

Colbert and the King, Les Gentilhommes-Verriers

Style à la Versaille, Venetian Artisans, and French Innovations in Plate Glass Production

Ana Matisse Donefer-Hickie

The origin of technical innovations in craft industries are often told by scholars as narratives of an inventor or craftsman as a hero figure; an innovation in technology is attributed solely to the genius of a single individual, at a single moment. In the case of the revolutionary invention of plate glass casting in 17th century France, however, the more interesting tale is not one of a single individual, but one more ambitious in scope. Indeed Bernard Perrot, the individual to whom plate glass technology is attributed, plays a comparatively small role in the conditions that led to its invention in 1673.¹ Despite his connection to its invention, the King forbade Perrot in March 1696 to use his plate glass casting technique in his crystal shop at Orléans.² It is the King himself, Louis XIV, and his Minister of Finance from 1665-1668 Jean-Baptiste Colbert, who created the conditions necessary for the triumph of plate glass casting technology. Their total control of both the aesthetic concerns shaping the market demands of the plate glass industry and the condition of the industry itself created a context in which the invention of plate glass casting became a near inevitability.

Before the invention of plate glass, sheets of glass for mirrors and windows were made using either crown or broad glass methods. Both of these, however, created problems for Louis XIV and Colbert; first, crown and broad glass limit the size of mirrors that can be produced. As larger mirrors became more desirable, this limitation became more and more frustrating to both consumers and producers of plate glass. In addition, both methods were imported from outside France. In particular, only artisans from Venice, its country of origin, possessed the skills for making crown glass. Colbert spent much of his term as Minister grappling with these problems, encouraging Venetian master glassworkers to immigrate to France and creating a centralized glass manufacturing company. From 1665 until 1687, the French glass industry was regulated by the monarchy's taste in interior design but dependent upon the techniques of foreign masters who would not teach their techniques to French artisans. The invention of plate glass casting came not only as a boon to the industry, but as a relief to the social and political tension created by reliance on foreign manufacturers. Plate glass casting was not the result of dynamic technical discovery within the industry as much as it was the culmination of social, economic, and political conditions within 17th century France.

¹ George Savage, *French Decorative Art 1638-1793* (London: Allan Lane The Penguin Press, 1969), 129.

² Warren C. Scoville, *Capitalism and French Glassmaking, 1640-1789* (Berkeley: University of California Press, 1950), 32.

Over the course of his reign the Sun King gained total control over almost every facet of France's decorative arts industry. The painting, sculpture, tapestry, lace, gilding, metalwork, and most pertinently glass industries were left in the hands of Jean-Baptiste Colbert. Both Louis and Colbert "intended that art should reflect the glory of France," and so upon his appointment as controller general of French Finance in 1665, Colbert began a reconstruction of the French economy by centralizing and organizing industry.³ Under Colbert, "artists, writers, painters, poets, and astronomers received pensions from the government to produce works or to make discoveries that would reflect favourably on the regime."⁴ In order to maintain "tight control over artistic life in France," Colbert established several Academies and Companies, each placed under the control of a single artisan or nobleman.⁵ The Academy of Painting and Sculpture (established 1663), for example, was placed under "Le Brun's "despotic" direction... [and] maintained a near monopoly of education in those arts."⁶ Thus the arts were brought "almost completely under Colbert's domination, and therefore that of the King, and uniformity of taste was in great measure achieved throughout France, especially in the larger cities."⁷ The aesthetic taste that dictated the prosperity of the decorative arts industry was controlled by, and thus indistinguishable from, the taste of the King.

Louis XIV's taste in decorative art has been designated 'style à la Versailles', after the King's lavish palace outside of Paris. The style was known for its opulence and attention to detail. Artisans focused on both the size and intricacy of decoration on architecture and household items, and this was perhaps most apparent in the style of mirrors exhibited at Versailles. The mirrors of the Louis XIV period were large and square, composed of several small panes inserted in intricately carved frames and separated by pilasters of bronze.⁸ Though it was not completed until 1679, the mirrors used in the Galerie des Glaces, the most famous example of Louis XIV style, were imported from Venice before the dominance of plate glass casting techniques, and were thus most likely made with crown glass.⁹ Designed by royal architect Jules Hardouin Mansart, the mirrors of the Galerie des Glaces are the best example of mirrors in the Louis XIV style made before the invention of plate glass casting.¹⁰ The largest Salon in the palace at 235 feet long, 30 feet wide, and with a height of 43 feet, the Galerie des Glaces was on display to anyone who wished audience with the King; it was "where the Court foregathered, and for which no special *entrée* was necessary."¹¹ Anyone, peasant or prince, could see their image reflected in the mirrors of the Galerie. Between one wall of mirrors and one wall of windows, visitors to the Galerie were enveloped in glass, and faced their own reflections everywhere they turned.

