

Metal threads: the historical development

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Abstract

Precious metals have been used for the decoration of textiles since ancient times to create luxury objects for the secular and religious elite. Metal threads have been interwoven into fabrics, used decoratively in tapestry, embroidery and lace making and have been traditionally associated with the use of silk, since gold threads, just like silk, are considered luxury materials engaged in the manufacture of the finest and most expensive fabrics.

This paper focuses on the development and production of metal threads through the study of European and Middle Eastern textiles. It presents the historical development of the various types of metal threads and the manufacturing techniques employed for their production. Furthermore, it gives a brief description of the coating methods used, from antiquity onwards, to cover baser metal which could have also been employed for coating the metal threads (Karatzani 2007).

Introduction

Textiles are essential to everyday life in all societies. Primarily, they have served functional purposes by providing protection and warmth but in many cases their use has been extended beyond these practical needs. Cloth can take many shapes and can be decorated in various ways through patterned weaving, embroidery, painting or dyeing. These broad decorative variations have been used to communicate information. Worn or displayed cloth has been, and still is, used to indicate class and position, represent qualification and legal rights, and also show wealth and social status. In the form of dresses and furnishings, cloth enables people to distinguish themselves from others and locate themselves within their society. In this context precious metals have been also used in combination with fibres in order to produce luxury fabrics for political and religious elites (Weiner and Schneider 1989, 1).

Metal threads

The metal threads are divided in two basic types, cut strips and wires-rolled strips. These types have been used for the production of combined threads (Braun-Ronsdorf

1961; Járó and Tóth 1991; Stodulski *et al.* 1985). Based on their morphological characteristics the combined threads can be (Fig. 1):

- Thin strips of gold or silver wound around a silk or fine linen thread.
- Gold or silver wire which is wound creating a spiral, also known by the Turkish term *tir-tir*.
- Gilt membrane strips. In this case very fine gold sheets are beaten on to an animal membrane, cut into lamellae (strips) and wound around a core yarn.
- Gilt leather or gilt paper strips. These are narrow strips of gilt leather or paper produced by the same method as the gilt membrane strips.



Fig. 1: Types of metal threads: a) metal strip, b) wire, c) strip wound around a silk yarn, *filé*; d) spiral wire, *tir-tir*; e) gilt membrane strip spun around a silk yarn, and f) gilt leather strip wound around a silk yarn. OM images, (mag. x40).

The metals mainly used are gold, silver and copper, either alone or combined; while zinc occurred frequently as a component of copper alloys. The organic supporting material could be cellulose based (paper) or protein based (leather, parchment and animal gut). The fibrous core could be a protein-based fibre such as silk, wool or hair, although so far wool has not been identified. The cellulose-based fibre could be linen,

cotton or hemp. Since the beginning of the 20th century new materials such as man-made fibres and aluminium are used.

Historical development of metal threads

The first written record about the use of gold wires and strips for the decoration of textiles comes from the Bible; it describes the decoration of Aaron's vestment for service (*ephod*), explaining the technique used during the 12th/13th centuries BC (Járó 1990a; Járó and Tóth 1991).

“And they made the ephod of gold, blue and purple, and scarlet, and fine twined linen. And they did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, with cunning work.” *Old Testament, Exodus, 39: 2-3*.

The first and most ancient type of thread was a narrow strip cut from a hammered gold foil. This technique of hammering a foil, which is described in the passage of the Bible, was already known to the Egyptian goldsmiths by the 5th millennium BC (Járó *et al.* 1993, 119) and presumably they were also able to produce narrow strips to be used in textiles. However, the earliest example of this type of thread (according to the author's knowledge) is the textile found in a Macedonian royal tomb in Vergina, dated from the 4th century BC. Flury-Lemberg (1988, 224-26), who has treated this object, notices that it was made “of pure gold hammered into about 0.03-0.04 mm thin foil and cut into strips about 0.3-0.4 mm wide”.

The winding of the gold strip around a fibrous core of vegetable or animal origin marked the first major change in metal thread production (Fig. 2a). Although the exact date of this innovation is not known, it was used during the late Roman period and according to Wild (1970, 40), was achieved by the use of a spindle. The spindle was rolled manually on the thigh producing an S or Z-twisted threads, but no further information is given. These round metal threads have a similar shape as organic yarns and became very popular because they were much easier to handle.

