Antico and the Development of Bronze Casting in Italy at the End of the Quattrocento

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PIER JACOPO ALARI-BONACOLSI of Mantua, called Antico (ca. 1460–1528), spent a lifetime in the service of the Gonzagas as a goldsmith as well as a sculptor of elegant bronze reductions of the marble statuary of the Hellenized Roman world then being unearthed in Italy. He was among the strictest of the classicizing artists of the late quattrocento, continuing the uniquely archaeological tradition founded in Mantua by Mantegna, and was one of the Italian sculptors responsible for the popularity of the small bronze as a tangible expression of antique forms and ideals.[1]

Antico was perhaps the first sculptor to realize the advantages of being able to cast identical replicas of his small bronzes and thus occupies a special position in the development of Italian sculpture. This study will be devoted to an elucidation of his technique, based on the close study—including radiography—of a few, choice examples of his work and an examination of contemporary knowledge and practice. "Technique" in this case is intended in the strict sense of technological expertise and skill in execution rather than accuracy in modeling and sculptural fluency. Antico was a sculptor of genuine intelligence and taste, but he will be considered here largely in the light of those tasks that he could safely delegate to others without compromising his artistic vision.

The casting of small bronzes as distinct from monumental works poses certain specific problems and opportunities unique to the genre. To understand the context in which the technology of the small bronze evolved, however, it is necessary to review the history of quattrocento bronze casting as a whole.

The recently discovered Madrid Codices of Leonardo contain our only extensive source of knowledge of casting in Italy during the quattrocento.[2] Madrid Codex II consists, in part, of Leonardo's random jottings on the technical problems of casting the great equestrian monument to Francesco Sforza, a project that involved some seventy tons of bronze. It is fairly obvious from the text that Leonardo had still not solved these problems when Lodovico Sforza's political misfortunes consigned the project to limbo in 1499.

The equestrian monument, certainly the bronze caster's greatest challenge, is so difficult and singular a genre that it is amazing that any examples were successfully executed during the quattrocento. The fact that the *Gattamelata* and the *Colleoni* were cast is

1. The essential study of Antico is still Hermann Julius Hermann, "Pier Jacopo Alari-Bonacolsi, genannt Antico," *Jahrbuch der Kunsthistorischen Sammlungen des Allerhöchsten Kaiserhauses* 28 (1909–10) pp. 201ff. For the best recent summary see Anthony Radcliffe, "Antico and the Mantuan Bronze," *Splendours of the Gonzaga*, ed. David Chambers and Jane Martineau, exh. cat. (London: Victoria and Albert Museum, 1981) pp. 46–69.

2. Leonardo da Vinci, *The Madrid Codices*, trans. Ladislao Reti (New York, 1974), 5 vols.; for the Sforza monument, see V, fols. 141–157.

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itself extraordinary; more extraordinary still is that virtually not a line of technical investigation into their casting has been published. Despite the peculiar and specialized nature of the material contained in Leonardo's notebook, it is still invaluable for the insights it gives into what must have been the most advanced technical practice known to a Florentine working in Milan in the 1490s.

Other than the Madrid Codex II, there is no important primary source concerning casting technique surviving from fifteenth-century Italy, that is, between Cennini's *Libro dell'arte*[3] of the late fourteenth century and the *De sculptura* of Pomponius Gauricus of 1504.[4] While both works afford valuable evidence, Cennini was a painter and Gauricus a humanist and amateur rather than a practicing artist. Furthermore, while Cennini seems to have a direct and practical knowledge of the methods of casting he chooses to discuss,[5] Gauricus does not. In Gauricus, we have what may well be described as the "Plinian" turn of mind, not only because Gauricus is frequently dependent on the Roman author for his information, but also because, like Pliny the Elder, he would rather resort to his own library for information than to the actual workshop next door. Whatever Gauricus says about contemporary practice is usually contaminated with classical precedents, even to the pretentious title of his section "Chemike."[6] Despite its importance, Gauricus's theoretical treatise on sculpture—the first surviving from the Renaissance with the exception of Alberti's opuscule *Della statua*—must always be used with circumspection.

Of greater practical interest is Biringuccio's exhaustive *Pirotechnia*, published posthumously in 1540 but certainly written no earlier than 1530.[7] Here we have a treasure trove of information from someone obviously well-practiced in his craft and writing about a lifetime of experience in what would now be called metallurgical engineering. Biringuccio is only incidentally concerned with artistic casting, but whatever he tells us seems to represent contemporary practice. Unfortunately for our purposes, he seldom bothers to explain what is old—that is, quattrocento practice—but rather revels in the latest novelties. Nevertheless, he seems to mention virtually every technique he has ever known of, even if occasionally in a somewhat elliptical and parenthetical fashion, and his work is consequently of the highest importance.

The next two authors—Cellini and Vasari—are better known. Cellini's sober *Trattati* and, to a lesser extent, his autobiography,[8] are the only extensive sources written by a practicing Renaissance sculptor in bronze, and an important one at that. Although not a sculptor, Vasari, as was his fashion, made himself quite well informed about bronze casting for the technical introduction of his *Vite*.[9] This should not surprise us, since he certainly supervised carvers in his capacity as an architect and modelers in his involvement with projects of interior and festal decorations. With Cellini and Vasari we have advanced far into the sixteenth century, but not so far as to be within the influence of Giambologna and his circle, who appear to have begun the regular production of small replica bronzes in Florence. Both Cellini and Vasari represent the culmination of local Florentine practice, tenacious and conservative and, with the exception of Cellini's experience in France, totally Tuscan.

In fact, apart from Gauricus in Padua, who was not even a professional artist much less a bronze caster, all the authors mentioned were Tuscan, and all save the Sienese Biringuccio were Florentines. Thus there is a Florentine-Tuscan bias built into the nature of the surviving technical literature comparable in some ways to that of Vasari's *Vite* as the major source for so much

3. Cennino d'Andrea Cennini da Colle di Val d'Elsa, *Il libro dell'arte*, ed. Daniel V. Thompson, Jr. (New Haven/London, 1932); also the excellent translation by Daniel V. Thompson, Jr., as *The Craftsman's Handbook* (New Haven/London, 1933).

4. Pomponius Gauricus, *De sculptura (1504)*, ed. and trans. (French) A. Chastel and R. Klein (Geneva, 1969).

5. Cennini is not interested in bronze casting but describes molding in plaster (for life masks, etc.) in great detail (Cennini, *Il libro dell'arte*, pp. 117–123; *The Craftsman's Handbook*, pp. 123–131).

6. Gauricus, *De sculptura*, pp. 209–215.

7. Vannoccio Biringuccio, *De la pirotechnia* (Venice, 1540); also *The Pirotechnia of Vannoccio Biringuccio*, trans. C. Stanley Smith and M. Teach Gnudi (1942; reprint, New York, 1959). As the translation is one of the masterpieces of the technical literature and the original edition is difficult of access, all citations will be to the translation. Biringuccio died before Apr. 30, 1539, and the *Pirotechnia* was certainly composed toward the end of his career (for this see *Pirotechnia*, pp. ix–x).

8. Cellini's *Trattati* were not published in their original form until the Milanesi edition of 1857 (the "edition" of 1568 was actually a humanist reduction by Gherardo Spini). The Rizzoli edition containing both the *Trattati* and the *Vita* is the most convenient: Benvenuto Cellini, *Opere*, ed. Bruno Maier (Milan, 1968).

9. The sections on the technique of sculpture are virtually identical in both the 1550 and 1568 editions of Vasari's *Vite*.

of Italian art history. This bias will prove as significant for our knowledge of the history of techniques as for that of the history of styles.

The technical study of bronze casting in the Renaissance is as yet in its infancy, and considerable confusion is generated by what at best can be described as inconsistent terminology.[10] Certain arbitrary definitions are therefore in order.

The original figure prepared by the sculptor directly for casting, whether modeled in wax or plaster or carved in wood, is referred to here simply as the *model*. If the model is necessarily destroyed in the course of being transformed into bronze, the bronze so produced will be described as *directly cast*; if the model is preserved, substantially undamaged, the bronze will be *indirectly cast*. Neither term implies that the sculptor who prepared the model necessarily cast the bronze himself, although in both cases he may have.

Indirect casting makes it possible to create multiple casts from the same model. These casts will be substantially identical in both form and size except for differences in chasing and finishing subsequent to casting. Such similar casts from the same model are here called *replicas*. They bear the same relationship to their common model as do the various printed impressions of an engraving to the same copper plate. As with the engraving, where inking, press work, and inevitable wear may affect the quality of the impression, so may the quality of bronze replicas vary, as well as their finishing after casting.

The replica has to be distinguished from two other states: the *variant* and the *aftercast*. A variant is a bronze similar to another but cast from an independently fashioned model. No two directly cast bronzes can be replicas, since by definition the model is destroyed in direct casting. A variant may range from a second essay by the same sculptor to a carefully fashioned fake by an alien hand; in either case new models have to be prepared. With an aftercast there is no new model. An already extant bronze is used as a model for a necessarily indirect cast. Notice that an aftercast is always an indirect cast, while two directly cast bronzes can only be variants.

Shrinkage is an important distinguishing feature between the aftercast and the replica. A casting is always smaller than its model. After the molten metal is poured into the mold and the metal solidifies, it is still red-hot. As it cools to room temperature it contracts and shrinks away from the walls of the mold. Even if the mold cavity is precisely the same size as the model, the casting is inevitably smaller. This shrinkage averages about 1½ percent of the linear dimensions of the model for most of the common alloys of copper.[11] As a practical matter the observed shrinkage is frequently greater, especially if an *intermodel* (to be explained below) was used to produce an indirect cast. The inter-model produced by casting in wax also shrinks and consequently with an indirect cast the overall shrinkage between the original model and final bronze is found to be more like 5 percent. As an aftercast is always an indirect cast after an extant bronze (the model in this case), the aftercast will always be about 5 percent smaller than the original.

As with all definitions, there are gray areas. A model may be changed between two casts which would otherwise be exact replicas. In Antico's work such changes are usually quite slight. This is not necessarily the case; experiments with interchangeable heads, limbs, and attributes in the original models have produced the phenomenon of groups of replicas with interchanged parts. The problem also exists of similar bronzes which, while cast indirectly from a common model, are cast so ineptly as to appear to be variants rather than replicas or, even more confusing, interchanged replicas slovenly cast. There is a very important class of what may be called near-replicas produced at the time when the knowledge of expert indirect casting had not yet been diffused through all of Italy. These near-replica bronzes will be described when we examine the work of Riccio and his circle.

There remains one other class of bronze to be discussed. In every Renaissance sculptor's studio (and probably in many painters' as well) there were little wax *bozzetti* of various degrees of finish which were essentially study pieces and were never intended to be cast. Wax being so fragile a material, virtually no *bozzetti* have come down to us intact. As long as they remained part of the studio properties, they would be saved or discarded as convenience dictated. There is, however, a small but extremely interesting class of

10. I have tried to follow contemporary technical usage whenever appropriate. Unfortunately modern usage is sometimes as inconsistent as that in the Renaissance.

11. A linear contraction of 1½ percent is equivalent to 3/16 in. per foot. For shrinkage allowances for various metals and alloys, see American Society for Metals, *Metals Handbook* (Metals Park, Ohio, 1970) V, pp. 164, 425.

bronzes which represent the urge, probably on the part of collectors, to preserve permanently these orphans of the atelier. Of course, such waxes may be indirectly cast and reproduced ad infinitum, as in the case of the Degas bronzes of modern times. Not infrequently, however, they are direct casts and consequently unique. These *relict casts*, as they may be termed, present some of the most thorny problems of connoisseurship.[12] Since a wax would have to be fairly battered to provoke so drastic a method of preservation as direct casting, a relict cast may at first create a very unfavorable impression. Yet such a cast, in its better-preserved portions, can give us a notion of the sculptor's least premeditated style. The problems lie in identifying a genuine relict cast from mere variants by other hands, since by definition a relict cast was never, as it were, intended for publication. Thus, for one reason or another, it does not necessarily conform to the sculptor's own criteria of quality, nor does it usually represent his standard casting technique. The relict cast is to be clearly distinguished from the "trial cast," an erroneous and profoundly misleading expression. There are successful casts and unsuccessful casts, and unsuccessful casts repaired more or less successfully, or casts partially repaired and then abandoned. But as to casts for the sake of mere practice (like a warm-up before a sporting event), there seems to be no evidence for their existence.[13]

The sculptor wishing to cast a small, solid statue in bronze must, because of the problem of shrinkage mentioned above, start with a model which is slightly larger than the statue he wishes to arrive at. His simplest approach is to make a model in beeswax, a very sympathetic, plastic, and universally available medium. To the finished model he must attach a wax rod at some convenient point; this will form the channel, or sprue,[14] through which the molten metal will be introduced into the mold. The wax model must now be invested, that is, covered with some refractory mixture which will harden to form the shell of the mold. The most common investment, although not the only one, is clay. Again, universally available and literally dirt-cheap, it can be worked up with water, applied to the wax model as a paste, and allowed to dry. Only the end of the wax sprue is left exposed.

When the clay mold has dried and hardened, it must be fired. Firing accomplishes two things: first, it melts away, then burns out all of the wax model inside the mold; second, it further dries and hardens the clay shell. After firing, the wax model has been totally destroyed, hence the universally used and evocative expression, the lost wax technique, or *cire perdue*. According to the terminology preferred here, the process is "direct casting from a wax model."

