Chapter II

Glassmaking and Ornamentation

To appreciate completely any art or product of craftsmanship, one must understand the processes by which it is created and the properties of the medium used. Of course, there are many collectors of glass who are content to use or enjoy the finished product of that art or craft without question or curiosity as to its genesis. On the other hand, the serious collector seeks that deeper appreciation which comes with the knowledge of the processes of fabrication—what materials are used and how, the methods and equipment which have been necessary to accomplish the result. Therefore, this chapter has been devoted to the consideration of how glass has been made and decorated and the equipment these processes have necessitated.

1. BASIC MATERIALS

There are probably as many recipes for making glass as there are for making cakes, but certain basic ingredients are essential. These are silica, usually in the form of sand, and alkalis such as potash and carbonate of soda or lime. When subjected to intense heat the alkalis act as a flux causing the fusion of the materials. It is a chemical process which Professor Silliman described as follows: "Silica has the property at a high temperature of acting the part of a powerful acid, and when the proper degree of heat is attained it drives out the carbonic acid (of carbonate of soda) before combining with the alkali, while the alkali unites to form a salt," called glass. Accessory ingredients such as white oxide of arsenic, alumina, nitre (saltpeter), oxide of lead or of manganese, borax or chalk are mixed with the essential materials according to the type of glass desired, or the purpose for which it is intended. The mixture of raw materials is called the batch; the process of cooking the batch, melting; and the melted batch, the metal.

2. BASIC KINDS OF GLASS

The basic kinds of glass which are of immediate interest to us are "green" glass, used principally for the production of flasks and bottles and, in our early days, for window glass; glass of soda, sometimes of potash, and glass of lead (flint glass) for our fine wares.

Green glass, common bottle glass, is the term applied to glass in its natural color—neither rendered colorless nor artificially colored—and generally made from coarser and less pure materials than those employed in the metal for fine wares. It had either soda or potash as its principal alkaline base and usually some form of lime as its second. The natural colors of its metal ranged through greens, olive-ambers, and ambers and were an accident of nature caused by the presence of metallic substances, such as iron or alumina, in the raw materials. It was undoubtedly the first glass made in America and made with potash from wood ashes, which was convenient and cheap to prepare because trees were more abundant in the land than anything else. While green glass was definitely the metal for bottles and flasks and early window glass, household utensils were frequently fashioned from it. The brilliant light green or aquamarine "lily-pad" pieces were blown from green glass.

Glass of soda was almost universally used for the production of wares necessitating a better grade of glass than bottles, such as table, "chymical" and "philosophical" wares. In its composition, carbonate of lime was usually the second alkali, and often some metallic oxides were added. A clear metal, also called white or crystal, was attained by the addition to the melting batch of black oxide of manganese which, in the proper proportions, neutralized the natural color of the metal. This glassmakers' soap, as the oxide of manganese was aptly called, was used also to decolorize glass of potash. Presumably, any clear glass which was produced in the colonies before the time of Baron Stiegel was made with soda as the principal alkali, though potash may have been used in some instances.

Flint glass or glass of lead is a type which is a later development than green or soda glass. However, when glassmakers perfected lead glass, they came nearer to their goal of simulating natural rock crystal than through any other composition. Because of this and of its place in our own glass production, it merits more discussion than we have given to the others, even though they are praiseworthy for other reasons. The essential ingredients of lead glass were sand, potash, and oxide of lead, either minium or red lead, sometimes with saltpeter (nitre) in addition; and of course, to make it "crystal" the glassmakers' soap was used. Why it was called flint instead of lead glass is a puzzle. Lead glass attained the reputation of being superior in quality to any other known type of glass. So it may be that the term "flint" was applied to lead glass because previously it had been thought that glass of the finest quality could be made only with the silica of burnt flints, that is, flints reduced to a powder or made friable by calcination. It was an extremely important development in the composition of glass not only because it fused at a lower temperature than others but also because of its remarkable plasticity which made it easier to manipulate. Also it had a greater and more liquid brilliance than soda glass. And because of its "softness" it was more adapted than other types of glass to decoration by copper wheel engraving and wheel cutting.

The perfecting of lead glass is credited to England. This metal was not a sudden invention, as has been thought by some authorities, but, as Powell points out, was the result of "successive tentative experiments to make a more readily fusible glass." As a matter of fact, the use of lead in glass was known as early as 1611 when Neri wrote his treatise on glass. In his fourth chapter, which is devoted to instructions regarding the use of lead, he begins with the statement that "glass of lead known to few in this art, as to colours, is the fairest and noblest glass of all others at this day made in the furnace." His recipe called for "calcined Lead 15 pound, and Crystall or Rochette or Polverina Fritt, according as you make the colors, 12 pounds." The fritts he mentioned were partial fusions of sand and salts. Neri's *Art of Glass*, at least our version, was translated into English in 1662. It may be that his dissertation on lead glass inspired English glassmakers to experiment with lead as a flux. At any rate, it was not long after the English edition was published that Ravenscroft succeeded in making a "flint" glass. However, the basic composition as we know it was probably not brought to perfection until about the middle of the 18th century.

The "lime" glass, referred to so frequently in connection with our pressed glass production after the Civil War, should also be mentioned, for while it was really a new composition of soda glass it was frequently called flint, probably to implant an impression of fine metal equal to lead glass. In 1864, after much experimenting, William Leighton of Hobbs, Bruckunier and Company of Wheeling worked out the formula for this lime glass. By using bicarbonate of soda and new proportions of lime and other ingredients he succeeded in producing a glass as clear as lead glass, though not so resonant and heavy. Moreover, it was far cheaper to produce than lead glass. For these reasons lime glass was of inestimable importance to the glass industry. Its use meant decreased production costs with little loss in appearance of "quality"—except to the critical eye. Consequently those factories which adopted lime glass, especially for tablewares, were in a favorable position to struggle with domestic and foreign competitors for the patronage of the buying public.

3. ARTIFICIAL COLORING

Though the glassmaker has for years striven through his own "crystal" to equal the beauties of nature's rock crystal, he has always sought to give his metal those colors with which the world is enriched.

As a matter of fact, the artificial coloring of glass was considered an art in itself and one which antedates the making of clear glass. It was discovered that the desired colors could be produced by the addition of coloring agents, such as metallic oxides, to the batch. For example, while black oxide of manganese in certain proportions decolorized the metal, in other quantities it produced amethysts, purples, and even "black," depending upon the amount used and the basic composition of the metal. Cobalt produced blues; copper and iron, greens; copper or gold, ruby. It was learned also that the same oxides might make one color in one composition and a different color in another; that sometimes the degree of heat or length of cooking the batch after the addition of the coloring agent determined the color or hue of the glass. Hence only through controlling all these factors could the glassmaker determine the color of his metal. And only as scientific research in coloring progressed were elements of uncertainty removed and the color range extended. Up until about 1830, the primary colors of American glass, that is, the artificial colors, not the natural ones, were various hues, tints, and tones of blues and emerald greens, of amethysts and purples, and, rarely of ruby and opaque white.

While the essential and accessory ingredients needed for the various kinds of glass and its coloring have remained the same, there has been continual change in their combinations, particularly in the last 100 years. There is a long history of constant search for better quality metals, for metal cheaply produced, as well as for new color effects and new uses to which glass could be put. Scientific investigation of the properties of materials and experimentation in combining them have accomplished the much sought for results.

4. PREPARATION OF RAW MATERIALS

Great care had to be exercised in the preparation of the raw materials, for in their natural state they contained "impurities," which had to be expelled lest they foul the metal in the melting—rebels against losing their individuality in the union of silica and alkalis. Therefore, each ingredient had to be made as pure as possible in order to obtain the best results. First the sand was washed "within an inch of its life," then dried, and the alkalis also were partially purified through leaching and evaporation which carried away soluble portions. These first steps of purification accomplished, the proper proportions of the dry materials were measured according to a recipe or formula and mixed thoroughly. The batch was then ready for fritting. For this process it was put into a furnace called a calcar (Fig. 1) where a partial fusion took place and any moisture present was evaporated. Also more stubborn impurities were driven off which, in the process of melting, might be injurious to the pots and to the quality of the metal. During this process of fritting, the batch was stirred occasionally with a rake or hoe-like tool. When through partial vitrification the frit was formed, it was taken from the calcar (later called the calker), broken up, washed and put away to age before being used for the final melting. However, when lead glass was made only the sand was burnt or calcined. Although in time, as it became possible to secure raw materials in a purer state, the making of frit could be eliminated, it was made as late as the 1830's in many places.

5. THE POTS

The manufacture of the clay pots, or crucibles, in which the batch was melted was an extremely important side line of the glass industry. As painstaking care was taken in their fabrication as could be given to the finest porcelain, for a defective or poor pot might break during the melting, bringing upon the glass house the disaster of lost time and precious metal. The pots were made from powdered clay of the finest quality with which grog—pulverized fragments of old pots—was usually mixed. First this mixture was wet down, then thoroughly trod to expel all air from the clay. The clay was trod by barefooted workmen as grapes are said to be crushed for wine. It was next modeled into long rolls from which the pots were built up gradually to the desired size and shape. Once formed, they were allowed to age and were carefully fired. It was considered unwise to put to work a pot under a year old. When they were ready to be used in the furnaces, it was necessary to bring them slowly to a white heat before they were charged, that is, filled with

Figure 1. From Handicquier de Blancourt's *The Art of Glass*, English Edition, 1699.
Calcar where the Frit is Made.

A. Fire compartment where the fuel was introduced and the ashes were removed through the arched opening.

B. Oven or frit chamber—where the cleansed and mixed batch was placed and stirred occasionally with a rake or hoe-like implement until the ingredients had vitrified.

C. Frit—The workman at the right is breaking up the frit with a crude sledge-hammer. The wood for the fire is shown at the left. Blancourt points out that in the time of Georgius Agricola coal was used in the calcar but that "The Moderns" considered wood a superior fuel, for if thoroughly dried it didn't smoke like coal.

the batch for melting. Otherwise, no matter how perfect, they might break in the melting as a cold glass sometimes does when filled with boiling water.

Throughout the years there have been few changes in the shapes of pots. Such as have been made were developed to meet new needs arising from changes in furnaces, compositions of glass or through efforts to improve the pot for its function. The ancients probably used small open-top pots, but we do not know their exact shape. The type used in the 16th and 17th centuries, and doubtless for a long time before then, can be seen in Fig. 4. According to Georgius Agricola, the German mineralogist (1494–1555), the height of these pots was two feet; the diameter of the belly, one and one-half feet; the diameter of mouth and foot, one foot; and the thickness "two digits." A later type was in the form of a truncated cone (Fig. 2). The hooded pot (Fig. 3) was possibly introduced in the early 17th century shortly after the English began to use coal as fuel in their furnaces and lead as a flux in their glass. At that time it was found that when the carbon in the fumes from coal came in contact with the metal it would cause the lead to precipitate. But smoke from burning wood did not have this effect, so where wood was used as fuel, lead glass could be made in open pots. While hooded pots superseded and largely replaced those with open tops, the latter continued to be used, particularly in green glass houses. As late as 1886, Atterbury & Company of Pittsburgh, manufacturers of tablewares, were melting their glass in open pots. Melting pots have varied more in capacity than in shape. It would appear that as the industry grew bigger and bigger so did the pots, which eventually could hold from 500 to 3500 or more pounds of metal. In fact they took on gargantuan proportions.

