Casting Rodin's Thinker

Sand mould casting, the case of the Laren Thinker and conservation treatment innovation

Beentjes, T.P.C.

Publication date
2019

Document Version
Other version

License
Other

Conclusions

Traditionally, technical art history has a strong focus on material analysis and textual sources with research often gravitating towards either analysing material or historical aspects of an art work. Although these two research methods have also been applied to this research, I have tried to bridge the gap between these two approaches by shifting the focus of this thesis towards the manual production process. With bronze sculpture, the technicalities of the execution of the moulding and casting process greatly determine the appearance of the final art work. The selected moulding technique, combined with the founder's choice of moulding materials and the procedure followed, is reflected in characteristic details captured in the bronze sculpture. These characteristics, such as alloy, construction, surface finish and patination, determine not only its final outer appearance but are also reflected in the interior surface. It is this interior surface, which provides often a wealth of information regarding the used founding technique, informing the researcher on the foundry technique, age and authenticity.

Historical development of sand mould casting

This research identified the absence of a chronological overview of the development of sand as a moulding material. By consulting source material such as manuals and other technical sources, a much better insight was created in this thesis, of the introduction and use of sand moulds in early modern Europe. One of the earliest uses of sand as a moulding material in Western Europe is in iron foundries in the late fifteenth century. Unfortunately, very little documentary evidence survives detailing this early use. Most of the early written references to sand mould casting are describing the casting of small, low relief objects such as precious and base metal seals, medals and plaquettes, carried out by goldsmiths and medal founders. From the end of the seventeenth century, sand moulds were beginning to be used for the production of other, more domestic, products such as copper alloy cauldrons and skillets. The founding of hollowware required more complex moulding techniques compared to the simple two-part moulding as practised by goldsmiths and medal founders. The first pictorial evidence for the use of these so-called piece-moulds was found in the eighteenth century. Other artisans making use of sand moulds were the cannon founders. Complex piece-moulds were developed and applied by a new generation of sand moulders who were going to be instrumental in the development of the sand moulding of sculpture.

Around the question whether sand mould cast bronzes are by definition from the nineteenth century and later, this study identified documentary evidence of piece-mould cast bronzes before 1800, in technical texts by Dossie (1758) and Sprengel (1770). These give descriptions of loam/clay piece moulding and are to date the earliest European accounts of the piece-moulding of a refractory sculpture mould, which was subsequently used for casting bronze directly into. They are possibly the earliest descriptions of sand mould casting of bronze sculptures and challenge the current accepted views that the sand piece-mould casting of bronze sculptures developed around 1800.

The intricacies of this moulding technique, as practised in the nineteenth century, has not been the subject of serious comprehensive study before. The research was based on three main types of source material: surviving objects, early written sources and pictorial material. For the first type of source material, bronzes and plaster models were studied. Pictorial source material was available in the form of drawings, paintings and photographs. For the late nineteenth and early twentieth century, photography is a very fortunate and welcome additional source, providing the researcher with accurate detailed information not available to researchers of earlier material. The last type of source material, textual sources, were available in the form of contemporary eye witness accounts, manuals and other technical sources such as encyclopaedia entries and patents. These workshop manuals proved to be a very rich source for practical technical research for this thesis and complemented object research very well. Textual sources research can provide technical information on bronzes that cannot be deduced from object study alone. Especially whereby materials used in the process, are removed during finishing, such as the lanterns and other core vents and outer mould material. As so often with research, the search for elucidation frequently results in more complexity. An example of this, as given in this thesis, is the use of hybrid moulding techniques in the nineteenth century. The clear distinction between lost wax and sand mould casting, as often described in the literature on bronzes, proved to be in practice, as established by this research, not so clear.

Apart from visual examination, a number of bronze sculptures were subjected to material analysis. Non-destructive X-ray fluorescence surface analysis was carried out, as well as sample analysis for alloy and core material. The metal samples were analysed with ICP-MS and core material was analysed with laser diffraction. The data collected with these analyses provided information on alloy composition and grain-size distribution of the cores. The effect of heat on the grain-size distribution of clay rich moulding sand was also studied. A form of sintering of the clay particles was observed, leading to a decrease in clay content. A correlation was established between the distance of the moulding sand to the hot cast metal and the clay content whereby the metal closest to the cast metal showed the largest decrease in clay content. This finding has important implications for the interpretations of past and future core analyses. It was also found that the choice of analytical method greatly determines the accuracy of the analysis of the grain-size distribution. This was demonstrated by comparing the Getty Schmidtling clay and silica values from 2008 using point counting and the recent, more accurate, laser diffraction method as used for this study.

Although the main focus of this thesis was the founding of metal objects, a great deal of attention is given to non-metallic materials, such as sand, clay and plaster. It is only with the help of these refractory materials that sculptors and founders can create their metal objects. Most of these refractory materials are removed during the making process and, unfortunately, outer mould material is therefore very rarely encountered on historic bronzes. Core material in contrast, is a common occurrence inside hollow bronze sculpture. Research into core material is now increasingly used in bronze technology research, forming now an essential part of bronze sculpture research. The interaction between the molten metal and the refractory material is a fascinating, albeit complex one. For modern mould materials and metals, due to

large economic interests, this is well researched and understood. For historic mould materials this is not yet the case, with still plenty of research to be done.

Researching the Thinker

The *Thinker*, as the main focus of this research, was chosen not only because of the treatment and exhibition on the Laren *Thinker*, providing a rare opportunity for detailed study of *Thinkers* but also because the *Thinker* can be seen as exemplary for Rodin's bronze sculptures. It is often assumed that bronzes, deriving from the same model and made in the same foundry, are identical. However, this is rarely the case. By comparing a great number of near identical casts of Rodin's *Thinker*, slight, but crucial, differing art-technological features were identified. These differences lent each cast its own character and these bronzes, although cast in multiples, should not be seen as factory produced identical objects which are interchangeable. Although these various casts may be artistically not unique, due to the intricacies of the founding and casting process and the manual finishing, each cast possesses an art-technological uniqueness. The availability of a large group of original size *Thinkers* for study, made this observation possible. Rodin was the first modern sculptor to produce his bronzes in such large editions, enabling to make this type comparison studies.

One of the main research questions concerned Rodin's preference for a particular casting technique for his bronzes. Very few personal references can be found with regard to the artist's choice for a casting method and if there is a preference expressed, it is for the lost wax technique. A broad approach is used in this thesis to document the use of the two competing casting techniques, lost wax and sand mould casting, from an art-historical as well as art-technological point of view. A picture emerges of an artist who is willing to try out a newly re-established casting method, lost wax, in favour of the well-established technique of sand mould casting, but in the end has to be pragmatic and chooses for the Alexis Rudier foundry and in effect the sand mould casting technique and possibly an aesthetic preference for a sand mould cast surface played a role as well.

Three times during his career Rodin tried out lost wax casting but every time he was disappointed by the foundry and went back to the trusted sand mould casting. Although Rodin looked critically at the prices asked by foundries, he was prepared to pay a premium if the foundry performed up to his standards. Rodin was, apart from an artist also a business man who demanded basically two things from his foundries: sound castings accurate to his models and prompt delivery within the agreed time. These lost wax foundries would time and time again fail to deliver on time. It was the young founder Eugène Rudier of the A. Rudier foundry who came to the rescue. By using the sand mould casting technique, he was able to full fill the increasing demand of Rodin bronzes, in time and consistent quality. From around 1902-03 he would cast the vast majority of Rodin bronzes including all the subsequent original size *Thinkers*. Around fifty authorized casts of the original size *Thinkers*, produced between 1884 and 1967, have been identified. Of the first one, the Ionides *Thinker*, the only one to be cast using lost wax casting, the foundry was still a mystery. Through the study of

the material aspects of this bronze, such as material analysis and comparing casting features, it was possible to gather enough information to support a firm attribution to the Gonon foundry.

Another research question relating to a specific *Thinker* was the question of the production date of the Laren *Thinker*. A specific technical feature on a toe of the Laren cast was observed, probably caused during the moulding and casting of the plaster foundry model. This feature was only observed on one foundry model, still in the collection of the Rodin Museum Paris. On a small group of bronze casts this feature was also observed and by comparing the dates of these other *Thinkers*, the period of use of this foundry model is now set between 1931 and 1939, narrowing the production date for the Laren *Thinker* somewhere between 1931-1937.

In addition to the use of traditional research methods as literature research, innovative techniques were also applied in the study. 3D imaging techniques, used successfully in the treatment of the Laren *Thinker*, were used successfully in a comparative study to determine the casting methods of a small group of *Thinkers*. In this study various casts of the original size *Thinkers* were 3D scanned in high definition. These 3D scans were subsequently used for a deviation study which identified foundry specific dimensional deviations. One of the initial research questions was whether differences could be observed between the lost wax casting and sand mould casting: potentially very interesting for authentication purposes. Indeed, the deviations, identified for the first time in this study, made it possible to make a distinction between lost wax and sand mould castings purely based on 3D imaging.

The treatment of the Laren *Thinker* was one of the earliest uses of 3D techniques for the restoration of sculpture. The complexity of using 3D printed replacement parts, which were placed in the sculpture, was not attempted before and the question arose whether these innovative 3D techniques were suitable to apply directly in sculpture conservation/restoration. Eventually the use of 3D techniques proved to be very effective and readily applicable.

The research, prior to the treatment of the Laren *Thinker,* was the start of my fascination with sand mould casting: why did an artist of such a stature have his bronzes cast with an ‘inferior’ casting method and how was this actually achieved. This thesis gives many new facts and previously unknown details of the use of natural sand as a moulding and casting material. By researching the intricacies of the technique, a picture emerged of a technique evolving over time, from a fairly basic founding technique to a very complex and skilled founding technique, capable of casting elaborate sculptures.

Suggestions for future research

This thesis gives for the first time a comprehensive overview of the technical development of sand as a moulding material for founding. It is based primarily on original historical textual source material. Other sources such as archeological evidence proved to be less fruitful. This is partly due to the ephemeral nature of sand moulds but also due to archeologist being unfamiliar with sand as evidence of a founding technique. If future excavations could be more aware of the presence of moulding sand, perhaps the extent of the use of sand moulding could become clearer.

Although I have tried to make my overview of the technical development of sand mould casting as comprehensive as possible, some knowledge gaps were easier to fill than others. Because this part of the research drew heavily on textual source material, this has its reflection on the research. Some trades, periods and countries are perhaps under-represented because of lack of available source material. The availability of textual sources can have several causes. Firstly, the most obvious one is the fact that not every trade in every country/language published in any given time period. Secondly, not all source material has survived to the present day. Thirdly, even if these texts have survived, it might not be easily accessible for today's researcher, due to language, lack of cataloguing or referencing in literature. The early development of sand mould casting specifically, is rather sketchy and could benefit from more research. Were there earlier uses of sand mould casting than the fourteenth century and is it possible to establish a possible knowledge transfer between the Middle East and the West?

In the area of technical features on bronzes, there remains still much to be researched. This study observed on some bronzes a specific technical feature, identified as portées. These portées have never been properly studied and its use seems to be not limited to only sand mould casting and the nineteenth century. It would be therefore very useful to find more examples to determine the precise use and context of this casting feature. This research found evidence of the use of hybrid techniques, how widespread was the use of these techniques or were these hybrids the result of experimentation in the early development of a technique?

This research made extensive use of comparison studies. For example, the specific damage to a toe of the original size *Thinker* was used to narrow the date of use of foundry plaster S. 2840. Future comparison with more casts could possibly narrow this date even more. The other comparison study, using 3D imaging, was able to discriminate between the different casting methods by comparing dimensions. Future research with more accurate 3D imaging methods could be used to map specific markers such as small damages. These damages could then, as with the above-mentioned research with the toe, be used in deviation studies which could potentially provide a chronological sequence.

The research presented here, is the first detailed technical study of Rodin's *Thinkers*, and although the number of studied *Thinkers* for this study is considerable, it is far from

conclusive and it is hoped that future examination of currently not accessible examples, can contribute to this study and confirm some of the findings.

Summary

Casting Rodin's *Thinker*

Sand mould casting, the case of the Laren *Thinker* and conservation treatment innovation

Chapter 1 provides for the first time a comprehensive overview of the historical technical development of sand moulding and casting. The lack of archaeological evidence shifted the focus of this research to early descriptions or depictions of sand mould casting. Historically, foundries have used predominantly natural occurring sands for moulding. The exception to this was the use of artificially produced finely powdered refractory materials by sixteenth and seventeenth century medal founders and goldsmiths to produce fine castings. Strictly speaking with these artificially produced powders one cannot speak of sand anymore and the modern term aggregate to denote this type of moulding material is therefore more appropriate. The moulding and casting recipes detailing the grinding of various refractory materials to a fine powder were common for the early modern period and the large variety of different mould materials described in these recipes suggest an experimental element. Of the natural moulding sands, it was the French moulding sand from Fontenay-aux-Roses that possessed a combination of properties that made it so desirable for sand moulding. Small uniformly round grains, each encapsulated with a fine layer of clay made for a moulding sand that took a very fine imprint but was still permeable enough to facilitate the escape of mould gases. The clay content of this sand was between 16-19%.

The earliest firm evidence for sand mould casting in Western Europe dates from the late fifteenth century. Most of the early written references to sand mould casting are describing the casting of small, low relief objects such as precious and base metal seals, medals and plaquettes by goldsmiths and medal founders. Evidence prior to the middle of the sixteenth century is exclusively Italian including well known early written sources as Da Vinci, Piemontese and Cellini. From the middle of the sixteenth century depictions of goldsmithing workshops illustrated casting flasks, an essential tool in the sand mould casting process. The use of sand moulds for casting is a general accepted practice amongst goldsmiths and medal founders in Europe, with evidence from Italy, France, Germany and the Low Countries. Apart from goldsmiths and medal founders, other professions were also making use of sand as a moulding material. From the end of the seventeenth century sand moulds were beginning to be used for the production of other more domestic products such as copper alloy cauldrons and skillets. Previously these cooking vessels were made using baked loam moulds or with lost wax casting. Some of the foundry knowledge was transferred from the Low Countries and Germany to Britain where sand moulding was also applied to cast iron wares. The founding of hollowware required more complex moulding techniques than the simple two-part moulding as practised by goldsmiths and medal founders. The complex shapes of hollowware and other undercut objects such as pulleys could only be moulded by making moulds made up of more

than two mould parts. The first pictorial evidence for the use of these so-called piece-moulds can be found in the eighteenth-century Diderot Encyclopédie in the section on the founding of pulleys. Other artisans making use of sand moulds were the cannon founders. Although sand moulds for gun founding had seen some limited use in England and France around the middle of the eighteenth century, the aftermath of the French revolution brought the sand moulding of cannon to full development. Complex piece-moulds were developed and applied by a new generation of sand moulders who were going to be instrumental in the development of the sand moulding of sculpture.

While chapter one looked at the historical development of sand mould casting in Western Europe in general, the focus of **chapter 2** was on the application of sand as a moulding material for the founding of sculptures. The research presented in this chapter demonstrates that the historical division between sand mould casting and lost wax casting is sometimes not so clear when dealing with the eighteenth and early nineteenth century. A picture emerges of several hybrid techniques incorporating elements previously thought to be exclusive to a specific moulding and casting technique. The use of plaster cores and wax was, for example, not exclusive to lost wax casting and additionally there is evidence that piece-moulding using loam moulds was also used for lost wax casting. It is difficult to determine the extent of the use of these hybrid techniques from just the textual sources. The early textual evidence found so far for these hybrid techniques, such as loam piece-moulding incorporating wax parts, describes only the use of these techniques for the founding of large bronzes. The traditional categorisation in lost wax or sand mould casting might not applicable to certain bronzes which used hybrid techniques. This study has shown that remains of core material or the appearance of the interior surface of a bronze does not always conform to the current accepted views on the used moulding technique.

Dossie's (1758) and Sprengel's (1770) descriptions of loam/clay piece moulding are to date the earliest European accounts of the piece-moulding of a refractory sculpture mould which was subsequently used for casting bronze directly into. These descriptions by Sprengel and Dossie are possibly the earliest descriptions of sand/loam mould casting of bronze sculptures and challenge the current accepted views that the piece-mould casting of bronze sculptures developed around 1800. The first French evidence for the casting of sculpture in sand piece-moulds is from 1798 and points to post-revolutionary Paris as the source of French sculpture casting in sand moulds. Piece-moulding in sand replaced in France lost wax casting as the preferred technique for the casting of monumental sculpture during the first quarter of the nineteenth century. This research found that Germany was closely behind France whereas for Britain and the United States it took till the middle of the nineteenth century for sand mould casting to become the main sculpture casting technique. In the countries where sand piece-moulding became the preferred method, the lost wax method was practised only very occasionally for the reproduction of sculpture and became nearly obsolete. Italy was a different story, up till recently it was assumed that sand mould casting of sculpture was not exercised and only the lost wax technique was practised. New evidence however points to use of sand mould casting for the casting of monumental sculpture in Milan by the Manfredini brothers. They acquired their sand moulding skills during their stay in Paris. This example of

knowledge transfer can also be observed in other countries where the foundry knowledge of sand piece-moulding transferred, either by French foundry men working abroad or foreign practitioners working in France. This research found that the French moulding techniques were exemplary and practised virtually unchanged in foreign workshops with even the Parisian sand being imported. As a result, the technique of piece-moulding in natural sand of sculpture was often referred to as French moulding.

The following factors were instrumental in enabling sculpture casting with sand as a moulding material to develop:

- the availability of a natural sand with superior moulding properties in Paris
- a pressing demand for an alternative – faster and less expensive – casting method for the founding of cannon in Paris at the end of the eighteenth century
- the bad track record of lost wax casting for the founding of monumental bronze sculpture as being costly, time-consuming and prone to failure

Several factors were instrumental for the change in preference from lost wax casting to sand mould casting during the nineteenth century. With monumental statuary especially, the sand moulding technique was welcomed as a more reliable and economical way of casting. The fact that the whole moulding process could be constantly monitored combined with casting in parts was a great advantage. While one of the aims of this chapter was to clarify the use of sand mould casting, one of the outcomes of this chapter is the complexity of this technique, especially during the early, more experimental, phase.

Chapter 3 looked at the modelling and plaster model making prior to the founding process. The transformation of the Rodin's clay model into the final bronze was complicated process involving various steps. The artist's soft wet clay model needed to be converted into a more durable medium to ensure long term preservation of this model and enable reproduction. This was usually done by making a plaster mould which was subsequently used to make a plaster model. Plaster models to be used in sand mould casting, called patterns, were made extra sturdy to withstand the moulding process whereas plasters, whose sole purpose was to be exhibited, were executed much lighter. This chapter discussed the making of these clay and plaster models in Rodin's atelier and suggests a new categorisation to identify and name the various types of plasters produced. As with the bronze casting process, no author has given to date a detailed description of the technical aspects of the making of these plasters in Rodin's workshop. This is most likely due the fact that Rodin was not involved in this and thus the making of these plasters was regarded as mere reproduction and not part of the artistic process. Indeed, the principal aim of the making of plaster models was to reproduce the clay model in plaster as accurate as possible without alteration of the artist's model. However, it is sheer impossible, using traditional mould making techniques, to make a perfect copy without loss of surface detail, shrinkage or minor moulding mistakes. It is the occurrence of these minor imperfections that enables to make distinctions between plaster models and ultimately their derivatives, the final bronze casts. By mapping these minor deviations between models and dated bronze casts, a first attempt is made in this chapter to make a chronological

sequence of certain bronze casts of the original size *Thinker*. The fortunate survival of most of Rodin's plaster models of the original size *Thinker* the Rodin Museum in Paris enabled detailed study that continued in **chapter 4.**

This chapter 4 gives a detailed study of the production process of Rodin bronzes and in particular *Thinkers*. It describes in detail the moulding, casting and finishing of bronzes using sand piece-moulds. Starting point for sand moulding is a pattern, a sturdy model of the sculpture to be reproduced. Patterns for sand moulding were made from various materials with plaster being favoured for the moulding of larger sculptures. The study of these original foundry plasters demonstrated the use of a complex system of mould pieces called false-cores in sand. The decline in availability of high quality moulding sand from Fontenay –aux-Roses, from the 1960s onwards, contributed greatly to the demise of the founding of sculpture in natural sand moulds. This chapter describes in detail the piece-moulding of bronzes in natural sand including the complex procedure to fabricate a core from sand, involving repeated assembly and disassembly of the piece-mould and the use of sand cones, called flies. An internal and external armature held the core together and in place, inside the outer mould and a core vent (lantern) facilitated the escape of core gases. Most of the Rodin bronzes cast before 1903 are in fact brasses. It is only when Rodin starts commissioning Eugène Rudier of the A. Rudier foundry that a true bronze alloy is used regularly. The A. Rudier foundry was remarkable consistent in using one particular alloy, casting all type of sculptures with this alloy, during the entire working period of the foundry. The time around 1900 was also a turning point for Rodin concerning the patination of his bronzes. Previously these bronzes were patinated by the commissioned foundry but from 1900 onwards Rodin bronzes were increasingly patinated by Jean Limet and later his son. These complex patinas involved the use of various chemicals often applied in multiple steps. This chapter also describes for the first time in detail the various markings one can encounter in the surface or the interior of Rodin bronzes. These can range from signatures, foundry marks or stamps and dedications with a suggested chronological sequence of some of these. Because the model of the *Thinker* is inherently unstable and has the tendency to tip forward a lead counterweight can be found inside most of the *Thinkers*. This study observed a development in form and position of these counterweights and suggests a possible chronological sequence.

While the previous chapter 4 looked at the making process and the characteristics it produced on the bronzes, **chapter 5** focussed mainly on the technical differences between the various Rodin bronzes. By comparing various *Thinkers* and other Rodin bronzes it was observed that the castings produced by Eugène Rudier share great technical similarity with Griffoul castings and a marked difference compared to the bronzes produced by his uncle François Rudier. It is possible that Eugène Rudier or one of his foundry men acquired some of their bronze moulding and casting skills from father or son Griffoul via the connection of his uncle François Rudier, once the business partner of father Griffoul.
A comparison study was also instrumental in establishing the possible founder of the Ionides *Thinker*. This first ever bronze cast of the *Thinker* has always been a sort of enigma. The only lost wax cast *Thinker*, has no foundry mark or documentation to attribute it to a specific foundry. Two founders have been suggested as likely candidates by art historians in the past,

namely Pierre Bingen or Eugène Gonon. Through analysis of the art technological features of this bronze and comparison with other bronzes by these founders Eugène Gonon was identified as the most likely founder of the Ionides *Thinker*.
Traditionally the technical study of bronze sculptures has focussed either on material analysis, textual source material or visual and radiographic examination. The application of innovative 3D imaging during the treatment of the Laren *Thinker* raised the question whether 3D imaging can also be used to distinguish between the various casts and models of the Thinker. By comparing the various 3D-scans of the *Thinker*, variations could be observed. Slight but significant differences in size, between the plaster foundry model, the sand cast bronze and the lost wax bronze were made digitally visible and made it possible to discriminate between the various casting methods. Although small variations in modelling between the Ionides *Thinker* and the other *Thinkers* could be observed, the similarity between the foundry model and the other casts is remarkable. This demonstrates the use of a master model taken from the original clay model. This master model was used to reproduce all the subsequent foundry models. When Rodin started, in the mid-1870s, to commission foundries to cast his first bronzes, sand mould casting was the pre-eminent founding method for bronze sculpture. As a result, these first Rodin bronzes were cast using sand moulds. Around this time however a renewed interest emerged in lost wax casting which according to contemporary art-critics was the preferred method for reproducing fine art sculpture. They argued that only this founding technique, used to produce the great bronze sculptures of Antiquity and the Renaissance, was suitable to reproduce the modern master sculptors. This prompted several artists, Rodin amongst them, to have, around 1880, their work reproduced in bronze using the lost wax technique. From 1882 Rodin, who never performed his own castings, used the Gonon and Bingen lost wax foundries until 1886. This was Rodin's first period of using lost wax founders and was ended for several reasons. Rodin popularity as an artist increased in this period and resulted in more commissions for bronzes. The artisanal nature limited the output and resulted in a long production process of these two foundries. This resulted in long delivery times for Rodin his bronzes which started to annoy Rodin. Quality of the casts might have been another issue for Rodin. Even though Gonon and Bingen were using both lost wax casting, their methods differed considerably, resulting in a difference in the quality of casting, with the surface detail rendering of Bingen's cast being superior to that of Gonon. The very detailed surface of Bingen's bronzes was however the result of a second modelling of the wax which Rodin could hardly have enjoyed. The second period was 1903-05 when he used the Hébrard lost wax foundry for two enlarged *Thinkers* and a handful of smaller bronzes. Hébrard convinced Rodin of the commercial potential of lost wax bronzes in the United Stated, received the commission for the first monumental *Thinker*, which would be exhibited at the St. Louis world fair. Hébrard was even prepared to lower his price in order to get this commission. However, the quality of this cast greatly disappointed Rodin and Rodin soon ended their collaboration. Rodin was going to use a lost wax foundry one last time around 1912-13 when the Montagutelli brothers produced busts and statuettes for the artist. This relationship however was short lived because Rodin soon discovered that this foundry was also producing unauthorised casts of his work which forced Rodin to take legal action against the foundry. Three times during his career Rodin was willing to try out lost wax casting but every time he was disappointed and went back to the trusted sand mould casting. Although

Rodin looked critically at the prices asked by foundries, he was prepared to pay a premium if the foundry performed up to his standards. Rodin was apart from an artist also a business man who demanded basically two things from his foundries: sound castings accurate to his models and prompt delivery within the agreed time. It is significant that of the more than fifteen hundred authorised life-time casts only a small fraction, around sixty, was cast using the lost wax technique and no life-time Rodin bronze was lost wax cast from 1913 onwards.

