Casting Rodin's Thinker

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

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Publication date
2019

Document Version
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Chapter 2 The casting of sculpture in the nineteenth century

2.1 Introduction

The previous chapter has covered the major technical developments in sand mould casting up till the end of the eighteenth century. These innovations made it possible to mould and cast increasingly complex models in sand moulds with undercut parts, thus paving the way for the founding of intricately shaped sculpture in metal. Research into the historical use of sand moulds for the founding of sculptures has been minimal and often limited to one artist or founder or a small geographical area, a thorough general overview is therefore lacking. A re-occurring question in the study of historic bronzes is whether these were cast in sand moulds before the nineteenth century.[282] Current scholarship however, has not been able to find convincing evidence yet of the use of complex sand mould casting to produce bronze sculptures before 1803.[283] This lack of knowledge regarding sand mould casting is also reflected in limited knowledge of the technicalities of this casting technique amongst curators and conservators.

One of the aims of this and the following chapters, is to clarify the use and the extend of the use of sand mould casting. Because of the alternating preference for the two main forms of casting, sand mould and lost wax, during the nineteenth century, sand mould casting cannot be covered in isolation. Part of this chapter will therefore also cover developments in the use of lost wax casting during the nineteenth century in the geographical area of Western Europe and Italy.

[282] In this thesis the terms bronze sculptures and bronzes will be used alternatively denoting hollow copper alloy sculpture of medium to large size, from circa 20 cm height and larger.
[283] Lebon. 2012g. 23. & Lebon, Elisabeth. 2012a. *La fonte au sable sous l'Ancien Régime: Possibilité d'application à la statuaire ? Le cas de Houdon*, Collections électroniques de l'INHA, 2012 [online] Available at: < http://inha.revues.org/3449>, [accessed 22 June 2018]

2.2 Evidence for the casting of bronze sculpture directly in piece-moulds before 1800

A reoccurring question amongst scholars of sculptural bronzes is whether sand mould cast bronzes are by definition nineteenth century and later. Many sand mould casts of Renaissance and Baroque bronzes exist and are assumed to be the product of nineteenth century foundries. This paragraph will examine possible evidence of sculpture casting in sand piece-moulds before 1800.

All major publications on bronze sculpture founding before 1800 such as Leonardo da Vinci, Gauricus, Biringuccio, Vasari, Cellini, Felibien, Boffrand, Mariette and Diderot, discuss, when covering the moulding and casting of sculpture, only the lost wax technique.[284] There is however, evidence of a piece-mould founding technique used in the eighteenth century which has received no attention in the literature on bronze casting.

This technique, using loam, is described in Sprengel's *Handwerke und Künste in Tabellen* from 1770.[285] Volume V contains under the heading *Das Gießen der metallenen Statuen*, an interesting account of piece-moulding in loam (*Lehmteilformerei)*.[286] Unfortunately the identity of the writer of this particular section, is not known. Peter Nathanael Sprengel (1737-1814), the editor of this encyclopedic series is most likely not the author. On page 75, introducing the account, it states that the description was taken from *Schauplatz der Natur*, Volume 10. A search for this earlier source has, up till now, been unfortunately unsuccessful. It refers probably to the following publication: *Schau-Platz der Natur, oder: Unterredungen von der Beschaffenheit und den Absichten der natürlichen Dinge: wodurch die Jugend zu weitern Nachforschen aufgemuntert, und auf richtige Begriffe von der Allmacht und Weisheit Gottes geführet wird* / [von Noël Antoine Pluche], published in Vienna around 1750. This was a German edition of Noël Antoine Pluche's *Le spectacle de la nature ou entretiens sur les particularités de l'histoire naturelle: qui ont paru les plus propres à rendre les jeunes-gens curieux, et à leur former l'esprit* published in Paris between 1732-51.[287] No example of this volume 10 of *Schau-Platz der Natur* can be traced in Worldcat and the original French edition does not contain any description on founding.

The writer described the indirect moulding of a life-size model of a horse and in the introduction, he states that the author of the original text from the *Schau-Platz der Natur* must

[284] 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; Brockhaus, Heinrich. *Über die Schrift des Pomponius Gauricus" De sculptura"(Florenz, 1504)*. FA Brockhaus, 1885; Biringuccio, Venice, 1540; Vasari, Maclehose, and Baldwin Brown. 1960; Cellini and Ashbee. 1967; Félibien, André. *Des principes de l'architecture, de la sculpture, de la peinture, et des autres arts qui en dependent. Avec vn dictionnaire des termes propres à chacun de ces arts*. J.B. Coignard, 1676; Boffrand, 1743; Mariette, 1768; Diderot, 1771.

[285] Sprengel, Peter Nathanael. "Meßing- und Eisenarbeiter" *P. N. Sprengels Handwerke und Künste in Tabellen*. Fortgesetzt von O. L. Hartwig. Fünfte Sammlung, Verlag der Buchhandlung der Realschule, 1770.

[286] Sprengel , 1770, IV. *Das Gießen der metallenen Statuen*, 80-84.

[287] I would like to thank Ad Stijnman for providing this information.

have had the equestrian statue of Elector Friedrich Wilhelm in mind. This statue, which still survives (fig. 2.1), was modelled by Andreas Schlüter (1659 or 1660-1714) and cast by the founder Johann Jacobi (1661-1726).

Fig. 2.1. Andreas Schlüter, *statue of Elector Friedrich Wilhelm*, bronze. Cast by Johann Jacobi in 1700 and erected in 1703. Current location in front of castle Charlottenburg in Berlin. (image Wiki commons)

This foundry pattern, which can be of plaster or clay, is first given a coating of oil or fat before applying the loam. The loam is not applied in the usual way, as a series of thin uniform layers covering the whole of the pattern, but in parts (*stückweise*).[288] These parts are so fabricated as to fit snuggly together and thus form, when put together, the entire negative mould of the pattern. The mould pieces are marked to facilitate re-assembly. The author prefers to use loam over plaster for the mould pieces because he considers plaster too susceptible to fracturing. When the mould is finished the core can be prepared by applying sheets of loam or wax to the inside of the mould.[289] The use of these sheets is akin to the 'lasagna' method described earlier in the chapter on Gonon's casting of the monumental bronze of Jeanne d'Arc.[290] The sheets are made by rolling with wooden rolling pins, similar to the rolling of dough in a kitchen.[291] In areas with deep and detailed surface relief the loam did not form itself very well to the mould impression and the author recommends therefore to use wax instead.[292] The core was made from loam mixed with horse manure and hair or made of plaster mixed with brick dust.

[288] Sprengel 1770, 81.
[289] The description does unfortunately not give details about the drying of the loam and how to prevent any cracking or distortion of the loam.
[290] See sub-chapterr 2.3.1 *Gonon and the casting of the monumental bronze of Jeanne d'Arc* in this thesis.
[291] "Sie rollen nemlich den Lehm mit Rollhölzern, wie man den Teich zu den Kuchen rollt, und damit sie ihm eine gehörige Dicke geben können"; Sprengel 1770, 81.
[292] This 'lasagna' method for making the core might be the cause of the smooth, angular contours sometimes observed on the inside surfaces of late seventeenth and eighteenth century bronzes, which can be mistaken for evidence of sand mould casting; Bassett and Bewer 2014, 205-214.

During the most recent conservation treatment of this equestrian statue of Elector Friedrich Wilhelm in 2004, borescopic investigation of the interior revealed the core to have a sandy appearance.[293] Unfortunately no sample material was removed for analysis to establish the composition of the core. As mentioned earlier lost wax cores, loam as well as plaster based, contain often substantial parts of sand and/or brick dust giving this core material an appearance similar to sand cores both in colour as well as texture. The conservation treatment did not establish whether the statue was cast using the loam piece-moulding technique. This is not surprising since all evidence of the use of piece-moulding would have been on the exterior surface which would have been removed due to extensive finishing of the surface. The main statue of the monument, rider plus horse, were according to the treatment report, expertly cast in one piece, with very few casting flaws.[294] This casting in one piece or pour was only a few years after Balthasar Keller achieved a similar feat with François Girardon's *Louis XIV on horseback*, cast in 1692 and erected in the place Louis-le-Grand (now Place Vendôme) in Paris in 1699.[295]

It is rather tempting to see the above-mentioned piece-moulding using loam as a precursor for the piece-moulding in sand, but one has to be careful in doing so.[296] Sprengel's publication appeared seventy years after Jacobi cast the statue and the source Sprengel took his information from dates probably from the middle of the eighteenth century still half a century after Jacobi's feat. What value has a secondary source writing such a long time after the technical event took place? Theoretically the writer of the entry on founding the *Schau-Platz der Natur* could still have recorded his experiences after such a long date. The descriptions by Keller's foreman Boffrand, of the founding of *Louis XIV on horseback* were published in 1743 while the statue was already cast in 1692. It is significant that Sprengel mentions that the author of the founding entry in the *Schau-Platz der Natur* tells his readers to have an equestrian statue like Jacobi's in mind, he does however not state that it was Jacob's actual working method. One can find Sprengel's description repeated by Tiemann in 1803 and 1806.[297] Basically it is one source, the elusive volume 10 of the *Schau-Platz der Natur*, repeated several times. There is only one other eighteenth century source I have been able to trace which also describes the use of the piece-moulding of a refractory mould: Robert Dossie (1758) mentions the use of a clay (mixed with sand or coal powder) piece-mould for the founding of statuary or any other metal:

> In the same manner figures, busts, etc. may be cast of lead, or any other metal, in the molds of plaster; only the expense of plaster, and the tediousness of its becoming sufficiently dry, when in large mass, to bear the heat of melted metal, render the use of

[293] Conservation treatment report Haber and Brandner. *Dokumentation, Berlin – Reiterstandbild Großer Kurfürst*, Haber & Brandner GmbH Metallrestaurierung (2004): 23.
[294] This was also confirmed in personal communication (November 2015) with the conservators who worked on the statue.
[295] Desmas, Anne-Lise. "Boffrand's and Mariette's Descriptions of the casting of Louis XIV and Louis XV on Horseback." Bourgarit et al 2014, 234.
[296] Martins 1824, 225.
[297] Tiemann. 1803 & Tiemann, Wilhelm Albrecht. *Neue artistisch-technische Encyklopädie, oder gründliche, auf Erfahrung beruhende Anweisung zur Verfertigung der vorzüglichsten Kunstsachen: in alphabetischer Ordnung herausgegeben. 1, 1*. Frölich (1806): 168-175.

> clay, compounded with some other proper materials, preferable where large subjects are in question. The clay in this case, should be washed over till it be perfectly free from gravel or stones; and then mixed with a third or more fine sand to prevent its cracking: or. Instead of sand, coal ashes sifted till they be perfectly fine is preferable.[298]

This rather cryptic term '*any other metal*' could include bronze because it would be technically possible to cast high temperature melting metals such as copper alloys in this type of mould, when dried. The only other metal used in the eighteenth century for casting would be tin, which was several times more expensive than lead and highly unusual to be used for casting large sculptures.[299] Sprengel's account, together with Dossie's, are the earliest descriptions of the piece-moulding of a refractory sculpture mould which was subsequently used for casting bronze statuary directly into.[300]

Whether the accounts by Sprengel and Dossie are the earliest descriptions of sand mould casting, depends on whether one regards Sprengel's loam or Dossie's mixed clay (with a third or more sand) as a form of sand. Krünitz defines *Lehm* as a form of clay mixed with sand, ochre and some chalk, which is not dissimilar to high clay moulding sand.[301] In an earlier chapter called *Der Roth-, Stück- und Glockengießer* (Brass/bronze, gun and bell founder) Sprengel described the properties of moulding loam for the bi-valve moulding of a flat iron:[302] the loam should not be too clayey to prevent cracking during heating and loam that is too clayey can be mixed with extra sand in addition to the dried and cured horse manure and hair which are always added to the loam.[303] This type of loam is very similar to the type of moulding loam used by bell founders and differs from the nineteenth century moulding sand which is not heated and not mixed with organic fibers.

In this respect it is interesting to go back to the earlier mentioned description of Stilarsky's first attempts of the founding of iron sculptures in 1813.[304] Stilarsky was experiencing difficulties with the bonding power of Fürstenwalder sand. He used clay water to increase the clay content but still resorted to use loam false cores for the most intricate parts.[305]

Again, the question hinges on the sand clay ratio of the moulding material. The Fürstenwalder sand was clearly a sand because of the lack of clay and the loam (*Lehm*) was not described as a clay for which the Germans use the term *Thon*. The use of loam pieces by Stilarsky seems

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[298] Dossie 1758, 355-356.

[299] The plaster available in the eighteenth century would not be able to withstand the high temperatures of cast iron.

[300] Eliminating the use of an intermediary plaster piece-mould.

[301] "Der Lehm, ist eine schmierige, ziemlich zusammenhangende, mit Sand und Eisen=Erde, auch etwas Kalk=Erde, vermischte Thon=Art." Krünitz, Johann Georg. Oekonomische Encyklopädie. Volume 70: *Lehm - Leib=Regiment*. J. Pauli [etc.] (1804): 6.

[302] Sprengel 1770, 13 –17.

[303] Ibid; 13.

[304] *12 Zoll hohe Statue*, (1 Zoll = 1/12th Fuß= 26.15mm, 12 Zoll = 1 Prussian Reichsfuß = 313 mm) Martins 1824, 226.

[305] "Er bediente sich zur Formmasse des feinen Fürstenwalder Sandes, den er met Lehmwasser tränkte, …und nur zu den tieffsten stellen, wozu er dieser Masse nicht hinreichend bindende Kraft zutraure, wendete er Lehmkerne an." Ibid 226.

therefore to be a continuation of the use of loam piece-moulding as described earlier by Sprengel. In Dossie, the clay is mixed with a third of more sand. These clays were probably not pure clays, with all grains <2µ, to start with and the addition of sand could well give this clay/sand/loam mixture a ratio sand/clay approaching 45/55, which would class them as a sandy (clay) loam.[306] Sprengel's use of the term *Lehmteilformerei* meaning loam piece-moulding was in fact a correct term for this type of moulding, and the later universally used term sand moulding or casting is basically incorrect because the clay content usually classifies it as a loam.

Simonds, covering the sand moulding technique in 1886 and 1889, actually used the more correct term loam moulding instead of sand moulding: "The trunk of the figure was laid in an iron box or flask of suitable size, and loosely packed in with the loam used by bronze founders."[307] Later, in 1896, Simonds literally used the term loam piece-moulding: "… in the same way as in ordinary loam piece-moulding."[308] The ordinary moulding technique Simonds refers to is standard sand moulding using a French type moulding sand. If the moulding technique as described by Sprengel used a sandy loam than this would be the earliest account of a form of sand mould casting, placing the date of the recorded first use almost a century earlier than previously thought. This would be a significant discovery because it challenges current views that sand cast bronzes are by definition from the nineteenth century.

The extent of the use of loam or clay piece-moulding is difficult to determine. The early textual evidence found so far, describes only the use of these techniques for the founding of monumental bronzes. These early written sources describing the loam/clay piece moulding, are scarce, basically only Dossie and Sprengel, the latter repeated several times by Tiemann. Whether the use of these piece-moulding techniques was common practice is difficult to establish. Both Dossie's and Sprengel's descriptions do not specifically state that this method was anything special or used only very occasionally. The study of the surviving bronze sculptures could also give more information although this should be carried out with care. Apart from the evidence the core can provide, it is very difficult to identify the use of piece-moulding on a finished bronze because all the evidence on the surface, in the form of flashing, has been removed in the finishing stage. Sometimes a weathering pattern on an outdoor bronze showing differently coloured lines in the patina can be observed which can be indicative of finished mould line flashes.[309]

[306] See also figure 1.4 USDA and the UK-ADAS soil textural triangle.
[307] Simonds 1886, 250.
[308] Simonds 1896, 665.
[309] Naudé, Virginia Norton. *Sculptural monuments in an outdoor environment: a conference held at the Pennsylvania Academy of the Fine Arts, Philadelphia, November 2, 1983*. The Academy (1985): 82. A probable explanation for this is that in the spots were the flashing has been removed the metal will have a slightly different metal structure due to a difference in cooling rate. The metal in these spots will react differently with the outdoor environment and will produce therefore a slightly different patina in these places.

2.3 The casting of sculpture in France using sand moulds: 1800-1900

The previous chapter concluded with the innovative founding of cannon in revolutionary France. With the investment by the new republic in foundries, materials and the training of foundry men, a formidable industry was set up with the capacity for large scale cannon production.[310] However, sufficient bronze cannon were soon produced, forcing the foundries and foundry men to look for other type of work for their foundries. Lebon has shown that some art founders in the post-revolutionary era were directly trained in the sand mould casting of cannon from 1794 onwards by Monge's teams, e.g. Jean-Baptiste Launay (1768-1827) and Jean François Denière (1775-1866).[311] Other founders such as the famous founder Charles Crozatier (1795-1855) and Louis Richard (1791-1879) acquired their sand moulding skills in workshops run by former revolutionary cannon founders such as Michel Brezin (1758-1828).[312] Since there is no proof of the application of sand moulding for the creating of complex sculpture before the French Revolution it is assumed that these, revolutionary founders, used their skills of moulding cannon in sand later for the production of industrial castings and art foundry.[313] However the earliest reference found in this research, by Hans Otto Philipp Martins (1777-1861), attributes the invention of the use of sand piece-moulds for the founding of sculpture to the Parisian founder Jean-Charles Rousseau (1756-1809) in 1798: "This, already 34 years ago described moulding method,.. invented in the year 1798, and first applied for monumental bronzes in 1800, for which the French founder was praised…"[314]

Martins unfortunately does not give any references for this date and neither do the French sources. This reference by Martins is somewhat puzzling since he mentions in 1824 that this new sand moulding technique, invented in 1798, was already described 34 years earlier. Martins must have confused 24 years with 34 years or he has got his dates wrong and meant to have written 1788 instead of 1798. This relative unknown founder Rousseau, for whom there is no connection yet with revolutionary gun founding, is mentioned in 1805 again in connection with sand moulding, now working together with the young founder Honoré Gonon (1780-1850).[315] This report gives the credit for the invention of piece-moulding in sand to Gonon. Rousseau, possibly descending from a family of founders active since the early eighteenth century, employed Gonon and is registered as a founder in *l'Almanach du*

[310] Lebon, 2012g, 15-19.
[311] Ibid, 21-22.
[312] Lebon, 2012e and Lebon, Élisabeth. 2012f. 'Brezin, Michel (1758- 1828)' in 'Répertoire' in *Le fondeur et le sculpteur*, Paris, Ophrys (« Les Essais de l'INHA »), 2012, [online], consulted on 12 January 2015. URL : http://inha.revues.org/3474>[accessed 22 June 2018]
[313] Lebon 2012g, 21-22.
[314] Translation author: "Diese bereits vor 34 Jahren gelieferte Beschreibung einer Formmethode, … deren Erfindung im Jahre 1798, und deren erste Anwendung im Großen beim Bronzeguß im Jahre 1800, von dem französischen Gießer Rousseau gerühmt wird, …" 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.) 3rd Year (1824): 226.
[315] 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.

Commerce at the address: Rotonde and Div. du Temple.[316] Very little is known about Rousseau's foundry activities. However, a great deal more is known on those of Honoré Gonon.

2.3.1 Gonon and the casting of the monumental bronze of Jeanne d'Arc

Honoré Gonon came presumably from a family of metalworkers since his brother Amélie Jacques Gonon (1773-1831) was also working in the foundry trade. His experimental work on sand mould casting in his early twenties, culminating in the casting of the first sand cast monumental bronze in 1804, was awarded a silver medal by the *Athénée des arts.*[317] When in 1804 Honoré Gonon managed to cast the first large bronze sculpture in sand, he started a branch of the foundry industry that would last for more than hundred and fifty years.

