Note from the Making and Knowing Project:

This essay was written in a graduate course at the University of Amsterdam offered by Tonny Beentjes, Ellen van Bork, and Tamar Davidowitz in 2014 and 2015 to students enrolled in the MA program in Conservation and Restoration. Students worked on various recipes from BnF Ms. Fr. 640 related to mold-making and metalworking.

This is an un-edited student paper that relies on an earlier state of the Making and Knowing Project's transcription and translation of Ms. Fr. 640. For an updated version of the text, see:

> Making and Knowing Project, Pamela H. Smith, Naomi Rosenkranz, Tianna Helena Uchacz, Tillmann Taape, Clément Godbarge, Sophie Pitman, Jenny Boulboullé, Joel Klein, Donna Bilak, Marc Smith, and Terry Catapano, eds., *Secrets of Craft and Nature in Renaissance France. A Digital Critical Edition and English Translation of BnF Ms. Fr. 640* (New York: Making and Knowing Project, 2020), https://edition640.makingandknowing.org. DOI: https://doi.org/10.7916/78yt-2v41.

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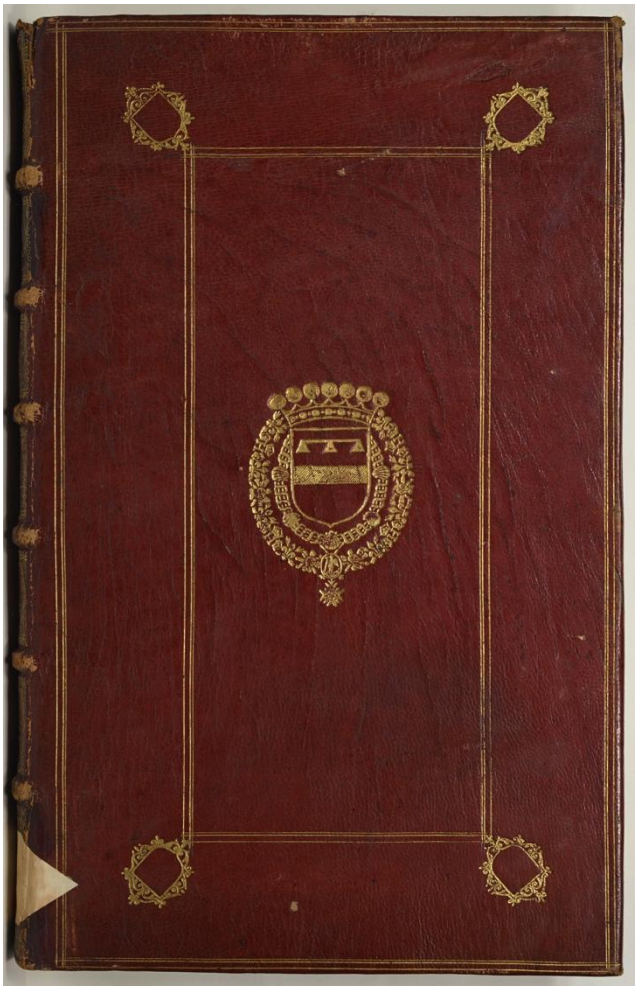

Concerning the incuse-reverse mould casting of medals

Cover of manuscript BnF. Ms. Fr. 640.

Date of completion: 27-3-2015

MA Conservation and Restoration of Cultural Heritage

Specialization: Metal

OGP II

Under the guidance of: T. Beentjes, E. van Bork & T. Davidowitz

Michaela Groeneveld

Marianne Nuij

Content

Introduction

On the fourth of February Tamar Davidowitz and Ellen van Bork informed the students of the master Conservation and Restoration of Cultural Heritage about *the Making and Knowing Project.* This project was initiated and is guided by Pamela Smith: Seth Low Professor of History and Director of the Centre for Science and Society at Columbia University in New York. It was set up with the purpose of researching an intriguing French manuscript dating from the last decades of the sixteenth century, referred to as BnF Ms. Fr. 640. In the manuscript an anonymous French writer describes a number of processes that one in this current time could classify as part of several crafts, fine arts and technology. The aim of the project is to produce an open-access digital edition and English translation of the script. However the process by which this critical edition is being produced is as important as its product.[1] Research for the edition promotes both cooperation and exchange of knowledge between students and academic and museum-based historians of art and historians of science based on different continents who work together in order to reconstruct the technical prescriptions included in the manuscript. These findings are used to get a better understanding of the text and could eventually be included as annotations in the digital edition.

The role we, as students of the Master of Conservation and Restoration of the University of Amsterdam, have fulfilled is that of support in interpreting practical descriptions that relate to metalworking. Because at the studio building of the UvA there is access to practical knowledge and the necessary facilities, we were asked to conduct research into two different recipes: the addition of the unknown material 'spath' to casting-sand and the incuse-reverse mould casting of medals. Two techniques of which in present time very little is known. At Columbia University, where the base of this project lies, the focus is mainly on the art historical aspects of the script. In this way, with our experience and with the facilities available to us in our study areas, we could supplement the research.

In this project file all the documentation that was kept during the analysis of the method by which one could cast a one-sided hollow relief medal with the use of an incuse-

[1] About the project. 26-03-2015. <www.makingandknowing.org>

reverse mould is included.[2] All the research and experimentation on this subject was done by Michaela Groeneveld and Marianne Nuij. The file consists of an annotation in which the processes of finding the right approach, performance of relevant experiments, results and conclusions were explained as well as compared to the annotation and experiments done by Rozemarijn Landsman and Jonah Rowen of the University of Columbia, who like us performed research on this subject. Further, there is often referred to different folia of the manuscript for clarification or substantiation.

Besides the annotation a report is added in which every experiment is accurately elaborated. Per experiment, all of the trials are discussed. The making of the moulds needed some extra clarification and for this reason two step-by-step procedures are contained in the project file. During the eight weeks of working on the *Making and Knowing Project* a log was kept, which is the final addition to the file. To substantiate to all findings pictures were included throughout the texts.

[2] Fol. 92r.

Annotation

Transcription [from tl_p092r, 20 December 2014]

<title id="p092r_a2">Mouler cave d'un costé et de relief<lb/>
de l'aultre</title>

<ab id="p092r_b2a">Et pour cet effect on gecte une medaille d'**estain** fin, qui est plus<lb/>
dur à fondre. Et co{mm}e elle est nette, on moule avecq icelle. Et on<lb/>
la laisse en l'une moictie du chassis & on l'y presse un peu affin<lb/>
qu'elle y tienne mieulx. Et apres tu gecteras dans ton chassis<lb/>
de la souldure cy dessus descripte, ou aultre plus fondante<lb/>
que l'estain fin, et ainsy la seconde medaille se fondra &<lb/>
moulera sur la premiere sans la gaster. Mays pour faire<lb/>
plus seurement, destrempe du **noir de lampe** avecq de l'**eau**, & avecq<lb/>
un pinceau donnes en une couche legere sur la medaille qui<lb/>
demeure dans le chassis & laisse seicher. Ainsy elle ne fondra<lb/>
poinct.</ab>

<ab id="p092r_b2b">Mays si tu as une medaille de **cuivre** ou d'**argent**, tu la peulx<lb/>
bien laisser dans le gect si tu veulx gecter de **plomb** ou **estaim**.<lb/>
Mays il fault qu'elle soict un peu chaulde, car la froideur feroit<lb/>
retirer l'**estain**.</ab>

<ab id="p092r_b2c">L'**estaim** veult estre gecté bien chault pour venir net.</ab>

<ab id="p092r_b2d">L'**estain doulx** qui est le meilleur pour le gect est celuy qui, estant<lb/>
gecté en grille, est luisant & poly co{mm}e un mirouer, & qui semble<lb/>
avoyr esté bruny. Et n'ha poinct de trous co{mm}e celuy qui est aigre & qui<lb/>
n'est point luisant co{mm}e bruny.</ab>

Translation [from tl_p092r, 20 December 2014] and suggested changes:

<title id="p092r_a2">Molding a hollow on one side and a relief on the other</title>

<ab id="p092r_b2a">And for this effect, one casts a **fine tin** medal, which is harder to melt. And since it is pure, we mold with it. And one leaves it in one half of the box mold and press it inside so that it holds. Then, thrown in the box mold soldering, the one described above, or something else that melts better than pure tin. In this way, the second medal will melt and mold itself on the first one without damaging it. But to make this is a better way, soak **noir de lampe** in **water**, and with a brush, apply a thin coat on the medal which is in the box mold, and leave to dry. In this way the medal will not melt at all.</ab>

<ab id="p092r_b2b">But if you have a **copper** or **silver** medal, you can leave it in the casting, if you want to cast in **lead** or **tin**; but the medal must be a bit warm, because otherwise, the **tin** will shrink.</ab>

<ab id="p092r_b2c">**Tin** must be cast very hot, to come clean.</ab>

<ab id="p092r_b2d">**Soft tin**, which is the best one for casting, is the one that, when cast en grille is shiny and polished like a mirror and almost looks as if it has been burnished. This **tin** has no holes like the one that is brittle, and is not shiny as if burnished.</ab>

Incuse-reverse mould casting of medals as described on folio 092r

Introduction

When a casting mould is made in which the original design is left inside whilst casting to create a one-sided hollow cast medal, one speaks of incuse-reverse moulding. This is a technique that is described in the BnF Ms. Fr. 640 manuscript on folio 92r. The basic steps for preparing such a mould are filling up one half of a casting flask with sand, making an impression with an original medal, then filling up the other part of the flask with sand and pressing in the original design so that it holds. In this way while casting, the liquid metal will flow between the original and the made impression. One could say that by this method a medal is cast on top of another. The intended result is a medal that has a positive relief on the obverse and an exact negative of the design on the reverse. On folio 92r of the manuscript the anonymous author describes this method as being especially useful when a fine tin medal is used.[3] The advice he gives however is not very extensive and he leaves out some relevant information on how such a mould should actually be prepared.

Rozemarijn Landsman and Jonah Rowen of the Columbia University in New York, have previously tried to interpret the method described on folio 92r and searched the manuscript for comparable techniques as well as art historical references for corroborating information. They found that during the late fifteenth century a large number of these medals were produced throughout Europe, which indicates a well-established practice. However, they did not find sufficient information about the way in which these medals were used, designed, how the moulds for their production were made or how these medals were cast.[4] An article on Renaissance casting techniques of incuse-reverse and double-sided medals written by Patricia Tuttle in 1978 has been an important source of information for their interpretation of the descriptions on folio 92r.[5] Related recipes from the manuscript were studied on their given descriptions as well as for the terminology used. Nevertheless,

[3] "And for this effect, one casts a **fine tin** medal, which is harder to melt. And since it is pure, we mold with it. And one leaves it in one half of the box mold and press it inside so that it holds." Citation from: Fol. 92r.
[4] Landsman & Rowen, 2014: 4.
[5] Landsman and Rowen in their annotation refer multiple times to Tuttle's method. Their interpretation of Tuttle's method can be found here: Landsman & Rowen, 2014: 10-11.

after performing several experiments based on all the found information, questions remained unanswered.[6]

Because of the available facilities at the studio building of the University of Amsterdam another attempt was made to reproduce the method described on folio 92r. The annotation written by Landsman and Rowen, as well as other manuscript pages concerning metal and metalworking were carefully read. The incuse-reverse mould for casting a one-sided hollow relief medal experimentation began with trying different ways to prepare the mould. As there was no suitable medal at hand a small, fairly detailed brass lion's head was used. Eventually two ways of making a mould were found useful and clarified by writing a step-by-step procedure.[7] The method that was found to be most suitable was casting in tin on a brass medal. Then it was decided to create an actual medal out of the lion's head so better conclusions could be drawn. A new 'original' medal was cast in tin and an attempt was made to cast one in brass and bronze. In this way the method by which the new tin medal would be left inside the mould and another tin medal would be cast on top could be tested. Through which the use of two metals with the same melting temperature was tested.[8] This experiment was also meant to be carried out with a metal of a higher melting temperature, hence the attempts for casting a new brass medal. Unfortunately all the attempts for casting a new brass medal failed. Therefore this experiment remains relevant for follow-up research. In this annotation all the carried out experiments are recorded. The procedures performed are explained and all findings described. Ultimately, a conclusion was drawn from all the information gained. To illustrate our findings pictures are included in the text, all made by the authors of this annotation unless otherwise stated.

[6] During the experimentation of Landsman and Rowen multiple questions arose. For example in which half of the mould the original medal should be left, what type of sand should be used, how deeply the medal should be pressed into the sand etc. Landsman & Rowen, 2014: 7-13.

[7] The step-by-step procedures can be found on p. 56-58.

[8] An experiment that was also noted to be interesting for research by Landsman and Rowen. Landsman & Rowen, 2014: 13.

Searching for the right approach

Before the method described on folio 92r could be tested, the manuscript and annotation written by Rozemarijn Landsman and Jonah Rowen needed to be studied carefully. Folios from the manuscript regarding the casting of metal, medals, hollow objects, and the making of moulds (as well as those concerning sand-casting) were sorted. These were selected because they could contain relevant information for the experiments. In this way they were at hand quickly in case we needed some extra information.

