Nails from the wood panelled nave ceiling of Peterborough Cathedral:

Technological investigation of nails from bay three (Phase Four) of the restoration programme.

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Introduction

A technological investigation on a first series of nails 8 nails from the nave ceiling was carried out and a report submitted as part of the Phase 2 programme of restoration work carried out in 2000. The nails investigated were those recovered during the restoration work on the first two bays of the ceiling (ie Phases 1 and 2 of the programme). This report on the second stage of the technological work on nails from the nave ceiling - in this case on nails recovered from Phase 3 of the restoration work on this wood panelled ceiling - should be read as the second part of a continuing report on an investigation that has had to be divided into several parts. For convenience the first three sections of the first report - Introduction and background (here renamed Background), Changes in post-medieval iron production and their detection, and Technological investigation of the nails) are repeated here but modified slightly to suit the correspondingly slightly different aims.

Background

A re-appraisal of the exceptional painted, wood-panelled nave ceiling forms part of the assessment of conservation work in this phase of the extensive programme of restoration within the Cathedral. The ceiling would appear to be a largely complete survival of the panelled and painted ceiling which was attached to the underside of the nave roof framework. A recent extensive dendro-chronological survey of the remnants of the medieval nave roof structure have shown that this was installed the period 1220 - 1230 (Tyers 1999). The nave is characteristically late Norman in style and the panelling was designed and painted in a repeating lozenge or diamond shaped pattern, done with perspective in mind, to give the impression of vaulting when viewed from the ground. It would appear that a stone vault was originally planned but that signs of instability in the walls forced a change of plan when the nave had reached roof height.

All that now remains of the original medieval roof structure are the parts to which the ceiling was fixed, although even some of these were replaced during later restoration or repair work. However, the ceiling itself appears to have survived more or less complete. Clearly this survival has involved later maintenance and restoration, but the extent of later work is uncertain, as is when it took place.

Once scaffolding was in place - firstly in the eastern half of the nave - close examination of the ceiling from above and below finally became possible. Apart from the inevitable restoration of some of the paintwork, it was clear that some panels had been taken out in the past and either put back, not necessarily in the same position, or replaced with newer panels. However, gauging the extent to which the original panelled ceiling had been previously taken apart and re-assembled, was found to be very difficult although it was noticed that several different types of nail had been used to attach the wooden panels to the framework above. It was realized that if these nails could be dated in some way then they might provide a method for separating and even approximately dating earlier phases of restoration to the ceiling. With this in mind the aim of this investigation

was to take examples of the different types of nail used, identify the production technology in each case, and match the results with relevant known developments in iron production technology.

Since the panels were nailed from below, and given that the ceiling is suspended 25 m (80 ft) above the floor of the nave, it seemed unlikely that much work like this could have taken place except when parts of the nave were fully scaffolded. As far as could be seen from initial examination, three different types of nail had been used to fix the panels in place at one time or another, suggesting two main phases of restoration. It appears from Cathedral records that the nave was last extensively scaffolded in the early 19th century and earlier on during restoration work of *c*1740, but it is not known what happened before that. It is perfectly possible that the three types of nail used to fix various of the ceiling panels correspond to the three known main phases of work involving scaffolding in the nave but this cannot be assumed. To match the nails with these known (or any other) building phases the nails need to be dated.

Nothing is now left of the original medieval nave roof and even the main joists, from which the ceiling framework is hung, are replacements. The minor joists, which form the lateral struts of the ceiling frame, would all appear to be original. An original feature of the ceiling are a series of longitudinal-struts running between the minor joists and above the panelling. These are slightly odd because they do not all coincide with the panelling layout below, although they do where this is essential for the fixing of parts of the boards. They are of interest here because each end was jointed into one side of the minor joists by means of a birds beak-shaped joint and held in place with an iron nail. Some of these longitudinal struts had been removed, presumably during later restoration work, usually leaving behind the fixing nails when they were pulled out. Several of these nails were removed and examined in the first stage of this technological investigation.

Changes in post-medieval iron production and their detection

It is known from historical records that iron production technology went through a series of changes (in this country) during the post-medieval period, most markedly during the industrial revolution in the 18th and 19th centuries. The indirect production of plain iron (or wrought iron as it became known), by the 'fining' (oxidation) of cast iron in a special furnace known as a finery, followed the introduction of blast furnace technology into Britain which is recorded as having taken place in Sussex in 1496 (Tylecote 1976, 82). Before this, all iron in this country was made by the much more ancient 'bloomery' process. In this process iron ore was reduced directly to a malleable form of iron, during the smelting process, although what was left in the furnace was a porous, spongy iron mass which had to be hammered together, a procedure known as bloom consolidation, to rid it of most of the non-metallic slag with which it was mixed.

Iron produced by the bloomery process is usually distinctive in having an uneven metallic structure which can be recognized by metallographic examination (mainly by looking at a polished and etched section using an optical microscope). Even after bloom consolidation the iron will still contain a relatively small proportion of the non-metallic slag left over from the smelting process. The density, form and composition of these slag inclusions can be identified by metallography and (electron-probe) micro-analysis, which can also be used to measure the proportion of alloying impurities in the metal.

By about the middle of the 17th century (in this country) bloomery iron had been more or less completely replaced by finery iron although telling the two apart is not easy because the finery

process re-introduces non-metallic slaggy material to the iron leaving it very similar to bloomery iron. However, much more oxidizing atmospheric conditions were used the finery process, leaving the iron with a much more even, more or less carbon free structure. Differences in the slag density, form and composition should be detectable by metallography and micro-analysis especially after the mid 1780's when developments in the finery process for making forgeable iron led to the introduction of the 'puddling' process in which the metal was separated from the fuel. Puddled iron continued to be made throughout the 19th century although after about 1860 it was gradually replaced by mild steel which is different in composition and comparatively free of non-metallic inclusions.

The purpose of the present investigation was to identify the structure and determine the composition of each type of nail, and match the results with what we can expect from known details of the history of iron production technology, given that all 11 nails examined here were identified as coming from one of three former phases of work on the ceiling .

Technological investigation of the nails from Phases 1 and 2 of the restoration work

In the first investigation four pairs of nails were chosen, each pair consisting of two good examples of each of the four varieties of nails observed in the ceiling, three of these holding the painted wooden panels in place, and the fourth from part of the sub-structure framework above. They were chosen from known positions and are thought likely to represent two different parts of the original ceiling structure, and two phases of later restoration, possibly those of *c*1740 and *c*1830. It was anticipated at the outset that more might need to be examined later depending both on the outcome of this investigation and on questions that arise as the restoration work progresses. Before Phase 3 of the restoration work had progressed very far it became clear that the pattern of nail use in Bay 3 was rather different to that seen in Bays 1 and 2.

In Phase 1 and 2 the original nails used to fix the ceiling panels in place (in *c*1220) appear to have been a wide headed form with a relatively narrow shaft (see Fig 1 in the first report). Technological examination of two of these nails indicated this interpretation to be correct given that the iron from which these nails were made was most likely of bloomery origin. Among these wide headed nails were other nails which were thought likely to belong to one of the two known phases of restoration, either that of *c*1740 or that of *c*1830. The most numerous of these was one form with a faceted head and a distinctive, slightly spade-shaped and pointed end (see Fig 7 in the first report). Two of the these were examined and these proved to be the type most readily identifiable as being from the restoration of *c*1830 by their having been made of puddled wrought iron, a typical and readily identifiable product of that phase of the industrial revolution, it having been produced between the late 18th and early 20th centuries.

The remaining panel fixing nails examined were less easy to separate and group either typologically or technologically. They all looked fairly similar, mostly with roughly faceted or domed heads, although they could be grouped into two sizes, one much smaller than the other (see Fig 10 in the first report). One nail from each of these two different sized sub-groups was examined technologically. Both appeared to have been made of a poor quality (?an early or prototype) form of puddled wrought probably consistent with the reported restoration of *c* 1740.

The remaining two nails examined in this first stage had been used in the 'birds-beak' joint fixings of part of the surviving underlying framework to which the painted panels were fixed.

Although of much the same date these nails were quite different both technologically and in shape from the wide headed nails used to fix the panels in place in Phase 1 and 2 (and in Phase 3 partly as well - see below). There seemed to be no doubt that they were of bloomery origin as well but in this case they were made of phosphoritic iron (with a mean phosphorus content of approximately 0.4%).

In Bay 3 (ie Phase 3) in addition to the wide-headed type a new form of nail was encountered in areas where the boards did not look as if they had been disturbed although it was difficult to be certain about this. This type which was similar in overall size to the wide-headed type identified for Bays 1 and 2 (ie Phase 1 and 2) as original panel fixing nails but generally had a smaller, flattish but (in plan) rather irregular shape. It was also a rather stouter nail with a with a rectangular section shank measuring, on average, approximately 2.5 x 5mm across.

Technological investigation of nails from Phase Three of the ceiling restoration

Altogether eleven nails were examined from Phase Three of the restoration work (ie the second stage of the technological investigation). Early during the restoration work on Phase Three it become clear that a different type of nail had been used in the original construction of the ceiling to attach many of the panels to the framework above. These were found interspersed with the 'large-headed original' panel fixing nails identified earlier (during Phases One and Two) as having been the main type of nail to have been originally used to fix the panels in place in the first four bays of the ceiling. Overall this 'new' type of nail was of a similar general size to the 'large-headed original' type but its appearance was rather different. Instead of the largish, slightly domed heads of the first type these nails had smaller, more-or-less flat, but more irregularly (or poorly) shaped heads plus shanks of rectangular (as opposed to more-or-less square) cross-section. The overall size of these nails appeared to be slightly bigger, the examples examined suggesting that, in length, they mostly fell within the range 40-60mm, although some were slightly shorter.

In most cases the contexts in which these nails were found suggested that this 'new' type of panel fixing nail was also used, at least in this part of the ceiling, to fix the wooden panels in place before they were painted, although the possibility still remained that these nails were part of a later campaign of restoration. It is clear that these nails were only used towards the western end of the ceiling and they would appear to represent an early or later batch of panel fixing nails depending on which end of the ceiling the panel fixing was started. A principal aim of this phase of the technological work on the ceiling was to examine and analyse some of these small headed nails to see if they were made of the same type of iron as the more widely occurring 'large-headed original' type of panel fixing nail and, if different, to see if their composition and structure was consistent with an early 13th century date. A total of five nails which appeared to be of this type (HM106, 109, 111, 124 and 126) were examined at this stage of the investigation.

A similar but generally larger nail was encountered during work on Phase 3 of the restoration work on the ceiling. The heads on these tended to be even irregular in plan and flattish or very slightly domed in profile. Also the rectangular shanks of these nails tended to be rather larger than those of the above group of 'flat headed original' nails. The context of some or most of these nails would suggest that they belong to the restoration of *c*1740 and another aim of this phase of the investigation was to determine whether they could be shown to belong to a different batch of nails to the slightly smaller but similar looking ones described above. In all three nails of this type (HM107, 110 and 112) were examined at this stage. One of these (the only complete

one) was 75 mm in length but the overall proportions of all three were much the same, and were noticeably bigger than those of the first group, and would all appear to have been about 70-75 mm in length.

Another new type of nail, thought to belong to the 1740's phase of restoration, was also now encountered. This was one with a smallish head that was faceted of pyramidal (with four sides) in form on top, although rather irregularly shaped in plan. Only the top part was recovered so its length is uncertain. One of these (HM123) was examined at this stage.

The surviving upper half of one further nail (HM125) thought to be from the restoration of *c*1830 was also examined as part of this batch. The rectangular shank looked very similar those of the very numerous faceted-headed nails already recognised as belonging to this restoration, although the head appeared to have been flatter and not faceted even if its now mangled state made its original form difficult to determine exactly.

Technological investigation of nails from Phases Four of the restoration campaign.

In all eleven nails were selected for analysis from this most western part of the nave ceiling (ie Bays 7 to 8). They were selected to shed further light on the main outstanding questions arising from the work, already reported on nails from the first three phases of the restoration campaign. main outstanding questions. The biggest remaining problem was whether or not it was possible to positively identify the selection of nails belonging to the restoration carried out in the 1740's, and separate these from those used to fix the painted panels in position in the original ceiling construction of c1220, without having to resort to technological analysis each time. With this in mind five nails identified as belonging to the original early 13th century work were chosen, including examples of both the main two types identified during the technological work on nails already undertaken as part of Phases One to Three of the present investigation. Also examined were four nails identified as belonging to the restoration work of the 1740's were selected, plus a further two nails associated with the work done in *c*1830.

As before, the heads and the upper parts of the shanks of these eleven nails were sectioned longitudinally and mounted and examined metallographically to look further for the visual characteristics that could be used to separate thirteenth century panel fixing nails from those used in the restorations of the 1740's and *c*1830. The sections were all etched with 2% nital (nitric acid in ethanol). Seven of these eleven nails, were also subjected to electron-probe micro-analysis (EPMA) to look further at the chemical characteristics of the nails belonging to each of these restorations and again to see further how they might be reliably separated from those used originally the fix the ceiling panels in place. The results of micro-analysis are shown in Tables 1-14 below.

Nails identified as belonging to the original ceiling structure

The five original panel fixing nails examined for this third phase of technological work included examples of the both the wide, slightly domed-headed type as well as some of the small flat-headed type. As before these nails were examined to see if their structure and chemical composition was consistent with a date of *c*1220, as well as to see if these could be tied in with their overall physical characteristics to allow for more ready identification.

1. **Phase IV, 17 I, Board N**: This nail (HM163) was typical of the smaller, 'flat-headed original' type of panel fixing nail first encountered in Bays 5 and 6. Only the head and part of the shank (measuring 27 mm in length) survived, the shank being approximately 4 mm square at the head, tapering to a rectangular profile of 3x2 mm at a point 15 mm down from the head (Fig 1). What remained of the nail was quite heavily corroded but despite this its overall form and original shape was quite clear. The head was irregular but roughly circular in plan and measured 11x13 mm across. The overall proportions of the nail are very similar to those of the smaller, 'flat-headed original' type already reported and an original length of approximately 50 mm would therefore be expected.

At low magnification in section the overall structure of the nail gave a rather blotchy or irregular patchy appearance typical of a very inhomogeneous, phosphoritic bloomery iron (Fig 2). In this case the larger dark areas visible in section represent corrosion voids in the metal, voids which filled with corrosion products as soon as they were formed. Much of this corrosion has focussed on non-metallic slag inclusions trapped in the metal either left over from the time it was smelted and consolidated, or from subsequent smithing/forging cycles. If one thinks away the dark corrosion voids on this view the overall content of non-metallic slag is fairly typical for a bloomery iron, although perhaps relatively low in this case.

The metal consisted of large grain phosphoritic iron (pale areas visible in this view where the phosphorus content was in the range 0.4-0.5%, see Table 1) and medium to fine grain iron (where the phosphorus content was below about 0.2%). Over much of the darker patches visible here the grain structure was overlain with the watery looking 'phosphorus ghosting' structure typical of areas of intermediate phosphorus content. In detail the structure looked much the same as seen at higher magnification in the next nail examined (HM 164; Fig 5). Its structure is entirely consistent with this nail belonging to the original construction of the ceiling in *c* 1220.

2. **Phase IV, 15 III, Board N**: Again a 'flat headed original' type the head of this slightly larger nail (HM164) was similarly irregular in its shaped in plan, this time measuring 14x16 mm across (Fig 3). This complete nail was 57 mm in length, and had a rectangular shank with an unusual shape. The upper part of this was 7x4 mm and only tapered slightly down to a point a little over one third of the way down the shank where it dipped in sharply on either side so the profile became much more nearly square from this point, from where it tapered down evenly to the tip.

In section the overall structure of the nail gave a rather blotchy or irregular patchy appearance very similar to that seen in the previous example, and again typical of a very inhomogeneous, phosphoritic bloomery iron. However this time there was rather more non-metallic slag present although this was very irregularly distributed and the inclusions also varied greatly in shape and size (Fig 4). Some of these slag inclusions were themselves quite large with two phases visible (mainly silicate but with some paler oxide phase present) at higher magnification when the very varied grain structure was also visible (Fig 5).

Some pale, large grain areas mark where the phosphorus content is high (again in the range 0.4-0.5%; see Table 3). These are very clear over much of the lower half of this view (Fig 5). In other parts of the section the phosphorus content is lower (again mostly about 0.2%) and a medium to fine grain iron structure shows up. As before areas of intermediate phosphorus content are marked by phosphorous ghosting, here visible as irregular, greyish watery looking patches. The structure of this nail was again entirely consistent with its being part of the original ceiling construction of *c* 1220.

3. **Phase IV, 11 III, Board AA**: Another complete example of a 'flat-headed' original nail (HM167) measuring 60 mm in length, with a head which was similar in appearance and size to (HM164) the previous example. This time however the shank, in profile very nearly square, was more typical of this type of nail, measuring approximately 5 mm across near the head. From here the shank tapered down evenly on all four sides down to the tip (Fig 6)

In section at low magnification a more homogeneous iron structure showed up than seen on the two previous examples although a relatively fine but slightly piebald appearance was indicative of this being a slightly inhomogeneous phosphoritic iron (Fig 7). Non-metallic slag inclusions could be seen dispersed unevenly across the section although the overall volume of these was relatively low. These inclusions were mostly small but a few larger inclusions were also present. The greyish patchy areas visible across much of the section showed up at higher magnification as the kind of watery appearance typical of phosphorus ghosting across zones of intermediate phosphorous content and one which, as here, masks the underlying grain structure of the iron. In between these a fine to medium grain (ferrite) iron structure shows up clearly (Fig 8). Also visible in this detailed view is a scattering of small medium grey spots, and these are non metallic inclusions mostly of just one (probably iron silicate) phase.

The structure visible in section suggests this sample again to consist of phosphoritic iron but one rather lower in phosphorus than in the two previous examples (HM163 and HM164) and EPMA analysis also showed this to be the case. Here the higher phosphorus areas (in this case those with a watery phosphorus 'ghosting' structure) varied approximately within the range 0.25-0.35% phosphorus (see Table 5), with the lower phosphorus areas approximately within the range 0.2-0.25% (except for one which was less).

4. **Phase IV, 14 III, Board N**: Although the two previous examples were about the same size, this nail (HM168) was the surviving upper part of a smaller 'flat-headed original' type (similar in scale to HM163 here, and HM124 in the previous group examined). The head also was much the same in size and shape to (HM163) the first of this group although this time it was damaged (Fig 10). The shank was slightly rectangular in section, measuring approximately 3x4 mm across near the head, and this again tapered gently on all four sides towards the tip the end of which was missing. A total length of 27 mm survived although the overall proportions suggested it would not have been much more than 40-45 mm long originally.

In section this nail (Fig 10) was found to consist mostly of medium grain plain iron with very little pearlite (iron carbide) showing indicating the carbon content to be mostly very low. This structure also indicates the phosphorus content to be fairly low, possibly below about 0.1-0.2%, although one or two larger grain patches, particularly one towards the head, suggest that the phosphorus content may be slightly higher in places. The overall content of non-metallic slag inclusions is relatively high although the distribution and size of these is very uneven across the section. At higher magnification the relatively even, medium grain structure of the iron, and the lack of phosphorus ghost structure, is clearly visible (Fig 11), and at higher magnification again the two phase structure of much of the non-metallic slag, with its very high iron oxide content (the pale constituent) can also be seen (Fig 12). Micro-analysis confirmed the phosphorus content of the metal to be relatively low with a mean phosphorus content of 0.1%.

5. **Phase IV, 17 III, Board N**: From what remained of it this nail (HM238) appeared to be a variant of the small-headed original type usually found with a flat head in the context of this ceiling. Only the head and a short length of the shank measuring 9 mm in all survived, this having broken off from the rest. In this case the head would appear to have been slightly domed from the time it was made, although in this way it simply resembled the other original nails with domed-shaped heads, but in this case the head was a little smaller and had also been damaged (Fig 13).

In section the iron structure of this nail strongly resembled that seen in the first three nails described in this report with its curiously piebald appearance at low magnification, with some pale areas visible against the slightly greyish surrounding areas (Fig 14). An uneven scattering of non-metallic inclusions (the dark spots here) is also visible although the overall content is relatively low, and their size relatively small.

At higher magnification (Fig 15) the very large grain structure of the iron in the pale areas is visible and is indicative of a high phosphorus content, probably in the region of 0.4-0.5% to judge from the other examples (HM163, HM164 and HM167). Also visible (low down on this view) on the boundary with the areas of finer grain is the watery looking phosphorus ghosting structure typical of areas of intermediate phosphorus content. The very large grain structure of the pale areas was in marked contrast to the much finer (but still) medium grain structure of the surrounding areas (Fig 16). Little or no iron carbide is visible in the medium grained areas where it would be expected (as pearlite) so the carbon content is clearly very low, and the medium grain structure of these areas suggests that the phosphorus content of these areas is unlikely to exceed 0.1-0.2%. Overall this structure is again indicative of the metal here being an inhomogeneous phosphoritic bloomery iron.

Nails identified as belonging to the ceiling restoration of the 1740's

A series of four nails from contexts associated with this phase of restoration was identified and submitted for examination. The aim was to add these to the series of nails already identified as belonging to this phase and which were examined earlier, and thereby to have examined and analysed a representative selection of nails belonging to this mid 18th century phase of restoration about which relatively little is known. The overall aim, as before, was to look at ways of separating and categorising visually distinctive types of nail so that they could be more readily grouped and allocated (if possible by eye) to this phase in the ceilings history, rather than the original construction or the restoration of *c*1830.

6. **Phase IV, 11 III, Board E**: The particular type of nail represented in this complete example (HM165) was referred to during the present restoration as a 'lost head square shank' type. It was relatively small, 45 mm long, with a low pyramidal or faceted head with four facets to the top (Fig 17). The head was also was small and very irregular in plan, measuring 9x12 mm across. Despite the term used to refer to it the shank, which was quite narrow, was in fact, slightly rectangular in profile, particularly near the head where it measured 3.5x2.5 mm. Also it only tapered towards the tip along one pair of opposing sides.

In section a regular banded structure along the shank of this nail was straightaway visible at low magnification (Fig 18). Although distorted the banded structure continued right through the head

indicating that this nail had been cut from a longer bar. The regular nature of the banding indicates that this bar has been produced using a rolling mill, technology that became more effective for iron in the 18th century. At low magnification the overall content of non-metallic slag inclusions is seen to be relatively low and unevenly distributed.

At higher magnification the pale bands were seen to consist of large iron (ferrite) grains and the banded effect was accentuated by lines of phosphorous ghosting marking the boundaries on either side as is particularly emphasised on either side of the pale band in the lower part of the view shown here (Fig 19). In this case these lines also mark zones of intermediate phosphorous content on either side of the pale bands in the rest of which the phosphorus content is higher. Further away from the boundaries the more greyish bands (as seen at low magnification) are seen to mainly consist of medium to fine grain plain iron with a little iron carbide showing up in a few places at the grain boundaries.

EPMA analysis showed the high phosphorus pale bands in this nail to contain phosphorus mostly in the range 0.3-0.5%, and the more grey low phosphorus bands mostly to contain approximately 0-1-0.2% phosphorus. The iron here appears consistent with either bloomery (direct) or finery indirect) iron manufacture. This and the use of a rolling (and probably slitting) mill to produce the bars from which the nails were made, is most consistent with an 18th century date.

7. **Phase IV, 10 IV, Board I**: This nail (HM166) was clearly much the same as the previous example of small 'lost head, square shank' nail. The shank was more or less exactly the same in size and shape although about 5 or 6 mm of the tip had broken off, the surviving nail measuring 39 mm in length (Fig 20). Its four-sided faceted head was again very irregular in plan and also measured 9x12 mm across.

In section however the structure of the iron was rather different although the pronounced banded structure running right along the shank and through the head was again indicative of the use of a rolling mill to produce the iron rod from which the length necessary to make this nail was cut (Fig 21). Pale bands are indicative of higher phosphorous regions although much of the section is seen here to consist of greyish bands. The content of non-metallic inclusions is mostly quite low and the distribution of these irregular, and their size mostly quite small.