The mold now needs only to be placed with the sprue end up and filled with molten bronze. When the bronze has cooled and congealed, the clay investment is broken away exposing the bronze statue inside, nominally identical in form to the original model, except for the protruding sprue which can be sawed or filed away.

The method sounds simple and up to a point it is. It has been routinely used for casting copper, gold, and silver, and their alloys in virtually every culture that has cast metals.[15] It is capable of exquisite delicacy even in cultures technically less advanced than that of fifteenth-century Italy. As has been shown by radiography, the Pollaiuolo *Hercules* in the Frick Collection was cast by this method, likewise the *St. John the Baptist* by Francesco da Sangallo in the same museum (Figures 1, 2). Both these statuettes are quite heavy, especially the *Baptist*, as they are solid casts. Solid casts, however, are costly, wasteful, and even technically unsound.

The preferred method is to cast a bronze hollow,

12. A possible example is a version of Antico's *Venus Felix* in the Victoria and Albert Museum, which while battered and unattractive in its present condition—it is coated with a thick layer of green paint—is just conceivably a relict cast of the original model for the Vienna example. No decision can be made before the bronze is cleaned.

13. The version of Antico's *Venus Felix* in the Capodimonte Museum has been called a trial cast. It is a weak variant by an unskilled hand. The notion of trial casts also implies that bronzes can be cast in permanent, reusable molds—like waffles! Neither Renaissance bronzes nor modern ones have ever been so cast.

14. A complex terminology has evolved in the casting industry to describe the entries and exits of a mold. Unfortunately the terminology is more or less standardized only for modern "green-sand" casting. This article uses the term "sprue" indifferently for the channel into the mold, for the projecting rod of metal formed in the channel by casting, as well as for the rod of wax joined to the model to produce the channel into the mold. (In this last case, stricter usage demands "sprue-former.") Modern users of wax models for casting seldom distinguish between these meanings, yet no ambiguity arises. One must, however, remember that in practice the passages into a mold were by necessity rather more complicated than the description of a single sprue implies.

15. One conspicuous exception to this is China of the Shang and Zhou periods when bronze vessels were cast directly into piece-molds without using wax models.

that is, with a core, making it less likely to be porous. The reason is that a bronze cast with a core needs less molten metal introduced into the mold. As the gas producing porosity is evolved from the metal during cooling, the smaller the quantity of metal the less the porosity and the sounder the bronze.

There is a simple method of casting a figure hollow, which is almost as great in its antiquity as the basic process of direct casting itself. The wax model is fashioned around a preformed core of dried clay. This core can vary from a crude lump whose only function is to displace metal to a quite accurately reduced and simplified version of the model. When the wax is modeled around the core to the desired thickness, it must be skewered through to the core with pins called chaplets. Then the wax must be invested and fired, and the metal poured as before. The purpose of the chaplets is to prevent the core from floating in the molten metal in the mold; they act as spacers between the core and the outer envelope of investment.[16] According to our terminology, this process is described as "direct casting from a wax model with a preformed core."

16. In modern usage, "chaplet" is more generally used to indicate a refractory spacing block between the core and the walls of the mold rather than a pin serving the same function; the term is capable of extension. As bronze is about eight times heavier than water, considerable force is exerted on the core by reason of its buoyancy in the liquid metal. The chaplets must be capable of resisting this force even at the temperature of molten bronze.

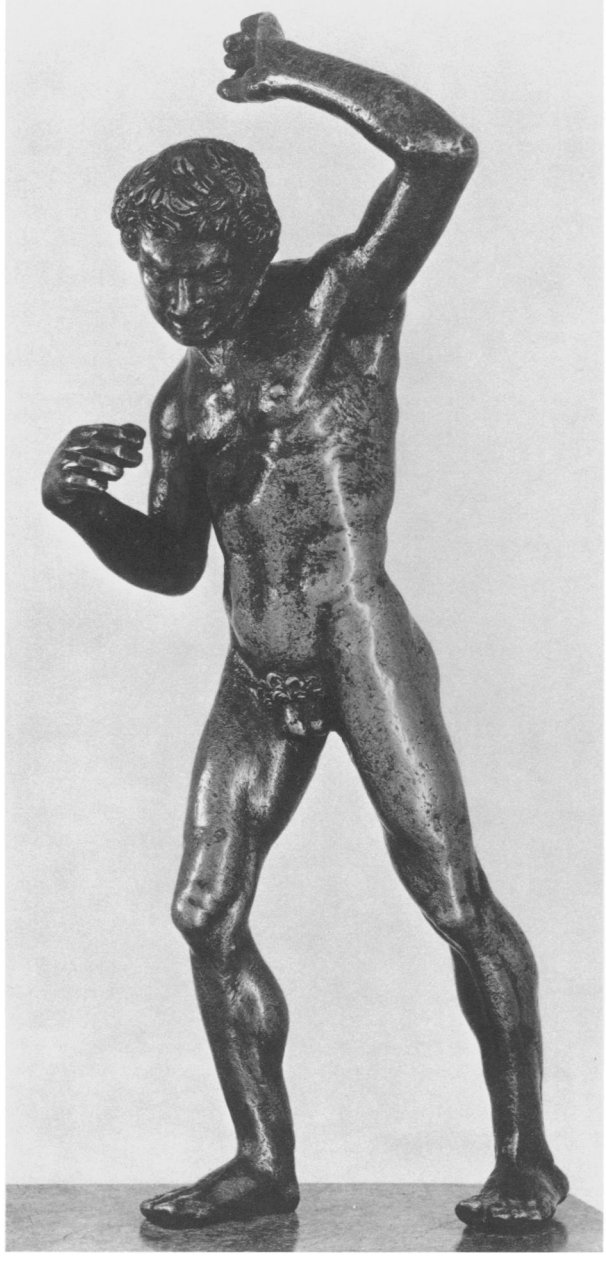
1. Antonio Pollaiuolo (ca. 1432–98), *Hercules*. Bronze, H. 44.1 cm. (incl. base). New York, The Frick Collection (photo: The Frick Collection)

2. Francesco da Sangallo (1494–1576), *St. John the Baptist*. Bronze, H. 53.1 cm. New York, The Frick Collection (photo: The Frick Collection)

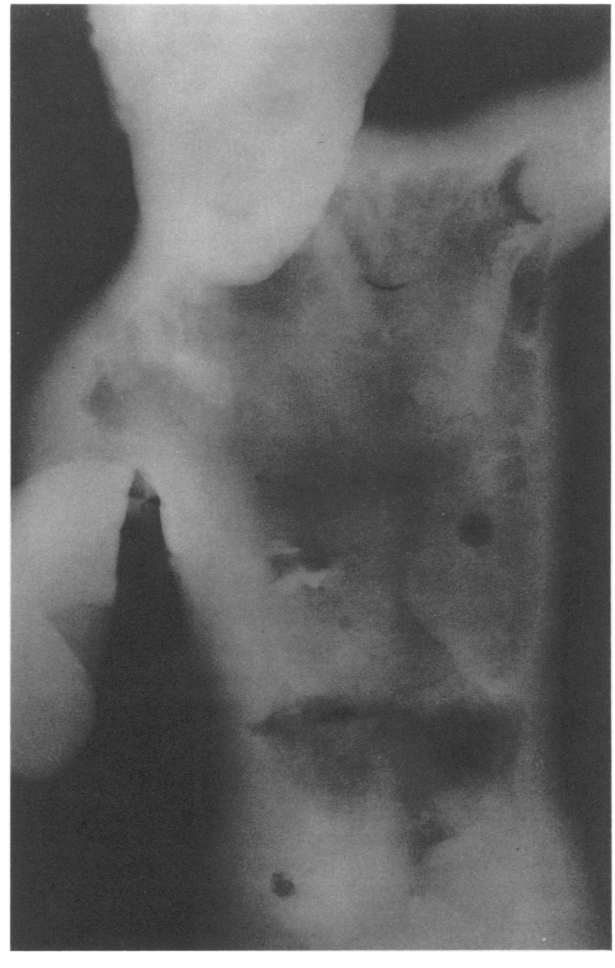
The main disadvantage of direct casting with a preformed core is the loss of the model; but there is another drawback. One of the functions of the core is to lighten the casting. If the sculpture is not very large, the core can be quite simple, just a roughly formed torso. For a sculpture of any size the core must extend into the extremities if the bronze is to be light enough to be picked up and examined. This immediately puts constraints on the sculptor, since the position of the extremities must be fixed from the very beginning and the spontaneity of direct casting from a wax model is totally lost.

Sometimes a Renaissance sculptor showed sudden technical inspiration. The *Surprised Youth* in the Frick Collection (Figure 3),[17] possibly an early work of Riccio, has been done with a certain naive ingenuity. The figure was apparently modeled in wax, then cut in two at the waist and the superfluous wax excavated from the chest. The scooping tool marks are clearly visible in the radiographs, especially in the shoulders (Fig-

3. Andrea Briosco called Riccio (?) (d. 1532), *Surprised Youth*. Bronze, H. 33.6 cm. New York, The Frick Collection (photo: The Frick Collection)



17. John Pope-Hennessy assisted by Anthony F. Radcliffe, *The Frick Collection, An Illustrated Catalogue*: III. *Sculpture, Italian* (New York, 1970) pp. 88–93.



4. Riccio (?), *Surprised Youth* (radiograph: Stone)

5. Bertoldo di Giovanni (d. 1491) and Adriano Fiorentino (d. ca. 1499), *Bellerophon and Pegasus*. Bronze, H. 32.5 cm. Vienna, Kunsthistorisches Museum (photo: Kunsthistorisches Museum)

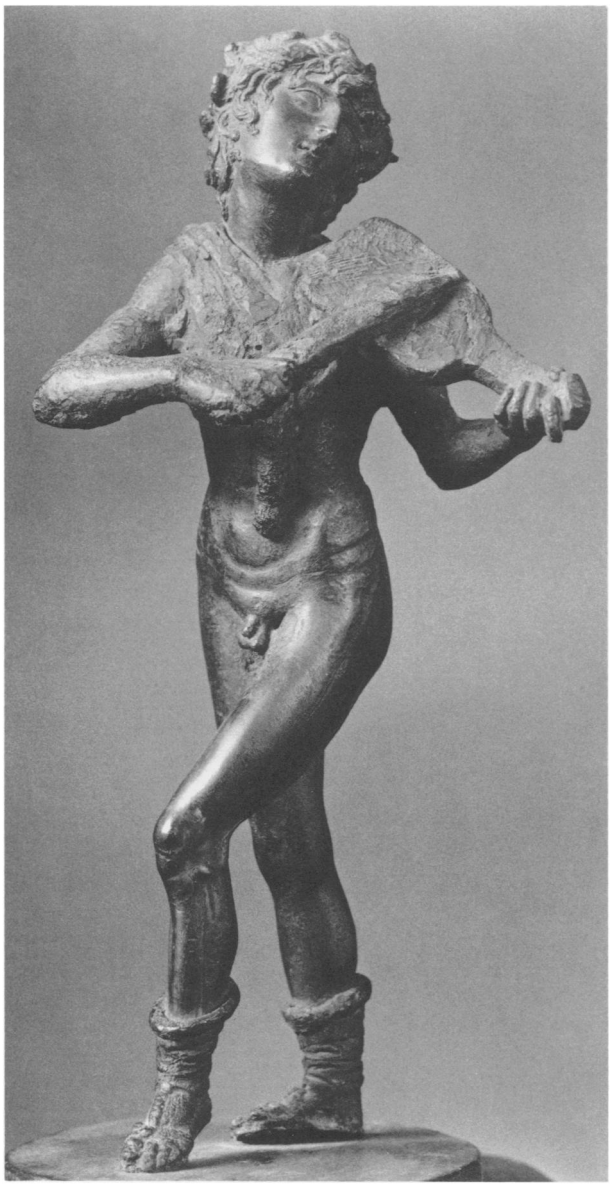
ure 4). The now-hollow chest was then filled with a refractory and allowed to dry, after which the two halves of the model were rejoined with a few drops of molten wax and the join smoothed over. Obviously unsuitable for a figure of any size or complexity, this is the typical and traditional method of hollowing leather-hard terracotta figures before their final drying and firing, a point that underscores the bronze's connection with Padua and that city's strong terracotta tradition.

In view of the loss of spontaneity involved in preforming a complicated core, it is not surprising to find that most fifteenth-century Florentine small bronzes were fashioned without cores. The author has examined only one exception, the *Bellerophon and Pegasus* of Bertoldo and Adriano Fiorentino in Vienna (Figure 5), where there is the impression left by a small preformed core in the belly of Pegasus visible through the hole in the belly used to evacuate the core material. Visual inspection and probing with a fine wire revealed that the hollow did not extend into the figure of Bellerophon.

The *Bellerophon and Pegasus*, even with its minuscule core, is extremely heavy, too heavy to lift with ease. The aesthetic of lifting and fondling bronzes had not yet entered the Florence of Bertoldo and Adriano.

