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*Historic Nail Development and Morphology as a
way of developing dating methods -
with case studies of British and Australian nails
for the period 1680 - 1890*

Thesis submitted towards the requirements for the award of the degree of Doctor
of Architecture & Engineering by

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*Now preye I to hem alle that herke this litel tretys or rede,
that if ther be any thyng in it that liketh hem,
that therof they thanken oure Lord Jhesu Crist, of whom al witte and al goodnesse.
And if ther be anything that displease hem, I prey hem that they arrette it to the defaute
of myn unkonnyng and nat to my wyl, that wolde fayn seyde better if I hadde had konnyng.
For our book seith, “Al that is written for doctrine”, and that is myn entente.*

Geoffrey Chaucer 1342-1400

Dedication

In fond memory of my late mentor and friend, John Ashurst.

His quiet dedication to the conservation of heritage buildings provided the example and stimulus to me to sustain the long effort needed during this study.

Acknowledgements

In a journey as long as this one it is inevitable that, due to their very large numbers, debts of gratitude will be omitted to many people worldwide who have all advanced the study with samples, encouragements and advice. To you I say a big thank you, and I apologise in advance for not mentioning you all individually. The many people, from trades to academia, who became friends and colleagues along the way, have made this journey enjoyable and fulfilling.

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Studies in the Baltic States, Sweden, and in Germany, have enabled a widening of the whole dimension of nail technology. I am grateful to my Godson, Jens Bode, for several late medieval finds in Swabia, and to Dr Wulf Müntzer for rare finds of good provenance at Wolfegg, which greatly added to this study. My particular thanks go to my colleague and co-author, Arturs Lapins in Riga, who has provided constant support and encouragement in the study of framing examples through the Baltic States and inside Germany, and has provided access to many examples of Baltic nails with their fascinating cross-cultural histories. Also his Riga colleague, Dr Ilmars Dirveiks, for sharing findings from conservation projects and for alerting me to the strange phenomenon of 'blue nails'.

The final stages of production often leaves the author blind to his various omissions and errors. I am thus eternally thankful for my staunch friends: Norm Yodgee, Dr Bill Vistarini, Dr Nigel Isaacs, and Sean Johnson, able to proof read and find weaknesses hidden to myself. Well done and thanks to all three.

Above all, I must thank my ever patient and long-suffering wife, Christine, a paragon of fortitude, for tolerance in accepting nails in nearly every room and disarray for such a long a time, but still with the ability to make allowances for all without loss of faith in a final outcome.

Preface

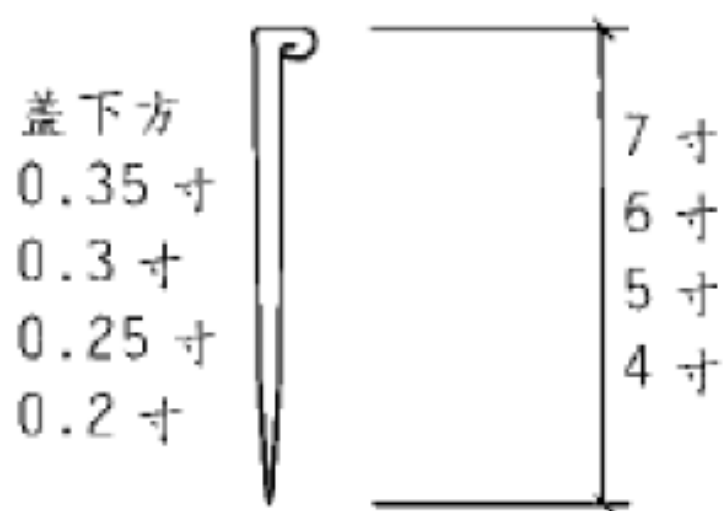


Fig. 1. Double-fold head Chinese nail as described in *Yingzao Fashi* (Vol.28), (12th century).

Guxi Pan (潘谷西), Jianzhong He (何建中), Courtesy Prof Yiting Pan.

ALTERNATIVE ASPECTS FROM THE ORIENT OF NAILS AND FIXINGS

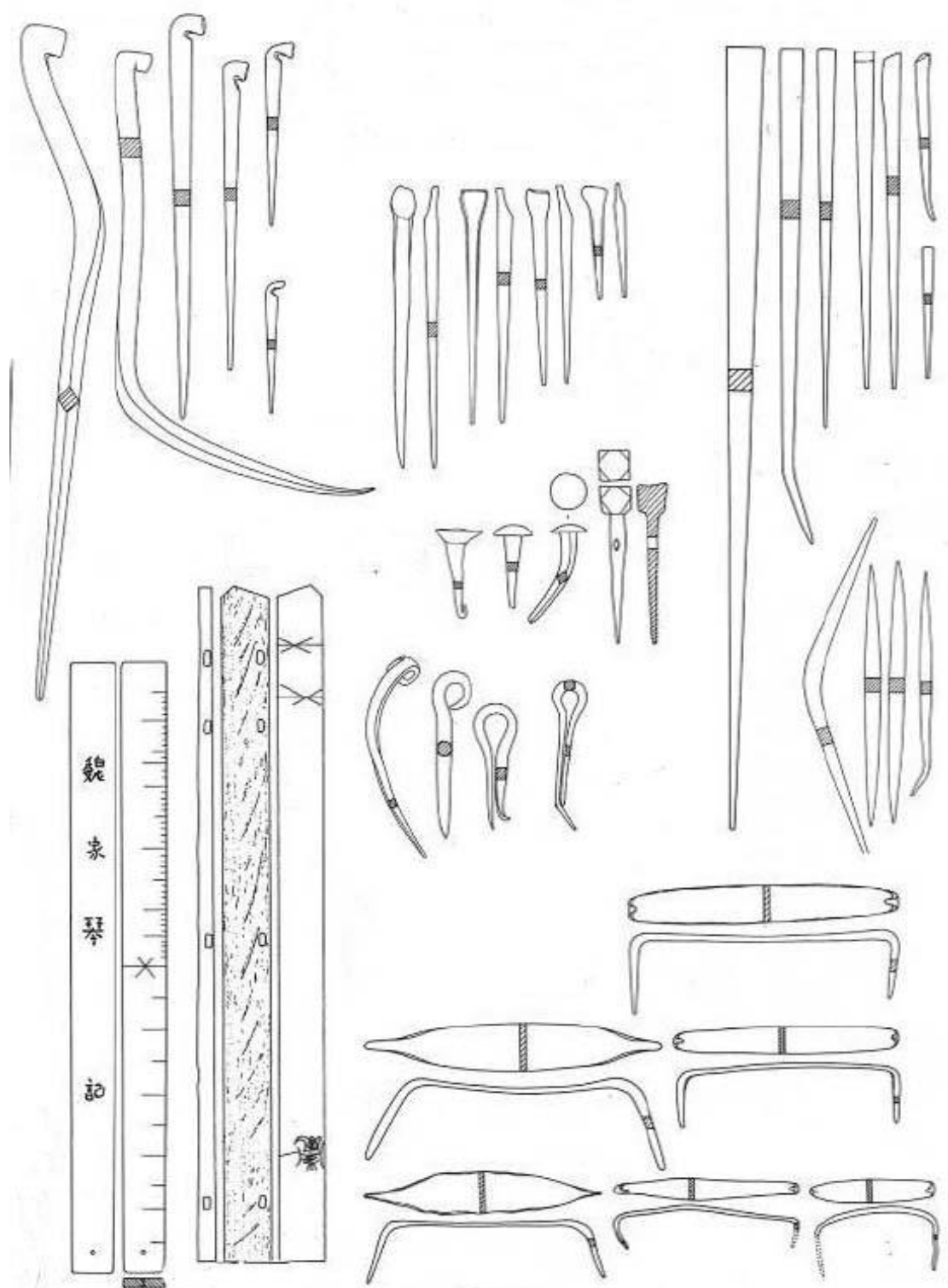


Fig. 2. Shipyard nails recovered from excavations at Baochuanchang shipyard, Nanjing, 15th to 17th centuries.
PAN & JIANGZAO 2017, 228-230. Compiled PAN 2018, 160

PREFACE

Do not speak to me of the difficulties.

The difficulties speak for themselves

Musée de Débarquement, Arromanches. 2016

This thesis, with its multidisciplinary approach and background research of unusually wide scope which covers a period of some 2600 years or so of nail activity, demands something of a “road-map” in order for the reader to stay connected, and hence this preface. The thesis has been cut back from an original wider study which had included screws and fixings and is now limited to nails used in buildings or in construction.

The thrust of the research has been to develop a practical means of dating buildings, their extensions, and their repairs, from their nail spectra. The resulting method of dating is of direct use to building historians, archaeologists, heritage officers, and to researchers generally. Because of the exceptionally long time taken for the research the method has already been used by me, with some success, in the dating of repairs to various buildings in Britain and in Australia. I have also been teaching elements of the dating system, as applicable to Australia, to heritage officers in Adelaide, South Australia, and at annual conservation courses run at the World Heritage sites of Woolmers and Brickenden in Tasmania.

Although the main thrust of the research is towards buildings it has been necessary to extend the boundaries in some circumstances to include nails of other sorts, since the technology behind nail making is eminently transferrable.

The research has been predicated by the need to identify and seek out datable changes by uncovering identifiable changes in nail technology or types. These changes can then be exploited as the core of the dating method. In principle, changes are not limited by any particular dates in history and so the choice of the core period, 1680 to 1890, is open to challenge. Certain logic dictates an alternative starting date of 1790, which saw the first industrialized nail patents issued on both sides of the Atlantic. Another logical choice for the end of the period would be 1914, the start of WWI, which initiated multitudes of changes in fixings generally. Likewise, there were at least two important events in nail technology of circa 1480 and the advent of slitting in 1576, which will need to be discussed, even though they lie outside the chosen date parameters. Albeit, the date of 1680 is selected as it represents an era of changes in building design across Europe caused, in part, by the disastrous Great Fire of London in 1666¹, and by the promulgation of an edict by Louis XIV² following a series of conflagrations in France.³ The date of 1890 has been selected since it neatly includes the first steel wire nails and, inter-alia, the effective demise of the American cut-nail industry. It saw the first attempts to cope with the higher strength material by modifying earlier machines. Each variation of change left clear dating possibilities on the nail morphology.

In order to detect changes it was necessary to spend some years in finding datable nails over a wide area of countries and of time, and then spend effort in careful cleaning, such that fabrication techniques could be seen and recorded, and so that patterns of normal use could be established.

¹ JARDINE 2002, 155, 160, 239, 269

² Bibliothèque Nationale de France. F-5009(20), ordonnance du 18 août 1667.

³ LE LOUP 2004, 119- 123

The research has been carried out in an empirical, opportunistic, and pragmatic fashion, - seizing windows of opportunity as they arose, obtaining access to ruined buildings, visiting museum archives, and exchanging information and samples with my conservation colleagues. It was known at the beginning that a long process would be involved, and research is now in its sixteenth year. This was preceded by some 30 years of my observing alterations to buildings in my capacity as a structural engineer.

The process comprised:

- Observing changes in nail types or usage against a background of contemporary nail use.
- Identifying change as they occurred and noting their historical contexts.
- Arriving, where possible, at definable dates.
- Identifying false information and false facts embedded in the accepted literature in order to correct the historical record.
- Identifying specialized terms and names, often in several languages.

The penultimate point has been particularly time consuming and the plethora of false leads and false accepted wisdom will be explained in the text later. Unusual terms will be explained in a glossary.

With respect to historic and geographical limits, it has been necessary to look further back to antiquity in order to build a fuller picture to answer questions as they arose during the research. These questions are sidelines to the main thrust of the research and so they are removed from the main text. They are sufficiently important to appear in separate appendices. Similarly, items such as a listing of sources, and the western world's links with the Roman past, have also been placed to the rear of the main text.

An overall picture of the research findings is:

- World nail technology consists of only two types; Western tradition, arising from our Celtic past and defined by Roman imposed order, and an Eastern school. This separate Eastern tradition almost certainly emanated from Chinese Imperial centralization. Each tradition has left fabrication differences on the nail types produced which are easily identifiable.⁴
- During the study period three major nail making industries dominated the western world; the British by colonial expansion, the Liege industry embedded as a nub in the European heartland, and then the American cut nail industry which took off soon after 1828, but which influenced world nail distribution from around 1860 or so.⁵
- Nail genres consist of essentially three subsets or groups;
 - (a) Those from professional nail makers conforming to standard patterns of a particular time. A medieval vogue for fancy visible nail heads used in locks, doors, and chests, never fully died out.
 - (b) Special fittings, some having the appearance of nails but made outside of the nail industry by other trades. These have been typified '*clou de ferronnier*' by Duhamel du Monceau.
 - (c) Lastly, votive and apotropaic nails, which appear only in the Western world. These disappear from the historical record after the fall of Rome but continue to appear on a random basis during the Middle Ages. For these the reader is referred to the author's paper given at Cambridge Construction History Society conference in April of 2019.⁶

⁴ PAN 2018, Chapter 5. 'Tools', plate 5.1. Items N1-N2

⁵ LOVEDAY 1983, 101-128

⁶ HOW 2019, 213-224

The problem of arriving at an appropriate nomenclature has been addressed by the research over a period of many years. The methods used in nail making technology have been slowly uncovered by examining source documents in English, French, and German, and by fortuitous contacts with my colleagues in Britain, Belgium, France, Germany, Denmark, Sweden, and Latvia. This has enabled a collection of the main nail types to be compiled which has included revealing some national variations along the way. A catalogue of the different types of wrought nails addresses the deficiencies of earlier works by relating photographs of historic samples to the sometimes confusing and inadequate sketches.

The data collected has been used to build a master chart of types and identifiable technological changes to arrive at a basic timeline of entries. The same data is synthesized to produce charts for each zone within a typical building covering the period 1680 to 1890. Certain nails, which changed often as new and cheaper techniques emerged, have been selected out as valuable 'indicator nails', thus simplifying the tasks of identification during the investigative process.

The conclusions reached fall into two categories:

1. Celtic forged iron nails dominated Pre-Roman Europe, but an enforced Roman discipline set patterns for forged nails during the medieval and pre-modern era. Some Roman nail typologies still influence nail designs to this day.
2. The main conclusion is that the method proposed produces close dating results, accurate to within a decade from 1790 onwards. However, certain earlier events provide clues to establishing dates during the period 1680 – 1790.

PRÉFACE - française

Cette thèse, avec son approche multidisciplinaire et ses recherches de fond d'une portée exceptionnellement large qui couvre une période d'environ 2600 ans d'activité des clous, exige une « feuille de route » pour que le lecteur reste connecté et donc cette préface. La thèse émane d'une étude exhaustive réalisée par l'auteur incluant également d'autres systèmes de fixations métalliques, tels que la visserie.

L'objectif poursuivi par ce travail de recherche est de proposer un moyen pratique et complémentaire pour la datation des bâtiments historiques par leur spectra des clous, souvent transformés au cours du temps, en utilisant l'examen typologique des clous d'assemblage. Par ailleurs, cette thèse se base sur l'expérience de l'auteur dans la datation des bâtiments historiques en Angleterre et en Australie ainsi que sur des cours de datation dispensés aux spécialistes du patrimoine à Adélaïde (état de l'Australie du Sud), ainsi que sur les sites du patrimoine mondial de Woolmers et Brickenden en Tasmanie. En tant que telle, la méthode de datation proposée souhaite apporter un éclairage historique complémentaire pour la compréhension du bâti ancien, valorisable tant par les historiens de la construction, les archéologues, les responsables du patrimoine et les chercheurs.

Bien que l'essentiel de la recherche porte sur la construction des bâtiments, il a été nécessaire d'étendre les limites de l'étude à d'autres applications constructives afin, dans certains cas, d'inclure des clous d'autres types, étant donné que la technologie de fabrication de clous est éminemment transférable d'une typologie constructive à une autre.

La thèse s'intéresse à l'étude des transformations datables du bâti à l'aide de l'identification des technologies employées pour le façonnage des clous et des typologies qui en résultent. La méthode de

datation s'appuie sur l'étude d'un corpus de bâtiments anciens ayant subi des transformations successives.

En principe, les modifications ne sont pas limitées par des dates particulières dans l'histoire et donc le choix de la période de base, de 1680 à 1890, est en quelque sorte arbitraire. Une certaine logique dicterait une solution alternative en commençant l'étude en 1790. C'est en effet à cette date que l'on voit apparaître les premiers brevets pour la fabrication des clous industrialisés émis sur les deux côtés de l'Atlantique. Un autre choix logique serait de fixer la fin de la période étudiée à 1914, le début de la première guerre mondiale puisqu'on sait qu'elle a initié une multitude de changements dans les systèmes de fixation métalliques en général. Par ailleurs, il y a eu au moins deux événements importants dans l'évolution technologique de la production des clous vers 1480 et en 1576 avec l'avènement de fendage. Ces deux progrès techniques seront discutés dans la thèse, même s'ils sont en dehors de la période de référence choisie. Certes, la date de 1680 est sélectionnée car elle représente une époque de changements dans la conception des bâtiments à travers l'Europe causée, en partie, par le désastreux grand incendie de Londres en 1666¹, et par la promulgation d'un édit de Louis XIV², suite à d'une série d'incendies en France³. La date de 1890 a été choisie car elle englobe l'apparition des premiers clous de fil d'acier et également la disparition, inter-alia, de l'industrie américaine des clous coupés. C'est également à partir de cette date que les premières tentatives sont apparues pour fabriquer des produits plus résistants, ce qui a eu également une répercussion sur le matériel de production.

Afin de dater un édifice à l'aide des clous employés, plusieurs années ont été nécessaires pour préalablement collecter et étudier des clous datés de façon absolue sur base de l'examen de documents historiques, des marques laissées par les différentes techniques de façonnage, et de l'utilisation et la fonction du clou.

La recherche a été effectuée de façon empirique mais pragmatique en explorant un domaine encore très méconnu. Cela a nécessité d'accéder à des ruines ou à des bâtiments anciens, souvent au gré des opportunités, la consultation d'archives conservées dans des musées ainsi que de nombreux échanges d'informations et d'échantillons avec des collègues impliqués dans le domaine de la conservation du patrimoine. Nous savions dès le début que le processus serait long et compliqué et la recherche est maintenant dans sa seizième année. Cela a été précédé par une trentaine d'années d'expérience en tant qu'ingénieur des structures ce qui m'a permis d'acquérir une expérience dans le domaine de l'examen et de la conservation du bâti.

Le processus suivi pour la collecte et pour l'identification des informations de la base de données est le suivant:

- Observer des changements dans la typologie ou dans l'utilisation des différents types de clous anciens comparant les résultats avec ceux des clous contemporains.
- Identifier les changements observables en le liant à sa contexte historique.
- Arriver quand c'est possible, à dater les clous sans équivoque.
- A partir d'une analyse bibliographique, Identifier les fausses informations et les faits erronés intégrés dans la littérature afin de corriger le dossier historique.
- Identifier des termes et noms spécialisés, souvent en plusieurs langues.

¹ JARDINE 2002, 155, 160, 239, 269

² LE DANTEC 2019, 316.

³ LE LOUP 2004, 119-123.

L'avant-dernier point a été une tâche très longue et la redondance de fausses pistes sera expliquée. Enfin, mentionnons que le lecteur trouvera à la fin du travail, un glossaire expliquant les termes inhabituels utilisés.

En ce qui concerne les limites historiques et géographiques, suite aux questions soulevées pendant la recherche, il a été nécessaire d'étendre la période étudiée à l'Antiquité pour broser un tableau plus complet et pour répondre à des questions soulevées lors de la recherche.

Ces questions restent néanmoins secondaires par rapport à la pointe de la recherche, raison pour laquelle cette partie est reprise en annexe du travail. De même, des éléments comme une liste de sources et des liens au monde occidental avec le passé romain, ont également été placés à la fin du texte principal.

L'idée globale des résultats de recherche peut se résumer ainsi :

- Les technologies cloutières mondiales ne comprennent que deux types : La tradition occidentale, découlant de notre passé celtique et définie par l'ordre imposé romain ; et une école orientale. Cette tradition orientale séparée résulte presque certainement de la centralisation impériale chinoise. Chaque tradition a laissé des différences de fabrication sur les types de clous produits qui sont facilement reconnaissables⁴.
- Trois grandes industries cloutières dominaient le monde occidental ; les Britanniques par l'expansion coloniale, l'industrie de Liège intégrée comme un nœud dans le cœur de l'Europe, et l'industrie des clous coupés de l'Amérique qui a démarré un peu après 1828 et qui a influencé la distribution mondiale des clous vers 1860⁵.
- Les genres des clous se composent essentiellement de trois sous-ensembles ou groupes : (a) Ceux des fabricants professionnels des clous se conformant aux modèles standards d'un temps particulier. Une vogue médiévale pour les têtes des clous visibles fantaisie utilisé dans les serrures, les portes et les coffres, ne s'est jamais complètement éteint.
 - (b) Les clous spécifiques émanant des autres corps de métier et qui ont été qualifiés comme « clous de ferronnier » par Duhamel du Monceau. Ceux-ci incluent les clous forgés individuellement.
 - (c) Citons également les clous votifs et apotropaïques qui sont essentiellement apparus dans le monde dans le monde occidental. Ils ont tendance à disparaître après la chute de Rome mais se maintiennent ponctuellement au Moyen-Age. En ce sujet, on se référera au document de l'auteur, prononcé lors du Congrès de Cambridge Construction History Society en avril 2019⁶.

La difficulté d'arriver à une nomenclature appropriée a été abordée par la recherche sur une période de plusieurs années, en identifiant les différents types de clous dans leurs contextes géographiques, et historique. Les techniques utilisées dans la fabrication des clous ont été découvertes progressivement en consultant des documents anglais, français et allemand, et en échangeant avec mes collègues en Grande-Bretagne, Belgique, France, Allemagne, Danemark, Suède, et la Lettonie. Cela a permis, entre autres, la compilation d'un catalogue des typologies des clous, y compris certaines variations nationales. Le catalogue met en évidence certaines erreurs antérieures en rattachant inadéquatement des photographies d'échantillons historiques à des croquis.

⁴ PAN 2018, Chapter 5. 'Tools', plate 5.1. Items N1-N2.

⁵ LOVEDAY 1983, 101-128.

⁶ HOW 2019, 213-224.

Les données recueillies ont été utilisées pour construire une vue d'ensemble chronologique des types et des changements technologiques identifiables. Les mêmes données ont été synthétisées pour produire des graphiques pour chaque zone en utilisant des bâtiments représentatifs construits entre 1680 à 1890. Certains types de clous qui peuvent par ailleurs régulièrement changer d'aspect avec l'apparition de nouvelles techniques moins chères sont sélectionnés comme « clous indicateurs » afin de simplifier la tâche d'identification lors du processus d'enquête. Les conclusions sont classées en deux catégories :

1. Les clous en fer forgé celtiques ont dominé l'Europe préromaine, mais la discipline forcée romaine a créé un modèle pour les clous forgés. Cette influence a perduré pendant l'ère médiévale et prémoderne et certaines typologies de clous romains influencent encore le dessin des clous fabriqués aujourd'hui.
2. La principale conclusion est que la méthode proposée produit de très bons résultats de datation, précis à une décennie près, à partir de 1790. Toutefois, certains résultats semblent également fournir des indices pour l'établissement d'une chronologie au cours de la période 1680-1790

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THREE DETERMINENT EVENTS:

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Image after BAKLANOV
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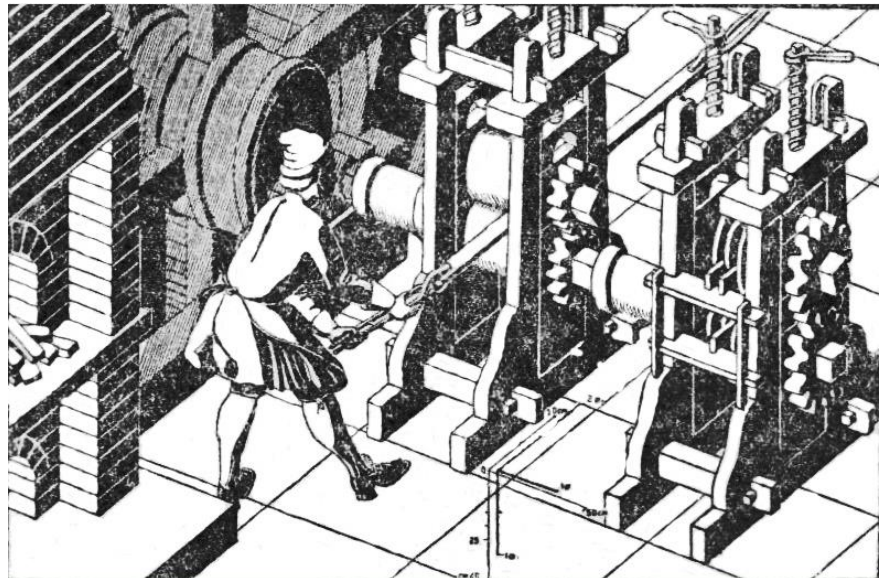


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INTRODUCTION

Here follows an exact Account of such Nails as are used in Building, which I have obtained at great Pains and Expence, and therefore it may be depended upon, which nothing of this Kind ever published can be.

William Salmon. 1738

0.1 QUESTIONS POSED BY THE RESEARCH

The aims and intentions of the study set out to provide answers to two main questions:

- To what extent can changes in nails help in the dating of buildings?
- What are the universal, historical, aspects of nail usage through time?

The first presents a hypothesis that identifying changes in nail use in heritage buildings, or in any particular part, can within limits, provide significant help in dating of the individual component parts. The work proceeds to identify these limits, and then further defines degrees of accuracy within the designated period 1680-1890. Although the research has been primarily aimed at Australia and Britain it has been necessary to seek out French and German texts in order to build a picture of what was happening across Europe at any particular time. This has revealed the rather obvious fact that changes on a large scale take time to travel. This does not equate to simply distance, however, but more to frequency of movements. For example, adoption of certain British nail types in Australia took say two years, but the Americans were aware of British developments within a few months, (and vice-versa). Much the same occurred between the southern Low Countries and England due to close and frequent contact and the traditional reliance of England on 'Belgian' technology.

The second issue springs from the first and is needed to give logical context to the pattern of finds obtained from all sources, thus providing essential background or 'baselines' against which changes can be identified. It attempts to fill in blanks left by pioneer authors on nail history such as Charles Frémont⁷ and Henry Mercer⁸ and it provides the first historical overview undertaken since Fremont's work, *Le Clou*. It also investigates a global image of nail use, which, although alluded to by both of these gentlemen, has never been attempted before. It fills many of the omissions in our knowledge of nails in construction history; knowledge generally neglected in heritage writings which tend to be over simplified, skimpy in detail, and often defective in reasoning. It attempts to provide greater clarity concerning nail idiosyncrasies and to correct various errors, by using background technology and historical events to arrive at a workable metaphor of building nails on a world scale.

0.2 AN ANALYSIS OF THE CURRENT STATE OF THE ART

0.2.1 Progressing knowledge of nail technology worldwide

Both of the above aspects of the work comprise worthwhile valuable extensions to world knowledge. Equally important (in the eyes of the author) has been de-bunking mythologies of entrenched false facts which have often skewed the argument away from rational analysis. Instead, the research places the study of nails into both scientific and historic categories using the author's engineering training, his many years as a heritage advisor, and his expertise in timber framing. It

⁷ FREMONT 1912

⁸ MERCER 2000

uses these assets in a fresh multidisciplinary approach to link historical and scientific analysis to arrive at consistent logical conclusions, at the cost of years of tedious collection of artefacts, site inspection, and recording. The lessons learnt are applicable, with some local variations, to the study of nail dating anywhere in the Western world, offering hugely beneficial prospects to building analysis and dating.

0.2.2 A positive advance

Heritage officers, and those working in the construction history fields, are aware of the limitations imposed by using methods of dating from secondary artefacts⁹. Even when sound documentary evidences exist concerning the original construction of a building, there are always the niggling aspects of repairs, alterations, and extensions, which can escape conventional analysis. Thus, any methods which add to the arsenal of analysis have been welcomed by English Heritage¹⁰, and methods having the potential to present more precise dates are significant advances to current means.

Current literature presents a blank as to how world technology divides across the globe with respect to underlying nail making technologies. Although it is not practical for this study to probe deeply into methods used in the Eastern School of nail making, the thesis arrives at some preliminary conclusions and thereby paves the way for further studies.

0.2.3 Evaluating existing texts and filling blanks

A fuller analysis of source documents will follow in the next chapter (Chapter 1), but readers need to be aware of the dearth of useful information clearly identifying wrought iron nail types. This is essentially limited to one major source document consisting of an anonymous illustrated list of nails drafted in 1812 at the Office of Ordnance in London for the Royal Engineers' garrison in Halifax, Nova Scotia, now a province of Canada. Often overlooked is the inclusion in this list of some early British cut nails. The usual reference source consists of a descriptive paper by the late Susan Bugey who first presented these drawings¹¹. Her paper was then used by the Sydney archaeological student Robert Varman in his PhD thesis of 1993, which concentrated on source information written in English¹². The thesis will draw on the extensive works of the French encyclopaedists, and on Salzman's magisterial work on medieval building down to 1540¹³. It will also draw on German sources, particularly Christoff (sic.) Weigel, as the only source found to date on the fore-runners to the slitting mill, the *Reckhammer* and *Zeinhammer*¹⁴.

0.3 CONFRONTING THE METHODOLOGY

0.3.1 The approach taken and the methods used

From the beginning of the study it was clear that significant review would be required from as much data as could be obtained from both written sources in English, French, and in German, as well as from actual field samples. It was also clear that a significant amount of revision would be necessary in order to dispel some entrenched myths.

⁹ EDWARDS & WELLS 1993, 1: see also MERCER 1923, 536-549

¹⁰ WOOD & HENRY 2013, 606-624

¹¹ BUGGEY 1976, 89-118. The document was found by the author's colleague Richard Bryrne

¹² VARMAN 1993, 186-194

¹³ SALZMAN 1952, 286-317: see also 355-602

¹⁴ WEIGEL 1698, 387-389

Opportunities to obtain samples came from travel and from fortuitous contacts in Australia, Britain, Germany, Denmark, Latvia, and France. Much direct field work was done in the Western District of Victoria which clearly showed that two systems of nails, British and American, came into common use by 1870. Establishing contacts in other states; namely South Australia and in New South Wales, took some years and such data showed minor variations between states. Some direct field work was done in Tasmania, in Britain, Latvia, and in Provence. Recent contacts through the Construction History Society has enabled access to some Swedish source texts and several rare samples have been obtained through Swedish colleagues.

Samples collected in the field were tagged according to the zone of the building in which they were found and the building date noted. The methods by which the buildings were dated is discussed in Appendix I. In most cases, the buildings, or their remains, were photographed from outside and within to aid future reference. Nail samples recovered were cleaned to allow forging marks to be identified. In recent years a modified practice has been adhered to of retaining at least some samples in a semi-cleaned condition to assist analysis of use and insertion practice. (See chapter 2, section 2.3.2. Diagnostics). Likewise, distortions or damage to the nail samples are also being retained to assist interpretation of design deficiencies. Similarly, there have been several modifications to the cleaning process to circumvent the destructive effects of acid and colour changes.

In the early years it was necessary to obtain as many samples as possible from a wide range of buildings over a large area, covering (in Victoria) the period of settlement, circa 1835 up to WWI. This exhaustive work enabled a picture of the normal range of nails found in most zones of a building in the decades from the 1830s onwards. Having established this background 'base-line' it was possible to detect changes in types with time.

Museum sources have, in the main, yielded only minimal information but the Salisbury and South Wiltshire Museum provided access to their archived 'Naish' collection of unused wrought nails which has been in the Museum's possession since 1941. A photographic record of the collection was made which has helped in matching nomenclature to wrought nail types found in the field. An even bigger collection of wrought nails is kept in the archives of the *Musées Royaux D' Art et Histoire* in Brussels, mainly collected prior to or during WWI, to which the Curator, Dr Sophie Balace provided access, to the author and to Dr Phillipe Sosnowska, for photographic and classification purposes, a task which is presently incomplete. Three other museums stand out; the Limes Museum at Aalen, Württemberg, the Arles Regional Museum, which graciously provided access to their Roman archives,¹⁵ and the museum at St. Germain-en-Laye whose displays include both Celtic and Gallo-Roman nail types. A very useful small collection forms part of the Historic Royal Palaces archives at Hampton Court Palace, and access was graciously provided for photographic purposes of Tudor and Queen Anne period nail specimens. Inspections have been made in Sri Lanka probing the extent of possible Roman influences which dominate the western school of nail-making via the National Museum in Colombo and the World Heritage site museum at Polonnaruwa. In the interest of simplicity discussions concerning the extent of the western school of nail-making have been kept to the appendices.

A large number of papers and articles have been written by the author as a way of introducing the subject to a wider audience and most have been accepted in a peer reviewed system. A disc of these works is provided for reference purposes at the end of this thesis. This includes some unpublished studies into framing involving translations from French and German which help

¹⁵ Courtesy the director Dr Claude Sintès and his co-curator M. Charron.

provide a guide to how nails were used in *Fachwerk* and in *colombage* in their various sub-zones. These studies help build the relationship of expected nail finds within timber framing which appears to have not been written of before.

0.3.2 The matrix hypothesis

Putting together the emerging information enabled an outline to be constructed of a principal diagram, (herein termed the 'matrix'), which has been modified as further information came to hand. The matrix vertical scale descends through time from a nominal date of circa 1470 down to 1914. The horizontal grid of the matrix comprises five zones pertinent to nail distribution in most buildings.

Critical to interpretation of the matrix diagram are three major determinant events: the appearance of the 'Zeinhammer' circa 1485, Fig. 4, the advent of slitting (*fendage*) in 1576, Fig. 5¹⁶, and then the use of the 'Oliver' within the nail making industry, Fig. 6. The interval between 1485 and around 1600, marks a grey zone in the watershed between nails made from bar iron and those shaped from cut rods of appropriate size, and this time-band is termed the 'medieval divide'.

The Oliver went through several adaptive phases but field evidence suggests it saw an advent in the nail industry around 1680¹⁷, used to provide flattened lining nails. It was then adapted to make a heading device circa 1820, followed by a 'stiddy' (vertical mould) version, circa 1872¹⁸, in which both point and head were struck by a single blow of the Oliver hammer.

Machine made nail patents appeared on both sides of the Atlantic in 1790 and continued in increasing numbers thereafter.

The matrix diagram appears in the next chapter, together with further explanations.

0.3.3 A need for a representative nomenclature

The problem of identification has been a constraint on previous nail studies, in part due to an inability to provide names for wrought iron nail types. Salzman's magnum opus demonstrates the large number of terms used for wrought nails in common use during medieval times.¹⁹ Reading about these one is aware of the sometimes strictly local (or even contrived) terminology, which followed from the medieval use of three languages: Latin, Norman French, and Old English²⁰, which at that time still contained remnants of Anglo-Saxon, Norse, or Celtic language.

This begs the question of when did terminology begin to standardise with respect to nails? There is no definite answer to this but it is clear from Chaucer's works, and the first printed books, that the Tudor period effectively commences a period of centralised stability which affected all trades, all new designs, and some degree of stabilisation of English language and spelling.

To overcome this naming dilemma and having regard to the availability of data, the post-Restoration period (after 1660) appeared to present the best solution to nomenclature problems. The source chart presented in chapter 4, Table 4.2, clarifies the problem, but from a practical standpoint there are only two writers who fit into the period: Moxon, and Neve. Fortunately Neve, in 1703, provides the next best source of information to the Ordnance Office tender document of

¹⁶ LAMBARDE 1576, 453

¹⁷ Samples found by Mr Richard Jones at the 1680 Wheatsheaf Inn at Brecon Powys.

¹⁸ BARRAS 1998, 15

¹⁹ SALZMAN 1992, 286-317

²⁰ Mc CRUM 1986, 66-88; CRYSTAL 2004, 121-139

1812. Some names are missing but occur in later documents such as Salmon.²¹ Thus the terminology used here is an amalgamation of sources and is open to criticism. It is nevertheless the most complete pictorial review of English wrought iron nail types made so far.

The nomenclature problem extends beyond just nail names into nail grades, which might alternatively be described as thicknesses or strengths. At this point there is some cross-relationship with the descriptions used in the Lowlands, in Germany, and in France, and these will be explained later. Considering the multitude of different names coming from the medieval period, a convergence of types across Britain and Europe becomes evident which is difficult to explain, although the ever present traditional links between England and 'Belgium' must have played a part. Some aspects of this cross-fertilisation of ideas and techniques appear in chapter 2.

0.3.4 Erroneous information and missing elements

At the start of this study six main 'factoids' dominated the accepted literature. Most of these have been dealt with by the author in a series of publications which will be explained further. Other minor points will be further amplified as is necessary and referred to in the text.

²¹ SALMON 1738, 65-68

INTRODUCTION - française

0.1 Problématique

Cette recherche a pour objectif de répondre deux questions principales :

- Dans quelle mesure l'évolution de l'aspect des clous peut-elle contribuer à la datation des bâtiments ?
- Quels sont les paramètres universels, dans l'espace et dans le temps, de l'usage des clous ?

La première question présente une hypothèse selon laquelle l'identification des changements dans l'utilisation des clous dans les bâtiments patrimoniaux, ou dans une partie particulière, peut, dans les limites, fournir une aide significative dans la datation des différentes composantes. Les travaux se poursuivent pour identifier ces limites, puis définissent davantage les degrés d'exactitude au cours de la période 1680-1890. Bien que la recherche ait été principalement destinée à l'Australie et à la Grande-Bretagne, il a été nécessaire de rechercher des textes français et allemands afin de se faire une idée de ce qui se passait à travers l'Europe à un moment donné. Cela a révélé le fait assez évident que les changements à grande échelle mettent du temps à se diffuser. Cela n'équivaut pas à une simple distance, mais plutôt à la fréquence des mouvements. Par exemple, l'adoption de certains types des clous britanniques en Australie a pris deux ans, tandis que les Américains étaient au courant des développements britanniques en quelques mois (et vice-versa). Il en a été de même entre les Pays-Bas du sud et l'Angleterre en raison de contacts étroits et fréquents et de la dépendance traditionnelle de l'Angleterre à l'égard de la technologie « belge ».

La deuxième question découle de la première : elle est nécessaire pour donner un contexte logique au modèle de découvertes obtenues de toutes les sources, fournissant ainsi un contexte essentiel ou des « lignes de base » par rapport auxquelles des changements peuvent être identifiés. L'objectif est de remplir les blancs laissés par des auteurs pionniers sur l'histoire des clous tels que Charles Frémont⁶ et Henry Mercer⁷ et d'établir un premier bilan historique depuis les travaux de Frémont dans *Le clou*. Il s'agit aussi d'obtenir une vision globale de l'utilisation des clous, qui, bien que évoquée par ces deux chercheurs, n'a jamais été tentée auparavant. Ainsi peut-on combler de nombreuses lacunes quant à la place des clous dans l'histoire de la construction ; ces connaissances sont généralement négligées dans les écrits patrimoniaux qui ont tendance à être trop simplifiés et limités à quelques détails, elles sont souvent défectueuses dans le raisonnement. Notre approche vise à clarifier les particularités des clous et de corriger diverses erreurs, en utilisant la technologie de fond et les événements historiques pour arriver à une métaphore réalisable de la construction de clous à l'échelle mondiale.

0.2 UNE ANALYSE DE L'ÉTAT ACTUEL DE L'ART

0.2.1 Améliorer la connaissance de la scène mondiale des clous

Les deux aspects annoncés ci-dessus comprennent des extensions précieuses à la connaissance du monde. Il était tout aussi important (aux yeux de l'auteur) de réfuter d'erreurs bien établies qui ont souvent faussé les raisonnements loin de l'analyse rationnelle. Au lieu de cela, notre recherche aborde l'étude des clous de manière scientifique et historique en utilisant la formation d'ingénieur

6 FREMONT 1912

7 MERCER 2000

de l'auteur, ses nombreuses années en tant que conseiller en patrimoine, et son expertise dans les structures en bois. Il utilise ces atouts dans une nouvelle approche multidisciplinaire pour lier l'analyse historique et scientifique pour arriver à des conclusions logiques cohérentes, au prix d'années de collecte fastidieuse d'artefacts, de visites de sites et d'enregistrement de nombreuses données. Les résultats s'appliquent, avec quelques variations locales, à l'étude de la datation des clous n'importe où dans le monde occidental, offrant des perspectives extrêmement bénéfiques à l'analyse de la construction et la datation.

0.2.2 Une avancée positive

Les agents du patrimoine, et ceux qui travaillent dans les domaines de l'histoire de la construction, sont conscients des limites imposées par l'utilisation de méthodes de datation à partir d'artefacts secondaires⁹. Même lorsqu'il existe des preuves documentaires solides concernant la construction originale d'un bâtiment, il y a toujours les aspects marginaux des réparations, des modifications et des extensions qui peuvent échapper à l'analyse traditionnelle. Ainsi, toutes les méthodes qui viennent s'ajouter aux moyens habituels d'analyse ont été bien accueillies par English Heritage¹⁰, et les méthodes ayant un pouvoir de datation plus précis sont des avancées significatives.

La littérature actuelle ne mentionne pas la variété technologique de la fabrication des clous à travers le monde. Bien qu'il ne soit pas pratique pour cette étude de sonder en profondeur les méthodes utilisées dans l'École de l'Est de la fabrication des clous, la thèse arrive à quelques conclusions préliminaires et ouvre ainsi la voie à d'autres études.