The report by Jean-Baptiste Rondelet et al, dating 13 Messidor of the twelfth year of the French Republican Calendar (2nd July 1805),[318] gives the account of the moulding and casting in sand of this bronze of Jeanne d'Arc (fig. 2.2) by the sculptor Edme-François-Étienne Gois (1765-1836).[319] In this detailed description we learn that the foundry of Jean-Charles Rousseau used an innovative sand mould casting technique, previously only used to cast statues up to 65-70 cm in height,[320] to produce for the first time a life-size bronze statue.[321] The report by Rondelet (1805) tells us that Gois initially was not able to find a foundry capable of casting his sculpture within the promised time and budget. Upon hearing of a recent cast performed successfully with a new casting method by Rousseau of a bronze cast of the Three Graces after Germain Pilon (c.1528-1590), he approached Rousseau to commission this cast. This bronze of the Three Graces was 138 cm high and proved larger bronzes could be cast using sand moulds.The un-illustrated report credits Gonon and not his employer Rousseau with the innovations making it possible to cast a monumental bronze in sand moulds; *"*Il faut render justice à l'ouvrier Honoré Gonon, en disant qu'il a montré dans ce travail, autant de dextérité que de savoir, et nous prierons l'Athénée d'arrêter un moment ses regards sur son talent."[322]

Gonon might have worked as early as 1798 for Rousseau, making the innovations possible for which Rousseau's foundry is credited by Martins, for example producing these smaller statues, 65-70 cm in height. This is quite plausible because Gonon, who can be described as an innovative founder, did not only developed the casting of monumental sculpture using sand moulds, he also experimented later in his career from 1829 onwards with lost wax casting.[323]

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[316] Rousseau, Jean-Charles (1756- 1809) see Lebon, 2012d.
[317] Lebon, E. *Dictionaire des Fondeurs de Bronze d'Art: France 1890-1950*, Marjon éditions (2003): 170.
[318] Rondelet 1805, 350-368.
[319] Also called Étienne Gois le fils.
[320] Rondelet 1805, 354.
[321] Ibid 350.
[322] Ibid 356.
[323] Lebon 2012g, 50. These early lost wax castings by Honoré Gonon were rather small bronzes, often animalier type of sculptures.

Fig. 2.2. Edme-François-Étienne Gois, *Jeanne d'Arc*, 1804. Life-size bronze statue cast in sand by Jean-Charles Rousseau and Jean-Honoré Gonon. Current location: the *Quai du Fort des Tourelles* in Orléans.

2.3.2 Gonon's early sand mould casting technique

Gonon's technique was to use a series of stacked wooden flasks; for the Jeanne d'Arc a total of seven.[324] In effect Gonon's technique of using multiple flasks builds on from the four-flask technique in the *Encyclopédie* and the multi flask technique described by Monge earlier. While the moulders of the 1760s, as described in the *Encyclopédie*, were using four simple false cores, Gonon was using now a multi-fold of false cores in order to capture the surface of the sculpture. This so-called piece-moulding, was akin to making a large three-dimensional puzzle utilising not more than compacted moist sand parts.

The report by Rondelet unfortunately does not specify the origin of the sand and it is therefore not certain that Fontenay sand was used by Gonon. It is very likely though that this latter sand was used because its use was already a well-established practice in Paris plus the fact that all subsequent writings on the sand piece-moulding invariably mention the Fontenay sand as the main source. All the pieces of the puzzle needed to fit snugly and logically against each other and upon completion of the mould, it allowed for the pattern to be removed without any damage to the mould pieces. On top of this, the mould pieces (false cores) needed to be re-assembled and be able to form a perfect mould again for the molten metal. In order to render the casting hollow Gonon had to fabricate a core. This was done by applying a thin layer of moist moulding sand to the inside of the mould and filling the rest of the cavity with plaster. Upon solidification of the plaster, the mould was opened and the layer of sand removed to create the space for the metal. The thickness of this layer of sand determined the final wall thickness of the bronze statue to be cast.[325]

[324] The flasks used were wooden frames of 2.20 metres long, one meter wide inside and sixteen centimetres high. The thickness of the wood was eight centimetres. Rondelet 1805, 354.

[325] This method shows some similarity to the "lasagna" method described by Cellini in his treatise on sculpture; Cellini and Ashbee 1967, 116-117.(Cellini used sheets of wax, clay or paste.) Other references to the "lasagna" method can be found in Hugh Platt's, *The Jewell House of Art and Nature,* 1594 (Platt described the use of a

The use of plaster for making cores was soon adapted with plaster cores being replaced by sand cores already in the early nineteenth century.[326] The figure, moulded by Gonon, was subsequently cast in one piece except for the base, arms and the hat feathers, which were cast in separate flasks and attached later. This practice of casting separate limbs and ornaments became universal practice for sand cast bronzes. What is interesting from Gonon's sand moulding technique is that apart from the core making all the other techniques as used by Gonon, such as the stacked flasks, and false core making, remained standard practise for sand mould casting well into the twentieth century.

2.3.3 Launay and the first manual

The first published manual describing the sand mould casting of bronze sculptures was written by Jean-Baptiste Launay and dates from 1827.[327] Launay, originally captain in the artillery, was most likely trained by Monge in the art of bronze founding in sand.[328] In September 1794 he was appointed head of the artillery foundry at Breteuil.[329] At the beginning of the nineteenth century he was casting mainly in iron and was involved with the production of several prestigious cast iron bridges in Paris. He ran into difficulties when he tried his hand at bronze casting for the column at the *Place Vendôme*, between 1805-1809, and fell from grace for several years.[330] Published shortly after he died, this *Manuel du fondeur* was one of the first in the Roret manual series, published in Paris by Nicolas-Edme Roret (1797-1860). [331] These Roret manuals were, contrary to dictionaries and encyclopaedias, intended to be used at the work place.[332] They were small, pocket size (15 cm x 9,5 cm), and inexpensive.[333]

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tough flower paste) and in an anonymous late sixteenth century French manuscript (BnF Ms. Fr. 640) to create hollow life-casts. Smith & Beentjes 2010, 148-152.

[326] The fact that a plaster core is used for a sand mould casting should be noted here because generally plaster cores are not associated with sand cast bronzes. See for example Ronald C. Schmidtling II on core analysis in Bassett 2008, 35..

[327] Jean-Baptiste Launay 1827 . Tiemann (1803) can be considered to be the first manual specifically devoted to foundry work. All previous descriptions of moulding and casting processes formed part of larger works such as encyclopedias, treatises on sculpture or descriptions of the making of a single monument.

[328] Lebon 2012, 30.

[329] Ibid, 30.

[330] Some of the castings were flawed because he was forced to use inferior bronze in the form of captured cannon. Additionally, he was also accused of stealing some of the bronze; Lebon 2012g, 31-33.

[331] The introduction to the plates informed the reader that Launay died as a result of a long and painful illness and was therefore not capable of finishing the transfer of all the plates and their descriptions which were done by others instead. Launay 1827, 311. In Chapter XV (volume 1) Launay also referred to a non-existing third volume that probably did not materialise because of the early death of the author. Launay 1827, 110.

[332] For more on these Roret manuals; Zindel, Christophe. *Güldene Kunst-pforte; Quellen zur Kunsttechnologie*, Hochschule der Künste Bern (2010): 446 and 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 > [acc. 13-6-2018]

[333] This explains probably why Launay's comprehensive book, 678 pages plus plates, was divided up into two volumes.

In his manual Launay gave a very comprehensive description of the layout of a foundry, descriptions and instructions on moulding and casting of bronze as well as cast iron. It was aimed at the founder in bronze as well as cast iron and covered industrial goods, such as machine parts and bridges, military goods such as cannon and more artistic castings such as statuary. Launay was an advocate of sand mould casting and was instrumental in developing many innovations in sand mould casting. He took every opportunity in his publication to demonstrate that with sand mould casting, everything traditionally cast with loam or clay moulds (*fonte en terre*), could be cast with sand moulds, and if not better, certainly faster and less expensive.[334]

Launay mentions the use of a new type of flask made from iron instead of wooden flasks, such as the type used by Gonon earlier.[335] The sides of the flask were now much thinner and very suitable for moulding small figures in the round.[336] For the escape of gases and air from the core, Launay also mentioned that major foundries began using hollow cast iron *lanternes à noyau*.[337] These *lanternes*, in English called lanthorns, lanterns, chimneys, breather tubes, vent pipes or core vents, are basically perforated tubes traversing the core and acting as a chimney and thus providing an escape route for the gases formed during the entering of the hot metal inside the mould.[338] Launay also mentions the famous sand from the quarry at Fontenay-aux-Roses being favoured by the Parisian founders and considers: "this sand to be unquestionably the best for [moulding] delicate parts, and one might even say [this sand] is the only one capable of forming an impression accurate enough for moulding medals"[339]

The author does however warn the reader for the fact that the sand from Fontenay does not withstand well the high temperatures of cast iron because it will fuse to the surface of the casting. This is because of the high clay content of the sand which adversely affects the refractoriness or heat resistance. When the sand is heated above 400°C the clay starts to lose its chemically combined water which is complete at 700°C. At even higher temperatures the clay changes mineralogically, involving crystallization of alumina and other components.[340] Launay therefore recommends mixing it with more siliceous (and less argillaceous) sand from, for example, Versailles.[341] Launay also warns, like van Laer, against using too much charcoal dust because this makes the sand less porous and thus less permeable to gases.[342] It is interesting to note that Launay mentions, not in the context of bronze sculpture casting though, the practise of green sand moulding (*le moulage en sable vert*). This is the first time

[334] Launay admitted there are objects such as bells and large boilers which sometimes could be cast better in loam; Launay 1827, 181 & 274-291.
[335] *Châssis en fer plat*: ibid 15.
[336] *Ces châssis sont très propres pour le moulage des petites figures de ronde bosse…*: ibid 15.
[337] These gases can have a detrimental effect on the cast, often causing defects such as mis-runs or porosity.
[338] Savile, John. *Extracts from Sir J. Savile Lumley's Report on bronze casting in Belgium*. At the Herald Press (1883): 13 & Spon 1889, 31; Jackson, H. *Lost wax bronze casting*. Van Nostrand Reinhold Co. (1972): 30-32, 50-51 & 84-86; James, Duncan. "The Statue Foundry at Thames Ditton." *Foundry Trade Journal*, Sept. 7 (1972): 287-288; Spon, Ernest. *Workshop receipts*, Fifth series, Spon's (1892): 225.
[339] Translation author: "Ce sable est sans contredit le meilleur pour les pièces délicates, et on pourrait même dire qu'il est le seul capable de former une empreinte exacte dans le moulage des médailles;" Launay 1827, 19.
[340] Beeley 2001, 203..
[341] Launay 1827, 19.
[342] Ibid 20.

this term is used in the French foundry literature.[343] Launay also described how the false cores (*pièces de rapport*) were assembled and held together within the outer mould (*chape*) with the aid of starch and iron pins.[344]

2.3.4 Innovations in Launay's manual

For making an irregular core, as opposed to a core made in a moulding box, Launay described for the first time, the making of a core entirely consisting of moulding sand. This is an important development because the vast majority of sand mould cast sculpture in the nineteenth and twentieth century will subsequently be made using sand cores and will have remnants of the sand core often visible inside the sculpture. The short period when plaster-based cores were used in France, for example by Honoré Gonon, can be roughly dated to the first three decades of the nineteenth century.[345]

Because sand cannot be cast as a liquid, like plaster inside a closed mould, another way to make a precisely fitting core inside the mould had to be found. Launay described a quite ingenious method that continued to be in use till the very end of the era of sand mould casting, in the last decades of the twentieth century.[346] The system Launay described was as follows. After the complete outer mould had been taken from the pattern, the mould was re-assembled in such a way that there were now only two halves, regardless whether each mould half was built up from multiple flasks. The inside of the mould was dusted with charcoal powder to prevent the sand of the mould and the sand of the core sticking together. The next step was to insert an iron armature inside the mould half, not only to reinforce the core, but more importantly, to make it possible to suspend the core and prevent it from moving during the casting.[347] Similar to the earlier description in Rondelet (1805), a layer of sand was now applied to the inside of one of the mould halves. Whereas Gonon only applied a thin layer of sand, in Launay's description the application of sand inside the mould continues till the entire mould cavity was filled and even higher.[348] The outside shape of the core corresponded now entirely to the inside shape of the mould. This meant there was now no space for the metal to flow. Therefore, one last step before the final drying, had to be performed before the core could be used. A thin layer, corresponding to the desired wall thickness of the final sculpture, was shaved off by scraping the surface of the core carefully with a spatula.[349]

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[343] Ibid 20.
[344] Ibid 22.
[345] Honoré Gonon began experimenting with lost wax casting around 1829 (Lebon 2012, 50.) although one cannot rule out the fact that Gonon or other founders continued to produce sand mould castings with plaster cores. There is evidence for the use of plaster cores in sand moulds later in the nineteenth century in England. Byrne 1851, 153. .
[346] Rama 1988, 166.
[347] This armature took the form of simple wires or a complicated frame following closely the outline of the mould.
[348] Launay 1827, 24.
[349] This cutting back of the core is not unique to sand mould casting. One can find early examples of the use of this already with Renaissance and Baroque sculpture; Bassett, Jane and Francesca G. Bewer. "The cut-back core

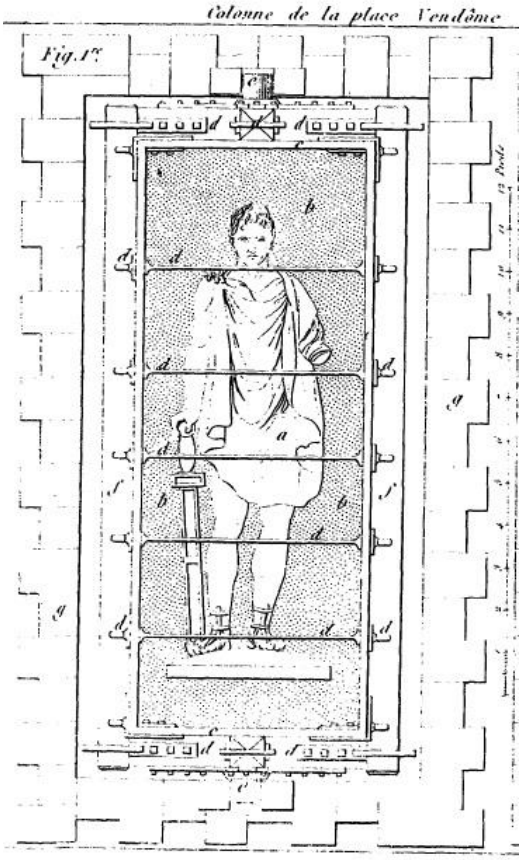

Fig. 2.3. Detail from plate IV from Launay foundry manual, depicting the statue of Napoleon by Chaudet, for the column at the Place Vendôme in Paris during moulding. Jean-Baptiste Launay, *Manuel du Fondeur*, Paris, 1827, volume I.

In Chapter XV (volume 1), Launay goes deeper into some practical aspects of his work on the column at the *Place Vendôme*. Although Launay would have preferred to have cast the massive parts of this monument in iron, the commission stipulated bronze had to be used instead.[350] The scale of these castings was immense, for example the more than life-size figure of Napoleon by Antoine-Denis Chaudet (1763-1810) on top, required a mould of twelve cubic metres weighing around thirty thousand *livres*, almost eighteen metric tons (fig. 2.3).[351] The amount of metal, in this case bronze, that is poured into such a large mould creates enormous outward pressure. To prevent the distortion of the mould or even worse, its collapse, Launay places an extra flask on the top and at the bottom. These false flasks (Fr. *fausse pièces*) are entirely filled with sand and carry no mould impression and have the sole purpose of reinforcing the mould from the outside.[352]

The handling of the flasks filled with the sand moulds was very cumbersome, requiring the use of cranes. The removal of the complex plaster patterns with undercuts prompted Launay

process in late seventeenth- and eighteenth-century French bronzes." *French Bronze Sculpture: Materials and Techniques sixteenth-eighteenth century*, Bourgarit, D., et al (eds) Archetype Publ. (2014): 205-214.

[350] Lebon 2012, 31.

[351] Launay 1827, 112.

[352] Ibid 112.

to come up with some unconventional methods.[353] For example with the moulding in sand of the huge reliefs for the base (fig. 2.4), there was the risk of damaging the impression in sand upon removal of such a huge pattern with undercuts. Launay therefore decided to heat the plaster, by placing a charcoal fire on top of the plaster, to make it fall apart in small powdery pieces which were easy to remove without damage to the mould impression.[354] These flasks for the reliefs were extremely long, *vingt pieds* (6.5 metres), *huit pieds* wide (2.6 metres) and only a few *pouces* (5-5.5 centimetres) thick.[355] Astonishingly, these wide, though narrow, frames could hold the layer of compacted sand in place, bearing in mind that these frames were open from both sides.[356] After making the impression of the front of the relief in the cope (upper mould), the workers needed to make an impression of the back, in the drag (lower mould). This was carried out in the same way as with the core of the statue of Napoleon, apart from cutting back the core to create the cavity for the metal. Launay considered this too much of a risk for damage to the mould and also too time consuming.[357] Instead of removing the top layer, he developed the idea of leaving a space between the cope (negative impression) and the drag (positive impression) and close off the sides of the mould. This way the final bronze relief displayed equal thickness everywhere.[358] Launay was basically using an up-scale version of a technique already used by Renaissance medal founders to produce a thin medal with a relief on the front side and with an exact negative of the image on the back, in the literature sometimes referred to as *incuse-reverse* cast, or *uniface*.[359]

[353] The commissioners and architects thought it would only be possible to cast these reliefs using the lost wax method; Launay 1827, 111. It is interesting to note that the lost wax casting method was in 1827 still considered a viable option for the casting of large bronze sculpture.
[354] Launay 1827, 111.
[355] Launay 1827, 113. A *Pied* is approximately 32.4 cm, a *Pouche* is approximately 27 cm.
[356] *"Personne, excepté nous pourtant qui avions l'expérience, ne pouvait croire que les sables contenus dans des espaces aussi grands pourraient se maintenir dans des châssis aussi minces lorsqu'il s'agirait de les retourner sens dessus dessous pour en faire la contrepartie."* ; Launay 1827, 113.
[357] Requiring the narrow and large and fragile mould to be turned over several times.
[358] Since the relief has undercut parts, the moulders must have made some parts detachable.
[359] Tuttle 1987, 209-210.

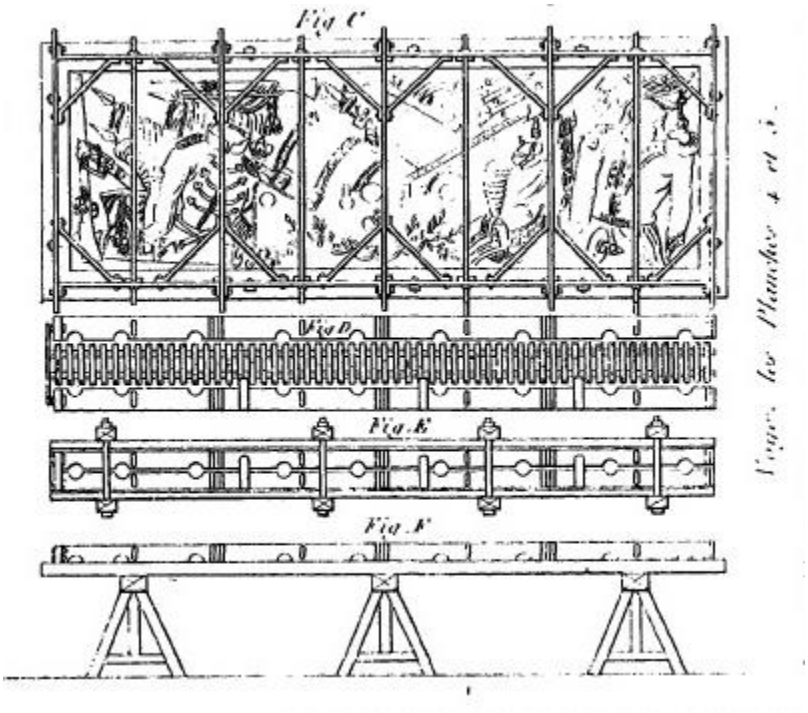

Fig. 2.4. *Détails relatifs à la fonte de la Colonne de la place Vendôme*, Detail from plate 7, illustrating the sand mould of a large bronze relief, Launay, *Manuel du Fondeur*, Paris, 1827, volume I.