There is more to be said of quattrocento Florentine casting. Foremost is its lack of technical expertise, combined with its tenacious conservatism. Let us consider a radiographed example: the Pollaiuolo *Hercules* in the Frick Collection.[18] Internally the bronze is flawed with enormous bubbles trapped in the metal; the exterior surface is likewise rough and slagged. No doubt the artist originally intended to bring it to a state of finish comparable to his *Hercules and Antaeus*

18. Pope-Hennessy, *Frick Collection*, pp. 22–29.



6. Bertoldo di Giovanni, *Apollo*. Bronze, H. 44 cm. Florence, Museo Nazionale (photo: Alinari)

in the Bargello. Why then was it abandoned? The answer seems to lie, as with the Bertoldo *Apollo* (Figure 6),[19] also in the Bargello, in the defectiveness of the casting. Having used a direct casting method capable of the greatest spontaneity, the sculptor was confronted by a surface so poor that it had to be filed away with the utmost diligence. The more it was filed, the more the interior bubbles were revealed; plugging was required, leading to yet more filing. It was the frustrations of this task that left so many Florentine bronzes surviving in a partially finished state. The sculptors were caught between an inadequate technique and the incompatible demands of an aesthetic that called for both artistic spontaneity and high surface finish.

It is only a slight exaggeration to say that Florentine bronzes were carved rather than cast. Beginning with Ghiberti's Baptistry doors (the chasing of which required an inordinate length of time) and extending even into the sixteenth century with Francesco da Sangallo's *St. John the Baptist*, Florentine bronzes were directly cast with a primitive technique, then filed, chiseled, and burnished into perfection. Direct casting was so universally practiced that it is doubtful if there was a bronze cast in replica in Florence before the arrival of Giambologna.[20]

What were the possibilities besides direct casting? All forms of indirect casting depend on the ability to make a piece-mold. There was no novelty in this since Cennino Cennini gave an adequate description of the technique in his *Libro dell'arte*, in which he suggested a life-mold of an entire human being be made from plaster of paris.[21] Plaster of paris is in many ways an ideal molding material. When mixed with water, it sets rapidly by means of a chemical reaction, which means that it need not be dried or fired to have considerable mechanical strength; at the same time, because it expands very slightly in setting, it is capable of registering the finest detail. Plaster has one great drawback, its rigidity. It cannot be flexed in order to remove it from a rigid three-dimensional form. Hence the necessity for piece-molding.

In piece-molding, the model must first be divided conceptually into sections, chosen so that there is no projection that may interlock with the plaster when

19. It is difficult to say whether the gaping flaw on the side of the chest of the Bertoldo *Apollo* is a displaced core or simply an area of very coarse porosity. The Bertoldo *Heraldic Wild Man* in the Frick is solid cast, as was shown by radiography. For the *Wild Man*, see Pope-Hennessy, *Frick Collection*, pp. 37–42.

20. Even the figures from the base of Cellini's *Perseus* appear to be direct solid casting. For illustrations of the back of the *Mercury* from the *Perseus* base, see Charles Davis, "Benvenuto Cellini and the Scuola Fiorentina," *North Carolina Museum of Art Bulletin* 13, no. 4 (1976) p. 15, figs. 13a,b. One can see the mounting socket let into almost the full thickness of the solid bronze torso. The *Mercury* is, of course, enormously heavy.

21. Cennini, *Il libro dell'arte*, pp. 120–121; *The Craftsman's Handbook*, pp. 127–129.

the mold is removed from the model. Then, section by section, the model is enveloped in plaster, each section separated by metal shims (as Cennino suggests)[22] or by little dams of clay. To ensure that the sections once removed from the model can be reassembled in proper registration, they are either notched into one another, or small eyelets or hooks that may all be tied together are imbedded in the plaster.[23] When the piece-mold has been completed, it is customarily greased and another shell of plaster is cast around it. This mold is a much simpler one, frequently just two halves; it greatly assists in reassembling the inner sectional mold once the latter has been removed from the model.

The piece-mold is an exact negative, or matrix, of the original except for the inevitable sutures between the various sections. It is evident that an object with complex surface textures or complicated postures will necessitate an enormous number of sections to accommodate the model. If the model is small, some sections of the piece-mold will be so tiny as to be impracticable.

A flexible molding material solves many difficulties but none was available in the fifteenth century. Biringuccio mentions molds in glue, wax,[24] even papier-mâché,[25] but all in rather specialized contexts. Glue was eventually to become the favored material, as a strong solution of glue is fluid when hot, yet sets to a firm but reasonably flexible gel when cool. There is no evidence that it was in common use for molding statues in the round before the time of Giambologna, if then. There is, in fact, considerable evidence to the contrary.[26]

It is, of course, possible to cast metal directly into a piece-mold, but this was virtually never done. Leonardo toyed with the idea for the Sforza Horse but he had already realized the major drawback.[27] Under the pressure of the molten metal every one of the seams in the piece-mold would leak. When the metal had hardened and the mold was broken away, every leakage would be a projecting fin, or flash, of metal, to be laboriously filed away. The problem would be especially acute for small bronzes since the fins would be so close together as to make finishing—without marring the rest of the surface—very tedious.

It is obviously easier to finish wax than metal. Why not cast wax into the piece-mold, instead of metal, producing a replica in wax of the original model? By and large this was the procedure followed in indirect casting, to cast an inter-model[28] in wax which could then be carefully finished and invested to produce the final cast in metal.

One problem remains unexplained—how to produce a suitable core for the inter-model. There are two difficulties to be overcome: first, to make a core uniformly smaller than the inter-model, that is, to control the thickness of the walls of the metal cast; second, to fix the core within the mold so that when the wax is burnt out and the molten metal poured in, the core will not shift or float.

By the end of the fifteenth century, several different methods for producing cored, indirect casts of varying degrees of fidelity to the original model had been developed. All of these methods were confined to north Italian sculptors. When the major center of production of small bronzes moved from Tuscany to

22. In making a life mask Cennini does not piece the mold. A human face is sufficiently pliable to permit a rigid plaster mask to be removed without too much difficulty.

23. This latter method using cords and eyelets is described by Cellini in the *Trattati* (Cellini, *Opere*, pp. 796–797).

24. Biringuccio discusses molding using glue and wax essentially in the context of high relief, not for sculpture in the round.

Wax may be used to mold from even wax models if one is sufficiently dexterous. The wax model is coated with honey-water as a release agent, then subsequently coated with molten wax to form a shell. The temperature of the molten wax must be just right or disaster ensues. The wax shell may be dissected away or threads may be laid on the model with honey-water which will cut the shell apart when the ends of the threads are pulled taut (Biringuccio, *Pirotechnia*, pp. 131, 132). Antico may have been aware of the wax-on-wax technique, but it must be remembered that his method would demand the *cire moulage* conjuring trick to be done twice to produce positive wax shells from his wax models.

25. Biringuccio saw Giambattista Pelori using papier-mâché to mold ancient sculpture for reproductive plaster casts (Biringuccio, *Pirotechnia*, p. 332). This method would obviously not be very suitable for small-scale work.

26. Though Biringuccio recognizes glue as a flexible molding material, his lack of any directions to add a plasticizer shows the limits of his expertise. The only one available to him would have been honey. In the 19th century glycerin was introduced with much better results. The glue–glycerin mixture was subsequently replaced with mixtures based on agar-agar which melt at lower temperatures and therefore with less danger to the model.

27. For Leonardo planning to cast the Sforza Horse directly into a piece-mold, see Bruno Bearzi, "Leonardo da Vinci ed il monumento equestre allo Sforza," *Commentari*, n.s. 21 (Jan.-June 1970) pp. 61–65.

28. The inter-model is also known as a "counter-model," but this term suggests that it is the *negative* of the model.

northern Italy, there seemed to be an advanced technology ready and waiting for the new artistic genre.

In April 1519 Antico wrote the following letter to Isabella d'Este:[29]

Illustrious Lady: A few days ago your Ladyship asked me if some of the antiquities had been found which at another time I made for the bishop [Lodovico Gonzaga, bishop elect of Mantua]. I looked for and found the nude that kneels on a tortoise (the one that was stolen from your Ladyship), also the satyr that caresses her, that beautiful thing—a girdle of leaves can be made to clothe him for the sake of modesty. I have also found the model of the Hercules who is killing Antaeus, which was the most beautiful antiquity among them all; also the horse of St. John in the Lateran, that is [Marcus] Aurelius Antoninus—about eight works from among the best.

I have again spoken with the master who worked for the bishop and he says that given the finished wax[es] he can make the figures half a *braccio* tall for twenty-five ducats a piece (which would be a great bargain), that is to say, the Hercules valued with the Antaeus for fifty ducats and the kneeling nude for not less than twenty-five—in which case you would have it for less than half the [original] cost.

I would give you these things for the love of your Ladyship, freely, if only to be called upon when your Ladyship should wish to adorn some place with any sort of bronze bust, as I now have a way of having them made which will make them even more beautiful than those busts which were made for the bishop.

However, said Master Iohan told me he would be willing to work by the month as he used to for the bishop—at six ducats a month, plus board for three people—and in this way he would be willing to deliver the figures cast in metal. That way, your Ladyship willing, we would be able to make them for no more than twelve and a half ducats a piece; this would be twice as good for you.

I hope your Ladyship is not displeased with this answer.

April 1519

It is obvious from the letter that Antico is offering to Isabella replicas of the bronzes that he had made at least nine years earlier for Lodovico Gonzaga. Although Isabella seems to have at first refused the sculptor's offer, she eventually must have changed her mind since the *Hercules and Antaeus* now in Vienna (Figure 7) bears her abbreviated name and title on the underside of the base.[30]

The letter also makes it clear, from the reference to "Master Iohan," that Antico routinely had bronzes cast from his models by others. We do not know whether casting also implied finishing and chasing, or, indeed, whether Antico always used the services of a caster. What is certain is that Antico had mastered the technique of indirect casting, that he kept his original wax models intact, and that he could produce replicas from them at will, as he did for Isabella d'Este.

Despite the existence of this letter we know very little from the documentary sources about Antico's methods of indirect casting. From an earlier letter to Isabella d'Este dated 1504, concerning the still unfinished model for a gold *St. John*,[31] he seems to have modeled in wax, apparently over an armature of iron

29. Umberto Rossi, "I medaglisti del rinascimento alla corte di Mantova: Pier Jacopo Alari-Bonacolsi detto l'Antico," *Rivista italiana di numismatica* 1 (1888) pp. 190–191. Antico to Isabella d'Este: "Illu. Signora.—I di pasati vostra signoria mi dimandò se el si trovava de quelle antichità che altra volta fece per il veschovo: ò cercho et trovato la nuta che inenochata in su la bisa schudelara, quella che fu robata a vostra signoria, ancor il satiro che la chareza, che bella cossa, il se pria farli la bracha de fogli per honestade, ancora io ho trovata la forma de l'Ercule che amaza Anteo, che la più bella antiquità che li fusse, anchora il chaullo de Santo Iani Laterano, zoè Auellio Antonino, circha oto cose de le migliore. Ancora io ho parlato come il maestro che laurava al veschovo, et dice dagandoli de cera netizate, chel faria per vinticinque ducati il paro dele figure di longeza di mezo brazo, dove seria grandissimo merchato, che l'Ercule val cum l'Anteo duchati cinquanta, la nuda inzenochiata non val manco de vinticinque, dove se aria per la mità mancho de la valuta. Io li daria li chose per amor de la signoria vostra voluntera per eservi obligato ancora quando vostra signoria volesse adornar qualche loco de alchuna testa di bronze, io ho il modo e farne fare che serà più belle che non è quelle del vescho. Il dito maestro Iohan ma ha dito chel staria al modo et lavoreria a mese chome faceva col veschovo, a sei ducati il mese et le spese per bochi tre et voria li dese le figure zetate di metalo, dove volendo vostra signoria chel lavora il faremo lavorar a dodese duchati e mezo dil p. . . . perchè sel starà el dopio meglio. Prego la signoria V. non li dispiatia la resposta; de aprilo 1519." (Translations of Antico's letters by the author.)

30. Hermann, "Antico," pp. 239, 240, fig. 15. Hermann describes the inscription as *engraviert*, which is certainly not true if by *engraviert* he means cut into the metal with a burin. As is clear even from Hermann's reproduction, the inscription was written in the wax with a pointed instrument before the bronze was cast, proving that the *Hercules and Antaeus* was made expressly for Isabella.

31. Rossi, "I medaglisti," p. 181. Antico to Isabella d'Este, Mar. 30, 1504: "Le mane et i piedi non sono finiti per eserge dentro filo de fero, perchè non se poria far altramente: bisognarà satisfar, in quel d'oro farasi ogni cosa più delichato."

wire. The principal evidence for his casting technique is supplied by the works themselves.

The author has been fortunate in having three bronzes by Antico available to him for extended technical study: the *Paris* in The Metropolitan Museum of Art; the *Standing Hercules* in the Frick Collection; and the *Spinario* in the collection of Mr. and Mrs. Charles Wrightsman (Figures 8–12). From these, as well as those radiographed in the Victoria and Albert Museum (the *Hercules and Antaeus*; the *Atropos*; and the *Meleager*, Figures 13–18), it has been possible to reconstruct Antico's working technique in considerable detail, with results borne out by what can be learned from the direct examination of the rest of Antico's work. A preliminary synopsis of these conclusions may make the technical details easier to follow.

