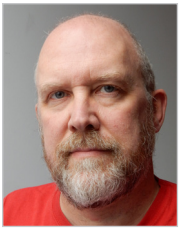

The Influence of Tools on Design: A Study on Openwork Silverware

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Introduction

In May 2019 I offered to write a paper about the influence of technical inventions and tools in relation to the appearance of silverware. I already knew of some examples where fashion and technology went hand in hand, so I thought I had a good starting point. My goal was to make a timeline of the development of tools and techniques from the late Middle Ages to the present and compare this with the styles of silver objects made during each period. The research question would be, "Is it possible to find a relationship between technical evolution and stylistic characteristics of silverware?"

In the process of my research, I discovered that this question was too broad for one survey. That is why I decided to limit myself in subject, place and time. The subject is openwork silverware. The geographical limit is Europe for the pre-Industrial Revolution era, and to the industrialized countries after that era. And the time limit is the period from the late Middle Ages (c. 1450) until the mid-19th century. There are two main reasons for limiting to this time period: The first descriptions and images of silversmiths' workshops appear in literature in the Middle Ages, and the many developments in instruments and machines of the 20th century are too numerous to cover in one paper.

Basic Goldsmith Techniques

If you ask a gold- or silversmith[1] today to tell you about the history of his tools, he will probably say most tools have existed for centuries. And for most of the tools, he will be right. Nevertheless, not all of his traditional gear could be found in earlier days for the simple reason it had not been invented yet. For some tools, like electric gear, it is obvious that they did not exist before the invention of the electric motor, but for other well-known silversmith tools, it is more difficult to date their first appearance.

From the late Middle Ages, silversmiths worked either in courts, in monasteries or in urban workshops, and the cities of Europe showed a growing number of masters. Jean de Garlande describes a silversmith's workshop in his *Dictionnaire* of traders and craftsmen in the 1220s.[2] First, I had to know which silversmith tools and techniques were available at which time. I started with a biographic research of recent studies on silversmithing from the Middle Ages until the 19th

century. The number of these publications is small, and most times they have the Middle Ages as the ending point instead of the starting point. Besides, most of these studies focus on the final objects and seldom on the tools used. Two papers by Jack Ogden, in which he mentions a number of medieval sources, were very useful as a starting point.[3,4]

Descriptions of Medieval Tools

The number of ancient manuscripts and handbooks describing the silversmith's craft can easily be counted on two hands. The usual suspects are *Naturalis historia* by Pliny (c. 78 AD), *De diversis artibus* by Theophilus Presbyter (c. 1122), *De naturis rerum* by Alexander Neckham (c. 1190), *De la pirotechnica* (c. 1540) by Vannoccio Biringuccio, *De re metallica* by Agricola, (1556) and *Due trattati* by Buenvenuto Cellini (1568). Contemporary editions of all of these titles can be found in different good translations.[5] The main topic of these books is often metallurgy, alloying, and the refining of gold and silver. Most publications hardly mention tools and were, therefore, not very useful for my research. The minority give a brief account of the tools and equipment that silversmiths used, and only a few are more detailed.

Alexander Neckham (c. 1190) describes the inventory for a silversmith's workshop.[6] The first thing he mentions is a furnace with bellows. The furnace was essential for melting and purifying silver and for soldering. Silversmiths usually connected separately cast or forged parts such as spouts, hinges, feet and decorations to the workpiece by soldering. Today, silversmiths have a range of possibilities to do so, but until the 19th century they depended on charcoal-fired furnaces or oil lamps in combination with lung-powered blow pipes.

The soldering of bigger objects was not an easy job. First, the silversmith had to tie the various parts together and then lay pieces of solder and flux along the intended connections. When everything was in place, the whole object would go into the furnace to be heated and allow the solder to flow. Although silversmiths tried to use solder as little as possible, they would use more solder than their colleagues nowadays just to be sure a joint would hold after the stay in the furnace. Due to this way of working, the solder seams of antique objects often show thick drops of solder, especially in places one would not see, for example, on the back of the object or on the inside of a foot. Considering the technique of soldering with a charcoal fire in a furnace, silversmiths in former times deserve great respect.

