Typography papers 1

Roman bronze inscriptional lettering: a note on methods of production

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The letters on some imposing Roman inscriptions appear originally to have been infilled with gilded bronze. Just how these fills were manufactured and attached to the background stone is not known. This paper describes a trial of one possible method and speculates about others.

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It is a fresh morning in March. A group of typography students is standing on the steps leading down from the Capitol to the Roman Forum; they huddle around their teachers, who are talking about the inscription on the arch of Septimius Severus immediately opposite them. The students are on a vacation course studying inscriptional lettering in Rome and Florence, and are already aware that the letters they are looking at originally contained metal infills. They are asked to speculate about how these were manufactured and fitted, and a discussion develops around the suggestions that emerge.

The intention behind the question is more didactic than technical; it is to encourage the students to look carefully at these particular letters and think critically about lettering in general. But the practical and technical points highlighted by the question are interesting in their own right, as are many of the students' speculations. In this paper I attempt to record and extend some of these discussions.

The Roman practice of inserting bronze infills into some public inscriptions appears to have arisen during the last few decades of the pre-Christian era, around the time of Rome's transition from a republic to an imperial state. The practice continued for at least three hundred years, and probably until the end of the empire. It seems to have been reserved for large, imposing public inscriptions on such buildings as temples and triumphal arches (figure 1). The size of these inscriptions, their position high up on buildings, and the costly materials from which they were made – bronze set into marble – imply that they were designed to be viewed from a distance and were intended to be powerful and lasting manifestations of the authority of the state. This is underlined by their textual content, which is frequently highly conventionalised and abbreviated (Gordon, 1983: 15 and 205–208). In such cases – to paraphrase Marshall McLuhan – the monument is the message.

Figure 1. An example of an inscription that once contained metal infills. (Fragment from an inscription celebrating Claudius's victories in Britain in AD 43. CIL VI920a.) Rome, Museo Nuovo of the Palazzo dei Conservatori.

The method of setting out these inscriptions is likely to have been similar to that used by the Romans for non-infilled inscriptions, which has been described in some detail by both Susini and Catich (Susini, 1973: 3 and 15; Catich, 1991: 44 and 172). They suggest that the 'ordinator' drew the letters, using a flat brush, or possibly a reed pen, directly on to the prepared stone after it had been assembled on the building. Using this method the overall design could be viewed from a distance, and adjustments made where necessary to letter size, spacing, symmetry, and so on, before any cutting was undertaken. In the case of letters that were to be filled with metal, the stonecutter would have

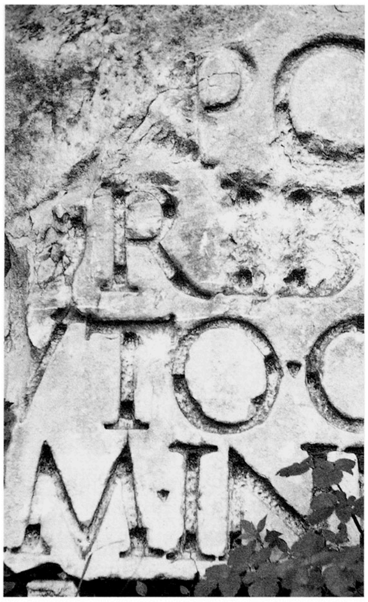

Figure 2. Letters with a rectangular cross-section, note the holes for attaching the metal infills. (Rome, Roman Forum; photograph James Mosley.)

Figure 3. Arch of Septimius Severus. (AD 203, CIL 6.1033, NW face.)