0.2.3 Évaluation des textes existants et comblement des manques

Une analyse plus complète des sources textuelles est proposée dans le chapitre suivant (Chapitre 1), mais le lecteur doit être averti de la rareté des données mentionnant clairement les types de clous en fer forgé. Il n'existe qu'une source importante fournie par une liste illustrée de clous rédigés en 1812 au Bureau des munitions à Londres pour la garnison des Royal Engineers à Halifax, en Nouvelle Ecosse, maintenant une province du Canada. Toutefois, il manque souvent dans cette liste certains des premiers clous coupés britanniques. La source de référence bibliographique habituelle est un article descriptif de Susan Bugey qui a présenté ces dessins pour la première fois.¹¹ Son article a ensuite été utilisé par un étudiant en archéologie de Sydney, Robert Varman, dans sa thèse de doctorat en 1993 ; il se concentrait sur des informations de source écrites en anglais¹². Notre thèse s'appuiera sur les œuvres françaises des encyclopédistes, et sur l'ouvrage magistral de Salzman sur le bâtiment médiéval avant 1540.¹³ Il s'appuiera également sur des sources allemandes, en particulier Christoff (sic) Weigel, comme la seule source trouvée à ce jour sur les précurseurs de l'usine de fendage, le *Reckhammer* et *Zeinhammer*.¹⁴

⁹ EDWARDS & WELLS 1993, 1: voir aussi MERCER 1923, 536-549

¹⁰ WOOD & HENRY 2013, 606-624

¹¹ BUGGEY 1976, 89-118. Le document était trouvé par un collègue Américain d'auteur, Richard Byrne

¹² VARMAN 1993, 186-194

¹³ SALZMAN 1952, 286-317: voir aussi 355-602

¹⁴ WEIGEL 1698, 387-389

0.3 METHODOLOGIE

0.3.1 L'approche adoptée et les méthodes utilisées

Dès le début de l'étude, il était clair qu'un examen important serait nécessaire à partir d'autant de données que possible à partir de sources écrites en anglais, en français et en allemand, ainsi que d'échantillons réels sur le terrain. Il était également clair qu'une révision importante serait nécessaire pour dissiper certaines idées reçues.

Les occasions d'obtenir des échantillons provenaient de voyages et de contacts fortuits en Australie, en Grande-Bretagne, en Allemagne, au Danemark, en Lettonie et en France. Beaucoup d'observations directes sur le terrain ont été faites dans le district occidental de Victoria qui a clairement montré que deux systèmes de clous, britannique et américain, sont entrés en usage commun en 1870. Établir des contacts dans d'autres États (à savoir Australie du Sud et Nouvelles Galles du Sud) a pris quelques années et ces données ont montré des variations mineures entre les États. Des travaux directs sur le terrain ont été effectués en Tasmanie, en Grande-Bretagne, en Lettonie et en France (Provence). Des contacts récents par l'intermédiaire de la *Construction History Society* ont permis d'accéder à certains textes de sources suédoises et plusieurs échantillons rares ont été obtenus par l'intermédiaire de collègues suédois.

Les échantillons prélevés sur le terrain ont été étiquetés en fonction de la zone du bâtiment dans laquelle ils ont été trouvés. Dans la plupart des cas, les bâtiments, ou ce qui en reste, ont été photographiés de l'extérieur et de l'intérieur pour faciliter le futur référencement. Les échantillons des clous récupérés ont été nettoyés suffisamment pour permettre d'identifier les marques de forgeage. Au cours des dernières années, une nouvelle méthode a été adoptée consistant à conserver au moins certains échantillons dans un état semi-nettoyé, où les restes de revêtements protecteurs et de débris révélateurs, comme la chaux ou le plomb, aident à l'interprétation de l'utilisation originale. (Voir le tableau chapitre 2). De même, des distorsions ou des dommages aux échantillons des clous sont également conservés car ceux-ci aident à interpréter l'utilisation ou ils peuvent être des indices de défauts de conception. De même, le processus de nettoyage a été modifié pour éviter les effets destructeurs de l'acide et la confusion créée par les changements de couleur causés par l'élimination de la rouille par électrolyse inverse.

Au cours des premières années, il a été nécessaire d'obtenir autant d'échantillons que possible à partir d'un large éventail de bâtiments sur une grande superficie, couvrant – à Victoria – la période de peuplement, de 1840 jusqu'à la Première Guerre mondiale. Ce travail exhaustif a permis d'imaginer la gamme normale de clous trouvés dans la plupart des zones d'un bâtiment dans les décennies à partir de 1840. Après avoir établi cette base de référence, il a été possible de détecter les changements dans les types avec le temps.

Les collections des musées n'ont, dans l'ensemble, fourni que peu d'informations, mais le *Salisbury and South Wiltshire Museum* nous a donné accès à leur fonds « Naish » de clous forgés inutilisés qui est en possession du Musée depuis 1941. Un enregistrement photographique de la collection a été réalisé, il nous a aidés à faire correspondre la nomenclature aux types des clous forgés trouvés dans la région. Une collection encore plus importante de clous forgés est conservée dans les collections des *Musées Royaux d'Art et d'Histoire* à Bruxelles, principalement réunie avant ou pendant la Première Guerre mondiale, auxquelles la conservatrice, le Dr Sophie Balace, nous a donné accès ainsi qu'au Dr Philippe Sosnowska pour un relevé photographique et des classifications, une tâche qui est actuellement inachevée. Trois autres musées doivent être mentionnés: le *Musée des Limes* à Aalen, Württemberg, le *Musée régional d'Arles*, qui nous a

gracieusement donné accès à ses collections romaines¹⁵, et le *Musée d'archéologie nationale* à Saint-Germain-en-Laye qui expose à la fois à la fois divers sortes de clous celtes et gallo-romains.

Une petite collection très utile fait partie des collections des Palais Royaux Historiques du Palais de Hampton Court, où l'accès nous a été gracieusement autorisé à des fins photographiques de spécimens des clous de l'époque des Tudor et de la Reine Anne. Des visites ont été effectuées au Sri Lanka pour sonder l'étendue des influences romaines possibles qui dominent l'école occidentale de fabrication des clous par l'intermédiaire du *Musée national* de Colombo et du *Musée du patrimoine mondial* à Polonnaruwa. Dans un but de simplification, les discussions sur l'étendue de l'école occidentale de fabrication des clous ont été reportées en annexe.

Un grand nombre d'ouvrages et d'articles ont été écrits par l'auteur afin de présenter le sujet à un public plus large et la plupart ont été validés par des comités de lecture. Toutes ces publications sont reproduites, à titre d'information, en complément de cette thèse. Cela comprend des études inédites, notamment des traductions de textes en français et en allemand qui aident à fournir un guide sur la façon dont les clous ont été utilisés de la *fachwerk* et dans le colombage dans leurs différentes régions. Ces études aident à prévoir la découverte de clous dans les charpentes en bois, ce qui ne semble pas avoir été étudié précédemment.

0.3.2 L'hypothèse de matrice

La mise en place de l'information émergente a permis de construire un schéma principal (appelé la « matrice »), qui a été modifié au fur et à mesure que d'autres informations sont venues à portée de main. L'ordonnée de la matrice descend à travers le temps d'une date nominale d'environ 1470 jusqu'en 1914. L'abscisse de la matrice comprend cinq zones pertinentes à la distribution des clous dans la plupart des bâtiments.

L'interprétation du diagramme de la matrice est essentielle à l'interprétation de trois événements déterminants majeurs : l'apparition du *Zeinhammer* vers 1485, Fig. 4, l'avènement de la machine à fendage en 1576, Fig. 5,¹⁶ puis l'utilisation de l'*Oliver* dans l'industrie de la fabrication des clous, Fig. 6. L'intervalle entre 1485 et vers 1600 marque une zone grise dans le passage des clous en fer à barres à ceux en forme de tiges fendues de taille appropriée, et cette période est appelée la « fracture médiévale ».

L'*Oliver* a traversé plusieurs phases d'adaptation, mais les preuves pour le terrain suggèrent qu'il a vu un avènement dans l'industrie des clous autour de 1680¹⁷. Il est utilisé pour fournir des clous de doublure aplatie. Il a ensuite été adapté vers 1820 pour faire les têtes à un dispositif de cap, suivie d'un *stiddy* (moule vertical) version, vers 1872¹⁸, dans laquelle la pointe et la tête ont été frappées par un seul coup du marteau Oliver.

Les brevets des clous fabriqués par machine sont apparus des deux côtés de l'Atlantique en 1790 et se sont poursuivis en nombre croissant par la suite.

Le diagramme de matrice apparaît dans le chapitre 2, (vide. 2.1.6), ainsi que d'autres explications.

¹⁵ Grace de le directeur Dr Claude Sintès et son co-curateur M. Charron.

¹⁶ LAMBARDE 1576, 453.

¹⁷ Exemplaires trouvés par Mr Richard Jones chez le 1680 Wheatsheaf Inn à Brecon Powys, Pays de Galles.

¹⁸ BARRAS 1998, 15.

0.3.3 La nécessité d'une nomenclature représentative

Le problème de l'identification a été une contrainte sur les études précédentes de clous, en partie due à une incapacité de fournir des noms pour les types des clous de fer forgé. L'ouvrage majeur de Salzman montre le grand nombre de termes utilisés pour les clous forgés d'usage courant à l'époque médiévale¹⁹. La lecture de ceux-ci nécessite la connaissance de la terminologie parfois strictement locale (ou même artificielle), qui a suivi de l'utilisation médiévale de trois langues : le latin, le Français normand, et l'ancien anglais, qui à cette époque contenait encore des restes d'anglo-saxon, de norrois ou de langue celtique.

Cela soulève la question de savoir quand la terminologie a-t-elle commencé à s'uniformiser en ce qui concerne les clous ? Il n'y a pas de réponse définitive à cela, mais il ressort clairement des ouvrages de Chaucer et des premiers livres imprimés, que la période Tudor commence effectivement une période de stabilité centralisée qui a affecté tous les métiers, tous les nouveaux dessins et une certaine stabilisation de la langue et l'orthographe anglais.

Pour surmonter ce dilemme de dénomination et compte tenu de la disponibilité des données, le vocabulaire utilisé pendant la période post-Restauration (1660) semblait présenter la meilleure solution aux problèmes de nomenclature. Le tableau source présenté dans le chapitre 4, Table 4.2, clarifie le problème, mais d'un point de vue pratique, il n'y a que deux auteurs qui s'inscrivent dans la période : Moxon, et Neve. Heureusement, Neve, en 1703, fournit la meilleure source d'information au document d'appel d'offres du Bureau des munitions de 1812. Certains noms sont manquants, mais se produisent dans les documents ultérieurs comme chez Salmon²¹. Ainsi, la terminologie utilisée ici est un amalgame de sources et est sujette à critique. Il est néanmoins l'examen graphique le plus complet des types anglais des clous en fer forgé fait jusqu'ici.

0.3.4 Informations erronées et éléments manquants

Au début de cette étude, six principales erreurs dominaient dans la bibliographie. La plupart d'entre elles ont été discutées par l'auteur dans une série de publications qui seront reprises plus en détail. D'autres points mineurs seront ponctuellement signalés et débattus dans le texte.

¹⁹ SALZMAN 1992, 286-317

²⁰ McCRUM 1986, 66-88: voir aussi CRYSTAL 2004, 121-139

²¹ SALMON 1738, 65-68

Chapter 1:

Nail Studies, the State of the Art

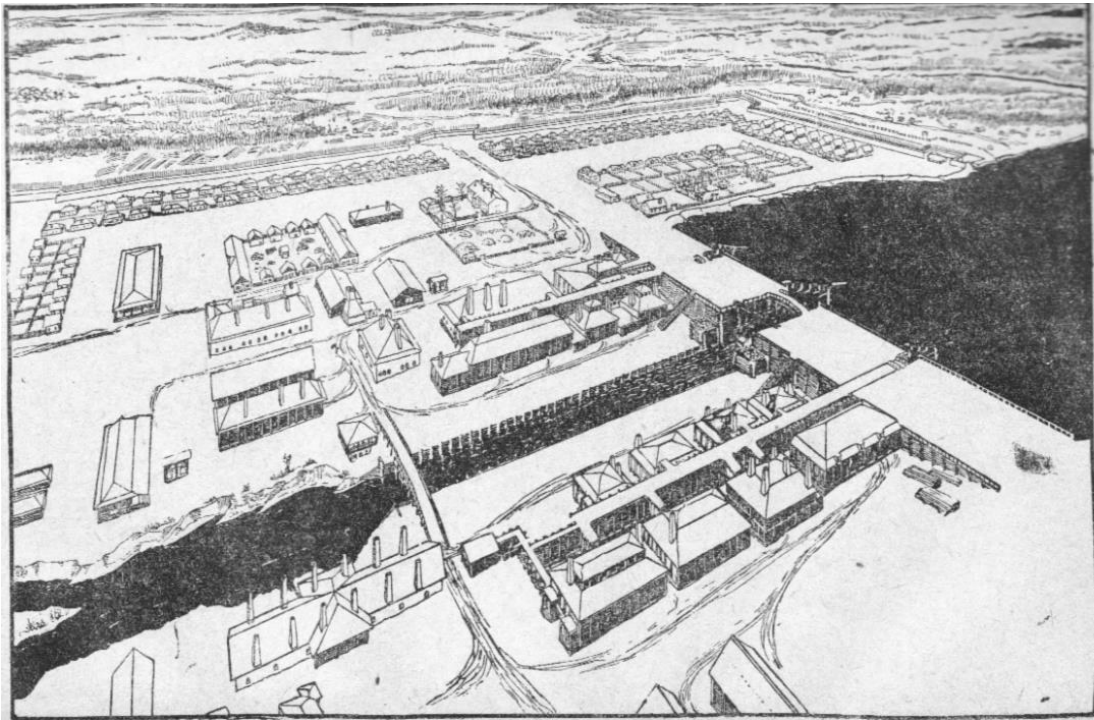


Fig. 7. State of the Art industrial complex, 1730 at Ekaterinburg. BAKLANOV 1935, 38

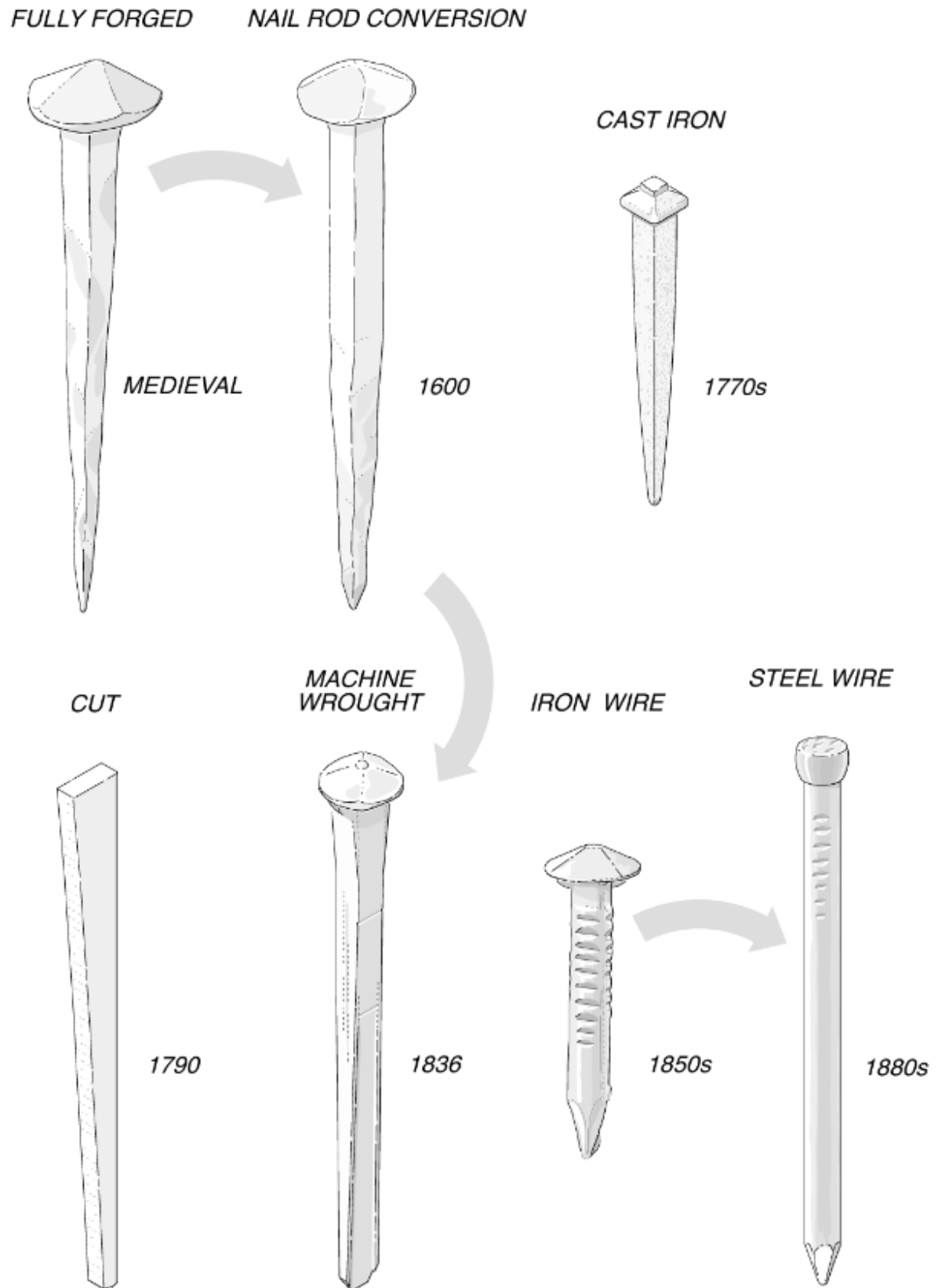


Fig. 8. The major changes in ferrous nail fabrication. Author/McCaig

CHAPTER 1: THE STATE OF THE ART

“Nail (Clou), a small artefact in gold, or silver, or iron, or copper, pointed at one end and headed on the other, of which the body is round or has faces, but which diminishes from head to point. The heads have large numbers of different forms according to the use to which the nail is destined. Iron nails are forged; the others are cast. The making of cast nails is nothing special as it is very common foundry work. We observe that there are two sorts: ordinary nails and pin-nails”.²²

OVERVIEW

This thesis draws its inspiration from the pioneering nail studies of Charles Frémont and Dr Henry Mercer, and treads in their footprints to take a long-term view of nail history. The author’s studies have looked back into antiquity to probe the question how nails began. However, in the interests of succinctness aspects such as these have been relegated to the appendices in order that the reader can concentrate on the main purpose of the thesis, which is to seek out identifiable changes to which dates can be assigned. The basic changes affecting the history of nail making are shown above, fig. 8, and the dominant processes relating to the field of construction concerns wrought iron nails, will be dealt with first below.

1.1 A CURRENT REVIEW

The author’s papers and publications since 2006 have to some extent acted as a spur on other researchers and have brought forth much support in the form of hard to obtain samples of nails and fittings, and coincidentally raised an enthusiasm for the subject of nail studies in a range of countries. (The author’s publications are set out as a separate section to the General Bibliography). This interaction has been acknowledged as a stimulus to the author’s colleagues in Belgium, the Baltic, UK, France, Australasia and America to make their own observations which they have passed on. There has been a significant joint advancement of nail studies coming from a range of disciplines since 2006 and these will be outlined below. The reader needs to be aware of erroneous but entrenched mythologies lurking in quite respectable publications. This thesis presents the current state of understandings of nail studies supported by detailed emerging evidence, with some unavoidable critiques.

In this latter regard it has been found that non-literary sources, mainly in the form of manuscript illustrations and actual samples provide a more accurate record of events rather than records written many years later.²³ Literary sources need to be treated with caution unless written by eye-witness observers writing at the times involved.

The sub-sections which follow provide a simplified historical overview of the development of metallic nails, since Roman times through to 1900, relevant to the study aims.

²² DIDEROT 1769, Vol III

²³ Over-reliance on patent information is one such fault: *Subsequent to (1790) not less than thirty or forty patents have been granted for making brads or nails, and some three or four of them have been successfully worked.* Holtzapffel 1847, 947-949

1.1.1 Objectives and ultimate aim

The aim of the research undertaken has been to build an eight step process:

- Examine the history of nail development with particular respect to wrought nails made from iron and steel from their beginnings.
- Build a global picture as a means of understanding the typologies of the requisite period. But a narrower tradition, that applying to Britain, Australia and New Zealand, is used as a setting for the changes affecting dating.
- Make a pictorial inventory of metallic nails used in construction, with respect to characteristics which undergo datable changes, concentrating on iron nails as being the most used, and identify the nuances of each. There is no complete inventory existing at the moment in print although the work done by the author for English Heritage has gone some way towards providing one²⁴.
- Match the inventory nails to historic descriptions to provide a nomenclature for wrought nails (in English). No such reference work exists at present and several names have been in doubt.
- Identify normal patterns of use within zones of a building and when the changes occur.
- Construct separate timeline of change for each type of nail selected.
- Construct timelines for building zones relating to 1680 to 1890 to provide a field guide.
- The seventh step deals will make brief comment about non-ferrous nails, noting the chronological entry point of those nails made of alternate metals.

The last four dot points are used to create a visual image of the nail matrix. Fig. 47. Timelines are required to encompass the entry point of each nail type and its effective exit date, and when switches to alternate types occur. Timelines can relate these changes wherever possible to changes in building types. However, regarding the first dot point the special peculiarities of nails need to be studied and understood in relation to their in-use applications, the historical background and technology, the stock material, and in some cases their visual effects.

1.1.2 Traditions and Geographical perspective

Three classes of building nails have been identified since Roman times. The boundary between one class and another is often blurred:

- Votive and magic nails. These formed a miniscule class like to no other, which played an important part in Greco-Roman beliefs. They do not directly concern this study, and as they have already been dealt with by the author,²⁵ they can be dispensed with except to note that they included the first use of decorative nail heads, whose influence continued into medieval times - a practice which never entirely died out.²⁶
- *Clous de Ferronnier*. These comprise a small finite group made by techniques adopted by smiths specialising in fine ironwork for fittings and fixings. Often appearing in prestige constructions they were also used in more mundane works such as in tying masonry to timber frames.²⁷
- Wrought (iron) nails made by nail-smiths. This is by far the largest group and comprise ordinary nails of mundane use which excludes the above groups. They were made by

²⁴ WOOD 2014, 605-614

²⁵ HOW 2019, 213-224

²⁶ LE DUC 1865, 'Clou' figs 2, 5, 7-10

²⁷ DU MONCEAU 1767, 43-49 PI IV

professional nailors to exacting standards in large numbers. The origins of the nail-smith trade almost certainly go back to Roman times, and during the middle ages the trade was regulated by its own guilds. Decorative nails form part of this group and they have some dating potential. They are not especially relevant to the period under consideration except in respect of establishing precedents for aesthetic and artistic effects on doors and a few other items. They will come up later in this thesis, but many of the effects have been dealt with by the author.²⁸ They were used to make a statement of opulence, often combined with a defensive function. They find curious applications further into the study period, such as coffin nails of gilded or coated cast iron.

These aspects will be touched on only briefly within the body of the thesis but will be discussed in Appendix I.

1.1.3 Wrought iron nail manufacture

Until the coming of gunpowder and the need for safe magazines, copper and bronze nails did not figure to any extent in buildings. They were restricted to naval and ornamental uses after 300AD or so. Non-ferrous supplies were devoted to alternate uses outside of construction until late in the study period, and until Australian non-ferrous sources were exploited.

Wrought iron nails can be divided into two broad traditions. The one we use in the Western world derives from Roman influence and Roman order, but almost certainly has its deep roots in Celtic iron working. These are marked by having a large part of the nail range forged using a heading tool, an obore (*cloutiere*). The obore is a tool of some antiquity, used to forge nail heads, fig. 9. It is not employed to make ornate decorative nail heads which have their heads formed by use of a stamp or 'trussel' (*estampe*).

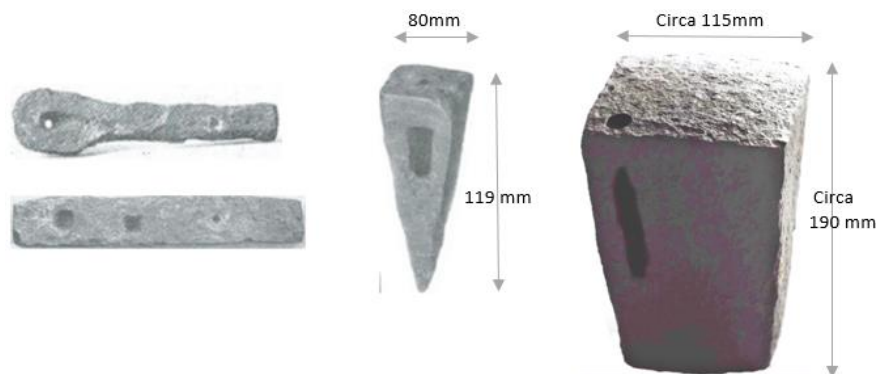


Fig. 9. Roman nail making tools: hand held obores from Saalburg circa 20AD, and Silchester 3rd century. Combined anvil and standing obore, Saalburg (after Mercer), Larger version from Annecy, 3rd century, Musée de St Germain-en-Laye. Author.

The Romans set the pattern for tools in the western nail making tradition, fig. 9. By dint of standardisation of their army support commissariat they dispersed this pattern throughout the Empire. Obore changed very little until they became incorporated into standing heavy anvils, as will be seen later.²⁹ Nails were a critical item of military use and so anvil weight was a consideration to their commissariat. The smaller anvil shown (Fig. 9 centre) has a top surface of around 80mm square which displays an adaption of a heading hole and release slot in the side as a means of combining anvil and obore in one unit. It would have been used to forge nails of up to 60mm long or so. A picture from

²⁸ HOW 2017b, 49-56. (The anvils shown in Fig.9 weigh 7.8 & 30 Kg respectively)

²⁹ HOW 2018b, 765-771

the Holkham Bible of 1327, fig. 14, shows a similar sized anvil still in use.³⁰ Larger nails and spikes for bridges etc, needed larger anvils to provide the inertia needed to absorb the hammer blows. The Musée de St. Germain-en-Laye, holds three different classes on nailors' anvils: a large anvil and an intermediate size and one almost identical to the small one found in Saalburg.³¹ The medium sized anvil is shown on the right, fig. 9.

In the Eastern School³² of nail-making only a hammer and a similar small anvil are employed to make the nail heads. This was done after the forging of the shank (*tige*) as is the normal sequence of steps used in the West. The head formation is done by folding; either one-fold, double fold, or by flattening the top end and rolling this on itself, reminiscent of a French floor T-head nail.³³ The Eastern School of nail-making has received almost no formal coverage in the West and so they are displayed in Appendix II. A selection of Chinese types is shown, figs. 1 & 2.³⁴ Japanese nails which form part of the eastern tradition may exhibit different shape and application. (Refer Appendix II. Glossary: Eastern School).

1.1.4 Historical review

For some time it has been usual to consider bar iron as constituting the normal stock material for blacksmiths and nailors alike prior to 1480. Bar iron was noted to be a standard commodity used as a form of currency by the Celts.³⁵ It was still a standard commodity issue to farriers in the British army, up to and during WWII.³⁶ Developments in the form of changes to the supply medium have been covered to some extent by papers presented by the author in Brussels and in Cambridge.³⁷

Late medieval manuscripts provide additional interpretation as to progress in nail making, the most important of these coming from sketches of brothers in Alms Houses (*Augustinians*) in Nuremberg and Landau, (*Nürnberger Zwölfbrüderstiftungen: Landauer Hausbuch*). These show the use of bar iron in the fabrication of nails in 1425, but indicate a probable change to *Krauss-Eisen* ('wavy' iron wands) by 1482.³⁸ A typically 'wavy' form baton can be seen under the almoner's seat in the 1482 sketch, fig. 10.



Fig. 10. From the *Nürnberger Zwölfbrüderstiftungen*, Nuremberg Library.

³⁰ See also HOW 2017, 9

³¹ Another small version, around 85mm square, is displayed in the *Neues Museen* in Berlin.

³² In this study the tradition comprises countries influenced by Imperial China.

³³ HOW 2017, 36, Fig. 54

³⁴ PAN 2017, montage

³⁵ CAESAR 2006, 77

³⁶ Reported to the author in May 1965 by former farrier Company Sergeant Major, Albert Cooper, of the Royal Army Veterinary Corps. Shoes for horses and mules were made from stock issue bar iron.

³⁷ HOW 2019b, 765-771: HOW 2016, 119-128: HOW 2015, 81-90: HOW 2014, 231-238

³⁸ Zwölfbrüderstiftungen, Brother Fritz Zorn, 1482. See also HOW 2015, 81-82

In 1425 the almoner can be seen using an obore in his left hand while a bar of iron is being heated in the furnace behind. In both cases tongs can be seen for handling the hot metal, whereas by 1525 thinner batons are seen being heated and there is an absence of tongs, fig. 10.

However, an English medieval manuscript shows that batons made of iron were in use by nail makers in 1338, fig. 11. Thus the stock iron form normally provided during medieval times is far from clear.³⁹



Fig. 11. Scene from the 'Romance of Alexander' 1338 -1342, Bodleian Library.

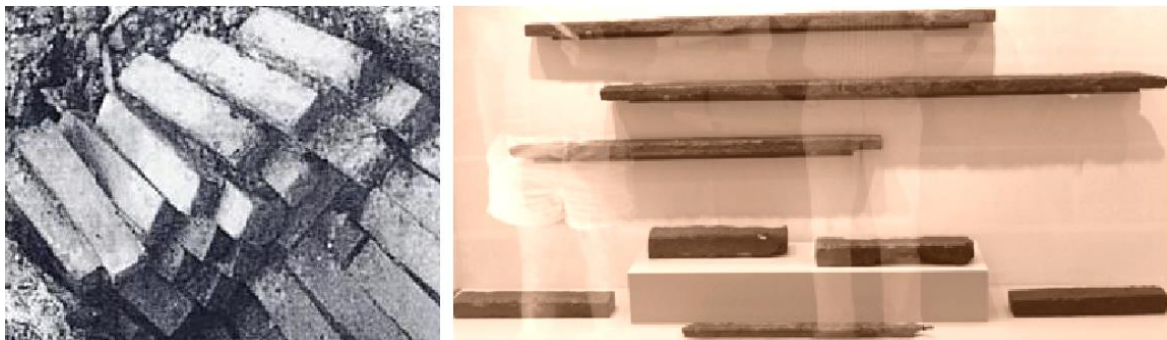


Fig. 12. Titan reef bar iron as found underwater, and as displayed in Arles Regional museum 2018. Note the iron baton about 25mm x 30mm in foreground. Bar iron lengths vary from 285mm to 330mm or so. Author

The recovery of a second century cargo of iron from off a Roman shipwreck on the Titan Reef off the Saintes Maries de la Mer on the edge of the Camargue, which contained both bar iron and thick iron battens, demonstrates how both commodities were supplied during Roman times, fig. 12. These findings suggest that a dislocation of trade practices in the iron industry following the collapse of the Roman Empire may have been less disruptive than imagined. A detailed study could well form the subject for future research. The findings pose a series of questions in regard to forging of the iron batons by manual means of iron bloom obtained by direct reduction. Simple tilt

³⁹ Emerson, in 1758, shows a machine captioned as a 'slitting mill', which it clearly is not, EMERSON 1758, 195 Pl. XXXIX: SCHUBERT 1957, 309 Fig. 35). Examination of the original diagram shows V-grooved rollers able to reduce bar iron in a series of passes in such a way as to roll out square bars with rounded corners in a limited range of sizes. The illustration also shows how water powered shears were used to cut the bars into marketable lengths. Bars in sizes larger than made by slitting were in demand for making both ship nails, sluice (*pertuis*) nails, and canal lock nails. With the growth of canals and channelized waterways during this period, (refer figs. 75/76), the timing is particularly apposite. See Appendix V.

hammers would allow simpler, and more rapid, means of forging a range of finished products. This form of forging, (Fig. 13), it is less onerous, and the sizes produced would conveniently fit overland transport, use, and shipment. The mechanical engineering abilities of the Romans are legendary. They include mechanical pumps and the industrial scale series of geared, water-powered flour mills at Barbegal, in Provence. An international seminar in 2007 at the Pont du Gard, explored the evidences of various Roman water powered machines, which included gearing of saws and stone sawing.⁴⁰ Against the evidence presented by several of these papers of complex machines from widely distributed parts of the Roman world, the simplicity of a tilt hammer assumes pygmy proportions and requires far less sophistication or planning. We can anticipate the story of the tilt hammer being developed at the end of the Middle Ages,⁴¹ to be revised by new archaeological evidence of Roman use.⁴²

There is a reference to these thicker batons coming from the pre-Conquest Anglo-Saxon period, circa 1043, in which the city of Gloucester had to supply “100 rods suitable to be elongated for nails for the King’s ships”, which makes an entry in the Domesday Book later.⁴³ Schubert interprets this as meaning the iron had to be ductile enough to be drawn by hammer to thinner sizes. This aspect of forged baton size has been recently re-examined by Dr Sjogren in his thesis on the British cut nail industry.⁴⁴ He quotes the work done by Gale on minimum sizes for baton sizes, based on cooling rates. This shows that the smallest size obtainable would be in the order of 20mm square, which is still an inconvenient size for the fabrication of most nails.

The next set of references for iron in thick baton form comes from Belgium with a set of references starting in 1449 from Franchimont, south-east of Liege.⁴⁵ This first reference unambiguously, refers to a percussion device: a ‘hammer for extended iron’, which was followed four years later by a further reference to an ‘extended-iron hammer’. The form of this hammer, and hence the method of production, was made clear by Hoffsummer and Bertholet finding a disused hammer head in the bell tower of Theux parish church.⁴⁶ This remarkable find has overturned previous understandings of nail technology and gives significant credibility to the set of references revealed by Bertholet. The findings are discussed more fully in Appendix III. Suffice it to say that the casual tone of the first references suggest the device may have existed for some time previously. Pending further analysis of the artefact it would appear to be allied to percussion cutters shown by Agricola,⁴⁷ with the important difference of being mounted on a handle, essentially in the form of a tilt hammer. But otherwise, like the *Zeinhammer*, it was most likely used to sever a wand-like strip from off the edge of previously prepared flat ribbon. As has been previously shown,⁴⁸ at ‘Black Heat’ the shear strength of iron drops to around 50% of that at room temperature, suggesting that the ribbons were first heated prior to cutting.

The cutting hammer discovered by Hoffsummer and Bertholet has a chisel shaped cross-section and what appears to be a blunt elliptical point. This suggests that it proceeded in a series of blows along the heated ribbon, starting at one end. One can speculate that the ribbon would be advanced

⁴⁰ BRUN 2007, 201-257

⁴¹ SJOGREN 2019, 42

⁴² REYNOLDS 1985, 67 suggests water powered tilt-hammers (*Pilae*) were used in St Gall in 820 AD

⁴³ SCHUBERT 1957, 72

⁴⁴ SJOGREN 2019, 45

⁴⁵ BERTHOLET 2012, 24-112

⁴⁶ HOFFSUMMER 2020. A personal note to the author of

⁴⁷ AGRICOLA

⁴⁸ RYZEWSKI AND GORDON 2008, 56

between each blow of the chisel hammer and separation of the strip would occur progressively by means of partial cut, and then partial tear - akin to cleavage signature in see-sawing. It should thus be possible to find a few larger nail specimens retaining a few tell-tale signature traces. However, since there is, as yet, no known clear starting date for the device there are no possibilities of dating from such nails, other than that they pre-date the introduction of slitting.

There is one further piece of evidence of the survival of forged batons which comes from Sweden. The author's colleagues in the Construction History Society graciously supplied samples and references to an unusual continuity of use of the tilt hammer in Swedish nail making. (Southern Sweden came under Danish sovereignty until 1658, so some care needs to be taken with respect to generalisations). Swedish nails were made by thinning out prepared iron batons, which from various images appear to be 20-25mm square in cross-section, fig. 13. This aspect of baton size is amplified further in the section which follows.

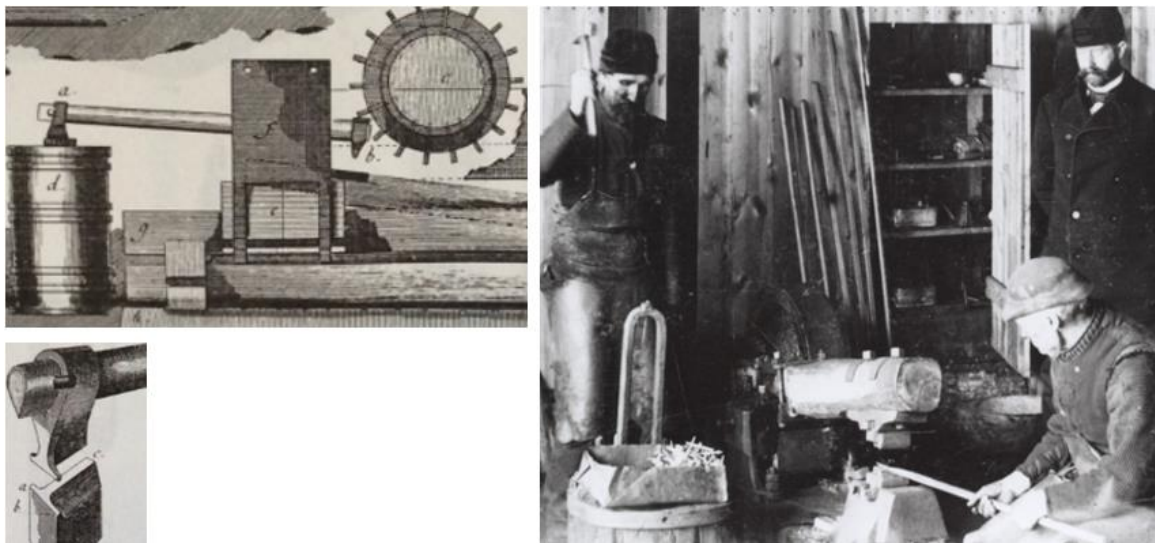


Fig. 13. Swedish nail-making circa 1789: left, tilt-hammer, hammer and anvil detail, after Rinman. Alga forge circa 1910, right. Note the thickness of the iron batons standing against the rear wall. Courtesy Matthias Hallgren.

The pictorial evidence shows the large amount of work involved in forging down from either batons or from bar iron, although it cannot be disputed that the batons were handier, Fig. 14.



Fig. 14. The forging down process in 1327 from the Holkham Bible, left, British Library. Jorg Flurrer forging shank and proto-head on an iron baton, 1568 -1572, from the *Nürnberger Zwölfbrüderstiftungen*, Nuremburg Library

Two methods of working are shown above for the forging down process, Fig. 14. The nail maker's wife is shown in 1327 having already created the proto-head bulb at one end, coloured blue. She has heated the shank section (coloured red) and is paring the shank. In the second image, Jorg is shown using forged iron baton and he has been able to work the heated end to form a pared down shank, whilst at the same time leaving sufficient of the baton to form a bulb for the nail head, which can be seen as intact baton. Following normal procedures his next task will be to drop the baton onto the hack iron, seen in front of the anvil, to sever the semi-complete nail. His last task will be to insert the shank into one of the holes shown at the end of the anvil and forge the four facets of the rose head. As will be seen later (Fig. 19), some medieval nails in excellent condition recovered in Riga show how nails made this way display oversized necks formed during the forging of the heads caused when placed into a larger than necessary hole of the obore, confirming the method of working used by Jorg in the image.

Around 1480 in the southern States of Germany (Franken, Bavaria, and probably Swabia), and in Austria, the advent of power drawing of iron wire created a need for change in the traditional baton or bar iron form of supply.⁴⁹ Power drawing, so nicely illustrated by Biringuccio,⁵⁰ completely over-taxed the supply of tilt hammer reduced sized batons, able to be fitted into the first passes of a draw plate.⁵¹ Formerly, the sole possibility of reducing the forged batons to a reduced size and a suitable cross-section was by further heating and re-forging. In smaller sizes they could be swaged into hexagonal cross section rod able to fit the first critical entry into the first pass of the draw plate orifice. One possibility regarding this process occurs in what appears to be the first illustration of a battery of hammers, also shown by Weigel.⁵² If this were the case then the reduced rod would be laid into a rounded trough, to be struck by powered hammers resembling the top swage, fig. 26. Regardless of this speculation, smaller cross-section stock wands, of longer length, would still have been needed to keep pace with water-powered drawing.

1.1.5 Thinner iron batons

1.1.5 (a) *Zeinhammer*

The first noticeable change to nail morphology effectively becomes apparent around 1485 or so and can be attributed to the *Zeinhammer* device, Fig. 4.⁵³ This device and its introduction as a precursor to power drawing also lightened work in the nail industry. It is not mentioned at all in English texts, (with the exception of the author's publications).⁵⁴ Neither does the device receive mention in French texts, although one of Weigel's illustrations is used to demonstrate a 17th century nail workshop⁵⁵. It was unknown to the author's colleagues in Denmark or in the Baltic States. There is no mention of it in the Lowlands, although detailed research of Flemish or Dutch language sources may arrive at a different result. Janse, for example, in his relatively recent book fails to mention it.⁵⁶ However, there is also a mention of 'lengthened iron' at Theux in Wallonia from between 1513 and 1546.⁵⁷

⁴⁹ HOW 2015, 81-90

⁵⁰ BIRINGUCCIO 1540, Fig. 73

⁵¹ HOW 2015, 82-83

⁵² WEIGEL 1698, 316

⁵³ WEIGEL 1698, 348-349

⁵⁴ HOW 2017, 6

⁵⁵ FREMONT 1912, 28

⁵⁶ JANSE 2004

⁵⁷ BERTHOLET 2012, 58. "*Un ussine a fer stendu ou fendrie*". This is further discussed in Appendix III.

Being a datable change of some significance in the history of nail-making, the details which have been uncovered as a result of this study receive a fuller explanation within this thesis, besides the author's research papers dealing with early devices.⁵⁸

Weigel's 1698 copperplate is the only known illustration of the *Zeinhammer* device available and modern Germans were unable to help with the term 'Zein', fig. 16.⁵⁹ Thus recourse was made to other German texts which deal briefly with nails of this era. In addition to Christoff Weigel there are four others who are relevant:

- Zedler in 1732 in his *Lexicon* project
- Jacob Krünitz in his massive *Oekonomische Encyclopedie*, from 1777 onwards.
- Ludwig Beck in his work *Die Geschichte des Eisens* of 1895, and
- Otto Johannsen in his *Geschichte des Eisens* of 1925.

These later German writers foresaw the need to clarify the *Zeinhammer* dialect names and the *Oekonomische Encyclopedie* provides the name *Stabeisen*, which roughly translates into English as 'Stave iron'.⁶⁰ Zedler presents the term for the cut iron wands as '*Zaehn-Eisen*' (Teeth iron), fig. 15. He then introduces an alternative term '*Krauss-eisen*' ('wavy iron') for the wands produced.⁶¹

**Zähn = Eisen, auch Zein-Eisen, nach der
verschiedenen Aussprache genannt, ist ein Eisen
in kleinen Stäbgen, für die Nagel- und Zwer-
cken-Schmiede, so ganz krauß geschmiedet wird;
daher es auch Krauß-Eisen heißt.**

Fig. 15. Excerpt from Zedler.⁶²

The *Zeinhammer* process is part of a two stage conversion of bar iron into thick batons. The first stage, the *Reckhammer*, (Fig. 4 on right), is needed to stretch out the bar as the name implies.⁶³ At this point the drawing by Christoff Weigel fails to convince anyone with an engineering background, as the head of the *Reckhammer* is shown flat whilst it ought to be curved in the direction of flow, as in a fulling tool, in order to stretch out the ribbon of iron.⁶⁴ The reference to 'teeth' becomes 'Zain' in Krünitz's *Encyclopaedia*, (published in Halle near Leipzig so presumably in Saxon dialect), but Beck is the only writer to link *Zein/Zain*, to *Zahn* (tooth), in the singular. We conclude from this that one edge of the *Zeinhammer* hung down, alike to a canine tooth, over the edge of the anvil, such that with each drop of the hammer a shearing action of the flattened iron ribbon took place, fig. 16.