Second, Neckham mentions iron hammers and anvils in his inventory for a silversmith's workshop. These tools were used for hammering or forging objects —a basic silversmith's technique. A flattened piece of silver was modeled on a wood or metal stake with hammers. The shape was produced through successive hammering. The power of the hammer blow, the place where the hammer landed and the application of the right stake defined the final result. For this job the silversmith used various hammers: convex and flat, wide and narrow, light and heavy. He chose the most suitable hammer and stake for each part to be hammered. Traces of the hammer and stakes can be found on almost all forged pieces, especially on the backside and on the inside of the object.

Flatware, like spoons and forks, was hammered from bars, which were given the desired thickness with the forging hammer. A perfect balance between the stem and the bowl of the spoon or the teeth of the fork was the goal so they would lay properly in the hand. Most hand-wrought flatware remained without ornaments. One should realize that table forks for consuming food were first made in the late 17th century.[7]

Other tools Neckham mentions in his inventory were tongs, a very sharp chisel to engrave figures, files, pottery vessels and cruets, a touchstone for testing gold and silver, a leather apron and a rabbit's foot for smoothing, polishing and wiping the surface of the work. Finally, he mentions a toothed saw (serra dentatam), which is most likely comparable to a hacksaw or a backsaw for cutting large pieces. The use of a toothed saw for cutting silver and gold was highly unlikely in medieval times, as it would result in lost metal and almost certainly would be too coarse for fine work.

Theophilus Presbyter, a monk who was trained in the craft of metalworking, gives detailed instructions on metalworking techniques and explains how one should set up a workshop in the third chapter of his manual, *De diversibus artibus* (On the different arts).[5] This book is the most comprehensive and pronounced manuscript from the Middle Ages that I know of. Like Neckham, Theophilus starts with the furnace and then mentions a variety of tools and how to make them. He describes anvils for different purposes, various types of hammers, files and chisels. Files were used in the manufacture of tools but also in some shaping and fitting operations for silver. Theophilus mentions many different files in relation to their manufacture as well as to their use, as does Cellini in his thesis on silversmithing.[5] The reason they do so is because, at that time, files had to be made by hand, as the first practical file-cutting machines date from the 18th century.

Other silversmith's tools in Theophilus' book are pincers, chasing tools, shears, draw plates for making wire and a special device called "organarium" for making beaded wire. At that time scissors and shears were the usual tools for cutting material, as one can also see in an illustration (Figure 1) from the mid-15th century in a manuscript of Pliny's *Natural History*.[8]

Figure 1 *A silversmith at work, using a shear for cutting*[8]
(© Victoria and Albert Museum, London)

The reason Theophilus and others went deeper into the different tools and how to make them is because, at that time, silversmiths could not buy tools and gear at a specialized store but had to make them themselves.

Not only were tutorials on how to make jewels and silverware, with detailed descriptions of the tools, rare in the Middle Ages, they were few in number later on as well. An almost unknown example is a remarkable manuscript, preserved in the Bibliothèque Nationale de France and written by an unknown French goldsmith at the end of the 16th century. It covers approximately 80 folios with recipes and descriptions for medicines, heraldry, plants, pigments and dyes, and over 90 folios describing the casting of plants and animals in metal.[9] An example of an 18th century tutorial, which I will quote in detail later on, is a guide for gold- and silversmiths published by the Dutch silversmith Willem van Laer.[10] Because of its popularity, this book was reprinted at least three times during the 18th century. To be brief, one can say that knowledge about early silversmiths' tools can hardly be found in books.

Early Images

Due to a lack of written sources, I had to rely on images of silversmiths' workshops as a visual source depicting an overview of the tools being used. Fortunately, there is a representative number of pictures and prints of silversmiths in their workshops through time. One print was by the Master of the Bileam (c. 1450) in the collection of the Rijksmuseum Amsterdam, showing Saint Eligius in his workshop[11] (Figure 2).