Initially it seemed logical to test several types of sand, including a number of types mentioned throughout the manuscript for preparing a mould. However, after careful consideration and consultation with lecturers Tamar Davidowitz and Ellen van Bork, it was decided to instead scrutinize the description mentioned on folio 92r, in an effort to fully understand the actual process and to get an idea of what other aspects were still unclear. In addition to the experiments carried out by Landsman and Rowen, the use of metals with a higher melting point could be tested (which was not possible in their faculties). By only focussing on the technique and how it works, new information about the process could potentially be obtained. The testing of different types of sand can act as a follow-up experiment and could be carried out in the future.

Making a mould

The first step in testing the procedure as mentioned on folio 92r was to try to make a mould. The right materials had to be picked and a method that concurs with the recipe and accomplishes good results had to be devised. The only sentence mentioned on folio 92r with regards to the making a mould is: “And since it is pure, we mould with it. And one leaves it in one half of the box mould and presses it inside so that it holds.” Many questions immediately emerged. The type of sand and what kind of flask should be used and in what way the impression of the medal should be made is open for interpretation. Additionally the use of sprues or vent-holes is not mentioned. The best way to begin was to understand the Landsman and Rowen annotation and the method they used to see if what could be used or added.

The sand used for the preparation of the mould was Delft clay,is a reddish sabulous clay that was suitable for making a sharp impression, as the initial aim was to test the

functionality of the technique. Before filling up the flask with sand, it was important to consider which half of the flask the medal should be left during the casting process. Unlike Landsman and Rowen, it was decided to try a method by which the medal is left in the first half of the mould, after making a negative imprint in the second half.[9] Also the way in which we came to make the imprint, differed from their approach. Landsman and Rowen in their annotation describe pressing the medal into the sand-filled first half of the mould until the flat reverse was levelled with the sand, followed by first filling the second half with sand after which they put it on top of the first. We found this approach to be very interesting, since they next describe to turn the flask upside down, take the halves apart while tapping on the first half, which left the medal, now on the second half of the mould, perfectly aligned with its impression on the first half.[10] The best functioning method known by us was to always put the second half of the flask on top of the first before you fill it up with sand. So a different approach was tried: first the first half of the flask was filled with sand, next the lion's head was put face up and slightly pressed into this half after which some talcum powder was applied as a separator. The second half of the flask was put on top and filled up with sand, during which it was made sure that especially the first layer of sand applied was pressed in very tight so that all detail of the lion's head would be captured in the impression. When both halves would be taken apart it would be certain the position of the medal in the first half and the impression on the second half would be aligned. The medal that is still in the first half of the flask could be pressed down a little, by which space for the molten metal to enter was created.[11]

This was tried several times before a mould was made that was suitable for casting. During the moulding preparation certain aspects came forth that needed some attention. A few times the impression in the mould seemed too crumbly to be prepared for casting.[12] A problem also Landsman and Rowen, even though they used a different type of sand, noticed

[9] They mention leaving the medal in the second half of the mould after making the impression in the first. "We hypothesized that it would only make sense to leave the medal in the upper, or male half of the flask, after making a negative imprint with it in the bottom, or female half." Citation from: Landsman & Rowen, 2014: 7.
[10] Landsman & Rowen, 2014: 12.
[11] This method is elaborated in the first step-by-step procedure that can be found further on in the file.
[12] For more information read trial 1 and 2.

during their casting process.[13] Also the right firmness by which the sand needed to be pressed in to be ensured of a good imprint but by which it was also possible to press the medal down to create enough space for the molten metal to flow was not easy to determine. By the fourth trial it seemed that the most suitable manner for this aim was found. Nonetheless Tamar and Ellen had additional advice on how a mould should be made. The difference between the two methods is that we placed the lion's head face up into the first half of the mould and made the impression of the face in the second half, by filling it up with sand. However, they suggested a similar approach as the one used by Landsman and Rowen. To make the impression of the lions head in the first half of the mould they suggested pressing the lions head face down and deeply into the mould so that it holds. After the second half of the flask could be put on top and the flask could be filled up with sand. [14] So it was decided to give this method a try and see if this would lead to a better outcome.

The new proposed method resulted in a very sharp imprint. Nonetheless, after pressing the lion's head in the second half of the mould there was still a granular outer edge. But because of the very sharp imprint we got from pressing the lions head face down into the first half of the flask and because Tamar and Ellen recommended this method, we decided for the following experiments to remain with this approach. It was not until later, when the brass lion's head was soldered on a small brass plate to create a medal in the original sense of the word, that our initial method for creating a mould seemed to be more useful.[15]

[13] "Before we poured the metal, we also noted that the sand had crumbled on the edges of the imprints in both halves of the flask. This most likely caused the molten pewter to extend beyond the edge of the original medal, enclosing it and making it a difficult task to separate one from the other." Citation from: Landsman & Rowen, 2014: 12.

[14] This method is elaborated in the second step-by-step procedure that was added to this annotation as an appendage.

[15] The reason that this approach was more useful in a later stadium was because of the way in which the imprint was made. Around the lions head on the brass plate small letters and numbers were captured with the use of punches. To capture these details, one had to press the medal face down and very hard into the first half of the mould, which seemed impossible to do. With the approach we initially thought of, the imprint was made by placing the medal face up in the first half of the mould, while later filling up the second half. In this way we had more control over the making of the imprint, because it was made by pressing the sand on the medal instead of the other way around.

It was found that for the making of an incuse-reverse mould no full instruction was given by the anonymous author on folio 92r. A lot was left open for interpretation and this therefore encouraged us to try different methods. During the experimentation a lot of moulds were made and sometimes steps in the procedure were changed to ensure a better result. Al the single trials are elaborated in a report in which all the performed experiments are combined. In the end a method was found with which a good imprint could be made which lead to the possibility of casting.[16]

Casting tin on brass

After the practice of making a good impression had been optimized, the moulds were prepared for casting by adding a sprue and vent-holes. Although the metal to be cast was of a considerably lower melting temperature than the brass original, lampblack was applied as mentioned in the manuscript, to prevent the two medals from melting together. Other ways of separating a cast from an original after pouring on top of it, although based on a similar principle, are mentioned in the manuscript. On folio 153r it is said: "You could also pour on the first cast of metal, lead or tin. This metal won't melt if you cover it with a very thin coat of crushed chalk, or a coat of dry albumen, or if you smoke it with the smoke of a candle". But because on folio 92r the author uses lampblack this is what has been used in the experiments as well. The metal used was presumably a lead-tin alloy as could be deducted by the colour. Several times in the manuscript the author mentions the good casting qualities of a lead-tin alloy as it comes to casting thin objects, so the alloy should not present any problems.[17] As the tin melted a contaminated layer floated on top, so this was taken off before casting. To see if the tin was ready to be cast it was stirred; if all the metal had been molten and the substance had shifted from viscous to liquid, it was poured.

The first two castings were done almost directly after each other using the same alloy and in the same fashion. The first casting had been cast fully but during the second casting the metal only went halfway into the mould (fig. 1-4). Both medals had maintained their details on the obverse and reverse sides, as was also the outcome of the experiment in the annotation by Landsman and Rowen. Another similarity is that with the second trial the

[16] For a more elaborate explanation about the making of the moulds read trial 1 to 5.
[17] Among others on fol. 48v & 49r.

metal had failed to flow into the entire cavity (fig. 3, 4). In the annotation is suggested that tilting the mould, heating the alloy to a higher temperature or widening the negative imprint might prevent this.[18] Two of these ideas were already implemented in the second casting – the flask was tilted and the imprint was quite deep- and had not prevented this. The temperature or even the size of the sprue could still be the cause. Something else that was remarkable was the fact that the medals had come out thicker than expected. During the making of the mould a lot of effort was put in to pressing in the lion's head deeply. Apparently this does not need to be done with this much pressure. This was taken in account by the making of the next mould, which resulted in a medal that was fully cast, thinner and still had the same amount of detailing (fig. 6, 7). It was thought that the medal could be thinner, which was the aim for the fifth casting. The medal that came out of this trial had the result that was hoped for; thin with as much details as the previous ones (fig. 8, 9). The biggest flaw was that it had two tiny holes under the cheeks of the lion's head. To broaden the experiment it was decided that instead of just the lion's head another design should be used for the casting; one that is slightly bigger and looks more like a medal. Since there were no medals to be used in the workplace the brass lion's head was soldered on to a round piece of brass. The performed experiments proved that the method described on folio 92r works and that an incuse-reverse medal can be cast this way. But to extend the research the same experiments should be performed with a model that looks more like a medal.

Fig. 1. Result of casting tin on brass, trial 1. Obverse.

Fig. 2. Result of casting tin on brass, trial 1. Reverse.

[18] Landsman & Rowen, 2014: 13.

Fig. 3. Result of casting tin on brass, trial 2. Obverse.

Fig. 4. Result of casting tin on brass, trial 2. Reverse.

Fig. 5. Result of casting tin on brass, trial 3. Obverse.

Fig. 6. Result of casting tin on brass, trial 4. Obverse.

Fig. 7. Result of casting tin on brass, trial 4. Reverse.

Fig. 8. Result of casting tin on brass, trial 5. Obverse.

Fig. 9. Result of casting tin on brass, trial 5. Reverse.

Casting tin on tin

After having cast several tin lion's heads on a brass example, according to our interpretation of the method, another experiment was undertaken where it was tested if casting a medal on top of another medal of the same metal would be possible. On folio 92r the writer mentions that the metal used for casting on a pure tin original should be "the one described above, or something else that melts better than pure tin", where the one described above is a mixture of soft tin, pure lead, bismuth and quicksilver. [19] But he also mentions that when applying "noir de lampe" on the medal "the medal will not melt at all". It remains unclear if the writer means that a medal will not melt at all as long as a metal with a lower melting temperature is used, or that after applying lampblack even a metal with the same melting point can be poured on top of it. The aim was to find out if, with applying lamp black, it would be possible to cast metals with the same melting point as the original. In the annotation written by Landsman and Rowen this idea is also coined because it would be a good way to see if this method is also usable for casting in bronze, which due to its high melting point (between 800°C and 1000°C, depending on the specific alloy) would otherwise only be possible with a steel or iron original (melting points between 1390°C and 1538°C).[20]

[19] Fol. 92r.

[20] Landsman & Rowen, 2014: 13.
Melting point iron steel: Callister & Rethwisch, 2011: 319.
Melting point bronze: Selwyn, 2004, 56.

It was decided that at first it would be tried to cast tin on a tin medal, because of its lower melting point and higher chance at success. Firstly a new original in tin had to be cast. This was done in the same flask as used before but the method of making the mould was slightly changed; the addition of the letters and numbers made it almost impossible to make a clean impression with the method used at the end of the tin on brass experiment. That is why the method used in the beginning; putting the medal in the first half of the mould face up, filling up the second half from above with sand and after pressing the medal deeper into the first half to create space for the metal to flow.[21] The metal used was pure tin.[22]

During the first trial to cast a tin on tin medal the result at first seemed very satisfying; the tin had flown through the mould very well and had covered the entire original. But although lampblack had been applied as advised on folio 92r the two medals were not easily separable. From a visual and microscopical analysis it was concluded that the two medals were stuck but had not molten together, at least not on the visible sides. After tapping the medals on a hard surface and pulling on the flashes with pliers it was managed to loosen the upper side. But it turned out that the two medals had in fact molten together at the other side, where the sprue was attached to the medal. It was impossible to separate them without damaging the casting; therefore it was pulled off, leaving a part of the medal behind on the original (fig. 10, 11). Apart from the part that got stuck to the original the medal turned out very well. The detail, especially on the reverse side, was very sharp (fig. 11). The backside had a very smooth surface whereas the obverse surface was a bit rougher. This can probably be contributed to the surface the metal was cast on, the obverse was cast on sand and the reverse was cast on metal.

[21] For more detailed information about the method step-by-step procedure 1 can be consulted.
[22] The purity of the tin was not tested.

Fig. 10 Result of casting tin on brass, trial 1. Obverse. In the image the oval indicates where the incuse-reverse cast medal was stuck to the original

Fig. 11. Result of casting tin on brass, trial 1. Reverse

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To try to succeed in casting a medal that would not get stuck, a new tin medal without a hollow reverse was cast; the first one had become unusable after melting together. This took several trials, possibly due to the use of a different alloy but unfortunately there was not enough of the formerly used tin alloy left . The medal that succeeded was cast from a tin-silver alloy.[23] The mould was altered so hopefully melting to the original could be avoided; the sprue was made smaller and did not proceed on top of the mould. To make separation even easier we pressed the original in until it was exactly levelled with the sand so the molten tin could not flow on the sides and a bigger amount of lampblack was applied. Unfortunately only a small part of the medal was cast. This is probably the result of the sprue being too small and also because it was tried to make the medal really thin. Another attempt was made, which failed as well, probably due to the same reasons as before, albeit to a lesser extent. Since there was no more time left only one more casting could be done; a bigger sprue was made and the impression was made deeper so the tin could flow better, again a tin-silver alloy was used. But when the molten tin was poured into the flask it burst

[23] Pieces of a silver-tin alloy were mixed with pieces of pure tin.

out accompanied by a sound that implicated a small blast inside the flask (fig. 12). This was probably caused by the lamp black still being wet. The moist had not yet been evaporated so the molten hot tin that was then poured into the flask turned it into steam that could not escape.[24]

A successful tin on tin casting has not yet been made. The first attempt was almost successful except for the casting head melting to the original, the trials following did not stuck together but were not well cast. Variations can be done on the mould by altering the sprue, like considering a forked sprue as is mentioned and illustrated on folio 091v and 086v off the manuscript. Also it is possible to investigate the effects of different temperatures. With more trials and experience it is thought that it is possible to cast a medal with a metal that has the same melting point as the original that is whole and without the two melting together

Fig. 12. Casting tin on tin, trial 5. Reverse.