Metal threads of the type of gold strip wound around a fibrous core have been identified in Spain in a textile fragment excavated at the ancient Roman necropolis of Cádiz (Giner 2001). The burial, where the textile was found, is dated to the Augustinian period, between the end of the 1st century BC and the beginning of the 1st AD and belongs to a young woman. The strip is 0.2 mm wide and 3.6 microns (10^{-6} cm) thick and was made of pure gold, indicating 23.4 carat gold. The thread was Z twisted and

unfortunately no core thread was present since the burial was from a cremation.

Gold wires have been employed in textile decoration since at least the 2nd century BC; these early examples are part of fabrics found at the Han-tombs at Man-Ch'eng in China (Járó 2004, 315). The earliest dated examples of wires used for the decoration of textiles in Europe are from Birka (9th/10th century), and are drawn wires. Geijer (1983, 89), who has studied these textiles, describes these wires as “round in cross section, which were produced by drawing a metal rod through progressively smaller holes, a technique also employed by the goldsmiths”. However, she suggests that the wires used at Birka were imported from Byzantium via Russia. Járó (1990a, 43) also claims that other early examples of wires found in Western European textiles might have been imported from the East.

Geijer (1983, 89) has also identified a rare type of thread among the samples examined from Birka, the spiral wire, which is a kind of *tir-tir* thread. This is a fine wire wound tightly around a core thread and is not commonly found in textile works of that period. The spiral wires found are made either of gold or of silver. According to her this unusual technique was known to the Lapps of Northern Sweden, who used it in their dresses, but their wires were made of pewter. However, trade contacts between the Lapps and merchants from Birka brought the technique into the Viking areas, where it was further developed using precious metals in their production.



Fig. 2. OM images of file threads a) gold b) silver (tarnished) and c) copper/brass (a) scale 4mm and b,c) mag. X40)

Silver based threads

Threads made of silver or silver alloys were also used for the decoration of textiles (Fig 2b). According to Járó (2003, 166) silver threads were probably used by the Greeks to decorate textiles, but she does not give any date, while the Romans are said to have used them in the 1st century AD. However, the first dated examples come again from Birka and are dated to the 9th/10th century (Geijer 1983, 89-96).

Gilt silver threads, made from a strip wound around a fibrous core, were already in

use during the 9th century (Járó 1990b, 301; Járó *et al.* 1993, 121). Their use spread through Europe in the 12th and 13th centuries, primarily for embroidery. Two types of gilt threads have been identified; those that are gilt on the external surface only and those that are gilt on all surfaces. The first type of threads were made by gilding sheets of silver, which were then hammered until a very thin sheet was produced and fine strips could be cut for making the spun thread. The second type was made by hammering/flattening a gilt wire. Biringuccio describes how the silver wire is gilded to produce a wire that looks like being made of pure gold (Smith and Gnudi 1959, 377-8).

Strips that are gilt on the external surface only have been used for the decoration of textiles since the 9th century. These are usually described as “*or de Milan*” or Milanese gold threads (Járó 2003). Such threads were used with gold threads during the 14th century, but by the 16th century they were used less frequently, as a new technique appeared. In this new method gilt threads were made of gilt silver wires which were flattened to form strips that are gilt on both sides. Nevertheless, threads made with the single side gilt sheet technique continued to be used in rare cases (Járó 2003, 31).

Gilt and silvered organic strips

During the 11th century the membrane thread also appeared. This thread was made by gilding organic material (leather, animal gut, or paper), cutting it into narrow strips and using these strips either flat or wound around a fibrous core (Fig. 3a). This new invention reduced the price and the weight of the fabrics. It became very popular and was used in large quantities.

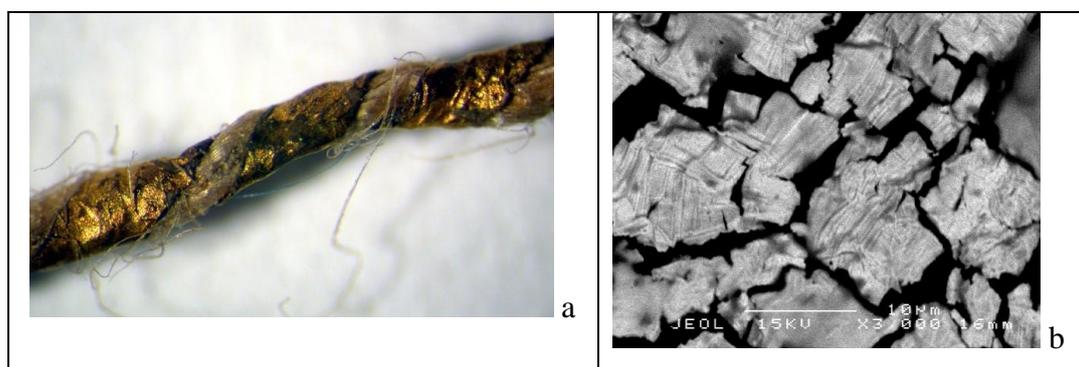


Fig. 3: a) Gilt membrane thread (OM image mag. X40). b) SEM photomicrograph of the gold leaf (mag. X3000)