Higher magnification revealed the narrow pale bands to consist of large grain phosphoritic iron (Fig 22). In between these the greyish bands could be seen to consist of fine grain low carbon iron with a carbon content of approximately 0.1%. The small non-metallic inclusions (the dark grey spots in this view) were found to consist mainly of iron oxide (paler inclusions) or iron silicate. Micro-analysis revealed the silicate inclusions to be rich in potash, and also revealed the much of the metal present to be rich in phosphorus, especially the pale bands whose phosphorus content fell approximately within the range 0.3-0.6%. Overall the structure and composition of is indicative of a bloomery origin for the metal in this case. This and the fact that this is rolled bar iron is suggestive of a date within the first half of the 18th century for production of this nail.

8. **Phase IV, 8 IV, Board O**: A third example of the same category of small 'lost head, square shank' nails, this nail (HM236) had the same sized, irregularly shaped, four-sided faceted head as the two nails just described. The shank too was very much the same size (again approximately

3.5x2.5 mm across near the head) although one variation in this case was that the shank tapered down more evenly towards the tip on all four sides. The main part of this nail survived although the tip end had broken off (Fig 23). What was left measured 32 mm in length, and like the previous example its overall proportions indicated its original length to be within the range 40-45 mm, or perhaps slightly less.

In section at low magnification a clear banded structure was again visible indicating the use of a rolling mill to make the iron bar from which the length of iron for this nail was cut (Fig 24). The overall content of non-metallic slag inclusions was again relatively low, and the inclusions mostly small and irregularly distributed. At higher magnification the pale bands were again revealed to consist of large grain iron high in phosphorus (Fig 25. The boundaries of these pale bands were here interleaved with bands (greyish at low magnification) marked by a watery looking 'phosphorus ghosting' structure. This was particularly marked at the head where finer grained bands lower in phosphorus were also visible (Fig 26). In one area, at higher magnification again, the boundary zone between the large grain phosphoritic iron (lower half of Fig 27), the areas of intermediate phosphorus content with their watery looking 'ghost' structure, plus the adjacent medium grain, lower phosphorus iron (near the top of Fig 27) are all very clear.

No micro-analysis was carried out on this section but similarities with other nails examined, particularly in this group, would suggest the pale bands to contain about 0.4-0.5% phosphorus, with the intermediate zones mostly varying between about 0.2 and 0.4%. Overall this structure is indicative of either a bloomery or finery iron having been used (it being difficult to say which here) that, together with this being a clear example of rolled metal, points towards an 18th Century date for this nail.

9. **Phase IV, 17 III, Board U**: A final example of this small 'lost-headed, square shank' nails was examined as part of this batch. This nail (HM237) was virtually identical in its proportions and shape to the previous example described (HM236), and although originally the nail must have been about the same size (approximately 40-45 mm long) more had broken off, this time with 24 mm surviving (Fig 28). The head was the same size, with the same irregular, low pyramidal shape as before.

Once again a clear banded structure was visible in section at low magnification (Fig 29) indicative of a rolled iron bar having been used to make this nail. Again the overall content of non-metallic slag inclusions was relatively low, and the inclusions variable both in size and distribution. Unlike previous examples there is a clear predominance of pale bands across the section.

At higher magnification the structure became clearer and the detailed view shown here is of the upper central part of the shank visible in Fig 29 and the same darker bands can be seen running through the upper part of this view (Fig 30). Much of the rest of the section is seen here to consist of pale large grain, highly phosphoritic iron. In a detailed view through one of the darker bands at higher magnification again these bands can be seen to consist of medium grain iron overlain in localised areas with the watery looking phosphorus 'ghost structure' (Fig 31). Two or three phases can be seen in much of the non-metallic slag visible in section (Fig 32).

This sample was also not subjected to micro-analysis but the structure described here is indicative

of an inhomogeneous but highly phosphoritic having been used to make this nail with a phosphorus content of approximately 0.5% having been used. Along the dark bands this probably drops to about 0.2% phosphorus. It is difficult to say whether this is more likely to be of bloomery or finery origin but, either way, the clear evidence for this nail having been made from a piece of rolled iron bar is indicative of an 18th century date.

Nails identified as belonging to the ceiling restoration of *c* 1830

Not only was this restoration much better documented but the nails associated with it have proved much easier to separate from the rest, particularly the type (like HM56 from the first of these reports) with their faceted or pyramidal heads, parallel wider side of shank and distinctive spade shaped ends. These have been found in large numbers and form the bulk of the nails identified from this phase of restoration. There were, however a few other nails that did not fit in to this category quite so readily. One of these (HM125) was examined and found to have the rolled, puddled iron microstructure so typical of the nails of this phase of restoration. Only the upper half of this nail was recovered, and it appeared to have a more irregularly shaped head than others of this phase but the head was very damaged so this may be misleading. Two nails identified as belonging to this phase of restoration, but unlike the spade ended type, were examined with this batch with the aim of helping to make other identifications to this phase more reliable.

10. **Phase IV, Position not known**: This well preserved nail (HM239) had a relatively small, but fairly regular pyramidal shaped head (13 mm across), the upper side of which had four facets. The shank too was very regular in shape and square in section, measuring approximately 4.5 mm across near the head, and all four sides tapering evenly down to the tip (Fig 33). The total length of this nail was 64 mm. Its overall regular shape, pyramidal head and generally well preserved nature is strongly suggestive of it belonging to the restoration of *c* 1830 although few nails of this form appear to have been used.

In section the structure was found not to be a simple rolled, puddled iron structure as was found for other nails of this 19th century phase of restoration. Instead a more complex structure dividing into three areas (or parts of the nail) was found although in each of these the structure was almost certainly one of puddled wrought iron demonstrating that this nail does indeed belong to this phase of restoration. This nail has almost certainly been made from at least three pieces of recycled puddled wrought iron (Fig 34). The head and very short length of shank (approximately 1 mm) is made of banded wrought iron reused so that the bands now run across the head, and in one place are actually folded, rather than running straight through it along the main axis of the shank as we would (now) expect for fresh rolled bar iron (Fig 35).

The rest of the section consists of two similar pieces of puddled wrought iron welded along a line running diagonally through the section of the shank (Figs 34 and 36). Neither of these two pieces has a banded structure as such although the heavy but relatively even concentration of non-metallic slag inclusions is indicative of its puddled (and therefore very late18th or 19th century) origin. Micro-analysis was not carried out on this nail although the generally medium to fine grain nature of the iron would suggest that the phosphorus content is generally relatively low (approximately 0.2% or less). As would be expected for puddled wrought iron no carbon is visible.

11. **Phase IV, Tie beam of *c*1830**: This was one of a group of six similar nails of a very distinctive type found, not forming any structural function, sprouting like a group of (horizontal) mushrooms sprouting from a tie beam of the *c*1830 phase of restoration. What they are doing there is something of a puzzle as no nails of this type have so far been noted in any part of the ceiling structure. It is too bulky a nail to have been used for fixing panels in position but nails of this type may have been intended for use part of the restored or reconstructed sub-structure to the ceiling but perhaps not used. Unlike any other nails examined from this ceiling this example had been made from a piece of iron bar circular in section and approximately 9mm in diameter. The head was roughly circular, quite thick and measured approximately 22 mm across. The nail was 67 mm long and most of the shank had been forged down from the original circular section to give four sides tapering down to a relative blunt tip (Fig 37).

Although not very pronounced there is a clear banded structure visible in section indicative of a rolled bar origin to the iron used for this nail (Fig 38). Unexpectedly the concentration of non-metallic slag inclusions was relatively low indicating this not to be a puddled wrought iron although the technology is unlikely to be much earlier as micro-analysis reveals the potash content of the iron silicate rich slag inclusions to be very low (Table 14), indicating the use of a reverbatory furnace of mid to late 18th century date if not later as would tend to be suggested by the very regular, circular profile of the unaltered part of the shank at the top. At higher magnification the pale bands were revealed to consist of large grain phosphoritic iron, with the slightly darker zones being not much different in actual structure and this was masked and appearance owing to (the now familiar watery looking) phosphorous 'ghosting' phenomenon indicating these to be zones slightly lower in phosphorus. A few irregular non-metallic slag inclusions, of both two and three phases, could also be seen (Fig 39).

Summary and conclusions

Overall the examples from each of the three groups of material examined for this report produced results which fitted well with what we know of the iron-making and iron-working for each of the periods involved, the *c* 1220 date of the original construction of the wood panelled nave ceiling, the reported but little known restoration which appears to have been carried out in the 1740's, and the better recorded restoration of *c* 1830.

It is now clear that the wooden panels were originally fixed in place, in nearly every case, with one of two types of nail, one of which had a slightly domed head and relatively delicate shank, either square or slightly rectangular in section. The other was one a slightly smaller flat head and a similar or slightly bigger shank in section. Most of these nails were within the range of 40-60 mm in length although some were found to be a little shorter. It would appear that the domed headed nail may have been more common towards the western end and the 'flat-headed' original type more common towards the eastern end but this would need confirming. The domed headed nails were found to have been made of either of plain or low carbon iron, or of phosphoritic iron and had relatively regular and roughly circular heads. In both cases their irregular structure was typical of bloomery manufacture which must, in any case, have been used at this early 13th century date.

By contrast the 'flat headed' original nails, of which five were examined in this phase of analytical work, were almost invariably found to have been made of inhomogeneous phosphoritic iron and their heads were smaller and more irregular in plan. The identification and division of nails into

these two groups has become much clearer now more nails of this construction phase have been examined.

The same generally speaking is true of nails identified as belonging to the poorly recorded restoration of the 1740's. Nails identified as belonging to this phase generally appear to be bigger than those used in the original construction, and even where the nails have been broken the shanks are usually bigger as well. Where complete most of these nails appear to be approximately 60 -75 mm in length. Many (?most) of them appear to have small, low pyramidal heads with four facets, but the heads of some of the nails used in this restoration appear to have been flatter but much less regular. However the four nails identified as belonging to this restoration and examined in this phase of analytical work were all identified as being of the small-headed pyramidal ('lost-headed square-shanked') type and all were found to have structures entirely consistent with their mid 18th century identification (from their contexts). In each case these nails were found to have been made from pieces cut off from a longer bar, shaped by passing through a rolling mill, a device which developed and became more effective for iron in the later 17th and 18th centuries (Singer, Holmyard *et al* 1957, 32 and 342).

Two more unusual nails identified as belonging to the restoration of *c*1830 were also examined in this phase of analytical work and both were found to have structures consistent with an earlier 19th century date, and one of these (HM239) was found to have been made of recycled iron of this period which probably explains the more hand made looking profile, unlike most of the panel fixing nails used in this later restoration. The other nail examined formed part of a group probably belonging to this phase even though they were not actually used in the restoration of *c*1830, and would have been much too bulky for fixing the wooden ceiling panels into position. This nail was examined for comparison with the others and its structure again appeared consistent with this phase of restoration work.

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Acknowledgements

In addition to the metallographic and assessment work reported above, the detailed composition of the metal and non-metallic slag inclusions of seven of the nails discussed in this report was determined using electron-probe micro-analysis (EPMA). This was carried out by Chris Salter of the Oxford University, Department of Materials, Begbroke Science and Business Park, Sandy Lane, Begbroke, Oxford and the results are included in this report as Tables 1 to 14 below (shown after the figures). In addition to determining the composition of the metal at selected points this work included the compiling of phosphorus maps to show the distributions of the different levels of phosphorus present although these are not reproduced here.

Fig 1. Surviving upper part of a flat-headed panel fixing nail (HM163) identified as belonging to the original nave ceiling construction of *c*1220; length of nail fragment 27 mm.

Fig 2. Longitudinal section through the upper part of this 'flat-headed original' nail (HM163) showing an uneven, blotchy looking structure typical of an inhomogeneous phosphoritic bloomery iron. Magnification x9; etched with 2% nital.

Fig 3. A complete flat-headed panel fixing nail (HM164) identified as belonging to the original nave ceiling construction of *c*1220; length of nail 57 mm.

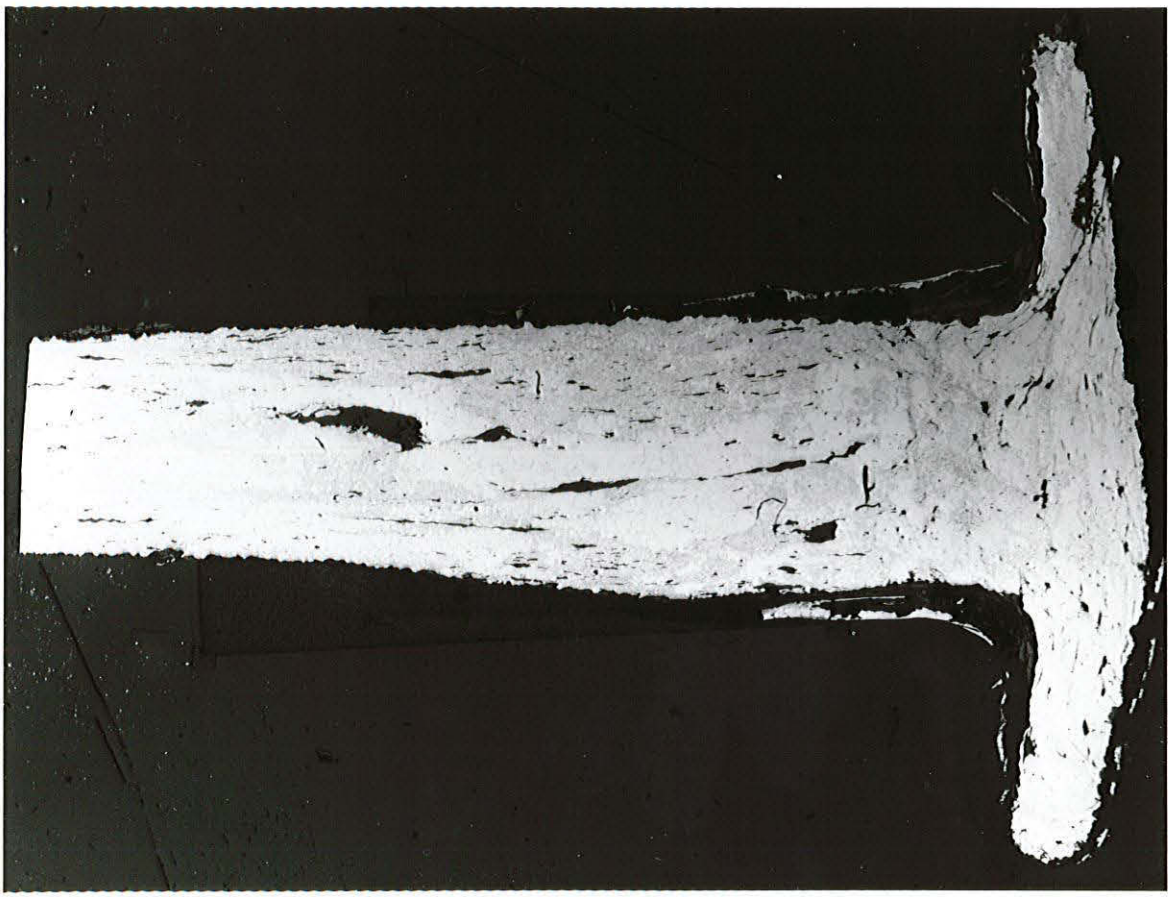

Fig 4. Longitudinal section through the upper part of this 'flat-headed original' nail (HM164) again showing an uneven, blotchy looking structure typical of an inhomogeneous phosphoritic bloomery iron. Magnification x9; etched with 2% nital.

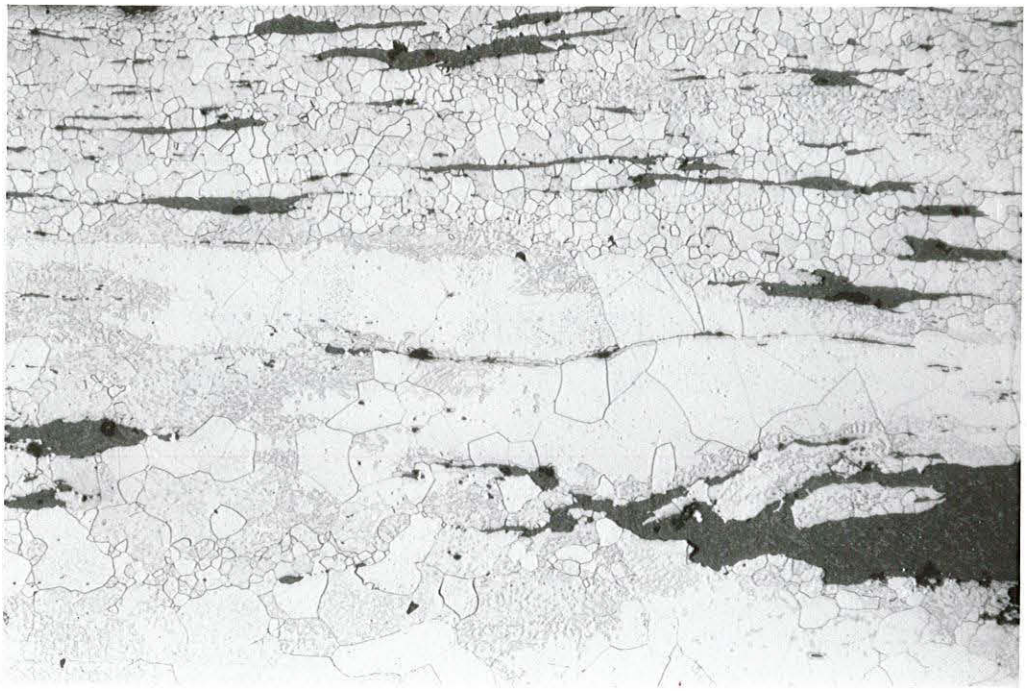

Fig 5. Detail of Fig 4 showing the very variable ferritic grain structure of this iron visible as large grain phosphoritic, areas of fine to medium grain less phosphoritic iron (lower half of this view) with intermediate areas of phosphorus ghosting (greyish patches here). Magnification x200; etched 2% nital.

Fig 6. Another complete flat-headed panel fixing nail (HM167) identified as belonging to the original nave ceiling construction of *c*1220; length of nail 60 mm.

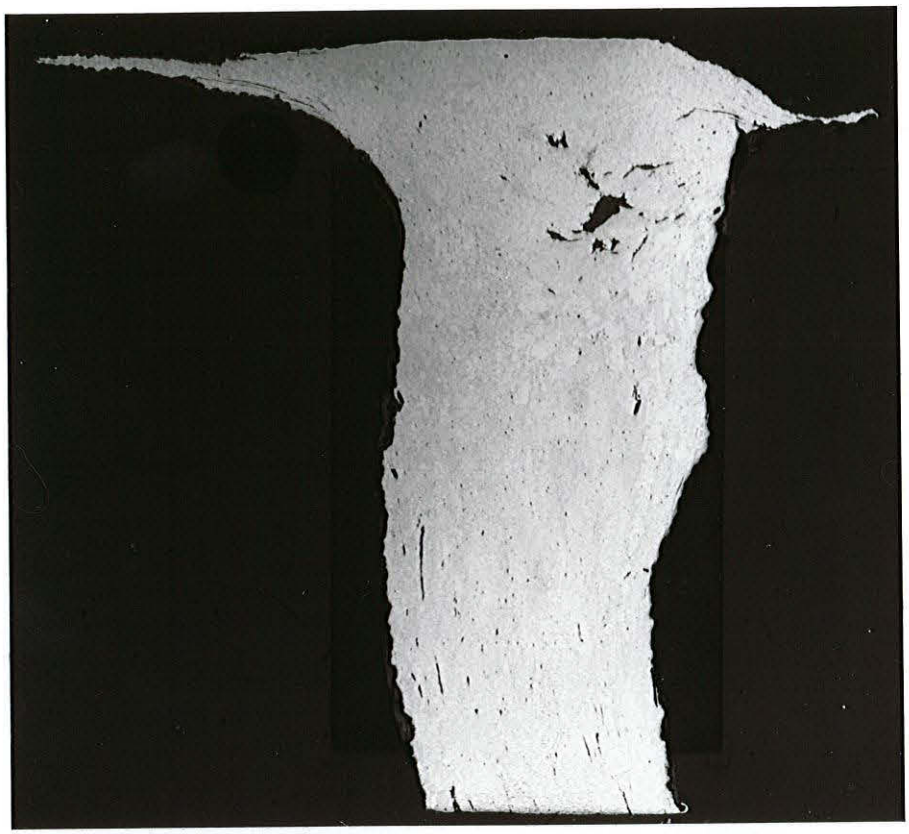

Fig 7. Longitudinal section through the upper part of this 'flat-headed original' nail (HM167) again showing an uneven, blotchy looking structure typical of an inhomogeneous phosphoritic bloomery iron. Magnification x9; etched with 2% nital.

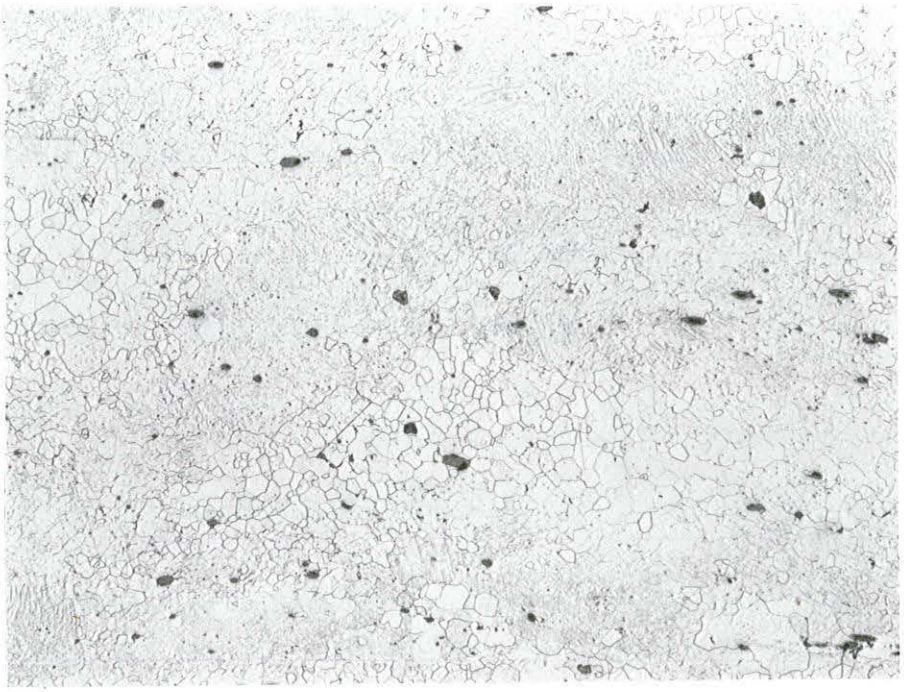

Fig 8. Detail of Fig 7 showing the very variable ferritic grain structure of this nail, this time the more readily visible areas are those of fine to medium grain iron with less phosphorus, large grain areas of phosphoritic iron in between being partially obscured here by phosphorus ghosting (again greyish patchy looking). Magnification x200; etched 2% nital

Fig 9. The surviving upper part of a smaller 'flat-headed original' panel fixing nail (HM168) identified as belonging to the nave ceiling construction of *c*1220; fragment 28 mm long.