Volume II of Launay's treatise, almost entirely describes the founding of cannon and other artillery although several points mentioned in the book are worth stating here. Chapter XI, introduces the reader to feeders: a feeder (Fr. *masselottes*) is a reservoir built into a metal casting mould to prevent cavities due to shrinkage and now standard practice in foundries but innovative at the time of Launay's manual.[360]

Fig. 2.5. Engraving of a sphinx with the projected gating system with a feeder (Fr. *masselottes*). Detail from plate I, Launay, *Manuel du Fondeur*, Paris, 1827, volume I.

[360] "Des masselottes et de leur insuffisance pour fournir du métal a la pièce a mesure qu'elle prend e l'affaissement par la solidification." ; Launay 1827, 58. (Vol II)

Launay illustrates (fig. 2.5) a drawing of a sphinx with the projected gating system, where halfway the main runner a spherical reservoir, the feeder, is constructed. Not only does this feeder compensates for the shrinkage of the metal, it also provides extra pressure on the liquid metal inside the mould improving detail and density of the casting. Launay gives several depictions of complete sand moulds within their cast iron flasks (fig. 2.6). This system clearly derives from Monge's segmented flask system for the casting of cannon in sand. It provides great strength to the mould and flexibility during the moulding process.

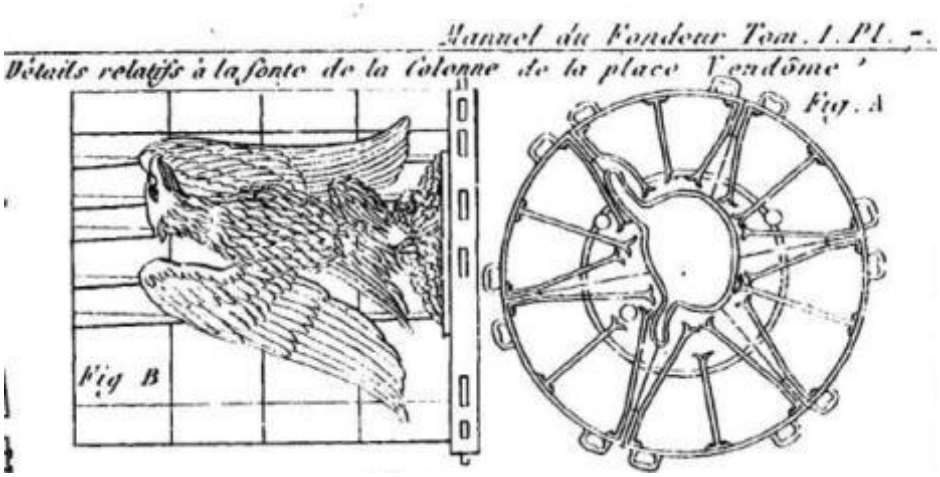

Fig. 2.6. *Détails relatifs à la fonte de la Colonne de la place Vendôme*, Detail from plate 7 illustrating the sand mould of a bronze eagle, Launay, *Manuel du Fondeur*, Paris, 1827, volume I.

The last folding plate (no. 7) has some intriguing drawings (figures 7-9) of the model and mould of an equestrian statue (fig. 2.7). It is not surprising that Launay illustrates an equestrian statue since the moulding and casting of these huge statues is considered the pinnacle of the founders art. Since the creating of Donatello's (c. 1386-1466) equestrian statue of Gattamelata at Padua, completed in 1450, erecting this type of statue is the aim of many an absolute ruler and Donatello's statue served as the prototype for other equestrian monuments executed in Italy and Europe in the following centuries.[361]

Tantalisingly, no text in the manual refers to these figures apart from the description accompanying the plate. This description informs us that these figures should be seen as a sort of preview of the intended third volume on the casting of large statuary. This third volume unfortunately never materialised due to Launay's untimely death, although in the plate's description the hope is expressed that the heirs of Mr. Launay will soon provide the manuscript for this third volume for publishing.[362]

[361] Inspired of course by the antique statue of Marcus Aurelius on horseback in Rome. See also Museum of Fine Arts (Springfield, Mass.). *Glorious horsemen: equestrian art in Europe, 1500-1800*. Museum of Fine Arts, 1981.
[362] "Ce que l'on vient de voir sur la fonte des statues équestres, ne doit être considéré que comme le détail préliminaire ou prospectus d'un mémoire que M. Launay se proposait de publier sur cette partie si importante de l'art du fondeur. …. On ne doit point douter que l'auteur ne l'eût mis au jour très prochainement, pour faire suite à son Manuel, si la mort, qui l'a frappé trop tôt, ne l'en eût empêché; cependant, nous pensons que les héritiers de M. Launay ne tarderont pas à le livrer à l'impression." ; Launay 1827, 317-318.

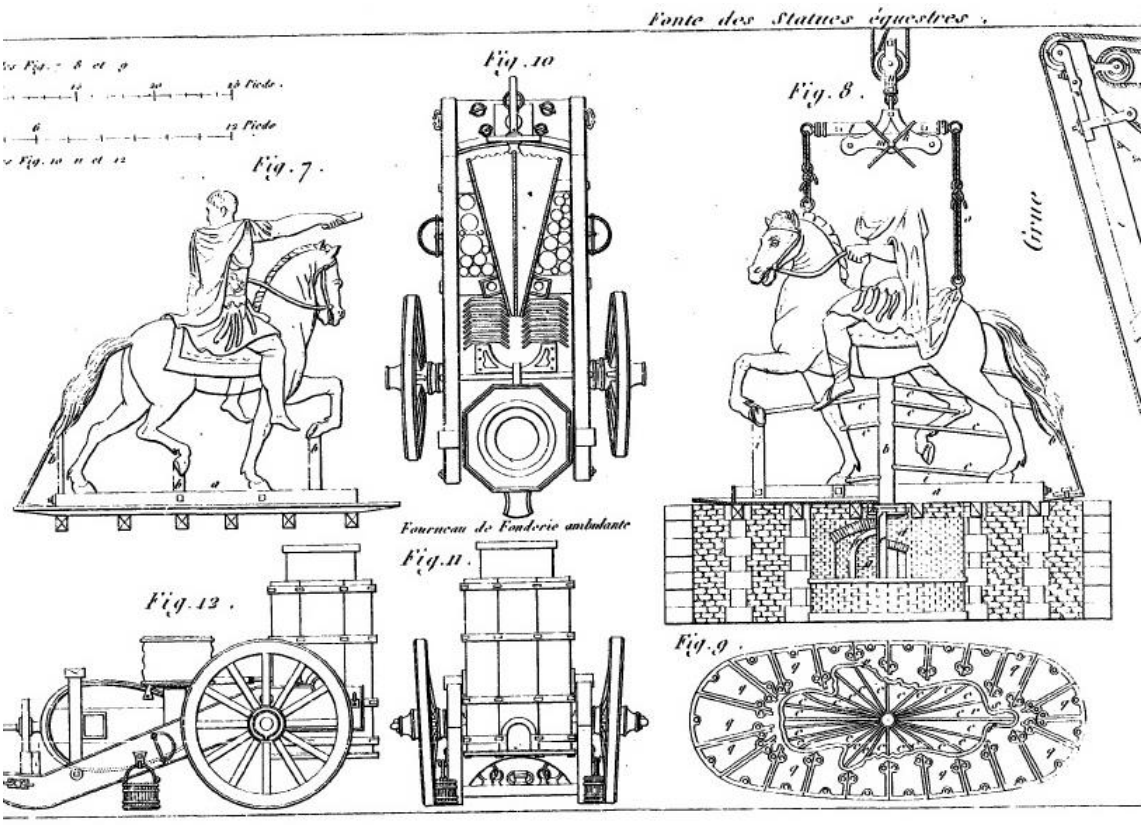

Fig. 2.7. *Fonte des Statues équestres*, illustrating the model and mould of an equestrian statue. Detail of plate 7 from Launay, *Manuel du Fondeur*, Paris, 1827, volume II

In 1836 the revised second edition appeared of Launay's *Manuel du Fondeur*, reworked by Armand Denis Vergnaud (1791-1885).[363] Vergnaud had, like Launay, a background as a captain in the artillery.[364] Vergnaud added to this edition of Launay's manual substantial parts which were literally taken from the volumes XXIV, XLII & LII from Dionysius Lardner's *Cabinet Cyclopædia: A treatise on the progressive improvement, and present state of manufactures in metal*. Published a few years earlier, between 1831 and 1834, and written by John Holland, this interesting treatise consists of three volumes, the first two on iron and steel and the third one on non-ferrous metals.[365] With the 1836 edition of Launay's manual, the original main text of 1827 was still mostly intact with several additions notably on the situation in Great Britain. Unfortunately, Launay's intended third volume on the founding of statuary did not materialise in this second edition.[366] What was added on the topic of the

[363] 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)
[364] Launay 1836, frontispiece. Vergnaud contributed to many Roret manuals starting with the *Manuel de l'artificier* in 1826.
[365] Holland, John. *A Treatise on the Progressive Improvement, and Present State of Manufactures in Metal*, volume LII in Lardner's Cabinet Cyclopædia, published by Longman, Reese, Orme, Browne, Greene, and John Taylor, Vol. I Iron and Steel (1831), Vol. II Iron and Steel (1833), Vol. III Tin, Lead, Copper, Brass, Gold, Silver various alloys (1834).
[366] Also not found in the third and last edition appearing in 1854; Launay, Jean-Baptiste. *Nouveau manuel complet du fondeur en tous genres, faisant suite au Manuel du travail des métaux;*, A la Librairie encyclopédique de Roret, 1854. (2 Vols), expanded and revised by Armand Denis Vergnaud, M. Vergnaud (son) and M.F.Malepeyre. The successor to Launay's manual in the Roret series, appearing in 1879, was still drawing

founding of statuary was in fact a description of older technology: lost wax casting. Largely taken from Lardner's *Cabinet Cyclopædia*, this description of lost wax casting, would have Launay, a staunch advocate of sand mould casting, probably turn in his grave.[367]

While Gonon and Launay are well represented in the literature, with good practical descriptions of their working methods, this is not always the case for other well-known founders of this era in France. The successful Parisian sculptor and founder Charles Crozatier (1795-1855) is credited by Lebon with innovations facilitating the serial production of sand mould castings.[368] Mandet attributes other improvements, making it possible to cast very large bronzes, also to Crozatier.[369] None of these publications however, go into the practical technicalities of Crozatier's working methods.

Fortunately, a correspondence survives, providing more insight into Crozatier's working methods.[370] This is described in letters from the Berlin founder Johann Baptist Dinger (nd-1834) to his sponsor Christian Peter Wilhelm Friedrich Beuth (1781-1853). These letters were written between January and April 1828 during Dingers stay at Crozatier's workshop.[371] The working methods of another Parisian founder of this period Louis-Claude-Ferdinand Soyer (1785-1854) can be found described in detail in 1836 when his foundry, Soyer et Ingé, was commissioned to cast the bronze statue of the *Genie de la liberté* by Augustin-Alexandre Dumont (1801-1884) for the column on the Place de la Bastille in Paris.[372] Unfortunately none of his so-called innovations on sand mould casting can be labelled as such as they have already been introduced earlier by Gonon or Launay. By the late-1820's most innovations in sand mould casting had taken place and one has to wait till the end of the nineteenth century when founders such as Jean-Baptiste Griffoul (?-1894) and Eugène Rudier (1878-1952) perfected the sand mould casting of sculpture further.[373]

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heavily on Launay's manual and used even Launay's illustrations; Gillot, Auguste and Lockert, Louis. *Nouveau manuel complet du fondeur de fer et de cuivre ... : Suivi de la fonte des statues et des cloches*, 2 vols., Librairie encyclopédique de Roret, 1879.

[367] Holland 1834, 207-210. See for a more detailed description of this, sub-chapter 2.2 *Evidence for the casting of bronze sculpture directly in piece-moulds before 1800* in this thesis.

[368] Lebon 2003, 28.

[369] "Non qu'on doive lui attribuer l'invention de ce système [la fonte au sable], […]toutefois , il convient de rappeler que jusque-là on en avait fait seulement usage pour les pièces de petite dimension, tandis qu'il s'en servit, sans exception, dans ses plus colossales entreprises." ; Mandet 1855, 15, (excerpt from Lebon, 2012d, http://inha.revues.org/3474#tocto2n79> [accessed 13-6-2018]

[370] I would like to thank Frank C. Möller, for kindly sharing this information with me.

[371] This correspondence will be covered in detail in sub-chapter 2.4.3 *Bronze founders using sand piece-moulds: Dinger and contemporaries* in this thesis.

[372] 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 (1836): 365-378.

[373] For more on this see sub-chapter *5.2.1 Assembled bronze Thinkers versus Thinkers cast in one piece* in this thesis.

2.4 The casting of sculpture using sand moulds in Germany: 1800-1900

2.4.1 Iron founding preceding bronze founding

Up till now, I have focused in this chapter almost entirely on French bronze founding although it important to realise that the development of founding techniques was not exclusive to France and its bronze foundries. In the neighboring German lands, Prussia specifically, sand mould casting was also practiced at a very high level. However, a distinct difference can also be observed. While the focus, in first quarter of the nineteenth century, in French sculpture casting was mainly on bronzes, the Germans were equally interested in bronze as well as iron sculpture. It is not uncommon for a German foundry to make of the same model, a bronze as well as an iron cast.[374] The German love for decorative cast iron is partly due to the patriotic image of iron in Germany during the first quarter of the nineteenth century. This was due to the fact that the Prussians were asked, during the Napoleonic Wars (1801-1815), to financially support the war effort by exchanging their gold jewellery for cast iron jewellery. Wearing cast iron jewellery, also known as *fer de Berlin* or 'Berlin ironwork' and sometimes donned fittingly with the motto 'Gold gab ich für Eisen', was seen as a patriotic act and created the German love for decorative items made from cast iron.[375]

The first German account of a successful casting of a metal sculpture in a sand piece-mould is for the year 1813.[376] Wilhelm August Stilarsky (c. 1780-1838), working for the *Königlichen Eisengiesserei* in Berlin, managed to cast a small (c. 30 cm high) figure of a pilgrim in iron.[377] Stilarsky used for this Fürstenwalder sand tempered with clay water.[378] For areas with deep surface relief and the core, Stilarsky did not trust the properties of this sand entirely and still preferred to use loam mould pieces (false cores).[379] The Fürstenwalder sand did apparently not contain enough clay to hold the sand together for intricate moulding which explains the use of clay water to increase the clay content. A year later, when the foundry was casting a large bust of Martin Luther by Schadow in iron, they again did not trust the new sand mould casting technique entirely and opted for traditional lost wax casting in a loam mould.[380] The German

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[374] "Eine dieser Gruppen…wurde durch den Formereivorsteher Müller [in 1823 in the Royal iron foundry in Berlin] in Sand mit Kernstücken geformt, und einmal von Bronze, einmal von Eisen abgegossen." Martins 1824, 230.

[375] "I gave gold for iron." (translation author). For more on the German love for cast iron; Vorsteher, Dieter. "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,* Willmuth Arenhövel (1982): 262.

[376] The first large figural sculpture cast in iron, in the German lands, was carried out in 1784 at the Lauchhammer ironworks in southern Brandenburg near Dresden. This was a lost wax casting performed using loam moulds. Johann Friedrich Trautscholdt. *Geschichte und Feyer des ersten Jahrhunderts des Eisenwerks Lauchhammer*. Meinhold & Soehnen (1825): 24.

[377] *12 Zoll hohe Statue*, (1 Zoll = 1/12th Fuß= 26.15mm, 12 Zoll = 1 Prussian Reichsfuß = 313 mm) Martins 1824, 226.

[378] "Er bediente sich zur Formmasse des feinen Fürstenwalder Sandes, den er met Lehmwasser tränkte, ..." ; Ibid 226.

[379] "…und nur zu den tieffsten stellen, wozu er dieser Masse nicht hinreichend bindende Kraft zutraure, wendete er Lehmkerne an."; Ibid 226.

[380] Ibid 227.

founders, however, were learning fast and by 1815-'16 the founding of busts in cast iron, using sand piece-moulding, was a well-established practice in the German lands.[381]

In 1830 the Viennese professor Georg Altmütter (1787-1858) produced an article on the casting of monumental statues (*Bildgiesserei).*[382] He described basically the eighteenth century method of lost wax casting as described in Boffrand and Mariette and refers to the latter for illustrations of the process.[383] At the end of his entry on the casting of statues Altmütter mentions a new way of casting in sand, *Gießens in Sand.*[384] He says it offers several advantages over lost wax casting: "one does not have to use the expensive wax and because there is no wax burn-out it is faster, less complicated and therefore less costly; the big advantage is also the fact that one can easily repair the mould right up till the end."[385]

Altmütter mentions that with sand mould casting the core can be made from sand as well as clay (*Thon*).[386] Unfortunately he does not expand further on the casting of large statuary and finishes his entry with some remarks on the moulding of busts. He says this is much easier because there are less undercut parts, the gating system is simpler and the thickness of the metal is not such an issue. The author continues with a curious description of core making using a wax model. The wax model is slush cast in the plaster piece mould and then cut with a hot knife in two or three parts. A hand moulded core is made from clay mixed with some sand, charcoal powder or smoke black around an iron armature.[387] The core is moulded to fit perfectly inside the wax model. The wax model with the core inside can now be used to make the sand piece mould. Unfortunately, Altmütter does not go into the details of this moulding in sand and only mentions the piece mould is held together by a bi-valve outer retainer mould (*Mantel*) also from sand.[388] More detailed descriptions in German of the sand moulding

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[381] The Gleiwitzer Eisenhütte for example, records for 1815; 11 cast iron busts and for 1816; 218 cast iron busts; Vorsteher 1982, 262 & 271.

[382] Altmütter. "Bildgießerei" *Technologische Encyklopädie oder alphabetisches Handbuch der Technologie, der technischen Chemie und des maschinenwesens*, Prechtl, Johann Joseph, Ritter von & Karmarsch, Karl, (eds.) J.G. Cotta [etc.]. Vol. 2 (1830): 152-167. Altmütter was professor of mechanical technology at the Polytechnic Institute in Vienna. The entry is signed with the initials G. A. which stand for Georg Altmütter see Hartmann, Carl Friedrich Alexander. *Handbuch der Metallgießerei*, B. F. Voigt (1840): 343-344.

[383] 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.
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.

[384] "Ein diesem ganz ahnliches Verfahren ist in der neuesten Zeit unter der Benennung des Gießens in Sand, wieder eingeführt worden." Altmütter 1830, 165.

[385] Translation author. "Man sieht leicht, daß auf diesem Wege nicht nur das theure Wachs ganz erspart werden kann, sondern auch das Brennen der Form in der Grube, und daß daher der ganze Prozeß viel einfacher, schneller und weit weniger kostspielig wird; wozu noch der große Vorteil kommt, daß mann das Innere der Mantelstücke vors ich hat, und jeden Fehler in denselben liecht zu verbessern im Stand ist." Ibid 166.

[386] Ibid 165-166.

[387] "Mit einigen Eisenstangen armirten Kern aus Thon, dem man etwas Sand, nebst Kohlenpulver oder Kienruß beigefügt hat"; Altmütter 1830, 166.

[388] Ibid 166. The description ends here and we have to assume the next step would be to remove the wax model by stripping it from the core and then to subsequently dry all the mould parts including the core. After drying the mould is re-assembled and probably placed in a sand bed as preparation for pouring of the metal.

process would be published 10 years later by Hartmann as well as Wallack.[389] The academic Carl Friedrich Alexander Hartmann (1796-1863) based his descriptions of sculpture founding largely on Altmütter and French sources such as Mariette, Launay and Soyer.[390] Of these two accounts, Karl Friedrich August Wallack (1815-1876), sculptor and brass and bronze worker (*Gürtler*) at the court of Grand Duke Karl Friedrich von Sachsen-Weimar-Eisenach, gives a significantly more detailed and hands-on description of the piece-moulding process compared to Hartmann.