As we have said, Antico modeled in wax on a wire armature. His models were prepared in the knowledge that they were to be indirectly cast, hence they were finished to a considerable degree. A piece-mold in plaster of paris was then made from the wax model. Once the piece-mold was disassembled from the model, the latter could be put aside. The piece-mold was then reassembled, but in sections, not completely. In general there were five sections of partially reassembled piece-mold: the main section, consisting of the head and torso, plus four for the limbs.

Hardened plaster of paris has a convenient property. While it is not easily soluble in water, it readily absorbs it, creating a surface to which molten wax will not adhere. Thus, wax objects can conveniently be cast in wet plaster molds. So much was known to Pomponius Gauricus, who recommended the method for casting hollow wax figures.[32] If the limbs of the statue were to be cast solid, Antico (or his assistant) took the piece-mold sections for the limbs, thoroughly wet them, then promptly filled them with molten wax. When the wax had chilled through and hardened, the piece-molds could be easily disassembled, leaving wax replicas of the original model of the limbs. These replicas would, of course, still be marred by the projecting fins from the seams of the mold.

32. Gauricus, *De sculptura*, pp. 226–227. As Chastel and Klein note, the procedure of casting wax shells from wet molds was known to Biringuccio and Vasari. Chastel and Klein also note that "Gauricus, cependant, ne semble pas songer à l'emploi de ces cires creuses pour la fonte du bronze, mais seulement à la fabrication de masques ou autre moulage en cire" (p. 226 nn. 32, 33).

Next would come the casting of the head and torso in wax. These were always cast hollow by means of a very simple trick. The head-and-torso section of the piece-mold, like the others, would be wetted and filled with molten wax. This time, instead of being allowed to congeal through and through, the wax would be

7. Pier Jacopo Alari-Bonacolsi called Antico (ca. 1460–1528), *Hercules and Antaeus*. Bronze, H. 43.4 cm. overall, figures 39.7 cm. Vienna, Kunsthistorisches Museum (photo: Kunsthistorisches Museum)

left in the mold only long enough for a relatively thin skin to form against the surface of the mold. When Antico judged that this skin was sufficiently thick, he simply poured out the surplus wax. He now had a plaster piece-mold lined with a thin shell of wax into which he poured the investment to form the core: fresh, liquid plaster of paris mixed with fine sand. When the plaster had hardened, the piece-mold for the torso was disassembled, leaving the finished wax head-and-torso with its cast core already in place.

The inter-model could now be assembled. The wax limbs, already cast, could be heated at their points of attachment and fused to the torso at the hips and shoulders.

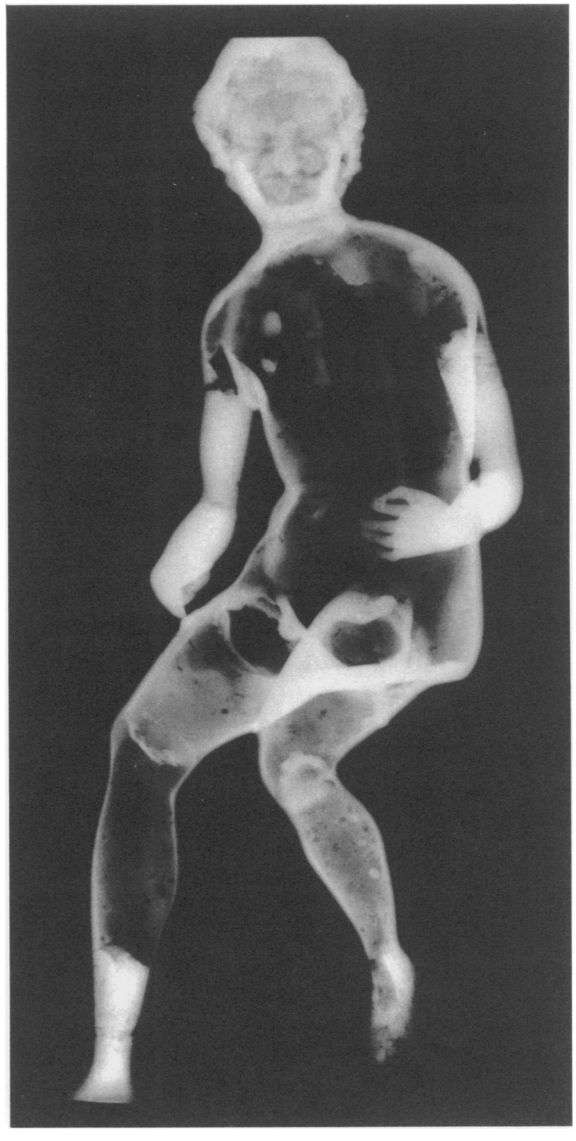
It was at this stage that the inter-model would be prepared for casting, or fettled. All the seams left from the piece-mold could be easily smoothed away, as well as any roughness left from the joining of the limbs to the torso. With the original model as a guide, any imperfections in the wax could be touched up, or small additions—such as attributes or changes in decorative details—made.

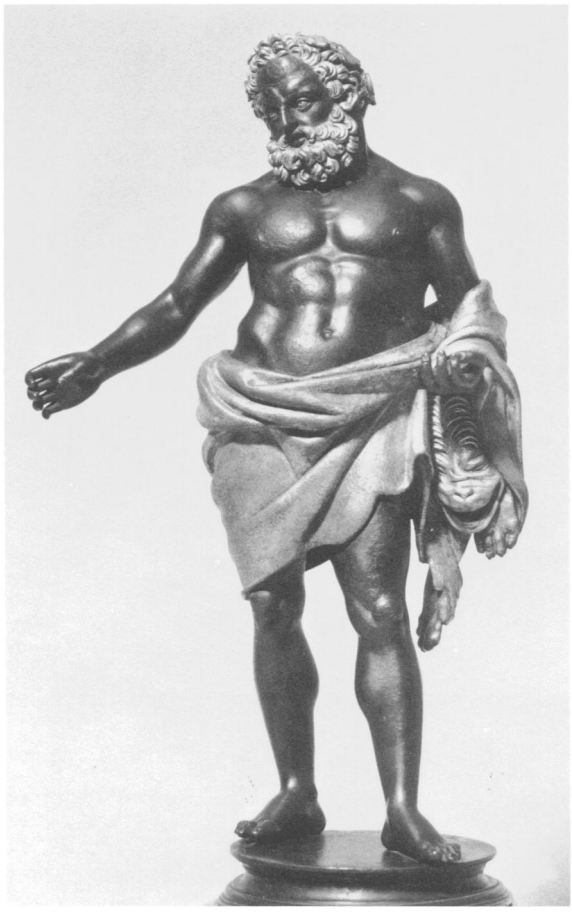
The next step was to insert the chaplets. Antico used drawn iron wire about a millimeter in diameter which he simply pushed through the wax shell, like a pin, until it struck the plaster core.[33] He usually chose

33. The maximum diameter of the wires is about 1 mm.; they are frequently smaller. When visible on the surface they are always quite accurately round in section.

8. Antico, *Paris*. Bronze, H. 37.1 cm. The Metropolitan Museum of Art, Edith Perry Chapman Fund, 55.93

9. Antico, *Paris* (radiograph: Stone)





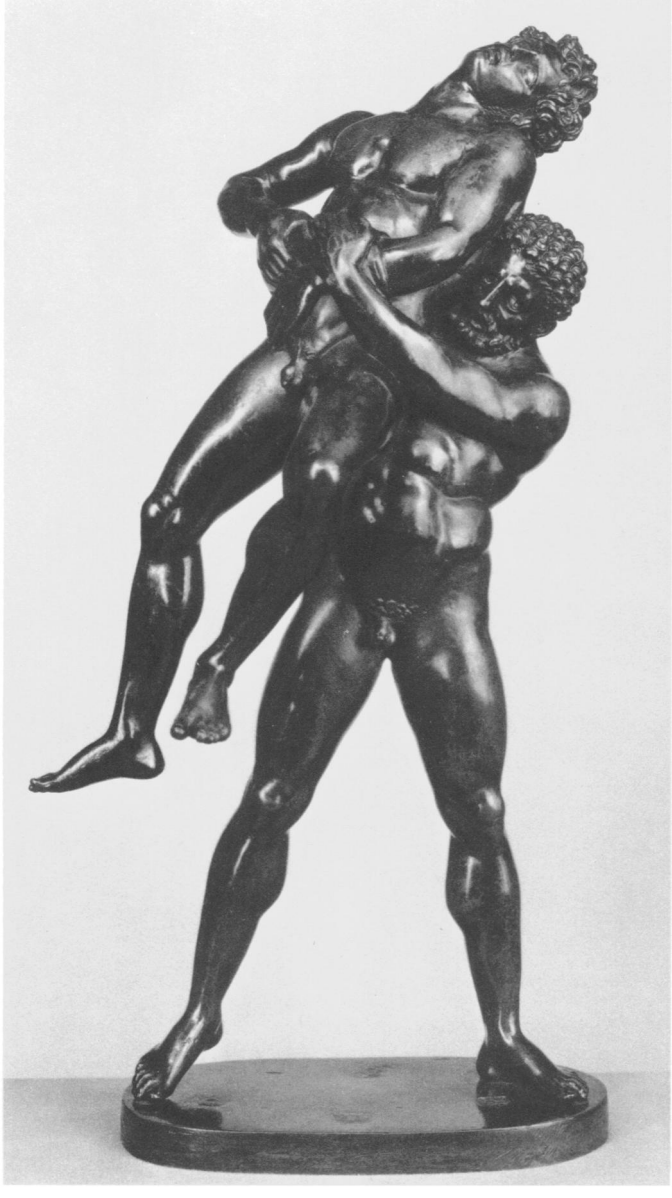
10. Antico, *Standing Hercules*. Bronze, H. figure 34.8 cm. New York, The Frick Collection (photo: The Frick Collection)

12. Antico, *Spinario*. Bronze, H. 19.8 cm. New York, Collection of Mr. and Mrs. Charles Wrightsman (photo: Stone)

11. Antico, *Standing Hercules* (radiograph: Stone)

13. Antico, *Hercules and Antaeus*. Bronze, H. 46.7 cm. overall, figures 39.1 cm. London, Victoria and Albert Museum (photo: Victoria and Albert Museum)

14. Antico, *Hercules and Antaeus*, Victoria and Albert Museum (radiograph: Victoria and Albert Museum)



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15. Antico, *Atropos*. Bronze, H. 29.6 cm. London, Victoria and Albert Museum (photo: Victoria and Albert Museum)

16. Antico, *Atropos* (radiograph: Victoria and Albert Museum)

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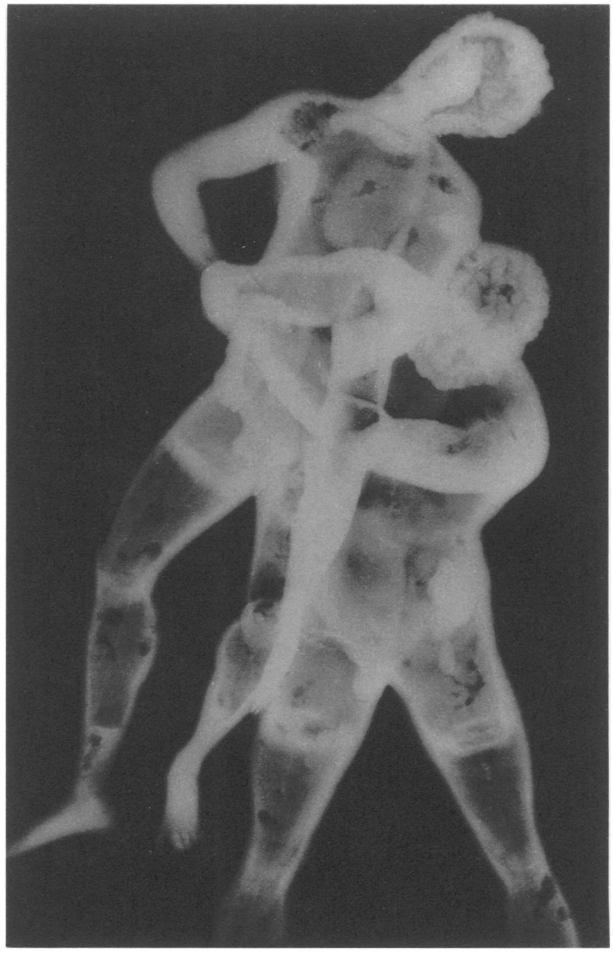
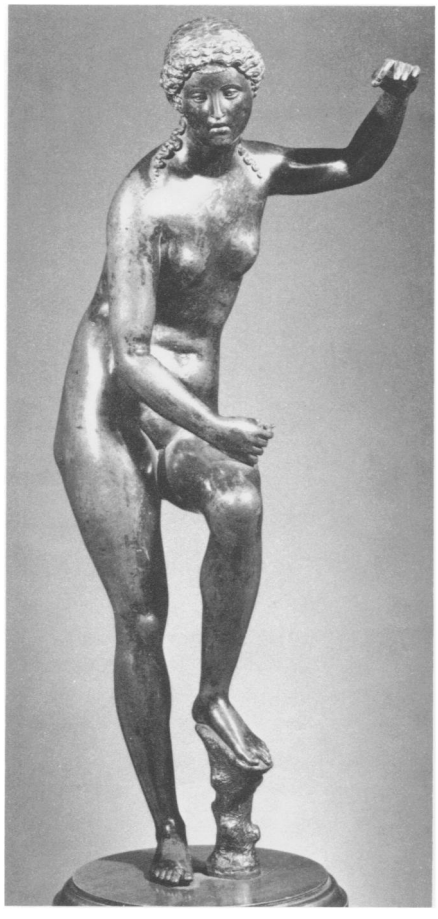
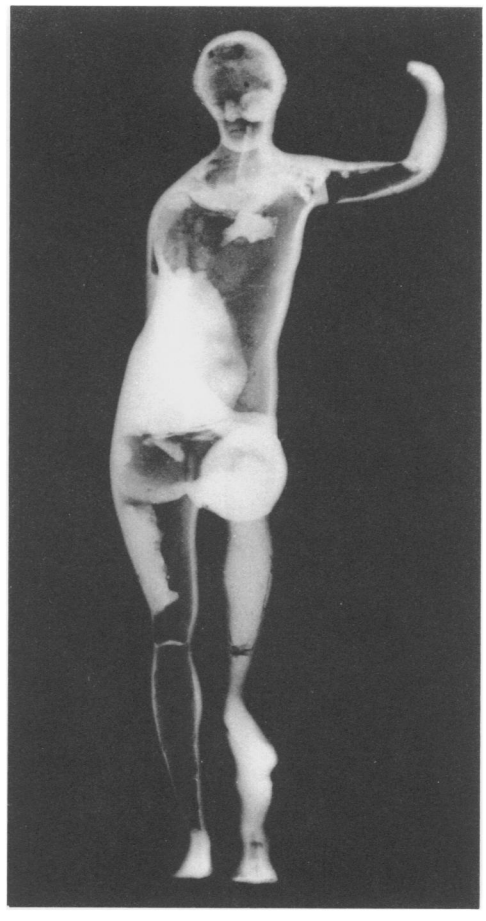
17. Antico, *Meleager*. Bronze, H. 30.8 cm. London, Victoria and Albert Museum (photo: Victoria and Albert Museum)