Since about 1890, in those factories where tank furnaces are used in the manufacture of window glass and common containers, the metal is melted in tanks lined with the same material as that used in making pots. However, pots are still used, those of the hooded type, for fine wares.

In addition to the melting pots, small crucibles called skittles and piling pots were used for special purposes. Colors or enamels were melted in the skittles. The piling pots, which were later called jockey and monkey pots, rode on top of the melting pots in the furnace and were probably used for small batches of artificially colored glass which in our early days was not made so lavishly as the clear and green glasses.

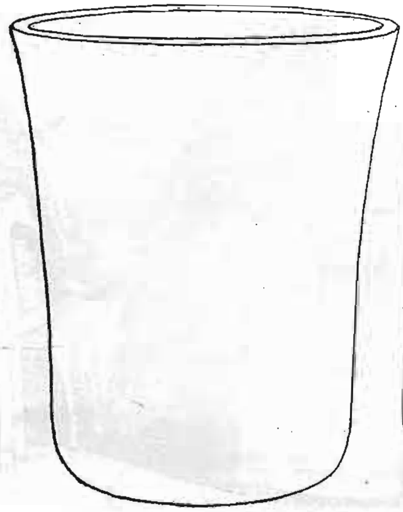


Figure 2. Melting Pot—Truncated Cone Shape.

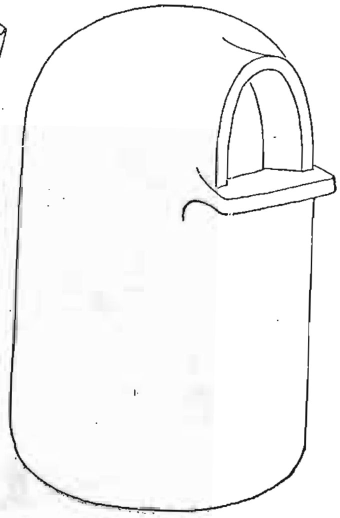


Figure 3. Hooded Melting Pot.

6. THE FURNACES

Fire and heat are such important factors in the equation of glass that there could be no answer without them. But the answer will be wrong unless the fire produces the right degree of heat for the different steps, from melting the batch to and through the annealing. Therefore, the fire must be kept within certain bounds—steady and easily regulated as in any cooking process. Its heat must be spread as evenly as possible, and the fumes and smoke must be carried away by drafts. In the melting furnace every effort must be made to protect the metal, whose color and quality may be affected by impurities in the fumes and smoke which vary with the types of fuel used. Also, since glass will "fly" (break into pieces) if it cools suddenly, the heat in the annealing chamber must be so regulated that cooling will be very gradual. Likewise, since the finished glass as well as molten metal may be injured by the smoke, it must be protected from it.

Hence the construction of the furnaces so as to solve the problems created by the fire is of primary importance and has a definite bearing on the quality of metal produced. Consequently, these problems have been the object of careful study and experiment by glassmakers. Since the days of the ancient glassmakers, the construction of glass furnaces has undergone as much change and development as there has been from the fireplace to the electric cooking stove of today. The developments more or less dovetailed with those in the composition and coloring of glass and the introduction of new fuels such as rosin, natural and artificial gas, and oil; slow in pace for hundreds of years, rapid in the 19th century as in other branches of industry.

We have found no positive evidence as to the furnaces of the ancient makers of glass. It may be that in the beginning they used a sort of pit hearth lined with stones, as has been suggested by Dr. Manrach of Germany. The remains of the furnace, circa 1400 B.C., found at Tel el Amarna, seem to indicate that the Egyptians of the time used a box-like structure similar to furnaces of the middle ages of which Theophilus, the Benedictine, writing probably in the 11th or 12th century A.D., gave a description.

The furnace he describes was rectangular in form. At about two-thirds of its length, a perpendicular wall divided the structure into a melting furnace and calcar. The roof, which was

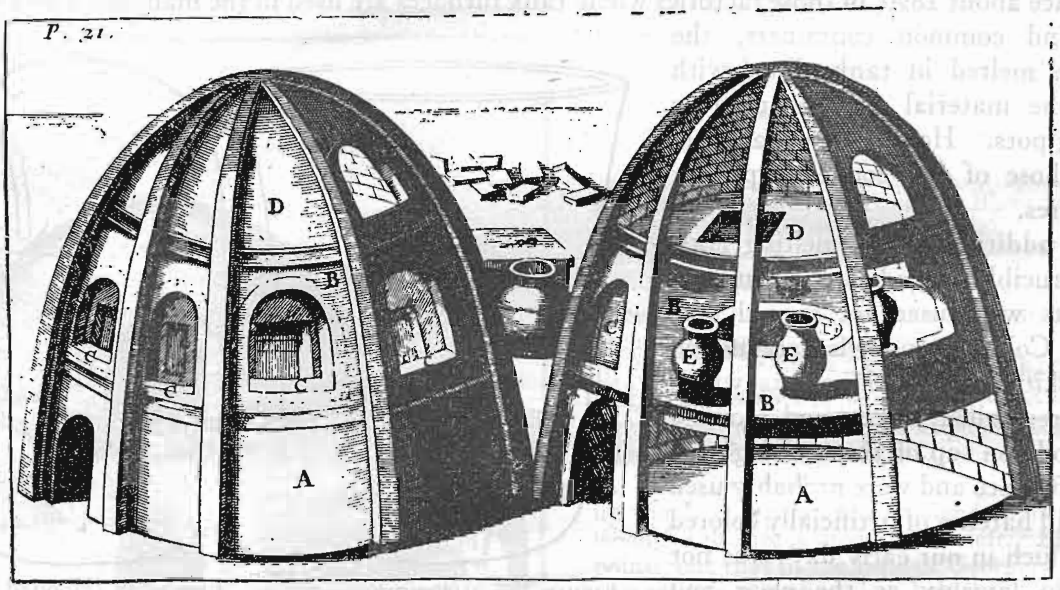


Figure 4. Blancourt's *The Art of Glass*, English Edition, 1699.
Seventeenth-century Working Furnace, a Combination of Melting Oven and Kiln.

A. Fire compartment—"where the servant flings the wood to keep a continual fire." Its crown, the floor of B, had a large circular hole at center besides smaller vents to allow the passage of the flames into the chamber above.

B. Melting chamber or oven—where the pots were set.

C. Bocca—"Great working hole through which the pots are put in and taken out. Arch windows stopped each with cover in the middle of which there is a hole, somewhat wider than a palm wide which is called the little working hole." The cover was a temporary screen in the working apertures. Two pots were placed at each hole; a large one with batch to be "purified or made fine," a smaller one with metal ready to work.

D. Upper vault—the kiln or annealing chamber. Finished vessels were put in through the single arched opening and left to cool by degrees. A large opening in the floor admitted the heat from the oven below.

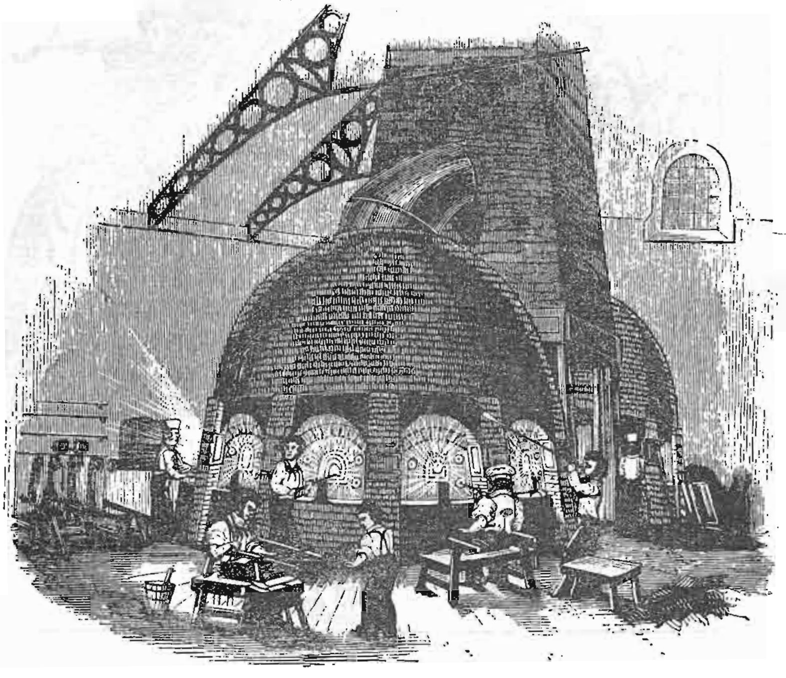
E. Melting pots or crucibles.

higher over the furnace than over the calcar, was arched because the arched form threw back more heat onto the pots than a straight or flat surface. In the melting or working furnace there was a large pit where a wood fire was made and an aperture at the bottom of the end wall through which it was stoked. Along the two sides were platforms with openings in which the pots, probably of a modified truncated cone shape, were set. In the wall opposite each pot was an arched window or working hole which, as has always been the case, could be closed or reduced in size, by a temporary screen of clay. At the top of the dividing wall was an opening to allow the heat to pass into the calcar. In the end wall of the calcar was an opening through which the batch was introduced, and another opening in the crown served as a chimney allowing the smoke to escape. The annealing oven, as described by Theophilus, was a separate rectangular structure, but a little later the function of the smaller compartment of the furnace was changed from fritting to annealing. Or it may be that this compartment was used for either function in different localities. Also, solid platforms seem to have replaced those with openings to hold the pots. Furnaces of this general type were used over a long period; after all, there was little progress in any field of human endeavor

Figure 5. Blancourt's *The Art of Glass*, English Edition, 1699.
Blowers Working at a 17th-Century Furnace.
The letters A, B, C, and D, on the side of the furnace indicate the features as in Figure 4.
A. Blowpipes—metal pipes with a pronounced lip at the end on which the gather was made and, on the blowing end, a wooden casing to protect the worker's hands from the heat.
In the foreground the object, looking something like a hairpin, may have been intended for a pucellas or other shaping tool. The square and circle with intaglio designs represent molds. The blower at the extreme right is inflating a gathering of metal. The next one is intent on securing a gather. The next arch shows plainly the temporary screen with small working hole. The blower in front of it is flattening his gather on a marver. Beyond him at the left is a workman, perhaps a servitor, holding a tool which probably is a 17th-century pontil. At the extreme left a blower is swirling his gather.
The season can't be the winter, for Blancourt says that they wore few clothes in winter, "only taking care to cover their Heads for fear of catching cold." The blower's chair which Blancourt mentions is unfortunately omitted from his illustration.
Note: A nearly identical illustration appears in the Hoover translation of *De Re Metallica* which was completed by Agricola about 1553. The hairpin-like tool was called the "forceps" and the molds described as "hollow copper moulds." Whether of brass, bronze or iron the blowpipes, according to Agricola, had to be three feet long.

in the Dark Ages. In the August, 1939, issue of *The Magazine Antiques* there is reproduced a Flemish miniature painting of a 15th-century glass furnace in operation. The furnace appears to be of the same general construction as that described by Theophilus, but with the second compartment used as an annealing oven.