2.4.2 The Gleiwitz manual

An earlier, unpublished and very detailed account of sand moulding is described by Vorsteher.[391] At the back of his article on the moulding workshops of the Saynerhütte, Vorsteher gives a transcript of an unpublished manuscript manual from 1820, detailing the moulding of a bust in a sand piece-mould. Although this manuscript describes only the moulding for iron casting, and not bronze, the techniques used are similar and worth mentioning here because some innovations, later used in bronze sculpture founding, are described and illustrated for the first time in this manuscript. This anonymous German manual gives a remarkably detailed description of the moulding process. The manuscript was most likely intended as an in-house manual for the production of a specific model of bust, that of Abraham Gottlob Werner (1749-1817) of which still several casts exist (Fig. 2.8).[392]

The manual is part of a collection of papers from the archive of the former Saynerhütte (iron works). Originally deriving from the Gleiwitz (now Gliwice, Poland) iron foundry these papers describe all facets of iron foundry work.[393] Written over a period of four years the papers cover *The Melting in Crucibles*, *The Moulding of Fine Work as performed at the Berlin iron foundry* (1816) followed by another chapter on *Fine Moulding Work* and *The Moulding of Fine Work at Gleiwitz* and *Covering Founding* (1818).[394]

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[389] *Dritter Abschnitt. Von der Bronzegießerei*. Hartmann 1840, 321-379 & *§ 3 Von der Formerei und dem Gießen der Busten, Statuen*,. August Wallack. *Vollständiges Handbuch des Gürtlers und Broncearbeiters*. Voigt (1840): 94-114.

[390] Mineralogist, foundry engineer and author.

[391] Vorsteher 1982, 259-273. The original of this manuscript is preserved in the historical archive of the company Friedrich Krupp GmbH, Essen, Villa Hugel and is part of the file WA IV 1895.

[392] Abraham Gottlob Werner (1749-1817), German geologist, inspector and teacher in the Freiburg School of Mining, sometimes referred to as the "father of German geology."

[393] Königlichen Eisengießerei Gleiwitz (founded in 1796) formed together with the Königlichen Eisengießerei Berlin (founded 1804) the Königlich Preußische Eisengießerei (Royal Prussian Iron Foundry). Both foundries were disbanded at the end of the 19th century. The town Gleiwitz is now called Gliwice and part of Poland.

[394] (translation author) "Über das Schmelzen in TiegelÖfen und die Tiegelhütte oder feine Förmerey, besonders in Rücksicht ihrer Ausübung auf der Berliner Eisengießerei, Feine Foermerei, zur feinen Foermerei in Gleiwitz und Über Gießerei."

Fig. 2.8. Johann Carl Friederich Riese, *bust of Abraham Gottlob Werner*, 1810, cast iron. Sand mould casting from c. 1820 by the Eisengießenrei Gleiwitz, Germany. H. 26.5 cm, private collection.

Two years later, in 1820, the final chapters were added on *The Moulding of Busts*, *Instructions for Moulding Knife Rests* as well as several recipes for the preparation and application of lacquered finishes.[395] The step by step instructions are illustrated with drawings of certain stages in the moulding process. These drawings are the earliest depictions of piece-moulding using sand for the production of figural sculpture. The most important innovations that can be found in this text are described below. The manual begins by stating:

> The moulding of busts […] while this is one of the most interesting however also one the most difficult one in the foundry business and is therefore carried out by experienced older moulders. […] The cast is never perfect and requires chasing, especially the hair parts. […] The inevitable holes, due to porosity, are filled with copper rivets. […] The patterns can be made of brass, lead or in some cases even iron.[396]

This bust of Werner required a total of four false cores, two on either side of the head. The dividing line is determined by the ear which has an undercut area. This is indicated as a vertical line in figure 2.9.

[395] *Über Büstenfoermerei* and *Anleitung zum Formen von Messerträgern* (translation author)

[396] Translation author; "Die Büstenfoermerei, […] da solche eine der interessantesten aber auch der schwierigsten ist, deßhalb auch bloß eingeübte alte Foermer zu gebrauchen[…] Der Guß liefert aber nie eine Büste ganz untadelhaft, sondern sie muß nochmals ciselirt werden, was besonders die Haarpa[r]thien betrifft. Es ist auch unvermeidlich, daß meist beim Gu[e]sse kleine Blasen & Poren vorfallen sollten, [..] diese vernietet man aber gewöhnlich durch Kupfer. […]daß die Modelle theils aus Messing, theils aus Blei oder auch in einzelnen Fällen selbst aus Eisen bestehen." Vorsteher 1982, 264.

Fig. 2.9. Unknown artist, drawing c.1820, illustrating the pattern for the *bust of Werner* with the position of the false cores indicated with the dotted line (from Vorsteher, 1982, 267).

The manuscript also illustrates a sideways arrangement of the main sprue (fig. 2.10). This is an early example of bottom filled casting. The vast majority of castings before 1900 are top filled. By providing a riser on top acting as the air escape route in combination with the sprue coming in from the side, the moulder/founder creates a much better flow of the metal and gases in the mould.[397]

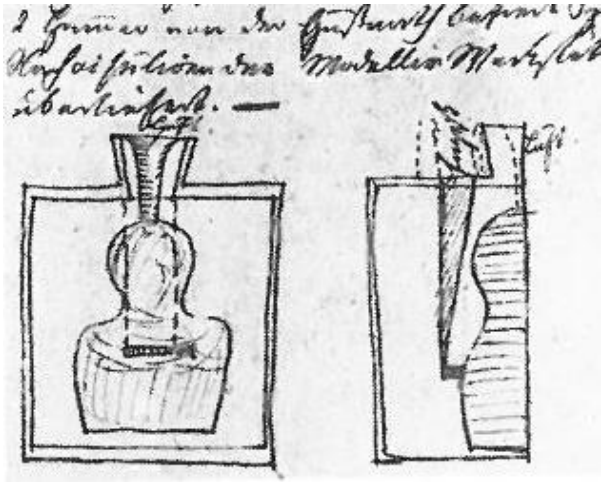

Fig. 2.10. Unknown artist, drawing c.1820, illustrating the pattern for the *bust of Werner* on the moulding board with the false core indicated with the dotted line. Also visible is the wedge shaped wooden pattern for the main sprue (from Vorsteher, 1982, 266).

Before the assembled cope can be placed on the drag, a core needs to be made. To facilitate the escape of gases from the core during the casting, the moulder will work three lanterns into the core. Fabricated from perforated sheet rolled into a tube, the central lantern is partially

[397] Bottom filling reduces considerably the amount of bi-films in the casting which can be a cause of brittleness; Campbell 2003, 300. Vasari already described bottom filling in 1568 when he discussed Guiglielmo della Porta's casting of monumental statue of pope Paul III; Vasari, Giorgio, and Gaston du C. De Vere. *Lives of the most eminent painters, sculptors & architects*. Macmillan and Co., ld. & The Medici Society, ld. vol 9 (1912): 235. The advantages of ascended filled moulds were already described in 1886; Simonds, George. "Artistic Bronze Casting." *The Journal of the Society of Arts*, Vol. 34, No. 1733. February 5 (1886): 253.

covered with loam before being placed inside the pattern.[398] Once inside the pattern the empty space between the lanterns and pattern is filled with moulding sand which is subsequently compacted with a rammer (fig. 2.11).

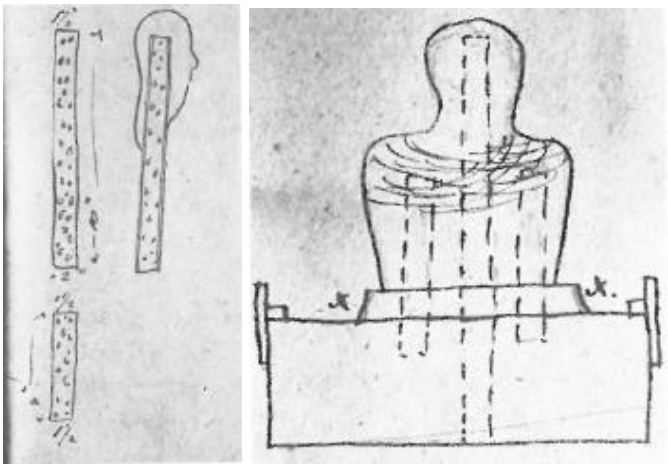

Fig. 2.11. Unknown artist, drawing c.1820, illustrating the lanterns(left) and their position within the core during the moulding of the *bust of Werner*. (from Vorsteher, 1982, 269).

This is the earliest depiction of the use of lanterns in connection with sand mould casting I have found during the course of this investigation. It also shows that German founders where following closely their French colleagues.

2.4.3 Bronze founders using sand piece-moulds: Dinger and contemporaries

The founding of hollow cast iron figural sculpture in the German lands, using sand moulds, was by 1816 a well-established practice. The casting of bronze sculptures, however, was a different story. Although larger figural bronzes were cast in Germany during the first decades of the nineteenth century, they were mostly the products of rather inexperienced founders and lacking in finesse.[399] In order to gain the experience and intimate knowledge of sand mould casting the Germans had to import this knowledge from France. This was done by inviting Parisian founders such Claude François Lequine and the pioneer Honoré Gonon around 1818 to work in Berlin, by now the center for sculpture casting in the German lands.[400] Not much is known about Gonon's time in Berlin, his occupation in 1818 in Berlin is described as a

[398] The position of the lanterns is somewhat puzzling. Normally lanterns act as chimneys for the gases during the casting but in the set-up as described and illustrated in the manual their openings are facing downwards instead of upwards.

[399] 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): 26

[400] Maaz, Bernhard. *Skulptur in Deutschland zwischen Französischer Revolution und Erstem Weltkrieg*. Deutscher Kunstverlag (2010): 632-633 & Lüer, Herman. *Technik der Bronzeplastik*. H. Seemann Nachfolger (1902): 101. Lequine was appointed as tutor at the Kunstgussschule (art foundry school) in Berlin in 1824. His working practices received a mixed response and he was dismissed in 1828 when the bronze cast of Christian Daniel Rauch's (1777-1857) statue of Friedrich Wilhelms I was deemed as rather unsatisfactory. This also signaled the end of the Kunstgussschule; ibid 100.

chaser.[401] Gonon is also listed with four cast bronzes in the catalog of the Berlin Academy exhibition of 1824, under works entered by the chaser Coué where Gonon is given as the founder of the works.[402] Gonon was apparently working on the monument for field Marshall Blücher by Rauch for Breslau (now Wroclaw, Poland) since three of the works in the catalog are related to this monument.[403] Coincidentally, 1824 is also the date Martins writes on Rousseau as the inventor of the sand piece-moulding technique for sculpture, could it be that Martins and Gonon have met during Gonon's stay in Berlin and Gonon informed Martins on the early days of sand piece-moulding? [404] As the Prussian inspector of mines (Ober-Bergrat), Martins was based at the Prussian Home office in Berlin at the time.[405]

The patriotic Germans were keen to set up a more home-grown skills base and also began sending German founders to Paris, such as Johann Baptist Dinger (?-1834) and Wilhelm Ludwig Feierabend (?-?).[406] Feierabend, who seemed to have had his Parisian training with Jean-François Denière (1774-1866),[407] was famous for the perfectly cast surface of his bronzes.[408] Dinger, who was working for Charles Crozatier, would be known for perfect, extremely thin walled and smoothly cast bronzes (figs. 2.12 & 2.13).[409]

Fig. 2.12. August Kiss, *Telephos with doe*, conceived 1828 (plaster model). This unique copper-alloy casting dates from 1834 and was cast by the Königliche Gewerbeinstitut of Berlin. Possible founders, Johann Baptist Dinger or Wilhelm Ludwig Feierabend H. 23.1 cm, W. 30.8 cm & D.13.9 cm, private collection. (image Frank C. Möller Fine Arts Hamburg)

[401] Anonymous. *Amtlicher Bericht über die Allgemeine Deutsche Gewerbe-Ausstellung zu Berlin im Jahre 1844*, Volume 2, part 2 (1846): 139.
[402] Akademie der Künste (Berlin, Germany) and Börsch-Supan, Helmut. *Die Kataloge der Berliner Akademie-Ausstellungen 1786-1850*. B. Hessling. (1971): 400. (Nr. 379– 382) (reprint of the original from 1824)
[403] Ibid Nr. 379– 382.
[404] Martins 1824
[405] http://kupferspuren.artwork-agentur.de/index.php?option=com_content&task=view&id=182&Itemid=76> [accessed 13-6-2018]
[406] Sometimes spelled as Feyerabend. These two founders would train later themselves the next generation of founders when connected to the Königliches Gewerbe-Institut in Berlin; Maaz 2010, 633.
[407] Geheimes Staatsarchiv Preußischer Kulturbesitz Berlin (Secret State Archives Prussian Cultural Heritage); GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829, Fol. 9; Letter Ministry to Dinger, 20.1.1828
[408] The successful Dernière foundry (before 1820 called Dernière et Matelin) was famous for its ormolu and employed hundreds of workers. Lebon 2003 144-145.
[409] Lüer 1902, 100. Already around 1823 the Royal Iron Foundry in Berlin was casting very thin walled bronzes as well as iron sculptures. Martins 1824, 230.

Fig. 2.13. Underside of the base of *Telephos*, illustrating the smooth sand mould cast surface with a wall thickness between 2-3 mm.

From Dinger, a correspondence survives between him and Christian Peter Wilhelm Friedrich Beuth, a key figure in the development of the Prussian trade and industry (*Gewerbe*). The latter was Dinger's sponsor, working at the Ministry of Trade and Industry (*Ministerium für Handel und Gewerbe*), in Berlin. Preserved in the *Geheimes Staatsarchiv Preußischer Kulturbesitz* in Berlin, the correspondence provides us with an interesting insight in contemporary working practices.[410] It is tempting to say that these founders were sent to Paris as some sort of industrial spies, reporting back their findings, but it appears that this was more an exchange of knowledge for commissions. Although Dinger was reporting to the above-mentioned ministry and the ministry was asking Dinger to look for specific information, the foundries in return also got commissions out of this. Dinger as well as Feierabend were working in the Parisian workshops on large bronzes commissioned from Berlin.[411] Charles Crozatier, originally trained as chaser in the silver and ormolu workshops of Odiot and Thomire, entered on the age of 18 into fine art founding when he started in the workshop of the sculptor Pierre Cartellier (1757-1831). This is followed by a three-year apprenticeship with the cannon founder Michel Brezin (1758-1828), who, as we saw earlier, once supplied the master models for the revolutionary cannon foundries. Known for his moulding, alloying, patination and chasing skills, Crozatier developed himself into a sand mould founder famous for his reproductions and pastiches of antique sculpture.[412] His speciality was the founding of monumental sculpture such as the quadriga on top of *Arc de Triomphe du Carrousel* (1828), the second Napoleon figure on top of the Vendôme Column (1833) and equestrian statues

[410] GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829. I am extremely grateful to Mr. Frank C. Möller of Hamburg for pointing out this correspondence and providing the transcription and to Jan Dorscheid for help with the translation.

[411] "Das erste Stück wird ohnehin hier der Brunnen auf dem inneren(?) Hofe des Gewerbeinstituts seyn…. Es sind deren 4 und ich würde Sie 2 und Feyerabend 2 machen lassen." Fol. 9 Letter Ministry to Dinger, 20.1.1828. GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829.

[412] Scholten, Frits (ed.) *Adriaen de Vries: 1556-1626 Imperial Sculptor*. Rijksmuseum (1999): 152.

such as Louis XIV at Versailles (1836).[413] Crozatier's workshop was highly successful and made him a wealthy man and after his death, an annual price for a chaser was instigated and a museum in his birth place Puy-en-Velay.[414]

Dinger earned Crozatier's complete trust as he comments:

> Mr Crozatier trusts me so much, not a Sunday goes by whereby I do not eat as his place. In every aspect I have every opportunity to educate myself as a man who can serve the state that treated me so well. There is no greater goal for me than to demonstrate this by working hard. Your highly born, I honestly thank you for putting me in this position and I hope that your highly born will let me know by way of a short note whether I did justice with my descriptions [of the casting process], your humble servant.[415]

Dinger reports on his work on several projects, in particular the moulding and casting of a large horse. When describing the sand used in Crozatier's workshop he comments:

> The sand used here by all the founders is surely somewhat finer than we find in Berlin and distinctly finer than the sand instructed by Mr. Lequine. This sand is, apart from fine, also a little bit greasy and does not have to be pounded so much, so one is able to make core parts out of this. I suspect one must know this in Berlin because Lequine makes the big mistake by adding clay to this sand. Because of this the sand is getting hard when dried often before but mainly during [casting] which burns the clay. It is lucky for us Lequine is so secretive about this so nobody else is using this. Crozatier cannot stop wondering enough why this carried on for so long. One only knows [here] one mass, no black or wet mass and this has taken away the greatest disadvantage.[416] Here [in Paris] one begins with the good sand and adds a small portion of the urine of calves, then this is dried and the missing moisture is replaced by a greasy water namely clay water.[417]

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[413] The first statue of Napoleon Bonaparte was destroyed after the Bourbon restoration. Crozatier's Napoleon still survives in the Musée de l'Armée in the Hôtel des Invalides in Paris.

[414] Crozatiers workshop is said to have been taken over by *bronzier* Carl Drechsler and subsequently in 1867 by *bronzier* and luxury cabinet maker Henry Dasson; Mestdagh, Camille. "Henry Dasson célèbre bronzier et ébéniste du XIXe siècle." *L' Estampille. L'objet d'art*. no.417 (2006): 60-72.

[415] Translation author: "Herrn Crozatier zeicht sich jetzt besonders zutrauend zu mir, es vergeht fast kein Sonntag, wo ich nicht bei ihm speisen muß. Überhaupt, stehen mir alle Wege offen, um immer weiter zu kommen, um mich zu einem Mann auszubilden, der dem Staate, der doch so sehr viel an mir gethan hat, einst nutzen zu können. Und gewiß es soll bei mir kein größeres Ziehl sein, als dieses einst durch Fleiss und Ordnung zu beweisen. Ew. Hochwohlgeboren danke ich aber recht ganz besonders, daß Sie mich in diese schöne Lage gebracht haben, und indem ich hoffen darf, daß mir Ew. Hochwohlgeboren durch ein kleines Schreiben mittheilen, ob ich durch diese Beschreibung recht gethan habe, verbleibe ich Ew. Hochwohlgeboren unterthänigster Diener J. Dinger, Paris, d. 1.ten Januar 1828"; Letter Dinger to Beuth, 1.1.1828, Fol. 17R, GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829.

[416] Dinger mentions here that only fresh, not previously used sand coloured black by the hot metal, is used by the Crozatier foundry.

