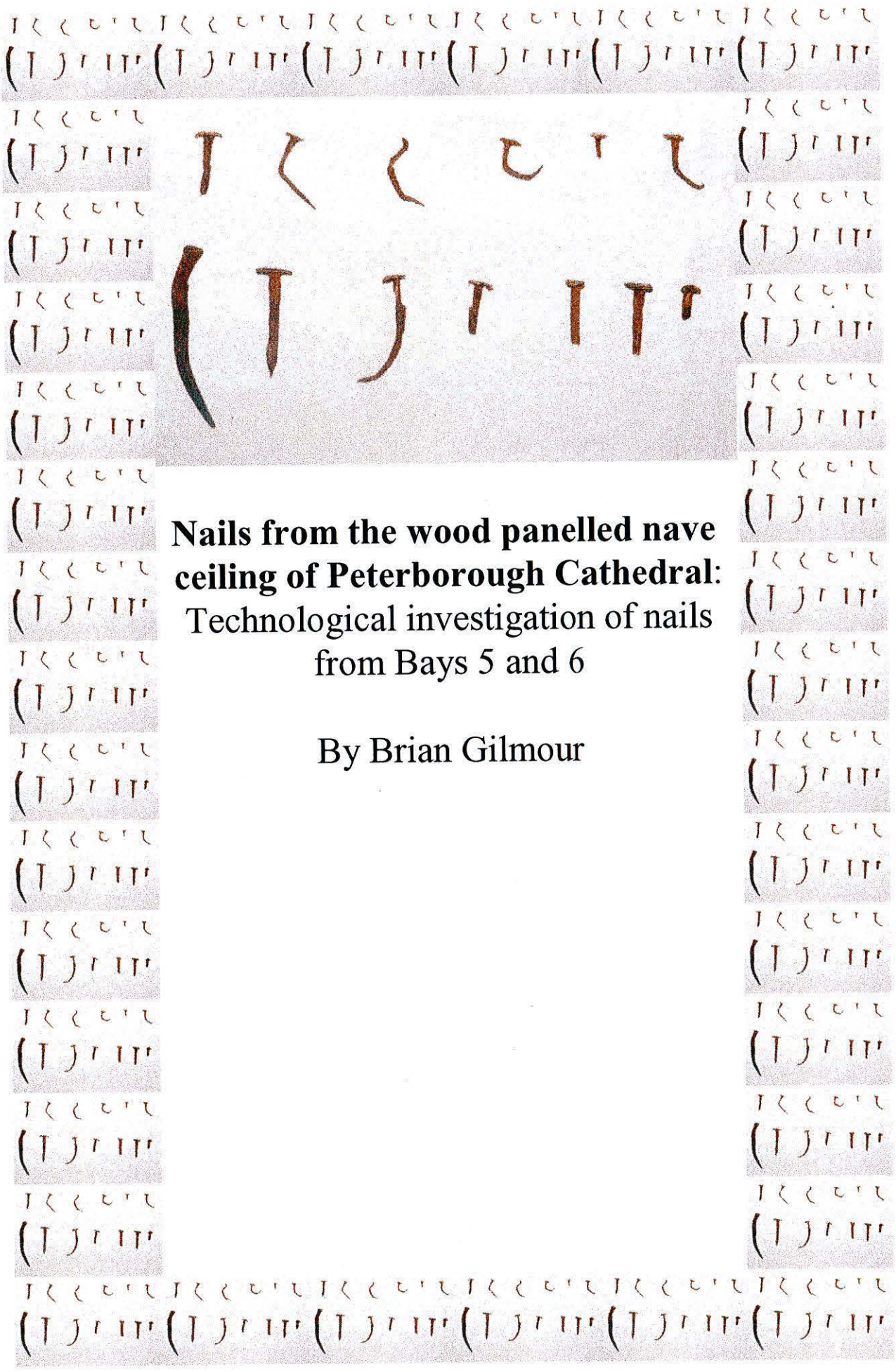

Nails from the wood panelled nave ceiling of Peterborough Cathedral: Technological investigation of nails from Bays 5 and 6

By Brian Gilmour

Nails from the wood panelled nave ceiling of Peterborough Cathedral:

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

Brian Gilmour

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.

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 (?early or proto) 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.

Examination of nails from Phase three of the ceiling restoration

Early during the restoration work on Phase three it become clear that a 'new' type of nail had been used 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 Phase 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, much more irregularly (or poorly) shaped heads plus shanks of rectangular (as opposed to more-or-less square) cross-section.

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 similar but slightly larger nail was encountered during work on Phase 3 of the restoration work on the ceiling. The heads on these were again very irregular in plan and flattish or very slightly domed in profile. 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.

Altogether eleven nails were examined from Phase 3 of the restoration work (ie the second stage of the technological investigation) and these were selected on site (Fig 1). A further two nails were recovered (Fig 1) but the sample cut from HM108 was too thin and uneven for polishing

to be successful so could not be examined (although the remaining larger half of the head could be examined in future). However it was clear that this nail belonged to the same group of nails (as HM106 and the others) which this investigation identified as having been one of the original types of panel fixing nails. The other (HM113) was a well preserved and clearly identifiable example of one of the nails with spade-shaped ends and faceted heads belonging to the restoration of *c*1830 and further investigation at this stage was felt to be unnecessary, although this nail has been kept in reserve for further comparative work should this become necessary.

As before, the heads and the upper parts of the shanks of these eleven nails were sectioned longitudinally and mounted and examined metallographically. The sections were all etched with 2% nital (nitric acid in ethanol). A representative proportion of this batch of nails was then subjected to electron-probe micro-analysis (EPMA), this part of the work by necessity being split into two parts; one involving the analysis of the metal at various points across a particular section, while the second entailed pin-pointing particular non-metallic inclusions and analysing these separately. The results of micro-analysis are shown in Tables 1- 4 below. For the results of this part of the work to be valid the different types of inclusions present had to be approximately identified by eye (under the microscope) and then a representative selection analysed.

Nails thought to belong to the original ceiling structure

Several of the small (mostly) flat-headed nails were examined to see if their structure and composition was consistent with a date of *c*1220-1230. These nails were all very similar in physical size and shape as well as in internal shape and chemical composition (of both metal and non-metallic inclusions) although the latter was only determined for the first two nails.

1. **Phase III, 24 IV, Board M**: This example (HM106) was typical of the type of panel fixing nail newly encountered in Bays 5 and 6 in what looked to be an undisturbed original context. It was complete and measured 53mm in length with an irregularly shaped head approximately 12 mm across, and with a rectangular shank, tapering along each side and measuring 4.0 x 2.5 mm in section at a point approximately one third of the way down from the head (Fig 2).

In section this nail is distinctive for the very irregular size of the iron grains of the metal when etched. At low magnification this gave the section a rather blotchy appearance in the central part near the head but a more streaky look further down the shank (Fig 3). The difference is these two areas is the result of much more forging out (ie hammering out longitudinally to shape while hot) to which the shank has been subjected by comparison with the area near the head. At higher magnification it becomes possible to see that the contrasting appearance across the section is due entirely to differences in the iron (ferrite) grains with virtually no carbon (pearlite) visible at all (Fig 4). The darker irregular areas also visible in section are non-metallic slag - with two and three phases visible in the inclusions - residual non-metallic material trapped in the metal during its manufacture (Fig 5). Characteristically this has become more elongated along the shank where the iron has been forged out proportionally more in this longitudinal direction. The overall uneven appearance of this structure is suggestive of a bloomery origin for the metal but without little or no carbon (pearlite) visible it was difficult to be sure of this.

Detailed compositional analysis and elemental mapping by scanning electron micro-probe showed that the differential iron structure visible in section was the result of inhomogeneous phosphoritic

iron (ie one with a variable phosphorus content) having been used to make this nail. This showed the phosphorus content of the iron to vary between 0.14 and 0.42% (Table 1). Apart from the high level phosphorus (mean level approximately 0.3%) the iron is low in alloying impurities which is characteristic, although not necessarily diagnostic, of early iron made in a bloomery furnace. In a similar way the non-metallic inclusions (Table 2) are fairly typical of a bloomery metal although the high level iron oxide in these, as opposed to iron silicate, together with the virtual absence of carbon means that a post medieval finery origin (ie iron made as a secondary product from cast iron) is also a possibility although less likely in view of the inhomogeneous nature of the iron.

This was partly problem because at the outset of the present investigation no detailed compositional and structural analysis had previously been done to identify a phosphoritic medieval iron of quite this composition and appearance. The structure of the phosphoritic iron of the 'birds beak', early 13th century ceiling framework joint fixing nails (identified from the structure above bays 3 and 4 of the ceiling and described in late 1999 in the technological report on the first batch of nails from this ceiling) was rather more typical of phosphoritic bloomery iron encountered before. In an effort to find a definitely medieval parallel for the phosphoritic iron of the 'small-headed' panel fixing nails encountered in Bays 5 and 6, a search was carried out and fortunately, a good compositional match was found with a nail used in an original window frame in house, at Aston Tirrold in Oxfordshire, dated to 1286 by dendrochronology.

2. **Phase III, 25 IV, Board L**: In appearance this nail (HM109) was very similar in size and shape to the previous example (HM106), although this time the head, again very irregular in plan, was slightly domed in profile (Fig 6). This nail was complete and measured 56 mm in length and, in cross-section, the shank measuring 5 x 3 mm at a similar point.

In longitudinal section after etching this nail was found to be similar in structure to the previous example (HM106) with an uneven patchy appearance, but with a less streaky or banded appearance indicating a lesser degree of forging along one direction than for the other, this being particularly apparent a low magnification (Fig 7). As before this differential appearance was due mainly to a very variable iron (ferrite) grain size plus the presence of an irregular distribution of, mainly dark grey, non-metallic slag inclusions (Fig 8). Three different phases were again visible in the slag although the proportion of the paler grey iron oxide (wüstite) was lower for this nail (Fig 9).

Electron-probe micro-analysis (EPMA) showed the composition, of both the iron (Table 3) and the non-metallic slag inclusions (Table 4) present in the metal, to be very similar to the previous nail (HM106). As for that nail it is clear that the irregular grain structure of the iron is the result of a high but uneven phosphorus content to the metal with very little other alloying constituents present. Likewise the overall compositions of the non-metallic inclusions is very similar even if the balance of the constituents appears slightly different with less iron oxide present. As for the previous example a phosphoritic iron has been used to make this nail although the overall phosphorus content at 0.4% is a little higher.

3. **Phase III, 19 II, Board Y**: Although only the upper 21 mm of this nail (HM111) was recovered it is clear that originally it was about the same size and shape as the previous two examples (HM106 and HM109). Near the break the rectangular cross-sectional profile of the

tapering shank measured 4 x 2.5 mm. The flattish head was very slightly domed, probably the result of damage when being hammered into place.

In section this nail contained more non-metallic slag than the two previous panel fixing nails so far described (HM106 and HM109), and some of these inclusions were very large especially one massive inclusion in the centre of the shank. The iron also had a less patchy or streaky appearance at lower magnification (Fig 10). This appearance is consistent with a more even iron grain size visible at higher magnification which also showed up (rather watery looking) traces of phosphorus 'ghosting' (Fig 11). The non-metallic inclusions were all quite similar, with a little iron oxide (wüstite) showing up as a pale grey constituent against a mixed darker grey iron silicate/ glassy matrix (Fig 12).

No detailed micro-analysis was carried out on this nail but the relatively even sized, medium grain structure and phosphorus 'ghosting', would suggest that somewhere between about 0.1 and 0.3% phosphorus may be present, rather less than for the phosphoritic iron nails already described. The quantity and distribution of the non-metallic slag present indicates this to be a poor quality iron, most likely either of bloomery or finery origin, therefore a date anytime between the early 13th and mid 18th century is possible given that its structure does not clearly match any of the categories of nails examined and analysed in detail. Micro-analysis might help to narrow down the possible date range. Given the great similarity of its physical shape and size (of what was recovered) of this nail it seems most likely to belong to the same group of small flat headed nails almost certainly used originally to fix many of the wooden ceiling panels in place in this part of the nave. If so it would appear that it was made of a different batch of iron, perhaps one of poor quality that was not extensively used in the construction of this ceiling.

4. **Phase III, 19 III, Board K**: In size and shape this complete nail (HM124), with its small flat head, was very similar to the first example described here (HM106) and although a little shorter, at 38 mm in length, the cross-sectional dimensions of the tapering rectangular shank, at 4 x 2.5 mm, were much the same.

The patchy/ streaky iron structure visible in the etched section of this nail was also very similar to that seen in the other example (HM106) as was the quantity, size and distribution of the non-metallic slag present, this being particularly apparent at low magnification (Fig 13). Although the character of the metal is very much the same there are less paler, larger grained, areas in this particular nail (Fig 14). The character of the slag in this nail is also more or less identical with that seen in the nail (HM106) described earlier (Fig 15).

5. **Phase III, 26I, Board M**: Approximately three-quarters of the shank plus the smallish flat head of this nail (HM126), measuring 39 mm in length, was recovered. About one third of the way down, the cross-sectional profile of the tapering shank measured approximately 5 x 3 mm.

There seems little doubt from its etched appearance in section that this nail belongs to the same group as the other small (originally) flat headed nails grouped together and described in this section of the present report. As before it has an uneven patchy or streaky appearance, especially evident at low magnification (Fig 16), but this time it differs in that the large grain pale iron areas cover most of this upper part of the nail, except for some places, mainly the area towards one side of the nail head which was mostly occupied by fine grained iron (ferrite) with a very little carbon

visible as pearlite. The clear distinction between these areas (Fig 17), as well as their structure in each case, is indicative of the pale areas consisting of iron high in phosphorus - a level of about 0.5% being likely - but the way these contrast with what show up as grey areas which must consist of fairly plain iron low in both carbon (although a little is present) and phosphorus, although the levels of both elements are likely to be below 0.1%. Most noticeable in the centre of the section is a very large, irregular non-metallic slag inclusion consisting of three phases, as before with a pale iron oxide (wüstite) constituent, partly visible as a needle-like distribution across the inclusion, against a darker grey iron silicate or glassy background matrix (Fig 18).

The very irregular, in shape, size and distribution, of the (darker) non metallic slag inclusions visible, together with the very uneven distribution of the apparently different types of iron (ie phosphoritic and non phosphoritic) present, as well as the presence of some carbon, when taken together all suggest that this nail has been made from a piece of incompletely consolidated bloomery iron. The crack visible between the shaft and the head on one side is almost certainly the result of a band of highly phosphoritic iron being present in a generally non phosphoritic part of the nail. In this case the inherent brittleness in this area must have give rise to the crack when the nail was made rather than when it was driven into place, given that the crack and the area round about does not show any sign of distortion.

Nail found in a 15th to 16th century dovetail repair joint in the ceiling support structure

6. **Phase III, Joist 22, south end**: In both size and form this very well preserved and complete nail is completely unlike any of the nails so far encountered in this project. It is 110 mm in length and has a square cross-section to the shank which tapers evenly on all sides down to the tip, while at the other end the shank is only slightly splayed out to form a square head measuring 10 mm across (Fig 19).

In section it is also noticeably different to any of the nails feature in this (or the previous) report. It has a slightly streaky appearance at low magnification when an uneven, but mostly not very dense, scattering of small well flattened slag, non-metallic slag inclusions is also visible (Fig 20). As far as the iron is concerned most noticeable is a relatively wide grey central band with an uneven, slightly wavy striated structure on either side. Rather more non-metallic slag is visible in the paler areas on either side of the central grey band, particularly on one side nearer the head (upper right on Fig 20). At higher magnification the grey banded zones can be seen to consist of variable but mainly fine grain iron (ferrite) with a little carbon unevenly distributed as pearlite, visible as small dark areas between the iron grains (Fig 21). The carbon content, however, is low with, at most, little more than 0.1% present. Although the side areas appear slightly striated at low magnification this is barely noticeable at higher magnification, the main visible difference being a relatively small variation in the grain size of the iron (Fig 21). Unlike all the previous nails most of the smaller non-metallic slag present is visible as dark iron silicate, probably mixed with a glassy constituent, but with little of the pale iron oxide phase (wüstite) visible mainly in some of the larger inclusions, of which there are relatively few.

Micro-analysis confirmed the impression of the observed structures and showed the metal (Table 5)and the non-metallic inclusions (Table 6) to be quite different to any of the other nails featured in this report. It confirmed that the low carbon iron central grey band also contained little more than about 0.1% phosphorus. The paler bands on either side, in which the little carbon present

was confined to a few elongated patches, were slightly phosphoritic but with little more than 0.1 to 0.2 % phosphorus present.

Taken together the inhomogeneous structure and chemical composition of this his metal is very typical of a relatively high quality, slightly phosphoritic bloomery iron, probably exactly what might be expected of the bloomery smelting industry of the late medieval or early post-medieval period.

Group of nails of uncertain date but thought possibly to belong to the restoration of *c* 1740

Of the four nails in the following group the first three were found to be identical both in shape, size, internal structure and chemical composition (of both metal and non-metallic slag inclusions) although the latter was only determined for the first two nails. The fourth was quite different and had a faceted head similar to other nails thought to belong to the restoration of *c* 1740. Its structure also favoured an 18th century date.

7. **Phase III, 19 II, Board L**: In overall appearance this nail (HM 107) was similar to the two (HM106 and HM109) described above although it was larger, measuring 75 mm in length (Fig 22). Its head was slightly larger, even more irregular in shape and slightly domed in profile, and the rectangular shank measured 5 x 3 mm at a comparable place approximately one third of the way down from the head.

The initial impression when viewed in section at low magnification was that the iron of this nail was somewhat different to that of the previous two nails described (HM106 and HM109), although closer inspection revealed that actually the iron was very similar in appearance but there was more non-metallic slag present (Fig 23). As before, the iron had a patchy appearance at the head and a streaky or banded appearance along the shank, the differences again being the result of there being a greatly dissimilar iron (ferrite) grain size present in the different areas (Fig 24. The non-metallic inclusions present were also very variable in size and distribution although, as for the previous examples described, three main phases could be seen, with a pale grey iron oxide constituent visible against a matrix consisting darker grey (iron silicate and glassy) phases (Fig 25).

Detailed compositional analysis (by EPMA) showed this to be the result of very variable phosphorus content across the metal, the average content being approximately 0.4% (Table 7). In composition (Table 8) the non-metallic inclusions were also very similar, at least chemically, to the other two already mentioned (HM106 and HM109). It is quite clear that this nail (HM107) 0is made of a similar phosphoritic iron, the principal difference being that it contains considerably more non-metallic slag.

8. **Phase III, 24III**: Only the head and part of the shank of this nail (HM110) was recovered although in shape and size it was closely similar to the previous example. What remained of the nail measured 20 mm in length and, in cross section at the broken end, the rectangular tapering shank measured 6 x 3 mm.

It is clear from the etched section, particularly at low magnification (Fig 26) that the iron of this nail is more or less identical to that of the previous nail (HM107) and the description of the

microstructure given for that applies equally well to this example (Figs 28 and 29). EPMA analysis further confirmed this nail to be made of what looks to be the same phosphoritic iron (Table 9) as the previous example. The phosphorus content overall was again approximately 0.4% and the chemical composition of the non-metallic inclusions was very much the same (Table 10). The great similarity of these two slightly larger nails (HM107 and HM110) suggests they are likely to be part of the same batch of nails, or at least to have been made in the same place at much the same time.

9. **Phase III, 24 IV, Board C**: Only the upper half of this nail (HM112) was recovered. It measured 36 mm in length and was very similar in size and shape to the two similarly slightly larger nails (HM107 and HM110) described above, and the cross-sectional dimensions of the tapering rectangular shank were also about 5 x 3 mm.

In section it was also remarkably similar to both these examples both in terms of the (patchy near head and streaky along shank) appearance at low magnification together with the volume and distribution of non-metallic slag (Fig 30). As before the uneven appearance of the iron was due to widely differing (ferrite) grain size in different areas (Fig 31) and the non-metallic slag also was virtually identical in its three phase structure to that seen in both the other two nails (Fig 32). It is clear therefore that this nail belongs to the same group, and is possibly from the same batch as both the other two examples (HM107 and HM110).

10. **Phase III, 20 IV, Board E**: The faceted, domed form of the head of this nail (HM123) is quite different to any of the nails described above. Only the upper part of the nail was recovered and this measured 21 mm in length. The flatter rectangular cross-sectional profile, measuring 5 x 2 mm, was also different.