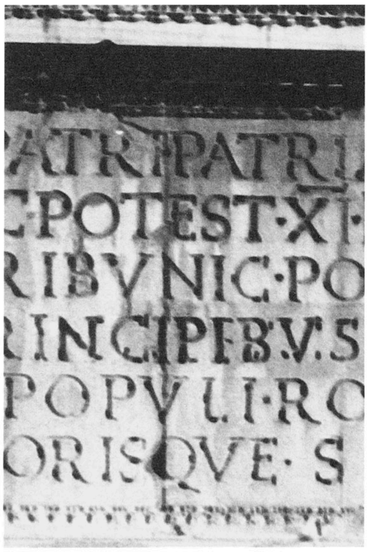

Figure 4. Detail of the inscription on the NW face of the Arch of Septimius Severus.

been able to cut out the holes for the bronze infills using the drawing as a guide, but interpreting it where necessary to ensure that the exigencies of the casting process were satisfied. The cavities of these inscriptions differ from those of conventional 'v' section inscriptions in that they have 'square' cross-sections, that is, they are vertical sided and flat bottomed (figure 2). The letters of these inscriptions are also 'bolder' than 'v' cut letters and have larger serifs; additionally they have between two and five holes cut in the bottom of the cavities so that the bronze infills can be fixed to the stone.

The infills from major inscriptions of this kind have disappeared; we can only imagine what they must have looked like, and have to work out how they were made from what remains on the stone. Figure 3 illustrates one of two almost identical inscriptions on the arch of Septimius Severus in the Roman Forum. The one shown here, dated AD 203, is on the NW face of the arch; it is a very large but otherwise typical example of this type of inscription. The panels on which the two inscriptions are cut both measure about 19.0m by 2.7m and together contain about 650 letters, each about 300mm high. The letters are all recessed into the stone about 10mm and the thick strokes are about one seventh of the letter height. Thus the cavity for a letter 'I', ignoring its serifs and attachment tangs, has a volume of about 111cc; it would take about 1kg of bronze if cast solid, assuming its specific gravity to be 8.96. The cavity for a letter 'M' would be between three and four times greater. If we assume that most other letters contained about twice the amount of bronze as a letter 'I', the two inscriptions together must have accounted for between a ton and a ton and a half of bronze. This alone explains why the bronze is no longer there.

It is probable that the letters were gilded, because it is difficult to see how else such an inscription could be maintained. Susini notes that the Roman bronze letters to be seen in the Archaeological Museum at Stuttgart still show signs of gilding (Susini, 1983: 70, end note 48). We also know that bronze was used extensively in Rome and that some important buildings had roof tiles that were made of gilded bronze.

There is no treatise on bronze working that dates from Roman times, although quite a lot is known about working methods from a study of Roman bronze artefacts (Brown, 1976: 25–29). Examples of Roman bronze infills for inscriptional lettering are very rare and those that exist are spread widely throughout Europe. There is one bronze letter still in place high up on an inscription in Ostia, which is helpful in confirming what the letters may have looked like *in situ*. However, because it cannot be removed, it is not much help in arriving at any conclusions about how it and similar letters were made and fitted. Susini refers to examples of other metal letters at Tarracini, Budapest, and Stuttgart (Susini, 1973: 70). Nicolete Gray reproduces a photograph of a bronze 'R' in her *History of lettering* (Gray, 1986: 22). Two or three further examples of metal letters are to be seen in the Museum of the Book in The Hague, but these appear to be made of lead and are without attachment tangs. A small portion of a Roman bronze letter discovered at Silchester, and now in the Silchester Gallery at the Museum of Reading in England, consists either of the bottom half of the left limb of a letter 'A' or the top right half of a letter 'V'. It still has its attachment tang, which is square in section and significantly

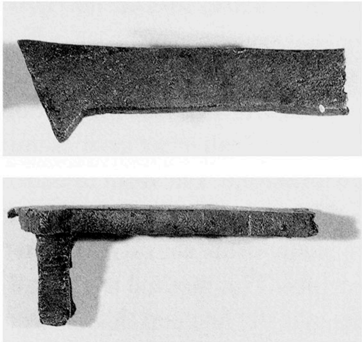

Figure 5. Fragment of a bronze letter found at Silchester, England; *top* front elevation. *bottom* side elevation, showing 'tang'. (Reproduced with permission of Reading Museum Service, Reading Borough Council, part of the Silchester collection.)

narrower than the stroke to which it is attached. The letter has sharply defined edges and is square in section. Although a somewhat lowly and untypical example of this style of Roman lettering, to the author it is the most accessible of specimens (figure 5). For this reason it is referred to in the technical trials described below.