[417] Translation author: "Der Sand, den sich hier nun semtliche Former bedienen, ist freilich um bedeutendes feiner, als ich ihn in Berlin gefunden habe, und vorzüglich feiner als die Komposition aus Lehm und Sand, die Herr Lequin lehrt. Diesem Sande ist aber auch neben seiner Feinheit noch eine gewisse Fettigkeit gegeben; man

This account by Dinger illustrates the importance of the preparation and quality of the sand in the sand mould casting process. The local German sand used by Lequin apparently did not contain sufficient clay and this had to be added by the moulder, whereas the Paris sand (most likely from Fontenay-aux-Roses) had a natural high clay content of between 16-20% which did not require the addition of extra clay. A possible explanation why the addition of clay in itself did not give the Berlin sand the same properties as the French, was the fact that the Fontenay-aux-Roses sand is characterised by small grains of a uniform size with each grain surrounded by a ring of clay.[418] Dinger continuous by stating not only the advantages of the Paris sand:

> The French sand has apart from advantages also disadvantages, one can only use the French sand once. When used twice it burns completely. Yesterday a bust was cast here and by mistake some previously used sand was used [again] for the moulding of the mouth and when cast the mouth was like a round lump. In a word this sand can only withstand the heat once.[419]

Dinger described in detail the making of the core for a horse. The core is supported by six to eight iron bars traversing the core and to enable it to be suspended in the mould. Then a rib cage structure is applied to give the core its shape and support for the outer surface. This is comparable to what had been described earlier, in the eighteenth century, by Boffrand, Mariette and Diderot (fig. 2.14).[420]

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brauch ihn nur wenig zu stoßen, so ist man schon im Stande, aus ihm Kernstücke zu bereiten. Dieses,vermuthe ich, muß man in Berlin recht können, wodurch Herrn Lequin das große Versehen macht, und setzt Lehm zu demselben. Hierdurch wird der Sand nur erstens zu fest bei de[m]Trocknen, und oft zuvor und Hauptsächlich, verbrennt [so]der Lehm. Dann aber kommt auch noch die sogenannte schwarze Masse mit ins Spiel; ein Glück möchte ich es nennen, daß [es] so sehr geheim damit ist, daß dieser doch durchaus dort nicht weiter verarbeitet wird. Herr Crozatier kann sich nie genug über diese Maniren wundern, und weiß kaum, wie es möglich sei, daß das noch so lange stand gehalten hat. Man kennt hier eine Masse, aber keine [schwarze] und keine nasse Masse, und darin ist schon dem Hauptübel abgeholfen. Hier nimmt man den guten Sand, setzt zu diesem eine unbedeutende Portion Kälberharn, trocknet ihn zuvor, und ersetzt dann die ihm dadurch fehlende Feuchtigkeit mit einem fettigen Wasser, nemlich mit Thonwasser." Fol 14 verso-fol 15, Letter Dinger to Beuth, 1.1.1828 GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829.

[418] Bassett & Schmidtling 2012. See also chapter 1 in this thesis.

[419] Translation author: "Dieser französische Sand hat aber auch nun neben seinem Guten noch etwas sehr schlechtes. Man kann mit demselben nur einmal formen; sobald man ihn zum zweitenmale braucht, verbrennt er ganz und gar. Gestern wurde hier eine Büste gegossen, worin man durch Versehen von demselben bei dem Formen des Mundes genommen hatte, und es wurde dieser daher im Guße ein runder wulst. Mit einem Worthe, [wider]steht dieser Sand also nur einmal der Metallhitze." Fol 14 verso-fol 15, Letter Dinger to Beuth, 1.1.1828 GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829.

[420] Boffrand, 1743; Mariette, 1768; Diderot, 1771.

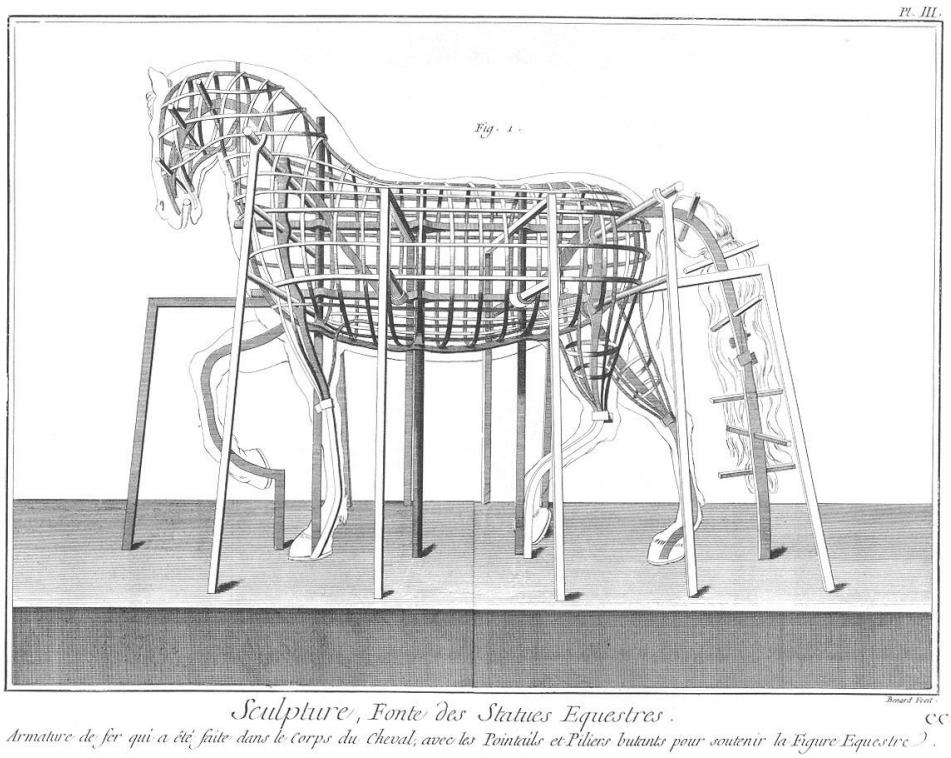

Fig. 2.14. Engraving, Plate III: The armature, showing the framework supporting the core: from Sculpture fonte des statues equestres. Diderot, D. & d'Alembert.1771, *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers*, edited by Denis Diderot, Plates vol. 8, Paris.

Dinger continues:

> On this cage a plaster layer of 2 zoll [thickness] is applied and on top of this a sand layer of 2.5 zoll.[421] The space inside stays empty. In the top part of the core are two holes made. This is for drying with a fire inside though heating the core from the outside is also necessary. I believe a core made this way [Crozatier's method] has an advantage over other. Crozatier [however] is not satisfied with this core and has made an exceptional invention. When the rib cage of iron is ready, instead of applying plaster, he wraps the rib cage with straw bands. The straw can give way to the cooling and shrinking metal. A core like this is not heated from inside though only from the outside.[422]

[421] 5.23 centimetres.

[422] Translation author:"und auf diesen Kasten macht man eine Gypsdecke von 2' und auf diesen dann eine Sand[-] oder Kerndecke von 2 1/2' und darin der Raume bleibt leer. Dann muß man denselben aber auch auf zwei Stellen nach oben öffnen können. Durch diese Öffnungen wird nun nachher, nachdem er also vollendet ist, zuerst ein bedeutendes Feuer von inwendig gemacht, wodurch er schon fast [hinlänglich]trocken genug wird, aber dennoch soll er [nachher]von außen noch dieselbe bekommen….. Herr Crozatier,… ist aber doch für sich mit diesem Kerne nicht zufrieden, und hat daher eine außerordentlich schöne Erfindung dabei gemacht. Er hat nemlich, nachdem er den Rippenkasten von Eisen fertig hatte, keinen Gyps genommen, sondern auch diese Stelle derselben mit Strohbändern umwunden. Dieses scheint mir bis jetzt auch in jeder Hinsicht [ein] vielmal besserer Kern zu sein, weil das Stroh bei dem Erkalten des Metalls mehr nachgibt als der Gyps, und vorzüglich wegen seiner Gewölle im Stande ist nachzugeben. Auch wird dieser Kern nicht von inwendig, sondern blos von auswendig getrocknet."; Fol 14, Letter Dinger to Beuth, 1.1.1828, GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829.

Crozatier's improvement, by making a hollow core flexible enough to compensate for the contracting metal surrounding it, is a clever one and shows a founder who understands the casting process thoroughly. The sand used for the core is the standard moulding sand, which is sifted and mixed with some plain sand.[423] The, 'cut-back', core is made in the usual way by cutting a thin layer from the surface. Dinger comments on this as being one of the most difficult parts of the moulding process though not difficult to learn for someone with modelling experience.[424] This cutting back of the core required skilled shaving or peeling away of the top surface layer of the core. This is done with fine spatula and needs to follow the surface morphology closely in order to create an even wall thickness of the bronze (hence the need for modelling skills).[425] The thickness of this removed layer determines the thickness of the final bronze which can vary from just over 1mm with very fine castings to more than 6-7 mm for monumental size bronzes.

The horse Dinger described was probably part of Crozatier's large assignment, in 1827-28, for the new quadriga on top of the *Arc de Triomphe du Carrousel* in Paris (fig. 2.15). Since in 1815, after Napoleon's defeat at Waterloo, the famous horses of Saint Mark's Cathedral from Venice and captured in 1798 by Napoleon were taken of the monument and returned back to Venice.

Fig. 2.15. François Joseph Bosio, *La Paix conduite sur un char de triomphe*, 1828, bronze and gilt bronze. On top of the *Arc de Triomphe du Carrousel.* Cast by Crozatier (H. 3.5 m.) (image Wikipedia commons)

[423] "Man nimmt den ganz gewöhnlichen Formsand, siebt denselben fein, und vermischt ihn alsdann mit etwas reinern oder ungebrauchten Natursande", ; Fol 12 verso-fol 13, Letter Dinger to Beuth, 1.1.1828, GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829. Presumably from Fontenay-aux-Roses although this is not specifically mentioned.

[424] "Nach dieser Regel erhält man den Kern nun ganz so wie das original, und es muß von diesem dann die gleiche Dicke rundum abgeschnitten werden, [wobei] dieses im allgemeinen das Schwerste von der ganzen Formerei genannt [wird], und es auch wohl [ist]. Jedoch aber, wo Kenntnisse im Modelliren vorausgehen, da fällt dieses keineswegs schwer zu erlernen."; Fol 13 verso, Letter Dinger to Beuth, 1.1.1828, GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829.

[425] See for more details on this cutting back of the core sub-chapter 4.2.4 *The core* in this thesis.

Dinger, who would gain himself later a reputation as a founder of producing extremely thin walled castings,[426] must have learned this whilst at Crozatier's workshop, because we learn from his letters also the following:

> The Mary that will be cast here in silver, was divided in the middle, with the upper part which was left just over 3 feet high.[427] This was already miscast once. This [cast] is considered impossible to cast [in] silver this way [only] half a line thick.[428] For this reason each half of the cast is moulded again and [sprued] and poured from the top and other side, and [this cast] was done without faults this Saturday evening. This was cast also with a thickness of half a line. Through skill full assembly these two halves were joined.[429]

This is quite an achievement. Casting a silver sculpture almost one metre high with a wall thickness of just over one millimetre is even today with modern casting technology still a major challenge. As Dinger already indicated, this is no straightforward casting and already failed once. The problem with thin walled castings in general is the fact that as soon as the liquid metal is poured into the mould it begins to cool down with the risk of premature solidification, resulting in a failed casting. The nineteenth century founder, not able to use modern inventions such as vacuum or centrifugal force assisted casting, could still try to counter-act this in several ways; firstly, by increasing the wall thickness, effectively enabling more metal to flow into the mould in the same time which in this case would mean a much higher cost because more silver will be used. Secondly the mould could be pre-heated to prevent the metal from cooling down during pouring. Sand moulds are usually only heated up to 200°C, to just drive off the moisture.

The only example I found during this research of extensive heating of sand moulds was with iron casting in Réaumur to produce white malleable cast iron by casting into red hot sand moulds.[430] The third way to improve the flow of metal inside a narrow mould cavity is to heat the mould to increase the temperature of the metal before it is poured into the mould. This is standard practice for founders and the finer the casting the higher the pouring temperature.[431]

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[426] Dinger presented at the exhibition of the Berlin Akademie in 1830 two busts which are described in the catalog as raw (unfinished) cast except for the removal of the mould lines. *Roher Guß, bis auf das Wegnehmen der Gußnaht*: Akademie der Künste and Börsch-Supan. 1971. *1830*. Nr. 730 f.

[427] Prussian *Reichsfuß* = 313 mm

[428] *Halbe linie* = 1/12 of an *Zoll* (sometimes 1/10) this is equal to 1.1 mm!

[429] Translation author: "Die Maria, die hier in Silber gegossen werden soll, hat man in der Mitte getheilt, und den Obertheil, der doch noch viel über 3 Fuß hoch bleibt. Hierzu hat man schon einmal fehlgegossen. Man sieht dieses aber jetzt als eine Unmöglichkeit an, Silber in dieser Art nur eine halbe Linie dick zu gießen. Es wird daher jede Helfte derselben von der Seite wieder zur Helfte geformt, und ein solcher Guß, von der Oberen und zur anderen Seite, wurde am Sonnabend aber ganz fehlerfrei gemacht. Es war auch hierbei die Dicke des Metalls nur eine halbe Linie. Auf dem Wege der geschickten Montur wird nun hier aus diesen Helften nachher dieselbe zusammengesetzt." ; Fol 17 verso, Letter Dinger to Beuth, 1.1.1828, GStA PK I.HA Rep. 76 Vb Sekt.4, Tit. XII, Nr. 1, Bd. 2, 1827-1829.

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

[431] The life-casting recipes described in BnF ms.Fr. 640 to produce very fine castings often recommend to heat the metal and mould red hot. Smith & Beentjes 2010.

Higher pouring temperatures tend to give rise to risks such as poor mechanical properties of the cast. A final way to enable such a thin walled casting is to feed the liquid metal into the mould from different directions, Dinger described casting from both sides, thereby reducing the amount of travel of the liquid metal inside the mould. The disadvantage of this can be the trapping of air or other gases inside the mould or insufficient fusing were the two flows meet, a so-called cold shut.

The German founders were greatly inspired by the quest for the perfect cast: a light thin walled casting not requiring any after-work in the form of chasing.[432] The German sculptor and graphic artist Johann Gottfried Schadow (1764-1850) expressed this ideal as early as the 1790s.[433] And when the Prussian architect Karl Friedrich Schinkel (1781-1841) visited Crozatier's workshop in 1826, Schinkel remarked: *"*Crozatier casts the biggest and most complicated statues in such a way they don't need chasing."[434]

And in a letter written in the same year to Friedrich Wilhelm III, Beuth writes:

> Crozatier as a skilled sculptor, recognized the need to complete the cast in bronze in such a way that no reworking through chiselling would be necessary and that [the] work of the sculptor could be brought to its original state for posterity [and] also to save costs. Crozatier managed to do this in a way which leaves everything behind that has come to us from antiquity […] Professor Rauch who was in Paris after me […] shares Schinkel's and my deep admiration for the incredible […] created by Crozatier.[435]

It is therefore not surprising that the Germans commissioned Crozatier for their bronzes and were sending founders as Dinger in 1827 to his workshop.[436] Being able to cast a surface so

[432] Although founders throughout the ages have always strived to produce castings that required minimal to no chasing this was never so ideologically fueled as in Berlin around 1800. See for more information on (the lack of) chasing on Renaissance bronzes: van Langh, Robert. "Casting and chasing of Renaissance statuettes: the use of TOF-neutron diffraction for studying finishing techniques on bronzes.": 65-74 & van Langh, Robert. "Innovations in the casting technology of sixteenth-century European bronze sculptures.": 77-103, both in van Langh, Robert. *Technical Studies of Renaissance Bronzes*. Rijksmuseum, 2012.

[433] "das in einem Guß bestand, dessen Oberfläche keiner weiteren Ziselierung bedürfte". Maaz 2010, 631.

[434] Translation author: "Crozatier, der die größten und kompliziertesten Statuen so gießt, daß keine ciselure nötig ist…": Riemann, Gottfried. *Karl Friedrich Schinkel. Reise nach England, Schottland und Paris im Jahre 1826*. Koehler & Amelang Verlag (1986): 109.

[435] Translation author: "Crozatier, der als ein geschickter Bildhauer, die Notwendigkeit erkannte, das Gießen in Bronze so zu vervollkommnen, daß kein Überarbeiten durch Ziselieren nöthig wird, und so daß Werk des Bildhauers in seiner ursprünglichen Gestalt auf die Nachwelt zu bringen, auch an den Kosten zu sparen. Dem Crozatier ist dies auf eine weise gelungen, welche alles hinter sich zurücklaßt, was aus dem Alterthum auf uns gekommen[…]und der Prof Rauch der nach mir in Paris war […] theilt des Schinkels und meine Verwunderung über das Unglaubliche von dem Crozatier geschaffte." : advertisement feature by Frank C. Möller Fine Arts, Hamburg, In: Achim Stiegel, "Der Ritt der Nereiden von Pompeji nach Berlin, eine Gruppe vergoldeter Bronzefiguren nach Entwurf von Karl Friedrich Schinkel aus dem Jahre 1827", Cover and first three pages in : *Weltkunst*, February 1999, n.p. see also 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): 55.

[436] Stiegel 1999 n.p.

close to the original model and therefore not requiring chasing has several advantages.[437] First of all, this means that the cast has minimal deviation from the artist model and therefore stays true to the artist's intent. Furthermore, the cast object, not requiring laborious extra work can be produced faster and thus more economically. It was especially this economical factor which inspired the Prussian government to stimulate a casting industry in Berlin.[438]

2.5 Evidence for sand mould casting in nineteenth century Italy

Also, in other parts of Europe the new technique of casting sculpture with sand was introduced. Even in Italy, a country famous for its lost wax founding history, one can find evidence for the use of sand mould casting. Similar to Germany, the transfer of knowledge can be traced back to Paris.

In 1806-7 the Manfredini brothers Francesco, Luigi and Antonio established the *Manufacture Royale de Bronze de Fontana* part of the Eugenia works in Milan. This was by order and under the protection of the Viceroy, Eugène de Beauharnais (1781-1824), stepson of Napoleon Bonaparte. In effect this was the continuation of a foundry established in Paris in 1803 by Francesco.[439] All three Manfredini brothers are known to have worked in Paris between 1803 and 1806.[440] In 1810, Francesco died and Luigi and Antonio continued the foundry. A-typical and perhaps even unique for Italy during this period, is that the Manfredini foundry performed sand moulding and casting. A source even claimed they adapted the sand moulding technique to make the casting of monumental bronzes in sand possible implying the Manfredini's invented the casting of sculpture in sand moulds.[441]

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[437] Chasing (Fr. *Ciselure*, Germ. *Ziselierung*) is a decorative technique involving the use of various shaped punches and a chasing hammer to model the surface of a metal object. Beentjes 2000, 83-84.

[438] The Gewerbe-Institut in Berlin was a driving factor in this. Started in 1821 by Beuth as the Königliches Technisches Institut and in 1827 renamed as Königliches Gewerbe-Institut, it employed people such as Feierabend and Dinger. The Gewerbe-Institut trained young founders, producing high quality ormolu and patinated bronzes by using the perfected sand mould casting technique they learned in Paris. Together with producers such as Werner & Mieth, later Werner & Neffen, they created serious competition for the Paris ormolu and bronze industry, as intended by the Prussian Government. The fact that the Germans were able to produce casts which required minimal chasing meant that they could offer their wares at very competitive prices. (personal communication with Frank C. Möller Sept.2013) This is reminiscent of the knowledge transfer at Prussian court of Frederick II (1740-1786) in Potsdam which recruited skilled craftsmen from Paris in 1751 for the production of high quality ormolu: Locker, Tobias. "A Prussian factory of gilt bronzes *à la française*: Johann Melchior Kambly (1718-84) and the adoption of Parisian savoir-faire."in Bourgarit et al (2014): 166-177.