Casting a new medal in brass

After the lion's head was soldered on the sheet metal a new medal had to be cast so there would be no undercuts like in the soldered one and so the molten metal would not interfere with the solder. This proved to be very difficult, over a course of time six attempts have been made to cast the medal and all of them failed (fig. 16-21). The first two attempts were made

[24] As suggested by Tonny Beentjes.

with a type of sprue that proved to be sufficient to cast the head, but not to cast the entire medal. Alterations were made in the mould by widening the sprue significantly and a third trial was done. This proved to be a big improvement, but there were still some vacancies on the sides (fig. 18).

To further improve the medal more research was done in the manuscript about making a mould. A drawing was found about how to make a mould on folio 086v where the author speaks of “Excellent sand for lead, tin and copper”. He writes: “When you mold make some grooves around your mold in the box frame, so that you draw in this manner the matter from all sides” and added the drawing (fig. 13). A similar drawing of a mould with spike-like forms at the bottom can be seen on folio 091v (fig. 14). Here he writes: “If the piece is difficult to cast, and composed of various pieces, cast it with a forked pattern, of three or four grooves, and make these grooves where the metal is the thickest. Also make these grooves around the medal and directly on the head because this attracts the metal and will fill the figure best”. On this folio the author writes about casting objects that are difficult to cast and composed of various pieces, but in the drawing the object in the mould had the same shape as the medal we like to cast (fig. 13-15). Right next to this drawing is another one, but this one is even harder to interpret (fig. 15).

The grooves suggested by the author were taken in account with the making of the fourth mould; three triangular shaped pockets were made on the bottom side of the mould, hoping that they would draw matter in from all sides like the writer mentions. Unfortunately in the small flask that was used, it was not possible to make more sprues like in the drawing. The result of the casting with this mould was not satisfying; the medal had been cast less well than in the trial before (fig. 19). The reason for this was not clear.

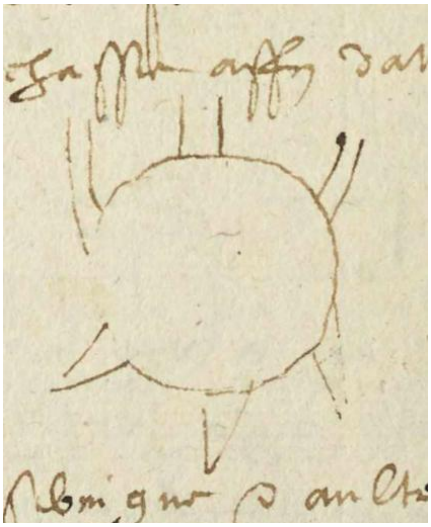

Fig. 13. Drawing of a mould on fol. 86v.

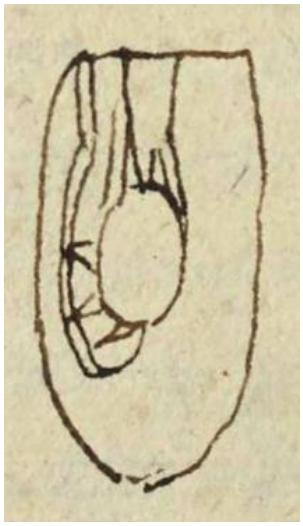

Fig. 14. Drawing of a mould on fol. 91v.

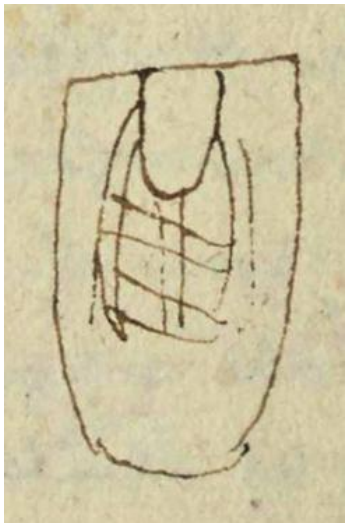

Fig. 15. Drawing of a mould on fol. 91v.

A decision was made to try this casting method with the use of a bigger flask. In this way there would be room for a forked sprue and the risk of the metal being cooled off by the iron flask would be reduced. Also the triangular pockets were added. This cast was better than the one before, but still not as complete as the third trial (fig. 20). One last attempt was made where the sprues on the sides were connected exactly to the point where the failures most often happen. Unfortunately it was not helpful; the metal that was going through the sprues on the sides had solidified before it reached the medal (fig. 21).

The author writes about casting with brass and that it is done "with difficulty". [25] He advises to add a small quantity of copper and a bit of tin to make it run better. Also he says that it is necessary to cast it very hot.[26] The latter is also mentioned on folio 136v. Here the use of calamine (a mixture of zinc oxide with ferric oxide or a zinc carbonate) is also mentioned. These suggestions have not been taken account during the casting because it would demand an extensive research on the characteristics of calamine. The anonymous writer also mentions "latten", by which he meant a copper alloy, but of which it is not certain with what it was alloyed.[27] The way of what the author of the manuscript describes as to be the best way to cast brass, should be researched. Unfortunately the time was

[25] Fol. 154v.
[26] Fol. 70r
[27] Google Drive, The Making and Knowing Project: vocabulary.

missing to conduct such a research or to make another attempt at casting a brass medal. This has the additional drawback that an experiment with casting brass on brass cannot be conducted either.

Fig. 16. Casting a brass, medal, trial 1.

Fig. 17. Casting a brass medal, trial 2.

Fig. 18. Casting a brass medal, trial 3.

Fig. 19. Casting a brass, medal, trial 4.

Fig. 20. Casting a brass medal, trial 5.

Fig. 21. Casting a brass medal, trial 6.

Conclusion and further research

After conducting these experiments it can be said that the method for casting medals with a positive relief on the obverse and the negative of this relief on the reverse, as described in the manuscript, works. But the metals used greatly influence the ease with which this type

of medal can be cast. If a metal with a lower melting point than the original medal has is used, like is done in the tin on brass castings, the experiments present good results. A detailed relief can be seen on both sides and the cast medal does not melt to the original. When using a metal with the same melting point as the original more problems arise; the molten metal cannot be too hot or it will melt to the original, but when the temperature is too low the metal will not flow completely. Unfortunately we have not succeeded in casting this kind of medal yet, but it is thought to be possible when enough experience is reached and the right approach has been found. Additionally, these experiments could not be conducted whilst using a metal with a higher melting point since the casting of a new 'original medal' in brass did not succeed.

Many experiments have been conducted to test the method mentioned on folio 92r but still numerous questions remain unanswered. This is partially due to a lack of time to conduct more experiments, but also because essential knowledge and experience is missing. Although it has been established that the method as proposed by the anonymous author works, more experiments could be undertaken to refine it.

Firstly it is still not clear how thick the medals made by this method are supposed to be. This could be researched by further investigating the manuscript but also by looking at extant examples. Although this was planned at the beginning of the project, no actual incuse-reverse mould casted medals have been seen. Besides, this could have clarified the purpose of the method to cast with a hollow reverse because this is a fact that still remains unclear. In the manuscript is mentioned: "Tin recoils if thick, therefore it is better to cast it thin and from one piece, to make two and then solder them together, if necessary."[28] This could be a reason for making a hollow reverse; to avoid having to cast a piece that is too thick. It would be interesting to look deeper into the use and aim of this purpose because this would also explain the use of a paste for a hollow reverse, which would not ensure a detailed reverse.[29]

At the same time it was wondered how much the specific used alloys were influencing the outcome of the experiments. Much advice is given by the author about what

[28] Fol. 103v

[29] On fol. 130v and 153v the use of a paste is described by which a hollow reverse could also be obtained. Due to restricted time this method was not tested.

metals to use for what intent and also the addition of extra copper to brass to make it run better. This has not been taken in account while performing the experiments because it would induce a time-consuming research that unfortunately was not an option for this moment. Especially in the casting of a new brass medal the benefits of this research could have been discernible, because no good result had been achieved, just as a further exploration of the making of a mould. With this not the making of the impression would profit but a better-argued way of making the sprues could be the outcome. Multiple times the author gives advice on how to make a mould, some of that knowledge has been used but some of it has not been implemented. For example the words that are giving on making a notch at the top of the mould; “Do not forget to notch the top of your mould, that way metal won’t run too fast” and “Always notch the intake of the medal you will cast, it kills the violence of the metal”.[30]

To fully conclude the experiment also the different types of sands should be tested, since this could be of influence for the results. It can be said that the experiments conducted regarding folio 92r, by Landsman and Rowen and by us, have confirmed the workability of the method but therewith have cultivated a whole new range of questions.

[30] Fol. 122v and Fol. 129v

Report

The purpose of the experiments was to find out the exact way in which a mould should be made for casting *one sided hollow cast medals* as described on folio 92r of the BnF Ms. Fr. 640 manuscript. In this technique pressing in and taking out the original medal makes one half of the mould, while leaving the medal in makes the other half. To find the best way in which such a mould should be made and one-sided hollow medals should be cast we had different trials. The results varied and we tried to consider all the found conclusions during the progress of experimenting. The manuscript as well as the annotation written by Rozemarijn Landsman and Jonah Rowen was consulted during the experiments to gain understanding and to support in making decisions and trying different methods.

We divided the overall experimentation into different experiments which include the making of a mould, the casting of a tin on a brass medal, making a new 'original' brass and tin medal and casting a tin on a tin medal. All performed trials were explicated per experiment and the found results and conclusions were noted. To illustrate our findings pictures are included in the text, the authors of this report made all of these unless otherwise stated.

Making a mould

Used supplies

- Manuscript BnF Ms. Fr. 640.
- Landsman, R., J. Rowen. *Annotation concerning the production of one-sided hollow cast medals.* Annotation University of Columbia, New York 2014.
- Apron
- Delft clay (sand)
- Iron casting flasks
- Brass lion's head (instead of a medal)
- Talcum-powder
- Brush
- Two metal plates, one big to prepare the mould on and one small to scrape overflowing sand off.
- Lamp black
- A small wooden block (for deviding the pressure equally while pressing the lion's head into the mould)
- Some sharp tools like dentist hooks for making the sprue and vent-holes.

Trial 1

We started the experiment by making a mould as described in the first step-by-step procedure that was previously written.[31] The sand we used was Delft clay, which is a reddish, sabulous clay. This type of sand was not mentioned in the manuscript, but since our first aim was to test the functionality of the technique described, we decided upon using the sand we know works well. In addition not an original medal was used but a small brass cast lion's head. We decided to use the brass lion's head, because we did not have an original medal at hand and the lion's head had enough detail to find out if the mould would function properly. Besides the lion's head had a good size to fit in the casting flask and would not need a large amount of metal to be cast.

[31] The step-by-step procedures are included in the file on p. 56-58.

During this trial we made sure that the sand in the half where the medal should stay was not packed too tight, so that it would not be too hard to press the lion's head down. The sand in the other half of the flask on the other hand was pressed in as tight as possible, so the impression would come out clear and detailed. We pressed the lion's head in by hand until it was around a millimetre deep.

Results

The idea of packing the sand less tight on the half where the medal should stay in the mould first seemed right because in this way the lion's head could be pressed easier into the mould. But the top layer of the sand turned out to be a bit granular. The impression of the lion's head in the other half of the flask turned out a bit granular as well, mainly along the outer edge (fig. 22).

Fig. 22. The impression of the lion's head on the first trial.

Conclusion

The impressing of the lion's head into the mould as well as the result of both the impressions was not as good as expected. It seemed we should think about different methods by which we could make a less granular impression.

Trial 2

During the second trial the making of the mould was tried by packing the sand a little tighter in the half where the lion's head should be left. After putting a decent amount of pressure on the lion's head, we again were able to press it in around a millimetre. The question that rose was how thin the one-sided hollow cast thin medal should actually be. Since there are no measurements of thickness mentioned on the folio, we decided we should try to make a medal in different thicknesses starting with a fairly thick one of around 5 mm. We thought to begin with casting a fairly thicker lion's head, since there would be more room for the metal to flow whereby it probably would be easier to cast. So we tried to push the lion's head into the mould as deep as possible.

Results

After pulling apart the two halves of the flask, we saw that the lion's head was stuck to the wrong side (it had remained in the impression). We took it out with a sharp tool and were able to put it back on the right place. The impression in the sand was good but it still was a little bit too granular on the outer edges, so we decided to try another time (fig. 23).