⁵⁸ HOW 2015, 81-90: HOW 2018, 769

⁵⁹ *Zeiner* is the term used for a maker of baskets. With hindsight it can be seen that in this context it relates to the longitudinal splitting of the cane or willow used in basket making with a 'tooth' device.

⁶⁰ KRÜENITZ 1777, 605. In this regard he mentions *Nagelstab* (nail rod) as being smaller and thinner than *Stabeisen*. This appears to be the only reference suggestive of slitting being available in North Germany by 1777.

⁶¹ ZEDLER 1732, 1102

⁶² *Teeth-iron, also Zein-Eisen, as named in various dialects, is iron in small batons, for nails and for other intended iron working, cut to a curvy line; such that it is also known as 'wavy-iron'.* Author's translation.

⁶³ 'Reck' means to 'stretch out' and hence the word 'rake', in English.

⁶⁴ KAMENSCHIKOV et al 1970, 150-157

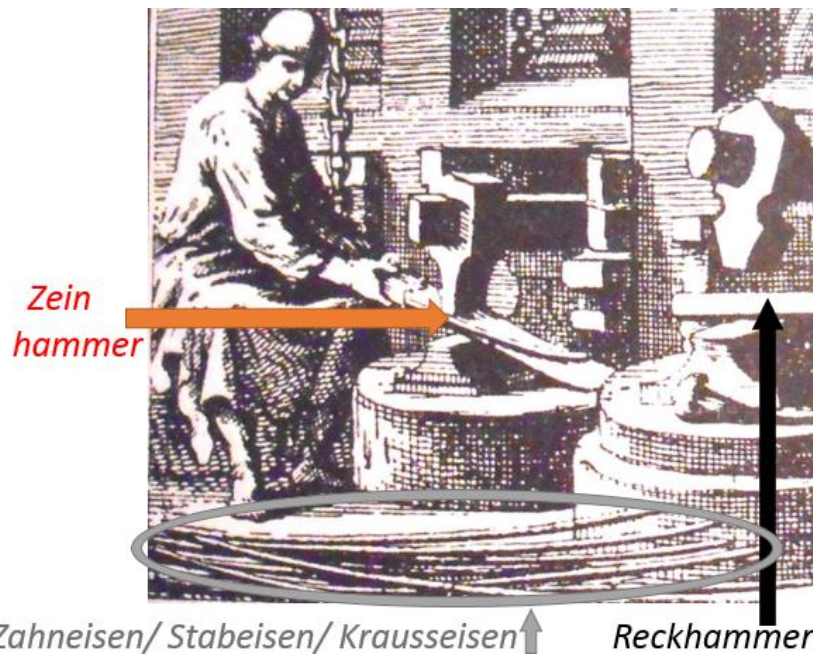


Fig. 16. Zeinhammer cutting iron wands (seen in foreground), Regensburg, 1698. After Weigel.

The whole process was controlled by eye so a wavering edge resulted, at each advance of the iron ribbon under the hammer. This effect shows in samples of early German nails, fig. 17 top:



Fig. 17. Wavy edged Sparrennagel, 1500-10 d, Beutelsbach, and straight edged Aufschiebling nagel, circa 1750, Schloss Wolfegg, Oberschwaben. Author.

Since the cutting progress was controlled by eye alone, primary shear problems demanded a minimum lateral dimension,⁶⁵ and the sample shown appears to come from beaten ribbon of 13mm thick but is 14mm wide, plus or minus 1.5mm average, fig. 17 top. This is an advancement on the much thicker forged batons. Thus nails smaller than 11mm thickness would have to be worked down as was done by fabrication from bar iron.⁶⁶ In the same Beutelsbach building a 62mm long *Bretterwand* nail was recovered, used to secure sawn fir planks fixed to the internal frame. This was fully tapered in the shank, much in the manner of medieval or Roman nails, fig. 18.



Fig. 18. *Bretterwand* nail, 1500-10, Marktstrasse 23, Beutelsbach, Stuttgart, 1500 – 1510d. Author

⁶⁵ Otherwise a triangular or rhomboidal section iron wand would result.

⁶⁶ HOW 2017, 9

Keeping in mind the background events of the locus quo, fig.17 (bottom). The official end to the Thirty Years' War came in 1648⁶⁷, but Catholic Oberschwaben had been devastated by Swedish Lutheran forces whose involvement saw the roof of Schloss Wolfegg lost by burning.⁶⁸ Restoration is estimated to have been carried out around 1651 and the *aufschiebling* (tilting sprocket) nails present clear signs of having come from slit nail rod, fig. 17 bottom.

However, the *Zeinhammer* was still in operation in 1698, as can be seen in Weigel's etching (Figs. 4 & 16), and there was also a viable nail industry in Regensburg.⁶⁹ Thus there is a lap of at least 150 years, during which time both types of nail rod (*baton*) may have been in use in parts of Germany. Weigel's text is quite emphatic in stating that the *Zeinhammer* was not known in other German States, and he mentions only Regensburg, Nuremberg, Munich, and the *Steiermark* in Austria. *Die Geschichte des Eisens* implies that the *Zeinhammer* was not in use in 1895 in northern Germany (Braunschweig).⁷⁰ It should be noted that Beck points out that there were really three stages to the process and not two. The heavy stave of iron arrived at the workshop as a foundry product whereby a *Raffinierhammer* (or *Streckhammer*) had been used as part of the finery process⁷¹. Beck proceeds to show how the process improved the choice of nails available:

*Partly due to the Zainhammer (Sic) and partly due to slitting, the manufacture of wrought iron nails was simplified by virtue of stock iron supplied in baton form and as rods. This shows in the hand work of normal house construction, in which the supply of iron in different forms followed, conferring important benefits to the population. With the development of this industry, nail forms increased. Some forms modified as can be seen from the following price list for the district of Saxony in the year 1623.*⁷²

Beck suggests that the foundry and cutting processes merged, thus economising on transport costs,⁷³ but he fails to clarify how the two methods of preparing iron were distributed inside the German states. Similarly, Beck fails to explain why two different systems could have operated in parallel for such a long time.

These leads were followed up by visiting the Library of Technische Universitaet Berlin with no real success.⁷⁴

Krünitz appears to be the only German speaking writer to use the term 'slitting' (*schlictern*).⁷⁵ It is possible, albeit on the basis of a limited number of field samples, to arrive at some idea of how slitting affected Europe, fig. 19. One possible interpretation of the German texts suggests an 'isolation' of the dialect areas of Bavaria/Franken and the *Steiermark*. Saxony and the Hansa ports had other trade and production interests drawing them more into the international field of ore export and mining technology, which linked them to Antwerp as an international trade hub, and to English outreach centred on the Antwerp English colony. These curious combinations may have

⁶⁷ The Peace of Westphalia. From May to October a series of treaties were signed at Osnabrück & Münster.

⁶⁸ A captured Swedish commissariat wagon dating from this campaign, is displayed in Dinkelsbühl Church.

⁶⁹ HOW 2018b, 768

⁷⁰ BECK 1895, 973

⁷¹ BECK 1895, 971

⁷² Author's free translation.

⁷³ *Die Geschichte des Eisens* page 972-973

⁷⁴ HERNEMANN 2014 (Personal communication March 2014). Frau Dr Hernemann advised that she had found references suggesting the use of the Reckhammer continued up until WWI. This of course does not necessarily imply combined use.

⁷⁵ KRÜENITZ circa 1795, 631. His lexicon starts in 1777 but it was constantly being updated. His entry concerning the Clifford patent shows that the particular edition used was post 1790.

brought together the ingredients for design of a new cutting device, the slitter. This leaves some doubt in the case of Westphalia and the north German plain, well integrated with both the Hansa and the Regensburg/Nuremburg iron supply outlets.

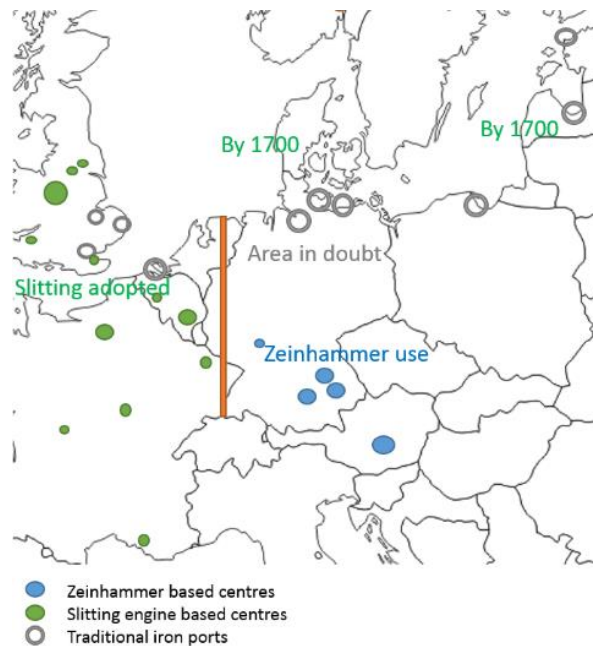


Fig. 19. An approximation of *Zeinhammer* distribution, the probable boundaries, and later spread of slitting based on samples obtained in Denmark and the Baltic States. Author

1.1.5 (b) Theux splitting hammer (*Fer stendu*)

The remarkable find described above, of a badly worn and cracked chisel hammer head by Professor Hoffsummer and Paul Bertholet adds a wider perspective to the manufacture of iron batons from prepared ribbons.⁷⁶ It is a significant historical event presenting a strong possibility of predating the *Zeinhammer*. The iron ribbon might have been prepared in several thicknesses. A 1556 mention of eight types of nails being made from batons made by this process suggests that *fer stendu* could be appropriately and variously supplied.⁷⁷

1.1.6 Slitting (*Fendage*)

The invention and development of slitting constitutes the single most important event in the history of wrought nails. It significantly reduced the time, labour, and the fuel expended in the making of wrought iron nails. In the words of the patent issued to Bevis Bulmer⁷⁸ (post facto) in 1588;

...to the benefytt of the Commonweale devised a newe apte or compendious forme or kynde of engyn or instrument to be put in use driven and wrought by water or waterworke as well for and concerning a quicker and more apt and speedy waye and meanes then heretofore within the time of man's memory hath bene knowen experimented and used within our realms and dominions for in and about the cutting and making of yron into small barres or roddees to serve for the making of nayles and other thynges for the necessary use and service of us and our subjects as also for the better saving and better remedying then heretofore hath bene used in our said realms and dominions of the wast that commonly growth and happeneth of the yron which is usually cutt into the said small roddees by reason of the often

⁷⁶ BERTHOLET 2012, 55-107

⁷⁷ BERTHOLET 2012, 56

⁷⁸ Varman incorrectly refers to the patent renewal of 1606 thereby putting the chronology forward by 39 years. He also refers to the patentee as "Sir Davis Bulmer".

heating and inapt instrument devised nowe used and practiced for the cutting thereof. (English patent number XLV, 4th December 1588).

Because of its great importance to the history of nail-making, and because of the grossly overdue need for correction of accumulation of myths, it is crucial that the facts be presented here at some length. The brief explanation which follows is further amplified by copies of original documents which are set out in Appendix II.

1.1.7 How the engine operated

The little known image shown at the start of the Introduction is used to explain the state of the art of slitting arrived at in 1730 by the construction of the 'green site' industrial complex at Ekaterinburg, fig. 5.⁷⁹ This image was copied from a 1730 water colour sketch, and it is easier to understand than that provided by the *Grande Encyclopedie*.⁸⁰ So far no earlier representation of a slitter has been uncovered other than this image made by Baklanov from the original watercolours prepared by its designer, Georg Gennin. Bar iron is shown being heated in an elevated hearth on the left hand side, to be rolled into a ribbon using water powered rollers, shown in the centre. The overall setup of the Ekaterinburg industrial complex, fig. 7. A wooden dam wall is illustrated with timber boarded sluices which take subsurface water from the dam (presumably to overcome winter ice formation).⁸¹ The flow from the main sluice was delivered via side feeds onto overshot wheels inside the factory workshops, (shown in the near foreground on the right). Other etchings demonstrate the internal workings in more detail.⁸²

The slitting process had by then been in existence for nearly two centuries. It provided a major gain in output and made available iron rod in various smaller dimensions than the minimum size of 'wavy' cut iron (*Krausseisen*) obtainable from the *Zeinhammer*. After rollers were introduced the thickness of the iron ribbon could be adjusted by high-rate turn screws seen on the top of the roller frame. The iron ribbon was passed while still hot, through intersecting discs, shown on the right, Fig. 5, to emerge on the far side as bundles of rods. Each rod would present two sheared faces (excepting the ribbon edges which would have been sent back as scrap for re-melting), fig. 20. The slicing discs themselves consisted of a series of circular steel plates able to be assembled on an axle. The *Grande Encyclopaedie* conveniently shows both the assembled discs and a loose one.⁸³

The full story of the slitter development is discussed in Appendix III, Volume 2 of this thesis.

1.1.8 Identification of slit rod

Just as the 'wavy' iron provides a signature to iron wands coming from the *Zeinhammer*, so slit rods bear their own distinctive marks which require non-abrasive cleaning of the specimen, careful examination by magnifying glass, and by sensitive touch along the edges, for the burrs to be made out.

⁷⁹ BAKLANOV 1935, 107. The author acknowledges heritage architect Arturs Lapins of Riga, who provided images and translations of the Russian text.

⁸⁰ DIDEROT 1769 VOL III, 37. Plate III

⁸¹ BAKLANOV 1935, 38

⁸² BAKLANOV 1935, 139 & 114

⁸³ DIDEROT 1769 VOL III, 38. Plate VII

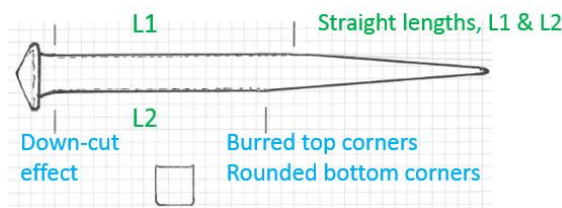


Fig. 20. Typical nail morphology displayed by British and Belgian wrought nails coming from nail rod. Author

Wrought nails made from rod did not require the same amount of hammer work to their shanks since they could normally be made from appropriately sized rod. The nail makers of Belgium and England found that only the paring-down and point needed to be wrought by hammer.⁸⁴ In a typical nail the worked lengths, L1 and L2, (Fig. 20), are similar but not necessarily the same. The unworked length below the head and neck belling would still retain the shear marks from off the cutting discs. In the figure the top side is being forced down by the cutting disc onto two discs below, fig. 20. These intersect but need to be set a small distance apart to avoid friction which would lead to binding as the machine warmed up. Diderot shows how grease was applied to the cutting discs with a swab, as a lubricant.⁸⁵

The effect of the small clearances between discs causes minor bending to occur on the bottom two corners, thus causing a rounding off prior to the shear taking effect. The top corners have sharp burring of the metal forced upwards. Thus, two corners on one side are burred whilst the other two corners tend to be smooth. These seemingly ineffective features play their part in nail efficacy as will now be explained.

1.2 DEFINING AND UNDERSTANDING NAIL FUNCTION

Despite Diderot's attempt at defining a nail, as seen above below the chapter heading, a definition is not easy, and Frémont made it clear in his pioneering study that not all nails are metallic⁸⁶. In a joint paper with the author at Cambridge in April 2019, Dr Le Dantec demonstrated numerous examples of how bone nails (primarily mutton bones) had been used to secure the 'plaster of Paris' renders to building in Paris and environs, these being sufficiently strong to be driven into lime mortar and Jurassic masonry⁸⁷. Likewise, some oak wooden pegs, driven into pre-bored, under-sized holes, were recovered by the author in 2008 from a 1700 Danish 'long house' at Asferg in Jutland, and these retained the essential characteristics of nails.

Although most nails had pointed ends it was known for some time that blunt ends would crush timber fibres, causing the fibres to deflect downwards and thereby provide greater withdrawal resistance. This led to common use of spade-ended or chisel ended nails, effectively from Tudor times. (See Fig. 27, third nail). By the same token, not all nails were provided with heads, although the effect of being driven usually involves some top burring - suggestive of a quasi-flange. True nails, those capable of being driven, are invariably stronger than the receiving medium but some nail look-alikes made of a lead alloy were used as tied fixings in the Victorian era.⁸⁸

⁸⁴ French nails of the pre-revolutionary period tend to exhibit the full tapered shanks of Roman and Medieval times.

⁸⁵ DIDEROT 1769, 37 (note 3). See also HOW 2017, 107

⁸⁶ FREMONT 1912, 1-6

⁸⁷ LE DANTEC et al 2019, 314-320

⁸⁸ Used to secure slates to rolled iron angles and to iron roof frames, shown in figs. 93 and 94.

The distinctive element defining a 'nail' is that it is intended to be driven by a hammer, but not necessarily without first drilling a pilot hole, a Gallo-Roman practice.⁸⁹ Modern research shows that there is an increase in withdrawal capacity when nails are driven into a pre-bored, but undersized hole.⁹⁰ This was almost certainly the case of the oak thatching pole 'nails' examined at Asferg, fig.21.

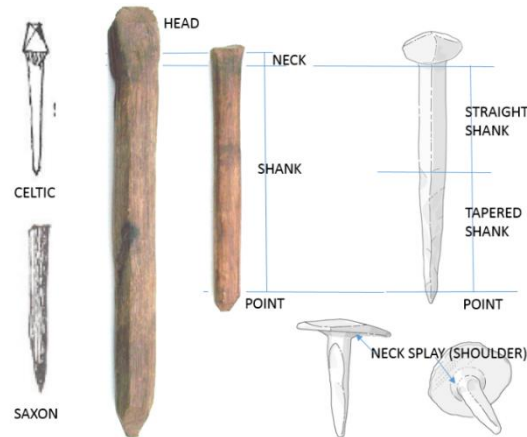


Fig. 21. Trenail origins (after Schaeffer 2001, 99, 17)⁹¹, with a Danish rafter/plate oak 225mm trenail and 122mm thatching pole trenail from a longhouse at Asferg, Jutland, relocated in 1700.. A post-slitting wrought iron common rosehead (right) with a wrought clout, showing below-head splay or shoulder. Author/McCaig

Much can be learned from the comparisons made, particularly with respect to the oak thatching-pole nail, and the functions of nail shanks and heads will be explained later, fig. 21.



Fig. 22. Fully developed head to an oak nail, ringed in yellow, driven through fir thatching poles, squared on two sides only, and into fir rafters. A rear view of the 1560 oak frame Asferg longhouse during renovation in 2008. Author

1.2.1 Nail shanks

Every driven nail is a small structural member, and like all parts of a structure it has to deal with shear, bending, and tension when in a withdrawal mode, or deal with combinations of two or more forces. In rare cases, such as in furniture or door construction, the nail shank is concurrently required to take small levels of torsion. In direct shear, as for example occurs at the interface of two timbers, the shanks of metal nails are stronger in their shear capacity than that of the

⁸⁹ MARLIER 2014, 144: See also MARCO 2012, 10-13.

⁹⁰ RAMMER 2010, 8-5

⁹¹ SCHAEFER 2001, 19 gives the term 'wood-nails': *The wood-nails should be split, not sawn, such that the wood fibres stay intact. One end should be somewhat pointed.* Author's translation.

surrounding timbers on both faces. Thus, as the timber fibres are locally overstressed some bending is also induced in the nail shank(s) as the over-stressed timber fibres collapse. This scenario is greatly reduced when larger wooden trenails are used, since the bearing areas are greater and the adjoining timber fibres less stressed.

The wooden nail (Fig. 21) has an octagonal cross section, which after 308 years of in service has become roughly rounded in appearance. Each of the eight arrises bite into the softer fir of the tiling pole and develop significant friction against direct withdrawal. It was impossible to remove the trenail fragments without first splitting the fir poles, fig. 22. The minor taper of the neck, Fig. 21, provides a hold-down component to the top timber, thereby bringing the interfaces of the two timbers into tighter contact. This is supplemented by provision of a nail head, the shoulders of which add to the downward acting force.



Fig. 23. Crushing and deflection of timber fibres in Baltic pine from cut floor brad 1887, Stringybark shingle circa 1843, and Hoop pine tiling battens showing deflection of timber fibres and secondary effects of zinc corrosion. Author

These effects apply equally to most nails and can be observed when salvaging historic nails, fig. 23. Wire nails present the least degree of deflection due to the points forcing the fibres apart.

It follows that withdrawal resistance will generally be comprised of at least three components:

- Side friction
- Fibre deflection – maximised by crushing from a blunt ended nail
- Corrosions and protective chemical reactions from the timber of tyloses, tannins and phenols.⁹²

In the vast majority of cases more than just withdrawal capacity needs to be considered since more than one structural condition is usually present. However, as bending is limited in most circumstances, and shear in the nail shank is rarely critical, it is the columnar aspect of the nail shank which becomes the common determinant factor, relating to flexure within the shank itself.

In recent times it has been possible to adopt very thin shank nails for use with a nail gun. A nail gun is provided with a slide-controlled drive mechanism and a driving bolt which is held on a perfectly

⁹²WILSON et al 1986, 209 -212. Durability is to some degree a measure of the timber's ability to produce tyloses, which accounts for oak being a preferred building timber since production of tyloses in oak is high. (Ibid.). Nails are notoriously difficult to extract from oak and often the nail heads will fracture first.

aligned slide. The effect of the slide and its exact alignment is to deliver the full driving force along the nail axis, whilst providing a modicum of lateral support to the shank. Consequently, modern power-driven nails have thinner shanks. The problem of localised overstressing of the supporting timber fibres is overcome by using multiple nails in combination and this aspect is set out by all modern codes.⁹³

1.2.2 Nail heads

In contrast to modern alignment solutions, handmade wrought nails depended on the skill of the nailor in forming the centre of the rosehead directly over the shank axis as she or he formed the head.⁹⁴ At the moment when the hammer first strikes the nail head the carpenter holds the shank firmly between his finger and thumb providing some lateral restraint, but the nail reacts to the blow in accordance with Euler's first mode of failure to form a simple bow shape.⁹⁵



Fig. 24. The simple case of Euler buckling.

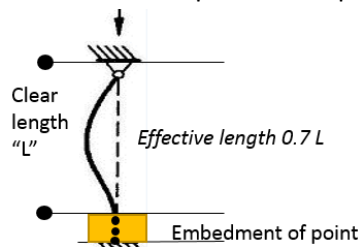


Fig. 25. Euler second case with fixity at one end. Author

This is the point at which the nail is most vulnerable to bending, Fig. 24. Any false, or off-centre, impact by the hammer exacerbates the bending process, either resulting in a bent nail or a rebound of the nail from the timber surface as a 'spring' effect takes place.

In 1678 the process had already been noted and was well described by Moxon:

There is required a pretty skill in driving a Nail; for if (when you set the point of a Nail) you be not curious in observing to strike the flat of the Hammer perpendicularly down upon the perpendicular of the Shank, the Nail (unless it have good entrance) will start aside, or bow, or break; then you will be forced to draw it out again with the Claw of the Hammer.⁹⁶

The problem of bending in the shank reduces as the nail embeds in the timber fibres, fig. 25. At this initial stage three things happen:

- * A reduction in the 'free' length occurs due to the embedment already achieved.
- * The structural model changes to the second Euler case with partial fixity in the embedment, the protruding length now able to bend, is factored down to 0.7 of the new free length.
- * The structural model changes to the second Euler case with embedment. The protruding length is less able to bend due to partial fixity, the equivalent free length factors down to 0.7, fig. 25.

⁹³ Australian Standard: AS 1720 1975, 4.1.1 – 4.2.2

⁹⁴ Women and children formed about half the work force, specialising in nails sized below 52mm.

⁹⁵ Leonard Euler, the eminent Swiss scientist and mathematician, first solved the laws governing bending and buckling in columns. His formulae take account of the column end fixities and the slenderness on each axis by adopting a series of coefficients which are used in structural analysis worldwide.

⁹⁶ MOXON 1678, 124-125

This change is intuitively recognised by the carpenter as a safer or more secure ‘hands-off’ hammering situation. However, in order to effect this second condition the point of the nail must be securely established into the wood, and a second problem is posed in nail design. What sort of point is the most effective for the nail in its intended use? The answer usually relates to the type of timber in use: softwood or hardwood, (or masonry), and to the density of the receiving medium.

In relation to Euler’s Law of column action it should be noted that the proclivity towards bending will always cause a nail of rectangular section shank to fail on its lesser axis. In this regard it is difficult to understand why many historic English or British nails were made from rectangular section rod. Belgian wrought nails, for example, are nearly always made from square section rod, which seems to be more logical from an intuitive viewpoint. Once mechanically made nails made their debut this oddity of English nails tends to be compensated by the lesser axis section swelling out between one third, or to around half of the free shank length, as will be explained in Chapter 4.

If the resistance by the timber fibres (or masonry as is sometimes the case), is high, then either the nail shank will bow and break, or a sturdier form of nail must be used to overcome the resistance. Nails designed to be driven into masonry have shanks with the most effective cross section for columns, which is circular. Thus pipe nails always have a round shank similar to bolts and their predecessors, forelock bolts. As will be seen in Chapter 4, prior to 1785 or so pipe nails and die-dogs could only be produced by laboriously forging down square rod, using a special swaging tool and its corresponding bottom swaged block, fig. 26 bottom. (See **N 10** and **N 22**).

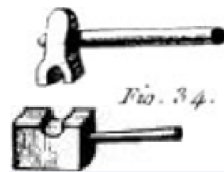


Fig. 26. Image of a contemporary top and bottom swages. DU MONCEAU, 1767

1.2.3 Nail points

The terms given to describe the points of wrought nails need some explanation, and sometimes more than one name can be applied. The basic forms are:

- **Sharp** (Full sharp). The shank is tapered on both axes to arrive at a needle-sharp point.
- **Spear** (Flat sharp, or flat point). The nail is normally made from rectangular rod and brought to a point in one plane, sometimes with the end belled out like a spear head.
- **Spoon**. Usually similar to the above or can be square rod tapered on one axis to a flat and the very end belled out with a flat (chisel) end. This end is an intuitive recognition of the fact that timber fibres react elastically and try to spring back after the spoon end has been driven past, resulting in an increased withdrawal capacity, fig. 27. They are hence often applied to roof nails where suction can lead to uplift forces on the roof. They hardly ever occur in non-roof situations.
- **Chisel**. The point extends slightly like a spade end. ‘Chisel’ and ‘spoon’ are inexact and so are often used incorrectly as interchangeable terms.



Fig. 27. Sharp, Spear, Spoon and Chisel points. Author

Wrought iron nails required more skill in driving with a hammer than do modern steel nails. An appropriate selection of nail types to match the timbers was needed for point and shank thickness, which is explained below. They then required careful attention in the driving process:

*--the violent driving in of the nail will either break the head or bow the point thereof or rive and split that which should be fastened therewith.*⁹⁷

Apart from contemporary nail lists, which often lack clear reference in regard to the nail (shank) grades, the first explanation of this phenomena came from Neve in 1703.⁹⁸

1.2.4 Grades and aspect ratios

In visual terms there are three grades of nail shank which translate into stout, medium and slender shanks and this attention to nail detail applies across Europe. They are best expressed in terms of the shank's aspect ratio: its length divided by its width. Similarly the type of wood into which the nail is driven reflects in nail design and particularly the nail shank aspect ratio. Shorter stubbier nails could be driven into thick hardwood whereas long thin nails are suitable only for softwoods, fig. 28.



Fig. 28. Four wrought roof nails: Provence, 1795; Latvia, 1861; Somerset, 1760; & Warrnambool, Victoria, 1851. Author

The slenderness, (or aspect ratio) for the nails shown is: 1:30, 1:26, 1:17, and 1:10, used in Black pine, Scots pine, Elm, and Eucalypt (white gum). Using the Australian Timber Code⁹⁹ the timber crushing strengths for the species shown correspond to safe crushing strengths of 4, 7, 10, & 14 Mega-Pascals respectively, which can be seen to reflect in the slenderness ratios of the nails selected.

⁹⁷ NICHOLSON 2004, 69, taken from a sermon by the preacher Thomas Fuller in 1652.

⁹⁸ NEVE 1703, Nails 4 (no page number). See also HOW 2014, 231–238

⁹⁹ SAA- AS 1720-1975 pp 17, 103-109: See also PEARSON & KLOOT 1958, 32-37.

Slenderness has been expressed since medieval times in curiously inconsistent and varying terms. Sorting through the numerous documentary sources quoted by Salzman¹⁰⁰, a fair assessment reduces these to three recognisable classes of slenderness or relative shank thickness: *Double*, *Middle*, and *Single*. The terms form part of the identification process (and of our understanding of nail technology). Turning to later writers it is found that the extra thick *Double* (*DUBEL*) does not seem to repeat in English sources yet occurs both in Dutch¹⁰¹ and German sources.¹⁰²

Neve in 1703 records only two classes of slenderness: *Strong*, and *Long*.¹⁰³

Fielder in 1879 records three classes: *Strong*, *Bastard*, and *Fine*.¹⁰⁴

To these must be added the ultra-fine nails made by the British specifically for use in softwoods termed 'Canadas'. (Refer 3.6.3).

1.2.5 Nails matching timbers

Nail design across Europe simplifies in areas which traditionally use only softwoods, such as the Baltic States, parts of southern Germany, Norway and Sweden. These areas traditionally use mainly high aspect ratio nails in softwood timber.¹⁰⁵ The distinction between hard and softwoods goes one step further since two very similar nails, hurdle nails and gate nails, have curious differences, Fig. 28. English hurdles, for folding sheep,¹⁰⁶ are often made from fissile chestnut (*châtaignier*) timber, whereas gates are conventionally made of elm (*orme*) with its notoriously distorted grain. The 'sharp' point of the gate nail with its stout square shank is better suited to penetrating the complex grain of elm, fig. 29.

Chisel points, (Fig. 28 nails 3 and 4), are intended to initiate crushing of timber fibres from the moment of first penetration, and the 'spear' point, (nail 2), is adopted to make this initial penetration simpler whilst still proceeding to crush the timber fibres.

It is certain that for certain heavy timbers, as for example used in canal locks, sluices (*pertuis*) and so on, pre-drilling of holes to take heavy spikes and large nails, was an accepted practice.¹⁰⁷

Certain timbers are 'fissile' and split easily, which is an advantage for making palings, shingles, or hurdles (as opposed to gates). In the cooler areas of East Anglia in eastern England, fissile chestnut is less readily available so alternatives of harder timbers set a need for a stouter nail. Thus the flat, clenched hurdle nail (termed a 'Kent Hurdle' nail) is not used, and with subtle modification become an 'Essex Hurdle' nail. Similarly for making elm gates the shank become slightly more robust, fig. 29.

¹⁰⁰ SALZMAN 1992, 303-317

¹⁰¹ JANSZ 2004, 28

¹⁰² BECK 1895, 975

¹⁰³ NEVE 1703, Nails 4

¹⁰⁴ FIELDER 1879,

¹⁰⁵ More extenuated examples existed in antiquity with Roman ship nails of much higher aspect ratios. These were driven longitudinally through end grain of oak pegs in the keel and ribs and then double clenched inside the vessel. Their heads were made extra-large to cover augured trunnel holes. (MARSDEN 1966, 14-29). Marlier shows how the Gallo-Roman trennel pegs were drilled longitudinally (MARLIER 2014, 143-145).

¹⁰⁶ A temporary pen made of hurdles used for holding sheep is correctly termed a 'sheep fold'.

¹⁰⁷ Albrecht Dürer shows this being done in his crucifixion etching of 1511 in the 'Small Passion' series.

This has an effect on the nail design for softwood areas as will be seen later. Another brittle and fissile timber is teak which often requires holes to be pre-drilled prior to nailing. Conversely, the complex interwoven and distorted grain of elm is non-fissile and resists splintering, thus making it the preferred deck timber for war ships and field gates. Oak is also a non-fissile timber which is another reason that it was the preferred timber for building.¹⁰⁸ Gates made from oak require a heavier stouter nail as do hurdles. This makes an interesting comparison on these nails, the uses of which are now rapidly fading into history but form a vital part of understanding nail design, fig 29.



Fig. 29. L to R; two sizes of gate nails from the Naish collection, Salisbury, with a stout gate nail from Woolmers Tasmania 1828. An Essex Hurdle and a Kent 'Fine' Hurdle nail (both from Naish) and an 1880 Sussex Hurdle nail from Marden, Sussex. Last is a 1732 rafter nail, Bowlsh House, Darshill. Author

Nails driven into fissile timbers can initiate a crack in the timber surface which might then lead to a larger crack as the particular piece adjusts to a drier in-situ moisture content.¹⁰⁹ For this reason it is the practice of experienced joiners, when using wire panel pins, to first tap the point with the hammer to deliberately blunt the ends. Thus, the first blows of the hammer cause a local area of crushing across the grain and perpendicular to the cell walls, which obviates the tendency towards a crack developing and coincidentally improving withdrawal capacity.

The joint developments by the Americans and the British of early cut nails recognised that there was no need for the end of cut nails to be pointed, and they are instead blunt; ideally suited to crush softwood timber cell walls but less suitable for use in hardwoods when the driving force becomes excessive.¹¹⁰

One further aspect should be noted. This is the way that a blunt or square point fractures sections of the timber cell walls, forcing sections of the cell fibres downwards as the nail is driven home, thus increasing withdrawal capacity, fig. 23. This does not occur with round wire nails which instead force the cells apart as the smooth round parallel shank is driven down.¹¹¹ Tests on both sides of the Atlantic went to great lengths to prove the superiority of cut nails with regard to this aspect, (Chapter 2, section 2.4), but alas, wire nails could be produced much cheaper than cut or wrought

¹⁰⁸ RACKHAM 2000, 86. He is referring to English grown oak

¹⁰⁹ WILSON 1986,

¹¹⁰ HOW 2006, 76,77

¹¹¹ A misleading comparison by WE Axon in *The Mechanic's Friend* of 1875 suggested the opposite but has been accepted verbatim by Varman (VARMAN 1993, 136) and by McCarthy (McCARTHY 2005, 91), both of whom repeat the offending diagram.

nails, and for reasons of economy carpenters were faced with using an inferior product. It is for this reason that there is a history of wire nail modification based on deforming the wire nail shanks by twisting, fluting, or by corrugating the shanks, all in order to improve nail withdrawal capacity. (Refer to Fig. 45 in section 1.4.4).

1.2.6 Historical background – West and East

It must be borne in mind that wrought iron nails predate most of written history and that the pre-Roman, Celtic world extended from Galatia in Turkey to Ireland. Roman supremacy, and the spread of its empire into North Africa, the Levant, and then Egypt and the Gulf, ensured that wrought iron nail technology became much more inclusive than just the Empire's limited areas in Europe. (A further spread of Roman influence will be examined in Appendix III).

Fig. 8 demonstrates how wrought iron nails in the western world were fabricated and shows the nominal dates at which identifiable changes occurred. There is a level of uncertainty in recognising medieval nails as such as at times they were also forged with parallel sides. There is also the paradox of why the Isle de France nail-makers¹¹² retained tapered shanks as a feature for more than a century after Britain and Belgium had adopted minimal shank conversion. This is a level of uncertainty with which we are forced to live. In principal, however, the changes provide the basis of a macro dating system, and the idiosyncrasies between different parts of Europe will emerge from this research. It goes without saying that there are no abrupt changes from one system to another.

However, another tradition of making nails existed in Imperial China and countries nearby, but since form tends to follow function worldwide, certain specific nail types in both the western world and in the East can bear a strong resemblance to each other, fig. 30. (This aspect will be covered in Appendix III. Volume 2).

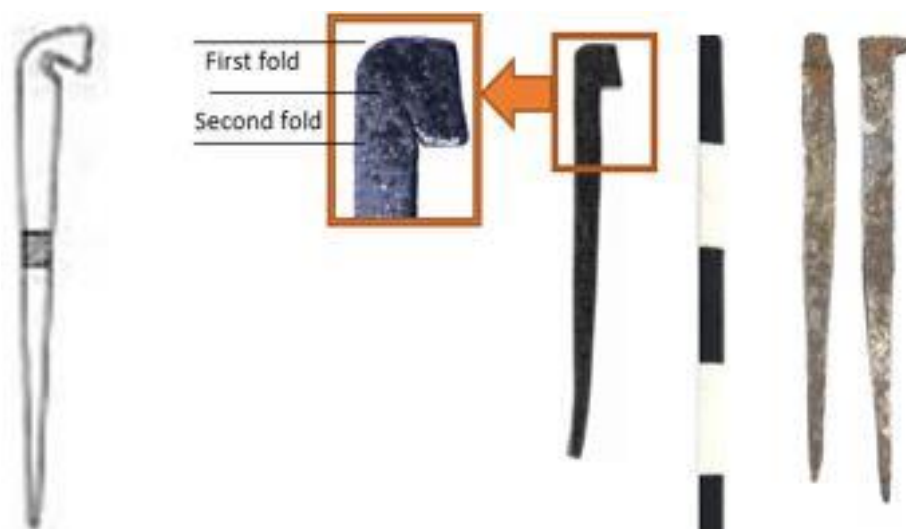


Fig. 30. Chinese fold-head brad, Baochuanchang shipyard, Nanning, left, Japanese lining brad with broken point, Edo period, Tokyo, centre. Wrought lining brad, Sydney, 1837, side and front views. Author

In both cases the wrought iron brads were formed by folding the shank to form a head, but in the eastern school tradition of Imperial China, its dominions, spheres of influence, and also in Japan, nail heading tools (*obores/cloutières*) were not used. All shaping work was done simply by just using hammer and tongs to fold the head of the newly formed shank. In the European tradition the

¹¹² Samples of Provençal historic nails retain a square section from slitting and are thinner as appropriate to the wide use of pine (*Pinus nigra*), in the region. See Fig. 23 below.

majority of nail heads (but not all) were formed using an obore and nails showing this western introduction show towards the end of the Baochuanchang shipyard period in the 17th century. The extent to which Western nails influenced the rest of the world will be explored further in the appendices, but it is a feature which might best be researched in China or possibly in Japan as it lies outside the scope of this thesis.¹¹³

1.2.7 Nail origins in the Western World

Within Europe there are few resources available for researching pre-Roman wrought nails, but the museum at St Germain-en-Laye collection shows the fine art to which iron working had been brought by the Celtic Gauls. These include chariot fixings such as wheel rims secured by iron nails, and hub reinforcing rings, from the 5th century BC.¹¹⁴

Somewhat older wrought iron nail remains can be found in Greece circa 600 BC¹¹⁵ and earlier copper alloy nails, capable of being driven by hammer, appear in ancient Egypt around 1250 BC and 1400 BC.¹¹⁶ However, it was Roman industrialised nail-making and its organisation which set standard forms for nails, and it is this combination of Celtic know-how and Roman organisation which we know best. A more detailed analysis of Roman organisation of the iron and nail industries appears in Appendix IV. This explores the enormous range of Roman influence, outside the empire's nominal borders. Aspects of this phenomenon will be mentioned in 2.1.2 and some have already been covered in the author's paper on votive and magic nails.¹¹⁷

1.2.8 Sawn timbers dictating nail specialisation

Fragments of Roman saws appear all over Europe and sawn timber was in wide use as seen from several excavations, even in the Cannon Street burnt remains of *Londinium* after Boudicca's raid and arson of 60 AD.¹¹⁸ Sawn timbers imply greater use of nails and as part of the study samples from several Roman sources have shown significant proportions of common nails in the sizes expected for fixing sawn planks. They have also produced many clenched and double clenched nails of sizes common to simple plank doors.

The Pont du Gard Museum has a Roman tombstone which shows trestle sawing in progress, Fig. 31. However, the Empire was contained within the fortified customs barrier of the Limes, such that it is to the north of this line that hewn construction predominated right through to industrial times, Fig. 31. Parts of southern Germany retain aspects of Roman timber walling (*Bretterwand*) in *Allemanisch* framing,¹¹⁹ whereas above the Limes this tends to not be present in Saxon or Frankish framing.¹²⁰

Rome's influence did not stop at the Limes as trade contacts reached well up into the Baltic. fig. 31.¹²¹

¹¹³ Professor Pan is aware of the current blanks in the history of Chinese Empire nails and has taken this aspect on board as part of her framing course.

¹¹⁴ From tombs at Jonchery-sur-Suippe and La Gorge-Meillet, both in the Marne region.

¹¹⁵ SHARP 2011, 1029-1041

¹¹⁶ PEPLAR-HARCOMBE 2011

¹¹⁷ HOW 2018b

¹¹⁸ PERRING 2002, 98

¹¹⁹ SCHAEFFER 1937, 79

¹²⁰ SCHAEFFER 1937, 16-73, 74-81.

¹²¹ GLOB 1972, 92, 93, 100.



Fig. 31. Roman trestle sawing and the timber conversion divide set by the Limes frontier. The green stars indicate the extent of Roman influence found in artefacts located well to the north of the Limes.