In the beginnings the “organic threads” appeared as imports from the East and were usually known as *Cyprus gold threads* or *Byzantine threads*, because of their place

of origin (Braun-Ronsdorf 1961, 5; Járó 1990a, 50). These threads were made of membrane gilt with gold leaf, but the membrane threads of Byzantine origin were wider and heavier gilt than the Cyprian ones. Furthermore, a yellow silk core was used throughout Byzantium, while the core of Cyprus gold threads was yellow or red, and always white in silver threads. From the 13th century onwards such threads were also produced in European workshops. Instead of membrane, a very thin animal gut was used as organic support and gilt silver leaves were applied for the gilding (Járó and Gondár 1988, 260-1). These threads were only wound around a linen core (Járó *et al.* 1993, 123), and were used only rarely in embroideries because the gold was worn off easily. From the early 15th century onwards gold and silver threads were incorporated into velvet weaving with the design created in relief. The membrane threads were no longer appropriate for the weight of these fabrics and the velvet brocade weavers once again began to use the flattened gold and silver wires. This was also one of the reasons why gilt organic strips disappeared from Europe after the 16th century.

Gilt and silvered leather strips were used for the decoration of brocade fabrics in the Far East, and were used as untwisted wefts for the fabrics. Chinese fabrics with this kind of decoration became popular in Western Europe during the 14th century and influenced Italian silks (Braun-Ronsdorf 1961, 7). During the same period (14th century) Chinese weavers adopted the use of strips cut from gilt mulberry paper used as flat threads. The winding of these paper strips around cotton or silk cores was practiced only rarely.

Copper based metal threads

The use of copper in European metal thread making can be traced back to the 15th and 16th centuries. These threads were cast, drawn and rolled in the same manner as silver and silver gilt filaments and are typically spun around cotton core threads (Fig. 3c). Such threads were much cheaper to produce as much less precious metal was required. During the earliest period of their introduction gilt or silvered copper threads were only used for the decoration of vestments by less wealthy people who could not afford the cost of the precious metal threads (Járó and Tóth 1991, 181). Some countries had introduced laws against the use of copper based threads, allowing their use only for the production of theatrical costumes and second quality objects (Glover 1967, 4). Biringuccio in the 16th century refers to wires made from gilt copper as a great fraud. He also mentions that the wire produced with this technique can be drawn so fine so that it

cannot be seen with the naked eye, and it is indistinguishable from gold wire (Smith and Gnudi 1959, 380). In the same book he also refers to silver coated copper drawn into thin wires. Such threads are recorded from the 16th century onwards and are typically found with copper threads that are first silvered and then gilt (Járó 2003, 168; Járó *et al.* 2000, 100).

Brass has also been used to imitate gold since the 14th-15th centuries and similar threads were also used until the 20th century (Járó 1990a, 42; 2003, 169). From the early 20th century new materials began to be used, namely laminated metal threads made by combining transparent or pigmented plastic materials with aluminium (Járó *et al.* 2000, 95). These threads are primarily interwoven into fabrics, while the solid metal strips were still used for embroidery.

Manufacturing techniques

Strips

Solid metal strips can be produced either by cutting them from a sheet of metal, or by flattening a wire. The average width of the strips used for making metal threads is between 20 and 40 μm , and the average thickness varied between 6 to 30 μm . Unfortunately, there is a lack of information concerning the length of these strips or the methods used for joining them to obtain the necessary length. Joining by overlapping has been suggested as well as the creation of a longer sheet of metal by cold hammering before cutting it into strips (Járó 1990a, 47; Járó and Tóth 1991; Járó *et al.* 1993, 120). However, since gold and silver foils (thickness $> 1 \mu\text{m}$) are typically only about 10 cm long, too many joins would be required to obtain the length necessary for the production of threads. Another method that has been suggested is the elongation of a cut strip (Járó *et al.* 1993, 121). A strip may have been stretched using a tool similar to that depicted in the Mendelschen manuscript from the 14th century.