By the mid-16th century, except perhaps in isolated places, while the rectangular annealing oven consisting of two chambers was retained, the rectanguiar or square working furnace had been superseded or replaced by a round furnace consisting of two chambers or compartments, the lower for the fire, the upper for the pots. In his *De Re Metallica* which was completed about 1553 Agricola described and illustrated a round working furnace and rectangular annealing oven of this type. He stated that "some glass makers use three furnaces, others two, others only one." The third furnace was a rectangular calcar. The single furnace which was probably developed about or a little before the period of Agricola was the "Beehive" type, oval outside, round within and consisted of three chambers or compartments of which the lowest was for the fire, the middle for the pots and the upper for annealing. Agricola's illustration of this type is almost identical with that shown in the 1699 English edition of Blancourt's *The Art of Glass* and reproduced here by Fig. 5. Blancourt states the square or rectangular forms "are no longer in use among us." In Italy and Spain, as well as in France, the round furnaces were in use in this period. On the other hand, the English translator of Neri (1662), who appended an account of the furnaces because they were "pretermitted by the author," speaks as though both round and square or rectangular types were used in England. While there might have been slight variations on the theme in different localities, the beehive type, Figs. 4 and 5, enjoyed general usage by the 17th century. Undoubtedly, our earliest colonial glass furnaces were of the old-fashioned beehive construction.

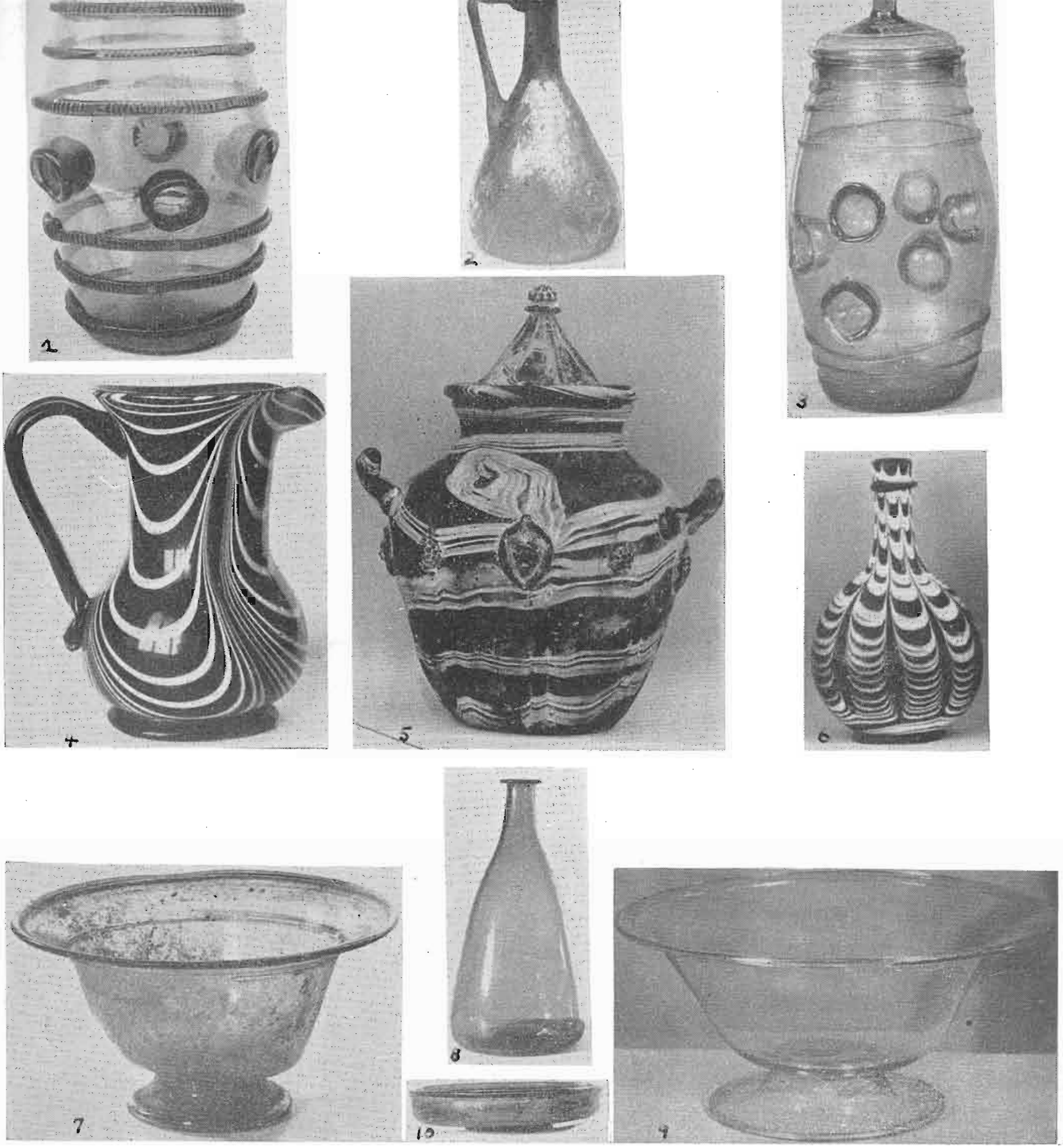


Elevation of the furnaces, and interior view of the Glass-house and working operations.

Figure 6. From Pellatt's *Curiosities of Glass Making*, 1849.
About 1830, two furnaces—as shown—each of six pot capacity and connected by a large flue with a central chimney were substituted for one of the twelve pot furnaces in the Falcon Glass Works of Pellatt & Co. Though of the same general construction as the twelve pot furnaces, they had but half their diameter and effected a great saving in fuel.
Foreground left, a gaffer is shown, apparently fashioning a wine glass. With his left hand he is holding the blowpipe which rests on the slanting arms of the chair; with his right he is forming the stem with his pucellas or "The Tool." Center, an assistant, perhaps the footmaker, is rolling a gather on the marver. At the furnace, a worker is collecting a gather through the small working hole in the screen of the "Bocca." His pipe is resting on the tower, a block or iron. At the next arch to the right, the man seated in the chair is heating the pontil in a bye hole. At his right a blower, standing by a marver, is inflating a gather.

Later, while the round form was retained, radical changes were made in the interior of furnaces; occasioned in part, at least, by the introduction of coal as fuel instead of wood. The furnace still had three compartments: an upper level under the domed roof with a chimney at its center; a domed working oven with arched windows and a rectangular grate on which the fire was built in the center of its floor, called the siege; and a basement vault into which the cinders fell and which provided a better draft than was possible in the old-fashioned beehives.

Besides the large working holes in the arches there were one or more small apertures called nose or bye holes. These were used during the processes of finishing to reheat small articles or parts such as necks of bottles. Also, through these holes the blowpipe and punty rod were introduced into the furnace for the necessary heating before they could be used. The irons which were heated through the bye hole, especially in furnaces fired with coal, were likely to be injured by the sulphides in the smoke and fumes of the fire. A sulphate was formed on the end of the iron which frequently stained the molten metal. Later, the irons were heated in a crucible. The narrow



1. German deep green communal drinking glass; free-blown, applied rigaree bands; 17th century. **2.** Free-blown bottle, originally clear glass; Antiquities Classical, 1st—3rd century A.D. **3.** Green communal drinking glass; free-blown, applied rigaree bands; possibly American, early 19th century. **4.** American free-blown South Jersey pitcher; amber with opaque white loopings; probably mid-19th century. **5.** Roman purple and white molded marble glass covered jar; post classical period. **6.** German free-blown bottle; dark amber with opaque white loopings; 18th century. **7.** Light aquamarine free-blown bowl, originally clear glass; Cyprus 2nd—3rd century A.D. **8.** American clear light amber free-blown bottle; Connecticut glass, 19th century. **9.** American aquamarine free-blown footed bowl; Lancaster, New York, circa 1850. **10.** Roman aquamarine free-blown dish; 1st century B.C.-1st century A.D. (Nos. 1, 2, 4-7, 10 courtesy of the Metropolitan Museum. Nos. 3, 8 and 9 collection of the authors.)

PLATE 1

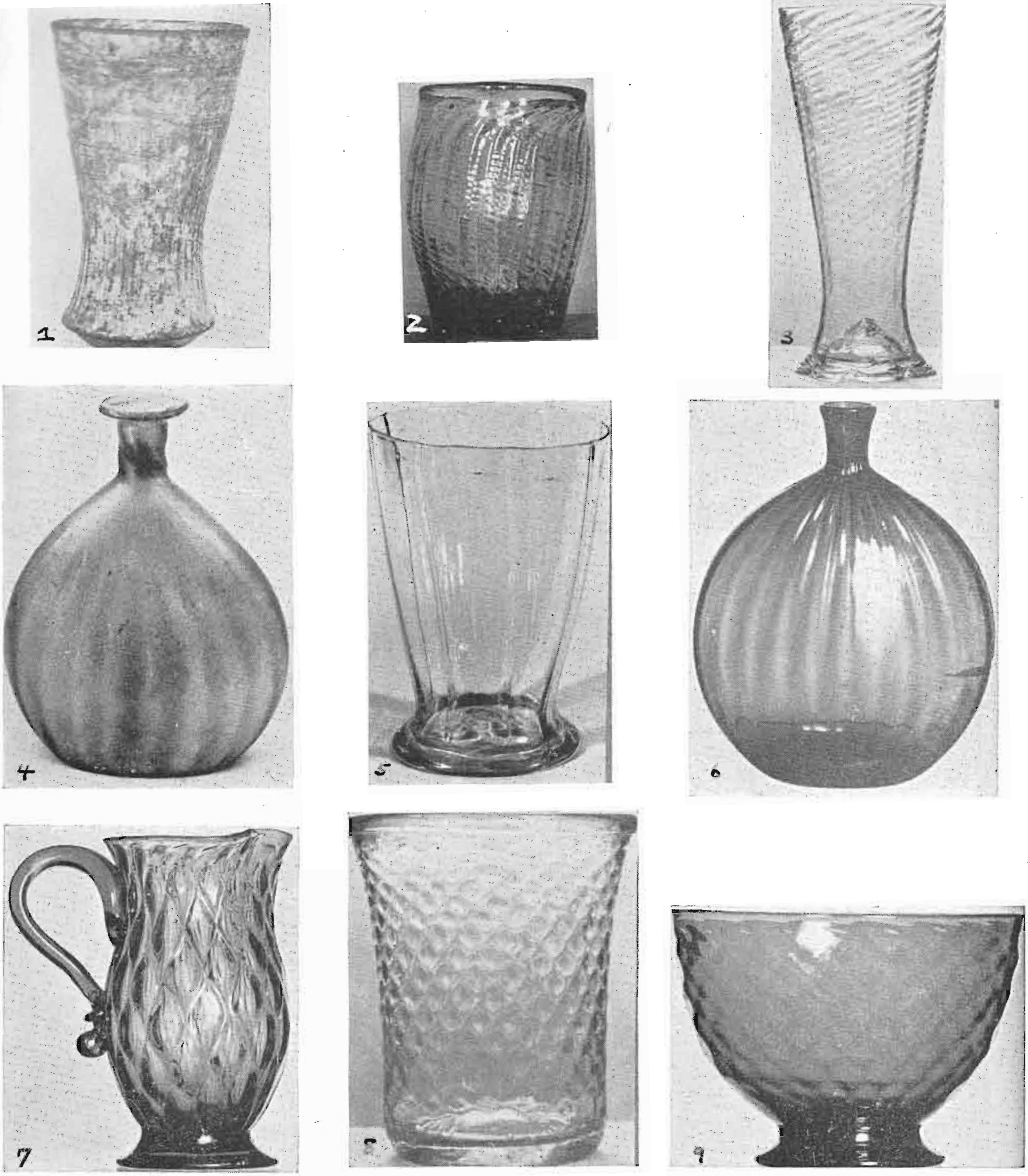
Text, page 5; *also* 183.

