Mercury Gilding in Today’s Japan: An Amalgam of Old and New

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Mercury gilding (amalgam gilding or fire gilding) is an ancient technique, and it is apparently attested in the West from around the mid first millennium BC. We must note, however, that only very few gilt objects have been properly analysed and that, until now, the problem of the origin of mercury gilding is generally very little researched in different parts of the world. The earliest examples of amalgam gilding in Asia seem to come from China and are dated to the Chan Kuo or Warring States period (475–221 BC). It is unknown exactly when the earliest amalgam gilt objects appear in Japan. This technique, however, seems to have been used surely since the Nara period (710–794 AD), and it was widely employed in the Edo period.

In recent times, this technique has disappeared from all decorative metal workshops, with very few exceptions, because of the high toxicity of mercury. A notable exception is the Morimoto Kazari Kanagu Seisakujo in Kyoto, a specialized workshop that is very active in the restoration and reproduction of decorative metal details in the field of Cultural Heritage. The workshop has operated since 1877 (Meiji period) by using ancient techniques, including amalgam gilding, to produce architectural metal fittings, metal decorations of shrines and ceremonial utensils. In this paper, the beginnings of the technique will be briefly outlined, and the procedures employed in the Morimoto workshop for the production of traditional decorative metalwork will be described and discussed.

KEY WORDS: mercury gilding; Japan; Jofuku; cinnabar.

1. Introduction

Mercury gilding—also known as amalgam gilding or fire gilding—is an ancient technique, and it is attested in the West from around the mid first millennium BC. For the moment, however, only very few gilt objects have been properly analysed; the problem of the origins of mercury gilding, therefore, is very little researched in most parts of the world.

For a long time, the earliest example of amalgam gilding in the West was considered to be a gilt fitting1,2) found in excavations in Rathgall, Ireland, dated to the 6th century BC (i.e., to the local Late Bronze Age). Another gilt object from the same context, however, does not contain mercury, like the other analysed finds belonging to this period;3,4) its date therefore has been recently challenged.5)

Fire gilt objects dated to a couple of centuries later—to the Iron Age and Hellenistic times—are known from other parts of Europe. Some Greek and Iberian objects have been identified,6–9) but the well known and widely quoted Bronze Age sword hilt from North Rhine Westphalia10) now seems to be modern,11) and not much is known from other areas.

The use of this technique must obviously be connected with the availability of mercury and/or with the know-how necessary for the distillation of cinnabar.

Mercury boils at 357°C, and cinnabar, burnt in the presence of oxygen, breaks down and releases mercury vapour at 600–700°C. Metals with a low melting and boiling temperature—such as mercury, arsenic and zinc—when smelted in a common furnace, will decompose and disappear as vapours up the chimney. One way to recover and use them is to employ the mineral as it is and produce an alloy by cementation with another metal. This would be done in a crucible covered with charcoal to avoid oxidation as much as possible. The process already may have been known in the Bronze Age and employed with copper and arsenic to produce arsenical copper. It was certainly used in Roman times, with copper and zinc to produce brass.12,13) A second possibility to avoid the decomposition and volatilisation in air of metals with a low melting and boiling temperature is the distillation of the mineral, as was done in the case of mercury.

2. The History of Mercury

2.1. The Distillation of Cinnabar in European Prehistory and Classical Antiquity

Ancient distillation processes are known from as early as the 4th–3rd millennium BC. A well-known early distillation vessel found in Mesopotamia was most probably used for distilling herbs, gums and oils in the production of perfumes,14,15) as described in later cuneiform texts.16) Several

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classical texts mention distillation.\textsuperscript{17} The most detailed examples come from the Alexandrian alchemists, and they also contain various illustrations of aludels (\textit{i.e.}, condensers) and alembics (\textit{i.e.}, stills).\textsuperscript{18} Some of the classical texts even describe the distillation of cinnabar.