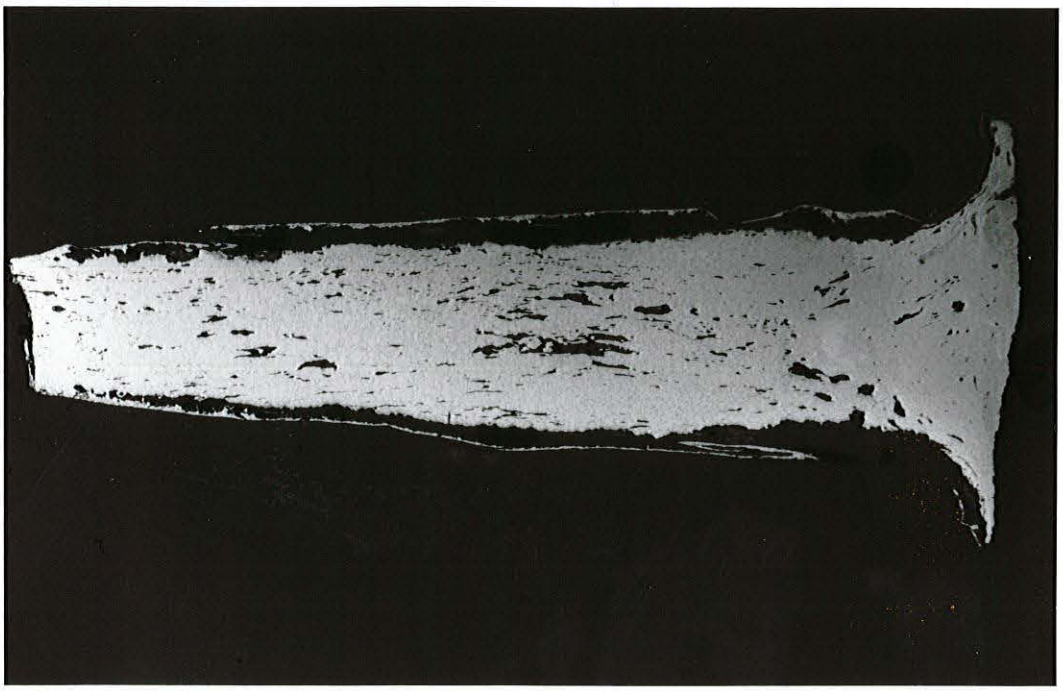

Fig10. Longitudinal section through the upper part of this 'flat-headed original' nail (HM168) with its much more even generally fine to medium grain iron structure along much of the section. Towards the head it becomes a more blotchy looking structure typical of an inhomogeneous phosphoritic bloomery iron. The overall content of non-metallic slag inclusions is high but irregular in its distribution. Magnification x9; etched with 2% nital.

Fig11. Detail of Fig 10 showing the more even medium grain ferritic grain structure along the shank of this nail, and also clearly visible was the higher content of non-metallic slag inclusions than was seen on the other three nails of this type examined in this phase of work (HM163, HM164 and HM167). Magnification x50; etched 2% nital.

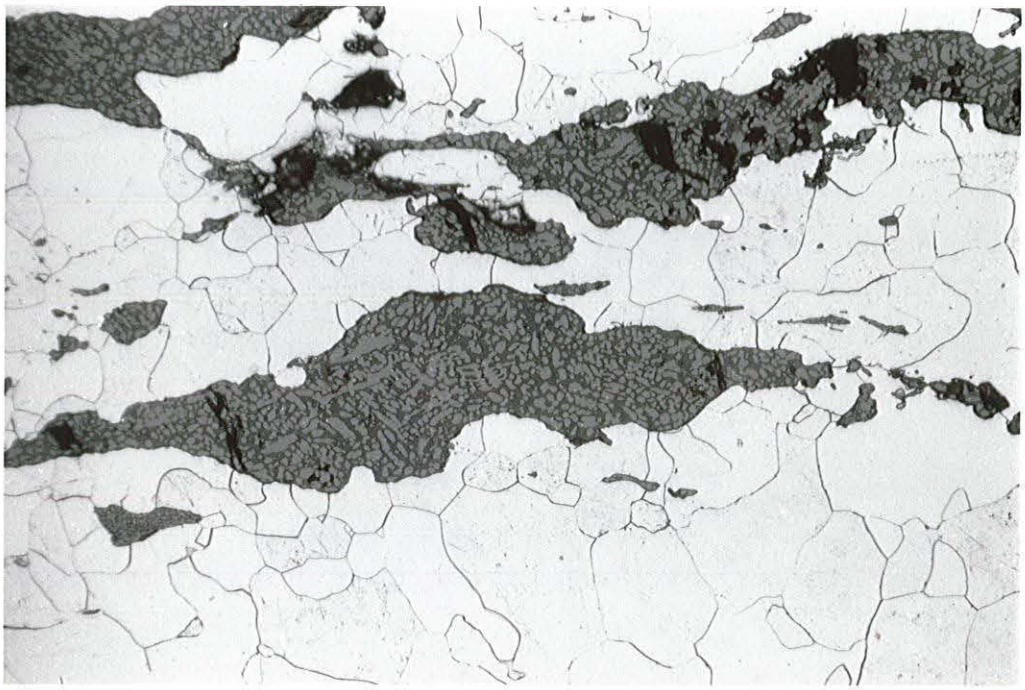

Fig12. Detail of Fig 11 showing the relatively even medium grain ferritic grain structure along the shank of this nail. Also clearly visible is a two phase - iron oxide (paler gray) and (probably) iron silicate structure in the irregularly shaped non-metallic slag inclusions, typical of much of the slag in this part of the nail. Magnification x200; etched 2% nital.

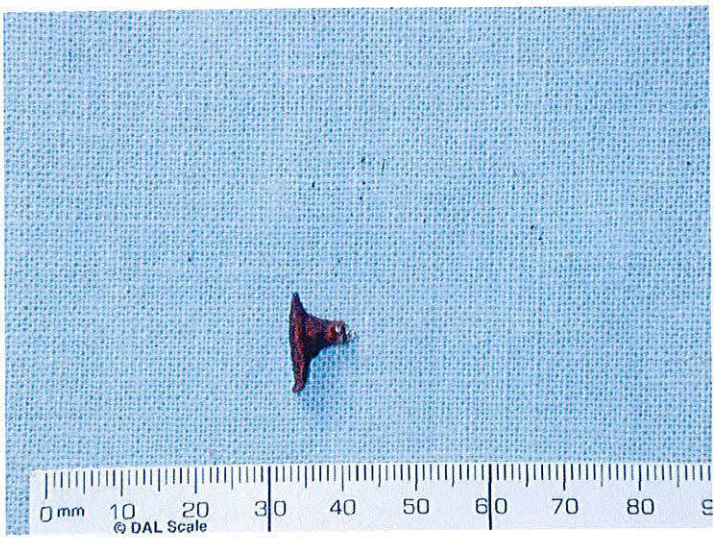

Fig13. The surviving upper end of a smaller 'flat-headed original' panel fixing nail (HM238) identified as belonging to the nave ceiling construction of *c*1220; fragment 9 mm long.

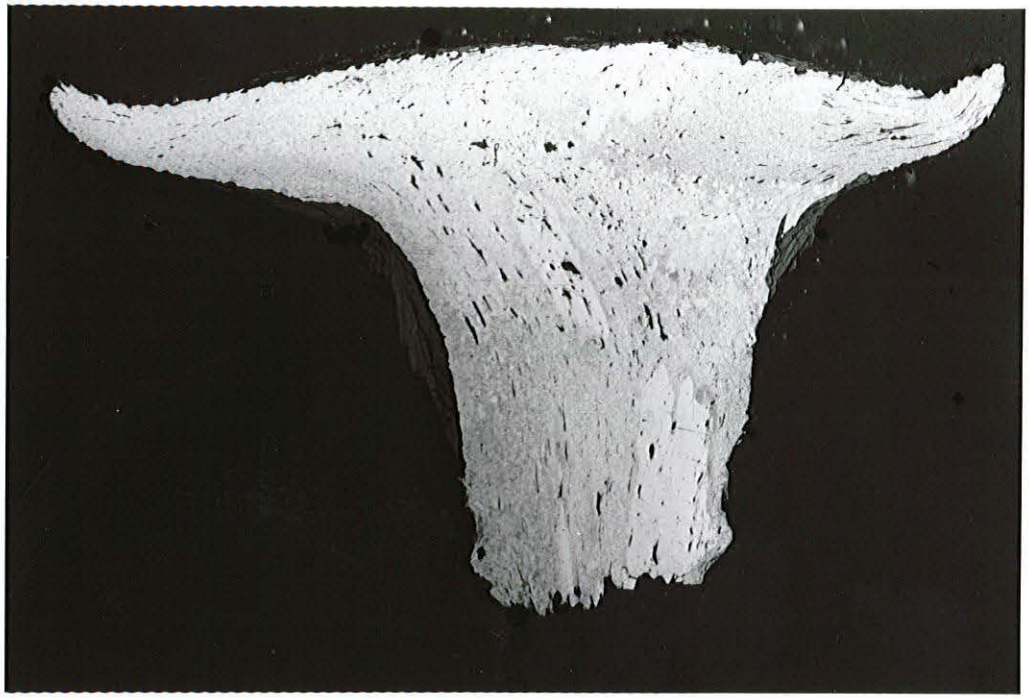

Fig14. Longitudinal section through the remaining upper part of this 'flat-headed original' nail (HM238) with its irregular iron structure, patchy looking at this low magnification, typical of an inhomogeneous phosphoritic bloomery iron. The overall content of non-metallic slag inclusions is also fairly typical in content for bloomery iron as is their irregular distribution. Magnification x9; etched with 2% nital.

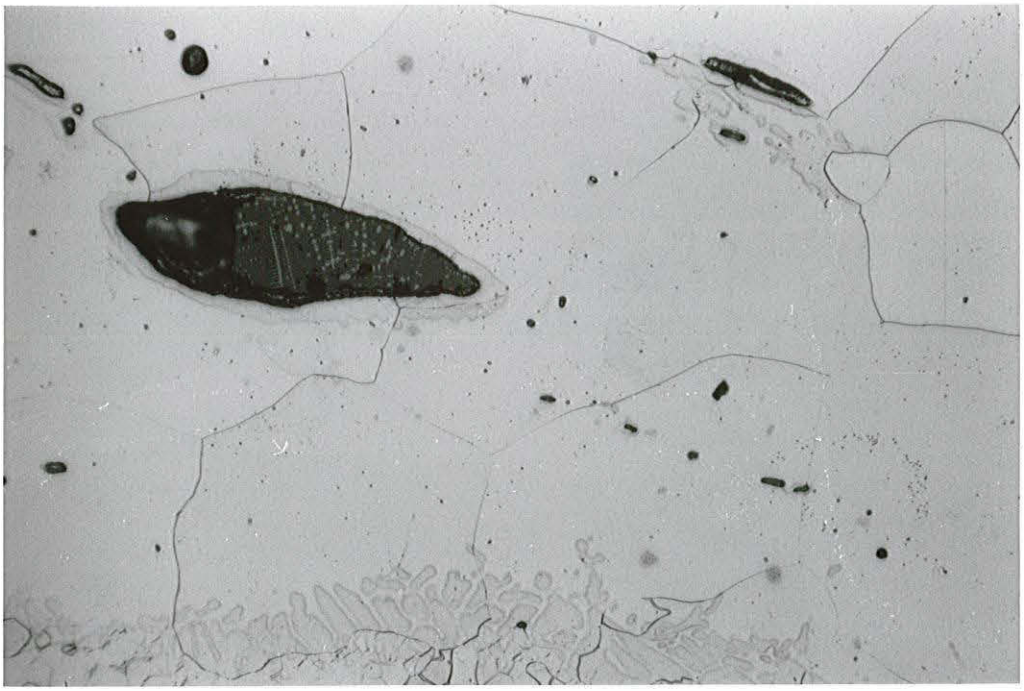

Fig15. Detail of Fig 14 showing the typical very large ferrite grain structure of a phosphoritic area of the shank of this nail. Also clearly visible is one larger two phase non-metallic slag inclusion and several very small slag inclusions. An area of (watery looking) phosphorus ghosting, marking the boundary zone between this area and the less phosphoritic adjacent area is visible along the lower part of this view Magnification x200; etched 2% nital.

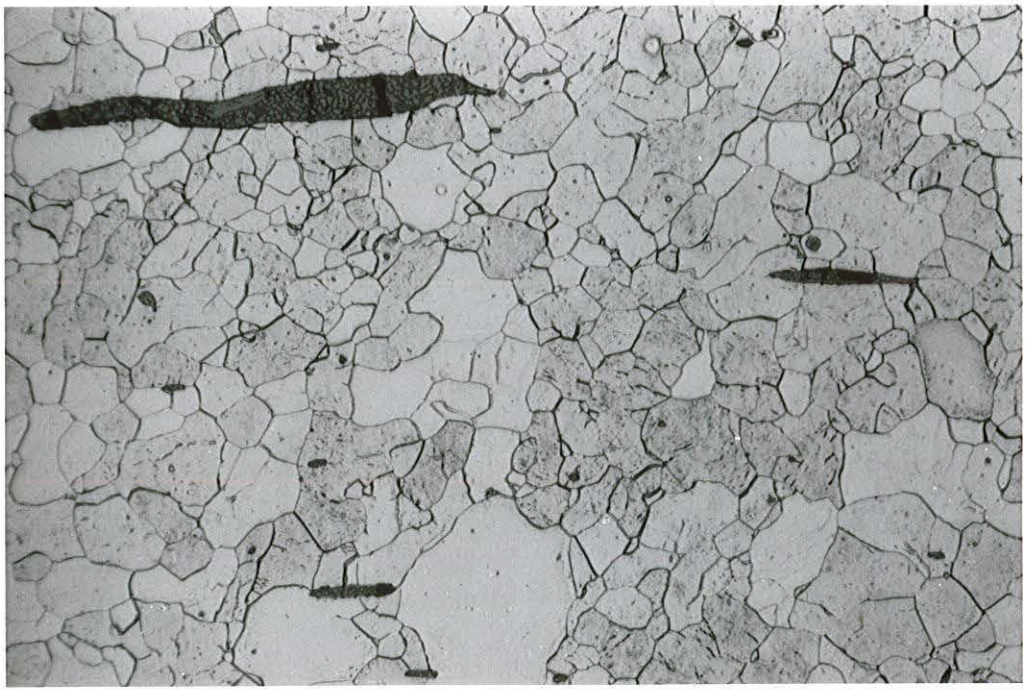

Fig16. Detail of Fig 14, showing an adjacent part of the shank to that seen in Fig 15, showing the medium to fine grain ferritic grain structure in this area. Two-phase non-metallic slag inclusions are again visible although in this area the proportion of the paler iron oxide phase is greater. Magnification x200; etched 2% nital.

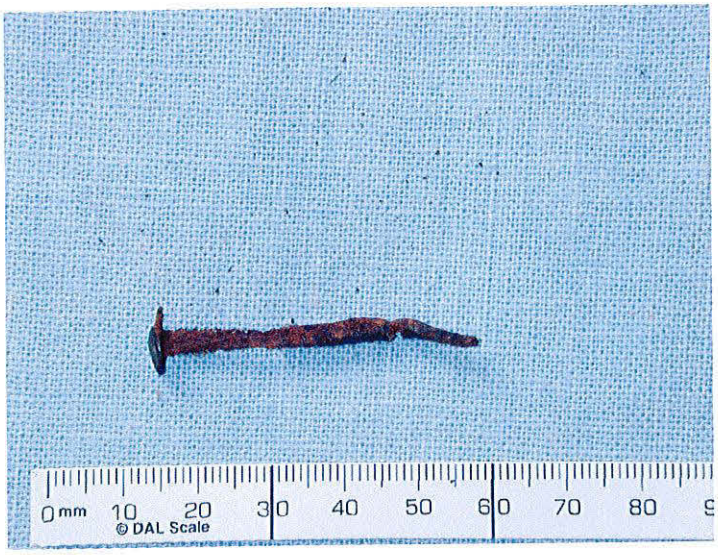

Fig17. A complete but corroded 'lost head, square shank' nail (HM165) with a small pyramidal head with four facets and (despite the name) a slightly rectangular shank. Identified as belonging to the restoration of the 1740's. Length of nail 45 mm.

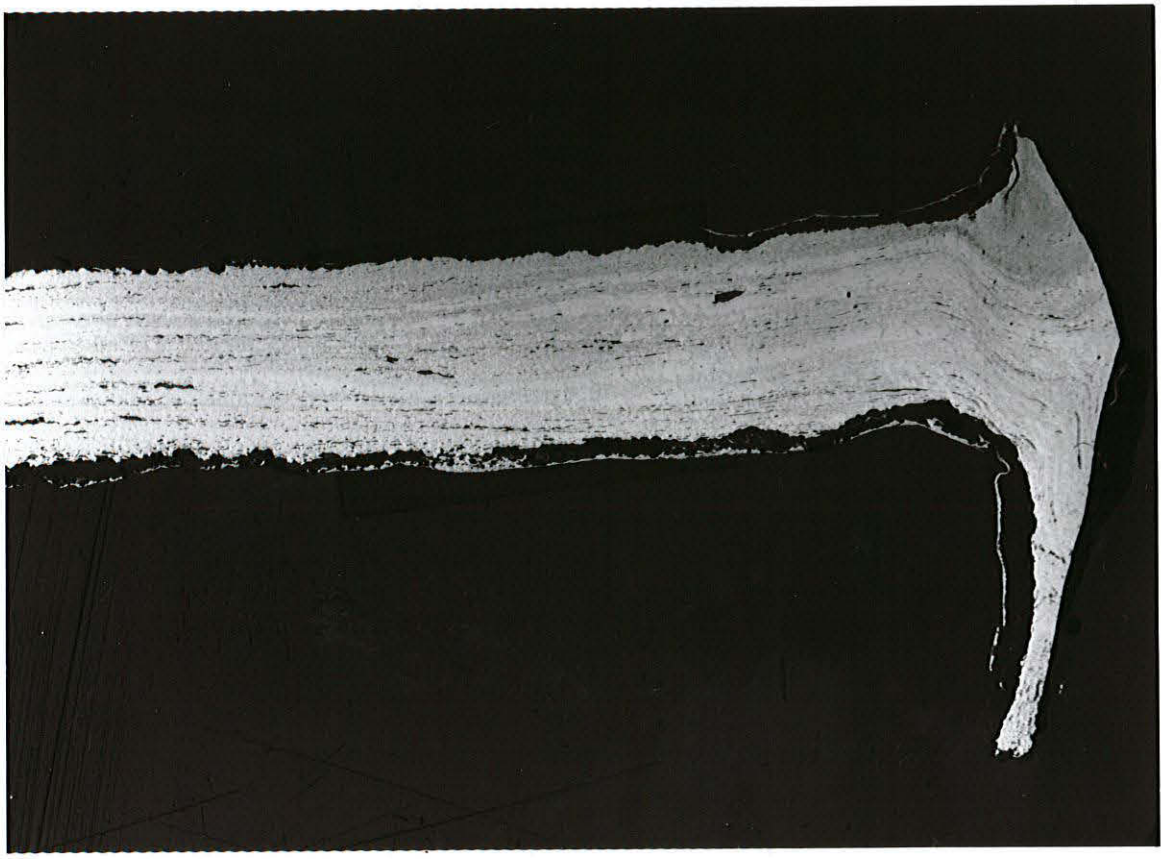

Fig18. Longitudinal section through the upper part of this 'lost head, square shank' nail (HM165) with its distinctive faceted head. Also very clear at this low magnification is its banded structure typical of an inhomogeneous iron that has been through a rolling mill as part of the production process. The overall content of non-metallic slag inclusions is relatively high but relatively evenly distributed, and the overall appearance is similar to puddled iron although the slag content probably lower. Magnification x9; etched with 2% nital.

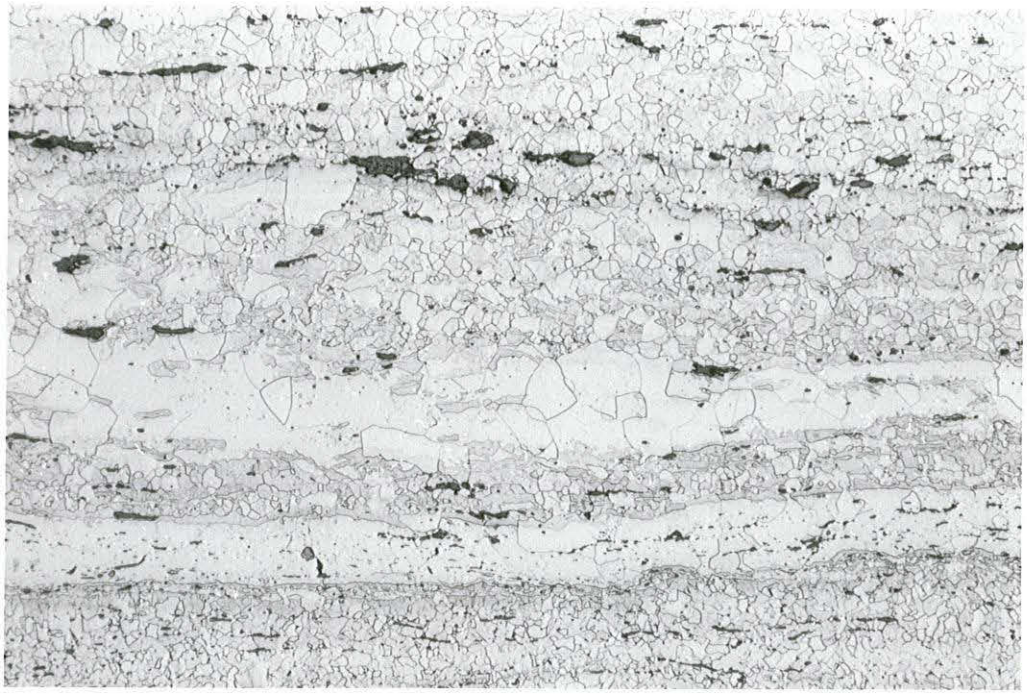

Fig19. Detailed view of part of the banded structure seen at low magnification (in Fig 18) showing the (mostly) narrower pale bands to consist of large grain phosphoritic iron, the banded effect accentuated by phosphorus ghosting along the margins with the medium to fine grain iron bands which are low in phosphorus. Little or no carbides are visible and the carbon content is clearly very low. Magnification x50; etched 2% nital.

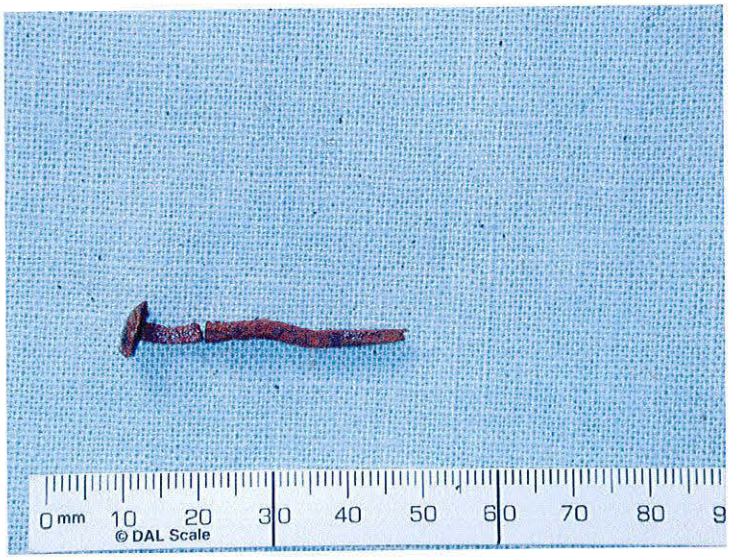

Fig20. A nearly complete although damaged 'lost head, square shank' nail (HM166) again with a small pyramidal head with four facets and a slightly rectangular shank. Identified as belonging to the restoration of the 1740's. Length of surviving nail 39 mm.

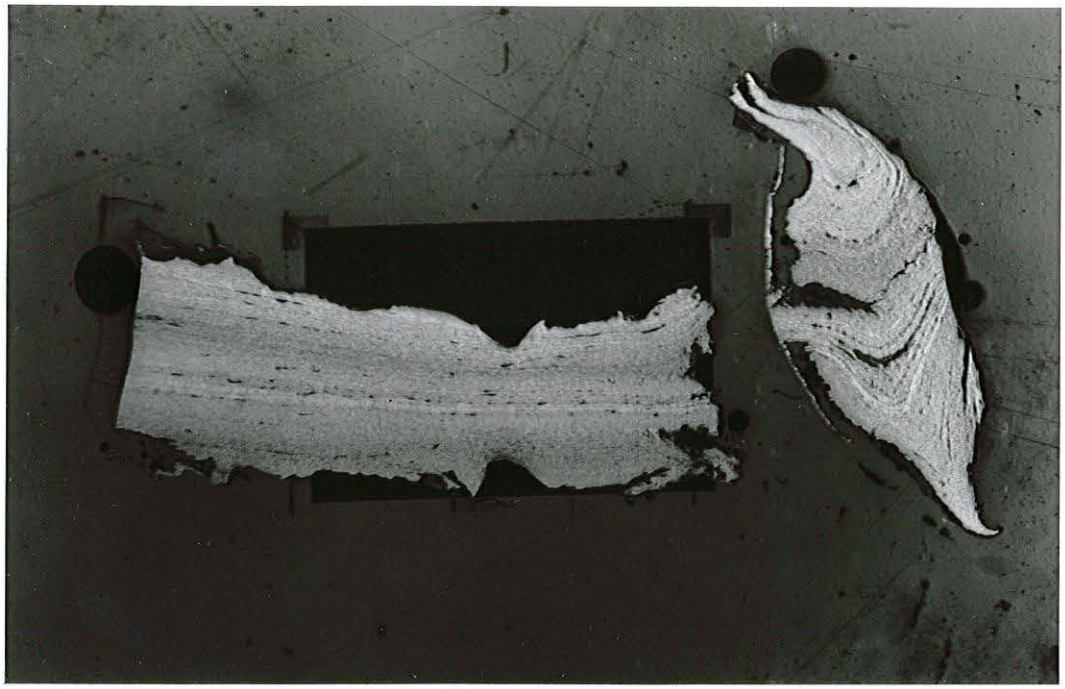

Fig21. Longitudinal section through the upper part of this 'lost head, square shank' nail (HM166) with its distinctive faceted head. Very different to the previous example the slightly banded structure but generally grey appearance at low magnification this time probably representing a relatively homogeneous, low carbon bloomery iron that has been through a rolling mill as part of the production process. Magnification x9; etched with 2% nital.