Even foreign visitors to Versailles remarked on the beauty of such an extensive collection of mirrors. Though, "until the eighteenth century window-panes were small, the surface irregular,

³ Savage, *French Decorative Art*, 3; Warren C. Scoville, *Capitalism and French Glassmaking*, 4.

⁴ Andrew Trout, *Jean-Baptiste Colbert* (Boston: G.K. Hall & Co., 1978), 179.

⁵ Trout, *Colbert*, 186.

⁶ *Ibid.*, 182.

⁷ Savage, *French Decorative Art*, 5.

⁸ Catherine Oglesby, *French Provincial Decorative Art* (New York: Charles Scribner's Sons, 1951), 134; Savage, *French Decorative Art*, 22.

⁹ Charles Woolsey Cole, *Colbert and a Century of French Mercantilism* (New York: Columbia University Press, 1939), 310. Colbert had them brought to France right before he effectively ceased importation of Venetian mirrors by increasing their import tax in 1667.

¹⁰ Savage, *French Decorative Art*, 128.

¹¹ *Ibid.*, 22.

and the glass... set in numerous glazing bars,” even in the 17th century mirrors and windows were an important and memorable part of life in the French court.¹² Though unimpressed with other marvels, upon his visit to Versailles in 1755 English gentleman A.R. thought “the royal Apartments... grand, more especially the long Gallery, which is superb, and about two hundred Feet in Length; it is ornamented with large Pannels of Glass, instead of Wainscot or Tapestry.”¹³ Even in the 18th century, when mirrors of high quality were comparatively easy to attain, the Galerie des Glaces was a marvel to visitors of Versailles. Expensive both to import and manufacture, mirrors were an indication of Louis XIV’s wealth and power, and by extension, anyone who owned a large mirror claimed for themselves some of the glory of their monarch. The glory and grandeur of the Galerie des Glaces indicates the importance of mirrors to high ranking French society; the more times you saw yourself in a courtier’s chateau, the greater their wealth and power.

Mirrors such as those composing the Galerie des Glaces, manufactured before the invention of plate glass casting, were made using two similar techniques, depicted in the engravings of *L’Encyclopedie, ou Dictionnaire Raisonné des Sciences, des Arts et des Métiers*, a compendium of manufacturing techniques compiled over the course of the 17th and into the 18th century by Denis Diderot. These images, several of which are included as appendices to this paper, provide excellent insight into the techniques used in 17th century mirror production. The most common method of producing glass plates in the early 17th century was a technique characteristic of Bohemian and German glasshouses, called ‘broad’ or ‘German sheet’ glass. Primarily used in the regions of Alsace and Lorraine, broad glass plates began as a small gather of molten glass on the end of a hollow pipe. This was shaped into a cylinder of roughly constant diameter, and transferred to a pontil.¹⁴ The cylinder would then be slit lengthwise with shears, creating a sheet of about 36 by 48 inches.¹⁵ The glass was then laid flat on a table and transferred to an annealing oven. This began the long process of hardening that occurs when glass is cooled slowly. Since broad glass plates began as vessels, their size was limited to what could be safely handled by an artisan working alone. In addition, broad glass had to be extensively polished before the silvering agents could be applied or the glass could be used for windows. Since it was rolled out on a flat surface and manipulated with iron and wooden tools before annealing, broad glass bore the marks of its manufacture after it was removed from the oven. Panes made by this method were used for common window glass or mirrors of lower or average quality.

Most desirable for the clarity of their glass, the best mirrors made prior to 1687 used panes of crown glass. The crown glass technique consistently produced small, clear panes ideally suited for the manufacture of small mirrors and windows. Similar to broad glass, an artisan gathered glass on the end of a hollow pipe and formed it into a cone, shaping it with his breath, the heat of the furnace, and iron tools.¹⁶ Then the piece was transferred to a pontil, and the mouth of the vessel opened and softened in the heat of the furnace. Spun rapidly, using the centrifugal force of the materials weight, the vessel was flared first into a shallow bell shape and then into a flat disk, attached at the centre to the pontil.¹⁷ Before they cooled, these large circular sheets were placed on a bed of sand and the pontil detached before they were placed in the annealing oven. Once they were cooled, the crowns, never more than forty-eight inches in diameter, were cut into smaller

¹² Savage, *French Decorative Art*, 128.

¹³ A.R., *The curiosities of Paris in nine letters* (London: printed for W. Owen, 1760), 154.

¹⁴ A solid iron rod used to handle the glass once the artisan has finished blowing.

¹⁵ See Figure 1, Diderot, plate 252.

¹⁶ See Figure 2.

¹⁷ See Figure 3.

squares, silvered, and assembled in large and ornately carved frames.¹⁸ Since they were spun and not tooled flat onto a marver,¹⁹ crown glass disks were not marred by tool marks like the sheets produced by broad glass.