In longitudinal section its structure varies widely but instead of a consistently patchy or streaky appearance at low magnification there was a much more markedly segregated appearance after etching, with a single large very pale area occupying most of the central part of the section with grey areas on either side, further down the shank and across much of the head (Fig 33). As before this difference in appearance was the result of differential iron (ferrite) grain size across the different areas, fine to medium grains producing the grey effect and the much larger grains of the paler areas giving a more nearly whitish effect (Fig 34). The non-metallic slag content was very variable both in terms of size and distribution and mostly consisted of three phases, mainly two darker grey phases (presumed to be iron silicate and a glassy constituent) with a relatively fine dispersion of paler iron oxide visible against this background (Fig 35).

To some extent this slag is very similar to much of the slag seen in several of the phosphoritic iron nails described earlier but there is a noticeable difference in the overall distribution (as seen best in Fig 33) as well as the much greater volume of very small slag particles (most obvious in Fig 34) which is more typical of a puddled wrought iron. Although superficially similar to the previous three examples the iron was different in two other significant ways. Apart from the overall segregation of the grey and paler areas already described, there was some slight degree of patchiness within these main zones but instead of these plus the boundaries between the zones, and much of the slag being oriented consistently along the shank (ie along the main direction of forging), as well as across the head, much of the orientation is either across the shank as well or is much more random. Taking all these factors together the most likely reason for the metal to

have both such a mixed structure but one which is more randomly oriented is if a mixture of recycled iron probably of two different types, one (the paler, large grained areas) consisting of phosphoritic iron and the other (the finer grained grey areas) of iron relatively low in phosphorus. In this case the resemblance to puddled iron may (as for HM54 in the first report, p7) indicate the early use of a reverbatory furnace (which kept the fuel and charge separate) to make the iron. If so, it is unlikely that this iron was made very much earlier than the 18th century. Compositional (micro-) analysis of the slag inclusions would probably help determine whether or not puddled iron has ben used here but that has not so far been carried out on this nail.

The transverse crack extending across much of the shank near the head may either have been the result of a transverse flaw or is simply the result of the phosphoritic iron being rather brittle at this point. Either way not only does this nail have a faceted head - previously only noted on nails identified as belonging to one of the restorations of the 1740's or *c* 1830 - but the probably use of recycled iron also marks it out as quite different to the other nails described above. This is probably more consistent with (what would appear to be) the smaller scale restoration work of the 1740's.

Nail from the restoration of c1830.

11. **Phase III, 22 III, Board P**: Only about half this nail (HM125) was recovered and the head was rather mangled although it appeared to have been a flattish domed shape beforehand. Near the break the cross-section of the rectangular shank measured approximately 5 x 3 mm near the break and the total length of this piece was 38 mm.

After etching a very regular banded structure showed up particularly clearly at low magnification and in distorted form this continued up through the head (Fig 36). This is quite different to any of the other structures described in this report but very similar to the puddled iron used for the spade-shaped ended nails (which were also made with four sided, faceted heads) associated with the restoration of *c*1830 which were described in the technological report on nails from Phases I and II of the ceiling restoration, and a type of nail which is very common throughout the length of the ceiling. At higher magnification what is most noticeable is the wide but relatively even though heavy concentration of elongated but generally smaller non-metallic slag inclusions (Fig 37). This is again very typical of puddled iron and is much the same structure as was observed for the spade-ended, faceted headed nail examined in the previous report (for restoration Phases I and II, p 5, HM 53; and p18, Fig 8a and b). The visible structural appearance of the non-metallic slag (Fig 38) is also very variable which seems to be typical of puddled wrought iron.

The close similarity of this example to the banded structure to the other (spade ended) nails associated with the restoration of *c*1830 strongly suggests that this nail belongs to the same 19th century phase of restoration work although if so then not all the nails used at this time had quite the same characteristic four-sided faceted heads. There seems to be no obvious reason for this banded structure in a puddled iron, which all the metal of these nails clearly is, and the only obvious conclusion is that this is puddled iron of a fairly unusual (or unrecognised) variety that is the specific product of a particular place and time. It is most likely to have been produced not much before it was used in *c*1830, and in any case is unlikely before the recorded introduction of puddled iron in 1784. Their similarity also suggests all these nails to be more or less contemporary products of the same rolling mill.

Conclusions and discussion

From their overall appearance, visible structure and chemical composition it eventually became clear that four out of the five nails in the first group dealt with in this report were part of a single large batch, or several near contemporary batches of nails made of phosphoritic iron of rather uneven composition which is to be expected for a likely product of British iron ores many of which are phosphoritic. As yet little exists in the way of a database of analysed medieval or post-medieval iron so it is difficult, as yet to find close parallels and hence to place ironwork like this in context, especially given that most ironwork that has been analysed (of any date) tends to be relatively low in phosphorus. The fifth nail (HM111), which was not analysed chemically, consists of a poorer quality, rather less phosphoritic iron and its structure is consistent with a bloomery origin and its close similarity in size and shape would suggest that this nail belongs to this same group of 'small-headed original' panel fixing nails

However, the majority of this group of iron nails is closely similar in structure and chemical composition, if smaller in size to the nails used in *c*1230 to hold the 'birds beak' noggin joints in place in the ceiling framework of joists above the wooden panels (see previous report of 1999). The iron is also closely similar to that used for an iron nail (HM183) used to fix part of an original window frame in place in a medieval house at Aston Tirrold, Oxfordshire, dated by dendrochronology to 1286 and appears therefore to be one type of late medieval bloomery iron that was in fairly widespread use, at least for the production of nails in the midland areas of England at this time. Apart from its uneven phosphoritic nature this iron has a characteristic non-metallic slag content and distribution. Most of these inclusions were relatively small and the overall volume relatively low even though the distribution was uneven.

A similar volume of non-metallic slag was seen in the larger, well preserved nail from the ceiling framework repair of 15th/16th century date. In this case the very variable structure and chemical composition of the nail were much more typical of a much less phosphoritic bloomery iron, and in this case, of a rather different method of smithing, possibly one on a larger scale. The continuous evenly banded structure of his nail and the highly flattened nature of many of the slag inclusions shows that the iron from which it has been made from a much longer bar of iron forged out then cut into the desired nail-sized lengths. In fact each nail was probably forged to the final shape before being cut off the end of the bar, with no need for a separate nail-heading operation.

Most problematical of the nails dealt with in this investigation are the group of three nails (HM107, HM110 and HM112) described above as being of uncertain date but thought to belong to the restoration of *c* 1740. This group of nails although similar in shape are identifiably bigger, being correspondingly larger in all their dimensions by a factor of approximately a third to a half and this alone made them relatively easy to separate out physically from the smaller but otherwise similar looking nails. In terms of the iron they were made from they were very similar to the group of phosphoritic iron, 'small flat-headed' nails identified here as being one of the batches of nails originally used to fix the wooden ceiling panels in position in *c* 1230.

They were again found to consist of iron of an unevenly phosphoritic composition (again approximately 0.4% overall) which gave rise to a patchy (head) or streaky (shank) appearance in section iron (when etched). There was, however, much more non-metallic slag in the iron used for these three nails and this was particularly noticeable at low magnification when the complete

sections could be viewed and compared. Many more large, irregularly shaped inclusions are visible and these show that this iron although the metal is similar in this case it has been much less well consolidated during manufacture and is therefore of much poorer quality than used for the smaller phosphoritic nails which we are sure belong to the original 13th century phase of construction. The difference in appearance made them relatively easy to identify and separate as soon as the complete sections could be examined and compared with the rest.

The contexts in which each of this group of three nails was found suggests strongly that they belong to the restoration of *c* 1740 although in other cases it is not always so easy to tell, from their context alone, to which phase of the ceiling's history other apparent examples of this type belong. Although physically the slag content and distribution looks different to that of the earlier group of nails the actual chemical composition of the slag is very similar with the possible exception of the sulphur content which is slightly higher for this latter group of three nails. The similarity between them, structurally and chemically, probably means that both groups of nails are of bloomery manufacture, and perhaps also means that they were produced in the same area.

If so the iron used for the latter group of three nails would seem to belong to the very final phase of bloomery iron in this country which seems to have ceased around 1720 or not long after (Tylecote 1986, 207). Although a poorer quality product may be typical of the final phase of British bloomery iron production, the actual demonstration of this awaits the examination of much more medieval and post-medieval iron (very little having been examined in detail so far) and the establishment of a reasonably good database which does not exist as yet. Overall it does seem quite clear that nails of this size were only used to fix any of the wooden panels in position on this ceiling during one of the post-medieval phases of restoration work. From the evidence of this randomly selected group of three nails it appears that nails of this type can at least be identified by their size and appearance in section at low magnification where their characteristically high slag content and distribution can be identified.

We can be more confident about the associating the final two nails of this report with one of the two known phases of restoration work on the panelled underside of the wooden ceiling, one (HM123) probably belonging to that of *c* 1740, while the other (HM125) clearly relates to the work of *c* 1830. The faceted form of head of the first of these two nails has so far only been noted on nails we are fairly sure (or more certain) were used to refix various panels into position. In this case a mixture of phosphoritic and low carbon iron with little or no phosphorus have also been used. In marked contrast to the previous examples the orientation of the paler and darker areas to a large extent does not follow the direction of forging, in particular along the shank. The orientation is much more random and suggests the use of recycled iron for this nail. Much of the slag in the pale areas is of just one or two darker phases (ie there is little iron oxide present) whereas there is much more iron oxide present in the slag of the darker areas, also suggesting the combination of two different pieces of iron (one phosphoritic and one not) during recycling. In of itself.

The use of puddled wrought iron, which has clearly been made into bars via a rolling mill before being cut off and forged into shape, indicates that the second nail (HM125) belongs to the restoration of *c* 1830. Its structure is very much the same as that of the two nails previously identified (HM53 and HM56) as being part of this later restoration.

Perhaps the main recommendation to come from this report, apart from the obvious need to increase the database of analysed medieval and post-medieval nails, is that more nails of the group of three referred to in this report as being of uncertain date should be examined so that we may be more confident of identifying them as a distinct group, and of assigning this group to the restoration of *c* 1740.

Bibliography

Schubert, HR 1957: *History of the British Iron and Steel Industry from 450 BC to AD 1775*. London: Routledge and Kegan Paul.

Tylecote, RF 1986: *The Prehistory of Metallurgy in the British Isles*. London: Institute of Metals.

Acknowledgements

In addition to the metallographic and assessment work reported above, the detailed composition of the metal and non-metallic slag inclusions of five 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 10. I am very grateful to Chris Salter for carrying out this detailed analytical work and for discussing the results and their implications and also for carrying out the additional analysis for the nail; from Aston Tirrold, Oxfordshire.

Fig 1. Nails recovered for technological investigation from Phase Three of the restoration work on the Peterborough Cathedral nave ceiling: From left to right on the top row are: HM112, HM106, HM109, HM108, HM111, HM124; and on the bottom row: HM105, HM113, HM107, HM110, HM125, HM126 and HM123.

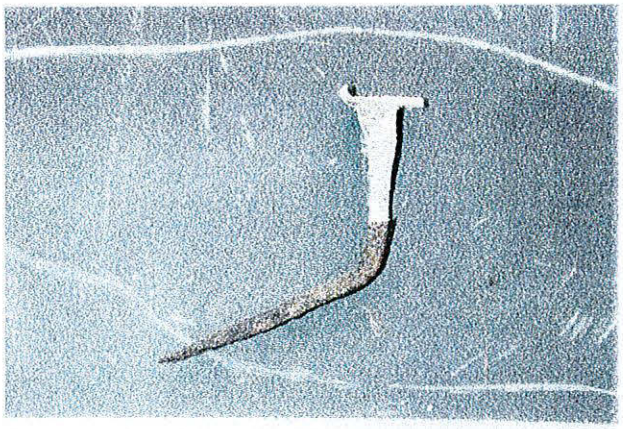

Fig 2. Flat-headed panel fixing nail thought to be part of the original work of *c* 1220 - 1230. Length of nail 53 mm.

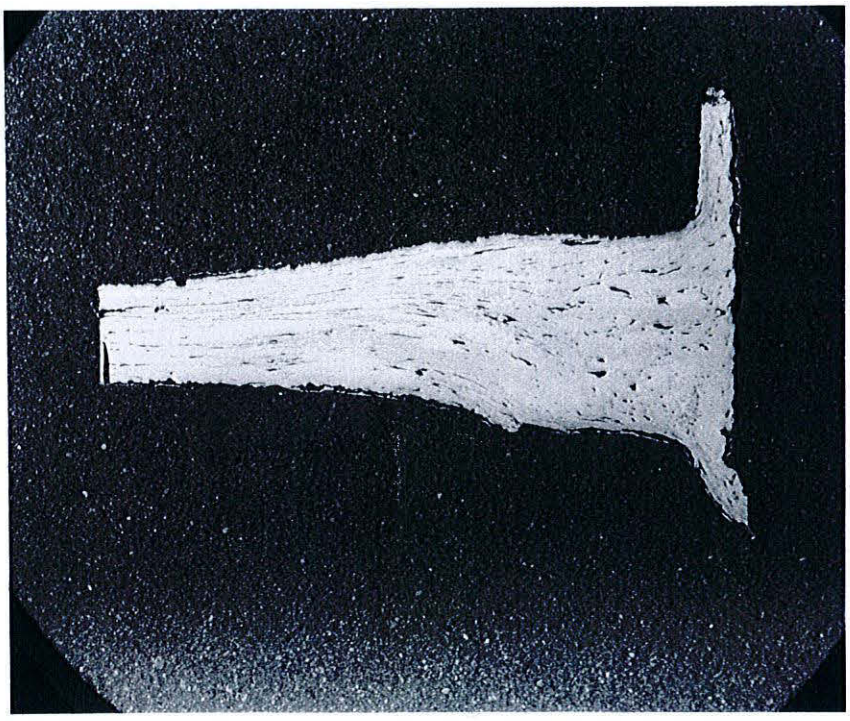

Fig 3. This flat-headed panel fixing nail (HM106) in longitudinal section at low magnification. Magnification x6; etched with 2% nital.

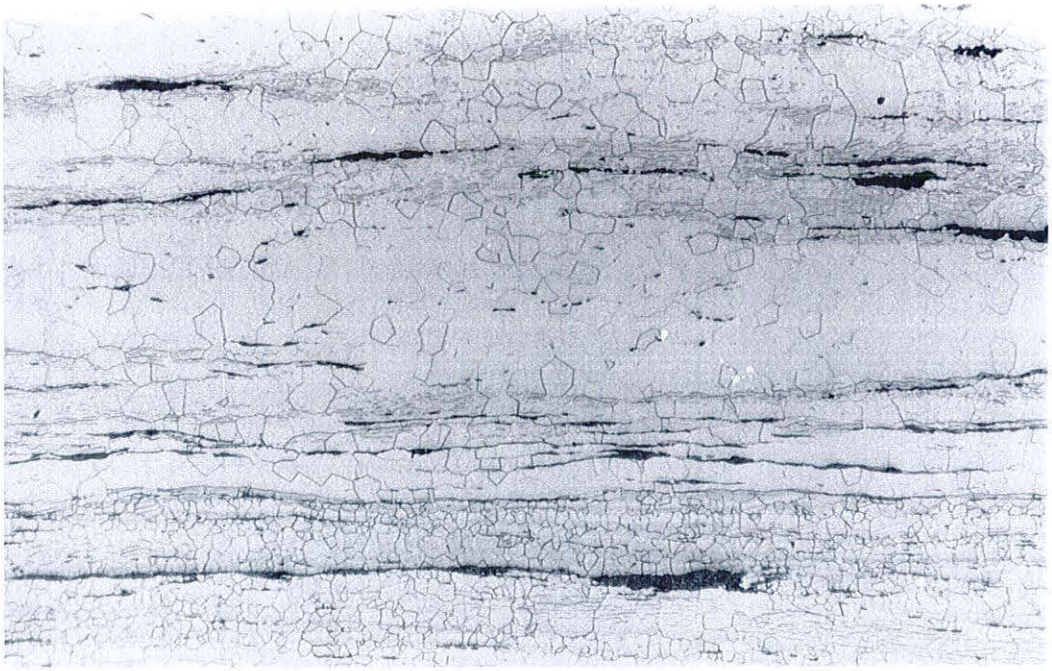

Fig 4. The structure of part of the shank of this nail showing the differential ferrite grain structure of the iron plus the elongated darker non-metallic slag inclusions. Phosphorus 'ghosting' is also visible as pale, streaky looking formations resembling water droplets. Magnification x50: etched 2% nital.

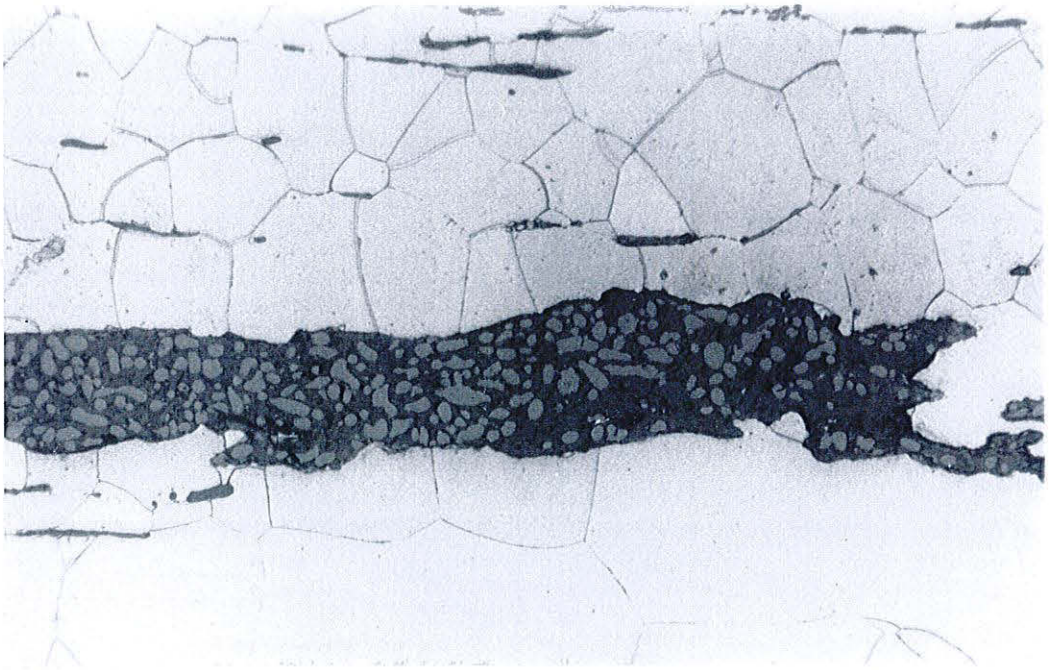

Fig 5. Detail of one of the larger non-metallic slag inclusions shown in Fig 3 with three phases visible as different shades of grey. Magnification x200: etched 2% nital.

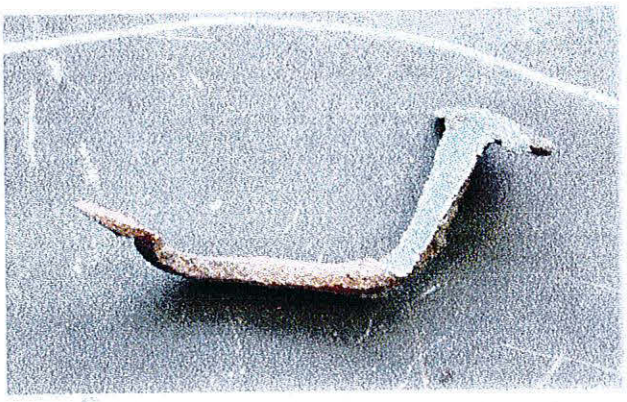

Fig 6. Flat-headed panel fixing nail thought to be part of the original work of *c* 1220 - 1230. Length of nail (HM 109) 56 mm.

Fig 7. Flat-headed panel-fixing nail (HM109) in longitudinal section at low magnification. Magnification x6: etched with 2% nital.