18. Antico, *Meleager* (radiograph: Victoria and Albert Museum)







19. Antico, *Paris*, radiograph of right foot (radiograph: Stone)

convex surfaces in which to insert these chaplets, making it easier finally to trim them back to the bronze.

The inter-model, looking now like a pincushion with its protruding wire chaplets, was next provided with rods of wax to form the sprues. There had to be several, to provide entrance for the molten bronze into the mold and egress for the trapped, heated air.

The inter-model, equipped now with both sprue-formers and chaplets, was then invested. There is no reason to doubt that Antico used the same investment for the exterior mold as he used for the core: plaster of paris mixed with sand. From here on the casting procedure followed the standard course: the wax was fired out and the now-hollow mold was filled with molten bronze. When the metal had cooled, Antico broke away the exterior mold and began the chasing of the bronze. He seems to have made no effort to remove the core, unless it was readily accessible, as in the open-based Wrightsman *Spinario*. This indifference seems not to have been shared by Antico's contemporaries, such as Severo da Ravenna or the Paduan founders, who apparently went to great lengths in order to remove as much core material as feasible, even if this meant cutting a port in the walls of the bronze to do so.

Any bronze, no matter how carefully cast, requires at least a minimum of cleaning and chasing. When broken out of the mold, it is inevitably covered with black copper oxides which must be removed, generally by pickling, that is, soaking in dilute acid, or by scraping. The sprues and chaplets must be sawed and filed away. Then the surface of the bronze must be polished with the use of abrasives or by scraping and burnishing. Antico seems to have preferred the second method. Wherever the patination has worn thin on one of his bronzes, one can see, especially in raking light, fine parallel striations of a type produced by a polished steel burnisher.

Antico made good use of his intact cores when dealing with the disfiguring areas of porosity or even gross flaws that are inevitable in casting bronze. The damaged metal was cut away and the core within excavated, generally quite extensively, undercutting the sound bronze walls to key in the patch. Into this excavation fresh molten bronze was poured until it filled the hole in the core as well as the hole in the wall of the bronze. After the cast-in patch had cooled, the superfluous metal could be filed back to the original surface of the cast. When scraped and burnished these cast-in repairs are virtually invisible except in radiographs.[34]

On at least one occasion, Antico made a major repair by a similar method. The legs of the Metropolitan Museum *Paris* (which would be Antico's largest statuette if it were a standing figure) are cast hollow. Apparently the right, extended foot was defective and was sawn off at the ankle. Returning to his original piece-mold Antico cast a new foot in wax. After excavating the core at the ankle some way up the calf he fixed the new wax foot to the bronze stump of the ankle. He then proceeded as usual, attaching a wax sprue, and investing the wax foot and the calf. After locally burning out the wax, he poured a new foot in bronze. The junction between the new foot and the calf at the ankle is now completely invisible and the repair was totally unsuspected until the *Paris* was radiographed. In the radiographs the plug of bronze extending into the calf is quite obvious, and even the

34. In both the *Meleager* and the *Atropos*, the amount of core excavated and filled with new bronze is much greater than the actual size of the flaw would lead one to expect was necessary. On neither of these two bronzes are the repairs visible to the naked eye. The Wrightsman *Spinario* has a large, relatively shallow cast-in repair on the back. The edges of the flaw are just visible in a good light.

seam beween the new bronze and the old within the calf is visible (Figure 19). As the molten bronze of the repair cooled and contracted, it left a minute gap between the plug and the inner surface of the walls of the calf. This tiny gap is visible in the radiographs. Essentially, the new foot is fixed in place by a mechanical bond, the plug running into the calf, tapering outward from the ankle. This was an advantage to Antico; by not relying on actual fusion to hold his repair in place he could use the same alloy for the repair as in the original bronze. Hence the new foot would be identical in color with the old leg and the repair quite inconspicuous once the seam between the old and new had been burnished over. Antico seems to have relied very seldom, if ever, on soldering or brazing—that is, true fusion to the bronze—to effect repairs. The lighter-colored solder alloy would have been too conspicuous.

Of the bronzes studied in order to arrive at these conclusions about Antico's casting technique, the Metropolitan Museum *Paris* was the most important for several reasons: first, it has been constantly available to the author; second, it seems to employ the entire repertory of Antico's technical methods; third, it has been partially mutilated in a way that greatly aids its examination.

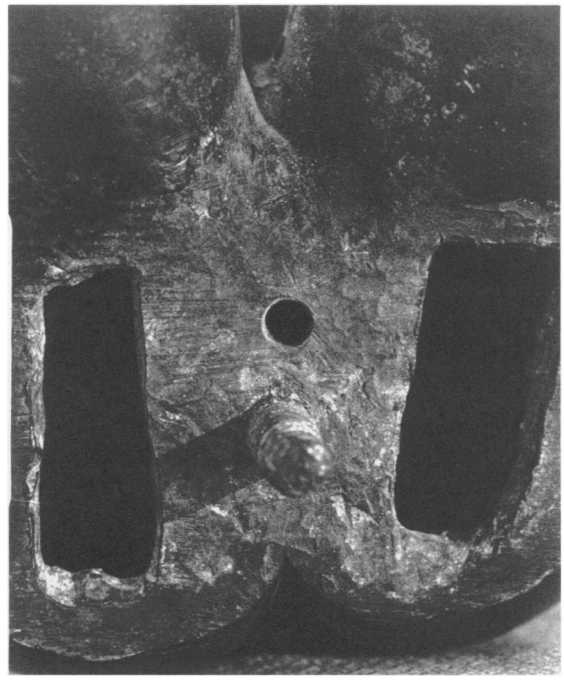
When the figure came to the Museum it was seated on a bronze stump which, as an obvious addition, was removed; it is now displayed seated on a wood plinth. In the entire Antico canon there survive only four seated figures: the *Paris*; the *Spinario*; the *Satyr* in Vienna; and the Rothschild *Seated Woman*,[35] which is currently inaccessible. As Sir Francis Watson points out,[36] the *Spinario*, seated on a tree stump, was never intended to have any further base as there are absolutely no signs of attachment. On the other hand, the Vienna *Satyr* was originally intended to sit on a stone plinth, since projecting down from the buttocks is a tapered bronze tang, notched along the side, which was clearly designed to be inserted into a hole drilled in a stone block and plastered in place; the notches were to key the tang into the plaster.[37] When we examine the buttocks of the *Paris* (Figure 20), we find that they have been filed flat, partially revealing the interior, in a way that was certainly not Antico's intention. Either the figure was originally seated on an integral bronze base like the *Spinario*, or it was tanged to be fitted to a stone plinth like the *Satyr*. In the former, where the boy's buttocks join the tree stump, there is internally simply an unobstructed hole. With the *Paris*, however, there is still a septum of metal between the buttocks, as we would expect to find on the *Satyr* if we were to file off the tang and buttocks to make it sit flat on an unperforated base. This leads to the conclusion that the *Paris* was designed, like the *Satyr*, to be tanged into a stone plinth. It explains why the interior of the *Paris* is fully visible and the core almost totally removed. Thus, among all of Antico's statuettes, only two, the largest and one of the smallest in scale, the *Paris* and the *Spinario*, have visible interiors.[38]

35. Reproduced in Hermann, "Antico," p. 256, fig. 31.

36. Sir Francis Watson, "Sculpture," *The Wrightsman Collection*: V. *Paintings, Drawings, Sculpture* (MMA, New York, 1973) p. 359.

37. The tang of the *Satyr* is rectangular in section and the notches, made with a saw, face the rear. The tang projects from the proper left buttock. While both buttocks are flattened, even deliberately filed, the core is nowhere exposed. The tang is certainly coeval with the bronze.

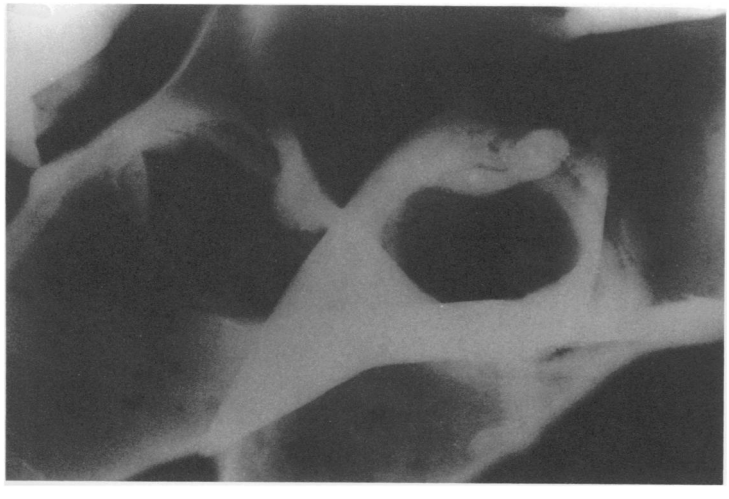
38. The interior of the Vienna *Venus Felix* would be visible if one could remove its almost certainly alien wooden base. The turned, black-lacquered base with inserted gilt-silver Roman coins is closer in taste to the Kunstkammer than to Mantua.



20. Antico, *Paris*, underside of buttocks (photo: Stone)

21. Antico, *Paris*, radiograph of shoulders (radiograph: Stone)

22. Antico, *Standing Hercules*, radiograph of upper portion (radiograph: Stone)



23. Antico, *Paris*, radiograph of thighs (radiograph: Stone)

24. Antico, *Hercules and Antaeus*, Victoria and Albert Museum, radiograph of legs (radiograph: Victoria and Albert Museum)

We have previously referred to Antico's method of producing hollow bronzes by making thin wax shells in wet plaster piece-molds. The technique of allowing a molten substance to harden against the walls of a cold mold, then pouring out the excess molten material to form a shell, goes by the rather inelegant name of slush-molding. It is still widely used to produce hollow trinkets—souvenirs of the *Statue of Liberty* and the like—in low-melting alloys of lead and tin. In a similar vein, the chocolate Santas and Easter bunnies that appear at their appropriate seasons are made by slush-molding chocolate in chilled metal molds. Inside these hollow confections is a feature that turns out to be rather significant, surprisingly enough, for our interpretation of Antico's working methods. Molten chocolate (especially that used for slush-molding) has properties rather similar to those of beeswax, for as it cools it gradually becomes more and more viscous until it finally solidifies. When the mold is inverted and the excess chocolate poured out, what still adheres to the mold is sufficiently fluid to drip and sag, until it too finally solidifies. The drip marks inside a chocolate bunny or Santa are usually quite conspicuous.

In fact, the same drip marks are visible in the X-rays of Antico's bronzes, normally in the shoulders, although they can be seen occasionally in any hollow member.[39] They are fairly conspicuous in the shoulder of the *Paris* (Figure 21) and in the radiographs of the Frick *Hercules* (Figure 22). In the *Paris*, where they can be observed directly with the use of an endoscope, their waxy appearance is quite striking.

Further proof that Antico was using wax shells is provided by an incidental feature produced in the bronze when hollow limbs were attached to a hollow torso, as in the *Paris*. Imagine two hollow wax cylinders that are to be joined together. The ends of both cylinders are gently heated until they just begin to melt, then they are aligned and quickly pressed together while the wax is still molten. The excess wax will be extruded on both the outer and inner surfaces of the cylinders. The wax on the exterior can be pared away to produce an apparently seamless join, but this is unnecessary on the interior where the ring of extruded wax is allowed to remain. Inside the leg and thigh junctions of the *Paris* these rings of extruded wax, now preserved in the bronze, are visible directly as well as in the radiographs (Figure 23).