Apart from economic motives (lost wax casting was more expensive), quality of the castings and the reliability of the foundry, there might have been another motive for Rodin to prefer sand mould casting over lost wax casting: the aesthetic quality of a sand mould cast surface. It is conceivable that Rodin, with a background in stone carving, preferred the soft tactile surface of sand mould cast surface over an, too detailed, lost wax surface. The difference between the two surfaces is usually the type of detail and the extend of the undercutting of these surface details. This gives a sand moulded surface a closed and more solid appearance similar to a stone carved surface. A lost wax cast surface can have as a contrast, very sharp, almost harsh details which can sometimes detract the attention from the overall shape of the sculpture. And although Rodin never expressed himself about the difference between sand mould cast surfaces and lost wax cast surfaces, it is known that he distanced himself from the overly detailed commercial work he produced early in his career.

The last chapter documents various aspects of the treatment of the Laren *Thinker*. The theft, recovery and treatment were from the start a very public affair. The recovery of the sculpture initiated an interesting, at times very public, discussion regarding its future. In this **chapter 6**, I have looked at the different arguments used in this discussion and reflected on this from a conservator's and technical art-historian's point of view.

As the owner and main stakeholder, the Singer Museum decided to investigate the options for restoring the sculpture. The complexity of decision making process justified setting up an expert committee. The extent of vandalisation of such an important work of sculpture is fortunately not an often-occurring event and one has to look at paintings restoration - conservation to find similar expert committees.

The treatment of the Laren *Thinker* was one of the earliest uses of 3D techniques for the restoration of sculpture. It's complexity with 3D printed parts that were placed in the sculpture was not performed earlier. The use of 3D techniques proved to be very effective and readily applicable. This chapter also looks at the implications of the use of 3D techniques in conservation/restoration and gives recommendations for best practice. Because of the complexity of some of the techniques and equipment and their expense, most of the 3D imaging and 3D printing is carried out by non-conservators whose objectives might differ from conservators. Conservators should be aware of this and be selective in their choice for professionals to perform their 3D imaging. These 3D techniques have been developed initially for industrial purposes and it is only by interacting with this technology that one can discover new possibilities for the conservation profession.

Samenvatting

Het gieten van de *Denker* van Rodin

Zandgieten, de zaak van de Larense *Denker* en innovaties in conservingsbehandelingen

Dit proefschrift geeft voor het eerst een historisch overzicht van de technische ontwikkeling van het gieten van metaal in mallen gemaakt van natuurlijk zand. Deze traditionele manier van gieten is bijna geheel in onbruik geraakt. Van oudsher gebruikten gieterijen hiervoor natuurlijk zand, van verschillende bronnen. Het zand gewonnen aan de rand van Parijs, in Fontenay-aux-Roses, bezat van nature de perfecte eigenschappen om als vormzand voor de mallen te dienen. De combinatie van kleine uniforme ronde korrels en een natuurlijk kleigehalte van 16-19% maakte dit zand zeer gewild. Het is dit kleigehalte dat het zand bijeenhoudt en het produceren van perfect gedetailleerde mallen mogelijk maakt. Dit zand is wezenlijk anders dan het moderne vormzand, dat gebonden wordt door synthetische polymeren.

In dit onderzoek is een vergelijking gemaakt, op basis van historische bronnen, tussen het zand gebruikt in de negentiende eeuw en in de twee helft van de twintigste eeuw. Hierbij is vastgesteld dat de korrelgrootte en vorm van de zandkorrels groter en grover werd waardoor de vormkwaliteiten van het zand achteruitgingen. Tevens is het effect van hitte op het kleigehalte onderzocht. Hierbij is vastgesteld dat er een verandering in korrelgrootte is waar te nemen bij het zand dat zich het dichtst bij het gegoten metaal bevindt. Dit is hoogst waarschijnlijk toe te schrijven aan een vorm van sintering van de kleideeltjes. Deze bevinding laat zien dat de plaats van monstername van kernmateriaal van cruciaal is voor het verkrijgen van een representatief onderzoeksresultaat. Deze bevinding heeft repercussies voor het interpreteren van korrelgrootte-analyses gedaan in het verleden.

Het vroegste bewijs voor zandgieten in West-Europa dateert van de laat vijftiende eeuw. De eerste geschreven bronnen, daterend vanaf 1500 en veelal Italiaans, beschrijven het vormen en gieten van kleine eenvoudige voorwerpen zoals penningen en plaquettes. Het gebruik van zandgieten door goud- en zilversmeden en penninggieters vindt in de loop van de zestiende eeuw algemene ingang in Europa met voorbeelden uit onder andere in Italië, Frankrijk, Duitsland en de Lage Landen.

Vanaf eind zeventiende eeuw zien we bewijs voor het zandgieten als productiemethode voor gebruiksvoorwerpen zoals bronzen en messing potten en ketels. Het vormen en gieten van deze, vaak holle, objecten vereiste meer complexe mallen dan de eenvoudige tweeledige mallen zoals gebruikt door de edelsmeden en penninggieters. Deze zogenaamde deelmallen worden voor het eerst afgebeeld in de achttiende-eeuwse Encyclopédie van Diderot en d'Alembert in het hoofdstuk betreffende het gieten van katrolschijven. Het gebruik van deelmallen in zand neemt na de Franse Revolutie een grote vlucht, m.n. bij het gieten van

kanonnen, en zal dan vervolgens ook worden gebruikt voor het vormen en gieten van sculpturen.

Hoofstuk 2 gaat dieper in op dit gebruik van zand als malmateriaal in de productie van sculpturen en laat zien dat het traditionele onderscheid tussen zandgieten en het alternatief, verloren-was-gieten, niet zo duidelijk was als voorheen gedacht. Dit proefschrift beschrijft voor het eerst diverse hybride technieken met overlappende kenmerken die voorheen enkel werden toegedicht aan een bepaalde techniek. Het gebruik van was en gips was niet exclusief voor de verloren-was-techniek en omgekeerd werden lemen deelmallen soms ook gebruikt voor het afvormen van wasmodellen.

Dossie (1758) en Sprengel (1770) zijn de vroegste beschrijvingen van het gebruik van lemen en/of klei deelmallen voor het gieten van monumentale bronzen beelden. Dit kan waarschijnlijk gezien worden als de voorloper voor het gebruik van deelmallen uit zand. Door ambivalent taalgebruik is het onderscheid tussen leem en zandmallen is soms moeilijk op te maken uit de beschrijvingen in oude geschreven bronnen. De vroegste tekst die deze studie heeft gevonden van het gebruik van zandmallen voor het gieten van beelden, dateert uit 1798 en dicht deze uitvinding toe aan de Parijse gieter Rousseau.
In het eerste kwart van de negentiende eeuw zal zandgieten het verloren-was-gieten bijna geheel verdringen als vervaardigingswijze voor bronzen beelden in Frankrijk en Duitsland en rond het midden van de eeuw ook in het Verenigd Koninkrijk en de Verenigde Staten. In Italië daarentegen bleef de verloren-was-methode in zwang, alhoewel er wel degelijk bewijs is voor het gebruik van zandgieten voor het produceren van monumentale bronzen beelden in dit land. De gieterijen buiten Frankrijk haalden de kennis van het gieten van beelden in zandmallen uit Frankrijk. Ook het zand werd, vaak tegen hoge kosten, uit Frankrijk gehaald.

Het uit zwang raken van de verloren-was-techniek ten faveure van het zandgieten in de negentiende eeuw had meerdere oorzaken:

- de noodzaak van een alternatieve – snellere en goedkopere – methode voor het gieten van kanonnen in Frankrijk aan het einde van de achttiende eeuw
- de beschikbaarheid van geschikt natuurlijk vormzand in Parijs
- technische problemen met het gieten van monumentale bronzen met de verloren-was-methode

Hoofdstuk 3 en 4 gaan dieper in op het vorm- en gietproces zoals dat aan het eind van de negentiende eeuw uitgevoerd werd, met name in Frankrijk, en toegespitst op het vormen en gieten van de *Denker* van Rodin. Rodin bronzen en de *Denker* in het bijzonder, vormen goede representatieve voorbeelden van laat negentiende en vroeg twintigste eeuwse bronzen. Rodin bronzen werden geproduceerd gedurende een lange periode, van rond 1875 tot recent, door bijna alle belangrijke Parijse gieterijen, met alle toen gangbare giettechnieken. De nadruk ligt op het originele of middenformaat *Denker*, de afgeleiden hiervan, de vergrote (monumentale) of verkleinde versies worden minder uitvoerig behandeld. Hoofdstuk 3 behandelt het proces

van modelleren en het vervaardigen van het gipsen model, dat grotendeels plaats vond in het atelier van Rodin, terwijl hoofdstuk 4 de gieterijprocessen rond de *Denker* behandelt.

De transformatie van het kunstenaarsmodel in klei tot het definitieve bronzen beeld is een gecompliceerd proces met vele handelingen. Wanneer het kleimodel afgerond was, werd dit door middel van mallen vervangen door een meer duurzaam gipsmodel.
Gipsen modellen kunnen, op basis van hun functie, in verschillende groepen onderverdeeld worden. De gipsen modellen die als gietmodel dienden, waren extra stevig uitgevoerd. Gipsen modellen voor tentoonstellingen waren juist dunwandig en dus licht uitgevoerd, om het transport te vergemakkelijken. Ook waren er verschillende modellen nodig voor de diverse stadia in het proces van klei- tot definitief gieterijmodel. De variatie in modellen wordt in deze studie voor het eerst beschreven en gecategoriseerd aan de hand van de verschillende modellen voor de *Denker*. De diverse stappen van kleimodel naar definitief gipsen model laten hun sporen na in de vorm van detailverlies en andere kleine onvolkomenheden op het oppervlak. Deze sporen zijn vaak terug te vinden op de uiteindelijke bronzen beelden. Voor deze studie is een begin gemaakt met het in kaart brengen van deze afwijkingen bij de diverse uitvoeringen van de *Denker*. Zodoende kon een chronologische opeenvolging worden opgesteld waardoor een betere datering van de diverse bronzen *Denkers* mogelijk is. Dit kon vooral doordat een groot aantal originele gipsen modellen bewaard is gebleven in het Rodin museum in Parijs (locatie Meudon).

Hoofdstuk 4 onderzoekt in detail alle stappen in de gieterij die noodzakelijk zijn om van het gipsen gieterijmodel, met behulp van zandmallen, een bronzen afgietsel te maken. Wederom staat de *Denker* hierbij centraal, soms aangevuld met informatie met betrekking tot andere bronzen. Door bestudering van de originele gietmodellen en contemporaine technische literatuur komt een beeld naar voren van een zeer complex systeem van deelmallen, waarbij de zandmal, soms bestaande uit honderden maldelen, verscheidene keren af- en opgebouwd moest worden. Vooral het fabriceren van de kern, vaak van hetzelfde vormzand gemaakt, vereiste een grote vaardigheid. Hierbij werd gebruik gemaakt van interne ijzeren armaturen alsook van kernpijpen voor de afvoer van gassen die ontstaan tijdens het gieten. Het verlies aan kwaliteit en beperkte beschikbaarheid van hoogwaardig natuurlijk vormzand vanaf het begin van de jaren 1960 zorgde voor een afname van het gebruik van de natuurlijke zandgietmethode voor bronzen beelden. Samen met technische vernieuwingen in de verloren-was-methode zette dit de teloorgang van het gebruik van het traditionele zandgieten voor bronzen sculpturen in gang.

Naast de handelingen van het vormen en gieten zijn ook de materiële aspecten van het bronsgieten in zandmallen onderzocht, waarbij vooral naar de samenstelling van de legering is gekeken. De koperlegering die gebruikt is voor het merendeel van Rodin's beelden van vóór 1903, is messing. Pas vanaf 1903, wanneer Rodin gebruik gaat maken van de gieterij van Rudier, zien we dat doorgaans brons gebruikt wordt. De gieterij van Rudier blijkt daarbij heel consistent een bepaalde legering te gebruiken, voor verschillende sculpturen van Rodin en over een lange periode. Rond 1903 gaat Rodin ook steeds vaker gebruik maken van één firma voor het patineren van zijn bronzen, namelijk vader en zoon Limet. Deze patinas en het

aanbrengen ervan worden in detail beschreven, net als andere oppervlakte-elementen, zoals signaturen en gieterijstempels. Ook hierbij wordt een chronologische volgorde voorgesteld. Ook de specifieke kenmerken aan de binnenzijde van de bronzen worden geanalyseerd. Een opvallend kenmerk aan de binnenzijde van Rodin's *Denkers* is het loden tegengewicht, dat moet voorkomen dat het beeld voorover valt. Ook voor dit loden tegengewicht wordt een chronologische volgorde gesuggereerd.

Hoofdstuk 5 richt zich op de technische verschillen tussen diverse bronzen van Rodin en specifiek zijn *Denkers*. Daarbij is vastgesteld dat de bronzen die gegoten zijn door Eugène Rudier grote technische overeenkomsten vertonen met die van de gieter Griffoul, wat wellicht duidt op een vorm van kennisoverdracht tussen deze twee gieterijen.

Van de originele middelgrote formaat *Denker* zijn uiteindelijk meer dan vijftig afgietsels gemaakt. De eerste bronzen *Denker* is vanuit kunst-technologisch oogpunt enigmatisch. Van dit beeld, dat zich nu in de National Gallery of Victoria in Melbourne bevindt, weten we sinds kort dat het rond 1884 met de verloren-was-methode is gegoten. Het is de enige *Denker* in het originele middelgrote formaat die met deze techniek is gegoten. Archiefonderzoek heeft tot nu toe nog niet kunnen achterhalen welke gieterij hierbij betrokken was; de gieterijen van Pierre Bingen of Eugène Gonon zijn eerder geopperd. Voor dit onderzoek is daarom gekeken naar de kunst-technologische kenmerken van deze gieterijen, die vervolgens zijn vergeleken met die van de *Denker* uit Melbourne. Hieruit is geconcludeerd dat Gonon de meest waarschijnlijke de gieter van deze *Denker* is.

Bij de vergelijking tussen de diverse gietingen van de *Denker* is gebruik gemaakt van 3D scans. Hierbij is ook gebruik gemaakt van een 3D scan van een gipsen gietmodel. De verschillen in modellering tussen de diverse modellen bleken miniem te zijn, maar er is wel een formaatverschil waargenomen tussen de diverse *Denkers*. Dit verschil is toe te schrijven aan de krimp die veroorzaakt wordt door afvormen en gieten. De krimp was het grootst bij de verloren-was-gegoten *Denker* uit Melbourne.
Toen Rodin rond 1875 zijn eerste bronzen liet gieten, was de zandgietmethode de meest gangbare methode en werden ook zijn bronzen op deze wijze gegoten. Rond 1880 begon in Frankrijk een hernieuwde interesse in het verloren-was-gieten en liet ook Rodin, vanaf 1882, bronzen gieten volgens deze methode. Dit gebeurde in de gieterijen van Bingen en Gonon en duurde tot ongeveer 1886. Dit was Rodin's eerste, korte periode van het gebruik van verloren was; vanaf 1886 ging hij weer gebruik maken van zandgieterijen. Hiervoor zijn verschillende oorzaken aan te voeren. Uit Rodin's correspondentie kunnen we afleiden dat de kunstenaar vaak lang moest wachten voordat de verloren-was-gegoten bronzen beelden werden afgeleverd. Wanneer we naar deze beelden kijken, bijvoorbeeld de *Denker* uit Melbourne (1884), zien we dat de kwaliteit van deze vroege brons nogal te wensen overlaat. Bij Bingen moest de kunstenaar tijdens het gieterijproces nogmaals aan de detaillering van het wasmodel werken, een handeling waar Rodin waarschijnlijk niet naar uitkeek. Rodin's tweede periode van verloren-was-gieten was tussen 1903 en 1905, toen hij de gieterij van Hébrard gebruikte voor twee monumentale *Denkers* en een handvol kleinere bronzen beelden. Ook nu weer duurde de aflevering lang en was de kwaliteit niet naar Rodin's wens. Rodin ging nog

eenmaal in zee met een verloren-was-gieterij, die van de broers Montagutelli, rond 1912-'13. Deze samenwerking eindigde echter abrupt, toen Rodin ontdekte dat deze gieterij buiten zijn medeweten bronzen beelden naar zijn ontwerp produceerde, waardoor Rodin genoodzaakt was juridische stappen tegen deze gieterij te ondernemen.

Driemaal tijdens zijn carrière probeerde Rodin dus zijn bronzen te laten produceren volgens de verloren-was-methode en telkens werd hij teleurgesteld, om steeds opnieuw terug te keren naar de vertrouwde zandgieterijen. Rodin was niet alleen kunstenaar, maar ook een zakenman die twee dingen van zijn gieterijen verlangde: goede bronzen, die binnen de afgesproken termijn werden geleverd. Hoewel Rodin waarschijnlijk ook naar de prijs keek (zandgieten was goedkoper), was dit vermoedelijk niet doorslaggevend voor zijn keuze. Rodin kreeg bijvoorbeeld een aanbod van Hébrard om tegen een concurrerende prijs met de verloren wastechniek zijn bronzen te laten gieten. Het aantal bronzen beelden van Rodin dat is gegoten met de verloren-was-methode is dan ook maar een fractie (rond de zestig) van zijn totale bronzen oeuvre, dat bestaat uit ongeveer vijftienhonderd exemplaren.

Wellicht is er nog een andere reden voor de keuze van Rodin voor het zandgieten, namelijk de esthetische kwaliteiten van het gegoten oppervlak. Het is denkbaar dat Rodin, met een achtergrond in steenhouwen, gecharmeerd was van het wat zachtere uiterlijk van een zandgieting met minder dieperliggende details. Kleine detailleringen in het oppervlak met ondersnijdingen zijn moeilijk af te vormen in zand en komen niet goed over of worden soms preventief gevuld. Dit geeft het uiteindelijk oppervlak van een zandgegoten brons dikwijls een meer 'gesloten' oppervlak, dat gelijkenis vertoont met dat van een stenen sculptuur. Hoewel Rodin zich hierover nooit heeft uitgelaten, weten we dat hij niet tevreden was met zijn vroege, overmatig gedetailleerde werk, waar hij zich later dan ook van distantieert.

Het laatste hoofdstuk behandelt diverse aspecten van de behandeling van de in 2007 na een diefstal zwaar beschadigde *Denker*. Dit vormde het vertrekpunt van het onderhavige onderzoek. De diefstal, het terugvinden door de politie en de keuze voor de restauratie hadden een sterk publiek karakter. In dit hoofdstuk komen de diverse standpunten ten aanzien van de restauratie van dit exemplaar van de *Denker* aan bod en reflecteer ik hierop als restaurator en technisch kunsthistoricus, waarbij ik kijk naar de materiaal-technische aspecten die, naar mijn mening, soms in de discussie onderbelicht zijn gebleven.

De voorwaarden die door de eigenaar van het beeld, Singer Museum in Laren, mede op advies van een begeleidingscommissie, werden gesteld aan de restauratie, vroegen om een innovatieve benadering. Van de verschillende opties die zijn overwogen, bleken het 3D scannen van diverse andere exemplaren van de *Denker* en van het gietmodel en het printen van de sinds de diefstal en beschadiging ontbrekende onderdelen het meest geschikt. Het gebruik van deze technieken ten behoeve van de restauratie van de Larense *Denker* was een van de eerste toepassingen daarvan in de geschiedenis van de restauratie van beeldhouwkunst. De inzet van 3D technieken bleek, na grondig onderzoek, effectief en probleemloos toepasbaar en leverde een belangrijke bijdrage aan de realisatie van het uiteindelijke resultaat. Dit hoofdstuk kijkt ook naar de implicaties van het gebruik van 3D technieken voor

conservering en restauratie van bronzen beelden en geeft aanbevelingen voor het toekomstig gebruik ervan.

Bibliography

Accardo, G. “Le tecniche laser per la documentazione e la realizzazione delle copie” *Monumenti in bronzo all'aperto: esperienze di conservazione a confronto*. Arte e restauro. Letardi, P. et al. Nardini Editore (2004): 77-85.

Aleshina, Tatiana. "Some Problems Concerning the Restoration of Rembrandt's Painting Danae." *Rembrandt and his Pupils*, 1993.

Anonymous. *BnF Ms. Fr. 640*. Bibliothèque nationale de France. c.1580.

Anonymous. *Encyclopædia Britannica or, a Dictionary of Arts and Sciences*. A Society of Gentlemen in Scotland. volume 2 (1771): 626-627. (entry *Foundery of Statues*)

Anonymous. *Secrets concernans les arts et métiers*. Jombert (1716): 308-326. (entry *Pour jeter une figure de bronze)*

Anonymous. *Secrets concernant les arts et métiers*, E.T. Chaillot. Volume 1 (1810): 213-227. (entry *Pour jeter une figure de bronze)*

Anonymous. *The brass founders', braziers' and coppersmiths' manual.* Cowie & Strange, 1829.

Anonymous. “The Wellington Statue” *The Art Union 7* (1845): 321.

Anonymous. *Amtlicher Bericht über die Allgemeine Deutsche Gewerbe-Ausstellung zu Berlin im Jahre 1844*, Volume 2, part 2 (1846): 136-139. (entry *Bronze – Statuarguß*)

Anonymous. “Casting the Henry Ward Beecher Statue for the City of Brooklyn.” *Scientific American*, Vol. LXIV.-No. 26, June 27 1891.

Anonymous. “‘Lost Wax’ A Visit to Paul Bartlett's Studio.” *New York Daily Tribune*, Sunday September (1895): 23.

Anonymous. “Bronze Foundries” *The Brooklyn Daily Eagle*. 9 Sept. (1869): 4.

Anonymous. “*Artistic Bronze and Brass: Architectural, Ecclesiastical Ornamental Statuary.*” Gorham Manufacturing Co (1903): 9.

