Casting Rodin's Thinker

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

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Chapter 4 Casting Rodin's *Thinker*

4.1 Introduction

This chapter will investigate the casting and finishing techniques as practised by foundries commissioned by Rodin to reproduce his bronzes. Since the majority of Rodin bronzes were cast using the sand mould casting method, this technique will be covered extensively. Very little is known on historic working practises of nineteenth century foundries using sand moulding and more specifically, the piece-moulding used for the production of sculpture. This makes it difficult for conservators and curators to interpret these bronzes. By looking at contemporary accounts such as manuals, newspaper articles, this chapter adds to our knowledge of the founding of Rodin bronzes, the *Thinker* in particular and will answer the question of how this sculpture was produced by casting.

The casting in natural sand piece-moulds of intricate shapes, such as figural sculpture with a multitude of undercuts, is a complex, very labour-intensive and intricate process. Because of rising labour cost and lack of skilled founders, sand mould casting, using natural sand, is rarely practised anymore.[618] Because of the complexity, this process is poorly understood by curators and conservators. This means that sand mould cast bronzes are often not recognised as such. The use of complex cores and the resulting art-technological evidence in the form of core irons and flashing, could not be fully understood by consultation of existing literature on nineteenth and early twentieth century bronzes. This chapter seeks to elucidate the process of sand mould casting by giving a step by step account of the casting in sand of a *Thinker*. A detailed picture of moulding and casting is created through the use of early descriptions, photographs and through close study of existent sculptures. As far as possible, the working methods of the foundries commissioned by Rodin are described. In some cases, this information is not sufficient and is supplemented by other sources such as contemporary manuals, to enhance our understanding of late nineteenth century foundry practices. By using these contemporary sources, such as manuals, movies and by studying surviving foundry plasters, tools and bronzes, a detailed picture is given of a now largely vanished casting technique that produced the majority of nineteenth and early twentieth century bronzes.

[618] To my knowledge is the Bedi-Makky foundry in Brooklyn (NYC), the only foundry still performing this type of work.

4.2 Sand moulding

4.2.1 The pattern

The vast majority of Rodin's *Thinkers* were cast using sand moulds. This applies to the original (medium) size, as well as the mechanically enlarged or reduced size *Thinkers*.[619] Of the approximately fifty legitimate casts of the original size,[620] only the first one, the so-called Ionides *Thinker* in Melbourne, was cast by the lost wax method.[621] There are twenty-two recorded legitimate casts of the enlarged monumental size *Thinkers* with only two of them lost wax castings, both by the Hébrard foundry.[622]

The pre-requisite for sand moulding is a sturdy pattern capable of withstanding the forces of compacting (so-called ramming) moulding sand against it. Sand moulders have used a wide variety of materials in the past for patterns such as: copper, brass, iron, lead, tin or pewter alloys, wood, plaster and very occasionally even wax.[623] Wax is not very suitable for sand moulding because of its softness which makes it susceptible to damage and deformation, plus the fact that the moulding sand has the tendency to stick to wax surface. Generally speaking, the patterns made from metal were used for the moulding of series of smaller items such as statuettes, up to 60 cm, whereas for larger items, plaster patterns were usually preferred.[624] These were less expensive to make, easier to handle and the cutting of the false cores was easier to perform on plaster.[625]
Larger or intricately shaped smaller patterns were often composed of detachable parts. Usually this was done to simplify the casting by dividing up the pattern in parts, which then could be cast separately (fig. 4.1).

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[619] The focus of this research is the original size *Thinker*, the enlarged or reduced *Thinkers* are outside the main scope of this research although occasionally references are made to the enlarged *Thinkers*.
[620] Blanchetière in Tilanus 2011, 45. Legitimate or authentic casts are casts reproduced under the supervision of Rodin or the Rodin Museum, Paris.
[621] National Gallery of Victoria, Melbourne (inv.no. 1196-3). This anomalous cast, dating from 1884, has some deviating details in the modeling but is basically the same model as the later *Thinkers* and will be discussed in detail in sub-chapter 5.3.4 *The lost wax cast Ionides Thinker: Bingen or Gonon?* in this thesis.
[622] One cast in 1903 and currently in front of Grawemeyer Hall at the University of Louisville USA and a 1904 cast currently in garden of the Ny Carlsberg Glyptothek in Copenhagen. For the complete list of *Thinkers*: see appendix 2.
[623] Copper: ter Kuile, Onno. *Koper & Brons*. Rijksmuseum (1986): 295-311; brass, lead, iron: "…daß die Modelle theils aus Messing, theils aus Blei oder auch in einzelnen Fällen selbst aus Eisen bestehen."*;* Vorsteher 1982, 264; tin: Hartmann 1840, 376; wood: The pattern for the 4.5 metre high cast iron statue of Henry Clay, cast in 1853 by the Philadelphian foundry of Robert Wood, was an assembly of 150 wooden parts; Hincley, C.T. "A day at the Ornamental Ironworks of Robert Wood." *Godey's Lady's Book,* 47, July (1853): 5-12; wax: Altmütter describes the use of wax amongst other materials as pattern: "Modelle aus Eisen, Blei, Gyps (mit Leinöhlfirniß getränkt), Wachs… kommen nur in einzelnen besonderen fällen vor."; Altmütter, *Messinggiesserei sandabformen*, in Prechtl & Karmarsch 1838, 595 & Lebon 2012g, 9 footnote 4 and Altmütter, *Bildgießerei*, in Prechtl & Karmarsch 1830, 166.
[624] Gillot 1879, 226-227.
[625] Guettier 1858, 266.

Fig. 4.1. A copper alloy pattern (*chef-modèle*) for sand moulding, taken apart into its various components. Emmanuel Fremiet, *Char de Diane,* Dijon. Musée des Beaux-Arts, inv.no. 4184 (from Lebon 2003, 45)

The Rodin Museum in Meudon preserves various assembled copper alloy patterns, called *chef-modèles* in their collection (figs. 4.2 & 4.3): invariably these were used for sand moulding smaller models. These patterns are well finished with great detail and can show the typical feature of thickened edges (*bourrelets*) (fig. 4.2).

Fig. 4.2. Close-ups of the assembled pattern of Rodin's *Youth triumphant* (*La jeunesse triomphante*), 1898, illustrating the thickened-up edges of parts. This copper alloy pattern (*chef-modèle* or *maître-modèles*), cast by Thiébaut Frères, Fumière & Gavignot, dates from 1898. Rodin Museum, Meudon, inv.no. S.2474

Fig. 4.3. A. Rodin, *Youth triumphant* (*La jeunesse triomphante*), Paris, 1898. This copper alloy pattern was cast by Thiébaut Frères, Fumière & Gavignot. Rodin Museum, Meudon, inv.no. S.2474

Fig. 4.4. Detail of a pattern at the Chardon & Petit Fils foundry in Paris, illustrating the male part of a sleeve or roman join. (image Jane Bassett, Getty Conservation Institute, Los Angeles)

These are the edges where the different parts are joined by a Roman or sleeve joint (*emmanchure à la romaine*) (fig. 4.4). This is a mechanical fit whereby a male and a female part are fitted together and secured and locked in place by a riveted pin (*cheville*). The purpose of the thickened edges is to provide extra material for finishing the join. It is virtually impossible to fit the two parts together without a distracting visible gap. By hammering the excess metal, with the aid of hammers and chasing punches, towards the gap, it is possible to close the gap completely and therefore render the join almost invisible (fig. 4.5).

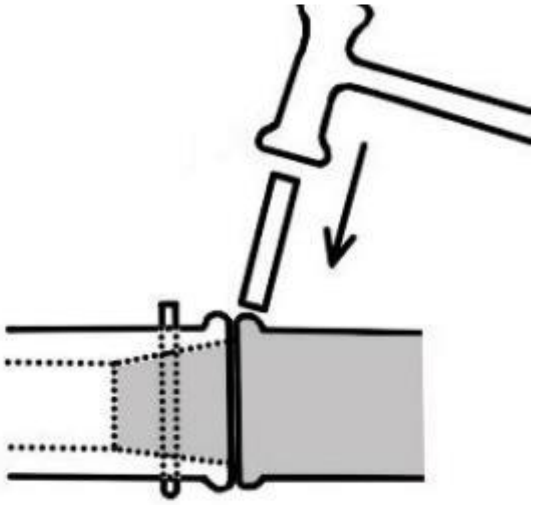

Fig. 4.5. Drawing illustrating the hammering of the thickened edges of a Roman joint to close the gap. (drawing V.Veenemans)

The pattern of the medium size *Thinker* was not made of metal but made of the lighter plaster instead. Plaster patterns of this size were cheaper to make and easier to handle. One other motive for choosing a pattern made from plaster, could be that a plaster cast is usually more detailed compared to a metal cast, also because it is one step closer to the original. Of three foundries, commissioned by Rodin, it is known with certainty that the patterns, used to cast the *Thinkers,* were all made from plaster.[626] For the other foundries it is very likely they were also using plaster patterns to cast this sculpture, although there is no documentation to confirm this.[627] None of the surviving plaster patterns have thickened edges. Contemporary images illustrating the casting of a monumental *Thinker* at the Rudier foundry in January 1950, show however, these thickened edges on the bronze cast. The extra space for these edges must therefore have been carved directly into the sand mould. This can be seen on figure 4.6, which is a detail of a photograph taken by Robert Doisneau in the Alexis Rudier foundry at Malakoff in Paris in 1950.[628]

[626] Namely the Alexis Rudier foundry, Georges Rudier foundry and the Petermann foundry. The Georges Rudier foundry produced, after the closure of the Alexis Rudier foundry, eleven more original size *Thinkers* between c. 1955 and 1969.
[627] Seven original size *Thinkers* were produced by other foundries, before Rodin began working with the Alexis Rudier foundry. This foundry was commissioned to cast all the original size *Thinkers* from ca.1901 till the closure of the foundry in 1952. See for this appendix 2 with the list of pre-dating 1940 original size *Thinkers*.
[628] Robert Doisneau (1912 - 1994) was a well know French photographer who made around 1950 a series of photographs in the Alexis Rudier foundry. This thesis will illustrate for the first time, a number of these photographs from the Doisneau family estate. I am indebted to François Blanchetière for making this possible.

Fig. 4.6. Thickened edge around a joint. Detail of an image depicting a monumental *Thinker* during finishing at the Rudier foundry. Image taken by Robert Doisneau in the Alexis Rudier foundry at Malakoff in Paris in 1950. (image Doisneau estate)

The three, original size, *Thinker* foundry plasters, preserved by the Rodin Museum, where originally all composed of detachable parts. Only one of these, foundry plaster (S.3189) has still all its parts detached (fig. 4.7).

The fact that a pattern consisted of separate sections does not imply the sculpture was also cast in parts. For example, the Alexis Rudier casts of the medium size *Thinker* are, upon examination, to be all cast in one piece (*fonte d'un seul jet*), whereas the plaster foundry models used by the Alexis Rudier foundry all consisted originally of detachable parts.[629] The reason for this was that the ability to remove certain parts from an intricate pattern, such a figural sculpture, greatly facilitates their moulding in sand.

Fig. 4.7. Foundry plaster S.3189, as displayed during the exhibition in Laren in 2011, together with its detachable parts.

[629] The foundry model of the monumental size *Thinker* was also divided up in parts, subsequently cast in parts and then assembled. The division in parts of the foundry model of the monumental *Thinker* is different from the original, medium size, *Thinker*.

The foundry decided whether a particular pattern needed to be moulded in parts and most likely performed this dividing of the plaster. Fesquet remarks on this the following:

> The pattern sent to the foundry is generally of plaster of Paris. It may be reproduced whole in sand, but the operation will be difficult, and the casting less sound than if made in parts. [...] he [the founder] cuts the plaster with small saws…. or with brass or iron wires twisted together. […] The next operation consists in providing the portions of the pattern thus cut, with the different tenons and mortises […] Thus the pattern, if not hollow already, is hollowed out for the mortise, and a plaster tenon added to the corresponding piece a neck or an arm, […] The joints of the tenons and mortises need not be made as tight and perfect as a corresponding work in joinery; a certain amount of "play" is or looseness being desirable.[630]

The foundry plasters were not sectioned by simply cutting a plaster cast into segments. The detachable parts, usually limbs such as arms, hands and legs, are fitted to the main body with sophisticated joints, for example dove-tail and mortise-and-tenon joints similar to cabinetmakers joints (figs. 4.8-4.11).

Fig. 4.8. Detail of foundry plaster S.2840, showing the dovetailed joint.

Fig. 4.9. Left hand of foundry plaster S. 3189.

Since it is impossible to make these complicated joins merely by cutting the plaster model, the foundry plaster could have been made out of two plaster casts supplied by Rodin's plaster moulders. Another possibility is that certain detachable parts such as hands, arms and legs were supplied to the foundry with excess material, enabling the foundry to make the complicated joins. Perhaps the foundry made a mould, allowing them to make a copy of this first foundry plaster (with all the separate parts), since foundry plasters have a limited working live and would have to be replaced in the future anyway.[631]

[630] Fesquet in Overman 1881, 258-259.

[631] The number of times a foundry model could be used before the plaster needed to be replaced is not clear. This was to a large extent determined by the skill of the moulder and the care for the plaster in the foundry. Normally, one could expect a life span of at least 10-12 mouldings for a foundry plaster.

Fig. 4.10. Details of foundry plaster S.3189 illustrating the mortise and tenon construction.

Fig. 4.11. Detail of foundry plaster S.3189 illustrating the mortise and tenon construction.

To reinforce foundry plasters, a wooden support structure was often added internally (figs. 4.12 & 4.13), a practice also described by Fesquet:

> Where the plaster pattern is large and hollow, like the body of a horse or the trunk of a man, it is well for the preservation of the pattern, and for the facility of handling, to support it internally with cross pieces of wood, which are fastened with plaster of Paris.[632]

[632] Fesquet in Overman 1881, 259.

Fig. 4.12. Underside of the base of foundry plaster S.2520, with the wooden reinforcement visible.

Fig. 4.13. A view of the underside of the base of foundry plaster S.2839, with remnants of the wooden cross and another wooden reinforcement deeper in the plaster visible.

One of the features of foundry plasters is their lacquered finish. This lacquer, often shellac, was applied to prevent the moulding sand from sticking to the surface of the plaster pattern during moulding. This coating was purely functional and therefore seldom applied uniformly, resulting in a patchy appearance (fig. 4.14). In the past, foundry plasters were unfortunately often cleaned whereby this lacquer finish was removed, to give the plaster a more aesthetically pleasing uniformly fresh white surface. This practice not only permanently removes historical evidence of its use, it also tries to alter the status of the plaster from foundry plaster, which is basically a tool, to an exhibition plaster, a finished product.

Fig. 4.14. Detail of foundry plaster S.3189 illustrating the patchy lacquered finish.

Another surface feature discernable on foundry plasters are the cutting lines which are caused by the piece-moulding process (fig. 4.15).

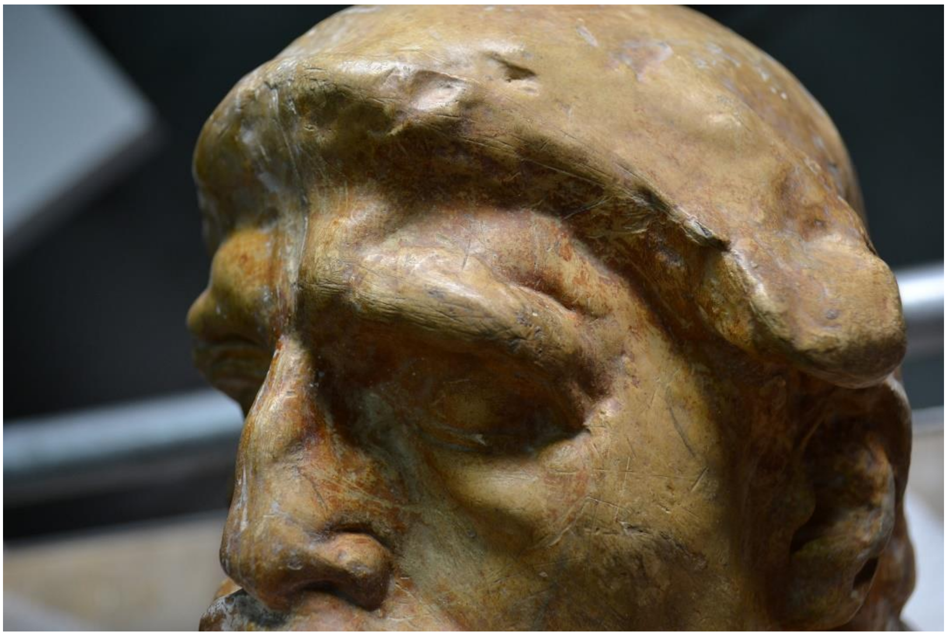

Fig. 4.15. Various cutting lines visible on foundry plaster S.3189. These lines mostly follow the high points of the pattern such as the nose, eye brows and hairline.