In the Victoria and Albert *Hercules and Antaeus*, all four legs are similarly joined, although the joins can be seen only in the X-rays (Figure 24). There is another feature in the X-rays to prove that the shells of the legs were cast separately from the torso.[40] Apparently Antico decided to fill the shells of the legs with plaster cores before joining them. To strengthen the cores he inserted in each a longitudinal wire, probably of iron. These wires terminate abruptly at the thighs, just where the internal rings of wax appear.

Another curious set of features occurs in the radiographs of the *Paris* and the *Hercules* (Figures 25, 26). Through the walls of the bronze they appear as neatly circular opacities; when seen edge-on they are clearly hemispherical. These domes of metal projecting from the interior of the bronze look like air bubbles adhering to a surface, as indeed they once were. Inevitably, when the liquid plaster was poured into the wax shells, it would trap bubbles of air next to the wax. When the mold was fired and poured, the air bubbles in the core investment filled with molten bronze, producing the typical bubble marks in the X-rays. Actually, radiography shows clearly only the very largest of these marks. In the Wrightsman *Spinario* numerous small "bubbles" of bronze, all of which are too minute to be seen in the radiographs, are visible to the naked eye on the interior of the tree stump (Figure 27). Bubbles in liquids naturally tend to assume a spherical shape, hemispherical if attached to a surface; thus the "bubbles" visible on the inner surface of the bronze are evidence that the core investment was originally liquid.

Actual core substance has been recovered from the *Paris*, the *Spinario*, and the Frick *Hercules*. In all three cores, X-ray diffraction analysis unequivocally demonstrated that the core had been made from a mix-

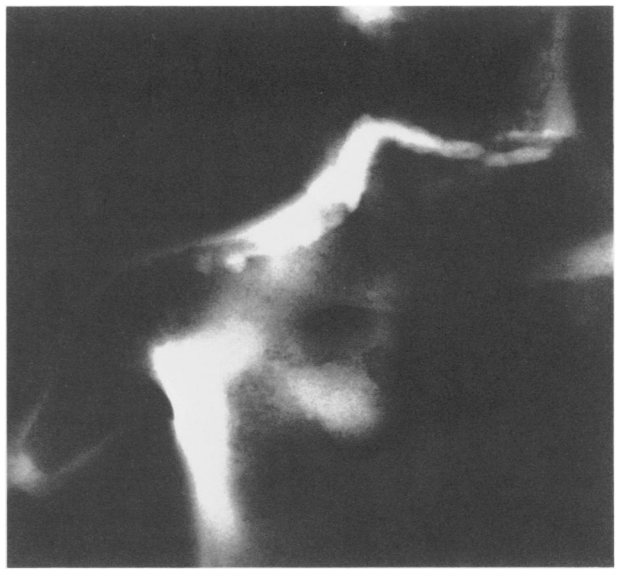
39. They can be seen in radiographs of the Victoria and Albert *Meleager* dripping *upward*. Presuming that both legs were shells of wax opening at the top, one would expect them to drip "upward," i.e., when inverted and draining toward the openings at the thighs.

40. Not only limbs were joined in such a fashion. The head, neck, and part of the shoulders of the Victoria and Albert *Atropos* were formed as a separate little "bust" in wax, and were joined to the torso in the same manner. Despite what I have said previously about the inevitable shrinkage between a model and the bronze cast from it, notice how the nature of these joins in a wax inter-model can easily produce small discrepancies in height between otherwise identical bronze replicas of the same model.

25. Antico, *Paris*, radiograph of shoulders seen from side (radiograph: Stone)

ture of plaster of paris and fine sand.[41] The bubble marks demonstrate that the mixture was indeed fluid and poured into the shells rather than being modeled and subsequently covered with wax.

The iron wire chaplets can be seen only in radiographs of the finest quality, and then recognized only by careful inspection of stereographic pairs. Chaplets can usually be spotted, however, by the naked eye in places where the patina is thin, where they appear as round silvery spots. They are frequently even more conspicuous in gilded areas where they appear as rust stains against the gold. There is an especially noticeable one, right at the crown of the head of the *Spinario* (Figure 28). The tiny bits of fine iron wire are, of course, magnetic, and this property can be used to detect them.



26. Antico, *Standing Hercules*, radiograph of right shoulder (radiograph: Stone)

Some features of our reconstruction of Antico's technique of indirect casting remain hypothetical. For instance, did Antico use plaster and sand for his external investment as well as his cores? There is every reason to suppose he did, as we shall discuss further, but direct evidence—"bubbles" on the exterior surface of his bronzes—has not yet been found.[42] The advantage of the radiographic technique is that it allows us to examine the one surface of a bronze we can be sure has never been chased or finished: the interior. In the process of chasing and finishing the exterior, such minor blemishes as bubble marks would have disappeared with the first strokes of a scraper. There is much we can do, however, to confirm our hypothesis by returning to the primary literature on casting, in order to compare Antico's methods with the recorded technology.

The first author to describe the making of wax shells

41. The three cores all contain anhydrite (anhydrous calcium sulfate) and alpha-quartz (fine silica sand). The *Spinario* and the *Paris* also contain unchanged gypsum. Gypsum dehydrates to anhydrite if the mold is fired to a sufficiently high temperature.

42. The author has not, unfortunately, had the opportunity to examine an example of the *Hercules and Antaeus* in the Houston Museum of Fine Arts. It appears to have an unfinished surface with the sprues intact.

from wet molds—that is, slush-molding—is Pomponius Gauricus. He does not, however, suggest how these wax shells may be employed for casting bronze. Biringuccio is more explicit. Curiously, he suggests the method for those who wish to form the piece-mold not in plaster but in damp clay:

This clay is well beaten so that it is hard enough to stand by itself, and it can stand in two, three, four, or six pieces as needed. Then they pour melted wax into the empty space. If they wish to make them solid, they put in enough so that by turning it about and then upside down they prevail upon it not only to be spread all over but to make the thickness which they wish the statue to be in bronze taking out the superfluous wax by decantation. When it is cold, the wax is taken out of the mold and the fins made by the junctions are carefully taken off. It is exactly cleaned and finished just as it is to be.[43]

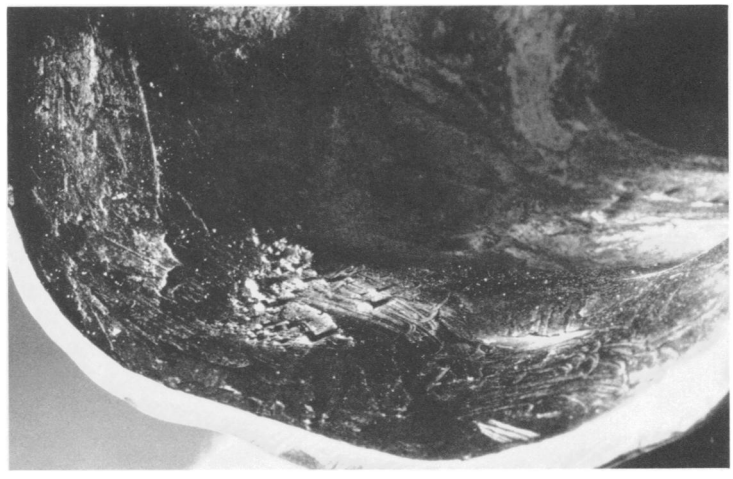
The use of damp clay is interesting, for within certain limits stiff clay can function as a flexible molding material if carefully handled. Biringuccio suggests a piece-mold of anywhere from two to six sections. Even if we allow for some flexibility in the damp sections of clay, he could not have been thinking of casting from a very complex model.

Biringuccio goes on to suggest a liquid investment for the core, "liquid clay composed of cloth clippings, horse dung, an half of young ram's-horn ashes and a little fresh plaster of Paris."[44] The clay core is to be allowed to dry well, an important point.

Vasari's description of 1550 is more explicitly related to what was probably Antico's technique for making a plaster piece-mold:

Now should the artificer wish to cast small figures in metal, they are first made of wax, or if he happen to have them in clay or other material, he makes the shell of plaster over them in the same way as for the large figures, and fills it all with wax. But the shell must be moistened that the wax, when poured into it, may set (with a hard skin) by reason of the coldness of the wet cast. Then by shaking about and agitating the cast, the wax (which is not hardened) within the cavity is thrown out, so that the cast remains hollow in the interior: the craftsman afterwards fills up the vacant space with clay and puts in skewers of iron. This clay serves then for core, but it must be allowed to dry well.[45]

Vasari does not say that clay used to fill the wax shell should be liquid but he too insists that it be "allowed to dry well."



27. Antico, *Spinario*, detail of the interior of the tree-trunk base (photo: Stone)

28. Antico, *Spinario*, detail of crown of head (photo: Stone)

Both Biringuccio's and Vasari's admonitions to let the core dry well skillfully skirt certain major technical difficulties. Clay within an impervious wax shell will simply not dry well, and until clay is quite dry it has little mechanical strength. Moreover, as it dries, it shrinks. Biringuccio has obviously given some

43. Biringuccio, *Pirotechnia*, p. 231.

44. Ibid.

45. Giorgio Vasari, *Vasari on Technique*, trans. L. S. Maclehose, ed. G. Baldwin Brown (1907; reprint, New York, 1960) p. 163. This translation of the technical sections of Vasari's *Vite* is in general reliable although the annotation is antiquated.

thought to the matter; his mixture is at least a liquid so as to fill the shell with ease. Unfortunately, he gives no proportions for his mixture. He starts with a liquid clay slip mixed with fibrous organic material (cloth clippings and horse manure) as well as a refractory grog (bone ash from the core of a ram's horn) with the addition of a "little" plaster. If the ingredients were listed in order of decreasing quantity, Biringuccio's liquid investment would not be very satisfactory. A "little" plaster will not do, for unless the liquid investment is mostly plaster it will not set hard by chemical action but simply dry with painful slowness within its waxen bottle. Why not simply suggest plaster as the core investment?

Here we must digress a bit on the role of plaster in casting. Plaster of paris, or *gesso*, as it is called by Italian writers, is produced by heating the common mineral gypsum, which is found plentifully on both the southern and northern slopes of the Apennines. In heating, gypsum (calcium sulfate dihydrate) loses some of its water to form plaster of paris (calcium sulfate hemihydrate). If the heated product is ground and mixed with water, the water recombines with the plaster to form gypsum again, that is, it sets hard. These properties of calcium sulfate have been known since ancient times. Yet, although objects have been cast in plaster since antiquity, there is no early notice of its use as a refractory investment. This is somewhat puzzling since it is an excellent investment for casting bronze. The only difficulty is that a mold made simply of plaster will crack if heated red-hot. This deficiency is easily remedied by adding a sufficient quantity of ordinary silica sand as a grog to control the thermal expansion that causes the cracking.

Despite the simplicity of this solution to the problem of thermal cracking, it seems to have occurred to no one until the end of the fifteenth century. Leonardo is the first to record its use for casting medals (in the Madrid Codex II).[46] One side of the model is to be coated with regular liquid plaster to be followed immediately with another coat of plaster which is this time mixed with twelve parts of "renella da orilogi," that is, the fine sand used in hourglasses. (The other side of the medal is to be done in the same fashion, the first half of the mold being greased to prevent it sticking to the second.)

Before we credit Leonardo with yet another miraculous invention, let us remember that Antico was already at work when Leonardo made that entry in his notebook. Furthermore, the mixture that Leonardo suggests is far too sandy to be used directly against the model. The model must first be coated with regular plaster, an unnecessary complication if the proper ratio of sand to plaster is used. Nevertheless, it is the first mention of plaster and sand as an investment suitable for casting bronze.

Cellini, whose *Trattati* were written by 1565,[47] only fifteen years after the publication of Vasari's first edition of the *Vite*, was apparently the first author to be aware that plaster has real advantages as a refractory, especially for making cores.

Cellini gives a quite explicit account of how to cast a monumental bronze indirectly.[48] After the inevitable piece-mold is made from the original model, a core must be fashioned. Cellini's solution is to line the section of piece-mold with an even layer of dough. This layer of dough, or to use his picturesque terminology, the *lasagna*, establishes the minimum thickness of the final bronze. He then independently models a core of clay on an iron armature until the core seems to be of just sufficient size to fit within the piece-mold lined with *lasagna*. This fitting of the lined piece-mold onto the core requires considerable handwork. Section by section, the damp core is pared down so as to fit the preformed shell of the piece-mold while, in similar fashion, fresh clay is added to the interior of the piece-mold. Inevitably, the thickness of the *lasagna* is merely the minimum thickness of the walls. Paring away too much of the core will simply mean thicker walls; paring away too little will prevent the sections of piece-mold from fitting on the core at all. Considering the limits of human patience, the bronze walls will always be thicker than the original lining of *lasagna*.

46. Leonardo, *Madrid Codices*, V, fol. 141: "Togli giesso scagliolo e vela liquido la tua medaglia. Poi subito copri col altro giesso, il quale sarà conposto di 12 parti di renella da orilogi e una di giesso. E ffa ogni cosa liquido e gitta e po' ricoci. E il simile fa poi dall'oposita parte della medaglia, ma prima ungi acciò che giesso a giesso non s'apichi."

47. The original dedication of the manuscript is to Francesco I of Tuscany on the occasion of his marriage to Giovanna of Austria in 1565 (Cellini, *Opere*, p. 621).

