CHAPTER 1

The Glass Age

Glass is an ancient material, but its use as a mass consumer material is attributed to Irish-American glassmaker Michael J. Owens (1859-1923). For almost two thousand years, glass had remained a specialty material of artists and craftsmen. Before Michael Owens, things like milk bottles, pop bottles, beer bottles, whiskey bottles, peanut-butter jars, and fruit jars were costly and uncommon.

To a large degree, Owens revolutionized the American diet as well as the glass industry by allowing for better storage and preservation of foods. Even pasteurization and bottle-feeding had to wait for Owens' commercialization of bottle making. His automatic bottle-making machine produced over twenty-four bottles a minute, compared to a hardworking glassblower, whose rate was one per minute. Such production rates changed forever the beer-making, food, and soft-drink industries.

In 1982, his automatic bottle machine was declared an International Engineering Landmark, achieving the same distinction as Edison's electric light bulb. In fact, without Owens' first invention for automatic glass-bulb production, Edison's electric light bulb might have lost out to the arc lamp. Later in his career, Owens similarly automated the production of flat glass, which also led to the development of automotive safety glass.

In 1913, the Owens Company received a letter from the National Child Labor Committee of New York, commending the Owens machine for its major role in the elimination of child labor. Also, because of the uniformity of bottles produced by the Owens machine, the Pure Food and Drug Administration was able to enforce laws that assured proper amounts for the consumer. The standardized height of bottles in turn allowed for the development of high-speed packing and filling lines.

It was prophesied at the start of the twentieth century that the names of the steel and glass industries would mark the century. The Owens name has been adopted in five corporate names—Owens Bottle Company, Libbey-Owens Sheet Glass, Owens-Illinois, Libbey-Owens-Ford Company, and Owens-Corning.[1] One of the fastest-growing community colleges in the United States carries his name as well.

Owens was bigger than his forty-nine patents and automated glass-making machines. Owens brought automation to all the process industries, years ahead of Henry Ford's pioneering assembly line for manufacturing. His early glass plants were centers of automation. He applied conveyors and moving lines for materials handling on a scale never seen before. He automated all types of glass-making machinery, including grinding and polishing machines. He even worked on inventions for his customers to automate beverage- and beer-filling equipment. He was a pioneer of cam-operated and gear-controlled machinery. Owens was far ahead of the automotive industry of Detroit in automated and process-control production techniques. In addition, his machines were some of the first-ever standardized equipment. His use of standardized gauges and parts was far ahead of most industries. He even pioneered the idea of timely calibration of shop gauges.

The machine shops of Owens' companies were the most advanced in the world. It wasn't just automation and machinery that he piloted, but management techniques as well. Owens took the organization of research and development beyond the earlier model of Edison into the twentieth century by developing project management and matrix management methods to innovate.

Owens looked at mechanical invention as art. He lacked all mechanical skills of inventors like Henry Ford. He rarely used hand tools. He could make few household repairs. He was neither an engineer, mechanic, nor scientist. He could not understand engineering drawings, and he was poor at drawing. He understood little of the chemistry of glass and the raw materials. He was as poor at mathematics as he was at spelling. Yet his designs were more complex than Ford's Model T or the Wright Brothers' airplane. His bottle machine weighed over four tons and had over ten thousand fashioned parts (even today's car has only about two thousand parts). His talents were vision and creativity. He stands with creators such as Thomas Edison, Henry Bessemer, and Steve Jobs. He would mentally design the most complex machines. For him, invention was a craft of its own, and he was a master craftsman. Like a master craftsman, he conceived the invention and put his shop to fashioning it. The best analogy is that of Dale Chihuly, the master glass artist, who no longer physically crafts his pieces but manages a group of apprentice artists. The finished piece is a Dale Chihuly creation but not of his hands.

Owens, like Edison, created one of the earliest research and development centers. Invention to Owens was the combination of art and creative thinking. He believed that the process of invention needed to be managed. Owens, however, modeled his approach on the crafts system. The process of invention was considered a craft in itself. Owens took on the role of master craftsman in his research function. The technicians were specialized and guided by the master inventor. Owens even talked of a "Venetian" research and development approach. Clearly, Owens was the Dale Chihuly of invention. In his later years, Owens was more fascinated by the process of invention than by the invention itself. In this respect, Owens took the study of invention farther than anyone had before, as well as established management techniques for the corporate research and development function. A biography of Owens offers as much to the inventor and manager as it does to the historian. Owens linked the new science of project management to the science of invention. With the help of Edward Libbey, Owens created the concept of a profit-centered engineering company.

Some see masters of glass such as Michael J. Owens as the lords of civilization; yet today few know his story. Alan Macfarlane, an anthropologist at the University of Cambridge, sees glass technology as a measure of civilization. He claims:

> Progress in everything from astronomy to medicine to modern genetics would have been impossible without it. . . . Louis Pasteur would not have identified infectious diseases and launched a medical revolution. Biologists could not have observed cell division, understood chromosomes, or unraveled DNA's structure, leaving us bereft of modern genetics. Much of Galileo's work on the solar system would have been restricted to philosophy. . . . It was essential to the barometer, manometer, thermometer and the air pump.[2]

Macfarlane's statement overlooks what might be the greatest symbols of civilization—the electric light bulb and the mass-produced bottle, both of which Michael Owens is responsible for. Edison, at his Menlo Park research center, maintained a glasshouse and a number of master glassblowers, which were key to the invention of the electric light bulb. However, it took Owens to make the light bulb the commercial reality that would support the exponential growth of electrical power.

Macfarlane was not the first to recognize glass as a barometer of the advance of civilization. Samuel Johnson noted the following in an eighteenth-century article:

> Who, when he first saw the sand or ashes . . . melted into a metallic form . . . would have imagined that, in this shapeless lump, lay concealed so many conveniences of life? . . . Yet, by some such fortuitous liquefaction was mankind taught to procure a body . . . which might admit the light of the sun, and exclude the violence of the wind; which might extend the sight of the philosopher to new ranges of existence, and charm him, at one time, with the unbound extent of material creation, and at another, with the endless subordination of animal life; and, what is of yet more importance, might . . . succor old age with subsidiary sight. Thus was the first artificer in Glass employed, though without his knowledge or expectation. He was facilitating and prolonging the enjoyment of light, enlarging the avenues of science, and conferring the highest and most lasting pleasures; he was enabling the student to contemplate nature, and the beauty to behold herself.

Michael Owens represents one of the glass masters who influenced the very course of civilization. Owens was part alchemist, part artist, and part designer. He rose from the poorest part of American society, breaking many "glass ceilings" as he rose through management. His was a real-life Horatio Alger success story of the time, far more dramatic than those of Carnegie, Edison, or Westinghouse.