In addition to the historical precedent, nail usage, especially the shank aspect ratio, tends to be indicative of the predominating timber type of the region. Transport of timber over large distances was rarely done except by conversion to planks for wainscoting and transport by ship and by barge was strongly preferred. Daniel Leloup paints a morbid picture of the difficulties involved in transporting timbers by road (as well as their rarity in long lengths), and how these factors preferentially dictated modifications in framing design.¹²²

Using a concept proposed by Hoffsummer an approximate idea of nail design relative to timber, - either softwood or hardwood, - which can be estimated via natural forest areas, fig. 32.¹²³

¹²² LE LOUP 2007, 22-26 & 13-15

¹²³ HOFFSUMMER 2014, 127

Forest & trees used in framing circa 1100 AD



Fig. 32. Local timber availability based on travel observations. Author

Nail typologies on softwood zones tend to follow a trend towards more slender shanks, yet while the softwood/hardwood divide is an approximation, there are some surprises. The effect on nail design is most clearly seen in the Baltic States and in Sweden where historically very long and tapering shank nails were used. Many of the Latvian samples displayed a pronounced curve when extracted, fig. 28, second nail. The author's colleagues in Riga suggest that the long taper was intended to deflect laterally as it ran against the curve of the hard summer growth rings of the timber. ((Normally *pinus sylvestris*). The author's Swedish colleagues, both of whom are carpenters, describe a slight deflection is first put on the end of the nail point to encourage such a skew off the direct line, thereby increasing withdrawal strength. A similar phenomenon was observed by Leonardo Da Vinci, fig. 33.¹²⁴

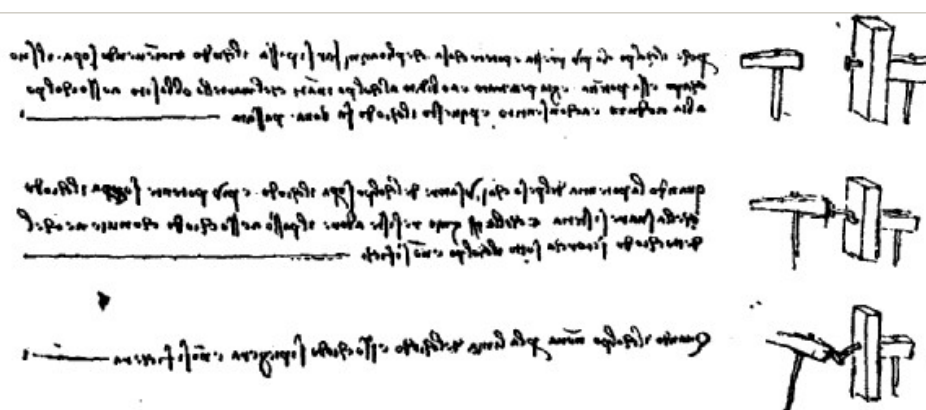


Fig. 137. — Fragment de manuscrit de Léonard de Vinci, relatif à l'enfoncement du clou. (Manuscrit C (vers 1490). T. III, folio 22 recto.)

Fig. 33. Extract from *Le Clou* (1912) showing the da Vinci sketch.

¹²⁴ FREMONT 1912, 55

Charles Frémont appears to be the only researcher to have commented on this peculiarity of carpentry practice, or to have correctly identified Da Vinci's diagram. The Swedish comments allude to bending the end 5mm of the nail tip prior to driving. The comments on driving modern nails in softwood coming from Latvia are shown in fig, 34. This is very similar to the procedure shown by Da Vinci. The method would not be suitable when using hardwoods since stronger shanks would have to be used and hardwoods are more uniform in strength between Spring and Summer growth rings. With some practice it is possible to identify these unusual Baltic nails. Recording the methods used is pertinent to the state of the art achieved by this phenomenon, albeit in a relatively restricted area.

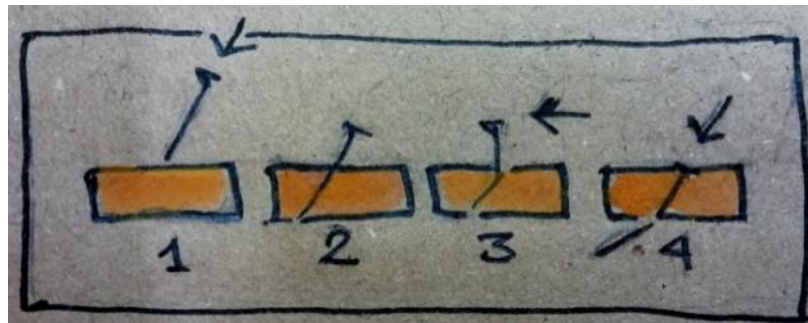


Fig. 34. Sketch of deflected driving of nails used in Latvia. Courtesy Heritage Architect Arturs Lapins.

In France there is a noticeable change between forged common nails used in the north and those of the Midi. Many of the Midi nails, used almost exclusively in softwood, are quite spindly, fig, 35. The Normandy sample came from an oak waling strip fixed to oak bearers.¹²⁵



Fig. 35. Common nail, 1684, Le Petit St Jean, Pertuis, Provence, and from Les Autels St Bazile, Normandy, circa 1720. Author

The noticeable 'downgrading' and sparing amount of metal used per nail in the Midi poses another question, since Provence was a late comer to France, not fully incorporated until 1486 on the death of King Rene. Provence exhibits various degrees of independence both in construction, language, and in design elements. Daniel Leloup has shown how framing follows the language frontiers within France.¹²⁶ It thus seems possible that nail making also followed on similar lines with territory south of Clermont Ferrand not seriously affected by the Isle de France guild rules, , fig. 35,.

¹²⁵ HOW Unpublished, 30

¹²⁶ LE LOUP 2004, 7-9

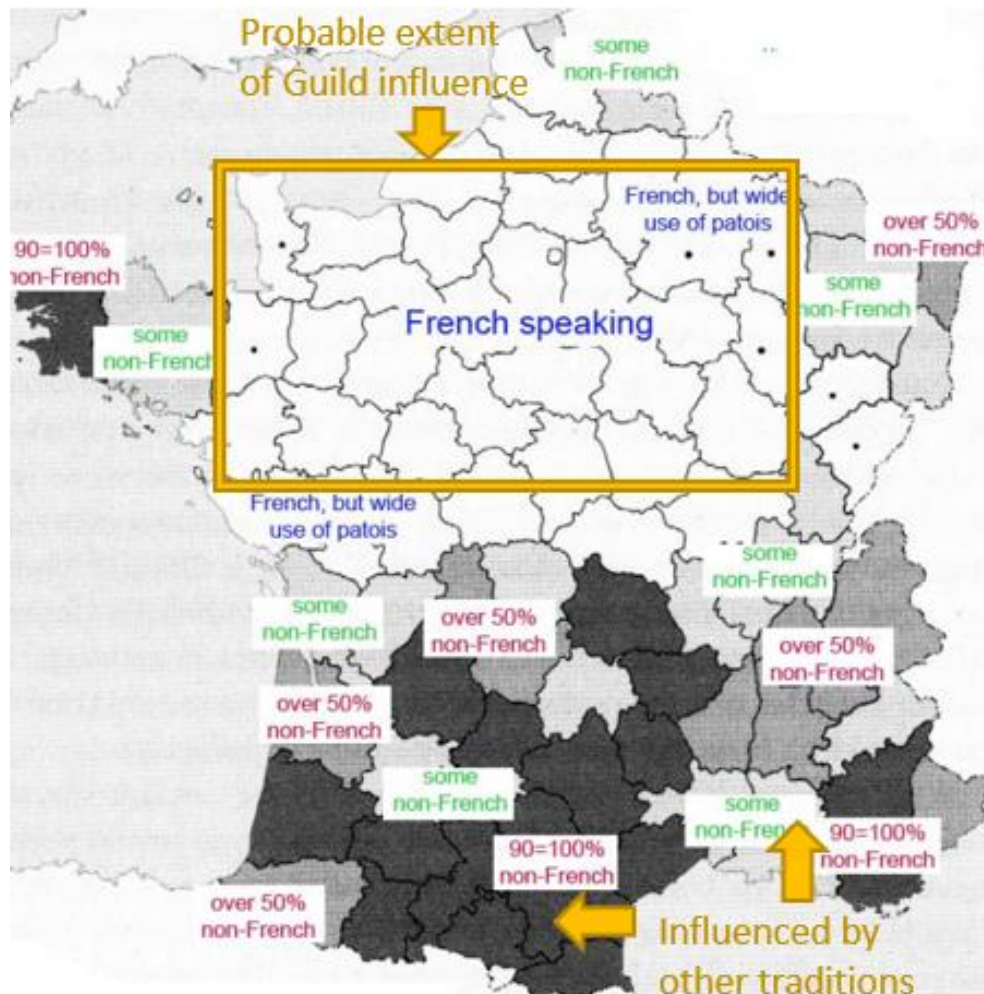


Fig. 36. Language distribution in post-revolutionary France based on Robb.¹²⁷

1.2.9 Medieval nails

Medieval European construction was carried out at two very different levels of society with Church and Royal construction taking precedence, followed by that at small town and rural level. Likewise many of the nails also fall into two categories:

- Those high quality, carefully made, and often elegant ones, such as the one recovered from Salisbury Cathedral, as seen below, fig. 37 top left, and bottom left.
- The crudely made local blacksmith variety.

The difference is more marked in the English specimens recovered so far, but the selection of Belgian ones recovered have mostly come from ecclesiastical properties. Medieval nails found in England are almost impossible to obtain in reasonable condition as they usually display severe weather degradation. Only one early medieval nail in identifiable condition of circa 1320, coming from the Muniment Room roof in Salisbury Cathedral, was found in the archives of Salisbury and South Wiltshire Museum. Other unprovenanced finds appear in the Museum's illustrated catalogue and appear as archaeologists' sketches of the objects which fail to convey the forging features as these can normally only be seen after careful cleaning. Another crudely made nail was

¹²⁷ ROBB 2007, 67

found in the 1410 section of the roof to Tower House at Wells, a former diocesan house for the Cathedral School headmaster. Two crudely made rafter/plate scotch¹²⁸ nails, possibly 1495, were recovered by the Weald & Downland Museum head carpenter from a house in Chichester.¹²⁹



Fig. 37. Salisbury Cathedral Muniment room roof 112mm nail and one from the spire, both circa 1310 on left. Tower House discarded roof nail, 1410, and rafter scotch nail circa 1495 Chichester on right. Author.

The problems of finding medieval nails in recognisable condition had to be resolved from outside Britain. Belgian sources of medieval nails are more plentiful and in better condition than English ones, and gracious assistance was provided by the author's colleagues in Liège, and from contacts in Germany and in Riga in finding provenance samples. In their typologies these reveal to some extent the close ties England formerly had with the continent, reflecting in a uniformity of nail types across Western Europe. This contact lasted until 1564 and included a major part of what has since become France.

Even so, some of the earliest samples in interpretable condition came from two other sets of samples, circa 1180, from excavations in *Marstala iela* (Butcher Street) in Riga, Fig. 38. Identification was made possible by a peculiar set of ground conditions which led to them being preserved by the formation of a crystalline phosphoric compound, Vivianite,¹³⁰ onto the iron surfaces. This then provided protection against rusting, fig. 39.



Fig. 38. Finds from 17 Marstala Street on left and 19 Marstala Street, Riga, on right circa 1150 and 1180 respectively. Photos: Arturs Lapins.

¹²⁸ Prior to birds-mouthing rafters over top plate, triangular sockets or 'scotches' were used.

¹²⁹ The former head restoration carpenter, Roger Champion, salvaged these from a bin during house renovation by local builders, and the author is indebted to him for these two samples and the date estimation.

¹³⁰ HOW et al 2016, 124-128. I am obliged to Dr Dirveiks in Riga for this observation.

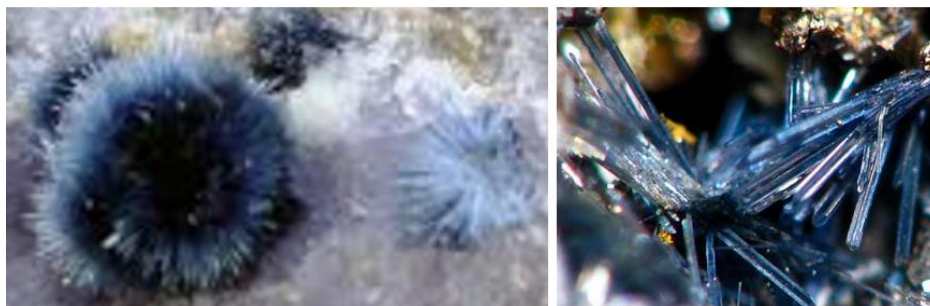


Fig. 39. Hydrated iron phosphate, Vivianite, growths enlarged under microscope. Source: Google.

Nails having a blue furry appearance are found in excavations in the silty soils around Riga, which contain organic materials with residual phosphates. Such nails are known as ‘blue nails’.¹³¹ The blue coloration remains even after cleaning as can be seen, fig. 38, second group.

1.3 ADVENT OF CHANGES IN NAIL SHANK CHARACTERISTICS

A curious phenomenon resulting from the Roman tradition persisted in Europe until relatively recent times. This was a fully tapered shank which tended to be the norm in medieval wrought iron nails,¹³² but as seen in the *Grande Encyclopaedie*,¹³³ it persisted in the Isle de France guild dominated nail workshops up to the French Revolution when guilds were then abolished by the *Loi Le Chapelier* of June 1791.¹³⁴ (See Fig. 40 below). The evidences and arguments for this tapering effect are discussed in Appendix II.) The tapering effect was by no means absolute, even during medieval times, as seen above, (Fig. 37), but a firm belief that modern replicas of historic nails should have tapering shanks persists in France even until this day, fig. 40.



Fig. 40. Replica ‘medieval’ nail by A S Metaux, Les Milles, Aix-en-Provence. May 2019. Author

1.3.1 Changes in shank due to development of the slitter

The stories concerning the origins of the slitting engine are a quagmire of myths and false leads which have taken years of difficult research to untangle and it is incumbent on this study to set the true record in proper order. In particular the relevant dates which are likely to apply to changes in nail shanks. There still exists an active tug-o-war between protagonists supporting the eminent Welsh writer on engineering history, Rhys Jenkins, whose researches were first published in 1915, and other claimants. Most of the other factions are locked into Howe’s 1631 edition of Stowe’s

¹³¹ Dr Ilmars Dirveiks of *Arhitektoniskas izpetes grupa*, Riga, drew attention to this phenomenon, April 2014.

¹³² Nails from the vault debris, circa 1330, shown in the Palais des Pape Museum, Avignon, show full taper.

¹³³ DIDEROT 1790, Vol II, Plate 20. See also HOW 2017, 28, 29, 30, 34, 36, 37 for nail examples.

¹³⁴ CARAMARI 2014, 240 The *Loi* banned guilds, campionage, and workers strikes, but it was not repealed until 1864 even though Chapelier had been sent to the guillotine in 1794.

Annals, which first suggested that a Flemish refugee, Godfrey Box (*Geofroy Buchs* or *Godefroi Boche?*), built a slitting mill at Dartford in Kent: [Box]... *set up the first mill for that purpose neere Dartford in Kent*. There are numerous other claims, many of which are patently spurious, which will not be given light here.

The full story of the slitting engine is set out in Appendix III and it begins on 26th August 1567 with a hand written note issued under the Queen's 'placarde'.¹³⁵ This came from the Lord Chancellor of England's residence at Gorhambury, near St Albans, and introduces Peter Anthony van Ghemen with his company. The name suggests he may have been from Brabant and he is described as being a subject of the King of Spain. The note sets out a series of claims by Van Ghemen to expertise and inventions in a wide range of fields.

Van Ghemen was welcomed by Elizabeth's government. Since 1565 they had been desperately trying to resolve the production of iron wire needed for carding, which had become urgent after the loss of wool sales to Hainault and Flanders¹³⁶ following unrest in the southern Lowlands.¹³⁷

A trial pilot plant for drawing iron wire was in hand at Tintern Abbey in south Wales, under the metallurgist and assay-master William Humfrey. In 1567 Humfrey had imported a Westphalia finery expert, Corslett Tinkhaus, to resolve issues with poor iron quality. His intended task was to make Osmond iron at Rhyd-y-Gwern, Glamorgan, thirty two km south of Tintern.¹³⁸ Humfrey was in partnership with the Saxon metallurgist, Christopher Schütz of St Annenberg, a disciple of Georgius Agricola.¹³⁹ In 1565 they received two joint Licences for the mining of ores for brass production in relation to the drawing of brass wire at the Tintern Abbey. These became the basis for a patent of incorporation of the 'Mines and Battery Company'.

It seems probable that it was Humfrey's social superior, Thomas Gresham, recently the Antwerp factor, who had presented Van Ghemen to the Lord Chancellor, Willian Cecil. Hence the top-level government note, from which it can be assumed that Van Ghemen had gone to Tintern in order to build the cutting machine as a necessary precursor to the drawing of iron wire process.

1.3.2 Van Ghemen's special licence

A few months after the grant of the Humfrey-Schütz licence, a twenty one year special licence, Number XVIII, was granted to Van Ghemen on 26th August 1567, which involved '*the cutting and tempering of iron*'.¹⁴⁰ The coincidence of dates and the licence description confirms these were adjunct processes to the wire mill since substantial quantities of prepared iron rod stock would have been needed to keep pace with the mechanical process.

Van Ghemen disappeared from further reports and his absence coincided with the start of the tragic civil wars in the Lowlands. There appears to have been an element of subterfuge by the English government who sent the experienced Saxon engineer, Christopher Schütz (alias 'Jonas'), and his

¹³⁵ Calendar of Public Rolls Elizabeth I 1566-1569

¹³⁶ The ancient and semi-independent cloth towns, traditionally sympathetic to England, were clustered around the current French/Belgian border. Louis XIV took several of them in 1667 for his expansion of France.

¹³⁷ HOW 2015, 81-90

¹³⁸ McNEIL 1996

¹³⁹ BEVAN 1878, 30. This records how W C Aitken, writing circa 1860, attributed the slitter to Schütz.

¹⁴⁰ WYMDHAM HULME 1896, OLL 53

younger English associate, Bevis Bulmer (1536-1615), to oversee the completion of the development of the engine later that year.¹⁴¹

1.3.3 The eyewitness reports

The next step in the evidence trail is an eye-witness account of 1576,¹⁴² of the slitting mill site near Dartford in Kent by the lawyer William Lambarde. His eye-witness report is discussed in detail in Appendix III, but the salient point to note from is the reference to *barres for windowes*. This suggests dimensions of 8-9mm square was achieved:

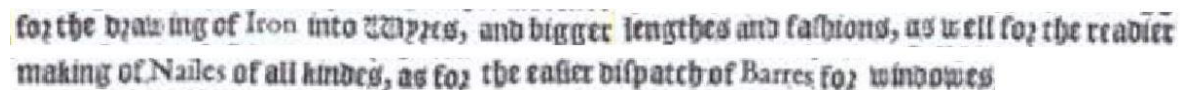


Fig. 41. Excerpt from 'Periginations through Kent', page 453. Cambridge Library edition.¹⁴³

Resolving the need for a controlled site close to London lay in the availability of the two mills on land owned by the Crown, situated on the River Darent and on its parallel leat. Both of these were in proximity to the nearby settlements of Hawley and Sutton at Hone.¹⁴⁴

1.3.4 Slitting machine patent summary

In December 1588, a patent for 12 years, Number XLV, was issued to Bevis Bulmer for a slitting 'engyn', some three months after the expiry of Van Ghemen's special licence. A patent extension was granted to Bulmer in 1606, after Elizabeth's death, on the basis of improvements to the slitting engine and he was knighted in the same year. His 'mechanic' Godfrey Box (a Fleming) had died in February 1603 and Bulmer had appointed Clement Dawbeney to take over. Dawbeney may have been Bulmer's illegitimate son, as the patent rights were transferred to him in 1608, prior to Bulmer's death. In 1616 Dawbeney was called in but was granted a further patent extension.¹⁴⁵

1.3.5 The False Trail of Godfrey Box

It is frequently claimed that both the slitting machine and Box came from Liège. Although challenged by several authorities since 1918, it continues to be quoted as fact. The scenarios involved go against the run of events taking place west of the Liège which are also discussed in Appendix III.

1.3.6 The Liège slitters

Bearing in mind the 1576 observation and the probable earlier machine at Tintern¹⁴⁶ the claim can be dispensed with, since the late Georges Hansotte has researched this very point:

'Le début de l'expansion de la clouterie liégeoise, a la fin du XVI e siècle, est lié a une innovation technique : l'adaption de la « fenderie », engin capable de produire mécaniquement les « verges » ou baguettes du fer qui servant a la fabrication des clous. Jusqu'alors, ces verges étaient faconnées au marteau, par un procédé beaucoup plus long et plus couteux que le « fendage » mécaniques. C'est entre 1583 et 1587 que sont construites, sur la Vesdre et la Hoëgne, les quatre plus anciennes « fenderies » connues du pays wallon.

¹⁴¹ JENKINS 1971, 15

¹⁴² LAMBARDE 1576, 453

¹⁴³ "for drawing of iron into wires, as well as the readier making of Nails and dispatch of bars for windows."

¹⁴⁴ Appendix II shows the two mills and their locations.

¹⁴⁵ SPEDDING 1872, 135 "Mr Attorney's certificate touching the Patent for slitting iron bars, Jan 27th 1616."

¹⁴⁶ One source says that the Tintern slitter ran from 1580 – 1591. (Early Modern History: Metal Working). This is after the first sighting at Dartford, but an absence of earlier records may be due to official reticence.

Huit autres sont aménagées sur l'Ourthe et la Vesdre au cours du XVII^e siècle'.¹⁴⁷

These dates are later than the process licensed to Peter van Ghemen in England in 1567. There is a later claim that the invention of such a machine originated near Liège, by Dwelshau vers-Dery, but this does not appear until 1744:

'C'est a cette province [Liège] de tous temps fécondes en habiles artistes que l'on est redevelable de l'art de fender le fer, c'est-a-dire de la réduire a peu de frais en baguettes fort mince. Un ouvrier appelé Gisard est l'auteur de cette invention'¹⁴⁸.

No date is given so the statement fails to be convincing. Franquoy, however, is categorical that the engine originated in England:

'Il parait que les premières fenderies furent établies à Dartford, en Angleterre, vers l'an 1590 : mais s'est au Pays de Liège qui revient certainement l'honneur de leur introduction sur le continent.'¹⁴⁹

1.3.7 Visual signatures and dating

Changes in nail morphology would have taken some time to make an effect since it took time for the invention to spread. In both countries (England and Belgium) early samples show how the nails rapidly modified due to the new form of supply as nail rod, as shown in find and replace 8, top centre. As already mentioned above, this change in technique did not occur in northern France. A suitable time frame of between 1590 and 1610 might be appropriate from an identification viewpoint. The shear burrs left by slitting can often be seen on the upper unworked length of nail shank. Franquoy reports that the first slitting mills in France were established in Lorraine in 1617.¹⁵⁰ This seems a little later than expected and out of character with French enthusiasm for new technologies. By 1626 help from Liège with this new technology was sought by Sweden.¹⁵¹

1.3.8 The multi-purpose 'Oliver'

The third exemplar of the determinant events shown above, Fig. 6, affecting the history of wrought iron nail manufacture, the 'Oliver', had a chequered career. It started as a large hammer mounted on a flexible sapling pole during the Middle Ages.¹⁵²

¹⁴⁷ HANSOTTE 1972, 4. "The start of the Liege nailery expansion at the end of the sixteenth century lay in an innovative technique: the adaption of slitting, a machine capable of producing wands or bundles of iron serving to assist the making of nails. Until this point these 'rods' were fashioned by hammer in a long, more costly process than the mechanical one. Between 1583 & 1587 these were placed on the rivers Vesdre & Hoëgne, the four most ancient slitting mills known in Wallon territory. Eight others were arranged on the Ourthe & Vesdre later in the seventeenth century".

THOMASSIN 1879, 439 tabulates four slitters on these rivers, with an output of 5280 tonnes of slit rod per year prior to 1780 or so.

¹⁴⁸ JENKINS 1971, Note 3

¹⁴⁹ "It was in this province, Liege, at all times fertile & skilled in art that there came an improved method of mincing iron, that is to say, reducing the iron into finer pieces in bundles. A worker called Gisard was the inventor of this process". FRANQUOY 1861, 63. Translation by author.

¹⁵⁰ "It appears the first slitter was established in England at Dartford towards the end of the 1590s: however, the honour of introducing it to the continent should be accorded to the state of Liege". FRANQUOY 1861, 63. Translation by the author.

¹⁵¹ YERNAUX 1939, 76: Louis de Geer and Henri Daniel set up the first Swedish slitting mill.

¹⁵² HOW 2018b, 765-761: HOW 2017, 81-88

In its simplest form it transferred across to meet the needs of the trade for flattened nails used in linings. The earliest samples of these distinctive nails, Fig. 42, found so far date from circa 1700, and these rapidly grew more widespread. In each case the flattening is done with a single blow of a very large hammer apparently after the individual nail (normally a common) had been heated. None of the samples show cold fracture, fig.42. No images of these earlier Oliver devices have been found.



Fig. 42. Flattened nails circa 1715, Wells; c1680 Brecon Powys; 1780, & Harley Street, Westminster, 1784. Author

However, both the Avoncroft and the Black Country Open Air Museums have original Olivers from a later period, circa 1860 -1880. The Avoncroft version provides two pedal operated hammers, one of which has a simple flat face, the other is capable of being fitted with changeable dies for heading purposes.¹⁵³

A further development, the 'stiddy' or 'tommy hammer', forged a point and a head at the same strike of the hammer.¹⁵⁴ This was done by placing a heated offcut of nail rod in the 'stiddy', which was a vertical mounted mould. This version can be dated with some accuracy because of a strike by the nail-makers at Belper in Derbyshire in 1872.¹⁵⁵ It had already been successfully introduced for making medium sized spike nails, fig. 43, in the Black Country around Birmingham. Its introduction there may date from circa 1850, fig. 43.



Fig. 43. Stiddy spike, Telegraph Station, Port Fairy, Victoria, 1858. Author

A significant number of datable samples suggest it was used well in advance of this as a die-heading device for the production of slating nails. To minimise interference with the slate the heads were made flat, like to a tack, and round. So far the earliest Australian source has been 1836, (see **N 28** nails 3 and 4), but identical nails were shown in the Royal Engineer's tender document of 1811 and were itemised as numbers 70-72.¹⁵⁶

¹⁵³ HOW 2017, 82 Fig. 1

¹⁵⁴ HOW 2017, 82 & 83, Fig.s 1 & 2

¹⁵⁵ BARRAS 1988, 15 & 16

¹⁵⁶ BUGGEY 1976, 89-118

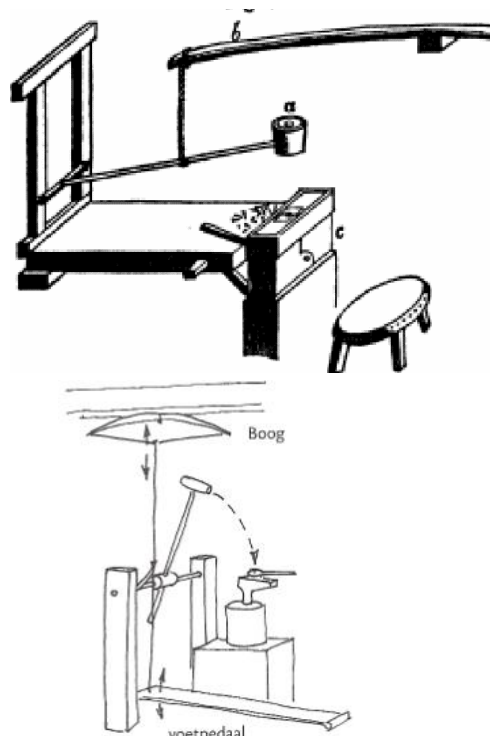


Fig. 44. Oliver with two hammers at Avoncroft Open Air Museum. The die header is on left & the plain face hammer for flattening nails is on right, circa 1880. (Author). On the right hand side is a bench Oliver for tack nail heading after Lardner¹⁵⁷, top, and a *Smeedhammer* by Janse, bottom.¹⁵⁸

An earlier simpler form, in which an operator sat at a bench and held the head of the nail shank with a clamping handle using the left hand, pulling down the oliver hammer with the right hand, is shown by Lardner as an appurtenant to the Wilmore and Tonks patent of 1808. The small nails, or tacks, would be cold-headed, fig. 44 top right. Janse shows one adapted as a plain faced *smeedhammer* whereby a hand held die is applied prior to the strike of the for nail making, fig. 44, bottom right.¹⁵⁹

1.3.9 Wigzell's twisted nails

Montague Wigzell of Exeter invented a machine for twisting standard production nails for which he obtained two British Patents, Number 14 of 1859, and Number 1369 of 1861. He established a factory at Topsham near Exeter to make these machines.

By chance, a half bucketful of wrought and cut nail twisted samples was found at Glastonbury in Somerset. Several of these had been driven after twisting as timber fragments were found adhering to some of them. It is possible to see the holding pinch marks on the nail samples¹⁶⁰ and from the multiple twists in some of them it seems these were first heated prior to being placed in the machine, fig. 45.

¹⁵⁷ LARDNER 1849, 208-209

¹⁵⁸ The anvil is similar to one shown by Amman's *Staende und Handwerker* of 1568, (JOHANNSEN 1925, 52).

¹⁵⁹ JANSE 2002, 22

¹⁶⁰ See Fig.61 for further interpretation.



Fig. 45. Two wrought spur head floor brads from the Wigzell examples recovered in Glastonbury. Author.

Although this is not a datable or useful change in itself, partly due to the scarcity of samples, it sets in place a trend for twisted nails influencing the nail industry both in Britain and America, and patented deformed nails appear in both countries later.

1.4 REVIEW OF INFORMATION SOURCES

A broad outline of the available literature has already been provided in the Introduction which will not be repeated here. The essential thing to note has been the need for a multi-disciplinary approach to the study using a wide range of sources, to provide answers as to why nails segmented into their main groups and thence into sub-groupings. The answers which follow in Chapter 6, go a long way towards explaining how nail shapes have evolved the way they have. However, the desired goal of dating depends on achieving a firm grasp of the context of nail morphology and idiosyncrasies. At present, the only writings covering aspects of dating have come from the author,¹⁶¹ and from Varman's thesis of 1996,¹⁶² which includes a page of his own sketches of wire nails.¹⁶³

As already discussed above, nail-making within the southern German States clung to a core belief in a strict guild system (as in the Isle de France), centred on Nuremberg, Regensburg, and Munich.¹⁶⁴ Christoff Weigel strongly implies that guild trained nailors were able to move around the other German States seeking work. No other information has so far been uncovered from other German writers relating to how the nail trade operated elsewhere, but Krünitz demonstrates the wide range of nails available in Saxony in the late 1770s.¹⁶⁵ Since no other translation exists of the critical document, a basic translation of Weigel's description of the trade, made by the author, is included in Appendix I. The first thing to notice is that although the Steiermark (around Graz in Austria) is mentioned in connection with the *Zeinhammer*, no claims are made concerning the other States of northern or eastern Germany, thus leaving an element of doubt as to whether slitting or the *Zeinhammer* prevailed in northern and eastern Germany. The reader will have already noted the links between England and the protestant States such as Saxony, Hanover, and Westphalia. Without data about a more widespread distribution of the slitter in northern Germany it is difficult

¹⁶¹ WOOD 2013, 605-613

¹⁶² VARMAN 1993, 182

¹⁶³ Varman's thesis relates to the post 1788 period & is geographically limited to Sydney and environs.

¹⁶⁴ WEIGEL 1698, 388

¹⁶⁵ KRÜENITZ 1777, 618-635, and 687

to otherwise explain the distribution of samples found in the field in Denmark and Latvia *Courland*, fig. 28: second nail.

The best descriptions of both the wrought nail making process and that for wire nails comes from the French encyclopaedists, whose passages are now translated into English.¹⁶⁶ The origins of wire nails have also been explored through the French '*Brevets d' invention*',¹⁶⁷ but to do this involved the difficult task of negating one of the treasured pervasive myths: that American know-how was involved in the first French wire-nail making machine.

The most relevant original historic documents, those pertaining to nail names and shapes form the basis of Table 2.2 in chapter 2 which sets out a comparison of nails according to their strength category. It was found that many nail types escaped clear identification and so the very late (1940) Naish collection source was photographically recoded as it was necessary to confirm and back-up written sources such as Neve. It is also clear that many names used in some historic lists were strictly local and these lack mainstream confirmation.

A list of sources, such as museums etc, providing details of nails and nail-making has been placed in Appendix I. As noted above, there are numerous populist references to be found on the internet, which tend to churn out simplistic and inaccurate information that is not worthy of serious study. Thus, only those sources containing hard data have been admitted to the list. It should be noted that a list of documents exists, albeit somewhat out of date and aimed towards an American audience.¹⁶⁸ There are no images in this document as it deals with sources from an American perspective. (There is, however, an excellent resume which would be useful to explore elsewhere.) It can be used to select useful sources which might pertain to a more global scene and many of these sources had already been used and acknowledged within the body of this thesis.

This brief review of identifiable changes affecting European nail-making is, of necessity, incomplete, but as so much of this has not been collated before it constitutes a step forward in construction history and fills part of the aim of arriving at a dating system. It is unfair to our Flemish colleagues in that the author is ill-prepared linguistically to source and sort the necessary documents. This remains a project set aside for some future studies. Likewise, very little has come up for review in respect of southern Europe. Because of the dominant position of Spanish steel and nail-making during the late middle ages, the author has briefly discussed this with Professor Santiago at Madrid University. He sees this work as being on a far horizon at the moment. The same criticism of neglect could be levelled by our Italian colleagues and the author has presented his concerns with Prof Pietrogrande at Padua. It seems obvious that some high class nail-making was being pursued in connection with the building boom of the Medici Popes etc, but lack of language skills, and lack of opportunity, regrettably precluded study in this direction also.

1.5 SUMMARY

In summary, the research presented in this review provides a tolerable assessment of the research at the present time in terms of volume of nails fabricated within the nominated study period, albeit with some omissions which lie outside of the construction industry.

¹⁶⁶ HOW 2017, 23- 48, 105 – 111

¹⁶⁷ HOW 1018, 345-356

¹⁶⁸ KREILECK 1999, 1-27

The next chapter will examine the state of the art reached, and how, and why, this study has taken the various directions. Not all of these have been successful per se, but as pieces of a mosaic, they contribute to building world knowledge of this under-studied branch of construction history.

Chapter 2: Research Background & Methodology

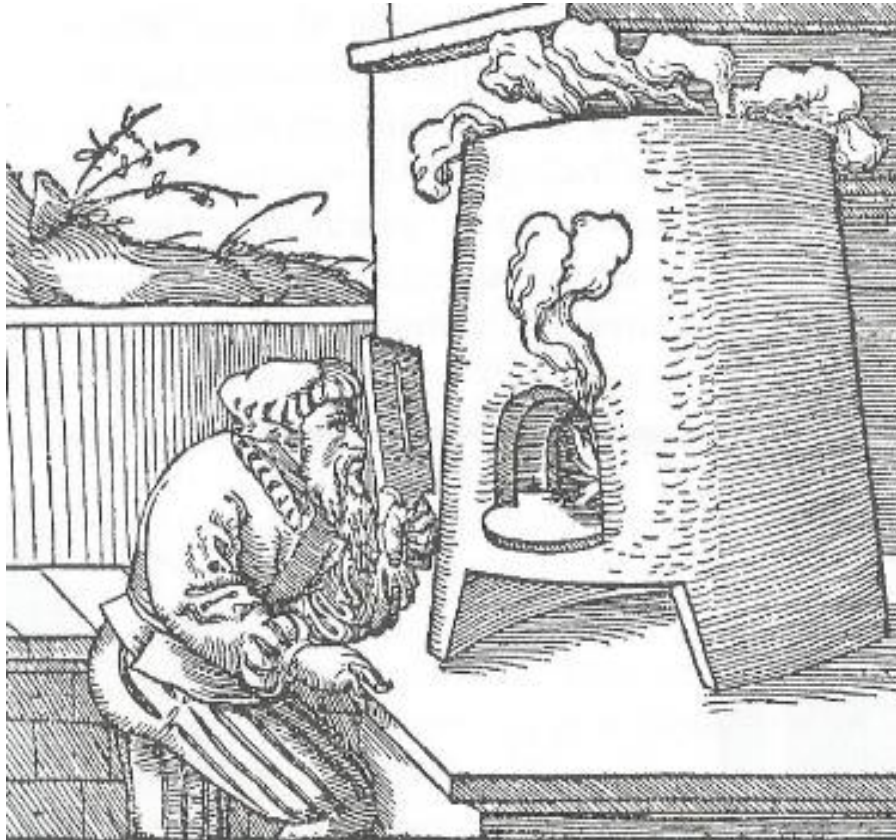


Fig. 46. Assay methodology from *De Re Metallica*, AGRICOLA 1556. Book VII.

CHAPTER 2: RESEARCH BACKGROUND & METHODOLOGY

These are a Material so well known, that they need no description. Richard Neve. 1703.

Les clous sont trop connu pour que j'en donne aucun détail, ---. André Jacob Roubo. 1769.

OVERVIEW

This chapter introduces the reader to the difficulties involved in gathering and grasping the subject matter of the study. It proceeds to detail the way in which the various gaps in existing information have been filled and how these have been made available in a series of papers to practitioners in the heritage and conservation fields.

It uses historical texts to probe how different nail grades, pertinent to their applications applied in a surprising continuity of terms for across Western Europe.

It describes how the preparation and storage of samples was done and how diagnostic features found on nails, or parts of nails, assist in their identification and to what use the nails were put. It describes how test programmes were undertaken on historic samples and how these relate to earlier historical tests made.

It concludes by describing how the research methodology was adapted to achieve a dating system based on nail spectra within a building, extension, or a repair.

2.1 A RATIONAL APPROACH

Research has focussed on the primary objective of noting datable changes to arrive at a system for dating buildings, in whole or in part, such as in later extensions or repairs. To do this there has been a need to seek out changes in fabrication techniques affecting nail morphology. To note change it is of course first necessary to have a clear image of what constitutes a normal pattern of use for any period. As part of the methods used to build the basic research base chapter 1 has set out seven step precursors to the construction and development of a matrix diagram. The matrix becomes the key to unlocking the skeleton supporting this seemingly impenetrable mass of data, fig. 47. In the case of British (and hence Australian) nails there is excellent resource in the form of listed patents which have run since the Tudor period. The American patent system, although essentially a repeat of the British, had the unfortunate incident of a fire of 1836 in the Patent Office destroying most of their early documents¹⁶⁹, which although supposedly made good since, has left some lingering doubts on some specifics.

From the beginning of the study it was clear that a significant review would be required from as much data as could be obtained from both written sources in English, French, and in German, as well as from actual field samples. It was also clear that a significant amount of revision would be necessary in order to dispel some entrenched myths.

The author was in the fortunate position to be able to visit large numbers of heritage buildings as part of his professional work when historic material was being exposed and often being removed. On the other hand, initially most structures examined were in Australia with its short history regarding nails.

¹⁶⁹ There was a second fire in the US patent office in September 1877.

Using the author's contacts in Britain, France, and Germany, it was also necessary to accumulate material from these countries, and by happenchance, from Denmark and Latvia also. As far as possible this was done at source by the author. A full inventory of the nails collected, and also nails examined is given in Appendix I which also sets out the parameters used in arriving at an estimation of sample dates.

The second dominating priority was the need for a visual index of historic nails. Such an index does not exist but using a long term opportunistic approach it has been possible to go a long way towards this objective, albeit at the cost of a long period of assembling samples and data.

A third objective has been to probe antiquity for traces of a descent path for the morphologies which later developed. This incurred a small digression into nail finds in the Far East, with respect to China and Japan. From this aspect developed the surprising conclusion that only two main technologies affect the historic pattern of wrought iron nails worldwide.

Lastly, the data revealed by the study demonstrated the need to set within the framework of the study objectives how the American cut nail really developed (as opposed to some optimistic presentations of its history). This in turn drew forth a further surprising conclusion that effectively only three main nail centres operated on a worldwide basis: the Liège industry, the British, and the American industry.

2.1.1 Methodology and sources

Given that no perfect assembly of samples and facts would ever be possible with such a wide, multi-disciplined approach, and facing a finite term for exploration, it was clear that research needed to proceed along the lines of probing the various possibilities. The author's own limitations with respect of age, mobility, and language conversancy had to be factored in. This resulted in an extensive programme of:

(a) Fieldwork, laboratory work, testing, and recording

- Finding and cleaning samples for each decade since 1790 when nail patents first appeared.
- Obtaining samples from earlier years wherever possible.
- Observing nail distribution and photographing nails in buildings as opportunities occurred.
- Contacting owners of suitable ruined buildings for permission to make sketch surveys, photographic records, and to take nail samples.
- Seek out museums and archives with nail sources which could be photographed.
- Destructive UTS testing of historic samples on a limited scale.
- Commissioning and organising drawings of nail features and production methods.

(b) Document and literature review

This comprises the following:

- Searching out early manuscripts showing nail making and historical references. With the exception of one manuscript in the British Library and one to do with slitting research in the National Archives at Kew, all illuminated manuscripts have come from internet sources. The most informative, perhaps, being *Die Hausbücher der Nürnberger Zwölfbrüderstiftungen*, manuscript in the Staatbibliothek Nuremberg.
- Obtaining patent details for certain British and American types. These were acquired on a needs basis in connection with papers given at Melbourne University, Cottbus International Conference on Construction History, and the Construction History Society at Cambridge, between 2006 and 2019.

- Reading the available English literature relating to nail names and production. (A list of these sources appears in Table 4.2.)
- Selectively seeking out documents in German. This has been rewarding in the sense that many unknown details have come out of this line of research. The main German authors writing about nails comprise: Christoff Weigel 1698; Johann Zedler, *Lexicon*, 1732; Johann Krünitz, *Oekonomische Encyclopaedie*, 1799; Josef Wagner, *Das Hertzogthum Kaernten*, 1847; Ludwig Beck, *Geschichte des Eisen*, 1895; and Schoenermark und Stüber, *Hochbau-Lexicon*, 1905. Several other minor documents dealing with medieval nails were also found. The general background to iron is well covered by Otto Johannsen, *Geschichte des Eisens*, 1935, and remarkably contains information which has not shown up in general English texts, although critical to English history.
- Translating information on nails from French and Belgian literature and probing the on-line *Brevets d' Invention* in the Paris records. The French encyclopaedist writings relating to nails have been translated into English,¹⁷⁰ and much of the writing of the Belgian authority, Charles Hansotte.¹⁷¹ The other Belgian writers researched and translated include: Jean Franquoy, *La Metallurgie liegeoise*, 1861; Andre Warzee, *L'Industrie du Fer*, 1861; Louis Thomassin, *Memoire Statistique de l'Ourthe*, 1879; and Jean Yernaux, *La Metallurgie liegeoise*, 1939.

(c) Analysis and Cataloguing

Nails and associated items collected, as described in (a) above, were then sequentially reviewed and, where possible, these were matched to historical texts. Nails presenting similar morphologies were noted and named. Some of these present evolutionary changes which were noted for development of nail timelines. Draft evolutions of nail type, and progressions were developed, fig. 47.