[439] Imbellone, Alessandra. "Manfredini, Luigi" *Dizionario Biografico degli Italiani* – Vol. 68 (2007) available through : < http://www.treccani.it/enciclopedia/luigi-manfredini_%28Dizionario_Biografico%29/ [accessed 5-6 2018]

[440] Catalogue entry for lot 46, "An Italian gilt-bronze and bronze athenienne by Luigi and Francesco Manfredini, Milan, circa 1811-13." in Sotheby's London TREASURES, princely TASTE July 3rd, 2013. Online available through : <http://www.sothebys.com/it/auctions/ecatalogue/2013/treasures-princely-taste-l13303/lot.46.esthl.html > [accessed 5-6-2018]

[441] "Merita poi particolare attenzione l'estesa manifattura dei Manfredini introdotta in Paese dell fusione, cesellatura e doratura de' Bronzi lavorati. E quanto all fusione, se il metodo di fondere in sabbia, e staffia era giàconosciuto, ed adoperato per pezzi minuti, è dovuta pero ai fratelli Manfredini l'applicazione di esso alle grandi fusioni, il di cui perfezionato processo ha dato l'importantissimo risultamento al confronto degli antichi

Although it is probable they were the first in Italy to cast bronzes in sand moulds it is more likely they acquired their sand mould casting skills whilst in Paris, where the sand moulding of sculpture had just been developed and published.[442] Some of their work still survives, for example their work on the *Arco della pace del Sempione* in Milan. Recent conservation work confirmed the use of the sand mould casting technique for this monument (fig. 2.16).[443] In 1852 the Manfredini's Eugenia foundry was taken over by the Barigozi brothers Ermanno (1805-1882) and Prospero (1807-1866) who continued the foundry as an art and bell foundry. It is not clear yet to what extent the sand moulding and casting continued to be used by the Barigozis. The Barigozi foundry eventually ceased working in 1975.[444]

The scarcity of Italian foundry literature detailing sand mould casting of sculpture is another indication that this technique was probably not in general use in Italy. The Nuovo Dizionario Universale Tecnologico o di Arti e Mestieri discusses the sand mould casting of sculpture in sand moulds but this dictionary is basically a translation from French.[445]

Fig. 2.16. Interior of *Arco della pace del Sempione* in Milan, bronzes cast by the Manfredini foundry between 1827-1834. (image Studio Restauri Formica S.r.l. Milan)

It must be of some significance that the entry on statuary founding (*fonderia di statua*), which was actually written by an Italian,[446] described only lost wax casting albeit briefly.[447] In contrary to France, Germany, Britain and the United States, very few foundry manuals were

incerti, e sconvenevoli metodi d'ottenere con singolare facilita, con sicurezza, e moderato dispendio la fusione du statue gigantesche: ….''; letter from 2 June 1821 transcribed in Beretti, Giuseppe [ed.] *Gli splendori del bronzo : mobili ed oggetti d'arredo tra Francia e Italia 1750-1850*. Omega Arte (2002): 41-43.

[442] Rondelet 1805, 350-368.

[443] Righini Ponticelli, Sylvia., Luciano Formica, Vittoria Castoldi Formica. "Una Pace Rinnovata Per Milano. L'intervento di conservazione dei bronzi dell'Arco della Pace." 2015 online available through : < http://www.restauriformica.it/?Szn=Interventi_Restauro&id=308> [accessed 5-6-2018]

[444] Fonderia Napoleonica Eugenia. "Fusioni artistiche | la storia." 2015 Online available through : < http://www.fonderianapoleonica.it/storia4.html> [accessed 6-6-2018]

[445] Lenormand, Louis Sebastien. *Nuovo dizionario universale tecnologico o di arti e mestieri e della economia industriale e commerciante*. Venezia: Antonelli, (1830) Vol III (1833): 121.

[446] A certain Giovanni Pozzi. I have not been able to find any biographical information for this person.

[447] Giovanni Pozzi in Lenormand 1830, Vol XXIII (1839): 271-274.

published in Italy during the nineteenth century and one has to wait for as late as 1889 for the first proper manual to be published.[448] This manual is aimed at the founder of more industrial work in iron, brass but also bronze and covers the moulding in sand in detail but again the sand moulding of sculpture is conspicuously absent while the founding of bells is covered. The founder looking for detailed practical information on lost wax casting in nineteenth century Italy had to consult older sources such as Cellini which appeared in several editions during the course of the nineteenth century.[449] Perhaps the fact that Cellini's treatises and his autobiography gave such detailed technical information on lost wax casting there was no need in Italy to write another manual on the same topic.

2.6 The casting of sculpture in Britain using piece-moulds: 1800-1900

For the reproduction of medium to large sculpture, bronze was only very occasionally used in Britain during the eighteenth century.[450] Sculpture was usually carried out in marble or lead,[451] with the latter often painted, or gilded.[452] Because there was no widespread tradition of bronze sculpture casting and therefore no foundry industry facilitating the casting of medium to large bronzes, sculptors who wanted their work executed in bronze had to use foreign foundries or initiate the founding themselves.[453] Artists such Sir Richard Westmacott RA (1775-1856) and Francis Chantrey (1781-1841) organised the casting of their own bronzes.[454] Lost wax casting was most likely practised, as was an alternative method using plaster and brick-dust based piece moulds.[455] The application of the latter for bronze casting is only described in British sources and derived most likely from the casting of lead sculpture as practiced during the

[448] Belluomini, Giuseppe. *Manuale del fonditore in tutti I metalli*. Hoepli, 1889.
[449] Cellini's original edition was from 1568 with only one eighteenth century reprint in 1731. Carpani's (1806) edition of the collected writings of Cellini – his autobiography and treatises- appeared between 1806 and 1811; 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.)*. Milan: Società tipogr. de' classici italiani. (1806-1811.) Several other editions appeared during the course of the 19th century – 1835, 1852, 1857- of which the 1857 edition by Milanese was the most important and accurate because this was for the first time based on Cellini's original manuscript which was rediscovered in the early 19th century in the Biblioteca Marciana of Venice (codex 5134) . Cellini and Milanesi. 1857.
[450] The Gunnis database records only 17 signed and/or documented bronzes cast between 1750-1800; Sullivan, M.G. "Brass sculpture and the ideology of bronze in Britain from 1660-1851." *Sculpture Journal*, XIV (2005): 38.
[451] James, Duncan. "Alfred Gilbert and his Use of 19th Century Founding Techniques." *Alfred Gilbert; Sculptor and Goldsmith*, Dorment, Richard (ed), Royal Academy of Arts (1986): 21.
[452] Lead statues were often painted white to imitate marble statues or sometimes they were naturalistically painted with a variety of colours.
[453] Most of the founders were of continental origin; Sullivan 2005, 30.
[454] Both in Pimlico, London; Simon 2011. Sir Francis Legatt Chantrey, RA (1781-1841), who established his own foundry, employing French workman, at Eccleston Place, Pimlico, London in 1828. He would produce here mainly his own bronzes till 1839. 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]
[455] James 1986, 21.

eighteenth century.[456] A practical account of British lead casting of statuary during the eighteenth century can be found in Robert Dossie's (1717-1777) *Handmaid to the Arts* of 1758.[457]

A later, nineteenth century, account of this plaster piece-moulding technique, as used for bronze sculpture founding, can be found in Rees.[458] The founding of sculptures is covered in two entries: *Bronze* (1805) and *Foundery* (1810).[459] The *Foundery* entry covers the lost wax process and the earlier entry *Bronze* describes plaster-based piece-moulding.[460]

The sand mould casting of bronze sculpture in Britain sees a relatively late introduction. Possibly deriving from the founding of cast iron sculpture the first evidence of sand mould cast bronze statuary in Britain appears around the middle of the nineteenth century.[461] The earliest description is that of the founding of the Matthew Cotes Wyatt's (1777-1862) Wellington monument.[462] This bronze equestrian statue was cast in 1845-46 by French workmen employed by Wyatt using sand piece-moulds. The anonymous author observing this work was clearly not impressed by this work:

> It is known that French workmen have been employed by Mr. Wyatt, … It was formed of sand, and put together in square pieces, … these numerous parts could not be so perfectly joined as to leave no indication … thus the cast is seamed in squares, the marks of which must be removed by the tool. The method pursued by Sir F. Chantrey

[456] Similar eighteenth century descriptions of this technique, can be found in Diderot, "Jetter les Figures de plomb." Vol. 8 (1771): 529 and Plate I and description Volume 25 Page 22:4; & in Fiquet; 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): 598-600. A nineteenth century source largely bases on Fiquet is Lebrun, Frédéric Deniau. *Manuel complet du Mouleur.* Librairie encyclopédique de Roret (1829): 179-185.(*Moulage du plomb*). Lead sculpture casting in plaster moulds can be traced back as early as the seventeenth century; 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*, Vol. 31, No. 1/2 (2004 -2005): 54-89. & Arndt, Caroline. *Untersuchung zur Herstellungstechnik der vier barocken Bleiplastiken von Lerchenborg Slot in Dänemark*. Fachhochschule Potsdam(2012): 44-60.

[457] Dossie, Robert. *Handmaid to the Arts*. J.Nourse (1758): 349-356. Unfortunately his description is rather brief and not illustrated. However, it does mention the use of a plaster mould divided in sections to avoid undercuts or as he calls them *under-workings*. When dealing with large sculptures Dossie recommends the use clay as a mould material, mixed with at least a third part of fine sand or coal-ashes to prevent crack in the mould after drying. In addition to this he recommends reinforcing protruding parts of the mould, plaster as well as clay, with cloth.

[458] Rees 1802 and 1820, entries *Bronze* in volume V (1805) and *Foundery or Foundry* in volume XV (1810)

[459] *Bronze*, Rees 1805, volume V, no page number. Rees 1810, volume XV, no page number.

[460] Entry *Founding* in Martin, Thomas. *Circle of mechanic arts; containing practical treatises on the various manual arts, trades and manufactures*. Rees (1813): 342-347. Although Martin's entry on founding is largely based on Rees (1805 & 1810), it is re-worded and has some extra insightful details added, probably by a knowledgeable practitioner or scholar; *Casting statues* in the entry *Founding* in Smedley, Edward, et al. *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.

[461] The foundry of Robinson and Cottam of Pimlico (London) is recorded using sand moulds for sculpture founding in 1852; James 1986, 21.

[462] The equestrian statue of the Duke of Wellington was when revealed at Hyde Park Corner in 1846, the largest equestrian statue in Britain, measuring 9.1 m in height. In 1885 the statue was moved to Round Hill close in Aldershot where it remains to this day.

was, to form the mould of brick dust and plaster, which not only left no seams, but yielded the handling and precise feeling of the sculptor;[463]

While this author, writing in 1845, is clearly not impressed with the quality of this sand mould casting and favours the plaster-based piece-moulding, Simonds in 1896, considers the plaster piece-moulding technique: "…more in the nature of a makeshift than a process to be recommended,…".[464] So why are these two techniques so diametrically judged? A possible explanation is perhaps that the sand moulding, as employed by Wyatt's French workmen, was not so perfected as the work carried out almost half a century later.

Detailed practical descriptions, in English, of sculptural piece-moulding using sand can be found in Byrne's *Practical Metal-Worker's Assistant* from 1851.[465] Byrne described the moulding and casting of a bust using a dry sand mould with a plaster-based core. This core, a mixture of one-part plaster with two parts sand or fine brick-dust, is cut back to create the space for the metal. This paring down of a fine layer from the surface is a rather precise and tedious job and Byrne described a clever trick involving the use of a stop-drill with a collar. This enabled the drilling of holes at equal depth over the entire surface. Subsequently the surface of the core could now be shaved down uniformly to the depth of the drill holes.[466] Byrne continues his account of sculpture founding with a description of the lost wax casting for "objects which are exceedingly complex in their form, or soft and flexible in their substance, and which do not therefore admit of being moulded in sand".[467]

In the same year the *Moulder's and Founder's Pocket Guide* appears and touches only briefly on statuary founding describing an ancient Greek method and the standard lost wax casting, which is referred to as; 'French Mode of Moulding Statues'.[468] When in 1881, the edition with the supplement on statues appears by the Frenchman Fesquet, a rather confusing situation is created because the sand piece-moulding, described in the new supplement, is also called the 'French system' or new system.[469] Although Fesquet briefly described the lost wax technique,[470] he was clearly, like Launay, no great enthusiast for what he calls the 'wax process'. Fesquet continues with a description of the sand mould casting method, as practised by the Philadelphian foundry of Messrs. Bureau Brothers & Heaton.[471] The sand moulding method he described does not differ greatly from the methods used in France and Germany discussed earlier in this chapter.

[463] Anonymous. "The Wellington Statue." *The Art Union 7*. London (1845): 321.
[464] Simonds, George. "The art of bronze casting in Europe." *Journal of the Society of Arts*, XLIV, 19 June (1896): 665.
[465] Byrne 1851, 153.
[466] Ibid 153.
[467] Ibid 153.
[468] Overman 1851, 139-143.
[469] Overman 1881
[470] Ibid 253-255.
[471] Ibid 255-271.

As is evident from Byrne's description, the use of plaster-based cores was still being described around the middle of the nineteenth century.[472] Although Honoré Gonon was using a plaster core as early as 1805,[473] the use of plaster-based cores appears to be rather short lived in France, of any rate, there is no mention of the use of plaster cores in Launay's manual (1827).[474] Rondelet's (1805) description of the making of plaster cores by Gonon as well as Byrne's description both mention the use of a filler material. This filler was added for two reasons: to counteract the shrinkage of the plaster and if not too finely ground, to create a more porous core. [475] This would facilitate the escape of gases and allow for the compression of the core when the surrounding solidifying bronze would contract around the core. When studying the composition of nineteenth century bronzes it is important to realise the existence of plaster-based core material inside sand mould cast bronzes.[476]

It must be noted here that the sand or brick dust can take up a substantial part of this core and this core therefore does not have necessarily the appearance of plaster, in colour as well as texture. Chemical analysis is therefore recommended to determine the composition of this core material. Generally speaking, plaster-based core material is not associated with sand mould cast bronzes and the presence of plaster core material is interpreted as evidence for lost wax casting.[477]

2.7 The lost wax casting of bronze sculpture in the nineteenth century

In order to understand fully the position and development of sand mould casting in the nineteenth century, it is important to also look at the alternative, lost wax casting, during this period. The history of lost wax casting of figural sculpture in the nineteenth century is one of mixed fortunes. Apart from the above-mentioned examples by Sprengel and Dossie and the experimental castings by Rousseau and Gonon, one can safely say that around 1800 nearly all medium to large figural bronzes were cast using the lost wax method (fig. 2.17).[478]

[472] The 1874 edition of Byrne still contains the 1851 text on the making of a plaster-based core. Byrne 1874, 251.
[473] Rondelet 1805, 357.
[474] Launay 1827.
[475] Rondelet mentions one part brick dust to one part plaster and Byrne two parts sand or brick dust to one part plaster.
[476] It must be noted here that because the core material contains substantial parts of sand and or brick dust, the appearance of this core material can look similar to sand cores both in colour as well as texture and further analysis is required to determine the composition of this core material.
[477] See for example Ronald C. Schmidtling II on core analysis in Bassett 2008, 35. & Bewer et al 2009, 40.
[478] See also sub-chapter 2.3.1 *Gonon and the casting of the monumental bronze of Jeanne d'Arc* in this thesis.

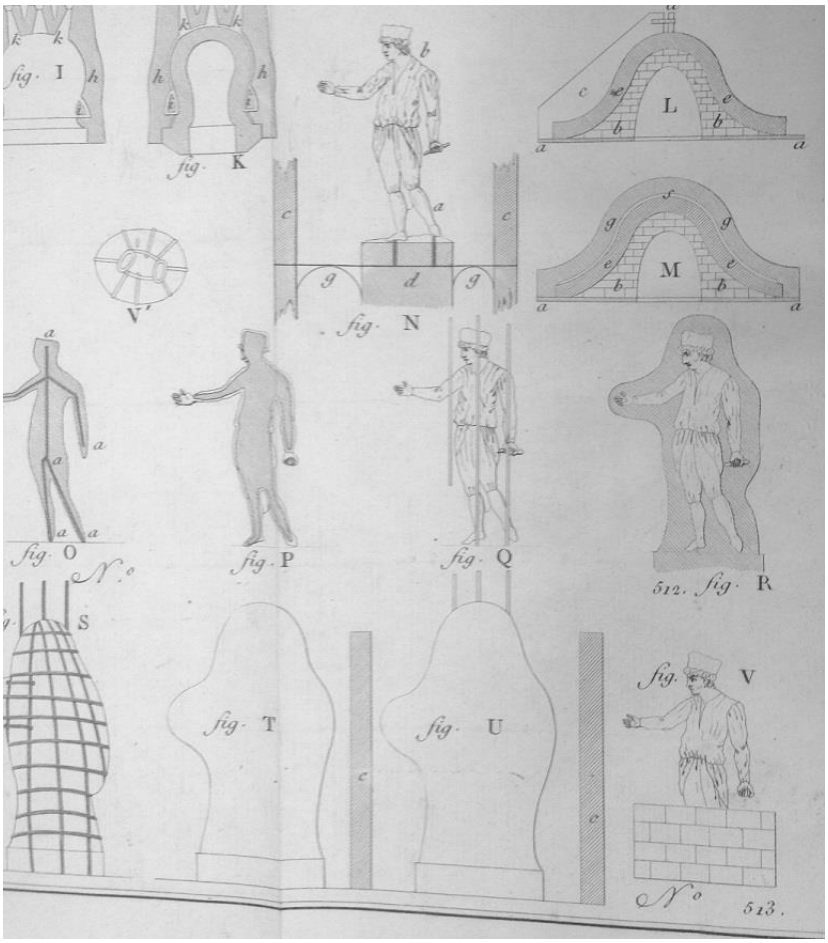

Fig. 2.17. Engraving illustrating various stages in the lost wax moulding and casting of a statue, plate 35 from Hassenfratz, *Siderotechnie*, 1812, Vol 2.

This is reflected in contemporary technical descriptions of sculpture founding. French technical literature before Launay's first proper manual of 1827, invariably described the lost wax process when covering sculpture founding.[479]

Petr Petrovitsj Chekalevsky published in 1810 a treatise on the founding of monumental statuary which is loosely based on Boffrand's treatise but contains some interesting additional practical details and original engravings.[480] This bilingual (Russian/French) treatise, which hitherto has never been described in literature on bronze casting, differs from the treatises by Boffrand, Mariette and Lafolie by describing the casting of human figures and large plaquettes instead of equestrian statues (fig. 2.18).[481]

[479] Anonymous. *Secrets concernant les arts et métiers*, E.T. Chaillot. Volume 1 (1810) 213-227. (*Pour jeter une figure de bronze*); & Hassenfratz 1812 vol 2, 272. and figure 35; & Lebrun 1829, 176-179.(*Moulage de la cire*) The exception being of course Rondelet in 1805 (350-368), giving the account of Honoré and Rousseau's innovative sand moulding of the Jeanne d'Arc.

[480] Chekalevsky, Petr Petrovich. *Opuit vayaniya iz bronzui, odnim priemom, kolosal'nuikh statui. Essai sur les operations pratiquées, lors de la fusion en bronze des statues colossales, d'un seul jet*. F. Drekhsler, 1810.

[481] Boffrand, 1743; Mariette, 1768; 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.

The situation in the German technical literature is comparable, with Wuttig giving in 1814 a very practical account of the lost wax casting of monumental sculpture.[482] Wuttig's treatise with its pocket size, moves away from the prestigious large folio size treatises such as

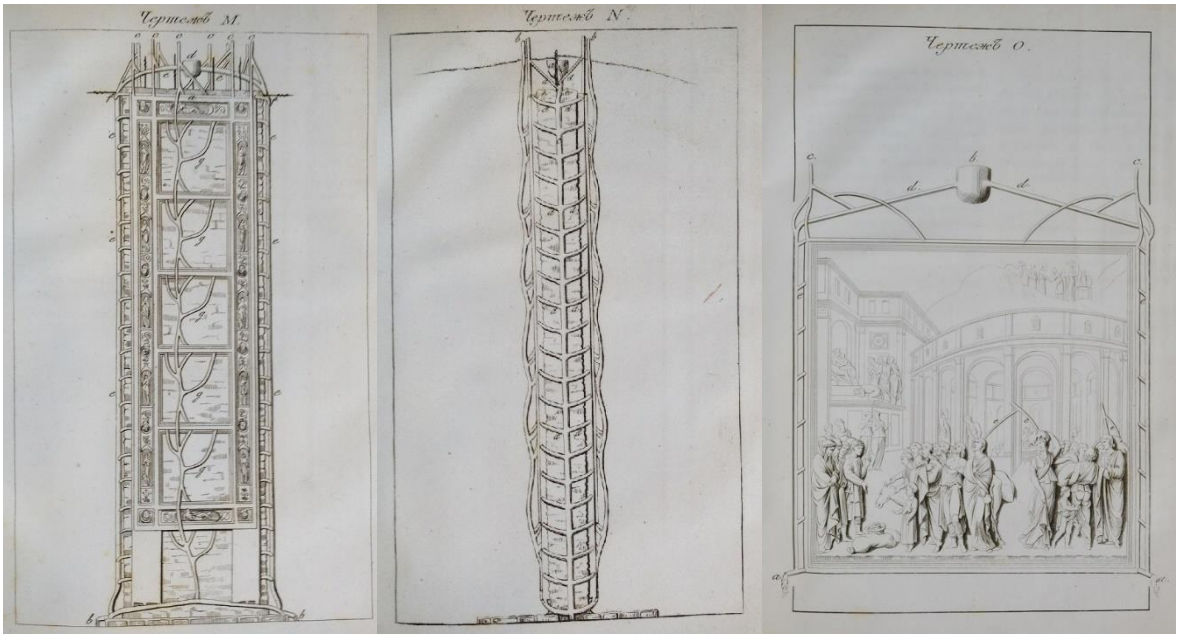

Fig. 2.18. Three plates (p.61, p.63, p.65 from Chekalevsky (1810) illustrating the gating system for the doors and one of its plaquettes for the cathedral of our lady of Casan in St. Petersburg.