To make sharply defined mould pieces, the moulder cuts the sides of these mould pieces using a knife or sharp spatula, which leaves marks on the surface of the plaster. For convenience of moulding, the divisions between the various mould pieces usually followed the high points of the pattern (fig. 4.15).

Fig. 4.16. A detail of the underside of the left thigh of foundry plaster S.3189 showing pencil marks from the moulding.

This is done because it is easier to work on a high spot than in a depression, during moulding, especially when finishing the bronze. The removal of the flashing, caused by metal seeping between the false cores, requires mechanical action involving cutting tools such as chisels, files and scrapers and this is done with much more ease on a concave surface than a convex surface. Sometimes moulders indicated on the pattern, before moulding, the position of the mould divisions with a pencil (fig. 4.16).[633]

4.2.2 Flasks or moulding boxes

Moulded sand needs to be contained within a frame. This frame, in which the mould part is made, is called flask (Fr. *chassis*) and makes it possible to manipulate the mould-part it contains. Sand moulding intricate objects, such as figural sculpture, requires often multiple flasks (fig. 4.22) and these need to be assembled and disassembled occasionally. The bottom flask is called the drag or nowel, the top flask is called the cope and the intermediate parts are called cheeks.[634] Smaller flasks were sometimes made from wood, although most of the flasks used for sculpture founding were made of iron. Slotting the sturdy iron flasks tightly together enabled the moulder to make very rigid moulds, eliminating any possible play that might cause inaccuracies in the cast.

[633] Rama illustrates the division of mould parts on a pattern in his book, although he mentions this was not standard practice, since moulders usually decided during moulding, where to make the boundaries between mould parts: Rama 1988, 145.
[634] Tate and Stone 1909, 74.

Fig. 4.22. Flasks stacked on top of each other in Rudier foundry, Paris 1936 or earlier. (image Malvina Hoffman)

4.2.3 False-cores

The first step in the piece-moulding process was to fill the bottom flask, the drag, with a bed of sand.[635] This side of the mould, called the false side (faux *moule* or *couche*), was only going to serve as a temporary support for the pattern. The sand used for this false side was not going to be used for the final mould and could therefore be of inferior quality. The plaster foundry model or pattern was buried half way in the sand of the drag and sand was pushed up against the plaster by hand and the remainder of the flask was also filled with sand by light ramming. This first flask, with the pattern partly submersed, now served as a foundation to build subsequent flasks on top of this. The top surface of this supporting bed of sand, did not have to have a flat surface flush with the upper rim of the flask, it usually just followed the contours of the pattern. This surface was dusted with a parting compound, usually in the form of fine charcoal or talc powder. The shape of the pattern determined its position in the false side and was based upon what was most advantageous for ramming the sand, but also the withdrawal of the false cores and later the handling and position of the core.[636]

No photographs or contemporary descriptions are known of the piece-moulding in sand of the original sized *Thinker* and in order to get an idea of the position of the plaster pattern, inside the false side, this research looked at the surviving plaster patterns. The cutting pattern on the

[635] Duncan James mentions an old English term 'gulletting' for the piece-moulding process, a term I have not been able to find in any other foundry literature to date: James 1972, 287.
[636] Fesquet in Overman 1881, 260.

original foundry plasters is not very visible on photographs and is therefore indicated on a small plaster study model made for this research. The pattern of cutting lines which can be found on the surviving foundry plasters of the *Thinker* is as follows (fig. 4.23).

Fig. 4.23. Three different views of the same reduced plaster model of the *Thinker*, the lines on the surface indicate the cutting lines of the false cores, as observed on the original plaster foundry model (S.2840). The orange lines are where the original foundry plaster is divided in separate parts.

The cutting lines on the *Thinker* foundry plasters are not all exactly on the same spot, often one can discern a multitude of cutting lines, parallel to each other in a zone of 2 to 3 cm wide, due to repeated cutting for multiple mouldings. This is not unique to *Thinker* foundry models, this has also been observed on other plaster foundry models. When the tempered sand was deemed to be of the right consistency, a start with a false-core was made by pressing this sand locally against the plaster pattern. (fig. 4.24 left) This first layer of sand is also called facing sand and the best quality fresh sand is used for this. The lump of sand is further compressed by the moulder with a rammer (*fouloir*) (fig. 4.24 right), followed by a mallet (*maillet*) (fig. 4.25).[637] Several different types of these mallets were in use, for general ramming a large double faced *maillet à batter or maillet à double bobines* was used (fig. 4.26a) for finer work on mainly on the false-cores, a more tapered mallet was used, *maillet conique* (fig. 4.26b).

[637] A more precise term in use in the nineteenth century for the moulder of this type of work, is *fine art false-core sand moulder*: James 1972, 287.

Fig. 4.24. First step in the making of a false-core in sand, with on the left the pressing by hand and on the right with a rammer (*fouloir*). (from Baudry 2005, 279)

Fig. 4.25. The making of a false-core in sand with the use of a mallet. (from Baudry 2005, 279)

Fig. 4.26. Various sand moulding tools. (from Baudry 2005, 282)

Often false-cores were reinforced by placing a core iron or in the case of very large false-cores, an armature inside.[638] When the design of the gating system required runners to go through false-cores, the space for the runner was created by placing a conical lead pipe (*cornichon*), inside the false-core during the ramming of the sand. After completion of the false-cores, the lead pipes could be pulled out easily because of their conical shape, thus creating a tapered canal which could now be used as a runner.[639] With the sand compacted enough, the sides of the false-core were cut flat with a spatula, rendering the outside shape of the false-core geometrical. Often recesses were cut into the surface for keying, but also to facilitate the handling of the false-core (figs. 4.27 & 4.28).

[638] Rama 1988, 149-150.
[639] Ibid 146-147.

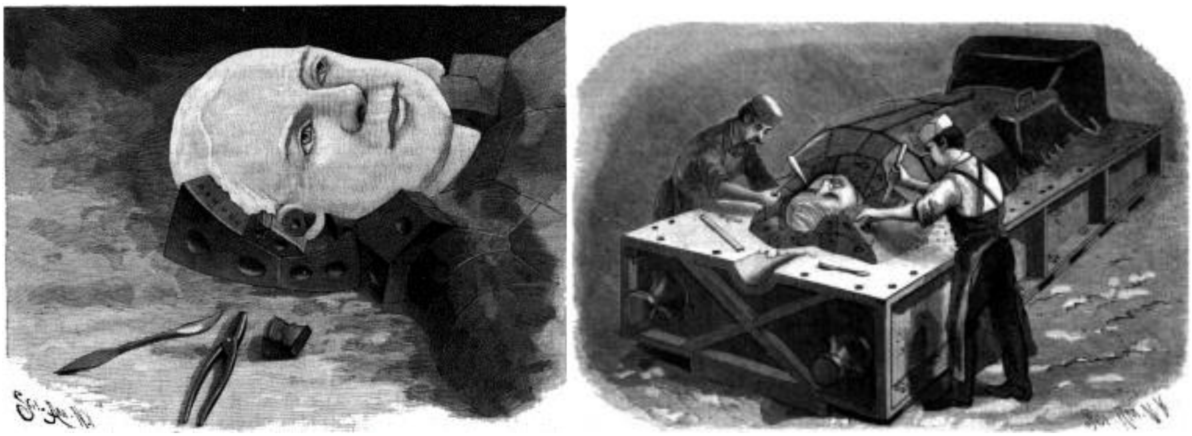

Fig. 4.27. The moulding, in 1890, of John Quincy Adams Ward's statue of Henry Ward Beecher in a sand piece mould (with more than a thousand false cores) by the Henry-Bonnard Bronze Company of NYC. Notice the concave keys in the surface of the false-cores on the left image. (images from Anonymous. 1891. 'Casting the Henry Ward Beecher Statue for the City of Brooklyn'. *Scientific American,* Vol. LXIV.-No. 26, June 27)

Fig. 4.28. Robert Doisneau, silver gelatine print, 1950. The monumental *Thinker* during moulding. The plaster foundry model in the drag mould with still a false-core visible around the ankle. The ovoid depressions are keys and the grooves and visible between the keys and the pattern are runners. This foundry model is in line with the foundry models of the original size *Thinker* divided up in parts. Image taken by Robert Doisneau in the Alexis Rudier foundry in 1950, documenting the moulding and casting of a monumental *Thinker*. (image Doisneau estate)

Fig. 4.29. One half of a piece-mould without the core at the Bedi-Makky foundry of Brooklyn. On the right a false-core is removed to illustrate the modular nature of the mould.

Smaller false-cores were sometimes manipulated by sticking a kind of fork, called core-pin (*fourchette*), into the false-core (fig. 4.30). The term core-pin is a somewhat confusing term with several different meanings. In the literature on the casting of historic bronzes, the term core-pin is often used instead of chaplet: a pin going from outer mould into the core and thereby holding the core in place during casting.[640] The industrial foundry literature uses the term core-pin to describe a fixed element in the mould that creates a void in the cast part.[641] The nails used to pin small false-cores to each other were also sometimes called core pins. The term core-pin can therefore have four meanings depending on the period or the type of foundry work.

Fig. 4.30. Manipulation of false-cores with the aid of core-pins. (from Rama 1988, 143)

The shape and size of a false-core was largely determined by its ability to withdraw from the pattern without damage, caused by undercut surface details on the pattern.
Once the false-core had reached its final shape, it was dusted with a parting compound, and the moulder could commence making the neighbouring false-core by repeating the process.

[640] McWilliam, Andrew and Longmuir, Percy. *General foundry practice*, Charles Griffin & Company (1907): 30.
[641] Sharp, John. *Modern foundry practice, dealing with the green-sand, dry-sand and loam moulding process; the materials used; also detailed descriptions of the machinery and other appliances employed, with pracitical examples and rules, including revised subject matter and tables from N.E. Spretson's 'Casting and founding*. E. & F.N. Spon (1900): 377-378.

This time by applying sand against the pattern as well as the previous false-core. The entire surface of the pattern was thus covered and depending on the size and complexity this could require hundreds of individual false-cores.[642]

With the entire upper part of the pattern now covered with false-cores, the cope flask was placed on top of the drag and filled completely with a lower grade sand. This extra layer of sand acted a mantle mould by holding the false-cores in place.[643] Often, as an extra measure, the moulder used small pins or needles to fix the false-core to each other or when dealing with very small false-cores, glue was used.[644] The whole mould, cope and drag together, was now reversed by turning this upside down. The drag with the false-side was now on top and was subsequently removed, flask as well as the support sand, thereby exposing the other half of the pattern. With the exposed side of the pattern facing upwards, the moulder can now proceed further with making the remainder of the false-cores. The number of false-cores, required for the moulding of an original sized *Thinker*, was somewhere between 40 and 50.[645] The rest of the mould was completed in the same way as the first half, by making a mantle mould of sand covering the false-cores. With large piece-moulds, the mantle mould was often reinforced with an internal armature of iron bars (fig. 4.31).

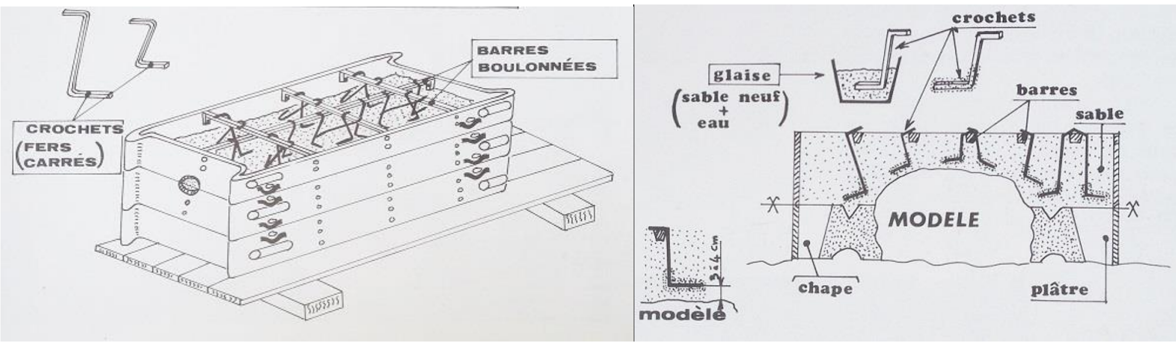

Fig. 4.31. Drawings illustrating the reinforcement of the mantle mould with hooks and cross-bars. (illustration from Rama, 1988; 157)

4.2.4 The core

Since all of the *Thinkers* are cast hollow, a core was required to achieve this.[646] By the end of the nineteenth century, most cores for sand mould casting were made entirely from sand and not anymore from plaster or plaster filled with brick dust. Since moulding sand cannot be poured, such as plaster, the lasagne method for making a core could not be used and the

642 One thousand to fifteen hundred false-cores were estimated to have been used for the Henry Ward Beecher Statue; see Anonymous 1891.
643 Some moulders applied an extra layer of plaster on top of the sand mantle mould as a reinforcement. Wallack 1840, 99.
644 Byrne remarks on the use of pins; "It is frequently necessary to thrust two or more broken needles through the green cores into the neighbo[u]ring parts to connect them together, in imitation of the pins in the flasks", Byrne 1851, 153. Flour paste was used as a glue, see Overman 1881, 262.
645 This estimation is based on the pattern of cutting lines observed on the surviving foundry plasters.
646 The name core derives from the French *coeur* which means heart.

moulders had to resort to a different method. This quite ingenious method was carried out as follows:

After completing all the work on the outer mould, this outer mould was almost entirely taken apart in the various different sections, in order to be able to remove the plaster pattern.[647] After removal of the pattern, the false-cores are placed back again in their original position inside the bottom mantle mould (drag). The bottom half of the mould was now assembled again, forming a cavity left by the removal of the pattern. The surface of this cavity is dusted again with a parting compound because the next step was to fill this negative space with sand again. Depending on the complexity and size of the core, often an armature of core-irons was suspended inside this mould cavity to reinforce the future core (figs. 4.32-4.34).

Fig. 4.32. Core armature inside the drag mould (from Kowalski & Weisner 1984, 20)

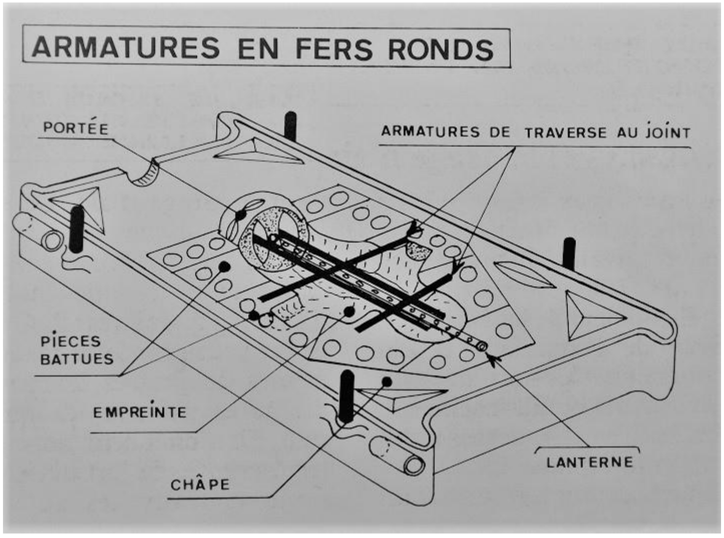

Fig. 4.33. Illustration showing the core armature and the lantern suspended inside the drag. (from Rama 1988, 163)

Figs. 4.34a & b. Iron armature consisting of round and square iron, in various diameters, suspended inside the drag mould. Images of piece-mould making in natural sand at the Bedi-Makky foundry in Brooklyn New York City, taken in May 2015.

[647] The false-cores are taken apart to enable the removal of the pattern, the top and bottom mantle mould stay in one piece.

This armature was made from iron bars and wires, whereby the armature extended beyond the cavity to affix the core armature to the outer mould. This makes it possible for the armature and core to be suspended inside the mould cavity, without making contact with the impression on the inner mould surface. In addition to the iron bars and wires, the moulders often added lanterns to act as a chimney for the gases created in the core during casting.[648] These lanterns were made from perforated iron tube, often open from the side or conical to facilitate easy extraction after casting.[649] I found that remains of the core armature can often be detected inside Rodin's *Thinkers* in the form of square or round iron bars (Ø 8-10 mm) and iron wire (Ø 1-2 mm). The lantern is often removed, although evidence of its use can usually be found in the form of a plugged hole in top of the skull (fig. 4.35). This plugged lantern hole in the top of the skull was found on all studied *Thinkers*.

Fig. 4.35. Detail of the interior of the Yale *Thinker,* illustrating the plugged lantern hole in the top of the skull.