Fig. 23. Result of the mould, trial 2.

Conclusion

Supposedly the lion's head could get stuck in the wrong half of the flask by pushing it too hard and uncontrolled into the first half. This way the lion's head could have moved during the impressing, making the impression wider allowing the lion's head to move or fall out.

Trial 3

A third trial to make a good mould was executed in which the sand was pressed in slightly tighter on both halves of the flask, so the impression would turn out clear and detailed. The lion's head was pressed in firmly and deep.

Results

Again when the halves of the flask were taken apart the lion's head was stuck on the wrong side. We realized that we should think of an improvement for the way we press the lion's head into the mould. In addition to falling to the other side of the flask, the lion's head also has not been pressed in deep enough, sometimes even lop-sided.

Conclusion

We suppose the lion's head could get stuck again in the wrong half of the flask by pressing it too firmly and uncontrolled into the first half. This way the lion's head could have moved during the impressing, making the impression wider allowing the lion's head to move or fall out. In addition the lion's head seemed not to be on a plane level and this resulted in failing to press it deep enough or even lop-sided, because this makes it hard to divide pressure equally.

Trial 4

After three trials that were not as successful as hoped, we made some changes in the method. The first half of the flask was filled up with sand tightly. After pressing the lion's head face up into the sand, we put the other half of the flask on top and first filled it up with just one layer of sand that was pressed in very tight, so the surface, when the halves would be taken apart, would be smooth. Then the rest of the flask was filled up with sand that was pressed in looser. The tight layer would ascertain a sharp imprint of the outer edges of the

lion's head. But by filling up the second half of the flask around the face of the lion tightly, the sand of the first half was pressed down. Because of this, it was even harder to press the lion's head into this half but with the aid of a small piece of wood we succeeded in pressing it fairly deep and also to press it in straight (fig. 24). The loose sand on the outer edges of the impression in the second half was pressed down so that the sands could not come loose when the metal would be poured in.

The next step was the making of the sprue and the vent-holes. The last ones we made only in the mould of the second half of the flask so we would not damage the impression of the lion's head and in case the tin would flow into these vent-holes, it would only clot to the thickened part.

Results

The impression of the lion's head came out fairly clear and detailed. The result was better than previous attempts. We succeeded in finding a way for pressing in the lion's head straight and deep (fig. 25).

Fig. 24. Pressing the lion's head down with a piece of wood.

Fig. 25. Result of the mould, trial 4. Including sprues and vent-holes.

Conclusion

This method worked fine and got us a clear impression we could cast with. The flask was prepped for casting.

Trial 5

Whilst discussing our new method for making a mould with Ellen and Tamar, some tips came forth on how to make a mould in a way that would give an even better and deeper impression without granular outer edges. This method was tried. The difference between the two methods is that we at first placed the lion's head face up into the first half of the flask and made the impression of the face in the second half of the mould by filling it up with sand. They suggested making the impression of the lion's head face down into the first half of the mould by pressing it in deep before filling up the flask completely.

Results

The new proposed method resulted in a very sharp imprint. Nonetheless, after pressing the lion's head in the second half of the mould there was still a granular outer edge. We corrected this by making the impression of the face in the first half even deeper, this way we didn't have to press the backside in the second half of the flask. For this we used tools like a blunt piece of wood. We decided to keep both of the moulds to see the difference in the casting process and result (fig. 26).

Fig. 26. Result of making a mould, trial 5. Including the sprue and vent-holes.

Conclusion

The way of making a mould proposed by Tamar and Ellen is the best way to get a clean and sharp impression. Nevertheless pressing the backside of the lion's head into the second half of the mould still led to granular outer edges of the impression. To press the lion's head face down deep into the first half of the mould to get a lot of detail was not easy to accomplish.

Suggestions for further experimentations

In the next part of the experiment, the casting, it should be checked what the result of the granular edges are, if they can still be seen and for consequences that has for the finishing of the medals after casting.

The casting of a lion's head in tin

Used supplies

- Manuscript BnF Ms. Fr. 640.
- Landsman, R., J. Rowen. *Annotation concerning the production of one-sided hollow cast medals.* Annotation University of Columbia, New York 2014.
- Apron
- Delft clay (sand)
- Iron casting flasks
- Brass lion's head (instead of a medal)
- Talcum-powder
- Brush
- Two metal plates, one big to prepare the mould on and one small to scrape overflowing sand off.
- Lamp black
- A small wooden block (for dividing the pressure equally while pressing the lion's head into the mould)
- Some sharp tools like dentist hooks for making the sprue and vent-holes.
- Hot air gun
- Goggles
- Crucible
- Tin

Trial 1+2

In folio 92 the anonymous writer mentions that to separate the original medal from the newly cast, one should 'soak noir de lampe in water, and with a brush, apply a thin coat on the medal which is in the box mould, and leave to dry'. A few drops of water were added to a pinch of lampblack and mixed together. Then it was applied to the two lion's heads that were made in mould 4 and 5 and left them to dry.

When preparing the moulds for casting by tying them shut with iron wire, it turned out that the lion's head of mould 5 was not secure in it's place but could fall from one side of the flask to the other. To make sure it stayed in the right position we placed the flask slightly oblique so gravity would hold it to the right side. Because we had not cast with tin before the first casting was done in the presence of Tamar. Both mould 4 and 5 were cast so the difference in the two methods could be seen. The tin was obtained by cutting up a little old jug, it was melted with a heat gun. It melted really fast but a darker layer of metal floated on top of the molten tin; this had a darker colour than the rest of the tin. This layer was probably contamination due to impurities in the tin and was taken off with a spoon. A graphite bar was used to test if the tin on the bottom of the crucible had also melted. Before casting the crucible was already tilted a bit in the right direction and held close to the flask because tin solidifies fast if it cools down.

Firstly mould 4 was cast, all the tin went in but it was not certain if enough tin was molten to fill the entire mould. The process was repeated after putting new tin in the crucible. The second time a bit more tin was but while pouring the metal a little bit went next to the flask.

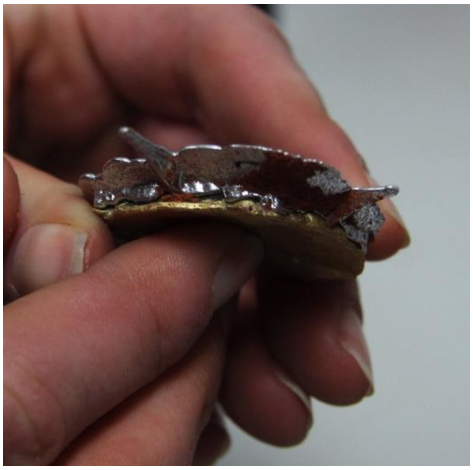

Fig. 27. Result of casting tin on brass, trial 1. Still stuck together.

Fig. 28. Result of casting tin on brass, trial 2. Still stuck together.

Fig. 29. Casting tin on brass, seen from the side.

Results

The results of the casting were fairly satisfying for a first trial, although in mould 5 the tin had only flown halfway (fig. 28). The result of mould 4 was a lion's head with a sharp relief on one side and a clean hollow relief on the backside. But it was very thick and it had flashes around the head (fig. 27). The second lion's head was even thicker and it also had flashes on the top of his head, which was the downside when it was cast. On the surface you can see a layer of thin tin that had solidified first.

Conclusion

The impressions of the head could be a lot thinner because these medals that are made now are actually quite thick and the recipe is to cast 'thin medals'. Although it is not mentioned what the measurements of a thick or a thin medal are, it is assumed that these are too thick to be considered 'thin medals'. The anonymous Frenchman writes in folio 102v that *'tin casts better when it's is tin and delicate, then when it is thick, because when it is thick it contracts in high heat*'. This is why he suggests that if you need to cast a thick piece you can better cast two hollow halves and solder them together. There is no mention on this folio of the type of objects to cast.

It is very important to pour the tin very quick and not give it any time to cool off. This is probably the reason that the second casting did not succeed.

Trial 3

This time the mould was made the same way as mould trial 5. This method was proposed by Tamar and Ellen and involves making the imprint of the lion's head by pushing it deep and face down into the first half, leaving it in, putting the second half on top, and filling it up with sand. Then when the two halves are taken apart, the lion's head should still be in the first half. This way the imprint of the lion's head will turn out clearer. The pressing in of the lion's head in the first half determines the thickness of the cast. Because in the first two trials the cast lion's head turned out to be fairly thick, this time the head was not pressed in too deep, to try and cast a thinner one.

But when reading the manuscript page again it came to notice that the writer describes *"one leaves it in one half of the box mould and press it inside so that it holds."* So the method of making a mould was slightly adapted. Instead of pressing the lion's head to deep into the first half it should just be levelled with the sand. Then, when the flask is filled with sand and the halves taken apart, the lion's head will be taken out of the first half and pressed in more firmly into the second half, so that it holds while casting. In this way the thickness of the cast is determined by the space between the original lion's head that is pressed face up into the male half and the impression made in the female half, instead of only the deep impression into the female half. The tin we used for this casting was the same as yesterday.

Results

The result of this cast was a lion's head that was a thinner than the ones cast yesterday. But still it seems that the medal could be a lot thinner. The details on the front- and backside are good, just like the casting before. But on the front side of the lion's head it looks like some layers can be detected. This could be due to pouring the tin not fast enough. Also there are still flashes around the medal. We think that they might be reduced as well if we make the lion's head thinner because when pressing in the original not only an impression is made but also all the sand is pressed down a bit thusly creating an open space between the two halves. That's why they don't joint perfectly and the metal might seep in.

Conclusion

Contrary to what was concluded yesterday it now seems better to impress the lion's head on the second side of the mould. This way it is less likely to move to the wrong side of the mould. Also pressing the medal in is easily overdone, because the medal still came out quite thick; thicker than was expected. So next time the head should only be pressed in lightly.

Trial 4 and 5

This time an attempt was made to make a lion's head as thin as possible by pressing it in just as much as was thought necessary to still let the metal flow. The original stayed in the right place when taking the halves apart and we pressed it in the second half with very little pressure. Two moulds were made in one time in the same fashion. The casting process was the same as was done before but another type of tin was used from a different source. Two castings were done.

Results

Trial 3 did not succeed; the tin, instead of flowing solely on the front side of the original, had flown a bit on both sides (fig. 30). This was probably because the original, like in the first casting, had come loose from his place and herewith creating room for the tin to flow on the front- and the backside. This was concluded because the original was surrounded with tin. This one was not covered in lampblack before closing the mould.

Trial 4 had succeeded quite well. Although it is not easy to measure we are guessing that it is around 1.5 or 2 mm thick. But two small holes can be seen under the lion's cheeks.

Fig. 30. Casting tin on brass, trial 3. Still stuck together, seen from the side.

Conclusion

It is still thought that the head could be cast thinner, even though some holes had appeared in the last trial. Success has been booked in casting a lion's head on top of the original without having the two melt together, although progress could still be made in making the lion's head thinner and without flaws. So it can be concluded that the method described in the manuscript works but that more experimentation is needed to fully perfect the method. The granular edges in the mould did not result in a disturbed appearance at the sides of the medal.

Suggestion for further experimentation:

To broaden the experiment it was decided that another original should be used, one that looks more like medal. This would additionally be easier to measure since it would have a flat surface on the sides. Since there were no medals to be used it was decided to solder one of the lion's heads on to a round piece of brass. The lion's head had to be prepared to be soldered; the backside had to be smoothed and the piece of brass had to be shaped and filed.

Making a new medal

Another mould was made with the lion's head soldered on a plate, but it came to notice that it could have been too wide for the flask as it had only 2 mm on each side. With the heat that would come of casting brass, there might not be enough space to let the heat escape. In hindsight it could have been better to place the lion's head on a thicker sheet of brass, because the thin sheet of brass might warp through the heat when casting brass on brass (fig. 30).

Fig. 31. Making a new medal, first attempt.

This was the reason for taking the lion's head of the brass plate and solder it on to a thicker one. Before heating the whole piece to take the lion's head off, a hole was made in the back to let the heated, expanded air escape and to prevent the lion's head from shooting off and potentially causing damage. The solder used has a melting temperature of 600°C. Firstly paillons were molten on the backside of the lion's head. Then it was placed on top of the plate, not yet cut to the right size, and they were both heated resulting in the melting of the solder and connecting the lion's head to the brass plate.

The stamping of extra details onto the medal

To add extra detail to the medal the plan was made to stamp ‘M&K’ and ‘2015’ into the sheet with the aid of punches. The letters were going to be in inward-relief and some decoration on the left and right side would be added in outward-relief, to see how these two methods would work and differ.

Since the letter punches were quite small the idea of ‘M&K’ was changed to ‘MAKING & KNOWING’. There were some doubts about if the outward-relief punched in from the backside would be well visible. In the end it was decided to punch the medal just from the front side (inward-relief) because otherwise there could be a risk of warping the medal when hot air would gather behind the medal (fig. 32-33). So the letters and numbers were punched in and some of the lost details in the lion’s head were brought back, for example the eyes and whiskers. The right contour of the medal was drawn on the sheet and cut with shears. It was finished with files and sandpaper.