The earliest description known—at least until now—of the distillation of cinnabar is in the \textit{Materia Medica} (\textit{περὶ \upsilon ιατρικῆς}), written in the 1\textsuperscript{st} c. AD by Pedanius Dioscorides, a Cilician-Greek born in Anazarbos in Asia Minor, who was a physician, pharmacologist and botanist.\textsuperscript{19} He states: “\textit{Putting an iron bowl containing cinnabar in a clay vessel, they cover it with a helmet (\textit{shaped vessel}) smearing it with clay, then they heat it with coals; the soot which adheres to the vessel, becomes mercury when scraped off and cooled}” (transl. Giumlia-Mair).

Pliny, the famous Roman encyclopedist of the 1\textsuperscript{st} century AD, describes this process with almost the same words and adds: “\textit{the cleaned condensed liquid which becomes the colour of silver and (has) the fluidity of water, ... is also divided into drops and runs down like a slippery liquid}”\textsuperscript{20} Pliny is also the first author who makes a distinction between \textit{argentum vivum} (\textit{i.e.}, native mercury) and \textit{hydrargyrum} (\textit{i.e.}, mercury obtained by distillation from cinnabar).

A further famous text describing the extraction of mercury is that written by Vitruvius, the illustrious Roman architect: “\textit{Now I will proceed to explain the treatment of minium (here vermilion or sulphide of mercury) The material, which is called ore, is dug up, then they produce minium by treating it. In the veins the ore is like iron, more ruddy in colour, and having reddish dust around it. When it is dug up and beaten with iron tools, it exudes many drops of mercury, which are collected quickly by the miners. Once this ore has been collected in the workshop it is placed in a furnace to dry because of its large amount of moisture. Next, when the steam stirred up by the heat of the fire condenses on the floor of the furnace, it is discovered to be mercury. After the ore is taken away, the drops which remain because they are too small to be collected are swept together into a container of water where they run together and are combined into one mass. When they are weighed, four sextarii of mercury come to 100 librae... Mercury, moreover, is useful in many instances. For neither silver nor brass can be properly gilt without it. And when gold is embroidered in clothing and the garment, worn out with old age, has no decent use, the cloth is put into a clay vessel and burnt over the fire. The ash is thrown into water and mercury is added to it. The mercury then gathers all the particles of gold onto itself and combines with them. Once the water is poured off, the remainder is spread over a cloth and pressed by hand. The mercury, since it is liquid, passes through the texture of the cloth when forced by the pressure, and pure gold is found in the cloth}” (transl. Humphrey et al.)\textsuperscript{21}

There is one caveat, in this text Vitruvius is calling cinnabar “\textit{minium}” (\textit{i.e.}, lead oxide) instead of vermilion (mercury sulphide), but the process he describes refers to cinnabar.

\subsection*{2.2. Early Mercury Mines in Europe}

The earliest known cinnabar mine in Europe is that of Šuplia Stena, on Mount Avala in Serbia. The cinnabar was already dug out of that mine in the Eneolithic. The local Kostolač Culture employed it as the bright red pigment vermillion.\textsuperscript{22} At the famous site of Vinča, approx. 20 km away from Šuplia Stena, several furnaces have been found during an excavation. Both Miloje Vasić and Alexander Durman hypothesized that these structures had been employed for smelting the cinnabar of the mine.\textsuperscript{23,24} After Dioscorides,\textsuperscript{19} cinnabar was extremely expensive and came from Libya. The most important mercury mines in antiquity were the Cilbian Fields of Ephesus, in western Anatolia and the famous Almaden mines in Spain, but there was also cinnabar of lesser quality in Colehis, Carmania and Ethiopia.\textsuperscript{25} From Vitruvius,\textsuperscript{21} we know that the Spanish cinnabar was brought to Rome and dealt with by the \textit{publicani} in the workshops between the temples of Flora and Quirinus.

\subsection*{2.3. Gilding in Classical Antiquity}

Fire gilding, amalgam gilding and mercury gilding are different names indicating the same technique that, in the
West, was perhaps invented in the Hellenistic period, but it became common only in Roman times. This was neither the only nor the oldest technique known in antiquity. After plating with a thicker gold sheet, foil gilding seems to have been the earliest technique on metals. The foil was applied directly on the surface and simply burnished with hard polished stones such as agate or hematite. On non-metallic materials (e.g., wood, leather and ceramics), the gold foil was attached on the objects by using organic glues such as apple juice, fish glue, milk, garlic juice, egg white or blood.