GLASS WITH APPLIED AND TOOLED DECORATION

1. French clear glass pitcher; 18th century. **2.** Small aquamarine pitcher; originally clear glass, trimmed with blue; Eastern Mediterranean, probably Syria, 1st-3rd century. A.D. **3.** American clear glass pitcher; probably New England Glass Company, circa 1820-1835. **4.** American aquamarine pitcher; New York State, mid-19th century. (Nos. 1, 2 courtesy Metropolitan Museum. No. 3 courtesy David Hollander. No. 4, collection of the authors.) **5.** German clear glass sugar bowl with Swan finial; 17th-18th centuries. (Courtesy Metropolitan Museum.) **6.** American clear glass sugar bowl with Swan finial; late 18th—early 19th century. (Courtesy Brooklyn Museum. **7.** Persian blue vase; 17th-18th century. **8.** Spanish olive-amber flask; 17th century. **9.** American aquamarine gemel bottle; South Jersey; 19th century. **10.** Spanish amber vase; 16th century. (Nos. 7, 8, 10, courtesy of the Metropolitan Museum; No. 9, courtesy of the Philadelphia Museum.) (Aquamarine; color due to oxidation.)

PLATE 2

Text, pages 5 and 6.

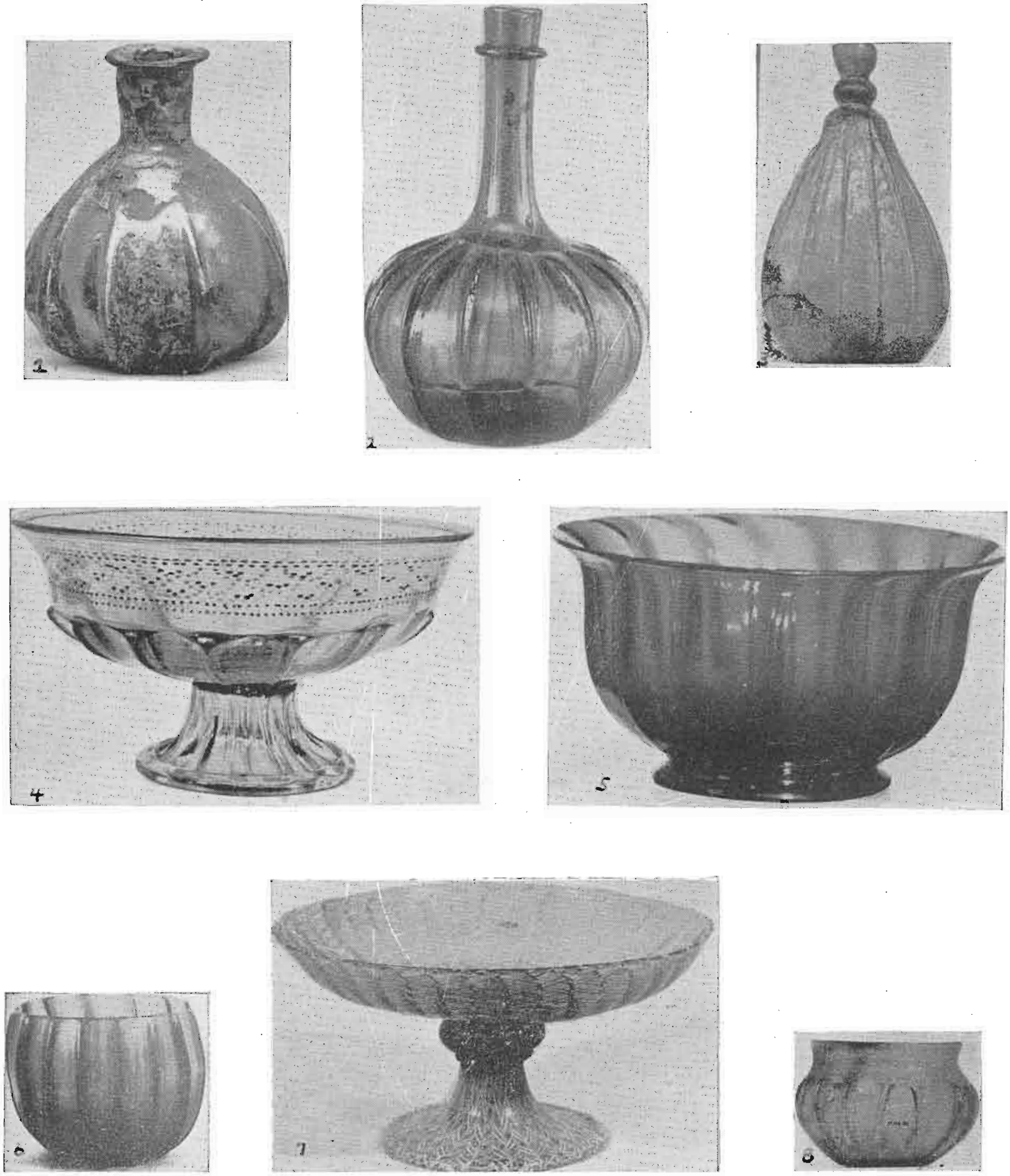


PATTERN-MOLDED GLASS

1. Aquamarine, originally clear glass, vase; Roman period, 1st—4th centuries A.D. **2.** American clear glass tumbler; possible Midwestern, early 19th century. **3.** German clear glass beaker; 17th century. **4.** Persian translucent turquoise blue flask; 17th-18th century. **5.** Venetian clear glass beaker; 16th century. **6.** American amber "chestnut" flask; Ohio, early 19th century. **7.** Blue creamer, English and American type, 18th century. **8.** German beaker of clear glass; 17th century. **9.** Blue sugar basin, English and American type; 18th century. (Nos. 1, 3, 4, 5, 8 courtesy of the Metropolitan Museum; Nos. 7, 9 formerly in collection of Mrs. Frederick S. Fish; Nos. 2, 6 collection of the authors.)

PLATE 3

Text, page 6.



PATTERN-MOLDED GLASS AND LATTICINIO BOWL

1. Iridescent bottle, originally clear glass; Roman period, 2nd century A.D. **2.** German blue bottle; probably 17th century. **3.** Aquamarine bottle, originally clear glass; Roman period, 1st — 4th century A.D. **4.** Venetian clear glass molded and enameled bowl; 16th century. **5.** American amethyst bowl; possibly Midwestern; 19th century. **6.** amethyst finger bowl; possibly Pittsburgh; 19th century. **7.** Venetian latticinio or lace glass bowl; 17th century. **8.** Aquamarine bowl, originally clear glass; Roman period, 1st—4th century A.D. (Nos. 1-4, 7 and 8 courtesy of the Metropolitan Museum; No. 6, collection of the authors; No. 5, privately owned.)

PLATE 4

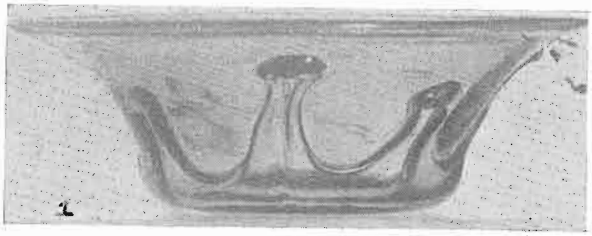
Text, page 6.

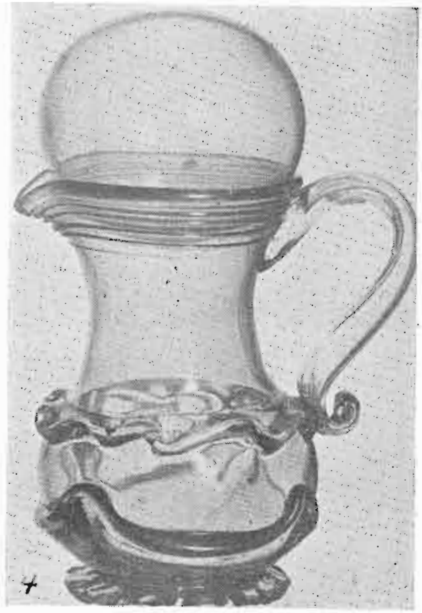
GLASS BLOWN IN FULL-SIZE PIECE-MOLDS

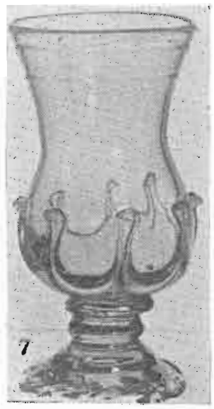
1. American clear glass Blown Three Mold pitcher in Baroque Shell and Ribbing pattern, G. V-8; 19th century. **2.** French Baroque Blown Three Mold decanter; 19th century. **3.** Sidonian yellow glass pitcher, inscribed ENNION ENOIEI, (maker Ennion); 1st century B.C.—1st century A.D. **4.** Tyrolean Blown Three Mold flask of clear glass; probably 19th century. **5.** Sidonian aquamarine cup; Roman period, 1st century B.C.-1st century A.D. **6.** Deep greenish glass pitcher from Palestine; 4th century A.D. (Nos. 3, 5 and 6 courtesy of the Metropolitan Museum. Nos. 1, 2 and 4 collection of the authors.)