Owens was truly a multidimensional visionary. Unable to read or draw engineering prints, he envisioned complex machines and saw them to realization. Owens was able to combine the operational necessities of design with the demands of product marketing. Part showman, part operations manager, he could rival Preston Tucker and Thomas Edison as a marketer.

Owens was a man gifted with superior debating skills but cursed with a legendary temper. He managed with his fists as much as with his brain. His temper caused him as many setbacks as successes. He was a fiery union leader as well as a strict executive. His legendary smile and charm were disarming. He was a natural middle manager who inspired the potential of middle management. He loved the crafts system but changed the roles for both the workers and supervisors, thus transforming the glass industry into a factory system. Though he was no crusader for abolishing child labor, his inventions would do more for that cause than did the politicians.

Owens was a man who answered to no boss. His boss, Edward Libbey, actually had a picture of *Michael* hanging in his office. He could swear with the best of them, yet he was a devout Catholic who prayed daily. Owens was a workaholic who ultimately found escape in golf, car collecting, playing cribbage with the neighbors, and family vacations. He kept his life in two very distinct boxes—business and personal. With the exception of his friend Msgr. A. J. Dean, very few people really understood Michael J. Owens. He left no writings and kept no records. He drew on a blackboard, leaving no sketches of his many inventions. He cleaned his desk of excess material often, keeping no files.

Owens was a very private man, but one whose generosity rivaled that of the better-known philanthropists. He left a legacy of giving, but it is one lacking monuments, plaques, and engraved nametags, by his own design. His generosity can be seen in a beautiful altar in Rosary Cathedral in Ohio and stained-glass windows of a mission church in Michigan. They are all unmarked; in fact, Owens requested that the church keep no records of his giving. His mother had taught him that charity must be its own reward.

Owens' real generosity was invested not in buildings but in people. He supported the education of many priests without receiving any recognition. He handed out tens of thousands of dollars to the poor and needy in Toledo, requesting that they not reveal his giving. When many came forth with these stories after his death, it was clear that he was a one-man community chest. He spoiled his family to a fault as well. Also, to be a friend of Mike was an honor owned for life.

In the end, it was never about money but work. Owens found serenity in work and invention. The money he received belonged to God, and Mike was merely a caretaker of it.

Edward Libbey described Michael J. Owens on the event of his death in 1923:

> Self-educated as he was, a student in the process of inventions with an unusual logical ability, endowed with a keen sense of farsightedness and vision, Mr. Owens is to be classed as one of the greatest inventors this country has ever known. He has done more to advance the art of glass manufacturing than any other person during the last fifty years. The results of his inventive power alone should win for him a place among those already enrolled in the Hall of Fame. As time goes on, I believe the name of Michael J. Owens will stand out as a pronounced example of what can be accomplished by vision, faith, persistence and confidence in one's creative efforts.

Most important, Michael shared Samuel Johnson's love of glass.

Michael Owens was the apostle and avatar of automated technology, process control, and continuous flow. He built model automated factories years ahead of other industrialists, such as Henry Ford. Owens pioneered the use of automated conveyor belts, electrical power, cam control, and moving lines. Two of the first glassmaking plants were models for integrated process control. Prior to Michael Owens, it would take weeks for a piece of glass to be produced from raw materials. Owens cut that time to hours. This automated, integrated, and fast throughput not only slashed labor costs but reduced inventory and delivery times. His glass factories were examples for all continuous operations, such as steel, oil refining, and even commercial bread making. His concepts of continuous production revolutionized the batch-product industry, just as Ford's assembly line transformed manufacturing. He even invented automated filling systems for the food and industry, making their processes continuous.

Yet Owens was a true Victorian, who saw romance in science and industry. He viewed them as integrated in the "industrial arts." He saw management as a blend of art and science as well. The crafts model of work fascinated him, and he found in it a purity that automation seemed to take away. He was the ideal of the craftsman, who dignified work and the product of it. Owens found happiness and fulfillment in work. He was self-actualized, and like so many self-actualized people, he had trouble understanding those who could not find fulfillment in work. Like most Victorian managers, he rose from the worker ranks, but he saw management as a special distinction. His management style was always paternal. Like many great industrialists of his time, Owens followed the leadership style of Napoleon, which he had studied from childhood. Loyalty and chain of command were central to his concept of organization. The "boss" or manager was to be a general. For Owens, managers made decisions, and workers executed them. The Victorian concept of management, while autocratic in philosophy, was paternal in practice. Owens had actually been a union officer early on, but he did not want to share leadership with unions in his plants. He believed in hard work to an extreme, expecting others to meet his high standards. Like the later Victorians, he feared and resented the rising class of college-educated managers. Still, he had risen to exclusive financial circles where Irishmen were not normally welcome during that time. In some ways, Owens functioned in two different worlds and was never fully comfortable in either.

To understand Michael Owens requires knowledge of the material he so loved. Glass is mainly silica (silicon dioxide), which is the most abundant molecule in the earth's crust. Silicon dioxide is commonly known as sand or, as a natural glass, obsidian. Actually, volcanic obsidian consists of sand (silicon dioxide), soda (sodium oxide), and lime (calcium oxide) fused with iron and manganese, giving it its dark color. There is an entire mountain of obsidian in Yellowstone Park. Volcanoes are natural glasshouses producing an array of glasses, such as hyalopsite, Iceland agate, and mountain mahogany. Another natural glass is flint. Flint and obsidian became the material for the first human toolmakers. Paleo-Indians cherished their flint mines in places such as Flint Ridge, Ohio, which, interestingly, has become the center of the glass industry. These mines were the hubs of the first known trading routes and networks. One of the most unusual types of natural glass is a "fulgurite." Lightning striking and fusing sand results in fulgurites, and collecting fulgurites is popular in Alabama. Another natural glass is from space, known as a "tektites." While the stellar origin of tektites is questioned, glass is known to be common on the moon.

The History of Glass

The discovery of glassmaking is unknown, other than that it was a result of serendipity. The first written description of glassmaking goes back to Pliny (*Historia Naturalis*) in the first century. Pliny attributes its discovery to the early Phoenicians. The story suggests that a beach campfire formed glass. There, silica (sand) contacted soda ash from the fire and formed a hard material.

The earliest physical proof of manmade glass goes back to 4000 B.C. in Mesopotamia. Like the Mesopotamians, the Egyptians developed and improved the production of glass vases. The Egyptians were master glassmakers. They pioneered colored glass, pressed-glass pieces, and bottle making. The latter involved a much different process than that of Owens' day. The Egyptians cast their bottles and vessels in sand core molds, the way metal parts are sand cast today. They actually cast liquid glass into a sand mold with a sand core. The core created the hollow bottle. The surface of cast bottles was rough, requiring some finishing.