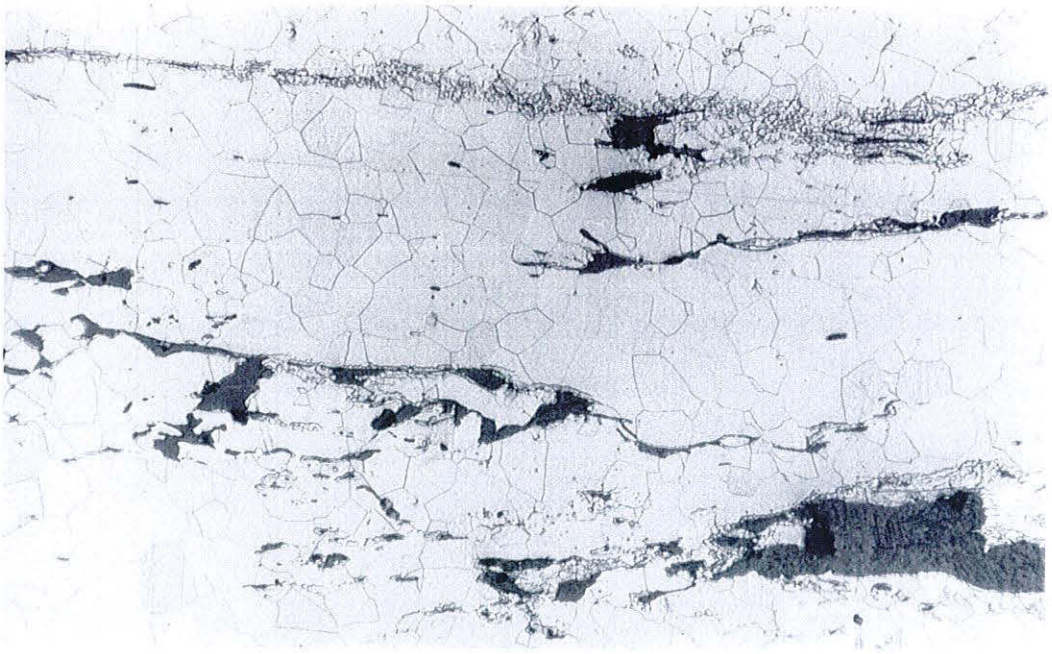

Fig 8. The structure of part of the shank of this nail (HM109), again showing differential ferrite grain structure of the iron plus the elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

Fig 9. Detail of one of the larger non-metallic slag inclusions shown in Fig 8 with three phases again visible as different shades of grey. Magnification x200: etched 2% nital.

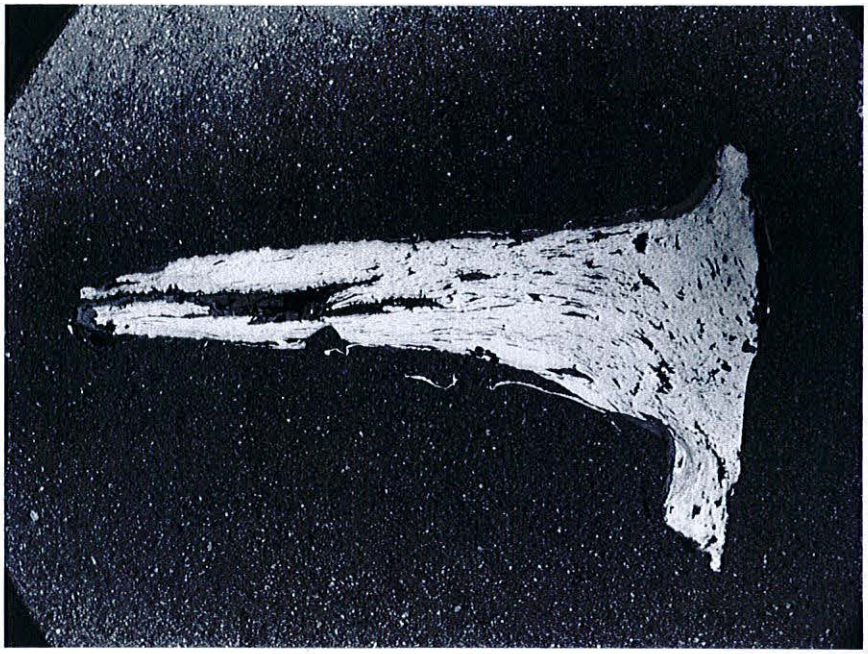

Fig 10. Flat-headed panel-fixing nail (HM111) in longitudinal section at low magnification. Magnification x6: etched with 2% nital.

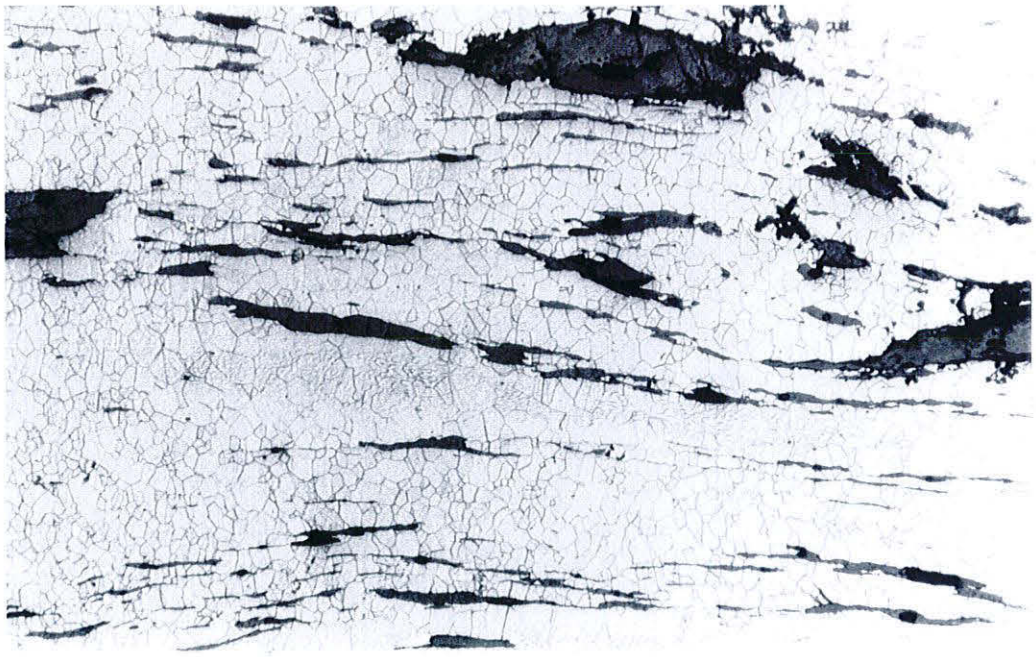

Fig 11. The structure of part of the shank of the same nail (HM111), showing the rather more even ferrite grain structure of the iron (compared to HM106 and HM109) plus the grater volume of elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

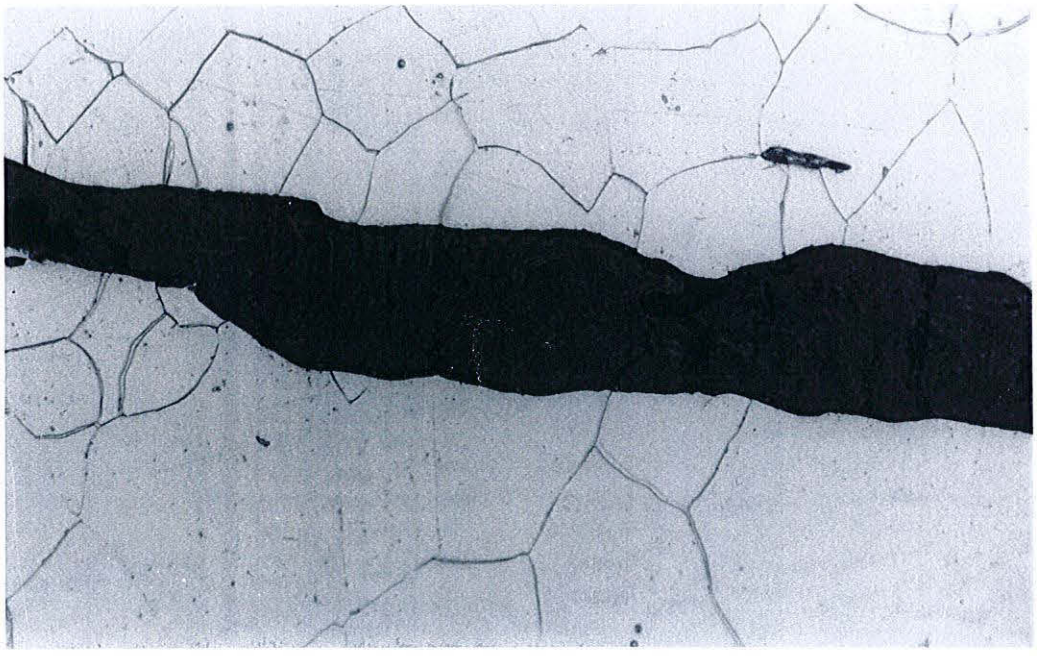

Fig 12. Detail of one of the larger non-metallic slag inclusions shown in Fig 11 with three phases again visible as different shades of grey. Magnification x200: etched 2% nital.

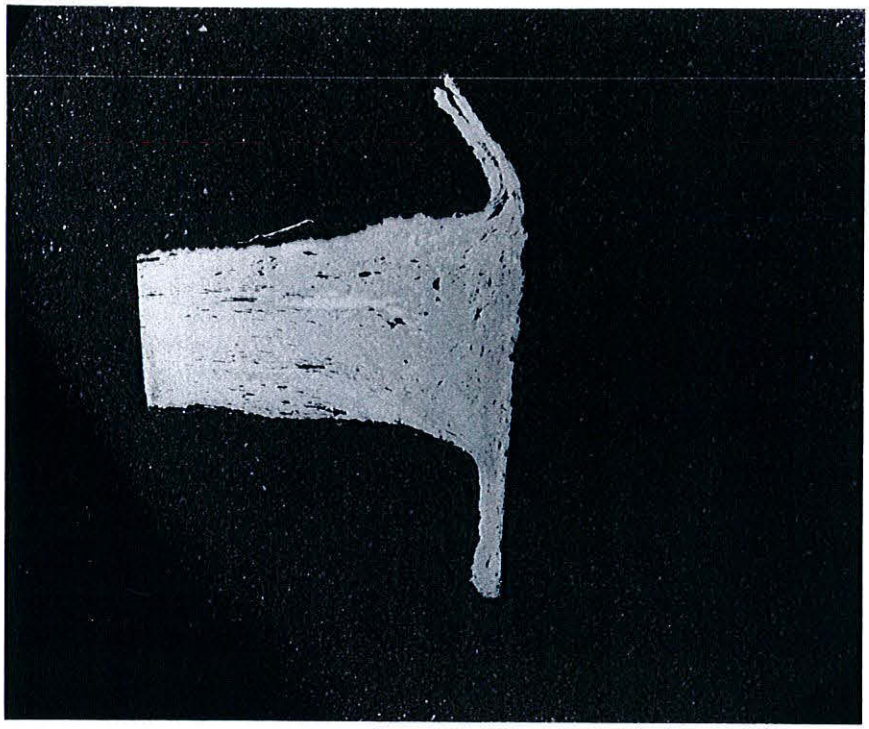

Fig 13. Flat-headed panel-fixing nail (HM124) in longitudinal section at low magnification. Magnification x6: etched with 2% nital.

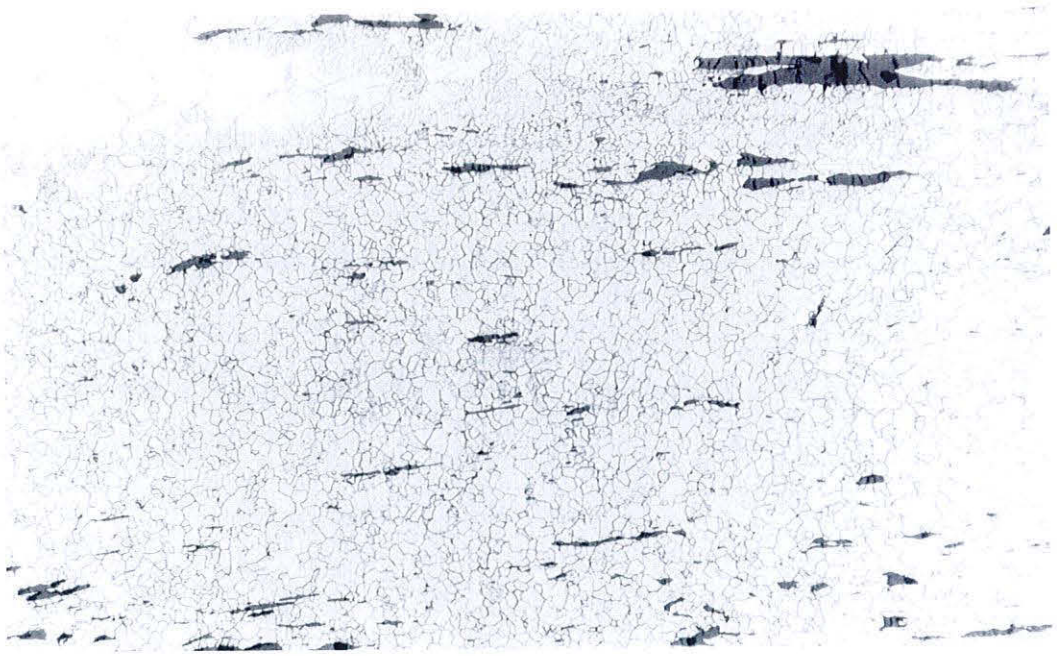

Fig 14. The structure of part of the shank of the same nail (HM124), again showing differential ferrite grain structure of the iron plus the elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

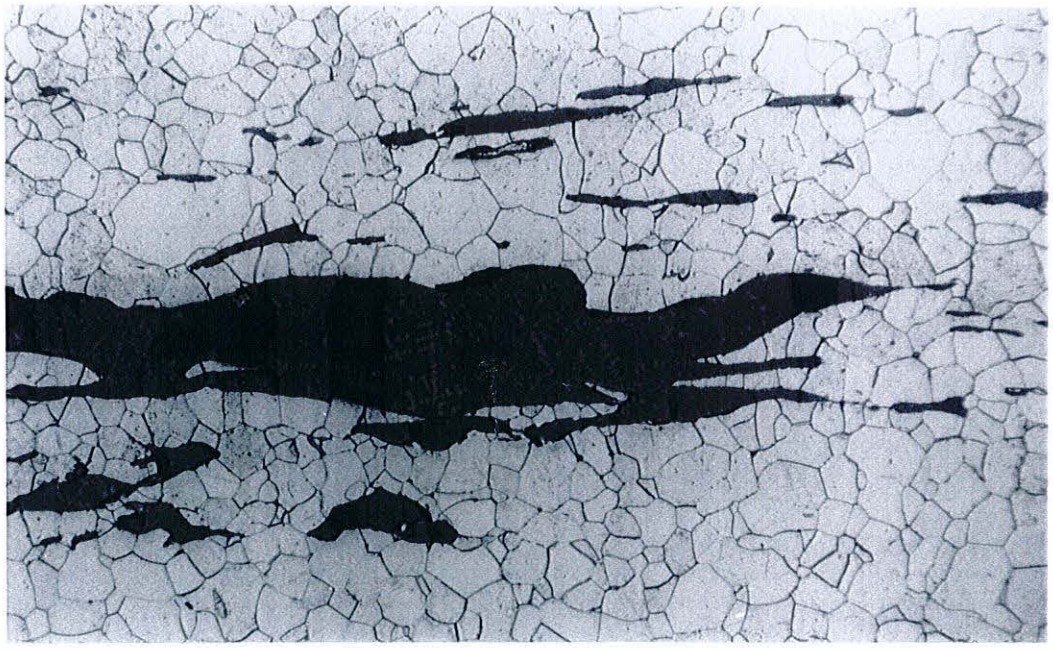

Fig 15. Detail of one of the larger non-metallic slag inclusions shown in Fig 14 with three phases again visible as different shades of grey. Magnification x200: etched 2% nital.

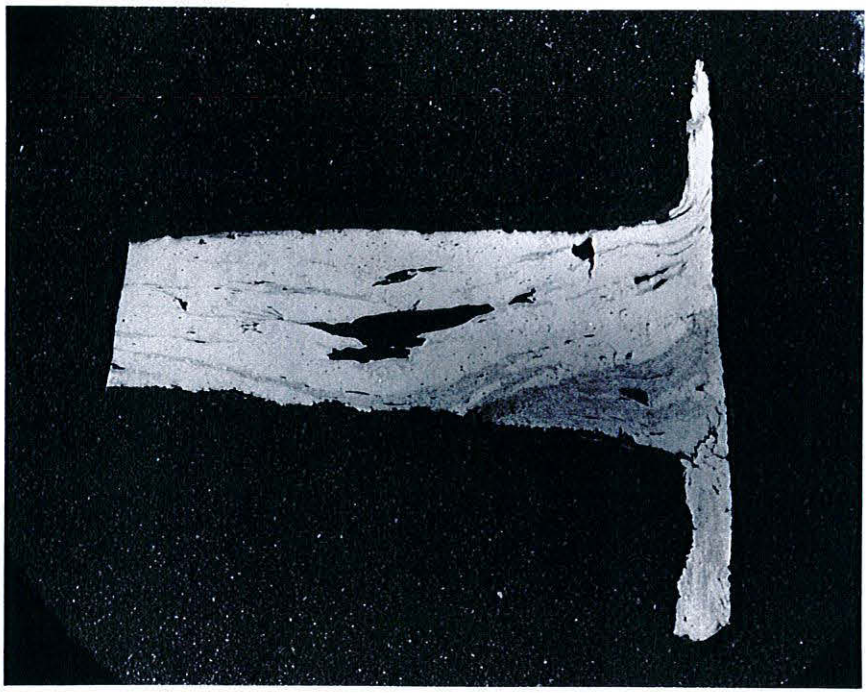

Fig 16. Flat-headed panel-fixing nail (HM126) in longitudinal section at low magnification. Magnification x6: etched with 2% nital.