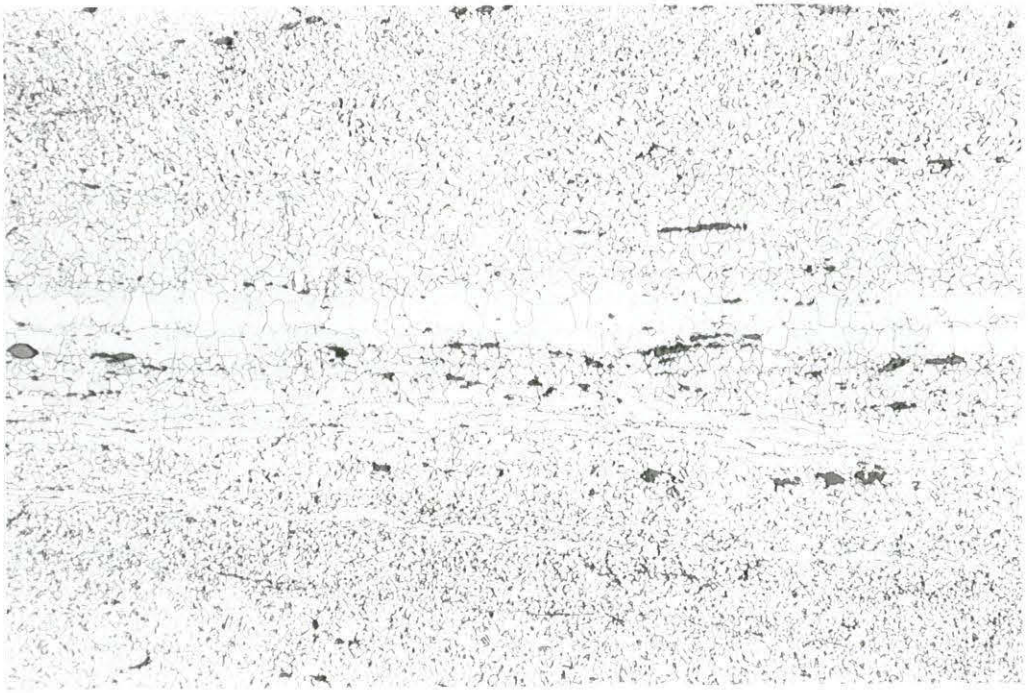

Fig22. Detail of part of the shank visible in Fig 21, showing the structure to be one of a generally fine grain, slightly inhomogeneous low carbon iron, the pale, medium grain bands (with no visible carbon) probably representing areas of the original iron locally enriched in phosphorus. Some unevenly distributed, small single medium grey single (probably silicate) phase non-metallic inclusions are also visible. Magnification x50; etched 2% nital.

Fig23. The surviving upper part of a 'lost head, square shank' nail (HM236) again with a small pyramidal head with four facets and a slightly rectangular shank. Identified as belonging to the restoration of the 1740's. Length of surviving nail 32 mm.

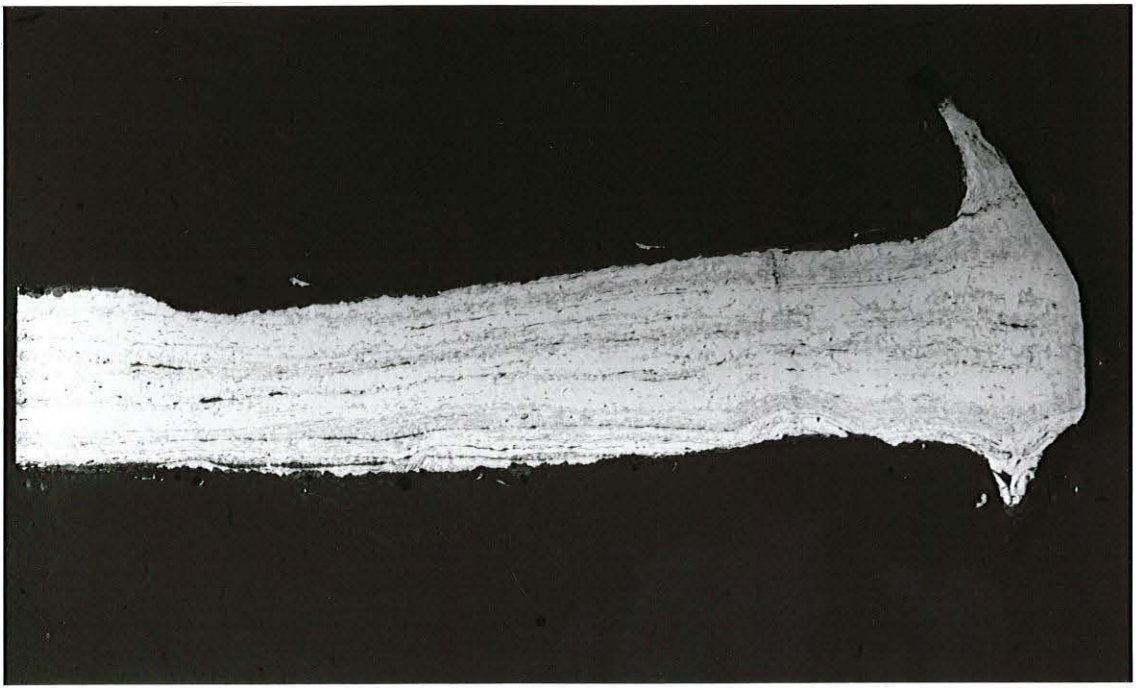

Fig24. Longitudinal section through the upper part of this 'lost head, square shank' nail (HM236) again with its distinctive faceted head. The regular banded structure is very similar to that seen in another of this group of nails (HM165) and again is likely to be the highly 'stretched-out' result of an inhomogeneous iron that has been through a rolling mill as part of the production process. Magnification x9; etched with 2% nital.

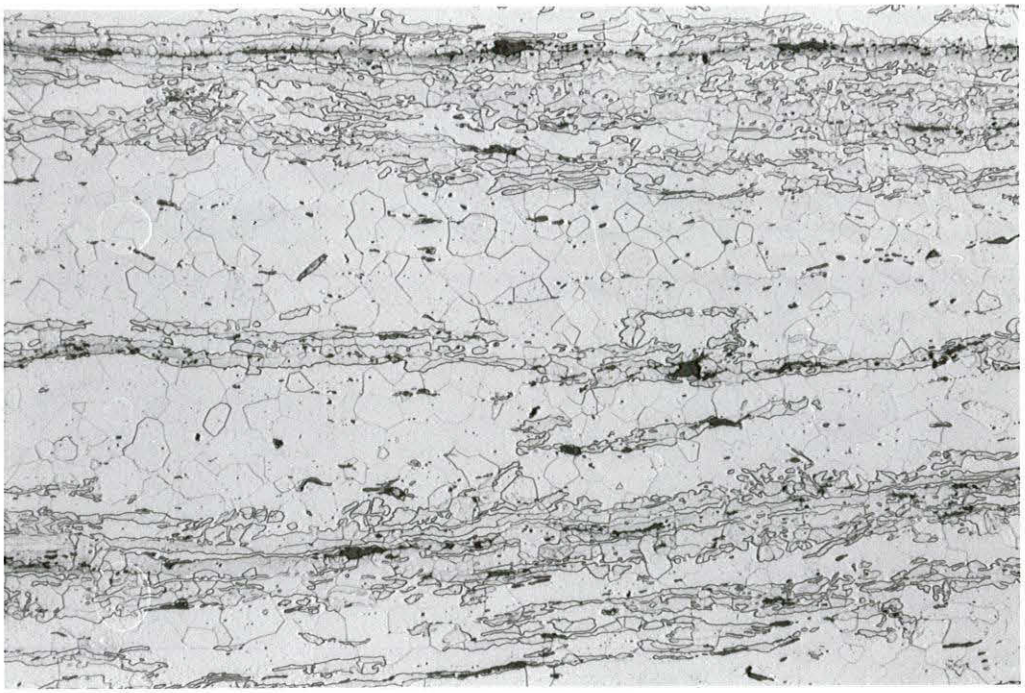

Fig25. Detailed view of the banded structure seen in section above (HM236), showing the large grain phosphoritic pale bands which occupy much of the section, these contrasting with the intermediate bands where the grain size is smaller and which also show phosphorus ghosting (where the phosphorus content is less). Magnification x50; etched 2% nital.

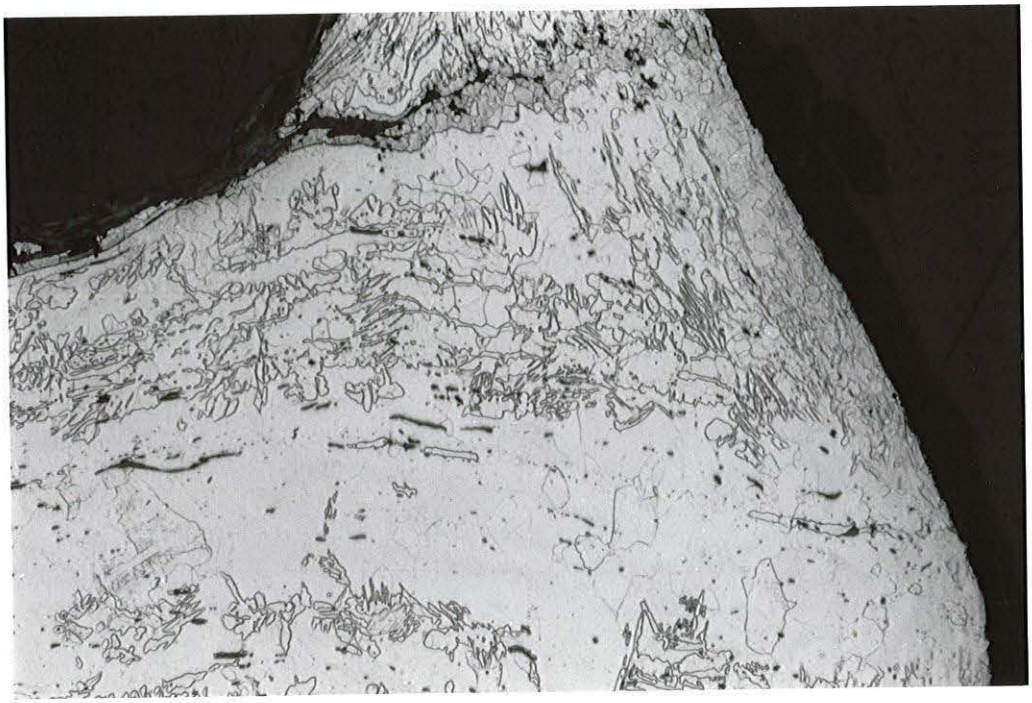

Fig26. Further along the section (of HM236) the same banded structure visible in the previous view (Fig 26), is seen here to continue little changed through the head of the nail. Magnification x50; etched 2% nital.

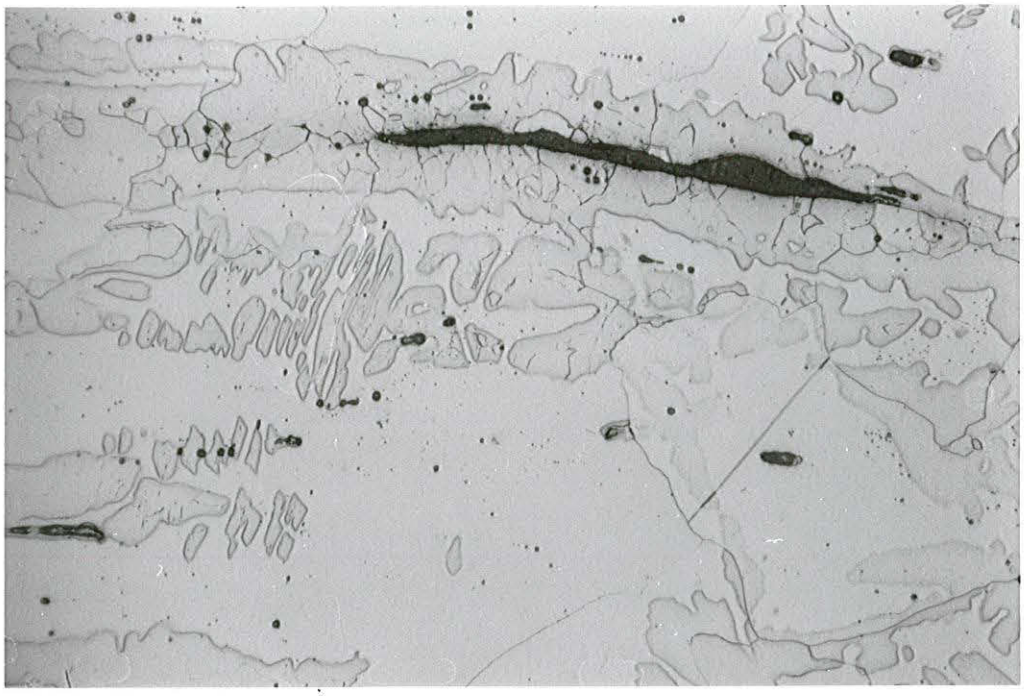

Fig27. Detailed view of the structure in part of the shank of the same nail (HM236) showing part of one of the pale, large grain phosphoritic iron bands (over much of the lower part of this view) and a finer grain area lower in phosphorus surrounding a larger ribbon-like slag inclusion near the top of this view. In the in-between areas of intermediate phosphorus content the grain structure of the metal is obscured by a watery looking structure characteristic of phosphorus ghosting. Magnification x200; etched 2% nital.

Fig28. The surviving upper part of a 'lost head, square shank' nail (HM237) again with a small (damaged) pyramidal head with four facets, and a slightly rectangular shank. Identified as belonging to the restoration of the 1740's. Length of surviving nail 24 mm.

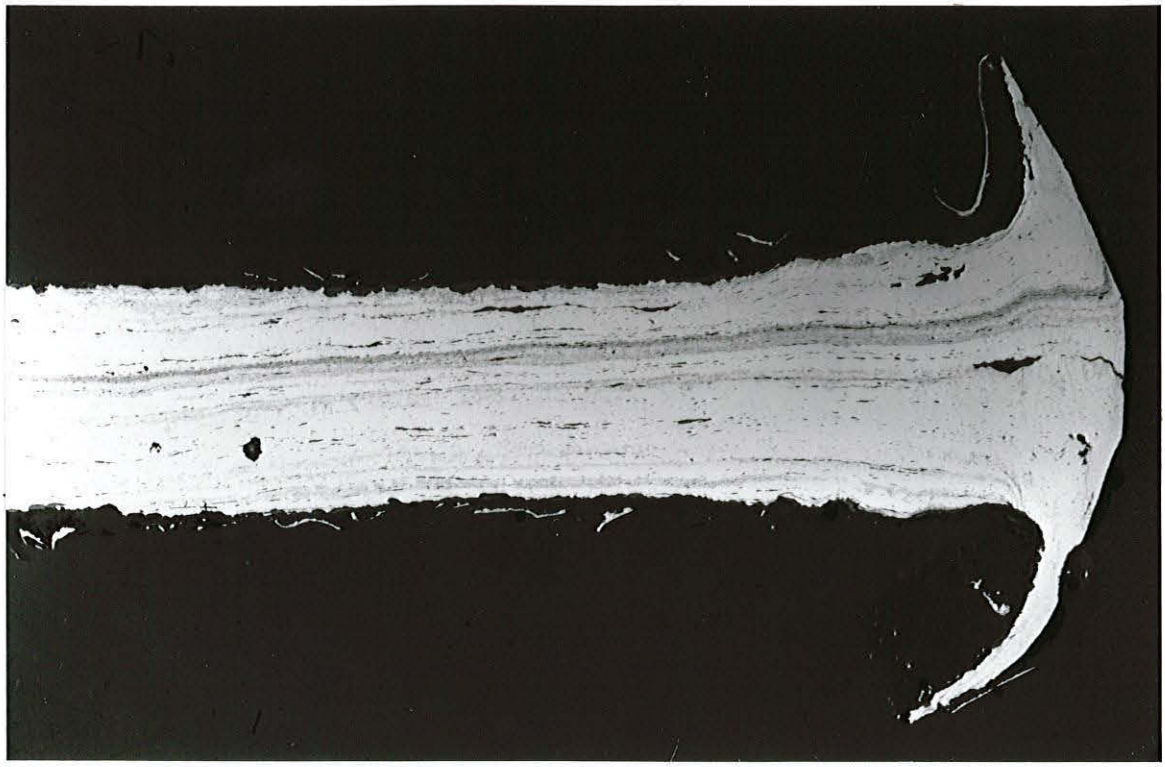

Fig29. Longitudinal section through the upper part of this 'lost head, square shank' nail (HM237) again with its distinctive faceted head, now more rounded through damage. A regular banded structure is again seen running along the shank and through the head. Again this is characteristic of the highly 'stretched-out' result of an inhomogeneous iron from a rolling mill as part of the production process. Magnification x9; etched with 2% nital.

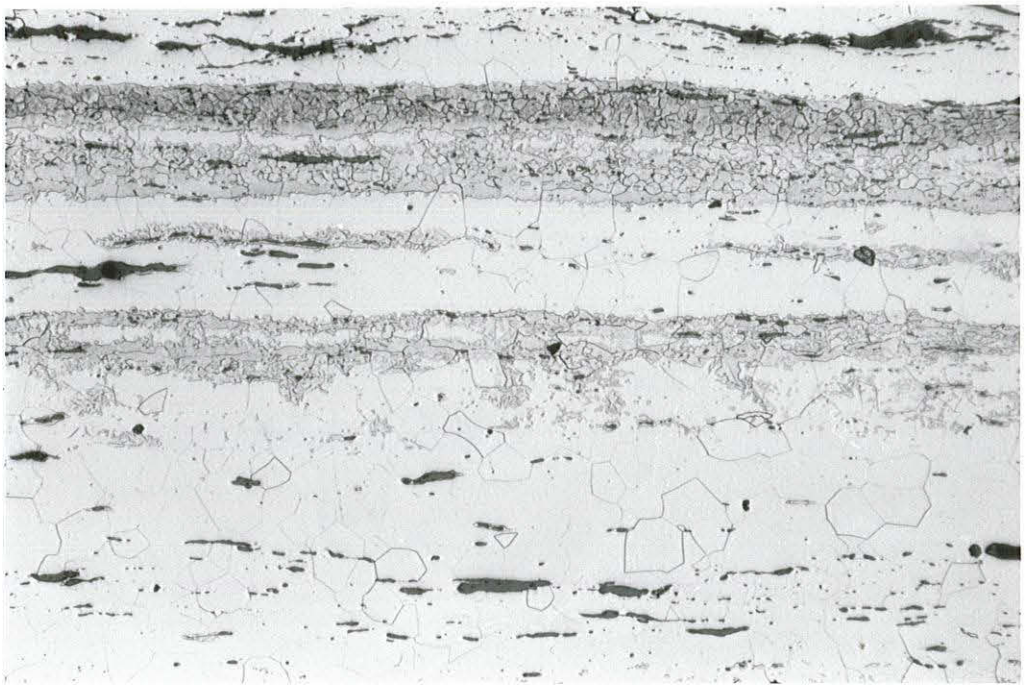

Fig30. Detailed view of the banded structure seen in section above (HM237), showing the very regular banded structure with large grain phosphoritic iron forming the wider pale bands, and relatively fine grain ferrite (much lower in phosphorus) forming the narrower grey bands. The borders (and hence visual contrast) between these bands is accentuated by areas, and some continuous lines of the phosphorus ghosting effect typical of zones with an intermediate phosphorus content. Magnification x50; etched 2% nital.

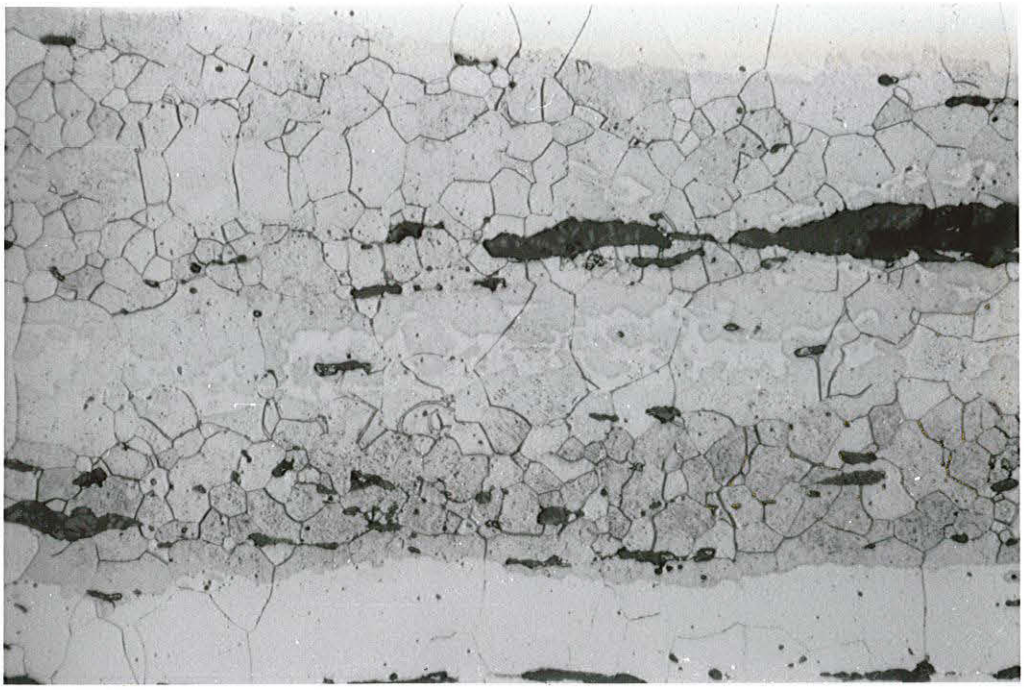

Fig31. Detailed view at higher magnification across one of the narrower, finer grained grey bands visible in the previous view. The border between this and the pale, large grained phosphoritic bands (top and bottom here) is marked by a more or less continuous phosphorus ghosting line. The watery looking areas visible in the grey central band here are more isolated areas (of localised phosphorous enrichment) showing the phosphorus ghosting effect. Magnification x200; etched 2% nital.

