

## **CASTING DOUBT: ECONOMIC AND TECHNOLOGICAL CONSIDERATIONS REGARDING METAL CASTING IN THE ANCIENT WORLD**

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### **ABSTRACT**

The lost wax casting technique is almost impossible to use if the finished object must be of a specified weight or must utilize all of a given batch of metal. This basic fact helps to explain why Old World ancient gold jewelry, particularly of Hellenistic, Roman and Byzantine origin, is almost always hand wrought rather than cast. Similar considerations relate to the manufacture of copper-alloy weights or other objects which appear to be of pre-determined weight.

The study of the manufacture of archaeological and ancient art objects should attempt to explain why they were made by a particular method. Frequently the answer is obvious, but sometimes the ancient choice of technique can reflect practicalities or features of economics that are less readily apparent today. Consideration of ancient craft practices along these lines can shed light on problems concerning many manufacturing processes. For the purposes of this paper, metal casting is taken as a case in point.

Lost wax, and related investment casting methods, are an ideal way to produce precise decorative metal objects. The use of casting in antiquity is taken for granted for a wide variety of metal objects ranging from weapons to jewelry. As Maryon noted 'Casting in metal is one of the oldest arts in the world'.<sup>1</sup> However, casting was of limited use if the final volume or weight of the object was pre-defined. Such instances include objects where the finished casting must be of precisely pre-determined weight - such as weights and coins - and those objects made of a predetermined amount of metal without wastage - a typical example is jewelry made from gold supplied by the patron.

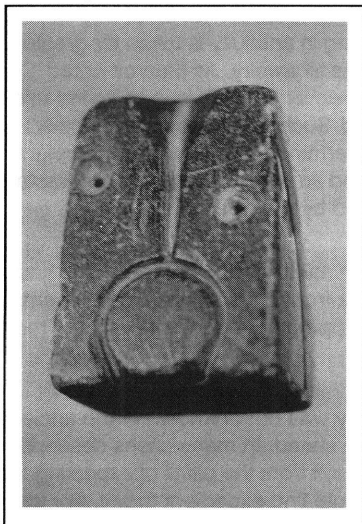
Whereas counterfeit coins could be made in multiple moulds, real coins had to be produced to precise weights, and so were struck from blanks. The blanks themselves could be made by melting together grains or clippings of metal totalling the required weight.<sup>2</sup>

The use of lost-wax casting for gold jewelry was not unknown in the ancient Old World but was far less widespread than has been stated. In many cases descriptions of ancient gold jewelry as cast are erroneous and result from the pitfall of expecting the ancients to have done things in the way that we would find expedient today. For example the famous Hellenistic Greek Nike gold earring in the Museum of Fine Arts, Boston - showing the winged goddess in her chariot - has been described as 'a casting of extreme delicacy',<sup>3</sup> when, in fact, it was produced in typical Hellenistic Greek manner from

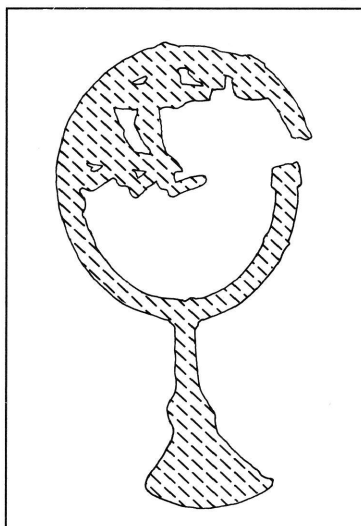
numerous components - actually well over 200 in number! In another instance, an elaborate Etruscan fibula of characteristic flimsy sheet gold, filigree and granulated construction, is referred to as made up from cast components.<sup>4</sup> Another authority has described not only an example of hand wrought Etruscan goldwork as cast, but also a very simple hammered and chisel-cut gold Bronze Age dress-pin from the Rhineland and a sheet-gold Scythian ornament.<sup>5</sup> Most recently the minute individual links on the chains hanging from a Bronze Age Anatolian earring in Philadelphia were described as cast in open moulds.<sup>6</sup> In fact the links, of the square cross section typical for this earring type, were hand wrought. The slight lip along the edge of the links is due to the flattening or smoothing operation rather than from a casting 'overflow', as suggested by the writers. In fact, the production of such precise square section links with an 'overflow', by casting in an open mould, would defy the laws of surface tension.

There are, of course, ancient Old World gold objects produced by casting, but they are limited in number. For decorative goldwork and jewelry, open or one-piece casting moulds are useless apart for production of a basic blank from which an object can be worked. Examples of this include some of the Roman gold snake bracelets where a rod with one end slightly enlarged could be cast in an open mould in clay, stone or even a slot in a piece of charcoal. This blank would then be hammered, chased and bent into the desired form.