With the armature suspended inside the bottom mould half, the moulder could now fill the mould cavity with core sand. This sand was usually recycled moulding sand which was compressed inside the mould through ramming, although this compressing of the sand was done to a lesser extent than for the outside mould. It was not essential for the core to take up an impression of all the fine surface detail, and by not compacting this sand too much, the core stayed porous and kept its ability to absorb gases and compress when the surrounding cast metal shrank around it. When the mould cavity inside the drag was completely filled with core sand, the moulder continued adding sand to form the top half of the core. Because this part of the mould was protruding from the drag, the moulder had to shape this other half of the core free hand. Since it was impossible to complete the shape of this part of the core entirely, just by estimation, the French moulders devised a clever way using sand cones.
The moulder finished the free hand shaping of the core with a shape that was still within a safe margin smaller than the final core.

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648 Fesquet described using also tallow candles for this, which are melted out during the drying of the core; see Overman 1881, 267.
649 Guettier 1858, 259-260.

Small cone shaped lumps of moulding sand, called flies or mosquitoes (*mouches*), were now applied over the entire surface of the top half of the core (figs. 4.36a & 4.37).[650] These flies were small, 2,5 to 3 cm high, and evenly spaced.
When the drag was now placed over the topside of the core, the inside of the drag with the mould impression touched the tops of the flies. The flies were, because of their pointed shape, capable of slight compression and when the drag and cope touch each other completely, the tops of the flies were compressed to exactly the contours of the mould impression of the drag (fig. 4.36b).

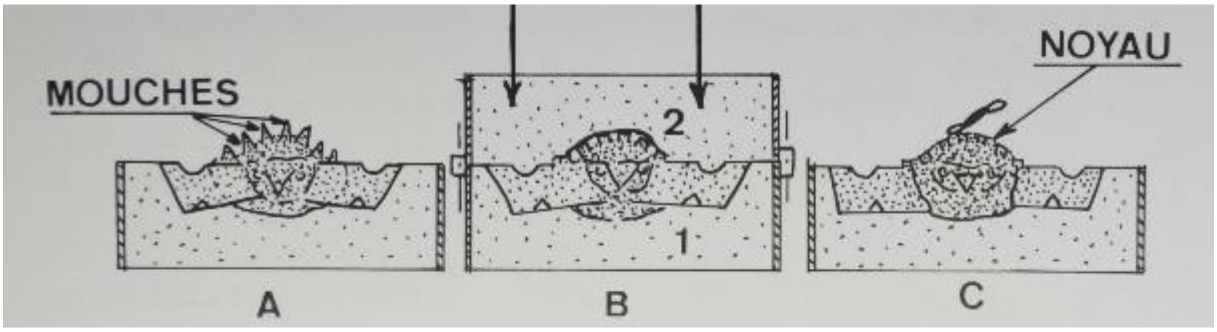

Fig. 4.36. Drawing illustrating the steps in making a sand core with the aid of flies, the so-called *mouchetage*. When the cope (2) is lowered down onto the drag, the flies are compressed (B). This determines the outline of the top half of the mould and the spaces between the flies can now be filled with moulding sand to complete the outline of the core (C). (from Rama 1988, 166)

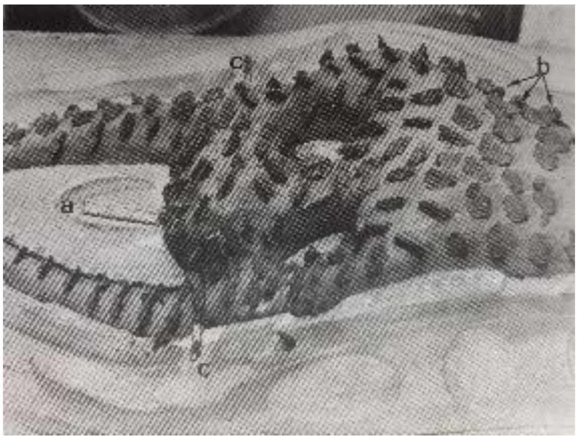

Fig. 4.37. Detail of the *mouchetage* with the flies (b), the core-irons protruding into the outer mould (c) and the lantern (a). (from Baudry 2005, 280)

Fig. 4.37. Cutting back the sand core with the aid of a spatula. (from Baudry 2005, 280)

[650] The term mosquitoes is used in the Bedi-Makky foundry, there is no mention of this term in the English foundry literature.

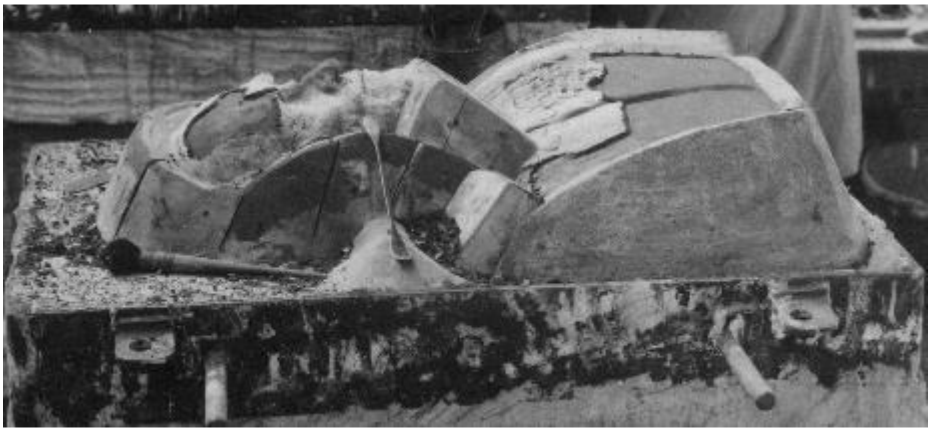

Fig. 4.38. The cutting back of the core of a bust in progress. (image taken in unknown foundry, probably French first half twentieth century, image private collection)

With the outer parameter of the top half of the mould established by the compressed flies, the moulder would now fill the spaces between these flies (fig. 4.36c). The outer surface of this core now conformed exactly to the inner surface of the mould cavity of the assembled cope and drag. This however did not leave any space for the bronze to flow into and therefore the core was reduced by paring down the surface. This was done by carefully slicing away, with a spatula, a layer corresponding to the required wall thickness of the sculpture, creating thus a so-called cut back core (figs. 4.37 & 4.38). This reduced core could now be used for casting, although sometimes the moulder carved grooves into the core at specific points, creating reinforcing ribs in the interior of the bronze (fig. 4.39). These ribs can be observed on the Washington *Thinker* (1903) in Washington and the Ordrupgård *Thinker* (1931) in Copenhagen (fig. 4.40).[651]

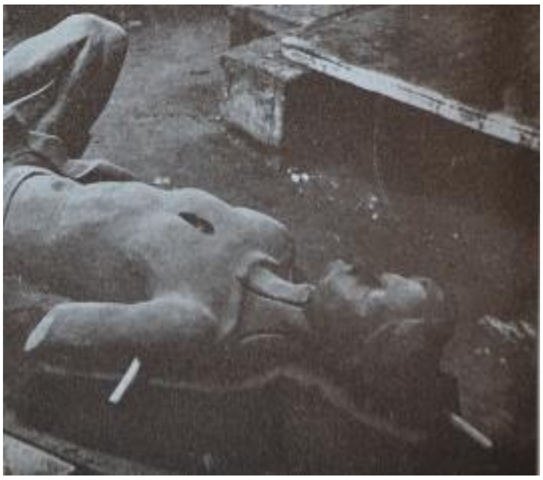

Fig. 4.39. Detail of the sand core for Malvina Hoffman's *Brahman in meditation* in the Rudier foundry (1934-36). In the neck are channels carved, creating reinforcing ribs in the interior of the bronze. (from Hoffman, 1936; 88. original by Clarence Buckingham Mitchell, Malvina Hoffman's son in law)

Fig. 4.40. Reinforcing ribs on the interior surface of the Washington *Thinker* (image National Gallery of Art Washington)

[651] This technique was not used exclusively by the Alexis Rudier foundry since these ribs for example, can also be found on George Gardet's bronze Great Danes (1904 or earlier) in the collection of the Rijksmuseum (inv.no. BK 18771), cast by the Siot-Decauville foundry of Paris.

The fabrication of a core for the original size *Thinker,* cast in one piece, was more complicated. The fact that limbs such as arms and legs protrude from the main body, and these also being quite slender, made it very difficult, if not impossible, for the moulder to a pattern in one piece. The foundry plasters for the original size *Thinkers* were therefore divided in parts: the main body, the right leg, the left arm and the left hand. This, not only simplified considerably the making of the false-cores, but more importantly also the core.
Because we do not have a contemporary description of the making of this type of complicated core, one has to examine surviving bronzes to form an idea of how such a complicated core was produced.[652] Protruding ridges, called veins or fins, can often be observed on the inside of sand mould cast bronzes.

Fig. 4.41. Robert Doisneau, silver gelatine print, Paris, 1950. The core of the monumental *Thinker* during moulding in the Rudier foundry. Note the lantern protruding from the top of the skull. (image Doisneau estate)

Most of them are fairly small, usually a few centimeters long and protruding a few millimeters, have an irregular outline, and are randomly dispersed over the interior surface of the bronze (fig. 4.42). This so-called veining, is the result of small cracks in the surface of the core and can also be observed on lost wax cast bronzes. These cracks occur as a result of drying of the core (fig. 4.43).

[652] Often contemporary descriptions such as eye witness accounts or manuals, do not detail very intricate aspects of working methods. Eugène Rudier prided himself on the fact that he could cast, in one piece, such complicated bronzes. This knowledge and skill which could give him an economical advantage, was therefore perhaps kept within the foundry.

Fig. 4.42. A detail of the veining visible on the interior surface of the Brussels Petermann *Thinker*.

Fig. 4.43. Cracking of the core's surface. Detail of monumental *Thinker* during moulding. The core is already suspended inside the mould, resting on the core support irons. Note the gap between the core and the mould. The black stripes are the charcoal coating of the mould interior. Image taken by Robert Doisneau in the Alexis Rudier foundry in 1950 documenting the moulding and casting of a monumental *Thinker*. (image Doisneau estate)

Another group of much thicker fins, called flashing, are of a more regular shape and can be found repeatedly at the same places inside a sand mould cast sculpture. This type of flashing, exclusive to sand mould castings, can protrude several centimeters. When found inside a small cavity such at the inside of a leg or arm, they can form a collar running in some cases almost from side to side and thereby almost completely block the cavity. Often the point where this type of flashing occurs, is also the place where the core support irons terminate (fig. 4.44). This type of extensive flashing has been often removed by cutting, usually in the accessible parts of the interior of the bronze leaving an abraded shiny surface (fig. 4.45).

Fig. 4.44. Extensive flashing visible in the interior of the Geneva *Thinker*, also note the core-iron does is bent and does not extend beyond the flashing.

Figs. 4.45a & b. Underside of the Ordrupgård *Thinker* with in the lower right corner the finished shiny flashing lines visible.

Based on the prospective gained in this research, I propose that, since the position of this type of flashing is often congruent with the dividing lines of the detachable parts of the foundry model, that this type of flashing lines occurred where the metal seeped between the assembled core sections (fig. 4.45). In the past, these flashing lines have sometimes been mistaken for joints, both by visual inspection and X-radiography.[653]

[653] The original size *Thinker* at the National gallery of art in Washinton in Washington was till recently thought, on the basis of X-radiography, to consist of six parts: Butler, Ruth & Suzanne Glover Lindsay. *European Sculpture of the Nineteenth Century*. National Gallery of Art (2000): 321.

Figs. 4.46a & b. Detail images of the separate left leg of the plaster foundry model S.3189 from the Rodin Museum, Meudon.

By composing the core in sections, it was easier for the moulder to produce a core that enabled the moulding and casting of complex model such a human figure.

4.2.5 Gating system

With the core now finished, the moulder would make final adjustments to the false cores by carving channels into the surface of the cope and drag for the gating system (fig. 4.46). With the larger moulds, whereby *cornichons* were used, the holes created by their removal would be connected to larger channels of the gating system.

Fig. 4.46. The cope of a bust with the carved gating system, note the space for the lantern in the top of the mould. (image taken in an unknown foundry, probably French first half twentieth century, image private collection)

4.2.6 Drying the mould

With the moulding process now completed, it was necessary to remove the moisture from the mould pieces. This drying was carried out in a special oven with a temperature high enough to drive of the moisture in the sand. Hoffman mentions a temperature between 400 and 500 F (204-260°C).[654] The mould pieces remained in the oven till thoroughly dried, which could take, depending on the size of a mould, from 24 hours to up to two weeks.[655]

Fig. 4.47. Mould-pieces in the drying oven of the Rudier foundry. (between 1934-52) (image from an undated Dutch article called "*Hoe men bronzen beelden giet"* in the Malvina Hoffman papers, Box 15.2, Special Collections Getty Research Institute, Los Angeles.)

Once completely dry, the mould pieces were removed from the drying oven and re-assembled into a cope and drag part. The interior of the mould was now often smoked over a cork or pitch resin fire, to apply a coating of soot to the inner surface of the mould.[656] Fesquet mentions the application of a series of three successive coatings, containing flour paste, charcoal dust, molasses and oil, to the mould surface.[657] These coatings would not only close or cover up small cracks formed during drying, but also prevent the metal from penetrating or fusing with the sand. The cope and drag were clamped together and were now ready to receive the hot liquid metal. These ready moulds were often kept slightly warm to keep them dry.[658]

[654] Hoffman 1936, 100.
[655] Anonymous. "*Artistic Bronze and Brass: Architectural, Ecclesiastical Ornamental Statuary."* Gorham Manufacturing Co. (1903): 9. Soyer states that for the drying of a 4-5 meter high statue mould it takes up to 14 days in an oven; see Héricart de Thury 1836, 369.
[656] Byrne mentions coke, see Byrne 1851, 153. Launay mentions a pitch fire; "On les noircit avec des flambeaux de poix résine", see Launay 1827, 45.
[657] "First, one of water, holding flour paste and charcoal dust ; second, one of charcoal and molasses ; and third, one of whale oil. A smooth brush is used": Overman 1881, 269.
[658] Ibid 270.

4.2.7 The bronze alloy

Of all the aspects of foundry work, the choice of alloy and applied patina are probably most shrouded in mystery. Fine art foundries have a reputation of being traditional and secretive on the specific alloy composition and patination recipes, they use for their bronzes. Several factors determine the choice for a specific alloy: castability, mechanical finishing properties, patination properties, welding and brazing properties, cost and availability of metals. Future environmental conditions of the sculpture, artists' or commissioner's personal preference and tradition within the foundry also played a role. Archival information on the specific alloys used for Rodin bronzes is minimal. Although the occasional reference can be found. Nicoladze remarks for example:

> Rudier was the owner of the workshop where Rodin's masterpieces were cast in bronze, and the composition of alloy was specified by Rodin him-self. […] The bronze consists of: copper, tin and silver. Sometimes they add some lead. Depending on the proportion of these metals taken for alloying, the bronze gets a different quality. But if the proportion is wrong, one cannot produce a cast.[659]

By the time Rodin began to work with Eugène Rudier, around 1901, he had almost 25 years of experience with foundries, and Nicoladze's statement of Rodin specifying the alloy, could well be correct.[660] This cannot be said of Nicoladze's next claim that the bronze contained silver, because to date no data has been published where silver has been detected in a Rodin bronze, as a deliberate alloying component. Perhaps Nicoladze had mistaken the silvery appearance of zinc for silver or more likely he had not visited the foundry himself and the bronze containing silver was just a foundry myth, circulated to increase the mystique. Rodin might have used, for smaller sculptures, silver as the main alloying component as Bartlett states in 1889: "When possible, he casts his models in silver."[661]

It is likely that Bartlett was referring to the *bust of Mrs. Russell*,[662] cast in silver a year earlier by Griffoul et Lorge.[663] Silver sculptures by Rodin are exceedingly rare.[664] Bartlett could also have referred to silver plated bronzes, of which the bust of Saint John the Baptist in the Rodin Museum Paris is a well-known example.[665]

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659 Nicoladze 1946, 56. Translation Svetlana Burshneva.

660 It is likely he was also advised on this by Jean Limet, the person who patinated and sometimes finished Rodin bronzes.

661 Bartlett writing in 1889 on Rodin. Elsen 1965, 84.

662 Currently in the collection of Musée des Jacobins in Morlaix. (inv.no. RF 2655) see online: http://www.culture.gouv.fr/public/mistral/cdoa_fr?ACTION=RETROUVER&FIELD_98=AUTR&VALUE_98=Auguste%20Rodin&NUMBER=44&GRP=2&REQ=%28%28Auguste%20Rodin%29%20%3aAUTR%20%29&USRNAME=nobody&USRPWD=4%24%2534P&SPEC=3&SYN=1&IMLY=&MAX1=1&MAX2=1&MAX3=50&DOM=All

663 Le Normand-Romain 2007, 522 note 3. I would like to thank François Blanchetière for pointing out this information.

664 Apart from this bust, are there also small silver and silver plated pendants with *the head of St. John the Baptist*. Le Normand-Romain 2007, 647.

665 *Bust of saint John the Baptist*, cast in 1880 by Gruet, inv.no. S.6670.