A less well-known technique, described in the Leyden papyrus, was gilding with lead. This method involved mixing one part of gold filings with two parts of lead filings. The mixture was applied with an organic glue to the surface of the pieces to be gilded and strongly heated to oxidize the lead and induce its evaporation.

Mercury gilding (Fig. 2) was obtained by mixing gold filings with mercury to obtain an amalgam that was then applied on copper-based objects containing very low amounts of tin and/or zinc and mostly no lead. The objects were then heated, and the mercury evaporated leaving a porous gold layer. The last stage was the burnishing of the gilt surface.

3. Mercury in Asia

3.1. Distillation of Mercury and Early Amalgam Gilding in China and Japan

Several Chinese texts, dated to the last centuries of the 1st millennium AD, discuss the distillation of mercury and describe in detail the apparatus. The Sung text Pen Chao Tu Ching, dated 1062 AD, recommends: “Take a jar made at Yang Cheng and fill it with cinnabar mixed with small pieces of hard charcoal. Cover the mouth of the jar with a piece of iron sheet that has been perforated with small holes. Hold the iron sheet in position by fixing a length of iron wire around the jar. Then invert the jar and place it over another similar jar containing water in such a way that the two come into contact mouth to mouth. Apply a lute composed of salt, clay and pig’s hair all over the upper jar, and especially round the rim where the two jars meet. After the lute has dried bury the lower jar in the ground so that the rim appears about an inch above the earth. Then build a stove surrounding the upper jar so that fire can be applied all about it to heat the contents. Let four openings be made, one on each side of the stove, to supply air for the burning. After heating for two hours the mercury will trickle down into the lower jar.”

A second description of the process, mentioned by Needham, is in the book Ling Wai Tai Ta (Information on What is Beyond the Passes), dated 1178 AD. It states: “The people of Yung turn cinnabar into mercury as follows. Iron is used to make an upper and a lower bowl-like vessel. The upper vessel holds the cinnabar, which is separated by an iron plate with small perforations. The lower vessel contains water and is buried in the ground. The two are joined mouth to mouth and sealed together just at ground level. A strong fire is then applied. On being heated the cinnabar changes into vapour, and on coming into contact with water it condenses, descending thus in the form of mercury.”

By this time the process was quite advanced. The earliest examples of amalgam gilding in Asia come from China, and are dated to the Chan Kuo or Warring States period (475–221 BC). We do not know when exactly the earliest amalgam gilt objects are to be found in Japan, however; this must have happened at a time in which both mercury and gold were available.

3.2. Jofuku

The story of the Chinese “magician” Hsu Shi, who was sent by the Chin Emperor Shi Huang Ti (259–210 BC) from China to Japan to the “three supernatural islands” in which “the immortals and the drug which prevents death can be found”, seems to be connected with both mercury and gold. Hsu Shi prepared an expedition and went by ship—together with 3 000 young men and women and many labourers—to the Japanese islands (the three sacred islands in the midst of the sea) on the quest for the wonderful drug that, as in all Chinese alchemistic recipes, must have contained mercury and gold, but he never went back to the emperor. The grave of the alchemist Hsu Shi, known in
Japan as Jofuku or Joshi, is still venerated as that of a sage and wise man by the locals who pray there for longevity and happiness. The grave is located in the city of Shingu on the main island of Japan, at the easternmost point of the Wakayama Prefecture, at the estuary of the Kumano River, and it is one of the places of interest in the Yoshino-Kumano National Park. The story of the alchemist Hsu Shi is also reported in the Chinese book Shi Chi (Historical Memoirs) by Su Ma Tan and Su Ma Chien (2nd–1st century BC), so it is quite clear that at this time alchemists were also active in Japan. At the latest in the time of Hsu Shi amalgam gilding, which was already used in China, must have been known in Japan, too.