Figure 2 *The Master of the Bileam, Saint Eligius, in his workshop, c. 1450*[11] *(© Rijksmuseum, Amsterdam)*

Saint Eligius (or Saint Eloy) is patron of all smiths in west continental Europe, comparable with Saint Dunstan in the Anglo-Saxon world. This print is one of the oldest images of a silversmith's workshop, and at the same time one of the most detailed and useful ones. It shows Saint Eligius on a throne, hammering a cup on a stake. Two journeymen are working at the workbench. One is preparing soldering work; the other one is stamping with a die. On the workbench one sees several parts of a chalice and different tools such as a hammer, files, punches, a compass, pliers and a solder dispenser. On the wall behind these two workers hangs a collection of hammers, pliers, shears, burins (engraving tools) and files. On the left of the picture a third journeyman is drawing wire. Behind him are the furnace with bellows and casting molds hanging on the left side of the window.

Comparable tools, but fewer in number, can be found in other prints from the same era. An example is an anonymous print (Figure 3) of a market in Florence (c. 1464) in the collection of the British Museum. This shows a silversmith with an anvil, hammer, pliers, a compass on his workbench and, again, with a furnace in the background.[12]

Figure 3 *Anonymous print of a market in Florence, c. 1464*[12]
(© British Museum, London)

A series of pictures of all kinds of craftsmen is found in the *Mendelschen and Landauerschen Hausbücher* from Nuremberg.[13] These so-called *Twelve Brothers' Books* were created as chronicles and death books of two Nuremberg social foundations of the late Middle Ages. Included are the craftsmen who were admitted to two different elderly homes. Starting around the year 1425, every member was portrayed with a full-page portrait. By 1806 five books bundled a total of 1,171 representations of craftsmen. These books depict over twenty goldsmiths, silversmiths and jewelers, and about thirty related craftsmen like thimble makers and wire drawers. The representations show the members of the two brotherhoods mainly in the exercise of their craft, with characteristic manufacturing processes, tools, workshop equipment, materials and products, e.g., the silversmith Cuntz Rott (Figure 4). These pictures do not necessarily reflect reality like contemporary photographs do, but with a sufficient number of images, they do offer the possibility to draw conclusions. The tools in 47 drawings of silversmiths are hammers, anvils, punches and scrapers, supplemented with wire draw dies for the wire makers and a pump drill for a thimble maker, in this case not for making holes but only for making dimples.

Figure 4 *Mendelschen Hausbuch, Silversmith Cuntz Rott, 1543*[13]
(© Germanisches National Museum, Nuremberg)

A painting on the left wing of a triptych ordered by the guild of painters and goldsmiths of Bern, Switzerland, made by Niklaus Manuel Deutsch in 1515, once again shows Saint Eligius in his workshop (Figure 5).[14] Eligius is hammering a chalice on a stake while one journeyman is engraving a decoration and the other is polishing a ring. The tools on the working bench are a burin (engraving tool), a compass, a solder dispenser, a dish with flux and a rabbit's foot. In the background of this scene one sees a third journeyman with a bellows, heating the furnace.

Figure 5 *Niklaus Manuel Deutsch, Saint Eligius in his workshop, 1515*[14]
(© Kunstmuseum, Bern)

Similar tools can be seen in a drawing by the Master of the Roundels, depicting Saint Eligius giving alms to a beggar in a goldsmith's workshop (Figure 6). This was made around the same time.[15] Because of the detailed tools on the workbench, it is assumed that this drawing was made by someone who was closely involved in the goldsmith craft, possibly a silversmith from Augsburg.

Figure 6 *Saint Eligius giving alms to a beggar in a goldsmith's workshop, c. 1515 by Master of the Roundels*[15] *(© British Museum, London)*

Two other prints were made by Étienne Delaune and date from 1576 (Figures 7 and 8).[16] These prints probably show the same workshop from two different angles. According to the legends on both prints, one is looking at a workshop in Augusta, most likely the German city of Augsburg, which is called Augusta Vindelicorum in Latin.[17] Compared to previous images of workshops, one obviously sees the best equipped workshop so far. Besides the anvils, hammers, tongs, pliers, files, solder dispensers and rabbit's feet, there are some new kinds of tools to be seen. Next to the door, the drawing bench has a prominent place, and left from the windows one can see pump drills hanging on the wall.