PLATE 5

Text, page **6.**



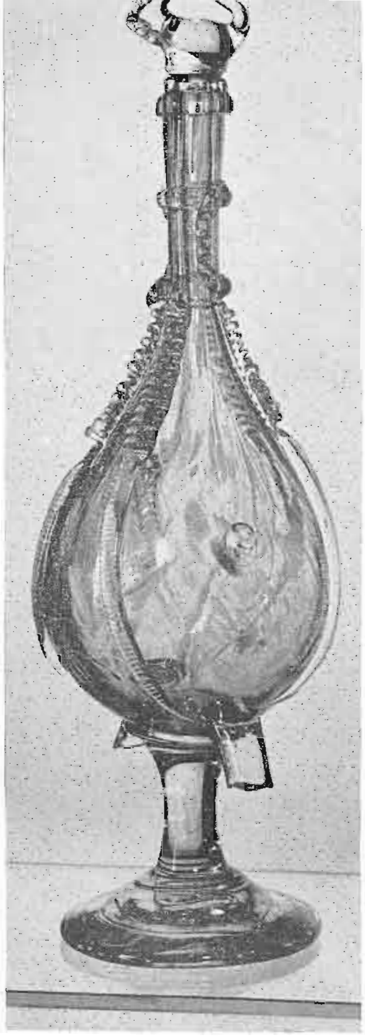


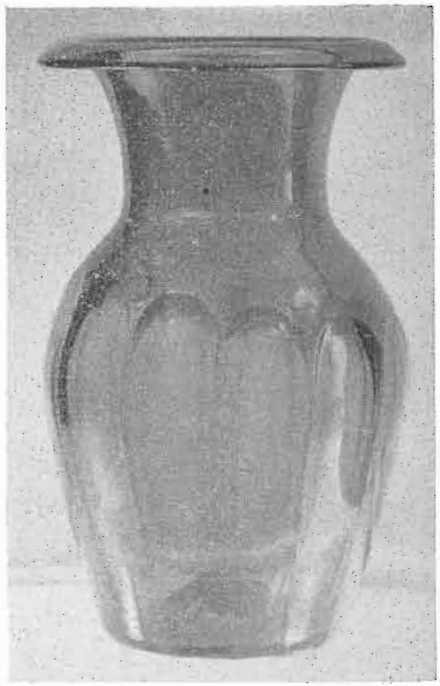


1. Bowl with lily-pad decoration Type II; aquamarine; attributed to Redford, New York, circa 1831-1852. (Collection of the authors.) **2.** Sugar bowl and cover; brilliant clear flint glass; top of cover and body of bowl bearing superimposed decoration of tooled swirled ribs; applied chain on cover and bowl; commercial type produced by the New England Glass Company, probably circa 1820-1835. (Collection of David Hollander.) **3.** Mug; deep aquamarine glass with milk-white loopings; South Jersey, possibly Bulltown, circa 1850-1870. (Courtesy of the Philadelphia Museum.) **4.** South Jersey pitcher aquamarine glass; rare combination of applied and superimposed decoration; threaded neck, wavy band around base; crimped foot. (Privately owned.) **5.** South Jersey gemel bottle; brilliant aquamarine glass; applied quilling on ends and prunts in the form of leaves on the sides; first half of 19th century. (Courtesy of the Philadelphia Museum.) **6.** South Jersey pitcher; brilliant deep green glass; neck threaded in ruby glass; superimposed lily-pad decoration Type III on body; rare. (Courtesy of the Metropolitan Museum.) **7.** Rare South Jersey glass vase; aquamarine; lily-pad decoration Type I having small bead-like pad; knopped stem and crimped foot; early 19th century. (Privately owned.)

PLATE 6

Text, pages 27 *and* 28.



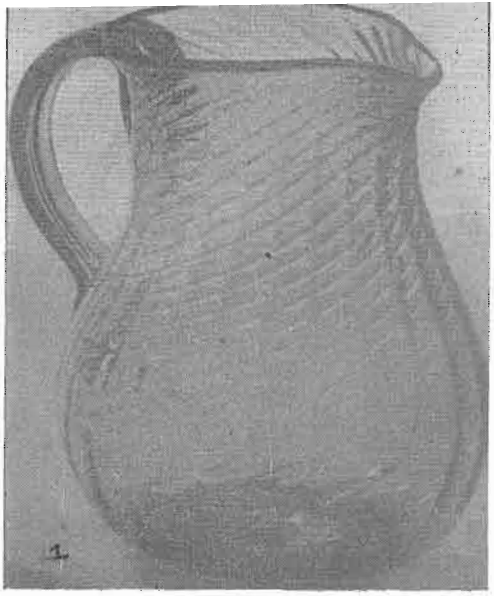


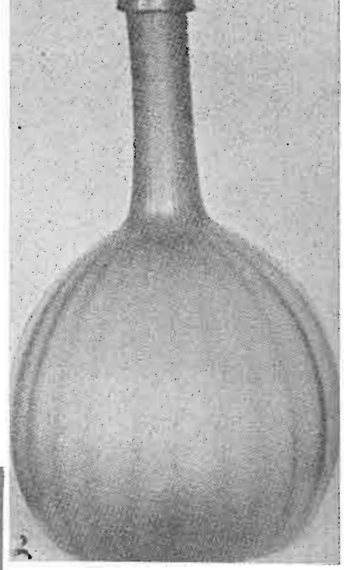
ORNAMENTATION OF BLOWN AND MOLDED GLASS

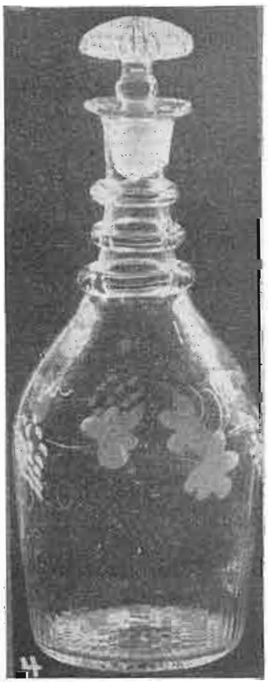
1. Celery vase; clear glass; engraved with festoons, small flowers and leaf band above molded gadrooning at bottom; probably made in Baltimore, Philadelphia, Pittsburg areas in the early 19th century. (Collection of the authors.) **2.** Rare Sandwich ornamental piece in form of a bellows bottle on standard; clear glass bottle streaked with rose, blue and opaque white and decorated by applied rigaree and quilling bands, leaf prunts and with chicken finial; circa 1830-1850. (Privately owned.) **3.** Stiegel type panel vase; cobalt blue; 12 sunken panels impressed on single gather of metal; type attributed to Stiegel 1765-1774 and probably produced also at Sandwich in the 19th century. (Collection of the authors.) **4.** Stiegel type Flip; clear glass; engraved band above 12 sunken panels impressed on a second gather of glass; type possibly made at an early New York City glass house in the 18th century. **5.** Sugar bowl; clear glass; expanded diamond pattern; low domed set-in flanged cover with swan finial; 18th-century type possibly made at Millville, New Jersey in the early 19th century. (Courtesy of the Metropolitan Museum of Art.)

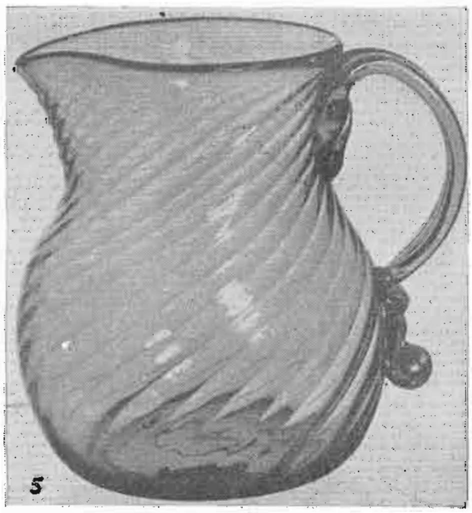
PLATE 7

Text, pages 27-29 *and* 32.





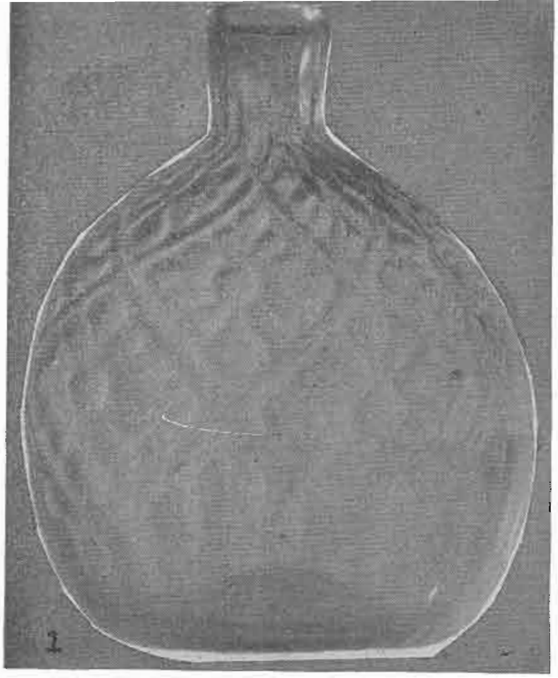


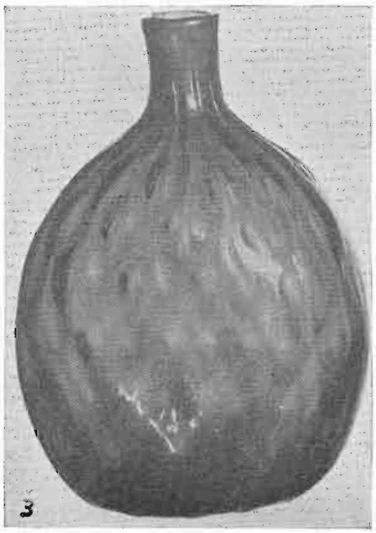


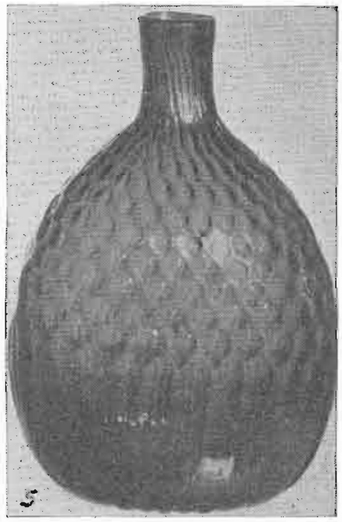
1. Rare Ohio pitcher; light green pattern-molded and expanded in broken swirl fluting; early 19th century. **2.** Ohio bottle; amber; pattern-molded and expanded in wide-spaced ribbing; early 19th-century type characteristic of the output of the Midwest. **3.** Candlestick; clear flint glass; pattern-molded and expanded in vertical ribbing; long candle socket and knop in fine ribbing; domed saucer base with wide expanded ribbing; late 18th-century type. **4.** Quart decanter clear glass: rayed base and band of vertical ribbing encircling lower part of body formed in a dip mold; engraved grape and leaf vine above ribbing; 3 applied rounded neck rings or collars; pressed ribbed mushroom stopper; late 18th- and early 19th-century type. **5.** Zanesville, Ohio, pitcher; light green glass; pattern-molded and expanded swirled fluting. The Ohio pieces are fine examples of the type popularly called "Ohio-Stiegel" because of the similarity in decorative technique to the products attributed to Stiegel. They represent the continuation of the Stiegel tradition carried into the Midwest by workmen from Manheim and other blowers trained in the same techniques.

PLATE 8

Text, pages 29 *and* 30.