One of the problems when trying to work out what processes ancient Romans must have used to make infilled inscriptions is that so few examples of the metal letters survived. We have to rely mainly on what we can learn from the empty stone forms to which the letters were attached. Four hypotheses for the production of infilled inscriptions are set out below, with comments on the practicality of each of the methods described.

Method A: *Place the unfilled inscription in a horizontal position, then pour molten bronze directly into the letter cavities.*
At first sight this method appears simple and straightforward. However, if the inscription was delineated, incised, and filled with metal while horizontal and before being fixed in position on the building, it would have been difficult to view the design from a distance before the work commenced. This difficulty could only have been overcome by assembling the background stones temporarily in a vertical position. After the design had been set out in this way the stones would have had to be dismantled, placed horizontally to pour the bronze, and then erected on the building. Both prospects are, in the author's view, unlikely as they would have involved moving the inscription after the bronze had been cast into the letter cavities. Careful inspection of the Septimius Severus inscription suggests that this method was not used in this case (figure 4). The panel on which the inscription was made consists of several separate pieces carefully joined together. Several of the letter cavities cross these joins. The problem of re-positioning all the separate stones on the arch without disturbing their bronze infills would have been daunting indeed.

The holes, which can be seen in each of the letter cavities and are presumed to have been made to attach the bronze to the stone, would have been unnecessary if this method had been used: slight undercutting at a few places around the edge of each letter would have sufficed and would have been much simpler in terms of production.

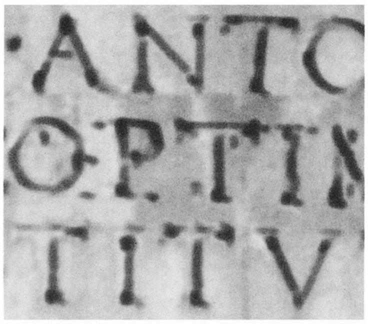

Figure 6. Detail of the first few letters of the amended fourth line on the Arch of Septimius Severus (NW face).

The fourth line of the Septimius Severus inscription has had some of its original letters deleted and others added. Originally the inscription named Caracalla and Geta, the two sons of Severus, but after the father's death a dispute arose between the sons which resulted in Geta's assassination and the obliteration of his name from all public inscriptions (Gordon, 1983: 158; Keppie, 1991: 50). This removal of the reference to Geta was done by removing the original bronze letters and chiselling down the background stone (figure 6). An amended inscription was then superimposed on top of the erasure. The holes used to attach the original letters can still be seen. If method A had been used for the amendments, it would have been easier to use a new piece of stone which had the revised inscription already cast into it. The fact that this was not done suggests that the normal practice was to work on the inscription with the stone in a vertical position after it had been put in place.

Method B: *Cast the bronze into the letter cavities with the inscription in its final vertical position.*
This method is far from simple and is no more plausible than A. An experiment with pouring molten metal into a vertical inscription has been tried by the author. Several 150 mm-high letter cavities imitating Roman originals were incised into limestone. The front of each of these cavities was sealed by clamping a thick slab of clay over its face. Entry and exit points for the metal were made within the clay. Molten type metal was then poured into the cavities. This method was found to work, but was troublesome. It gets over the first and third objections to method A, but still fails to explain the need for attachment tangs. The experiment also revealed another difficulty, which was that the letter cavities sometimes failed to fill completely. When this happened, the cooled metal was almost impossible to remove without damaging the inscription. This last point is an important one: it implies that any method that relies on pouring molten metal directly into the stone is inherently extremely risky.