Figure 7 *Étienne Delaune, a goldsmith's workshop, 1576*[16]
(© British Museum, London)

Figure 8 *Étienne Delaune, a goldsmith's workshop, 1576*[16]
(© British Museum, London)

To my knowledge, the engravings made by Étienne Delaune are the first depiction of a pump drill in a silversmith's workshop. Drills in general were already known in other crafts, for instance, carpentry and stone masonry. However, it seems they were not yet in use by silversmiths. The first Mendelschen Hausbüch depicts a thimble maker with a pump drill in c. 1425[18] (Figure 9). He uses a rather huge pump drill to make dimples in thimbles. Although the depicted craftsman is a thimble maker and not a silversmith, it is the first depiction of a pump drill in relation to metalsmithing.

Figure 9 *Mendelschen Hausbüch, a thimble maker using a pump drill*[18]
(© Germanisches National Museum, Nuremberg)

A second image of a jewelry-related craftsman using a pump drill is shown in a mid-15th century manuscript of Pliny's *Naturalis Historia*, preserved by the Victoria and Albert Museum (Figure 10). It shows a lapidary drilling precious stones with a pump drill.[8] One should be aware that the drill didn't have a spiral drill bit as we know today and that the drill at that time was more or less a sharpened piercer that could turn around quickly. Pump drills are still used nowadays for fine work, such as jewelry, because they can be operated very accurately with little physical strength.

Figure 10 *A lapidary using a pump drill to pierce precious stones*[8]
(© Victoria and Albert Museum, London)

Based on images, books and manuscripts, one can conclude that in the 15th and 16th centuries a silversmith would have a workshop with a furnace and that he used different tools, among which were hammers, anvils, stakes, tongs, pliers, files, burins and scrapers. In later times it was supplemented with a drawing bench and pump drills.

Since most techniques remain constant and many tools are still being used, contemporary silversmiths will recognize most of these tools with specimens in their own workshop. Some tools are less common these days, like the often-depicted solder dispensers and the rabbit's feet. A big difference with today's silversmiths is that until the 19th century, their colleagues made almost all tools themselves. Essential for making good tools was good-quality steel. During the Middle Ages, mankind was already capable of making reasonable-quality steel. Only after the 17th century did more and better steel became available, as it was produced in larger quantities after the invention of the blast furnace. This led to the manufacture of better and more precise tools. At the same time, specialization became more common and some metal workers began to focus on manufacturing tools.

Silver Openwork

Openwork is a decoration technique, known from ancient times on, where parts of an object have openings in geometric patterns or more complicated figures. In certain utensils openwork is functional such as in incense vessels for the incense to escape through the openings, or like the small openings in casters and braziers. In other objects the open motifs only serve as decoration, for instance, in borders or objects of silver, glass or earthenware that are encased in a sheath of silver having openwork decorations.

There are different ways to produce openwork, of which the oldest are by casting and by piercing. An easy way of making openwork is casting it. Large cast objects are relatively rare because they require larger amounts of material than other manufacturing techniques. Therefore, often only attached parts and ornaments are cast. The advantage of casting is that the silversmith can reproduce objects easily. Even when he only needs one specimen, casting the object can be simpler to make compared to hammering. For larger surfaces with many different openings, it is most times less time-consuming to cast the work instead of first hammering it and then piercing it (Figure 11). The two main casting techniques the silversmith uses are sand casting and lost-wax casting. These two methods have remained essentially unchanged over time.

Figure 11 *An example of a partially cast censer, c. 1325 (© Victoria and Albert Museum, London)*

Sand casting works with two frames (flasks) filled with a tightly pressed molding sand. A full-size model in stone, wood or metal of the intended object, or parts of it, is pressed into the molding sand in the middle of two casting flasks in a way that the molding sand encloses the pattern, and the parts of the flask can be handled without the sand falling out. The two halves are separated and the model is removed. Openings are cut through the sand and the flask is reassembled. After molten silver is poured into one of the openings, the cavity of the pattern is filled with silver (Figure 12). When the silver is cooled, the object is removed from the sand and the pouring spout and air ducts removed.