Though crown glass mirrors were far clearer than any other kind of reflector, the techniques used to produce them were difficult for French artisans to obtain. While native Frenchmen using German and Bohemian techniques manned the broad glassworks of Lorraine and Alsace, the only artisans capable of manufacturing crown glass were those of the Venetian island of Murano. In 1665, Colbert invited several Venetian craftsmen to France in an attempt to increase French production of crown glass and to reach economic independence in the plate-glass industry. Tired of relying on Venice for the import of high quality mirrors, Colbert set up the Manufacture Royale des Glaces, a French company that would employ the Venetian artisans.

The company was issued a patent by the King in October of 1665, securing them the exclusive rights “to silver mirrors and to make plate... glass for a period of twenty years.”²⁰ Before bringing workers from Venice, “Colbert had selected Nicolas du Noyer to be the central figure in the new company.”²¹ A wealthy nobleman who had previously engaged in glassmaking experiments, du Noyer was to finance and direct the Manufacture Royale during its early years. Du Noyer, however, did not have the expertise necessary to produce high quality crown glass. Without the participation of Venetian artisans, Colbert, du Noyer, and the Manufacture Royale des Glaces had no hope of rivalling the output and quality of Venetian glasshouses and, given the rising popularity of mirrors as “an article for the decoration both of boudoirs and reception rooms,” no hope of arresting French dependence on Venetian imports.²² In creating a company and granting them exclusive rights to manufacture, Louis XIV and Colbert gained complete control over the French mirror industry. They could not support it, however, without the expertise of Venetian artisans.

Obtaining Venetians willing to work on French soil was not easy for Colbert. Venetian authorities were anxious to keep their workers secrets, and the monopoly on mirror production, within their own borders. Through Piero de Bonzi, the French ambassador at Venice, Colbert learned that there were few truly skilled mirror-makers, and the Venetian government had strict laws preventing their emigration. If workers attempted to leave Venice they were, “likely to loose [their] property or even [their] life and to subject [their families] to retaliation.”²³ Not only was Colbert forced to offer the Venetian glassworkers large sums of money to entice them to France, he had to protect them and their families from the Venetian authorities, whose ambassadors attempted everything in their power to reclaim their artisans.²⁴ Despite these obstacles, by 1666 Colbert had convinced at least four skilled artisans to stay in Paris and establish themselves in the glassworks of the Manufacture Royale des Glaces. Thus Antonio de la Rivetta, Civrano, Barbini, and Morasse were contracted to remain in France for 4 years, at a cost to the Crown of over 3250 *livres per annum*.²⁵

The vast sums expended by the Crown in the interest of the French mirror industry reflect its unusually high status in French society. As artisans, the Venetian mirror makers were granted

¹⁸ Diderot, plate 235.

¹⁹ The metal table used to shape and lay out glass.

²⁰ Scoville, *Capitalism and French Glass*, 28.

²¹ Cole, *Colbert and a Century of French Mercantilism*, 308-9.

²² *Ibid.*, 304.

²³ *Ibid.*

²⁴ *Ibid.*, 305.

²⁵ *Ibid.*, 304.

the same status as French citizens. In addition to presents of money, Colbert assured the artisans his political protection and provided housing and pensions for their wives and children.²⁶ When Louis XIV visited the mirror works in 1666, he “showed great interest in the operations and skill of the Italians and had Colbert make them presents of money on the spot.”²⁷ If the Venetian artisans were treated well by Colbert and Louis XIV, the French entrepreneurs were treated almost as family. Du Noyer and his associates did not impair their noble status by becoming directors of a manufacturing company, but “were to have the privileges of members of the royal household and were to be exempt from all taxes and duties, including the *taille*.”²⁸ Though in effect they were artisans and merchants, the Crown bestowed favour on both the Venetians and the directors of the Manufacture appropriate to high-ranking ambassadors and noblemen. They were not simply *ouvriers*²⁹, but *gentilhommes-verriers* – gentlemen glassworkers.

Despite the privileges granted by the French crown to Venetian mirror-makers, they maintained their silence, and the secrets of Venetian craft were not shared with French glassmakers. Early in 1666, newly appointed Venetian ambassador Giustiniani, persuaded the workers “to promise not to teach their secrets to anyone,” and indeed during their time in France few Venetians took on French apprentices.³⁰ Ultimately, it was this silence that ended the dominance of Venetian craftsmen in French industry. By 1667, Colbert had effectively ceased importation of mirrors made in Venice by increasing their import tax in a sliding scale according to size. The larger the mirror, the more expensive it was to import.³¹ The economy of the French glass industry now depended solely on the output of the Manufacture Royale des Glaces, which employed almost exclusively Venetian *gentilhommes-glaciers* and French *ouvriers* who did not have the specialized skills of the Venetians. By 1670, most Venetian *gentilhommes-glaciers* had returned home, and they had caused so much trouble and cost so much money to the Crown, Colbert was not sorry to see them go.³² The broad glass method made inferior, small mirrors; without the quality granted by crown glass, small mirrors were hardly worth manufacturing. In maintaining their silence, the Venetian craftspeople ensured that Colbert would have to look elsewhere for glass of the same quality as crown.