Anonymous. “Note on Art Metal Work Made from Brass Castings.” *The brass world and platers’ guide*. Volume VI, No. 1, January (1910): 1-2.

Anonymous. “Eugène Rudier, Europa’s Kunstgieter van beroemde beeldhouwwerken.” *Telegraaf*, Sunday 13 August (1939): 6.

Akademie der Künste (Berlin), and H. Börsch-Supan. *Die Kataloge der Berliner Akademie-Ausstellungen 1786-1850*. B. Hessling, 1971.

Aitchison, L. *A History of Metals*, volume II, Interscience Publishers, 1960.

American Foundrymen's Society. *Casting copper-base alloys*. American Foundrymen's Society, 1984.

Al-Jazari (Ismail ibn al Razzaz) and Hill, D. R. *The book of Ingenious Devices*, (1206) translated from the Arabic by D. R. Hill, Kluwer Academic Publishers, 1973.

Allan, J. W. *Persian Metal Technology 700-1300 AD*. Ithaca Press, 1979.

Allison, A. H., and Pond, R.B. "On copying bronze statuettes" *Journal of the American Institute for Conservation*, Volume 23, Number 1, Article 4 (1983): 32-46. <http://cool.conservation-us.org/jaic/articles/jaic23-01-004.html>, [accessed 22 June 2018]

Altmütter, G. "Bildgießerei", *Technologische Encyklopädie oder alphabetisches Handbuch der Technologie, der technischen Chemie und des maschinenwesens*. Prechtl, J. J., Ritter von & Karmarsch, K., (eds.) J.G. Cotta [etc.]. Vol. 2 (1830): 152-167

Altmütter, G. "Messinggiesserei sandabformen" *Technologische Encyklopädie oder alphabetisches Handbuch der Technologie, der technischen Chemie und des maschinenwesens*. Prechtl, J. J., Ritter von & Karmarsch, Karl, (eds.), J.G. Cotta [etc.]. vol 9 (1838): 590.

Adil, C. P. and De Phillips Jr, H. A. *Paul Wayland Bartlett and the Art of Patination*. The Paul Wayland Bartlett Society, 1991.

Ammen, C. W. *The complete handbook of sand casting*. Tab Books, 1979.

Appelbaum, B. *Conservation treatment methodology*. Routledge, 2012.

Arbace, L. et al. "Innovative uses of 3-D digital technologies to assist the restoration of a fragmented terracotta statue." *Journal of Cultural Heritage*, 2010. <http://dx.doi.org/10.1016/j.culher.2012.06.008>, [accessed 22 June 2018]

Arminjon, C., and Bilimoff, M. *L'art du métal: vocabulaire technique*. Éd. du Patrimoine / Imprimerie Nationale Ed, 1998.

Arndt, C. *Untersuchung zur Herstellungstechnik der vier barocken Bleiplastiken von Lerchenborg Slot in Dänemark*. Fachhochschule Potsdam (Facharbeit), 2012.

Aronson, J. *Bessie Potter Vonnoh: Sculptor of Women*. Ohio University Press, 2008.

Avery, V. and Dillon, J. *Renaissance and Baroque Bronzes from the Fitzwilliam Museum, Cambridge*. Daniel Katz, 2002.

Baker, T.F.T., et al. "Hampstead: Hampstead Heath", *A History of the County of Middlesex*: Volume 9, Paddington (ed.), C R Elrington (1989): 75-81. <http://www.british-history.ac.uk/vch/middx/vol9/pp75-81>[accessed 22 June 2018]

Baker, S.G., and Werling, J.M. "Expansion Control Method for Sand Cores." *AFS Transactions*, 2003.

Barbour, D. S. and Sturman, S. G. “Degas The Sculptor And His Technique.” *Edgar Degas Sculpture*, Glover Lindsay, S. et al., National Gallery of Art (2010): 35.

Barbour, D. S. and Glinsman, L. “Auguste Rodin’s Lifetime Bronze Sculpture in the Simpson Collection.” *Facture: Conservation Science Art History*. National Gallery of Art, Volume 2 (2015): 54-81.

Bassett, J. and Fogelman, P. *Looking at European Sculpture*: *a guide to technical terms*. The J. Paul Getty Museum, 1997.

Bassett, J. *The Craftsman Revealed: Adriaen de Vries, Sculptor in Bronze.* Getty Publications, 2008.

Bassett, J. and R. E. Schmidtling II. *Sand casting core summary 6 March 2012*; Unpublished internal report J. P. Getty Museum, 2012.

Bassett, J and Bewer, F G. “The cut-back core process in late seventeenth- and eighteenth-century French bronzes.”, *French Bronze Sculpture: Materials and Techniques sixteenth-eighteenth century*. D. Bourgarit et al. (eds.), Archetype Publ. (2014): 205-214.

Baudry, M. *Sculpture; méthode et vocabulaire*. Imprimerie Nationale, 2005.

Beeley, P. *Foundry Technology,* Butterworth-Heinemann, 2001.

Beentjes, Tonny. “Sand casting” *Materials & Techniques in the Decorative Arts: an Illustrated Dictionary,* Lucy Trench (ed.). John Murray, 2000.

Beentjes, Tonny et al. “The Treatment of the Damaged Bronze of Rodin’s the Thinker from the Singer Museum in Laren, the Netherlands: an Innovative Approach.” *METAL 2010: Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group*, Charleston, South Carolina 11-15 October 2010. P. Mardikian, et al.(eds) Clemson University (2010): 269-277.

Beentjes, Tonny et al. “3-D imaging as a research tool for the study of bronze sculpture.” *METAL 2013: Interim Meeting of the ICOM-CC Metal Working Group, Conference Proceedings, 16-20 September 2013, Edinburgh, Scotland.* Hyslop, E. et al (eds.) Historic Scotland and International Council of Museums (2013): 301-306.

Beentjes. Tonny and Van der Molen, R. “An innovative treatment of a severely damaged bronze, the Thinker by Rodin.”*Lasers in the Conservation of Artworks IX.* David Saunders et al (Eds). London: Archetype Publications in association with the British Museum (2013): 146-153.

Beentjes, Tonny and Smith Pamela H. “Sixteenth Century Life-casting Techniques, a reconstruction.” *The Renaissance workshop*. D. Saunders, M. Spring and A. Meek (Eds). Archetype Publications in association with the British Museum (2013): 144-151.

Beentjes, Tonny. “The casting of western sculpture during the XIXth century: sand casting versus lost wax casting.” *Study Days of the SFIIC* 15 (2014): 120-129.

Beentjes, Tonny. “Breaking the mould: A history of sand mould casting in Western Europe based on early written sources. ” *Sources on art technology : back to basics : proceedings of the sixth symposium of the ICOM-CC Working Group for Art Technological Source Research,* Sigrid Eyb-Green, Joyce H. Townsend, Kathrin Pilz, Stefanos Kroustallis and Idelette van Leeuwen (Eds.). London: Archetype Publications (2016): 79-87.

Bellanger, Patrice. “Bingen/ Carriès: le renouveau de la fonte à la cire perdue.” *Jean Carriès (1855-1894): la matière de l'étrange*. Simier, Amélie. (Ed.) Paris-Musées (2007): 59-68.

Belluomini, Giuseppe. *Manuale del fonditore in tutti I metalli*. Hoepli, 1889.

Berg, Sven Dan and Hassell, George. *The Geddy Foundry*, The Colonial Williamsburg Foundation, 1992.

Bernardoni, Andrea. “Artisanal Processes and Epistemological Debate in the Works of Leonardo da Vinci and Vannoccio Biringuccio.” *Laboratories of Art: Alchemy and Art Technology from Antiquity to the Eighteenth Century*. Sven Dupré (ed.). Springer (2014): 53-78.

Beretti, Giuseppe, ed. *Gli splendori del bronzo: mobili ed oggetti d'arredo tra Francia e Italia: 1750-1850*. Omega (2002): 41-43.

Bewer, Francesca G. *A Study of the Technology of Renaissance Bronze Statuettes*, Ph.D. diss. University of London, 1996.

Bewer, Francesca G., David Bougarit and Jane Bassett. “French Bronzes (sixteenth-eighteenth Centuries): Notes on Technique.” *Cast in Bronze: French Sculpture from Renaissance to Revolution*, G. Bresc-Bautier, G. Scherf & J.D. Draper (eds.). Louvre (2009): 28-41.

Biringuccio, Vannoccio. *De la Pirotechnia Libri X*, V. Rossinello, 1540.

Birks, Tony. *The Alchemy of Sculpture*, Pangolin Editions, 1998.

Blanchetière François and David Thurrowgood. “Two insights into Auguste Rodin's The Thinker.” *Art Journal of the National Gallery of Victoria*, 52 (2013): 42-53.

Boffrand, Germain. *Description de ce qui a été pratiqué pour fondre en bronze d’un seul jet la figure equestre de Louis XIV, elevée par la ville de Paris dans la Place de Louis le Grand, en Mil Six Cens Quatre-Vingt-Dix-Neuf [1699]*. Chez Guillaume Cavelier, 1743.

Boffrand, Germain and Helen Tullberg. *Sculpture and casting of equestrian statues*. Picton Pub, 1974. (translated excerpt from Boffrand 1743)

Bolland, S. *The encyclopedia of founding and dictionary of foundry terms used in the practice of moulding*. Wiley, 1894.

Bondil, N. *La Sculpture: art du modelage.* Editions Fleurus, 1996.

Boon, H.F. and Langedijk, C.H. *Vingerhoedmakers en hun bedrijven in de tijd van de Republiek*, PhD thesis, University of Amsterdam. 2008 [online] available at:< http://dare.uva.nl/record/274014 > [accessed 22 June 2018]

Boulton, Ann. "The art bronze foundry of Antoine-Louis Barye." *Untamed: The Art of Antoine-Louis Barye* (2006): 66-73.

Boulton, Ann. 2007a. "The making of Matisse's bronzes." *Matisse Painter as Sculptor*. D. Kosinski (ed.). Baltimore Museum of Art (2007): 73-97.

Boulton, Ann. 2007b. "Altered states: Henri Matisse's sculpture Aurora." *AIC Objects Specialty Group post prints*, volume 14, (2007): 110-129.

Brepohl, Erhard. *Theophilus Presbyter und die mittelalterliche Goldschmiedekunst*. Edition Leipzig, 2007.

Bresc-Bautier, Geneviève, Guilhem Scherf, James David Draper. *Cast in Bronze: French Sculpture from Renaissance to Revolution*, Musée du Louvre Éditions, 2009.

Brett, Vanessa. *The Sotheby's Directory of Silver 1600-1940*. Sotheby's Publ, 1986.

Brockhaus, Heinrich. *Über die Schrift des Pomponius Gauricus" De sculptura"(Florenz, 1504)*. FA Brockhaus, 1885.

Brooks, B. "The genesis of a Bronze Statue", *Boston Evening Transcript*, Nov 27, 1901. https://news.google.com/newspapers?nid=2249&dat=19011127&id=03o-AAAAIBAJ&sjid=0FkMAAAAIBAJ&pg=3026,3525117&hl=nl, [accessed 22 June 2018]

Brown, John R. *Foseco Ferrous Foundryman's Handbook*, Butterworth-Heinemann, 2000.

Buchetti, Jacques. *La fonderie de cuivre actuelle: bronzes, laitons, aluminium, etc. procédés, outils, matériel*. C. Béranger, 1898.

Buchanan, John F. *Foundry Nomenclature*. Spon, 1903.

Buchner, Georg. *Die Metallfärbung und deren Ausführung mit besonderer Berücksichtigung der chemischen Metallfärbung*. Fischer, 1891.

Bundesverband der Deutschen Giesserei-industrie. *Das traditionelle Lehmformverfahren zum Herstellen von Läuteglocken*, BDG, 2. (2015) [online] available at:<http://www.bdguss.de/fileadmin/content_bdguss/Der_BDG/Richtlinien/F_01.pdf > [accessed 22 June 2018]

Busquet, Alfred. "Bronzes modernes et bronziers contemporains." *L'Artiste*, (26 October 1856): 248-251.

Butler, R. and C. Green. *English Bronze Cooking Vessels & their Founders 1350-1830*. Roderick and Valentine Butler. 2003.

Butler, Ruth and Suzanne Glover Lindsay. *European Sculpture of the Nineteenth Century*. National Gallery of Art, 2000.

Byrne, Olivier. *Practical Metal-Worker's Assistant*. Henry Carey Baird, 1851. (later editions: 1864, 1869, 1874, 1880, 1882, 1884, 1887 and 1899.)

Campbell, John. *Castings*. Butterworth-Heinemann, 2003.

Carradori, Francesco. *Istruzione elementare per gli studiosi della scultura*. Tipografia della Società Letteraria, 1802. (English annotated edition: Elementary instructions for students of sculpture, Los Angeles: J. Paul Getty Museum. 2002)

Carrera. Francesco M.P. "The "ex laboratori Gentili" workshops in Chinzica, Pisa." paper presented at the international symposium; *Medieval copper, bronze and brass*, Dinant-Namur 2014, Patrimone Wallonie.

Castelle, M. *Les techniques de fabrication de la grande statuaire en bronze 1540-1660 en France*, 2016. (Doctoral dissertation, Paris Saclay).

Cennini, Cennino, and Daniel V. Thompson. *The craftsman's handbook. ("Il Libro dell' Arte",* c. 1400) Dover Publications, 1954.

Cellini, Benvenuto and C.R. Ashbee. *The treatises of Benvenuto Cellini on goldsmithing and sculpture*. Dover, 1967.

Cellini, Benvenuto and Thomas Nugent. *The life of Benvenuto Cellini a Florentine artist. ... Written by himself in the Tuscan language, and translated from the original by Thomas Nugent ... In two volumes*. Printed for T. Davies, 1771.

Cellini, Benvenuto and Giovanni Palamede Carpani. *Opere di Benvenuto Cellini... - Vita di Benvenuto Cellini,... da lui medesimo scritta... accompagnata con note da Gio. Palamede Carpani. - Due trattati... uno dell'oreficeria... l'altro della scultura. Con aggiunta di... altre operette... (con una prefazione da Antonio Cocchi.)*. Società tipogr. de' classici italiani (1806-1811)

Cellini, Benvenuto and Milanesi. Carlo. *I Trattati Dell'oreficeria E Della Scultura*. Felice Le Monnier, 1857.

Cherry, John. *Goldsmiths: Medieval Craftsmen*. British Museum, 1992.

Christman, Bruce. "Twenty-five years after the bomb: maintaining Cleveland's the thinker." *Journal of the American Institute for Conservation* 37.2 (1998): 173-186.

Cladel, J. *Rodin: Sa vie glorieuse, sa vie inconnue.* Bernard Grasset, 1936.

Clarke, Mark. "Reworking Theophilus: Adaptation and Use in Workshop Texts." *Zwischen Kunsthandwerk und Kunst: Die, Schedula diversarum artium '*. Speer, A. et. al. (eds.) Walter de Gruyter (2014): 72-89.

Collareta, Marco. “The Historian and the Technique: On the role of Goldsmithery in Vasari’s *Lives*.” *Sixteenth-Century Italian Art*. Cole, Michael W.(ed.) Blackwell (2006): 291-300.

Conner, Jannis. "Harriet Whitney Frishmuth and Her Founders." *Sculptured Motion: The Sculpture of Harriet Whitney Frishmuth* Hohmann Holding LLC (2006): 52-99.

Conner, Janis. “After the Model: Bessie Potter Vonnoh's Early Bronzes and Founders.” *Bessie Potter Vonnoh: Sculptor of Women*. Aronson, Julie, Bessie Potter Vonnoh, and Janis C. Conner (eds.) Cincinnati Art Museum (2008): 225-247.

Cox, Nancy. “Imagination and Innovation of an Industrial Pioneer: The First Abraham Darby.” *Industrial Archaeology Review*, XII, 2 (Spring 1990): 127-144.

Croke, James. *Guide to bronzing and enamelling*. Hungerford-Holbrook Co, 1897.

Dajnowski, Andrzej, et al. "New trends in art conservation, the use of lasers to clean as well as generate an augmented reality representation of an iconic public monument in bronze: The Alma Mater." *Studies in Conservation* 60. sup1 (2015): 65-72.

Da Vinci, Leonardo. "Il codice atlantico: edizione in facsimile dopo il restauro dell'originale conservato nella Biblioteca Ambrosiana di Milano." *Giunti-Barbèra*, 1974.

Da Vinci, Leonardo, and Ladislao Reti. *The Madrid Codices*. MacGraw-Hill, 1974.

Davis, Ron. *John Wilkinson - Ironmaster Extraordinary*. The Dulston Press, 1987.

Davidowitz, Tamar, van der Molen, Rozemarijn and Beentjes, Tonny. “Recreating Patina: the filling and retouching of Rodin’s ‘The Thinker’” *Symposium Filling and Retouching: paintings and painted surfaces held on 23 May 2011*, Seymour, K. and van Haaften, C. (eds), Symposium Proceedings of SRAL, 2011. www.sral/symposia.html

Debonliez, G. and F. Fink. *Nouveau manuel complet du bronzage des Mètaux et du platre*. Roret, 1870.

De Caso, J. and Sanders P. *Rodin’s Thinker: Significant Aspects*. Fine Arts Museums of San Francisco, 1973.

De Caso, J. and Sanders P. *Rodin’s Sculpture: A Critical Study of the Speckels Collection, California Palace of the Legion of Honor*. The Fine Arts Museums of San Francisco, 1977.

De Courtivron, le Marquis et Bouchu, Étienne Jean. “Des fontes moulées [quatrieme partie], Tome II. Les quatre premières sections sur les fers.” *Descriptions des arts et métiers*. Bertrand, Jean-Elie, et al. (eds.) l'imprimerie de la Société typographique, 1774 [online] Available at:<http://cnum.cnam.fr/CGI/redir.cgi?4KY58.2> [accessed 22 June 2018]

De Heer, A.R.E. “Constantijn Huygens en de penningkunst.” *Jaarboek voor munt en penningkunde*, v. 80 (1993): 271-288.

Delon, Michel. *Encyclopedia of the Enlightenment*. Taylor and Francis, 2013.

Dent Weil, Phoebe. “A Review of the History and Practice of Patination.” *National Bureau of Standards Special Publication 479*, proceedings of a Seminar on Corrosion and Metal Artifacts: A Dialogue between Conservators and Archaeologists and Corrosion Scientists held at the National Bureau of Standards, 1976. Gaithersburg, MD: National Bureau of Standards (1977): 77-92.

Dent Weil, Phoebe. *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, N.S. Price, et. al. (eds.) The Getty Conservation Institute (1996): 394-414.

de Montalembert, Marc René, and Jean-Augustin Grangé. *Mémoire historique sur la fonte des canons de fer: pour servir a la connoissance des traités que le Marquis de Montalembert a passés à ce sujet avec la marine, depuis l'année 1750*. l'Imprimerie de Grange, 1758.

De Roos, H. *The critique of the Toronto exhibition 3: The R.O.M. exhibition would mix up studio and foundry casts (3): The definitions supplied by the R.O.M. exhibition (1) & (2)*, 2003, [online] Available at: <www.rodin-web.org/report_rom/2_4_3a.htm> [accessed 22 June 2018]

De Roos, H. “The Digital Sculpture Project: Applying 3D Scanning Techniques for the Morphological Comparison of Sculpture.” *Linköping electronic articles in computer and information science*, Vol. 9, 2004, no.2. [online] Available at: <http://www.ep.liu.se/ea/cis/2004/002/cis04002.pdf > [accessed 22 June 2018]

Derui, Tan and Haiping, Lian. “The ancient Chinese casting techniques.’ *China foundry*, vol. 8 nº 1 (2011): 127-136

Descatoire, David. “Les carrières de sable de Fontenay-aux-Roses.” *Liens de memoire no.13; Bulletin des Archives municipales*, Fontenay-aux-Roses (second semestre 2009): 5-8.

Diderot, Denis, and Jean Le Rond d' Alembert. “Forges ou art du Fer. Troisieme section” *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers*, Diderot, Denis, and Jean Le Rond d' Alembert (eds.) Vol. 4, 1765.

Diderot, Denis, and Jean Le Rond d' Alembert. “Fonte de l'or, de l'argent et du cuivre.” *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers.* Diderot, Denis, and Jean Le Rond d' Alembert (eds.) Vol. 5, 1767.

Diderot, Denis, and Jean Le Rond d' Alembert. “Jetter les Figures de plomb." *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers.* Diderot, Denis, and Jean Le Rond d' Alembert (eds.) Vol. 8, 1771.

Diderot, Denis, and Jean Le Rond d' Alembert. “Sculpture – Fonte des statues equestres.” *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers.* Diderot, Denis, and Jean Le Rond d' Alembert (eds.) Vol. 8, 1771.

Dossie, Robert. *Handmaid to the Arts*. J. Nourse, 1758.

Dujardin-Beaumetz, F. *Entretiens avec Rodin*. 1913 (reprint Editions du Musée Rodin 1992)

Dussaussoy, O.C.J. “Du Résultat des Expériences faites sur les Alliages de cuivre, d’étain, de zinc et de fer considérés sous le rapport de la fabrication des bouches à feu et autres objets semblables.” *Annales de chimie et de physique*. Gay-Lussac L. J et Arago F., (Eds) Vol. 5. Crochard (1817): 225-234.

Eamon, William. *Science and the secrets of nature: books of secrets in medieval and early modern culture*. Princeton University Press, 1994.

Eggert, Gerhart. *Plastiline: Another Unsuspected Danger in Display Causing Black Spots on Bronzes.* VDR Beiträge (2006): 112-116.

Eisenwerk, and Johann Friedrich Trautschold. *Geschichte und Feyer des ersten Jahrhunderts des Eisenwerks Lauchhammer: Schloss Mückenberg am 25ten August 1825*. Kunstguss Museum, 1825. (Facsimile reprint, Kunstguss Museum, 1996)

Elliot, Patrick. “The Nineteenth and Twentieth Centuries.” *Bronze,* David Ekserdjian(ed.) Royal Academy of Arts (2012): 94-100.

Elsen, Albert E. *Rodin’s Gates of Hell*. University of Minnesota Press, 1960.

Elsen, Albert E. *Auguste Rodin: readings on his life and work*. Prentice-Hall, 1965.

Elsen, Albert E., and Albert Alhadeff. *Rodin rediscovered*. National Gallery of Art, 1981.

Elsen, Albert E. *Rodin’s Thinker and the Dilemmas of Modern Public Sculpture*. Yale University Press, 1985.

Elsen, Albert E. *Rodin’s Art: The Rodin Collection of the Iris & B. Gerald Cantor Center for Visual Arts at Stanford University*. Oxford University Press, 2003.

Eremin, Katherine. (with a contribution by Josef Riederer) “Analytical Approaches to Ancient Bronzes.” *Ancient Bronzes through a Modern Lens: Introductory Essays on the Study of Ancient Mediterranean and Near Eastern Bronzes,* Susanne Ebbinghaus (ed.) Harvard Art Museums, 2014.

Fahrenholtz, William G. “Clays” *Ceramic and Glass Materials: Structure, Properties and Processing,* James F. Shackelford and Robert H. Doremus (Eds) Springer US (2008): 111-133.

Félibien, André. *Des principes de l'architecture, de la sculpture, de la peinture, et des autres arts qui en dependent. Avec un dictionnaire des termes propres à chacun de ces arts*. J.B. Coignard, 1676.

Ferguson, John. “The Secrets of Alexis. A sixteenth century Collection of Medical and Technical Receipts.” *Proceedings of the Royal Society of Medicine 24*, 1930.

Fiquet, M. “Art du mouleur en plâtre.” *Descriptions des arts et métiers*, Bertrand, Jean-Elie (ed). volume XIV, Académie des sciences, l’Imprimerie de la société typographique, 1780.