Figure 12 *Jan Luyken, a silversmith sand casting, 1694 (© Rijksmuseum, Amsterdam)*

Another method of casting is lost-wax casting. This is a technique for casting metal objects in an investment mold in which wax models or small organic objects are encased in an investment mold. The mold is fired to burn out the wax or organic object, leaving a cavity. The melted silver is then poured into the mold and the cavities where the models used to be are filled with silver. After cooling, the flask is put in water and the investment dissolves. A silver sprue with the cast objects is the result. Lost-wax casting gives a much finer result than sand casting, and it is an ideal and widely used technique for mass production of small, non-hollow objects. However, for openwork lost-wax casting is less suitable.

Theophilus describes a type of openwork which he calls "opus interrasile." This work is not cast but made by making holes or openings in silver objects with piercers, chisels and files. Therefore, this kind of work is also known as pierced work. For making small holes in the often-thin sides of an object, the silversmith used a piercer or awl. For more complicated and larger cuttings, he would apply a chisel struck with a hammer. In order to keep hollow objects in shape, he would use a substrate of wood, lead or pitch to support the object during the piercing. Piercing with chisels is not always a precise process. The silversmith would be required to do some filing after the openings were made. If repeating identical openings were needed, the silversmith could force a chisel shaped like the opening through each hole. Until the 18th century, the tools for pierced work were limited to piercers, chisels and files.

Changes Affecting Openwork

For the application of openwork, two major changes took place during the 18th century. The first was the invention of the industrial rolling mill for producing silver sheet, and the second was the introduction of the fretsaw.

Nowadays, the silversmith can purchase silver sheet from wholesalers, but before the invention of the industrial rolling mill, all sheet was hammered by hand as depicted in *A New Touchstone for Gold and Silver Wares* (Figure 13).[19] For centuries silversmiths made silver sheet themselves by hammering it from an ingot or a large silver nugget (Figure 14). The greatest potential change in the manufacture of silver sheet came with the invention of the rolling mill, which rolls the metal between two iron or steel rollers. This saved time and labor because it produced sheet quicker than a craftsman could with a hammer.

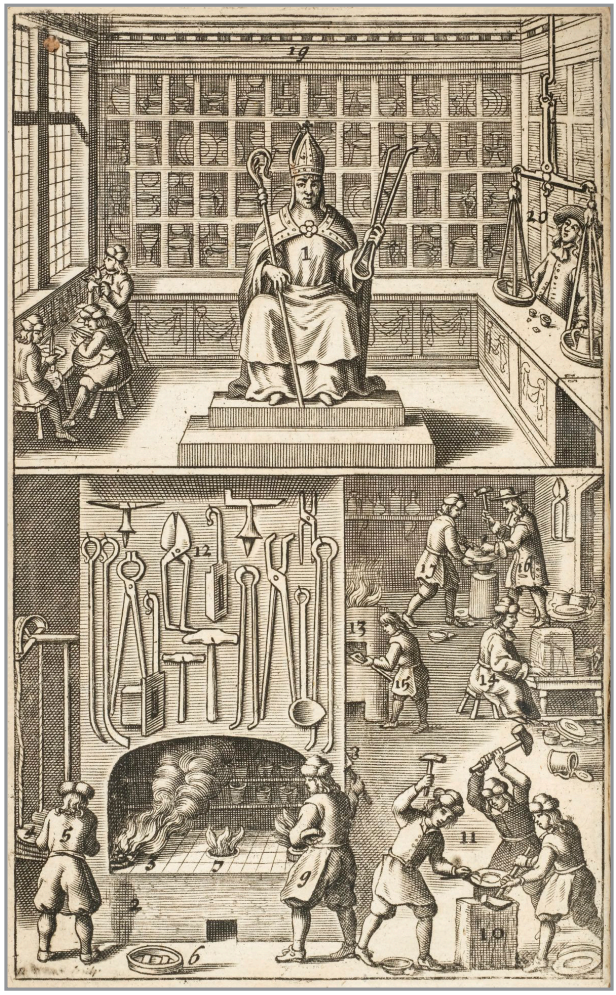

Figure 13 *Title page of* A New Touchstone for Gold and Silver Wares[19]