Once the bottle was cast, they might add designs by hot forming or pressing. Mold-cast vessels and pressed-glass pieces were found in the tomb of King Tutankhamon (around 1400 B.C.) in an array of bright colors. The Egyptians' knowledge of using metal oxides to color glass was amazing. Turquoise, cobalt blue, dark green, copper red, manganese violet, uranium yellow, and many other colors were common to the Egyptians in 1300 B.C. They also developed a multicolored, twisted color product known as *millefiori,* which imitated natural agate and onyx. Millefiori was a hot fusion or working process, where "canes" or sticks were fused together in a mold or around a shape. Using different colored "canes" produced the multicolored twist. One of the lasting impacts of the Egyptians was establishment of glassmaking as a "priestly" art. The technology was known by only a handful of clerics.

The Greeks seem to have improved lathe cutting and engraving of glass as early as 200 B.C. The Romans took glass applications a step further with architectural uses such as windows. They discovered the use of manganese oxide (known as glass soap) to clarify glass for superior windows. Excellent examples of Roman windows are found in the villas of Pompeii and Herculaneum.

Bottle casting remained the method of manufacture until the first century A.D. The Syrians appear to have "invented" bottle blowing, but archeology continues the search. These early efforts were extremely thin and more decorative than utilitarian. They also appeared to be free blown without molds, similar to what a carnival glassblower might do with heated glass tubing. The Islamic glassmakers applied hot pressing to increase the thickness. The thick mold-blown wine bottle can be traced to fourth-century France. Color had disappeared during the ninth and fourteenth centuries, allowing the product to have a natural green and bluish transparent color. This early European bottle glass was known as *Waldglas* (forest glass) because of the need to be near the fuel supplied by trees of the forest. From the Syrian and French technology of bottle making in the fourth century, there were no significant advances in bottle making until Michael J. Owens.

The Venetians took glassmaking to a high art with cutting, engraving, coloring, pressing, gilding, and painting. Their craft was in the priestly tradition of the Egyptians. The Venetians recorded their practices to pass on but only to a privileged few. The roots of Venetian glassmaking go back to the production of *Waldglas,* which of course was done in forest communities. Remote, self-contained communities became the centers of glassmaking. In the Middle Ages, the Venetian Council of Ten Doges moved most of the glasshouses to the island of Murano. The Doges created a prisonlike island, except that the craftsmen were well taken care of, even pampered. Venetian glassmakers were smuggled out around the world and interrogated for their knowledge. In other countries, Venetian glassmakers formed a guild known as *façon de Venise,* which means "made in the style or fashion of Venice." These guilds were key in passing on the secrets of the trade to following generations. The glass-mix formulas were particularly guarded. Only the glasshouse owner had them and personally supervised the mixing. None of the workers knew the amounts mixed. This tradition of secret formulas existed well into the twentieth century. The Venetian methods and work positions were the same that existed in Owens' day. Many of the terms and names used today are from the Venetian practice. Glassmakers of the nineteenth century like Michael Owens and Edward Libbey were first trained in the methods of the *façon de Venise.* They found a beauty in this approach to one's work, a beauty that is lost in the unskilled operation of automated machines.

Venetian glassmakers were the earliest to perfect a clear glass known as *cristallo* (meaning crystal). Soda-lime glass was the earliest Venetian composition. The recipe calls for calcined limestone, silica sand, soda ash (sodium carbonate), and potash to be blended or added to wood ashes, which contains both soda and potash. The composition varies, using 60-75 percent silica, 12-18 percent soda, and 5-12 percent lime. The glass produced can have a green tint due to impurities such as iron. The exact additions the Venetians used to clear the glass remain unknown. It is known that they used a much purer form of silica than is found in most sand. The Venetians handpicked silica pebbles from riverbeds for their whiteness. Eventually, glassmakers discovered the use of manganese oxide (glass soap) to decolorize glass. This basic decolorized glass was used in windowpane making and bottle making. Glass melting is facilitated by a much lower melting point than the component oxides; oxides of sodium and calcium that reduce the melting point of silica (silicon dioxide) are known as fluxes. Lime (calcium) glass is the cheapest and easiest to produce and form. The Venetians, however, had an extensive treasury of formulas. They produced all the colors of the Egyptians as well as inventing many themselves. One of these was an opaque white glass produced from the addition of tin oxide.

Even the basic ingredients of soda, potash, and lime varied widely among glassmakers. The English favored more soda than did Americans, which made glass more fusible in the melting process. It also produced a slightly yellow color and less weight. The Irish and Bohemians, like the Venetians earlier, preferred more potash and lime, giving their glass a slightly gray tone and higher hardness for cutting. The early Venetians favored higher lime and potash for clarity and hardness. In fact, they were the first to replace soda with potash. They produced the potash by burning seaweed. In central Europe, burning woods such as oak and beech produced potash. The additional lime also gave the glass hardness, which was necessary for cutting and engraving. The Americans' use of additional lime resulted in a hard glass and a related rise in cut art glass.

In England, George Ravenscroft developed flint glass in 1676. Flint glass derives its name from the use in the early days of glassmaking of calcined (roasted) flint minerals as the source of silica, but these flint materials do not really define flint glass. Lead oxide was added, and the lead content is the distinguishing component of "flint glass." The lead oxide content reached as high as 33 percent, which gave the product a very heavy feel compared to soda-lime glass. The lead addition also imparted a brilliant reflectivity and a unique ringing sound.

The flint glass recipe does, however, require the highest-quality sand to eliminate any green or brown tint from impurities such as iron. Ravenscroft found that a sand of this purity in the Wicklow Mountains of Ireland worked best, which started an Irish tradition in flint glass that remains to this day. Initially, like the Venetians, Ravenscroft used handpicked silica flints to assure purity. Most sand has natural impurities that tend to leave an unacceptable green or brown tint in glass, but the Wicklow sand was of exceptional quality. As a marketing tool, Ravenscroft segmented his market by advertising "flint glass."

Because of its beauty and weight from the lead additions, flint glass was said to approach natural crystal. This comparison led to the use of the term "crystal." This flint-glass process was used in the making of high-quality tableware, large punch bowls, crystal chandeliers, and scientific equipment. Most of these products also had wheel-cut patterns, thus flint or crystal glass became synonymous with cut glass. The cut facets increased the glass's brilliance. Other minor improvements were applied, such as the use of chalk in Bohemia, which produced even more reflectivity.