The solution to the twin problems of inferior mirror quality and size came from an unlikely source. Granted a royal privilege for the manufacture and sale of glassware to cities on the Loire from Nevers to Poitiers in 1661, Jean Castellan and his nephew Bernard Perrot engaged in experiments on glassmaking techniques, obtaining patents for various inventions from 1662 until 1673.³³ Having sent him several presents of glassware, the pair quickly gained Colbert’s favour. On April 22 1673, Perrot received royal privilege to make glass sheets larger than 40 inches.³⁴ Until his invention, the Manufacture Royale was the only company authorized to make mirrors, but since they could not manufacture anything over 40 inches, Perrot’s patent did not interfere with the company’s privileges. Even so, Perrot’s glassworks only retained his patent for 20 years before it was absorbed into the Manufacture, and became the dominant technique for large-scale

²⁶ Cole, *Colbert and a Century of French Mercantilism*, 309.

²⁷ *Ibid.*, 306.

²⁸ *Ibid.*, 310.

²⁹ Common workers.

³⁰ Cole, *Colbert and a Century of French Mercantilism*, 306.

³¹ *Ibid.*, 310.

³² *Ibid.*, 308.

³³ *Ibid.*, 317.

³⁴ *Ibid.*, 318.

manufacture of plate glass. Over the course of their careers, Perrot and his uncle enjoyed Colbert's particular favour. As a result of earlier experiments with furnace fuel in 1666, "Perrot was styled a gentleman, and it was provided that his activity in manufacturing... should not impair his status as such."³⁵ Having gained the privileges of Colbert's favour before his invention of plate glass casting, Perrot was able to gain patent for his invention within the framework of the Minister's centralized industry. Colbert's complete control of the industry made it possible for Perrot to experiment in a successful glasshouse; glasshouses without patents granted by the King were shut down to maintain the monopoly of the Manufacture Royale des Glaces. Without the favour of Colbert, Perrot's invention of plate glass casting would have been impossible.

More efficient than both crown and broad glass techniques, plate glass casting relies not on manipulating blown vessels, but on pouring molten glass directly onto large copper sheets. Workers would place large square ladles into the furnace next to a pot of molten glass, and transfer the glass from pot to ladle with large iron dippers through a small hole in the furnace door. When full, the ladle would be removed by means of a hand-held chariot like device.³⁶ The carriage, a pair of pincers attached to two wheels and a wooden handle, was manned by two or three workers and used to transport the heavy ladles. Workers moved quickly, as the glass had to remain molten long enough to be poured into the waiting copper plates.³⁷ Hoisted into the air on iron chains, the ladle was suspended from the ceiling above the casting plates. The largest of the casting plates employed at St. Gobain before 1750 was 116 inches long, 70 wide and 3²³ thick. A table of that size required between nine and eleven tonnes of pure copper for its manufacture.³⁸ The casting tables were attached directly to an annealing furnace so that they could be wheeled in as quickly as possible. While two workmen tipped the ladle to pour the hot glass onto the plate, six others pushed it flat under a large copper roller, while one assistant smoothed imperfections with a flat metal broom. Once the glass was smoothed, the copper table was rolled on metal wheels into the annealing oven. The workshop pictured in Figure 5 has at least four tables, probably used on a rotating basis as the individual sheets cooled.

While they were larger than anything possible with blown methods, cooled sheets of glass produced by casting were far from perfect. The large amounts of copper used to manufacture the sheets and rollers meant that they were expensive to make, and therefore difficult to obtain. Depending on their size, tables cost anywhere from 8, 250 to 24, 200 *livres*.³⁹ In addition, the annealing ovens, built according to the size of individual tables, were specially manufactured for individual glasshouses. At St. Gobain, the equipment that the glassworkers used was valued at 322, 903 *livres*.⁴⁰ The cost of the equipment, however, was made up for by both the increased output of large glass sheets and the reduced pay of the *ouvriers*. Instead of a few *gentilshommes-verriers* blowing sheets by crown or broad glass methods, glasshouses using cast plate techniques could employ several relatively unskilled *ouvriers*, sometimes even children. The lump sum cost of setting up plate glass casting tables paled in comparison to the exorbitant sums spent on the upkeep of Venetian masters.

Besides the high one-time cost of equipping a glasshouse with casting tables, cast plate glass was not as clear as crown, so its production required more resources designated to polishing. Since

³⁵ Cole, *Colbert and a Century of French Mercantilism*, 317.

³⁶ See Figure 4.