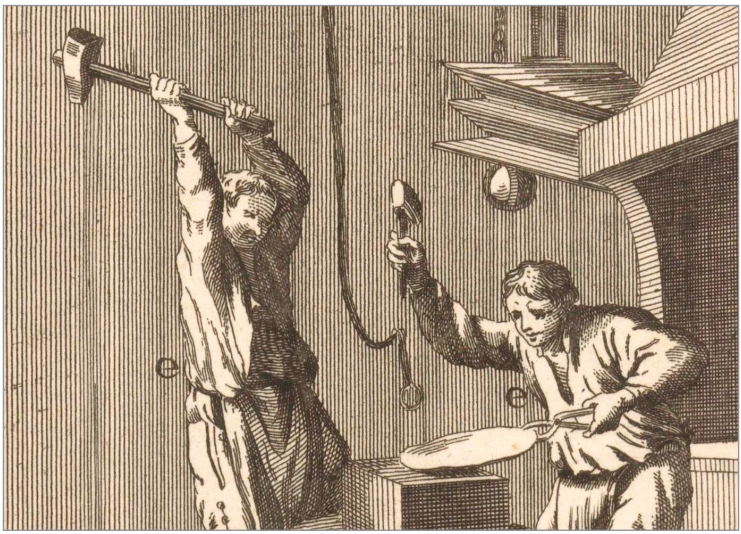

Figure 14 *Silversmiths hammering silver sheet. Detail of a silversmith's workshop depicted in* Encyclopédie *of Diderot & d'Alembert*[20]

The first known design of a rolling mill dates back to Leonardo da Vinci who, in one of his drawings dated 1480, described for the first time the possibility of making a material pass between two cylindrical rollers with parallel axes to modify its thickness. Like more inventions of Da Vinci, it was probably never built. A painting by Jan Bruegel the elder, showing Venus visiting Volcan in his workshop, depicts a small rolling mill (Figure 15).[21] It is not very big and was most likely used to make small strips, but not yet larger sheets to forge into hollowware.

Figure 15 *A small rolling milling lying on the ground to the left of the young boy. Jan Brueghel (I), The fire, 1611*[21] *(© Musée des Beaux Arts, Lyon)*

There are reports of rolling mills from the seventeenth century, describing their use to make gold and silver strips of uniform thickness for coin production. The exact dates of the first rolling mills used for large silver sheets are unknown. It is safe to say this was around the year 1700, but during the century that followed they improved and the production of larger, thinner and cheaper sheets became available. The improved rolling mills of the 18th century were able to make larger silver sheets. This doesn't mean every silversmith had direct access to silver sheet right away, or that every silversmith had a rolling mill in his workshop from that time on. The *Encyclopédie* of Diderot and d'Alembert from the year 1771 shows a simple hand-rolling machine for use by jewelers (Figure 16), but another picture still shows workers hammering a silver plate (Figure 14).[20]

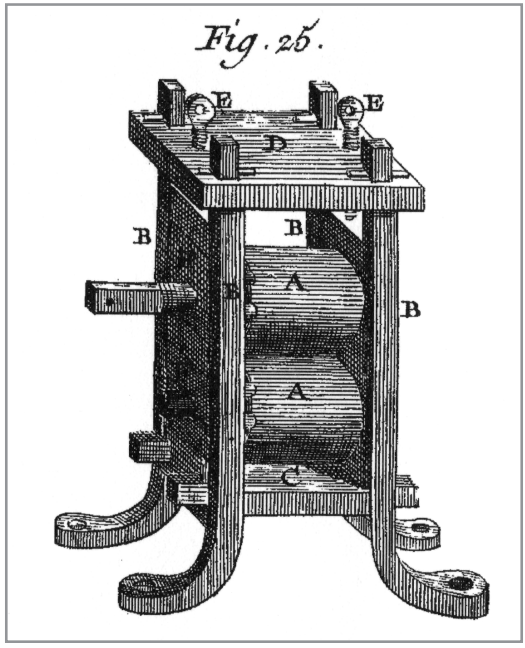

Figure 16 *Rolling mill in* Encyclopédie *of Diderot and d'Alembert*[20]