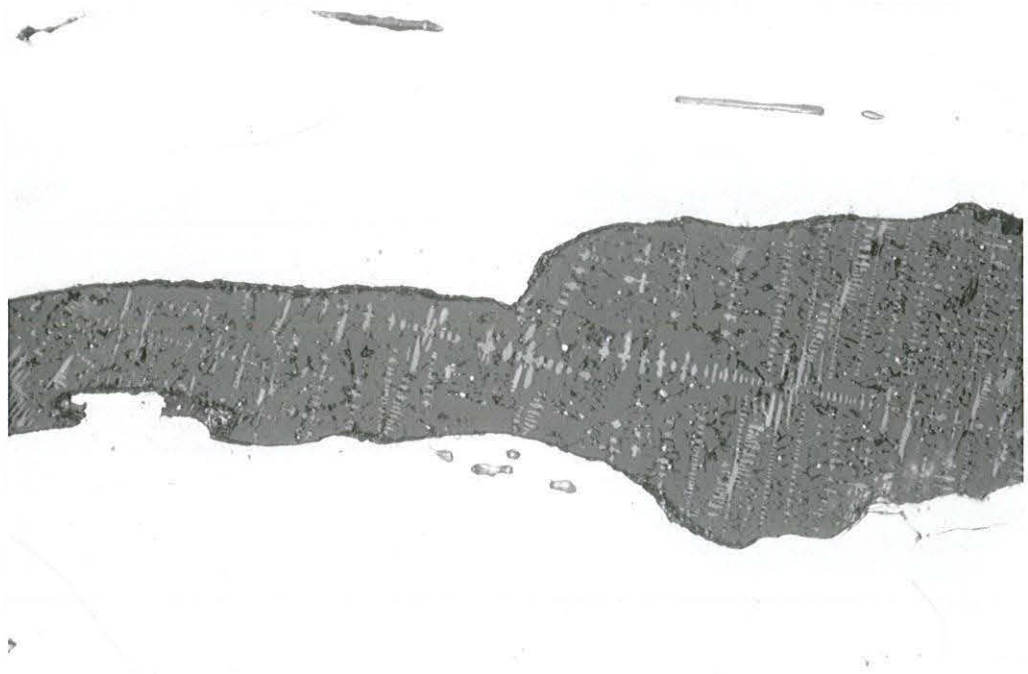

Fig32. Detail of one of the large grain, pale phosphoritic bands visible in this same section (of HM237) showing one relatively large non-metallic slag inclusion with a three-phase structure with iron oxide (fir tree-like) dendrites visible against a mainly medium grey matrix, probably of iron silicate, plus specks of a darker grey, probably glassy constituent. Smaller inclusions like this are visible elsewhere. Magnification x400; etched 2% nital.

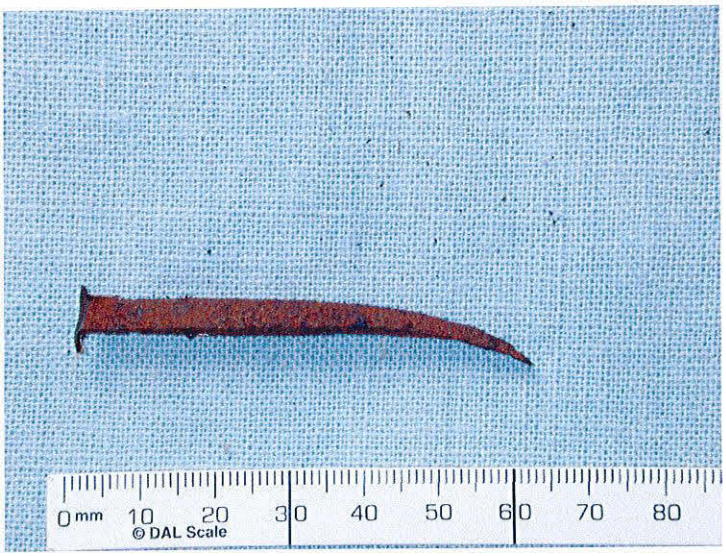

Fig33. A complete nail (HM239) which is well preserved except for damage to the smallish pyramidal head which has four facets. Unlike others of this date the shank is more or less square in cross-section. It belongs to the restoration of *c*1830 and its length is 64 mm.

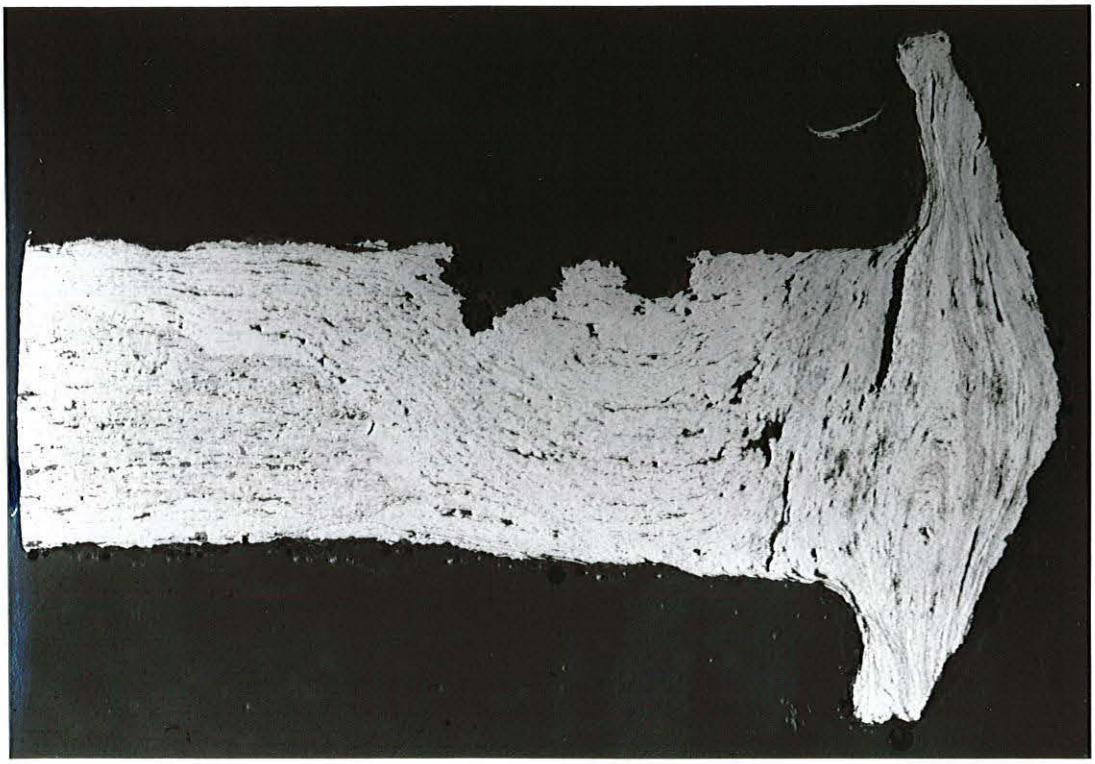

Fig34. Longitudinal section through the upper part of this pyramidal-headed nail (HM239). The very high slag content and its even fairly distribution is indicative of a puddled wrought iron but its convoluted and unevenly, partially banded structure suggests the use of recycled metal here. A probable weld zone can be seen running diagonally (lower right to upper left) across this part of the shank. Magnification x9; etched with 2% nital.

Fig35. Detail showing the convoluted forged structure visible in the head of the nail. Magnification x50; etched 2% nital.

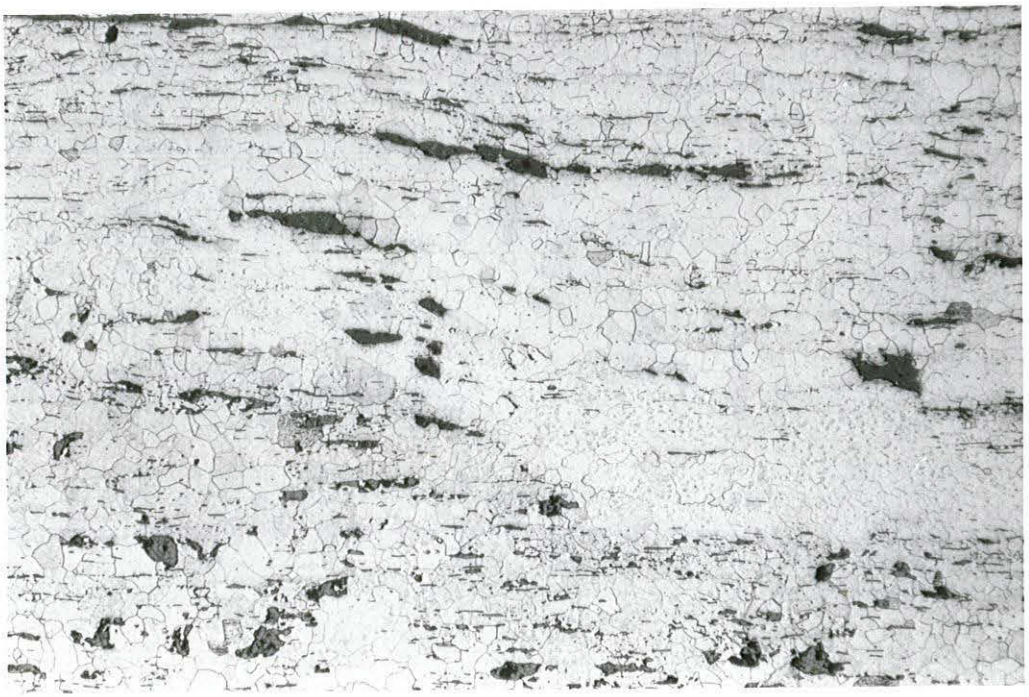

Fig36. Detail of the probable weld zone running diagonally (lower right to upper left) across this part of the shank. Magnification x50; etched 2% nital.

Fig37. A heavy duty nail, one of a group of six found protruding from a part of the ceiling support framework inserted during the restoration of *c*1830. Length of nail 67 mm.

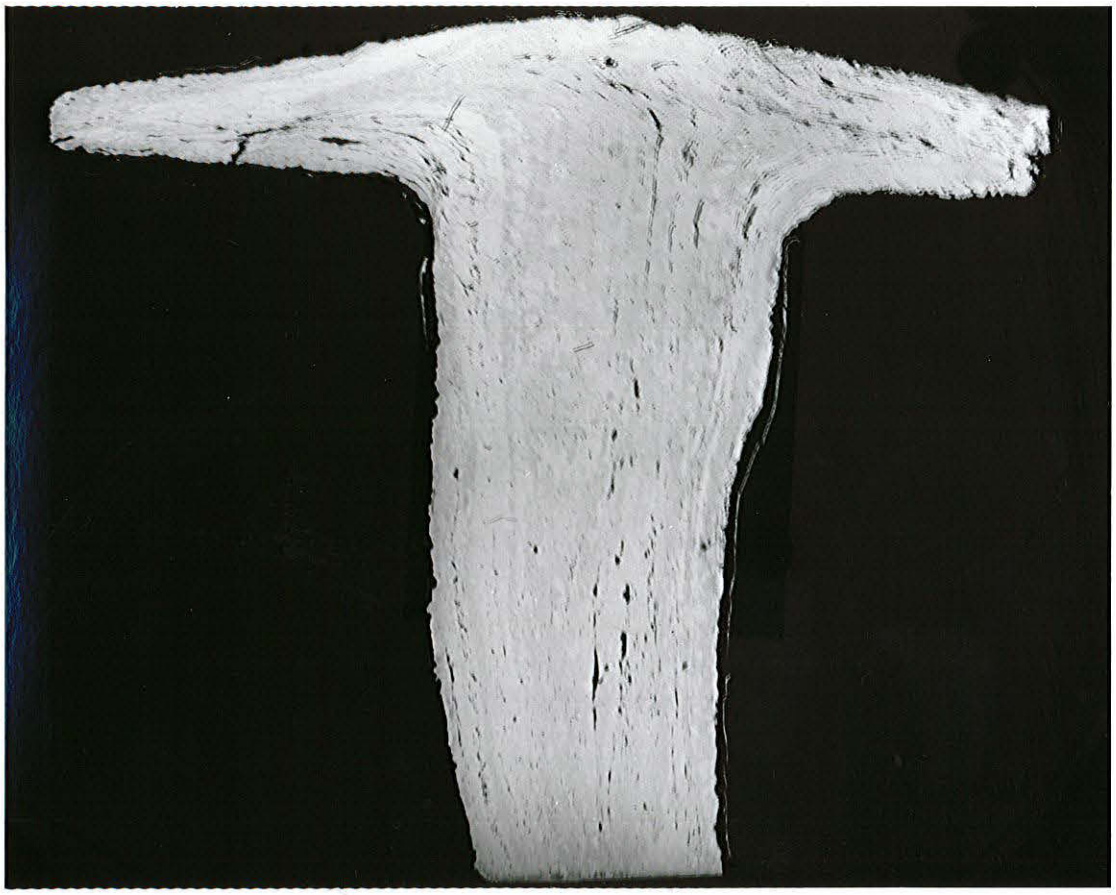

Fig38. Longitudinal section through the upper part of this heavy duty nail (HM169) with its thick shallowly domed head. It shows an evenly banded, slightly inhomogeneous iron macro-structure, the likely product of a rolling mill. Magnification x6; etched 2% nital.

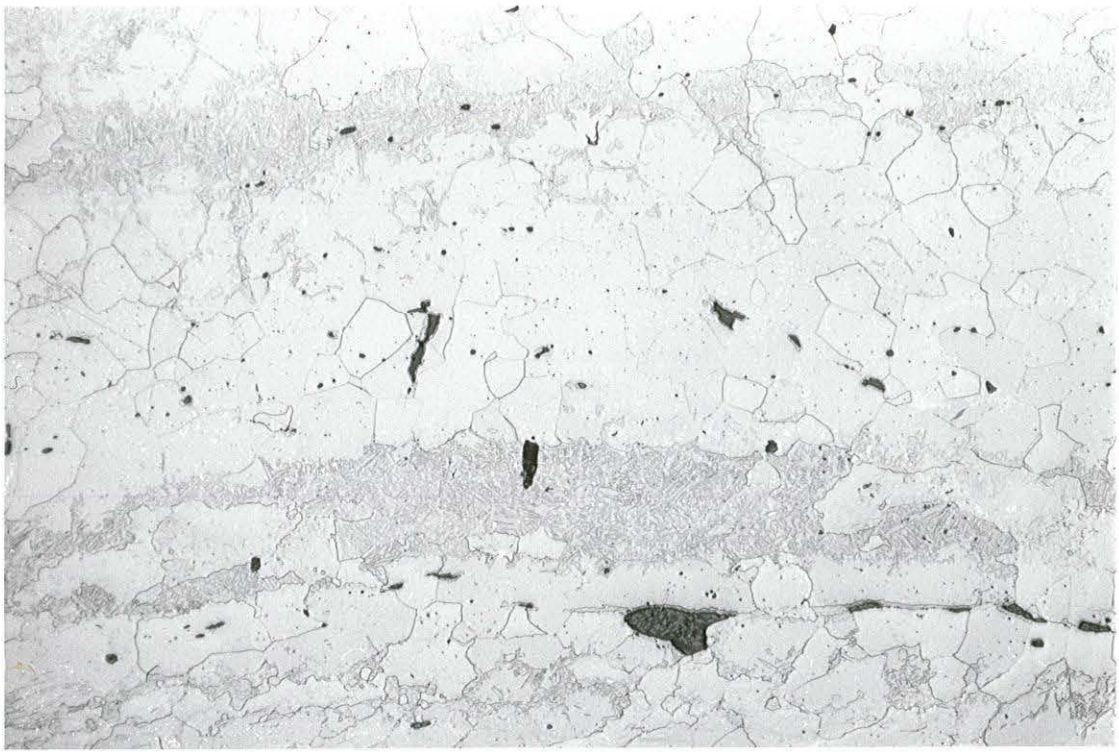

Fig39. Detail of part of the structure seen in the shank of this same nail. It shows pale bands of large grain phosphoritic iron bordered by narrower grey bands whose appearance is due, not to the underlying iron grain structure which is little different, but to the effect of phosphorus ghosting which has a typically watery appearance here, these areas being slightly lower in phosphorus content. Magnification x200; etched 2% nital.

Results of electron-probe micro-analysis (EPMA) by Chris Salter

Table 1: Small flat-headed nail HM163 [c1220]: Composition of the metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Fe	Total	Comment
1	0.001	0.003	0.315	0.008	0.000	0.001	0.000	0.000	0.005	0.004	0.029	0.009	0.079	99.546	100.000	HM163 A 1
2	0.000	0.002	0.181	0.005	0.000	0.000	0.000	0.004	0.000	0.002	0.024	0.000	0.075	99.707	100.000	HM163 A 2
3	0.000	0.003	0.283	0.008	0.000	0.000	0.002	0.000	0.006	0.000	0.020	0.000	0.075	99.603	100.000	HM163 A 3
4	0.000	0.001	0.445	0.005	0.001	0.000	0.003	0.001	0.016	0.000	0.029	0.000	0.075	99.424	100.000	HM163 A 4
5	0.000	0.002	0.350	0.004	0.000	0.000	0.000	0.006	0.012	0.000	0.021	0.000	0.072	99.533	100.000	HM163 A 5
6	0.000	0.001	0.189	0.000	0.000	0.007	0.001	0.004	0.000	0.000	0.025	0.000	0.066	99.707	100.000	HM163 A 6
7	0.000	0.003	0.333	0.006	0.000	0.001	0.000	0.000	0.000	0.000	0.012	0.000	0.071	99.574	100.000	HM163 A 7
Minimum	0.000	0.001	0.181	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.066	99.424	100.000	
Maximum	0.001	0.003	0.445	0.008	0.001	0.007	0.003	0.006	0.016	0.004	0.029	0.009	0.079	99.707	100.000	
Average	0.000	0.002	0.299	0.005	0.000	0.001	0.001	0.002	0.006	0.001	0.023	0.001	0.073	99.585	100.000	
Sigma	0.000	0.001	0.093	0.003	0.000	0.003	0.001	0.002	0.006	0.002	0.006	0.003	0.004	0.100	0.000	

Table 2: Small flat-headed nail HM163 [c1220]: Composition of the non-metallic inclusions (oxide by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	NiO	CuO	SrO	BaO	Total	Comment
1	0.351	0.419	3.048	21.857	4.407	0.399	0.000	1.137	2.110	0.214	0.011	0.003	0.235	62.445	0.028	0.033	0.000	0.055	0.263	97.015	HM163 A Inclusion 1
2	0.345	0.434	3.017	22.331	5.572	0.357	0.000	1.249	2.217	0.121	0.018	0.093	0.281	60.887	0.000	0.000	0.023	0.000	0.144	97.089	HM163 A Inclusion 2
3	0.435	0.365	2.946	20.535	10.473	0.579	0.000	1.464	2.561	0.082	0.011	0.014	0.291	56.121	0.000	0.000	0.121	0.014	0.078	96.090	HM163 A Inclusion 4
4	0.312	0.415	2.954	21.394	4.532	0.360	0.015	1.061	2.019	0.159	0.071	0.000	0.375	61.247	0.000	0.016	0.000	0.032	0.198	95.157	HM163 A Inclusion 5
5	0.329	0.368	2.883	20.469	5.938	0.694	0.021	1.110	1.970	0.139	0.053	0.070	0.284	62.745	0.000	0.039	0.000	0.000	0.099	97.206	HM163 A Inclusion 6
6	0.324	0.459	2.787	22.255	4.655	0.336	0.000	0.981	2.010	0.197	0.014	0.000	0.321	59.962	0.011	0.114	0.102	0.000	0.033	94.561	HM163 A Inclusion 7
7	0.319	0.405	2.946	21.536	4.161	0.382	0.000	1.151	2.067	0.169	0.000	0.020	0.369	62.325	0.056	0.094	0.062	0.000	0.197	96.259	HM163 A Inclusion 3
8	0.384	0.424	2.984	21.118	4.145	0.426	0.004	1.159	2.010	0.152	0.045	0.017	0.375	62.298	0.000	0.000	0.000	0.043	0.109	95.692	HM163 A Inclusion 3
9	0.385	0.375	3.282	23.738	6.275	0.658	0.000	1.159	2.321	0.088	0.007	0.000	0.357	57.693	0.009	0.000	0.071	0.000	0.178	96.596	HM163 A Inclusion 8
10	0.399	0.393	3.096	22.680	5.804	0.540	0.000	1.312	2.305	0.149	0.000	0.048	0.299	60.403	0.000	0.000	0.024	0.000	0.044	97.496	HM163 A Inclusion 9
11	0.320	0.438	2.877	21.835	6.088	0.495	0.000	1.048	2.330	0.144	0.011	0.026	0.305	61.233	0.000	0.029	0.035	0.000	0.210	97.424	HM163 A Inclusion 10
12	0.243	0.180	1.515	13.418	23.252	1.116	0.000	1.201	0.994	0.080	0.119	0.062	0.769	56.526	0.006	0.000	0.000	0.000	0.065	99.546	HM163ai 11
13	0.000	0.035	0.125	0.199	0.061	0.000	0.137	0.002	0.082	0.018	0.000	0.000	0.020	0.775	0.000	0.000	0.000	0.041	0.157	1.621	HM163ai paint
Minimum	0.000	0.035	0.125	0.199	0.061	0.000	0.000	0.002	0.082	0.018	0.000	0.000	0.020	0.775	0.000	0.000	0.000	0.000	0.033	1.621	
Maximum	0.435	0.459	3.282	23.738	23.252	1.116	0.137	1.464	2.561	0.214	0.119	0.093	0.769	62.745	0.056	0.114	0.121	0.055	0.263	99.546	
Average	0.319	0.362	2.651	19.490	6.566	0.488	0.014	1.080	1.923	0.132	0.028	0.027	0.329	55.743	0.008	0.025	0.034	0.014	0.137	89.366	
Sigma	0.107	0.120	0.869	6.302	5.495	0.257	0.038	0.346	0.664	0.053	0.035	0.031	0.161	16.665	0.016	0.038	0.042	0.021	0.071	26.393	

Table 3. Flat-headed 'original' nail HM164 [c1220]: Composition of metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Fe	Total	Comment
1	0.000	0.001	0.220	0.005	0.000	0.004	0.004	0.003	0.005	0.019	0.046	0.000	0.004	99.689	100.000	HM64A metal 1
2	0.000	0.000	0.248	0.010	0.000	0.002	0.000	0.000	0.007	0.016	0.041	0.000	0.010	99.666	100.000	HM64A metal 2
3	0.000	0.000	0.196	0.007	0.000	0.000	0.000	0.000	0.002	0.011	0.052	0.000	0.012	99.720	100.000	HM64A metal 3
4	0.000	0.000	0.124	0.007	0.000	0.003	0.001	0.005	0.010	0.021	0.048	0.000	0.019	99.762	100.000	HM64A metal 4
5	0.000	0.000	0.232	0.010	0.000	0.000	0.000	0.000	0.010	0.016	0.051	0.000	0.013	99.668	100.000	HM64A metal 5
6	0.000	0.000	0.234	0.009	0.000	0.001	0.003	0.000	0.005	0.006	0.036	0.000	0.014	99.692	100.000	HM64A metal 6
7	0.000	0.000	0.478	0.026	0.000	0.001	0.005	0.002	0.007	0.024	0.051	0.000	0.006	99.400	100.000	HM64A metal 7
8	0.000	0.000	0.482	0.032	0.000	0.000	0.000	0.000	0.003	0.011	0.057	0.000	0.019	99.396	100.000	HM64A metal 8
9	0.000	0.000	0.468	0.049	0.000	0.000	0.001	0.009	0.010	0.013	0.042	0.000	0.013	99.395	100.000	HM64A metal 9
10	0.000	0.004	0.384	0.056	0.000	0.000	0.001	0.003	0.007	0.006	0.043	0.000	0.010	99.486	100.000	HM64A metal 10
11	0.000	0.000	0.352	0.022	0.000	0.000	0.002	0.000	0.008	0.020	0.056	0.000	0.012	99.528	100.000	HM64A metal 11
12	0.000	0.000	0.226	0.012	0.000	0.001	0.003	0.000	0.012	0.021	0.047	0.000	0.002	99.676	100.000	HM64A metal 12
13	0.000	0.001	0.405	0.028	0.000	0.000	0.001	0.001	0.013	0.017	0.071	0.000	0.006	99.457	100.000	HM64A metal 13
14	0.000	0.000	0.439	0.028	0.000	0.000	0.000	0.000	0.015	0.019	0.046	0.000	0.013	99.440	100.000	HM64A metal 14
15	0.000	0.000	0.406	0.024	0.000	0.000	0.000	0.000	0.007	0.015	0.047	0.000	0.009	99.492	100.000	HM64A metal 15
16	0.000	0.000	0.252	0.014	0.000	0.003	0.000	0.000	0.012	0.005	0.075	0.000	0.002	99.637	100.000	HM64A metal 16
Minimum	0.000	0.000	0.124	0.005	0.000	0.000	0.000	0.000	0.002	0.005	0.036	0.000	0.002	99.395	100.000	
Maximum	0.000	0.004	0.482	0.056	0.000	0.004	0.005	0.009	0.015	0.024	0.075	0.000	0.019	99.762	100.000	
Average	0.000	0.000	0.322	0.021	0.000	0.001	0.001	0.001	0.008	0.015	0.051	0.000	0.010	99.569	100.000	
Sigma	0.000	0.001	0.117	0.015	0.000	0.001	0.002	0.003	0.004	0.006	0.010	0.000	0.005	0.131	0.000	