The first strips were made of gold, but these threads were very fragile and difficult to work and additionally they were very expensive, so they were soon replaced by silver and gilt silver strips. The production of gilt silver threads is more complicated than those made of pure metals. Theophilus in the 12th century describes the technique for the production of gilt silver; first the silver is hammered into a rectangular piece and is covered with gold, and then the two metals are soldered together with a soldering material containing copper (Hawthorne and Smith 1979, 156). He also describes how gilt silver was hammered to a narrow band, from which fine strips were cut for making

spun thread, used for weaving of less expensive fabrics.

Biringuccio in his ninth book refers in detail to the method used for the production of gold and silver for spinning (Smith and Gnudi 1959, 381-2). He describes the gilding of the silver, which is then hammered into foils (thickness $> 1 \mu\text{m}$) or leafs (thickness $< 1 \mu\text{m}$), depending on the thickness required. The strips are then cut with a long pair of scissors. He also specifies that women were involved with this job because they are more patient than men. These strips would have been as long as the gilded sheet and were wound around a linen thread either with a spindle or by some other means. He also mentions that the width of these strips is enough to cover the thread without any excess when the cut edges come together.

The production of metal strips by flattening a drawn wire (by hammering or passing between rollers) was a simpler and more practical method (Járó and Tóth 1991, 176). The strips produced were longer and no joins were needed. Tímár-Balázs (1998) also argues that since the length of the wires needed for the manufacture of metal thread is much greater than that needed for jewellery making, only drawn wire was employed in metal thread production. According to Járó *et al.* (1993, 121) a wire with a diameter of about 0.05 mm was needed for the production of the strips. However, they suggest that such a diameter was difficult to be achieved until at least the 12th century when wire drawing was introduced more widely.

Wires

The study and analysis of jewellery has provided detailed information concerning the manufacturing techniques of wire and has shown that most of these techniques remain the same from the Roman period and throughout the medieval period, when the use of the draw plate finally replaced them (Oddy 2004). The main methods for producing wire were:

- by *hammering* out a metal ingot until a wire with a more or less round section was obtained,
- by *block twisting*. The wire is produced by hammering out a metal ingot until a rod of the required thickness and a square section is obtained. The rod is then twisted as tightly as possible and is rolled between two flat pieces of wood,
- by *strip drawing*, this involves the drawing of a strip, cut from a metal foil, through holes of decreasing diameter causing the metal to curl on itself and form

a hollow tube. The tube can be pulled through subsequent smaller holes so that the hollow centre gets narrower and,

- by *strip twisting*, it also involves a metal strip cut from a foil, which is twisted around a mandrel or an existing wire. The wire produced is then tightened and gently extended by hand.

Drawn wire

The technique of wire drawing involves the gradual reduction of the thickness of a metal rod by pulling it through a series of holes with decreasing diameter, so that after each pass the length of the wire is increased and its thickness is reduced (Fig. 4). For the production of such fine wires to be used as metal threads the appropriate reduction per pass of the die is between 15 and 25%, indicating that the wire was passed through a number of dies until it is reduced to the required size (Dieter 1961, 533).

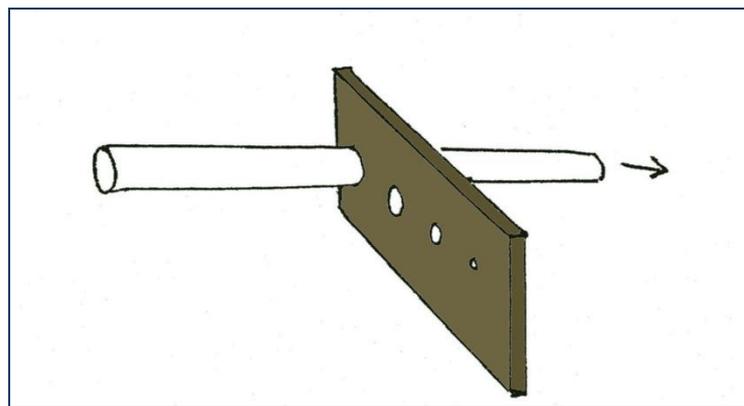


Fig. 4: The principle of wire drawing

The location and exact date when wire drawing was first used have not yet been identified. Specialists dealing with this issue still argue about the exact date, since draw plates have been recorded well before the first evidences of drawn wires. Duczko (1985, 16), who has studied Viking filigree work, has shown that wiredrawing was known by the 9th century AD. Geijer (1983, 89) has also made the same claim when studying the textile objects from Birka, which also date to the 9th/10th century. Smith (1981, 38) mentions that in Achaemenid Persia (c. 559-330 BC) only gold wire was produced with the use of draw plates, implying that harder metals could not be drawn. Oddy (1988, 183), based on a survey of gold jewellery carried out at the British Museum, states that the earliest pieces of drawn wire date to the 6th/7th century and originate in Sweden and Egypt for example, suggesting that this was an independent invention.