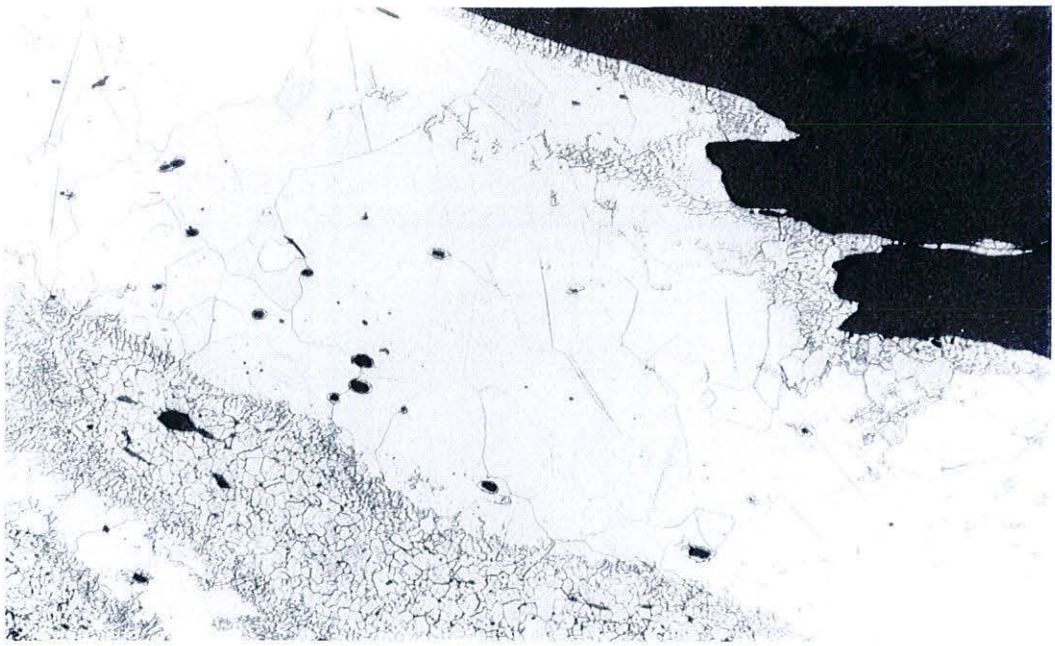

Fig 17. The structure of part of the shank of the same nail (HM126), again showing differential ferrite grain structure of the iron plus the elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

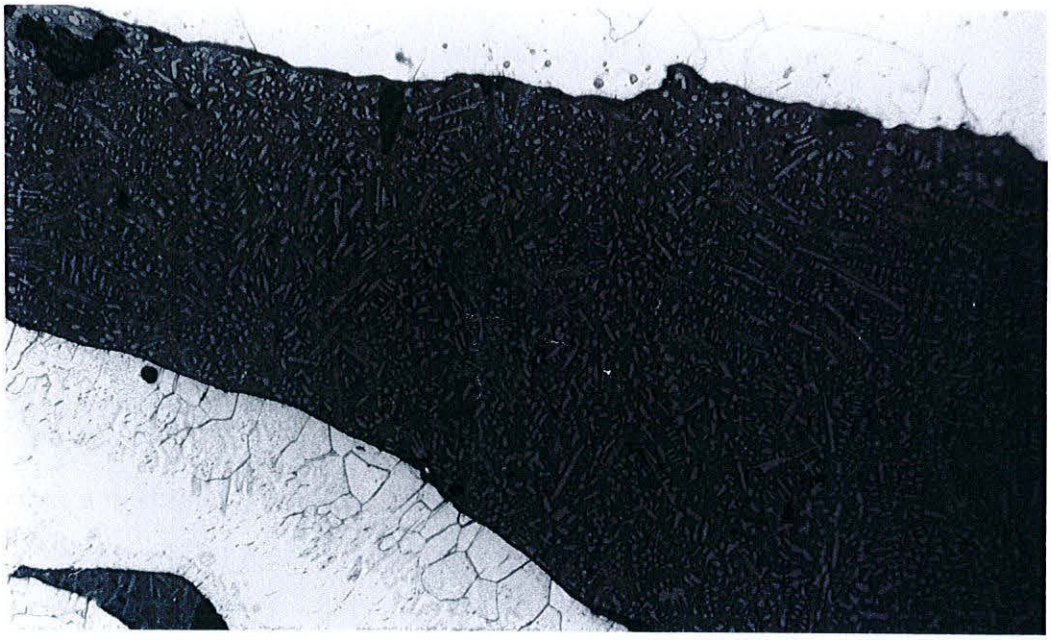

Fig 18. Detail of one of the larger non-metallic slag inclusions shown in Fig 17 with three phases again visible as different shades of grey. Magnification x200: etched 2% nital.

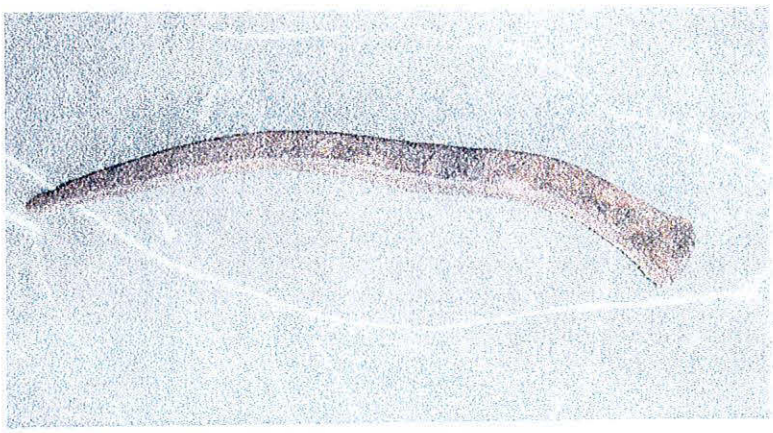

Fig 19. Medium sized brad type nail from Joist 22, south end.

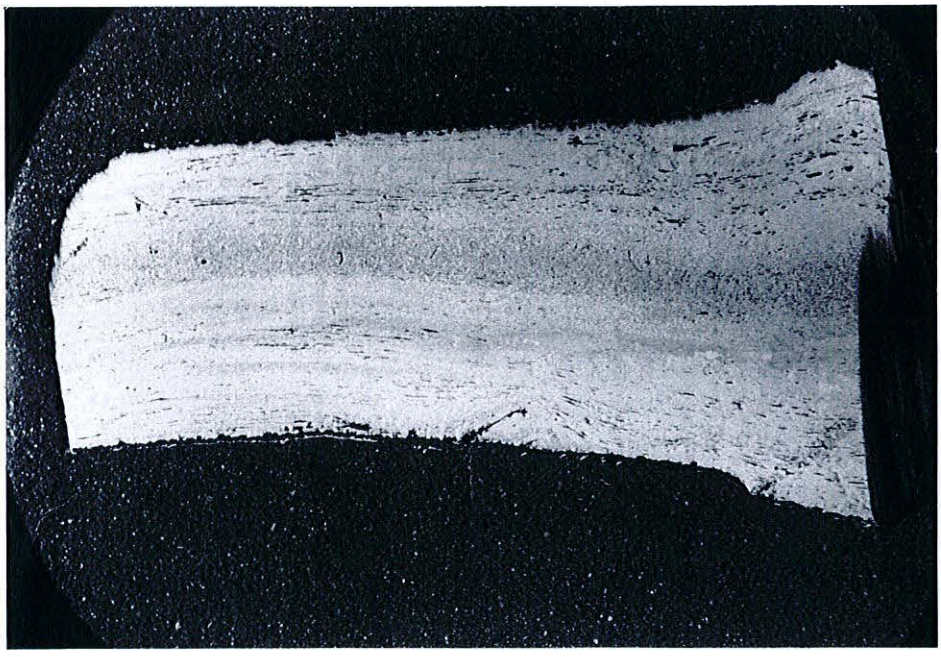

Fig 20. Longitudinal section through the head end of this same brad type nail at low magnification
Magnification x6; etched 2% nital.

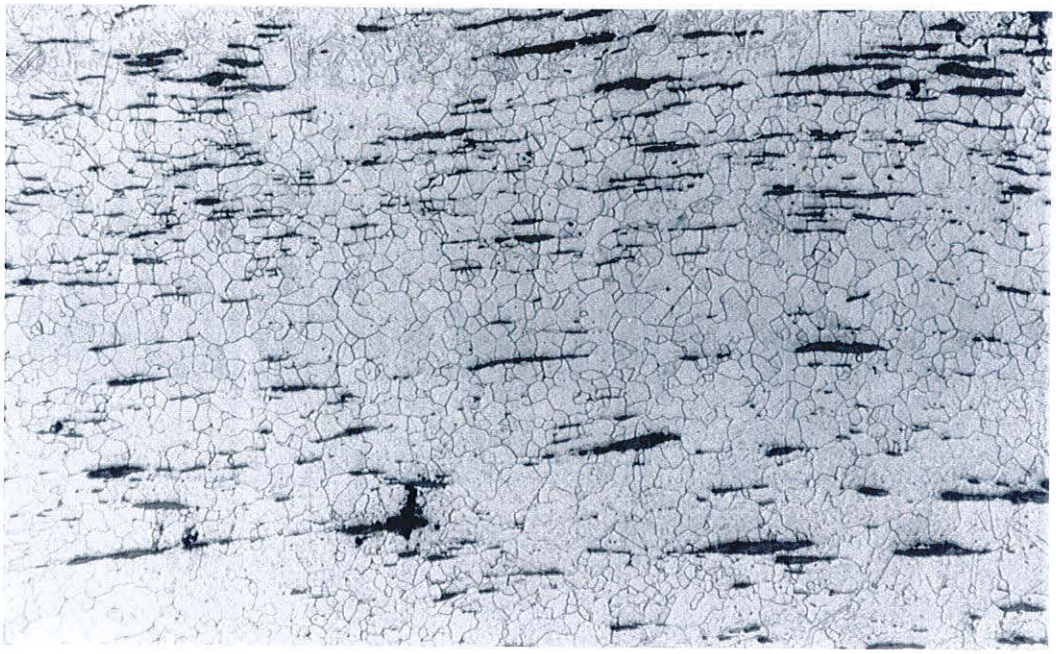

Fig 21. The structure of part of the shank of the same nail (HM105), showing differential ferrite grain structure of the iron plus the elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

Fig 22. Panel fixing nail of uncertain date, but associated with the 1740's restoration (HM107); Length of nail 75 mm.

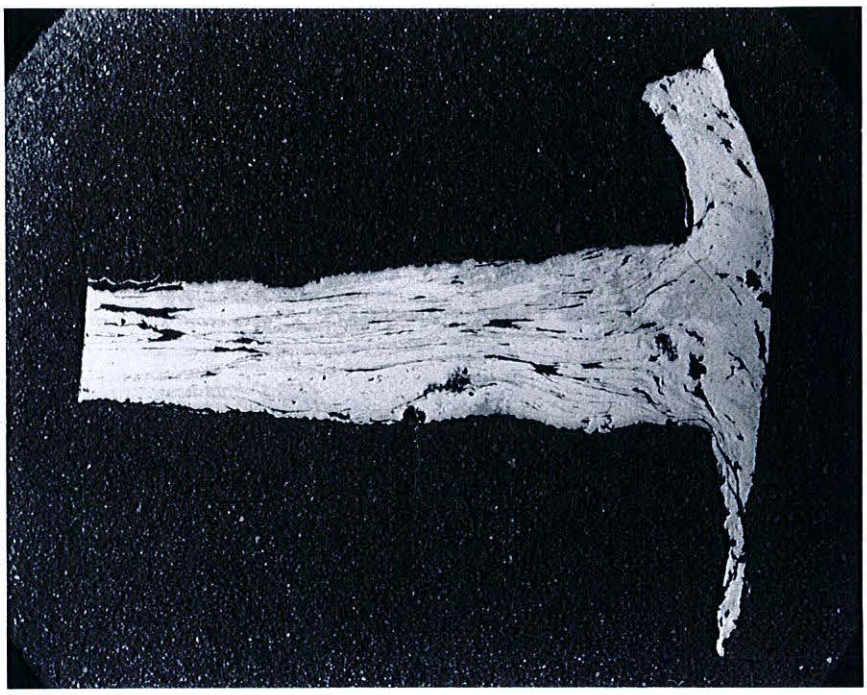

Fig23. Same nail (HM107) in longitudinal section at low magnification showing a streaky appearance and relatively high slag content. Magnification x6; etched with 2% nital.

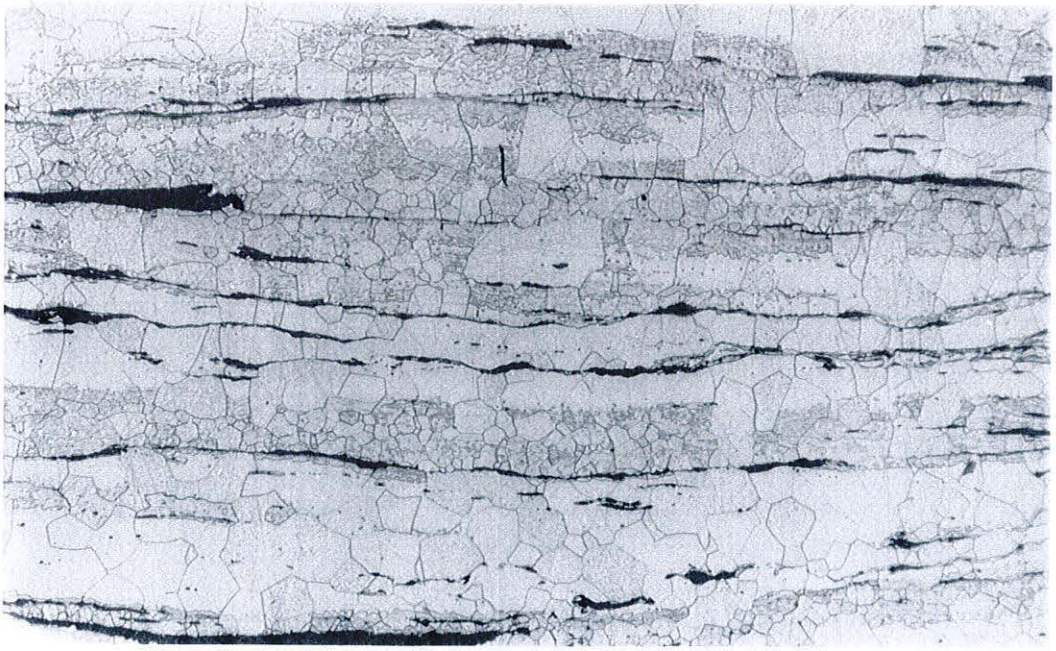

Fig 24. The structure of part of the shank of the same nail (HM107), showing differential ferrite grain structure of the iron, giving the banded structure, plus the elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

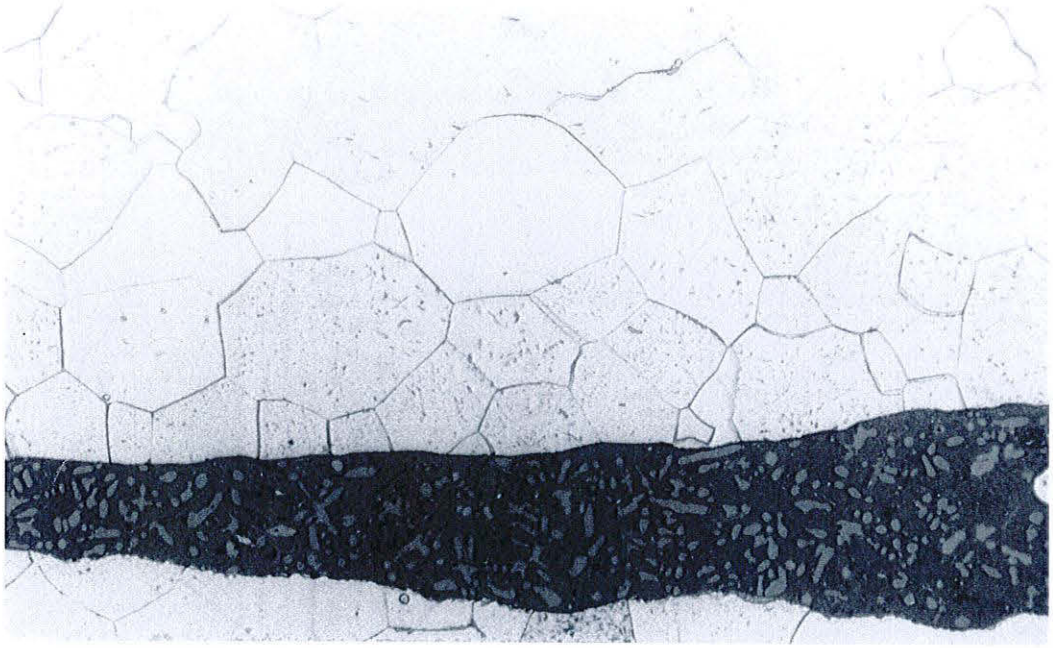

Fig 25. Detail of one of the larger non-metallic slag inclusions shown in Fig 24 with three phases again visible as different shades of grey. Magnification x200: etched 2% nital.

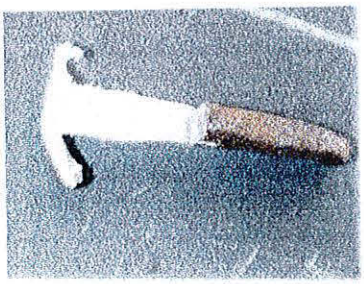

Fig 26 Very similar panel fixing nail (HM110) again of uncertain date but most likely associated with the 1740's restoration, this example being incomplete but very similar to HM107.

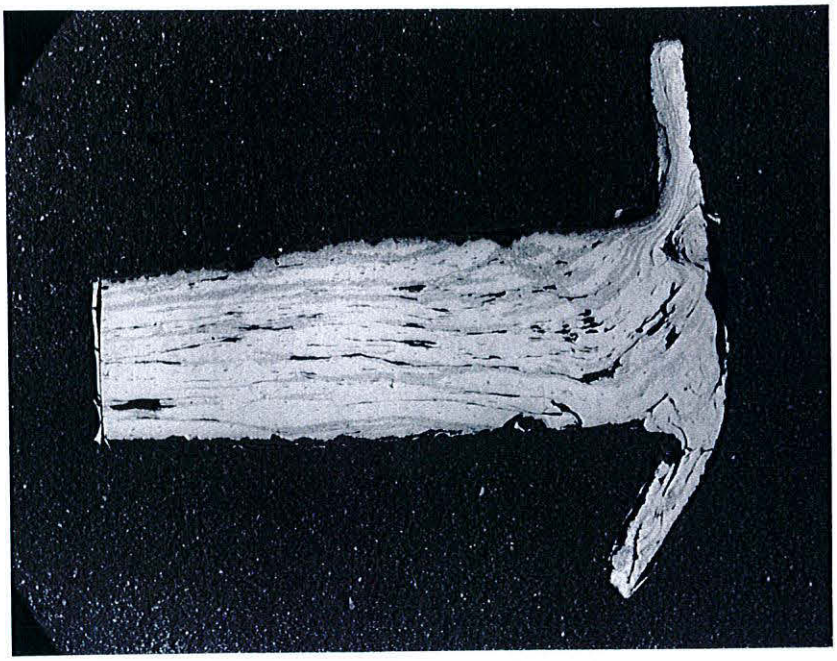

Fig 27. Same nail (HM110) in longitudinal section at low magnification showing a streaky appearance and relatively high slag content. Magnification x6; etched with 2% nital.

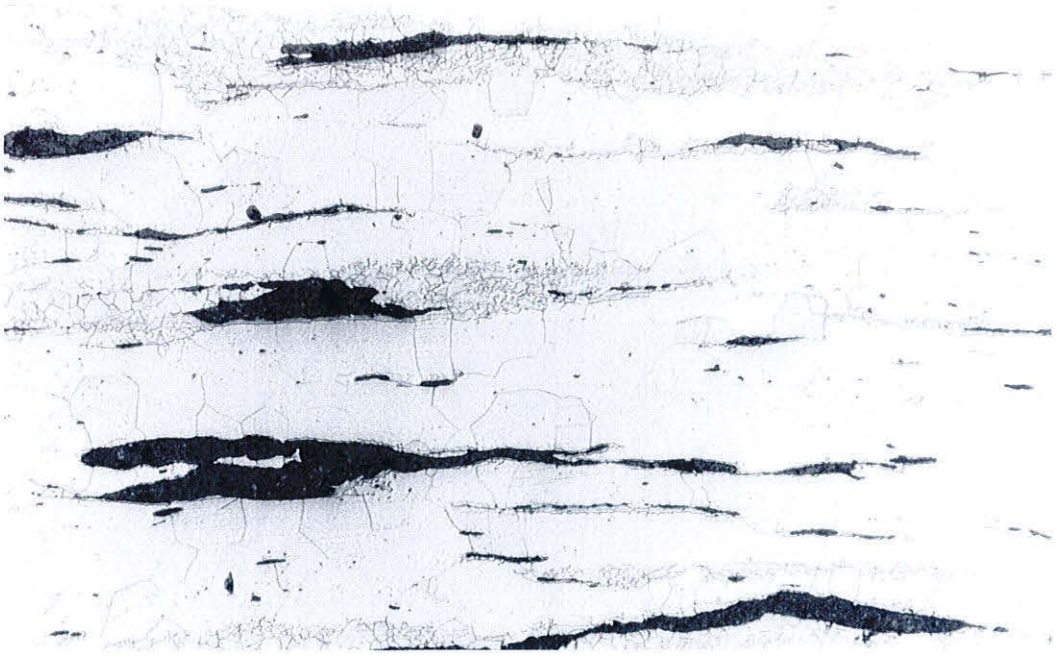

Fig 28. The structure of part of the shank of the same nail (HM110), again showing differential ferrite grain structure of the iron, giving the banded structure, plus the elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

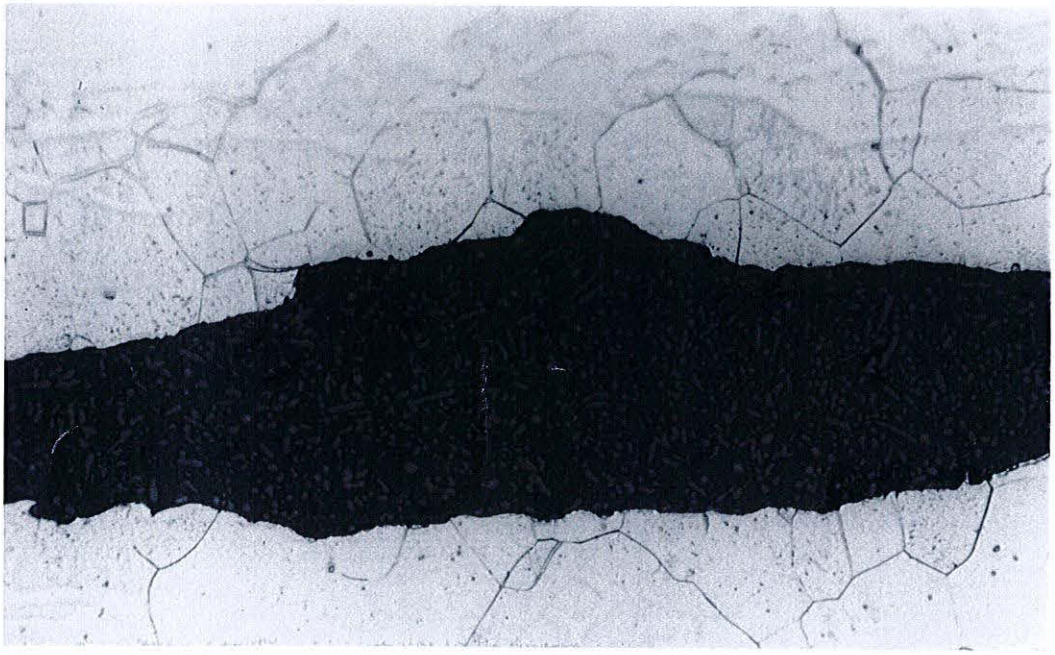

Fig 29. Detail of one of the larger non-metallic slag inclusions shown in Fig 28 with three phases again visible as different shades of grey. Magnification x200: etched 2% nital.