2.1.2 Sifting and Sorting

The most important aspect, and the most time consuming part of this research, related to the first four research aspects outlined in section 2.1.1 (a). These consisted of obtaining, cleaning, logging and photographing specimens which is described in more detail below. They comprise a prelude to the interpretation of the data. In the search for small changes, the possession of a large range of samples of given provenance greatly improved the chances of identifying different techniques and nuances displayed by the particular nail. In most cases it was worth laying out the relevant exemplars in a time sequence, and sketching the points noted, much as was done in building the portfolio of nail sketches between the author and his illustrator, Iain McCaig.¹⁷² This was carried out over four years and involved visits to Bristol in England, the provision of 'ideal' specimens and numerous sketches, and then corrections by email. It was necessary to guide the pen and shadow phenomena used by the illustrator as even highly experienced people, well versed in technology, are unable at first to pick up the small nuances sometimes needed to identify and interpret changes.

In addition to these specific changes, interpretation of the data consists of appraising multiple facets. These can be summarised in seven main aspects:

- A simple grasp of names, purpose, and the likely size range for any particular nail.
- What was the predominant/expected spectrum for nails in each zone for any given period?

¹⁷⁰ HOW 2016, 23-65

¹⁷¹ HOW 2016, 78-83

¹⁷² The author was asked by English Heritage to provide a dating timeline for roof nails. WOODS & HENRY 2013, 605-614. Iain McCaig was their illustrator and his work greatly improved the author's own sketches.

- What changes to the pattern of nail common usage occurs, and when?
- Do existing nail types begin to appear in alternative settings and to new purposes?
- Do these changes relate to datable changes in building design?
- When do the changes in nail making metals first appear in field studies?
- Does the ore, smelting, and discovery background impact on field samples?

There is then a need to keep in mind the ever changing geo-political situations which often impinge on activating changes in both iron production and in nail making:

- Does the nail-making industry reflect geo-political events of the period?
- How do technological changes in themselves reflect the historical geo-political situation, and can these changes be dated?

An example of the first point is the assertion that Liège exported a slitting machine to England in the 1580s.¹⁷³ It is difficult to reconcile this with the politics of the immediate period since the State of Liège was then administered by the Church through the offices of the Prince-Archbishop of Liège. England was held to be apostate by the Pope who had excommunicated Elizabeth and her reign had been declared illegal in what amounted to a declaration of Holy War.¹⁷⁴ This escalated to active war with Spain then involved with suppressing rebellion and heresy in the adjoining Lowlands. Transport for heavy items from Liège was via the Meuse which flowed north into provinces engaged in civil strife. Normal trade via Flanders had ceased with the closure of Antwerp in 1567, which did not resume until 1606, after the King James VI ascended to the English throne as James I. The assertion is therefore more than just improbable, but impossible, since it would have involved the Archbishop of Liège breaking his oath of office. (A full account of the slitter development is given in Appendix III.)

An example of the second point is the stoppage of iron exports to Britain in 1705 and then again in 1715/16, as seen in Table 3.2 in Chapter 3.¹⁷⁵ This was resolved short term by Britain buying iron from Russia. In the long term the British accelerated their search for more efficient coking and smelting. This produced a series of minor improvements leading to the potting and stamping process of 1763. It was followed by the successes of the reverberatory furnace, using the reflected heat obtained from burning coal, and then the puddling process of 1784, discussed in 3.2.7 to follow.

In this regard it is pertinent to also quote the well-used commonplace of war economy acting as a stimulant to industry during the study period, which Richard Hayman seizes on with the near continuity of three wars in succession.¹⁷⁶ These periods were 1756-1763, 1776-1783, and 1793-1815, comprising the Seven-Year' War, the American Rebellion, and the French/Napoleonic wars respectively.

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¹⁷³ LEWIS et al. 2008, 67

¹⁷⁴ The Papal Bull *Regina in Excelsis* of 25 February 1570.

¹⁷⁵ HILDEBRAND 1958, 8-9; ASTRON 1982, 140

¹⁷⁶ HAYMAN 2005, 19

¹⁷⁷ ASHTON 1948, 90, disputes this nexus by using the march of patents as a yardstick. He stresses instead the interconnectivity of inventions clustered around this period, (Ibid, 82-89).

2.2 KEYS TO COMPARISON

The methods adopted in searching out changes involved establishing an insight into background conditions in nail uses and appearances (since all identification must be done visually to be of use to heritage exponents). The pioneers of identification-linked dating, such as Henry Mercer¹⁷⁸ and Trevor Nelson¹⁷⁹ in America, were aware of the need to concentrate on the fine detail. The European scene, however, displays a bigger picture, which had transferred to the American and to the Australasian colonies, in regard to wrought nails. To be thorough there has been also the need to probe this aspect of the longer history and wider geographical spread.

To enable penetration of this maze of information a large number of specimens was needed from a wide variety of countries before the emergence of even a glimmer of a path. As has been seen above, this was a cumulative process dependent on travel opportunities arising in order to acquire samples with the necessary provenance needed to establish dates. To arrive at an exemplar for the type of nail was a more complicated process since most nails recovered are defective in appearance even after cleaning. It will be appreciated that all nails get struck on the head (by inconsiderate carpenters), which frequently obliterates the head forging or formation marks. Heads exposed to the weather are invariably subjected to rusting which effectively wipes out the information needed. This aspect is further covered below and was the subject of a paper given at Capri in 2015¹⁸⁰.

The gathering of samples initially came from the three main pioneer areas of the Western District of Victoria in an area where the author had practised as a structural engineer: Portland, Port Fairy, and Warrnambool. This had two advantages: firstly, most of the builders involved in renovating historic buildings were known to the author and vice-versa. It was gratifying to see how quickly builders and tradespeople saw the importance of the study and then went to some lengths to supply samples. Methods of dating the age of the buildings is detailed in Appendix I which also discusses the sample treatment.

More than 15836 Australian nails have been retained in archived form whilst others have been left in-situ in a collection of historic timbers as this assists the understanding of nail distribution patterns. This aspect is only briefly alluded to within this thesis but several practices which relate to savings in the cost of nail can be noted up to 1860 or so. In England there is a similar trend in conserving the amount of iron used, as nails grow marginally in size after 1680 or so. There is a statistical aspect to the collection in that less than perfect samples have all been kept, since experience enables the types to be identified, even when in a parlous, corroded condition.

Methods then perforce had to change to meet the areas of the world where the author happened to be. This came from contacts and from museums both in Australia and overseas which is described further below in section 2.1.6 and as listed in Appendix I.

Interpretation of the samples is explained for each exemplar. Approximately forty British wrought nail named exemplars are shown individually in Chapter 4, in many variations, and the procedure involves looking at each nail separately from each of the seven groups shown in Fig. 8, Chapter 1. For examining the fine detail, a 10x magnifying glass was used in conjunction with a USB microscope. This latter proved very useful as it enabled the fibrous structure in iron to be explored, photographed, and

¹⁷⁸ MERCER 1923 & MERCER 2000, 29 fig 29

¹⁷⁹ NELSON 1968

¹⁸⁰ HOW 2015, disc reference ID 172

explained. A small jig was made for sectioning certain nail types longitudinally. These would then be treated with a weak acid and sanded back to expose the surface before further acid treatment. Other samples were used in destructive ultimate tensile strength (UTS) tests which added some information to the nail analysis which is explained fully later.

Since large numbers of unprovenanced nails were given to the author, the need for some further diagnostic information became evident. The interpretation of loose nails becomes possible if one is aware of the ways in which detritus adhering to the sample helps determine the nail's application. There is also the question of interpreting colour of the metal. Unfortunately, photographs taken by amateurs do not necessarily match the true colour due to colour shift of the light used in illuminating the object. Nevertheless, some description of colour changes in steel will be explained later as it is a factor which appears to have never been remarked on before.

The diagnostic identification features are explained in Appendix I.

2.2.1 Historical review and supporting data

This follows from the examination of historical records and sources already discussed in Chapter 1 and from the author's paper given in Brussels¹⁸¹.

It is possible to conveniently divide nail history into four phases:

- Antiquity. A search of Sumerian and ancient Egyptian sources has been made which will be discussed in Appendix IV. A preliminary finding is that prior to the Ptolemaic period there was little use of nails as driven points, but frequent use of bronze pins placed in pre-bored holes. Ancient Greece. Iron nails used in many applications appear in 700-600 BC in Komos, Isthmia, and Olynthus.¹⁸² This was a period of expansion of Greek colonies around the Mediterranean, which included their base at Masala (Marseilles), so it is possible that aspects of Celtic (Gallic) technology in iron was shared with mainland Greece.
- Celtic nails are widespread throughout Europe, but their poor condition has limited possibilities of identification in most circumstances. Evidence supports the Celtic invention of iron tyres and the nails used for fixing them and for wheel hub rims. At present there is little to suggest that nails were used in Celtic buildings. Schaeffer points to Celtic buildings being of log construction, (*piece sur piece*) and he shows how trenails could be adopted to fill many of the functions which we would deem more easily accomplished using iron fittings.¹⁸³ Celtic ships were acknowledged to be better built than Roman ones and this was specifically attributed to their being held together with large iron nails.¹⁸⁴ Of the numerous archaeological reports consulted regarding Gallo-Roman ships, none have clearly been in a solely Celtic time period and zone. (These aspects of nail history and others coming from antiquity are located in Appendix IV.)
- Roman (Gallo-Roman) nails. The Western world is arguably still dwelling in this latter period. One might say that the period lasted as long as wrought nails were still being made, which in Britain extended into WWII.¹⁸⁵ The reasons for this are also discussed in Appendix IV.

¹⁸¹ HOW 2018b, 765-771

¹⁸² SHARP 2011, 14-22, 37

¹⁸³ SCHAEFFER 2001, 83-94, 97, 99, 101

¹⁸⁴ CAESAR 2006, 49; HOW 2019, 213-215

¹⁸⁵ KELLY 1940, 2. Naish Collection Box 1 in Salisbury & South Wiltshire Museum, Salisbury. Letter dated 16 March 1940, MacArthur & Co. Bristol from C V Kelly.

2.2.2 Celtic-Roman origins and prototypes

An important aspect of the methodology used was to probe for type origins and searching out pre-Roman nails was made possible by reference to the displays in the *Musee de St. Germain-en-Laye*. These are limited to a small number of nail finds that suggest that the start of professionally made iron nails in a series of regular types, came from the Celts who populated Europe between 800 and 300 BC.¹⁸⁶ Unfortunately only traces of their pre-Roman handiwork remain but the impressive finds provide insights into the level of sophistication reached prior to the Roman conquest of Gaul. They include nails and fittings used on chariots and carts, rivets in armour and utensils. (Discussion of this topic is located in Appendix IV.) Research in the Midi of Gallo-Roman nails has concentrated on the static displays of the Arles Regional Museum. Permission was granted to photograph the archived nail sources which proved to be in superb condition due to their being found as part of the recovery of a river 'trow' or barge (*chalande*) in near ideal anaerobic conditions from deep silt in the Rhone.¹⁸⁷

2.2.3 Medieval nail sources

Similarly it was part of the methodology to try to confirm continuity of nail types through into the middle Ages period. As noted above, Britain is not a good resource of viable medieval nails, due to the ravages of the damp climate, but identifiable nails have been sourced from the Liège archives and pictures from the author's Belgian colleagues.¹⁸⁸ Medieval and later nail finds formed bases of joint papers to the Construction History Society, Queens' College Cambridge.¹⁸⁹ The former Papal palace complex at Avignon in Provence currently displays dropped nails in unused condition from vault interiors and such like, which confirm the continuity of various Roman nail characteristics.

2.2.4 Providing a clear framework and starting point

One aspect of the methodology adopted defies retrospective logic. In respect of a detailed nail study there was the need to first establish a large fund of data. Initially this presents as a maze, having no clear logic or sequencing possibilities. To attempt a linear progress with a clearly outlined path could not be done in advance. However, the advantages offered by first obtaining a large number of samples has been the learning process of observing those minute differences of signature left by production methods. There was a side benefit to this extended period of data collection in that it provided time to carry out further research by reading, reviewing and reflecting on the emergence of consistent facts that allowed for consideration of many increasingly apparent anomalies.

2.3 METHODOLOGY MEANS OF REFERENCE

As part of the methodology of classification there was a significant lacuna in respect of nail names, and hence a concomitant need to establish (or find) a clear nomenclature. This latter has still not been resolved in full or to everybody's satisfaction. The author's colleague, Professor Lewis, has categorically stated that he rejects descriptions which do not relate to the manufacturer.¹⁹⁰ However this ideal approach lacks recognition of the vagaries of documents available and of the need for a simple set of reference names. In search of a satisfactory method of nomenclature resort reference was made to the earlier writers of the modern period, starting with Moxon, 1683/4. This was closely followed by Richard Neve in 1703 who provides good descriptions of nails, including some which

¹⁸⁶ KNEALE 2917, 6 notes a caste system among the Celts which included artisans & ironworkers

¹⁸⁷ HOW 2019a, 213-224

¹⁸⁸ The author is obliged to Mme Caroline Bolle, Dr Phillipe Sosnowska, Dr Jean-Marc Leotard, and Professor Jean-Louis Vanden Eynde, for sharing finds with him.

¹⁸⁹ HOW 2016a, 119-128; Le DANTEC 2019b, 313-329

¹⁹⁰ Personal communication of 7 February 2018 referring to naming wire nails.

disappeared from use in the next half century. There was then a dribble of information in the following years which extended to the end of the selected study period.

Having exhausted the English texts, the unusual form of some German nails of circa 1500 gave impetus to a search of sources written in the German language. This ultimately revealed the existence of the earliest device used to sever wands of iron from an iron ribbon; the *Zeinhammer*, as has already been discussed in Chapter 1. At the same time, the conventional chronology and the varied attribution theories discussed in Chapter 1 concerning the slitting engine led to a prolonged search of around five years' duration for data and documents. (These are discussed more fully in Appendix III.) The two critical determining events provided the start of a vertical scale for a matrix analysis. The third machine to appear, the 'Oliver' then went through several phases, each of which could be determined or estimated.

It was anticipated that the advent of cut nails would be the next factor, but the extensive American writings raised many challenges with respect to a starting date.¹⁹¹ The year 1790 was established by consideration of the more reliable American authors.¹⁹² Quite coincidentally 1790 is the start of machine made nail patents in Britain. There was however an earlier innovation which entered into the linear development of nail making with the introduction of annealed cast iron nails in 1764.¹⁹³

There is an identifiable line of descent which follows the appearance of changes caused by introduction of fresh techniques;

Circa 1485 – the *Zeinhammer*¹⁹⁴

1576-1600 – the slitting process as adopted in England and in Liège¹⁹⁵

1680 – 1715 – Oliver flattened lining nails¹⁹⁶

1764 – Annealed cast iron nails¹⁹⁷

1810 - 30 – Oliver formed regular heads¹⁹⁸

Circa 1860 – 'Stiddy' formed spikes¹⁹⁹

Using these identifiable events, and by adding information acquired as a result of researching a range of sources, the data which emerged in various papers,²⁰⁰ it became possible to present a Master Chart of major changes affecting nail production as a series of timelines:

¹⁹¹ KING 1788. Lt P G King of HMS Sirius at Norfolk Island records in his journal on 17 November 1788 how a navy blacksmith was engaged cutting shingle nails from iron barrel hoops. (Quoted by VARMAN 1993, 172)

¹⁹² MERCER 2000, 235-255; LOVEDAY 1983, 8

¹⁹³ MOSELY 1968, 31-36

¹⁹⁴ HOW 2015, 81-90

¹⁹⁵ HOW 2017, 81-90

¹⁹⁶ HOW 2017, 81-88

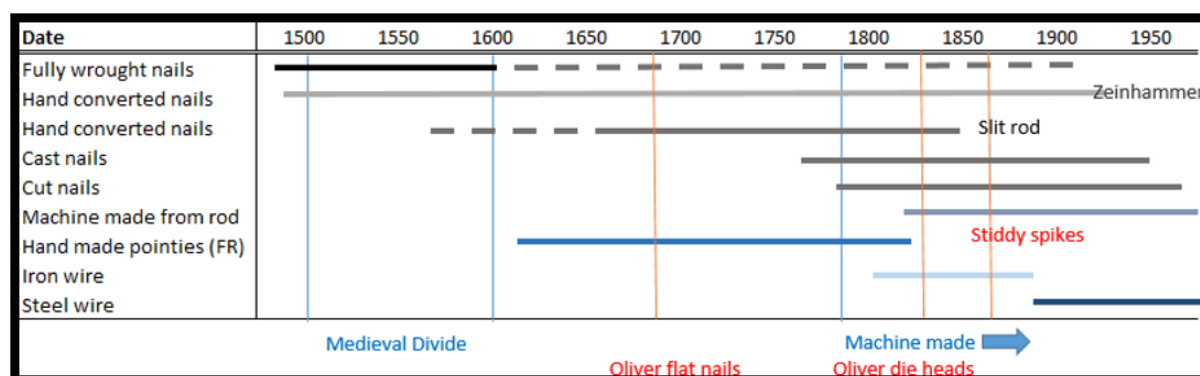
¹⁹⁷ MOSELEY 1968, 6-36)¹⁹⁷

¹⁹⁸ HOW 2017, 81-88

¹⁹⁹ HOW 2017, 81-88

²⁰⁰ HOW 2009a, 74-86; HOW 2009b, 829-836; HOW 2014, 231-238; HOW 2015f- Disc; HOW 2018, 345-356

TABLE 2.1: MASTER CHART OF MAIN CHANGES IN NAIL MAKING



2.3.1 Developing the matrix axis

Having made a start on a vertical timescale it was then a question of finding other datable changes in improved production methods reflecting in changes to nail morphology. One such change was the first indication of rolling of iron rod affecting nail-making which arose from one sample found in Tasmania, recovered from the Hobart Art Gallery of circa 1813-1820 vintage. It was used to secure leaden downpipes in an inner covered court situation, and hence was in remarkably good condition. Round rod is only used for certain specific nail types, in particular those driven into masonry, such as 'pipe' nails. As such they are of limited as a means of dating, but nevertheless provide another indicator of change.²⁰¹ Apart from this introduction and the annealing patent for cast iron nails of 1769,²⁰² the starting point (on both sides of the Atlantic), for mechanically made nails is 1790.²⁰³

In 1790 the French system was seriously disorganised by the effects of the Revolution and French patents do not reappear until after Napoleon's rise to power offered some stability in which inventions could flourish, be reported, and then acquire a patent (*brevet d' invention*).

It became clear that the concept of a general matrix of nail use was a valid one worth pursuing. It was established by using a mixture of patent sources, sample information, and the sparse literary sources. Information gained directly from samples was necessary in order to sort out those patents which were successful commercially, as well to understand the nuances of production changes.

Using the collected data the basic form of matrix can be conceptualised as a spectrum of five zones on the horizontal axis, descending vertically through time. With the coming of various inventions from 1790 onwards the vertical steps then can be usefully divided into decades: 1790-1800, and so forth. Experience shows that, once fully complete, for practical purposes this degree of definition is sufficiently accurate to satisfy the needs of heritage practitioners:

²⁰¹ Pipe nails are discussed further in Chapter 4.

²⁰² MOSELEY 1968, 31: HOW 2019, 94,95

²⁰³ HOW 2009, 74-86

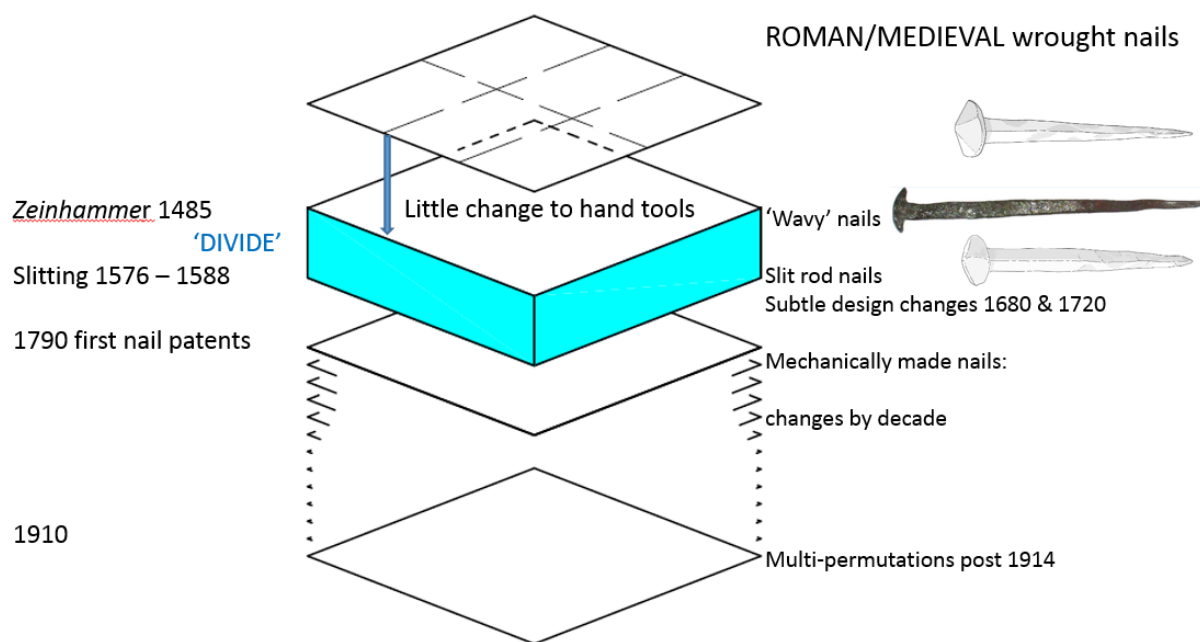


Fig. 48. The first stage of the 'Matrix' concept.

Before embellishing the matrix diagram, fig. 48, with the other historical data, the reader will realise that on-going researches were necessary, fig. 49, which necessarily took place alongside the other aspects of analysis. Finding samples and piecing together a fuller story of nail development turned into a long exercise. As further information came to hand additional questions emerged as how to complete a more complete framework of events and development.

It was decided to deal with these as an engineering exercise and test the following limits:

- Geographically, since the nail trade was worldwide, major centres needed to be defined
- Nationally, as new concepts displaced traditional methods. Questions needed resolution with respect to parts of Germany, the curious Swedish anomaly, and the separate Eastern school of the Chinese Empire influences and of Japan, whereby no heading tool was used.²⁰⁴
- Historically, was there an 'Ur-nail',²⁰⁵ and was it the Celts or the Romans who set nail norms?
- Uniformity: given the normal time lag from inception to production, e.g. - wire nails, from 1818 -1845 did not take over until the 1890s.
- Accuracy: the need to weed out legends & factoids and to dispel false wisdom/entrenched concepts/errors.

Nevertheless, the first four steps of the underlying logic driving this research could be deemed sufficient to arrive at a dating system. There is a second significant aspect to the study, however, which is to explain why these events occurred. In particular, why the phenomenon of the tapered shank held on for so long and, why the Western school tradition, (springing from the Roman world), spread so

²⁰⁴ The system of folding and rolling the head during formation is explained in Appendix 3. Traditionally the heading tool, or 'obore' was not used in South-east Asia or the off-shore islands, but, surprisingly medieval headed nails have been found in Myanmar (Burma). NYUNT & KYAW 2014, 32.

²⁰⁵ An original source nail. See also Charles Frémont's attempt to define a source nail. FREMONT 1910, 5-8

The core to the research method lies in first establishing the concept of a matrix. In discussing the study with heritage architects, practitioners, archaeologists, and academics across Europe, Australasia, and Asia (Sri Lanka, Macao, and Singapore), the concept has been widely appreciated as a method of providing dates for buildings and repairs of unknown provenance. Most specialists in the heritage field are already aware of how nails tend to be pertinent to time and specific building zones. The zones themselves are arbitrary to a degree and tend to change in importance throughout history. Even so, it is possible to grasp the centrality of a workable matrix of use through time as a crucial key to unlocking dates from data.

Step two comprises the virtually unknown data relating to an earlier method of preparing iron wands which pre-dated the slitting process by a century. Following from these events was a need to provide an identification method for the benefit of all interested parties. Step three provides this in pictorial form in sufficient detail for an educated layman to identify nails from the past. Such an index has not been adequately developed before, due to lack of specimens to identify, and a lack of awareness of names appearing in historic documents.

Step four establishes benchmarks in time and consolidates dating aspects by establishing the datable events. This is easily understood from the aspect of certain inventions setting threshold dates. For example, rolled rods, as used in pipe nails had to wait on several advances of technology before the necessary accuracies of alignment of both sets of rollers could be resolved. Likewise, cast iron nails had been made since Tudor times but for practical purposes the method had to wait on an adequate method of annealing the brittle castings into a malleable form.

Step five comprises the initial phases of cleaning and classifying of the samples collected. It will be obvious that this is an integral part of the whole process needing to be done after every new find. Until clean, a proper analysis is not possible. (Or risky, since much of the necessary detail dwells below a rust layer.) By a process of comparing samples one with the others, the detail emerges to reveal the manufacturing process (or clues thereto.) Finding the ideal exemplar is often not possible, but usually the identification points will emerge by having three or four 'semi-ideal' specimens. In the case of later machine-made nails, or cut, or wire nails, it is sometimes necessary to use micrometre measurements to test for lesser detail such as tolerances and containments. A detailed case of such small manufacturing clues for the Ewbank nail, which is particularly useful as a date indicator and is ubiquitous in both Australia and Britain, follows in Chapter 4, part 4.

2.3.3 Methodology extended

Identification of the different types of Ewbank nail will follow in Chapter 4, but it can be seen that recourse to patent information might be seen as small, but adds to the analysis methodology. Working outside the nail making industry we find a continuity of 'special' nails made by artisan iron workers alike to medieval blacksmiths, or by trades with a need to make nails fit to purpose and to size. For these the term 'ferronnier' nails has been adopted, taken from Duhamel du Monceau.

Recording of the samples revealed some broad lines of similarity across Europe (even into the Ukraine). This extra data raises questions as to why this level of similarity should be present, and so step 5 was extended back to probe Gallo-Roman nails and literature concerning the most likely spread mechanism: the Roman Empire. This line of research was deemed necessary as part of encapsulating a worthwhile contribution to knowledge of nail history, identification and dating methodology.

capable of rolling rods from bar iron, but the machine is incorrectly labelled a 'slitting mill', (EMERSON 1758, Pl, 39). Beck records a 1678 English patent to Thomas Harvey for a machine to form rounds. (BECK 1895, 977).

Because of the absence of earlier research (excepting Charles Frémont's brief mentions and an equally brief mention by Henry Mercer), the need to expand the study to resolve anomalous data was clear.²⁰⁷

2.3.4 Iron supply and conversion methods

The different forms in which the supply of iron to the nail workshops took has already been outlined above, and a nomenclature based on wrought nail names established towards the beginning of the analysis period is set out in Chapter 3.

The entry point of the different methods of nail manufacture provides the major vertical divisions of time-scale in the matrix diagram, fig. 53. These entry points appear in tabular form Fig 5. In order to familiarise the reader with an understanding of the different methods and their appearances the following brief explanations are relevant.

Cut nail samples found in Britain and Australia were believed to be machine cut from flat sheet. This posed some problems in interpretation of some 1825-1890 samples which needed to be resolved by further research. It was found that virtually all writers on the subject of nails had provided an overly simplistic analysis by considering just two methods: American and British. Reverse engineering and patent information revealed a further aspect; that the British approach used two forms of feedstock: flat iron ribbon and profiled ribbon. This will be explained further in Chapter 4. The serious American researchers have covered aspects of their production exceptionally well, including the inferior iron and cross-grained ribbon problems.²⁰⁸ It fell to the author to establish some papers outlining the British side of cut nail evolution.²⁰⁹

Cast nails have shown up in many different types, as is appropriate to the method which allows for any shape to be formed in the mould. The author was alerted to these at the Weald & Downland Open Air Museum of Buildings at Singleton (UK), but cast iron lath nail samples soon showed up in Sydney, in Oxford, and in the English Midlands. Production methods had been set out in a brief but informative manner from a Wolverhampton Technical College study.²¹⁰

Mechanically wrought nails show in different forms in many patents, most of which used nail rod feedstock. Emeritus Professor Miles Lewis has created an excellent website resource devoted to this²¹¹ and other patent information, but samples obtained show only two definite types which have affected Australia. Particularly the Ewbank nail, which appears in tens of thousands in every State of Australia, such that extensive research has been devoted to its subtle changes.²¹²

2.3.5 Data based framework

Using the information obtained from the sample collections and from patent and literary research, it was possible to extend the data towards the American cut nail development. These cut nails appeared in Australia during the mid-1860s but were common by 1870 when imports of North American and Baltic softwood timbers became significant as exhaustion of Australian softwoods occurred. It was also possible to see how the migration of several American inventors to Britain had influenced British nail production as a sturdier form of cut nail of British manufacture appears around 1850.²¹³

²⁰⁷ FREMONT 1911, 7-8: MERCER 1960, 241-243

²⁰⁸ EDWARDS 1993, 27-57: RYZEWSKI 2008, 50-64

²⁰⁹ HOW 2009a, 74-86: HOW 2009b, 829-836: HOW 2014, 231-238: HOW 2015, ID172: HOW 2017a, 81-88

²¹⁰ MOSELEY 1968, 6-38

²¹¹ <https://www.mileslewis.net/australian-building/pdf/08-metals/8.06a-nails-and-screws.pdf>

²¹² HOW 2009, 829-836: HOW 2105, AustICOMOS website

²¹³ SJOGREN 2019, 79-129

A complete matrix diagram, Fig. 50, can then be constructed using a semi-iterative approach:

MATRIX DEVELOPMENT

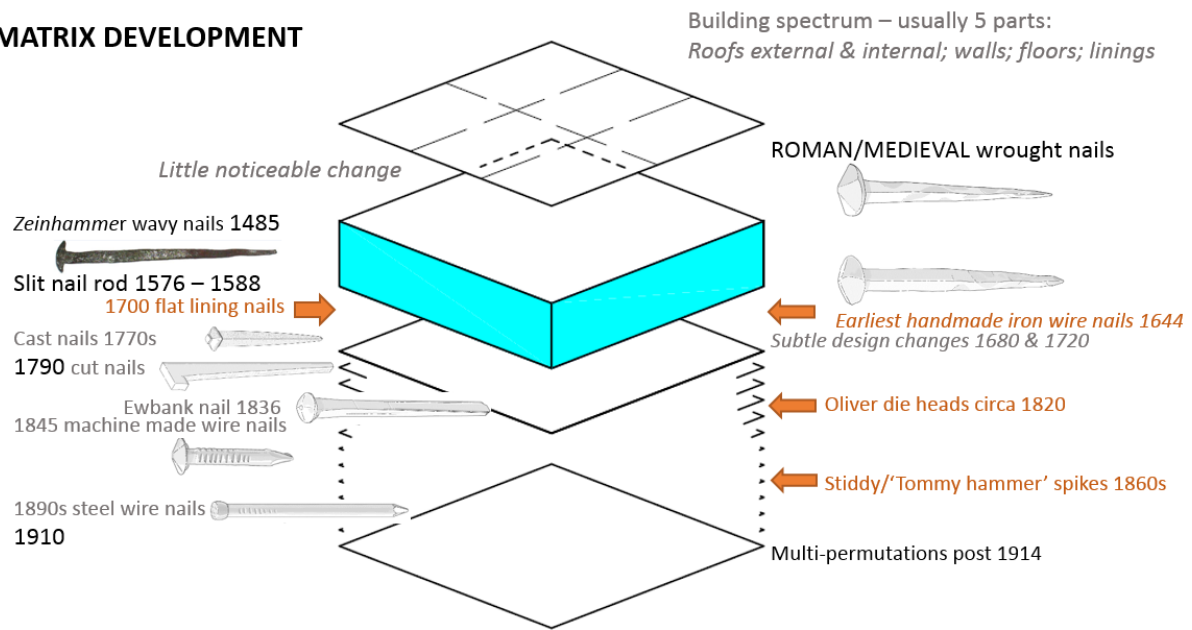


Fig. 50. Matrix extended form. Author

In addition to changes due to technology and patents, mining developments reduced the price of alternative metals, fig. 51. These add to the arsenal of changes in building nails.

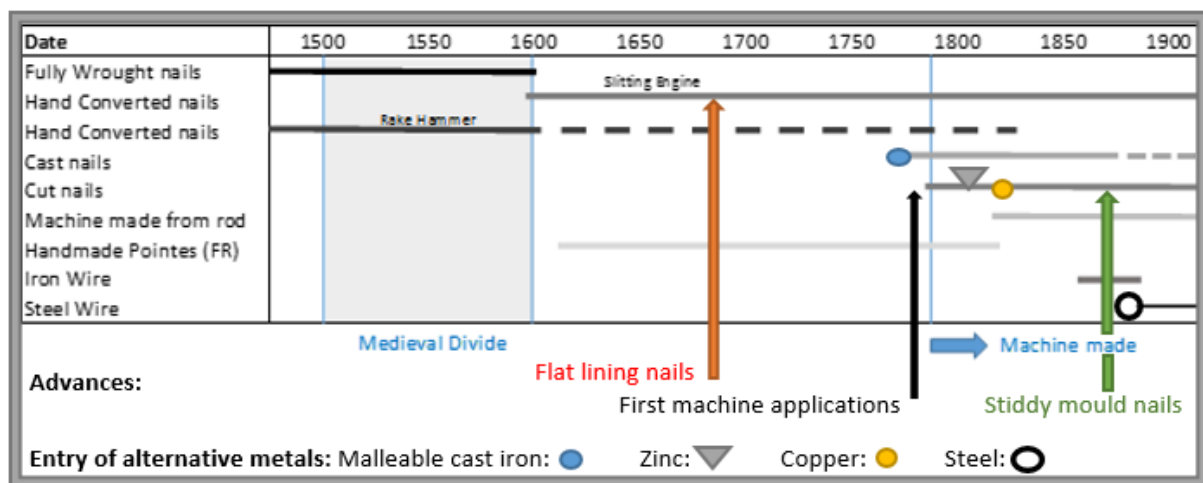


Fig. 51. Master chart extended to include alternative metals and nail making events.

2.3.6 The Matrix spectrum

The horizontal axes, shown as divided in six parts, is more easily thought of as comprising five main zones of a building. The number of zones chosen is somewhat arbitrary, but conveniently dealing with five zones has proved practical. These are:

- Roof claddings: coverings, flashings, eaves, and launders.
- Roof construction: battens nails, rafter spikes, joist and hanger nails.
- Walls: partitions, stairwells, fixed closets, and lath nails.
- Floors: floorboard nails, floor joist and bearer spikes.
- Linings: door frames, architraves, reveals, casement and shutter nails.

In seeking out exemplars from an historic building, (or zone of a building), the reader needs be aware of intervening factors also influencing change. These can be briefly described as:

- Architectural trends.
- Trends forced by exhaustion of certain materials, such as timbers.
- Changes in imported materials due economic or political reasons.
- Changes due to introduction of new machine-made nail types.
- Changes in the relative availability and cost of certain metals.
- Changes due to advances in technology.
- Access to technology, as for example an inadequate road network hindered the size of steam engines imported into pioneer Australia.
- Advancement of local skills relating to technology changes.

This thesis will attempt to factor in these changes in the analysis charts to follow in Chapter 6.

2.4 INTERPRETATION METHODS – SAMPLES, GRADES AND SOURCES

Obtaining field samples needed to complete the mosaic of types was not always possible, but it was expected that museums located in industrial areas would possess nail collections. In Britain, only one museum resource stood out as possessing a collection of wrought nails which fell within the study period. This was the Salisbury and South Wiltshire museum and access was obtained to view their achieved collection and to photograph it. The collection had been made just prior to and during the early years of World War II, donated to the Museum in 1940. It consists mainly of unused wrought nails which were by then in the last stages of manufacture. Two grades in the same sized nails were noticed in some cases. This observation reflects nail name issues seen in medieval documents,²¹⁴ which continue through to the main source English writers as seen below:

TABLE 2.2: NAIL GRADES

SOURCE/DATE	GRADES OF NAIL			
Salzman (Medieval)	<i>Double</i>	<i>Middle</i>	<i>Single</i>	-- also <i>Stonnayl</i> (1325)
Other terms used: <i>Dubel</i> 1423, <i>Dowbil</i> 1533, <i>Thaknail</i> 1327, <i>Dubelthaknail</i> 1530, <i>Afalthaknail</i> 1530, <i>Middelspykyng</i> 1292				
Richard Neve 1703	<i>Strong</i>	-	<i>Long</i>	
William Salmon 1738	--	<i>Middle</i>	--	
<i>Jacob Krunitz</i> 1777			<i>Halbe</i>	
<i>Adrian Corver</i> 1825	<i>Dubbelde</i>	<i>Basterde</i>	<i>Enkelde</i>	
Henry Fielder 1879	<i>Strong</i>	<i>Bastard</i>	<i>Fine</i>	
<i>Ludwig Beck</i> 1895		<i>Mittlere</i> 1623 Saxony		
		<i>Doppelte</i> 1660 Pfalz		
<i>Schonermark/ Stuber</i> 1905	<i>Doppeler</i>	-	-	also <i>Extrastarker</i>

It can be seen that some terms for the grades of nails continue across Western Europe in similar vein in Dutch and German nail names. There are only a few references to nail grades by the French encyclopaedists. Diderot makes reference to heavier nail shanks used in fixing metal plates to timber.²¹⁵ Roubo refers to two gauges of wire used in the same size of handmade wire nails.²¹⁶

²¹⁴ SALZMAN 1952, 304-317

²¹⁵ HOW 2017, 33

²¹⁶ HOW 2017, 45

A major benefit which came as a result of recording the Naish collection was clarification of some wrought nail names, since although large numbers of samples had been collected, it was not always clear as to what the intended uses were to be. Significant interchange of nail types can occur according to supply difficulties and to availability pertaining at that time.²¹⁷

In Australia the author was already involved in assisting in the heritage and conservation courses at the World Heritage listed Woolmer's and Brickenden Estates, near Longford in Tasmania. Both the former and present Woolmer's managers extended full access to their unsorted collections of mainly used, recovered nails, screws and other fittings. Likewise the owners of Brickenden generously allowed access to their workshops and reserves of historic materials, sometimes containing nails in-situ. These were cleaned and a selection made to mount on explanatory display boards at both sites.

2.4.1 Sample preparation and storage

This is referred to in 2.1 above and is covered in greater detail in Appendix I, but in order to properly examine samples for changes in technique or tooling, a particularly high level of preparation is needed to reveal tooling marks and like features. Virtually all of the nail illustrations in existence, particularly those done to exacting archaeological standards across the world, are useless from the aspect of full identification, recording only the rusted state. This means that a great deal of time is wasted in collecting large numbers of samples in order to recover one single 'good' example. In fact, this 'rare bird' often does not appear at all, so an ideal shape must be concocted from features displayed across several samples. It follows that the task of recording these nuances can only be done by an unusually experienced and adept illustrator, and then by providing images from several angles. This problem has only been partially resolved by the author working in close collaboration with Mr McCaig, but much more time and money needs to be spent on this issue.

2.4.2 Sources, references, and reliabilities

From the medieval sources set out by Salzman a European picture emerges as affecting, not only nails in England, but governing nail-making technology across Christendom, almost certainly due to the international nature of the Church itself. In this perspective England was a poor, pastoral cousin to the industrious towns of the southern Lowlands, and the city-states of southern Germany, to both of whom England turned for help. As part of the study the necessity to research documents in French and in German was paramount to a key understanding of developments during the Middle Ages and leading up to the age of inventions.

An ideal approach would have been to extend the search for documents and sources in the Flemish language. Sadly, the author has no familiarity with this, nor proper grammatical German. As a result, accumulating sufficient documentation from German sources took several years, and was complicated by the antique forms of Gothic fonts used and also by their use of dialect. No Flemish documents have been traced, but some information in Dutch became available during the course of the research. This was useful since it showed continuity of one form of anvil shown by a Frankfurt manuscript of 1568,²¹⁸ and an adapted form of Oliver die heading device.²¹⁹

²¹⁷ A former Public Works officer in Warrnambool, Ron Bishop, told how in late 1939 when he was a carpentry apprentice, the exigencies of WWII left only cut floor brads available for all house construction purposes.

²¹⁸ AMMANS 1568, - Nagler

²¹⁹ JANSE 2004, 3 and 22: See also WOODWORKER 1941 July edn, 184

In French, the immediate path lay open via the trove of information written by encyclopaedists, starting with Andre Félibien's *Des Principes de l'Architecture*.²²⁰ Since there was no translation²²¹ of the relevant passages from the encyclopaedists, the author published a book for furniture enthusiasts in Australia and in Britain.²²² Jacques Besson's *Theatrum Instrumentorum* of 1572 was also consulted, as well as Charles Frémont's *Le Clou*, and the French *Brevets d 'Invention* website.

Belgian sources in the French language are rich in information, and as part of the exercise of translation a substantial part of Charles Hansotte's book²²³ was included in the author's published book.²²⁴ Hansotte's references enabled a search of the texts by Franquoy,²²⁵ Thomassin,²²⁶ and other papers by Hansotte.²²⁷

Working from sources written in English it has been necessary to apply a rigorous critique as much information was found to be tainted by opinion or chauvinism and so on. It was realised back in 2006 that the only recourse to hard facts lay in examples obtained, or in images, etchings, paintings, or photographs. Coupled with this task has been the need to fully comprehend the technology of the particular time. The rules applied to sorting the data will be clear within the thesis as most of the doubtful information is well known and so has been dealt with by an exacting scrutiny.

2.5 THESIS INTENT

The next chapter will examine the reason why the Liège nail-making industry rose to world prominence, and why the nail industries of the German states remained fragmented in spite of possessing excellent supplies of ore and advanced technology. It will show how Britain plunged to a low of having to import over half the iron used, - only for the iron industry to recover by curious circumstance, and how by dogged persistence it eventually emerged as a world leader.

Chapter 4 will touch on further findings as part of establishing a workable nomenclature for wrought nails. It will proceed through the technological advances which forced wrought nails into decline and will identify the changes created.

Chapter 5 will provide the synthesis of changes with respect to location and time, and it will then present the sets of tables setting out change events.

Chapter 6 will be dedicated to discussions.

Chapter 7 will set out the conclusions.

²²⁰ FELIBIAN 1699, 80; 210-213; 352-357; 379-389

²²¹ Roubo's *L' Art de Menuiserie* was published in English translation at the same time by Lost Arts Press in America.