Ravenscroft discovered the importance of overall formula balance in producing clear "crystal." His early work with crushed flint as a silica source produced a "crizzling," a network of fine, branching cracks. It appears as a surface condition but reflects an inherent instability of the glass, causing decomposition. To fuse the crushed flint, Ravenscroft increased the potash, which improved fusion but caused more crizzling. He found that by substituting lead oxide for potash, he could eliminate this problem of crizzling. Ravenscroft then adjusted his formulas. Amazingly, in 1918, crizzling would be the major problem preventing Michael Owens from producing commercial window glass. The solution would ultimately be the same formula change used by Ravenscroft.

Colored glass has a long and complex history. Glass can be colored by metal oxides of elements, such as chromium, copper, nickel, gold, cobalt, and uranium. Basic soda-lime glass tends to take on a green or brown tint form impurities such as iron. The earliest colored glass goes back to 1600 B.C. in Egypt. A. Sauzay, in his 1871 book, *Wonders of Glass and Bottle Making,* noted, "The priests of Egypt, who were constantly occupied with experiments, made in their laboratory some glass equal to rock crystal; and profiting by the property they had discovered in oxides of metallic substances obtained principally from India, to vitrify under different colors, they conceived and executed the project of imitating every species of precious stone, whether colored, transparent, or opaque, furnished to them by the commerce of the same country." Recent research shows that the Egyptians had a monopoly on colored glass, and they sold colored glass ingots throughout the world. This monopoly would remain unrivaled in size until the arrival of Michael Owens.

Using copper, the Egyptians were able to produce an opaque red glass. Medieval glassmakers, using the Egyptian color technology preserved in the great records of the Benedictine monasteries, started a period of rediscovery. They added ruby red from copper, and by the 1600s, an alchemist used a gold addition to develop a rich ruby red as well. The Venetians invented a crimson-pink.

The first half of the nineteenth century saw an explosion of color in flint glass tableware. Bohemian manufacturers produced a deep yellowish green (called "Anne green") from the addition of uranium oxide. They produced an opaque black from iron and manganese oxides. A deep blue was produced from the use of cobalt. Other shades of blue were produced from nickel and copper oxides. Chromium oxide produced a green color. Opalescent effects could be produced from tin, arsenic, and metal fluorides.

Any biography of such a great glassmaker and technician as Michael Owens requires some knowledge of the production process, since Owens' legacy was to completely change thousands of years of glassmaking. The glassmaking process contains a special language that was incorporated in even the names of the jobs in the industry. The process that Owens started with in Wheeling in 1869 was not much different than that of the Phoenicians of the first century. The glass factory was called a "glasshouse." In Owens' time, glass was made in a "batch" of materials, such as sand, soda ash, potash, lime from calcined limestone, and recycled, broken glass called "cullet." Cullet played the very important role of reducing the melting time of the mix. This dry mix of components might include other oxides such as lead or oxides for color. The mix was done on the floor. In many glasshouses, such as in New England, the person who did the mixing was known as the "metals man." Molten or liquid glass in the furnace is called "metal." In some cases, the mix or metal was preheated to remove moisture, in a process called "fritting" or calcining. Lead mixes were not dried as a mix because lead oxide would cause low temperature fusion.

A furnace or "kiln" was used to melt these "batch" components. A kiln was a beehive-shaped furnace, which was fired by wood, coal, coke, natural gas, or producer gas. The competition of these fuels as we will see had a large impact on the career of Michael Owens. Wood was the earliest fuel and was preferred in the Venetian process. The wood had to be hardwood like oak, hickory, and walnut. Softwoods like pine supplied inconsistent heat and had a lesser caloric value. Generally in the eighteenth and early nineteenth centuries, wood was the preferred fuel until its availability was depleted. Coal replaced wood in Britain in the eighteenth century and in America in the nineteenth century because of a shortage of hardwood. Coal supplied cheaper and higher heat but with the disadvantage of dust and dirt. Gas was efficient and supplied high heat but availability was a problem. Gas and oil replaced coal starting in the 1870s.

The batch or mix was put into a pot and then into the furnace. With wood, the batch could take thirty to thirty-six hours to melt, while the higher heat of coal or gas could cut this time in half. The furnace refractory brick required special clay to withstand the heat. For most of the nineteenth century, this refractory clay was imported from Strourbridge, England, Bavaria, or special deposits in France. Later, excellent clays were found in New Jersey, western Pennsylvania, and Missouri. Refractory clay deposits were often a key factor in selecting a location for a glasshouse.

Inside the furnace or kiln, refractory pots were arranged around arched openings, each of which was known as a "Bocca," siege, castor door, great opening, or working hole. *Bocca* is Italian for "mouth." The floor area around the furnace is often called the siege floor.

The batch mix was added to each pot and represented a unique batch of glass. A typical pot held a ton of melted glass and stood four feet high. Libbey's first Toledo glassmaking plant in 1889 used for its pots German and Missouri clay mixed together by barefoot mashing. Pot makers were craftsmen in their own right. Pot durability was a major factor in glassmaking. A well-made pot could last five to seven months. If the timing was good, all the pots could be changed during the long summer vacation. If a pot had to be removed from a running furnace, the heat complicated the job of removing the pot. Old pots were cemented to the furnace floor by residue glass. It might take as many as twenty-four men, working in three- to four-men crews, a day to remove the pot. The Libbey Glass factory of 1888, which would launch Michael Owens' management career, contained a thirteen-pot furnace.

The "glory hole" was a reheating area to allow the continuous working of glass forms. The glory hole appears to be a nineteenth-century innovation, first mentioned in 1849 in a glassmaking book by Apsely Pellatt.[3] In most glasshouses of Michael Owens' time, the glory hole was actually a separate furnace used for reheating. In fact, one of Michael Owens' first jobs on the crew was to maintain the glory-hole furnace. Sometimes very small openings known as "noses" or "bye holes" (the older Venetian name was *Bocellas*) were used to reheat product in the furnace.

The glory hole was where the crew of workers (known as a "gang," "shop," or, in England, "chair") assembled to work a batch of glass. A gang or shop consisted of five to eight men. When Michael Owens started at Hobbs, Brockunier & Company in Wheeling in 1869, a shop was five men, but this varied by glasshouse and the product being made. The master craftsman and gang leader was known as the master glassblower or "gaffer." Becoming a gaffer was the dream of every young boy like Michael Owens who entered the glasshouse. Gaffers held the social status of artists in the community. They were highly paid and, in Owens' time, generally foreign born, having been heavily recruited by the growing American glass industry. The gaffer sat on a special

Boys at the "glory hole," where glass pieces were reheated before going to a finisher, 1908. (Library of Congress) bench to supervise the gang. He had full responsibility for the quality and design of the product and reviewed the drawings of the piece before starting. Some glasshouses such as Hobbs, Brockunier, where Michael learned the craft, had assistant gaffers.