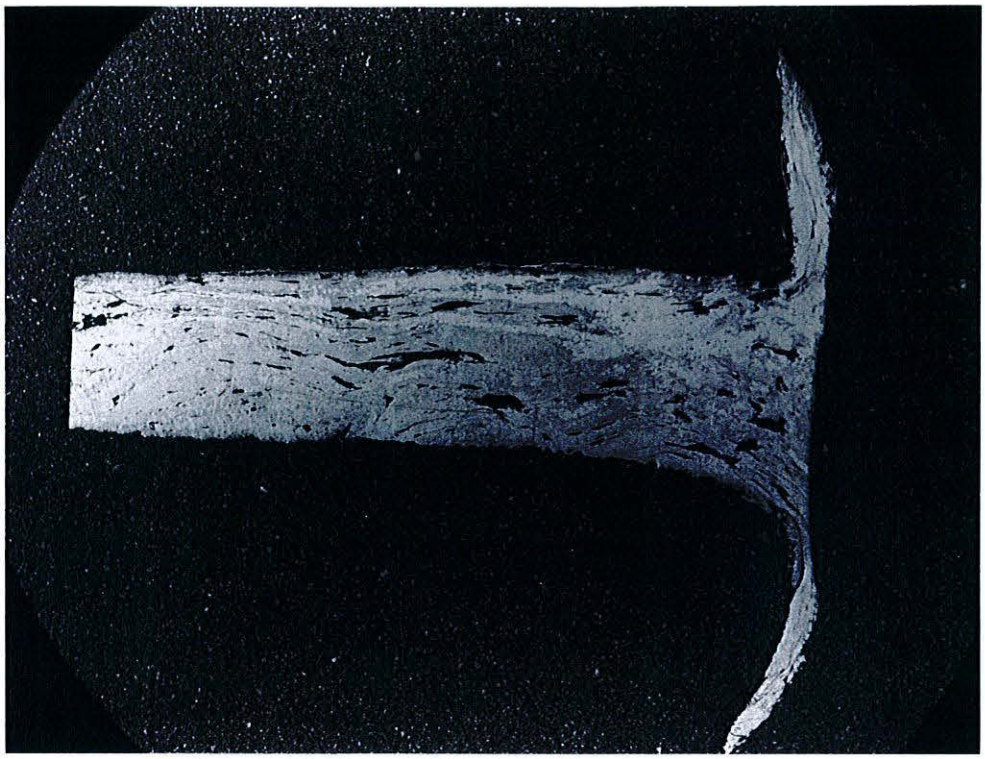

Fig 30. Nail (HM112) - again identified as being part of the restoration of *c* 1740 - in longitudinal section at low magnification showing a patchy or streaky appearance and relatively high slag content. Magnification x6; etched with 2% nital.

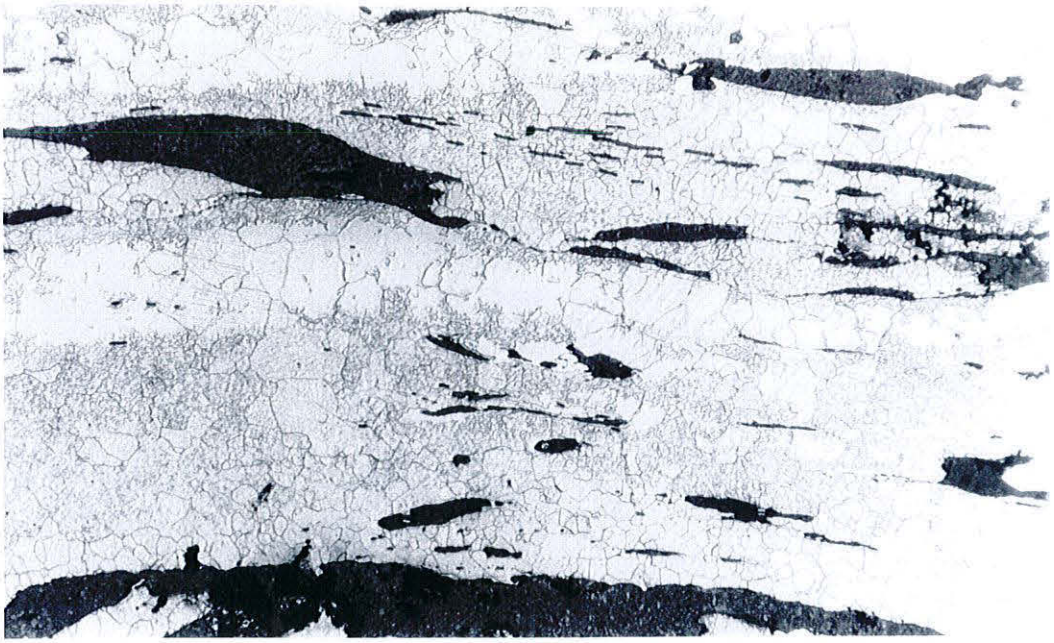

Fig 31. The structure of part of the shank of the same nail (HM112), as before showing differential ferrite grain structure of the iron, giving the banded structure, plus the elongated darker non-metallic slag inclusions. Magnification x50: etched 2% nital.

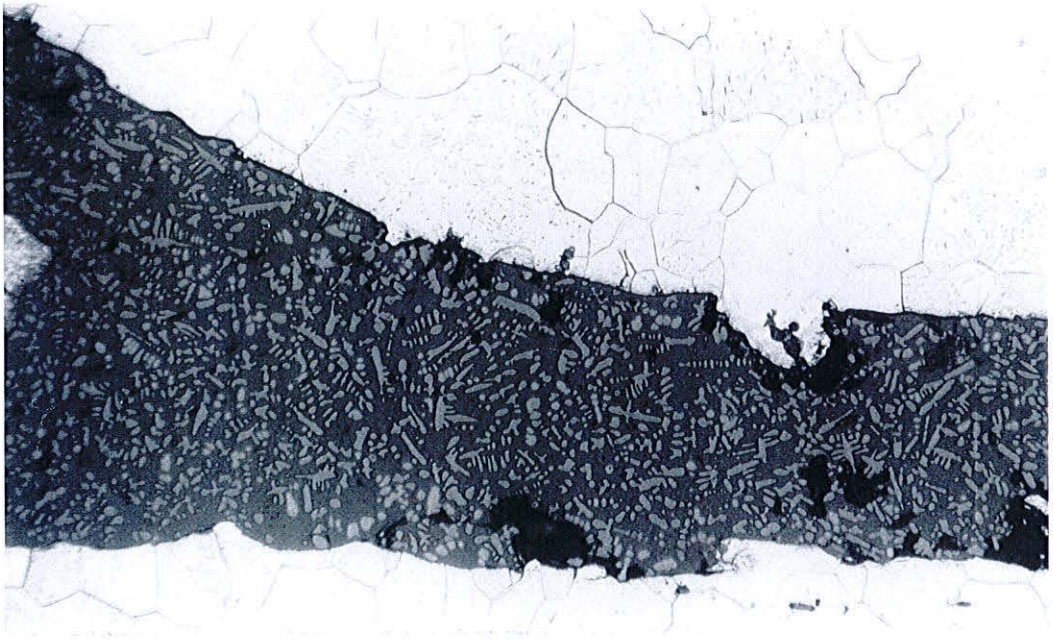

Fig 32. Detail of one of the larger non-metallic slag inclusions shown in Fig 32 with three phases again visible as different shades of grey. Magnification x200: etched 2% nital.

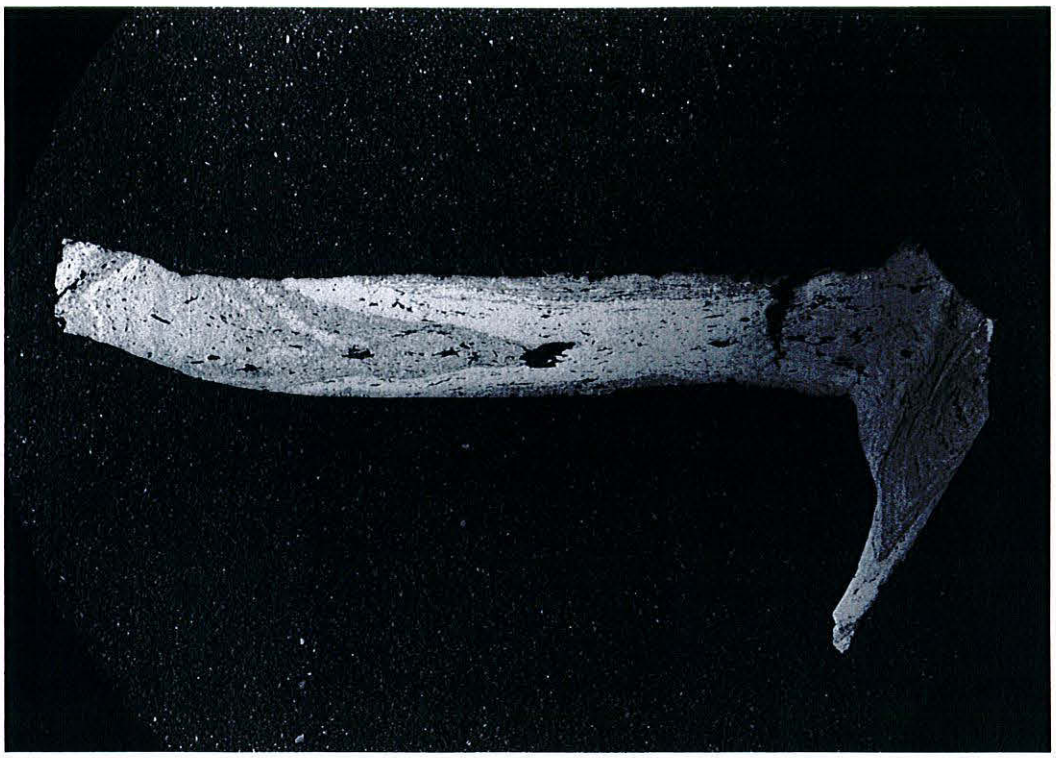

Fig 33. Panel fixing nail (HM123) of more uncertain context but the form of the head plus the structure suggesting association with the 1740's restoration. Note the very convoluted distribution of adjacent areas of iron suggesting the likely use of recycled iron. Magnification x6; etched with 2% nital.

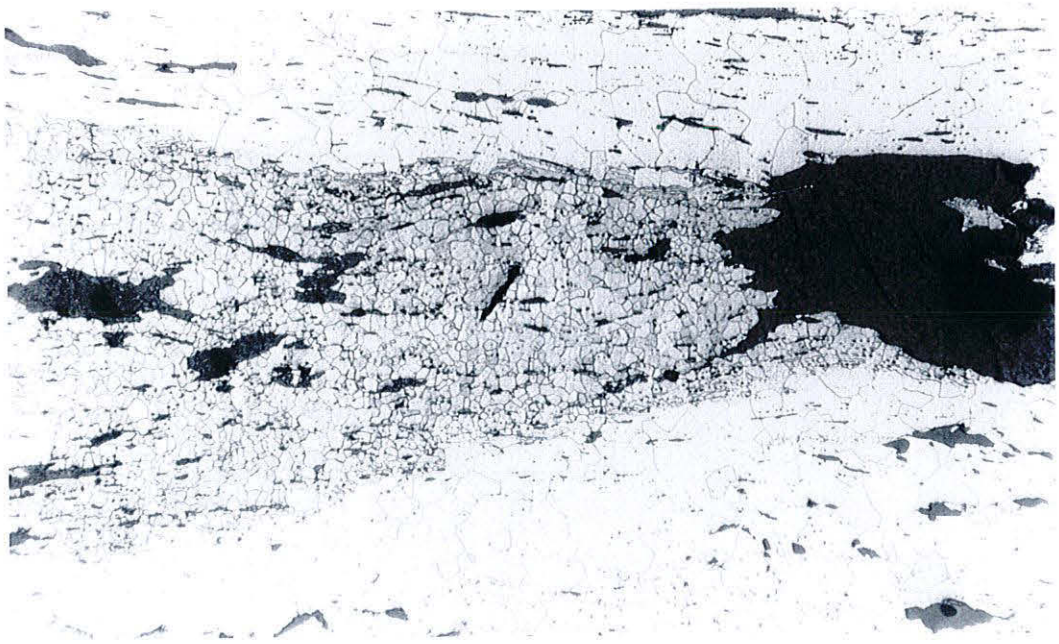

Fig 34. The structure of part of the shank of the same nail (HM123), showing adjacent sharply differentiated areas with a larger (pale) and smaller (grey) ferrite grain structure to the iron, note the high density of very small non-metallic slag inclusions. Magnification x50: etched 2% nital.

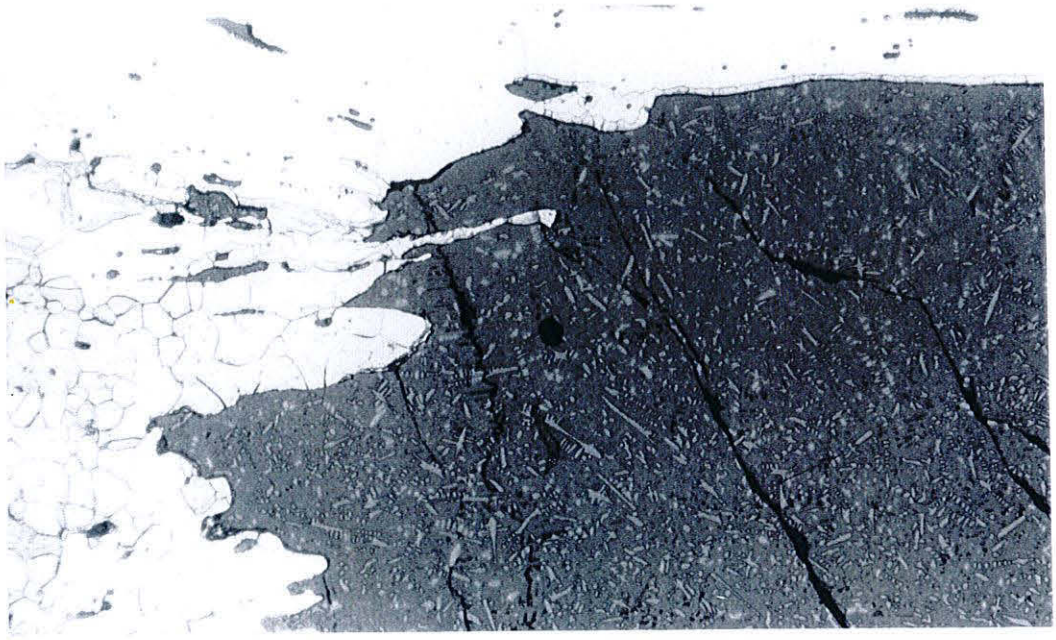

Fig 35. Detail from Fig 34 of the very large non-metallic slag inclusion trapped at the fold in the probable weld between, at the top here, the pale, large grained (probably phosphoritic) iron and the fine grain very low carbon iron at the lower left. In the cracked, very large slag inclusion three phases are again visible as different shades of grey. Magnification x200: etched 2% nital.

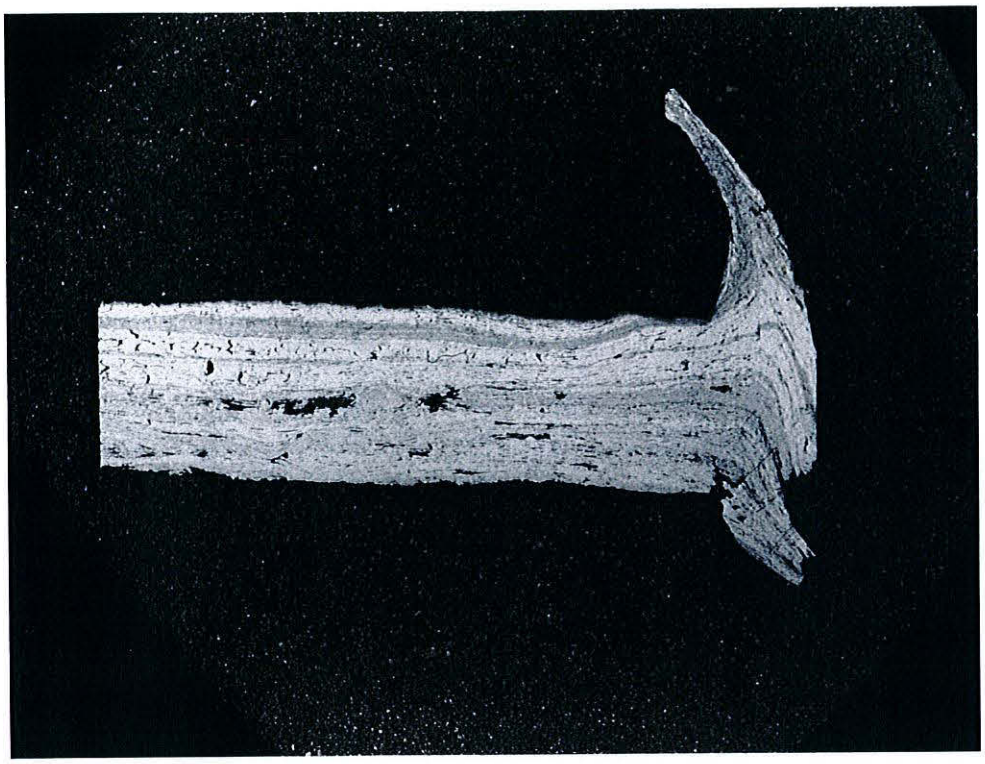

Fig 36. Panel fixing nail (HM125) of uncertain context although the distinct banded appearance is identical with nails already identified (see previous report) as 19th century puddled iron. The damaged head here appears to be domed but, elsewhere, looked once to have been faceted like the others of the restoration of *c*1830 to which it undoubtedly belongs. Magnification x6; etched with 2% nital.