Fretsaw

In the book by the Dutch silversmith Willem van Laer[10] mentioned before, the author spends a chapter on the subject of pierced work. He recommends using chisels for large, simple openings because that is faster than drilling and filing. For fine openwork, he advises filing. Besides these two methods, Van Laer also talks about the possibility of creating an open structure by saw cutting with the use of a "watch." From his description it is obvious the word "watch," in this context, is a balance spring for a clock that has been toothed and hardened and, when fixed in a bracket, can be used as a saw. One would nowadays call such a tool a fretsaw or piercing saw. To my knowledge, in 1721 Van Laer is the first one to mention a fretsaw.[10]

The novelty of the fretsaw made it possible to make more detailed and precise pierced work with less labor. However, the first saws were difficult to make by hand and, compared to their modern mass-produced counterparts, were more vulnerable to breaking. This means fine, handmade iron-piercing saws would not always have been worth the time and effort to make prior to their mass production in later times.

Nevertheless, at the end of the 18th century the fretsaw had largely displaced the chiseling technique of piercing. At first glance, it is quite difficult to see whether a silversmith used piercing with chisels or saw cutting. In general, decorations created by piercing and chiseling show a greater irregularity than when they are sawn.

Van Laer distinguishes two types of openwork: 1) openings that occur when the ornament is removed while the background remains in silver and 2) openings where the figures remain and the background is removed. According to van Laer, both methods are equally good. It all depends on the function of the object. In a design where the openwork motif is only for decoration, he prefers the background removed with engraved figures that remain in silver. According to van Laer, this method can be applied to sugar casters, although, in practice, one usually comes across the other form of openwork on sugar casters (Figure 17). With casters the openwork decorations must remain small so it is better to remove the figures. Van Laer shows two designs for a brazier and a basket (Figure 18) depicting the different type of piercings. He concludes with the words, "Please let no one believe that everything I tell about piercing is perfect. No, I only do this to let the pupil understand how easy it is to make beautiful figures, just by making simple piercings."[10]

Figure 17 *Example of a sugar caster by Adam Loofs, The Hague, 1688 (© Rijksmuseum, Amsterdam)*

Figure 18 *Willem van Laer, examples of pierced work*[10]

The rolling mill and the fretsaw provided the opportunity to make larger objects with openwork. This led to a new fashion of making more and larger openwork silverware, starting with braziers and soon after followed by breadbaskets, casters and sugar sifters.

As an example of a large 18th-century pierced silver object, a description follows of the way a breadbasket was made. Usually the pierced breadbasket was constructed of three parts: two equal upstanding rims and a smooth, unprocessed bottom. To make the openwork rim, a model was first made in copper. This model was fixed with a few clips on a flat sheet of silver of the same shape and size. The drawing was transferred to the silver plate with a steel scratch pen by tracing along the openings of the model. In a part that had to be cut away, a hole was drilled into the silver plate and the saw blade was inserted vertically and fixed in

the bracket. Part by part all the openings were cut out. After finishing both rims, they were bent into shape and soldered against each other. Finally, the smooth bottom and eventual borders and handles were soldered to the rims (Figure 19).

Figure 19 *Example of an 18th century openwork breadbasket, Reynier Brandt, Amsterdam, 1770 (© Rijksmuseum, Amsterdam)*

Industrial Revolution

In the 19th century a number of major changes in the production of many utensils took place as well as for the silversmiths' craft. In time, the driving force evolved from manpower, horsepower and water-wheel power to the steam engine and finally the electric motor. As steam power grew and the quality of steel evolved, not only could rolling mills produce larger metal sheets, but also heavier machines could be used for technologies such as spinning, die cutting and die stamping, which enabled the production of silverware at lower costs. Some new production methods even completely changed, for instance, the way cutlery was made.

Due to industrialization, the manufacture of silverware developed in two directions. On the one side, an industry of silverware factories began with cheaper and faster production; on the other side was the independent silversmith who continued on the old footing. Heavy machines were not affordable for silversmiths working on their own, and competing with machines was hard. All these developments changed the role of the silversmith. Initially working on his own, at most assisted by a number of journeymen and apprentices, the place of the silversmith's workshop was more and more taken over by larger companies. Many silversmiths became employed by the factory and were just a link in a production chain (Figure 20).