Fig. 32. Punches used for applying letters and details onto the medal.

Fig. 33. Medal with punched letters, being refined.

Casting a new 'original' medal in brass

Used supplies

- Manuscript BnF Ms. Fr. 640.
- Landsman, R., J. Rowen. *Annotation concerning the production of one-sided hollow cast medals.* Annotation University of Columbia, New York 2014.
- Delft clay (sand)
- Apron
- Iron casting flasks
- Brass lion's head
- Talcum-powder
- Brush
- Two metal plates, one big to prepare the mould on and one small to scrape overflowing sand off.
- Lamp black
- A small wooden block (for dividing the pressure equally while pressing the lion's head into the mould)
- Some sharp tools like dentist hooks for making the sprue and vent-holes.
- Blowtorch
- Goggles
- Flux (borax)
- Crucible
- Hard solder
- Brass

Trial 1

Since the soldering of the lion's head on the brass plate was not perfect and some gaps were still visible between the brass plate and the lion's head, it was tried to cast an original brass medal to use for further experimenting. The reason behind this decision was that in this way during the experiments where the medal stays in the mould, no liquid metal could flow between the brass plate and the lion's head nor could the soldering used for connecting the

lion's head on the brass plate melt.[32] But before a new original medal could be cast, a mould had to be made.

The making of the mould was not easy because the letters and numbers that were punched into the background around the lion's head are relatively small and not very deep. During the first attempt the mould was made in the same way as was done before: by filling up one half of the flask, pressing in the medal with the lion's head face down and then filling the flask up with sand while the other half was on top (step-by-step procedure 2). But after trying this method two times, it seemed as if it did not work. So it was tried in a different way. First one half of the flasks was filled up with sand in which the medal was pressed face up. After the other half of the flask was put on top and filled up with sand. In this way the sand could be pressed firmly around the lion's head and onto the background of the medal to ensure a detailed outcome of the mould (step-by-step procedure 1). After making the mould by this method two times, one was made that was good enough for casting. A sprue and vent-holes were applied and the flask was bind shut with iron wire.

For the casting process leftover brass casting-heads were used, because this brass was used for castings before and could in this way ensure us to be a good brass to cast with. The amount of brass was weighed to be sure it was enough. A small oven was built out of bricks for capturing as much heat as possible during the melting process. The brass was put into a crucible and sprinkled with flux. Borax was used as a flux because it recently is the most appropriate one to use. The brass was molten using a blowtorch.

Results

The molten brass poured to the top of the flask and some was left behind in the crucible. Because the amount of brass that would be needed to cast was estimated by weighing it previously, this could be a sign that the casting was unsuccessful. After opening the mould it came to notice that only the bottom and the top were cast connected by a thread of brass. A small part of the bottom of the medal including a part of the lion's chin and the top of the medal in which only the letters *& kno* can be read were cast (fig. 34).

[32] Soldering used had a melting point of 600 degrees Celsius.

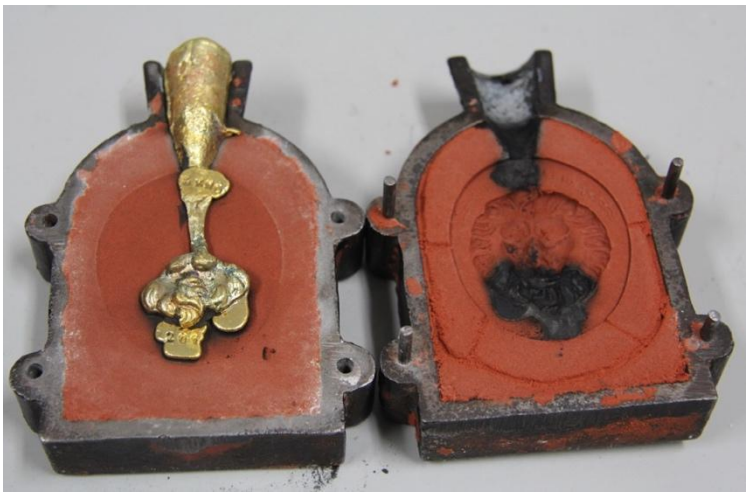

Fig. 34. Casting a new brass medal, trial 1. Still in the flask.

Conclusion

The result of this casting was not good. Only small parts of the medal were cast. Among other reasons it could be that the sprue was not big enough thereby the brass was slightly held back when pouring it into the mould. Brass is not a type of metal that is easy to cast with.[33] It could be that the molten brass was not hot enough for casting, causing it to solidify too quickly. Another reason for a quick solidification of the brass, could be due to the little space between the cast and the cooler iron edge of the flask, as it only had 2 mm to each side. In addition it could have been that the mould was not eligible, making the part between the mould halves wherein the medal should be cast to thin. So for the next time a bigger sprue should be used and it should be tried to cast a slightly thicker medal.

Trying another method for making a mould

Tamar gave some advice on how to make the sprue in the mould, to ensure a better outcome. She gave two options: more sprues and/or vent-holes or making one that is significantly bigger. We chose to make a significant bigger sprue, because the iron flask we use is too small to make more sprues in the mould. During this discussion the thought emerged to search the manuscript again for clues on the use of sprues and vent-holes. This resulted in a drawing found on folio 86v. that gives indications about the shaping of sprues.

[33] Brass has a higher melting point than a tin-lead alloy. Selwyn, 2004: 53, 142.

Also in the publication *Le Bronze d'Art et ses techniques* by Jean Pierre Rama it was found that bigger and more sprues were used for the casting of (bigger) medals.[34] Because of these clues that the use of bigger and more sprues would ensure a better outcome, it was decided to try this method. In the atelier there is only a bigger wooden flask present so this flask was used (fig. 35). In addition, the first two trials of casting the brass medal could have failed, as described above, due to the little space between the cast and the cooler iron edge of the flask which made the molten brass solidify too quickly. By using the bigger wooden flask, this disadvantage was removed.

Results

Making a detailed impression in the mould using the wooden flask turned out to be very hard. Both rear sides of the flask are sealed, thereby making the impression of the medal by the method described in step-by-step procedure 1 was impossible. No time could be spared on cutting out the rear of the flask halves, so the experiments were continued by using the iron flasks that were used previously.

Fig. 35. Wooden box mould in which it was tried to make a mould.

[34] Rama, J.P. *Le Bronze d'Art et ses techniques.* France 1988 : 100-106.

Conclusion

To not lose to much detail of the impression of the medal, it was decided to move further by using the smaller iron flasks that were used previously. Since in this smaller flask it is not possible to add more sprues, a significantly bigger sprue would be used next time to ensure a better outcome.

Trial 2

The small iron flask was used and the mould was made by filling the first half of the flask with sand in which the medal was pressed face up. Thereafter, the other half of the flask was put on top and the flask was filled up with sand. In this way the sand could be pressed firmly around the lion's head and onto the background of the medal to ensure a detailed outcome of the mould (step-by-step procedure 1). The medal was pressed in slightly harder than last time and a fairly big sprue was made. Vent-holes were applied and the flask was tied with iron wire. The brass was molten using a blowtorch.

Results

Despite of making a deeper impression and the use of a bigger sprue we still did not succeed in casting a complete medal, but the outcome was better than last time. The top of the medal, the lion's head and a small part of the bottom were cast but the sides of the medal were not.

Conclusion

It seemed as if the use of a bigger sprue worked in our advantage, since the outcome was better than the first try. Still the sides of the medal were not cast. The reason for why the sides of the medal cast the least well is still unclear. However a view reasons can be considered. The molten brass could have been not hot enough to cast, or the sprue or mould could have been insufficient.

Suggestions for next trial

Maybe the use of more sprues, with which both sides of the medal could be reached, would work better. In this way the brass will be helped to flow to the sides and the medal could be

cast in whole. Unfortunately this method could not be tried until a bigger iron flask came to the disposal. This is the reason why first two more attempts were made, using the smaller iron flask in combination with applying a bigger sprue in the mould.

Trial 3

The mould was made as mentioned above in the first two trials (step-by-step procedure 1). The first half of the flask was filled with sand in which the medal was pressed face up. Thereafter, the other half of the flask was put on top and the flask was filled up with sand. In this way the sand could be pressed firmly around the lion's head and onto the background of the medal to ensure a detailed outcome of the mould.

During the melting process the blow torch fell out, probably due to a shortage of oxygen in the small stone oven built around the crucible. One small part of brass did not seem to melt well. A bad result was expected.

Results

The casting failed. The medal came out better than in previous attempts, it only missed a tiny piece on both sides. The detail was good, mainly on the bottom side. Another attempt was made.

Conclusion

The use of a bigger sprue worked in our advantage again. Unfortunately the melting and casting process did not go as well as was hoped for: it was not enough to have a positive outcome. Just like during the trial before, the sides of the medal were not fully cast. Reasons for not fully casting the sides remained unclear. Again a view reasons can be considered. The molten brass could have been not hot enough to cast, or the sprue or mould could have been insufficient.

Suggestions for next trial

The details in the medal were good, especially on the bottom side. To this trial we made the impression in the mould with the top op the lion's head pointing to the sprue-hole, but since

the detail in the medal turned out better on the bottom of the cast we decided to next time turn the medal up side down, because the bottom of the medal has less detail to capture.

Trial 4

During the last attempt using a smaller iron flask the impression of the medal into the mould was made with the bottom pointing up towards the sprue. This was done, because the medal has more detail on the upper part, but during casting the bottom part of the mould captures the most detail. We found something similar is described on folio 83v:

It is wise to always mould the faces not close to the cast but the head in bottom because the strength of the material concentrates at the entry of the medal and where the force of the impurity is. Thus if you moulded the face close to the cast in this manner, you could find impurities there. It is better that impurities remain on the clothes, which you can repair more easily.

And also on Folio 72r: *"Cast from the foot of the medal up, so that the face, further away from the heat, comes out better and the violent effect of the heat is softened."*

Furthermore, the mould was made in a similar manner as before.

Because of the drawings that were found on folio 86v, three more vent-holes were added to the bottom of the mould, to pay more attention to the flowing of the metal to the sides. During the melting and casting process everything seemed to go fine, there were no complications during the heating or melting of the metal.

Results

The medal failed. This time the outcome was worse than the previous attempts. The detailing was bad and only the most upper part and the lion's head were cast. No part of the background of the medal was captured (fig. 36).

Fig. 36. Result of casting a new medal in bras, trial 1, 2, 3 and 4.

Conclusion

The poor result was suprising. Maybe the brass was not hot enough or the flask is just to small to cast this type of medal with, which makes the brass solidify to fast due to the coolness that comes from the iron sides of the flask. After discussing the results with Tamar and Ellen it was decided to leave the casting of a new original brass medal for now and to try it again next week when Ellen could bring a similar but bigger iron flask.

Fig. 37. Big casting flask with the mould of casting a new medal in brass, trial 5.

Fig. 38. Small casting flask with mould for casting tin on tin, trial 1.

Trial 5

This time for the casting of the new original medal in brass a bigger iron casting flask was used (fig. 37, for comparison fig. 38). This was done so that there would be more room to apply multiple sprues and because in this way there would be no chance for the brass to be cooled off and solidify faster for being to close to the cold iron flask edges. For making the sprues the descriptions and drawing that were found in the manuscript were considered to ensure a better result. Three triangular vent-holes were made at the bottom of the mould and three sprues; one connected to the top and one to each side of the mould (fig. 37, 39). For casting leftover brass casting heads were used, which were from a different casting process. This brass was used as it had been cast before, so it ensured being a good alloy to cast with. Despite these assumptions, during the melting process the brass melted in a very strange way. It was very granular and became red and black as if it burned. The melting process was stopped. Supposedly it was a different alloy-element that made this happen. Some pieces of plate brass were used instead to continue the experiment.

Results

This melting and casting process went successful but the result was not. Even though a bigger flask was used and more sprues and more vent-holes were added, again some small parts to the sides of the medal were not cast. Although, the detail in the lion's head as well as the medal were very good (fig. 40).

Fig. 39. Mould for casting a new medal in brass, trial 5. Forked sprue and pockets at the bottom.

Fig. 40. Result of casting a new medal in brass, trial 5.

Conclusion

Our intention for the final attempt was to bring the sprues on either side of the mould a bit more down so the brass could flow to those places on the sides where the cast usually failed. Unfortunately this trial failed again. It remains a mystery why these sides of the medal keep being a problem to cast. This time a bigger casting flask was used, so the molten brass could not have been cooled off by the iron edges of the flask. However, the molten brass itself could still have been not hot enough, or the mould and sprues could have been insufficient.

Trial 6

This was our final attempt for casting a new original brass medal. The mould that was made was the best yet. The sprues and vent-holes again were made as described in the drawing of the manuscript, but this time with the sprues that follow to the sides a bit more down so the brass could flow to those parts where the cast usually fails (fig. 41). The casting process went successful. Also another description from the manuscript was tried in which it is said to *"throw a small piece of brass into the molten brass to check if the brass would be hot enough for casting".*[35]

Results

The final attempt unfortunately failed. The brass that flowed into the side sprues had not even reached the mould before it was solidified. The part of the medal that pointed to the bottom side of the flask was missing. The details however came out fairly good (fig. 42).

