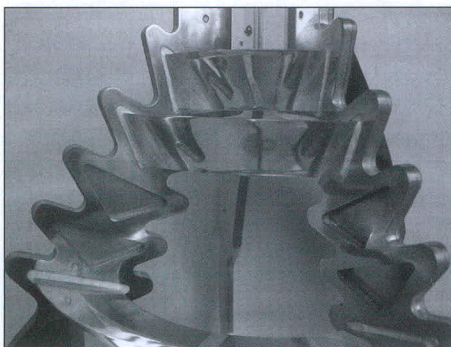
The manufacturing of the lens frames is more straightforward. Historic frames were made by pouring molten bronze into molds to give the basic form, and machined and polished to acquire the final shape. Today the frames are manufactured by cutting the outside shape and triangular pockets for the prisms with a water-jet cutter. This machine operates with a high-pressure water stream that follows a computer program to cut through a brass plate. Machining is also required to drill and tap holes for mounting and assembly purposes. The final step is the sanding and polishing process.



Above: A sixth-order brass framework with a water-jet cut profile, machined and polished to a mirror finish.

Below: Prisms are assembled in brass framework with glazing compound.

Both images courtesy Artworks Florida.



Assembly

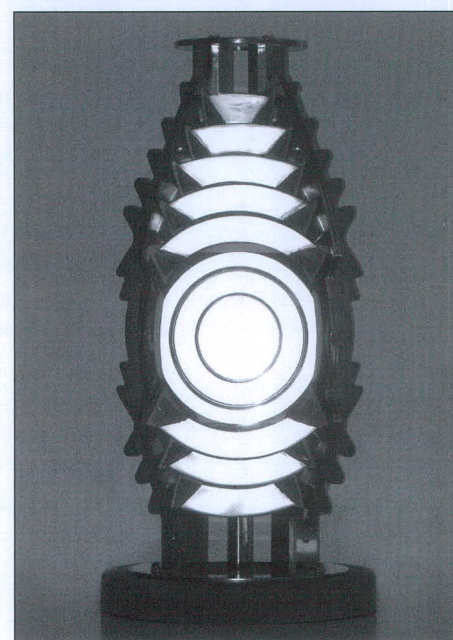
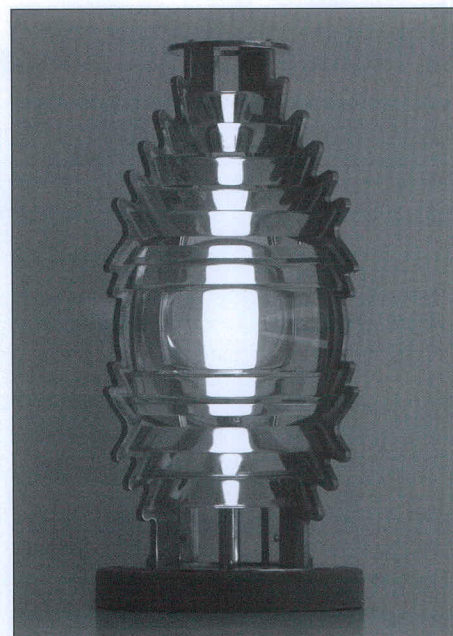
The assembly process for replica lenses is very similar to the way historic Fresnel lenses were constructed in the 1800s. The prisms are isolated from the frames with hardwood shims and set in place with DAP window glazing. This glazing material does not contain any lead as the litharge that was used on original lenses.

Fresnel Lens Replicas in the Lighthouse Community

As the U.S. Coast Guard relinquishes ownership of lighthouses around the country and private organizations and the Park Service take over, replica lenses are being put into use. Lenses are being manufactured to replicate the same style lenses the lighthouses once exhibited, and they are being installed in the lantern rooms as a functioning light or even an

Aids to Navigation. Individual prisms are also becoming more popular in original Fresnel lens restorations where color matching to the original glass is a priority. Full-scale replicas are being used in museums as interpretive exhibits. And as a smaller exhibit, individual prisms are displayed. Exhibits are also being built for educational purposes showing the function of a Fresnel lens through refraction and reflection displays. Showcased in this same exhibit is a replica Fresnel lens

with one fixed panel and one flash panel, to show how they exhibit a unique light pattern. One lighthouse has even commissioned the manufacturing of a 1/4-scale model of its first-order lens, including the pedestal.



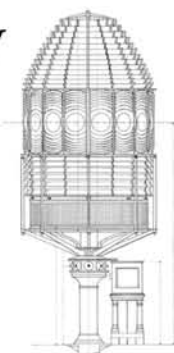
Light pattern of completed fixed (top) and rotating (bottom) flash panels. Courtesy Artworks Florida.

For any other information or questions regarding the design or fabrication of Fresnel lenses please contact:

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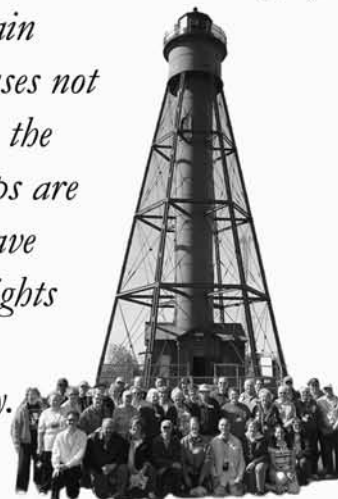
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