Method C: *Cast the letters from prepared patterns, then cut the stone to fit the casts.*
This method appears feasible and, according to Susini, was the one used by the Romans. He states that:

> Bronze letters, or, at any rate, metal letters, destined for *inscriptiones caelatae* and prepared in a foundry from permanent moulds, were the only exception to the normal procedure for the execution of an inscription within a stone-mason's shop. It follows, therefore ... that metal letters, whose moulds were kept and used over a long period of time, to a large extent escaped the effects of both palaeographic evolution and changing chisel techniques, i.e. of the general development of the letters concerned (Susini, 1973: 18).

Susini does not provide any evidence to support this view, and it is not one shared by the author. If such a method had been used, we would expect to find that each of the occurrences of any letter of a particular size in an inscription would be identical, as it would not be necessary to have more than one pattern for each character. Furthermore, we would expect to find that the attachment holes of each example of the same letter would match. This exact duplication of letter shape and attachment hole position is not found. If the Romans had used this technique, they would effectively have invented type; we would expect to see exact duplication of letters not just on stone inscriptions but in other contexts where lettering was used.

Method D: *Take separate casts of each of the letter cavities and the surrounding stone surface using either clay, softened wax, or plaster (all three materials were familiar to Roman bronze workers)*(Brown, 1976: 26–30). *Make female impressions in sand, clay, or plaster of those parts of the casts that are below the original stone surface. These new 'moulds' are effectively duplicates of the original letter cavities. Cast bronze infills from these duplicate cavities.*

This method, although complicated, seems to be a technique that meets the objections outlined for methods A, B, and C. It also provides a positive explanation for why the sides of the letter cavities are never

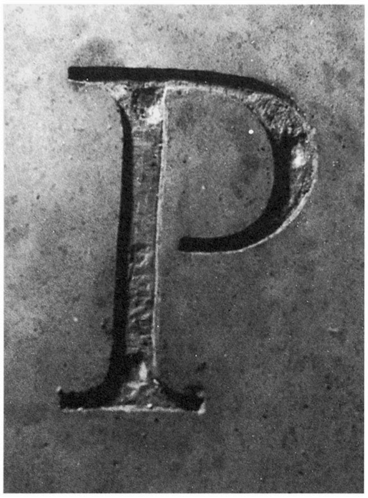

Figure 7. Simulated Roman letter cavity cut in limestone (approx. height 200 mm).

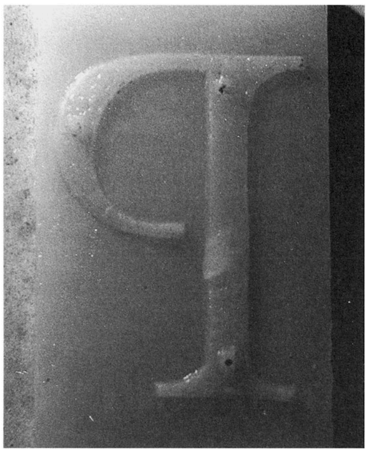

Figure 8. Wax cast of the simulated letter cavity.

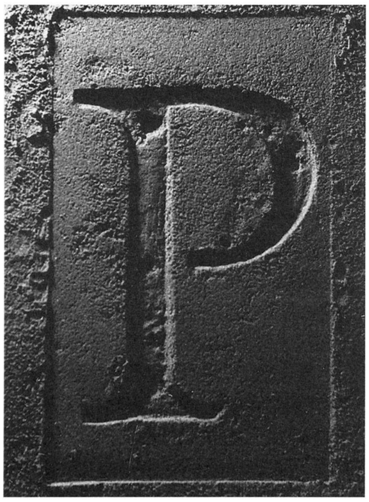

Figure 9. Impression of the wax cast in sand.

undercut. The principle underlying this method is that the metal infills are cast, not in the original cavities of the inscription, but in duplicates of them. This brings with it several advantages:
– imperfect castings can be rejected and new ones made;
– both the back and front of the metal infills can be inspected; and hand-finished before insertion into the inscription;
– the background stone is not at risk during production of the casts.