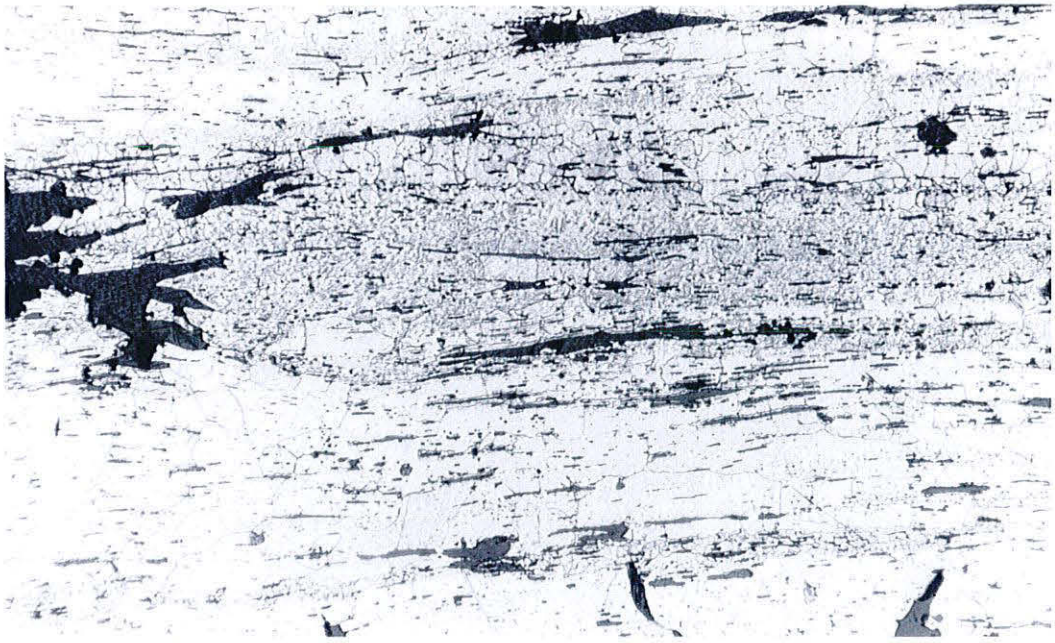

Fig 37. The structure of part of the shank of the same nail (HM125), with the (probably) phosphoritic iron of the larger grain pale bands contrasting with the adjacent smaller grain grey bands. Especially noticeable is the very high density of many small, ribbon-like non-metallic slag inclusions, also with many spot-like inclusions, altogether very typical of puddled iron. Magnification x50: etched 2% nital.

Fig 38. Detail (of Fig 37) showing a cluster of, in shape, more irregular, larger non-metallic slag inclusions, with the different internal appearance of these visible, in particular the varying presence of the pale grey, iron oxide phase (wüstite).
Magnification x200; etched 2% nital.

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

Table 1: Small flat headed nail HM106 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	0.000	0.420	0.009	0.000	0.000	0.003	0.002	0.012	0.006	0.000	0.003	0.011	99.53		Metal point 1
2	0.000	0.000	0.386	0.007	0.002	0.002	0.000	0.000	0.013	0.002	0.000	0.000	0.014	99.57		Metal point 2
3	0.000	0.000	0.148	0.000	0.001	0.001	0.002	0.002	0.007	0.009	0.019	0.000	0.011	99.80		Metal point 3
4	0.000	0.000	0.250	0.004	0.001	0.001	0.003	0.000	0.008	0.002	0.005	0.009	0.002	99.72		Metal point 4
5	0.000	0.000	0.175	0.002	0.006	0.003	0.000	0.000	0.020	0.005	0.016	0.000	0.010	99.76		Metal point 5
6	0.000	0.000	0.176	0.005	0.000	0.000	0.000	0.002	0.019	0.017	0.015	0.000	0.000	99.77		Metal point 6
7	0.000	0.000	0.374	0.005	0.003	0.000	0.003	0.000	0.018	0.014	0.000	0.003	0.014	99.57		Metal point 7
8	0.000	0.000	0.278	0.002	0.001	0.000	0.000	0.001	0.011	0.006	0.012	0.000	0.029	99.66		Metal point 8
9	0.000	0.000	0.315	0.006	0.000	0.001	0.003	0.000	0.016	0.024	0.000	0.000	0.071	99.56		Metal point 9
10	0.000	0.000	0.349	0.007	0.001	0.004	0.000	0.000	0.017	0.020	0.011	0.000	0.058	99.53		Metal point 10
11	0.000	0.000	0.194	0.004	0.000	0.004	0.001	0.000	0.011	0.015	0.000	0.000	0.000	99.77		Metal point 11
12	0.000	0.000	0.140	0.002	0.004	0.003	0.000	0.000	0.012	0.008	0.003	0.015	0.020	99.79		Metal point 12
13	0.000	0.000	0.301	0.006	0.000	0.003	0.003	0.000	0.007	0.025	0.000	0.000	0.043	99.61		Metal point 13
14	0.000	0.000	0.196	0.002	0.000	0.000	0.007	0.000	0.007	0.014	0.000	0.002	0.034	99.74		Metal point 14
Minimum	0.000	0.000	0.140	0.000	0.000	0.000	0.000	0.000	0.007	0.002	0.000	0.000	0.000	99.53		
Maximum	0.001	0.000	0.420	0.009	0.006	0.004	0.007	0.002	0.020	0.025	0.019	0.015	0.071	99.80		
Average	0.000	0.000	0.264	0.004	0.001	0.002	0.002	0.001	0.013	0.012	0.006	0.002	0.023	99.67		
Sigma	0.000	0.000	0.095	0.003	0.002	0.002	0.002	0.001	0.005	0.008	0.007	0.004	0.022	0.103		

Table 2. Small flat headed nail HM106: Composition of non-metallic inclusions (oxide by weight percent)

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	SrO	BaO	Total	Comment
1	0.00	0.03	0.74	0.35	0.45	0.04	0.01	0.05	0.22	0.15	0.02	0.02	0.18	88.67	0.00	0.02	90.97	Inclusion 1 oxide
2	0.12	0.49	1.04	13.41	21.95	0.17	0.01	0.41	1.63	0.01	0.01	0.00	0.69	57.80	0.00	0.15	97.90	Inclusion 1 olivine?
3	0.18	0.20	3.96	10.72	17.66	0.43	0.00	1.83	7.08	0.06	0.01	0.03	0.54	53.10	0.03	0.06	95.87	Inclusion 1 dark
4	0.01	0.11	1.12	4.13	8.83	0.28	0.00	0.31	1.57	0.11	0.01	0.01	0.34	80.34	0.01	0.00	97.17	Inclusion 1 Oxide(M?)
5	0.10	0.45	1.56	11.32	17.49	0.11	0.01	0.36	1.40	0.23	0.01	0.00	0.54	66.41	0.00	0.00	99.98	Inclusion 1 Needle
6	0.09	0.40	0.88	13.13	21.66	0.10	0.01	0.27	1.35	0.03	0.00	0.01	0.74	60.89	0.00	0.06	99.61	Inclusion 2 Olivine?
7	0.01	0.03	1.06	0.79	0.91	0.05	0.00	0.03	0.14	0.17	0.02	0.00	0.13	91.75	0.00	0.00	95.09	Inclusion 2 Oxide?
8	0.08	0.14	4.49	8.02	12.24	0.47	0.00	1.55	3.39	0.39	0.00	0.01	0.30	67.58	0.04	0.00	98.70	Inclusion 2 needle
9	0.20	0.14	6.15	9.13	21.62	0.61	0.00	2.52	7.49	0.22	0.00	0.00	0.46	48.76	0.00	0.10	97.39	Inclusion 2 dark
10	0.08	0.12	3.54	8.16	7.73	0.06	0.00	0.34	1.04	0.66	0.00	0.02	0.24	73.90	0.06	0.03	95.99	Inclusion 2 neddle
11	0.01	0.02	0.97	0.28	0.14	0.05	0.00	0.03	0.17	0.21	0.00	0.01	0.22	90.39	0.00	0.00	92.49	Inclusion 3 Oxide
12	0.04	0.58	1.23	23.03	18.48	0.12	0.00	0.43	2.06	0.03	0.00	0.03	0.96	68.04	0.03	0.04	115.09	Inclusion 3 Olivine?
13	0.02	0.46	0.78	18.19	15.24	0.09	0.01	0.21	1.47	0.03	0.00	0.02	0.80	61.45	0.00	0.00	98.76	Inclusion 3 Olivine?
14	0.22	0.21	6.19	15.35	19.97	0.67	0.00	2.04	7.77	0.05	0.00	0.01	0.63	42.88	0.05	0.18	96.21	Inclusion 3 dark
15	0.09	0.23	2.80	13.91	13.30	0.50	0.01	1.01	3.85	0.10	0.00	0.02	0.52	59.88	0.00	0.08	96.28	Inclusion 3 10 mu average
16	0.08	0.26	2.23	13.61	12.22	0.43	0.01	0.34	3.33	0.11	0.00	0.00	0.60	64.10	0.03	0.13	97.47	Inclusion 3 10 mu average
17	0.04	0.22	2.50	11.71	12.74	0.35	0.00	0.23	2.93	0.13	0.05	0.02	0.52	65.79	0.02	0.06	97.31	Inclusion 4 10 mu average
18	0.09	0.24	2.68	11.36	14.05	0.31	0.02	0.46	3.86	0.11	0.01	0.00	0.54	65.24	0.05	0.00	99.01	Inclusion 4 10 mu average
19	0.00	0.04	0.85	1.22	1.00	0.02	0.00	0.04	0.34	0.22	0.04	0.00	0.22	90.86	0.03	0.08	94.95	Inclusion 4 Oxide
20	0.03	0.36	0.84	16.74	16.51	0.11	0.00	0.30	2.83	0.00	0.02	0.01	0.75	61.84	0.00	0.09	100.44	Inclusion 4 Olivine
21	0.24	0.15	4.80	12.82	22.60	1.58	0.00	1.47	9.05	0.04	0.00	0.05	0.68	47.69	0.04	0.07	101.30	Inclusion 4 dark
22	0.02	0.00	0.00	0.08	22.70	0.47	0.00	0.00	0.01	0.00	0.00	0.00	0.71	82.31	0.00	0.00	106.30	Inclusion 5 dark small round
23	0.02	0.07	1.16	0.40	0.44	0.02	0.00	0.02	0.26	0.19	0.03	0.00	0.18	88.53	0.04	0.08	91.45	Inclusion 6 Oxide
24	0.03	0.59	0.64	16.67	16.90	0.06	0.01	0.04	0.64	0.05	0.00	0.02	0.85	60.64	0.02	0.10	97.25	Inclusion 6 Olivine
25	0.12	0.20	3.51	8.58	22.91	0.86	0.00	1.97	8.64	0.05	0.03	0.00	0.74	43.42	0.03	0.12	91.20	Inclusion 6 dark
26	0.06	0.38	1.89	13.38	14.93	0.27	0.00	0.54	2.31	0.05	0.00	0.00	0.68	62.08	0.00	0.01	96.60	Inclusion 6 dark 10 mu average
27	0.03	0.24	2.07	9.98	23.49	0.74	0.00	0.52	2.05	0.11	0.00	0.01	0.51	58.28	0.02	0.07	98.11	Inclusion 7 single phase
28	0.03	0.06	0.71	0.05	0.06	0.03	0.02	0.02	0.15	0.15	0.02	0.02	0.20	93.66	0.00	0.09	95.27	Inclusion 8 Oxide
29	0.06	0.49	1.10	17.09	16.20	0.18	0.00	0.60	1.49	0.04	0.00	0.03	0.77	57.31	0.02	0.10	95.47	Inclusion 8 Olivine
30	0.16	0.24	5.62	14.79	19.54	1.49	0.00	2.57	8.79	0.06	0.03	0.00	0.67	39.60	0.03	0.10	93.70	Inclusion 8 Dark
31	0.07	0.13	1.90	4.85	4.51	0.37	0.02	0.23	1.38	0.16	0.01	0.00	0.33	82.83	0.01	0.00	96.78	Inclusion 8 10 mu average
32	0.06	0.21	1.25	7.91	16.55	0.35	0.00	0.11	0.74	0.13	0.00	0.00	0.43	67.43	0.00	0.06	95.23	Inclusion 9 10 mu average
33	0.10	0.32	2.58	15.24	15.70	0.39	0.00	1.10	2.99	0.07	0.02	0.00	0.62	57.85	0.00	0.02	97.01	Inclusion 10 10 mu average
34	0.08	0.40	1.96	14.97	15.79	0.28	0.00	0.54	3.01	0.05	0.01	0.02	0.67	58.49	0.00	0.03	96.28	Inclusion 11 10 mu average
35	0.09	0.28	2.05	13.88	18.73	0.77	0.00	0.92	3.99	0.08	0.01	0.01	0.68	55.26	0.07	0.10	96.91	Inclusion 12 10 mu average
36	0.11	0.18	2.32	6.23	5.61	0.54	0.01	0.40	2.03	0.13	0.02	0.00	0.37	78.48	0.00	0.06	96.48	Inclusion 13 10 mu average
37	0.16	0.34	2.02	15.53	12.01	0.52	0.00	0.70	2.99	0.05	0.01	0.00	0.66	63.33	0.01	0.07	98.39	Inclusion 14 10 mu average
Minimum	0.00	0.00	0.00	0.05	0.06	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.13	39.60	0.00	0.00	90.97	
Maximum	0.24	0.59	6.19	23.03	23.49	1.58	0.02	2.57	9.05	0.66	0.05	0.05	0.96	93.66	0.07	0.18	115.09	
Average	0.08	0.24	2.19	10.19	13.59	0.38	0.00	0.66	2.82	0.12	0.01	0.01	0.53	66.40	0.02	0.06	97.31	
Sigma	0.06	0.16	1.60	6.08	7.44	0.37	0.01	0.73	2.65	0.12	0.01	0.01	0.22	14.70	0.02	0.05	4.16	

Table 3: Small flat headed nail HM109 Composition of the metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As
1	0.000	0.005	0.237	0.000	0.000	0.000	0.002	0.002	0.021	0.025	0.019	0.000	0.000
2	0.000	0.004	0.348	0.007	0.000	0.000	0.001	0.000	0.017	0.031	0.024	0.003	0.000
3	0.001	0.008	0.428	0.004	0.000	0.000	0.001	0.000	0.015	0.014	0.021	0.000	0.000
4	0.000	0.008	0.446	0.008	0.000	0.006	0.003	0.002	0.012	0.030	0.018	0.000	0.000
5	0.000	0.006	0.382	0.001	0.000	0.000	0.004	0.000	0.021	0.022	0.014	0.000	0.006
6	0.000	0.022	0.495	0.004	0.000	0.001	0.004	0.001	0.018	0.034	0.007	0.003	0.000
7	0.000	0.006	0.209	0.002	0.000	0.000	0.000	0.000	0.019	0.039	0.021	0.000	0.004
8	0.000	0.007	0.352	0.006	0.000	0.000	0.000	0.004	0.022	0.028	0.002	0.000	0.000
9	0.000	0.007	0.213	0.000	0.000	0.000	0.005	0.000	0.017	0.029	0.021	0.000	0.000
10	0.000	0.007	0.410	0.006	0.000	0.000	0.000	0.000	0.022	0.025	0.025	0.000	0.000
Min	0.000	0.004	0.209	0.000	0.000	0.000	0.000	0.000	0.012	0.014	0.002	0.000	0.000
Max	0.001	0.022	0.495	0.008	0.000	0.006	0.005	0.004	0.022	0.039	0.025	0.003	0.006
Aver	0.000	0.008	0.352	0.004	0.000	0.001	0.002	0.001	0.018	0.028	0.017	0.001	0.001
Sigma	0.000	0.005	0.101	0.003	0.000	0.002	0.002	0.001	0.003	0.007	0.007	0.001	0.002

Table 4. Small flat headed nail HM109: Composition of non-metallic inclusions (oxide by weight percent)

No.	Na2O	MgO	Al2O3	SiO_2	P2O5	SO3	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	SrO	BaO	Cl	Total	Comment
1	0.00	0.12	1.04	1.19	0.34	0.00	0.04	0.28	0.23	0.00	0.01	0.46	90.50	0.00	0.00	0.01	94.22	Incl 1 FeOx
2	0.22	0.91	3.39	22.54	12.45	0.30	0.76	2.17	0.05	0.00	0.00	1.39	55.80	0.05	0.02	0.02	100.05	Incl 1 Main
3	0.31	0.47	6.75	19.52	12.68	0.84	1.66	5.95	0.11	0.00	0.00	1.28	50.01	0.04	0.11	0.01	99.74	Incl 1 IM
4	0.04	0.00	0.00	0.04	32.34	1.28	0.01	0.00	0.00	0.00	0.00	0.89	64.16	0.00	0.09	0.00	98.85	Incl 2 single Phase
5	0.00	0.02	0.00	0.02	20.44	0.46	0.00	0.04	0.01	0.00	0.06	0.55	95.62	0.01	0.00	0.01	117.23	Incl 3 single Phase Round small
6	0.01	0.00	0.00	0.19	33.66	1.57	0.00	0.02	0.03	0.00	0.01	2.06	63.68	0.00	0.00	0.00	101.22	Incl 4 single Phase ?
7	0.00	0.04	0.00	0.17	20.31	0.71	0.01	0.00	0.02	0.00	0.01	1.13	74.46	0.00	0.00	0.00	96.85	Incl 4 single Phase Needle overgrowth
8	0.02	0.13	1.44	3.08	2.06	0.12	0.10	0.74	0.16	0.03	0.00	0.52	87.31	0.04	0.06	0.00	95.81	Incl 5 FeOx
9	0.11	0.81	2.35	22.08	12.23	0.27	0.45	1.35	0.05	0.00	0.01	1.20	58.89	0.00	0.00	0.00	99.82	Inclus 5 Main
10	0.31	0.40	8.72	21.53	13.55	1.30	1.80	5.04	0.17	0.00	0.01	1.08	46.78	0.00	0.36	0.00	101.03	Inclus 5 IM
11	0.18	0.53	3.87	19.01	10.42	0.58	0.81	2.60	0.10	0.00	0.00	1.02	61.46	0.00	0.14	0.01	100.73	Inclus 5 Average 20 mu
12	0.17	0.57	3.93	18.76	11.38	0.53	0.63	2.58	0.13	0.02	0.00	1.16	59.36	0.03	0.14	0.00	99.40	Inclus 6 Average 20 mu
13	0.16	0.55	3.98	19.54	11.57	0.54	0.81	2.74	0.13	0.00	0.00	0.97	59.28	0.00	0.03	0.00	100.29	Inclus 7 Average 20 mu
14	0.12	0.54	3.87	18.31	11.98	0.59	0.75	2.42	0.13	0.00	0.02	1.10	59.86	0.03	0.13	0.02	99.84	Inclus 8 Average 20 mu
15	0.21	0.56	3.84	19.66	11.37	0.53	0.86	2.71	0.07	0.00	0.00	1.09	59.49	0.03	0.22	0.00	100.62	Inclus 10 Average 20 mu
16	0.17	0.63	3.77	18.30	15.39	0.59	0.85	2.60	0.11	0.03	0.00	0.96	58.09	0.01	0.21	0.00	101.72	Inclus 9 single phase point
17	0.08	0.62	2.52	18.94	12.62	0.20	0.34	1.44	0.11	0.00	0.02	1.23	61.68	0.00	0.00	0.01	99.80	Inclus 10 Main
18	0.31	0.40	5.08	15.89	12.03	2.08	1.21	4.81	0.14	0.04	0.00	0.89	56.85	0.01	0.14	0.00	99.87	Inclus 10 IM
19	0.16	0.54	3.78	18.15	12.09	0.53	0.67	2.46	0.12	0.00	0.00	1.08	59.29	0.00	0.17	0.00	99.04	Inclus 10 Average 10mu
20	0.08	0.64	3.69	16.96	11.55	0.44	0.60	2.04	0.17	0.00	0.00	1.19	63.19	0.00	0.02	0.00	100.56	Inclus 11 Average 10mu
21	0.19	0.78	3.98	20.42	14.74	0.43	0.87	2.55	0.12	0.00	0.02	1.57	54.53	0.00	0.00	0.00	100.20	Inclus 11 Average 10mu
22	0.10	0.66	3.75	17.48	13.85	0.53	0.47	2.08	0.15	0.01	0.02	1.29	60.07	0.04	0.02	0.00	100.53	Inclus 12 Average 10mu
23	0.14	0.60	3.51	16.60	17.67	0.74	0.71	2.09	0.08	0.02	0.00	1.13	56.32	0.07	0.10	0.02	99.78	Inclus 13 Average 10mu
24	0.19	0.42	4.21	20.59	11.33	1.06	0.92	3.31	0.09	0.00	0.00	0.92	57.64	0.04	0.06	0.01	100.79	Inclus 14 Average 10mu
25	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.05	0.00	0.03	0.00	0.04	93.97	0.01	0.00	0.00	94.13	Hammerscale Bright
26	0.03	0.00	0.00	0.04	0.02	0.02	0.00	0.03	0.01	0.05	0.02	0.05	92.34	0.00	0.00	0.00	92.60	Hammerscale Bright
27	0.00	0.02	0.01	0.05	0.00	0.00	0.00	0.07	0.01	0.00	0.03	0.01	88.87	0.05	0.00	0.01	89.12	Hammerscale Dark
28	0.42	0.07	0.04	0.08	0.42	0.10	0.05	1.02	0.00	0.04	0.00	0.00	73.02	0.03	0.00	0.19	75.44	Hammerscale rust