This technique therefore seems to have been widely employed in Japan from early times and until the Meiji period (1868–1912). In the rich Japanese cultural heritage, innumerable examples of amalgam gilding exist, particularly in temples, and they need care and skillful hands for restoration.

4. Mercury Gilding in Today’s Japan

4.1. Mercury Gilding in Modern Times in Japan

The employment of mercury in industry and for other applications has greatly diminished in the last decades, together with the increase of health and safety regulations. In the European Union, for example, trade and industrial employment of mercury have been banned from the entire Union territory since 2011 because of its high toxicity.
The aspect of amalgam gilt objects however is very different from that of electroplating gilt objects, and in the case of the restoration and conservation of cultural heritage items, the different finishing would clearly show. In Japan the care of ancient monuments, such as temples and other historical buildings, often requires the replacement of amalgam gilt architectural decorative fittings, and this must be done by employing ancient techniques and adapting them to modern regulations and needs.

The Morimoto family has specialized for four generations in decorative metalwork at their workshop in Kyoto, Japan. They use the ancient Japanese techniques of traditional arts and crafts. The family has been active for decades in the difficult art of kazarishi (decorative metalwork) and has been employed by the Imperial Household Agency, the Cultural Heritage Institution and the Association of Shinto Shrines, to reproduce and restore many traditional decorative items: ceremonial objects, architectural metal fittings for both Buddhist temples and Shinto shrines, Buddhist altar equipment, bells, candle stands, lanterns, and also smaller decorative details, such as handles (fusuma) and nail covers (kugi kakushi) of traditional Japanese sliding doors.

5. Conclusions

All objects by the Morimoto Decorative Metal Workshop are produced using the ancient Japanese tradition, and gilding still employs mercury. The pieces to be gilded with amalgam are made of unalloyed copper, because the presence of other elements such as tin, lead or zinc would produce ugly spots on the gilding (Fig. 1). The parts are cast, hammered, engraved and decorated—for example, by chasing and embossing. The surface is prepared first by employing a file and then a special tool (similar to a knife) called kisage. After finishing with the tools, plain charcoal is rubbed on the surface to remove tiny imperfections. When the surface is perfectly smooth, it is polished with a cloth and degreased. Then mercury and nitric acid are applied (Fig. 2), and finally three to five gold foils are wrapped around the piece. In this way, the three metals—copper, mercury and gold—form an amalgam. During this process, the metal worker must wear a mask to avoid inhaling poisonous gases. The object is heated in a brazier over 352 °C (the boiling point of mercury) to drive off the mercury in the amalgam are made of unalloyed copper, because the presence of other elements such as tin, lead or zinc would produce ugly spots on the gilding (Fig. 1). The parts are cast, hammered, engraved and decorated—for example, by chasing and embossing. The surface is prepared first by employing a file and then a special tool (similar to a knife) called kisage. After finishing with the tools, plain charcoal is rubbed on the surface to remove tiny imperfections. When the surface is perfectly smooth, it is polished with a cloth and degreased. Then mercury and nitric acid are applied (Fig. 2), and finally three to five gold foils are wrapped around the piece. In this way, the three metals—copper, mercury and gold—form an amalgam. During this process, the metal worker must wear a mask to avoid inhaling poisonous gases. The object is heated in a brazier over 352 °C (the boiling point of mercury) to drive off the mercury in the form of vapor (Fig. 3).

After the evaporation of mercury, an opaque layer of gold is left on the surface. It must be polished first by rubbing it with dried rice seedlings (Fig. 4), then processing it in ash lye to eliminate impurities; next, the piece is cleaned in a plum vinegar bath and carefully washed and rinsed.

Finally, the gilt layer is burnished with steel tools of different shapes, depending on the type of the objects and kind of decoration. When the piece is finished and shiny, a thin coat of rice glue is applied for protection and to enhance the reflection.

The difference in texture and sheen is immediately evident when objects gilded by electroplating are compared to those that have been gilded with amalgam metal in the traditional Japanese tradition.