²²² HOW 2017. For the Furniture History Society of Australasia, and the Tools and Trades History Society.

²²³ HANSOTTE 1972, 1-29

²²⁴ HOW 2017, 77-85

²²⁵ FRANQUOY 1861, 63-66; 128-129

²²⁶ THOMASSIN 1879, 439-441

²²⁷ The eminent Belgian metallurgist, Francois Pasquasy, kindly assisted with these other texts and established contact with Dr Anne Stelmes, curator at the *Maison de Metallurgie*, in Liege.

Chapter 3: Ores

Influences on nail-making

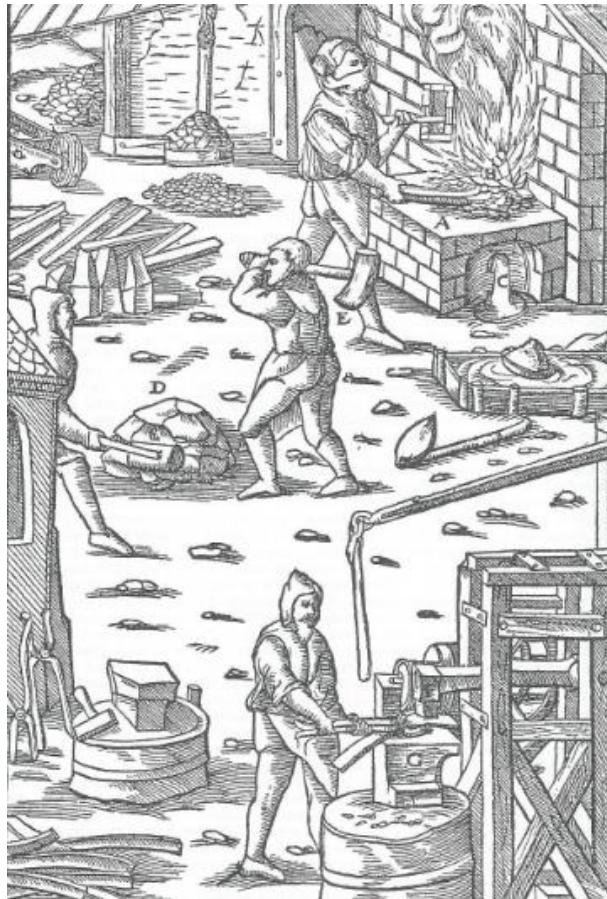


Fig. 52. Smelting yard with removal of silica shell circa 1550, (AGRICOLA 1556, Book IX).

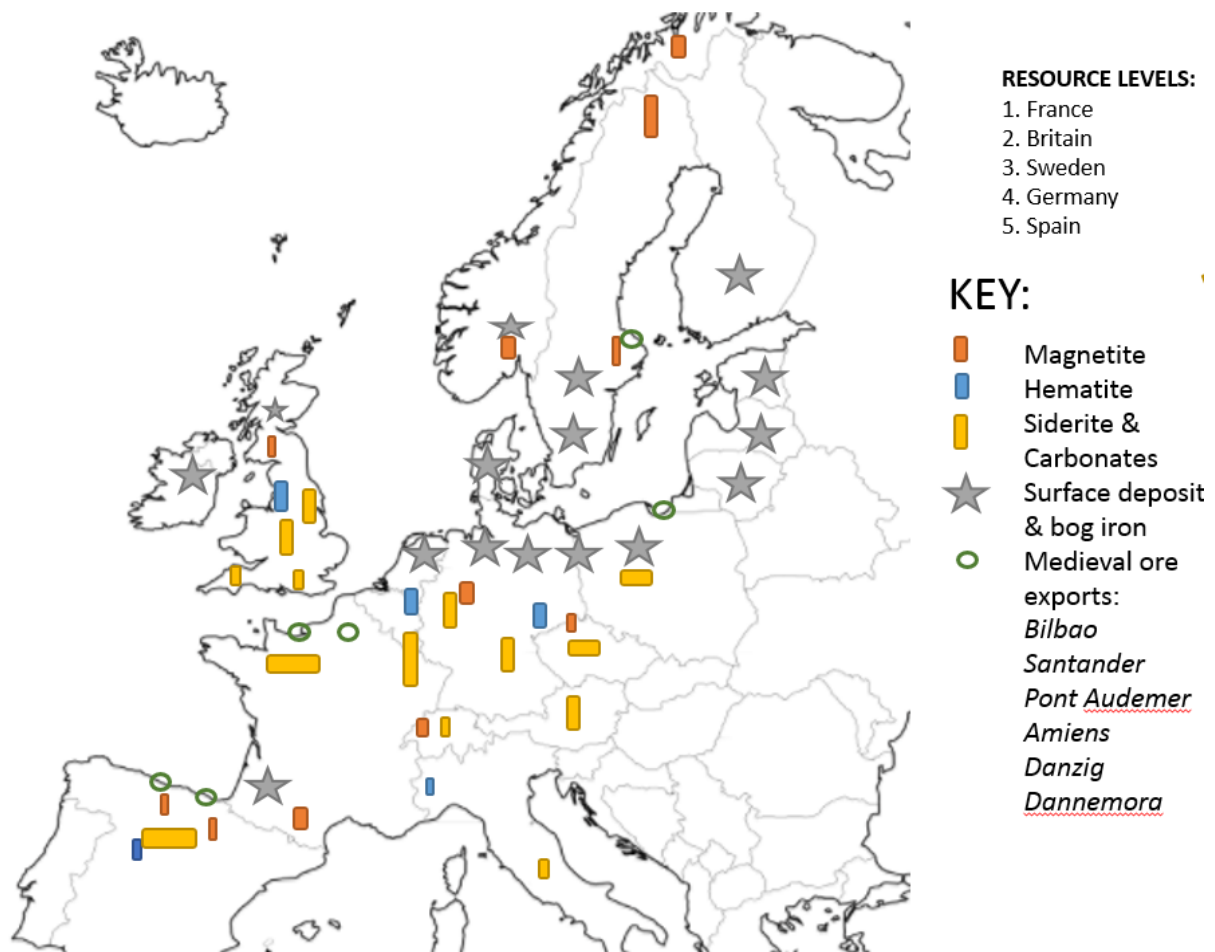


Fig. 53. Basic major European Iron Ore sources simplified.

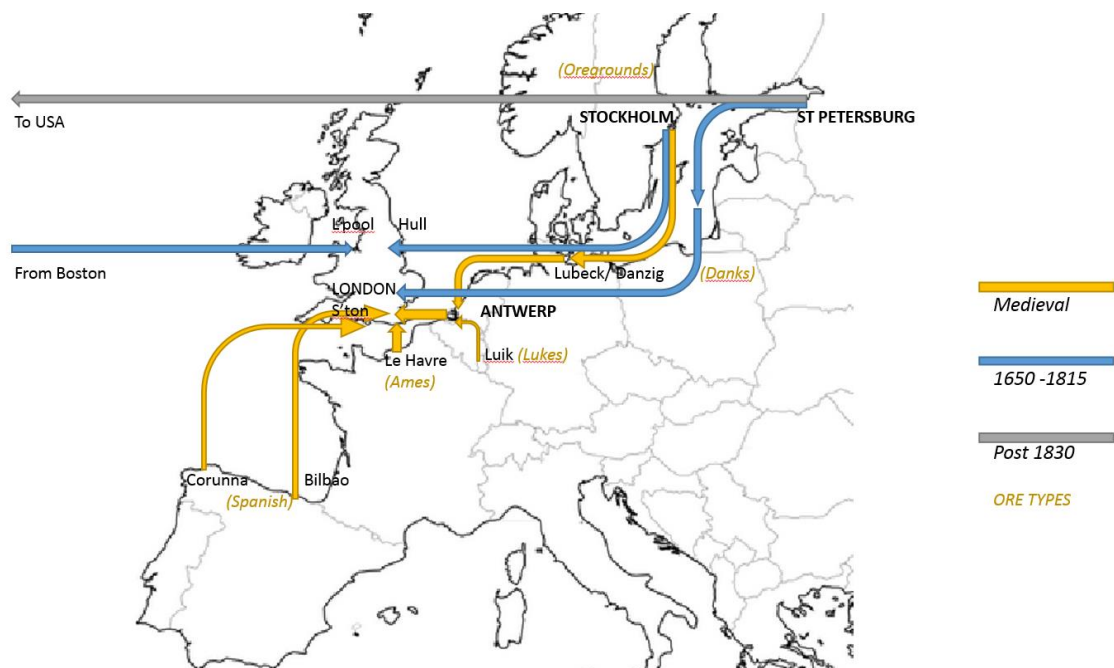


Fig.54. Changes in iron and iron-ore movements with time.

CHAPTER 3: ORES – INFLUENCES ON NAIL-MAKING

As the hunger for fuel increased ironmasters were forced to migrate into more remote lands; salvation could only be found in solitude, and the industry of smelting and refining was literally fleeing to the wilderness to escape destruction.

Public Record Office, Star Chamber, 1606 ²²⁸

OVERVIEW

This chapter will demonstrate how the disposition and qualities of iron ore bodies locations across northern Europe shown in Fig. 1 influenced the story of iron. Why it was a determinant factor in the industrial revolution and how this affected the history of nail-making. It will show how a range of convergent factors resulted in three main players controlling nail-making in the Western World.

3.1 IRON FROM ORES

To produce iron four things are needed:

- Iron ore, which in terrestrial ores always occurs in oxide form.
- A fluxing agent, such as limestone.²²⁹
- Heat.
- Power: for forced draught and for the ejection of impurities by hammering or squeezing.

Iron ore, in one form or another, is widespread on the Earth's crust since iron is the fourth most common element. The second most common element is silica and all iron ores formed on Earth contain both elements.

Smelting iron consists of providing a supply of air containing oxygen to raise sufficient heat from carbon rich fuels, such as charcoal or coal, in order to separate iron from the oxides. The products then comprise a mass of silica rich iron, and a glassy residual slag. The latter usually contains some iron which has escaped full separation within the furnace.

In its most primitive form man-powered bellows would be used²³⁰ to provide air to a small closed furnace. At a minimum temperature of 900 degrees Celsius the process would be allowed to continue for three or four hours, when the 'iron' produced would seep to the bottom as a mass termed a 'bloom'. Blooms rarely exceeded seven to nine kilograms in weight. By working the hot mass by hammer the silica would be squeezed out as a surface residue as the iron content was forced together. Some skill in estimating the timing of the process and in tending the furnace was involved in order to achieve the best results. Production of good quality iron started with a careful selection of the ores and their preparation prior to loading the furnace in appropriate layers of charcoal and flux.

²²⁸ CREW & WILLIAMS 1985, 20-30

²²⁹ Certain ores are self-fluxing as they contain calcareous traces.

²³⁰ The one exception to this consisted of wind furnaces driven by monsoonal winds which existed in parts of Indian and Ceylon (Sri Lanka), and these could reach higher temperatures in which excess carbon would be driven off which resulted in the first steel production, (COOMARASWAMY 1908 [reprint1956], Plate LIII).

3.1.1 Europe's ore history

Although the occurrence of iron ores is widespread across Europe, fig. 53, the struggle to obtain iron was a complex one which can be summarised in four main historical phases:

- Roman to late medieval times were characterised by a concentration of surface, or shallow subsurface 'potting', and by searches for seams and shallow deposits.²³¹
- The growth of mining, primarily concentrated on non-ferrous metals from around 1400 or so, and with it a concomitant growth of metallurgical knowledge.²³²
- Increased active iron ore mining by open-cast and underground methods, which were well established by 1500.²³³ This phase then became governed by new fuels, by improved smelter design, and then by on-going increased use of steam power from the early 1700s, to achieve increased air blast.²³⁴
- Finally, more effective transport of materials released the need for reliance on proximity to sources, as canals and steam driven transport became more widespread and cost effective.²³⁵ The world is currently at the apex of this latter phenomenon as superior ores and fuels are now sourced world-wide in the search for maximising smelting efficiency at the lowest costs.

To understand the development of the above, with their apparent contradictions, the ores themselves need to be briefly explained; but first, a simplified picture of Europe's iron resources helps in analysis²³⁶, fig. 53.

3.1.2 Pure Iron

The closest thing to the pure element Fe comes from meteoric sources. These were known to the ancient Egyptians who attributed magical properties to them – said to be the substance of the Phoenix Bird's eggs.²³⁷ Several large meteors containing nearly pure iron were found in Greenland, some of which were used by the Eskimos to edge tools. Several of these meteors were photographed by the American explorer Robert Peary prior to 1900, one of which, weighing several tons, was recovered and proved on analysis to be 91% Fe.²³⁸

3.1.3 Iron's natural occurrence

Terrestrial iron is always found in oxide forms of which the most common are²³⁹:

Oxides.....	{ Fe ₂ O ₃ .FeO.Magnetite.
	{ Fe ₂ O ₃ Hematite.
	{ Fe ₂ O ₃ .H ₂ O.Goethite (crystalline), limonite (amorphous).
Carbonate.....	FeO.CO ₂ ...Siderite.
Complex silicates.	Chamosite, thuringite, and glauconite.

²³¹ CLEERE 1981, 27-31: SCHUBERT 1957, 41-42

²³² HOOVER 1950: ERCKER 1580

²³³ SCHUBERT 1957, 209-211

²³⁴ HAYMAN 2005, 69-70 and 73-76

²³⁵ DEANE 1965, 78-86

²³⁶ The North German plain, Ireland, the Baltic States, Denmark, Finland & southern Sweden relied on bog iron. Britain has large reserves of poor quality ore. Spanish ore is of high quality but limited extent. Italy has widespread small sources. Sweden has superior ores from igneous sources requiring mining as well as bog iron. The preponderance of Jurassic limestone across Europe leads to some good quality haematite ores from selected locations. (ROESLER 1925, 14-20).

²³⁷ JOHNSON ET AL 2013, 997-1006

²³⁸ PEARY 1914, 558, 602, 617

²³⁹ ROESLER 1925, 13

These give rise to the most commonly known variations in ores:

Magnetite-hematite.....	$\text{Fe}_2\text{O}_3 \cdot \text{FeO} - \text{Fe}_2\text{O}_3$
Hematite-goethite.....	$\text{Fe}_2\text{O}_3 - \text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$
Brown ores.....	$\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O} - \text{Fe}_2\text{O}_3 \pm \text{H}_2\text{O}$

The type of ore has a big effect on the final cost of iron produced and typical values for British ores,²⁴⁰ are:

Magnetite	65% Fe
Red Haematite	55–60% Fe
Brown Haematite (Limonite)	30-45% Fe (as found in the Forest of Dean area)
Ironstone	20-32% Fe (as found in the Cleveland Hills of NE England)
Blackband – from coal measures	17-30% Fe (as typically found in Nottingham coal fields)

Fig. 68 shows how the best quality Magnetite ores are few and well dispersed. The largest accessible deposit was in southern Sweden, fortuitously surrounded by forest and close to the coast where the Osa River exits, and hence the smelted iron was termed *Osa mund*²⁴¹ by the German traders. Spain too had accessible deposits of magnetite, as did Bohemia and Austria. There was also a Pyrenees source of the *Montaigne noir* at Les Martys, Aude, which was exploited by the Romans. This has been demonstrated by a cargo of iron bars and rods recovered from the Titan reef off Saintes Maries de la Mer, now on display at Arles Regional Museum.²⁴² In contrast, the small Scottish deposit was not easily accessible, and the rich deposits of Malmburget - Kiruna of north Sweden, fig. 53, were not accessed during the historic mining boom period.²⁴³

Next in quality came the Haematite (red) ores, which demanded proportionally more fuel for smelting and, in some cases, more sorting and preparation.²⁴⁴

The use of Blackband ore draws attention to the need for smelters to be close to fuel sources. Blackband ores were banded with interleaves of carbonaceous material which assisted the roasting/drying process.²⁴⁵ Other ores often needed to be roasted or cracked by heating. In the case of the better ores the weight of fuel needed for smelting is around 115 – 125% of the ore weight. Low grade ores required more fuel, but this might prove acceptable should the fuel sources occur close by. Limonite and ironstone, in particular, often needed to be dried and ‘cracked’ on open hearths by burning faggots of wood with carefully selected ore, as is seen in early metallurgical works.²⁴⁶

²⁴⁰ CLAUGHTON 2005, unnumbered draft

²⁴¹ Literally ‘Osa Mouth’. (*Mündung* meaning a river mouth).

²⁴² HOW 2019, 213-224

²⁴³ MAGNUSSON 1985, 21-33

²⁴⁴ Schubert quotes a Byrkenott incident, circa 1400, how the pieces of ore were broken down by hammer by both men and women into egg sized pieces, (SCHUBERT 1957, 124).

²⁴⁵ JONES 1987, 44

²⁴⁶ ERCKER 1580, 97, 226, 244; HOOVER 1950, 271-278; BIRINGUCCIO 1990, 65, 141- Fig. 69. The Process is termed ‘sintering’, which drives off water, sulphur dioxide and arsenic compounds, to leave behind ‘sinter’. This resembles gravel, and comprises mainly magnetite, (BURCHILL 2010, 2).



Fig.55. Breaking metal ore from rock and roasting ore on a pyre after Agricola 1556.

The material removed from the ground and commonly referred to as 'ore', contains the metalliferous content embedded within rock formations, - such as gneiss or siltstone, - in banded or similarly tightly held forms. The 'rubbish' proportion, even in good ore is around 40% waste and early illustrations show how much time was devoted to breaking out, and carefully sorting the better material prior to smelting, fig. 55. With the lesser forms of iron ores, such as alluvial iron and bog iron, it became progressively more expensive to treat since separation of the components by crushing and washing, and (for particularly stubborn ores), by 'cracking'. English ores mainly fell into this latter category and preparation costs were high. The Forest of Dean and Weald areas contained numbers of Roman cracking hearths and some of the Roman waste was later re-used to assist the smelting processes.²⁴⁷

Insofar as nail production was concerned, the presence of sulphur residue or phosphorus made the iron hard to work and the nails made from it were prone to break in bending, especially when cold worked. In high concentrations sulphur could also make the iron prone to crumble when hot worked. Liège, perhaps the major nail making centre in Europe since Roman times, was blessed with 'soft' iron, which was easy to work. Luxemburg, however, lying in a very similar geological condition, produced a so called 'hard' iron, which was acceptable for larger nails but which significantly increased the manual effort and the fuel needed to make smaller nails.²⁴⁸ Hematite, the base of some Swedish and Spanish ores, but found also in Sussex, produced a 'tough' iron.²⁴⁹ Quality Spanish iron was also prized in France and an unusually big piece was used in restoration work undertaken in the late 14th century at Rouen Cathedral.²⁵⁰

Prior to the invention of puddling, ores containing phosphorus were avoided as even small proportions tended to make the iron harder to work and to be more brittle. It was this less malleable iron which was used for the bulk of 'common' nails in Britain and in the early years of the North American Colonies whereby most of the ore came from alluvial or near surface deposits.

²⁴⁷ CLEERE 1957, 31; MILLET 2012, 543

²⁴⁸ HANSOTTE 1972, 8-11

²⁴⁹ SALZMAN 1952, 286

²⁵⁰ L'HERITIER ET AL 2010, 25. L' Heritier notes that Troyes and Rouen documents both provide rare references to Spanish iron which he suggests cannot be considered significant, (Ibid, 29). In regards to quality a reverse conclusion is possible in the opinion of the author, especially since Normandy iron was held in such esteem in England. See 'Ordemer' in 3.2.1 below

In contrast to wrought iron, which contains almost no carbon, cast iron is brittle due to a high carbon presence. The annealing processes for cast iron primarily aimed to increase the workability by reducing the carbon content to a minimum. This produced a so-called 'malleable iron' suitable for nails and such like. Malleable iron and mild steel are very similar and contain comparable amounts of carbon. Analyses of English cast iron firebacks from the beginning of the study period show typical chemical contents as: Carbon 3.7%, Silica 0.8%, Magnesium 0.65%, Sulphur 0.07%, and Phosphorus 0.6%.²⁵¹

Development of the annealing process used to soften cast iron is dealt with in Chapter 4.

Both wrought iron and cast iron contain traces of lesser metals and these would typically be Chromium, Titanium, Vanadium, and Boron. Also occasionally found are: Tin, Molybdenum, Aluminium, Tungsten, Bismuth, Antimony, and Tellurium.²⁵² Moxon, writing before the annealing process was resolved, observed that the first run of metal from the furnace was preferred for the manufacture of wire, and presumably ductility was improved by the presence of these lesser metals.²⁵³

3.1.4 Basic smelting

To maximise the extraction of iron a flux was used which was nearly always limestone:



Traces of other elements can be found in most ores, some of which are deleterious to the final product: mainly Phosphorus, Sulphur, Silicon, Carbon and Manganese. Phosphorus is perhaps the worst impurity to be dealt with and it is unfortunately readily taken up during the smelting process. Its presence can be tolerated if less than 0.01%. It starts to make the iron liable to fracture in-situ ('cold short') at 0.5% content. Sulphur has to be kept below 0.03% in wrought iron or it will result in 'red-short', or an unworkable condition.²⁵⁴ Silica occurs in all cases, but it can be expelled at the cost of much squeezing and working.

Smelting at higher temperatures changes the character of the iron to a more workable material by simply burning off carbon. 'Wrought iron' requires the carbon concentration to be kept below 0.25%. Failure to reach proper temperature or to keep to a normal smelting period was likely to result in retained carbon, and hence the 'art' of smelting in earlier times. Manganese had some advantages, but it had to be below 1% in order to avoid cracking and welding problems.²⁵⁵

The characteristics found in working the smelted iron were well understood by smiths, who classified iron into two main categories: 'soft' and 'hard'. The Liège ores, which lay at the extremity of the huge 'Minette' ore-body, Fig. 53, were blessedly 'soft'. Iron from these ores could be worked easily by hammer, with minimum effort. It displayed neither 'cold-short' (tendency to fracture), nor 'red-short' (resistance to working and to welding). Just to the south, in Luxemburg, the same ore-body trends to hardness. With changing requirements (from the Dutch Navy) the Liège factors were able to exploit this aspect too for the manufacture of larger ship nails where residual hardness was desirable.²⁵⁶

²⁵¹ SCHUBERT 1957, 389-399

²⁵² Ibid.

²⁵³ MOXON 1703, 14

²⁵⁴ FIDLER 1879, 247-249; SALMON & SIMONS 1966, 278-9, figs. 147-149

²⁵⁵ KAMENSHCHIKOV et al 1970, 27-28

²⁵⁶ HANSOTTE 1972, 7-17

The famed area in Roman England, the Sussex Weald, was prized for a different reason, its toughness. The extra effort needed to work the Sussex irons was of little concern to the Romans, nor to the following generations of ironmasters. This division is also seen in Salzman's analysis of medieval documents when imported iron was specified as *tenaci* or 'tough'. Imported irons, as for example from Spain, carried these sorts of grade appellations.²⁵⁷ Recent work by Scottish Heritage has shown that the Romans carried this grading to its logical conclusion by selecting 'tough' iron for the *clavi caligulae* used in soldiers' sandals.²⁵⁸

Quality ores, which were high in iron but low in Phosphorus and Sulphur, were so much sought after that they were often sourced from as far away as Dannemora and Hungary.²⁵⁹

Prior to the introduction of blast smelting, iron within the bloomery furnace would begin to ooze out at a temperature of 900 degrees Celsius and slowly seep to the bottom of the furnace to form a 'bloom' - a mixture of iron and silica. In European history it was the invention of the blast furnace in 'Flanders' which allowed higher temperatures to be gained and it was said to have been introduced into England by Bishop Langley of Durham at Byrkeknott in 1408.²⁶⁰ Darby believes its introduction may have been earlier - sometime after 1350, following the labour shortages of the Black Death; a view echoed by Schubert.²⁶¹ The blast furnace enabled continuously fired furnaces to reach 1300 degrees Celsius, at which level the iron becomes molten,²⁶² causing carbon to be burnt off and the molten iron could then be tapped off at intervals to be run into moulds forming 'pigs'. (*Loupes*).²⁶³ This could then be taken to a second furnace for re-heating, and the mass formed would be hammered and squeezed to remove the silica, termed 'fining' (*raffinage*). Thus 'wrought' iron is always a stringy mixture of iron and silica in which the process of hammering caused a grain in the material which we conventionally term as 'iron', fig. 56.²⁶⁴

3.2 BRITISH IRON PARADOX

3.2.1 English reliance on foreign iron

Great Britain (England, Scotland and Wales) had the second highest reserves of iron of all Europe, but because of its mainly inferior ores and lack of suitable sources of charcoal, it came to rely on iron imports at a very early stage.²⁶⁵ The names given to imported iron usually related back to the original sources of the ore:²⁶⁶

- AMES was from around Amiens in France but could include some Normandy iron.
- DANKS iron, from Danzig, originated in southern Sweden.²⁶⁷

²⁵⁷ SALZMAN 1952, 286-289, 301

²⁵⁸ ANGUS 1962, 956-968

²⁵⁹ HAYMAN 2005, 35; TYLECOTE 1985, 160; GOMORI 1985, 240

²⁶⁰ HAYMAN 2016, 13

²⁶¹ HAYMAN 2016, 13

²⁶² Recent metallurgical research this year (2019) has revealed first evidence that a Roman bloomery furnace in Snettisham, Norfolk, had reached full melting temperatures, (LANG ET AL 2019, 8-11).

²⁶³ In England the practice was to run the molten iron into a central channel in a sand bed on either side of which were side pockets. The ingots of 'pig-iron' formed this way appeared like suckling piglets. In Belgium a single central channel was formed and the cold mass, the 'loupe' resembled a supine wolf.

²⁶⁴ EDWARDS & WELLS 1993, 11-33

²⁶⁵ PARSON 2018, 470

²⁶⁶ SALZMAN 1992, 287-288

²⁶⁷ DOLLINGER 1970, 222, 237 238

- FOREST iron came from the Forest of Dean hematite ores.
- LUKES iron came from Liège (*Luik*).
- ORDEMER iron was exported through Pont-Audemer in Normandy.
- OREGROUNDS iron came from the Dannemora mine in Sweden.

For most of the period prior to 1790 'iron' was understood in similar basic terminology, based on the ore source and from characteristics exhibited when forging. The term 'iron' does not properly describe the true nature of the mixture of iron, silica, carbon, other contaminants, and minute amounts of lesser metals. Iron making was, however, an advanced art, requiring skill and experience, and in the case of wrought iron much of the carbon would need to be burnt off, together with most of the phosphorus and arsenic. Silica in the ore was removed primarily by it being separated in the furnace and the balance, intimately involved with the iron metal, had to be squeezed and then beaten out (hence the term 'wrought' or 'worked'). The inferior nature of English iron ores was well known:

*In most parts of England we have an abundance of these sorts of Iron-Stones; but our English iron is generally a coarse sort of iron, hard and brittle, fit for Fire-bars, and other such coarse uses; unless it be about the Forest of Dean, and some few places more, where the iron proves very good.*²⁶⁸

As a consequence of the prevalence of silica, what is known to us as 'iron' is really a stringy, mixed material, whose grain can be detected by the naked eye after etching the incised metal surface, fig. 56.

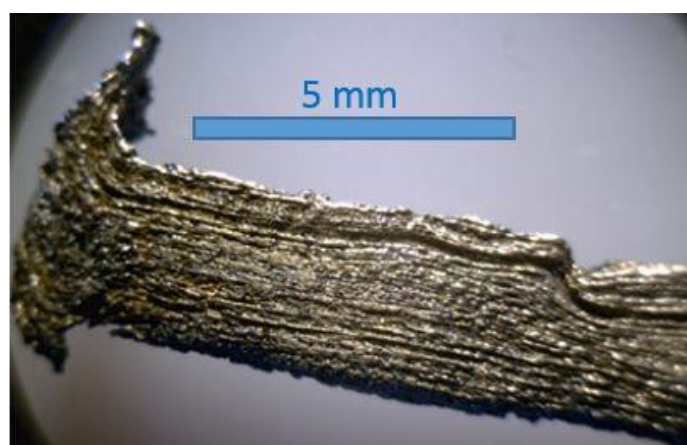


Fig. 56. Common (rose-head) circa 1760, Glastonbury, Somerset, bisected and etched (x10). Author.

From around 1200²⁶⁹ the Hansa League had a stranglehold on high quality iron ('steel') imported into England, but such was the importance of this commodity that the League was granted tax concessions and exclusive use of an area of the City of London (now Cannon Street). Their use of the site lasted to 1598. The Hansa site figures widely in English history as the 'Steelyard' and it was the root of constant friction with English merchants. Naval supplies, grains, iron, and Baltic oak boards ('wainscoting'), were all held in warehouses behind a secure wall surrounding the yard.²⁷⁰ Hansa

²⁶⁸ MOXON 1704, 13

²⁶⁹ GAIMSTER 2005, 419. The Cologne Merchants are recorded as having a Guildhall there in 1175, the south aisle wall of which was excavated by the Museum of London in 1988.

²⁷⁰ STOW 1598, 264

merchants also controlled part of the wool trade with warehouses in Ipswich in Suffolk and they were obliged to maintain one of the gates leading out of London towards Ipswich.

The role of the Hansa was part of a vast web of iron movements through what is now Germany and Austria, and onto foreign destinations, the story of which has been described by Johannsen. His text is cited in some length. Apparently no other English translation exists.

During the Middle Ages there generally were only small bellows available for forced draught (to produce) iron in the various sizes. The production of special goods lagged: namely steel, and a similar situation existed with respect to products in the ready-to-use iron trade. Eventually a single industrial trade came about early in the Middle Ages, which, in intermediate steps of modest extensions, succeeded in producing a great iron trade ring of extraction.

The most important sites of the Germanic iron industry were Steirmark and Kaernten. (Close to Graz).²⁷¹ Iron & steel went southwards to Judenburg & St Veit, (Near Klagenfurt). At this point a staple-law required goods to be unloaded and put up for sale. These goods then went via the old 'iron road' towards Aquila, Venice, and further into Italy, and on to Turkey. To upper Steyr the 'Steirish' or Hungarian Iron went to Germany, and then further on by the Rhine as 'Limbrick stuff' (Leoben-Brucker wares) to England. Also in the Tyrol stood a forced draft iron industry. This trade went through Innsbruck. From there the Tyrol iron was directed to England and it was known as 'Isebrokestuff'.

Between the Danube and Main rivers, the upper Pfalz region was the most important ore region. Although the Hartz was famous for its zinc, Amburg was an iron ore town. The Hartz, due to trade in its famous steel cauldrons exported to central Germany and also sent iron to northern Germany. Most important of all the Hansa controlled the Northern iron trade. They had three main arms; first the admirable Spanish iron, in which its ships did the 'Bay trip', bringing it out across the Bay of Biscay. Secondly the northern Osa Mouth; & thirdly the Westphalian steel. The Hansa dominated all the northern trade in which the northerners sold them their natural products of pelts and wood which were their most important industries.

The Osa Mouth (Osmund) ores were smelted in Danzig and Lübeck and were brought into the Westphalia Marches, where it was worked and drawn into wire which would then be sent on. This trade in Osmund iron was in the hands of the Wends (Sorbish), in who, particularly in Lübeck, lay the Royal strength of their Patronal Elector, due to his Westphalian descent. The Westphalian iron came in first line from Siegerland (to the east of the Ruhr), which especially provided both raw and finished steel to the 'Klingen' smiths to be worked in the land of the mountainous Marches.

The mid-point of the Westphalian trade was Cologne. There also stood the Market-Staple for the Rhine ----commanding upper Germany, which became the most important trade town of Germany. The main destination of iron from Cologne was England. The Hansa merchants, the 'Osterlings' had a walled-off depository in London, well known in the Hansa steel trade, which was colloquially termed the 'Steelyard'. The English needed the Hansa, especially for their wool export which was at that time an important valued industry. The Hansa were excused taxation by the English Kings, and this possibly gave rise to the 'Eastern Pound' (Stirling) and (support by the Hansa) ensured victory by the English over the French.²⁷²

²⁷¹ BUCHWALD 2005, 124-129 provides a detailed background.

²⁷² JOHANNSEN 1925, 57-58. Author's translation.

From this extract it can be seen how the export of ready-made iron to England figured large in the trade with the central European and German States.²⁷³

3.2.2 The need for Swedish iron and steel

Swedish iron was so highly prized throughout Europe that it retained a price premium throughout and so its use was kept to a minimum. Although nails would normally be made from the cheapest iron, Swedish iron was required for horse-shoe nails and for door nails, both of which needed to be bendable in order to be clenched, whereas cheaper iron retained some brittleness making it unacceptable for these purposes. The bulk of high-quality Swedish iron came from the so called 'iron mountain' of Norberg, which in 1539 had 62 furnaces in production, and the smelted iron was exported through Stockholm and Vasteras.²⁷⁴

Quality 'Osmund' iron was produced in Norberg from 1250 onwards and matched in price the best quality Spanish iron.²⁷⁵ During the middle ages it entered England through the four North Sea ports of Yarmouth, Kings Lynn, Kingston and Newcastle, (Ibid). Sweden exported other varieties derived from bog iron in bar form, notably through Lübeck and Danzig, which had customs advantages. Iron from Hungary and from upper Poland also went through Danzig, often destined for England.²⁷⁶ Refer to page 74 for the pattern of iron trade movements, fig. 54.

3.2.3 English dependence on foreign technology

The period selected for this study starts in a pre-industrialised Britain, a condition which would last for another sixty years or so²⁷⁷. The medieval principle of sustainability by use of copse oak for construction purposes was no longer possible and after the Great Fire of London in 1666 the dire need for building timbers saw a major recourse to Norwegian pine (*Pinus sylvestris*) which was then imported in much larger quantities than previously.²⁷⁸ Up to the Tudor period England had been a pastoral country and had relied on wool for the wealth of the realm, but it lagged the Lowlands, the German States, and France, in technology. Its proximity to 'Flanders' (as modern Belgium was colloquially known) was both a blessing and a curse.²⁷⁹ England could always look across the narrow seas for help and it was able to import experts in weaving, ironwork, and the building arts, such that 'Flemings' were give protection in 1351 by King Edward III against English xenophobia.²⁸⁰ This remarkable long-term historic cooperation was interrupted in 1336 when the Count of Flanders sided with the French king and banned English wool. Churchill ascribes this as one of the causes of the 100 Years War.²⁸¹ The burgers of the main cloth towns were sympathetic to the English cause following

²⁷³ Caveat: the translation by the author needs to be considered as 'basic' only due to the author's dialect German and his limited grammar.

²⁷⁴ FORNANDER 1985,13, 21, 29

²⁷⁵ SPRANDEL 1985, 309, 310

²⁷⁶ SPRANDEL 1985, 307-317: GOMORI 1985, 233

²⁷⁷ DEANE 1965, 4. Professor Ashton sets a date of 1760 for the start of the industrial revolution with a caveat that a stability set in during the 1840s, (ASHTON 1967, 4).

²⁷⁸ BARLEY 1990, 89: LOWELL-CUMMINS 1979, 10-15. INNOCENT 1971, 103-104. Innocent suggests that importation of Norwegian pine was already increasing by the 1640s and he also shows how quantities of sawn Norway boards were imported through Southampton as early as 1253. He implies a change away from oak to pine flooring occurred around 1690.

²⁷⁹ HOW 2015, 84

²⁸⁰ LAMBERT 2016, 633-637

²⁸¹ CHURCHILL 1956 Vol I, 266

this long relationship.²⁸² When civil war broke out in the Low Countries in 1567, the 300 year old English colony in Antwerp, had to be withdrawn and its infrastructure abandoned. This discontinuity resulted in a loss of wool sales which caused distress and unemployment in England and it renewed the then current interest in overseas colonisation.²⁸³ Elizabeth's Ministers were forced to look for quick solutions in respect of wool processing and for technological advances for which England had traditionally depended on the Low Countries. To redress this loss, England turned to Saxony and the other sympathetic German States.²⁸⁴

3.2.4 Outreach solutions

The Tudor monarchs were fully aware of the backward condition of English technology and of the limitations of English ores.²⁸⁵ Saltzman describes one particularly bad instance of poor quality English iron and cites a complaint of 1324 from the smith, Nicholas Lythfoot, when a 'flail' (a pivoted locking bar) for the Watergate of the Tower of London lost two-thirds of its weight in seven weeks of forging, due to the poor quality of the iron supplied by a John de Thorney.²⁸⁶ He provides examples of how Spanish, French, Swedish, and Liège (*Lukys*) irons were imported in 1266, 1285, 1316, & 1473.²⁸⁷ He quotes instances of expensive Spanish nails being imported in 1495, and of some 10000 nails being imported from Normandy in 1532.²⁸⁸

3.2.5 The dispersed English iron and nail-making industries

A picture emerges of concentrations of English post medieval iron-making and nail-making in three main centres: the Sussex Weald, the Forest of Dean, and the West Midlands- clustered around Birmingham, fig. 57.²⁸⁹ Schubert gives much importance to Medieval York as a metals centre followed by Coventry.²⁹⁰ His own map suggests that York was tied to iron works at Leeds and Sheffield.²⁹¹ The rapid growth period for English iron is thought to be between 1500 and 1540.²⁹² It was during this period that the price of timber in Sussex rose by 200% in 15 years.²⁹³

²⁸² LAMBERT 2016, 637

²⁸³ HILL 1965, 154,155

²⁸⁴ HOW 2015, 81-90

²⁸⁵ WYNDHAM- HULME 1896, note 20: SCOTT 1972, 94-110: BURGON 1809, note 22

²⁸⁶ SALZMAN 1992, 301

²⁸⁷ SALZMAN, 1992, 286-8

²⁸⁸ SALZMAN 1992, 316

²⁸⁹ CLEERE 1981, 27, 31, 33

²⁹⁰ SCHUBERT 1957, 142

²⁹¹ SCHUBERT 1957, 96

²⁹² SCOTT 1985, 286-289

²⁹³ SCOTT 1985, 287-288. A parallel viewpoint sees the Act of 1550 exemptions for 'masterless men' to build cottages in forest and common land, as assisting the rise of small scale iron makers, and of nail makers in the Forest of Dean area, (HILL 1991, 43-44).

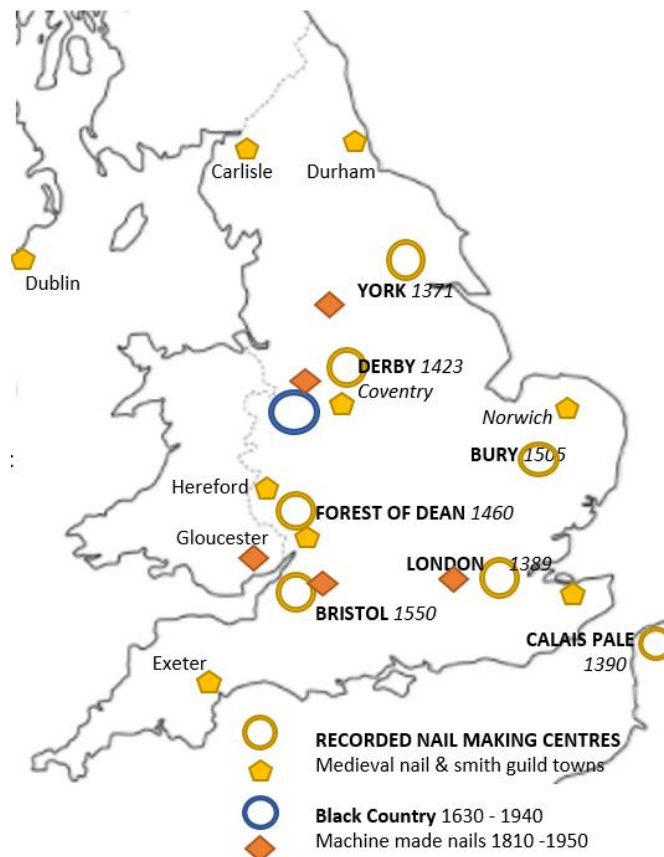


Fig. 57. English Nail-making centres.

The Sussex Weald does not figure as a nail making centre which is almost certainly due to the need to conserve the tougher Sussex iron for use in cannons,²⁹⁴ and ships' fittings, fig. 72.²⁹⁵

In the case of the West Midlands, the extensive iron-industry set up by the Romans had a long pause, possibly due to exhaustion of suitable vegetation for charcoal, and the industry did not revive until the 1750s - well after the first development of coke in 1709.

It would appear that nail-makers had been forced to rely on coal as a hearth fuel from Elizabethan times.²⁹⁶ Coal was also used as furnace fuel - as seen in the interesting surviving picture of an Elizabethan metal smelter shown in Appendix III, but brittleness in the iron could be linked to contact with sulphur, and so coal use was restricted to those coals of low sulphur content. There is evidence that coal had been tried with limited success during Roman times for the smelting of iron.²⁹⁷ The major impediment to English progress lay in its inability to produce adequate fuel in the form of charcoal for smelting. The peak period for charcoal iron had been prior to the Civil War during the decade 1625 - 1635, with an annual output of 26000 tons of iron.²⁹⁸

²⁹⁴ SCHUBERT 1957, 165-167

²⁹⁵ The recorded nail making centres are from Salzman, pp 299-317. The guilds for nail making, girdling, and items made "in the hammer way" are from Figueroa 2004, Rogerson 2011, Durham City 2006, Hoffman 2011, Lobel & Tann 2015, Blair & Ramsay 1991, 183-184, Coldewey 1993, 2- & London & Dublin Magazine 1825. Machine made nail centres refer HOW 2006, 2009, and 2014.

²⁹⁶ GODDARD 2012, 99-100, cites evidence of its use in nail forges in 1327, and cites 'smog' pollution in 1257. See also ASTON 1967, 42.