Flood, N. J. *Material Characterisation of Modern Bronze Sculpture; Composition and microstructure of the Thinker*, The University of Melbourne, Centre for Cultural Materials Conservation, 2011. (unpublished master thesis)

Fock, Willemijn C. "Werkelijkheid of schijn. Het beeld van het Hollandse interieur in de zeventiende-eeuwse genreschilderkunst**."** *Oud Holland*, Vol.112(4) (1998): 187-246.

Forrest, Michael. *Art Bronzes*, Schiffer Publ, 1988.

Friedman, Terry and Timothy Clifford. *The man at Hyde Park Corner*. Temple Newsam, 1974.

Fronsmark, Anne-Brigitte. *Rodin. La collection du brasseur Carl Jacobsen à la Glyptothèque Copenhagen*. Ny Carlsberg Glyptotek (1988): 76.

Fulton, Moira. "John Cheere; the Eminent Statuary, His Workshop and Practice 1737–1787." *Sculpture Journal* (2003): 21-39.

Gabriele, Mino. *Le incisioni alchemico-metallurgiche di Domenico Beccafumi*. Giulio Giannini & Figlio, 1988.

Gamboni, D. *The destruction of art: iconoclasm and vandalism since the French Revolution*. Reaktion books, 1997.

Gamboni, Dario. "Le Penseur Pansé: The Thinker and the paradox of iconoclasm." 2016-17. Online available <http://www.brokenthinker.nl/usedthinker/nl/editie_12/le_penseur_panse/.> [accessed 24-11-2017]

Ganio, Monica et al. "From sculptures to foundries: elemental analysis to determine the provenance of modern bronzes." *Métal à ciel ouvert: la sculpture métalique d'extérier du XIXe au début du XXe siècle: identification, conservation, restauration = Open air metal: outdoor metallic sculpture from the XIXth to the early XXth century: identification, conservation, restoration*. Journeés d'étude de la SFIIC. (2014): 136-144.

Garçon, Anne-Françoise. "Innover dans le texte. L'Encyclopédie Roret et la vulgarisation des techniques, 1830-1880." Colloque Les Archives de l'Invention, May 2003. [online] Available at: <https://halshs.archives-ouvertes.fr/file/index/docid/29498/filename/garcon.af_Roret.pdf > [accessed 22-6-2018]

Gaurico, Pomponio. *De sculptura.* P. de Giunta, 1504.

George E. Gee. *The Practical Gold - Worker –or the Goldsmiths and Jeweller's Instructor.* Crosby Lockwood & Co, 1877.

Gentle, Rupert and Field, Belinda. *Domestic Metalwork 1640-1820*. Antique Collectors' Club Woodbridge, 1994.

Giaccai, Jennifer, Lauffenburger, Julie and Boulton, Ann. "Copper Alloys Used in Barye's Hunt Scenes in the *Surtout de Table* of the Due d'Orleans" *Materials Issues in Art and*

Archaeology VIII, Materials Research Society Symposium Proceedings, 1047, Materials Research Society (2008): 233-242.

Gillot, A. and L. Lockert. *Nouveau manuel complet du fondeur de fer et de cuivre ...: Suivi de la fonte des statues et des cloches*. Librairie encyclopédique de Roret. 1879. (2nd ed. Enlarged by N. Chryssochoïdès; 1905, 3rd ed.; 1920)

Glinsman, Lisha. *The application of X-ray fluorescence spectrometry to the study of museum objects*. University of Amsterdam, 2004. (PhD thesis)

Godin, Frederik. *Antiquity in plaster*, University of Amsterdam, 2009. (PhD thesis)

Goldmann, Klaus. "Guß in verlorener Sandform – Das Hauptverfahren alteuropäischer Bronzegießer?" *Archäologisches Korrespondenzblatt* 11(1981): 109 –116.

Goldmann, Klaus. "Bronzegußtechniken im prähistorischen Mitteleuropa." *Archäologische Bronzen, antike Kunst, moderne Technik*. Hermann Born (ed.) Museum für Vor- und Frühgeschichte, Staatliche Museen Preußischer Kulturbesitz (1985): 52-58.

Gonon, Eugène. *L'art de fondre en bronze à cire perdue*, Paris, 1876. (The manuscript is preserved in the collections of the l'École nationale supérieure des beaux-arts, Paris, Ms.514. (A full transcription of the manuscript can be found online at: http://inha.revues.org/3522)

Goossens, D. "Techniques to measure grain-size distributions of loamy sediments: a comparative study of ten instruments for wet analysis." *Sedimentology* 55 (2008): 65–96.

Grunfeld, Frederic V. *Rodin: a biography*. Holt, 1987.

Gsell, P. "Auguste Rodin" *La revue de Paris* 25, 15 January (1918): 400-417.

Gsell, P. *Rodin on Art*, Dover, 1983. (originally published as *L'Art: entretiens Réunis par Paul Gsell*, Paris 1911, translated by Fedden in 1957)

Guettier, A. *De la Fonderie telle qu'elle existe aujourd'hui en France et de ses nombreuses applications à l'industrie*. Lacroix et Baudry, 1858.

Guettier, André. *La Fonderie en France*. E. Bernard, 1882.

Guettier, André. *Le fondeur en métaux*. E. Bernard, 1890.

Gullentops, F., and L. Wouters. *Delfstoffen in Vlaanderen*. Ministerie van de Vlaamse Gemeenschap, 1996.

Haber and Brandner. *Dokumentation, Berlin – Reiterstandbild Großer Kurfürst*, Haber & Brandner GmbH Metallrestaurierung, 2004.

Hallopeau, A. "Le bas-relief de la chambre des Députés – Mirabeau et le marquis de Dreux-Brézé: 23 juin 1789." *Le Génie civil*, Paris, 17 octobre 1891. Tome XIX, No 25 (1891): 399-406, pl. XXVII. Collections électroniques de l'INHA, [online] Available at: <http://inha.revues.org/3634> [accessed 22 June 2018]

Hammes, J. *Goud, zilver en edelstenen*. H. Stam, 1945.

Hartmann, Carl Friedrich Alexander. *Handbuch der Metallgießerei*, B. F. Voigt, 1840.

Hasse, Stephan. *Giesserei-Lexikon*. Schiele & Schön, 2007.

Hassenfratz, Jean H. *La sidérotechnie, ou l'art de traiter les minérais de fer pour en obtenir de la fonte, du fer, ou de l'acier: ouvrage ordonnée par S. Ex. le Ministre de l'Intérieur, approuvé et adopté par la première Classe de l'Institut Impérial de France, pour faire partie de la Collection des Arts et Métiers qu'elle doit publier.* Didot, 1812.

Hayez, Valerie et al. "Study of Copper Nitrate-Based Patinas." *Journal of Raman Spectroscopy* 37 (2006): 1211– 1220.

Hayward, J.F. *Virtuoso goldsmiths and the triumph of mannerism, 1540-1620*. Rizzoli International, 1976.

Heginbotham, Arlen, et al. "An evaluation of inter-laboratory reproducibility for quantitative XRF of historic copper alloys." *Metal 2010. Proceedings of the International Conference on Metal Conservation, Charleston, South Carolina, USA, October 11–15, 2010*. Clemson University Press (2010): 244-255.

Heirman, Johan. *Jan II Brueghel en Het Vuur: een studie van de metallurgie in de zeventiende eeuw*. Kunstacademie Hamme, 2002.

Héricart de Thury, Louis-Étienne. "Rapport fait par M. Héricart de Thury, au nom du Comité des arts méchaniques, sur les ameliorations et perfectionnements introduits par M. Soyer dans le moulage, la fonte et la ciselure de la statuire en bronze." *Bulletin de la Societé d'encouragement pour l'industrie nationale*, 35th year, no. 388. Imprimerie de Mme Huzard (1836): 365-378.

Hinckley, C.T. "A day at the Ornamental Ironworks of Robert Wood." *Godey's Lady's Book,* Louis A. Godey, 47, July (1853): 5-12.

Hiorns, Arthur H. *Metal-colouring and bronzing*. Macmillan and Co, 1892.

Hirschberg, Carl Anton. *Der vollkommene Metall-Arbeiter oder die neue Goldgrube für Schlosser, Zeugschmiede, Spengler, Sporer, Kupferschmiede, Stahlarbeiter, Gürtler, Platirer, Goldschmiede, Uhrmacher, Meachniker u.s.w.: auf geprüfte Erfahrungen gegründet, gesammelt auf mehrjährigen Reisen in Deutschland, England, Frankreich und Holland, in den berühmtesten Fabriken praktisch ausgeführt und gelehrt, nun aber ohne Rückhalt, in alphabetischer Ordnung, an das Tageslicht gegeben*. Campe, 1835.

Höcherl, H. *Rodins Gipse: ursprünge moderner Plastik*, Peter Lang, 2003.

Hoffman, Malvina. *Heads and tales*. Charles Scribner's Sons, 1936.

Hoffman, Malvina. *Sculpture inside and out*. W. W. Norton & company, 1939.

Holland, John. *A Treatise on the Progressive Improvement, and Present State of Manufactures in Metal,* volume LII in Lardner's Cabinet Cyclopædia, Longman et al. Vol. I Iron and Steel (1831), Vol. II Iron and Steel (1833), Vol. III Tin, Lead, Copper, Brass, Gold, Silver, and various alloys (1834)

Holmes, Edwin F. "Sewing thimbles" *The journal of the tool and trade history society, Tools and Trades,* volume 4 September (1987): 59-72.

Holmes, Edwin F. "A forgotten Buckinghamshire Industry: Thimble Making at Marlow." *Records of Buckinghamshire* 35, for 1993 (June 1995)

Hughes, A., and Ranfft, E. *Sculpture and its Reproductions*. Reaktion books, 1997.

Hunt, L.B. "The Long History of Lost Wax Casting." *Gold Bulletin*, June 1980, Volume 13, Issue 2 (1980): 63-79.

Huret, Jules. "Un artiste: a propos du monument d'Eugène Delacroix." *L'Écho de Paris*, 7 October (1890): 2.

Hutchison, Charles S. *Laboratory handbook of petrographic techniques*. Wiley, 1974.

Huygens, Constantijn. *Musica, medica, phijsica, odofera, perfumatoria, fusoria, coquinaria, philosophiaca, mathematica, artificialia, Constantini Huginii, Ars Formandorum et poliendorum votorum ad usum astronomicum*. (c.1629-87) Manuscript collection preserved in the Royal Library, The Hague. (inv.no. KA XLVII, Fol. 185ff)

Hyde, Charles K. *Technological change and the British iron industry 1700-1870*. Princeton University Press, 1977.

Imbellone Alessandra. "Manfredini, Luigi" *Dizionario Biografico degli Italiani* - Volume 68, 2007. Available through: < http://www.treccani.it/enciclopedia/luigi-manfredini_%28Dizionario_Biografico%29/ > [accessed 22 June 2018]

Jackson, Harry. *Lost wax bronze casting*. Van Nostrand Reinhold Company, 1972.

James, Barry. "Roller Controversy in Amsterdam: The Restoration of Modern Art." *The New York Times.* 11/02/1991

James, Duncan. "The Statue Foundry at Thames Ditton." *Foundry Trade Journal*, September 7 (1972): 279-289.

James, Duncan. "Alfred Gilbert and his Use of nineteenth Century Founding Techniques." *Alfred Gilbert; Sculptor and Goldsmith*, Dorment, Richard (ed), Royal Academy of Arts (1986): 21-26.

Jamnitzer, Wenzel. *Perspectiva corporum regularium*. Heussler, 1568.

Javel, Firmin. "Auguste Rodin." *L'art francais*, Revue Artistique Hebdomaire, no. 115, (6 July 1889)

Jerrold, William Blanchard. *The children of Lutetia. Vol. 2. Vol. 2*. Low & Marston, 1864.

Kampmann, M. "Composition des sables employés pour la fabrication des moules dans les fonderies." *Annales des mines*, série 4 Vol. VIII (1845): 689-690.

Karmarsch, Carl. "Über Formsand" *Mittheilungen des hannoverschen Gewerbevereins* (1862): 210.

Karmarsch, Carl. *Geschichte der Technologie seit der Mitte des achtzehnten Jahrhunderts.* R. Oldenbourg, 1872.

Karpinski, Caroline. "The Alchemist's Illustrator." *The Metropolitan Museum of Art Bulletin*, Summer (1960): 9-14.

Knight, Edward H. *Knight's Mechanical Dictionary*. Hurd and Houghton. 3 Vols, 1877.

Kmosek, J., and Leroux, M. Restoration of an Archaeological Iron Object using 3D Technology: A Case Study." *METAL 2016, Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group* (2016): 61-67.

Kowalski, Klaus. *Wie eine Bronzeplastik entsteht: Didakt. Ausstellung zur Technik d. Bronzegusses, Kunsthalle Bielefeld, 22. März - 13. Mai 1984*. Kunsthalle, 1984.

Krünitz, Johann Georg. *Oekonomische Encyklopädie.* J. Pauli [etc.], 1773-1858.

Lafolie, Charles Jean. *Mémoires historiques relatifs à l'élévation de la seconde statue équestre de Henri IV sur le terre-plein du Pont-Neuf à Paris avec des gravures à l'eau-forte représentant l'ancienne et la nouvelle statue, publié par ordre de son excellence le ministre secrétaire d'État et de l'Intérieur*. le Normant, 1819.

Landau, David, and Peter W. Parshall. *The Renaissance print, 1470-1550*. Yale University Press, 1994.

La Niece, Susan. "Medieval Islamic Metal Technology." *Scientific Research in the Field of Asian Art: Proceedings of the First Forbes Symposium at the Freer Gallery of Art*. P. Jett (ed.) Archetype (2003): 90-96.

La Niece, Susan. "Sand casting in the Islamic World." *Verborgenes Wissen: Innovation und Transformation feinschmiedetechnischer Entwicklungen im diachronen Vergleich.* Armbruster, et al.(eds.) Tagungsbeiträge des Netzwerks Archäologisch-Historisches Metallhandwerk 1. Workshop Berlin, 5.–6. Mai 2011 (2016): 263-276.

Langlois, Juliette, et al. "Analysis and conservation of modern modeling materials found in Auguste Rodin's sculptures." *Studies in Conservation* 62.5 (2017): 247-265.

Larkin, James. *The practical brass and iron founder's guide: a concise treatise on the art of brass founding, moulding, etc.* Hart, 1853. (the frontispiece of the 1853 edition states this is the second edition, the first edition however, has not been located to date. Later editions appear in 1855, 1866, 1872 and 1892)

Launay, Jean-Baptiste. *Manuel du fondeur sur tous métaux ou traité de toutes les operations de la fonderie*. Librairie encyclopédique de Roret, 1827.

Launay, Jean-Baptiste. *Manuel complet du fondeur en tous genres, faisant suite au Manuel du travail des métaux.* Librairie encyclopédique de Roret 1836. (expanded and revised by Armand Denis Vergnaud)

Launay, Jean-Baptiste. *Nouveau manuel complet du fondeur en tous genres, faisant suite au Manuel du travail des métaux.* Librairie encyclopédique de Roret, 1854. (expanded and revised by Armand Denis Vergnaud, M. Vergnaud (son) and M.F. Malepeyre)

Laurent, Monique. "Observations on Rodin and His Founders'." *Rodin Rediscovered, exh. cat., National Gallery of Art, Washington [1981-82]* : 285-293.

Lebon, Élisabeth. *Dictionaire des Fondeurs de Bronze d'Art: France 1890-1950*. Marjon éditions, 2003.

Lebon, Élisabeth. *Naissance de la rivalité entre fonte au sale et fonte à cire perdue, Colloque* INHA/Musée Rodin 17 December 2009; [online] Available at: < http://www.jamespradier.com/Texts/Colloque_bronze_musee_Rodin_17_dec_2009_Elisabeth_Lebon.pdf> [accessed 22 June 2018].

Lebon, Élisabeth (2012a) *La fonte au sable sous l'Ancien Régime Possibilité d'application à la statuaire? Le cas de Houdon*, in *Le fondeur et le sculpteur* Collections électroniques de l'INHA, 2012 [online] Available at: < http://inha.revues.org/3449> [accessed 2 June 2018].

Lebon, Élisabeth (2012b) Le *Surtout du duc d'Orléans*: une nouvelle interprétation, in *Le fondeur et le sculpteur*, Collections électroniques de l'INHA, 2012 [online] Available at: < http://inha.revues.org/3514> [accessed 22 June 2018].

Lebon, Élisabeth (2012c) *Le moulage à la* gélatine in *Le fondeur et le sculpteur*, in *Le fondeur et le sculpteur*, Collections électroniques de l'INHA, 2012 [online] Available at: <http://inha.revues.org/3469> [accessed 22 June 2018].

Lebon, Élisabeth (2012d) *Eugène Gonon, L'art de fondre en bronze à cire perdue, 1876*, in *Le fondeur et le sculpteur*, Collections électroniques de l'INHA, 2012 [online] Available at: < http://inha.revues.org/3522> [accessed 22 June 2018].

Lebon, Élisabeth (2012e) *Sable ou terre?*, in *Le fondeur et le sculpteur*, Collections électroniques de l'INHA, 2012 [online] Available at: < http://inha.revues.org/3468> [accessed 22 June 2018].

Lebon, Élisabeth (2012f) Répertoire », in *Le fondeur et le sculpteur*, Collections électroniques de l'INHA, 2012 [online] Available at: < http://inha.revues.org/3474> [accessed 15 June 2018].

Lebon, Élisabeth (2012g) *Fonte au sable – Fonte à cire perdue: Histoire d'une rivalité*. INHA, 2012.

Lebon, Élisabeth (2012h) *La pension d'Eugène Gonon*. Collections électroniques de l'INHA, 2012. [online] Available at: < http://inha.revues.org/3474#tocto3n4 > [accessed 15 June 2018].

Lebrun, Frédéric Deniau. *Manuel complet du Mouleur*. Librairie encyclopédique de Roret, 1829.

Lein, Edgar. *Ars Aeraria: Die Kunst des Bronzegießens und die Bedeutung von Bronze in der florentinischen Renaissance*, Verlag Philipp von Zabern, 2004.

Lenormand, Louis Sebastien. *Nuovo dizionario universale tecnologico o di arti e mestieri e della economia industriale e commerciante*. Antonelli, 1830.

Le Normand-Romain, Antoinette. *Rodin: The Gates of Hell*. Musée Rodin, 1999.

Le Normand-Romain, Antoinette. 2001a. 'Rodin's Studio.' *In Rodin: A Magnificent Obsession*. Iain Ross and Anthea Snow (eds.). Merrel Publishers Ltd, 2001.

Le Normand-Romain, Antoinette. 2001b. *Rodin en 1900. L'exposition de l'Alma.* Exh. Cat. Musée du Luxembourg, 2001.

Le Normand-Romain. Antoinette. *The Bronzes of Rodin*: *Catalogue of Works in the Musée Rodin*. Musée Rodin, 2007.

Le Normand-Romain, Antoinette et al. *RODIN L'accident, l'aléatoire*, Exh. Cat. Musée d'art et d'histoire, 2014.

Lijster, Thijs. "Replica van *De Denker* is even origineel." *NRC Handelsblad*, 6 Feb. 2008.

Lins, Andrew. "Houdon's studio practice: creating multiple versions of a portrait bust." *Encountering Genius: Houdon's Portraits of Benjamin Franklin*. J. Hinton, (ed.). Philadelphia Museum of Art (2011): 65-88.

Locker, Tobias. "A Prussian factory of gilt bronzes *à la française*: Johann Melchior Kambly (1718-84) and the adoption of Parisian savoir-faire." *French Bronze Sculpture: Materials and Techniques sixteenth-eighteenth century*. Bourgarit, D., et al.(eds.). Archetype Publ. (2014): 166-177.

Logan, J., et al. "Saving the Ferryland cross: 3D scanning replication and anoxic storage." *Conservation of archaeological materials: current trends and future directions* (2010): 127-34.

Long, Pamela O. *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance.* Johns Hopkins University Press, 2001.

Lüer, Herman. *Technik der Bronzeplastik*. H. Seemann Nachfolger, 1902.

Luyken, Jan and Casper Luyken. *Spiegel van het Menselyk Bedryf*. Kornelis van der Sys, 1694.

Maaz, Bernhard. “Zur Entwicklung des Bronzegusses in Deutschland im 19. Jahrhundert.” *Bronze- und Galvanoplastik: Geschichte, Materialanalyse, Restaurierung*. Meissner, Birgit, Anke Doktor, and Martin Mach(eds.). Landesamt für Denkmalpflege Sachsen (2001): 25-40.

Maaz, Bernhard. *Skulptur in Deutschland zwischen Französischer Revolution und Erstem Weltkrieg*. Deutscher Kunstverlag, 2010.

Mariette, Pierre Jean. *Description des travaux qui ont précédé, accompagné et suivi la fonte en bronze d’un seul jet de la statue équestre de Louis XV, le bien aimé.* P.G. Le Mercier, 1768.

MacCurdy, Edward. *The Notebooks of Leonardo da Vinci*. George Braziller, 1955.

McCave, I. N., et al. "Evaluation of a laser-diffraction-size analyzer for use with natural sediments." *Journal of Sedimentary Research* 56.4 (1986): 561–564.

McKim-Smith, Gridley. "The rhetoric of rape, the language of vandalism." *Woman's Art Journal* 23.1 (2002): 29-36.

McWilliam, Andrew and Longmuir, Percy. *General foundry practice*, Charles Griffin & Company, 1907.

Martin, Thomas. *Circle of mechanic arts; containing practical treatises on the various manual arts, trades and manufactures*. Rees (1813): 342-347. (entry *Founding)*

Martins, Hans Otto Philipp. “Zur Geschichte der Eisengießerei im Allgemeinen, und insbesondere der Bildgießerei von Eisen.” *Verhandlungen des Vereins zur Beförderung des Gewerbfleißes in Dresden*. E. L. Schubarth (ed.). Duncker & Humblot, 3rd Year (1824): 215-230.

Mattusch, Carol C. “The preferred Medium: “The Many Lives of Classical Bronzes.” *The Fire of Hephaistos: Large Classical Bronzes from North American Collections*, Harvard Art Museums (1996): 15-43.

Meighan, Melissa. “Houdon's Studio Practice: Creating Multiple Versions of a Portrait Bust.” *Encountering Genius: Houdon's Portraits of Benjamin Franklin.* Hinton, Jack, Melissa Meighan, and P. Andrew Lins(eds.). Philadelphia Museum of Art (2011): 65-88.

Mestdagh, Camille. “Henry Dasson célèbre bronzier et ébéniste du XIXe siècle.” *L' Estampille. L'objet d'art*. no.417 (2006): 60-72.

Mitchell, W. D. *The Art of the Bronze Founder: Especially in its relation to the casting- of bronze statuary and other sculptural work*. Jno Williams, 1916.

Miyazaki, Daisuke, et al. "3D digital archive of the burghers of calais." *International Conference on Virtual Systems and Multimedia*. Springer, Berlin, Heidelberg, 2006): 399-407. <https://link.springer.com/chapter/10.1007%2F11890881_44> [accessed 6 June 2018]

Monge, Gaspar. *Description de l'art de fabriquer les canons*. L'Imprimerie du Comité de Salut Public, 1793-94.

Monteiro, S. N., and Vieira, C. M. F. “Solid state sintering of red ceramics at lower temperatures.” *Ceramics International*, *30*(3), (2004): 381-387.

Montalembert, M. de. *Mémoire historique sur la fonte des canons de fer*, de Grange, 1758.

Möller, Frank C. “Idea – Form – Ornament Schinkel’s Influence on Prussia’s Arts and Crafts as Illustrated by Three Rediscovered Objects.”*The Michael Werner Collection: I Sat Beauty on My Knees...And I Reviled Her*, Arthur Rimbaud (ed.). Walther König (2012): 47-55.