The vast majority of Rodin bronzes are ternary bronzes containing copper, tin, zinc and lead or brasses containing zinc and some tin. Very occasionally, Rodin was tempted to use a different alloy, for example when he commissioned the, somewhat mysterious, Parisian founder V. Philippet around 1903-04, to cast some busts. This founder, only known from a few Rodin casts and a trade card, used an aluminium bronze he called 'Le Metalor'.[666] Advertised as an alloy with a "golden appearance which does not oxidise", it is therefore somewhat surprising that the surviving bronzes by this founder are all patinated.[667]
None of these above-mentioned accounts give an exact chemical composition. To my knowledge, there are only few accounts giving a precise alloy. One of these, is the alloy composition given in 1901 by La Société Nationale des Bronzes of Brussels, as a suggestion to use for the monumental cast of the *Burghers of Calais* group: 90% copper, 6% tin and 4% zinc.[668] This is a fairly standard bronze alloy for sculpture casting and does not deviate greatly from the alloy used by the Alexis Rudier foundry, discussed further in this chapter.

Compositional analysis of bronze sculptures using XRF

To collect compositional data from bronze sculptures, two main types of analysis can be used: invasive and non-invasive. The former requires removal of original material and the latter should have no effect for the object. Understandably, non-invasive (also referred to, as non-destructive) analysis is favoured for elemental analysis of artworks, and as a result frequently used on museum objects.

This however, gives only the surface composition, which may not represent the bulk composition. This is particularly relevant for metal sculpture subjected to the elements, such as archaeological or outdoor objects, in which chemical alteration of the surface is common. A frequently used form of non-destructive analysis for objects is X-ray fluorescence (XRF) spectrometry, which uses a primary X-ray beam to cause electronic transitions within the atoms in the metal, resulting in emitted X-rays characteristic of the elements present.[669] The accuracy of the measurement is greatly enhanced by aiming this beam perpendicular on flat, bare metal surfaces. Appropriate copper alloy standards should be used to quantify object compositions. The surface penetration of the X-ray beam in copper alloys is limited to only 20 to 30 microns.[670]

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[666] The use of aluminium bronze for sculpture founding was already described by Fesquet in 1881. Overman 1881, 280-281.

[667] "Le Metalor est un métal ayant, sans dorure, absolument la couleur et l' éclat de l' or.
Il a l'avantage d'être d'une très grande inaltérabilité": from a trade card in the archive of MR: Le Normand-Romain 2007, 27. Rodin's patineur Jean Limet writes to Rodin about patinating ("oxidising") this 'rustproof' aluminium bronze in a letter from 12 December: ibid 32.

[668] "Voici l'alliage de notre bronze : 90% cuivre rouge, 6% étain, 4% zinc"; letter from La Société Nationale des Bronzes in Brussels to Rodin dated 11 December 1901, in the archives of MR. Vassalo 1992, 45.

[669] Eremin, Katherine. (with a contribution by Josef Riederer). "Analytical Approaches to Ancient Bronzes." *Ancient Bronzes through a Modern Lens: Introductory Essays on the Study of Ancient Mediterranean and Near Eastern Bronzes*, Susanne Ebbinghaus (ed.) Harvard Art Museums (2014): 66.

[670] Glinsman, Lisha. *The application of X-ray fluorescence spectrometry to the study of museum objects*. Diss. University of Amsterdam (2004): 38.

This makes quantification of chemically altered surfaces problematic, not only for excavated or outdoor bronzes but also for patinated bronzes. As will be discussed further in this thesis, the surface of a bronze undergoes often an acid treatment in preparation for patination, which is likely to alter the surface composition by leaching out certain alloying constituents of the alloy. In addition to this, the surface is subsequently subjected to heat and chemicals, often containing metal ions such as copper, iron and even silver and gold.[671] XFR readings taken from the outer 'artistic' surface of a bronze, should therefore be carefully interpreted. If possible the reading should be taken from bare, un-patinated, surfaces such as scraped areas, preferably from the interior or from well-worn areas such the edge of a base.[672] Of equal importance is software used to quantify the XRF data and the calibration of the XRF equipment with reference standards close to the alloys being analysed.[673] As Heginbotham has demonstrated, the issue of inter-laboratory reproducibility of XRF data of historical metals is problematic, although the recent use of a historic copper alloys standard and new software has largely addressed this problem.[674] Therefore, in chapters where compositional data is given, only the base metal (Cu), the two major alloying elements (Zn and Sn) and the minor alloying element (Pb) are given. Even with these elements, the data from different sources can show considerable deviations.[675]

More accurate alternative techniques, require the removal of small samples for compositional analysis. Examples of this are, inductively coupled plasma-optical emission spectroscopy (ICP-OES), inductively coupled plasma mass spectrometry (ICP-MS) and Scanning Electron Microscope with Energy-Dispersive X-Ray Spectroscopy (SEM-EDS). Studies comparing the ICP methods with XRF show deviations in the order of 3 wt.% between XRF data and the more accurate ICP data for the alloying elements.[676]

With both methods, invasive and non-invasive, the accuracy of the analysis is increased by taking multiple readings or samples of one sculpture. These samples or sampling locations should not be too small, in order to avoid analysis of a non-representative part of an alloy such as an undissolved lead globule. With these caveats in mind, XRF can still be a useful analytical tool especially when no sampling is allowed and XRF is the only viable option.[677]

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[671] Barbour and Glinsman 2015, 74.

[672] Young, M. L. and D. C. Dunand. - *Comparing compositions of modern cast bronze sculptures : Optical Emission Spectroscopy versus x-Ray Fluorescence Spectroscopy,* In: JOM : the journal of the Minerals, Metals & Materials Society, published online 27 May (2015) fig.1.

[673] Ibid 4.

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

[675] Ibid 244-255.

[676] Young & Dunand 2015, 8.

[677] For more on p-XRF used for compositional analysis of bronzes: Smith, D. "Handheld X-ray fluorescence analysis of Renaissance bronzes: practical approaches to quantification and acquisition." *Handheld XRF for art and archaeology* (2012): 37-74.

Alloy composition of Thinkers

Before settling with the Alexis Rudier foundry, around 1904, Rodin used a great variety of foundries, all using their specific alloys, as becomes clear from table XIV:

Table XIV. Compositional analysis of various original size *Thinkers* cast between 1884-1937.

object[678]	collection	Foundry	Cu (wt.%)	Zn (wt.%)	Sn (wt.%)	Pb (wt.%)	tool
Thinker (1884)	NGV Melbourne (1196-3)	Gonon?	84	11	1	0.2	p-XRF[679] on un-patinated surface[680]
Thinker (1896)	MAH Geneva (1896-0011)	Griffoul	88.6	7.4	2.4	0.5	p-XRF on patinated surface[681]
Thinker (1901)	Ny Carlsberg Glyptotek Copenhagen (MIN 605)	F. Rudier	83.2	14.3	1.8	0.3	p-XRF on un-patinated surface[682]
Thinker (1903)	NGA Washington (1942.5.12 (A-76)	E. Rudier	94.7	1.2	4.0	0.1	p-XRF on un-patinated surface[683]
Thinker (1910)	MMA New York (11.173.9)	A. Rudier	92.4	0.8	5.8	0.1	p-XRF on patinated surface[684]
Thinker (1924)	Rodin Museum Philadelphia (F1929-7-123)	A. Rudier	93.2	0.83	5	0.1	p-XRF on patinated surface[685]
Thinker (1931-37)	Singer Museum Laren (56-1-412)	A. Rudier	94.5	1	4	<0.5	p-XRF on un-patinated surface[686] + EPMA[687]

What is evident from this table, is that the *Thinkers*, cast before Rodin's collaboration with Eugène Rudier, are all invariably brasses. The alloy used by Eugène Rudier and all subsequent Alexis Rudier *Thinkers* are ternary tin bronzes. The range of this alloy is as follows:

678 All original, medium, size *Thinkers*.
679 Portable X-ray fluorescence: non-invasive in-situ XRF analysis
680 From Flood 2011, 81. (Bruker Tracer III-V with titanium filter and instrument settings of 40kV and 2.15µA for between 112 and 206 s. without the use of vacuum.)
681 Data kindly provided by Bertil van Os from RCE, Amerfoort. Data collected with a Thermo Scientific Niton Xl3t-goldd (silicon drift detector, X-ray tube 50 kV)
682 Data collected with a Bruker Tracer III SD, kindly provided by Lisha Glinsman and Daphne Barbour from the National Gallery of Art in Washinton DC.
683 From Barbour, Daphne S. & Glinsman, Lisha. "Auguste Rodin's Lifetime Bronze Sculpture in the Simpson Collection." *Facture: Conservation Science Art History*. Volume 2. National Gallery of Art (2015): 70.
684 Data collected with a Bruker Tracer III SD, kindly provided by Lisha Glinsman and Daphne Barbour from the National Gallery of Art in Washinton DC.
685 From Young and Dunand, 2015. Data collected with a KeyMaster's TRACeR III with a Rh anode and an Al filter, which was operated at 40 kV and 1 mA for 60 s.
686 Average of data from p-XRF Bruker Tracer III-V with a rhodium tube operating at 40 kV and 2.2 uA with a 0.0012 Al/ 0.0001 Ti filter in the primary beam and a Si-PIN detector and electron probe micro-analyzer (EPMA) at 20Kv. Kindly provided by Luc Megens (RCE) and Hans van der Weijde (Tata)
687 Electron probe microanalyzer

Copper:	92.5-95.1% (wt.%)
Tin:	3.8-6.7% (wt.%)
Zinc:	0.74-2.2% (wt.%)
Lead:	<0.5% (wt.%)

This is in line with other published studies with compositional data on Alexis Rudier bronzes.[688] It can be deduced from these studies, that the Alexis Rudier foundry consistently used this alloy, over a long period.[689] The small percentage of lead reduces the occurrence of porosity in tin bronzes and facilitates any mechanical after-work such as chasing. Lead is nearly insoluble in copper and its alloys. Only about 1 percent goes into solution, with excess lead remaining in the alloy as pure lead globules within the alloy matrix, rendering alloys very brittle.[690] The lead content in the A. Rudier foundry alloy, stays within the lead solubility threshold and forms a true alloy with the copper.[691] The zinc hardens the alloy and increases the ductility, whereas the tin improves the corrosion resistance. The latter might be the reason why this alloy was used so consistently by the Rudier foundry, because this foundry not only produced statuettes for indoor use but in addition to these, also monumental bronzes for outdoor use.

Analyses demonstrates, that the Alexis Rudier alloy was used for all types of sculpture produced by the Alexis Rudier foundry, from small to large. This was most likely done to streamline the production whereby the same crucibles could be used and off cuts and other scrap could be easily recycled. The use of a uniform alloy also enabled the production of consistent patinas on Rudier bronzes. Rudier however, used this alloy not exclusively for Rodin bronzes. Young for example, showed that the alloy used by Rudier for Rodin bronzes, is not significantly different from bronzes cast for other sculptors such as Chana Orloff (1888-1968) or Joseph-Émile Brunet (1893–1977).[692] Later Rodin bronzes, cast by Georges Rudier, show a much greater variation, well outside the values for Alexis Rudier bronzes.[693]

If one considers bronzes from other foundries, commissioned by Rodin, a great variance in used alloys can be observed, not only for *Thinkers* but also for other Rodin bronzes.[694]

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[688] Robbiola and Hurtel 1991, 812. (CuSn3.6Zn1.3), Young et al 2009, 175. (CuSn4.3Zn1.5 & CuSn3.8Zn0.7), Monica Ganio et al 2014, 141.(CuSn3.8Zn2), Young and Dunand 2015 table IV (CuSn5Zn0.83)

[689] This alloy is remarkably similar to Cellini's alloy for the *Nymph of Fontainebleau* from 1543. This might just be pure coincidence, although, this alloy has very good properties for use in statues. See for Cellini's alloy: Welter, Jean-Marie. "French Bronzes from Renaissance to Revolution: But Are They Bronzes." In Bresc-Bautier 2009, 45.

[690] Eremin 2014, 68.

[691] Metallographic examination show minimal amount of free lead in the bronze alloy of the Laren *Thinker*. See also appendix 3.

[692] Young 2009, 177 & Selwyn, L.S., et al. "Outdoor Bronze Statues: Analysis of Metal and Surface Samples." *Studies in Conservation*, Vol. 41, No. 4 (1996): 208.

[693] Ganio 2014, 141.

[694] The alloy used for the Ionides *Thinker* and the question of attribution to a specific foundry will be covered in sub-chapter 5.3.4 *The lost wax cast Ionides Thinker: Bingen or Gonon?* in this thesis.

Barbour and Glinsman for example found most of the non-A. Rudier Rodin statuettes in the Simpson collection at the National Gallery of Art in Washington to be brasses.[695]

The second contemporary account for the alloy composition of a Rodin bronze is Vauxcelles, which details the working methods of the Hébrard foundry.[696] Rodin commissioned this foundry in 1903 and 1904, to cast two monumental *Thinkers* (plus some smaller bronzes) and in his article Vauxcelles gives the alloy of the first Hébrard cast as: pure Cu 81; Ag 4; Sn 9; Ni 6.[697] This is a very strange alloy, especially the high amount of silver and nickel are most unusual and peculiar. A nickel and silver content of this amount, should render this alloy not only almost white and very hard, but also rather expensive.[698] Again as with Nicoladze earlier, silver was given as a deliberate alloying constituent, most likely to either make the alloy appear more impressive, mysterious and expensive and perhaps also to mislead competitors.[699] Compositional analysis, carried out during conservation work on the Louisville *Thinker* in 2011-2012, gave a much more realistic alloy for this bronze: 82.5 Cu, 8.8 Zn, 8.0 Sn and ~0.7 Pb (wt.%).[700] This alloy is comparable to recently published data on Hébrard alloys, of which the following range can be compiled:[701]

Copper:	79.5-81.4 (wt. %)
Zinc:	8.2-11.8 (wt. %)
Tin:	3.9-5.4 (wt. %)
Lead:	0.9-5.7 (wt. %)

From the above data can be concluded that the Hébrard foundry was, like the A. Rudier foundry, consistent in using one alloy for monumental as well as diminutive bronzes and did so over a long period.[702]

695 *The Kiss,* NGA inv.no. 1942.5.15 (A-79)(CuZn8,5Sn3) and *Head of Balzac,* NGA inv.no. 1942.5.14 (A-78) (CuZn9.5Sn5), *A Burgher of Calais*, NGA inv.no. 1942.5.13 (A-77)(CuZn13.5Sn2); Barbour & Glinsman, 2015; 70
696 Vauxcelles, Louis. "La fonte à cire perdue." *Art et Décoration*, vol. 9 (1905): 189-197.
697 "L'alliage du Penseur, de Rodin (qui fut fondu dans les ateliers A.-A. Hébrard en décembre 1903, était le suivant : cuivre pur, 81 ; argent, 4; étain, 9; nickel, 6": Vauxcelles 1905, 195.
698 Requiring almost 40 Kilograms of silver.
699 Silver, as a minor trace element (<0.5%Wt), is found frequently in copper alloys from before the nineteenth century, due to the fact that earlier refining techniques, were not capable to remove all silver from the alloying constituents of copper alloys.
700 Information kindly provided by Christopher Fulton and Andrew Lins. SEM-EDS analysis using 12 samples was performed in high vacuum mode and 20KV accelerating voltage using an Oxford INCA EDS in a JEOL 6460 LV SEM.
701 Based on the alloy compositions of four Hébrard casts: one Bernard (1910) and three Degas (post 1920) bronzes. See Young and Dunand, 2015; table IV. Ganio (2014) gives two additional Hébrard alloy compositions which fall slightly outside the Young and Dunand values which might be explained by the fact that Ganio obtained the data with p-XRF on patinated surfaces and Young and Dunand with p-XRF on scraped surfaces and ICP-OES.
702 The analysed alloys range from 1903 to post-1920 with the Hébrard foundry operating from 1902 till 1934; Lebon 2003, 182.

4.2.8 Pouring the bronze

Smaller bronze castings were usually performed by one or two foundry men carrying a crucible (fig. 4.48). Larger moulds were filled from a reservoir constructed on top of the mould, called the runner box. The runner box consisted usually of several casting flasks stacked on top of each other and lined with clay. In the centre, a clay-covered plug was positioned which, when pulled upwards, would allow the content of several crucibles of molten bronze to flow, at once, into the mould (fig. 4.49).