If there was no assistant gaffer, the second-highest gang member was the "gatherer." The gatherer represented the start of the blowing process by gathering glass through the Bocca. He used a six-foot-long iron blowpipe to "gather" a ball of molten glass from the furnace pot. The consistency was that of taffy candy—a sticky mass.

The gatherer or another gang member known as "servitor" rolled the mass of molten glass on a metal table ("marver") to form a ball. The gatherer, once the mass was rounded, handed the blowpipe to the gaffer. The gaffer was usually seated in a special chair (hence the origin of the term "chair" for a gang in England) because of the weight of the six-foot iron pipe. The blowpipe goes back to at least 1900 B.C.; pictures of its use can be seen on Pharaoh Usetesen's tomb. For free-blown art pieces, the gaffer would blow and roll the glass into shape. If the glass was mold blown, a "mold-boy" set up a cast-iron mold for the glassblower. Working the glass caused some cooling; when reheating was required, the glass would be handed to a "stick-boy" or "middle-boy." The middle-boy put the partially formed piece into the glory hole or a small side furnace to reheat it. These smaller "glory hole" furnaces began to be common and maintained a very high heat. The high heat caused the piece to be "fire polished," attributing to the smoother appearances of bottles made after 1880.

Near the completion of the forming, the gaffer or assistant attached a "pontil" or "punty" rod on the piece opposite the blowpipe. Tongs known as "pucellas" might aid the forming. Once the piece was near finished, the gaffer took the blowpipe off by touching the contact point with a water-cooled rod of iron, which allowed the gaffer to break it off. The gaffer or assistant might continue to form the piece using the pontil rod. In complicated pieces, handles might be added at this point. A "bit-boy" was responsible for attaching these parts. Wooden tools were often used for additional shaping. Again, several reheats might be required. Finally, the pontil rod was broken off in a similar manner as the blowpipe. The scar left by the pontil rod was known as the "pontil mark." By Michael Owens' time, a slight modification of the pontil-rod practice had evolved in which a molten bit of glass was used to attach the pontil rod and reduce the scar. At the time that Michael had advanced to assistant gaffer, the "snap case" tool was used, completely eliminating the scar. The nature and shape of the pontil marks are used today to help date antiques.

The last step was to put the piece in an annealing furnace known as a "leer" or "lehr." Annealing is required to relieve stress and reduce the possibility of cracking. The lehr was a tunnel-like oven that would slowly cool the glass pieces. A "carry-in boy" or "taker-in boy" carried hot finished pieces to the annealing furnace. After starting at age ten as a fire boy shoveling coal, Michael Owens at age eleven became a carry-in boy. A "carry-out boy" or "snapper-up boy" transferred the cooled, annealed pieces from the lehr to storage or shipping. Another entry-level job was "glasspustere," which entailed cleaning the blowpipes and blower's tools.

Depending on the type of glass, annealing might take days. Prior to 1880, firewood was burned and the lehr was filled with pieces and then sealed for several days. Later, lehrs used gas as the fuel and were sixty feet long. A conveyor moved glass pieces through in about twenty-four hours. Again we see Michael Owens, the apostle and avatar of automated technology, being the first to use conveyor annealing. Annealing was a critical and key step in producing all types of glass. Poor annealing could cause the piece to crack or burst simply if it were placed in sunlight!

Another ancillary job in some glasshouses was that of the "lip-boy," who would grind glass parts that did not meet customer specifications. This was one of the most dangerous jobs, requiring working the part against a water-drenched abrasive wheel. It was a cold and miserable job that the boys hated over all others.

The gang had its hierarchy, but it was not a progressive ladder. Blowing and gathering were distinct crafts, each requiring an apprenticeship and journeyman study. A blower apprenticeship, because it led to the highest-paid position, was difficult to enter. The blower apprentice was usually part of a blower's or manager's family. Sometimes, as with Michael Owens, a hardworking "boy" might be selected as an apprentice. The acceptance, time in learning the trade, and requirements of apprentices were set by a combination of management, union, and masters that varied by company. These guidelines were a constant matter of debate and struggle between the union and management. Once accepted, he might apprentice for five to six years to obtain journeyman status, which might require another five years before he became a blower. An apprentice was paid half as much as a journeyman but after a year was as productive.

Boys at the lehr, 1908. (Library of Congress)

A fifteen-year-old "carry-in boy" at the annealing furnace, 1908. (Library of Congress)

The Rise of American Glass

Surveys of the time showed glass craftsmen to be the highest paid of the period 1870 to 1880.[4] Skilled workers in glass received "at least two, and most often three times the wages of ordinary laborers" and "one-third to two-thirds more than many skilled craftsmen." For centuries labor made up around 40 to 50 percent of the total cost of glassmaking. Glass paid considerably more than the other major industry in the Wheeling, West Virginia, area—steel. One survey reported that in 1896, blowers earned larger incomes than did professors and ministers.[5] The highest-paying segment of the glass industry was the window-glass segment. Glassblowers lived in some of the best homes in Wheeling, which were monuments of hope for boys such as Owens. It is no wonder that jobs in the glass industry were competitive and controlled by lodges. Irish immigrants joined lodges in hopes of entering the glassmaking industry. There was a "glass ceiling" in the 1870s that restricted the Irish from advancing beyond the level of gaffer. Mike Owens would be the first Irish-American to break into the glass executive world of Anglo- and German-Americans.

When Michael Owens began his career, the glass industry had four very distinct branches, which consisted of: plate glass, window glass, glassware (lime and flint), and green glass (bottles and containers). Glassware, where Owens started his career, represented the largest segment of the industry. It was diverse, ranging from household glassware to expensive art and cut glass. New England Glass, Hobbs, Brockunier & Company, and Bakewell were examples of glasshouses in this segment. In 1879, there were seventy-three glasshouses in the segment, with an average of 173 workers per glasshouse. The next-largest segment was window glass. In 1879, there were forty-nine window factories, with an average of 79 workers. The green-glass segment was third, while plate glass was the smallest. The green-glass segment had forty-two plants and plate glass had four in 1879. Plate glass was a thicker, flat product for industrial and architectural applications. Polished plate was also popular in the front windowpanes of larger homes. Plate was a very different product from the others, since it was cast.