Table 5. Brad type nail HM105: Composition the metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As
1	0.000	0.000	0.130	0.006	0.003	0.000	0.002	0.010	0.011	0.021	0.011	0.000	0.006
2	0.000	0.000	0.102	0.002	0.000	0.000	0.004	0.000	0.007	0.016	0.003	0.000	0.006
3	0.000	0.000	0.095	0.005	0.000	0.000	0.000	0.006	0.010	0.015	0.001	0.000	0.000
4	0.000	0.000	0.163	0.007	0.000	0.000	0.003	0.000	0.006	0.010	0.013	0.005	0.006
5	0.000	0.000	0.131	0.002	0.000	0.003	0.002	0.006	0.010	0.008	0.008	0.009	0.001
6	0.000	0.000	0.098	0.006	0.000	0.000	0.004	0.000	0.000	0.005	0.010	0.000	0.006
7	0.001	0.000	0.054	0.002	0.000	0.003	0.001	0.000	0.012	0.014	0.012	0.009	0.000
8	0.000	0.000	0.115	0.009	0.000	0.005	0.000	0.009	0.000	0.004	0.014	0.000	0.006
9	0.000	0.000	0.099	0.011	0.000	0.004	0.000	0.000	0.004	0.008	0.000	0.015	0.000
10	0.000	0.000	0.088	0.006	0.000	0.000	0.005	0.001	0.000	0.013	0.012	0.000	0.002
11	0.000	0.000	0.056	0.006	0.000	0.000	0.006	0.006	0.008	0.016	0.001	0.023	0.000
12	0.000	0.000	0.038	0.009	0.000	0.004	0.002	0.000	0.005	0.021	0.004	0.005	0.000
13	0.000	0.000	0.191	0.018	0.000	0.000	0.003	0.014	0.012	0.015	0.018	0.008	0.004
14	0.000	0.000	0.139	0.011	0.000	0.000	0.010	0.026	0.003	0.016	0.014	0.000	0.000
15	0.000	0.000	0.145	0.017	0.000	0.004	0.007	0.029	0.000	0.006	0.020	0.000	0.000
16	0.000	0.000	0.121	0.011	0.000	0.001	0.000	0.016	0.004	0.005	0.000	0.000	0.000
17	0.000	0.000	0.110	0.040	0.002	0.000	0.000	0.070	0.006	0.011	0.001	0.000	0.000
18	0.000	0.000	0.099	0.010	0.000	0.009	0.003	0.031	0.011	0.014	0.021	0.006	0.000
19	0.000	0.000	0.119	0.009	0.000	0.000	0.003	0.036	0.003	0.000	0.008	0.029	0.011
20	0.000	0.000	0.196	0.011	0.000	0.001	0.005	0.019	0.001	0.013	0.009	0.000	0.007
21	0.000	0.000	0.213	0.019	0.000	0.002	0.003	0.025	0.007	0.017	0.000	0.017	0.005
22	0.000	0.000	0.179	0.020	0.000	0.000	0.005	0.021	0.001	0.020	0.017	0.000	0.010
23	0.000	0.000	0.140	0.007	0.000	0.000	0.003	0.000	0.000	0.013	0.016	0.005	0.014
24	0.000	0.000	0.178	0.010	0.000	0.003	0.002	0.000	0.018	0.016	0.000	0.000	0.000
25	0.000	0.000	0.148	0.006	0.000	0.003	0.002	0.009	0.005	0.010	0.008	0.000	0.000
26	0.000	0.000	0.152	0.010	0.000	0.000	0.000	0.002	0.004	0.012	0.001	0.000	0.000
27	0.000	0.000	0.058	0.002	0.000	0.000	0.000	0.007	0.000	0.007	0.003	0.000	0.003
28	0.000	0.000	0.086	0.000	0.000	0.001	0.001	0.004	0.007	0.012	0.000	0.007	0.011
29	0.000	0.000	0.177	0.005	0.000	0.000	0.000	0.000	0.007	0.015	0.018	0.000	0.007
30	0.000	0.000	0.297	0.013	0.000	0.000	0.001	0.000	0.014	0.004	0.007	0.013	0.010

Table 6. HM105 Larger brad type nail: Composition of Non-metallic inclusions (oxide by weight percent)

lo.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	Cl	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	CoO	SrO	BaO	O	Total	Comment
	0.14	1.13	0.86	19.38	5.20	0.55	0.00	0.94	2.73	0.09	0.02	0.00	4.28	54.30	0.00	0.08	0.04	0.00	89.72	Inclusion 1 1 dark
	0.09	1.41	0.68	14.82	7.05	0.96	0.00	0.39	1.53	0.17	0.02	0.02	3.09	73.50	0.02	0.08	0.01	0.00	103.83	Inclusion 1 2 brighter area in matrix
	0.11	1.35	0.91	22.78	11.85	0.54	0.00	1.07	2.67	0.04	0.03	0.01	4.60	52.98	0.03	0.06	0.01	0.00	99.04	Inclusion 1 3 matrix
	0.02	0.19	0.32	0.23	0.07	0.03	0.00	0.02	0.05	0.23	0.10	0.12	1.48	93.57	0.00	0.01	0.02	0.00	96.46	Inclusion 1 4 oxide
	0.03	0.21	0.29	0.25	0.02	0.00	0.00	0.00	0.04	0.23	0.10	0.10	1.51	91.34	0.00	0.00	0.00	0.00	94.10	Inclusion 1 5 oxide
	0.01	0.01	0.01	0.07	0.00	0.00	0.01	0.00	0.01	0.16	0.13	0.15	1.24	90.86	0.00	0.00	0.05	0.00	92.72	Oxide
	0.07	0.07	0.02	19.58	13.60	2.01	0.00	0.64	2.73	0.06	0.00	0.00	4.25	54.47	0.00	0.01	0.00	0.00	97.50	Matrix
	0.09	0.05	0.01	12.48	19.67	0.40	0.00	0.30	0.74	0.06	0.00	0.02	3.22	61.66	0.00	0.00	0.08	0.00	98.77	Round
	0.00	0.02	0.01	0.37	0.13	0.00	0.01	0.02	0.14	0.35	0.23	0.08	1.67	95.65	0.00	0.00	0.03	0.00	98.71	Oxide with 10
)	0.10	0.06	0.03	22.53	10.37	1.71	0.00	0.76	2.58	0.13	0.03	0.01	5.16	54.43	0.00	0.00	0.02	0.00	97.91	Matrix with 9
1	0.12	0.05	0.02	20.45	11.64	4.90	0.00	0.86	3.63	0.12	0.01	0.01	4.56	53.37	0.00	0.00	0.06	0.00	99.80	Matrix
2	0.12	0.06	0.02	20.98	12.00	2.44	0.00	0.74	3.10	0.11	0.00	0.02	4.91	52.92	0.00	0.03	0.00	0.00	97.42	Matrix
3	0.09	0.06	0.02	23.18	9.16	2.05	0.00	0.68	2.99	0.16	0.02	0.00	5.32	53.91	0.00	0.01	0.02	0.00	97.67	Matrix
4	0.23	0.06	0.03	22.40	9.80	4.95	0.01	0.95	4.40	0.14	0.03	0.01	5.12	50.93	0.00	0.01	0.09	0.00	99.18	Matrix
5	0.11	0.10	0.05	27.16	6.09	1.22	0.01	1.25	2.71	0.24	0.14	0.04	6.72	49.85	0.00	0.00	0.00	0.00	95.67	Matrix
6	0.29	0.24	0.09	58.65	0.04	1.57	0.00	2.96	9.22	0.72	0.06	0.03	10.65	8.21	0.00	0.00	0.15	0.00	92.88	Matrix (silicate)
7	0.31	0.24	0.09	59.42	0.04	0.67	0.00	3.21	9.19	0.77	0.02	0.02	10.16	6.28	0.00	0.04	0.00	0.00	90.47	Matrix (silicate)
8	0.29	0.21	0.08	60.02	0.02	0.75	0.01	3.06	9.26	0.76	0.04	0.03	9.87	5.42	0.00	0.05	0.00	0.00	89.88	Matrix (silicate)
9	0.40	0.26	0.08	51.29	0.32	0.41	0.00	2.57	6.49	0.50	0.03	0.01	6.63	45.42	0.00	0.04	0.00	0.00	114.44	Matrix (silicate)
0	0.32	0.21	0.08	56.55	0.49	0.97	0.00	2.77	8.17	0.61	0.06	0.03	11.84	12.50	0.00	0.00	0.05	0.00	94.66	Matrix (silicate)
1	0.23	0.20	0.07	53.44	0.56	0.96	0.01	3.06	7.80	0.58	0.12	0.00	11.15	13.73	0.00	0.05	0.02	0.00	91.95	Matrix (silicate)
2	0.28	0.18	0.07	52.16	0.56	0.97	0.00	2.80	7.68	0.64	0.12	0.00	11.06	14.97	0.00	0.01	0.16	0.00	91.65	Matrix (silicate)
3	0.26	0.18	0.07	51.08	0.56	0.86	0.00	2.91	7.76	0.63	0.13	0.06	10.78	16.16	0.00	0.06	0.06	0.00	91.55	Matrix (silicate)
4	0.30	0.20	0.06	52.55	0.64	0.51	0.01	3.05	7.86	0.61	0.08	0.04	9.64	16.58	0.00	0.00	0.12	0.00	92.23	Matrix (silicate)
5	0.22	0.11	0.05	34.76	5.93	1.41	0.01	1.97	5.66	0.37	0.13	0.05	8.36	35.66	0.00	0.07	0.09	0.00	94.85	Matrix (silicate)
6	0.21	0.12	0.05	35.90	3.21	1.59	0.00	1.58	4.95	0.43	0.08	0.07	8.94	36.07	0.00	0.00	0.00	0.00	93.19	Matrix (silicate)
7	0.18	0.07	0.02	24.79	8.78	1.51	0.00	1.07	3.84	0.08	0.00	0.00	4.54	51.07	0.00	0.04	0.00	0.00	95.99	Matrix in two phases
8	0.01	0.02	0.00	0.07	0.01	0.02	0.00	0.03	0.09	0.18	0.13	0.10	1.58	90.77	0.00	0.00	0.00	0.00	93.00	Oxide in two phases
9	0.17	0.07	0.03	24.29	8.94	1.63	0.00	1.21	4.35	0.12	0.05	0.02	4.42	51.82	0.00	0.00	0.09	0.00	97.22	Matrix in two phases
0	0.00	0.02	0.00	0.12	0.00	0.00	0.00	0.01	0.07	0.20	0.09	0.09	1.63	91.31	0.00	0.00	0.08	0.00	93.62	Oxide (M?) in two phases
1	0.00	0.01	0.01	0.07	0.04	0.01	0.00	0.02	0.07	0.24	0.15	0.09	1.67	92.67	0.00	0.01	0.00	0.00	95.05	Oxide (W?) in two phases

Table 7: Medium sized panel fixing nail HM107: Composition of the metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Fe	Comment
1	0.000	0.004	0.376	0.025	0.000	0.000	0.000	0.000	0.000	0.022	0.018	0.000	0.006	99.549	HM107 1
2	0.000	0.004	0.391	0.021	0.000	0.000	0.000	0.003	0.007	0.022	0.014	0.000	0.009	99.529	HM107 2
3	0.000	0.005	0.453	0.024	0.000	0.000	0.000	0.000	0.017	0.022	0.015	0.000	0.012	99.452	HM107 3
4	0.000	0.008	0.384	0.024	0.000	0.000	0.000	0.000	0.008	0.010	0.023	0.000	0.019	99.524	HM107 4 on slag line
5	0.000	0.006	0.306	0.012	0.000	0.000	0.000	0.000	0.008	0.020	0.019	0.000	0.016	99.613	HM107 5
6	0.000	0.006	0.451	0.021	0.000	0.000	0.000	0.000	0.003	0.023	0.010	0.017	0.011	99.458	HM107 6
7	0.000	0.012	0.218	0.009	0.000	0.005	0.004	0.000	0.011	0.032	0.023	0.000	0.007	99.679	HM107 7 depleted in P
8	0.000	0.009	0.393	0.022	0.000	0.002	0.008	0.001	0.009	0.020	0.011	0.003	0.010	99.512	HM107 8
9	0.000	0.010	0.355	0.021	0.000	0.001	0.001	0.000	0.000	0.016	0.025	0.000	0.003	99.568	HM107 9
10	0.000	0.009	0.294	0.012	0.000	0.000	0.001	0.002	0.004	0.021	0.022	0.000	0.000	99.635	HM107 10
11	0.000	0.010	0.396	0.011	0.001	0.003	0.000	0.000	0.010	0.011	0.020	0.006	0.003	99.529	HM107 11
12	0.000	0.006	0.488	0.023	0.000	0.005	0.003	0.000	0.005	0.018	0.022	0.000	0.000	99.430	HM107 12
13	0.000	0.008	0.430	0.030	0.000	0.001	0.000	0.000	0.006	0.012	0.021	0.000	0.011	99.481	HM107 13
14	0.000	0.008	0.482	0.027	0.000	0.000	0.000	0.002	0.016	0.021	0.006	0.000	0.012	99.426	HM107 14
15	0.000	0.006	0.449	0.025	0.000	0.001	0.002	0.000	0.009	0.026	0.009	0.000	0.009	99.464	HM107 15
16	0.000	0.005	0.302	0.018	0.000	0.000	0.000	0.000	0.011	0.017	0.006	0.000	0.007	99.634	HM107 16
17	0.000	0.012	0.255	0.006	0.000	0.003	0.002	0.000	0.000	0.029	0.012	0.000	0.010	99.671	HM107 17

Table 8. Medium sized panel fixing nail HM107: Composition of non-metallic inclusions (oxide by weight percent)

Analyses with lost locations

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	SrO	BaO	Cl	Total	Comment
1	0.00	0.18	0.88	0.43	0.12	0.07	0.01	0.09	0.26	0.03	0.00	0.17	91.69	0.03	0.00	0.01	93.95	Incl A FeOx
2	0.17	2.06	3.35	17.74	14.89	1.19	1.08	1.78	0.04	0.00	0.01	0.54	54.62	0.00	0.00	0.01	97.46	Incl A 1 Olivine
3	0.49	1.18	8.97	17.46	16.06	1.73	2.46	4.55	0.07	0.02	0.02	0.58	46.59	0.04	0.04	0.01	100.25	Incl A 1 IM
4	0.18	1.30	3.86	12.92	10.80	4.40	1.00	2.18	0.11	0.00	0.00	0.43	62.59	0.00	0.26	0.03	100.06	Incl A 10 mu aver
5	0.21	1.30	3.90	13.68	11.30	1.66	1.09	2.50	0.13	0.03	0.01	0.51	61.09	0.10	0.00	0.02	97.51	Incl A 10 mu aver
6	0.33	1.64	4.38	15.86	13.05	1.88	1.06	2.31	0.13	0.00	0.00	0.54	58.28	0.02	0.11	0.00	99.58	Incl A 10 mu aver
7	0.27	1.52	4.50	17.39	14.29	2.03	1.15	2.61	0.08	0.00	0.01	0.55	53.98	0.01	0.00	0.02	98.40	Incl B 10 mu aver
8	0.27	1.77	4.15	16.83	14.01	1.44	1.12	2.58	0.07	0.01	0.00	0.59	55.57	0.00	0.00	0.01	98.41	Incl B 10 mu aver
9	0.19	1.14	3.46	11.50	9.72	2.22	0.86	2.26	0.15	0.00	0.00	0.43	65.21	0.00	0.02	0.02	97.17	Incl B 10 mu aver
10	0.00	0.27	1.22	0.77	0.53	0.26	0.03	0.23	0.23	0.00	0.02	0.20	91.63	0.00	0.03	0.00	95.41	Incl B FeOx
11	0.14	2.02	2.11	17.67	13.22	1.17	0.59	1.09	0.04	0.00	0.00	0.73	57.71	0.00	0.13	0.00	96.61	Incl B Olive
12	0.29	1.20	7.87	16.12	14.72	1.48	2.22	4.71	0.06	0.01	0.02	0.53	45.82	0.10	0.18	0.00	95.31	Incl B IM
13	0.18	1.04	3.76	10.05	10.08	1.42	0.93	2.39	0.15	0.00	0.01	0.34	67.63	0.00	0.01	0.00	97.99	Incl B IM
14	0.17	1.30	2.40	10.80	9.19	0.81	0.51	1.01	0.12	0.01	0.01	0.37	69.44	0.01	0.09	0.00	96.23	Incl C IM
15	0.16	0.86	2.62	8.55	7.37	1.63	0.45	1.26	0.16	0.01	0.00	0.36	72.97	0.01	0.15	0.00	96.55	Incl D IM
16	0.17	0.85	3.12	8.65	9.18	1.44	0.84	2.41	0.15	0.04	0.02	0.47	70.24	0.02	0.00	0.00	97.58	Incl E IM
17	0.21	1.14	3.39	11.47	11.43	2.14	0.82	2.09	0.13	0.00	0.01	0.46	65.05	0.03	0.12	0.01	98.50	Incl F IM
18	0.09	0.88	2.50	7.28	6.46	1.51	0.35	1.12	0.18	0.00	0.01	0.31	76.18	0.00	0.00	0.01	96.89	Incl G IM
19	0.11	1.08	2.97	9.27	8.45	1.22	0.60	1.36	0.19	0.01	0.03	0.36	70.43	0.00	0.00	0.00	96.08	Incl H IM
20	0.29	1.26	3.59	14.24	13.19	2.26	1.41	3.33	0.10	0.01	0.01	0.51	56.67	0.00	0.00	0.02	96.87	Incl I IM
21	0.22	1.17	2.82	10.84	17.20	3.32	0.89	2.07	0.13	0.00	0.02	0.39	59.44	0.00	0.13	0.00	98.65	Incl J IM
22	0.15	1.16	3.68	12.80	12.59	2.58	1.05	2.69	0.15	0.02	0.01	0.53	60.04	0.00	0.06	0.01	97.51	Incl K IM

Analyses with associated with images

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	SrO	BaO	Cl	Total	Comment
23	0.21	1.97	1.72	16.45	14.41	0.45	0.86	1.42	0.03	0.00	0.00	0.64	56.21	0.00	0.04	0.00	94.40	Incl 1 Oliv
24	0.01	0.16	0.77	0.32	0.15	0.01	0.03	0.08	0.24	0.00	0.00	0.15	93.43	0.01	0.01	0.00	95.37	Incl 1 Fe OX
25	0.55	1.07	6.38	16.83	15.67	1.00	1.95	4.33	0.02	0.01	0.00	0.59	49.73	0.03	0.02	0.00	98.17	Incl 1 Fe IM
26	0.03	0.24	0.84	0.31	0.04	0.05	0.01	0.07	0.25	0.01	0.00	0.14	93.39	0.02	0.02	0.00	95.41	Incl 2 FeOx
27	0.22	1.71	2.37	15.76	14.51	1.12	1.00	1.53	0.06	0.00	0.00	0.57	55.39	0.00	0.27	0.00	94.50	Incl 2 Oliv
28	0.54	0.42	7.89	14.65	15.83	3.50	3.73	8.71	0.09	0.02	0.03	0.43	38.30	0.13	0.25	0.01	94.52	Incl 2 IM
31	0.09	2.11	0.33	9.07	26.30	0.03	0.02	0.25	0.00	0.00	0.03	0.70	56.74	0.00	0.00	0.00	95.67	Incl 3 Oliv
32	0.02	0.75	3.10	5.67	8.01	0.46	0.07	0.30	0.29	0.02	0.00	0.33	77.88	0.00	0.11	0.01	97.02	Incl 3 Unknown
33	0.00	0.88	2.53	6.89	13.09	0.43	0.36	0.42	0.05	0.06	0.00	0.40	71.29	0.00	0.00	0.02	96.41	Incl 3 Unknown