This reservoir had a dual purpose: to collect enough metal to fill the entire mould in one continuous flow and to provide extra pressure on the liquid metal inside the mould to fill the mould well and capture all the details of the mould impression. When the metal was heated inside the crucible and began to liquefy, the upper surface of the melt developed an oxide layer. This formed, together with inclusions in the metal, a crust floating on the top, called dross. If any of this would enter the mould during pouring, it would cause a blockage with a failed casting as the result. An extra workman was usually standby with a skimmer, to keep the spout of the crucible free from any dross. Spilled liquid bronze, entering the risers, could have a similar detrimental effect to the cast, and the riser openings were also protected by a workman with some sort of spatula (fig. 4.50). The mould was filled with liquid bronze until the moment the bronze had risen high enough in the risers to become visible to the founders, an indication that the liquid bronze had reached every part of the mould.[703] The lantern provided an escape route for the gases formed in the core. With larger sculptures, this release of core gases was quite spectacular, as a former foundry man recalls:

> When casting a large mould the so-called “air” escapes with a roar and is lighted at the orifice of the vent pipe […] It will burn with a Bunsen-burner-like flame two or three feet high for several minutes. If not set fire to, the vented gas has a most unpleasant odour.[704]

The bronze in smaller moulds solidified fairly quick, and these moulds were usually opened within hours of casting the metal. Larger moulds required more patience and were usually opened the next day.[705]

[703] Mitchell 1916, 19.
[704] Account from the late Mr. F. Braddock, foreman sand-moulder at the Thames Ditton foundry. James 1972, 287-288.
[705] Overman 1881, 271.

Fig. 4.48. Pouring the molten bronze into the mould in the Alexis Rudier foundry, Paris (1934-36) (from Hoffman, 1936, 89, original probably by C. Mitchell)

Fig. 4.49. Foundry men filling the runner box on top of a large mould in the Alexis Rudier foundry Paris (1934-36). Pulling the plug allowed the content of several crucibles to flow at once. (original photograph probably by C. Mitchell, from the Malvina Hoffman papers, Box 15.2, Special Collection Getty Research Institute, L.A.)

Fig. 4.50. Robert Doisneau, silver gelatine print, Paris, 1950. Pouring molten bronze into a mould, with the workman on the left protecting a riser hole by using a skimmer to prevent any dross from entering the mould. (image Doisneau estate)

4.2.9 Finishing the cast

When the mould and cast were sufficiently cooled down to allow handling, the freshly cast bronze was now removed from the mould that enabled its creating. This was done by removing surrounding sand and thereby destroying the sand mould (fig. 4.51).
This sand could be re-used for a future mantle-mould or core, but not for false-cores because these were made only with new sand. Whether this was typical for French sand is not known,

although one nineteenth century German source claims this indeed is the case.[706] The colour of this re-used sand was black because hot metal burned and thus charred the first layer of sand of the mould, but also because charcoal was often used as a separating agent or to impregnate the inner mould surface.

Fig. 4.51. Robert Doisneau, silver gelatine print, Paris, 1950. The monumental *Thinker* during removal of the mould (image Doisneau estate)

Perhaps the contamination with burned particles was the reason for using new sand. Larger runners were now removed from the cast by cutting with a hacksaw, whereas the smaller runners and risers were often cut off using sharp chisels (fig. 4.54).

[706] "...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." (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, 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.

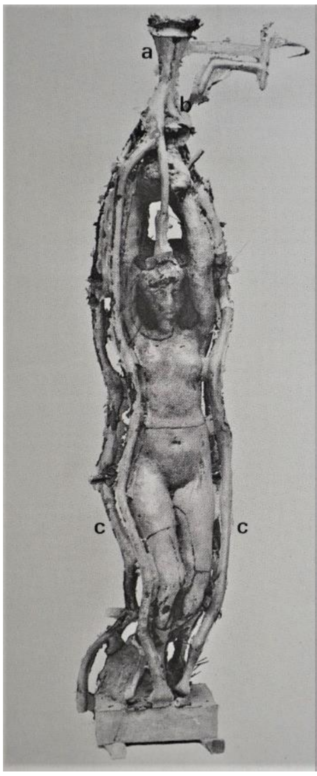

Fig. 4.52. Unfinished cast, with the gating system still attached: a) casting cup, b) main gate or b) main gate or central runner, c) secondairy runners. (from Baudry 2005, 282)

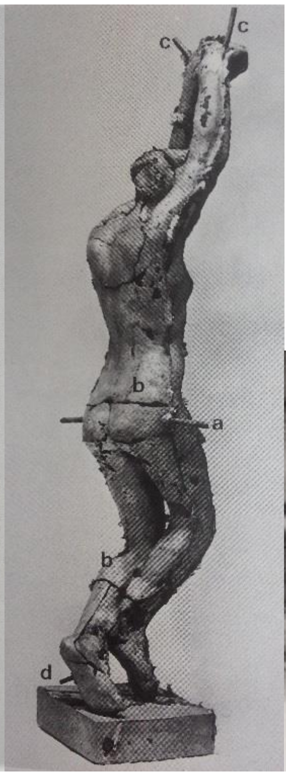

Fig. 4.53. A cast with its gating system removed but with core irons still in place: a & d) core support irons b) flashing, c) lantern (from Baudry 2005, 283)

Fig. 4.54. The removal of runners by cutting with a chisel (from Baudry 2005, 282)

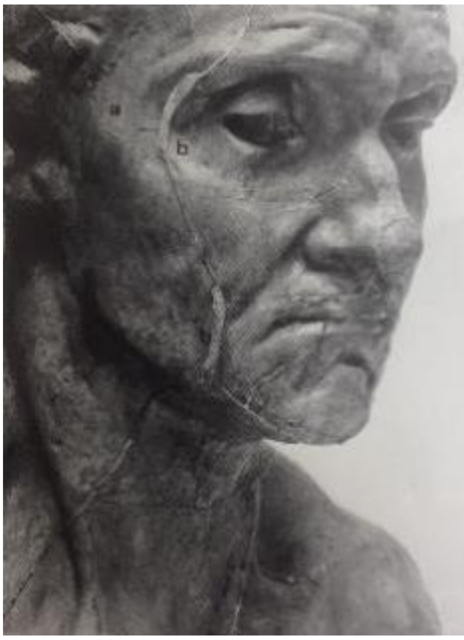

Fig. 4.55. Unfinished face of Rodin's Jean d'Aire, a sand mould cast by the Godard foundry of Paris in 1973. The remnants of runners (b) are still visible as are flashing fins from the false-cores (a) which have not been removed. (from Arminjon 1998, 83)

Fig. 4.56. Detail of the monumental *Thinker* during finishing, with the holes still visible where the core support irons have been removed. Image taken by Robert Doisneau in the Alexis Rudier foundry at Malakoff in Paris in 1950. (image Doisneau estate)

Core irons going through the bronze and protruding outwards, such as lanterns and chaplets, were removed (fig. 4.56) and plugged with threaded plugs in the same alloy as the main cast (fig. 4.57).

Fig. 4.57. A close-up of the interior of the Yale *Thinker*, showing the combination of a core plug held in place with a threaded plug.

Other core-irons, not going through the wall of the casting, were often left inside the bronze, especially in tight areas such as arm and leg cavities. In addition to plugging, brazing was also used to fill small holes or cracks and sometimes to join separately cast parts together (fig. 4.58).[707]

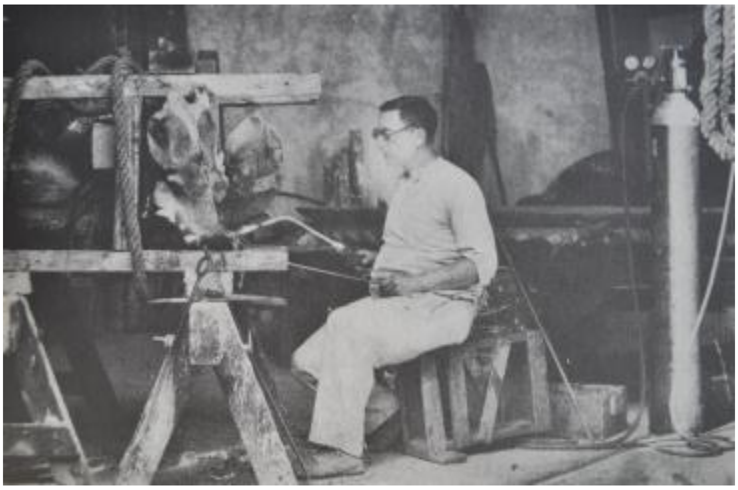

Fig. 4.58. The joining of two cast parts together by brazing, at the Rudier foundry with the aid of an oxygen-propane flame. (1936 or earlier) (from Hoffman 1939, 301)

Fig. 5.59. A brazed plug inside the Yale *Thinker*, note the heat discoloration.

[707] Welding, a much used joining technique in modern foundries, became the preferred way of joining bronze parts with the arrival of easy to weld silicon bronze alloys in the course of the twentieth century.

Fig. 4.60. Underside of Rodin's *La Terre* (Rodin Museum, Paris, S.623). A sand mould casting by E. Groult, dating from probably 1897, where two separate castings are joined in the middle by brazing.

The joining of separately cast parts by brazing, was made possible by the development of powerful blow torches in the 1880s. Older methods for hot joining cast parts were, however, still being practised despite the availability of brazing, such as casting-on or burning, whereby parts are joined by casting another part against it. A good example of the latter is Rodin's statue *Idylle,* known as the *Antony Roux Idylle,* where the figure was cast-on to the background (fig. 4.61). This had two advantages: firstly, the moulding could be carried out in stages and was therefore easier to perform and secondly the first cast part, the background, could already be finished in areas, later inaccessible. The casting-on was performed by first casting one part, and then fixing a new mould against the already cast part and subsequently casting the next part against it (fig. 4.62).

Fig. 4.61: Auguste Rodin, *Idylle*, known as the *Antony Roux Idylle*. Conceived before 1887, cast by Griffoul et Lorge in 1891, unique sand mould cast bronze (H. 48, 1 cm; L. 30 cm; D. 31 cm) Rodin Museum, Paris (S.1118) (image left Rodin Museum, Paris). The image on the right shows the interior of this intriguing bronze, which was cast in two stages with one-part cast onto the other part.

It was important though, to use the same alloy and more importantly to use sufficient metal, to enable a perfect fusion of the parts. The already cast part, needed to heat up enough in the contact area and was therefore sometimes pre-heated or brought up to temperature, by using a surplus of molten metal that was run over the contact area first.[708]

Fig. 4.62. Details of the interior surface of the *Idylle* illustrating two spots were the figures were joined by burning. The rough and slightly higher surface is where the metal fused. Also visible on the right image is a cast-on surface repair.

This type of joining, with cast-on parts, has not been observed on any of the studied *Thinkers*, where the various separate parts of the sculpture, were invariably, joined together mechanically with sleeve joints fixed with dowels or bolts and nuts. Only four original size *Thinkers* are known with mechanical joined parts: the Petermann cast of 1899 and the three François Rudier casts of 1901.[709] All these bronzes have the left leg as a separate casting, joined at the upper part of the leg with a sleeve joint with dowel, and the lower part under the feet, with nuts and bolts. Late casts of the monumental *Thinker* were also sometimes constructed from separately cast parts as can be seen in figure 5.9.

Fig. 4.63. The interior of the Brussels Petermann cast of the original size *Thinker* from 1899, illustrating the mechanical joining of the left leg.

[708] William & Longmuir 1907, 180.

[709] Petermann cast; Musées royaux des Beaux-Arts de Belgique, Brussels (inv.no. 3517) François Rudier casts; Ny Carlsberg Glyptotek, Copenhagen (inv.no. MIN 605), the two other François Rudier casts are in private collections. Images of the interiors supplied by Mr. Jerome le Blay, have been studied for this.

Fig. 4.64. The interior of the Copenhagen (Ny Carlsberg Glyptotek) François Rudier cast of the original size *Thinker* from 1901, illustrating the mechanical joining of the left leg.

The reason for the different type of mechanical joining of the leg, is the fact that the upper part of the leg is joined to the rest of the sculpture, in a difficult to access part of the sculpture. The joint under the foot was easy to access by the foundry man's hands and tools and could be carried out using nuts and bolts. The joint at upper part of the leg is much higher up in the sculpture and was very difficult for the foundry worker to reach. The solution for this was to use conical pegs to fix this part to the rest of the sculpture. The male part of the Roman joint was slotted into the female sleeve part, and from the outside, holes were drilled going through both parts of the joint. The holes were often enlarged eccentrically so that when the conical peg was inserted, the two parts were pulled towards each other and thus minimising the gap between the parts. This was first done with a conical steel dowel because this could withstand the forces much better, and then subsequently replaced permanently with the final bronze peg.[710]

Once all the separate parts of the sculpture were assembled, the actual finishing could commence. The edges of Roman joints were hammered and filed flush to render the join near invisible. Any protruding excess material was also removed by filing or scraping, followed by sanding. Any surface detail lost by this finishing (and moulding and casting) was recreated by chasing with punches (figs. 4.66-4.68). For example, the flashing fins from the false cores, caused by metal seeping between the false cores, needed substantial finishing in the form of filing and chasing. This chasing of the flashing fins was often done very skillfully and can only be detected after close examination, using raking light. Chasing was also used to sharpen up details lost by moulding and casting although with Rodin bronzes, especially his later work, this was kept at a minimum.

[710] Personal communication with Jean Dubos, former head of the Coubertin foundry. 9-12-2011

Fig. 4.65. Electric drill used at the Rudier foundry to drill holes for the mechanical joining of parts. (image 1936 or earlier) (from Hoffman 1939, 301)

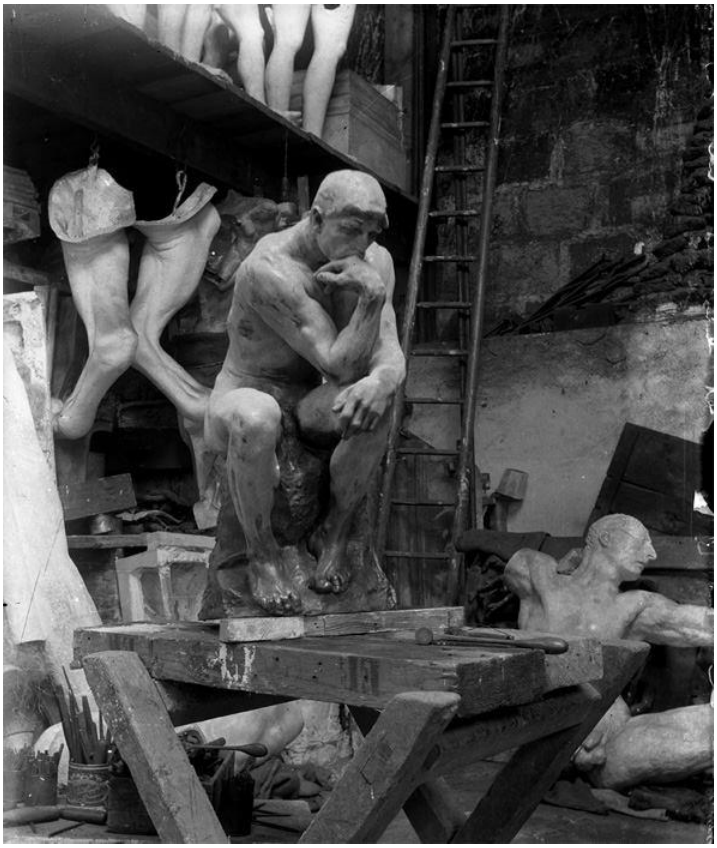

Fig. 4.66. The original sized *Thinker* in the Rudier Foundry during the chasing process. The chasing hammer can be seen lying on the working platform, with underneath in the left corner the chasing punches visible. Image taken probably between 1920 and 1940.[711] (image http://mymagicalattic.blogspot.nl/2014/09/mapplethorpe-rodin-at-musee-rodin-paris.html.> [accessed 22 June 2018])

[711] I would like to thank Annie Barbera for this information.

Fig. 4.67. The chasing workshop at the Rudier foundry, 1933. (original photograph by C. Mitchell, from the Malvina Hoffman papers, Box 15.2, Special Collection Getty Research Institute, Los Angeles)

This restraint in the finishing of Rodin bronzes, goes even further with his later bronzes, where mould lines are often not completely removed and remain visible on the surface of the finished bronze (fig. 4.68). In an undated letter from Limet sr. to Rodin, it is clear that the mould lines were preserved at the request of Rodin himself: "as for the seams, I preserved them on your orders. It's true that [if] the bronze wasn't patinated and that they were a lot less visible. I'm perfectly willing to remove the seams as you and your client have come to a decision."[712]

From this interesting quote, can be deduced that preservation of the mould lines on a Rodin bronze, was the choice of the artist, as well as the client. This explains the occasional occurrence of these lines on Rodin bronzes. The occurrence of these mould lines on Rodin bronzes, fits very well in Rodin's working methods, where accidents and evidence of working methods remain visible on the final artwork. Rodin's choice for keeping these mould lines and the chasing in general, to a minimum, was most likely artistically motivated although economic motives might have been at play as well: chasing was very labour intensive and costing as much as the entire moulding process.[713] Up till, now none of these intentionally left

[712] "quant aux coutures je les ai conservées sur votre ordre. Il est vrai que le bronze n'était pas patiné et qu'elles étaient beaucoup moins visibles. Je suis à votre disposition pour enlever les coutures dès que vous aurez décidé avec votre client". Undated letter from Limet to Rodin in the Rodin archives at the Rodin Museum, Paris. Translated in Le Romain-Normand 2007, 32.