[35] Fol. 72r.

Fig. 41. Mould for casting a new medal in brass, trial 6. Forked sprue, pockets at the bottom were added later.

Fig. 42. Result of casting a new medal in brass, trial 6.

Conclusion

The attempts made for casting a new original brass medal with the use of a bigger casting flask were to no avail. Also the use of a larger or more sprues did not have a completely successful result. Detailing in the medal came out fairly well, although the sides of the medal kept being a problem. Brass is not easy to cast with. This is a fact that was also noticed by the author of the manuscript. On folio 72r he therefore advices to add some pure copper to the brass. This is an observation that was not tried during this experiment. Figuring out if the brass is hot enough for casting is not easy to do either. It could have been that during some trials the molten brass was still not hot enough. In other trials the preparing of the mould or sprues could have been insufficient. Despite these setbacks, it is expected that casting a new original medal can be done by the method described above. For further experimenting it could be tried to cast an original medal with another copper alloy as for example bronze. Bronze is a copper alloy that should be more forgiving when it comes to casting (for an overall summery of the trials including pictures view the table on page 61).

Casting a new 'original' medal in tin

Used supplies

- Manuscript BnF Ms. Fr. 640.
- Landsman, R., J. Rowen. *Annotation concerning the production of one-sided hollow cast medals.* Annotation University of Columbia, New York 2014.
- Apron
- Delft clay (sand)
- Iron casting flasks
- New brass 'original' medal
- Talcum-powder
- Brush
- Two metal plates, one big to prepare the mould on and one small to scrape overflowing sand off.
- Lamp black
- A small wooden block (for dividing the pressure equally while pressing the lion's head into the mould)
- Some sharp tools like dentist hooks for making the sprue and vent-holes.
- Hot air gun
- Goggles
- Crucible
- Tin

Trial 1

After all the setbacks with casting a new original medal in brass, another attempt was made to cast a medal in tin. This worked out perfectly. The casting process went very well. The tin melted fairly quick and it was enough to fill up the mould.

Results

The outcome was very successful. The medal was very detailed, it had even captured more detail than was expected (fig. 43).

Fig. 43. Result of casting a new medal in tin, trial 1.

Conclusion

To cast a medal with tin is very different from casting with brass. In addition to the process, there is also a clear difference in how the metal reacts to heat and how it behaves in a liquid state. It was made clear here, that casting with tin is easier and more likely to have a better result.

Trial 2, 3, 4 and 5

A new tin medal was cast. This was done because for the experiment where a tin medal against an original tin medal would be cast an original tin medal was needed. This had to be done a few times because a detailed and good impression in the mould was hard to obtain. When the making of the mould was successful it was tried to cast the new original tin medal. For this experiment a different type of tin alloy was used than before.

Results

Trial two was almost successful but a few small pieces on the sides of the medal were not entirely cast, the same way as was experienced during the casting of a brass medal. During the third trial the outcome was the same; again some small pieces to the sides of the medal were not cast. So another trial was done but this time with a different type of tin alloy. Unfortunately again the casting failed and only some part of the lion's head came out. Another attempt followed but the tin that was supposed to be used did not melt well at all. The alloy that was used was most likely a tin and lead alloy, but with a higher concentration of lead and more impurities. The tin seemed to solidify rapidly and was very viscous during the cast. It was decided that this tin was not suitable. A tin-silver alloy was used instead because this alloy was expected to be more forgiving than the other ones we tried so we could proceed and not loose to much time on making a new original medal. The result bear out our expectations, the medal turned out good (fig. 44).

Fig. 44. Results of casting a new tin medal, trial 2, 3 and 4; counting from left to right.

Conclusion

What was realized this day is that the alloy has a major effect on the outcome of the casting. The scrap tin that was used of which the specifics were not known was a lot harder to cast then the tin-silver alloy. The difficulty in casting of this new medal was a surprise since the very first try turned out perfect. But The last trial, in which the tin-silver alloy was used, went

good as well so it was assumed the other failed, at least partially, because of the alloy that probably had impurities.[36]

[36] It was thought that there were impurities present in the alloy used, because they could have been responsible for failing the castings. The tin alloy used was coming from an old cast plate that had been kept in the atelier. During the melting process the alloy was quite syrupy and dark. Also it solidified very rapidly. Overall it did not give as good as an appearance as did other used alloys.

Casting tin on tin

Used supplies

- Manuscript BnF Ms. Fr. 640.
- Landsman, R., J. Rowen. *Annotation concerning the production of one-sided hollow cast medals.* Annotation University of Columbia, New York 2014.
- Apron
- Delft clay (sand)
- Iron casting flasks
- New 'original' tin medal
- Talcum-powder
- Brush
- Two metal plates, one big to prepare the mould on and one small to scrape overflowing sand off.
- Lamp black
- A small wooden block (for deviding the pressure equally while pressing the lion's head into the mould)
- Some sharp tools like dentist hooks for making the sprue and vent-holes.
- Hot air gun
- Goggles
- Crucible
- Tin
-

Trial 1

The cast tin medal that was made earlier needed to be finished before it could be tried to cast a double-sided hollow medal on top of it. The cast sprue was sawn off and the flashes were removed with files. The surface of the medal was sanded to enhance the smoothness and remove the grainy structure. On the left side the lion's face had a little hole in the medal. To avoid having the incuse reverse moulded medal stick to it, it was filled up with

sand and some chalk was put on top of it. Then the mould was made and with a brush lampblack was applied all over the medal (fig. 46).

Results

The casting went well and on top of the medal there was a well cast medal. But problems arose when the medals needed to be separated. This did not go easy although the two metals did not look like they were molten together. To get a better view a microscope was used, it still looked like the two had not melted together. With the aid of a plier and tapping frequently on the table one part of the medal was loosened. But close to the sprue the two medals had in fact melted together and were not separable (fig. 47-48). The sprue is the place where the most heat is accumulated so it makes sense that if it would melt together it would be at this place. It was not possible to get it off without breaking the new medal, which in the end was done. Apart from this the newly cast medal is very detailed and also the punched in letters and numbers came out good (fig. 49).

Conclusion

A few things can be changed to try avoiding the melting together of the two medals. Firstly the medal should be pressed more deeply in the first half of the mould so that no part but the relief sticks out. This way you will not get any tin around the original, like it was the case this time, and should be more easily separable. Also in this casting the sprue continued on the backside of the medal. If this is avoided during the next casting, hopefully less heat accumulates and the medals will not melt together. It is also an option to try and make the tin alloy less hot while casting.

Fig. 46. Mould for casting tin on tin, trial 1.

Fig. 47. Result of casting tin on tin, trial 1. Reverse. The circle indicates where the two medals got stuck.

Fig. 48. Result of casting tin on tin trial 1. Original still attached at the side of the sprue, but loosened on the other side.

Fig. 49. Result of casting tin on tin, trial 1. Cast loosened from the original with the loss of a piece at the side of the sprue.

Trial 2

A mould was made where the sprue was thinner and did not extend on the backside of the medal. In this way it was hoped that the melting of the two medals could be avoided.

Results

The result of the casting was not very pleasing, only the beginning of the medal was cast (fig. 51). However, the medals did not melt together.

Fig. 50. Mould for casting tin on tin, trial 2.

Fig. 51. Result of casting tin on tin, trial 2.

Conclusion

Although it is true the medals did not melt together, the sprue was not big enough to let a sufficient amount of tin through before solidifying. The medal was quite thin as well, so this could also have been a reason for the failure of the casting.

A way should be found to make a mould where the sprue is big enough to let the metal through but not hot enough to melt the two medals together. Hopefully this can be done by making the sprue wider instead of letting it run too far onto the medal. Next trial the mould could be a bit deeper as well, to give the tin a bit more room to flow.

Trial 3

Because of the last outcome, a mould was made with a bigger sprue that was also wider. Because it is bigger in size it could be possible that the sprue negatively effects the detail of the upper part of the medal.

Results

The result was not bad, all the details were there but the bottom part did not cast completely. The medal was easily loosened from the original and the letters and numbers had a lot of detail. Even the '2015' part, that was closest to the sprue, had been cast very well. The relief on the backside was very sharp, sharper than on the front side, but there were some very small holes in the tin. Also on the front side a profile can be seen, but this looks different than the one from the back; more an uneven surface and tiny holes.

Fig. 52. Result of casting tin on tin, trial 3.

Conclusion

It is assumed a certain thickness of the mould is needed to get a full and clear result. So this should be noted next time. The fail of this cast could also be because of the type of tin alloy used. The difference in detail for front and back is probably because of the sharpness of the mould that gives detailing to the front and the clear image of the original which is responsible for the back of the medal. Because of the sand imprint, the front of the medal will be less sharp in contrast to the sharp image obtained on the back side by the metal example. However the positive note on this experiment was the fact that no part of the cast medal got stuck to the original.

Trial 4

This tin on tin casting attempt was very disappointing. During the casting process, there was a small bang and some of the tin got out of the flask again (fig. 53). This was probably caused by the lamp black on the original tin medal not being dry. The moist in the lamp black was during the casting process instantly becoming steam that in turn wanted to escape the mould causing pressure and the small explosion.

Results

The result of this attempt, although interesting, was not a good cast of an incuse-reverse mould medal (fig. 53, 54 and 55).

Fig. 53. Result of casting tin on tin, trial 4. Seen from the backside, still in the mould.

Fig. 54. Result of casting tin on tin, trial 4. Obverse.

Fig. 55. Result of casting tin on tin, trial 4. Reverse.

Conclusion

To conclude on these experiments using tin alloys the type of alloy for casting an original tin medal in quite important for a successful outcome. A tin alloy with not a lot of impurities is probably the best to use. As to the tin on tin castings, the alloy is also of importance. Pure tin or a tin alloy which is good for casting can be used. Also the mould should be very sharp, as the image that will be created on the rear side of the medal will be very detailed because of the use of an original medal. One should bear in mind that the tin alloy should not be made to hot during the casting process, otherwise the sprue could be the reason for melting the original to the new cast medal. Also there should be some consideration by the application of the sprue. It should be slightly bigger or wider in size and it should not continue far into the mould. This can lead to the melting of the new cast medal to the original on this point. And lastly always wear safety goggles and make sure there is absolutely no moisture in the mould.

Extra day for experimentation

Because the right results had not yet been reached an extra day for experimentation was planned. During this day attempts would be made to make a successful tin on tin cast medal and to make a bronze on bronze cast medal for which the bronze original had to be made as well. It was decided to use bronze because it is easier to cast with.

First the moulds had to be made. Different types of sprues were thought of, off which three types were selected. These types were selected because some were mentioned by the author of the manuscript in a drawing on folio. 86v, 91v and others have been used during previous experiments with a more or less successful outcome.

Tin on tin

Trial 1

The first attempt at casting a tin on tin medal was made with the the type of mould that had multiple sprues, as this was the mould represented by Tonny Beentjes, who has a lot of experience with casting. Before casting, in contrast to earlier experiments, the mould was heated, to slow down the solidification process of the tin. In this way the molten metal could flow through the entire mould. Also a different type of crucible was used. It was an iron crucible (fig. 56). In this crucible it took longer to heat up the tin, but once it was molten it held onto the heat longer so there was more time to do the casting. This also introduced a new problem, because it was not very clear when the tin had the right temperature to cast. There was a discussion about placing the mould in a tilted angle but in the end it was decided not to do that, because it was not thought necessary.

Fig. 56. The iron crucible used.

Results

Unfortunately, the cast had failed. Only a small part of the medal had been cast (fig. 57).

Fig. 57. Only a small part of the medal was cast.

Conclusion

It could have been better to put the mould at a tilted angle. At this point, because of the failure of the cast, it was not sure if this selected mould was good for this purpose or if the tin was hot enough for casting. Although the reason for the failure of the cast was probably due to the movement of the model inside the mould and not putting the mould at a tilted angle.

Trial 2

Another mould was made using the example with the multiple sprues. This mould was also preheated before casting. To ensure a better outcome this mould was put in a tilted angle during the casting process (fig. 58).

Fig. 58. The mould in a tilted angle.

Results

The result was very good. Although the new cast medal was firmly stuck to the original, this was not due to the two melting together, but was becau
se the new cast medal clammed the original. After the two had been separated an incuse reversed moulded medal had been made, that had no damages and had remained a clear relief on both sides (fig. 59, 60, 61).

Fig. 59. Tin on tin cast. Both clammed together.

Fig. 60. The obverse of the cast medal. Fairly good detail obtained.

Fig. 61. The hollow reverse of the cast.

Conclusion

It seemed as if this type of mould as proposed by Tonny Beentjes, who has a lot of experience with casting, was a good type to use. Also the use of multiple sprues seems to be a good way to go. Putting the mould in a tilted angle made the casting more successful than the previous one.

Casting a new bronze medal

In order to try and cast this type of medal while using a higher melting point metal like bronze, a new original had to be cast. Two moulds were made. One mould had one sprue that led to the middle of the impression, the other mould had a sprue as was drawn in the manuscript (folio. 86v, 91v). The two moulds were not used simultaneously but the method was the same. The moulds were first heated and then closed.