Moreau-Vauthier, Paul. “Le maître fondeur Eugène Rudier.” *L’Art et les artistes*. March 1936: 203-209.

Müller-Karpe, Michael. “Der Guss in der verlorenen Sandform in Mesopotamien.” *Mitteilungen der deutschen Orient-Gesellschaft* 122 (1990): 173-192.

Musée Rodin. *Rodin : la chair, le marbre*. Paris: Musée Rodin Paris. Exh. Cat. 2012-13

Musée Rodin. *Rodin: the Laboratory of Creation*. Musée Rodin Paris. Exh. Cat. 2014-15.

Museum of Fine Arts (Springfield, Mass.) *Glorious horsemen: equestrian art in Europe, 1500-1800*. Museum of Fine Arts, 1981.

Naudé, Virginia Norton. *Sculptural monuments in an outdoor environment. A conference held at the Pennsylvania Academy of Fine Arts, Philadelphia, November 2, 1983*. Pennsylvania Academy of the Fine Arts, 1985.

Neto, Maria João, and Fernando Grilo. "John Cheere's lead garden statues workshop and the important commissions of Prince Pedro of Portugal in 1755–56." *Sculpture Journal* 15.1 (2006): 5-18.

Nicoladze, J. *God u Rodena*. Zarja Vostoka, 1946.

Ottomeyer, Hans and Pröschel, Peter. *Vergoldete Bronzen: Die Bronzearbeiten des Spätbarock und Klassizismus*. Klinkhardt & Biermann, 1986.

Overman, Fred. *The Moulder’s and Founder’s Pocket Guide*. Hart, 1851. (other editions appeared in 1852, 1853, 1856, 1872, 1874, 1875, 1878. A revised edition with an added supplement on the casting of statuary by A.A. Fesquet appeared in 1881 with later editions in 1885, 1889, 1891, 1893, 1906)

Parlanti, E.J. *Casting a Torso in Bronze by the Cire Perdue Process*, Alec Tiranti, 1953.

Partridge, W. O. *Technique of Sculpture*. Ginn & Company, 1895.

Peković, Željko, and Nikolina Topić. "A late-medieval and post-medieval foundry in the historic centre of Dubrovnik." *Post-medieval archaeology* 45.2 (2011): 266-290.

Percy, John. *Metallurgy, the art of extracting metals from their ores, and adapting them to various purposes of manufacture*. Murray, 1861.

Perrault, G. *L'œuvre originale et la sculpture d'édition: 3. Du XIX au XX Siècle: 3.1. La mode du bronze d'art*. 2011 [online] Available at: <http://www.gillesperrault.com/blog/loeuvre-originale-et-la-sculpture-dedition/ > [accessed 3 June 2018]

Petrowitsch, Demeter. *Andeutungen über Bildgiesserei nach der Methode der Alten, in ihrem Verhältnisse zur Galvanoplastik und der Bildgiesserei-Methode unserer Zeit*. Höfel, 1845.

Piemontese, Alessio. *De secreti del reverendo donno Alessio Piemontese*, Sigismondo Bordogna, 1555.

Pinet, Hélène. *Rodin et la photographie*. Gallimard & Musée Rodin, 2007.

Platt, Hugh. *The Jewell House of Art and Nature: Containing divers rare and profitable Inventions, together with sundry new experimentes in the Art of Husbandry, Distillation, and Molding*. Peter Short, 1594.

Podany, Jerry C. "Evaluation of rapid prototyping technologies for use in the production of art and artifact study copies." *MRS Online Proceedings Library Archive* 267 (1992): 1079-1087.

Prasad, B.K., A. H. Yegneswaran and A. K. Patwardhan. "Influence of the nature of microconstituents on the tensile properties of a zinc-based alloy and a leaded-tin bronze at different strain rates and temperatures." *Journal of materials science* 32 (1997): 1169-1175

Prechtl, Johann Joseph, Ritter von and Karmarsch, Karl. *Technologische Encyklopädie oder alphabetisches Handbuch der Technologie, der technischen Chemie und des maschinenwesens*. J.G. Cotta; [etc.], (1830-55)

Rama, Jean Pierre. *Le bronze d'art et ses techniques*. Éditions H. Vial, 1988.

Réaumur, R. F. de. *L' Art de convertir le fer forgé en acier et l'art d'adoucir le fer fondu, ou de faire des ouvrages de fer fondu aussi finis que de fer forge*. M. Brunet, 1722.

Réaumur, René-Antoine Ferchault de. "De l'arrangement que prennent les parties des matières métalliques & minérales, lorsqu'après avoir été mises en fusion, elles viennent à se figer." *Histoire de l'Académie royale des sciences ... avec les mémoires de mathématique & de physique... tirez des registres de cette Académie*. J. Boudot (1724): 307-316.

Réaumur, René-Antoine Ferchault de. *Nouvel art d'adoucir le fer fondu et de faire des ouvrages de fer fondu aussi finis que de fer forge*. H. L. Guerin et L. F. Delatour, 1762.

de Réaumur, René-Antoine Ferchault. *Reaumur's Memoirs on steel and iron: a translation from the original printed in 1722*. University of Chicago Press, 1956.

Reddaway, T.F. and L.E.M. Walker. *The early history of the Goldsmiths Company 1327-1509: the book of ordinances 1478-83*. Edward Arnold (1975): 213.

Rees, Abraham. *The Cyclopædia; or, Universal Dictionary of Arts, Sciences, and Literature*. Longman et al (eds) (1802-1820) (entries *Bronze* in volume V (1805) and *Foundery or Foundry* in volume XV (1810))

Riccardelli, Carolyn, et al. "The treatment of Tullio Lombardo's Adam: a new approach to the conservation of monumental marble sculpture." *Metropolitan Museum Journal* 49.1 (2014): 48-116.

Richter, Ernst-Ludwig. *Altes Silber: imitiert-kopiert-gefälscht*. Keyser, 1983.

Riemann, Gottfried. *Karl Friedrich Schinkel. Reise nach England, Schottland und Paris im Jahre 1826*. Koehler & Amelang Verlag, 1986.

Ries, H., and F. L. Gallup. *The clays of Wisconsin and their uses. With a Report on molding sands / by H. Ries and F. L. Gallup*. State (1906): 197-247.

Righini Ponticelli, Sylvia, Luciano Formica and Vittoria Castoldi Formica. *Una Pace Rinnovata Per Milano, L'intervento di conservazione dei bronzi dell'Arco della Pace*, 2015. available through: <http://www.restauriformica.it/?Szn=Interventi_Restauro&id=308> [accessed 5 June 2017]

Rionnet, Florence. "Barbedienne ou la fortune de la sculpture au XIXe siècle." *Bulletin de la Société de l'Histoire de l'Art français*(2001): 301-324.

Rizzo, Giuseppe. "Clemente Papi" Real Fonditore": vita e opere di un virtuosistico maestro del bronzo nella Firenze dell'ottocento." *Mitteilungen des Kunsthistorischen Institutes in Florenz* (2010): 295-318.

Rizzo, Giuseppe. "Il Risorgimento dell'industria furiosa a Firenze: la regia fonderia di statue in bronzo di Clemente Papi prima e dopo l'Unità d'Italia (1837-1875)." *Bollettino della Società di Studi fiorentini* 20.20 (2011): 121-132.

Robbiola, Luc, and L-P. Hurtel. "Nouvelle contribution à l'étude des mécanismes de corrosion des bronzes de plein air: caractérisation de l'altération de bronzes de Rodin." *Mémoires et études scientifiques revue de métallurgie* Décembre (1991): 809-824.

Robert, F.B. *Manuel du Mouleur en Medailles*. Librairie encyclopédique de Roret, 1833.

Robinson, Sir John. "Thoughts on the Casting of Statues in Metal." *The Edinburgh New Philosophical Journal*, Volume 14 (1833): 364-367.

Robinson, Sir John. "Notes on Daguerre's Photography." *The Edinburgh New Philosophical Journal*. Robert James (ed.). Volume XXVII, (1839): 155-157.

Robinson, William H. and Dansereau-Tackett, Julie. "Who Bombed The Thinker?" *Rodin – 100 years: Rodin in the Cleveland Museum of Art*. Cleveland Museum of Art (2017): 10-18.

Roe, Joseph Wickam. *English and American Tool Builders*. McGraw-Hill, 1926.

Rondelet, Beauvallet and Duchesne fils. “Fait à l’Athénée des Arts de Paris, par MM. Rondelet, Beauvallet et Duchesne fils, sur la fonte en bronze de la statue de Jeanne d’Arc, moulée en sable par MM. Rousseau et Honoré Gonon, fondeurs, sous la conduite de M. Gois fils, statuaire.” *Magasin encyclopédique,* Volume 1, (February 1805): 350-368.

Rothenstein, W. *Men and Memories: Recollections of William Rothenstein*. Faber and Faber. (1931-32)

Sachs, Hans. *Panoplia omnium liberalium mechanicarum et sedentariarum artium genera continens*. Sigmund Feierabend, 1568. (German title: *Eygentliche Beschreibung aller Stände auff Erden, hoher und nidriger, geistlicher und weltlicher, aller Künsten, Handwercken und Händeln)*

Salmon, William. *Polygraphice: or the art of drawing*…, Jones, 1672.

Sanders, Patricia. “Auguste Rodin (1840-1917)” *Metamorphoses in nineteenth-century sculpture.* Wasserman, J.L.(Ed). Exh. Cat. November 19, 1975-January 7, 1976, Fogg Art Museum, Harvard University.

Savile, John. *Extracts from Sir J. Savile Lumley's Report on bronze casting in Belgium*. At the Herald Press, 1883.

Sawday, Jonathan. *Engines of the Imagination: Renaissance Culture and the Rise of the Machine*. Routledge, 2007.

Schadow, Johann Gottfried, and Julius Friedländer. *Gottfried Schadow: Aufsätze und Briefe nebst einem Verzeichnis seiner Werke; zur hundertjährigen Feier seiner Geburt, 20 Mai 1764*. Ebner & Seubert (Paul Neff), 1890.

Schmoll-Eisenwerth, J.A. *Rodin –Studien: Persönlichkeit – Werke – Wirkung – Bibliography*. Prestel, 1983.

Scholten, Frits et al. *Adriaen de Vries: 1556-1626 Imperial Sculptor*. Rijksmuseum, 1999.

Scholten, Frits. "The Larson family of statuary founders: seventeenth-century reproductive sculpture for gardens and painters' studios." *Simiolus: Netherlands Quarterly for the History of Art* 31.1/2 (2004): 54-89.

Scholten, F. “Exposeer de kapotte Rodin en koop een nieuwe.” *NRC Handelsblad*, 16 February, 2009.

Schoonenboom, Merlijn. “Tonen beschadigd beeld is teveel eer voor dieven.” *NRC Handelsblad*. 20 February 2009.

Scott, David A. *Copper and Bronze in Art: corrosion, colorants, conservation*. The Getty Conservation Institute, 2002.

Seelig, Lorenz, Barbara Hardtwig, and Peter Volk. *Modell und Ausführung in der Metallkunst.* Bayerisches Nationalmuseum, 1989.

Selwyn, L.S., et al. “Outdoor Bronze Statues: Analysis of Metal and Surface Samples.” *Studies in Conservation*, Vol. 41, No. 4 (1996): 205-228.

Shapiro, Michael Edward. *Bronze Casting and American Sculpture 1850-1900*, University of Delaware Press, 1985.

Sharp, John. *Modern foundry practice, dealing with the green-sand, dry-sand and loam moulding process; the materials used; also detailed descriptions of the machinery and other appliances employed, with practical examples and rules, including revised subject matter and tables from N.E. Spretson's 'Casting and founding*. E. & F.N. Spon, 1900.

Simon, Jacob. “Sir Francis Chantrey.” *British bronze sculpture founders and plaster figure makers, 1800-1980 – C*, National Portrait Gallery, 2011, [online] available through : <http://www.npg.org.uk/research/programmes/british-bronze-founders-and-plaster-figure-makers-1800-1980-1/british-bronze-founders-and-plaster-figure-makers-1800-1980-c.php > [accessed 13 June 2018]

Simonds, George. “Artistic Bronze Casting.” *The Journal of the Society of Arts*, Vol. 34, No. 1733. February 5 1886, 245-260.

Simonds, George. “The art of bronze casting in Europe.” *Journal of the Society of Arts*, XLIV, 19 June 1896, 654-666.

Smedley, Edward, Hugh James Rose, Henry John Rose, and Samuel Taylor Coleridge. *Encyclopaedia metropolitana; or, Universal dictionary of knowledge, comprising the twofold advantage of a philosophical and an alphabetical arrangement, with appropriate engravings*. London: B. Fellowes. Volume VIII, Mixed sciences Vol. 6, London (1845): 652-654. (Casting *statues* in the entry *Founding*)

Stanley Smith, C., and M. Teach Gnudi. "The Pirotechnia of Vannoccio Biringuccio: the Classic Sixteenth-Century Treatise on Metals and Metallurgy." The American Institute of Mining and Metallurgical Engineers. 1959. (reprint Dover Publications, New York, 1990)

Smith, Cyril Stanley. “The early history of casting, molds, and the science of solidification.”*A search for structure: selected essays on science, art, and history*. MIT (1981): 127-173.

Smith, D. "Handheld X-ray fluorescence analysis of Renaissance bronzes: practical approaches to quantification and acquisition." *Handheld XRF for art and archaeology* (2012): 37-74.

Smith, Dylan. “Technical characteristics of bronze statuettes from the workshops of Antonio and Giovanni Frencesco Susini.” *The Renaissance Workshop.* D. Saunders, M. Spring & A. Meek (Eds.), Archetype Publications (2014): 29-41.

Smith, Pamela H. *The body of the artisan: Art and experience in the scientific revolution*. University of Chicago Press, 2004.

Smith, Pamela H., and Tonny Beentjes. "Nature and art, making and knowing: Reconstructing sixteenth-century life-casting techniques." *Renaissance Quarterly* 63.1 (2010): 128-179.

Smith, S.M. and L. Petitt. "Conservation Treatment of Malvina Hoffman's Bushman Family, Kalahari Desert, South Africa (1930) using 3D Technology." *METAL 2016, Proceedings of the Interim Meeting of the ICOM-CC Metal Working Group*, New Delhi, (2016): 276-283

Spon, Ernest. *Workshop receipts*. Spon. 1892.(Fifth series)

Spon, Edward, and Francis N. Spon. *Spons' Mechanics' Own Book: A Manual for Handicraftsmen and Amateurs*. E. & FN Spon, 1889.

Sprengel, Peter Nathanael. "Meßing- und Eisenarbeiter." *P. N. Sprengels Handwerke und Künste in Tabellen*. Verlag der Buchhandlung der Realschule. Fortgesetzt von O. L. Hartwig. Fünfte Sammlung, 1770. (2nd ed. 1790)

Stichting het Rijksmuseum. *Bulletin van het Rijksmuseum*, year 20, No; 3(1972)

Stiegel, Achim. "Der Ritt der Nereiden von Pompeji nach Berlin, eine Gruppe vergoldeter Bronzefiguren nach Entwurf von Karl Friedrich Schinkel aus dem Jahre 1827." Advertisement feature by Frank C. Möller Fine Arts, Hamburg, in: *Weltkunst*, February 1999, Cover and first three pages, n.p.

Stephens, Rob. "A Short History of Baptist Mills Brass Works Part One: The Early Years, 1700 – 1720." *Living Easton Web Site*, nd [online] Available at: <http://www.cems.uwe.ac.uk/~rstephen/livingeaston/local_history/brass1.html> [accessed 26 November 2016]

Stone, Richard E. "Antico and the Development of Bronze Casting in Italy at the End of the Quattrocento." *Metropolitan Museum Journal* 16 (1981): 87-116.

Straube, Bly. "*Artifact Hunt: The Curator's Curiosity Cabinet*." Jamestown Rediscovery Newsletter, 2014. [online] Available at: < https://historicjamestowne.org/selected-artifacts/sand-casting-mold-2/ > [accessed 3 June 2018]

Strauss, K., ed. *Applied science in the casting of metals*. Elsevier, 2013.

Street, Ronald, P. Cunningham, M. Bak, and D. Fridline. "Exploring the use of laser scanning and finite element analysis in the restoration of Tullio Lombardo's marble sculpture of Adam." *LACONA IX, 9th conference of Lasers in the Conservation of Artworks.* David Saunders et al (eds.) Archetype Publications in association with the British Museum (2013): 163-172.

Sullivan, M. "Brass sculpture and the ideology of bronze in Britain 1660–1851." *Sculpture Journal* 14.1 (2005): 30-40.

Tate, James Murray, and Melvin Oscar Stone. *Foundry Practice: A Treatise on Moulding and Casting in Their Various Details*. HW Wilson Company, 1906. (2nd edition 1906, 3rd edition 1909)

Teolato, Chiara. “Roman bronzes at the court of Gustavus III of Sweden: Zoffoli, Valadier and Righetti.” *The Burlington Magazine*, Vol. 153, No. 1304, November 2011: 727-733.

Teolato, Chiara. “I Righetti a servizio di Canova.” *Studi di Storia dell'Arte 23* (2012), Todi, Ediart, 2013: 201-260.

Ter Kuile, Onno. *Koper & brons*. Staatsuitgeverij, 1986.

Thomas, N., Leroy, L. and Plumier, J. *L’or des dinandiers: Fondeurs et batteurs mosans au Moyen Age*. Maison du patrimone medieval mosan, 2014, 55-60.

Tiemann, Wilhelm Albrecht. *Abhandlung über die Förmerei und Gießerei auf Eisenhütten: ein Beitrag zur Eisenhüttenkunde*. In der Raspeschen Buchhandlung, 1803.

Tiemann, Adolf Wilhelm. *Neue artistisch-technische Encyklopädie, oder gründliche, auf Erfahrung beruhende Anweisung zur Verfertigung der vorzüglichsten Kunstsachen: von Abdruck bis Kupferstecherkunst. Erster Band*. Frölich, 1806.

Tilanus, P., et al. *Rodin: De Denker*. Thoth Publ., 2011.

Travis, John. "Laser replication of rare art." *Science* 256 (1992): 969.

Tuttle, Patricia. "An Investigation of the Renaissance Casting Techniques of Incuse-Reverse and Double-Sided Medals." *Studies in the History of Art* 21 (1987): 205-212.

Tylecote, Ronald Frank, and R. F. Tylecote. *A history of metallurgy*. Institute of materials, 2002.

Tyler, John D. "Technological Development: Agent of Change in Style and Form of Domestic Iron Castings." *Technological Innovation and the Decorative Arts* (1973): 141-165.

van Duijn, Esther. *“Vandalism and the Rijksmuseum: three vandalised paintings restored by Luitsen Kuiper in the nineteen seventies.”* Paper given at the conference Vandalism & Art held on 8 and 9 June 2017 organised by the Stichting Restauratie Atelier Limburg (SRAL) in collaboration with the Bonnefantenmuseum, CeROArt and MACCH, 2017.

van Laer, Willem. *Weg-Wyzer Voor Aankoomende Goud en Zilversmeeden*. Frederik Helm. 1721.

van Langh, Robert, et al. "The study of bronze statuettes with the help of neutron-imaging techniques." *Analytical and bioanalytical chemistry* 395.7 (2009): 1949-1959.
van Langh, Robert. "Technical studies of Renaissance bronzes." Diss. TU Delft, Rijksmuseum (2012).

Vasari, Giorgio, et al. *Vasari on Technique-Being the Introduction to the Three Arts of Design, Architecture, Sculpture and Painting, Prefixed*. Dover Publications, 1960.

Vasari, Giorgio, and Gaston du C. De Vere. *Lives of the most eminent painters, sculptors & architects*. Macmillan and Co., ld. & The Medici Society, ld. 1912.

Vassalo, Isabelle. *Rodin et ses fondeurs*. Université Paris I, 1992 (unpublished MA thesis)

Vauxcelles, Louis. 1905. 'La fonte à cire perdue. *Art et Décoration*, vol. 9, 1905; 189-197.

Vorsteher, D. "Die Kunst der hohlen Raumes in der Formereiwerkstätten der Saynerhütte." *Eisen Statt Gold; Preußischer Eisenkunstguß aus dem Schloß Charlottenburg, dem Berlin Museum und anderen Sammlungen.* Arenhövel, Willmuth, Christa Schreiber, and Jörg P. Anders (eds.), 1982, 262-271.

Wallack, August. *Vollständiges Handbuch des Gürtlers und Broncearbeiters... sowie einer praktischen Anleitung zur Förmerei und Gieserei im Kleinen und Großen: mit beifügung der besten und bewährtesten Vorschriften zur Anfertigung der Bronce... usw. Mit 33 lithogr. Taf., welche viele hundert Abb. enthalten*. Vol. 108. Voigt, 1840.

Wasserman, J.L. *The Young Cyclist by Aristide Maillol*, Acquisitions (Fogg Art Museum), No. 1962/1963 (1962-1963): 17-20.

Wasserman, Jeanne L. *Metamorphoses in nineteenth-century sculpture*. Harvard University Press, 1975.

Wautelet, M., "La sculpture entre art et technique: la réhabilitation de la cire perdue en Belgique au XIXe siècle." *Histoire de l'art: bulletin d'information de l'Institut national d'histoire de L'art*, Volume 67 (2010): 59-70.

Whatmore, Stan. "From art to industry: developments in English bronze casting during the nineteenth century." *From marble to chocolate: the conservation of modern sculpture. Tate Gallery conference, 18-20 September 1995*. Archetype Publications, 1995.

Wenley, Robert, ed. *French bronzes in the Wallace Collection*. Trustees of the Wallace Collection, 2002.

Welter, Jean-Marie. "French Bronzes from Renaissance to Revolution: But Are They Bronzes."Bresc-Bautier, Geneviève, Guilhem Scherf, James David Draper; *Cast in Bronze: French Sculpture from Renaissance to Revolution.* Musée du Louvre Éditions. 2009, 42-45.

v Wuttig, Feodor Iwanowitsch. *Die Kunst aus Bronze kolossale Statuen zu giessen*. Amelang, 1814.

Young, Marcus L., et al. "Matisse to Picasso: a compositional study of modern bronze sculptures." *Analytical and bioanalytical chemistry* 395.1 (2009): 171-184.

Young, M. L., and D. C. Dunand. "Comparing Compositions of Modern Cast Bronze Sculptures: Optical Emission Spectroscopy Versus x-Ray Fluorescence Spectroscopy." *JOM* 67.7 (2015): 1646-1658.

Zindel, Christophe. *Güldene Kunst-Pforte: Quellen zur Kunsttechnologie: eine chronologische Übersicht gebundener Quellenschriften zu Baukunst, Bildnerei (Skulptur und Plastik), Malerei, Graphik, Kunstgewerbe, Kunsttheorie und Restaurierung von der späten*

Antike bis 1900 mit bibliographischen Daten, Kurzkommentar und Registern. Hochsch. der Künste, 2010.