48. Cellini, *Opere*, p. 794. Chap. III of the *Trattato della scultura* is entitled: "Un altro modo si usa fare figure di bronzo di getto, quando le figure sieni grandi quanto il vivo, o poca cosa più." It is obvious from the description that the method *alla lasagna* would be impractical for small bronzes as Cellini's title implies.

Cellini must have realized that this was a very tedious process for ensuring that the core would be uniformly smaller than the inner surface of the piece-mold, for after a long digression on the casting of the *Perseus*, he suddenly remembered another method of forming the core:

> instead of making the core of your figure in clay, you make it of *gesso* mixed with burnt bone and pounded brick . . . in this way you make a sort of slurry, which you pour into the piece-mold coating the *lasagna* and which soon sets.[49]

Now this is obviously more expeditious than the "cut and fit" method over a clay core that Cellini suggests as general practice. When the plaster hardens, the piece-mold and the *lasagna* can be removed, leaving a core which is smaller than the model by exactly the thickness of the *lasagna*.

Whether a clay or plaster core was used, Cellini's method would subsequently be the same. After the core had dried out the piece-mold would be reassembled around it, this time without the *lasagna*. Molten wax would be poured in between the core and the piece-mold to form the inter-model. From then on the procedure would be standard: remove the piece-mold; fettle the inter-model; invest and fire the completed mold.

Despite the fact that the liquid plaster core is so much easier to manage than clay, Cellini is quite hesitant to suggest plaster for either the core or the outer investment. What he finally admits is that "the *gesso* in our part of Tuscany does not lend itself so well to works of this nature as that of Mantua[!], Milan, and France."[50] Regardless of Cellini's reasons for slighting the quality of Florentine *gesso*, his choice of those places where he supposes good plaster to be available is fascinating and pertinent.

France, of course, means Paris, where Cellini had lived and worked, and "plaster of paris" is no idle figure of speech. Montmartre is a hill of gypsum. But what of Mantua and Milan? Neither city has immediately convenient sources of gypsum; they both stand in the great alluvial plain of northern Italy and gypsum deposits are not to be found in alluvial plains.[51] In Milan, where Leonardo found the practice of casting into plaster and sand, was accumulated technical skill. In Mantua there was Antico.

Although Vasari in the *Vite* never mentions Antico's name, Cellini seems to be very well aware that in Lombardy they know how to cast in plaster, and the first Lombard city that comes to his mind when he thinks of casting in plaster is Mantua. We cannot press the evidence too far, for Antico had been dead for over thirty years when Cellini was writing. Yet this proves a point: Florence, compared with metal-working centers in northern Italy, was technically backward. What was standard practice for Antico in 1510 was still a novelty for Cellini in the 1560s. Despite the fact that Cellini was certainly acquainted with indirect casting technology, the two monumental works in bronze that he chooses to describe in detail, the *Nymph* of Fontainebleau and the *Perseus*, were both cast directly. As we know from the famous passage in his autobiography regarding the casting of *Perseus*, this decision caused him considerable anxiety. Why Cellini chose to cast directly is not clear except that Florentine artists, at the very forefront of stylistic advance, were frequently steely conservatives in technical matters. In this the Florentine character seems to have played as important a role as Florentine command of technology.

We may conclude from the literary sources that the three Tuscan authors of the sixteenth century, Biringuccio, Vasari, and Cellini, had at least a peripheral knowledge of all the methods used by Antico before 1500, but that not one of them was sufficiently acquainted with the details to be able to reproduce them as a technological ensemble. Even Cellini, the latest of them, was still hesitant about using plaster as a refractory, although he knew that plaster was being successfully used in northern Italy and France.

The methods used by Antico were not merely an accumulation of shop formulas but a carefully thought-out technology to enable him to reproduce his bronzes with the greatest simplicity and economy of means. Slush-molding, permitting Antico to control the thickness of the walls of his bronzes without

49. Cellini, *Opere*, pp. 814–815: "e questo si è che in cambio di far quel nocciolo alle figure di terra, ei si può fare di gesso mescolato con osso arso e con mattone cotto pesto . . . in questo modo di fa come un savore, il quale si getta si quel cavo sopra la lasagna, si questo si rappiglia subito."

50. Cellini, *Opere*, p. 816: "Gli è bene il vero che in questa parte di Toscana el gesso non è tanto a proposito per far simili opere, sì come gli è in Mantova e in Milano e in Francia."

51. Gypsum is only relatively insoluble in water and dissolves with surprising rapidity in a continually wet environment.

the tedious and indirect method *alla lasagna*, necessitated the use of a fluid, pourable core if he was to fill his wax shells with speed and security. Since no clay could serve his purpose, he turned to plaster of paris mixed with sand; this mixture remains, even today, the standard investment for statuary bronzes. Starting with the wax model, progressing to the slush-molded inter-model with its poured plaster core, and finishing with the replica bronze, each step led to the next, without fumbling, misdirection or technical insecurity. Security was indeed the watchword, for Antico did not hesitate to hand over his precious wax models to trained technicians for actual casting, to be returned undamaged along with what was probably at least a partially finished bronze replica ready to receive the final exquisite chasing from his own hands. Antico was either a technical genius or the recipient of an earlier, unrecorded technology, developed in the fifteenth century toward some very specialized aims.

To the author's knowledge there are no bronze replica castings before Antico. Only one other sculptor, Severo da Ravenna, who was apparently an exact contemporary of Antico, seems also to have achieved this level of technology, although on a much lower level of artistry.

No more need be said here about Severo's methods except that they were entirely different from Antico's, despite their similarity of technical aims, the production of replica bronzes.[52] Thanks to Ulrich Middeldorf, who has revivified Severo studies by the rediscovery of the unnoticed work of Silvio Bernicoli in the Ravenna archives,[53] we can be relatively sure that Severo Calzetta da Ravenna was indeed from Ravenna. Despite the enthusiastic praise from Pomponius Gauricus which had led all to believe that Severo was a mere appanage of the Paduan school, it would seem that the sculptor spent most of his life in

52. The author plans to participate with Anthony Radcliffe and Jonathan Ashley Smith in a separate study of Severo's works.

53. Silvio Bernicoli, "Arte e artisti in Ravenna," *Felix Ravenna* 4 (1914) p. 555.

29. Riccio, *Warrior on Horseback*. Bronze, H. 34 cm. London, Victoria and Albert Museum (photo: Victoria and Albert Museum)

the relative isolation of his home town of Ravenna, mass-producing (that is the only term to use) bronzes with considerable technical ingenuity but in an increasingly impoverished style.

When all those pieces which really hail from Ravenna are winnowed out from that stylistic wastebasket called the School of Padua, there is an amazing discovery to be made. Not one sculptor in Padua, not even Riccio himself, could replicate a bronze. This calls for some explanation.

It is well known that there are numerous bronzes loosely considered to be by the hand of Riccio. Some are products of Severo's workshop. Others are almost certainly post-Riccio, as for example the notorious *Mountains of Hell*, which as Leithe-Jasper has proved are actually by Agostino Zoppo, a sculptor in the entourage of Sansovino.[54]

For our immediate purposes the remaining core of Ricciesque bronzes may be divided into two groups: those that seem unique and are of the highest quality; and those that while of high quality seem to be produced in multiples. Of the first group, we will consider only two, both in the Victoria and Albert Museum: the great *Warrior on Horseback* and the *Satyr and Satyress* (Figures 29, 30). Neither has ever been questioned.

The author has examined both carefully and has also examined their radiographs. Both, or rather all three, for the horse and rider are cast separately, seem to be directly cast over preformed cores. There are neither drip nor bubble marks and the walls of the bronzes seem relatively thick.

Here yet another technical concept must be introduced: the conformality of the core. If we examine a bronze in cross-section, as in a radiograph, we can compare the outlines of the exterior with those of the interior surface as produced by the core. In an "ideal" cast, where the thickness of the bronze walls would always be the same, the interior surface would closely parallel the exterior one, hence be "conformal." The shell-casting technique of Antico produces highly conformal walls, as their thickness depends on the rate of chilling of the molten wax in a wet mold. The rate of chilling is, of course, not entirely uniform and as we have seen there are the drip marks typical of Antico's methods. Nevertheless, Antico's bronzes have extremely conformal cores and hence quite even wall thicknesses.

In general, the degree of conformality of the core and the thinness of the walls are the most ready indices of the degree of a bronze's technical sophistication. If a bronze has been simply modeled in wax over a preformed core, even with the exercise of considerable care, there is very little likelihood that the core will be as conformal as in the case of indirect casting by a method like Antico's.

In both the *Warrior on Horseback* and the *Satyr and Satyress* the cores are only moderately conformal. The most plausible reconstruction of Riccio's technique is the following. He first made a sketch model to establish the general design of the bronze and its size. From this he carefully modeled a core by hand, probably in

30. Riccio, *Satyr and Satyress*. Bronze, H. 23.2 cm. London, Victoria and Albert Museum (photo: Victoria and Albert Museum)

54. Manfred Leithe-Jasper, "Beitrage zum Werk des Agostino Zoppo," *Jahrbuch des Stiftes Klosterneuburg*, n.s. 9 (1975) p. 122.

31. Riccio (?), *Nereid and Ichthyocentaur*. Bronze, H. 23 cm. (including shell and base plate). New York, The Frick Collection (photo: The Frick Collection)

32. Riccio (?), *Nereid and Ichthyocentaur*. Bronze, H. 22.1 cm. The Metropolitan Museum of Art, The Jules Bache Collection, 49.7.59

clay. He would endeavor to make the core as evenly and proportionally smaller than the sketch model as he could. When he was satisfied with the preformed core, it would be allowed to dry. From this point on, the pose—although not necessarily the surface modeling—would be determined. The next step would be to coat the core with wax as evenly as possible, either by brushing or dipping, until the walls were of the proper thickness.

With the sketch model as a guide, the surface of the wax would be finished by hand. Surface textures could be elaborated to any degree of complexity since Riccio did not have to consider the limitation of piece-molding. When he was satisfied with the modeling he simply invested the piece (probably with clay) and proceeded as with any other bronze casting.

This method is really no more complex than that used by Bertoldo and Adriano for casting the *Bellerophon and Pegasus*, although Riccio habitually modeled a more complicated core than did the two Florentines. We are once again dealing with direct casting from wax and a preformed core. Riccio, however, realized that walls had to be at least of moderate thinness to produce a sound cast. Lightness seems also to have been an aesthetic demand, for, as we mentioned earlier, the core of every Paduan bronze has been carefully removed.

Riccio was still subject to the fundamental limitation of all direct casting—if it failed he had to begin again from the beginning, with only the original sketch model to guide him. On the other hand, he had all the advantages of spontaneity of surface modeling and

unlimited complexity of form. Consider the problems that Antico would have had to face if he had tried to piece-mold the *Satyr and Satyress*. This group, with its interlocking forms, would present a piece-molder with insuperable difficulties, unless he were using a flexible molding material at that time seemingly unavailable.

The author believes that all the bronzes from Riccio's hand were directly cast in the manner described above, and that consequently there are no replicas extant of his work.

This leaves us to explain those numerous Paduan bronzes that may be described as near-replicas and that while quite Ricciesque reveal a variety of factures, none of which is as exciting as the master's. The *Nereid and Ichthyocentaur* groups are a good example; they are virtually identical in size and pose but differ in surface details. Are they all merely variants or do they have some more intimate connection?

The author has examined only three of the *Nereid and Ichthyocentaur* groups radiographically but they are three which are generally regarded as being of very high quality: the Frick, the Metropolitan Museum, and the Victoria and Albert examples (Figures 31–33). They show striking differences technically from the *Satyr and Satyress* and the *Warrior on Horseback*.

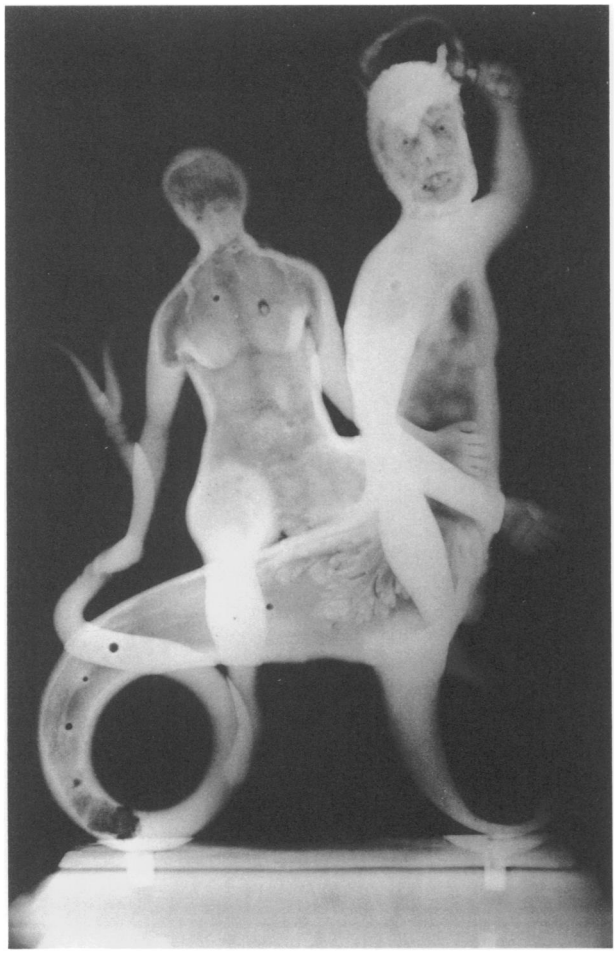
All three groups have thin, rather conformal walls. In spite of their virtually identical size, they are definitely not replicas, at least not in the sense in which we speak of Antico's replicas. His differ from one another only in surface finish. Each of these groups appears to have independently modeled surfaces, the result not merely of a difference in chasing but in the actual modeling of the original wax. Yet radiography shows their cores to be identical. The two bronzes in New York were X-rayed in the same position, with the nereid on her back and the ichthyocentaur on his left flank (Figures 34, 35). Tracings of the profiles of the interior, core surfaces were virtually superimposable, the exterior profiles markedly less so.[55]

Riccio's bronzes, as we have seen, were probably directly modeled over preformed cores. What if instead of using the core only once we made a piece-mold of it? Then we could cast cores, all identical, dip them in wax till a thick enough wall was produced, and model all the details of the surface into the wax. If such partial replicas were invested and cast they would have identical cores but differing surfaces, just as we find in the *Nereid and Ichthyocentaur* groups.