Rolling

Rolling is a process of plastically deforming a metal by passing it between a pair of rollers revolving in opposite directions. During rolling, compressive forces are involved and the final result is an increase in length due to the reduction of the section of the metal. According to Ogden (1994, 162) the invention of the rolling mill is attributed to Leonardo da Vinci who first provided a sketch of it. However, Glover (1967, 1) states that Augsburg was the place where flattened wires were first used for the production of metal threads. She gives the 16th century as a date for the introduction of this technique and mentions that the technique was kept secret so the details of this method are not well known. She also suggests that flattening of wire was performed manually during the 15th and 16th centuries.

Surface coatings and finishing methods

Due to its rarity, the supply of gold has been always insufficient to satisfy the great demand for gold objects. In order to reduce the quantity of this noble metal that was required for their objects, goldsmiths produced alloys of gold with silver and copper and invented methods of gilding less precious metals. Furthermore, they were always trying to develop new techniques that would allow them to use even thinner coatings in order to minimise the precious metal consumption. Nonetheless, the surface coatings could also have been used for decorative purposes in combinations with other metals.

Gilding can be defined as the application of a layer of gold on the surface of a less precious metal that can be attached either mechanically or physically. The origin of gilding can be traced back to the late 4th or early 3rd millennium BC, and very soon it spread throughout the Mediterranean and Middle East (Oddy 1993).

Metal threads seem to have been made of pure metals and alloys only in very early times. Gilt silver threads were already used before the 10th century AD (Járó and Tóth 1991), and were made by gilding rods of silver. The rod was hammered so thin that fine strips could be cut for making spun threads.

Silvering

Silvering is another method that has been used as a surface coating on baser metals such as copper, bronze and brass. The history of silvering is as long as the use of silver metal although silver plating is not as commonly found as gilding. Silver foil is more fragile than gold foil and tends to tarnish. These two characteristics put a limitation to

the fineness of plating. Moreover, the optical similarities with various coatings made from other white metals such as tin and arsenic make the identification of silvering difficult. The basic methods used for the application of silver coating are similar to those used for gold. Only those more commonly used are described here, as they have been discussed mainly by La Niece (1990 and 1993).

Gilding and silvering of organic materials

The weight of the finished object was another problem that craftsmen had to solve. During the 11th century much lighter strips made of *metal-coated organic material* were used (Járó *et al.* 1993). These consist of gold-leather, silver-leather, gold-paper, silver-paper or metal-coated animal gut (membrane threads). Generally the leather, paper and animal gut were gilded before being cut into strips. The strips could be used either flat or wound around a fibrous core.

According to Tímár-Balázsy (1998, 131), the gilding of leather and parchment was carried out either with gold leaf or gold powder, applied with the help of a binding medium or ironing (Fig. 3b). The information given from the gilding of manuscripts implies the use of a ground bole on the surface of paper before gilding and silvering (red for gilding and white for silvering), and it is supposed that the same method has been used for leather and paper threads. In the case of European membrane threads (Stodulski *et al.* 1985), animal guts covered with a metal, investigations have shown the application of very thin sheets (gilt silver leaves hammered from gilt silver foils) with the help of a binding medium. Járó (1998, 147) also describes the use of gold and gilt silver leaves for gilding leather and membrane strips, but without giving any information about the binding medium used. The same author has also identified the use of gold powder (Járó and Gondár 1988, 262).

Conclusion

All the developments related to metal thread production aimed to create lighter and less expensive threads. Pure gold threads were only used during the earliest times, and these were soon replaced by gilt silver threads and gilt organic strips. Copper based threads which were coated with gold and silver to imitate precious threads were occasionally used from the 15th century onwards, but only for second quality objects. More recently brass and brass coated copper threads were also used to imitate gold threads and in some rare cases the brass threads were also gilt. During the 20th century

even cheaper materials and modern coating techniques have been introduced in the manufacturing of metal threads, creating some new types.

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