In 1941, famous war reporter Ernie Pyle visited Libbey Glass to write a journal of glassmaking. Libbey Glass at the time specialized in art and cut glass. Pyle's journal offers a rare view of glassmaking through the eyes of a writer and reporter. He described a shop as such: "You get the impression in a glasshouse of a real artisan's caste system, and it is simply beneath the nobles of the craft to do minor things. There is actually a sort of heraldry about making a fine piece of glass. In fact I think it would be nice if the 'servitor' were to bow when he hands the pipe to His Lordship, the 'gaffer.'"[6] The "caste system" frustrated early unionization efforts because the blowers, gatherers, and boys each had their own unions. With this system, workers at the glasshouses lacked the solidarity needed to pressure the owners for better wages and conditions.

In cut-glass work, a finished piece was passed to another artisan in the cutting department. Cutting glass actually goes back to the Romans, but the seventeenth-century Germans perfected the technique. Cut glass reached a peak of popularity during what collectors call the Brilliant Period (1880 to 1915). Ernie Pyle wrote: "All of my life up to yesterday, I had thought that cut glass was cut by a man holding a pencil-sized stick in his hand, with a cutting wheel on the end. . . . No, cut glass is cut by emery wheels, spinning rapidly around on a spindle. The cutter holds the glass against the wheel, until it grinds whatever groove he's achieving. So you might say cut glass isn't the right word—it's ground glass!" The cutting process could be done by a single master cutter or split up into three parts—roughing, smoothing, and polishing. The cutting, or roughing, was done using a rotating iron wheel that had water and sand added as an abrasive. In Roman times, sandstone was used for the rough cut. The use of a pressed-in design could reduce or eliminate this roughing step. Smoothing used the less-abrasive pumice powder or the older abrasive of emery, which is the mineral alumina. Polishing was done with a rouge or tin-lead oxide known as putty powder. Some shops used special polishing agents, such as walrus leather.

For more intricate and delicate designs, engraving was applied. Engraving (known as copper-wheel cutting) used a copper wheel with emery and pumice as the abrasive, pumice being a volcanic rock and a mild abrasive. Copper-wheel cutters were considered the highest level of craftsmen employed in the 1880s. These copper-wheel cutters or engravers commanded as much as six dollars a day (the equivalent of blowers at the time), while rough cutters earned three to four dollars a day. The copper-wheel engraver of the 1880s had to work with foot-driven lathes. A piece could take weeks or months to complete. Like blowers, cutters were controlled by an apprentice system, which forced low wages early on as one broke into the trade. The cutter apprenticed for about three years, compared to five to ten for a blower. The cutter apprentice did, however, require a higher degree of artistic aptitude. The popularity of cut glass mushroomed in the Victorian period. In America, the popularity of cut glass goes back to the presidency of James Monroe, who demanded American cut glass for White House tableware.

Flat glass was a much different product, especially in the manufacturing process. Michael Owens not only revolutionized the cut-glass, pressed-glass, and glass-container industries, he also changed the nature of flat-glass production forever. With flat glass, Michael was not the inventor; he was the visionary, project manager, and promoter. Flat glass consisted of two very distinct products—window and plate glass. Window glass was generally thinner and produced in smaller square pieces. Plate glass was more commonly used in large store windows. Flat glass was even more labor intensive than container glass in Michael's time. The earliest colonial flat glass was produced using the crown method (known as "bullions" in Europe). This first required that a spherical bubble be blown. The bubble was attached to a punty rod and broken from the blowpipe. The bubble was spun rapidly using the punty until it collapsed by centrifugal force. Further spinning produced a round sheet of glass with a crown ("bull's-eye") in the middle where the punty rod connected. The glass produced had swirls in it, which distorted light and vision. In addition, the glass surface was uneven. The process also left a distinguishing bull's-eye. Michael saw the first improvement on this method in Wheeling glasshouses of the 1880s.

The new method was known as the cylinder method, which was really a rediscovered Venetian technique. The Venetians had for centuries gone to great lengths to maintain secrecy of the cylinder method. Flat glassmaking operations were among those moved to the island of Murano to maintain better secrecy. Many techniques, such as the cylinder method, became “lost.” By the 1700s, it is believed that French spies had cracked the secret. While the cylinder method only started to appear in the Wheeling valley in the 1880s, its first modern description appeared in French science-fiction writer Jules Verne’s novel *Mysterious Island* in 1874. Glassmaking was one of the first endeavors of the characters stranded on Verne’s island, as described below.

> A hundred parts of sand, thirty-five of chalk, forty of sulphate of soda, mixed with two or three parts of powdered coal, composed the substance, which was placed in crucibles. When the temperature of the oven had reduced it to liquid, or rather a pasty state, Cyrus Harding collected with the tube a quantity of the paste: he turned it about on a metal plate, previously arranged, so as to give it a form suitable for blowing, then he passed the tube to Herbert, telling him to blow at the other extremity.
>
> And Herbert, swelling out his cheeks, blew so much and so well into the tube—taking care to twirl it round at the same time—that his breath dilated the glassy mass. Other quantities of the substance in a state of fusion were added to the first, and in a short time the result was a bubble, which measured a foot in diameter. Harding then took the tube out of Herbert’s hands, and, giving to it a pendulous motion, he ended by lengthening the malleable bubble so as to give it a cylindro-conic shape.
>
> The blowing operation given a cylinder of glass terminated by two hemispheric caps, which were easily detached by means of a sharp iron dipped in cold water; then, by the same proceeding, this cylinder was cut lengthways, and after having been rendered malleable by a second heating, it was extended on a plate and spread out with a wooden roller. The first pane was thus manufactured, and they had only to perform this operation fifty times to have fifty panes. The windows at Granite House were soon furnished with panes; not very white, perhaps, but still sufficiently

transparent. [Verne's formula of coke and sulfate would suggest a yellow tint that plagued French glassmakers of the time.]

Jules Verne gives us a beautifully described process. While the cylinder method represented simple techniques, it was able to reduce costs over the crown method. More importantly, the quality was dramatically improved, with the elimination of the inherent swirls and the bull's-eye. The 1880 industrial view of cylinder plate manufacture is very similar to that of Verne's. The shop or gang consisted of the blower, the gatherer, a snapper (also called a capper), and a flattener. The gatherer first formed a hollow ball of molten glass from the furnace, weighing twenty to forty pounds. In this case the gatherer used a blowpipe and blew the ball into shape. The pipe was then passed to the blower, who reheated the ball. The reheated ball was then blown and swirled with a great expenditure of energy to produce a cylinder ranging from twelve to twenty inches in diameter and approximately seventy inches long. A blower of cylinders could produce 120 in a nine-hour day. In England, the Chance Brothers required a year to produce the glass panes for the Crystal Palace at the Great Exhibition of 1851. The Crystal Palace consisted of a million square feet of 300,000 cylinder-blown panes.