There are several possible ways in which this method could have been put into practice. Figures 7 to 12 show a practical trial of one such way. In this trial, lead was substituted for bronze because the equipment needed to melt bronze was not available to the author. The procedure was first to cut out a letter cavity, based on an example in the Roman Forum, from a block of limestone. This letter cavity was about 200 mm in height and about 7 mm in depth (see figure 7). Its sides were vertical and its base flat. Three square attachment holes, the same size and shape as the bronze tang from the Silchester fragment, were cut into the base of the letter (9 × 9 × 25 mm). The limestone slab was set up in a vertical position and a plaster cast made of the letter cavity. A good cast was obtained, but the plaster in the attachment holes broke off and remained in the limestone. A second attempt was made, with metal reinforcements inserted into the holes before casting, but the result was the same. A further trial was made with wax warmed into a plastic condition, instead of plaster. Again, the outcome was the same.

It seems worth considering whether the Romans found it necessary to obtain casts of the attachment holes at this stage in the production process. These can very easily be made at the next stage providing there is some indication of their position both on the letter cavity and the cast. All that is needed are shallow depressions in the base of the letter cavities wherever attachment tangs are required. These depressions would appear on the plaster or wax cast as small bumps (figure 8). Once the cast is made, the depressions in the original stone can be enlarged to the size needed to provide room for the attachment tangs and their surrounding lead.

The next stage in the experiment was to impress the casting into damp sand (plaster or clay might equally well have been used). The resulting 'print' produced a duplicate of the original letter cavity, including the indications of the attachment tang positions (see figure 9).The remaining task was to form the mould for these by pressing a small square stick into the sand at the places indicated before pouring the metal. Figure 10 shows the rough casting and figure 11 the casting after it was tidied up. Two rather awkward features of this method of producing metal letters now became apparent. First, the problem of tidying up the visible surface of the casting was more difficult than was anticipated, because the lead solidified rapidly on coming into contact with the mould, before its surface had properly levelled out (see figure 10). Secondly, when the cast letter was tried in the original cavity it was found to be a fraction short, where the metal had shrunk on cooling.

The unsatisfactory state of the surface of the casting might have been less troublesome if bronze had been used instead of lead, as the higher melting point of bronze is likely to have increased the time that the metal remained molten. However, if the sand mould had been

Figure 10. Infill made by pouring lead into the sand mould (note the uneven surface).

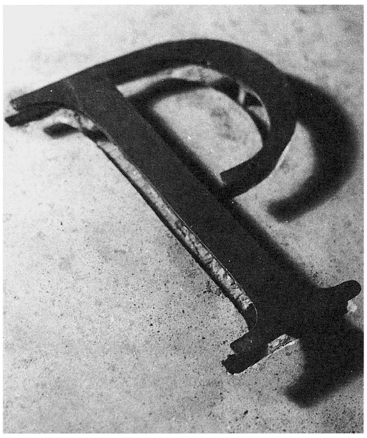

Figure 11. Lead infill after being cleaned up. It is positioned over the original cavity prior to being driven into position.

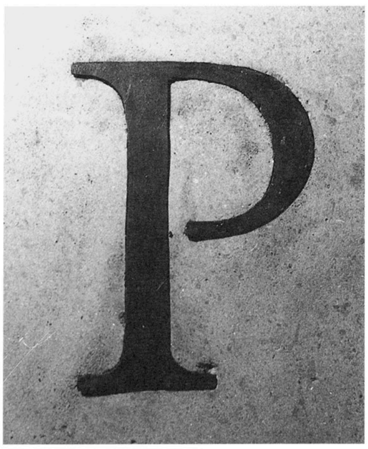

Figure 12. Lead infill fitted into the original cavity.

replaced with one made from clay, a clay lid could have been provided to blank off the face of the letter, totally enclosing the letter cavity. Furthermore, the tang holes could have provided the means of running the molten metal into the letter cavity, and letting air and moisture escape. In foundry parlance, they would become the 'runners and risers' for the mould.