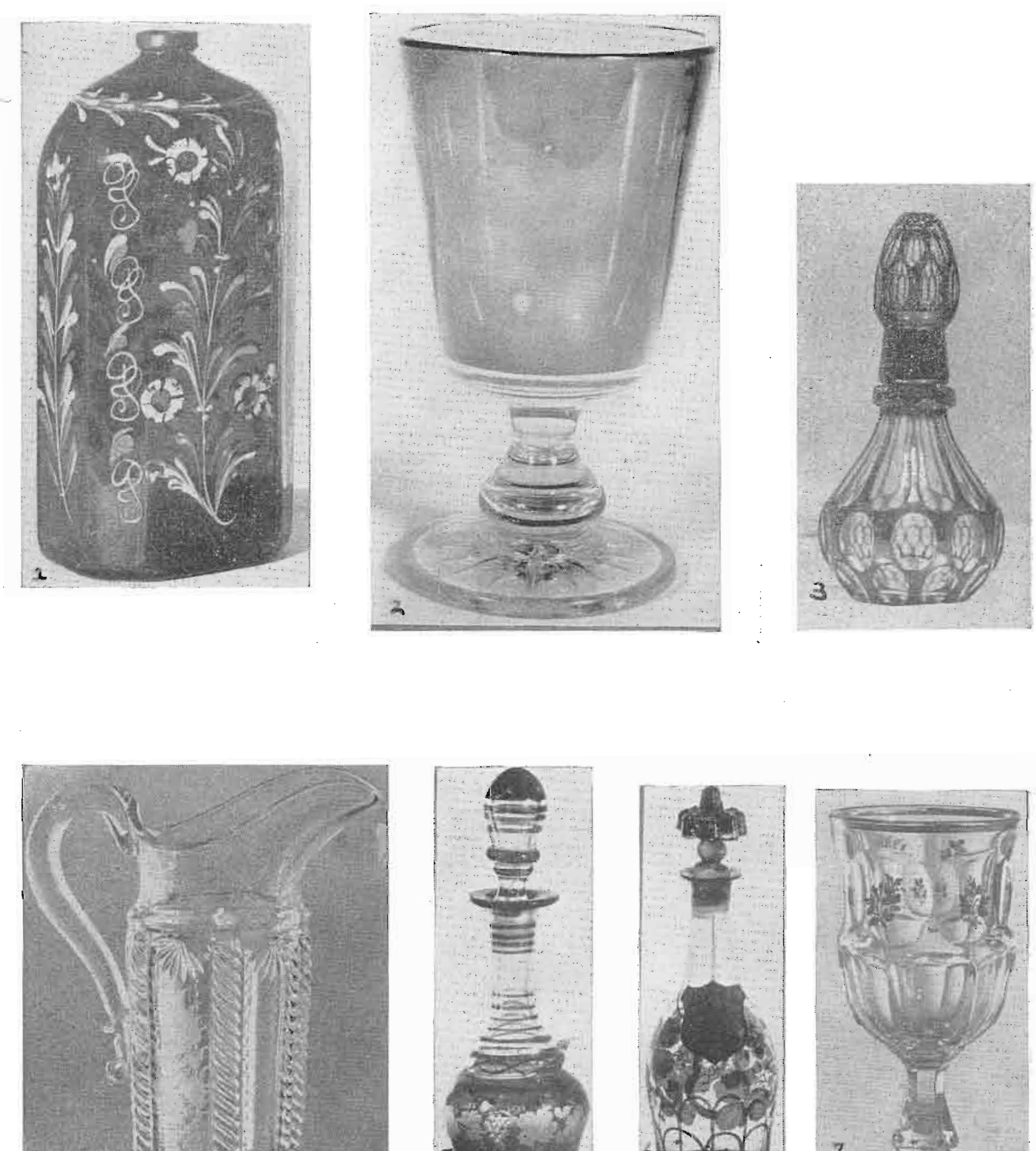




1. Stiegel diamond-daisy perfume bottle; clear glass; probably one of the first American contributions in pattern-molded designs; circa 1765-74. **2.** Midwestern creamer blown from translucent glass resembling a polished moonstone; pattern-molded and expanded large diamond or ogival design; characteristic Midwestern shape; extremely rare, probably blown at the "White Glass Works" in Zanesville, Ohio; circa 1820-25. **3.** Stiegel type perfume bottle; amethyst; pattern-molded and expanded diamond design; typical 18th-century form; possibly blown at Manheim 1765-74. **4.** Stiegel type salt; deep sapphire blue; bowl pattern-molded and expanded in checker diamond design; plain applied sloping foot; possibly a Stiegel product, 1765-1774. **5.** Stiegel perfume bottle; amethyst; pattern-molded and expanded in a design of small diamonds above 28 vertical flutes. So far this particular variation has been identified only with Stiegel's glass house.

PLATE 9

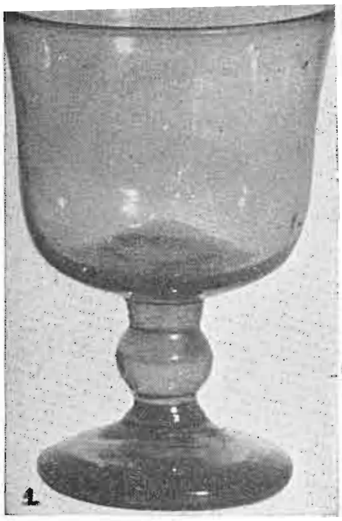
Text, pages 30 *and* 435.

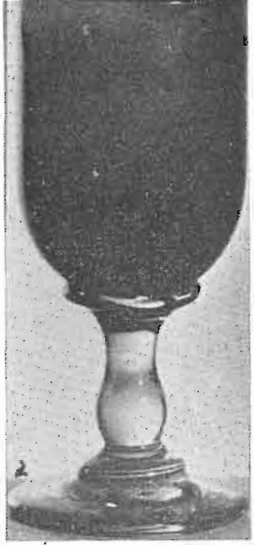


1. Bottle; sapphire blue; varicolored enameled decoration; type possibly made at Manheim. Height 7⅝". (Collection of the authors.) **2.** New England Glass Company goblet; bowl flashed with ruby glass; applied clear glass stem and foot. Height 9". (Collection of W. Griffin Gribbel.) **3.** Sandwich overlay toilet bottle; ruby and clear glass. Height 6¾". (Collection of Mrs. John MacMurtrie.) **4.** Cable creamer; clear glass with engraved floral design on amber (silver stain) panels. (Collection of the authors.) **5.** Toilet bottle; clear glass decorated with engraved grapevine band and red or ruby stain. (Collection of the authors.) **6.** Cologne bottle; clear glass decorated with ruby stain. (Collection of the authors.) **7.** Ashburton goblet; clear glass with gilt rim and leaf decoration; probably made by the New England Glass Company. (Collection of the authors.)

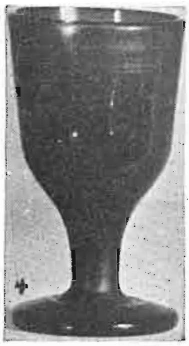
PLATE 11

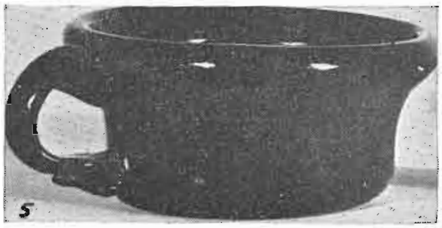
Text, pages 33 *and* 34.

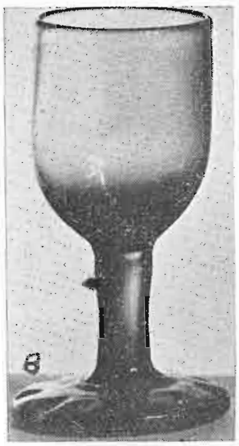


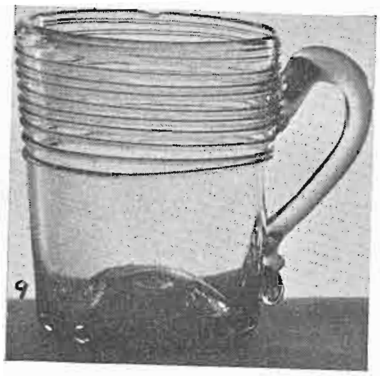


DRINKING VESSELS IN THE SOUTH JERSEY TRADITION FREE-BLOWN FROM BOTTLE GLASS









1. New York State goblet with applied knop stem and circular foot; early 19th century. Height 5¼″.

4. Wine glass; dark olive green; blown at the Saratoga (Mountain) glass house, 1844-1855. Height 3 15/16″.

7. New York State cup and saucer; aquamarine; circa 1830-1850. Overall height 3¾″.

2. South Jersey goblet; clear amber bowl, applied aquamarine stem and foot; probably early 19th century. Height 6⅝″.

5. Mug; dark olive-green (black); blown at the Saratoga (Mountain) glass house. Height 2⅜″.

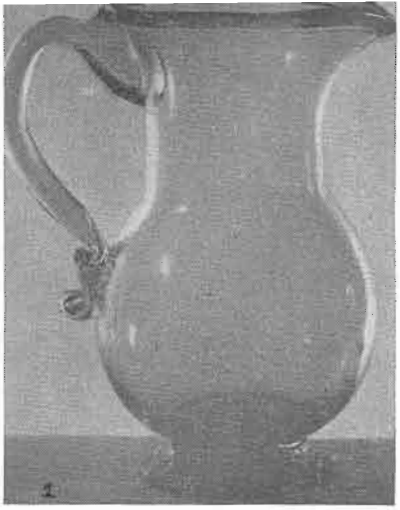
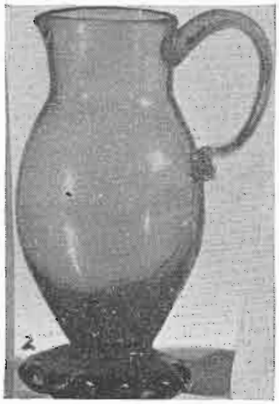
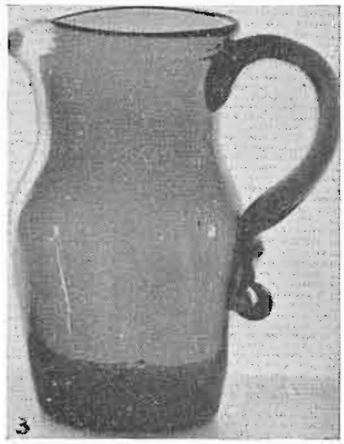
8. Wine glass with crimped foot; clear olive yellow; attributed to Lancaster, New York; circa 1850. Height 4⅝″.

3. Goblet of South Jersey type; light bluish aquamarine; early 19th century. Height 5¾″.

6. Wine with short air-twist stem; pale green; very rare; New York State; early 19th century. Height 4⅜″.

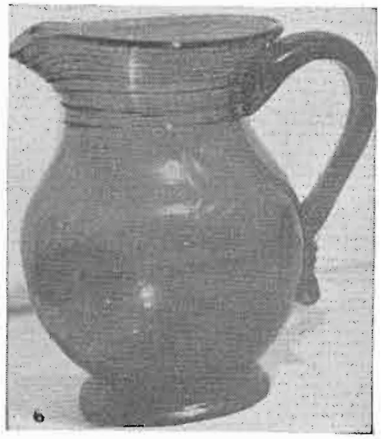
9. Mug, threaded at top; light green; attributed to Redford, New York, 1830-1851. Height 3⅝″.

Text, page 41; *also* 179.

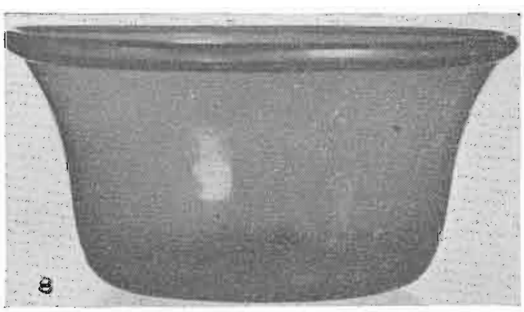
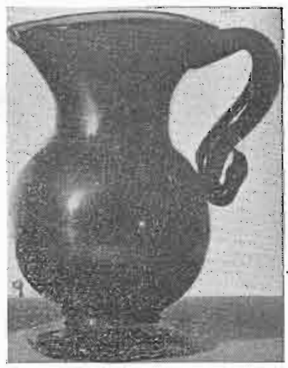




1. New York State blue-aquamarine pitcher with amber rim. Height 7″. **2.** Creamer of clear glass shading to pale amethyst in heavy scalloped foot; 18th century. Height 5¼″. **3.** Lockport clear blue pitcher; mid-19th century. Height 6″. (Nos. 1-3 collection of the authors.)