Figure 20 *Anthon Gerhard Alexander van Rappard: silver factory of Begeer in Utrecht, c. 1868 (© Rijksmuseum, Amsterdam)*

Industrialization also meant specialization in all industries. Although the tools for manual work did not change much, some of them could be mass-produced and more and more could be bought at wholesale stores. This also applied to semi-finished products, like silver bars, wire and sheet.

One of the new techniques was metal spinning, where one forces a silver disc down over a wooden form shaped like the inside of the object to be made. In this process a hand-held spinning tool is pressed against the outside of the silver disc and the metal is spun down onto the wooden form. Spinning is quicker and therefore cheaper than hammering. Spinning requires great strength and a powerful engine, and the steam engine provided that strength and power. On an object made by spinning, one can often see circles left by the spinning tool, where on a hand-forged object the hammer stroke can be identified, at least on the inside of the object.

When the steam hammer appeared in the silver industry, die stamping of ornaments and even whole objects became possible. Before that time, ornaments were often embossed or cast and soldered onto the object, but with the more powerful machines, ornaments were mostly stamped.

At first, the cutting of figures from an object or a sheet of silver was done by saw cutting or with small hand presses. However, with powerful presses this work could be done mechanically by die cutting A silver sheet was placed between a hardened steel cutting plate, with an opening the shape of the motif to be cut, and a steel punch, which was the same shape as the opening in the cutting plate. By pressing the punch through the die, a piece of metal of the desired shape was cut away and collected in a container arranged under the press.

When machining increased and took over the work of manual silversmithing, the production of openwork silver objects grew intensely. Die stamping and die cutting from sheet metal made mass production of openwork possible (Figure 21).

Figure 21 *Van Kempen & Begeer, an industrially manufactured bread basket*

Openwork was applied in all kinds of silver objects, and there was usually no question of a functional use for the decoration. Baskets, sugar casters and salt cellars were often assembled with blue glass inside to increase the contrast with the silver, but also to keep the object suitable to use. And because pierced decorations saved material, these objects contained less silver than solid silver items. This benefitted the price, which made them even more popular. The openwork silverware made by machines is often characterized by little variation in the shape of the openings (Figure 22). The few objects with more versatile motifs, such as flowers or leaves where every opening is different, were still cut by hand.

Figure 22 *An employee of a Pforzheim silver factory machine-piercing a piece of silver, 1938 (photographer Otto Kropf) (© Stadtarchiv, Pforzheim)*

Conclusion

Today, a self-employed silversmith would have the same tools in his workshop as his medieval predecessor, complete with a pump drill, a fretsaw and maybe a hand-driven rolling mill for small strips of silver sheet. I started this research being quite confident it would be fairly easy to prove that technical inventions in the silversmith's craft influenced fashion. During my research I found that in earlier days the introduction of new tools and techniques did not happen at one particular moment but was spread out more gradually over time. Therefore, constructing time lines for the development of tools and for the introduction of styles and objects was harder than I expected. Of course, one suspects a relationship between technical development and stylistic characteristics of silverware. However, both technique and fashion are in a continuous evolution, and it is difficult to point out specific dates.

For openwork there were a number of moments in which the tools and technique changed significantly. These were the introduction of the pump drill, the use of the rolling mill in the manufacture of silver sheet, the invention of the fret

saw and the use of power-driven machines. If one looks at openwork silver, it is obvious that technique and material did influence the style of silverware. By knowing the development of silversmith's tools and the various manufacturing options available to the silversmith, the appearance of openwork silverware can be understood.

Epilogue

Over the last decades several new techniques for cutting forms have been developed such as milling, waterjet cutting, laser cutting, oxygen cutting, plasma cutting, etc. In casting, one of the latest developments is the 3D wax printer for creating wax models with openings one would never be able to achieve with conventional techniques. And even the powder laser melting technique (PLM) offers the silversmith the possibility to make openwork objects. Today, the personal computer for making CAD/CAM designs can be found in almost every workshop, and it is probably just a matter of time before the future silversmith will find 3D wax printers and PLM gear just as common as the fretsaw is for us.

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