Boffrand, Mariette and Chekalevsky and for the first time the book resembles more the modern workshop manual. The fourteen-page supplement at the back, detailing a wide range of bronze and gunmetal alloys by Hermbstädt, is very practical for the founder in the workshop.[483]

There is only one plate illustrated in the treatise which Wuttig copied strait from Chekalevsky's treatise published four years earlier (fig. 2.19).[484] In 1830, Altmütter still described lost wax casting as the main casting method for monumental sculpture although it must be said that he mentioned, albeit briefly, a new process called sand mould casting (*des Gießens in Sand*).[485]

[482] Wuttig, Johann Friedrich Christian, *Die Kunst aus Bronze Kolossale Statuen zu Giessen*, Amelang, 1814.
[483] *Anhang über einige andere Kompositiones zu Bronze und Kanonenmetall (vom Geheimen Rath Hermbstädt)* ; Wuttig 1814, 57-70.
[484] Plates H, I, K, and L in Chekalevsky 1810.
[485] Altmütter 1830 Vol. 2, 152-167.

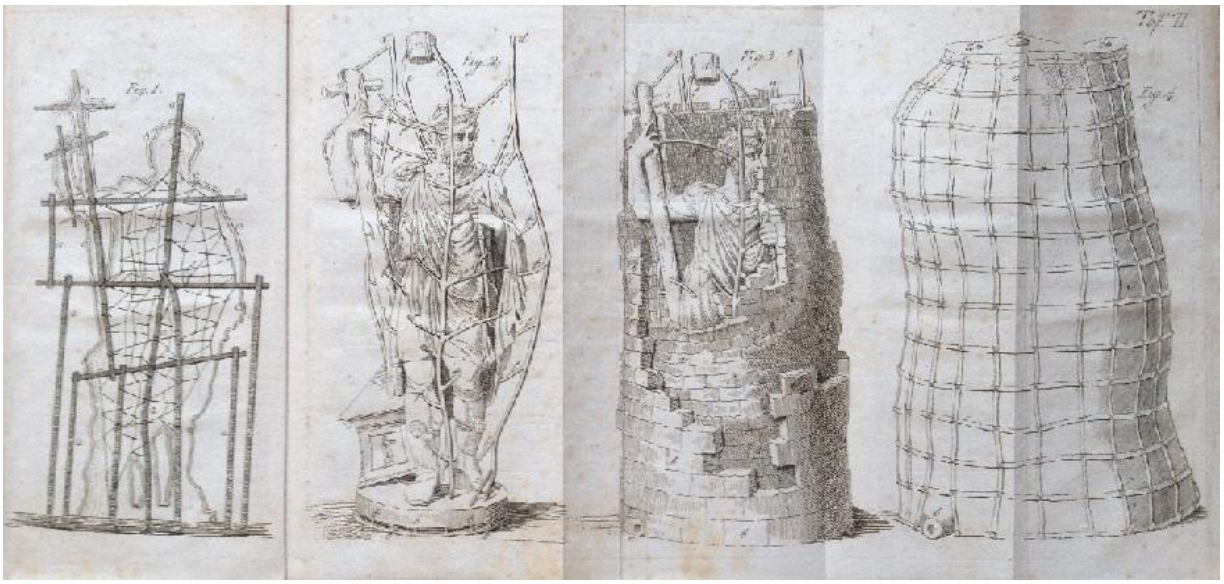

Fig. 2.19. Plate II from Wuttig illustrating various stages in the lost wax casting process. The four figures on this plate are exact copies of plates H, I, K, and L. from Chekalevsky treatise from 1810: Wuttig, *Die Kunst aus Bronze Kolossale Statuen zu Giessen*, Berlin.(1814)

Most of these descriptions of the lost wax process are taken from earlier sources. The section on sculpture casting in the 1810 edition of the *Secrets concernant les arts et metiers* is identical to the edition published almost a century earlier in 1716.[486] A similar pattern is discernible in Britain's technical literature on statuary founding. Rees in his entry *Bronze* actually refers to older texts, including Cellini.[487]

These early nineteenth century descriptions of lost wax casting, almost invariably describe the direct lost wax casting method. This can be explained from the fact that most of these are based on earlier texts such as Cellini or Pliny. The majority of nineteenth century lost wax descriptions are accounts of the casting of large monumental bronzes such as equestrian statues which were always unique castings not requiring moulds enabling serial production. In a direct lost wax casting a refractory core is made on which a thin layer of wax is applied. The surface of this layer of wax, with the thickness of the final bronze, is modelled with the details of the sculpture and when finished the wax is encapsulated within a layer of refractory mould material such as plaster or loam often mixed with brick-dust and animal fibres. This combination of the wax model enclosed in the mould, is heated to bake the mould and more importantly, to melt out the wax. The core is held in place by previously inserted small iron core pins. Once all the wax has been melted out and thus the negative form of the sculpture model inside the mould cavity has been created, the mould is ready to receive the hot molten

[486] "Pour jeter une figure de bronze"; Anonymous 1810, 213-227 and in Anonymous, *Secrets concernans les arts et métiers*. Jombert (1716): 308-326.

[487] *Bronze*, Rees 1805, volume V, no page number. Rees actually states the following: "Many particulars relating to this article may be found in Pliny's Natural History; in the life of Benvenuto Cellini, and Vasari's Lives, in the chapter upon bronze casting.": Rees 1805, volume V, no page number. This must have been Cellini's autobiography which was published in English in 1771, translated by Thomas Nugent; *The life of Benvenuto Cellini, a Florentine artist*. London: Davies. The first, and up till now only, English translation of Cellini's treatise on sculpture was published by Ashbee in 1898. Cellini and Ashbee 1967. Unless Rees used of course the first Italian edition of 1568 or a later edition of 1731.

bronze. Once the bronze has filled the mould and has sufficiently cooled down to enable handling, the outer mould or cope is removed by fragmenting it using hammers and chisels.[488] With the direct lost wax process the artist's wax model is literally lost in the process unless a mould is first made which will not be used for casting the bronze. Before the use of flexible mould material, such as gelatine and later silicone rubbers,[489] this mould was almost always a plaster piece-mould.

Rousseau's and Gonon's innovation, using sand moulds for the casting of sculpture, altered this situation. The next decades would witness a gradual shift away from lost wax casting towards sand mould casting and by the second quarter of the nineteenth century, sand mould casting was the preferred casting method for the founding of sculpture in France and Germany.[490] The sculpture foundries in Western Europe were almost exclusively using sand mould casting from the mid-1840s until c.1880.[491]

The increased popularity of sand mould casting was mainly due to the fact that this could be carried out using less time and at lower cost compared to lost wax casting. What perhaps is less well- appreciated, is the fact that sand mould casting was also, compared to lost wax casting, generally speaking a more reliable method of casting. The lost wax casting of large monumental bronzes especially, was frequently prone to failure. Héricart de Thury (1836) mentions the mishaps with the casting of several monumental statues, such as Falconnet's statue of Peter the Great in St. Petersburg, the statues of Louis XV by Varin and Bouchardin and others.[492]

Another example was the equestrian monument to Gustavus Adolfus II (1594-1632) by Pierre Hubert l'Archevêque (1721-78) in Stockholm. This sculpture was commissioned in 1757 and Archevêque's first cast failed. Whilst preparing a second cast in 1778, Archevêque died and

[488] The cope is the upper half of the mould.

[489] Gelatine as a mould material for sculpture came into use from the mid 1830's; Lebon 2012, 85-86 and further in the current chapter. The use of silicone rubbers as a mould material was introduced during the 1960's; Lebon 2012, 150.

[490] This situation is accurate for Western Europe but not for Italy. In Italy the tradition of casting using the lost wax method appears to have an uninterrupted history since at least the middle ages up till current times. In England one sees a similar trend. A notable exception was the sculptor Sir Francis Legatt Chantrey, RA (1781-1841), who established his own foundry, employing French workman, at Eccleston Place, Pimlico, London in 1828. He would produce here mainly his own bronzes using lost wax casting till 1839. For an interesting contemporary account of lost wax casting at Chantrey's foundry; Holland 1834, 207-210.

[491] With the notable exception in the form of the Gonon family foundry in Paris.

[492] "Falconnet fut obligé de recommencer la statue de Pierre le Grand, a Petersbourg depuis les genoux du cavalier et le poitrail du cheval jusqu'au haut de la statue; le Louis XV de la ville de Bordeaux, fondu par Varin, d'après le modèle de Lemoine en I739, fut manqué par suite d'un grave accident, le métal en fusion se répandit dans les terres après s'être porté dans les parties inférieures du moule de la statue et l' avoir en grande partie remplie; Bouchardon fut obligé de faire rétablir les forms délicates du cheval de sa belle statue équestre de Louis XV, qui avait été altérée dans la partie inférieure; la statue du général Desaix que nous avons vue sur la place Dauphine,… fut manquée deux fois et n'en fut pas meilleure à la troisième;… Je pourrais citer plus de vingt statues ainsi manquées en tout ou en partie. Les personnes qui ont assisté a la fontede la statue équestre de Henri IV, le 16 octobre 1817, peuvent se rappeler les anxiétés de Lemot, lorsque le fondeur Piggiani vint tout consterné lui témoigner ses inqúiétudes sur l'agglomération des métaux, par l'effet du refroidissement du fourneau, le feu le plus vif et le plus soutenu, dit M. de la Folie qui a décrit toutes les opératious de cette fonte, ne pouvant les remettre en fusion." Héricart de Thury 1836, 366 footnote

Gerhard Meyer was chosen as successor to cast the statue. His first attempt also failed and it was only in 1796, almost 40 years after the first commission, that Meyer, finally was able to produce a successful cast.[493] Even the Italian bronze founders were not always flawless with the lost wax casting of monumental bronzes. Teolato for example, details the failure by the Righetti's with their monumental cast of Antonio Canova's (1757-1822) *Napoleon as Mars the Peacemaker* in 1808, which had to be cast twice.[494] It must be said that the Righetti's learned from their mistakes and the next two monumental casts of Canova's equestrian statues of Carlos III (1734-1759) and Ferdinand I of the Two Sicilies (1751-1825) were successful with the first attempt.[495] The mishaps with these bronzes, were sometimes due to the size of the sculptures and/or problems with the melting of the huge amounts of bronze required for these monumental bronzes. More often, the cause of failure was the cracking of the mould during the burn-out of the wax.

Sand moulds had some distinct advantages over lost wax moulds. These moulds could be monitored and repaired during the entire moulding process, which is not the case with lost wax moulds. From the moment the first outer mould layer is applied to the wax model, its all-important surface is hidden from view, only to re-appear once the final bronze is cast and sufficiently cooled down to remove the outer mould. Any failures such as imperfections in the mould impression, as a result of mistakes in application or cracking of the mould during burn-out, are hidden from view. Shifting, cracked or crumbled cores, caused by the burn-out of the wax, can also contribute to failure of lost wax castings. Fesquet remarks in this respect:

> This heating [of a lost wax mould] is always very difficult, especially when the work is large and has an akward shape, like many equestrian statues… Moreover, during the drying of such an unwieldy mass, it is always to be feared that some portion of the cope or core will fall and clog the air passages or the gates for the metal…The finishing of the [lost wax] casting is also difficult, since there is no pattern to guide the operator [chaser]…[496]

It was precisely the failures with one of the last traditional monumental lost wax castings, François Frédéric's Lemot's (1772-1827) statue of Henri IV,[497] which prompted Honoré Gonon's interest in the lost wax casting process as Honoré's son Eugène recalls: "It was after the attempt of Lemot that my father, far from being discouraged by the bad outcome of this casting, became fascinated with searching for improved means of casting it, and, indeed, his prime was spend in costly attempts…"[498]

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[493] 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): 733.

[494] Second and successful cast carried out between September and November 1809. Teolato, Chiara. "I Righetti a servizio di Canova." *Studi di Storia dell'Arte 23* (2012) Ediart (2013): 206. This bronze has been on display in the courtyard of the Palazzo dell'Accademia e della Pinacoteca di Brera in Milan since 1859.

[495] Ibid 2013, 221-222. Cast between 1820 and 1828, both statues can still be found at the Piazza del Plebiscito in Napels.

[496] Overman 1881, 254-255.

[497] For the complete, albeit less critical, contemporary description of the creation of this statue; Lafolie 1819.

[498] Eugène Gonon in the Champeaux Manuscripts preserved at the library of the Musée des Beaux Arts Décoratifs in Paris. Shapiro 1985, 114.

Because of the difficulties with the lost wax casting of this statue, Honoré Gonon was asked to cast in 1817, using sand moulds, the figure of Henry IV and the bas-reliefs.[499] The obstinate Lemot apparently did not really learn from his previous failure because seven years later, in 1825, Gonon was asked again to do almost exactly the same for another of Lemot's lost wax casting projects, the equestrian statue of Louis XIV in Lyon.[500] It was the innovator Honoré Gonon who now began to experiment with lost wax casting from 1828 onwards. After years of experimentation, Honoré Gonon together with his sons Joseph Honoré (nd) and Eugène Paul Louis (1844-after 1875), established a foundry in Paris specialising in the lost wax founding of 'difficult to realise art objects'.[501] It is important though, to emphasize here that the lost wax casting technique was actually never completely 'lost'. Not only was the *cire perdue* technique in un-interrupted use by the founders of precious metals and other small art objects throughout the nineteenth century, it was also still practised by Lemot at least up till 1825.[502] It was whilst working for Lemot when Honoré Gonon was introduced into the lost wax technique.[503]

These early castings by the Gonon foundry were rather small bronzes, often animalier type sculptures. By 1832 however, the Gonon foundry managed to cast larger bronzes such as Francisque Joseph Duret's (1804-1865) *Fisherman Dancing the Tarantella*, now preserved in the Musée du Louvre, Paris (fig. 2.20).[504]

Fig. 2.20. Francisque Joseph Duret, *Fisherman Dancing the Tarantella*, lost wax cast bronze by Honoré Gonon in 1832. Acquired by king Louis-Philippe. (H. 1.58 m; W. 0.67 m; D. 0.58 m) Department of Sculptures Louvre Museum, Paris, inv.no. L.P. 62. (image Musée du Louvre / P. Philibert)

[499] Shapiro 1985, 114.
[500] Lebon 2003, 168.
[501] "fonderie d'objects d'art difficiles à réaliser": Lebon 2003, 169.
[502] Lebon 2012, 74.
[503] Gonon, Eugène. *L'art de fondre en bronze à cire perdue* (1878): 18.
[504] Francisque Joseph Duret (1804-1865), *Fisherman Dancing the Tarantella*, (H. 1.58 m; W. 0.67 m; D. 0.58 m) Musée du Louvre, Paris, inv.no. L.P. 62.

One of Gonon's clients was the famous animalier sculptor Antoine-Louis Barye (1796-1875) and in 1835, the Gonon foundry produced Barye's impressive *Lion and Snake* (fig. 2.21).[505]

Following on from this, Gonon together with his sons, produced some remarkably detailed lost wax casts between 1836 and 1838, for example Barye's *surtout de table* for the Duke of Orleans.[506] Commissioned by the Duke in 1834 for his dining room table, this grand centrepiece comprised five principal bronze sculptures together with some smaller sculptures. All five principal sculptures are now preserved at the Walters Art Gallery in Baltimore, three of them inscribed by Gonon with a most interesting inscription: "Bronze d'un seul jet sans ciselure fondu a l'hotel d'Angevilliers par Honore Gonon et ses deux fils"[507]

Fig. 2.21. Antoine-Louis Barye, *Lion and Snake*, 1832, bronze. Cast using the lost-wax process by the Gonon foundry in 1835. (H. 1.35 m; W. 1.78 m; D. 0.96 m) The plaster cast, dated 1832, was presented at the Paris Salon of 1833. Commissioned for the Tuileries gardens, where it stood from 1836 to 1911. Acquired in by the Musée du Louvre in 1836. Department of Sculptures, Musée du Louvre, Paris inv.no. L.P. 1184. (image Musée du Louvre / Thierry Ollivier)

Gonon's pride in being able to cast a bronze in one piece, with a surface not requiring chasing, is reminiscent of the German efforts earlier with sand mould casting. However, when studied closely, some of these bronzes were not entirely made in one piece as Gonon so

[505] Antoine-Louis Barye; *Lion and Snake*, 1832, lost-wax cast bronze by Honoré Gonon and sons in 1835 (H. 1.35 m; W. 1.78 m; D. 0.96 m) Department of Sculptures Musée du Louvre, Paris, inv.no. L.P. 1184.