Zweig, Stefan. *Le monde d'hier: souvenirs d'un européen.* J-P. Belmond, 1982. (trans. J-P. Zimmerman)

Zycherman, L., et al. *3-D scanning of Matisse, The Back I – IV: One thing after another*, 2012 [online] Available at:<http://ncptt.nps.gov/wp-content/uploads/zycherman.pdf > [accessed 6 June 2018]

Appendices:

Appendix 1: ICP-MS analysis

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
	W675	W676	W677	W678	W679	W680	W681	W682	W683	W684	W685	W686	W687	W688	W689	W690	W691
	Gonon?	Gonon?	Gonon?	E.Rudier	F.Rudier	Melb.	Bingen	Gonon	Bingen	Bingen	(blank)	Melb.	Bingen	Bingen	Gonon	Gonon	Bingen
Major, minor elements	(%) (1.04)	(%)	(%) (1.05)	(%) (1.25)	(%)	(%)	(%) (1.15)	(%) (1.05)	(%) (1.16)	(%) (1.07)	(%)	(%) (0.94)	(%) (1.10)	(%) (1.10)	(%) (1.06)	(%)	(%) (1.03)
Sn	0,181 (0,19)	0,969	1,83 (1,92)	2,803 (3,50)	1,51	1,536	1,326 (1,52)	1,094 (1,15)	0,24 (0,28)	1,181 (1,26)		5,18 (4,87)	3,18 (3,50)	1,34 (1,47)	1,31 (1,39)	2,623	3,239 (3,34)
Pb	0,252 (0,26)	0,242	0,199 (0,209)	0,0486 (0,06)	0,332	0,623	0,453 (0,52)	0,489 (0,51)	0,144 (0,17)	0,28 (0,30		0,465 (0,44)	0,116 (0,13)	0,16 (0,18)	0,491 (0,52)	0,585	0,257 (0,26)
Zn	7,17 (7,45)	6,912	6,95 (7,30)	0,983 (1,23)	14,69	11,41	1,345 (1,55)	10,11 (10,62)	3,92 (4,55)	4,612 (4,93)		9,51 (8,94)	1,34 (1,47)	1,31 (1,44)	9,23 (9,78)	9,24	4,8 (4,94)
Fe	0,0349	0,053	0,064	0,267	0,089	0,153	0,099	0,171	0,341	0,321		0,128	0,119	0,101	0,183 (0,19)	0,122	0,219
Ni	0,127	0,131	0,124	0,033	0,056	0,037	0,075	0,041	0,054	0,056		0,045	0,074	0,077	0,043	0,042	0,056
Al	0,056	0,011	0,032	0,416	0,020	0,014	0,066	0,084	0,271	0,111		0,0026	0,064	0,041	0,025	0,017	0,060
Cu	88,38 (91,9)	91,54	85,99(90,29)	75,44 (94,30)	83,13	85,43	83,49 (96,01)	83,36 (87,53)	81,33 (94,34)	86,46 (92,51)		90,27 (84,85)	85,56 (94,12)	88,09 (96,90)	82,59 (87,55)	86,66	88,33 (90,98)
As	0,003	0,058	0,078	0,031	0,026	0,062	0,016	0,047	0,063	0,022		0,15	0,036	0,018	0,046	0,080	0,0425
Cr	0,002	0	0,003	0,0025	0,001	0	0,001	0	0,0021	0,001		0	0	0,0008	0	0	0,0006
Sb	0,004	0,019	0,038	0,0051	0,007	0,022	0	0,017	0,015	0,0064		0,057	0,01	0	0,015	0,0282	0,012
Bi	0,022	0,024	0,061	0,022	0,020	0,022	0,02	0,023	0,023	0,023		0,018	0,019	0,023	0,018	0,0195	0,028
Cd	0,002	0,002	0,004	0,0006	0,003	0,016	0,001	0,003	0,0001	0,0006		0,012	0,0006	0,0008	0,0033	0,0031	0,0008
Mn	0,001	0,0002	0	0,0022	0,0001	0,0002	0,0005	0,001	0,0006	0,0013		0,0003	0,0004	0,0003	0,0007	0,0002	0,0003
Total:	96,2% (100%)	99,96%	95,37% (100%)	80,05% (100%) [oxides?]	99,88%	99,17%	86,89% (100%) [oxides?]	95,45% (100%)	86,41% (100%) [oxides?]	93,08% (100%)		105,84% (100%)	90,52% (100%)	91,16% (100%)	93,95% (100%)	99,42%	97,04% (100%)

Prog 1510 Bronze samples concentrations ICP-OES (major and minor elements)
and ICP-MS (trace elements) Tony Beentjes UvA, Metals Conservation, Aug 2015

VU code		dilution factor:
		1: ?
W675	Babes Swarf	5139
W676	Babes Cut	5066
W677	Babes Cast Line	10368
W678	Thinker Berlin	5063
W679	Thinker Ny Carlsberg Glyptotek	5176
W680	Thinker Melbourne NGV	5056
W681	S497 Victor Hugo M.Rodin	5158
W682	S978 Idylle Musee Rodin P. Gonon	5015
W683	91.7 # 1,2 flash Proper right chin	5026
W684	91.7 # 3 Blob Aon top of base	4945
W685	Blank	x
W686	Thinker Melbourne NGV	4915
W687	S497 Victor Hugo M.Rodin	4830
W688	S497 Victor Hugo M.Rodin	5255
W689	S978 Idylle Musee Rodin P. Gonon	5077
W690	S978 Idylle Musee Rodin P. Gonon	5215
W691	91.7 # 1,2 flash Proper right chin	4928
Ref 1A	32X PB11-G original	5144
Ref 1B	32X PB11-G standard addition	5145
Ref 2	31XTB1-J original	5258

32X PB11-G standard addition (added: 0.50 ppb REE[17x] and 0.5 ppb Sr and 0.5 ppb Rb)

Company. MBH analytical LTD, England

32X PB11 (batch G) *Phosphor bronze (Chill Cast)*		
Element:	*Concentration:*	*Uncertainty:*
	(%)	*(%)*
Sn	*3.306*	*0.015*
Pb	*0.995*	*0.014*
Zn	*1.71*	*0.02*
Fe	*0.399*	*0.005*
Ni	*0.898*	*0.009*
Si	*0.123*	*0.004*
As	*0.198*	*0.005*
Mn	*0.132*	*0.001*
P	*0.946*	*0.010*
Al	*0.081*	*0.003*
Co	*0.090*	*0.002*
Bi	*0.0310*	*0.0009*
Sb	*0.584*	*0.009*
S	*0.0148*	*0.0010*
Mg	*0.0091*	*0.0009*
Cu	*90.44*	*0.13*

31X TB1 (batch J) *Traces in Brass (Chill Cast)*		
Element:	*Concentration:*	*Uncertainty:*
	(%)	*(%)*
Sn	*0.231*	*0.005*
Pb	*0.201*	*0.003*
Zn	*36.90*	*0.09*
Fe	*0.038*	*0.002*
Ni	*0.220*	*0.003*
Si	*0.093*	*0.002*
As	*0.153*	*0.003*
Mn	*0.314*	*0.003*
P	*x*	*x*
Al	*0.210*	*0.003*
Co	*x*	*x*
Bi	*0.049*	*0.002*
Sb	*0.104*	*0.003*
S	*x*	*x*
Mg	*x*	*x*
Cu	*61.39*	*0.08*
Cr	*0.084*	*0.002*
Se	*0.006*	*0.001*
B	*0.0006*	*0.0002*
Cd	*0.0114*	*0.0006*

Appendix 2: Chronological list of original and monumental size *Thinkers*

Original size *Thinkers*

date	Collection	foundry	Material/ casting method
c. 1881	Rodin Museum, Paris	n/a	terra cotta
c. 1884	Nat. Gallery of Victoria, Melbourne (Aus)(1196-3)	Gonon?	lost wax
1896	Musée d'Art et Histoire , Geneva (CH) (1896-0011)	Auguste Griffoul	sand mould
1896	Nasjonalgalleriet, Oslo (N) (NG.S.00638)	Auguste Griffoul	sand mould
1899	Musées Royal des Beaux-Arts, Brussels (B) (3517)	J. Petermann Brussels	sand mould
1900	Musée des Beaux-Arts, Béziers (F) (00:7.1)	n/a	exhibition plaster
1900?	Rodin Museum, Paris (F) (S.02520)	n/a	plaster
1901	Private collection, London (UK)	François Rudier?	sand mould
1901	Private collection Italy	François Rudier?	sand mould
1901	Ny Carlsberg Glypotek Copenhagen (MIN 605)	François Rudier?	sand mould
1903	National Gallery of Art, Washington (USA)(1942.5.12 (A-76))	Eugène Rudier?	sand mould
1905 or earlier	Alte Nationalgalerie, Berlin (B I 210)	Eugène Rudier?	sand mould
1906	Private collection Oslo (Ralph Pulitzer *Thinker* with Rodin plaque)	A. Rudier	sand mould
1907 or earlier	Private collection Paris (Joseph Pulitzer *Thinker*)	A. Rudier	sand mould
1909 or earlier	Musée des Beaux-Arts, Montréal (1909.465)	A. Rudier	sand mould
1910	Metropolitan Museum of Art, New York (11.173.9)	A. Rudier	sand mould
1910-20	Private collection, Los Angeles	A. Rudier	sand mould
1917	Private collection, whereabouts unknown	A. Rudier	sand mould
1917?	Rodin Museum, Paris (S.01131)	A. Rudier	sand mould
1922 or earlier	Fogg Art Museum , Cambridge, USA (1943.1362.A)	A. Rudier	sand mould
1922 or earlier	Burrell Collection, Glasgow (7.8)	A. Rudier	sand mould
1923	Museum of Art, Baltimore	A. Rudier	sand mould
1924	Private collection, whereabouts unknown	A. Rudier	sand mould
1925	Musée des Beaux-Arts de l'Indochine, Hanoï, Probably destroyed	n/a	exhibition plaster
1924 or 1928	Rodin Museum, Philadelphia (F1929-7-123 or F1929-7-15)	A. Rudier	sand mould
1926	Museum of Art, Toledo, USA (26.4)	A. Rudier	sand mould
1928 or earlier	Yale University Art Gallery, New Haven, USA (1967.82.4)	A. Rudier	sand mould
1930	Ordrupgaard, Copenhagen (DK) (305 WH)	A. Rudier	sand mould
1931 or earlier	Giza Museum, Cairo	A. Rudier	sand mould
c.1931-1939	Rodin Museum, Paris (S.02840)	n/a	Plaster foundry model (A.Rudier)
1935?	Private collection	A. Rudier	sand mould

Between c.1931-1937	Singer Museum, Laren (NL) (56-1-412)	A. Rudier	sand mould
c.1931-1939	Private collection, Norway	A. Rudier	sand mould
1939	Musée cantonnal des Beaux-Arts, Lausanne, Switzerland (80)	A. Rudier	sand mould
Before 1940	Iris Cantor Trust, Los Angeles (New York?)	A. Rudier	sand mould
c.1943	Private collection	A. Rudier	sand mould
1945	National Museum of Western Art, Tokyo	A. Rudier	sand mould
?	Cleveland Museum of Art, Cleveland USA	A. Rudier	sand mould
?	Art Gallery of Ontario, Toronto	A. Rudier	sand mould
?	Private collection, Johannesburg, South Africa	A. Rudier	sand mould
1955	Private collection	G. Rudier	sand mould
1956	Galeria d'arte religiosa moderna, Vatican	G. Rudier	sand mould
?	Corporate collection, Japan	G. Rudier	sand mould
c.1960	Rodin Museum, Paris	n/a	Plaster foundry model (G.Rudier)
c.1960	Rodin Museum, Paris	n/a	Plaster foundry model (A.Rudier)
1964	Ateneum Art Museum, Helsinki	G. Rudier	sand mould
1966	Kept in the lobby of the Cantor Fitzgerald headquarters at the World Trade Center NYC. Reputedly survived the 9/11 attack and disappeared from rubble.	G. Rudier	sand mould
?	Cantor Collection	G. Rudier	sand mould
1967	Rodin Museum, Paris (S.00788)	G. Rudier	sand mould

Monumental size *Thinkers*

1904	University of Louisville, Alle R. Hite Art Institute, Louisville, USA.	A.A. Hébrard	lost wax
1904	Detroit Institute of Art, Detroit (22143)	A. Rudier	sand mould
1904	Rodin Museum, Paris (S.01295)	A. Rudier	sand mould
1904	Ny Carlsberg Glyptotek, Copenhagen	A.A. Hébrard	lost wax
1904	Staatliche Kunstsammlungen, Dresden	n/a	plaster
1904	National Museum, Poznan, Poland	n/a	plaster
1904	Metropolitan Museum of Art, New York	n/a	plaster
1906	Argentinian State (monument on the Plaza del Congresso), Buenos Aires	A. Rudier	sand mould
1907	Musée d'art modern, Strasbourg, France	n/a	plaster
1907	Ca' Pesaro, Museo d'Arte moderna, Venice	n/a	plaster
1909	?, Stockholm	A. Rudier	sand mould
1914?	California Palace of the Legion of Honor	A. Rudier	sand mould
1916	Cleveland Museum of Art, Cleveland, USA	A. Rudier	sand mould
1918	Rodin Museum (Meudon, on Rodin's grave)	A. Rudier	sand mould
?	Rodin Museum, Paris (S.00161)	n/a	plaster
?	Rodin Museum, Paris (S.05727)	n/a	plaster
1919	Rodin Museum, Philadelphia (F1929-7-123)	A. Rudier	sand mould
1923	National Museum, Kyoto, Japan	A. Rudier	sand mould
1926	Private collection? Laeken (cemetery), Belgium	A. Rudier	sand mould
1926	National Museum of Western Art, Tokyo	A. Rudier	sand mould
1928	Baltimore Museum of Art, Baltimore, USA	A. Rudier	sand mould

1930	Columbia University, New York	A. Rudier	sand mould
1942?	Puschkin Museum, Moscow	A. Rudier	sand mould
1950	Nelson-Atkins Museum, Kansas City, USA	A. Rudier	sand mould
?	Rodin Museum, Paris	n/a	plaster
1965	Prefectural Museum of Art, Shizuoka, Japan	G. Rudier	sand mould
1966	Kunsthalle, Bielefeld, Germany	G. Rudier	sand mould
1968 or 1972?	Iris and B. Gerald Cantor Foundation and Stanford University, Stanford, USA	G. Rudier	sand mould
1969	Norton Simon Art Foundation, Pasadena, USA	G. Rudier	sand mould
1974	City Art Museum, Nagoya, Japan	G. Rudier	sand mould
?	Galerie Sayegh, Paris	n/a	plaster

Appendix 3: reports technical analysis

The alloy of the Laren 'Thinker' has been analysed on three occasions. Twice with a portable XRF (X-ray fluorescence) and once with EPMA (Electron Probe Micro Analysis).

The first analysis was carried out by Luc Megens (RCE) on three different bare metal spots on the statue in March 2009 using a Bruker Tracer III-V with a rhodium tube operating at 40 kV and 2.2 uA with a 0.0012 Al/ 0.0001 Ti filter in the primary beam and a Si-PIN detector. Quantification was performed using the S1PXRF software.

The second analysis was carried on a sample from the left upper arm at the Tata steel research laboratories in Ijmuiden, the Netherlands in April 2009 using Electron Probe Micro Analysis (EPMA)

The third analysis was done during the Rodin exhibition in Laren by Bertil van Os (RCE) using a Niton Xl3t-goldd van Thermo Scientific, alloy mode, silicon drift detector operating at 50 kV (detection limits for metals of 10 mg/kg (10 ppm).

	Cr	Cu	Zn	Sn	Pb
Luc Megens (RCE) 31-3-2009 three bare metal spots (XRF)		93.6 +/- 0.5 %	0.9 +/- 0.2 %	3.9 +/- 0.4 %	<0.5 %
Bertil van Os (RCE)16-5-11 Lower part of base (XRF)	0.0%	91.25%	0.46%	6.42%	0.33%
Tata steel 10-04-2009 sample(EPMA)		96.1%		3.8%	0.1%

The alloy used for the sculpture is analysed as an average of 94,5 % Cu, 1 % Zn, 4 % Sn and < 0.5 % Pb

Analytical report Tata Steel research laboratory, 10 April 2009, by J. Winter and F. Twisk

Subject: **Characterisation of piece of 'de Denker' from Rodin**

Introduction

In 2007 the statue 'De Denker', sculpted by Rodin, was stole form the Singer Museum in Laren (NL). The statue was later found back, heavily damaged. In order to do repairs to the statue, it was important to know more about the chemical and metallurgical composition of the statue.
A small piece of this statue was therefore offered to MSA in order to characterise the material.

Aim

Aim of the characterisation was to supply information concerning the material of which the statue was made, in order to facilitate the repair of the 'Denker'.

Method

The sample was first analysed with LiM (Light Microscopy). The samples were analysed 'as-is' (without etching) as well as after etching with 10% ammoniumpersulphate during approx. 60 seconds.
The sample was subsequently analysed with EPMA (Electron Probe Micro Analysis), operated at 20 kV.
Mappings and quantative line scans were made for the elements Cu, Sn and Pb. An overview of the analysed element lines is given in table 1.

Table 1: elements, analysis parameters

Element	line	Xtal
Cu	k_α	LLiF
Sn	l_α	LPET
Pb	m_α	LPET

Results

The results of the LiM-analyses are presented further. These pictures show that the sample is made by casting directly, given the vast amount of slenk holes. There are a vast number of dendritic structures visible that support this assumption. Apparently no further working has been done on the structure, such as forging.

The results of the EPMA analyses are presented further.
These analyses show that there main element of the material is Cu. Sn is present as an alloying element. A second phase with more Sn is also visible in the mappings. Pb is present in isolated particles. The total chemical composition is approx. 96.1 % Cu, 3.8 % Sn and 0.1 % Pb.

Additional (not fully quantified) XRF-analysis suggested 93.6 % Cu, 0.9 % Zn, 3.9 % Sn and < 0.5 % Pb. The actual values for the different elements might be slightly different, since the XRF was at that moment not fully quantified.
Zn could be present as pollutant from the Sn. This element was however not taken into account during the EPMA analysis.

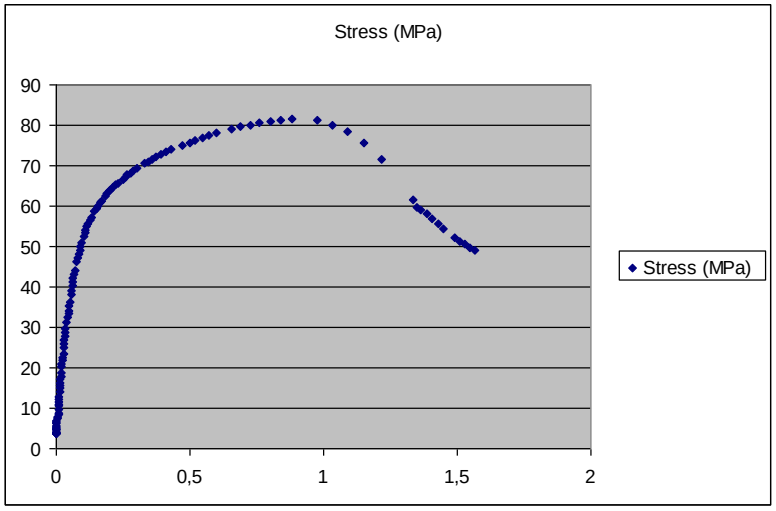
Conclusions

The material from 'de Denker' indicated that the material was a brass, consisting of approx. 96 % Cu and 4 % Sn. Some impurities of Pb are found, and XRF-analyses suggested also some Zn to be present.
The structure of the sample suggested a casted material with no further working like forging being done after casting.

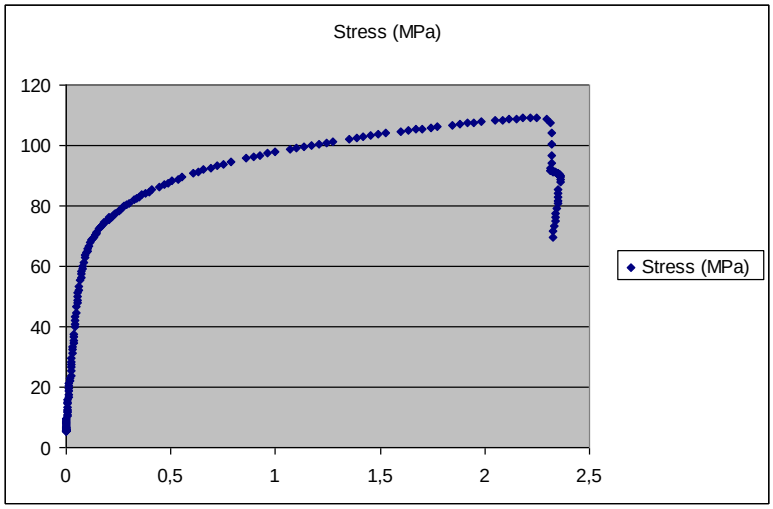
Tensile strength tests

Tests carried out at the Tata steel research laboratory Ijmuiden, Netherlands.
Tests performed on a Instron draw bench, draw speed 30 MPa/sec, Draw rod DP5, test rods 10 mm diameter, 200mm length

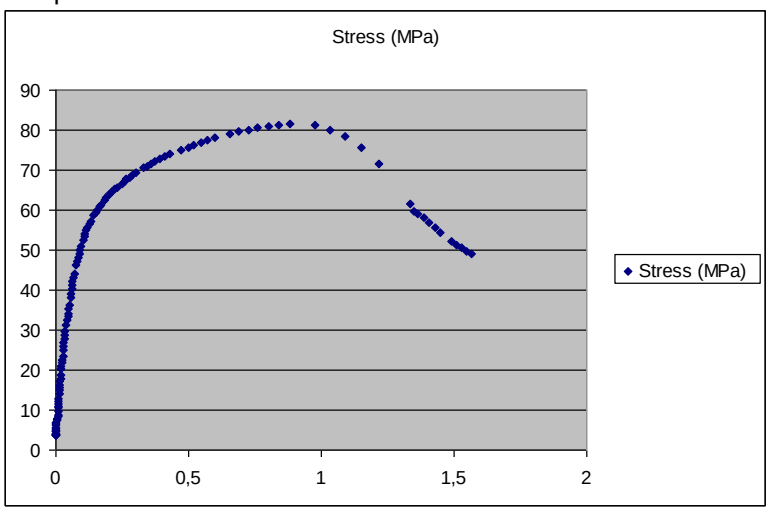
Sample 1 : E= 44000MPa



Sample 2 : E= 82000 MPa



Sample 3: E= 66000MPa



Metallographic analysis

The microstructure of the Laren *Thinker* has been studied three times, first on the sample from the upper left arm that was supplied to the research laboratory of Tata Steel in Ijmuiden for alloy analysis. The second time was in situ on the sculpture by localised polishing and etching of the inside of a saw cut where the left lower leg was detached. This was carried out together with Ineke Joosten (RCE and Daria Prantstraller (University of Bologna). The third study was carried out by Daria Prantstraller in the laboratories of the University of Bologna at the Ravenna Campus.

The in-situ metallography was carried out directly on a cutting surface by means of a digital microscope (Dyno lite) after grinding, polishing and etching with an acidic (HCl) solution of FeCl3 in ethyl alcohol. The next study was carried out by Daria Prantstraller in the laboratories of the University of Bologna at the Ravenna Campus on a small sample. This sample was taken from an edge of one of the saw cuts on the lower left leg. This sample was cold embedded in polyester resin and subsequently ground up to 2000 grit SiC paper followed by polishing with polycrystalline diamond particles on cloth up to 1 μm particle size. The polished surface was studied using optical microscopy before and after etching with a (HCl) solution of FeCl3 in ethylic alcohol.

Metallography in situ:

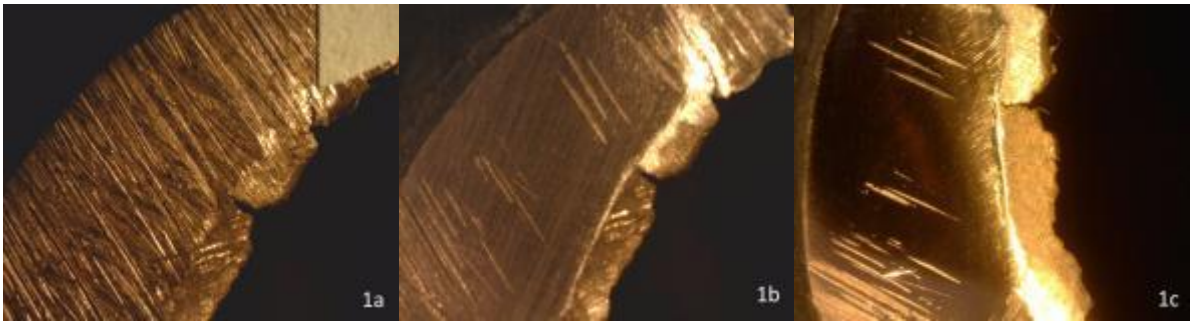


Fig. 1a-c: effect of in situ grinding and polishing on the cutting surface. a) as cut b) after grinding c) after polishing.