Because bronze has a higher melting point a propane torch was used. The mould was placed at a tilted angle, because during the last experiment this proved to be successful. First the iron crucible was heated with some flux already in it, then the bronze was added (obtained by cutting up an old sculpture after the composition was checked with XRD) (fig. 62, 63).

Fig. 62 The mould for one one of the bronze cast medal where one big sprue was used.

Fig. 63. Mould made for one of the bronze medal castings, using a sprue as was drawn by the author of the manuscript on folio 86v, 91v.

Results

Both castings went well and two bronze medals had been made. But the surface of both medals was not very smooth (fig. 64). The one that was cast using a larger sprue missed a very small part to the left side.

Fig. 64. Results of the bronze castings.

Conclusion

There are multiple ways of making a mould that can provide a successful result. Both medals had been cast quite successful, however both encountered the same problem with an uneven surface. The reason for obtaining the uneven surface could have been because of the alloy getting too hot before casting. This more often provides the obtaining of an uneven surface. Due to the alloy getting too hot, the mould material (in this case sand) could have burnt and sabotaged the casting. Tilting the mould again proved successful, as the medals were fully cast. Due to this result one could say the chosen moulds were fine to use as well.

Bronze on bronze

One of the medals was finished by removing the sprues and flashes. Another mould was made with a sprue as described in the manuscript, but this time the medal was left inside in order to cast a medal with a hollow reverse. Again by using the propane torch and iron crucible the bronze was heated and cast into the flask.

Results

The result was a hollow reverse medal that was almost fully cast on top of the original (fig. 65, 66).

Fig. 65. Obverse of the bronze on bronze cast medal.

Fig. 66. Reverse of the bronze on bronze cast medal with original medal still attached.

Conclusion

Unfortunately the separation of the medals has not been achieved. Although the medals don't look like they have molten together they are so firmly stuck that they cannot be easily separated. The casting was almost successful. The reason for obtaining an almost successful result is probably due to the good preparation of the mould and sprues, tilting of the mould, preheating of the mould, making the bronze hot enough to cast and the overall experience gained during these experiments. The difficulty is that the bronze should not be too hot or otherwise the two metals will melt together, but when it is too cold the metal will not flow through the whole mould, which will result in an incomplete medal.

Step by Step procedure 1

- Put the first half of the flask with the inside down on a flat surface.

  This way, when filling it up from what technically is the bottom, you'll get a smoother finish.

- Fill it with sand. Make sure the sand is equally distributed and that the flask is filled well. But do not fill it too tightly so that it is still possible to push in the medal later.

  The sand we are using is Delft clay, because this is easy to use and we have good expectations from it.

- Level the sand to sides of the flask by scraping of the excess sand.

- Put the original on top of the sand, face up, press it in until it is levelled with the sand.

- Put a thin layer of chalk on top of the sand and the medal to make sure the sand from the second half does not stick to it.

  There is no mention of the use of chalk in the manuscript but experience taught us that this makes getting the halves apart much easier.

- Put the second half of the flask on top of the first half.

- Fill it up with sand. Press the sand in hard, especially around the medal to ensure a good impression.

- Level the sand.

- Take the two halves of the flasks apart.

- Press the medal in the first half, the further you press it in the thicker the cast medal will become. If the medal sticks to the other side carefully take it out without damaging the impression and place on the other side.

  In folio 92 not a lot of attention is paid on how the mould should be made. They only say "And one leaves it [the medal] in one half of the box and press it inside so that it holds". So the rest of the technique is open to interpretation. We chose to make the mould in a different fashion than is mentioned in the annotation, because after tests the method described in this procedure seemed to work better for us.

- Brush lampblack mixed with water on the medal.

  In the manuscript they say it is also possible without, but that in this way you are sure your medal gets out unharmed. We will execute the experiments with and without the use of lampblack.

- Make a sprue through which the metal can be poured.

- Make vent-holes through which the air can escape.

  Make sure the vent-holes are not applied on the half of the mould were the impression is made on. In this way it is not possible to damage the imprint.

- Close the flask.

- Bind it shut with iron wire.

- Put the metal in a crucible.

  First off we want to use tin as the metal to cast with because it has a low melting point and is relatively easy to cast. Later we want to try the same experiment with different materials like brass and bronze.

- Add flux when needed.

For example when casting tin no flux is needed. For casting with brass it is.

- Heat the crucible until the metal melts.
- Pour the molten metal in the flask.
- Let it cool off.
- Open the flask and take the medals out.

Step-by-step procedure 2

- Put the first half of the flask with the inside down on a flat surface.

  This way, when filling it up from what technically is the bottom, you'll get a smoother finish.

- Fill it with sand. Make sure the sand is equally distributed and that the flask is filled well. But do not fill it too tightly so that it is still possible to push in the medal later.

  The sand we are using is Delft clay because this is an easy to use sand of which we expect good results.

- Level the sand to sides of the flask by scraping of the excess sand.

- Put the original on top of the sand, face down, press it in until it is levelled with the sand.

  This is what makes this method different from the first step-by-step procedure.

- Put a thin layer of chalk on top of the sand and the medal to make sure the sand from the second half does not stick to it.

  There is no mention of the use of chalk in the manuscript but experience taught us that this makes getting the halves apart again much easier.

- Put the second half of the flask on top of the first half.

- Fill it up with sand. Press the sand in hard, but keep in mind that you still need to press in the backside of the medal a little bit.

- Level the sand.

- Take the two parts of the flasks apart.

- If the medal sticks to the other side carefully take it out without damaging the impression and place it on the other side.

- Press the medal in the first half, do not press it too far.

  We have learned from the tests that pressing it in slightly is enought to get a decent casting.

- Brush lampblack mixed with water on the medal.

  In the manuscript they say it is also possible without, but that in this way you are sure your medal gets out unharmed. We will execute the experiments with and without the use of lampblack.

- Make a sprue through which the metal can be poured.

- Make vent-holes through which the air can escape.

  Make sure the vent-holes are not applied on the half of the mould were the impression is made on. In this way it is not possible to damage the imprint.

- Close the flask.

- Bind it shut with iron wire.

- Put the metal in a crucible.

  First off we want to use tin as the metal to cast with because it has a low melting point and is relatively easy to cast. Later we want to try the same experiment with different materials like brass and bronze.

- Add flux when needed.

  For example when casting tin no flux is needed. For casting with brass it is.

- Heat the crucible until the metal melts.

- Pour the molten metal in the flask.

- Let it cool off.

Tables with results

Casting tin on brass

Trial	Metal	Mould	Result	Conclusion	Picture
1	Cut up jug of lead-tin alloy.	Impres-sion made in second half by filling it up from above.	Good cast, details on obverse and reverse. But too thick	Can be pressed in much lighter	
2	Cut up jug of lead-tin alloy.	Impres-sion made in first half by pressing head in.	Only half cast, same amount of details. Even thicker	Pouring should be done very quickly. Can be pressed in lighter	
3	Cut up jug of lead-tin alloy.	Impres-sion made in first half, but depth created in second half	Metals has flown on front and backside of the lion's head	Original was not stable in the mould, should be pressed in harder	
4	Cut up jug of lead-tin alloy.	Impres-sion made in first half but depth created in second half.	Thinner cast, details on obverse and reverse.	A thinner impression in the mould can be made.	
5	Pure tin.	Impres-sion made in first half but depth created in second half.	Good, thin cast. Details on obverse and reverse. Tiny holes under the cheeks.	Another attempt should be made to make a cast as thin without holes.	

Casting a new 'original' medal in brass

Trial	Metal	Flask	Sprue(s)	Result	Conclusion	Pictures
1	Old brass casting-heads	Small, iron flask	One, relatively small	Only a small part of medal was cast	The sprue was very small, disadvantage of small flask	
2	Old brass casting-heads	Small, iron flask	One, slightly bigger	The entire head was cast well, the sides of the medal were missing.	Sprue can still be bigger or there can be more. Disadvantage of small flask.	
3	Old brass casting-heads	Small, iron flask	One sprue, very wide and deep	Head was cast well, two dents on the sides of the medal	More sprues can be tried in a bigger flask	
4	Old casting-heads	Small Iron flask	One wide sprue, on the bottom side triangular pockets.	Head was cast well, sides and bottom of medal are missing	Triangular pockets did not attract the metal. Try with a forked sprue	
5	Scrap brass sheet	Big iron flask	Three sprues. Triangular pockets at bottom of mould.	Head, bottom and top of medal cast well, sides are in-complete.	Sprue could be attached to the points where flaws often occur.	
6	Scrap brass sheet	Big iron flask	Three sprues, arms attached to the parts that fail	Only head and top of medal cast well, sides and bottom are missing.	Maybe not enough heat of difficult to cast alloy. Sprues too big, too much time/ room to solidify	

Casting a new 'original' medal in tin

Trial	Metal	Result	Conclusion	Picture
1	Pure tin.	Good cast. Only flaw is a tiny hole between the head and the medal, can be filled with sand	The making of a tin medal is a lot easier than one in brass.	
2	Silver-tin alloy.	Good cast except for one dent on the side of the medal.	The sides of the medal are problematic areas. But first trial was good, so should be possible again	
3	Silver-tin alloy.	Good cast except two dents on the sides of the medal. Same area as last casting.	Casting more problematic then expected enlarge the sprue for a better result.	
4	Lead-tin alloy from cut up plate.	Metal has only flown halfway.	Bad casting partially due to the alloy that would not melt very well either.	
5	Silver-tin alloy. Combi-nation of first trial and sprues from other castings	Good cast	Bigger sprue and well flowing alloy makes a good cast	

Casting tin on tin

Trial	Metal	Mould	Result	Conclusion	Pictures
1	Pure tin.	Small sprue, medium impress-sion.	Good cast, but medals molten together at sprue	Less heat should be accumulated at the sprue, maybe by making it smaller	
2	Pure tin.	Small sprue, low impress-sion.	Only a small part of the medal was cast	Sprue too small, and impression not deep enough	
3	Silver-tin alloy.	Bigger sprue, deeper impress-sion.	Cast almost good	Another attempt should be made, maybe add more heat.	
4	Silver-tin alloy.	Same sprue, same impress-sion.	Tin burst out of the mould, tin diffused in the mould	Probably caused by an accumulation of air that could not escape.	

Logbook

Wednesday February 4th, 2015

Time: 09.00 – 12.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The students of the master *Conservation and Restoration of Cultural Heritage* with a specialization in metal were informed about *The Making and Knowing Project* and the BnF Ms. Fr. 640 manuscript by Tamar Davidowitz and Ellen van Bork. The project is discussed with emphasis on how the students can contribute. They were given an assignment which proved useful as an exercise prior to the study that will be conducted.

Tuesday February 10th, 2015

Time: 09.00 – 17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The results of the assignment were discussed per student. This was followed by a visit to the Rijksmuseum to view some objects that contain life-cast objects. Back at the workshop building the students were divided into two groups. The students working on this log are: Michaela Groeneveld and Marianne Nuij. The research topics were divided. This research concerns the *One-sided hollow relief / incuse reverse mould casting of medals*. The students were provided with literature significant for their topics, so that they could read ahead and start with drawing up a plan of action, after which Tonny Beentjes gave an introduction to *The making and knowing project*.

Thursday february 12th, 2015

Time: 09.00 – 12.00 uur

Location: Rum Baba Bakery, Amsterdam.

The annotation of the students of the Columbia University in New York was discussed and immediate questions emerged. There will be tried to find an answer to these questions during the re-performing of particular experiments from the manuscript, which the students of the Columbia University also performed. Two experiments were prepared, whereby a list of supplies was made. This preparation was emailed to the teachers involved. It was also agreed to prepare a plan of action for the upcoming weeks and look for contemporary sources as regards to certain parts of the experiment before the next Tuesday.

Tuesday February 17th, 2015

Time: 09.00 – 17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

Together we went through the manuscript and selected the folios that would be relevant to discuss and use for our experiments. We created separate folders for each of the relevant subjects including: making sand, the use of different kinds of metals for casting and medal casting. Next we went through the folder of folios about making sand and selected the ones we thought would be important to discuss. This was followed by a discussion with Ellen, Tamar and Tonny about the best way we could start the procedure. Here forth the idea came to start the experiment with the method of casting described as *One-sided hollow relief / incuse reverse mould casting of medals* and see if this technique would actually work. If so, we could use metals with a higher melting point, which was not possible to do for the students in New York. This way we may collect new information about the process. After we will also try to carry out the lasagne paste method described in the annotation. Then later, when there is time left, we can try to test the use of different types of sand, as described in the manuscript, for the casting method.

Thursday February 19th,2015

Time: 09.00 – 12.00

Location: Home, Amsterdam.

Marianne adapted the procedure established on February 17th. Michaela updated the log. All relevant documents as regards to the research were put in the Google Drive. The procedure and how to start on February 24th was discussed.

Tuesday February 24th, 2015

Time: 09.00 – 17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The day was reviewed and a plan of action was made. For starters, several attempts were made to create the right mould and impression. Instead of a medal, a small brass lion's head was used.