[506] Because of time constraints, Barye did not commission the Gonon's exclusively to produce all the casts for the *surtout de table.* With two of the principal scenes Barye had to enlist the help of Eugène Quesnel, (c.1792-before 1858), Louis Richard (1791-1879) and Antoine Marie Fressange (?-?).
See for the latest interpretation of the execution of the centre piece; Lebon, Élisabeth. 2012b. "Le *Surtout du duc d'Orléans* : une nouvelle interpretation." INHA Les Collections électroniques, 2012, <http://inha.revues.org/3514> [accessed 13-6-2018]

[507] "Bronze cast in only one pour without chasing at the hotel d' Angevilliers by Honore Gonon and his two sons". (translation author) Walters art Gallery Baltimore (acc. No. 27.174, 27.176, 27.178

proudly states.[508] Although casting a bronze in one piece has often been regarded as evidence of superior skill, this is not necessarily always the case.[509] Sometimes a founder opted for practical reasons to cast a bronze in sections. These reasons could be limitations of furnace and kilns or convenience of handling or transportation. Other reasons for casting in parts, a practice already used by Renaissance founders, could be accessibility for finishing certain difficult-to-access parts of a bronze.[510] The wax models for these early lost wax castings by Gonon were probably made using gelatine moulds. The large-scale production of gelatine became possible as a result of an invention in 1829 by Jean-Pierre-Joseph D'Arcet (1777-1844).[511] In the same year Lebrun described, in his manual for the moulder: *Manuel complet du Mouleur*, the use of gelatine as a mould material albeit mainly for moulding fine delicate objects such as cameos and medals.[512] The Parisian moulder Hyppolite Vincent (?-?) is credited with the first use of gelatine for moulding and reproducing sculpture in plaster:

> … another Parisian artist has discovered a process by which he makes solid casts in plaster of small animals or other objects, without seams or repairs, and without destroying the model, (Moulage d'une seule pièce, sans couture ni reparage, et avec conservation parfait du modele). … among which are casts of the hand of an infant of six months, so delicately executed, that the skin shews evident marks of being affected by some slight eruptive disease.[513]

Lebrun on the other hand, did not see gelatine moulding as a recent invention and mentions its use as a moulding material already being covered in the eighteenth century Diderot *Encyclopédie*.[514] Lebrun might have actually referred to glue moulds. These flexible moulds can be considered as the predecessors of gelatine moulds, and were usually a mix of animal glue, molasses and a varnish or linseed-oil.[515] Gelatine moulding is strongly linked to lost wax casting and in countries where lost wax casting is introduced relatively late, gelatine as mould

[508] 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.
[509] "It has been said that no such skill is needed for casting part of a statue as for a whole one" : Fesquet in Overman 1881, 256.
[510] Smith, Dylan. "Technical characteristics of bronze statuettes from the workshops of Antonio and Giovanni Frencesco Susini." *The Renaissance Workshop.* D. Saunders et al. Archetype Publications (2014): 29-41.
[511] Lebon 2012, 85-86.
[512] *Moulage à la aide de gélatine ou de la colle-forte* in Lebrun 1829, 188-190.
[513] Robinson, Sir John. "Notes on Daguerre's Photography." *The Edinburgh New Philosophical Journal*. Robert James (ed.). Volume XXVII (1839): 157.
[514] "On a, de nos jours, voulu donner comme une découverte cette application de la gélatine au moulage: c'est une erreur; car dans l'ancienne Encyclopédie le chevalier de Jaucourt indique la manière d'employer cette substance à mouler différens objects" in Lebrun 1829, 189. Chevalier Louis de Jaucourt (1704-1779) was the most prolific contributor to the Diderot Encyclopédie. He contributed about 18,000 entries which constitutes approximately 25% of the entire Diderot encyclopedia. I have not been able to find Jaucourt's description of gelatine moulding. Fiquet (1780) does not mention the use of gelatine in his standard work on moulding.
[515] Overman gives a recipe for making elastic moulds, for casting plaster of Paris: "*8 parts of glue, 4 parts of molasses, mixed and boiled together, and to this gradually added one part of varnish or boiled linseed-oil. This mass is cast hot over a pattern*". Overman 1851, 175.

material sees a fairly late introduction as well.[516] The great advantage of a gelatine mould over a plaster mould was its flexibility. This offered a mould with some distinct advantages: first of all, undercut surfaces could be moulded, thus eliminating the need to divide the mould in many parts. The entire gelatine mould could consist, in theory, of only one part. For practical reasons a gelatine mould was often divided up into parts, although substantially less than would have been required for a rigid plaster mould. This in turn, meant considerably less or even the complete absence of moulding lines on the surface of the cast. Gelatine moulds did however have some disadvantages since the gelatine is sensitive to heat and moisture. The heating up of the mould, caused by hot weather and hot wax or the exothermic heat of solidifying plaster cast into the mould, had adverse effects on the properties of the gelatine.[517] The heat and moisture affected the surface and the strength of the mould and thus limited the number of successful casts from a gelatine mould. The maximum number of acceptable casts, with good surface detail and without distortion, which could be taken from a gelatine mould, was between seven (during summer) and twelve (during winter).[518]

The innovative Honoré Gonon was most likely an early user of gelatine moulding, as was his son Eugène (1814-1892), who continued the Gonon foundry after his father death.[519] This foundry was, by the middle of the nineteenth century,[520] probably the only foundry in Paris and perhaps also the only one in Western Europe, able to cast bronze statuary by the lost wax method.[521]

The fact that the knowledge and skill of lost wax casting was in the hands of only one founder, began to worry people. The ageing founder Eugène Gonon had no sons interested in succeeding him and he complained he could not find an apprentice.[522] Fearing Gonon would take his knowledge with him to the grave, a group of artists decided to take action and started a petition.[523] Eugène Gonon was then asked to write down his knowledge on lost wax casting and received in return a yearly state pension. This pension enabled him to continue his foundry and compete with foundries using the less expensive sand mould casting method.[524] In this manuscript of 1876, Gonon records a history of lost wax casting, his father's

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[516] The American sculptor William Ordway Partridge (1861-1930) mentions in 1895 that gelatine was only used as a moulding material within the previous twenty years; Partridge, William Ordway. *Technique of Sculpture*. Ginn & Company (1895): 82.

[517] See also 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].

[518] Ibid. Lebon also makes the plausible suggestion that this maximum number of twelve casts in a gelatine mould determined the number of twelve 'original' casts allowed by French law to be made from an artist model. For more on the French legal aspects of sculpture reproduction; Le Normand-Romain 2007, 65-77.

[519] Ibid Lebon.

[520] Roughly between 1829, when father Honoré began experimenting with lost wax casting and 1880 when Pierre Bingen also starts to cast using the lost wax method.

[521] "Un seul artiste français, un seul, M.Gonon, s'attache obstinément á la pratique de la cire perdue,.." in Busquet, Alfred. "Bronzes modernes et bronziers contemporains." *L'Artiste*, 26 October (1856): 248.

[522] Although Eugène Gonon had three sons, most of them metal workers, they did not follow in their father's footsteps probably because of the low income their father was generating with lost wax casting.

[523] Lebon 2012, 59.

[524] 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]

experience with lost wax casting, and his own working methods.[525] He mostly details gelatine moulding and gives some bronze alloys he uses for casting, however the manuscript is by no means an instructive manual.[526] Gonon mentions in this manuscript that when he took over the foundry in 1840, the lost wax process was far from perfect and he spend the next thirty years making improvements. One of the improvements he described, was the pouring of the mould, instead of the time-consuming brushed application of layers, as was done traditionally. He used for this a mixture of sand, brick dust and plaster,[527] enabling Gonon to take a large mould in only one day whereas the traditional way, with brushed successive layers, would take days if not weeks.[528] Another one of Gonon's improvements was to fix the gelatine mould, using a dovetail system, to the outer plaster shell. The purpose of this was to prevent gelatine movement or distortion which was common, especially with larger moulds.

As the artists' petition for Gonon demonstrated, a growing interest in the lost wax technique developed in France and gradually other founders such as Pierre Bingen (1842-1908) from 1880 and Gruet and Thiébaut Frères began to apply this method at the end of the 1880s.[529] Around the same time, a similar revival of lost wax casting occurs in Germany, Belgium and Britain.[530]

2.8 Lost wax casting of monumental sculpture in Italy between 1800-1840

Italy deviates from Western Europe in the sense that the tradition of lost wax casting in Italy appears to have an un-interrupted history since at least the Middle ages up till current times.[531] There is however a misconception stating otherwise, introduced in 1837 by Antonio Ramirez di Montalvo. In a document, now in the archive of Academy of Art of Florence, Ramirez di Montalvo argues that the lost wax casting of monumental sculpture was lost after Massimiliano Soldani Benzi's death in 1740, only to be re-introduced by Clemente Papi (1803-1875) in the 1830's.[532] Rizzo still repeats this statement despite the fact that we know

[525] Honoré Gonon was actively using lost casting between 1828 and 1840.
[526] Gonon 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> [accessed 13-6-2018]
[527] Sand from Belleville 2 parts, brick dust (*terre cuite écrase*) 2 parts & moulding plaster 2 parts; Gonon, 1876; 30. The brick dust and sand act as inert fillers to limit the shrinkage of the plaster.
[528] Gonon appears to have been the only one using a poured mould, the founders after Gonon such as Bingen, Hébrard and immigrant Italian founders all used the traditional brushing technique.
[529] Gruet before 1887; Shapiro 1985, 116. Thiébaut Frères before 1889; Lebon 2003, 246.
[530] Luer 1902, 117; J The *Compagnie des Bronzes* in Brussels, who started casting with the lost wax method in 1879, were still using in 1883 plaster piece-moulds instead of gelatine moulds; Savile 1883, 11-12. See also Marie Wautelet, "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; James 1986, 24.
[531] Shapiro 1985, 117.
[532] Antonio Ramirez di Montalvo, letter to Luigi Pratellesi, 23 December 1837, in: AABAF, anno 1837, ins. 103. Rizzo, Giuseppe. "Clemente Papi "Real Fonditore": Vita e opera di un virtuosistico maestro del bronzo nella Firenze dell'Ottocento." *Mitteilungen des Kunsthistorischen Institutes in Florenz*. 54. Bd. H. 2 (2010-2012): 314 note 26.

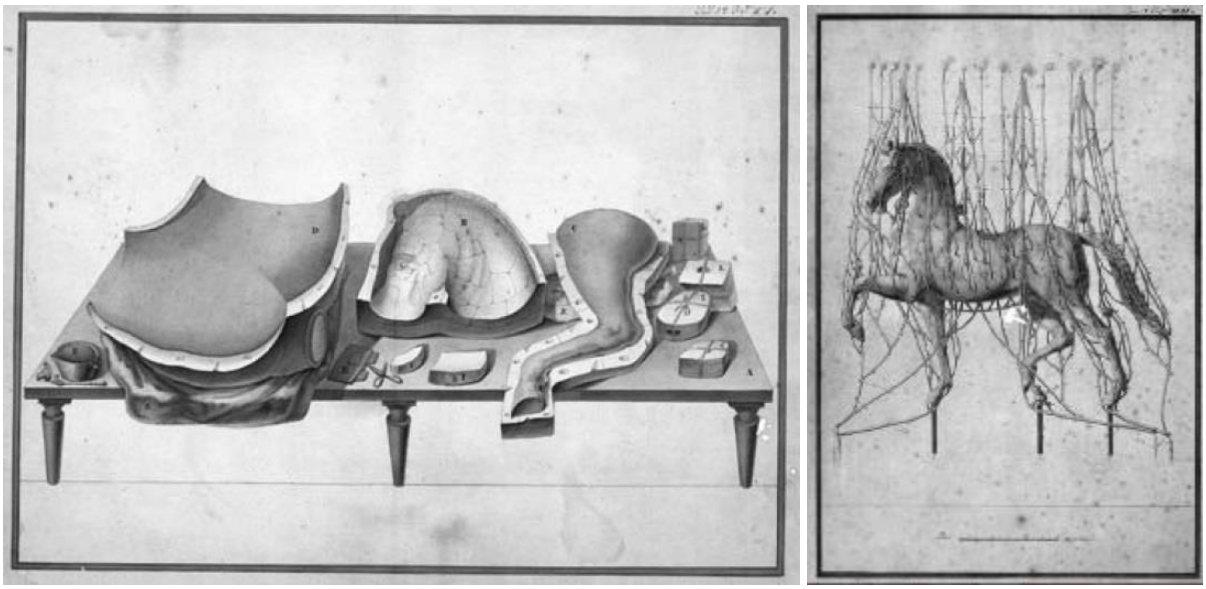
that the Righettis have been using the lost wax technique in their Rome and Naples foundries, with the latter working up till 1842.[533]

The leading founders for the casting of bronzes in Italy around 1800 were Zoffoli, Righetti and Boschi, mainly producing Grand Tour pieces in the classical taste, all three based in Rome, with the Righettis also running a foundry in Napels. The Zoffoli foundry ceased in or before 1805 and Giuseppe Boschi's (1783-1824) around 1810, giving the Righettis - Francesco (the elder) (1738-1819) and Luigi (1780-1852?) - free reign in Rome and Naples.[534] The Righettis were not only producers of collector's statuettes, they were also engaged in the casting of monumental bronze sculpture, some of the largest produced at the time.[535] These include the earlier mentioned commissions from Canova; *Napoleon as Mars the Peacemaker* and the equestrian statues of Carlos III (1734-1759) and Ferdinand I, king of the Two Sicilies (1751-1825) (Fig. 2.22).

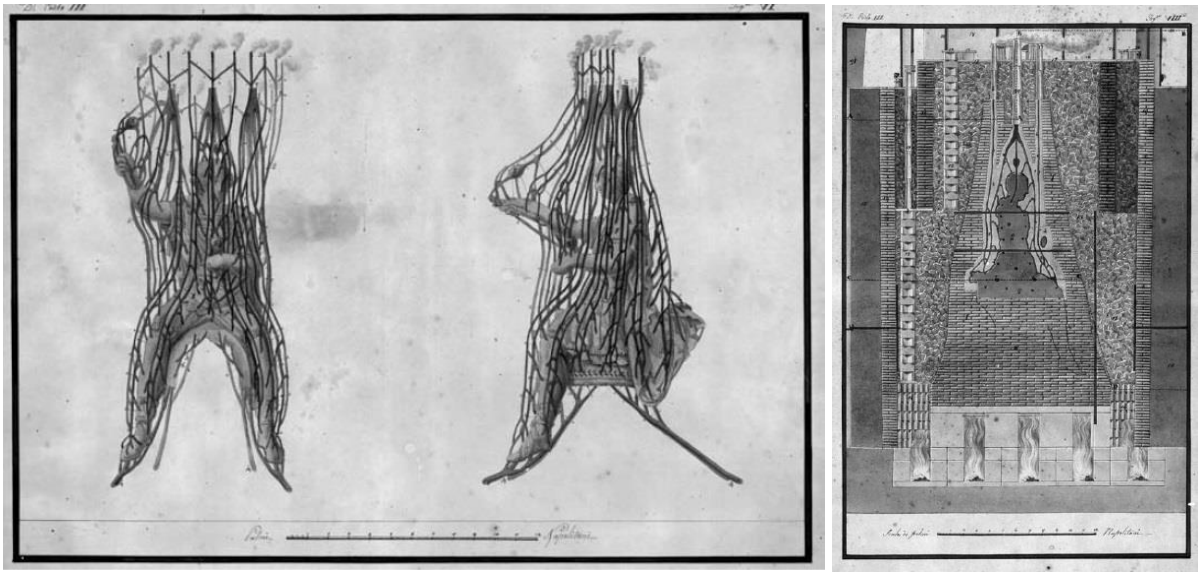
Fig. 2.22. Antonio Canova; Three monumental bronzes cast by the Righetti foundry. On the left *Napoleon as Mars the Peacemaker* on display in the courtyard of the Palazzo dell 'Accademia e della Pinacoteca di Brera in Milan. In the middle the equestrian *statue of Carlos III* and on the right the *statue of Ferdinand I of the Two Sicilies* both at the Piazza del Plebiscito in Naples. (images Wiki commons)

The Righettis were clearly proud of their casting achievements and documented the whole process in a manuscript which has fortunately survived.[536] Through detailed descriptions and illustrations of the steps in the making process and the used materials, it provides an excellent insight in the lost wax method as used by the Righettis (fig. 2.23-2.26).

[533] Rizzo 2010, 297 & Personal communication with Chaira Teolato, 5-6-2015
[534] Teolato 2013, 201-260.
[535] Righetti claimed to have cast fourteen life-size statues, in addition to the last Napoleon, during his career. Teolato 2013, 212.
[536] Archivio Segreto Vaticano (ASV), Instrumenta Miscellanea (Instr. Misc.) 8776, 8787, 8790. This document was found by Chiara Teolato in the Righetti archive in the Archivio Vaticano in 2008.



Figs. 2.23 & 2.24. Foundry S. Giorgio a Cremano (Righetti foundry Naples), left figure; preparation of wax model in plaster piece-moulds, note the scissors for cutting the wax plates. pl. n. 12, fig. XV. Right figure; the gating system attached to the wax model of the horse, pl. n. 18, fig. XXII. Both illustrations are pen drawing and watercolor, ASV, Instrumenta Miscellanea. (from Teolata, 2013)



Figs. 2.25 & 2.26. Foundry S. Giorgio a Cremano (Righetti foundry Naples), left figure; Illustration of the gating system for the horseman indicating the system of runners and risers. Pl. n. 1, fig. VI. Right figure; cross section illustrating the set up for wax burn-out. Pl. n. 1, fig. VIII Both illustrations are pen drawing and watercolor, ASV, Instrumenta Miscellanea. (from Teolata, 2013)

These depictions, of the steps in the casting process, are reminiscent of Boffrand (1743) and Mariette (1768), published in the previous century in France and suggest a possible familiarity of the Righettis with these French publications.

Luigi Righetti closed the Naples foundry in 1842 and died ten years later in Rome. It is not clear when the Righetti foundry in Rome was closed, the foundry and shop in the Piazza di

Spagna in Rome are known to have existed till at least 1834.[537] Around the same time Clemente Papi starts in Florence to experiment with lost wax casting.[538] There is no link yet found between Papi and the Righetti foundry and it is therefore not wise to speculate about a possible link. Perhaps Papi, akin to Gonon in Paris a decade earlier, started to experiment in isolation. Papi was a student of Francesco Carradori who wrote a book on sculpture techniques.[539] Papi was also using most probably Cellini's autobiography and treatise on sculpture of which several editions were published by then.[540]

2.9 Conclusion

Through analysis of technical contemporary descriptions, I have been able to build a more detailed picture of the founding of sculpture in the nineteenth century. 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 study of the bronze sculptures themselves, could potentially provide more information, although this should be done with care.
The traditional categorisation in lost wax or sand mould casting might not be 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. There is evidence for the use of plaster cores in sand piece-mould castings and vice versa, sandy loam was used for lost wax cores. In addition to this, it is very difficult to identify the use of piece-moulding for the exterior mould on a finished bronze.

The moulding and casting of complex hollow sculpture in sand is performed with piece-moulds. This research presents for the first time the earliest evidence for piece-moulding, which was found in the sub-chapter *Fondeur en Sable* from the chapter "*Fonte de l'or, de l'argent et du cuivre*", from Diderot's *Encyclopédie* from 1767. At the same time, the Diderot chapter on sculpture casting does not mention piece-moulding (*Sculpture fonte des statues equestres*, 1771). Dossie's (1758) and Sprengel's (1770) descriptions of loam/clay piece

[537] Teolato 2013, 224
[538] Rizzo 2010, 297.
[539] Carradori, Francesco. *Istruzione elementare per gli studiosi della scultura*, Tipografia della Società Letteraria, 1802.
[540] Personal communication (11-6-2015) from Giuseppe Rizzo who is working on a publication on Papi and his role in bronze founding in Italy.

moulding are to date the earliest European accounts of the piece-moulding of a refractory sculpture mould, used for casting bronze directly into. These descriptions by Sprengel and Dossie are possibly the earliest descriptions of sand mould casting of bronze sculptures and challenge current accepted views that the sand 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 during the first quarter of the nineteenth century, lost wax casting as the preferred technique for the casting of monumental sculpture.

It can be concluded that Germany was closely behind France, whereas for Britain and the United States it took until 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, a skill acquired during their stay in Paris. This example of knowledge transfer can also be observed in other countries, for example Germany and Britain, where the foundry knowledge of sand piece-moulding transferred, either by French foundry men working abroad or foreign practitioners working in France. 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 mould, to develop and thus contributed to the shift in preference, during the nineteenth century, from lost wax towards sand mould casting:

- 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 France 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

This chapter analyses in detail several contemporary manuals with the aim of understanding more closely the use of sand mould casting. One of the outcomes of this, is an increased awareness of the complexity of this technique, especially during the early, more experimental, phase.

It can be concluded, that the Gonon family played a crucial role in the technical development of nineteenth century bronze casting. Evidence was found, bringing back the earliest, recorded date for the first use of sand piece-moulding in France: Martins, writing in 1824, credits

Rousseau with the invention of this technique in 1798. Because it is this Rousseau, who employed Honoré Gonon in 1804 and possibly earlier, it is possible that Gonon and not Rousseau is the person responsible for the introduction of sand piece-moulding in France. This study also brought to light that Gonon worked for a short period, between 1818 and 1824, in Berlin. Gonon was also instrumental in the re-introduction of lost wax casting in France in the late 1820's. In a time when virtually all sculpture in France was cast using sand moulds, Gonon started to experiment in 1828 with the then virtually obsolete lost wax casting. He developed his own method using gelatine to make his own flexible moulds. His son Eugène would eventually continue his father's workshop. Father and son Gonon single-handedly kept the technique of lost wax casting alive in France between 1828 and 1880, when an increased interest in lost wax casting prompted other foundries, as Bingen and later Gruet and Thiébaut Frères, to start casting bronzes using this technique. Although the Gonon's introduced innovations in lost wax casting they did not re-invent or re-introduce lost wax casting in France.

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. Sand mould casting was also seen as a desirable innovative technique, whereas lost wax casting was considered as outdated and associated with the *Ancien Régime*.