Table 4. Flat-headed 'original' nail HM164 [c1220]: Composition of non-metallic inclusions (oxides by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	NiO	CuO	SrO	BaO	Total	Comment
1	0.180	1.931	2.919	15.022	11.921	1.140	0.000	0.804	1.286	0.126	0.007	0.028	0.536	61.257	0.000	0.042	0.064	0.007	0.110	97.380	HM64A incl 1 5mu
2	0.198	1.601	3.697	15.274	12.082	1.734	0.000	1.166	2.256	0.098	0.004	0.043	0.499	59.922	0.017	0.000	0.088	0.000	0.000	98.679	HM64A incl 2.1 4mu
3	0.239	1.461	3.675	14.824	12.002	1.883	0.019	1.182	2.428	0.195	0.014	0.052	0.568	59.755	0.000	0.020	0.052	0.026	0.278	98.669	HM64A incl 2.2 4mu
4	0.107	0.395	0.884	3.477	4.060	0.321	0.002	0.311	0.735	0.036	0.010	0.000	0.150	111.815	0.011	0.000	0.100	0.046	0.000	122.460	HM64A incl 3
5	0.370	1.913	4.866	19.438	9.057	1.176	0.020	1.770	3.806	0.219	0.015	0.029	0.584	57.075	0.000	0.007	0.044	0.000	0.045	100.429	HM64A incl 4.1 10mu
6	0.017	0.310	0.796	0.491	0.123	0.000	0.000	0.034	0.111	0.368	0.055	0.000	0.237	95.000	0.058	0.000	0.024	0.014	0.000	97.638	HM64A incl 4.1 FeOx
7	0.328	1.951	5.311	22.447	10.883	1.501	0.000	1.642	3.938	0.104	0.000	0.000	0.772	50.080	0.000	0.026	0.081	0.000	0.000	99.064	HM64A incl 4.1 Matrix
8	0.328	1.989	5.282	22.081	10.320	1.508	0.002	1.662	3.518	0.103	0.004	0.006	0.760	51.078	0.017	0.036	0.000	0.009	0.194	98.897	HM64A incl 4.2 10mu
9	0.315	1.994	5.076	20.275	9.713	1.657	0.001	1.645	3.246	0.129	0.029	0.038	0.639	56.059	0.000	0.003	0.000	0.031	0.000	100.850	HM64A incl 4.3 10mu
10	0.023	0.000	0.041	17.245	7.861	2.883	0.000	0.097	0.105	0.182	0.028	0.000	0.765	71.946	0.000	0.000	0.000	0.135	0.000	101.311	HM64A incl 5
11	0.302	2.304	4.600	20.996	10.617	0.951	0.004	1.536	2.519	0.128	0.000	0.029	0.707	54.654	0.000	0.000	0.000	0.000	0.170	99.516	HM64A incl 6
12	0.297	1.605	4.697	18.244	9.001	1.603	0.023	1.687	3.832	0.128	0.000	0.003	0.679	56.226	0.000	0.000	0.072	0.065	0.000	98.157	HM64A incl 7.1 10mu
13	0.305	1.522	4.474	17.490	8.144	1.389	0.019	1.628	3.981	0.169	0.000	0.012	0.605	58.246	0.054	0.000	0.000	0.093	0.135	98.262	HM64A incl 7.1 10mu
14	0.295	1.582	4.553	18.300	7.654	1.450	0.008	1.597	3.744	0.197	0.000	0.000	0.625	59.136	0.043	0.000	0.000	0.000	0.056	99.238	HM64A incl 8.1 10mu
15	0.374	1.980	5.528	23.789	9.875	1.823	0.000	2.264	4.193	0.068	0.019	0.021	0.711	47.636	0.003	0.000	0.085	0.048	0.173	98.590	HM64A incl 8.2 10mu
16	0.299	1.604	4.654	18.495	9.613	1.688	0.001	1.720	4.585	0.167	0.004	0.000	0.607	55.757	0.003	0.000	0.020	0.060	0.000	99.277	HM64A incl 9.1 10mu
17	0.255	1.639	4.313	17.420	8.231	1.426	0.000	1.685	3.687	0.106	0.000	0.000	0.599	60.661	0.020	0.016	0.024	0.000	0.045	100.127	HM64A incl 9.2 10mu
18	0.286	1.857	3.862	16.905	7.759	1.095	0.000	1.483	2.382	0.131	0.057	0.000	0.623	62.352	0.000	0.000	0.000	0.022	0.000	98.814	HM64A incl 10 5mu
19	0.271	1.702	4.967	20.280	8.953	1.711	0.001	1.876	3.670	0.116	0.004	0.041	0.616	56.011	0.009	0.016	0.000	0.001	0.034	100.279	HM64A incl 11 10mu
20	0.433	1.761	5.417	22.866	9.636	1.871	0.006	2.121	4.439	0.083	0.000	0.000	0.658	49.505	0.009	0.053	0.036	0.040	0.000	98.933	HM64A incl 11 10mu
21	0.308	1.561	4.654	19.046	8.582	1.591	0.000	1.804	3.944	0.105	0.033	0.000	0.621	57.072	0.000	0.010	0.000	0.010	0.068	99.409	HM64A incl 12 10mu
22	0.220	1.375	3.840	14.342	14.106	3.647	0.008	1.283	3.411	0.080	0.000	0.006	0.572	57.811	0.057	0.016	0.008	0.025	0.000	100.805	HM64A incl 13 10mu
23	0.334	1.431	4.177	16.936	9.820	2.075	0.000	1.865	4.156	0.165	0.000	0.018	0.575	57.661	0.000	0.039	0.004	0.001	0.147	99.404	HM64A incl 14 10mu
24	0.396	1.756	4.673	19.968	10.909	2.014	0.012	2.131	4.331	0.087	0.029	0.024	0.644	54.143	0.003	0.092	0.000	0.022	0.137	101.368	HM64A incl 14 10mu
25	0.293	1.896	4.315	18.079	10.929	1.949	0.000	1.638	3.063	0.128	0.000	0.000	0.742	56.241	0.040	0.000	0.000	0.023	0.045	99.381	HM64A incl 15 10mu
Minimum	0.017	0.000	0.041	0.491	0.123	0.000	0.000	0.034	0.105	0.036	0.000	0.000	0.150	47.636	0.000	0.000	0.000	0.000	0.000	97.380	
Maximum	0.433	2.304	5.528	23.789	14.106	3.647	0.023	2.264	4.585	0.368	0.057	0.052	0.772	111.815	0.058	0.092	0.100	0.135	0.278	122.460	
Average	0.271	1.565	4.051	17.349	9.274	1.603	0.005	1.465	3.095	0.137	0.012	0.014	0.604	60.684	0.014	0.015	0.028	0.027	0.065	100.277	
Sigma	0.102	0.549	1.450	5.286	2.728	0.706	0.008	0.588	1.311	0.065	0.017	0.017	0.143	13.936	0.020	0.023	0.035	0.033	0.080	4.740	

Table 5. Wide, slightly domed-headed 'original' nail HM167 [c1220]: Composition of metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Fe	Total	Comment
1	0.000	0.001	0.217	0.004	0.000	0.000	0.002	0.007	0.011	0.020	0.028	0.000	0.000	99.710	100.000	HM167A 1
2	0.000	0.001	0.214	0.004	0.000	0.003	0.002	0.000	0.011	0.025	0.031	0.001	0.009	99.699	100.000	HM167A 2
3	0.000	0.002	0.214	0.007	0.000	0.002	0.001	0.000	0.004	0.010	0.029	0.000	0.000	99.731	100.000	HM167A 3
4	0.000	0.000	0.211	0.003	0.000	0.002	0.002	0.000	0.008	0.012	0.032	0.000	0.000	99.730	100.000	HM167A 4
5	0.000	0.003	0.221	0.010	0.000	0.000	0.000	0.003	0.002	0.018	0.026	0.004	0.000	99.713	100.000	HM167A 5
6	0.000	0.001	0.230	0.003	0.000	0.000	0.000	0.000	0.017	0.016	0.018	0.000	0.000	99.715	100.000	HM167A 6
7	0.000	0.001	0.270	0.007	0.000	0.002	0.002	0.000	0.009	0.019	0.036	0.002	0.007	99.645	100.000	HM167A 7
8	0.000	0.000	0.263	0.007	0.000	0.000	0.001	0.000	0.006	0.017	0.022	0.000	0.010	99.674	100.000	HM167A 8
9	0.000	0.000	0.326	0.007	0.000	0.004	0.001	0.002	0.000	0.006	0.018	0.005	0.008	99.623	100.000	HM167A 9
10	0.000	0.000	0.227	0.007	0.000	0.001	0.000	0.000	0.014	0.016	0.018	0.000	0.000	99.717	100.000	HM167A 10
11	0.000	0.000	0.229	0.004	0.002	0.000	0.002	0.002	0.015	0.022	0.021	0.001	0.005	99.697	100.000	HM167A 11
12	0.000	0.000	0.394	0.012	0.000	0.000	0.000	0.002	0.008	0.027	0.021	0.000	0.000	99.536	100.000	HM167A 12
13	0.000	0.000	0.310	0.008	0.000	0.000	0.002	0.000	0.015	0.007	0.021	0.007	0.000	99.630	100.000	HM167A 13
14	0.000	0.000	0.286	0.007	0.001	0.000	0.000	0.000	0.011	0.007	0.027	0.000	0.004	99.657	100.000	HM167A 14
15	0.000	0.000	0.359	0.009	0.000	0.000	0.003	0.000	0.008	0.014	0.031	0.000	0.002	99.574	100.000	HM167A 15
16	0.000	0.002	0.311	0.008	0.000	0.000	0.004	0.000	0.008	0.022	0.029	0.000	0.006	99.610	100.000	HM167A 16
17	0.000	0.000	0.181	0.006	0.000	0.000	0.003	0.009	0.014	0.019	0.012	0.000	0.005	99.751	100.000	HM167A 17
18	0.000	0.001	0.218	0.003	0.000	0.000	0.000	0.000	0.009	0.012	0.029	0.000	0.003	99.725	100.000	HM167A 18
Minimum	0.000	0.000	0.181	0.003	0.000	0.000	0.000	0.000	0.000	0.006	0.012	0.000	0.000	99.536	100.000	
Maximum	0.000	0.003	0.394	0.012	0.002	0.004	0.004	0.009	0.017	0.027	0.036	0.007	0.010	99.751	100.000	
Average	0.000	0.001	0.260	0.006	0.000	0.001	0.001	0.001	0.009	0.016	0.025	0.001	0.003	99.674	100.000	
Sigma	0.000	0.001	0.059	0.003	0.001	0.001	0.001	0.003	0.005	0.006	0.006	0.002	0.004	0.060	0.000	

Table 6. Wide, slightly domed-headed 'original' nail HM167 [c1220]: Composition of non-metallic inclusions (oxides by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	NiO	CuO	SrO	BaO	Total	Comment
1	0.067	0.498	2.327	6.484	6.308	0.681	0.001	0.287	0.972	0.166	0.000	0.053	0.340	75.289	0.026	0.000	0.000	0.017	0.021	93.537	HM167Ai 01 average
2	0.085	0.679	2.660	8.111	8.229	1.825	0.000	0.376	1.109	0.099	0.017	0.048	0.420	70.189	0.000	0.034	0.023	0.032	0.000	93.936	HM167Ai 02 average
3	0.069	0.398	1.784	4.744	3.808	1.189	0.009	0.256	0.729	0.109	0.010	0.000	0.297	77.618	0.014	0.000	0.000	0.081	0.010	91.123	HM167Ai 03 average
4	0.099	0.654	3.021	8.924	4.274	0.613	0.006	0.395	1.103	0.154	0.010	0.056	0.422	73.872	0.041	0.024	0.000	0.000	0.064	93.731	HM167Ai 04 average
5	0.057	0.679	1.758	7.337	16.735	0.370	0.000	0.095	0.319	0.102	0.000	0.000	0.393	68.339	0.000	0.000	0.101	0.019	0.086	96.390	HM167Ai 05 2mu
6	0.044	0.012	0.024	0.001	30.986	1.748	0.000	0.000	0.033	0.000	0.045	0.066	0.096	63.647	0.000	0.003	0.047	0.016	0.000	96.768	HM167Ai 06 small
7	0.000	0.092	0.143	0.717	25.286	0.857	0.000	0.075	0.177	0.039	0.051	0.000	0.552	68.004	0.000	0.007	0.027	0.012	0.000	96.039	HM167Ai 07 small 2mu
8	0.021	0.166	0.101	0.786	31.491	1.393	0.005	0.130	0.226	0.043	0.011	0.008	0.757	56.821	0.000	0.000	0.047	0.000	0.000	92.005	HM167Ai 07 glass
9	0.000	0.060	0.277	0.606	10.816	0.280	0.042	0.022	0.024	0.000	0.020	0.003	0.240	79.640	0.000	0.014	0.000	0.048	0.000	92.083	HM167Ai 07 oxide
10	0.013	0.183	0.948	1.777	1.177	0.127	0.000	0.068	0.218	0.158	0.000	0.010	0.238	86.351	0.011	0.054	0.000	0.030	0.122	91.485	HM167Ai 04 FeOx
11	0.136	0.874	4.771	15.269	8.716	0.969	0.000	1.028	2.164	0.067	0.050	0.000	0.600	55.882	0.033	0.075	0.043	0.000	0.199	90.876	HM167Ai 04 Mat 1
12	0.231	0.914	5.897	18.176	9.231	1.332	0.000	1.158	2.514	0.090	0.000	0.035	0.554	54.203	0.021	0.007	0.000	0.043	0.201	94.607	HM167Ai 04 Mat 2
13	0.003	0.198	0.853	0.414	0.119	0.003	0.000	0.011	0.083	0.138	0.003	0.000	0.213	89.534	0.020	0.054	0.135	0.098	0.000	91.879	HM167Ai 04 FexS
14	0.035	0.461	0.448	10.008	5.766	0.580	0.038	0.159	0.635	0.022	0.016	0.000	0.331	86.765	0.000	0.000	0.034	0.000	0.050	105.339	HM167Ai 03 FexS
15	0.094	1.104	0.706	16.569	14.073	1.554	0.000	0.185	1.244	0.000	0.000	0.000	0.570	59.092	0.000	0.000	0.000	0.052	0.032	95.275	HM167Ai 03 Mat
16	0.118	1.127	0.743	16.506	13.769	1.835	0.000	0.207	1.263	0.029	0.010	0.000	0.608	58.785	0.000	0.017	0.027	0.000	0.000	95.044	HM167Ai 03 FeOx
17	0.000	0.152	1.146	0.265	0.110	0.232	0.001	0.038	0.059	0.157	0.006	0.000	0.247	91.942	0.000	0.027	0.077	0.067	0.000	94.526	HM167Ai 02 FeOx
18	0.027	1.346	1.405	15.718	14.726	0.193	0.000	0.049	0.566	0.014	0.000	0.000	0.786	59.060	0.000	0.069	0.000	0.000	0.055	94.014	HM167Ai 02 Mat 1
19	0.527	0.562	1.064	5.101	26.451	1.462	0.000	4.107	9.771	0.018	0.000	0.000	0.678	42.748	0.033	0.017	0.067	0.039	0.106	92.751	HM167Ai 02 Mat 2
20	0.044	0.597	7.378	8.140	5.255	0.191	0.000	0.138	1.012	0.163	0.010	0.000	0.273	71.767	0.053	0.072	0.000	0.031	0.075	95.199	HM167Ai 02 Needle
21	0.000	0.228	1.051	1.634	0.912	0.041	0.018	0.026	0.082	0.120	0.026	0.000	0.141	88.323	0.046	0.048	0.039	0.010	0.000	92.741	HM167Ai 01 FeOx
22	0.075	1.086	1.746	14.798	12.694	0.187	0.017	0.042	0.379	0.000	0.000	0.011	0.651	60.414	0.000	0.000	0.000	0.000	0.000	92.096	HM167Ai 01 Mat
Minimum	0.000	0.012	0.024	0.001	0.110	0.003	0.000	0.000	0.024	0.000	0.000	0.000	0.096	42.748	0.000	0.000	0.000	0.000	0.000	90.876	
Maximum	0.527	1.346	7.378	18.176	31.491	1.835	0.042	4.107	9.771	0.166	0.051	0.066	0.786	91.942	0.053	0.075	0.135	0.098	0.201	105.339	
Average	0.079	0.549	1.830	7.368	11.406	0.803	0.006	0.402	1.122	0.077	0.013	0.013	0.428	69.922	0.014	0.024	0.030	0.027	0.046	94.157	
Sigma	0.115	0.396	1.924	6.348	9.651	0.636	0.012	0.881	2.047	0.062	0.016	0.022	0.203	13.474	0.018	0.026	0.038	0.028	0.063	3.039	

Table 7: Small flat-headed 'original' nail HM168 [c1220]: Composition of the metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Fe	Total	Comment
1	0.000	0.000	0.091	0.007	0.000	0.000	0.000	0.002	0.113	0.138	0.028	0.003	0.524	99.094	100.000	HM168A 1
2	0.000	0.002	0.126	0.005	0.000	0.000	0.003	0.003	0.062	0.071	0.030	0.000	0.449	99.249	100.000	HM168A 2
3	0.000	0.001	0.150	0.000	0.000	0.000	0.003	0.009	0.055	0.050	0.044	0.000	0.193	99.495	100.000	HM168A 3
4	0.000	0.000	0.034	0.003	0.000	0.000	0.003	0.000	0.104	0.082	0.027	0.000	0.265	99.482	100.000	HM168A 4
5	0.000	0.002	0.024	0.004	0.000	0.000	0.001	0.006	0.095	0.066	0.031	0.000	0.204	99.567	100.000	HM168A 5
6	0.000	0.000	0.074	0.005	0.000	0.005	0.004	0.005	0.043	0.042	0.018	0.000	0.111	99.693	100.000	HM168A 6
7	0.000	0.001	0.087	0.001	0.000	0.000	0.000	0.002	0.045	0.043	0.037	0.000	0.116	99.668	100.000	HM168A 7
8	0.000	0.000	0.043	0.004	0.001	0.000	0.003	0.000	0.052	0.044	0.026	0.000	0.163	99.664	100.000	HM168A 8
9	0.000	0.000	0.169	0.002	0.000	0.000	0.000	0.008	0.047	0.034	0.013	0.005	0.103	99.619	100.000	HM168A 9
10	0.000	0.002	0.114	0.003	0.001	0.000	0.000	0.002	0.057	0.032	0.025	0.000	0.121	99.643	100.000	HM168A 10
11	0.000	0.000	0.122	0.002	0.002	0.002	0.001	0.004	0.052	0.048	0.027	0.000	0.142	99.598	100.000	HM168A 11
12	0.001	0.003	0.162	0.003	0.001	0.003	0.000	0.000	0.049	0.036	0.032	0.000	0.166	99.544	100.000	HM168A 12
Minimum	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.043	0.032	0.013	0.000	0.103	99.094	100.000	
Maximum	0.001	0.003	0.169	0.007	0.002	0.005	0.004	0.009	0.113	0.138	0.044	0.005	0.524	99.693	100.000	
Average	0.000	0.001	0.100	0.003	0.000	0.001	0.002	0.003	0.064	0.057	0.028	0.001	0.213	99.526	100.000	
Sigma	0.000	0.001	0.049	0.002	0.001	0.002	0.002	0.003	0.025	0.030	0.008	0.002	0.137	0.182	0.000	

Table 8: Small flat-headed 'original' nail HM168 [c1220]: Composition of the non-metallic inclusions (oxides by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	NiO	CuO	SrO	BaO	Total	Comment
1	0.013	0.130	1.296	3.802	0.795	0.095	0.011	0.127	0.209	0.065	0.000	0.000	0.560	87.258	0.066	0.075	0.120	0.054	0.071	94.745	HM168Ai 1 FeOx
2	0.126	0.351	3.942	22.129	7.776	0.729	0.000	1.464	1.559	0.031	0.065	0.015	1.419	53.147	0.000	0.000	0.000	0.003	0.147	92.903	HM168Ai 1 Matrix
3	0.172	0.288	3.793	17.616	5.496	0.783	0.010	0.899	1.279	0.060	0.000	0.000	1.161	64.051	0.021	0.021	0.044	0.051	0.101	95.844	HM168Ai 1 ?
4	0.089	0.207	3.105	13.893	4.744	0.635	0.021	0.829	1.113	0.046	0.000	0.000	0.978	67.831	0.018	0.007	0.000	0.014	0.065	93.590	HM168Ai 1 Average 5 mu
5	0.000	0.127	4.223	4.307	1.155	0.399	0.008	0.074	0.237	0.030	0.007	0.028	0.360	80.001	0.000	0.000	0.000	0.008	0.000	90.962	HM168Ai 2 Average 4 mu
6	0.010	0.106	1.792	2.950	0.532	0.300	0.000	0.064	0.202	0.022	0.026	0.000	0.243	84.688	0.035	0.041	0.000	0.000	0.175	91.186	HM168Ai 3 Average 4 mu
7	0.149	0.153	6.378	17.691	3.284	1.152	0.025	1.131	1.713	0.056	0.004	0.008	0.797	62.848	0.000	0.003	0.000	0.071	0.143	95.600	HM168Ai 4 Average 4 mu
8	0.000	0.093	2.564	5.228	0.859	0.750	0.000	0.261	0.180	0.067	0.056	0.000	0.183	82.769	0.049	0.034	0.000	0.000	0.031	93.124	HM168Ai 4 Average 4 mu
9	0.132	0.215	6.544	17.781	3.391	0.449	0.000	1.039	1.677	0.050	0.056	0.000	1.167	61.817	0.000	0.003	0.000	0.000	0.284	94.605	HM168Ai 5 Average 10 mu
10	0.033	0.071	1.389	1.762	0.185	0.014	0.005	0.074	0.148	0.115	0.000	0.017	0.516	86.273	0.043	0.000	0.000	0.085	0.000	90.729	HM168Ai 5 FeOx
11	0.136	0.245	8.072	24.756	4.657	0.512	0.010	1.467	2.156	0.055	0.000	0.012	1.405	51.339	0.039	0.034	0.000	0.000	0.225	95.118	HM168Ai 5 Matrix 1
12	0.204	0.196	9.860	25.615	4.900	0.861	0.008	1.699	2.799	0.055	0.000	0.000	1.369	47.349	0.021	0.051	0.008	0.000	0.194	95.187	HM168Ai 5 Matrix 2
13	0.042	0.155	5.802	12.466	1.771	0.358	0.007	0.430	0.987	0.138	0.007	0.000	0.884	75.854	0.006	0.031	0.051	0.044	0.181	99.212	HM168Ai 5 FeOx/FexS
14	0.076	0.174	4.347	10.123	1.737	0.731	0.016	0.472	0.668	0.050	0.000	0.021	0.533	76.520	0.020	0.041	0.086	0.106	0.000	95.717	HM168Ai 6 average
15	0.000	0.022	0.945	0.513	0.019	0.073	0.000	0.007	0.048	0.041	0.029	0.007	0.307	90.785	0.069	0.031	0.077	0.025	0.000	92.998	HM168Ai 6 FeOX
16	0.057	0.164	4.704	11.769	2.001	0.875	0.000	0.442	0.639	0.083	0.037	0.000	0.543	75.915	0.032	0.000	0.000	0.000	0.138	97.399	HM168Ai 6 FexS
17	0.179	0.200	5.528	13.516	2.290	0.432	0.004	0.538	0.567	0.093	0.000	0.027	0.547	74.219	0.000	0.000	0.000	0.032	0.032	98.203	HM168Ai 6 Mat 1
18	0.081	0.202	5.420	18.358	3.784	1.224	0.000	1.174	1.511	0.039	0.018	0.008	0.813	57.976	0.036	0.031	0.000	0.052	0.154	90.881	HM168Ai 6 Mat 2
19	0.093	0.191	3.852	17.009	6.255	0.709	0.010	1.071	1.610	0.051	0.112	0.000	1.167	61.147	0.000	0.000	0.000	0.000	0.088	93.363	HM168Ai 7 average diameter 4
20	0.051	0.139	2.378	10.846	2.985	0.293	0.000	0.663	0.694	0.039	0.000	0.000	0.772	71.552	0.000	0.000	0.043	0.000	0.000	90.455	HM168Ai 7 FeOx
21	0.154	0.252	4.504	23.129	8.709	0.768	0.018	1.273	1.985	0.050	0.000	0.000	1.281	51.581	0.000	0.000	0.000	0.000	0.246	93.946	HM168Ai 7 Mat
22	0.056	0.203	3.627	11.344	2.990	0.354	0.011	0.383	0.765	0.182	0.000	0.042	0.694	72.386	0.000	0.010	0.050	0.081	0.032	93.208	HM168Ai 7 Needle
23	0.080	0.144	3.665	7.849	1.341	0.519	0.000	0.335	0.563	0.076	0.007	0.003	0.515	79.038	0.000	0.003	0.023	0.000	0.000	94.161	HM168Ai 8
24	0.160	0.251	5.896	17.405	3.490	0.359	0.000	1.117	1.730	0.083	0.084	0.000	1.082	63.337	0.000	0.031	0.082	0.000	0.338	95.445	HM168Ai 9
25	0.146	0.122	4.205	9.830	2.852	0.903	0.035	0.397	0.630	0.047	0.000	0.040	0.578	71.543	0.000	0.017	0.054	0.023	0.032	91.446	HM168Ai 10
26	0.010	0.067	0.839	0.153	0.019	0.000	0.000	0.019	0.031	0.051	0.054	0.007	0.375	90.421	0.000	0.037	0.000	0.000	0.000	92.083	HM168Ai 8 FeOx
27	0.092	0.182	5.344	13.003	2.065	0.566	0.011	0.261	0.549	0.045	0.000	0.037	0.562	75.877	0.000	0.031	0.000	0.000	0.000	98.623	HM168Ai 8 FexS
28	0.216	0.218	5.454	23.675	3.861	0.995	0.000	1.507	1.523	0.037	0.000	0.000	0.887	55.487	0.009	0.000	0.000	0.066	0.322	94.257	HM168Ai 8 Mat
29	0.186	0.308	6.697	26.386	5.124	0.399	0.000	1.916	2.374	0.060	0.000	0.018	1.577	49.719	0.069	0.000	0.039	0.016	0.304	95.192	HM168Ai 9 Mat
30	0.049	0.023	1.218	1.919	0.322	0.116	0.015	0.135	0.195	0.105	0.013	0.000	0.670	86.793	0.000	0.017	0.000	0.019	0.000	91.606	HM168Ai 9 FeOx
31	0.286	0.187	8.661	25.621	4.973	1.048	0.000	2.162	3.209	0.000	0.000	0.012	1.325	48.081	0.018	0.000	0.031	0.015	0.352	95.981	HM168Ai 9 Mat2
32	0.030	0.001	0.943	1.326	0.190	0.083	0.000	0.032	0.084	0.075	0.022	0.015	0.325	87.316	0.014	0.007	0.092	0.035	0.010	90.600	HM168Ai 10 FeOx
33	0.051	0.028	1.264	4.489	1.236	0.618	0.206	0.137	0.479	0.004	0.036	0.000	0.286	73.889	0.037	0.000	0.039	0.013	0.072	82.838	HM168Ai 10 Mat 1
34	0.107	0.214	23.759	11.587	2.598	0.847	0.010	0.457	0.690	0.128	0.021	0.046	0.632	51.884	0.021	0.034	0.008	0.023	0.122	93.186	HM168Ai 10 Mat 2
35	0.110	0.167	5.332	18.552	5.053	0.989	0.012	0.591	1.136	0.074	0.000	0.000	0.883	63.757	0.000	0.062	0.078	0.000	0.153	96.946	HM168Ai 10 Mat 3
Minimum	0.000	0.001	0.839	0.153	0.019	0.000	0.000	0.007	0.031	0.000	0.000	0.000	0.183	47.349	0.000	0.000	0.000	0.000	0.000	82.838	
Maximum	0.286	0.351	23.759	26.386	8.709	1.224	0.206	2.162	3.209	0.182	0.112	0.046	1.577	90.785	0.069	0.075	0.120	0.106	0.352	99.212	
Average	0.096	0.166	4.781	12.811	2.955	0.570	0.013	0.704	1.027	0.063	0.019	0.010	0.783	69.556	0.018	0.019	0.026	0.024	0.115	93.753	
Sigma	0.071	0.082	4.013	8.140	2.218	0.336	0.035	0.599	0.825	0.037	0.028	0.014	0.387	13.413	0.022	0.020	0.035	0.030	0.112	3.026	