4. Clear green pitcher attributed to Suncook; 1839-1850. Height 6″. **5.** South Jersey type vase; 19th century. Height 5¾″. **6.** Ohio deep sapphire blue pitcher attributed to Zanesville; 1815-1850. Height 5″. (Nos. 4 and 5, privately owned; No. 6, collection of the authors.)

7. South Jersey clear cobalt blue creamer; double strap handle. Height 4½″. **8.** Connecticut sage green bowl, 19th century. Height 3½″; top diameter 7⅛″. **9.** South Jersey blue creamer with aquamarine crimped foot. Early 19th century. Height 4″. (Nos. 7 and 8 privately owned; No. 9 collection of the authors.)

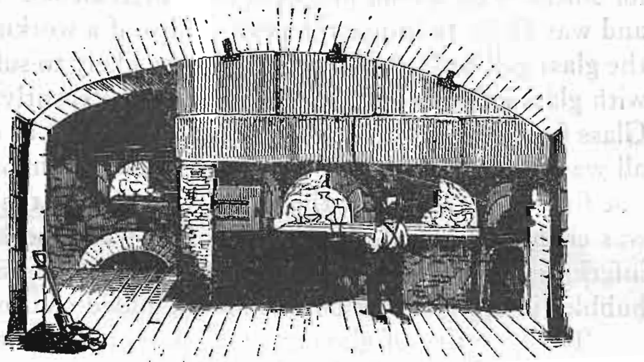
PLATE 13

Text, page 42; *also* 176.

into the flue, thence into the upper dome and chimney. In time, the chimney grew in height and diameter so that the furnace was conical in form. Also the subterranean vaults or caves were multiplied, providing a better draft system.

In 19th-century glass houses many improvements and economies were made through elaborate flue systems. In the United States, between the years 1815 and 1867, at least 16 patents for furnaces—both for construction and improvements—were taken out by our glass manufacturers.

Presumably about the same time that basement vaults or caves were introduced, the side leer (lehr) for annealing the finished glass vessels was added to the glassmaker's equipment. These leers, built about six feet above the floor of the glass house, were connected with the furnace near the top of the flues so that the flames and heat from the furnace provided the necessary heat for annealing the glass. However, this leer presented the same difficulty as the older annealing ovens; it was not possible to control properly either the heat or the smoke. About 1780, the low tunnel-shaped leer, made entirely separate from the working furnace and heated entirely or partially by its own fireplaces, was introduced. It is supposed to have been the invention of George Ensell of Wordsley, near Stourbridge, England. There is a possibility that he borrowed the idea while traveling in Germany, but he certainly invented it insofar as English glassmaking was concerned. In this leer the finished glass traveled in iron pans which were occasionally pushed along, moving from the heated, receiving end, to the discharging, or cool end. Later in the 19th century a mechanism was devised to move the pans at an even pace. (See note to Fig. 7)



Front view of the annealing arches, showing three sets of pans heating each with a separate fire, with the same cylindrical brick arches and cast-iron doors

Figure 7. From Pellatt's *Curiosities of Glass Making*, 1849.
Annealing arches, also called annealing ovens or leers, were open at each end. In the leer illustrated the iron pans holding the finished glass traveled on a sort of "miniature railroad," propelled by an endless chain running under the leer, and moved gradually from the heated—the receiving end—to the cool end, where the glass was discharged.

Another 19th-century innovation was the "glory hole," a very small furnace. The earliest mention of the glory hole which we have found was made by Pellatt in 1849. He spoke of this small furnace as having been used to reheat the finished glass before placing it in the annealing oven. Later, or perhaps at about the same time, it was used instead of the working furnace for the frequent reheatings of the glass during the processes of manipulation and in fire polishing. The latter was a reheating of a finished article in order to obliterate any marks left by tools or molds.

In the late 1880's, tank furnaces which had been in use in Germany for some years were experimented with in the United States. These furnaces, which instead of pots had tanks lined with the same material used to make pots, were to revolutionize the manufacture of window glass and cheap grades of bottles and jars. They made possible a large quantity production and a more uniform quality of metal. However, they have not completely displaced the pot furnaces. The latter will probably always be used for production of fine glass.

7. MELTING THE BATCH

Before the actual process of making glass could be started the furnaces and melting pots had to be prepared to receive the batch. First the fire was built to bring the furnace to the proper temperature and the pots were set on the siege facing the arches. When the pots had reached a white heat they were charged with the meticulously measured and mixed ingredients to which cullet—cleansed and broken glass—was usually added because it helped in the fusion. As the charge melted, its bulk decreased and more batch was added. This continued until the pot was fully charged, a period of 12 to 15 hours for large pots. The fire was then increased to raise the temperature to its highest point, about 2500 degrees Fahrenheit, and the opening of the arch was reduced by wet clay to a narrow aperture. Through this aperture the progress of the melting could be checked, any impurities rising to the surface removed, and samples withdrawn for testing.

The melting batch first became a pasty substance which liquefied gradually and lost its opacity by very slow degrees. Bubbles formed in the course of the melting carried glass gall to the surface. This glass gall, or sandever, which formed a white porous scum on the surface of the melting batch, was caused by salts, "impurities"—usually sulphates—present in the alkalis and having no affinity for silica, or by wrong proportions of ingredients. If not removed immediately, it became volatile and was likely to injure the pots. Also, if a workman introduced a wet iron into the metal before the glass gall had been removed, he was likely to suffer serious injuries, for water coming in contact with glass gall could cause an explosion. Recently, Mr. Frederick Carder, founder of the Steuben Glass factory and noted glass technologist, told us of an incident where a workman failing to heed all warnings against such an act was "blown almost across the factory." If any impurities were not fully expelled, or if the metal (vitrified batch) was incompletely melted, the resulting glass was clouded and full of bubbles. This was especially likely to happen in green glass made from inferior materials. But it must be confessed, in parenthesis, that to many of us, myriads of little bubbles in old globular bottles are an added charm.

The quantity of glass gall was proportionate to the impurity of the materials or the error in measuring them for the batch. However, when materials could be obtained in a sufficiently pure state, glass gall was not formed, at least not in injurious quantities. Under these conditions, after the pots were charged the arch could be completely stoppered up except for a small spy hole in the center through which progress of melting could be observed and samples withdrawn. When vitrification was complete, within about thirty to forty hours, the metal was in too fluid a state to be used, so the heat was lessened to about 1800 degrees. Then when the glass had thickened sufficiently, the working hole was opened and the fascinating operations of fashioning glass articles could begin.

8. TOOLS AND EQUIPMENT FOR FABRICATING GLASS

Unlike gold or wood, also mediums of the artists but created by nature, glass—as we have seen—is the result of a chemical process. And in only one stage in that process will it bend to the blower's will—in the state where it is plastic passing from a liquid to a solid. As an artist's medium, glass demanded certain tools; man found them. Yet demanding as glass is in its only workable state, in the hands of the skilled blower it is the most responsive of mediums—provided he keeps within the bounds it sets. The tools he uses in his art are simple in form and few in number. Only three of them are absolutely essential in order to form a simple object. They are the blowpipe, the pontil or punty rod or a similar holding device, and a tool for shaping. The others are essential only in that they extend the possibilities of design and manipulation. In a thousand years there have been only minor changes and but few additions to their number. The essential tools and some of the accessory equipment used in the art of glass blowing are shown in Fig. 9.

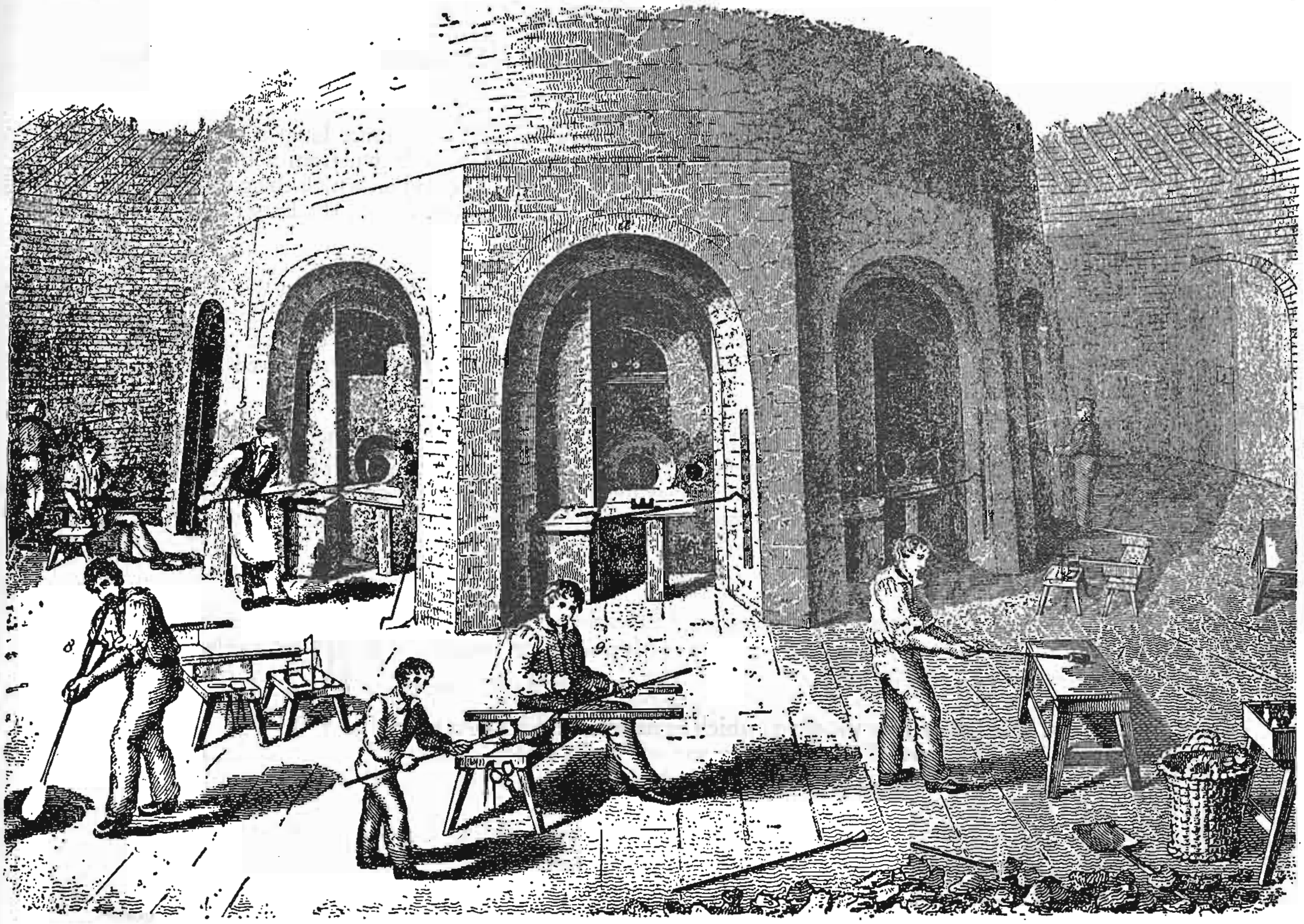


Fig. 1. FLINT-GLASS MANUFACTORY

Figure 8. From the Encyclopaedia Britannica, A dictionary of Art, Sciences and General Literature, Vol. X, 1894; furnished by Charles B. Gardner.
Interior of a 19th-century glass house of later type than that shown by Pellatt. The top of the furnace is missing in the illustration, but the furnace was probably of the conical type.