[713] "Chasing is an expensive operation and adds to the cost of the work considerably. In French sand molding or similar work, it is usually considered that the chasing costs as much as the molding". See Anonymous. "Note on Art Metal Work Made from Brass Castings" *The brass world and platers' guide*. Vol. VI, January (1910): No. 1; 2.

mould lines on original sized *Thinkers* have been observed, although sometimes the occur on the enlarged *Thinkers*.[714]

Fig. 4.68. A. Rodin, *Head of Iris*, bronze, sand mould casting by the Alexis Rudier foundry around 1908. Given by Rodin in 1914 to the English people. Victoria and Albert Museum London. (inv. no. A.41-1914)

4.3 Signatures and other markings

Although the core research of this chapter and the thesis is focused on sand moulding, various other aspects of the production of bronzes are also covered, such as finishing and patination. The production of an art bronze was, and still is, a collaborative undertaking, whereby all the different processes are connected and carried out by a team in the foundry. The exception to this is the patination. which, in the past and during Rodin's lifetime, was also carried out by specialist patinators. Patination will be discussed in the next sub-chapter.

Signatures and other markings, such as foundry marks/stamps and inscriptions, are an important art-technological aspect of Rodin bronzes. They can inform us on the date of manufacture a sculpture, the foundry, previous owners, authenticity and the history of a bronze. During the study of Rodin's *Thinkers* various forms of markings were found, each with a different purpose and meaning. They can be divided into the following groups:

[714] For example on the large *Thinker* at the California Palace of the Legion of Honor in San Francisco (inv no. 1924.18.1): De Caso, J. and Sanders P. *Rodin's Sculpture: A Critical Study of the Speckels Collection, California Palace of the Legion of Honor.* The Fine Arts Museums of San Francisco (1977): 130 & 132.

1) Rodin’s signature
2) foundry mark
3) raised foundry stamp inside
4) dedication

4.3.1 Rodin’s signature

Apart from the first *Thinker*, the Ionides cast from Melbourne, all of the original size *Thinkers* carry Rodin’s signature, albeit in differing script.

Fig. 4.69. The signature on the Geneva *Thinker,* Musée d’Art et Histoire Geneva, (inv.no. 1896-0011) This *Thinker* was cast by Auguste Griffoul Paris 1896.

One of the earliest signatures on a *Thinker,* is the name **RODIN** on the proper left side of the base, of the Geneva Griffoul cast, from 1896. The signature is lacking the initial **A** and is carved with a sharp chisel as can be seen in figure 4.69. Typical for carving, whereby metal is removed, is the sharp angular script and the burrs at the end of the carved lines.
The signature on the Brussels Petermann cast, from 1899, is also lacking the initial **A** and is probably chased, albeit with a fairly sharp chasing punch. The incised lines of this signature are more rounded, although in areas where the lines are sharply curved, the grooves are jagged and show burred edges. The script with the underlining is unique in the sequence of signatures on *Thinkers* (fig. 4.70).

Fig. 4.70: Signature on the Petermann cast of 1899, Musées Royaux des Beaux-Arts de Belgique, Brussels, (inv.no. 3517)

The next signature, found on a François Rudier cast from 1901, is chased with a more rounded chasing punch giving the incised lines a more fluid groove. The initial **A** is added here and the script with the typical **R** and **n,** appear here for the first time (fig. 4.71).

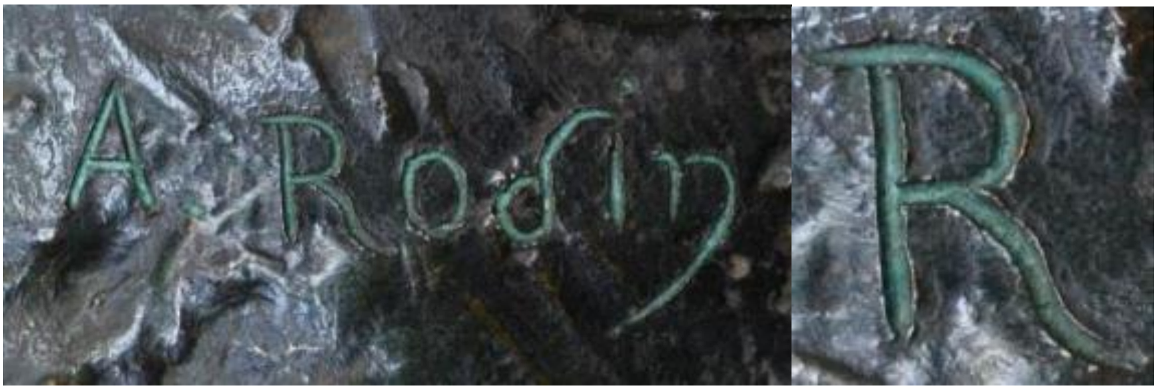

Fig. 4.71: Signature on the François Rudier cast of 1901 at the Ny Carlsberg Glyptotek, Copenhagen.

On the *Thinker* from the National gallery of art in Washinton, probably by Eugène Rudier from 1903, the signature developed a step closer to its definitive form.[715] The typical **d** with the curly top, the hockey stick **i** and the **n** with its extended curly last leg. This signature, which is chased, shows the skilled hand of a professional chaser. The letters are chased with a rounded punch in a continuous fluid movement (fig. 4.72).

[715] See for more information on these early unsigned casts attributed to Eugène Rudier see sub-chapter 5.2.1 *Assembled bronze Thinkers versus Thinkers cast in one piece* in this thesis.

Fig. 4.72. Signature on the 1903 Washington *Thinker*, probably cast by Eugène Rudier. National Gallery of Art, Washington. (image National Gallery of Art, Washington)

Figure 4.73 shows a signature on also, a probable, Eugène Rudier cast, from around 1905, at the Alte Nationalgalerie in Berlin. This fully developed signature, is exemplary of signatures that can be found on the vast majority of subsequent Alexis Rudier cast *Thinkers* (fig. 4.74).

Fig. 4.73. Signature on the Berlin *Thinker*, probably cast by Eugène Rudier, 1905 or earlier. (Alte Nationalgalerie, Berlin)

Fig. 4.74. Signature on a 1906 Alexis Rudier cast in a private collection. (image Sotheby's New York)

One would expect all casts of the *Thinker,* by the Alexis Rudier foundry, to be consistently marked. However, this is not always the case. The signature on the cast from the Metropolitan Museum of Art in New York, and the Musée des Beaux-Arts in Montreal, are unusual, in size as well as position on the statue.[716] The usual A. Rodin signature, found on Alexis Rudier casts, is about 10 cm long and 2-3 cm high, and incised diagonally on the left or right side of the base. The Metropolitan *Thinker's* signature, is very small and placed under the proper left foot and the, equally small, Montreal signature is placed in an unusual spot, on the side of the base (fig. 4.75). These could just be examples of a foundry, not working consistently in its early years, or perhaps the Metropolitan and Montreal signatures, are an example of a later

[716] Metropolitan Museum of Art New York City inv.no. 11.173.9. Gift of Thomas Ryan, 1910. Acquired from Rodin through Paul Rosenberg (Paul Rosenberg & Co) for 8,000 F & Musée des Beaux-Arts, Montreal, Canada inv.no. 1909.465.

applied signature.[717] Rodin bronzes, especially the early casts, were not always consistently marked and it is known that owners sometimes asked Rodin whether it was possible to apply a signature retrospectively. If that was the case, Rodin would, for example, send a sample signature on paper to the owner of the bronze, with the instructions to go to a foundry to have this signature incised in the bronze.[718] The Metropolitan *Thinker*, with its anomalous signature, might well be an example of this.[719]

Fig. 4.75. Early, unusual, signatures on original size *Thinkers*. Left the signature on the Metropolitan Museum *Thinker*, 1910 or earlier and right the Musée des Beaux-Arts *Thinker* from Montreal, 1909 or earlier. Both cast by the Alexis Rudier foundry. (image Montreal *Thinker* by Daphne Barbour)

None of the foundry plasters, of the medium size *Thinker*, carry a signature or any other marking, such as a foundry mark. Some of the copper alloy patterns, such as the *chef-modèle* of the *Youth triumphant* (*La jeunesse triomphante* S.2474), already carry a signature, reproducing automatically the signature in the cast (fig. 4.76).[720]

Fig. 4.76. The signature on the copper alloy pattern (*chef-modèle)* of the *Youth triumphant* (*La jeunesse triomphante*), 1898. Rodin Museum, Meudon, inv.no. S.2474.

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[717] The Metropolitan and Montreal *Thinkers* show all the characteristics of an early Alexis Rudier cast, and there is no doubt these are genuine casts.

[718] Personal communication with François Blanchetière curator Rodin Museum Paris in March 2015.

[719] The earliest provenanced date for the Metropolitan *Thinker* is 1910, when the bronze was donated to the Museum by Thomas Ryan. The bronze shares some characteristics however, with earlier casts such as the Berlin (1905) and Washington (1903) *Thinkers,* such as the shape and position of the lead counterweight (brick-shaped and positioned high inside the bronze), and the detail of the cast.

[720] It is likely that this cast signature would be 'freshened up' by re-chasing.

4.3.2 Foundry mark

Rodin's signature is the most frequently encountered marking one can find on Rodin bronzes, followed by the foundry mark. This mark gives usually the name and place of the foundry. Often the foundry mark on *Thinkers* is referred to as the foundry stamp. However, since all known foundry marks on medium sized *Thinkers*, are incised and not applied with a stamp, the term foundry mark is preferred.[721] Of the four foundries producing original size *Thinkers*, before the Alexis Rudier foundry began to cast these exclusively, only the Brussels Petermann cast was marked with the foundry name (fig. 4.77).

Fig. 4.77. The foundry mark on the Petermann cast of 1899, Musées Royaux des Beaux-Arts de Belgique, Brussels, (inv.no. 3517)

When Eugène Rudier starts to cast for Rodin around 1901, he did not mark his casts immediately.[722] For example, all the Rodin bronzes attributed to the Rudier foundry,[723] purchased by Mrs. Simpson in 1903-04 and donated to the National Gallery of Art in Washington DC in 1942,[724] lack the Rudier foundry mark, as do several Rudier casts in the Musée Rodin in Paris.[725] When Eugène Rudier took over his father's foundry, after his death in 1897, he maintained the Alexis Rudier name and continued to mark their products with the Alexis Rudier foundry mark. The earliest original size *Thinker*, known with this Alexis Rudier foundry mark, is the Pulitzer *Thinker* from 1906 (fig. 4.78).[726]

[721] The two lost wax cast monumental *Thinkers* by Hébrard, were marked with the foundry mark in the wax.
[722] The earliest cast by Alexis Rudier for Rodin, is most likely the full size *Age of Bronze,* commissioned by Dr Max Linde in September 1901, in replacement of a faulty Leon Perzinka cast. This Rudier cast is now in the collection of the National Gallery of Canada, Ottawa(inv.no. 6473). Antoinette Romain, attributes the 1896 bust of Dalou in Berlin to Alexis Rudier, but this must be a mistake, this bronze was more likely cast by François Rudier: le Normand-Romain 2007, 285.
[723] Barbour and Glinsman 2015, 54-81.
[724] *The Thinker* (inv.no. 1942.5.12), *Walking Man* (inv.no. 1942.5.11), *Age of Bronze* (inv.no. 1942.5.10, and *La* France (inv.no. 1942.5.9). Bought by Mrs Simpson in 1903-04.
[725] Le Normand-Romain 2007, 33.
[726] Private collection Oslo, purchased at Sotheby's New York 7 May 2013, lot nr. 45.

Fig. 4.78. Foundry mark on the Pulitzer *Thinker*, 1906, private collection (image Sotheby's)

This foundry mark is almost always expertly chased in the bronze surface with blunt, non-cutting, chasing punches with the Alexis Rudier name, usually executed in a larger font or capitals letters. The Alexis Rudier foundry applied this mark consistently to their casts from 1906 onwards, with the mark showing very little variation until the closure of the foundry in 1952.

4.3.3 Raised foundry stamp

The next marking one can find on Rodin bronzes is usually hidden from view, in the interior of the bronze. It is a mark created by pressing a stamp into the core during moulding, creating a raised mark or stamp on the interior surface of the bronze cast (fig. 4.79). Because of its raised appearance, this mark is sometimes thought of as being applied to the surface. This is not correct; the raised stamp is an integral part of the casting.

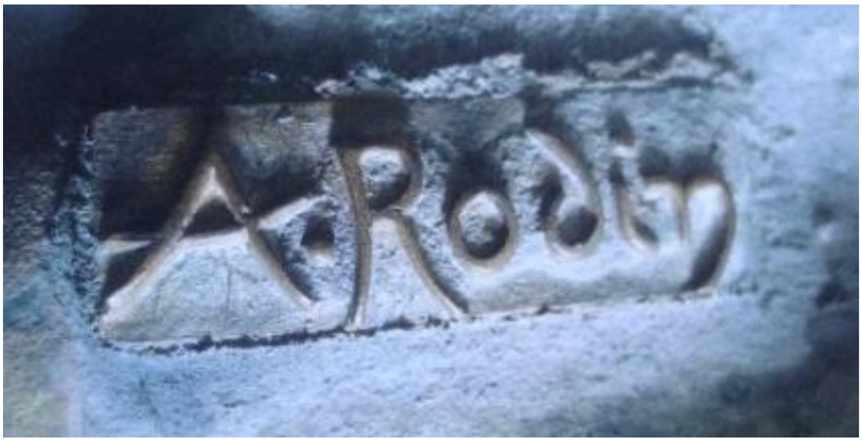

Fig. 4.79. Raised stamp inside the Washington *Thinker*. (image National Gallery of Art, Washington)

Depending on the depth of the impression in the core, the mark is sometimes found flush with the interior surface (fig. 4.80) but usually the contours of the stamp are clearly visible, because the stamp was impressed quite deep into the soft sandy core (fig. 4.81).

Fig. 4.80. Raised stamp inside the Yale *Thinker*.

Fig. 4.81. Raised stamp inside the Pulitzer *Thinker*. (image Jerome le Blay)

The raised inner stamp, is an invention by Eugène Rudier to distinguish the authorized Rudier casts from forgeries, which appeared around 1901-1902 in England and Germany, after the Alma show in 1900.[727] There is no evidence, this stamp was ever used by François Rudier or any of the foundries used by Rodin earlier. The only other foundry who used this stamp, was the Georges Rudier foundry, after the closure of the Alexis Rudier foundry. The stamp can also be found, albeit usually in a less detailed version, in the interior of the sand cast fakes, produced by Guy Hain in the 1980s and 90s.[728] Eugène Rudier started to apply this stamp earlier, than his incised foundry mark on exterior, and there is a group of Rodin bronzes which is attributed to the Alexis Rudier foundry, even though they are not marked by the foundry with the characteristic Alexis Rudier foundry mark (fig. 4.78).[729]

The inner raised stamp inside the Washington cast (1903), is one of the earliest occurrences of this mark (fig. 4.79) in general, and on an original size *Thinker* in particular. The only other *Thinker* with this inner raised stamp, and no foundry mark, is the Berlin Alte Nationalgalerie cast from 1905 or earlier. Le Normand-Romain illustrates a variation on this raised foundry stamp, whereby a raised capital **M** can be found just above the **A. Rodin**.[730] It is thought that this **M** stands for museum and was used only for posthumous cast by the Rodin Museum, Paris. I have this mark, to date, not observed on medium size *Thinkers*. Le Normand-Romain illustrates another raised mark, which too, has not been found on *Thinkers*, whereby the initials **M R** within a circle, above a number, was created again by stamping the core.[731]

4.3.4 Dedications

The last group of markings one can find on Rodin bronzes, are dedications. These inscriptions are usually of a personal nature and are unique to a specific bronze.

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[727] Personal communication with Jerome le Blay on 26-11-2014. See also le Normand-Romain 2007, 33.
[728] For more on the Guy Hain fakes: http://www.upi.com/Odd_News/2002/08/15/The-Art-World-Fake-bronzes-flood-market/12751029434341/ & http://www.rodin-web.org/report_rom/1_11.htm (THE GUY HAIN CASE: FRAUD AND FORGERY)
[729] le Normand-Romain 2007, 33.
[730] Ibid 39.
[731] Ibid 39.