Table 9: Small 'lost head' square nail HM165 [?1740's]: Composition of metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Fe	Total	Comment
1	0.049	0.016	0.213	0.018	0.000	0.000	0.000	0.005	0.013	0.011	0.012	0.000	0.000	99.663	100.000	HM165A 1
2	0.003	0.008	0.196	0.013	0.001	0.000	0.000	0.004	0.014	0.015	0.026	0.004	0.000	99.716	100.000	HM165A 2
3	0.003	0.006	0.132	0.010	0.000	0.000	0.000	0.005	0.006	0.016	0.008	0.000	0.000	99.814	100.000	HM165A 3
4	0.000	0.005	0.183	0.010	0.000	0.002	0.000	0.001	0.017	0.016	0.022	0.000	0.000	99.744	100.000	HM165A 4
5	0.000	0.002	0.095	0.004	0.000	0.000	0.000	0.008	0.002	0.009	0.009	0.000	0.000	99.871	100.000	HM165A 5
6	0.000	0.003	0.075	0.020	0.000	0.001	0.000	0.019	0.000	0.012	0.005	0.000	0.005	99.860	100.000	HM165A 6
7	0.010	0.023	0.182	0.026	0.003	0.002	0.000	0.006	0.006	0.015	0.024	0.004	0.000	99.699	100.000	HM165A 7
8	0.000	0.003	0.486	0.030	0.000	0.000	0.000	0.000	0.008	0.016	0.015	0.000	0.008	99.434	100.000	HM165A 8
9	0.000	0.006	0.091	0.013	0.001	0.001	0.000	0.011	0.012	0.018	0.018	0.000	0.001	99.828	100.000	HM165A 9
10	0.000	0.002	0.342	0.020	0.002	0.000	0.000	0.003	0.002	0.014	0.018	0.000	0.007	99.590	100.000	HM165A 10
11	0.000	0.001	0.268	0.015	0.001	0.001	0.001	0.007	0.000	0.012	0.024	0.000	0.008	99.662	100.000	HM165A 11
12	0.001	0.002	0.232	0.009	0.000	0.004	0.000	0.007	0.004	0.018	0.009	0.000	0.000	99.714	100.000	HM165A 12
13	0.000	0.003	0.307	0.015	0.000	0.000	0.000	0.000	0.001	0.009	0.013	0.000	0.000	99.652	100.000	HM165A 13
14	0.000	0.005	0.136	0.003	0.000	0.000	0.000	0.000	0.004	0.012	0.003	0.000	0.000	99.837	100.000	HM165A 14
15	0.002	0.007	0.162	0.007	0.000	0.000	0.004	0.000	0.005	0.020	0.012	0.000	0.000	99.781	100.000	HM165A 15
16	0.000	0.004	0.194	0.010	0.000	0.000	0.002	0.005	0.003	0.008	0.015	0.000	0.000	99.759	100.000	HM165A 16
17	0.000	0.004	0.368	0.015	0.000	0.000	0.002	0.000	0.000	0.021	0.005	0.000	0.002	99.583	100.000	HM165A 17
18	0.000	0.001	0.142	0.005	0.000	0.000	0.000	0.000	0.008	0.010	0.000	0.000	0.000	99.834	100.000	HM165A 18
19	0.000	0.001	0.177	0.014	0.000	0.000	0.000	0.000	0.002	0.005	0.016	0.000	0.000	99.785	100.000	HM165A 19
20	0.000	0.002	0.392	0.021	0.000	0.000	0.003	0.000	0.003	0.019	0.009	0.000	0.000	99.551	100.000	HM165A 20
21	0.000	0.004	0.338	0.025	0.001	0.000	0.000	0.002	0.005	0.010	0.021	0.003	0.000	99.591	100.000	HM165A 21
22	0.000	0.001	0.213	0.019	0.001	0.000	0.001	0.005	0.000	0.011	0.021	0.000	0.000	99.728	100.000	HM165A 22
23	0.000	0.000	0.156	0.006	0.002	0.000	0.004	0.000	0.007	0.012	0.000	0.000	0.000	99.813	100.000	HM165A 23
24	0.000	0.002	0.135	0.005	0.002	0.000	0.000	0.003	0.004	0.017	0.012	0.000	0.000	99.820	100.000	HM165A 24
25	0.000	0.002	0.362	0.008	0.000	0.000	0.000	0.008	0.010	0.016	0.018	0.000	0.000	99.576	100.000	HM165A 25
26	0.000	0.002	0.303	0.011	0.000	0.000	0.001	0.000	0.001	0.007	0.000	0.000	0.000	99.675	100.000	HM165A 26
27	0.000	0.004	0.042	0.003	0.001	0.001	0.000	0.001	0.001	0.010	0.010	0.000	0.000	99.927	100.000	HM165A 27
28	0.000	0.005	0.011	0.003	0.001	0.000	0.001	0.000	0.003	0.000	0.009	0.000	0.000	99.967	100.000	HM165A 28
Minimum	0.000	0.000	0.011	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	99.434	100.000	
Maximum	0.049	0.023	0.486	0.030	0.003	0.004	0.004	0.019	0.017	0.021	0.026	0.004	0.008	99.967	100.000	
Average	0.002	0.004	0.212	0.013	0.001	0.000	0.001	0.004	0.005	0.013	0.013	0.000	0.001	99.731	100.000	
Sigma	0.009	0.005	0.115	0.007	0.001	0.001	0.001	0.004	0.005	0.005	0.008	0.001	0.003	0.124	0.000	

Table 10: Small 'lost head' square nail HM165 [?1740's]: Composition of non-metallic inclusions (oxides by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	NiO	CuO	SrO	BaO	Total	Comment
1	0.020	0.049	0.210	0.283	0.139	0.000	0.007	0.000	0.062	0.207	0.518	0.228	1.067	94.265	0.066	0.000	0.027	0.000	0.000	97.146	HM165A Incl 1 FeOx
2	0.005	0.752	0.252	14.668	18.581	0.245	0.005	0.092	1.863	0.018	0.000	0.000	3.892	55.983	0.000	0.000	0.064	0.041	0.022	96.482	HM165A Incl 1 Main
3	0.000	0.468	0.239	10.270	15.659	0.367	0.026	0.008	0.827	0.122	0.113	0.023	3.370	64.819	0.000	0.018	0.028	0.000	0.133	96.484	HM165A Incl 1 IM
4	0.182	1.652	1.806	35.917	4.767	1.316	0.017	1.805	6.725	0.403	0.270	0.074	9.593	36.170	0.041	0.000	0.000	0.000	0.060	100.794	HM165A Incl 2
5	0.107	1.057	0.658	13.847	9.176	0.769	0.005	0.309	2.340	0.130	0.110	0.034	4.334	88.572	0.000	0.046	0.000	0.024	0.122	121.639	HM165A Incl 3
6	0.085	0.709	0.549	19.858	11.852	0.449	0.014	0.301	2.082	0.090	0.070	0.054	4.700	57.863	0.012	0.000	0.016	0.000	0.000	98.701	HM165A Incl 4 main
7	0.132	0.376	1.803	16.478	10.084	0.713	0.035	1.196	4.471	0.287	0.217	0.089	4.019	53.829	0.012	0.082	0.058	0.051	0.078	94.002	HM165A Incl 4 IM
8	0.080	1.571	0.587	21.908	15.046	2.118	0.000	0.401	5.895	0.273	0.623	0.144	11.087	42.722	0.015	0.041	0.012	0.067	0.056	102.646	HM165A Incl 5
9	0.058	0.718	0.310	13.241	19.542	0.046	0.018	0.041	1.748	0.050	0.028	0.003	3.747	57.156	0.027	0.000	0.078	0.000	0.033	96.840	HM165A Incl 6 Main
10	0.023	0.050	0.281	0.444	0.154	0.131	0.001	0.009	0.090	0.271	0.871	0.523	0.910	91.626	0.060	0.000	0.000	0.033	0.000	95.477	HM165A Incl 6 FeOx
11	0.027	0.015	0.348	0.460	0.362	0.037	0.010	0.001	0.106	0.205	0.481	0.247	1.092	93.517	0.009	0.014	0.042	0.000	0.000	96.971	HM165A Incl 7 FeOx
12	0.055	0.762	0.266	14.122	18.987	0.892	0.000	0.288	1.406	0.030	0.071	0.017	4.222	55.355	0.000	0.000	0.000	0.000	0.000	96.473	HM165A Incl 7 Main
13	0.000	0.255	0.259	6.583	10.609	34.097	0.027	0.209	3.085	0.039	0.000	0.012	2.139	67.679	0.000	0.000	0.031	0.043	0.136	125.197	HM165A Incl 7 Bright
14	0.069	0.452	0.315	10.655	17.899	0.387	0.012	0.089	5.305	0.020	0.036	0.026	4.117	52.906	0.000	0.038	0.043	0.043	0.134	92.543	HM165A Incl 7 IM
15	0.147	0.545	1.527	16.538	14.782	3.894	0.007	1.530	6.704	0.087	0.051	0.051	3.822	49.565	0.000	0.017	0.023	0.000	0.011	99.299	HM165A Incl 8 IM
16	0.063	1.029	0.536	17.427	15.152	0.283	0.000	0.364	1.784	0.052	0.074	0.000	5.326	55.219	0.003	0.034	0.000	0.000	0.000	97.346	HM165A Incl 8 Main
17	0.003	0.248	0.128	0.097	0.000	0.013	0.000	0.003	0.051	0.110	0.192	0.022	1.598	95.981	0.000	0.047	0.038	0.004	0.010	98.545	HM165A Incl 8 FeOx
18	0.071	0.786	0.337	17.649	14.183	0.216	0.020	0.315	1.023	0.050	0.000	0.000	4.199	58.465	0.087	0.000	0.000	0.000	0.000	97.396	HM165A Incl 9 main
19	0.131	0.478	1.271	18.628	10.373	2.408	0.007	0.780	1.072	0.076	0.000	0.036	3.532	57.327	0.000	0.007	0.088	0.015	0.000	96.227	HM165A Incl 9 IM
20	0.000	0.037	0.202	0.243	0.044	0.000	0.000	0.000	0.041	0.147	0.219	0.085	1.098	95.956	0.003	0.030	0.087	0.051	0.000	98.243	HM165A Incl 9 FeOx
21	0.000	0.084	0.234	0.333	0.124	0.048	0.011	0.002	0.069	0.151	0.221	0.132	0.991	95.040	0.000	0.000	0.000	0.058	0.120	97.616	HM165A Incl 10 FeOx long
22	0.000	0.087	0.201	0.560	0.262	0.019	0.003	0.012	0.059	0.202	0.282	0.069	0.920	93.499	0.000	0.000	0.107	0.025	0.060	96.366	HM165A Incl 10 FeOx round
23	0.080	0.718	0.372	16.925	14.569	0.224	0.000	0.303	0.885	0.054	0.000	0.031	4.063	57.614	0.059	0.020	0.043	0.000	0.000	95.960	HM165A Incl 10 Main
24	0.131	0.318	0.856	12.157	5.339	1.590	0.011	0.496	0.858	0.064	0.054	0.008	2.988	65.076	0.000	0.048	0.000	0.042	0.011	90.045	HM165A Incl 10 IM
25	0.055	0.792	0.715	17.811	14.492	1.985	0.011	0.872	2.635	0.180	0.241	0.135	5.156	52.132	0.024	0.058	0.071	0.060	0.000	97.423	HM165 incl 11
26	0.052	0.700	0.378	13.301	17.877	0.256	0.000	0.096	0.610	0.138	0.246	0.086	3.793	58.126	0.000	0.049	0.000	0.000	0.111	95.819	HM165 incl 12
27	0.045	0.501	0.832	12.549	13.539	3.393	0.012	0.279	1.408	0.115	0.140	0.061	3.931	59.507	0.030	0.060	0.088	0.008	0.056	96.551	HM165 incl 12 IM
28	0.061	0.532	0.309	9.491	12.254	0.930	0.017	0.050	0.935	0.114	0.226	0.074	3.073	69.405	0.003	0.000	0.000	0.086	0.096	97.652	HM165A Incl 1 average 1
29	0.093	0.352	0.414	7.996	9.242	1.331	0.021	0.033	0.823	0.174	0.389	0.180	2.707	72.922	0.032	0.000	0.051	0.031	0.000	96.786	HM165A Incl 1 average 2
30	0.014	0.607	0.310	10.716	13.076	0.370	0.000	0.056	0.896	0.120	0.110	0.025	3.434	67.184	0.000	0.031	0.012	0.000	0.000	96.961	HM165A Incl 1 average 3
31	0.039	0.576	0.359	11.295	14.183	2.987	0.000	0.079	1.418	0.116	0.136	0.067	3.358	63.853	0.080	0.024	0.000	0.000	0.000	98.570	HM165A Incl 6 average 1
32	0.095	0.539	0.507	12.733	16.267	1.512	0.000	0.061	1.984	0.092	0.081	0.031	3.697	57.927	0.000	0.000	0.028	0.028	0.066	95.648	HM165A Incl 6 average 2
33	0.057	0.538	0.427	13.420	17.356	0.817	0.009	0.083	1.395	0.095	0.007	0.029	3.768	57.840	0.063	0.072	0.000	0.031	0.033	96.038	HM165A Incl 6 average 3
34	0.041	0.499	0.305	10.057	12.142	1.956	0.000	0.082	0.974	0.131	0.259	0.080	2.945	70.408	0.000	0.000	0.004	0.000	0.163	100.046	HM165A Incl 7 average 1
35	0.038	0.468	0.395	9.841	12.124	2.078	0.010	0.064	1.334	0.125	0.198	0.089	3.277	68.412	0.089	0.000	0.000	0.039	0.065	98.644	HM165A Incl 7 average 2
36	0.011	0.580	0.324	12.002	13.698	0.325	0.017	0.043	1.128	0.057	0.150	0.067	3.564	64.992	0.000	0.000	0.000	0.036	0.044	97.034	HM165A Incl 7 average 3
37	0.108	0.467	0.452	10.958	7.500	0.578	0.006	0.267	0.862	0.103	0.195	0.051	2.722	72.502	0.000	0.052	0.098	0.000	0.000	96.920	HM165A Incl 9 Average
38	0.160	0.558	0.485	13.239	9.051	1.108	0.017	0.197	0.618	0.102	0.066	0.005	3.363	68.335	0.039	0.000	0.000	0.000	0.000	97.339	HM165A Incl 10 Average
39	0.081	0.636	0.805	19.683	10.741	1.358	0.000	0.587	3.366	0.145	0.186	0.054	4.461	55.348	0.065	0.000	0.019	0.000	0.186	97.721	HM165A Incl 4 average 5 mu
40	0.141	0.630	0.919	15.538	12.645	2.693	0.009	0.903	4.406	0.043	0.060	0.014	4.360	55.531	0.030	0.000	0.035	0.000	0.000	97.955	HM165A Incl 8 average 5 mu
41	0.017	0.233	0.133	0.160	0.041	0.000	0.000	0.000	0.032	0.102	0.214	0.117	1.517	94.658	0.000	0.000	0.031	0.000	0.060	97.315	HM165A Incl 8 average 5 mu
42	0.030	0.532	0.682	12.686	15.239	2.803	0.000	0.133	1.206	0.144	0.188	0.039	3.722	59.698	0.027	0.000	0.019	0.015	0.131	97.294	HM165 incl 12 average 5mu
43	0.010	0.774	0.752	17.853	14.638	2.220	0.000	0.858	2.782	0.144	0.221	0.070	5.097	52.874	0.021	0.014	0.031	0.000	0.000	98.359	HM165 incl 11 average 5mu
Minimum	0.000	0.015	0.128	0.097	0.000	0.000	0.000	0.000	0.032	0.018	0.000	0.000	0.910	36.170	0.000	0.000	0.000	0.000	0.000	90.045	
Maximum	0.182	1.652	1.806	35.917	19.542	34.097	0.035	1.805	6.725	0.403	0.871	0.523	11.087	95.981	0.089	0.082	0.107	0.086	0.186	125.197	
Average	0.061	0.552	0.536	11.875	10.786	1.836	0.008	0.309	1.799	0.125	0.182	0.074	3.599	66.462	0.021	0.019	0.030	0.019	0.046	98.338	
Sigma	0.049	0.346	0.406	7.276	6.105	5.145	0.009	0.422	1.786	0.078	0.178	0.091	1.940	15.913	0.028	0.024	0.032	0.024	0.055	5.956	

Table 11: Small, 'lost' (facetted) headed nail HM166 with square shank [?1740's] : Composition of metal (elements by weight percent)

No.	As	V	Ti	P	Al	Cr	S	Si	Mn	Co	Ni	Cu	Zn	Fe	Total
1	0.000	0.000	0.000	0.577	0.000	0.002	0.030	0.002	0.001	0.011	0.015	0.031	0.000	99.331	100.000
2	0.000	0.000	0.000	0.537	0.000	0.001	0.035	0.000	0.005	0.014	0.018	0.026	0.000	99.364	100.000
3	0.017	0.001	0.000	0.146	0.000	0.003	0.003	0.002	0.000	0.014	0.017	0.035	0.000	99.762	100.000
4	0.003	0.000	0.000	0.198	0.000	0.000	0.005	0.000	0.000	0.010	0.010	0.029	0.000	99.745	100.000
5	0.000	0.000	0.000	0.208	0.000	0.000	0.005	0.000	0.000	0.007	0.026	0.031	0.000	99.723	100.000
6	0.000	0.000	0.000	0.321	0.001	0.000	0.006	0.001	0.000	0.006	0.020	0.033	0.000	99.612	100.000
7	0.001	0.000	0.000	0.345	0.000	0.001	0.015	0.000	0.000	0.014	0.023	0.039	0.000	99.562	100.000
8	0.000	0.000	0.000	0.279	0.000	0.000	0.009	0.002	0.045	0.007	0.019	0.024	0.000	99.615	100.000
9	0.010	0.000	0.000	0.325	0.000	0.003	0.010	0.006	0.030	0.009	0.005	0.026	0.000	99.576	100.000
10	0.000	0.000	0.000	0.425	0.000	0.001	0.038	0.002	0.048	0.001	0.027	0.037	0.000	99.421	100.000
11	0.006	0.001	0.000	0.373	0.000	0.001	0.011	0.000	0.000	0.016	0.016	0.024	0.000	99.552	100.000
12	0.003	0.000	0.000	0.215	0.000	0.000	0.001	0.001	0.000	0.009	0.025	0.041	0.000	99.705	100.000
13	0.002	0.002	0.000	0.462	0.000	0.001	0.016	0.000	0.000	0.012	0.011	0.026	0.000	99.468	100.000
14	0.000	0.000	0.000	0.182	0.000	0.002	0.006	0.000	0.000	0.013	0.029	0.036	0.000	99.732	100.000
15	0.002	0.000	0.000	0.214	0.000	0.000	0.005	0.000	0.000	0.004	0.016	0.032	0.000	99.727	100.000
16	0.000	0.003	0.001	0.335	0.000	0.000	0.022	0.001	0.014	0.011	0.023	0.032	0.000	99.558	100.000
17	0.000	0.000	0.000	0.353	0.000	0.000	0.012	0.001	0.011	0.001	0.021	0.029	0.002	99.570	100.000
18	0.000	0.005	0.000	0.297	0.000	0.004	0.007	0.005	0.028	0.019	0.027	0.020	0.000	99.588	100.000
19	0.007	0.001	0.000	0.363	0.000	0.006	0.011	0.008	0.020	0.009	0.010	0.027	0.000	99.538	100.000
20	0.006	0.003	0.000	0.251	0.000	0.002	0.006	0.009	0.022	0.014	0.013	0.024	0.000	99.650	100.000
21	0.000	0.002	0.000	0.237	0.000	0.001	0.014	0.010	0.027	0.004	0.010	0.013	0.000	99.682	100.000
22	0.003	0.003	0.000	0.159	0.000	0.004	0.004	0.000	0.008	0.007	0.011	0.024	0.000	99.777	100.000
23	0.000	0.005	0.000	0.229	0.000	0.004	0.006	0.001	0.004	0.001	0.012	0.037	0.000	99.701	100.000
24	0.000	0.000	0.000	0.219	0.000	0.000	0.009	0.001	0.010	0.012	0.015	0.041	0.000	99.693	100.000
Minimum	0.000	0.000	0.000	0.146	0.000	0.000	0.001	0.000	0.000	0.001	0.005	0.013	0.000	99.331	100.000
Maximum	0.017	0.005	0.001	0.577	0.001	0.006	0.038	0.010	0.048	0.019	0.029	0.041	0.002	99.777	100.000
Average	0.002	0.001	0.000	0.302	0.000	0.002	0.012	0.002	0.011	0.009	0.017	0.030	0.000	99.610	100.000
Sigma	0.004	0.002	0.000	0.114	0.000	0.002	0.010	0.003	0.015	0.005	0.007	0.007	0.000	0.124	0.000