³⁷ See Figure 5.

³⁸ Scoville, *Capitalism and French Glassmaking*, 40-1.

³⁹ *Ibid.*, 41.

⁴⁰ *Ibid.*, 41.

they were manipulated by metal tools and cooled while in contact with copper tables, cast sheets were muddied by tool marks. They needed extensive polishing before speculum metal⁴¹ could be applied as a silvering agent. After the adoption of plate glass casting by the Manufacture Royale des Glaces in 1695, the polishing plant became nearly as important as the glasshouse itself.⁴² Though their glasshouse moved from St. Antoine to Tourlville and to St. Gobain, the Manufacture retained and converted their original property to a finishing plant.⁴³ To polish broad plates after the annealing process, artisans furbished the surface of the glass with felt affixed to jointed ribs to maintain constant pressure, and then removed remnants of grit with silk brushes.⁴⁴ This could take the work of several *ouvriers* over several days, and was punishing on both the felt and the workers. These disadvantages, however, could not stop the wide spread adoption of plate glass casting technology, simply because the mirrors it produced were significantly larger than any made before.

Like the mirrors that impressed A.R. at Versailles, the large mirrors produced using plate glass casting technology during the late 17th century bewildered visitors to France. During his 1698 visit to the glassworks at St. Gobain, Englishman Martin Lister remarked:

'Tis certainly a most considerable addition to the Glass-making; for I saw here one Looking-Glass foiled and finished, eighty-eight Inches long, and forty eight Inches broad; and yet but one quarter of an Inch thick. This, I think, could never be effected by the Blast of any Man; but I suppose to be run or cast upon Sand, as Lead is; which yet, I confess, the toughness of Glass metal makes very much against.⁴⁵

At 88 by 48 inches broad and not even a quarter inch thick, the mirror so amazed Martin Lister that he recognized the value of plate glass casting to the glass industry, even though he was not privy to the specifics of the technology. He immediately recognizes that the mirror is far larger than those produced by crown or broad glass techniques, and though he knows that mirrors of such a size cannot be made by either blown method he can only guess how they were produced. The Venetian penchant for secrecy in the glasshouse passed to the French plate-glass *ouvriers*. Instead of protecting individual skill, however, the secrecy of the plate-glass workers protected their technology. Though unable to discover how such a large mirror was manufactured, Lister is impressed by the mirror he sees at St. Gobain because its large size is unprecedented.

The most desirable attribute of plate glass mirrors was their size. The Style à la Versailles epitomized in the Hall of Mirrors called for large mirrors, and as soon as the technology was perfected mirrors made by plate glass casting were used in Louis XIV's final improvements to Versailles. The number of mirrors in each room was increased with the introduction of 'the French fireplace,' a design arrangement in which "the overmantel is formed by three juxtaposed sheets of mirror."⁴⁶ Both before and after the adoption of plate glass casting technology, the taste in interior design set by the King and adopted by the aristocracy meant that "mirrors were seen in every room of an apartment, and they became a standard in French-style interior architecture."⁴⁷

⁴¹ An amalgam of tin and mercury. Diderot plate 255, 256.

⁴² Scoville, *Capitalism*, 40.

⁴³ *Ibid.*, 28-9.

⁴⁴ See Figure 4.

⁴⁵ Martin Lister, *A Journey to Paris in the Year 1698* (London: printed for Jacob Tonson, 1699), 142.

⁴⁶ Felipe Chaimovich, "Mirrors of Society", in *Visual Resources: An International Journal of Documentation* 24:4 (2008): 357.

⁴⁷ Chaimovich, "Mirrors of Society", 353.

Large mirrors were ubiquitous in the French court; they pervaded every room of Versailles, and quickly became synonymous with the majesty of Louis XIV.

In their centralization of France's aesthetic industry, Louis XIV and Colbert sought to reflect the glory of the King's reign in the output of ever more glorious and arresting aesthetic objects. In control of both The Academy of Painting and Sculpture and the Manufacture Royale des Glaces through Colbert, Louis XIV dictated the way both paintings and mirrors were used in interior design. Between the start of his reign in 1643 and its end in 1715, mirrors, which were particularly favoured by the King, began to usurp historical paintings as the preferred interior wall decoration of French nobility. While historical pictures glorify the exploits of past monarchs and military heroes, by reflecting contemporary monarchs and nobility, "flat mirrors on the walls of apartment rooms were *pictures* of the history of the reign of Louis XIV."⁴⁸ Mirrors were the most effective way to glorify Louis XIV during every instant of his reign. Reflected in the many mirrors of Versailles, Louis XIV and his courtiers took the place of rulers of the past, subsuming past achievements under their own splendour. The larger and more perfect the mirror, the more glory is conveyed upon its reflected inhabitants.