They are the least numerous of all the markings and can be found on *Thinkers* in two forms, applied as a plaque or incised. An example of an applied plaque, is the dedication on the Pulitzer cast from 1906 (fig. 4.82).[732]

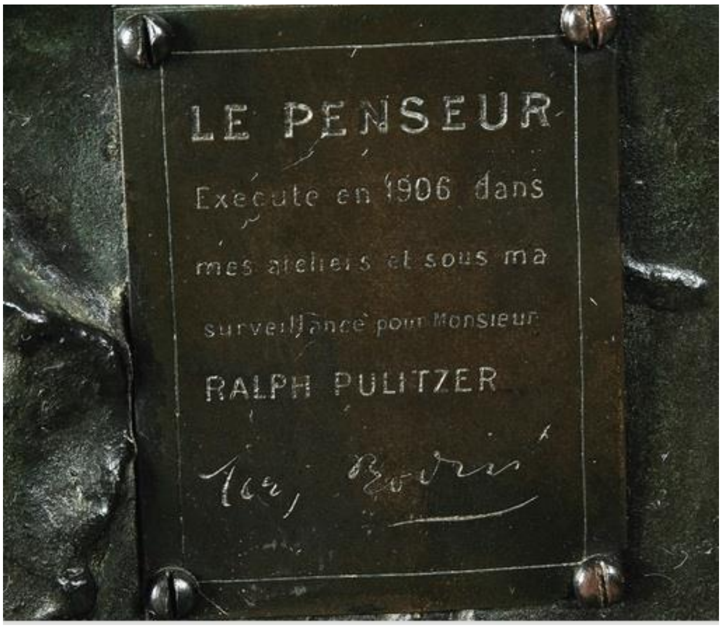

Fig. 4.82. Plaque with dedication applied mechanically to the outside of the Pulitzer *Thinker* from 1906. (image Jerome le Blay)

An example of an incised dedication is the inscription found on the Yale *Thinker* (fig. 4.83).

Fig. 4.83. Incised dedication on the Yale *Thinker*. (Yale Art Gallery, New Haven)

Also dating from 1906, this inscription has to be treated with some suspicion. The style of chasing is in a completely different hand, compared to the foundry mark on the same bronze (fig. 4.84). It is very likely that this dedication was applied later than the suggested date of 1906, especially since the bronze has characteristics of a later Rudier casting, such as the shape of the internal lead counterweight, which is typical of later Alexis Rudier casts.

[732] Apparently Ralph Pulitzer had requested this dedication by Rodin when he commissioned the bronze in 1906 from Rodin. When upon delivery the dedication was found to be lacking, the plaque was retrospectively applied to the bronze at the request of Ralph Pulitzer. (personal communication from Jerome le Blay, December 2014)

Fig. 4.84. Foundry mark on the Yale *Thinker*. (Yale Art Gallery, New Haven)

4.4 Patination

The final stage in finishing a bronze is patination, the colouring of the surface, a technique with a long history of use on bronze sculpture.[733] A patina on bronzes, is a desirable surface layer which can consist of oxides, sulphides, carbonates and other corrosion products often in combination with waxes, oils, lacquers, varnishes or other coatings and accumulated dust or dirt. There are basically two forms of patination: natural and artificial patination. With natural patination, the bronze acquires its patina as a result of interaction with its natural environment, such as soil or atmosphere. With artificial patination, the patina was intentionally and accelerated applied with the aid of chemicals and or heat.

Most of the nineteenth century technical literature covering fine art foundry-work, provide also details on artificial patination.[734] Later in the nineteenth century, manuals appeared entirely devoted to patination or bronzing (*bronzage*), as it was commonly referred to in this period.[735] All Rodin bronzes were artificially patinated. Whereas the majority of bronzes were patinated by the foundries who cast them, this is only the case for Rodin bronzes cast before the turn of the century. From 1900 onwards, Rodin entrusts father (Jean François Germain 1855-1941) and son (Jean Elie Auguste 1887-1965) Limet (figs. 4.85-4.89), with the

[733] Dent Weil, P. "A Review of the History and Practice of Patination." *National Bureau of Standards Special Publication 479*, proceedings of a Seminar on Corrosion and Metal Artifacts: A Dialogue between Conservators and Archaeologists and Corrosion Scientists held at the National Bureau of Standards, 1976. National Bureau of Standards (1977): 77-92; also published in *Historical and Philosophical Issues in the Conservation of Cultural Heritage*, N.S. Price, et. al. (ed.) The Getty Conservation Institute (1996): 394-414.
[734] Wuttig 1814, 53-56; Hirschberg, C. A. *Der Volkommener metallarbeiter*. Campe (1835): 29-38; Larkin, J. *The practical brass and iron founder's guide : a concise treatise on the art of brass founding, moulding, etc.* Hart (1853): 113 & 117; Byrne 1864, 573; Partridge 1895, 91.
[735] For example Debonliez and Fink 1870; Buchner, G. *Die Metallfärbung und deren Ausführung mit besonderer Berücksichtigung der chemischen Metallfärbung*. Fischer, 1891; Hiorns, A. H. *Metal-colouring and bronzing*. Macmillan and Co, 1892; Croke, J. *Guide to bronzing and enamelling*. Hungerford-Holbrook Co, 1897.

patination of the majority of his bronzes.[736] This is especially applicable to casts by the Alexis Rudier foundry, from around 1904 onwards, the principal founder for Rodin. Examples of exceptions are, V. Philippet in 1904 patinating eight bronzes, and a C. Durand in 1910, responsible for the patination of a dozen busts.[737] Also in 1904, the Hébrard foundry carries out the patination of their second and last lost wax cast monumental *Thinker*, probably using a patination technique Hébrard took from Adolphe-Léon Gruet (1855-?).[738] Vauxcelles describes this lengthy patination method, lasting for six months, involving treatment of the bronze with ammonium sulphite and various acids, followed by repeated burial in compost and beach sand, washing, drying and ten days in an oven.[739]

Fig. 4.85. Anonymous photographer, Jean François Germain Limet, Aristotype print from around 1902 (Rodin Museum, Paris, inv.no. Ph 15593)

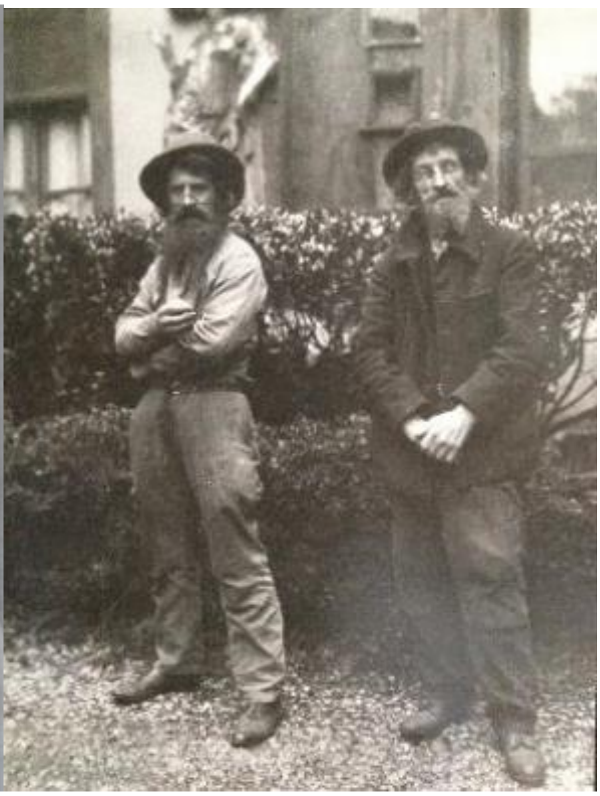

Fig. 4.86. Father (r) and son (l) Limet in 1932 (image by M. Hoffman or C. Mitchell. From the Malvina Hoffman papers, Box 15.2, Special Collections Getty Research Institute, L.A.)

Before Limet, Rodin bronzes were usually patinated by the producing foundry,[740] although on at least one occasion Rodin is known to have patinated a bronze himself, by "exposing it

[736] Le Normand-Romain 2007, 31.
[737] Ibid 31
[738] Le Normand-Romain 2007, 25.
[739] This lengthy method, lasting for six months, involved treating the bronze with ammonium sulphite and various acids followed by repeated burial in compost and beach sand, washing, drying and ten days in an oven is described in detail in Vauxcelles 1905, 195.
[740] There were some exceptions, for example, Liard patinating for Gonon, the bust of *Jean-Paul Laurens* in 1882: Vassalo 1992, 46.

alternately to humidity and sunshine".[741] This lengthy process is an accelerated form of natural patination and this method seems also to have been employed by the founder Adolphe-Léon Gruet, who cast some bronzes, no *Thinkers*, with much admired patina's for Rodin, between 1890 and 1895.[742] Father Jean sr. Limet, played a pivotal role in the final appearance of Rodin bronzes, during the last seventeen years of Rodin's career. Le Normand-Romain gives the period, for which correspondence survives between Jean Limet sr. and Rodin, as 30 May 1900 and 10 November 1915, but it must be assumed Limet continued to work for Rodin right up till the latter's death. Since only the correspondence between Jean Limet sr. and Rodin survives, one can't state with certainty that Limet Jr. ever worked on Rodin bronzes, although it is likely he did, given the fact that father and son worked closely together. The Limet's continued to work for the Alexis Rudier foundry, at least up till 1934, when Limet Jr. was photographed in the Rudier foundry (fig. 4.87). It is not completely clear how Rodin and Limet met. Grunfeld mentions they were boyhood friends,[743] whereas Lebon states he was introduced to the sculptor by Jean-Joseph Carriès (1855-1894).[744] Pinot is thinking along the same lines, suggesting it could have been any of the shared acquaintances, including Carriès or the art critic Arsène Alexandre (1859-1937).[745]

The foundry would send the finished bronze to Limet's workshop, where the finishing would be judged by Limet, and if necessary improved by him by through addition finishing, either in his Paris studio or in his studio in the country.[746] The fact that Limet Jr is pictured working in the Rudier foundry and not in the Limet studio, is unusual and suggest the photograph was taken at a later date, perhaps even after the death of Limet Sr. in 1941.

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741 Rodin writing to Jules Chavasse on July 1893: Le Normand-Romain 2007, 25.

742 Le Normand-Romain 2007, 25. I personally think the action of applying just water and leaving this to dry cannot create the patinas one can observe on Gruet's bronzes today. He must have added some chemical(s) to the water to speed up the process and to create a deeper colour. Natural patination of a bronze, even in the climate of Western Europe, is a process, that takes many years to develop a uniform patina of some intensity.

743 Grunfeld 1987, 559. Grunfeld, as so often in his book, does not give a reference for this and the information in his biography of Rodin must therefore be treated with some caution.

744 Lebon 2003, 114. Carriès and Limet were friends since 1876. See Bellanger, Patrice. "Bingen/ Carriès : le renouveau de la fonte à la cire perdue." *Jean Carriès (1855-1894): la matière de l'étrange*. Simier, Amélie.(Ed.) Paris-Musées (2007): 59.

745 Pinet, Hélène. *Rodin et la photographie*. Gallimard & Musée Rodin (2007): 176.

746 Vassalo 1992, 40 & 55, 57-58. His Paris studio address was 65 Boulevard Arago, Cité des Fleurs, Paris. This address can be found noted in pencil on the back of some of the images of the Limet's in the Malvina Hoffman Papers (box 125) at the Getty Research Institute LA. The country studio was in Cayeux-sur-Mer in the Somme region; le Normand-Romain 2007, 31.

Fig. 4.87. Jean Elie Auguste Limet patinating a bronze in the Rudier foundry, in Malakoff near Paris (between 1934-52). (from an undated Dutch article called "*Hoe men bronzen beelden giet*" in the Malvina Hoffman papers, Box 15.2, Special Collection Getty Research Institute, Los Angeles.)

Fig. 4.88. Jean Limet Jr. patinating in the Balinese cock fighter by Malvina Hoffman. (1933)

Fig. 4.89. Jean Limet Jr. working on the Balinese cock fighter watched by Limet Sr. (1938 but probably 1933)

(both images from the Malvina Hoffman papers, Box 83, Special Collections Getty Research Institute, Los Angeles)

An interesting series of photographs were taken, by Malvina Hoffman, of the Limets working in their Paris studio. The dates given to these images is contradictory: Malvina Hoffman used figure 4.90 in her book *Sculpture inside and out* published in 1939.[747] The date in the caption, 1938, is probably not correct, since this photograph is part of a series that Hoffman took, while she was working on the bronzes for the *Hall of the Races of Mankind* for the Field Museum in Chicago, between 1930-33. The original negatives are preserved in the Hoffman papers, in the special collections at the Getty Research Institute (box 152). Most of these images, capturing father and son Limet whilst working on Hoffman sculptures for the *Hall of the Races of Mankind*, are dated 1933 which is in line with the dates for the Field Museum project.[748]

The correspondence between Limet and Rodin gives some details of the Limet's patination technique, unfortunately, no workshop manual is known to have survived from the Limet workshop.[749] The Limet file in the Rodin Museum in Paris, however, does contain two manuscript notes with technical details on patination: both of them in relation to the ability of a patina to withstand weathering. The first note, in Jean Limet's hand, from probably 1903, mentions that: "the patina […] obtained by the reduction of copper salts using a blowtorch and thus creating a sub-carbonate of copper and no other matter.[750] This is the patina that can resist atmospheric agents longest."[751] The second note, probably of a later date, is in an unknown hand and details the modification of a green patina on bronze, with various acids, also to render the patina more resistant to the elements.[752] Additional information on Limet's patination technique are given by Nicoladze:

I know of one recipe for patination used by Limet. He started with rubbing the bronze with ammonia to degrease it. Then he covered the bronze surface with bluestone (copper sulphate) solution. This turned the bronze green. Then he heated the sculpture using a blowtorch to consolidate the green shade. After that he covered the bronze with copperas (iron sulphate) to

[747] Hoffman 1939, 303.

[748] Copies of some of these images can also be found in the Limet file at the Musée Rodin in Paris, where they are dated to around 1920. This however, is impossible, because the sculptures the Limet's can be seen working on, were only created ten years later.

[749] Technical writings from practitioners are not common and workshop notes from patinators are extremely rare. One example worth noting here are the workshop notes from Paul Wayland Bartlett (1865-1925) an American sculptor who was trained in Paris and worked briefly as an assistant in Rodin's studio before starting his own studio in Paris. His workshop notes, the majority on patination, are preserved in the Paul Wayland Bartlett Collection, Manuscript Division, Library of Congress. These workshop notes are reproduced in Adil, Carol P. and De Phillips Jr, Henry A. *Paul Wayland Bartlett and the Art of Patination*. The Paul Wayland Bartlett Society, 1991.

[750] Sub-carbonate of copper is an antiquated term for the green/blue patina found on weathered copper and its alloys. This consist mainly the green basic copper carbonate Malachite and blue copper carbonate Azurite although sometimes basic copper chloride or sulfate may be present. For more on the chemistry on copper alloy patinas and corrosion products, Scott, David A. *Copper and Bronze in Art: corrosion, colorants, conservation*. The Getty Conservation Institute, 2002.

[751] "La patine […] est obtenue par la reduction des sels de cuivre au moyen du chalumeau et composée de sous carbonate de cuivre sans aucune autre matière.Elle est donc la patine qui doit resister le plus longtemps aux agents atmosphériques.." Note from Limet, 1903, in the Limet file in the Rodin Museum, Paris.

[752] "Patine verte sur bronze, attenuée avec de l'acide ayotique (acétique or azotique?) et de l'eau chargée en acide carbonique dont un hydrocarbonate de cuivre, est la seule patine resistant aux intempéries. Je colore en brun par la reduction du carbonate de cuivre ou contact des matières organiques." note in the Limet file in the Musée Rodin archives. At the bottom of the note is written in pencil in a different hand the dates Jul. 1910 – Fin 1912.

give red shade to metal. Then Limet would give it a dark-violet shade. Then the bronze was heated again.[753]

Although copper sulphate was used in this period to produce patinas, evidence of the use of the above recipe has not been detected yet on Rodin bronzes.[754] Perhaps Nicoladze was mistaken with this recipe, he was not a metalworker by profession, or maybe this recipe was one of the lesser used ones by Limet. What has been detected so far on Rodin bronzes, is the use of copper nitrate, a much more common ingredient of patination recipes.[755] Barbour and Glinsman have detected this use of copper nitrate, on several of the Rodin bronzes bought by Mrs. Simpson, in the early years of the twentieth century.[756] Copper nitrate is also one of the chemicals found on each of the two invoices for chemicals, in the Limet file at the Rodin Museum Paris archive. These invoices, from May and June 1900, contain several other chemicals, also frequently used in patination recipes such as silver and iron nitrate (fig. 4.90).[757]

The first step in the patination process, was to prepare the surface of the bronze to enable the application of the patina. Nicoladze's observation only mentions degreasing with ammonia, this however, does not remove a thick oxide layer, such as the casting skin, from the surface, which can prevent good adherence and formation of the patina. Therefore, bronzes were sometimes additionally cleaned by dipping in acid, something Limet was not always happy with.[758] When for example, Limet received a bronze from the *Burghers of Calais* group in February 1903, he complained:

> My dear master, I brought you the small Burgher of Calais today to the rue de l'Université. ... Forgive me if I made you wait a long time for the small Burger but the cast was not good and the founder had submerged it entirely in acid. Unfortunately I was unable to prevent the formation of efflorescence's and blanching.[759]

Limet usually applied the chemicals by brush to the bronze, heated with a blowtorch (figs. 4.88-4.99).

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[753] Nicoladze 1946, 56-57. I am grateful to Svetlana Burshneva for this translation from Georgian.