After the glass blower created a cylinder, it needed to be prepared for flattening by removing the ends. The cylinder was passed to a snapper to remove both ends or caps of the cylinder and split the cylinder lengthwise. A February 21, 1889, article from the Tiffin, Ohio, newspaper, the *Seneca Advertiser,* described the operation.

> The next thing to be done is to cut off both ends of the cylinder evenly and this is accomplished sometimes with a glass cutter's diamond, but usually this is done by wrapping a string of hot glass around the cylinder where it is desired to cut it off. The hot glass makes a crease in the cylinder and after it is removed a drop of water or a cold iron applied to the spot causes the end to snap off very evenly. The next step is to slit the cylinder, which is done by drawing a hot iron along the inside where the crack is wanted.

The half-cylinders are moved to the flattener, who reheats the glass and flattens it with a hot iron. Finally, the flat pieces are annealed in a furnace before packaging.

The Industry Unionizes

The production of flat glass was extremely hard work, rivaling any industrial labor. Jules Verne compared bottle production to windows in his novel: "As to bottles and tumblers, that was only play." The nature of flat-glass production gave rise to the most powerful labor organization in the history of the United States—Local Assembly 300.[7] The labor movement prior to 1865 consisted of secret local "lodges." In 1865 the blowers of Pittsburgh's Monongahela Valley organized the first glass union. In 1867 the gatherers of the Monongahela Valley formed a union, and by the end of the decade, the snappers and flatteners each did the same. The gatherers were more progressive and joined the national labor movement known as the Knights of Labor. Under the Knights' influence, the gatherers joined up with the blowers' union to form Knights of Labor, Local Assembly 300 in 1875. The major company involved was Pittsburgh's United States Glass. The union consolidation continued as the snappers and flatteners amalgamated with Local Assembly 300 in 1879. This national organization became known as Local Assembly 300 of the Knights of Labor, Window Glass Workers of America. The strength of this new union was that it unionized all the crafts positions—blowers, gatherers, snappers, and flatteners—while preserving their hierarchy. Local Assembly 300 used its organization to formalize the Venetian system.

By 1881, the Window Glass Workers had national control of all the window-glass industry glasshouses. Still, their leader remained Local Assembly 300 of the Monongahela Valley. Local Assembly 300 was the first to set production limits and restrict the grueling schedule. It set limits on the number of cylinders produced in an hour. Snappers and flatteners were protected as well. Furthermore, Local 300 formalized the summer vacation of two months. Traditionally, because of the unbearable temperatures in the glasshouse during summer, the yearly working period was often shortened by a vacation period. Local 300 formalized the production period as September 1 to June 30. Local Assembly 300 members also were neo-Luddites who actively opposed any labor-saving devices. The Assembly's bylaws forbade its members from working in any glasshouses with automatic machines. These internal restrictions on automation would force a split in the union as Michael Owens and others brought automation to plate glass in the 1910s. The split would be between machine producers and cylinder producers. Ultimately, the Owens machine shops won out.

Local 300 also was the first to formalize the apprenticeship system. The entrance into apprenticeship followed the lodge practices of earlier times. Only legitimate brothers and sons were allowed into the window-glass trades after 1882. Wages were also based on the caste system. For every dollar made by the blower in 1879, the gatherer received fifty-seven cents and the snappers and flatteners received twenty-seven cents.

Local Assembly 300 was clearly the most powerful union in any industry. Because of the solidarity of the shop, the union actually strengthened the Venetian crafts system. Local 300 was a fortress against companies trying to reduce wages for the lower crafts positions. The crafts system was its own Achilles heel, because it separated workers according to a type of social class, allowing companies to break the lower positions. Local 300 had resolved the issue and created a powerful model for crafts unionization. This model, adopted by the national organization, the Window Glass Workers, made them too powerful for any single company to take on. This led to the formation of a window-glass manufacturers' association, but even this could not counter the union's power. Eventually, the manufacturers formed an alliance with the Window Glass Workers, which allowed monopolistic-type control of prices and wages. The other locals of the flat-glass industry never fully equaled 300's strength, but they emulated its structure. Had other glass segment unions, such as the bottle makers, adopted the Local 300 model, the structure of the whole glass industry might be far different today.

The non-flat-glass workers actually made some very early efforts to unionize, but success was spotty. The earliest was the Green Bottle Glass Blowers of the 1840s in the East. Bottle glass was the cheapest lime glass. The name "green bottle" referred to the green color of low-quality bottle glass. Common impurities such as iron and manganese caused the light green color. The major area of contention for the Green Bottle Glass Blowers was the use of low-wage boys as "apprentices" for the molder position and higher gang positions. The local Green Bottle Glass Blowers of New Jersey, Pennsylvania, and Maryland did hold a convention in 1857 to form a "Grand Union," but they failed to evolve into a strong national union. Since the blowers lacked full shop integration (the gatherers had their own union), they lacked the power and solidarity seen in Local 300. Management could easily break blower strikes by using gatherers and ambitious lower gang members instead. The national effort of the Green Bottle Glass Blowers fizzled out, but locals remained until 1886, when the Knights of Labor absorbed them. Still, the highly specialized art- and flint-glass workers remained only loosely organized, behaving more as a crafts lodge operating in secrecy.

The flint-glass industry was considered a separate segment from the bottle makers, flint glass being primarily focused on tableware, housewares, and art pieces. The variation in the processes, such as pressing and blowing, and in skill levels created difficulty in achieving a strong union. Unions tended to organize by gang position; that is, the blowers and the gatherers each had their own unions.

The first effort to unionize the flint-glass workers was in Pittsburgh in 1858. The organization was known as the Glass Blowers Benevolent Society. The Benevolent Society continued as a secret organization without much success. Again, as with most blower unions, they lacked the ability to strike successfully against a company who would use gatherers or non-union workers of the gang to fill in.

It wasn't until 1878 that the Knights brought a number of Eastern unions together in the American Flint Glass Workers. This was the first strong union to address the art-glass makers such as Hobbs, Brockunier & Company, where Michael Owens was working at the time. The Flint Glass Workers reorganized in 1881 as an American Federation of Labor (AFL) union. Michael Owens would be involved with the Flint Glass Workers as a young man and would become an officer. The Flint Glass Workers unionized the art and cut glasses factories, such as Hobbs, Brockunier & Company, Libbey Glass, and Corning Glass. The Flints tended to be more focused on the apprentice system and schedules than wage demands. This focus was natural since the flint-glass industry best represented the artisan tradition of Venetian glassmakers. The Flints modeled their union on Venetian glassmaking principles. There was a feeling of superiority and pride in their segment of glassmaking. The Flint Glass Workers also organized in product specialties, such as oil-lamp chimneys, pressed tableware, and bottles, which they called "departments." The chimney workers represented the largest segment when Owens started in the industry. Prior to electric lighting, oil-lamp chimneys comprised a huge growth market in America. The Flint Glass Workers wanted to maintain the crafts model but were open to some automation.