The revised procedure envisaged, which has not yet been tested, is as follows:

– A wax impression of the letter cavity is impressed into a slab of clay.
– The top surface of this clay is then made flat and tang holes, passing right through the clay, are made in the base of the letter cavity in the way described previously.
– Another flat slab of clay is prepared. The first slab is now inverted and placed on top of the second and pressed down firmly. The tang holes will now be visible on the top surface of the clay.
– One of the tang holes is modified into a funnel and molten metal is poured into the cavity. Pouring stops when metal appears at the other tang holes.

Shrinkage of casts is a well-known feature of metal casting and, nowadays, is normally tackled by having the pattern made an appropriate amount larger. However, it is difficult to see how this could be done in the circumstances envisaged here. The author's trial letters were fairly easily persuaded to expand into their cavities by gently hammering their undersides. However, these letters were made of lead. It is known that the Romans were aware of the possibilities of varying the proportions of copper, tin, and lead in their bronze, in order to change its working properties (Brown, 1976: 39). If their bronze letters were cold-worked after casting, the bronze they used must have been a compromise alloy. Bronze made from copper with the addition of tin alone is best suited for cold working, but does not flow well when casting; the addition of some lead to the melt improves its flow characteristics and lowers its melting point, but rapidly affects its cold-working properties.

Finally, something should be said about how bronze infills were attached to the stone in Roman times. Clearly, the numerous holes which occur within the letter cavities of surviving inscriptions have a part to play in this, but how precisely were these used? On close inspection, many of these holes are seen to be rectangular in cross section, with the long side of the rectangle usually running parallel to the letter stroke. Furthermore, in order that each part of a letter could be firmly attached to the stone, they are distributed widely over the letter, with no letter having fewer than two holes and some having as many as five. Wherever possible they are located in thick strokes. These holes are very similar in appearance to the ones seen in Roman stonework used to accommodate heavy staples for attaching marble cladding to travertine and when joining large stones together without the use of mortar. Surviving staples used for such purposes are sometimes made of iron, but are usually made of bronze encased in lead at the points where they enter the stones. The purpose of the lead is presumably to lock the bronze into the stone and to provide some resilience. Iron and bronze lie on either side of lead in the galvanic series, so neither metal would cause serious electrolytic problems and there might even be some benefit in a slight reaction between the metals for cementing the components together.

If the similarity between the appearance of the holes used for joining staples to stones on the one hand and letters to stones on the other is more than coincidence, it is probable that lead was used as the joining material for bronze letters too. Filling the holes with lead could have been done by pouring in molten lead via a clay spout, by cutting off a suitably sized portion of cold lead and driving it into the hole using a flat-ended punch, or by wrapping the bronze tangs with shot lead before insertion. The experimental bronze letter infills made from the duplicate letter cavities would have had bronze tangs on their undersides smaller in size than the lead-filled holes into which they were to be fitted, the difference in size providing the necessary fitting tolerance. It would have remained only to hammer into place the bronze infills which would be held firm by the displaced lead.

We do not yet have a definitive explanation for the way in which the Romans made infilled inscriptions. This paper suggests that, whatever procedures were used, they almost certainly did not pour molten metal directly into the stone inscription or make pre-cast letters from patterns. If this is accepted, the infills must have been made by casting from duplicates made from the original letter cavities. If we are to find out more about the production of such letters, we shall need the help of archaeologists and metallurgists in setting up trials of possible methods, using the range of bronzes known to the Romans. We also need to look further for examples of metal infills in museums. The stone parts of these inscriptions have received a great deal of attention from epigraphers and other lettering experts, but almost nothing appears to have been written about the metal infills and their methods of manufacture.

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