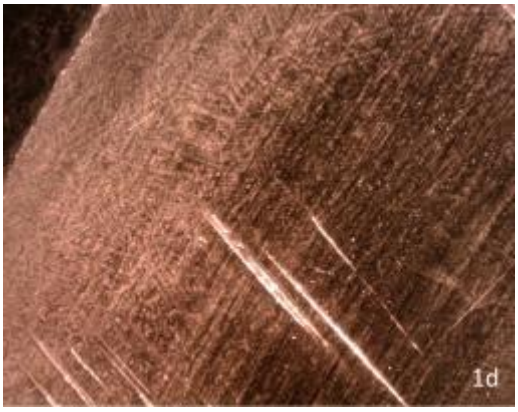


Fig. 1d in-situ metallography of the cutting surface after etching with FeCl3 + HCl + EtOH. The highest magnification possible with the Dyna lite was x 90 and was sufficient to clearly distinguish the presence of dendrites on the etched surface, but not enough to investigate other morphological features.

Metallography of sample:

For deeper metallographical analysis is was necessary to prepare and study the sample.

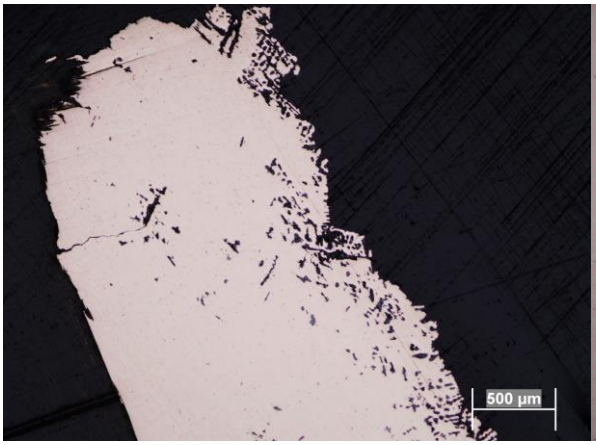


Fig. 2a: 5× unetched

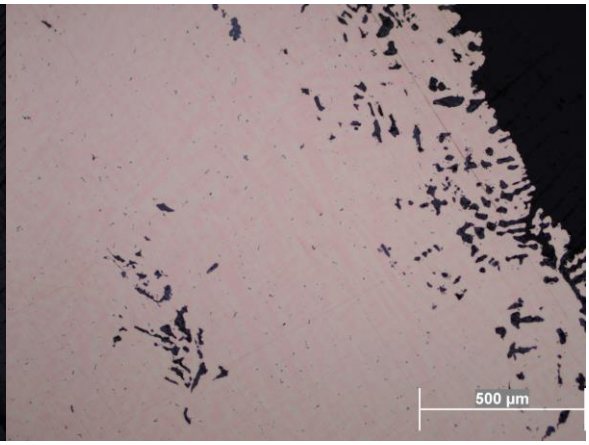


Fig.2b: 10× unetched

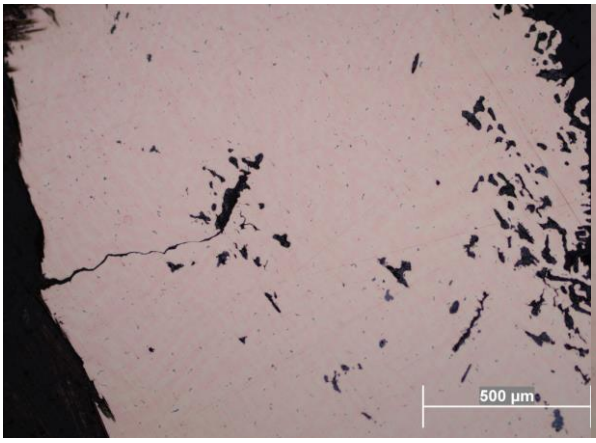


Fig 2c: 20× unetched

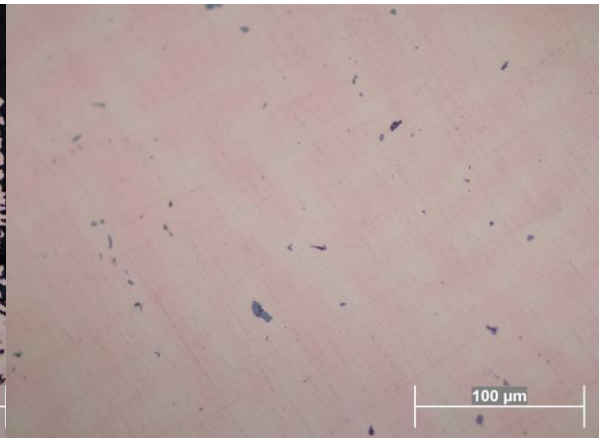


Fig.2d: 50× unetched

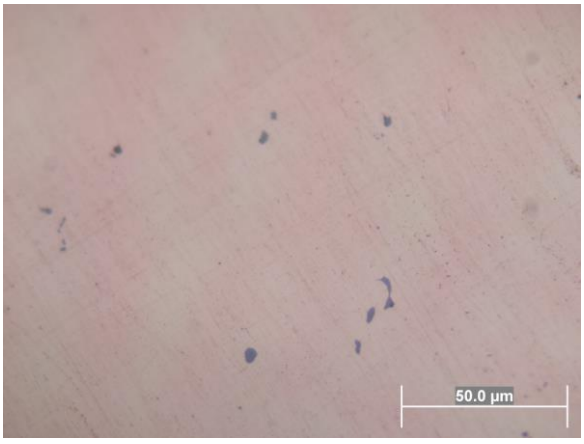


Fig.2e: 100× unetched

Before etching it is already possible to observe mainly at low magnification (fig.2 a-c) a cored dendritic microstructure even on the in-situ sample, due to micro segregation occurred during solidification from the liquid phase. Since hot working is known to be capable to eliminate coring, during the cut the frictional heat should have effectively removed most coring. The presence of few cracks, due to the cutting damage, are visible in fig 2a and c. The

microstructure is quite clean (fig. 2d, e), being composed of one single phase (Cu based solid solution) with the presence of few amounts of small inclusions, probably lead.

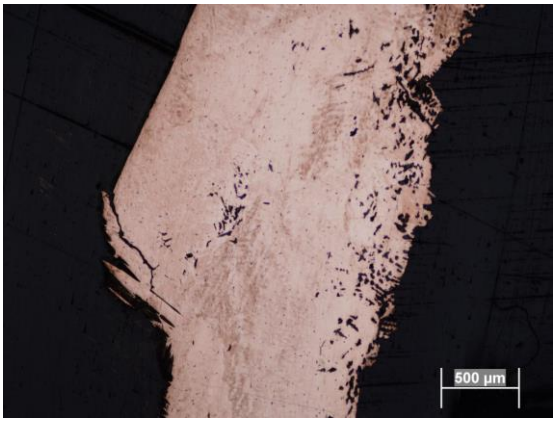


Fig.3a: 5× after etching

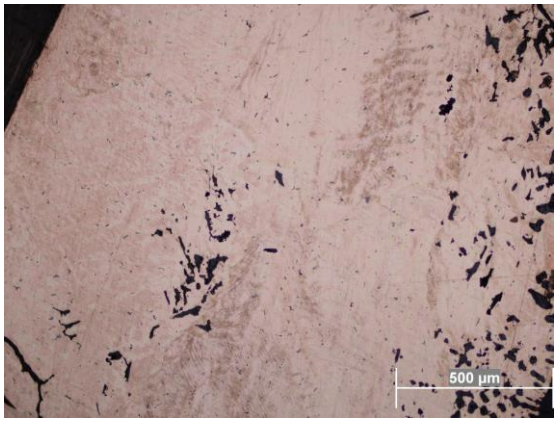


Fig.3b: 10× after etching

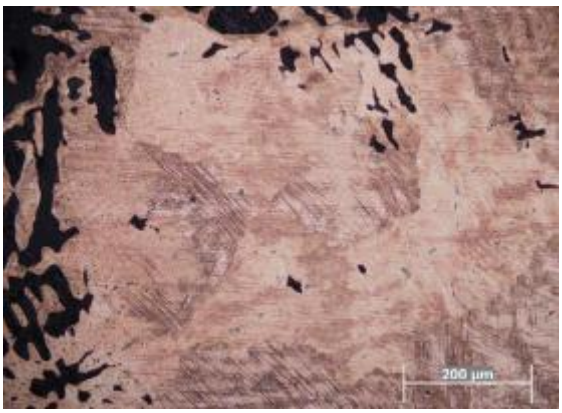


Fig.3c: 20× after etching

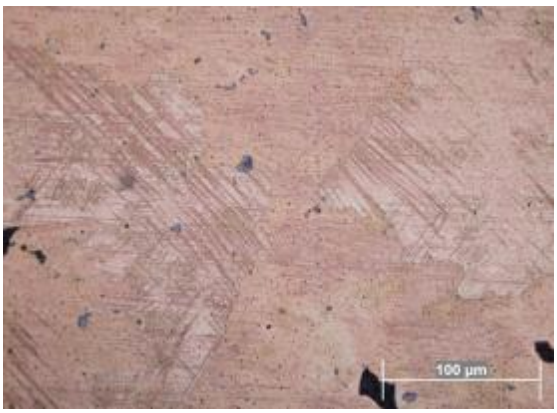


Fig.3d: 50× after etching

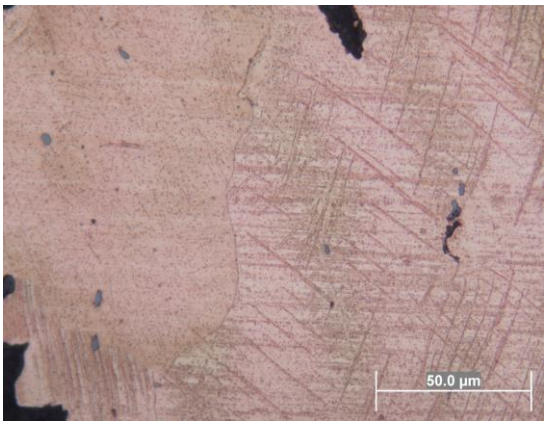
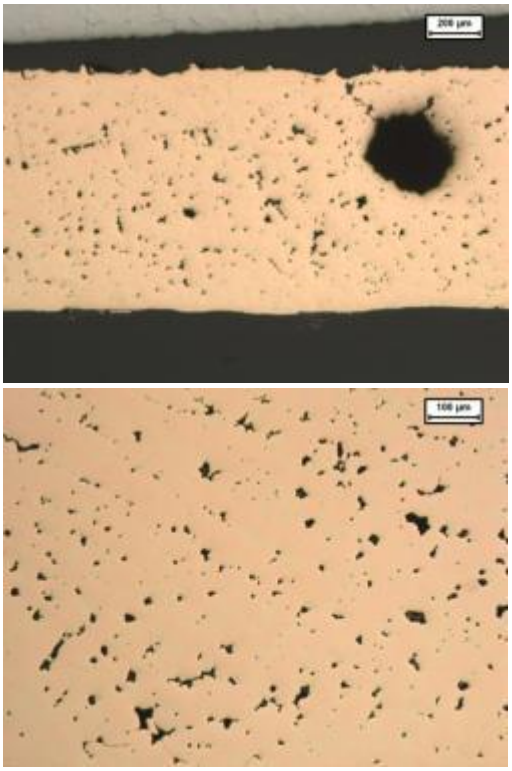


Fig.3e: 100× after etching

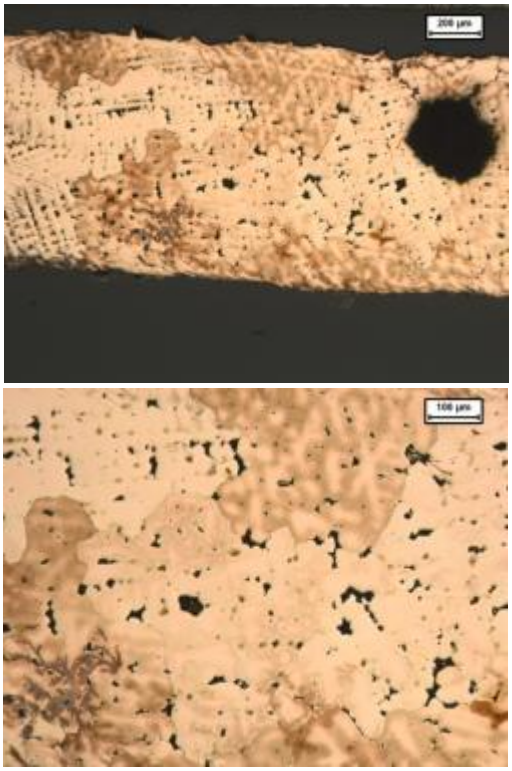
After etching the most evident microstructural features are the extended plastic deformation bands (figs. 3 a-e) caused by the cut. The presence of the already mentioned cored dendrites, together with the deformation bands, the twisted shape of grains boundaries (fig 3.c-e) and the absence of annealing twins prove that no re-crystallisation has occurred during cutting.

Tata steel research laboratorium, 10 April 2009, by J. Winter and F. Twisk.
The sample was analysed with light microscopy(LiM). The samples were analysed 'as-is' (without etching) as well as after etching with 10% ammonium per-sulphate during approx. 60 seconds. The sample is made by casting directly, given the vast amount of slenk holes and dendritic structures. No further working has been done on the structure, such as forging.

LiM photos unetched



LiM photos etched



Patina analysis

Main constituents of green patina are brochantite and some antlerite X-ray diffraction using Siemens GCCS with GADDS Bruker-AXS Analysis performed by Luc Megens, RCE, in November 2009.

The patina of the Laren *Thinker* has three distinct main colours: dark green, light green and yellowish green. In places were, due to plastic deformation of the bronze, the mineral upper part of the patination has flaked off, a reddish layer has been exposed.

Samples have been taken in 6 different places by carefully scraping the surface (area of around 1cm²) with a scalpel.
Two samples were taken from yellowish and dark green patina and one sample each of the light green and reddish patina.

The samples were analysed by means of powder X-ray diffraction (XRD) by Luc Megens (RCE) using Siemens GCCS with GADDS Bruker-AXS (Bruker HiStar, GADDS, EVA) with a detection limit of around 5%.

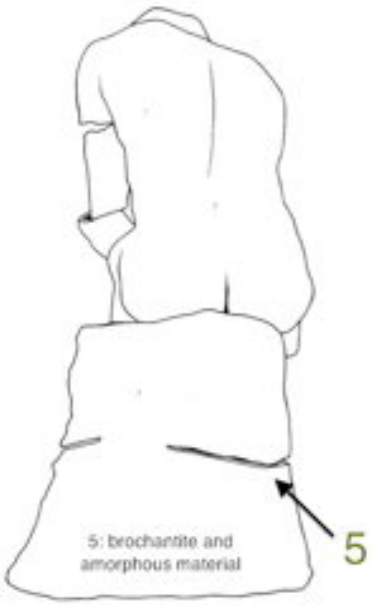
Results

Sample No.	Sample colour	analysis
1	Light green	antlerite
2	Dark green	Negative (no crystalline material, perhaps wax layer)
3	Yellowish green	Negative (sample perhaps insufficient)
4	red	negative
5	Yellowish green	Brochantite (although very little crystaline material)
6	Dark green	Brochantite and some antlerite

Conclusion:

The patina of the *Thinker* from the Singer museum Laren consists mainly of basic copper sulfates. Main constituents of green patina are brochantite and some antlerite.

Sample locations

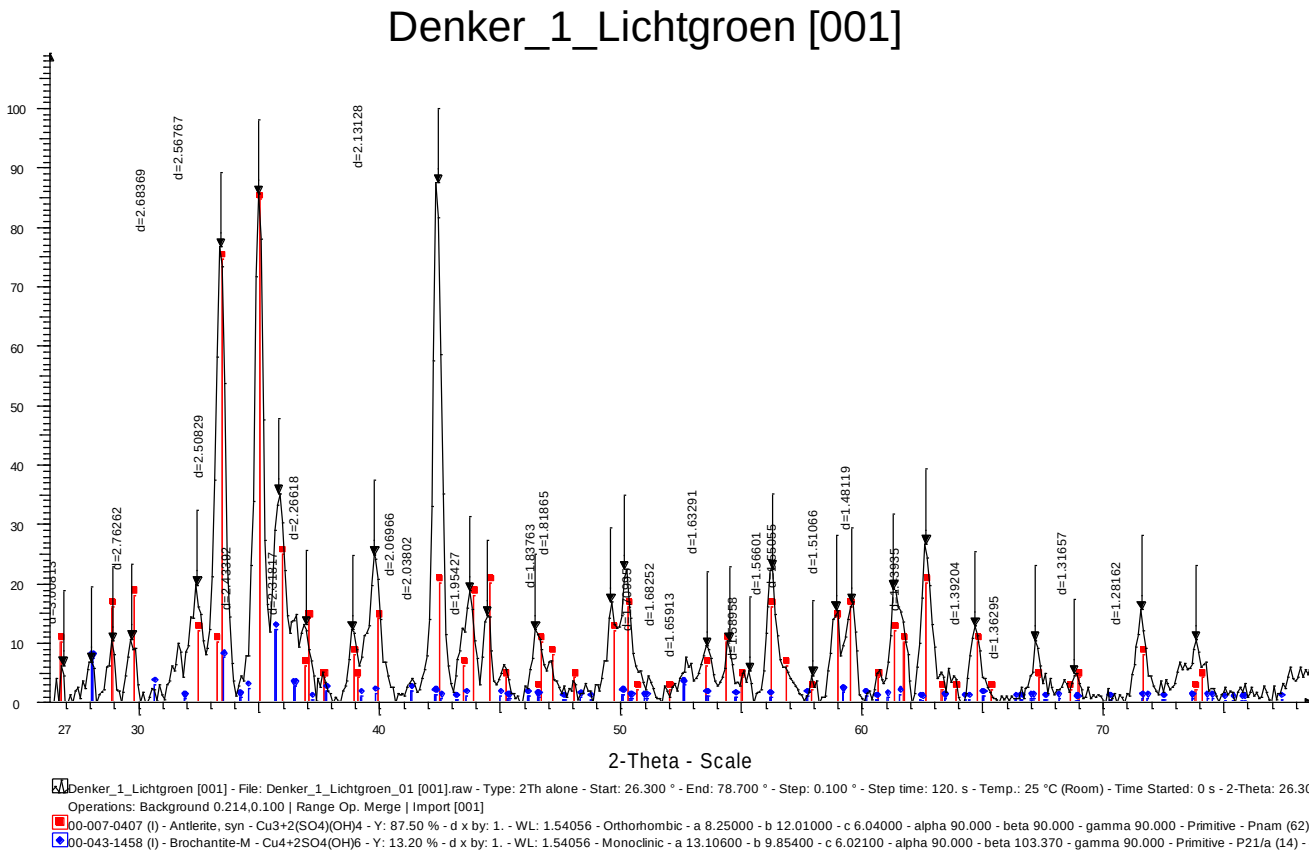


Drawing 1 Drawing 2 (drawing T.Davidowitz)

Drawing 3 Drawing 4 (drawing T.Davidowitz)

Sample 1, light green

Location of taking sample 1



XRD spectrum sample 1

Sample 2: dark green

Location of taking sample 2

Sample 3: yellowish green

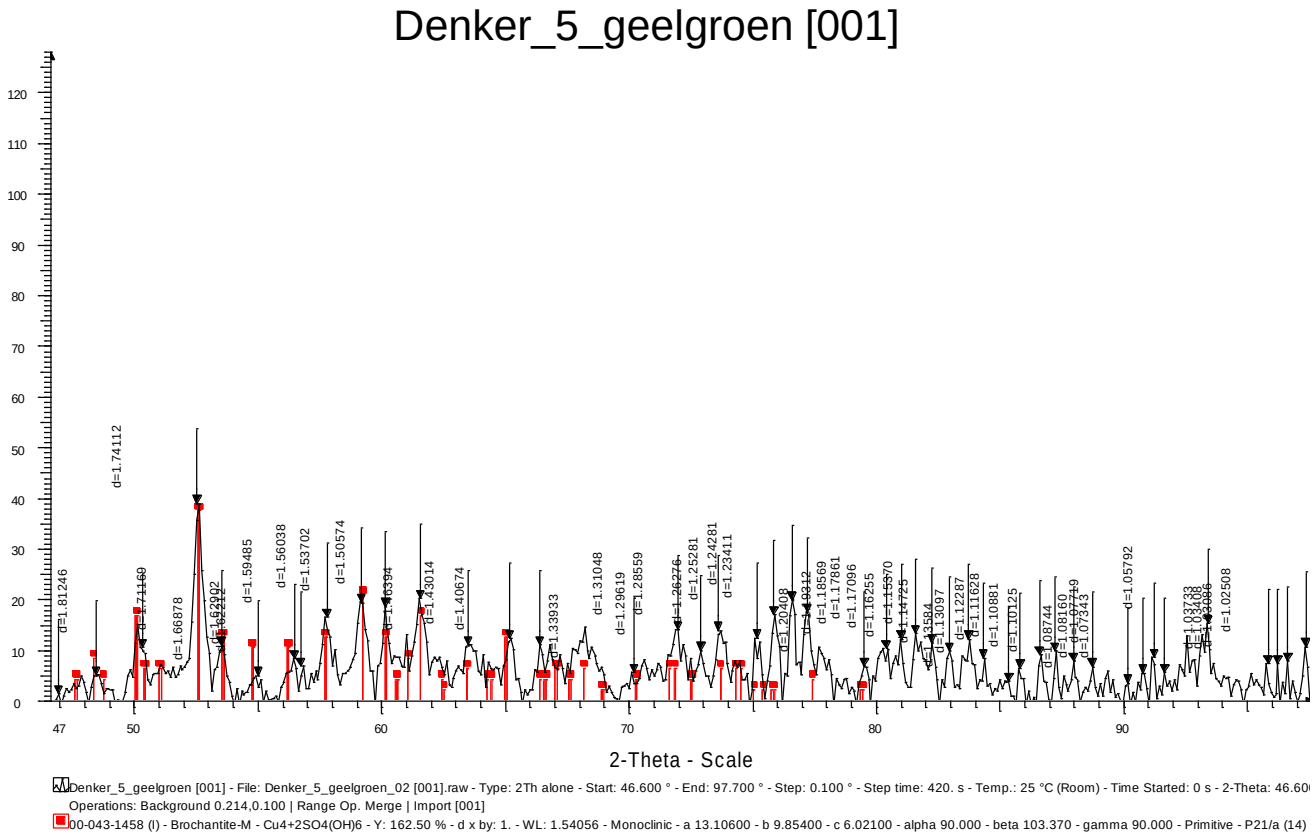
Location of taking sample 3

Sample 4: red

Location of taking sample 4

Sample 5: yellowish green

Location of taking sample 5

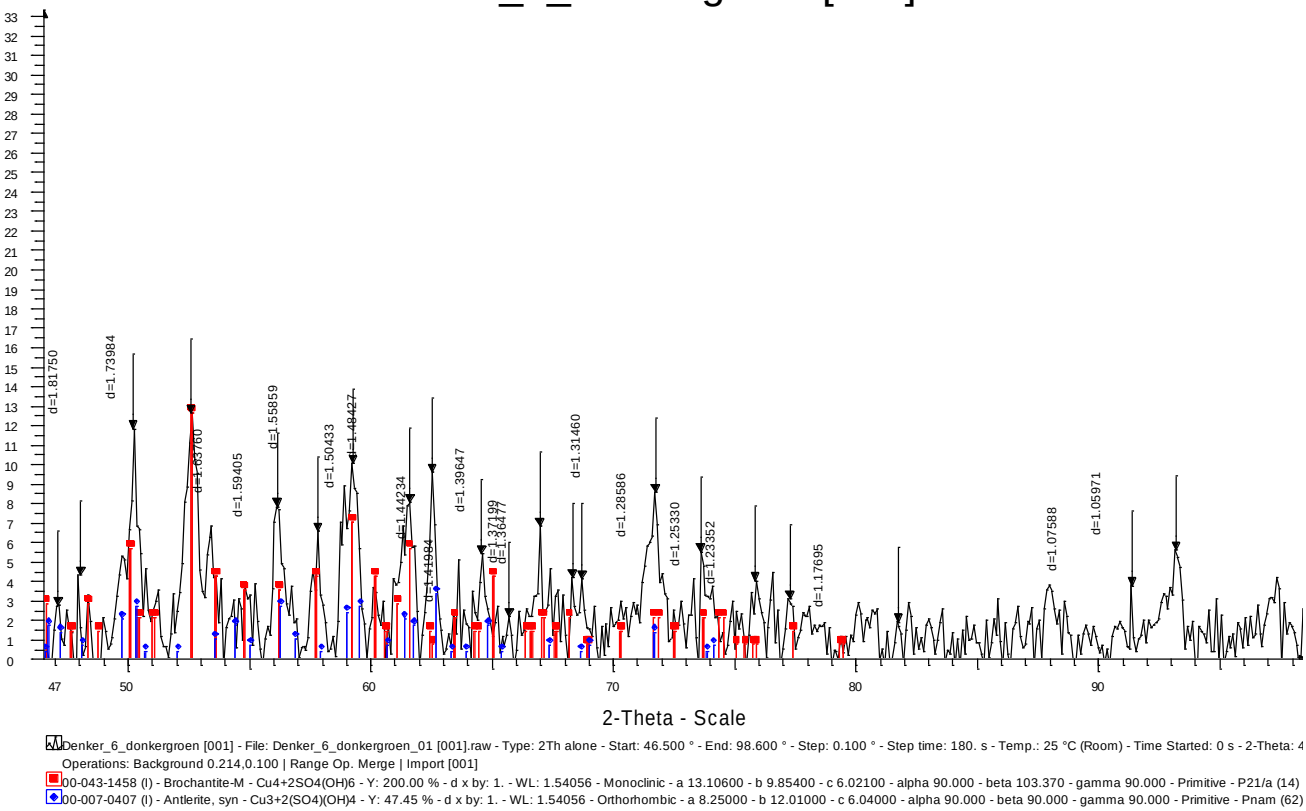


XRD spectrum sample 5

Sample 6: dark green

Location of taking sample 6

Denker_6_donkergroen [001]



XRD spectrum sample 6

Appendix 4: interview with Pierre Bingen

Jules Huret, "Un artiste: a propos du monument d'Eugène Delacroix" *L'Écho de Paris*, 7 October (1890): 2. (can be found online on the Gallica website: http://visualiseur.bnf.fr/CadresFenetre?O=NUMM-798992&I=2&M=imageseule)

ECHO DE PARIS. — 7 OCTOBRE

d'Anglemont, M. Saint Genest aura sa petite page dans cet intéressant recueil.