Labor was the critical element of glass manufacture, representing 75 percent of the product cost, when Michael Owens started his career. Even with unionization, the working schedules changed little throughout his time. A glasshouse would have ten to twelve gangs (or shops). The gangs were assigned to one of two shifts (moves). The first shift might have two sets of gangs, one working 1 A.M. to 6 A.M. and the other 7 A.M. to noon. The second shift's gangs were divided between noon to 5 P.M. and 6 P.M. to midnight. Boys such as the fire boy, Michael's first job, worked the full ten-hour shift. Many glasshouses had a " knocker-upper" to walk the streets waking up gang members as needed, knocking on windows. Most glasshouses closed during the summer because of the heat.

The leading local of the Flints was Owens' home district, Local 9 of the Wheeling area, and like Local 300 in the flat glass segment, Local 9 of the Flints was the dominant local in the national union leadership. Local 9 pioneered unionism in a crafts system. The flint factories saw flat-glass workers as factory or production workers versus true craftsmen.

The concept of unions, of course, was inconsistent with the crafts system. Glass workers had always favored secret organizations and guilds, which respected the glassmaking process as a craft or art. The union's success depended on its ability to honor the hierarchy of the glassmaking system while standardizing working hours, wages, and apprentice systems. Wage increases were, of course, important, but the wage structure had to be sensitive to the craftsman's position and apprentice system. One of the abuses of the Wheeling companies had been the insertion of cheaper and poorly trained workers into skilled positions. Companies saw the tradition of the crafts as restrictive and expensive. Glass industry executives preferred the factory system over a crafts apprentice system. The union itself struggled with the crafts concept and its application. Still, it was obvious that the crafts model had to be honored if the industry were to be unionized. For strikes to be successful, all the glasshouse workers had to be united. While the union wanted to preserve the crafts hierarchy, it realized it had to dumb it down to achieve the solidarity needed to deal with management. The model that evolved allowed for the hierarchy of the gang but also allowed one to move up the ladder based on seniority. This prevented the company from putting in "blower apprentices" from outside the union.

The most unusual branch of the glass industry was the plate-glass maker. Generally, plate glass required less skilled labor, but it still remained an art when Michael Owens started his career in 1869. Plate glass was similar to window or crown glass except produced in thicker and larger pieces for shop windows, showcases, and mirrors. The real craftsmen of the "French pot" method of plate glass were the pot makers. The few plate producers imported their clay for the pots from France until 1900. The pots required many pluggings of the clay, to increase density. The plugged clay was then aged for three to six months. The dense, aged clay could then be molded into crucible pots. A pot could hold around a thousand pounds of molten glass.

A pot of molten glass was transferred to a casting table, where it was poured by hand into the shape of a plate. Pulling an iron roller across the plate flattened the glass. A hand-operated winch pulled the iron roller. The rough plate was moved to an annealing furnace (lehr) for three days. The plate was then moved to a twenty-four-foot-diameter grinding table. Moving the table under grinding wheels ground both sides of the plate. Next both sides were polished. Handling of the plates was difficult and labor intensive. Clamps and cranes facilitated the handling. Finally the glass was hand cut into panes.

Plate-glass making was a highly labor intensive process, but the skill level was low. It lent itself to the factory system of heavy supervision with unskilled labor. Flat-glass production was growing along with the population. In 1887, the Chance Brothers of England improved the plate-glass casting method with the help of steel inventor Henry Bessemer. Michael J. Owens would in the 1910s help automate and revolutionize this branch of the industry as well.

The hand-blown or mold-blown bottle market was experiencing growth throughout the period 1860 to 1900 also. This “green bottle” industry was separate from art-glass or flint manufacturing due to the lower quality of glass used for bottles. Generally the inherent colors of green or brown were acceptable for most products.

Bottles were mainly used as alcohol containers in the nineteenth century. The Bininger family grocery store in New York popularized bottles for whiskey in the 1820s. One of the most popular glass bottles was “log cabin bottles” used for alcohol in the 1840s. Whitney Glass of New Jersey produced these souvenir-type bottles for E. B. Booz, a Philadelphia distiller. Booz was an active supporter of William Henry Harrison’s presidential campaign, and he made the log cabin bottle an American icon. He is the source of our word “booze” for liquor. Whitney Glass was the oldest bottle company in the United States, tracing its heritage back to Casper Wistar in 1738. Interestingly, Owens would purchase Whitney in 1918 and make it one of the most automated plants of the 1920s.

By the 1860s, whiskey was commonly sold in pocket and picnic flasks. The Revenue Tax Act of 1862 created demand for the "bitters" bottle. It put a higher tax on alcoholic beverages than medicines. Bitters were listed as medicine, being a mix of herbs and alcohol. Actually, bitters were very high proof. These bitters claimed all kinds of cures, but they were mainly purchased for their alcohol. The famous "Dr. Hostetter's stomach bitters" was purchased for Union soldiers in large quantities during the Civil War. Gin "bitters" were also a popular "medicine" in square bottles.

Henry Heinz started to bottle catsup during this period as well. Another application was fruit jars, which started to prosper with the invention of the Mason jar in 1858. The Mason jar used a

Three boys and their father, all of whom worked at a West Virginia glass factory, 1908. (Library of Congress) screw zinc lid to close the screw-type jar. The popularity of the Mason jar in the 1880s helped to standardize molds in the glass industry. Bottles and jars would require Owens' automatic machine to open up the full potential of the market.

While the demand for and usage of glass had increased throughout the 1800s, the "industry" in which Michael Owens began his career in 1869 was small and fractionalized. It represented a cottage industry. Capital requirements were rather small, and few major corporations in the industry existed. New England Glass was an exception, but no fortunes had been made in glassmaking. The glass industry of 1870 was concentrated in the areas of New England, New Jersey, Pittsburgh, and the West Virginia panhandle. Pittsburgh was considered the glass capital, with thirty-three glasshouses in 1870. Most companies were small proprietorships or partnerships and many were short-lived, ending in bankruptcies or partnership breakups. Glasshouse fires were common and led to very high insurance rates. Still, 1870 saw the rise of glass corporations among older companies. Two of these great corporations, New England Glass (Libbey Glass) and Hobbs, Brockunier & Company, would mold a young Michael J. Owens.