Louis XIV's desire for larger, more perfect mirrors in which to reflect his court drove both the decorative arts style of 17th century France and the industry that provided for it. Louis XIV, and by extension the rest of the French court, sought to glorify his reign by reflecting it in large, clear mirrors, unbroken by bronze pilasters. While Louis XIV homogenized the aesthetic tastes of the market, his agent Colbert centralized and organized the industry that was to supply them. The creation of the Manufacture Royale des Glaces and the strict regulation of patents allowing the production of broad, crown, and cast plate glass, ensured that only those who had the favour of the King could produce glass for him and his courtiers. First Venetian artisans expert in the production of crown glass plates, upon the invention of plate glass casting this favour was conferred to that technology, which was not dependent upon the skills of a few *gentilleshommes-verriers*. Just as the factors that contributed to its invention and eventual dominance were more than the genius of a single inventor, plate glass casting itself requires more than the virtuosic skill of a single artisan. The invention of plate glass casting was in effect a group effort. Its invention and subsequent takeover could only have occurred in the context of 17th century France and the social, economic, and political structures that defined it.

⁴⁸ Chaimovich, "Mirrors of Society", 360.

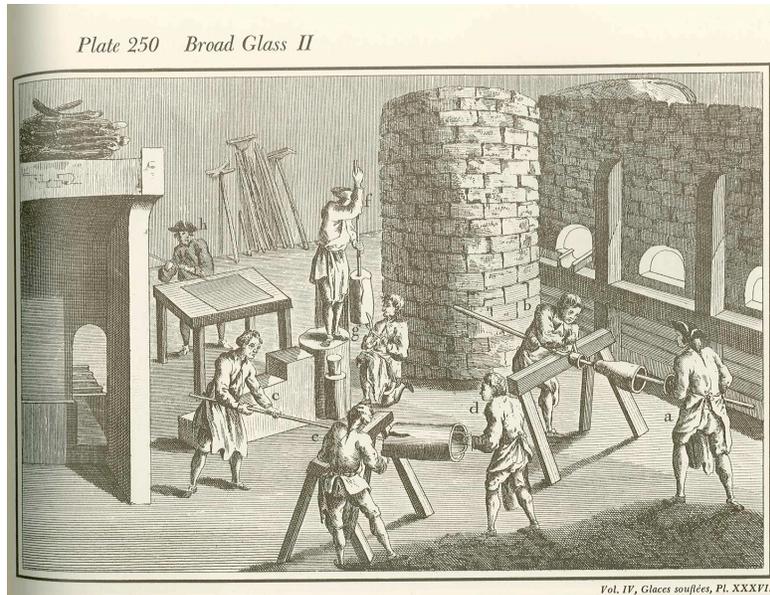


Figure 1. The manufacture of broad glass sheets.

Figures *a* and *b* switch a cylinder from a pipe to a pontil, opening up one end of the vessel. Figures *d* and *c* open up the end of the cylinder previously attached to the pipe, ensuring that it is of consistent diameter. Figures *f* and *g* split the cylinder lengthwise with shears. The resulting sheet is spread on the table behind them, where *h* picks it up with a two-pronged pontil and transfers it to the annealing oven.

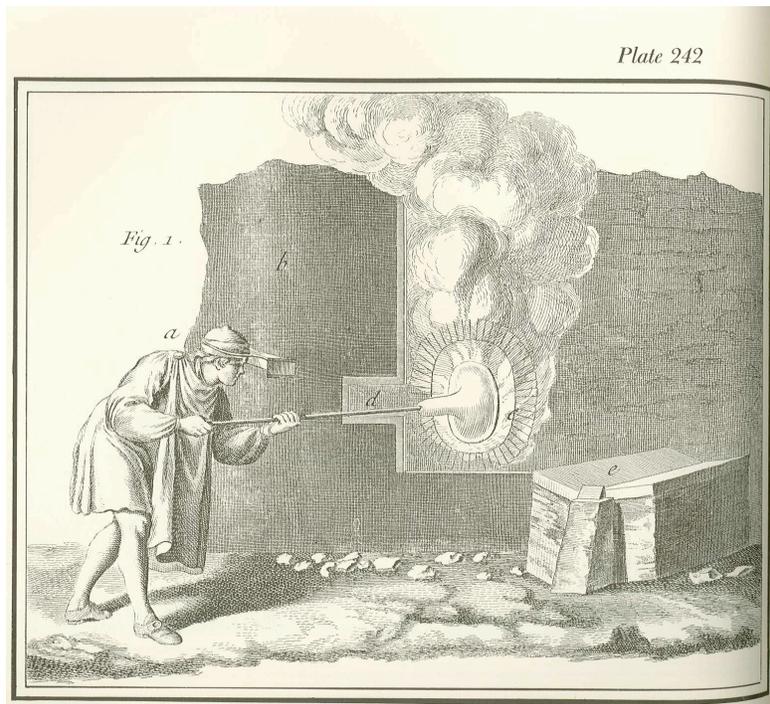


Figure 2. An artisan heating a crown glass disk.