²⁹⁷ SCHUBERT 1957, 44

²⁹⁸ DEANE 1965, 107

3.2.6 Exhaustion of fuel

Up to the first half of the 18th century the industry was scattered, migratory and restricted by lack of fuel and by legislation designed to keep the woodland environment intact.²⁹⁹ Damage to forest and its effect on the needs of the Navy and the environment led to an act of 1581 forbidding ironworks within 22 miles (35.2 km) of London or 14 miles (22.4 km) from the River Thames.³⁰⁰ This restriction was cited in the preamble to a patent for 'cooked coal' of 1589.³⁰¹ Charcoal made from softwoods did not travel well, and the best charcoal - able to sustain the weight of ore & flux placed over it in the furnace - came only from hardwoods such as oak. The American colonies in the 1700s had ample supplies of native oak from which they were able to make good quality charcoal and, although forced to use lesser ores, they produced excellent iron which between 1728 and 1756 is recorded as exported to the home country.³⁰² This started as 443 tons exported from Pennsylvania, Virginia, and Maryland to London, which rose to a maximum of 2227 tons in 1745, then dwindling to 389 tons in 1756.³⁰³

Metallurgical studies have shown that a second reason why English iron was so inferior lay in the dearth of suitable species to convert to charcoal, of which a large part, as early as the 1300s, came from under-storey species such as hazel, and saplings.³⁰⁴ As seen above, the most prized timber for conversion to charcoal was oak, which had a high calorific value and a high residual crushing strength within the furnace. Ways of increasing the calorific value by adding straw and dung were successfully adopted, but an act of 1559 reserved oak-charcoal for casting of cannon for the Royal Navy. This was followed by an act of 1610 to preserve dwindling supplies of oak in Ireland for construction of Royal Navy vessels.³⁰⁵

This dearth of suitable timber for fuel is exemplified by a remarkable case of 1605 from the mountainous area of North Wales where an ore body and a smelter were remotely situated. (The Star Chamber report contained the interesting synopsis of the situation is shown at the head of this chapter). The Sheriff of Merioneth was himself found to be complicit in the theft of 30000 trees from the Crown, taken from this remote area to feed the smelter located at *Dol y Clochydd*. He was hauled before the Star Chamber in Westminster to receive two years imprisonment in the Fleet Prison³⁰⁶ and a substantial fine.

This particular case, whilst dramatic, is merely a repetition of other major illegal deforestation events in English history. In 1306 the Bishop of Durham had to answer complaints at the King's Court concerning major loss of forests owned by the Church. A precursor event to this had been picked up

²⁹⁹ DEANE 1965, 107–110)²⁹⁹.

³⁰⁰ SCRIVENER 1854, 36

³⁰¹ SPANNAUS & WHITE 1977, 181

³⁰² HOW 2009, 74-75

³⁰³ FRENCH 1858, 7-9. Pennsylvania State University sets these figures much higher; 3000 tons in 1750 and 8000 tons in 1770, (Pennstate website, Medieval Technology and American History, 2019). This latter figure seems highly unlikely and should be compared to their TABLE 3.1 which shows 80% self-sufficiency only five years later.

³⁰⁴ YOUNG & POYNER 2014, 92. There was a prohibition on tree felling as early as 1272 but a critical period was 1255-1341, (SCHUBERT 1957, 112-114). Various events suggest the crisis in felling may have occurred earlier, in the 1170s, (GIMPEL 1976, 77). Like events, attributable to felling by some 60 smelters in the Royal Forest of Dean, were reported to the king in 1282, (Ibid. 79).

³⁰⁵ MADDIN 1985, 130 -131: SCOTT 1985, 160 – notes Liege workers recruited for new iron works in Ireland in 1610.

³⁰⁶ The infamous debtor's prison.

in 1270 by a Royal survey at Ross on Wye, near the Forest of Dean, whereby the Bishop of Hereford was also implicated in the destruction of some 9000 trees.³⁰⁷

One of the earliest actions of James I, as joint King of England & Scotland, was to ensure peace with Spain in 1606, in order that normal relations could be maintained with the Lowlands and *Lukys* (Liège) iron could once more be brought over from 'Flanders'. Other iron varieties were sourced from further afield, through the Hansa merchants, and eventually from St Petersburg, in order that the demands could be met.

The accompanying problems of transport and ever higher costs forced England to purchase ready-made iron at the best prices offered. In 1720 smelting with charcoal was still being used, but the annual production of iron had dropped to between 20000 and 25000 tons.³⁰⁸ The balance was made up of imported bar iron, largely of Swedish origin. Already in 1676 shortages of charcoal had driven up the price of English iron above that of imported bar iron from Sweden, Flanders, and Spain.³⁰⁹ Many contended that this was a desirable state of affairs as it combated the large wastage of wood involved in iron manufacture, (Ibid.)

3.2.7 Demands of the Royal Navy

In the 1720s the American Colonists had sold pig iron to Britain and by 1735 they achieved a significant success with the quality of their own home produced bar iron. Quantities sent for tests to the Navy Dockyard at Woolwich were deemed, “-superior in every respect to the best Swedish iron” and were recommended by purchase by the British Admiralty:

*That from the trials we have made from one ton of iron imported by Mr. Crawley, from America, it is, both in the nature, and goodness, and value, equal, in all respects, with Swedish iron.*³¹⁰

This question of iron supply was set against the background of great discontent felt by the Admiralty towards the British iron industry. They deemed British iron to be inferior and inadequate to Navy requirements.³¹¹ The Admiralty insisted on the superior Swedish 'steel' (Osmund iron). Britain was then not only Sweden's first customer for iron, but that of Russia also.³¹² The Navy would accept Russian iron as an alternative to Swedish, but no British iron was deemed acceptable. The inadequacy of British iron had become a national disgrace and in 1747 Malachy Poslethwayte wrote:

*Bar Iron is one of the Essentials belonging to our Naval Stores; and a happy Independency upon any foreign Nation for our supplies which so nearly concern the support of our maritime power, has always been judged desirable.*³¹³

³⁰⁷ SCHUBERT 1957, 113. It should be noted that this concept of 'destruction' is also disputed by Dr Rackham who believes a significant recovery of woodland occurred following the Black Death of 1349, (Ibid. 49).

³⁰⁸ DEANE 1965, 107

³⁰⁹ SMILES 1883, 107

³¹⁰ FRENCH 1858, 3

³¹¹ HAYMAN 2005, 46

³¹² SMILES 1886, 46

³¹³ HAYMAN 2005, 24 -28

There were three urgent aspects requiring resolution:

- Smelting from coal, which started to take effect with Abraham Darby's first, but limited success use of coke in 1709. (See 3.3 below).
- Avoidance of deleterious pollutants by improved furnace design and by the methods used in refining.
- Dependable power sources for air blast and for removal of silica using steam engines.

From 1760 Britain underwent a forced transition in iron production, activated by Henry Cort, a Naval Agent at Portsmouth. Cort's puddling process of 1783, using the reverberatory furnace, came at a particularly opportune time, following a series of successes with the production of coke. By 1790 a minor revolution in the British iron manufacturing industry had taken place.³¹⁴ The significant pressures which had been put on all branches of industry by the French Wars (1793-1815) by 1806 saw some 87% of iron production located on coalfields.³¹⁵ It is argued that conflict with the new United States of America (1812-1815), the short period of confrontation with Sweden whilst allied with France, and the political pressures placed by Napoleon on Europe, all gave rise to growth in the British iron industry.³¹⁶ During the Napoleonic Wars there had been an explosion of initiatives and enormous growth in the use of steam engines with 112 of them in use in London alone.³¹⁷ Pig iron output had grown to 250000 tons per annum from around 30000 tons in 1760.³¹⁸

3.2.8 Concentrations of industry

A patent dated September 1589 had been granted to Thomas Proctor & William Peterson of York for 'cooked coal' and this was followed by a second patent in 1610 to a Simon Sturtevant.³¹⁹ Numerous like patents followed, some 23 patents all told between 1620 and 1640, of which none were really effective. It was not until the advent of hot blast at high temperatures that the offensive elements (especially sulphur) could be fully driven off. But between 1709 and 1769 coke changed the whole nature of iron making, its cost structure, and placed its geographic locations within Britain around coalfields. It is discussed in more detail below in 3.3.1.

3.2.9 Increased demand for nails and building timber

Returning briefly to the late Tudor times and the period following, it should be noted how the forces governing society formed part of the equation. During Elizabeth's reign social conditions had improved,³²⁰ and consequent population growth then contributed to a new upward mobility³²¹. The population of London had increased eight fold between 1500 and 1650.³²² An artisan class emerged of 'masterless' men - quarry and foundry workers - not tied to any particular locality, but for whom special exemptions were made for dwellings on common land.³²³ A building boom developed which outstripped the supply of oak, making it very expensive.³²⁴ As a consequence greater use was necessarily made of sawn wood and more re-used timbers were used also along with imported softwoods.³²⁵ The rush to build was

³¹⁴ ASHTON 1946, 70. HAYMAN 2005, 46-53

³¹⁵ DEANE 1965, 109

³¹⁶ JONES 1987, Vol 1, 35 -37

³¹⁷ KNIGHT 2013, 352-353

³¹⁸ DEANE 1965, 111

³¹⁹ PRICE 1906, 176-181

³²⁰ HILL 1965, 22

³²¹ ROWSE 1951, 218, 244; HILL 1975, 39-53

³²² HILL 1975, 40

³²³ HILL, 1991, 39-56

³²⁴ BRUNSKILL 1994, 27. BARLEY, 1990, 48-53

³²⁵ CLIFTON TAYLOR, 1972, 300-302

nicely summarised by the south Essex eyewitness, Parson Harrison, in 1577; *never so much has been spent in a hundred years before as in ten years of our time, for every man almost is a builder.*³²⁶

By 1603 the changes in framing and conversion techniques were noted by Robert Reyce of Suffolk: - *the careless wast ---of our wonted plenty of timber, and other building stuffe, hath enforced the witt of this latter age to devise a new kind of compacting, uniting, coupling, framing, and building, with almost half the timber which was wont to be used, and far stronger.*³²⁷

As the sawn timbers got smaller, so the necessity for nailed connections accelerated the demand for nails and increased the use of softwoods. These factors in turn gave rise to wider range of nails, thus propelling the industry forward and increasing demand for iron.

A second picture emerges from fig. 57, which suggests that during the medieval period nail-making was more widespread and more on a local basis. It suggests that the emergence of the larger centres of industry did not eventuate until the advent of slitting (*fendage*) - possibly forcing an industry base by 1650 or so. In addition to the above a further big incentive to nail production had been the establishment of the North American colonies, which grew at a dramatic rate with a concomitant growth in demand for nails.³²⁸ An interesting example of this type of industrial enterprise in its maturing phase concerns Ambrose Crowley, who in 1683 shifted his London ironware factory to Sunderland in the North West to take advantage of the cheap shipping costs available from empty colliers leaving the metropolis. His ironworks used some local nailors but numbers of Catholic nail makers were recruited from Liège and his company rapidly grew to employ 100 nailors by 1688.³²⁹ This story also demonstrates the poor state of English overland communications prior to the coming of canals in 1770, and of railways in 1830.³³⁰ The building of roads by Turnpike Trusts took effect by 1750 and toll roads reached a peak of efficiency in 1820.³³¹

The rapid increase in demand for nails saw the loose conglomeration of local nail forges clustered south of Birmingham grow into an ad-hoc industry. By the late 1750s the historian Hutton estimated that there were 60000 people involved in nail-making in the West Midlands alone. This localised growth did not do away with other local centres entirely but set in place a major export base with possibilities of shipping out iron products from the ports of Liverpool and Bristol (via the River Severn).

3.3 SALVATION BY TECHNOLOGY

3.3.1 Coke, power, and heat regeneration

The final ingredients for the effective smelting iron in Britain came together around 1840. These were;

- Coke
- Hot-blast (regenerative heat)
- Furnace design (particularly with respect to furnace height).

Coke, in a process of long gestation which started in 1589 with Proctor and Peterson, was developed as a practical fuel by Abraham Darby in 1709, which at first relied on low sulphur coal.³³² In 1769 coking ovens were considerably improved and enlarged by John Williams, but it was not until 1808 that coke ovens were built in Sheffield in a battery system, thereby reducing heat losses and providing a more even output. By 1850 coke production in Britain had grown to over one million tons which increased sevenfold in the next 30 years.³³³

³²⁶ RYAN 2000, 18

³²⁷ LOWELL CUMMINS 1979, 15

³²⁸ ROWSE 1971, 224-251

³²⁹ ANDERSON 1973, Part 8

³³⁰ SNODIN 1978, 32-33

³³¹ HIBBS 1851, 11

³³² SNODIN 1978, 29

³³³ BEAVER 1981, 133-148

Hot air blast had started as a coal gas production initiative in Glasgow by Neilson and Macintosh,³³⁴ but the benefits of hot-blast were independently found to be of great use in iron smelting in Wales by Crane & Thomas, who patented the method in 1836. Thomas later took the method to America, but Cockerill and his Belgian colleagues developed the process further in 1853 at Seraing.³³⁵ The method recirculated the hot gases from the furnace through a set of tubes forming a heat exchanger for incoming air passing through the hot chamber – the so called ‘regeneration’ of heat.³³⁶

The change to hard coke as a fuel removed most of the impediment to vertical loading in the furnace, which had hitherto been greatly limited by the use, and the particular type, of charcoal. The improvement in internal stacking height permitted higher temperatures to be reached.³³⁷ In the case of Belgium, which had good quality ores, the increased volume of furnace led to improvements in the volume of iron produced,³³⁸ fig. 58.

It should be noted that charcoal remained the most effective means of smelting in the overall sense and for furnace heights up to 25 feet (7.5m) the English thermos-chemist, Isaac Lothian Bell in 1884 was able to show that there was a gain of 34% efficiency in the amount of heat needed by using charcoal, as opposed to coke. However, a balanced optimum between the two fuels occurs at around 30 feet (9.8m) which still remains the preferred height.³³⁹

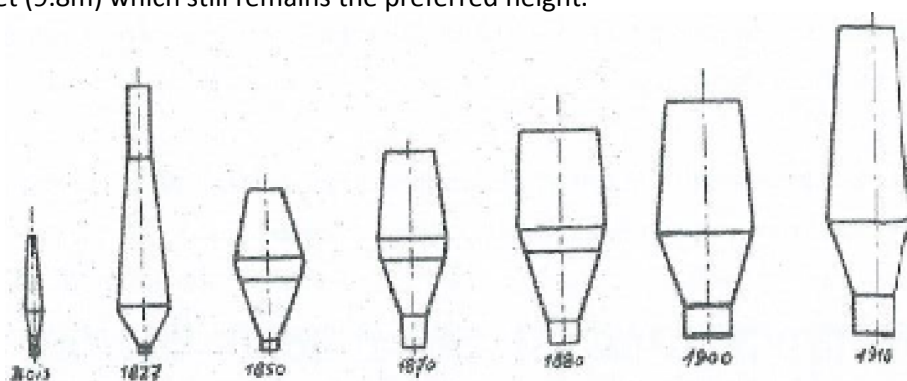


Fig. 58. The growth in height of iron furnaces in Belgium: wood to charcoal, and charcoal to coke, 1827 – 1918, (DE BOUW 2010, 70).

Table 3.1 demonstrates how improvements in Britain were pronounced as can be seen in the growth of volumes and smelter efficiency.³⁴⁰

³³⁴ James Beaumont Neilson was awarded a patent in 1828 for this major advance, (FRENCH 1858, 25: HAYMAN 2016, 37). It significantly reduced the amounts of fuel used and made it possible to smelt the poor quality Scottish Blackband ironstone ores previously considered next to worthless, (DEANE 1965, 113).

³³⁵ JOHANNSEN 1925, 177-180

³³⁶ JOHANNSEN 1925, 173-180. See also HAYMAN 2016, 36-39 for images

³³⁷ DE BOUW 2010, 69-70

³³⁸ DE BOUW 2010, 70 Fig. 111

³³⁹ WILLIAMS 2017, 88-89

³⁴⁰ JOHANNSEN 1925, 181

TABLE 3.1. CHANGES IN SMELTER VOLUME, OUTPUT, AND EFFICIENCY

Year	Builder	Location	Height	Volume	Output	Vol:Output
Jahr	Erbauer	Ort	Höhe in m	Inhalt in m ³	Erzeugg. in t	m ³ Inhalt je t Erzeugung
1861	Whitwell & Co.	Thornaby	18,3	360		
1862	Bolckow, Vaughan & Co.	Cleveland	23,0	340		
1864	Samuelson	Newport	21,0	440		
1864	Thom. Vaughan	Southbank	24,7	450		
1866	Bolckow, Vaughan & Co.	Cleveland	29,0	430	46,2	9,3
1866	Hopkins, Gilkes & Co.	Teesside	25,0	566		
1868	Bolckow, Vaughan & Co.	Cleveland	29,0	736	52,5	14,0
1870	Lowthian Bell	Clarence	24,4	700	60,0	11,7
1870	Cochrane	Ormesby	27,5	1165		

In addition to the gain in volume efficiency a significant reduction of the amount of coke used per tonne of iron produced was realised by regenerative heat (hot air recirculation), from seven tonnes of coking coal in 1788 to five tonnes in 1810, and three and a half tonnes in 1840.³⁴¹

As the benefits of the three developments were realised, not only production increased but ores which had previously been too expensive to smelt became available, fig. 59.³⁴² This resulted in increased competitiveness for the British iron industry as the inferior ores could be found within the coal measures, and transport costs dropped accordingly.

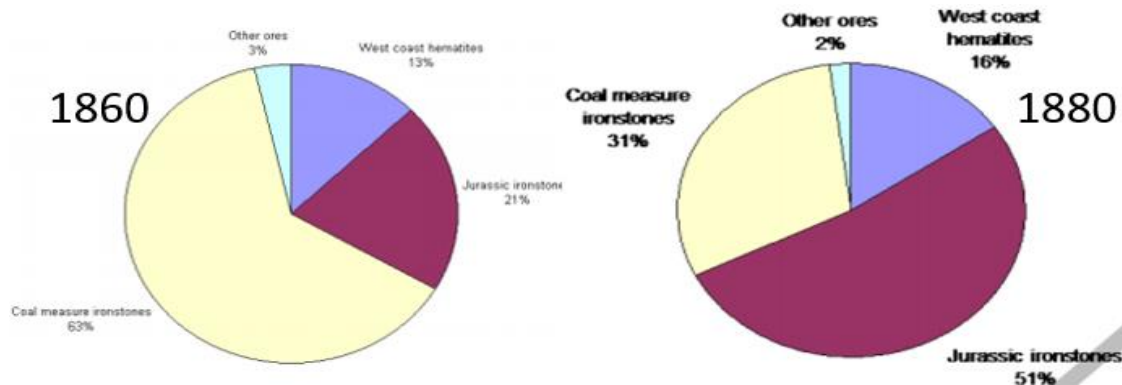


Fig. 59. Changes in ore type use, 1860 & 1880, after Claughton 2005.

3.3.2 An integration of technology, invention, and infrastructure

Professor Deane selects the date of 1775 as being the particular breakthrough of technology for the formation of the Industrial Revolution.³⁴³ There is much to be said for this choice and viewpoint. Certainly, the rise in production becomes dramatic soon after this date. (Refer Table 3.2). Professor Ashton counters this with the salient reminder from the scientist Michael Polyani:

³⁴¹ DEANE 1965, 113

³⁴² CLAUGHTON 2005, no page ref

³⁴³ DEANE 1965, 109

*Invention is a drama enacted on a crowded stage. He goes on; Applause tends to be given to those who happen to be on the boards in the final act, but the success of the performance depends on the close cooperation of many players.*³⁴⁴

To which must be added that the processes governing invention are supra-national, as for example has been demonstrated by the story of slitting, with input from the Lowlands, Saxony, Wales and England, (Chapter 2 and Appendix II). There is also the aspect of some incredibly long gestation periods as shown by the story of coke, starting with the 1589 licence for the 'cooking of coal' with numerous small advances along the way. The reader will be aware also of the keen interest shown by the French in what was happening in England, and vice-versa, as for example with the breakthrough in annealing, which some might think the work by Réaumur was the peak effort.

To project the cumulative efforts into visual form, and to identify the rising effects these made to the history of iron industrialisation and nail-making, some of the main features are shown in graphical form in table 3.2.³⁴⁵ Some of these aspects, as already covered above in 3.3.1, would benefit from some further explanation:

(a) The top panel shows in a timeline the three major elements involved in the production of iron:

- The progressive development of furnace design and smelting.
- Fuel. The dearth of charcoal resolved by the first practical cokes of 1709 and then the change to using indirect heat from coal by means of the reverberatory furnace. This was followed in 1749 by much improved coking methods.
- Power. Early steam was used simply to raise water, as in the draining of mines. If lifted to a higher pond level the water raised could be used to power conventional water wheels to provide rotary motion.³⁴⁶ The big advantage of Watt's engine was to provide direct rotation, via the moon and planet gear wheels, which was first employed in the iron industry in 1782.³⁴⁷

(b) The bottom panel presents the growth curve of British Iron production, which is annotated to include events of significance, and which read like a comedy of errors. England, towards the end of Elizabeth's reign, went from a situation of 90% self-sufficiency in iron to a disastrous need to buy in more than half the iron used in the combined realm by 1720. The stop-gap measure of importing high quality Swedish iron was twice shaken and nearly brought to a halt by political events, and the British iron and nail-making industry was saved by Russian willingness to sell iron at two-thirds the cost of British iron, enabling nail exports to surge. In 1722 production of bar iron in Russia was 6200 tons of which 1085 tons was exported to Britain. By 1790 production had risen to 88,500 tons and sales to Britain had risen to 25,000 tons.³⁴⁸

By grace of the new initiatives and invention, particularly Cort's processes and the steam engine, Britain recovered to 80% self-sufficiency in 1775. It reaped the benefit of improved coal mining (by de-

³⁴⁴ ASHTON 1948, 14-15

³⁴⁵ This composite diagram relies on several sources: Richard Hayman 2005 and 2016. Phyllis Deane 1965, T S Ashton 1948, Hugh Bodey 1983, David Snodin 1978, Samuel Smiles 1883, H R Schubert 1957, L F Salzman 1952, Otto Johannsen 1925, B F French 1858, Amos Loveday 1983, Evans & Ryden 2005

³⁴⁶ An example of this relates to the Welsh iron industry at Dowlais. Newcomen single acting steam engines were used to pump water to reservoirs which then fed a large water wheel, (JONES 1987, 39).

³⁴⁷ SNODIN 1978, 26

³⁴⁸ ATTMAN 1981, 188-191

watering) and canal transport, to produce quality iron at below Swedish iron prices. Britain thus became an iron exporting country by 1812. After 1815 it reaped the further benefits of high pressure steam engines, railway transport - on a developing scale, and then the 'ultimate' solution of Bessemer's converter with its exothermic reaction.



Fig. 60. Smelters and ports in 1717 after Schubert 1957.

A beneficial consequence of the technical advances and inventions was the concentration of industry around coalfields such that the dispersed nail-making industry gradually coalesced to favour secondary zones, not far from smelters and slitters. In the case of the West Midlands several centres were grouped around Birmingham.³⁴⁹ Other smaller centres were Gloucester and the adjacent Welsh marches, and Sheffield, fig. 60.³⁵⁰ Bringing coal and ores together was achieved by using waterways

³⁴⁹ SCHUBERT 1957, 193

³⁵⁰ Ibid.

and canals. The West Midlands and Gloucester region were well served by the major ports of Liverpool and Bristol for sea based exports.

Canals were not a new development but an extension of medieval practices of developing rivers into navigable waterways, the principle routes being based on the Severn River upstream of Bristol and the Thames west of London.³⁵¹ Oliver Rackham's estimate of comparable costs of transporting timber is quoted by Wazny as being:³⁵²

- Road: 50 miles.
- Inland waterway: 200 miles.
- Sea: 500 miles.

This may be a serious understatement of the problem since it effectively presents canals as four times cheaper than transport by road. In fact transporting goods by waterway in 1700 was ten times cheaper, and in most cases faster.³⁵³ For the North and West of England, and Wales, conditions restricted road transport to pack-horses.³⁵⁴ In the case of coal and ore movements, canals totally changed the cost structure of transport as exemplified by this quote from Adam Smith:

Six or eight men, by the help of water carriage can carry and bring back in the same time, the same quantity of goods between London and Edinburgh as 50 broad-wheeled wagons attended by hundreds of men and drawn by 400 horses.

James Ayers draws attention to the other transport cost saving device, the tramway.³⁵⁵ Although not an entirely new device it had been brought to a fine stage of development as a 'railway' servicing various Newcastle collieries. The French émigré Jean Desaguliers' fine copperplates show how these advancements had become little different by 1730 to a modern rail flatbed truck running on flanged wheels and iron rails.³⁵⁶ Its development by the tycoon Ralph Allen enabled the re-building of Bath to be advanced with significant reductions in the price of stone, and hence construction. Because it made connection with a navigable river it had a secondary flow-on effect in the expansions of Oxford and London, thereby boosting the already growing building and nail industries.

However, the improvement of waterways and canals, which took time to effect, started to become redundant with the coming of rail in around 1830.³⁵⁷

³⁵¹ BOGART ET AL 2017, 7-11

³⁵² WAZNY 2002, 119-121

³⁵³ SATCHELL 2018, 32-53

³⁵⁴ BOGART 2016, 4

³⁵⁵ AYERS 1998, 71/72

³⁵⁶ DESAGULIERS 1734-1744: The original copy in the Science Museum, South Kensington contained the images included by Ayers (FN 346)

³⁵⁷ Based on Bogart et al 2017 6-12, and Satchell 2018, 7-8 and 32-53.

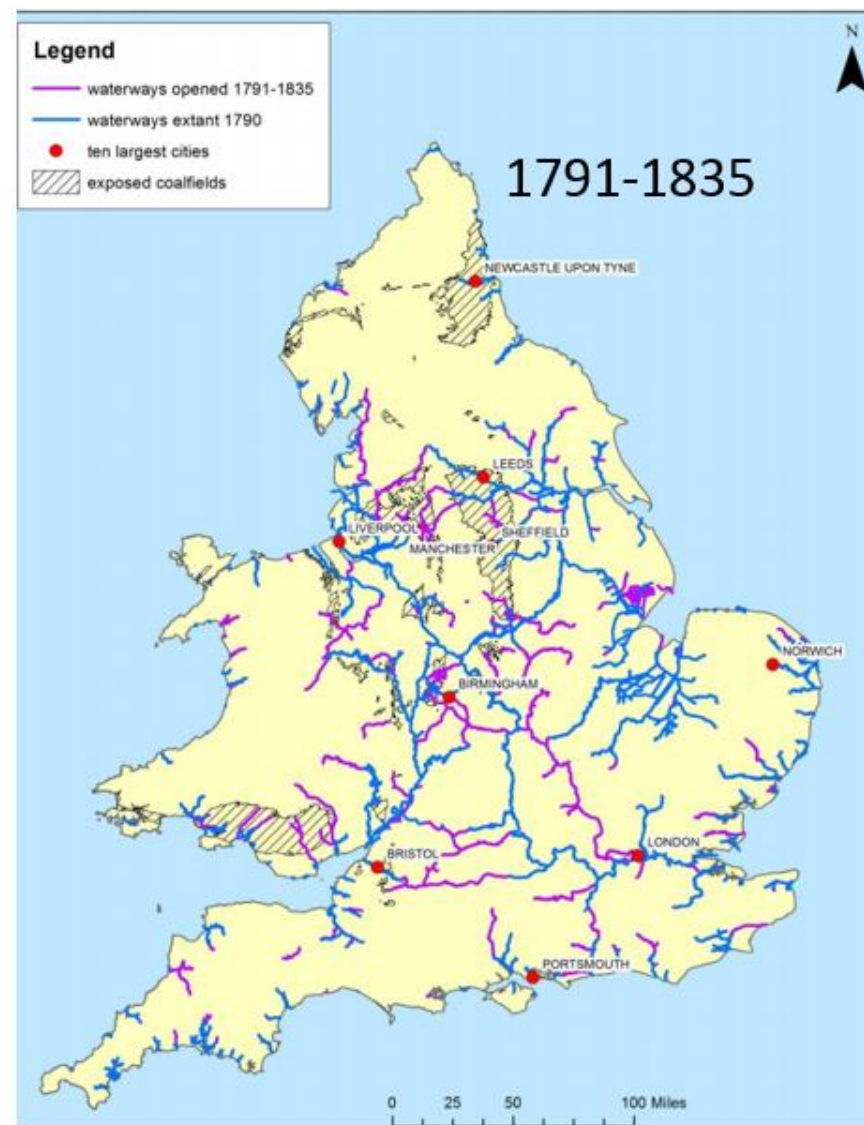
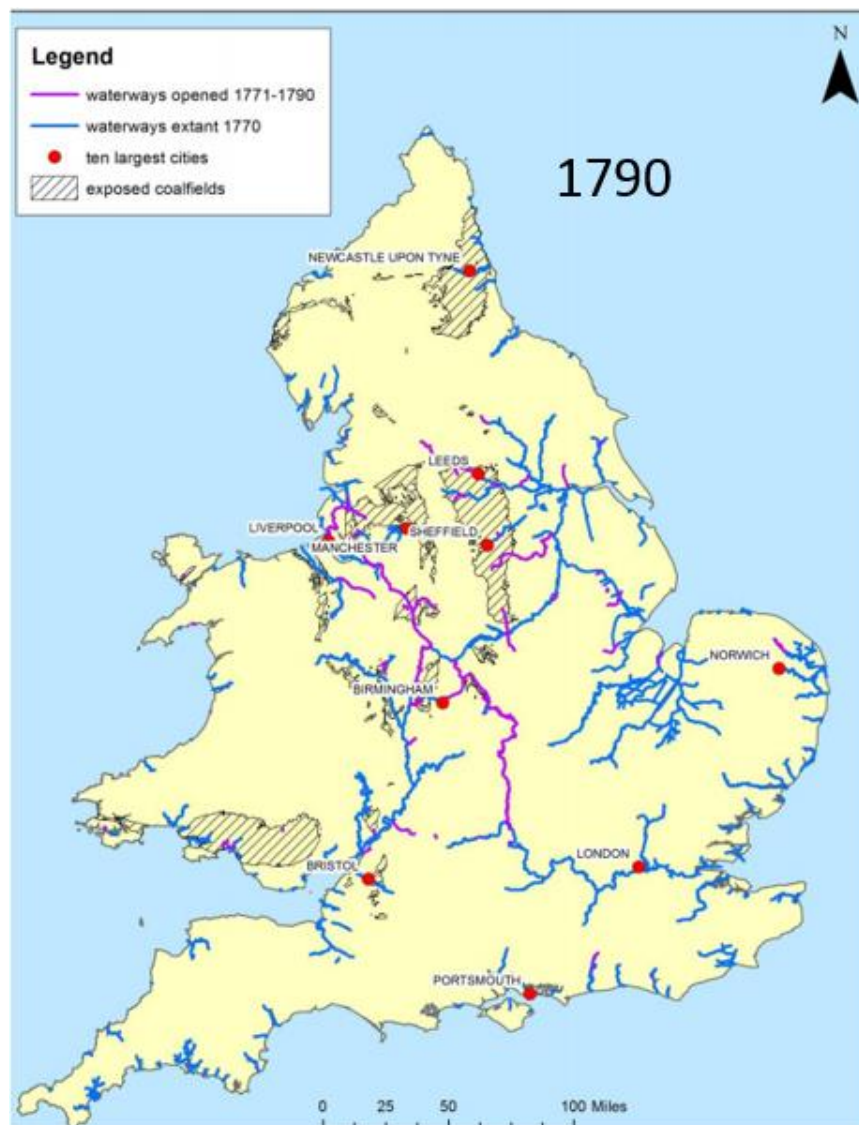
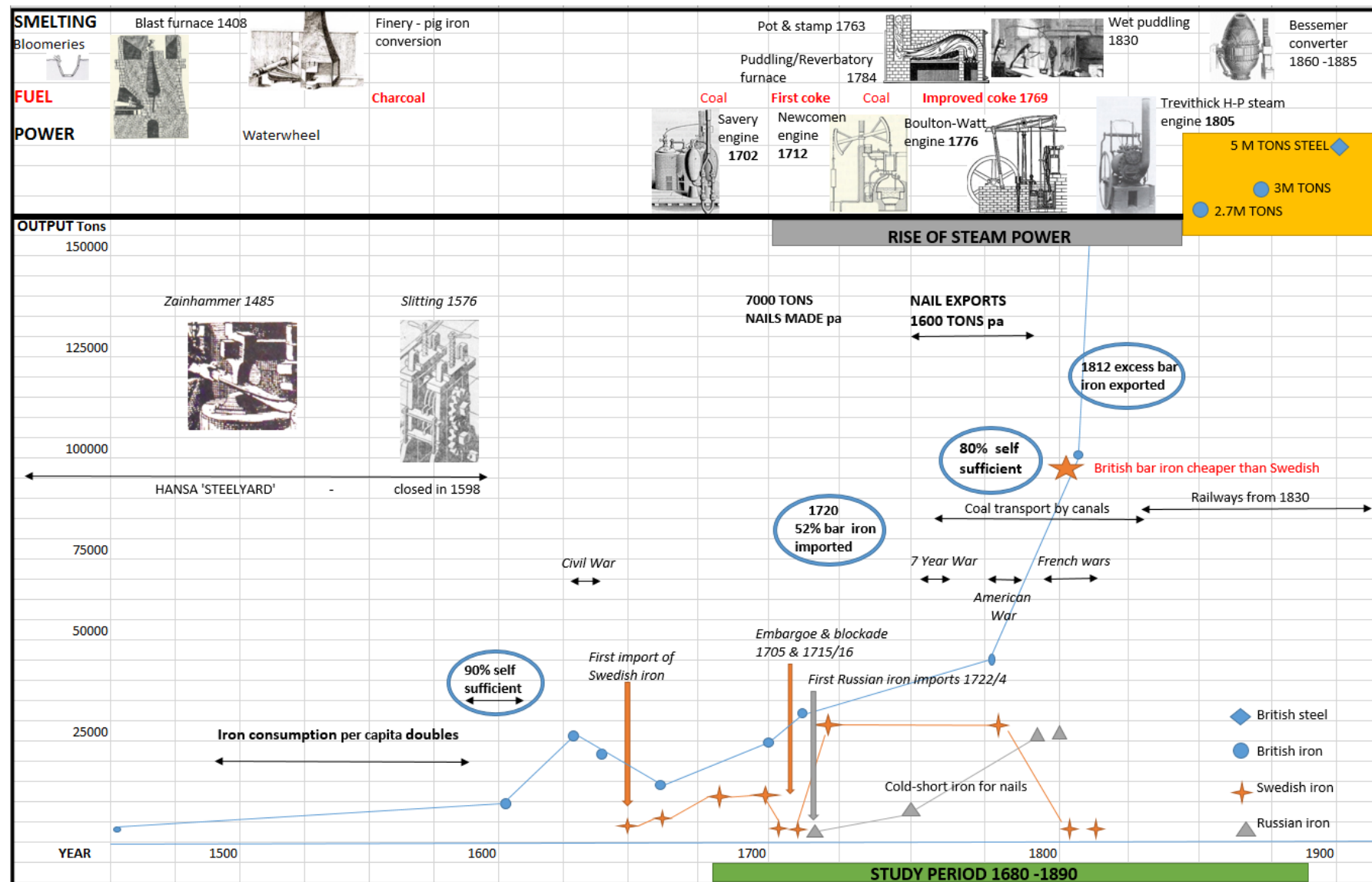


Fig. 61. Canals related to coalfields and canal growth 1790 – 1835, after SATCHELL 2018, 17, 25

TABLE 3.2. CHANGES IN IRON PRODUCTION AGAINST DEVELOPMENT OF THE BRITISH NAIL MAKING INDUSTRY



3.3.3 Nails and nail fabrication 1680-1890

At the start of the study period, in 1680, there were already four ways of making iron nails. In order of importance these were:

- **Wrought.** By 1680 these were invariably forged from nail rods which in Britain, the American colonies,³⁵⁸ France, and the Low Countries, were made by slitting (*fendage*). Some of the German States had the earlier device, the *Zeinhammer* (Tooth-hammer) still in use, together with the *Reckhammer*.
During the 1790s a further simplification became available with an improvement in the availability of rollers to form round bar. There had been a demand for round ship spikes and for strong round nails, used for fixing leaden pipes to masonry walls. These are still known today as 'pipe nails', but references go back to the Middle Ages.³⁵⁹ Their features will be explained further in Chapter 4.
- **Cast.** This was the simplest method available for making nails with intricate ornamental heads and for those nails used in armoured doors, such as for cells or strong rooms. The extent to which iron, as opposed to bronze, was used for these nails is in some doubt, but cast nails were widely used for ship nails made of bronze, copper or brass for fixing sheathing, in fixing the zinc linings of powder magazines, and in other shipboard use. It appears bronze nails were seldom used in buildings prior to 1800 or so.
Because cast iron nails needed to be made malleable before being used, there had been a string of English patents and licences dating back to 1567 dealing with annealing processes needed to effect malleability. Réaumur had produced an annealing method in 1722, but the most effective method was developed by Joseph Ashton in 1767. After this a plethora of different types of cast iron nail types became available, driven by the demand for ornate coffin nails.³⁶⁰ A further improved patent by Samuel Lucas in 1804 saw the introduction of malleable cast bolts which could be threaded after annealing,³⁶¹ several of which have shown up in the late post-Napoleonic war period in Britain, and in Australia around the 1820s.
- **Cut.** A reference to specialized glazing nails from Westmorland suggests that small cut iron brads were made once large panes of glass became common around 1680.³⁶² Such small 'sparrow-bills' could be hand cut cold from thin iron strip using shears or a small guillotine. After 1790, when rolled sheet or ribbon was used for the production of cut nails, protective coatings were applied to the sheet or to the finished nails, hiding the essential iron qualities. This appears to have been more common once cold cutting became into practice.
- **Wire.** Handmade wire nails, of brass and of iron, are invariably overlooked by the standard literature. The author and Professor Vanden Eynde identified some samples from a 1644 organ from the church of the Beguinage at St Truden.³⁶³ French sources make it clear that wire nails were available in two gauges and up to 54mm long by the 1740s.³⁶⁴ How many of these 'pins' were exported outside of France is unknown. Within the specialist profession of organ building (*Facteur des orgues*), due to the tight tolerances to which the organ

³⁵⁸ By 1750 there were four slitting mills and eleven plating forges (using tilt-hammers), operating in a quasi-defiance of British Parliament legislation, (FRENCH 1858, 7).

³⁵⁹ SALZMAN 1997, 267

³⁶⁰ MOSELEY 1968, 31-32

³⁶¹ MOSELEY 1968, 33

³⁶² LEVENS HALL 1692 -95 accounts book. See HOW 2014, 233

³⁶³ Courtesy Pierre Decourcelle of Tournai. He has methodically recovered & retained historic organ nails.

³⁶⁴ ROUBO 1769, 259

mechanisms are built using traditional materials, there still exists a tradition of making certain 'tailored' nails which may have included hand-crafted pin nails made of iron wire.³⁶⁵

3.3.4 The progress of nail iron

At some future time a detailed spectrographic analysis of a historic range of nail samples would reveal many more changes, but the principal of there being at least two grades of iron concurrently in use for wrought nails is beyond reasonable doubt. Common grade, 'cold-short' iron tends to a dull grey colour with a more open surface texture and breaks easily. Nails intended to be clenched appear more silvery and have a close formed surface which is more reflective to light. Cast nails, appearing as lath and door nails after 1769, also appear silvery and with a reflective sheen. Later Victorian era ones do not exhibit the same qualities as do these early ones.

Wrought nails were made of more than one grade of iron and, once samples are properly cleaned it is possible to observe the changes in colour of at least two of these grades, and sometimes of three different iron types, particularly when they are displayed as a group. However, the majority of common nails were made from an ordinary grade of iron known as 'cold-short' which when cold did not bend easily without fracture. Some continental ore sources of better quality would have figured in the local 'quality' nail production as being superior to common British nails. Four specific types of nails were necessarily manufactured from superior iron: horse-shoe nails, which had to be clenched over the hoof; door nails, which were normally double clenched and which often appear in London houses of 1750 in the form of wrought clasp nails; door rivets which had to be cold forged in place; and 'jobent' nails, used to secure thin iron hinge and cover plates for cupboard locks, etc, which functioned better to hold the lock or latch when clenched. Since simple plain doors were made of vertical planks fitted to ledgers, the preferred nail type used in Britain during the 1700s and up to WWII, was the clasp nail, which, having a peaked head, could be driven down to leave a plain external surface, fig. 62. It should be noted that in the Midi of France common rosehead nails were widely used for doors. These are noted to be better quality of iron in common nails than that used in Britain. Writing in 1777 & onwards, Jacob Krünitz states categorically that English common nails were made of Russian iron.³⁶⁶

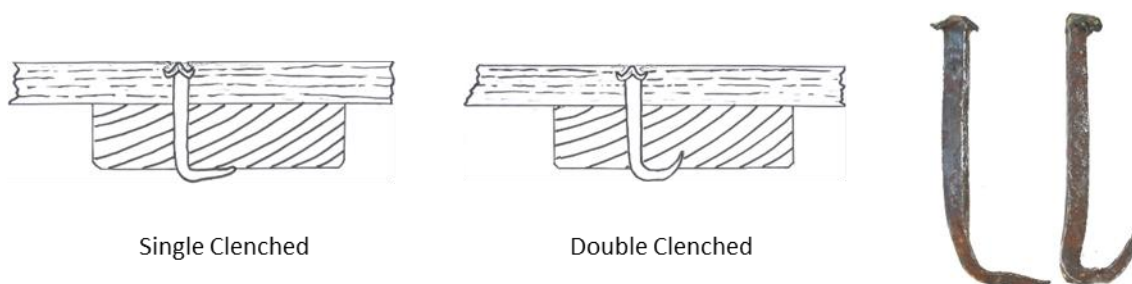


Fig.62. Example of single and double clenching c.1865 (Author).

It has come to light during this study that the quality of common iron also varied during the selected period. A relatively few historic samples which could be spared for destructive analysis by ultimate tensile strength (UTS) apparatus gave some surprising results, Table 3.3.³⁶⁷

³⁶⁵Organ builder Pierre Descourcelle demonstrated his own workshop made specialist nails, Nov. 2018.

³⁶⁶KRUENITZ 1777, 100/602

³⁶⁷The author is indebted to Dr Carl Schaller at the University of Ballarat (now Federation University) for help with the UTS tests, December 2010.