1. Blower at the chair is opening the top of a vessel with the pucellas.
2. The workman has inserted an iron into the working aperture at the right of which the nose or bye holes can be seen.
3. A blower is inflating a gather.
4. A gaffer is holding the blowpipe, on which is a partially finished stemmed vessel, to the foot of which an assistant is attaching a pontil.
5. Another workman is rolling a gather on a marver.
6. Coal for the fire can be seen in the foreground. Glass houses were not often clean places. When the fire was stoked from the factory floor level the fuel was kept in heaps on the floor, a condition which prevailed in many houses even into the 20th century.

"snap." Spring clips of various types were used especially to hold stemmed ware. One type was attached to the punty rod, others were complete tools in themselves having a spring which was inside a long hollow iron rod which operated the clip for the foot. The snap case is supposed to have been a "Yankee gadget" invented around 1850. It had vertical arms curving from stems and could be tightened by slipping a clip or ring far enough up the stems to hold the arms in place after they had received the object but not so tight that the arms would leave a mark on the soft glass.

Two other important pieces of glass house equipment used in blowing glass are the marver (Fig. 10) and the Chair (Fig. 11). After the workman has secured a gather on his blowpipe he rolls it on the polished surface of the marver to give it a preliminary form and an even surface so that in expansion the metal will have a uniform thickness. The Chair is used principally by the gaffer (master blower) who performs the operation of actually shaping the object—the operation which calls for the greatest skill and dexterity. Resting his blowpipe on the slanting arms of the chair he keeps turning the iron with his left hand, and with his right hand he shapes the object with his tools and frequently applies decoration such as threading. His wooden chair, humble and crude in appearance, was perfectly adapted to his purposes. The metal band along the top edges of the arms and the downward slant of the arms facilitate the necessary trundling of the blowpipe; the long broad seat provides a handy place to rest the tools needed on a moment's notice, and its right side, a place to hang some of them near at hand.

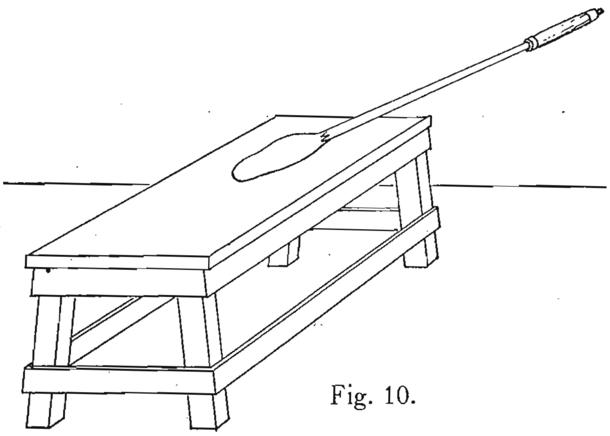


Fig. 10.

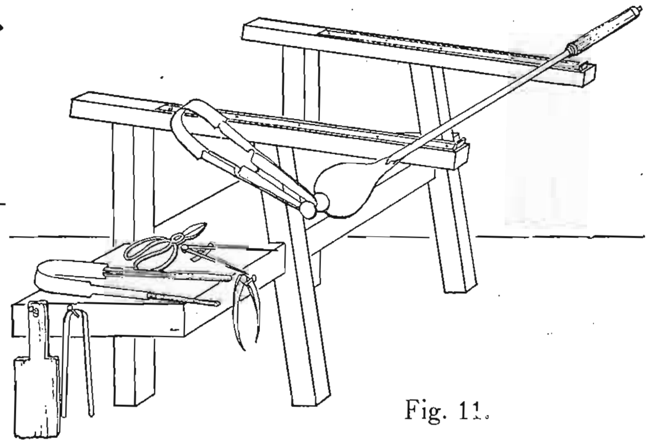


Fig. 11.

Figure 10. Marver, polished metal slab supported by a frame. Blowpipe with gather which is being rolled on the marver.
Figure 11. Glass blower's chair, wood, metal strips on top of slanting arms across which the blowpipe or pontil is laid and rotated during the processes of manipulation. Tools are placed on the broad seat and hung along the right end.

9. METHODS OF FABRICATION

Practically all the glass articles with which we are concerned, if classified according to the method of their manufacture, would fall into one of three main categories which, as usually termed by glassmakers, are *blown glass*, *molded glass*, and *pressed glass*. Blown glass is usually referred to as hand-blown, free-blown and off-hand-blown. Any piece so called was formed by blowing and manipulation, with the tools of the craft and without the aid of molds to give a decorative pattern or either a partial or complete final body form.

The workers in glass houses were divided into groups called shops. Each shop consisted of a gaffer, the master blower, and his assistants; at least a gatherer, a servitor who formed the parison, and a boy who was usually an apprentice in the craft, plus others if the nature of the work required more. The gaffer supervised all steps in fabrication, performed the delicate operation of final shaping and finishing and was responsible for keeping the output of his shop up to the standard of the glass house.

A. Blown Glass

Seeing is understanding as well as believing. It is particularly true in the art of glass blowing. If every collector could watch a shop blowing glass he would have a deeper appreciation of the glass he collects. However, since such an opportunity is not available to everyone, the steps in blowing and shaping a pitcher with stem and foot have been illustrated. (Fig. 12) A pitcher of this type was chosen because it illustrates so many operations.

While following the various steps it is necessary to remember two things; that the glass can be manipulated only when it is pliable and that the shape must be kept symmetrical. Consequently, during manipulation the blowpipe, and pontil when in use, must be kept in almost constant rotation. Also the glass has to be frequently reheated at the working hole, or at the glory hole, throughout the entire process. To know just when it has so cooled that reheating is necessary is part of the art. And, incidentally, the metal is literally red hot so that when wooden tools are used the wood is charred on contact with the glass.

At every step after the "puff" our imaginary blower could have done quite different things. For instance, he might have plunged the gather into a ribbed mold such as Fig. 9, No. 11, to impress a design of ribs on the plastic metal. Or, after flattening the end of the parison he could have attached the pontil and formed a bottle or some other stemless object. He could have omitted the stem or, after whetting the glass from the blowpipe, instead of shearing away metal to form the rim of the pitcher, he could have spread the neck and formed a vase, or widened the body to form a bowl or compote. If he wished to give the compote or vase a gauffered rim he would have pressed the straight edge of the piece, depending from the pontil held in a vertical position, down upon the crimper (Fig. 9, No. 14).

B. Molded Glass

Molded glass is usually called blown-molded by most collectors as it obviates any confusion between glass blown in a mold and that pressed in a mold. The molds are of two types; dip molds which are in one piece open at the top and piece molds which are comprised of hinged pieces or leaves. But there are several varieties of each type. Glass may be molded for shape only, either blown in a dip mold or open-top mold to give body shape, as wine bottles like Nos. 12 or 15 A and B, or in a full-size piece mold (Fig. 14) for entire shape like No. 13, Plates 221 and 222. Molded glass may be pattern-molded, that is, the gathering may be blown or rammed in a shallow or deep dip mold or in a part-size piece mold having an intaglio pattern or design cut on the inner surface. (See Fig. 9, No. 11 and Fig. 13.) After the gather has been impressed with the pattern it is then withdrawn, expanded, and the piece finished by the off-hand technique. Full-size piece molds are used for both form and pattern. This generalization, like all others, is rendered false by exceptions, such as Blown Three Mold dishes or bowls which were blown in decanter and flip molds for pattern and finished by hand. However, this was not generally practiced except in the manufacture of some Blown Three Mold articles.

Since there seems to be some confusion in regard to "pillar moulding," it demands some explanation. Apsley Pellatt gives a very clear description of it in his *Curiosities of Glass Making*. The mold used was a part-size open-top mold about one-third of the size of the object to be formed and was, as shown in his illustration, cut with deeper, broader and more rounded flutes than the molds used, for instance, for Pitkin type flasks or Stiegel type creamers. Two gatherings were used as in the old German post method of bottle blowing of which our Pitkins are an illustration, but the first gathering was allowed "to cool to a greater degree of hardness than usual." After the second gather was secured the whole was pressed into the mold as soon as possible so that the outer coating only received an impression of the design and the interior remained smooth.

Pressing in this sense means that the blower holding the blowpipe in a vertical position plunged the gather into the mold. When the gather was withdrawn from the mold it was inflated and at that moment or immediately afterward, the projecting "pillars" formed in the mold had "a centrifugal enlargement given to them by a sharp trundling of the iron." Shortly before 1850, this process was patented by an Englishman, James Green, as a modern invention but, as Pellatt points out, these projecting "pillars" and mode of their formation were known to the Romans. Actually, "pillar moulding" is only what we call pattern-molding but in a particular type of mold and design. Therefore, it is not an isolated technique but a type of pattern-molding which is a subdivision of the molded or blown-molded.

The third and last principal use of molds was for both pattern and shape through the use of full-size molds—that is, molds the approximate size of the finished article—composed of two or more pieces or leaves with the design or pattern chipped on the inside. The introduction of this type of mold by the Romans has already been mentioned. After that early period it seems to have disappeared for many years from the glass blower's equipment. Presumably, the full-size piece mold reappeared in the late 18th century, being used to *shape* bottles. However, it seems fairly well established that this type of mold with a pattern or design cut on the inside was not used in our glass houses until after 1800, probably not before 1815. All Blown Three Mold glass and the historical and pictorial whiskey flasks were blown in this type of mold which was operated by a foot pedal or by an assistant.

Figure 12—Blowing and Fashioning a Pitcher with Stem and Foot

No. 1. A workman passes the blowpipe through the arch in the furnace wall and inserts it into the hooded pot containing the red-hot metal. By twisting the pipe a gathering of metal is secured on the end. That accomplished, he withdraws the pipe. If the gather is not sufficient for the intended object it is allowed to cool, almost imperceptibly, and the operation repeated until the required amount of metal has been gathered.

No. 2. Then the workman rolls the blob of metal on the polished marver to give it its preliminary form and an even surface. (See also Fig. 10.)

No. 3. He then introduces the "puff," that is, blows lightly through the pipe forming a small pocket of air. At this point he may pass the pipe and gather over to the servitor who by swinging the blowpipe back and forth like a pendulum or rapidly around, held in a vertical position, elongates the gather.

No. 4. The gather is further expanded by blowing and the end turned in the wet block to aid in obtaining and retaining its symmetry. From this point on the inflated gather is called the parison, or "blow," and the ensuing manipulation is performed by the gaffer at the chair.

No. 5. With the tool or pucellas the parison is constricted below the end of the blowpipe, producing a pear shape.

No. 6. The end of the parison is flattened and smoothed with the battledore.

No. 7. In the meantime an assistant has secured a glob of metal on the end of a pontil or punty rod. The parison is elevated to a nearly vertical position to receive the glob of glass for the stem which drips on from the pontil, and the necessary amount of glass is cut off with the large shears.

No. 8. The pipe is again rested on the arms of the chair and rotated while the gaffer elongates or shapes the glob of glass with the pucellas or the Tool, forming a short stem.

No. 9. The parison is again elevated and receives, as before, a glob of glass from which the foot is to be formed.

No. 10. A glob of glass is compressed or extended in a disc form by the use of a clapper. This tool is made of two pieces of wood hinged together. The left hand part, which the gaffer operates with thumb pressure, has a semicircular opening so that the glass can be inserted.

No. 11. The foot is further leveled and smoothed with the battledore.