The artisan (*a*) handles a bell-shaped vessel, heating it in the mouth of the furnace (*c*). To the left of the furnace is a marver (*e*), used to shape the hot glass. Still attached to the pipe (*d*), the vessel is not yet open and, though hollow, still solid at the bottom, pointed towards the furnace.

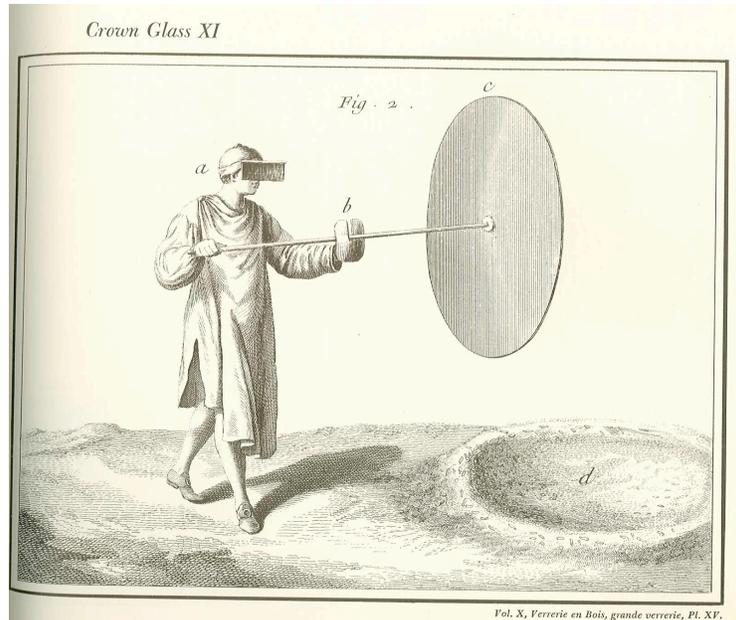


Figure 3. A finished crown glass disk.

The artisan (*a*) handles the disk (*c*) with a protective wooden paddle (*b*) before it is placed on the sand (*d*) to be removed from the pontil. By placing the disk on the sand, artisans are able to remove the pontil single-handedly. The manufacture of crown glass disks could be done from start to finish by a single artisan.

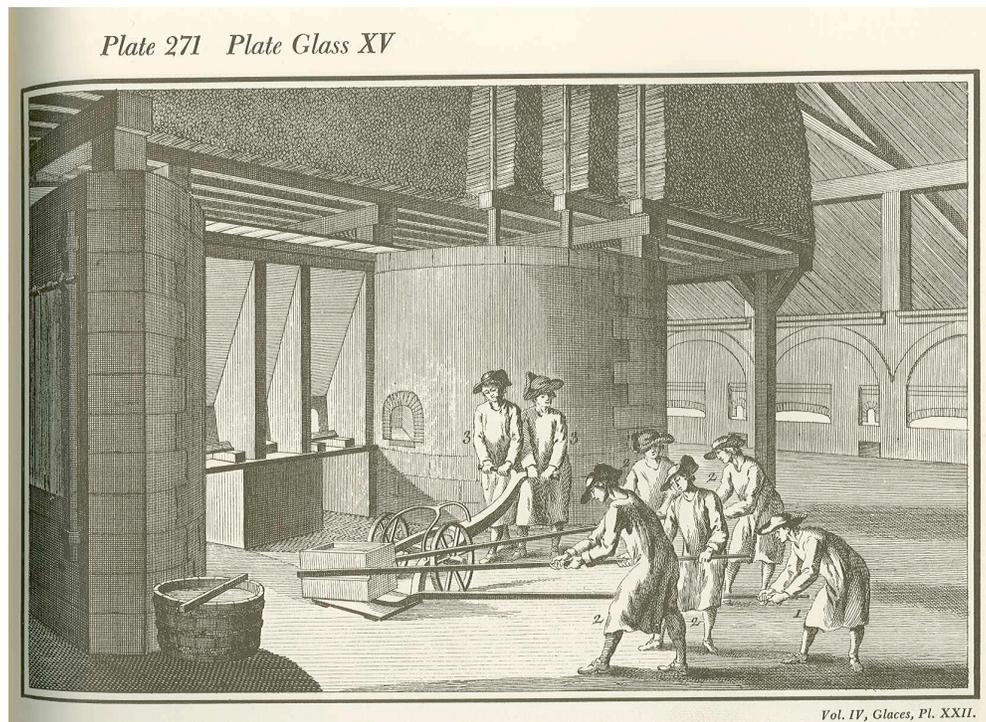


Figure 4. Workers remove a ladle full of hot glass from the furnace.