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	SrO	BaO	Cl	Total	Comment
34	0.33	0.71	1.70	3.69	28.04	1.48	3.50	5.27	0.04	0.00	0.02	0.73	49.50	0.03	0.12	0.00	95.15	Incl 3 IM
35	0.19	0.64	1.60	2.92	26.12	1.97	3.20	7.17	0.06	0.02	0.02	0.69	52.57	0.06	0.00	0.00	97.22	Incl 3 IM
36	0.10	1.94	0.56	8.71	24.52	0.22	0.07	0.36	0.05	0.00	0.00	0.68	59.31	0.00	0.08	0.00	96.59	Incl 3 Oliv?
37	0.01	0.24	0.86	0.25	0.08	0.02	0.03	0.12	0.31	0.05	0.02	0.17	90.94	0.07	0.00	0.01	93.17	Incl 4 FeOx
38	0.13	2.52	0.91	15.20	17.19	0.52	0.19	0.48	0.04	0.02	0.01	0.70	57.80	0.00	0.05	0.02	95.78	Incl 4 Oliv?
39	0.10	2.38	0.66	14.48	16.92	0.00	0.08	0.33	0.06	0.03	0.00	0.83	59.10	0.00	0.01	0.00	94.96	Incl 4 Oliv?
40	0.36	0.58	7.91	10.58	20.89	3.15	3.41	9.86	0.10	0.02	0.02	0.51	38.41	0.06	0.16	0.02	96.03	Incl 4 IM
41	0.08	2.78	0.41	14.35	18.44	0.00	0.03	0.34	0.06	0.01	0.00	0.57	58.35	0.04	0.01	0.01	95.47	Incl 5 Oliv?
42	0.00	0.30	0.78	0.23	0.03	0.02	0.03	0.10	0.30	0.02	0.00	0.18	93.76	0.00	0.05	0.01	95.80	Incl 5 FeOx
43	0.14	0.56	2.44	5.65	6.48	0.37	0.35	1.47	0.50	0.07	0.00	0.21	77.45	0.00	0.11	0.02	95.79	Incl 5 Needle
44	0.63	0.78	4.89	12.07	21.19	1.40	3.38	7.38	0.07	0.02	0.00	0.47	45.65	0.02	0.12	0.01	98.07	Incl 5 IM
45	0.00	0.28	0.80	0.23	0.04	0.04	0.03	0.10	0.33	0.00	0.01	0.16	93.99	0.00	0.06	0.01	96.07	Incl 5 FeOx
46	0.00	0.17	1.08	1.64	1.39	0.13	0.16	0.50	0.21	0.03	0.00	0.18	88.59	0.00	0.16	0.00	94.23	Incl 6 FeOx
47	0.21	2.05	1.27	15.41	15.88	0.25	0.43	0.85	0.08	0.00	0.01	0.67	59.04	0.00	0.03	0.00	96.18	Incl 6 Oliv?
48	0.08	0.97	4.29	10.28	6.54	1.11	0.50	1.39	0.40	0.00	0.00	0.32	69.66	0.01	0.07	0.00	95.61	Incl 6 Needle
49	0.54	0.53	9.48	11.85	19.17	2.27	4.09	10.01	0.09	0.00	0.00	0.46	36.35	0.08	0.11	0.00	95.00	Incl 6 IM
50	0.02	0.11	0.79	0.50	0.33	0.24	0.01	0.08	0.15	0.00	0.01	0.10	92.12	0.06	0.00	0.00	94.50	Incl 7 FeOx
51	0.02	0.57	3.91	7.03	4.62	1.32	0.47	0.67	0.47	0.00	0.03	0.14	77.25	0.00	0.00	0.00	96.52	Incl 7 Needle
52	0.29	1.79	1.13	15.48	16.19	0.58	0.37	0.66	0.01	0.00	0.00	0.60	57.29	0.02	0.00	0.01	94.41	Incl 7 Oliv?
53	0.04	0.66	3.20	6.67	4.27	1.14	0.05	0.34	0.35	0.01	0.03	0.22	78.43	0.03	0.00	0.01	95.45	Incl 7 Oliv? Brighter
54	0.03	0.00	0.01	0.21	25.89	1.19	0.00	0.01	0.02	0.00	0.00	1.17	75.04	0.00	0.08	0.00	103.66	Incl 7a small round
55	0.00	0.00	0.01	0.07	28.43	5.43	0.01	0.00	0.00	0.00	0.00	1.25	70.04	0.00	0.00	0.00	105.24	Incl 8a
56	0.04	0.00	0.01	0.02	11.29	0.74	0.00	0.01	0.00	0.01	0.02	0.16	113.77	0.00	0.02	0.00	126.09	Incl 8aa
57	0.01	0.14	0.80	0.22	0.03	0.01	0.01	0.06	0.26	0.02	0.00	0.12	92.73	0.00	0.09	0.00	94.50	Incl 8 FeOx
58	0.15	1.71	1.26	15.99	16.34	0.38	0.37	0.91	0.03	0.00	0.00	0.58	59.39	0.00	0.00	0.00	97.10	Incl 8 Oliv?
59	0.01	0.68	4.51	8.10	4.76	1.74	0.25	1.00	0.71	0.00	0.00	0.25	75.62	0.07	0.00	0.00	97.68	Incl 8 FeOX?
60	0.59	0.40	8.97	14.01	17.45	2.18	3.54	8.34	0.07	0.03	0.00	0.40	38.97	0.04	0.17	0.01	95.18	Incl 8 IM
61	0.01	0.15	0.80	0.28	0.14	0.06	0.02	0.19	0.28	0.00	0.02	0.14	89.60	0.00	0.03	0.00	91.73	Incl 9 FeOx
62	0.18	1.57	1.89	16.04	16.15	0.24	0.59	1.54	0.05	0.00	0.02	0.54	58.40	0.00	0.00	0.01	97.20	Incl 9 Oliv
63	0.53	0.48	9.28	13.04	21.01	1.09	3.52	11.03	0.21	0.00	0.00	0.41	34.40	0.10	0.16	0.01	95.25	Incl 9 IM
64	0.08	0.55	1.86	7.29	8.37	33.80	0.47	2.13	0.02	0.04	0.00	0.29	68.58	0.08	0.11	0.01	123.69	Incl 9 IM white
65	0.00	0.17	0.75	0.27	0.15	0.04	0.02	0.06	0.21	0.00	0.00	0.18	93.42	0.00	0.00	0.02	95.28	Incl 10 FeOx
66	0.07	0.71	4.45	8.34	5.45	4.31	0.47	1.08	0.42	0.00	0.00	0.25	72.90	0.03	0.00	0.01	98.47	Incl 10 Needle
67	0.19	1.44	1.50	15.58	14.91	0.71	0.58	0.93	0.00	0.05	0.03	0.59	59.23	0.00	0.06	0.00	95.78	Incl 10 Oliv?
68	0.15	0.46	4.50	8.25	8.27	32.48	1.22	2.44	0.08	0.00	0.00	0.26	66.65	0.03	0.19	0.02	124.99	Incl 10 Sulphide?
69	0.57	0.70	8.24	13.09	16.09	2.24	2.79	6.67	0.10	0.00	0.02	0.41	48.65	0.09	0.09	0.01	99.74	Incl 10 IM
70	0.03	0.00	0.04	0.46	1.13	70.35	0.16	0.25	0.00	0.00	0.03	0.08	86.72	0.05	0.05	0.00	159.35	Incl 11 FeOx?
71	0.02	0.53	3.60	7.47	6.53	0.36	0.11	0.22	0.51	0.00	0.01	0.26	77.18	0.00	0.00	0.00	96.81	Incl 11 Needle

No.	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O3	Cr2O3	MnO	FeO	SrO	BaO	Cl	Total	Comment
72	0.05	1.62	0.52	12.62	20.30	0.00	0.02	0.23	0.03	0.00	0.02	0.53	59.07	0.05	0.00	0.02	95.06	Incl 11 Main phase
73	0.61	0.51	2.61	4.11	28.28	1.71	2.86	7.91	0.01	0.00	0.00	0.51	47.79	0.09	0.35	0.01	97.35	Incl 11 IM
74	0.00	0.50	3.20	7.53	7.58	0.04	0.07	0.20	0.30	0.00	0.00	0.32	73.68	0.01	0.02	0.01	93.45	Incl 11 Brighter material
75	0.13	0.95	2.08	7.66	22.83	3.12	0.66	1.82	0.06	0.04	0.00	0.42	60.16	0.00	0.04	0.00	99.96	Incl 12
76	0.20	0.71	2.06	8.42	19.64	3.60	0.74	1.79	0.09	0.00	0.00	0.43	60.63	0.07	0.18	0.02	98.58	Incl 13 matrix
77	0.19	0.65	1.45	5.57	13.21	3.00	0.45	1.15	0.11	0.06	0.00	0.27	87.34	0.01	0.13	0.03	113.62	Incl 13 bright
78	0.15	0.88	1.88	7.90	19.26	2.81	0.50	1.10	0.14	0.00	0.01	0.30	64.63	0.08	0.00	0.00	99.64	Incl 13 crystalite
79	0.20	0.85	2.07	8.55	18.45	2.06	0.71	1.77	0.11	0.03	0.00	0.33	64.22	0.00	0.00	0.02	99.35	Incl 14 20mu average
80	0.12	0.94	2.38	8.76	8.37	1.85	0.56	1.43	0.14	0.00	0.05	0.32	74.20	0.01	0.04	0.01	99.17	Incl 10 20mu average
81	0.18	0.88	2.34	8.92	16.75	3.81	0.62	1.70	0.13	0.02	0.00	0.36	64.05	0.00	0.12	0.00	99.89	Incl 11 20mu average
82	0.21	1.10	3.36	12.63	13.01	2.94	1.09	2.54	0.08	0.00	0.02	0.41	61.09	0.03	0.08	0.01	98.59	Incl 09 20mu average
83	0.15	1.27	2.70	10.36	12.79	1.50	0.87	1.98	0.14	0.00	0.02	0.59	66.94	0.00	0.14	0.00	99.44	Incl 04 20mu average
84	0.21	1.14	3.15	12.06	10.60	2.24	0.93	2.37	0.15	0.00	0.00	0.55	64.82	0.03	0.00	0.01	98.24	Incl 02 20mu average
85	0.30	1.22	3.26	11.98	10.24	1.58	0.96	2.04	0.13	0.05	0.00	0.40	66.42	0.05	0.14	0.01	98.77	Incl 01 20mu average

Table 9: Medium sized panel fixing nail HM110: Composition of the metal (elements by weight percent)

No.	Al	Si	P	S	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	
1	0.000	0.013	0.321	0.008	0.000	0.000	0.003	0.000	0.006	0.014	0.028	0.000	0.005	point 1
2	0.000	0.011	0.220	0.005	0.000	0.001	0.000	0.000	0.007	0.026	0.012	0.000	0.000	point 2
3	0.000	0.009	0.421	0.019	0.000	0.002	0.002	0.000	0.002	0.023	0.020	0.000	0.005	point 3
4	0.000	0.009	0.439	0.023	0.000	0.000	0.002	0.000	0.006	0.023	0.002	0.000	0.013	point 4
5	0.000	0.012	0.391	0.014	0.000	0.004	0.002	0.000	0.018	0.013	0.002	0.000	0.000	point 5
6	0.000	0.010	0.178	0.007	0.000	0.000	0.001	0.000	0.021	0.020	0.017	0.000	0.000	point 6
7	0.000	0.013	0.421	0.014	0.000	0.000	0.000	0.006	0.004	0.026	0.014	0.000	0.004	point 7
8	0.000	0.014	0.149	0.000	0.000	0.000	0.000	0.004	0.017	0.022	0.007	0.000	0.000	point 8
9	0.000	0.018	0.395	0.016	0.000	0.000	0.003	0.001	0.009	0.008	0.019	0.000	0.006	point 9
10	0.000	0.024	0.487	0.017	0.000	0.004	0.000	0.000	0.007	0.022	0.009	0.000	0.000	point 10
11	0.000	0.021	0.471	0.015	0.000	0.001	0.000	0.000	0.003	0.019	0.000	0.000	0.014	point 11
12	0.000	0.019	0.425	0.018	0.000	0.001	0.000	0.000	0.007	0.022	0.019	0.000	0.005	point 12
13	0.000	0.015	0.467	0.024	0.000	0.002	0.000	0.000	0.011	0.024	0.017	0.000	0.000	point 13
14	0.000	0.017	0.420	0.016	0.000	0.000	0.002	0.002	0.007	0.010	0.012	0.000	0.003	point 14
15	0.000	0.015	0.151	0.005	0.000	0.001	0.006	0.000	0.011	0.026	0.012	0.003	0.004	point 15
16	0.000	0.008	0.147	0.003	0.000	0.000	0.003	0.000	0.009	0.022	0.016	0.000	0.005	point 16
17	0.000	0.016	0.583	0.036	0.000	0.000	0.000	0.000	0.002	0.014	0.019	0.000	0.000	point 17
18	0.000	0.012	0.648	0.045	0.001	0.000	0.001	0.002	0.006	0.011	0.026	0.000	0.000	point 18
19	0.000	0.009	0.531	0.026	0.000	0.000	0.002	0.008	0.008	0.021	0.004	0.000	0.001	point 19
20	0.000	0.006	0.488	0.021	0.000	0.004	0.003	0.000	0.001	0.011	0.008	0.000	0.012	point 20
Mini	0.000	0.006	0.147	0.000	0.000	0.000	0.000	0.000	0.001	0.008	0.000	0.000	0.000	
Max	0.000	0.024	0.648	0.045	0.001	0.004	0.006	0.008	0.021	0.026	0.028	0.003	0.014	
Aver	0.000	0.014	0.388	0.017	0.000	0.001	0.002	0.001	0.008	0.019	0.013	0.000	0.004	
Sigma	0.000	0.005	0.148	0.011	0.000	0.001	0.002	0.002	0.005	0.006	0.008	0.001	0.005	

Table 10. Medium sized panel fixing nail HM110: Composition of non-metallic inclusions (oxide by weight percent)

Point	Na2O	MgO	Al2O3	SiO2	P2O5	SO3	K2O	CaO	TiO2	V2O	Cr2O3	MnO	FeO	SrO	BaO	Cl	Total	Comment
1	0.00	0.03	0.00	0.06	23.99	1.49	0.00	0.00	0.00	0.02	0.04	0.12	83.87	0.07	0.00	0.00	109.68	Inclusion 1 single phase small
2	0.02	0.00	0.01	0.35	30.12	6.34	0.00	0.03	0.04	0.00	0.00	0.35	66.38	0.00	0.00	0.01	103.64	Inclusion 2 - 2 phase
3	0.00	0.00	0.00	0.02	34.31	2.03	0.00	0.01	0.01	0.00	0.00	0.32	66.24	0.00	0.20	0.02	103.17	Inclusion 2 - 2 phase
4	0.00	0.17	1.03	1.13	1.19	0.13	0.06	0.18	0.24	0.05	0.00	0.15	92.15	0.00	0.09	0.00	96.56	Inclusion 3 - 2 phase FeOx
5	0.20	1.63	2.02	16.29	15.49	0.48	0.75	0.94	0.03	0.02	0.00	0.55	59.85	0.00	0.08	0.02	98.34	Inclusion 3 - 2 phase Oliv?
6	0.27	0.74	5.67	15.00	16.47	1.74	2.25	5.07	0.07	0.00	0.00	0.45	48.28	0.04	0.06	0.00	96.10	Inclusion 3 - 2 phase IM?
7	0.28	1.09	3.20	14.33	13.25	1.27	0.89	1.85	0.07	0.06	0.02	0.49	62.76	0.01	0.17	0.02	99.74	Inclusion 4 - overall
8	0.03	0.23	0.86	0.52	0.21	0.00	0.00	0.09	0.28	0.00	0.05	0.19	92.90	0.05	0.00	0.00	95.42	Inclusion 5 - FeOx
9	0.23	1.86	3.32	19.18	14.31	1.25	1.31	1.90	0.01	0.02	0.01	0.59	52.56	0.01	0.00	0.02	96.59	Inclusion 5 - Olivine?
10	0.39	0.99	4.73	16.38	14.56	1.34	1.78	3.71	0.07	0.00	0.01	0.59	50.19	0.03	0.01	0.01	94.78	Inclusion 5 - IM
11	0.04	1.06	3.90	9.74	4.99	0.37	0.29	0.62	0.53	0.06	0.02	0.33	77.48	0.02	0.00	0.00	99.44	Inclusion 5 - Needle
12	0.24	1.00	3.13	11.31	8.51	1.30	0.75	1.78	0.15	0.00	0.00	0.45	70.71	0.02	0.00	0.00	99.36	Inclusion 5 - Overall 20 mu
14	0.17	0.96	3.04	12.11	17.14	1.22	0.65	1.61	0.16	0.00	0.00	0.44	62.10	0.00	0.00	0.03	99.63	Inclusion 6 main
15	0.22	0.75	3.50	12.60	17.49	2.68	1.15	2.95	0.11	0.00	0.00	0.52	58.62	0.03	0.02	0.00	100.64	Inclusion 6 IM
16	0.18	0.91	2.54	9.40	22.46	2.50	0.76	1.75	0.15	0.00	0.00	0.43	59.08	0.06	0.01	0.01	100.22	Inclusion 7
17	0.01	0.17	0.93	0.34	0.06	0.00	0.02	0.09	0.28	0.05	0.00	0.20	91.84	0.02	0.05	0.00	94.06	Inclusion 8 FeOx
18	0.25	1.48	2.94	17.71	14.96	2.34	0.81	2.46	0.10	0.00	0.00	0.76	57.67	0.07	0.19	0.00	101.74	Inclusion 8 Main
19	0.27	0.54	6.29	15.33	13.49	5.03	1.77	5.25	0.04	0.00	0.03	0.55	49.54	0.00	0.14	0.03	98.31	Inclusion 8 IM
20	0.28	1.30	4.01	17.13	14.44	1.71	1.26	2.43	0.05	0.01	0.02	0.62	55.94	0.05	0.15	0.03	99.43	Inclusion 8 average 10mu
21	0.18	1.53	3.23	16.43	13.88	1.15	1.01	1.69	0.13	0.00	0.01	0.63	57.29	0.00	0.17	0.00	97.32	Inclusion 9 average 10mu
22	0.02	0.27	0.99	0.89	0.31	0.07	0.04	0.10	0.21	0.00	0.03	0.13	92.15	0.00	0.04	0.01	95.25	Inclusion 10 FeOx
23	0.34	1.46	3.99	20.88	12.43	1.73	1.48	2.63	0.06	0.01	0.00	0.71	54.19	0.03	0.05	0.01	99.97	Inclusion 10 Main
24	0.43	0.64	6.49	18.40	11.08	2.40	2.42	6.73	0.12	0.03	0.00	0.52	46.93	0.03	0.03	0.00	96.25	Inclusion 10 IM
25	0.22	1.08	3.34	11.98	7.02	1.32	0.79	1.72	0.20	0.00	0.00	0.42	70.94	0.04	0.02	0.00	99.08	Inclusion 10 IM
26	0.03	0.01	0.00	0.05	37.53	1.28	0.00	0.04	0.00	0.00	0.00	0.21	61.48	0.05	0.07	0.00	100.75	Inclusion 11
27	0.01	0.18	0.95	0.45	0.09	0.01	0.04	0.12	0.30	0.07	0.01	0.14	92.58	0.05	0.05	0.01	95.06	i Inclusion 12 FeOx
28	0.21	1.51	3.46	19.74	13.66	1.66	1.25	2.63	0.06	0.00	0.00	0.58	53.89	0.00	0.00	0.02	98.64	i Inclusion 12 Main
29	0.26	0.82	4.96	18.32	12.78	3.07	1.39	4.21	0.12	0.00	0.02	0.60	52.87	0.06	0.14	0.00	99.60	i Inclusion 12 IM
30`	0.24	1.16	4.17	16.51	11.43	2.46	1.15	2.72	0.10	0.04	0.00	0.56	59.84	0.09	0.00	0.00	100.46	i Inclusion 12 Average