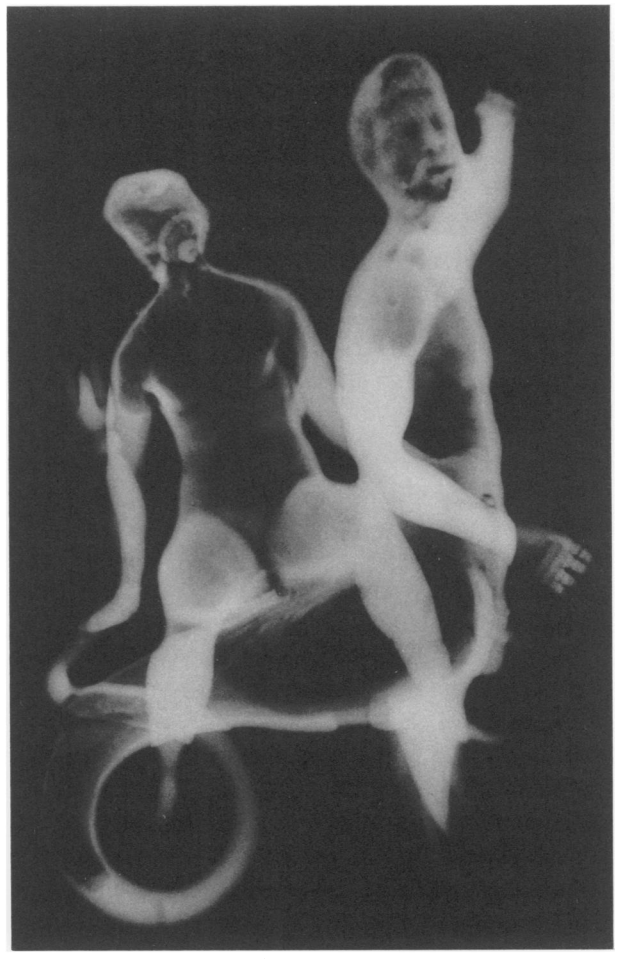
Such a procedure would obviate the need for pourable plaster cores such as Antico's method demands. Cores need not be elaborately modeled and can be made from clay in simple press molds like terracotta figurines. If one distrusted plaster as a core material, and evidently many did, here was a method for mass-producing cores from clay.

33. Riccio (?), *Nereid and Ichthyocentaur*. Bronze, H. 22 cm. London, Victoria and Albert Museum (photo: Victoria and Albert Museum)

55. The *Nereid and Ichthyocentaur* groups all have conspicuous holes left by chaplets of rather large diameter (about 3 mm.). Most of these holes have been plugged but are nevertheless quite visible especially in radiographs; their positions are fairly similar in the three examples of the group examined. Such a type of chaplet is never found in Severo's work nor can it be found in Riccio's *Warrior* and *Satyr and Satyress*.



34. Riccio (?), *Nereid and Ichthyocentaur*, The Frick Collection (radiograph: Stone)

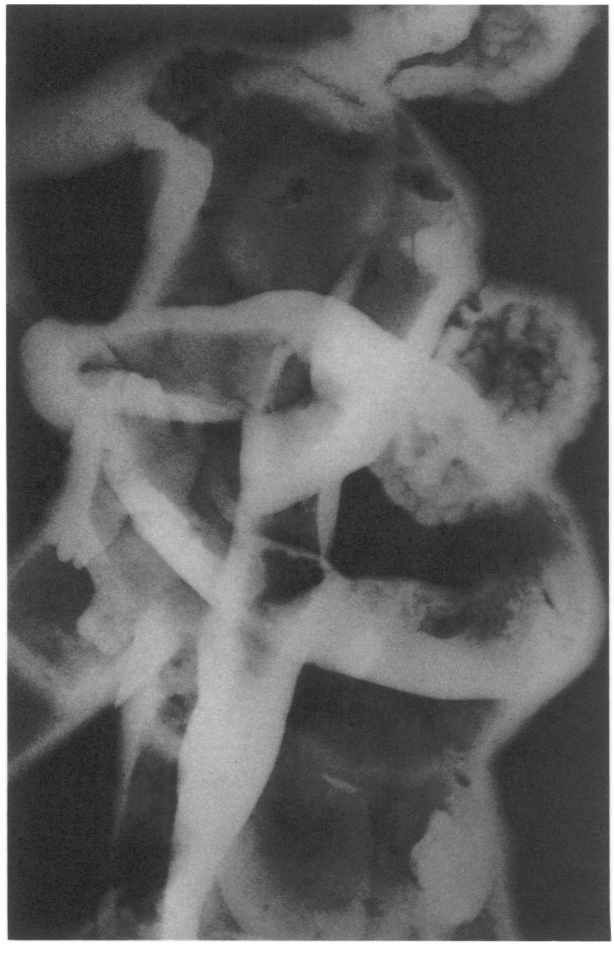


35. Riccio (?), *Nereid and Ichthyocentaur*, Metropolitan Museum (radiograph: Stone)

There is another more specifically stylistic reason for such an apparently "inside-out" procedure, and it has to do with the greater spatial complexity of poses in Riccio's Paduan circle, when compared to Antico and most especially Severo.

In the *Satyr and Satyress*, wherever the figures touch in their interwined pose, the preformed core is continuous through the juncture of their two bodies. This makes perfect sense if, as we assume, the core was modeled as a sculptural unit in clay, then coated with wax. But in the three *Nereid and Ichthyocentaur* groups examined radiographically, the core in the nereid, which fills the figure from head to knees, is discontinuous with the core in the ichthyocentaur. Where the two figures meet—at the buttocks of the nereid and the equine back of ichthyocentaur—there is a septum of bronze *twice* as thick as the average wall thickness of either figure. The implication is clear. The cores for the nereid and ichthyocentaur were formed separately, coated with wax separately, and then "glued" together with a drop of molten wax under the nereid's buttocks. This procedure vastly simplifies the modeling of the cores, allowing them to be formed in ordinary piece-molds of no great complexity. With the far more complex core of the *Satyr and Satyress* this would be impossible.

In all of Antico's work there is only a single model with conjoined figures, the *Hercules and Antaeus*. In the radiographed example in the Victoria and Albert Museum, the core is indeed continuous between the torsos of Hercules and Antaeus (Figure 36), but the group's relatively open composition would present far



36. Antico, *Hercules and Antaeus*, Victoria and Albert Museum, detail of torsos (radiograph: Victoria and Albert Museum)

fewer problems in piece-molding that that of Riccio's *Satyr and Satyress* or even of the *Nereid and Ichthyocentaur* groups. Severo, for his part, does not attempt conjoined figures; single figures are inevitably cast separately, then joined with threaded lugs to their bases and attributes.

To return to an earlier point, all methods of indirect casting that required plaster piece-molds to form the exterior surface, that is, all true replica casts such as Antico's and Severo's, put distinct limitations on the complexity of pose a sculptor could manage. For true freedom of expression there was still only the direct cast as in Riccio's *Satyr and Satyress*. At a slightly less complex level of composition the near-replica method of the *Nereid and Ichthyocentaur* would serve for a bronze intended to be produced in multiple examples. Had a flexible molding material been available to Antico, Severo, or Riccio and his circle, all these difficulties would have been obviated. The *Nereid and Ichthyocentaur* groups would be as identical as Antico's or Severo's replicas and, presumably, both Antico and Severo would have felt freer to use more complex poses. We must assume, therefore, that such a flexible material was not available for molding figures in the round, at least not in the first quarter of the sixteenth century.

We have tried to suggest the interaction between artistic desires and technical limitations in a period when the craft of casting was undergoing rapid technological change. The properties of bronze, clay, and plaster remain unvarying, and the sculptor must come to terms with them. Antico could bear his yoke mildly while Riccio, like all artists who belonged ultimately to the Florentine tradition, must have chafed badly.

One question of Antico's practice is still unanswered. Why did he not remove his cores? Both Severo and the Paduans inevitably removed theirs even if it was a considerable nuisance to do so. In the *Nereid and Ichythyocentaur* groups, for instance, it was necessary first to cut into the belly of the ichthyocentaur, scraping and soaking out the core, then to drill through his back and through the nereid's buttocks to remove the core inside her figure. As far as we can tell from radiographs and probing, this was done with great thoroughness. It would certainly appear that lightness was desired as an end in itself. In Antico's case this did not seem to matter. We have, of course, suggested that hollow casts are technically superior to solid ones, but did Antico develop his complex technology for that reason alone? The Florentines, after all, remained satisfied with coreless small bronzes. The answer seems to lie somewhere else, with the urge to save metal.

Bronze, around 1500, was no doubt relatively much more expensive than it is today but gold and silver were even more so, and from the surviving documents it seems that Antico was accustomed to cast in precious metals. The previously mentioned, little *St. John* that he made for Isabella d'Este was described as the "St. John that our Antico has cast" in Lodovico Gonzaga's letter accompanying the gold pendant when it was sent to Isabella on April 4, 1504.[56] The size of

56. Rossi, "I medaglisti," p. 183, n. 3: "san Zoanne che ha gettato lo Anticho nostro."

the *St. John* is unfortunately not known. It was probably quite small if, as it appears, Isabella intended to wear it as a *ferronnière*. In 1505, however, Antico sent Isabella models, presumably in wax, of a horse's head and an eagle, with the following note:

> Illustrious Madam: If I have been late in sending the horse's head as well as the eagle, do not blame anything other than illness; once again I am not quite about by reason of a chill. Hence I beg your pardon if your Ladyship has not been well served as you desire. If the master is not sufficiently experienced to cast it in silver, I will teach him as a favor, and if being otherwise able, I beg your command.[57]

Antico was thus accustomed to cast in silver, although he did not regularly expect other masters to have the necessary knowledge. A horse's head implies something rather larger than a trinket. If the model was of some size, it would have to be cast hollow for reasons of expense: besides, if it was merely to be cast solid, Antico's offer to instruct Isabella's craftsman would have seemed condescending and impertinent. No, the only conclusion we can draw is that Antico's casting technology was originally designed for precious metals, where the precise control of wall thickness was an economic as well as a technical necessity.

Casting statues in silver, as distinguished from medals and seal matrices, would seem to go against everything Cellini says about statuary in precious metals. Cellini worked his gold and silver almost entirely in repoussé, either with hammers and stakes (as in making vessels) or by hammering metal sheets, section by section, over a bronze model of the intended statue and then soldering the sections together. He suggests casting silver only for small additions, such as the handles to vases. In truth, silver and gold will always go further if worked, since precious metals can be hammered much thinner than they can be cast.

None of Antico's works in precious metals has apparently survived. This will surprise no one. It is the dearth of objects in precious metals surviving from fifteenth-century Italy that makes the antecedents of Antico's casting technology so difficult to follow. Perhaps the use of thin wax shells was developed originally for casting merely the head, hands, and feet of draped statues in silver. Drapery can be executed quite easily in repoussé, while the head and especially the hands and feet lend themselves far more easily to casting.

Regardless of its origins, Antico's technology was ideally suited to his aims. What probably started as an attempt to cast economically in silver (that is, with thin, conformal walls) turned out to be adaptable to the indirect casting of bronzes, a fact which Antico exploited to the full.

In the continuous dialogue of means and ends, different technical traditions evolved within the craft of goldsmithing, and the skills acquired within those traditions were transferred to another craft, sculpture. Contrasting attitudes toward sculpture were accompanied by contrasting sculptural techniques, and while in both central and northern Italy bronze sculpture frequently originated in the goldsmith's studio, there was despite this a striking diversity of methods. Thus, method and style developed simultaneously, though along different paths in Florence and Mantua, and the traditions of Italian sculpture were thereby enriched and enlarged.

ACKNOWLEDGMENTS

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57. Rossi, "I medaglisti," p. 186, n. 1: "Illu. Madama. Se son stato tardo a mandar la testa del chavallo come l'aquilla, non incolpate altro chel malle et iterum non son ben fora per esere inferdato. Ancora prego mi perdonate se non è cosi ben servita la S.V. come quella desidera. Sel maestro non serà practico a zetarlli d'arzento, li insignarò di gratio e potendo altro, pregui me comandate."