Worker *1* handles a long metal pole, flattened on one end, to provide leverage for the ladle, while workers *2* manipulate its position with leather straps, pulled taut. Workers *3* handle the carriage, ready to wheel it to the casting tables as quickly as possible.

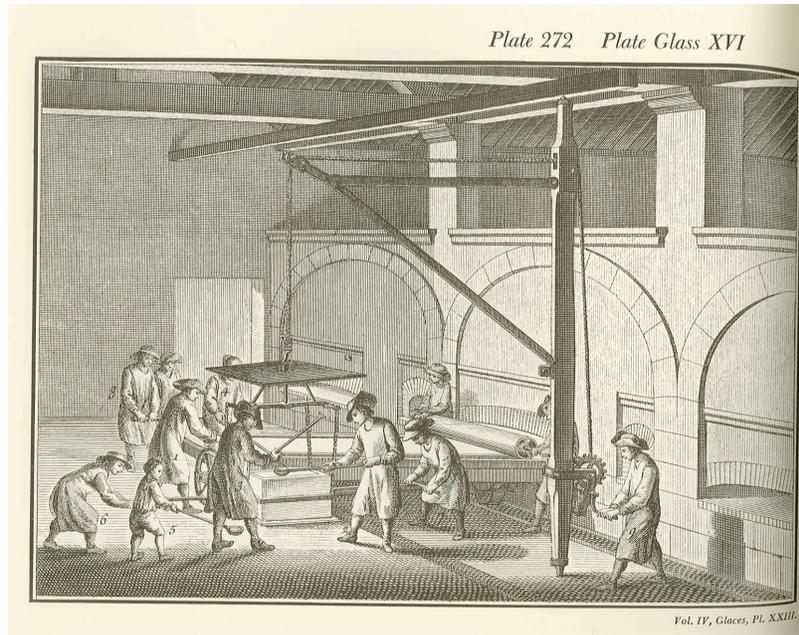


Figure 5a. The ladle is lifted over a casting table.

Two pourers (*1* and *2*) and two assistants (*3* and *4*), skim off impurities with large spoons, the ladle is fixed to a sling suspended from a crane. It will be hoisted over the casting table.

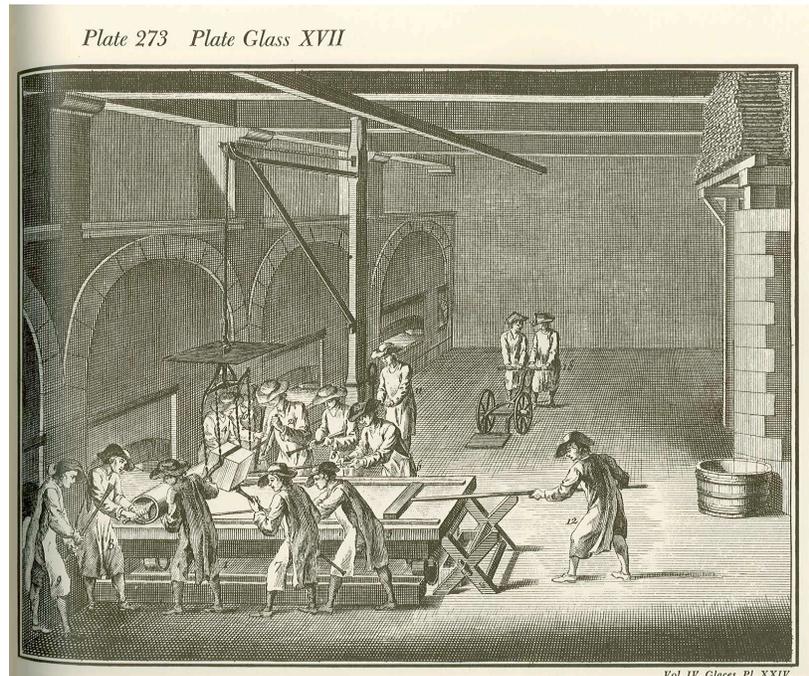


Figure 5b. The glass is poured onto the table.

1 and *2* tip the ladle onto its side with iron rods, while *3* and *4* roll the copper pin over the freshly poured glass to flatten it. While others guide the roller and watch for impurities (*5*, *6*, *7*, and *8*), *9* and *10* wait for the glass to stiffen, and then loosen the strips of iron that prevent the glass from spilling off the table and onto the floor before the glass can harden to them. *11* maintains the height of the ladle throughout the operation while porters return the carriage to the furnace (*13*). The master (*12*) surveys the process and perfects the level of the glass with a flattened metal broom.

All images from Charles Coulston Gillispie, ed. *Manufacturing and the Technical Arts in Plates Selected from "L'Encyclopedie, ou Dictionnaire Raisonné des Sciences, des Arts et des Métiers" of Denis Diderot, Volume 2*. New York: Dover Publications Inc. 1952.

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