[754] For example recipes for green patina's in Bartlett's notes on page 2 and 5; Adil and De Phillips 1991, 2 & 5.

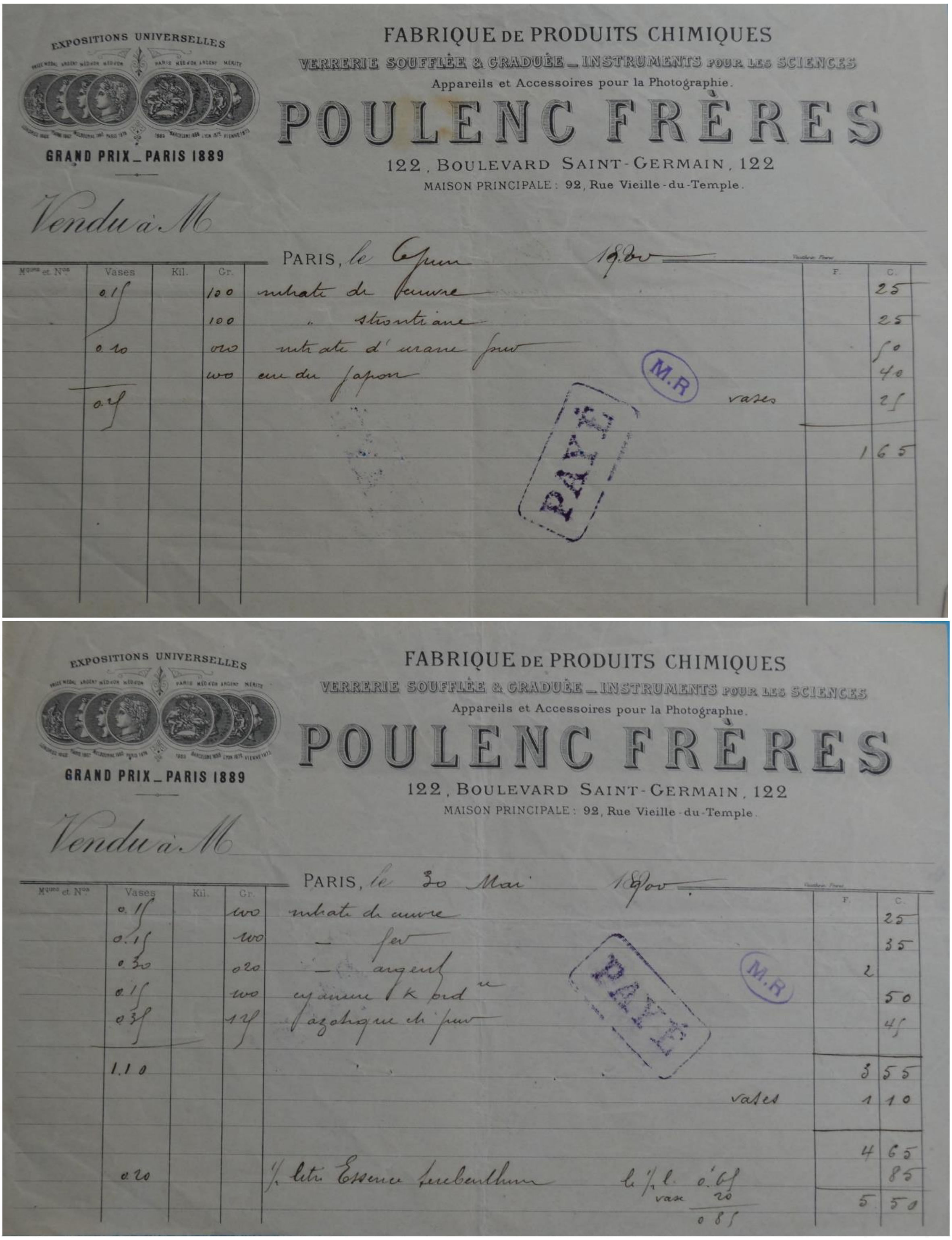
[755] Hayez, Valerie, Triana Segato, Annick Hubin. and Herman Terryn. "Study of Copper Nitrate-Based Patinas." *Journal of Raman Spectroscopy* 37 (2006): 1211.

[756] *The Walking* Man (NGA inv.no. 1942.5.11 (A-75)*, La France* (inv.no. 1942.5.9 (A-73)*, A Burgher of Calais* (inv.no. 1942.5.13 (A-77) and an original size *Thinker* (inv.no. 1942.5.12(A-76); Barbour and Glinsman, 2015.

[757] Bartlett's note books page 7 mentions iron nitrate to produce red patinas and page 8 to produce black patinas and page 12 to produce brown patinas, page 9 describes the use of silver nitrate to produce black patinas

[758] Debonliez gives several recipes for dipping bronzes prior to patination, this so-called *décapage* was done with sulphuric acid, nitric acid or combinations of these; Debonliez 1870, 9-11.

[759] Limet to Rodin, February 24, 1903, Rodin Museum Paris Archives, Limet file: "Mon cher maitre, je vous ai porté le petit Bourgeois de Calais aujourd'hui rue de l'Université […] vous me'excusez si je vous ai fait longtemps attendre pour le petit Bourgeois mai la fonte n'était pas bonne et le fondeur l'avait entierrment [missing word] dans l'acide sans retirer le noyoux et malgré [tous mes] efforts je ne pouvais l'empêcher d'avoir des efflourescences de blanchés. Je n'ai pas volu vous la porter."; Barbour and Glinsman 2015, 80 note 89.



EXPOSITIONS UNIVERSELLES
GRAND PRIX _ PARIS 1889
FABRIQUE DE PRODUITS CHIMIQUES
VERRERIE SOUFFLÉE & GRADUÉE _ INSTRUMENTS POUR LES SCIENCES
Appareils et Accessoires pour la Photographie.
POULENC FRÈRES
122, BOULEVARD SAINT-GERMAIN, 122
MAISON PRINCIPALE : 92, Rue Vieille-du-Temple.
Vendu à M
PARIS, le 6 Juin 1900

Mques et Nos	Vases	Kil.	Gr.		F.	C.
	0 15		100	nitrate de cuivre		25
			100	" strontiane		25
	0 10		100	nitrate d'urane pur		50
			100	eau du Japon		40
	0 25			vases		25
					1	65

PAYÉ
M.R

EXPOSITIONS UNIVERSELLES
GRAND PRIX _ PARIS 1889
FABRIQUE DE PRODUITS CHIMIQUES
VERRERIE SOUFFLÉE & GRADUÉE _ INSTRUMENTS POUR LES SCIENCES
Appareils et Accessoires pour la Photographie.
POULENC FRÈRES
122, BOULEVARD SAINT-GERMAIN, 122
MAISON PRINCIPALE : 92, Rue Vieille-du-Temple.
Vendu à M
PARIS, le 30 Mai 1900

Mques et Nos	Vases	Kil.	Gr.		F.	C.
	0 15		100	nitrate de cuivre		25
	0 15		100	— fer		35
	0 30		020	— argent	2	
	0 15		100	cyanure		50
	0 35		125			45
	1 10				3	55
				vases	1	10
					4	65
	0 20			½ litre Essence		85
					5	50

PAYÉ
M.R

Fig. 4.90. Two invoices from the chemical supplier Poulenc Frères in Paris from 1900, listing the various chemicals Limet used for his patination recipes. Preserved in the Limet file in the Rodin Museum, Paris.

The alternative method of patination would be to immerse the bronze in chemicals. For smaller bronzes this was common practice, but we have no evidence that the Limets made use of this method. The disadvantage of this method, is the risk of not being able to remove all residues of chemicals, which can seep into the porous cast metal or remains of core material, and in time could come out again as efflorescence, as Limet already mentioned earlier.

Another disadvantage of an immersion or dipping patina, is the formation of a rather bland uniform colour. The Limet patina was the opposite of this, consisting of various different colour variations including browns, reds, yellows, greens and even blues.[760] This could only be achieved with the brush and blowtorch technique, producing a multi-layered patina. Often nuances in the patina were extra accentuated by locally rubbing the patina, creating variations in colour intensities. The blowtorch used by the Limets was a relative new tool which came into general use in the 1880s, before this the immersion method was used or the very time-consuming method of brush application and air drying, sometimes with the aid of an oven.[761]

4.5 Lead counterweight

One of the added features that can be observed inside *Thinkers*, is a lead counterweight inside the base (fig. 4.91). Without this lead counterweight, the sculpture is inherently unstable and runs the risk of toppling forwards. This instability is largely due to the angle of the base. Because the *Thinker* was originally designed to be situated high above the doors of the *Gates of Hell*, the angle of the base was such, that the figure of the sculpture faced downwards. Since the enlarged and reduced versions of the *Thinker* are based on the same configuration of the base, they also are instable and as a rule also have a lead counterweight fixed inside the base. Although sometimes, other bronze sculpture has been weighted as well to increase their stability, the *Thinker* is rather unique with its inherent instability requiring a counterweight fixed to the back of the base.

Fig. 4.91. Interior view of the base of the original size Paris *Thinker*, illustrating the lead counterweight. (Rodin Museum, Paris, inv.no. S.01131)

[760] This blue is characteristic for Limet's patinas and was identified by Glinsman as Prussian blue, iron ferric cyanide; Barbour and Glinsman 2015, 75
[761] Debonliez 1870, 31.

Fig. 4.92. Interior view of the base of the reduced size *Thinker* (private collection) with the counterweight. (image Rupert Harris)

Fig. 4.93: Interior view of the base of the monumental size *Thinker* (Louisville) with the counterweight. (image Christopher Fulton)

The earliest original size *Thinkers* do not have these internal counterweights fitted. The lower rim of the back the base of the Ionides *Thinker* (1884), has a flap with a drill hole extending horizontally for a few centimetres, enabling the base to be fixed to an underground. None of the subsequent casts have this flap. The 1896 Geneva *Thinker* and 1899 Brussels *Thinkers*, have no counterweights fitted and are prone to tipping over unless supported. The earliest *Thinker* with a counterweight, is the 1901 François Rudier cast from Copenhagen, but whether this is original is debatable. During examination, it was not clear what constituted the material of this counterweight. Despite the grey colour, the surface does not appear to be lead but more like a modern resin such as epoxy or polyester. The surface morphology of this counterweight suggests the material was smeared in place like a paste (fig. 4.94).

Fig. 4.94. Interior view of the F. Rudier cast in the Ny Carlsberg Glyptotek, Copenhagen.

Fig. 4.95. Iinterior view of a F. Rudier cast in a private collection. (image Jerome le Blay)

Figure 4.95 shows the interior of another 1901 François Rudier cast, this time with a more standard type counterweight, although uniquely, the lower rim extends inwards to form the basin to cast the lead in, a feature not seen on any earlier and later *Thinkers*.[762]

Examination identified a small group of original size *Thinkers*, cast between 1903 and 1905 by Eugène Rudier. They have all the characteristics of a *Thinker* cast by the Alexis Rudier foundry but lack the foundry mark. They have brick shaped counterweights placed high up inside the back of base (fig. 4.96).

Fig. 4.96. Interior view of original size *Thinkers* cast by Eugène Rudier. On the left the Washington *Thinker* (1903) and on the right the Alte Nationalgalerie *Thinker* in Berlin (1905). Both display the early brick shaped counterweight, which is placed high up inside the back of base. (image left from the National Gallery of Art, Washington)

This type of lead counterweight was also observed inside a 1906 Alexis Rudier *Thinker* in a private collection, and inside the bronze from the Metropolitan Museum in New York (1910 but probably earlier). Both these casts are marked with the Alexis Rudier foundry mark. The next *Thinker* chronologically, is the Montreal cast from 1909 and the counterweight is taking another form, when it is cast flatly against the back of the base (fig. 4.97 left).

The Montreal counterweight is of an intermediate shape and already starts to look like the standard lead counterweight, one can observe on all the later Alexis Rudier casts (fig. 4.97 right). The counterweight inside the original size *Thinker* of the Rodin Museum Paris, has a shape closely to the Montreal bronze.[763] This Alexis Rudier cast (fig. 4.91) was donated to the museum by Eugène Rudier's widow in 1953 and has traditionally been dated to 1917 when it entered the museum, but could be earlier as well as later because lack of precise documentation.

[762] The third François Rudier *Thinker*, also from 1901, is in private hands and could not be examined.
[763] Rodin Museum, Paris: S. 1131.

Fig. 4.97. Interior view of original size *Thinkers*. Left the interior view of the Montreal *Thinker* of 1909, illustrating the intermediate counterweight and on the right the Lausanne *Thinker* of 1939, with the typical later Rudier lead counterweight. (image on the left by Daphne Barbour and image on the right by François Blanchetière)

A certain chronological development can thus be observed in the shape and position of the lead counterweight, with the brick shape as an early form, evolving to a cast-in flat slab, flush with the base. To come to better, more well-founded conclusions, on how the counterweights in the original size *Thinkers* have evolved, it is essential though to study more casts to increase the reference group.

4.6 Production time

The entire process of producing a bronze, using sand moulds, was complicated and lengthy. Unfortunately, there is not much documentation giving an idea of the total time involved in producing a bronze, from start to finish. The time span required to produce a bronze was dependent on several factors such as size and complexity of the model, and also the number of workmen who could work on the project concurrently. The quality of the cast, and the required finish and patina, played a role as well. With very large casts, such as the monumental *Thinker*, the amount of man hours involved increased greatly.[764] A Dutch newspaper article from 1939 states that the Alexis Rudier needed ten months to produce the large cast, involving fifty workmen![765] Since the Rudier archive was destroyed, when the foundry closed, it is not easy to verify this large number of workmen involved. Although the monumental *Thinker* is large bronze, it is physically not possible for fifty workmen to work on it at the same time, but it is conceivable that the total number of people involved with such

[764] For the second monumental lost wax *Thinker*, the Hébrard foundry needed 6 months alone for patination; Vauxcelles 1905, 195.

[765] Anonymous. "Eugène Rudier, Europa's Kunstgieter van beroemde beeldhouwwerken." *Telegraaf*, Sunday 13 August (1939): 6.

a large bronze, such as moulders, founders, chasers, finishers and patinators, comes close to that number.

4.7 Conclusion

The above chapter is a detailed study of the founding of Rodin bronzes and in particular *Thinkers*. It covers in detail the moulding, casting and finishing of bronzes, using sand piece-moulds. Starting point for sand moulding is a pattern, a sturdy model of the sculpture to be reproduced. Patterns for sand moulding were made from various materials, with plaster being favoured for the moulding of larger sculptures. The survival of many original plaster patterns or foundry models, in the Rodin Museum, Paris, enabled detailed study which is presented here and in the preceding chapter. Researching these foundry plasters demonstrated the use of a complex system of mould pieces called false-cores in the production of Rodin's sand mould cast *Thinkers.* The sand, enabling this complex piece-moulding, was of a special composition: high in clay with small rounded grains surrounded by a ring of clay. These properties gave this sand superior moulding properties. A decline was observed in the availability of high quality natural moulding sand from Fontenay-aux-Roses, from the 1960s onwards. This lack of good quality moulding sand contributed greatly to the demise of the founding of sculpture in natural sand moulds.

During the first quarter of the nineteenth century, sand mould casting replaced lost wax casting as the preferred method to reproduce bronze sculpture in Western Europe. This research found that several hybrid forms of lost wax and sand mould casting were being practised during this period. At the end of the nineteenth century, the sand mould casting technique was so well-developed, founders were capable of casting complex figurative bronze sculpture, such as Rodin's *Thinker*, in one piece.

The above chapter describes in detail the piece-moulding of bronzes in natural sand, including the complex procedure to fabricate a core from sand. This involved repeated assembly and disassembly of the piece-mould, and the use of sand cones, called flies. An internal and external armature held the core together and in place, inside the outer mould and a core vent (lantern) facilitated the escape of core gases. The alloys, used for Rodin bronzes, are described here for the first time in detail. Most of the Rodin bronzes cast before 1903, are in fact brasses and is it only when Rodin starts commissioning Eugène Rudier of the A. Rudier foundry, that we witness the regular use of a true bronze alloy.. The research into the alloys of the A. Rudier foundry demonstrated, that this foundry was remarkably consistent in using one particular alloy, casting all type of sculptures with this alloy, during the entire working period of the foundry.

The time around 1900, was also a turning point for Rodin concerning the patination of his bronzes. Previously these bronzes were patinated by the commissioned foundry, but from 1900 onwards, Rodin bronzes were increasingly patinated by Jean Limet and later his son. These complex patinas involved the use of various chemicals, often applied in multiple steps. This chapter also describes for the first time in detail, the various markings one can encounter in the outer or inner surface of Rodin bronzes in general and *Thinkers* in particular. These can range from signatures, foundry marks or stamps and dedications, with a suggested chronological sequence of some of these. Because the model of the *Thinker* is inherently unstable and has the tendency to tip forward, a lead counterweight can be found inside most of the *Thinkers*. A development was identified in shape and position of these counterweights and a possible chronological sequence is suggested.