The production of fine detail in casting requires lost wax or multi-part moulds. But here the provision for sprues (inlets for the molten metal) means that more metal must be melted and poured into the mould than was needed for the object. A reasonably large



**Fig. 1** Part of a 3-piece stone mould for casting a ring. Romano- Egyptian. c. 1st century AD. Private collection.



**Fig. 2** Cross-section of a mis-cast earring from Colombia showing sprue still attached. Museo del Oro, Bogata

sprue is required to provide a good 'head' or weight of molten metal to force it into the mould (figure 1). Even in modern jewelry production, the sprues can take up as much, if not more, gold than the ornament itself. This is not a problem when the sprues can be cut off and the metal recycled. This was possible in ancient times in societies where there was ample gold, or where the craftsmen kept a stock of precious metal. Such societies include some Pre-Colombian ones. For example figure 2 shows a mis-cast earring from Colombia. Even through this is clearly a poor casting, it is evident that the sprue would take up almost as much metal as the rest of the earring. In regions in the Old World where the goldsmithing industry was largely state or temple controlled, such as in Egypt and Sumeria, casting could be used. For example some gold figures of deities from Egypt were cast. However, even here, the thrones that they sit on are sometimes made from sheet metal - perhaps made from the recycled sprues.

In many ancient societies, gold jewelry was made to order from gold supplied by the customer, often in the form of coins, or ordered to be made to a certain weight. There is ample literary evidence for this.<sup>7</sup> For example the maid in Plautus' play *Menaechmi*, written in about 190 BC, says 'give me some earrings, have them made to weigh two nummi...'<sup>8</sup> In a letter written in Byzantine Egypt, Paniskos tells his wife to order anklets for their daughter to be made from three solidi (the gold coins of the period).<sup>9</sup> Now it is clear that the customer wanting, say a ring, and giving the goldsmith a coin to use as raw material, would not be happy to be handed back a small ring and plus a sprue. It is possible that for some objects the sprue could be used to form filigree, granules or other



**Fig. 3** Detail of a fake gold earring in Hellenistic style showing a casting 'seam' down its centre.

decorative components to decorate the casting, but it is also true that granulation and filigree were seldom, if ever, applied to solid rather than sheet goldwork in the ancient world.

It has often been believed that the figures of deities, for example, that decorate Hellenistic earrings, were small castings, but there are, to my knowledge, no clear ancient instances of this. On the other hand, forgers will often use modern methods. Figure 3 shows a detail of a fake Hellenistic earring of the Eros-hoop type, one of a pair made as one-piece castings. This was recently made in Italy using a silicon rubber mould taken from a genuine earring. The silicon mould was cut away from the real earring and then used to form the wax model for casting. Slight mis-alignment of the silicon mould when molding the wax has left a 'seam' line down the centre of the casting.

Over the last twenty years I have examined microscopically several thousand pieces of ancient gold jewelry. I have seen no certainly authentic Hellenistic or Roman gold ornaments that were unequivocally identifiable as cast. In every case it appears that they were made by hand work. Possibly some of the large Late Roman gold fibulae are exceptions, but even some of the largest and most massive Late Roman finger rings reveal that they were hammered and soldered, not cast. The elegant Classical and Hellenistic Greek finger rings provide little clear evidence as to how they were produced, but even here, when microscopic examination does reveal the mode of manufacture, this is again by hand working, not casting. Even the gold signets of the sixth century BC in Egypt - which can be very massive - were made up of separate components soldered together.

In retrospect this makes sense. Consider a Roman gentleman wanting a gold ring. He would take a gold coin or two to his goldsmith and ask for it to be made into the type of ring he required. In order to cast the ring by the lost wax process the jeweller would have to be able to create a wax model of the correct finger size and of precisely the same volume as the gold available. He would then have to add some gold of his own to allow for the sprue. Once cast, the surface of the ring would have to be cleaned up, but without using any abrasive that would reduce its weight. How much easier for a skilled craftsman to hammer, bend and solder the same ring. It is unfortunate that we have so few ancient literary references to jewelry construction. However, when the Greek writer Artemidorus, in the second century AD, contrasted hollow, sheet gold rings with their solid counterparts, he describes the latter as 'made of solid beaten metal'.<sup>10</sup>

It would be difficult and laborious, but not impossible, for an ancient craftsman to produce a wax model of the same volume as a given weight of gold. However, all the evidence suggests that the experiment and calculation required was seldom if ever used. The problem of how much metal was needed for a particular casting must have occupied many minds in early times. Pomponius Gauricus in the early sixteenth century wrote about bronze casting and gave the relative weights of equal volumes of clay, wax, lead, gold, and various copper alloys. But even he noted that 'any man of prudence will make sure

of everything by experiment before casting: recollecting in any case that the position of those who have too much material left over is even better than that of those who have too little.<sup>11</sup>

Copper alloys were undoubtedly cast from a date even before what we would term the Bronze Age. Nevertheless, a few of the points mentioned above sometimes need to be born in mind. For example, in the production of weights: bronze weights could be cast in open moulds - this is possibly true of the square and circular Byzantine weights - but could only be cast in multi-part moulds or by the lost wax process if the design was such that part of the object also formed the sprue. Even here, and with casts from one-piece moulds, the craftsman would still have to accurately judge the amount of metal required. From a practical point of view, it would have been advisable to make the castings a little over weight and then remove metal until the correct weight was reached. The alternative was to cast bronze weights hollow so that they could be filled with lead to bring them to the correct weight. This construction is typical for ancient steel-yard weights, for example.

A variety of cast copper alloy objects - including axes and mace-heads - have been considered by some over the years to fit into various weight distributions. While this is quite possible, such hypotheses must take into consideration the practicality of the ancient craftsman producing such objects to defined weight tolerances.

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