Table 12: Small, 'lost' (facetted) headed nail HM166 with square shank [?1740's] : Composition of non-metallic inclusions (oxides by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	NiO	CuO	SrO	BaO	Total	Comment
1	0.000	0.457	0.125	0.157	0.000	0.019	0.003	0.007	0.014	0.053	0.125	0.094	1.072	96.038	0.033	0.072	0.000	0.051	0.000	98.319	HM166A Incl FeOx
2	0.027	1.783	0.249	15.270	17.183	0.144	0.009	0.487	2.658	0.028	0.015	0.026	3.102	54.548	0.084	0.017	0.032	0.043	0.079	95.782	HM166A Inc 1 Surrounds
3	0.000	1.351	0.377	17.070	14.923	0.142	0.008	0.042	0.684	0.069	0.126	0.037	3.305	59.284	0.043	0.036	0.063	0.096	0.000	97.654	HM166A Incl 2 main
4	0.026	0.111	1.086	1.679	1.239	0.112	0.007	0.099	0.208	0.742	0.850	0.310	0.738	89.955	0.019	0.003	0.000	0.000	0.000	97.182	HM166A Incl 2 FeOx
5	0.120	0.558	0.584	7.736	21.510	0.115	0.000	1.701	8.014	0.050	0.000	0.000	2.983	46.028	0.000	0.000	0.000	0.034	0.000	89.433	HM166A Incl 2 Interstitial
6	0.000	0.006	0.000	0.048	21.603	0.849	0.000	0.000	0.019	0.019	0.000	0.043	1.417	78.430	0.011	0.013	0.055	0.031	0.000	102.544	HM166A Incl 3 small round
7	0.109	0.496	0.830	14.618	14.918	2.030	0.015	0.753	3.333	0.116	0.022	0.040	1.645	61.415	0.055	0.023	0.000	0.028	0.011	100.454	HM166A Incl 4 small elongate
8	0.077	1.895	0.148	14.464	16.015	0.123	0.000	0.028	0.542	0.030	0.000	0.000	3.156	59.053	0.000	0.023	0.028	0.022	0.221	95.825	HM166A Incl 5 Edge
9	0.000	0.438	0.141	0.143	0.000	0.016	0.000	0.000	0.016	0.072	0.155	0.164	0.858	97.423	0.000	0.089	0.000	0.046	0.000	99.561	HM166A Incl 5 Centre FeOx
10	0.032	0.426	0.499	8.054	22.203	3.683	0.027	0.305	2.648	0.080	0.032	0.000	1.581	60.713	0.000	0.030	0.000	0.000	0.022	100.329	HM166A Incl 6 Centre FeOx
11	0.078	0.579	0.482	8.143	21.016	1.169	0.007	0.174	1.107	0.088	0.120	0.008	1.446	63.512	0.020	0.102	0.020	0.000	0.077	98.146	HM166A Incl 6 Edge
12	0.085	0.493	0.736	13.760	17.096	3.085	0.000	0.903	3.673	0.095	0.073	0.064	1.677	58.166	0.052	0.142	0.000	0.035	0.011	100.146	HM166A Incl 7
13	0.019	0.938	0.864	14.882	15.907	2.634	0.000	0.662	2.292	0.148	0.129	0.029	2.931	58.412	0.009	0.033	0.000	0.000	0.000	99.889	HM166A Inc 8 5mu
14	0.240	2.087	3.079	42.004	7.503	0.997	0.002	5.418	7.998	0.451	0.095	0.017	5.830	22.570	0.042	0.046	0.000	0.021	0.135	98.535	HM166A Inc 9
15	0.247	3.062	3.162	54.322	1.265	0.774	0.009	6.455	12.448	0.625	0.160	0.017	8.092	8.902	0.000	0.000	0.000	0.047	0.127	99.712	HM166A Inc 10
16	0.215	3.307	3.253	55.104	0.154	0.900	0.000	6.555	13.824	0.664	0.025	0.056	6.573	10.374	0.015	0.007	0.000	0.052	0.102	101.180	HM166A Inc 11
17	0.202	3.615	3.033	55.903	0.070	1.018	0.000	6.151	14.198	0.681	0.082	0.000	7.902	8.133	0.000	0.000	0.004	0.079	0.140	101.211	HM166A Inc 12
18	0.036	0.400	0.468	8.069	20.256	3.175	0.000	0.292	1.936	0.081	0.107	0.091	1.543	62.257	0.037	0.000	0.043	0.002	0.022	98.815	HM166A Inc 13 4mu
19	0.034	0.429	0.413	7.454	19.468	3.166	0.004	0.316	1.734	0.072	0.071	0.070	1.757	69.246	0.000	0.000	0.000	0.036	0.000	104.269	HM166A Inc 14 4mu
20	0.049	0.532	0.454	9.159	17.560	0.192	0.000	0.010	0.596	0.144	0.143	0.022	1.706	67.516	0.000	0.000	0.000	0.000	0.000	98.083	HM166A Inc 14 4mu
21	0.003	0.229	0.168	0.116	0.020	0.062	0.000	0.008	0.008	0.123	0.215	0.025	0.985	96.590	0.000	0.000	0.051	0.000	0.000	98.603	HM166A Inc 14 4mu
22	0.078	0.559	0.618	9.221	18.958	0.634	0.007	0.244	1.858	0.155	0.046	0.056	1.932	64.847	0.051	0.020	0.039	0.060	0.000	99.381	HM166A Inc 14 4mu
23	0.047	0.319	0.443	6.871	21.508	2.216	0.000	0.351	1.891	0.081	0.025	0.025	1.333	63.562	0.000	0.000	0.086	0.000	0.132	98.890	HM166A Inc 18
24	0.017	0.534	0.354	5.263	21.981	1.746	0.025	0.166	1.156	0.060	0.025	0.039	1.510	62.598	0.011	0.039	0.059	0.000	0.000	95.577	HM166A Inc 19
25	0.000	0.638	0.337	8.233	21.979	1.156	0.010	0.212	1.208	0.127	0.109	0.006	2.824	61.899	0.000	0.010	0.000	0.000	0.000	98.746	HM166A Inc 20
26	0.485	4.323	3.548	52.184	0.076	0.641	0.017	9.838	11.802	0.703	0.000	0.000	1.949	21.205	0.024	0.000	0.000	0.023	0.013	106.827	HM166A Inc 21
27	0.457	4.616	3.904	53.798	0.052	0.489	0.004	5.397	13.360	0.705	0.000	0.000	2.102	29.756	0.000	0.046	0.036	0.037	0.184	114.942	HM166A Inc 22
28	0.344	4.921	3.980	56.064	0.028	0.387	0.000	5.307	15.513	0.938	0.046	0.000	2.619	10.266	0.000	0.000	0.000	0.071	0.242	100.726	HM166A Inc 23
29	0.145	2.308	2.255	38.370	3.259	1.188	0.000	2.226	8.408	0.453	0.237	0.137	7.420	31.937	0.032	0.013	0.032	0.057	0.000	98.477	HM166A Inc 24
Minimum	0.000	0.006	0.000	0.048	0.000	0.016	0.000	0.000	0.008	0.019	0.000	0.000	0.738	8.133	0.000	0.000	0.000	0.000	0.000	89.433	
Maximun	0.485	4.921	3.980	56.064	22.203	3.683	0.027	9.838	15.513	0.938	0.850	0.310	8.092	97.423	0.084	0.142	0.086	0.096	0.242	114.942	
Average	0.109	1.428	1.227	19.937	11.647	1.133	0.005	1.866	4.591	0.264	0.105	0.047	2.827	54.298	0.019	0.026	0.019	0.030	0.052	99.629	
Sigma	0.134	1.478	1.337	20.326	9.313	1.111	0.007	2.774	5.198	0.285	0.158	0.065	2.164	26.470	0.023	0.035	0.025	0.027	0.075	4.206	

Table 13: Bulky, medium sized nail (circular head and shank) HM169 [?1830's]: Composition of metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Fe	Total	Comment
1	0.000	0.020	0.436	0.002	0.000	0.002	0.018	0.007	0.068	0.760	0.028	0.000	0.022	98.637	100.000	Line 1
2	0.000	0.019	0.521	0.004	0.000	0.000	0.015	0.003	0.065	0.726	0.015	0.000	0.023	98.609	100.000	Line 2
3	0.000	0.017	0.310	0.000	0.001	0.000	0.015	0.005	0.071	0.849	0.041	0.000	0.010	98.681	100.000	Line 3
4	0.000	0.017	0.606	0.003	0.000	0.000	0.025	0.001	0.059	0.646	0.024	0.000	0.009	98.610	100.000	Line 4
5	0.000	0.015	0.458	0.004	0.000	0.001	0.031	0.002	0.052	0.582	0.014	0.000	0.014	98.827	100.000	Line 5
6	0.000	0.015	0.373	0.002	0.002	0.004	0.009	0.002	0.040	0.478	0.039	0.000	0.010	99.026	100.000	Line 6
7	0.000	0.018	0.273	0.002	0.000	0.000	0.005	0.000	0.043	0.469	0.039	0.000	0.010	99.141	100.000	Line 7
8	0.000	0.017	0.262	0.002	0.000	0.000	0.013	0.000	0.050	0.409	0.017	0.000	0.000	99.230	100.000	Line 8
9	0.000	0.017	0.241	0.001	0.000	0.000	0.015	0.001	0.053	0.433	0.019	0.000	0.005	99.215	100.000	Line 9
10	0.000	0.017	0.221	0.001	0.000	0.005	0.014	0.002	0.056	0.436	0.007	0.000	0.000	99.241	100.000	Line 10
11	0.018	0.038	0.274	0.001	0.000	0.000	0.010	0.000	0.054	0.453	0.024	0.000	0.006	99.122	100.000	Line 11
12	0.000	0.017	0.269	0.000	0.000	0.002	0.004	0.001	0.054	0.473	0.011	0.000	0.009	99.160	100.000	Line 12
13	0.000	0.020	0.323	0.000	0.000	0.000	0.007	0.000	0.054	0.426	0.018	0.000	0.010	99.142	100.000	Line 13
14	0.000	0.017	0.327	0.000	0.000	0.005	0.005	0.000	0.061	0.450	0.013	0.000	0.006	99.116	100.000	Line 14
15	0.000	0.018	0.219	0.001	0.003	0.003	0.008	0.000	0.061	0.464	0.019	0.000	0.004	99.200	100.000	Line 15
16	0.000	0.017	0.258	0.000	0.001	0.000	0.009	0.000	0.063	0.460	0.027	0.000	0.010	99.155	100.000	Line 16
17	0.000	0.017	0.233	0.001	0.000	0.003	0.009	0.000	0.065	0.477	0.027	0.000	0.000	99.168	100.000	Line 17
18	0.000	0.018	0.248	0.003	0.000	0.000	0.012	0.000	0.063	0.484	0.033	0.000	0.004	99.135	100.000	Line 18
19	0.000	0.018	0.157	0.000	0.000	0.000	0.014	0.000	0.056	0.471	0.019	0.000	0.000	99.265	100.000	Line 19
20	0.000	0.018	0.351	0.004	0.000	0.001	0.010	0.001	0.055	0.492	0.015	0.003	0.005	99.045	100.000	Line 20
21	0.000	0.019	0.512	0.000	0.000	0.000	0.007	0.000	0.044	0.535	0.029	0.000	0.018	98.836	100.000	Line 21
22	0.000	0.017	0.461	0.004	0.000	0.000	0.014	0.000	0.070	0.788	0.026	0.000	0.024	98.596	100.000	Line 22
23	0.000	0.016	0.442	0.003	0.001	0.000	0.017	0.000	0.069	0.740	0.033	0.000	0.022	98.657	100.000	Line 23
24	0.000	0.015	0.257	0.004	0.000	0.001	0.025	0.005	0.068	0.539	0.022	0.001	0.014	99.049	100.000	Line 24
25	0.000	0.011	0.312	0.006	0.000	0.004	0.034	0.000	0.069	0.783	0.026	0.000	0.018	98.737	100.000	Line 25
Minimum	0.000	0.011	0.157	0.000	0.000	0.000	0.004	0.000	0.040	0.409	0.007	0.000	0.000	98.596	100.000	
Maximum	0.018	0.038	0.606	0.006	0.003	0.005	0.034	0.007	0.071	0.849	0.041	0.003	0.024	99.265	100.000	
Average	0.001	0.018	0.334	0.002	0.000	0.001	0.014	0.001	0.059	0.553	0.023	0.000	0.010	98.984	100.000	
Sigma	0.004	0.005	0.114	0.002	0.001	0.002	0.008	0.002	0.009	0.138	0.009	0.001	0.008	0.239	0.000	

Table 14: Bulky, medium sized nail (circular head and shank) HM169 [?1830's]: Composition of non-metallic inclusions (oxides by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	NiO	CuO	SrO	BaO	Total	Comment
1	0.000	0.213	0.699	0.230	0.045	0.020	0.000	0.000	0.038	0.120	0.081	1.180	0.252	88.292	0.023	0.000	0.000	0.000	0.040	91.233	HM169 inc 1 FeOx
2	0.165	0.930	1.939	10.831	20.534	0.192	0.008	0.040	0.523	0.050	0.000	0.234	0.877	65.314	0.026	0.000	0.082	0.000	0.000	101.743	HM169 inc 1 Olivine?
3	0.110	0.458	2.267	10.537	10.701	1.050	0.041	0.033	0.371	0.076	0.052	0.180	0.846	64.766	0.009	0.050	0.069	0.018	0.000	91.625	HM169 inc 1 IM (etch out?)
4	0.049	0.626	1.372	7.541	13.413	0.636	0.000	0.029	0.309	0.067	0.014	0.457	0.632	72.930	0.084	0.023	0.025	0.000	0.021	98.228	HM169 inc 1 30mu
5	0.028	0.239	2.237	2.751	3.954	28.984	0.016	0.039	0.200	0.104	0.046	0.337	0.307	77.160	0.053	0.000	0.158	0.063	0.055	116.727	HM169 inc 1 bright spot
6	0.000	0.149	0.673	0.216	0.100	0.000	0.009	0.000	0.022	0.120	0.036	1.099	0.252	91.306	0.006	0.000	0.000	0.000	0.091	94.077	HM169 inc 1 FeOx
7	0.121	1.199	1.021	13.016	24.616	0.049	0.000	0.003	0.257	0.016	0.011	0.070	0.952	58.301	0.003	0.000	0.011	0.000	0.000	99.646	HM169 inc 1 Main phase
8	0.107	0.394	5.247	7.891	17.793	8.612	0.021	0.375	2.579	0.063	0.000	0.052	0.810	55.946	0.044	0.027	0.122	0.057	0.090	100.225	HM169 inc 1 IM
9	0.010	0.307	0.517	0.347	0.058	0.000	0.000	0.000	0.013	0.200	0.100	0.673	0.426	86.579	0.034	0.000	0.072	0.056	0.010	89.402	HM169 inc 2 FeOx
10	0.212	1.207	2.155	13.754	20.415	0.176	0.001	0.099	1.054	0.123	0.000	0.022	1.856	59.069	0.000	0.010	0.026	0.015	0.033	100.227	HM169 inc 2 Main
11	0.022	0.471	8.089	0.258	0.144	0.000	0.015	0.020	0.049	0.880	0.939	44.294	0.861	37.110	0.077	0.003	0.000	0.028	0.000	93.257	HM169 inc 3 FeOx?
12	0.185	1.486	1.628	14.897	21.275	0.103	0.013	0.172	1.046	0.160	0.032	0.082	2.132	55.529	0.000	0.000	0.035	0.006	0.000	98.778	HM169 inc 3 Main
13	0.215	1.333	1.769	15.943	20.332	0.252	0.008	0.203	0.935	0.127	0.021	0.079	2.271	55.427	0.006	0.000	0.000	0.006	0.132	99.057	HM169 inc 4 5mu diameter
14	0.055	0.000	0.000	0.081	4.140	0.099	0.045	0.000	0.007	0.000	0.056	2.274	0.137	77.862	0.000	0.000	0.027	0.000	0.102	84.875	HM169 inc 5 FeOX 1
15	0.023	0.000	0.004	0.085	0.290	0.073	0.009	0.000	0.000	0.018	0.010	2.553	0.085	87.101	0.000	0.000	0.129	0.032	0.000	90.410	HM169 inc 5 FeOX 2
16	0.000	0.000	0.000	0.145	32.253	0.614	0.006	0.021	0.039	0.000	0.000	0.315	1.722	59.848	0.006	0.000	0.000	0.000	0.000	94.968	HM169 inc 5 Matrix
17	0.003	0.093	0.551	0.862	2.254	0.066	0.000	0.000	0.048	0.087	0.059	0.894	0.113	87.327	0.003	0.080	0.022	0.077	0.020	92.559	HM169 inc 6 FeOx
18	0.102	0.775	0.578	7.510	28.937	0.038	0.016	0.183	1.149	0.060	0.057	0.123	0.732	61.132	0.000	0.030	0.000	0.000	0.000	101.418	HM169 inc 6 Matrix
19	0.236	0.712	0.613	7.427	25.096	0.100	0.008	0.040	0.479	0.031	0.014	0.250	0.700	66.898	0.000	0.010	0.000	0.068	0.000	102.680	HM169 inc 6 Matrix 2
20	0.185	2.131	1.063	18.013	16.232	0.041	0.028	0.218	1.540	0.031	0.000	0.088	1.530	53.866	0.026	0.027	0.061	0.025	0.000	95.099	HM169 inc 7 Matrix
21	0.010	0.396	0.566	0.343	0.010	0.000	0.025	0.000	0.056	0.201	0.035	1.038	0.498	86.545	0.011	0.000	0.029	0.012	0.110	89.879	HM169 inc 7 FeOx
22	0.633	1.089	3.254	13.767	12.495	0.149	0.000	0.352	0.655	0.084	0.049	0.107	1.699	59.343	0.006	0.000	0.000	0.000	0.022	93.704	HM169 inc 7 IM
23	0.000	0.774	8.437	0.198	0.050	0.040	0.011	0.000	0.009	0.696	0.791	35.081	0.696	47.892	0.000	0.000	0.091	0.063	0.000	94.827	HM169 inc 8 spinel
24	0.023	0.380	0.659	0.390	0.022	0.053	0.007	0.002	0.049	0.240	0.106	1.351	0.486	90.086	0.034	0.000	0.113	0.000	0.080	94.079	HM169 inc 8 FeOx
25	0.272	1.641	2.171	17.828	17.936	0.106	0.022	0.290	1.494	0.095	0.000	0.051	1.520	54.971	0.000	0.017	0.025	0.038	0.000	98.472	HM169 inc 8 Matrix
26	0.257	2.028	1.578	19.917	14.491	0.049	0.021	0.206	1.292	0.090	0.000	0.048	1.828	54.993	0.021	0.043	0.031	0.000	0.000	96.888	HM169 inc 9 Matrix
27	0.000	0.461	0.604	0.341	0.041	0.020	0.012	0.014	0.068	0.270	0.055	1.155	0.575	90.754	0.006	0.003	0.000	0.067	0.000	94.443	HM169 inc 9 FeOx
28	0.000	1.188	7.377	0.116	0.006	0.044	0.000	0.004	0.006	0.251	0.356	45.964	0.729	35.257	0.098	0.000	0.000	0.122	0.000	91.518	HM169 inc 10 block
29	0.476	1.996	2.249	19.294	14.701	0.054	0.000	0.421	1.936	0.045	0.011	0.440	2.048	56.792	0.041	0.000	0.038	0.037	0.022	100.601	HM169 inc 10 Matrix
30	0.033	0.417	0.607	0.306	0.032	0.000	0.015	0.000	0.075	0.276	0.174	1.707	0.579	93.725	0.025	0.000	0.003	0.006	0.000	97.977	HM169 inc 10 FeO
31	0.866	1.218	5.014	18.746	12.416	0.214	0.023	1.157	2.389	0.090	0.022	0.865	1.812	51.285	0.000	0.030	0.033	0.000	0.078	96.253	HM169 inc 10 IM
32	0.000	0.605	6.276	0.127	0.025	0.007	0.000	0.000	0.000	0.185	0.307	43.259	0.639	40.155	0.000	0.000	0.000	0.025	0.000	91.610	HM169 inc 11 1
33	0.020	0.185	0.568	0.463	0.217	0.000	0.000	0.000	0.017	0.252	0.132	1.082	0.349	96.103	0.050	0.000	0.018	0.016	0.000	99.472	HM169 inc 11 2
34	0.256	1.503	1.237	12.024	23.405	0.111	0.006	0.149	0.887	0.044	0.093	0.341	1.445	62.077	0.000	0.037	0.000	0.012	0.000	103.626	HM169 inc 11 3
35	0.204	2.003	0.956	19.030	15.346	0.038	0.000	0.068	0.502	0.043	0.000	0.019	1.923	58.371	0.058	0.003	0.000	0.000	0.000	98.564	HM169 inc 12 matrix
36	0.029	0.295	0.735	1.158	0.787	0.045	0.014	0.005	0.120	0.356	0.113	0.666	0.573	90.310	0.014	0.000	0.000	0.000	0.000	95.217	HM169 inc 12 FeOx
37	0.022	1.374	6.097	0.084	0.034	0.005	0.009	0.000	0.017	0.176	0.265	49.297	1.213	36.903	0.006	0.039	0.057	0.144	0.041	95.781	HM169 inc 13 Spinel
38	0.397	2.234	2.118	18.961	20.865	0.147	0.023	0.380	2.369	0.123	0.029	0.529	1.921	47.725	0.009	0.000	0.000	0.000	0.011	97.836	HM169 inc 13 Matrix
39	0.351	2.466	1.894	21.312	12.955	0.127	0.008	0.243	1.162	0.131	0.000	0.101	2.059	57.403	0.012	0.040	0.000	0.049	0.000	100.311	HM169 inc 14 Matrix
40	0.051	0.496	1.297	2.881	1.151	0.076	0.003	0.027	0.192	0.481	0.153	0.552	0.722	88.468	0.000	0.043	0.029	0.000	0.000	96.621	HM169 inc 14 FeOx
41	0.000	0.532	1.976	2.857	0.989	0.043	0.004	0.016	0.127	0.515	0.174	1.555	0.616	86.351	0.017	0.000	0.101	0.000	0.000	95.872	HM169 inc 14 FeOx
42	0.000	0.879	8.668	0.256	0.108	0.000	0.000	0.029	0.049	0.832	0.799	42.750	0.994	36.581	0.003	0.066	0.029	0.000	0.031	92.074	HM169 inc 14 Spinel
Minimum	0.000	0.000	0.000	0.081	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.085	35.257	0.000	0.000	0.000	0.000	0.000	84.875	
Maximum	0.866	2.466	8.668	21.312	32.253	28.984	0.045	1.157	2.579	0.880	0.939	49.297	2.271	96.103	0.098	0.080	0.158	0.144	0.132	116.727	
Average	0.136	0.878	2.304	7.208	9.778	1.010	0.011	0.115	0.575	0.186	0.124	6.743	1.010	66.282	0.019	0.014	0.034	0.025	0.024	96.473	
Sigma	0.187	0.688	2.441	7.669	10.076	4.616	0.011	0.207	0.737	0.209	0.219	15.265	0.651	18.326	0.025	0.021	0.042	0.034	0.037	5.181	