Firstly, the method for making a mould as described in the first step by step procedure was tried. The impression turned out okay but seemed not deep enough. Tamar and Ellen suggested another method. So this method was also tried using another casting flask and lion's head. During the preparation of the moulds in both methods, there was a variation in the firmness of pressing the sand. This was done in order to see in which extent the sand has to be pressed for the best impression of the lion's head.

In the end two moulds were actually prepared for casting. One by the method described in the step-by-step procedure, the other by the method proposed by Tamar and Ellen. During preparation the lions' heads were coated with a thin layer of lamp black as described in the manuscript. The flasks were closed and after it we came to notice that the lion's head in the mould prepared second had come loose out of the imprint. Since it was the end of the day it was decided to try and cast anyway. Tin was collected and melted with a hot air gun. The casting of the first flask went unexpectedly well. This mould was prepared as described in step by step procedure 1. The cast lion's head came out very detailed and fairly thick. The second casting went okay, some of the molten tin was spilled next to the flask. Only a half of the lion's head was cast and came out.

Wednesday February 25th, 2015

Time: 09.00 – 17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The casting of tin on brass lions' heads continued. The method proposed by Tamar and Ellen was applied first. But because of the lion's head coming loose out of the imprint during the first try, we decided to change some steps of the procedure. The manuscript was read again, and it was established that the author describes: "one leaves it in one half of the box mould and press it inside so that it holds."[37] This is why the way in which the thickness of the cast is determined was changed. Before, the thickness of the cast was determined by pressing in the lion's head deep and face down into the female half. But the disadvantage here was that the lion's head, that later was put on the male half but not pressed in that much, came loose and sabotaged the casting. This procedure was changed into not pressing the lion's head too deep into the first half, but levelling it with the sand. Then, when the flask was filled up with sand and the halves were taken apart, the lion's head was taken out of the first half and pressed in more firmly into the second half so that it held while casting. In this way the thickness of the cast was determined by the space between the original lion's head that was pressed deep face up into the second half and the impression made in the first half, instead of only by the deep impression into the female half.

The casting went pretty well, only the tin cast lion's head again turned out fairly thick. After this one casting it was tried two more times to make a thinner lion's head. This time on only one of the lions' heads lamp black was applied, to see what would happen if no lamp black was used. Only one lion's head was cast well and the other one unfortunately failed. The one without the lamp black failed, so it is still uncertain what would happen if no lamp black is used. The other lion's head came out fine. It was very thin and detailed.

Finally we decided to try something different and solder one of the original brass lions' heads on a small brass plate. In this way a more real type medal could be used and the edges of the imprint and lion's head would be clearer.

Thursday February 26th, 2015

Time: 09.00 – 12.00

Location: Home, Amsterdam.

[37] Fol. 92r.

The writing of the report was continued. A step-by-step procedure in which the advice of the teachers was taken account of was made. More argumentation was added to the procedures. Photos taken during the experiments were sorted.

Monday March 2nd, 2015

Time: 09.00 – 12.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The plan of action was discussed with Tamar. The brass plate the lion's head was soldered onto turned out to be not thick enough. Because of its thinness, the backside of the plate warped after the soldering process, so other options were discussed. The lion's head was taken of the plate and another thicker plate was prepped for soldering onto another plate. We decided to punch some letters and numbers into the brass plate around the lion's head to get more detail. A test plate was put in pitch and the punching of numbers and letters was experimented with. Here came forth, that for the medal we should not use pitch to secure the plate, but better a flat and hard surface. In this way, the medal would not warp while punching like the test plate did in the pitch.

Tuesday March 3th, 2015

Time: 09.00 – 12.00, 16.00-17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

First a plan was made to prevent losing time through unnecessary errors. It was thought to try and put relief on both sides of the medal with the punches. Later this proved to be a bad idea, as the medal could loose its flat shape. Finally we chose to put *Making & Knowing, 2015* only in deepened relief around the lion's head with some other small figures to add to the detailing. Some parts of the lion's head were also given extra detail with the punches. Next the oval shape of the medal was found, cut and finished. The medal was now ready for casting.

Since the soldering of the lion's head on the brass plate was not perfect and some gaps were left between the plate and lion's head, we decided to cast another original medal from brass to use for further experimenting, so that during the experiments where the medal stays in the mould, no liquid metal could flow between the lion's head and the brass plate. In this way the medal could also be made slightly thicker.

First a mould was made. Making a mould where the small letters and numbers of the medal came out clear was hard to accomplish. For the casting of another medal with brass, the original one was taken out of the mould. The casting was tried two times, both times unfortunately failed.

Tuesday March 10th, 2015

Time: 09.00 – 17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The structure for the final file for all the experiments was discussed. Next the casting of a new original brass medal was tried again. Tamar gave some advice on how to make the sprue in the mould, so that the result would be better than the first two trials.

During this discussion the idea emerged to search the manuscript again for clues on the use of sprues and vent-holes. On folio 86v a drawing was found that gives indications about the shaping of sprues. Also in the publication *Le Bronze d'Art et ses techniques* of Jean Pierre Rama it was found that significant bigger sprues were used for the casting of (bigger) medals.[38] Because of the drawing in the manuscript we decided to also make a mould in a bigger wooden flask, so that we could add more sprues like in the picture. Unfortunately making a detailed impression in the mould of the wooden flask turned out to be very difficult because both sides of the flask were closed, thereby making the impression of the medal in the way we thought was best for capturing detail was impossible. We did not want to loose any time by cutting out the rear of one of the flask halves, so we decided to

[38] Rama, J.P. *Le Bronze d'Art et ses techniques.* Frankrijk 1988 : 100-106.

continue with the smaller flask we used before. The sprue was made significantly bigger than before.

During the casting process the burner fell out, probably due to a shortage of oxygen in the small brick oven built around the crucible. One small part of brass did not seem to melt well. The medal came out better than in previous attempts, but still missed some metal on the sides. The detail on the other hand was good, mainly on the bottom side. So we decided to give it one last try. During the last attempt the impression of the medal was made with the bottom up, because the medal has more detail on the upper part, but during the casting the bottom part gets the most detail. And because of the previously mentioned drawing on folio 86v, we added three more vent-holes on the bottom of the mould, to pay more attention to the flowing of the metal to the sides. the medal unfortunately failed again. This time the outcome was even worse than previous attempts. After discussing the results with Tamar and Ellen it was decided to leave the casting of a new original brass medal for now and to try it again next week with a similar but bigger iron flask.

After these setbacks we tried to cast the medal in tin. The result was very detailed so next time we could try to cast a tin on tin medal, described in the annotation as an interesting experiment by which two of the same metals are used.[39]

Wednesday March 11th, 2015

Time: 09.00 – 12.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The tin medal was finished for casting a tin on tin medal. One small hole at the bottom of the lion's head was noticed and filled up with some sand. For this casting experiment we used the same tin alloy as for the original. We made the mould just like we did in the previous experiment where we had cast a tin on a brass lion's head. We used some extra lamp black on the original medal in the mould to prevent the new cast one from sticking to it.

The casting process went very well. The result was another thin tin medal on top of the first. But unfortunately the new medal got stuck to the original at the casting head. With

[39] Landsman, R., J. Rowen. *Annotation concerning the production of one-sided hollow cast medals.* Annotation University of Columbia, New York 2014: 13.

some wooden tools we got the two apart, but both the original and the new cast medal were damaged in the process.

Thursday March 12th, 2015

Time: 13.00-17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

The log was adapted and a plan of action for the last experiments was made. We noticed a not previously read process in the manuscript for: *moulding hollow seals or other things* on folio 153r and it seemed an appropriate addition to the research. It describes a way in which one could cast something fairly thin and hollow. Also in this description the use of the original metal seal for making a new one is mentioned, just in the way as described for casting a one sided hollow relief medal:

"..then pour your metal on it to make a seal or a similar work. You could also pour on the first cast of metal, lead or tin. This metal won't melt if you cover it with a very thin coat of crushed chalk, or a coat of dry albumen, or if you smoke it with the smoke of a candle."[40]

This process could give more insight into the moulding off a hollow metal relief by leaving the original in the mould.

A step-by-step procedure and a list of necessities for testing this description was send to Tamar and Ellen for approval. Also the description in the manuscript *for moulding thinly* on folio 130v and 153v in which the use of a lasagna de paste was mentioned was studied. This is a method already tested in the annotation by the students in New York, but which could be interesting, if Tamar and Ellen would disagree with our plan of testing the description on folio 153r. We decided to then follow the description in the manuscript and see if our results would differ from the one the students in New York got.[41]

[40] BnF Ms. Fr. 640. Fol. 153r.

[41] The results of the experiment with lasagna the paste by Rozemarijn Landsman and Jonah Rowen can be read in: Landsman, R., J. Rowen. *Annotation concerning the production of one-sided hollow cast medals.* Annotation University of Columbia, New York 2014: 14 -18.

Also Constantijn Huygens was mentioned in the annotation, who gives some descriptions on how to cast specific types of medals. Our last idea for a good experiment would require cooperation between us and our fellow students, who study the use of spar/spalt to make suitable moulding-sand for castings. Huygens as well as the manuscript mention the use of spar for casting medals. Since we are experimenting with a particular casting process for the moulding of medals and our fellow students are doing research on the use of this spar component for making moulding-sand, we could bring both studies together by testing them during one experiment. After contemplation on these ideas they could be emailed to Tamar and Ellen. Lastly, a division was made in the documentation that needs to be done for the coming into being of the file.

Tuesday March 17th, 2015

Time: 09.00-17.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

A mould was made for casting a new tin medal. This was done because we still wanted to try the tin on tin experiment. The making of the mould did not go very well and was tried several times. A number of times we did not manage to get a good impression of the details in the mould.

When the making of the mould was successful we tried to cast the new original tin medal. The first time the cast was unsuccessful. Only a few small pieces to the sides were not entirely cast, the same way as was experienced during the casting of a brass medal. During the second trial the outcome was the same. Again some small pieces to the sides of the medal were not cast. So we tried it another time. Unfortunately the casting failed and only some part of the lion's head came out. The alloy we used was most likely a tin and lead alloy, but with a higher concentration of lead. The melting process was moderate, because the tin seemed to solidify rapidly and was very viscous during the cast. Another attempt followed.

The fourth attempt of the day failed again. The tin we used melted in a very strange way, whereby it became very hard and brittle when solidified. For the last attempt we decided to use a tin and silver alloy because we expected this alloy to be more forgiving than

the other ones we tried and so we could proceed and not loose too much time on making a new original medal. The result bear out our expectations, the medal turned out good.

Before it was tried to cast a tin on tin medal, a new original medal in brass was tried to cast, so we could also experiment with casting two medals of the same metal against each other with a higher melting point than tin. For the casting of the new original in brass, a bigger iron casting flask was used for making the mould. During the melting process the brass melted in a very strange way. It was very granular and became red and black as if it burned, so we decided to stop. Supposedly it was a different alloy-element that made this happen.

During the last attempt of the day, small pieces of brass plate were used. This melting and casting went successful, but the result was unfortunately not. Again some small pieces on the sides of the medal were not cast. Our intention for the final attempt was therefore to bring the sprues that follow to the sides of the mould a bit more down so the brass will flow to those places on the sides where the cast usually fails.

Wednesday March 18th, 2015

Time: 09.00-12.00

Location: Workshop building of the Rijksmuseum in Amsterdam, UvA metal classrooms.

A mould was made for a tin on tin cast. There was not enough silver-tin alloy left to cast with, so the residual was mixed with some pure tin. The cast did not go well. The depth of the impression was presumably right but the sprue was probably not big enough; the medal was only cast for ⅓ part. The reason the sprue was made smaller was because last time the *2015* part got stuck to the original. We thought that this happened as the sprue had accumulated to much heat. A positive note on this casting was that no part of the cast medal got stuck to the original.

Because of this outcome another attempt was made using a slightly bigger sprue. The size of the sprue is expected to sacrifice the punched *2015* a bit, but we wanted to know if the use of a bigger sprue would contribute to a good cast. The result was okay. We got a lot of detail and the 2015 came out fine, but the bottom part did not cast. The fail of this cast

could also be because of the type of tin alloy used. However the positive note on this experiment again was the fact that no part of the cast medal got stuck to the original.

Our final attempt for casting a new original brass medal after which, when we succeeded, we wanted to experiment with casting a brass on brass medal, did not result in a good outcome. The mould we made was our best yet. The casting process was successful, but the outcome failed, so unfortunately there was no time left to try and cast a brass on brass medal.

Our final attempt for casting a tin on tin medal was very disappointing. During the casting process, the molten tin that was poured into the flask exploded. Probably this was caused by air accumulation in the mould that had nowhere to go or trapped moist that expanded because of the heat.

Acknowledgements

We would like to thank Pamela Smith for making it possible to involve us in *the Making and Knowing project.* Rozemarijn Landsman and Jonah Rowen for the research they have done and questions they provided for us. And of course, Tamar Davidowitz, Ellen van Bork and Tonny Beentjes for their guidance and advice during the project.

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