GRAINDORGE.

A L'ÉLYSÉE

M. le président de la République est rentré hier à Paris.

Le chef de l'Etat est arrivé à la gare de Fontainebleau, avec Mme Carnot, accompagné des colonels Kornprobst et Chamoin.

Du château à la gare, le président de la République a été accueilli sur son passage par de chaleureux applaudissements.

M. Carnot a été salué à son départ par le préfet de Seine-et-Marne, le sous-préfet de Fontainebleau, les généraux de Jessé et Moreau-Revel, et par les principales autorités du département.

Deux superbes bouquets ont été offerts à Mme Carnot par les dames de la ville.

Le train spécial, qui a quitté Fontainebleau à 3 heures 45, aux cris de : « Vive Carnot », est entré en gare de Paris à 4 heures 45.

M. Picard, ingénieur en chef du P.-L.-M., accompagnait M. le président de la République.

Le chef de l'Etat a été reçu par M. Constans, ministre de l'intérieur, accompagné de M. Demagny, directeur du cabinet et du personnel du ministère de l'intérieur, par M. Lépine, secrétaire général de la préfecture de police, remplaçant M. Lozé, et par le colonel Lichtenstein.

Une foule énorme attendait la sortie du président de la République et, lorsqu'il est parti en voiture, des cris nourris de « Vive Carnot! Vive la République! » se sont fait entendre.

Avant son départ de Fontainebleau, M. le président de la République et Mme Carnot ont laissé les sommes suivantes : 1,200 francs aux employés du château, 2,000 francs au bureau de bienfaisance, 500 francs à l'Orphelinat, 300 francs à l'Asile maternel, 300 francs à l'œuvre des sentiers de la forêt, 400 francs à un certain nombre de familles nécessiteuses non inscrites au bureau de bienfaisance, 200 francs à la Société de secours mutuels de Saint-Roch, 600 francs aux employés de la Compagnie des chemins de fer P. L. M. et diverses autres allocations discrètes dont le montant ne serait pas à dédaigner.

La voiture de M. le président de la République est arrivée à cinq heures dix minutes à l'Elysée, où le 11[e] de ligne était de service à cinq heures. M. Carnot était

de sa vie au *Triomphe de la République*, et qu'on a décoré hier des palmes académiques, sans qu'il bronchât, Bingen va nous le dire.

Je suis allé le voir, samedi, dans son atelier solitaire de la rue des Plantes, là-bas au diable, près des fortifications.

Je me heurte dès les premiers pas contre les énormes moulages du *Triomphe de la République*, l'œuvre géniale et grandiose de Dalou, qu'on a eu l'idée baroque d'exiler sur la place de la Nation. Bingen, qu'on a été chercher, vient au devant de moi. Il est en tenue de travail, il a le teint animé, les yeux luisants d'un homme qu'on surprend au milieu d'une occupation qui l'absorbe. Quand je lui ai expliqué la curiosité qui m'amène, en ajoutant que je sais qu'il n'est pas un ouvrier ordinaire, il me répond, avec cette idéale simplicité des artistes convaincus :

— C'est vrai, tout le monde ne peut pas faire ça ! Il faut aimer son métier, il ne faut pas être pressé de gagner de l'argent, il faut peut-être même se résigner à n'en gagner jamais beaucoup... Moi, j'ai l'air de marcher à reculons dans mon siècle ; il y a des omnibus, des voitures, des chemins de fer, de l'électricité, eh bien ! je vais à pattes, et j'irai toujours à pattes ! Je suis plus longtemps en route, c'est évident, mais je suis plus sûr d'arriver.

Tout en se livrant à ces considérations si peu fin-de-siècle, le fondeur me guidait à travers ses ateliers. Il y avait là les moules de plâtre des formidables lions de Dalou, et le Génie qui, le flambeau allumé, les mène. Dans ce coin sombre d'atelier, parmi le désordre et la poussière, ce morceau de plâtre sali resplendissait d'une immarcessible beauté.

— C'est donc vous qui fondez toutes les œuvres de Dalou ?

— Oui, et encore beaucoup de celles de Falguière, de Barrias, de Rodin, de Carrière, de Dubois, d'Injalbert.

J'étais presque anxieux de savoir quel art mystérieux pratiquait ce fondeur dont on m'avait parlé comme d'une sorte d'ouvrier du moyen-âge, ne ressemblant en rien à ses contemporains et usant encore, au dix-neuvième siècle, de procédés vieux comme le monde.

— Oh ! me dit-il, la fonte à cire perdue n'est ni un secret ni une nouveauté ; on l'a toujours pratiquée, seulement ça ne s'apprend nulle part, il n'y a ni explication, ni exemple qui puisse vous l'enseigner : il faut chercher soi-même et longtemps ; il faut être curieux, adroit et patient, oh ! oui, patient ! Et puis, voyez-vous, il faut aimer son métier par-dessus

Ces simples mots résument toute la vie de Bingen.

On a pu voir, hier, au Luxembourg, que cette ambition est réalisée.

JULES HURET

Le Monument de Delacroix

Il a été inauguré hier après-midi, à 2 heures, au Luxembourg, dans l'allée des Platanes, devant tout ce que Paris compte d'illustre dans les Arts et dans les Lettres.

Aussitôt le ministre arrivé, reçu à la grille du nouveau musée par M. Auguste Vacquerie, président du Comité de souscription, le voile est tiré et le monument apparaît au milieu des verdures qui commencent à se piquer de jaune. Il fait plein soleil à ce moment, et des rayons qui se sont faufilés à travers les branches viennent jouer sur le bronze des allégories.

Un tressaillement passe [en la foule, les yeux sont braqués sur l'œuvre admirable de Dalou et ne s'en détachent pas une seconde. Un édicule en marbre blanc émerge d'un bassin et supporte à son faîte le buste de Delacroix. Ce buste, on le sent à l'émotion curieuse des regards que lui jettent tous ces artistes qui sont là, paraît animé du souffle de la vie. L'œil perçant, profondément enfoncé dans l'arcade sourcilière et sous les paupières mi-closes, le menton carré, les maxillaires puissants de l'homme volontaire et du lutteur, sont là, comme en son portrait du Louvre, dans leur vivante éloquence. Sur un soubassement de marbre, le Temps ailé soulève dans ses bras la Gloire sous les traits d'une femme qui, dans un élan de tout son corps, tend vers le buste les palmes du triomphe tardif. En bas, assis sur le soubassement de marbre, Apollon, le cou tendu, les traits illuminés d'une joie divine, fait le geste d'applaudir de ses deux mains ouvertes.

Commencent les discours.

M. Vacquerie, souhaitant la bienvenue au ministre, fait la remise du monument à l'Etat. Il dit :

L'éditeur de Montaigne rougissait lorsqu'on lui parlait des *Essais*. Nous n'avons pas la faiblesse de nous croire si solidaires du monument dont nous ne sommes que les éditeurs, et dont nous ne nous sentons nullement gênés pour admirer tout haut cette œuvre superbe, le bâtiment de marbre du dieu enfin exaucé, le geste puissant dont le Temps élève la Gloire à la hauteur du génie, l'élan passionné de la Gloire, la fierté pleurante du buste, et plus encore que chacune des figures, l'ensemble magistral, le jet triomphal de la composition, l'harmonie de cette spirale irrésistible qui vous emporte dans son enroulement.

Puis il remercie les souscripteurs et tous ceux qui l'ont aidé dans sa lourde tâche de président du comité. Et il conclut :

C'est grâce à tous ces concours que nous avons pu entreprendre et mener à terme ce monument qui est une consécration et une réparation. C'est grâce à tous ces concours que justice est enfin rendue pleine et entière à l'admirable peintre-poète, à l'un des plus éclatants représentants de l'héroïque

de service. A six heures, M. Carnot était déjà dans son cabinet de travail où il recevait M. de Freycinet, président du conseil.

Le président de la République revient à Paris en excellente santé, et Mme Carnot est plus disposée que jamais à supporter, avec sa grâce charmante habituelle, l'assaut des fêtes et des réceptions de cet hiver.

UN ARTISTE

A propos du monument d'Eugène Delacroix

C'est hier qu'a eu lieu l'inauguration du monument d'Eugène Delacroix au Luxembourg. Le nom de Dalou, de l'artiste superbe et incomparable, a été hautement prononcé parmi les éloges officiels, et tout ce qu'on en a dit est resté au-dessous de la vérité. Mais Dalou a un *collaborateur*, — je souligne exprès le mot, — un collaborateur intime, obscur modeste, et dont on a peu parlé. Quand le ministre s'est levé pour lui donner les pauvres palmes académiques, on a eu tout le mal du monde à le découvrir dans la foule et à le faire avancer. Il aime et admire le maître, il le sert avec la ferveur, la passion d'un disciple, et c'est par lui que l'œuvre de Dalou vivra dans l'intégrité absolue de sa conception et de sa forme.

Assez généralement, je crois, on ignore quels sont les procédés de reproduction des œuvres d'art et ce qui les différencie les uns des autres.

Il est convenu que tout fondeur d'une œuvre artistique importante assume une grosse responsabilité, que la besogne est délicate et que l'ouvrier doit être intelligent en même temps que patient et adroit : c'est vrai au point de vue général, mais c'est bien autrement vrai quand il s'agit d'œuvres comme celle que nous avons vue hier et qui laisse bien loin derrière elle tous les bronzes dont foisonnent les places publiques.

Les maisons de fonderie sont des entreprises industrielles comme les autres entreprises ; il s'agit, là comme ailleurs, d'exécuter le plus de travail possible dans le moins de temps possible.

Pour cela, que fait-on ? On apporte à l'atelier l'œuvre d'un sculpteur. Là, on l'examine, on en fait le tour, et... en avant la scie ! Voici la statue sur-le-champ guillottinée, les bras et les jambes sont coupés, le torse dépecé, les accessoires du sujet séparés et rognés : bientôt l'artiste sensible peut se croire, au milieu de ces forges allumées, de ces fours, de cet appareil [illegible] vous, il faut aimer son métier par-dessus tout. Alors, ça devient plus fort que soi, on veut faire bien malgré tout et on se fiche du reste, comme M. Dalou.

— Il y a longtemps que vous vous y êtes mis ?

— Dix ans. Avant, j'étais ouvrier dans une grande fonderie d'art de Paris. Mais quand je tondais une pièce, il me semblait que je l'abîmais, que je la gâchais ; je voyais bien que la chair pétrie par l'artiste c'était de la chair, tandis que ce qu'on lui rendait à la place c'était du chaudron. Oui, du chaudron ! Ça se comprend : on coupe un bras en deux ou trois morceaux ; s'il est plié, on arrive à quatre ou cinq sections ! Comment voulez-vous que tout ça se raccorde et que la pensée reste ?

On taille, on rogne, on ébarbe, on polit les coutures, on triche ! le ciseleur achève tout ça, et la reproduction en bronze n'est plus que le fantôme de l'œuvre rêvée et modelée par le sculpteur.

Je me suis demandé ce qu'il fallait faire pour rendre à celui-ci, sans la moindre altération, la reproduction de son œuvre ? Il n'y avait qu'un moyen, difficile et coûteux, mais sûr, c'était de fondre en un seul morceau toute une figure. J'ai cherché longtemps, longtemps, j'y ai un peu blanchi, mais, vous voyez, voici la *Justice* de Dalou, qui a six mètres de hauteur et que j'ai fondue d'un seul bloc !

— Comment procédez-vous ?

— Voilà. Oh ! ça n'est pas simple ! L'artiste m'apporte son œuvre dont je fais avec le plus grand soin un moulage en terre ; je rogne sur ce moulage, et *sur toute sa surface*, une certaine épaisseur de terre, et j'obtiens ainsi un noyau, c'est-à-dire une espèce de squelette, une mutilation, si vous voulez, de la statue dont la chair est partie mais qui, pourtant, a conservé intégralement ses proportions et son allure générales. Je fais cuire alors ce *noyau* ; quand il est cuit, je le recouvre entièrement de cire à modeler, et je le livre, ainsi préparé, à l'artiste.

— L'artiste est donc obligé alors de recommencer ?

— Tout simplement !

J'avais compris. Mais je me disais qu'il fallait que l'artiste fût bien soucieux de son œuvre pour consentir à refaire le dur travail du modelage sur des surfaces aussi considérables que celles, par exemple, du monument de Delacroix et du *Triomphe de la République*, pour rechercher, dans un nouvel élan d'inspiration, la chair et l'expression définitive de sa première création.

Bingen me conduit devant le monument en cire de Victor Noir du même Dalou, et je reste saisi de la vie extraordinaire qui se dégage de cette œuvre qu'on sent modelée avec amour.

[illegible] génération de 1830, à une des grandes étoiles de la grande constellation, au créateur resplendissant qui peut regarder en face les peintres de tous les pays et de tous les temps, et dire, avec la confiance de Corneille :

Dans toute la peinture, il n'est pas de rival
A qui je fasse tort en le traitant d'égal.

Nous offrons à l'Etat, et nous remettons aux mains du ministre de l'instruction publique et des beaux-arts, sachant que nous le remettons en bonnes mains, ce chef-d'œuvre qui glorifie l'auteur de tant de chefs-d'œuvre.

M. Bourgeois, ministre de l'instruction publique et des beaux-arts, répond. Il passe en revue l'œuvre de Delacroix.

Dans le vaste domaine de son art, aucune partie ne lui reste fermée et, dans toutes, il marque sa place en maître. Lorsque l'on essaie d'embrasser d'un regard son œuvre entière, on est partagé entre l'admiration et l'étonnement devant ce qu'a produit cette existence relativement courte, car il mourut dans la force de l'âge et du génie. Les grands noms et les grandes actions de l'antiquité, les faits héroïques du moyen âge, les grands poètes de tous les temps, la pensée romantique, l'histoire de France, les aspects si opposés du Nord et de l'Orient, la nature, l'homme, tous les êtres, depuis les humbles modèles de la nature morte jusqu'aux grands fauves, il aborde tout par une création incessante.

Et il fait l'éloge du sculpteur en concluant :

L'auteur de *Mirabeau* et du *Triomphe de la République* a répondu à votre attente. Maître, l'œuvre dont le voile vient de tomber devant nous est un chef-d'œuvre. Vous ne nous avez pas seulement rendu l'image humaine et douloureuse du grand artiste, vous avez su dans ce groupe de bronze nous raconter sa vie, ses souffrances et son triomphe. Vous nous avez dit comment, d'un mouvement puissant et sûr, le temps sait faire son œuvre de réparation ; comment, après ces épreuves souffertes par le génie, s'élève et grandit pour lui, dans la pure lumière, la gloire radieuse, immortelle ; et dans le geste magnifique dont votre Génie des arts salue cette apothéose, vous avez su mettre, avec une force souveraine, l'applaudissement des siècles, le jugement définitif de la postérité.

M. Delaborde, au nom de l'Académie des beaux-arts, a prononcé quelques paroles. Et M. Paul Mantz a clos la série des discours en s'écriant :

Au nom de la justice, qui pour Delacroix fut si lente à venir, nous saluons devant le beau monument du, Dalou la mémoire vivifiée du grand lyrique.

Puis, M. Mounet-Sully s'est avancé, et de son magique organe il a lu les belles et émouvantes strophes de notre éminent collaborateur Théodore de Banville, que nous donnons d'autre part. Le hasard m'avait placé, dans la foule, près de M. Leconte de Lisle ; et je dois, à ma sincérité de reporter fidèle, de dire qu'il a fait peu d'efforts pour entendre les discours, qui nous arrivaient mal, d'ailleurs.

En revanche, quand Mounet-Sully a eu chanté son premier vers, l'auteur des *Poèmes Barbares* a dressé l'oreille et a écouté religieusement l'idéale musique des quatrains. Il pensait sans doute que'n somme c'était surtout ces vers et ce bronze qui pouvaient prétendre à glorifier aujourd'hui le grand peintre.

Avant de clore la cérémonie, le ministre a fait chercher M. Bingen, fondeur du monument. Tout le monde, excepté Bingen, croyait qu'on allait le décorer. Le ministre n'a trouvé sur lui que les palmes académiques.

forges allumées, de ces fours, de cet appareil d'enfer, et de ces hommes au torse nu, devant une peuplade de cannibales qui se préparent à dévorer l'enfant de son rêve et de son génie...

Et, en effet, qu'arrive-t-il? L'œuvre, ainsi morcelée, est moulée, le bronze liquide est versé dans les moules qu'il remplit. Mais voici le moment de l'ajustage. Le bronze refroidi s'est resserré... et il s'est resserré inégalement, puisque les morceaux fondus, tête, torse, bras, étaient de volumes inégaux! Aussi, la jambe ne s'emboîte plus dans la cuisse, le bras ne s'emmanche plus dans l'épaule, la moitié du cou est plus maigre que l'autre moitié, et il faut trancher dans tout cela, limer, polir, pour arriver, tant bien que mal, à rendre au sculpteur l'apparence de son œuvre. Hélas! ce n'est plus qu'une apparence, en effet. Que sont devenus le joli mouvement de tête trouvé par l'artiste, la proportion, la force ou la délicatesse des attaches, l'harmonie générale du sujet, comme le charme et la vivante réalité des détails?

Comment donc faire? Comment font Dalou, Barrias, Falguière, Carriès, quand ils réussissent à susciter en nous, dans leurs reproductions de bronze, la sensation aiguë et complète de vie, d'harmonie et de vérité, que nous donnent à peine cinq ou six des bronzes de nos musées, et que nous refusent, hélas! les « bronzes d'art » de nos plus riches magasins!

Bingen, qui travaille, depuis deux ans, de la façon qu'on va voir, à la fonte du monument Delacroix, qui va donner encore trois ans de son talent, de sa passion, sent modelée avec amour.

— Alors, demandé-je à Bingen, votre moulage en bronze saura reproduire exactement toutes les délicatesses de ce modelé, les plis de la lèvre et les rides des yeux?

— Oui, monsieur, absolument, me répond-il, la chair de bronze aura cette élasticité, les plis auront exactement cette profondeur. Et tenez, voici comment je procède.

Prenant un pinceau très doux, il se mit à badigeonner de boue liquide la face en cire de Victor Noir.

— J'applique ainsi des couches successives jusqu'à obtenir une épaisseur de dix à quinze centimètres de terre. Il n'y a plus, ensuite, qu'à mettre le tout dans le four chauffé à la température voulue, pour faire cuire cette enveloppe qui recouvre entièrement jusqu'aux moindres parties du sujet. Une chaleur un peu plus grande fera bientôt fondre la cire, et j'aurai obtenu ainsi un moule en creux d'un seul morceau, au milieu duquel se trouvera le *noyau*, dont je vous ai parlé tout à l'heure, laissant entre lui et l'enveloppe extérieure, faite de mes badigeonnages superposés, la place *exacte* qu'occupait la cire. Je verse le bronze liquide dans cet interstice et, lorsque le tout est refroidi, je casse le moule : la statue, dans son mouvement exact et avec son modelé rigoureusement précis, apparaît fondue d'une seule pièce et je puis dire alors que, si le bronze pouvait se pétrir, l'artiste n'aurait pas fait autre chose!

Et il conclut, dans une frappante et belle ingénuité :

— C'est là toute mon ambition.

qu'on allait le décorer. Le ministre n'a trouvé sur lui que les palmes académiques.

J. H.

INFORMATIONS PARTICULIÈRES

DE *L'ÉCHO DE PARIS*

Election Législative

Une élection législative a eu lieu hier, à Rambouillet (Seine-et-Oise).

En voici le résultat :

MM. Vian	5.747
Paul de Jouvencel.	2.345
de Caraman.....	5.893

(Ballottage)

Il s'agissait de remplacer M. Barbe, décédé.

On assure que, dès la rentrée des Chambres, un député appartenant au centre déposera une interpellation sur la politique générale du cabinet.

Dans la séance qu'il tiendra aujourd'hui, le Conseil supérieur de la Légion d'honneur s'occupera presque exclusivement de l'examen des demandes d'admission dans les trois maisons d'éducation de la Légion d'honneur.

Le produit de l'octroi de Paris pour le mois de septembre dernier est supérieur de 80,147 fr. aux prévisions budgétaires, et inférieur de 1,531,308 francs au produit de septembre 1889.

Le produit des neuf mois écoulés de 1890 est supérieur de 2,707,409 francs aux prévisions budgétaires, et inférieur de 5,133,113 fr. au produit de la période correspondante de 1889.

Il importe de rappeler, pour expliquer cette moins-value, que l'année 1890 a donné des