TABLE 3.3. ULTIMATE TENSILE STRENGTH TESTS, BALLARAT UNIVERSITY, DECEMBER 2010

			CSA (mm ²)	Instron full scale (kN)	Plot measure (mm)	Failure (kN)	UTS (Mpa)	Observation	Note
DATE:	15Dec '10								
IRON.									
1690. 1(a) lath sprig 2.8 sq mm			2.9	5	65.5	1.31	451	ME.	OK
1690. 1(b) lath sprig 5.0 sq mm			5	5	61.5	1.23	246	Flawed	Ignore
1690. 1(c) lath sprig 5.25 sq mm			4.75	5	82.5	1.65	347	Jaw slip	
1730. Clasp nail 11.22 sq mm			11.22	10	98	3.92	349	Inc	OK
1732. Spoon end rafter nail. 16.22 sq mm			17.48	20	89.5	7.16	410	Obl. Inc	OK
1803. Floor spike. 12.25 sq mm			11.56	10	148	5.92	512	Obl. Inc	OK
1855. Ewbank, original patent. 9.72 sq mm			9.72	10	88	3.52	362	ME. Obl.	OK
1861. Ewbank,			12.33	10	99	3.96	321	ME. Obl.	OK
1869. Ewbank, star-head. 5.98 sq mm			5.98	10	100.5	4.02	672	ME. Obl.	Re-do
1879. Wire rose head. 12.52 sq mm			12.52	20	51.5	4.12	329	Brittle	OK
1888. Wire sq facet head. 14.52 sq mm			14.52	20	132.5	10.6	730	ME. Brittle	Odd
1856. British cut nail. 8.12 sq mm			8.12	10	67	2.68	330	Oblique	OK
1867. Clasp nail			5.98	5	87.5	1.75	293	ME.	From fire
1877. American cut nail. 5.32 sq mm			4.8	10	38.5	1.54	321	Oblique	Recalced
STEEL.									
1879. Wire bun-head. 5.73 sq mm			5.73	10	90.5	3.62	632	Necking	Snap in jaw
1887. Wire bullet head. 15.90 sq mm			15.9	20	129.5	10.36	652	Necking	Normal
1910. Oval Samson wire. 6.6 sq mm			6.6	10	149	5.96	903	Necking	Normal
1910. Wire square section, Latvia. 9.3 sq mm			9.3	20	98	7.84	843	Necking	Snap in jaw
								ME.	Minor extn

3.3.5 Other contending nail-making centres

This study focusses primarily on British nails after 1680 but the relative ease with which these small items could be distributed, on a worldwide scale, and the influences of one particular national group upon the others, makes it necessary to review and consider the situation of the other nail producing centres of Europe, and of the rapidly developing North American market. In 1680 the most compact and consolidated nail-making industry was not in the English Midlands, but in the Principality of Liège, and both of these centres were to grow in strength and importance.

TABLE 3.4: ASPECTS OF BRITISH IRON RELATED TO CHANGES IN POPULATION, TECHNOLOGY, PRODUCTION, & EFFECTS ON NAIL STRENGTHS

YEAR	POPULATION	SMELTING	POWER	MAJOR EVENTS	OUTPUT Fe/steel	NAIL INDUSTRY	NAIL UTS TESTS
1200	4.5 M + Wales	Bloomery/charcoal	By water	BLACK DEATH 1348-1354		First specialisations	
1450	HALVED	Blast furnace 1490				Midlands, Bristol, North	
1558	3,2 M	Charcoal product restricted		Felling ban, lighter timbers used			
1567				First slitter trials			
1600	4.4 M		By water			4 slitting mills	
1628				Export of iron/metals licensed			
1650		Coal smelting trials		Civil War: first major import Swedish iron	26Kt		
1700	5.0 M + Scotland	Reverbatory hearth	Savery engine pumps	<i>(Waste of forest by paliamentiary army)</i>	20 Kt	400 tons exported	350 - 450 MPa
1708		Mechanical blast, first coke		Embargo on Swedish iron			
1720	5.9M (GB)		Newcommen engine	First Russian iron import. Swedish max	22 Kt		
1750	10 M (GB)	Malleable iron (A. Darby)		Roads & waterways improved	30 Kt	1600 t exported	410 MPa
1770	11 M (GB)			Turnpikes and waterway canals			
1778		66% iron from coke		American War		6600 t exported	
1784		Puddling trials		American sales resume			
1805		Wet puddling	HP steam (Trevithick)	Naval supremacy. 500 steam engines	250 Kt (60Kt export)	Cut nails common	
1823		Potting and stamping	Boulton-Watt engine	Australasian colonies well establised			
1830	15 M (GB)			Canal 5000 km network. Advent of rail			
1840				Iron & rail sales to Germany & Russia		Machine made common	
1850	22 M (GB)			Steam rail 8000 km network		M/c made iron wire nails	
1855					2M tonnes		340 Mpa
1870	26 M (GB)	Bessemer steel			2.7 M tonnes		330 Mpa
1885		Steel costs drop				Steel wire nails used	630 Mpa
1900	37 M (GB)				5.0 M tonnes		843 MPa

Based on Ashton 1967, Ashtrons 1988, Bodey 1983, Bogart et al 2017, Churchill 1957, Deane 1979, Snodin 1978, Harris 1988, Evans & Ryden 2005, Hayman 2005, Hayman 2016, Hill 1966, How 2017, Johannsen 1925, Jones 1987, Knight 2013, Loveday 1983, Rowse 1983, Satchell 1957, Schubert 1957, Wazny 2002,

3.4

LIEGE: FROM EUROPEAN TO INTERNATIONAL NAIL CENTRE

3.4.1 The Walloon naileries

These comprised three areas of Wallonia, Liège, Charleroi, and Charleville, the oldest of which was Liège. This industrial centre no doubt followed the ancient (pre-Roman) industry of the nearby Ardennes to become the Roman city of Leodium, fig. 63. Given the ore, the adjacent fuel sources, and the availability of river transport no break to the continuity of this iron industry is likely to have occurred since Celtic times. Raymond Brulet has explored these tantalising aspects reflected by the of ironworking workshops at Trier, Tournai and Amiens. These supported the forward reserve troops of the Roman front line in the event of a breakthrough by the German tribes.³⁶⁸ Some of these aspects of Roman *fabricae* form part of a recent thesis by Ashley Hern who adapts Raymond Brulet's map of Roman Belgica.³⁶⁹ Using Hern's adaption, fig. 63 highlights the major concentrations of Roman military equipment support which would have included nail production.

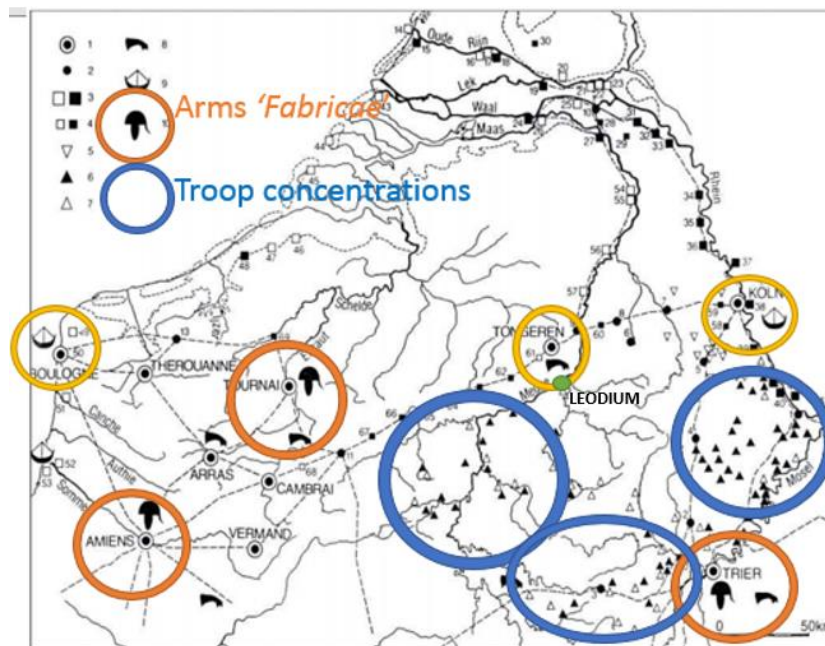


Fig. 63. Belgica. Based on Hern and after Brulet 1990, 383-403.

A remarkable confirmation of both the power of Rome's industrial standardisation and the expertise of Belgian ironworking was established by an inscription to the Belgian military smith, Julius Vitalis in Bath, England.³⁷⁰

In addition to Liège, further centres were established at Charleroi in 1751 and Charleville in 1759.³⁷¹ All three centres were reliant on the northern end of the massive ore body known as the 'Minette' field, Figs. 63 & 64, which stretched through Lorraine, Luxemburg, and into southern Belgium. The first underground coal mine in Liège in 1189 has been attributed to the need for forging iron.³⁷² The even spread of ore extraction points has been remarked on by Maggi³⁷³. Using his map³⁷⁴ showing these

³⁶⁸ BRULET 1990, 383-403

³⁶⁹ HERN 2013, 7

³⁷⁰ SCHUBERT 1957, 58

³⁷¹ THOMASSIN 1879, 440

³⁷² JOHANNSEN 1925, 28-29

³⁷³ MAGGI 2014, 225-6

³⁷⁴ MAGGI 2014, 227

points the nail making localities can be added, fig. 64. There were some 23 localities active south-east of Liège and at least three outlying villages. The 26 locations which developed to the west were spread mainly between Charleroi and La Louvière, but also Gosselies and one outlying village. Later still came a group of 5 remote localities loosely based on Bohan which has become known as Charleville after the French town, fig. 79. What the various concentrations of localities have in common is water power and close proximity to the navigable Meuse and Sambre rivers. Maggi sees this as a factor in facilitating ore movements also.³⁷⁵

Like all ore bodies the constituent parts of the 'Minette' field varied, giving rise to 'hard' iron in Luxemburg and around Charleroi & Charleville, fig. 79. When the soft iron ores started to decline in Liège around 1700, more of the 'soft' ore type was obtained from Habay la Neuve in the Rulles basin.³⁷⁶ The nailors were adept in classifying the iron into three categories based on colour and how the iron behaved under the hammer: 'soft', 'bastard', and 'hard' iron.³⁷⁷

Surface outcrops of the bedrock lodes were worked for iron, which started during the Celtic period before the Romans came, fig. 64, but the ores mined also contained traces of Pb, Zn, Mn, and Au.³⁷⁸

The Liège nail industry was blessed with this ore producing a 'soft' iron - much preferred by nailors as it made the nail making process easier. The late Charles Hansotte, an acknowledged expert in the history of the nail-making centres, notes that by 1545 the industry in Liège had reached a condition of high prosperity, but he makes a reference to a nailors' strike of 1406 indicating that it was much older.³⁷⁹ Salzman shows how nail workshops in the Ross on Wye area of the English Midlands around 1273 AD sold nails at the medieval fairs, but this can be interpreted as an inference only.³⁸⁰ It is most likely that, with the frequent contacts between the two countries (England and Belgium), the events combined to give birth to an industry (as opposed to individual nail makers) coincided in some way. The Liège nailery experienced the start of a decline in 1566,³⁸¹ and by 1600 the nailery had fallen into the control of nine major merchants, who in the first part of the century monopolised the commerce. They farmed out nail rods to small family workshops in an area limited to the north banks of the Vesdre and to the valley of the Sambre. In the 1646 accounts of the deceased Burgomaster of Vevriers, around 100 families inhabiting some 20 villages in this region, were noted to be in his service.³⁸² Franquoy states that the Liège nails were made using bar iron bought from Namur, to be used in Belgium, but nails were also exported to Holland, Spain and Germany, and to the Indies and America.³⁸³

There was also a change in sales policy due to the selling tactics used by the Charleroi merchants who extolled the benefits of their hard iron ship-nails to the Dutch authorities. Very large nails required proportionally less work than does the same weight of numerous small nails. Ship nails were usually greater than 180mm long or so, and could rise to 200mm long.³⁸⁴ Hansotte shows that Liège reacted quickly to this challenge by importing nail rod from Luxemburg to satisfy their largest customer.³⁸⁵

³⁷⁵ MAGGI 2014, 230

³⁷⁶ HANSOTTE 1972, 10

³⁷⁷ HANSOTTE 1972, 9-10

³⁷⁸ GOEMAERE 2016, 29

³⁷⁹ HANSOTTE 1972, 4

³⁸⁰ SALZMAN 1997, 304

³⁸¹ HANSOTTE 1972, 1

³⁸² YERNAUX 1939, 77

³⁸³ FRANQUOY 1861, 64

³⁸⁴ JOHANNSEN 1925, 52

³⁸⁵ HANSOTTE 1980, 317

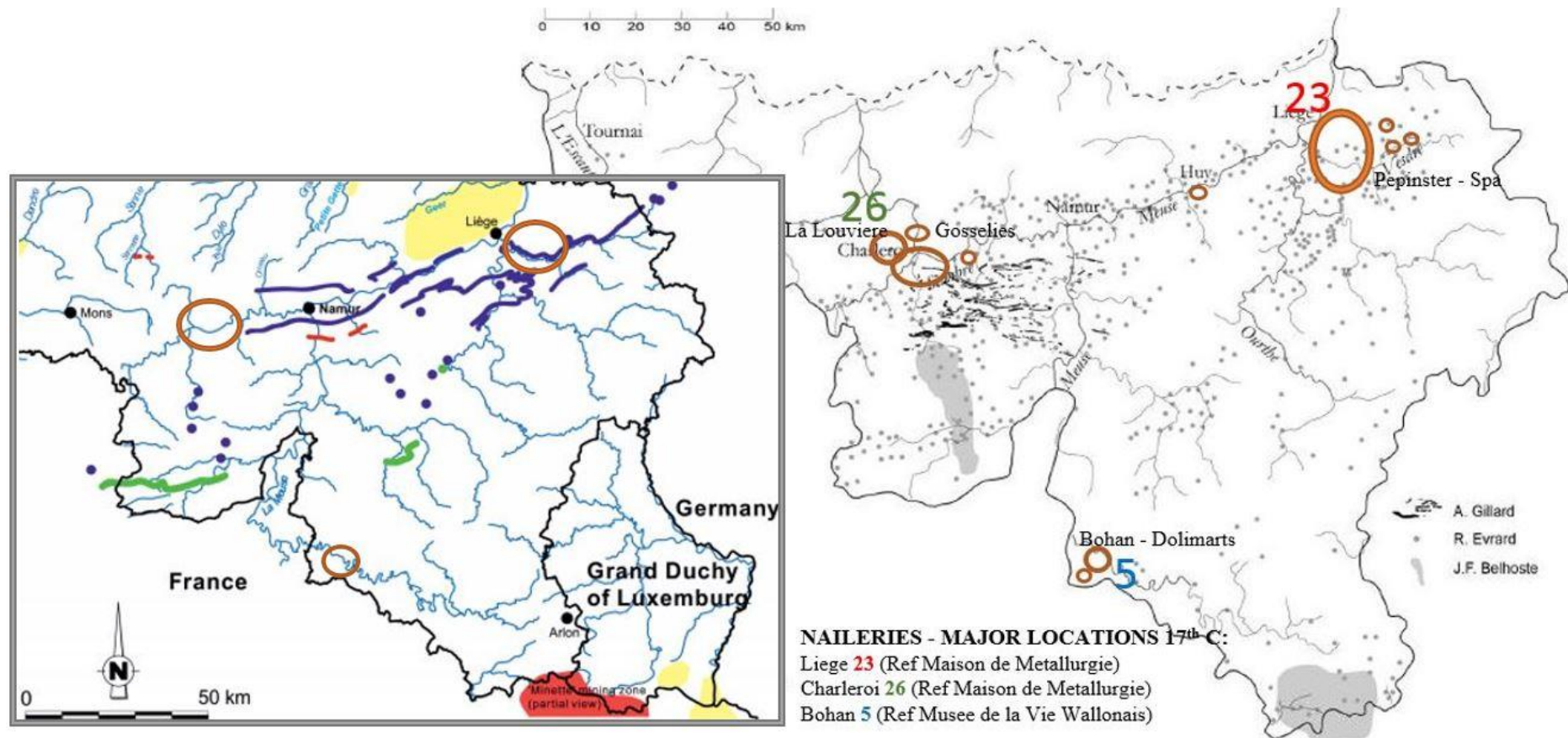


Fig. 64. The Wallon lodes, (left) and extraction points (right) after Maggi, with nailmaking agglomerations ringed. GOEMAERE 2016, MAGGI 2014, 227.

An estimated 15000 people were employed in the nail industry of Wallonia during the first half of the 1700s, but, in the light of a later estimate of 25000 in Liège and Hainault following a period of decline, this figure seems low.³⁸⁶ In 1765 there were some 800 nailors in the bailiwicks of Soiron and Herve producing annual quantities approaching 385000 lbs. (Say 194.5 tonnes -see footnote 17). During the same period, the widow Péron's nail factory at Ensival had 32 nailors using rod obtained from a slitting mill at Goffontaine, with the finished nails being exported to Germany. In 1770 the village of La Rochette had 321 workers in a nail making factory, which included a slitting mill and 22 forges, each with five or six nailors, all working for a Liège company. In 1771 Liège exported nails in large quantities to Holland, whilst the other centres sent to France, Spain, Portugal, Italy and elsewhere.³⁸⁷

A study started in 1806 during the Napoleonic period, shows the exports for 1812, Table 3.5:

TABLE 3.5. THE FOUR MAJOR LIEGE EXPORTERS AND AMOUNTS SENT, 1812.

CLASS	Merchants names	Sent to Holland	Sent to France	Sent to Germany	TOTAL
1st	Dengis & Cajot	225 Tonnes	43 Tonnes	30 Tonnes	300 T
	Maquinay & Arnouldy	225 Tonnes	45Tonnes	30 Tonnes	300 T
	M J Closset	235 Tonnes	25 Tonnes	40 Tonnes	300 T
	Bleret-Dupont	210 Tonnes	50 Tonnes	Nil	260 T
2nd	T Bonjean	180 Tonnes	Nil	20 Tonnes	200 T
	G H J Pirotte	200 Tonnes	Nil	Nil	200 T
	B J Gomree	150 Tonnes	26 Tonnes	10 Tonnes	186 T
3rd	Widow Rodberg	90 Tonnes	Nil	60 Tonnes	150 T
	Etienne Maquinay	136 Tonnes	10 Tonnes	4 Tonnes	150 T
	Martin Hanquet	83 Tonnes	6 Tonnes	13 Tonnes	102 T
4th	Bayet & Leroi	70 Tonnes	4 Tonnes	Nil	74 T
	Legrande elder	10 Tonnes		40 Tonnes	50 T
	Dresse	Nil	32 Tonnes	Nil	32 T
	GRAND TOTALS	1814 Tonnes	243 Tonnes	247 Tonnes	2304 T

The major importers were Holland (78%), France (11%), & Germany (11%).³⁸⁸

The sources of slit iron rod imported by the Liège naileries are shown by Hansotte³⁸⁹, table 3.6:

TABLE 3.6. NAIL ROD IMPORTED INTO LIEGE IN THE THREE DECADES PRIOR TO 1800

Decade	From Namur		From Luxemburg		From Limburg		Total
1761 - 1770	348781 lbs	91%	8045 lbs	2%	25683 lbs	7%	382509 lbs
1771- 1780	245463 lbs	38%	377184 lbs	58%	23886 lbs	4%	646533 lbs
1781 - 1790	406458 lbs	36%	703862 lbs	62%	17607 lbs	1.5%	1, 127927 lbs

³⁸⁶ JOHANNSEN 1925, 52: WARZEE 1861, 71

³⁸⁷ WARZEE 1861, 70, 71

³⁸⁸ THOMASSIN 1879, 440

³⁸⁹ The *livre* referred to is not clear but might be 460-500 grams. The colloquial term *pfund* is still used in vernacular trade in Swabia for 500 grams. Author.

Using this table Hansotte suggests that although the supply of Luxemburg rods was adequate in 1773, they rapidly became predominant. He also deduces that the use of slit iron by Liège factories from outside the area never ceased.³⁹⁰

As the Ancien Regime came to a close, the Charleroi nailery suffered a greater decline than Liège as it was affected by the effective closure of the French market. Liège, however, was dependent almost entirely on exports to Holland and so suffered only a slow decline.³⁹¹

The first machine-made nail factory in Belgium was erected in Liège in 1830 by Geoffroy Closset.³⁹² Others were built after by M Lassence and by M Francotte. These could make 600 varieties of nails in iron, copper and zinc, (Ibid). Nails in excess of 1½ inches (37mm) continued to be made by hand.

By 1856 the Liège Chamber of Commerce reported that forged nails were still in big demand but that the conditions were getting harder in Liège. The number of naileries was reducing each year, mostly affecting those specialising in medium sized nails of 50 – 100mm long. The work was seasonal, favouring winter, but between April and November three-quarters of the workforce worked elsewhere. An estimated 25000 people were still working in Liège and Hainault.

With the arrival and establishment of machine made nails, Belgian manually wrought nails were doomed to extinction and the death blow arrived in 1899.³⁹³ Belgium was denied its traditional nail sales to France in the south, and Genart refers to the appearances of German and Austrian nail industries posing a challenge.³⁹⁴ Within the same region the mutual area of the Ardennes was closed by the frontier which on the French side saw a reduction in nail production in favour of bolt and screw manufacture.³⁹⁵ Within Belgium, Bohun took a similar path to Liège and successfully sold nails into Holland, whereas Hainault developed new markets for machine made nails in Central and South America (especially Chile), the British West Indies, and some to Holland also. Genart reports machine made nail exports from Belgium to the Orient: China and the East Indies, to South America, to Australia and then later to the Congo.³⁹⁶

A group of seven aluminium roof slating nails from the inner Adelaide suburb of Fulham, marked with the Vieux Montagne (**VM**) trademark, provide clear proof of Belgian nail sales into early Australia.³⁹⁷

Table 3.7 shows the changing pattern of Belgium's nail industry, which unfortunately does not differentiate between wrought and machine made nails.³⁹⁸ Imported materials, which first included nail rod, changed to include iron wire and then steel wire after 1895,³⁹⁹

³⁹⁰ HANSOTTE 1972, 316

³⁹¹ HANSOTTE 1980, 321: HANSOTTE 1972, 17

³⁹² WARZEE 1861, 72

³⁹³ GENART 1900, 68

³⁹⁴ Ibid, 63, 66

³⁹⁵ Ibid, 63, 68

³⁹⁶ Ibid, 61

³⁹⁷ From the White family mansion 'Weitunga', Fulham, built in 1878. Samples courtesy heritage architect Luigi Vitale. See Fig. 88.

³⁹⁸ Ibid, 64-65

³⁹⁹ GENART 1900, 68. Extracts are from Volume III of Genart and Beatse, and were all written by Charles Genart, *L'Industrie en Pays Wallon*.

TABLE 3.7. NAIL IMPORTS AND EXPORTS

Year	IRON <i>Import</i>	Tonnes <i>Export</i>	STEEL <i>Import</i>	Tonnes <i>Export</i>
1875	613	2300	-	-
1880	495	10834	-	-
1885	431	7512	-	-
1890	668	10867	-	-
1895	779	5395	4795	6435
1898	724	3314	6475	9048

Genart is sparing with dates in his text and the actual years in which Belgian nail sales came under pressure from German and Austrian exports is not clear. He makes another useful, undefined reference to the effect of American nail sales into the Orient (and presumably the Antipodes too).⁴⁰⁰

The various texts quoted above show that the naileries were organised into an industry well before that of England or the British - perhaps as much as 250 years earlier – but both operated on similar lines from the 1600s. There are no mentions relating to a guild system but there are several references to cross-flow of techniques to one country or the other and the long history of cooperation points to influences working in both directions.

3.5 EUROPE'S CROSS-CONNECTIONS

3.5.1 Nail Making in the Holy Roman Empire

Some of the lesser known facts of nail-making within the central European area are revealed in German language texts. These place nail-making in the context of the more familiar English, Belgian and French scenarios. Weigel shows that an alternative method of making iron batons (or 'wands') by use of the *Zeinhammer* and *Reckhammer* was little known in other German States outside of the Nuremberg-Augsburg area, and the *Steiermark* of Austria.⁴⁰¹

In contrast to the decay of the guild system in England, a similar system to the medieval guild persisted in Regensburg and, by implication, throughout the Holy Roman Empire. Christoff Weigel writing in Regensburg during 1697-8 provides this illuminating glimpse of a demanding set of guild rules:

Nailors, or nail-smiths, have an advantage in their trade as the journeymen can practice their skills and work both in and outside of the Roman Empire [The Holy Roman Empire] with the chance to travel through foreign lands. But there is a difference in this trade between the makers of sturdy nails and fine nails. The making of fine nails requires some specialised knowledge and more expensive tools are needed.

Weigel then enumerates various nail types before detailing the exacting trade examination:

Their [Trade] Masterwork has to be done in Nuremberg, which includes the fitting-out of working vehicles, in steel as well as in iron, within four days, based on their own skill. They must present:

⁴⁰⁰ GENART 1900, 66-67

⁴⁰¹ WEIGEL 1698, 388-390. A full translation is provided in Appendix VI.

- *A total of 2,900 finished nails including... such as 400 large service nails, like those driven into the ironwork and to secure the town gates.*
- *Forge 1,000 studded items with round-top heads and with square shanks, but they must themselves forge all eight-sided below.*
- *Forge 1,500 of the tiniest fabric floater nails; so light that they can float on water.*

A final comment by Weigel strikes a common theme, used in both French and in English, of the division between the 'white' (tinned) nails and the common 'black' nails:

*All of these trades and types are of iron which the nailors themselves refer to as the black trade.*⁴⁰² (Ibid).

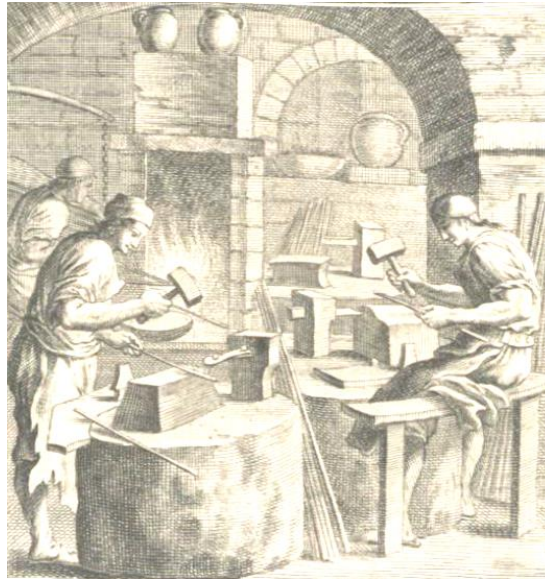


Fig. 65. Nailors at work in Regensburg after Weigel

Weigel also provides what appears to be the earliest image of the interior of a German nailor's workshop, fig.80. The picture raises the possibility that the familiar layout of tools shown by Diderot evolved out of the Nuremberg trade practices.⁴⁰³

This layout of devices is confirmed, albeit at a later date, by the *Oeconomische Encyclopædia*, fig. 66.⁴⁰⁴



Fig. 66. The nailor's block with obore after Krünitz, Braunschweig, Date unknown

⁴⁰² Ibid.390

⁴⁰³ HOW 2018-2, Draft - soon to be published.

⁴⁰⁴ KRUEINITZ 1777- 1858, Fig.s 5998 and 5989),

3.5.2 The Hansa-Baltic effect

The evidences of spread to the Baltic States (Estonia, Latvia, Lithuania) suggests that that the northern German methods of nail making arrived with their colonising settlers well before the first mention of *Krauss-staben* (wavy iron wands) but samples available for analysis are few. Sweden, however, suggests some separate development of its own in respect of the larger nails and spikes made. There was also strong cross contact between Belgium and Sweden, Louis de Geer saw to the transfer of smelter improvements into Sweden, and Angerstein and Svedenborg both made investigative journeys southward, which included Belgium.

3.5.3 Isle de France nail industry

Studies of examples found in various parts of France suggest that the guild system was not uniformly applied across the whole of France, and in particular, not in the Midi, where some rustic nail samples have been found. It seems probable that the nail industry described by Diderot, and as so brilliantly recorded by his illustrator Jean Moreau, may have extended from the Isle de France, down to the Loire, and as far north as the recent new border with the Lowlands imposed by Louis XIV.⁴⁰⁵ Moreau himself came from Lille, which like other 'plum' towns had previously been part of the Lowlands until being absorbed by France. The same equipment, with only minor variations, appeared on both sides of the frontier, across into the Palatinate,⁴⁰⁶ and across to Bavaria/ Franken, as Weigel shows similar assemblies in use in Regensburg in 1697/8, fig. 65.⁴⁰⁷

*There are two sorts of nailors, the 'Pin-nail Nailors' and just simply 'Nailors'. The Guild for these is governed by four sets of rules of which two allude to the number of years required, one governs the enrollment of new master craftsmen, and one covers the enrolment of existing ones. Each master is only allowed two apprentices. There is a five-year apprenticeship with a 'compagnon' time, which for Paris apprentices is of two years and of three years for workers in the provinces. All become craftsmen and there are certain exceptions for the sons of masters.*⁴⁰⁸

***Nail** (Clou), a small artefact in gold, or silver, or iron, or copper, pointed at one end and headed on the other, of which the body is round or has faces, but which diminishes from head to point. The heads have large numbers of different forms according to the use to which the nail is destined. Iron nails are forged; the others are cast. The making of cast nails is nothing special as it is very common foundry work. We shall proceed to how one fabricates iron nails but first we observe that there are two sorts: **ordinary nails** and **pin-nails**.* (Ibid).

French iron ores were superior, and more accessible than those found in Britain, and they were also more widely distributed throughout France, fig. 53. Perhaps because of this the application of steam power (in which the French were also pioneers) did not get the acceptance that it did in England. The massive dislocation caused by the Revolution is partly to blame for the slow emergence of machine made nails in France. However, their ingenuity applied to making nails from wire, both manually and by machine, has lasted to this day.⁴⁰⁹

⁴⁰⁵ DIDEROT 1769, Vol 20 Pl I & II

⁴⁰⁶ HOW 2017, 84 Fig.116

⁴⁰⁷ WEIGEL 1698, 388

⁴⁰⁸ DIDEROT 1769,

⁴⁰⁹ HOW 2018, (DRAFT), 343-356

This outcome does not reflect in nail quality however, and it is easy to see that iron for nails was given a low priority such that it was usually the cheapest and less acceptable, verging on the ‘cold-short’ range; malleable when hot but resisting deformation, and prone to breakage when cold. The chequered history of iron can be seen reflected in the very few tests made to date using historic samples, TABLE 3.3, but a thorough study needs to be carried out at some future time such that this interesting aspect must be set aside until more representative testing can be organised. The background changes in the iron industry help explain some of the visible changes in colour, surface texture, and reflectivity which can be observed when comparing different nail samples, 3.3.

3.6 THE NORTH AMERICAN SCENE

3.6.1 Colonial nail demand

Professor Ashton credits one of the reasons for the rapid growth of the British nail industry to the demands of the rapidly growing North American and West Indian colonies.⁴¹⁰ Krünitz, in his 1777 encyclopaedia, provides this useful description on Britain’s nail trade;

A greater part of the trade goes to North America, East and West Indies, Spain and Portugal, -one part of the English nail trade is done by casting from raw iron, especially saddle and cabinet nails. The iron passes through hand operations, from models impressed in sand moulds, then cast and taken out. From here the nails are cleaned, tinned, polished and varnished. ⁴¹¹

The consequences of the Seven Year War (1756-63) saw the 13 Eastern seaboard (American) colonies grow into a loosely assembled group, each capable of supporting their own state militia. Each commonwealth had successfully contributed to the British led counter to the French military’s thrust down the Hudson Valley, demonstrating to themselves the strength and benefits of their own economics and forces whilst acting in unison.⁴¹² In their mode of formation, and by their geography, they were divided. A set of complex and different dynamics applied to most colonies: Quaker Pennsylvania, Catholic Maryland, and maritime New England with its religious dissenters, and slave states in the south.⁴¹³ Climate and the nature of the land, also played a role in these characterisations. In the early years most colonies relied on alluvial sources of iron ore, bog iron and similar surface seams.

3.6.2 American nail-making

The common ingredient for all states was farming, and in the north the severe winters forcibly set in place indoor activities such as spinning and nail-making during the dormant period of the year. In the warmer south the staple crop was cotton which was labour intensive only during the picking season.

⁴¹⁰ ASHTON 1948, 42-43

⁴¹¹ KRÜNITZ 1777, 100 and 602. Translation by the author.

⁴¹² In 1750, British colonists in North America already numbered 1.5 million, with an estimated 5000 French in Louisiana. In Canada, (including Nova Scotia) British colonists numbered 81000 and French colonists numbered around 65000 (who became British in 1763). France’s population was the largest in Europe with an estimated 22 million. The population of Britain plus Ireland was then less than half that of France, with a population of around 9.7 million.

⁴¹³ The formal Mason-Dixon Line of 1763-67 split the free from the slave states, setting the boundary between Pennsylvania and Maryland. Support for separation from Britain was strongest from the wealthy slave owners of the South. Slave catchers from the South were allowed to operate in the northern “free states”, but emancipation sympathisers would pass escaped slaves up into Canada where freedom could be assured.

Plantation owners like Jefferson, at Monticello, and Washington at Mount Vernon in Virginia,⁴¹⁴ used their slaves to make wrought nails for general sale. Jefferson is recorded as making \$2000 per annum from his nail making concern run by a senior slave, Isaac Jefferson, fig. 67. Thomas Jefferson's work force mainly comprised of young slave boys who used nail rod brought down from Philadelphia.⁴¹⁵

It can be seen from the samples of slave wrought nails found at Monticello in fig. 67, that these are slightly cruder than those made by professional nailors in Britain, in Liège, or in the Isle de France, but still effective in supplying the urgent needs of the rapidly growing colonies using predominantly softwoods.

The dispositions of the early American iron industry and its known nail-making centres are shown in fig. 68, which indicates how the new country resolved its transport infrastructure difficulties following separation from Britain.

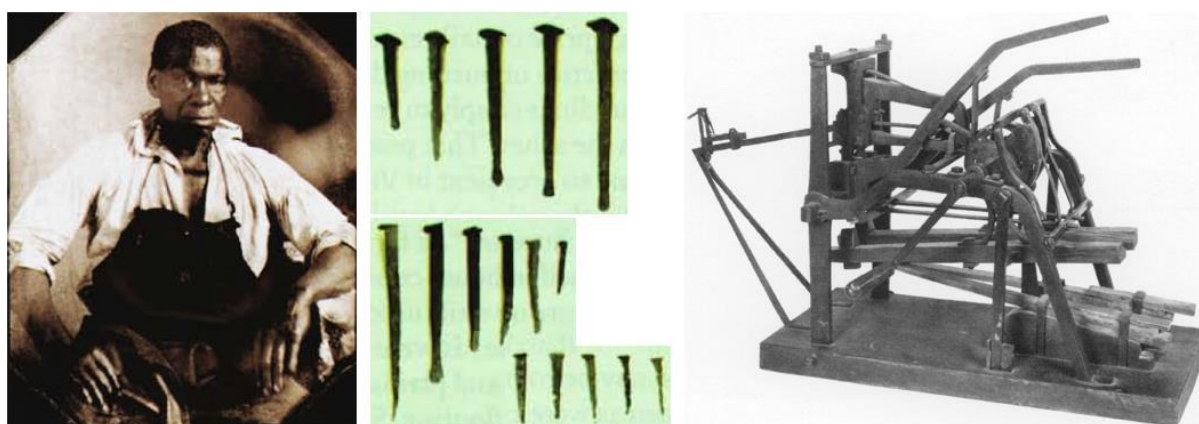


Fig.67. Isaac Jefferson with Monticello nails from 1794, and model of the lever operated Read nail plate cutter, with heading pedals of 1798. (Photos: the Thomas Jefferson Foundation and Peabody Essex Museum, Salem, Massachusetts).

In theory, the colonists were expected to buy their iron and nail-rod from Britain,⁴¹⁶ but this impractical rule was widely ignored in the course of normal trade.⁴¹⁷ By the late 1720s the colonists were supplying pig-iron of excellent quality to the home country.⁴¹⁸ Several slitting mills were in operation by 1669 but nail manufacture relied on the import of preferred Swedish or Russian iron. The individual small nail workshops could not keep up with demand as population growth was dramatic. It is widely believed that Walter Raleigh had sent forge equipment, possibly including a slitter, to his colony of Virginia.⁴¹⁹ Johannsen attributes this to Raleigh's first expedition of 1565 finding suitable iron ore close to Falling Creek in Virginia.⁴²⁰ He notes the foundation of a smelter there in 1619, which was destroyed by Indians prior to being able to commence operations.⁴²¹

⁴¹⁴ FELLOWS 2019,32/33: Washington ordered one million nails from his London agent between 1754 & 1773

⁴¹⁵ LEFEVER (sic) 2008, 63

⁴¹⁶ LOVEDAY 1983, 5

⁴¹⁷ LOVEDAY 1983, 7

⁴¹⁸ HOW 2009, 74-88

⁴¹⁹ JOHANNSEN 1925, 103

⁴²⁰ Ibid.

⁴²¹ Ibid: HOLOWATY & SQUARCY 1935, 3,4 set the construction by Sir Edwin Sandys in 1621, destroyed in 1622

Iron work furnaces were built in Maryland,⁴²² Virginia, and Pennsylvania between 1730 and 1741,⁴²³ and one in French Canada in 1740.⁴²⁴ The first major industrial iron works was in 1798 in the upper Ohio Valley, which then spread to West Pennsylvania by 1805.⁴²⁵

After 1790, when simple nail cutting guillotine devices were in use by the Americans, fig. 67, only flat plate in the form of narrow ribbons, was needed to make cut nails, and prisoners in penitentiaries were also employed in the manufacture of cut nails.⁴²⁶ Cut nail production caused a curious two-way exchange of information in which three notable inventors left America for Britain to take advantage of the more advanced technology there. All three formed their own nail factories; Dyer and Perkins in Birmingham, and Cordes in Newport (now in Wales). Research into this topic of joint American/British cut nail development comprises Chapters 3 and 4 of Dr Sjogren's recent thesis.⁴²⁷

Not spoken about is the large number of loyalists who remained in the new United States, and also the lingering regard for British products. Professor Deane demonstrates this in terms of the trade balance between the two countries. She shows that there was a 32% increase in trade with the new United States in 1797/8 against the 1750 trade figures, and American imports from Britain doubled during the same period.⁴²⁸ There was however misguided legislation passed by the American Congress, aimed at protecting American interests (in regard to the traditional cottage industry of nail-making), by the imposition of tariffs. Its effect was to stimulate industrial nail making, which was lagging in technology when compared to that of Britain, and its effect took work away from the farm nail-makers. The first act was promoted in 1789 by Congressman Fisher Ames of Massachusetts. This was a prelude to three more protectionist Tariffs of 1816, 1818, and 1823. Ames' intent was clearly spelt out:

*It has become common for country people in Massachusetts to erect small forges in their chimney corners, and in the winters and evenings when little other work can be done, great quantities of nails are made, even by children. These people take the nail rod iron of the merchant and return him the nails; and in consequence of this easy mode of barter, the manufacture is prodigiously great.*⁴²⁹

The new tariff gave added impetus to manufacturers of cut nails.⁴³⁰ Aspects of this false move were a set-back from a technical viewpoint. Suffice it to say that although a new industry was founded it is generally accepted (by serious American writers) that the flaws of narrow rolled ribbon took until around 1828 to be resolved, and even after that it was done in a piecemeal fashion. This aspect will be discussed further in Chapter 4.

⁴²² JULEFF 2019, 12. Maryland supplied 50,000 tons of pig iron to England, 1718-1755

⁴²³ FRENCH 1858, 9

⁴²⁴ VINCENT 1993, 159

⁴²⁵ LOVEDAY 1983, 39

⁴²⁶ HOW 2009, 74-88

⁴²⁷ SJOGREN 2019, 79-103; 104-129

⁴²⁸ DEANE 1965, 58

⁴²⁹ LOVEDAY 1983, 15

⁴³⁰ LOVEDAY 1983, 15 and 21

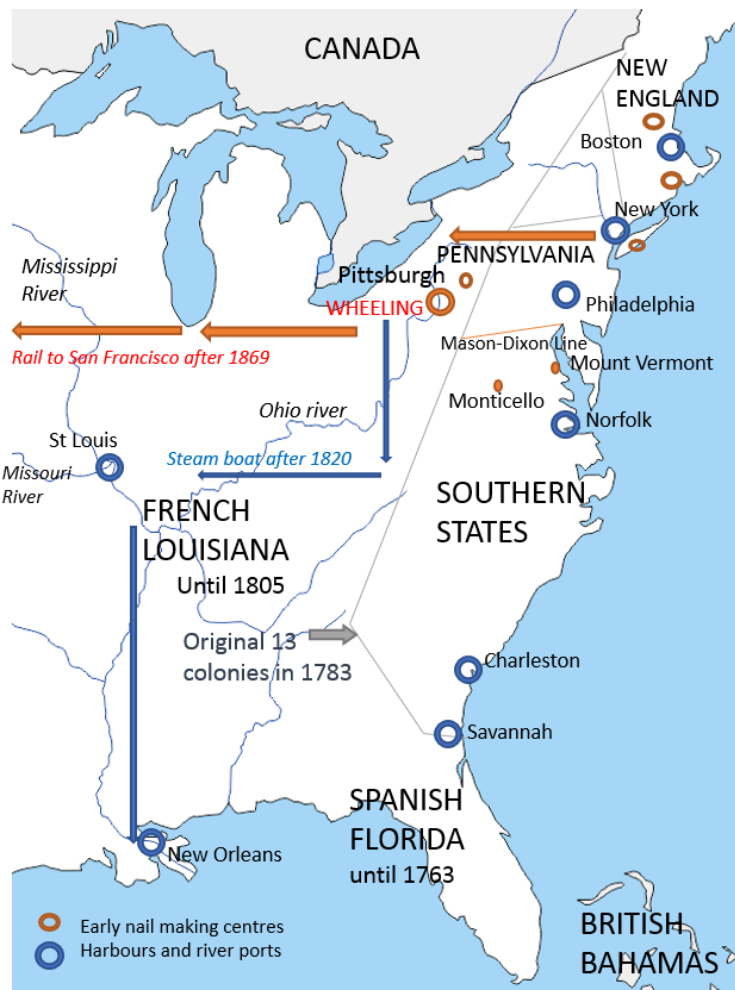


Fig. 68. Development of American iron and nail-making industries and transport/export solutions. Author

On the positive side, nail manufacturing workshops were established in Connecticut, Rhode Island, Massachusetts, and in Pennsylvania on the upper Ohio River.⁴³¹ Between 1807 and 1810, some 280 tons of nails were exported.⁴³² Pennsylvania supplied most of the iron ore and there was a drop in the import of Swedish and Russian ores as the former colonists adopted British improvements from the old country, notably puddling and recirculated hot air.

Following the British pattern, the economics dictated by puddling⁴³³ saw Pennsylvanian ironworks and rolling mills progressively situated closer to coal fields, at Pittsburgh, Steubenville, East Liverpool, and, (much later), Wheeling Fig 68.⁴³⁴ An English visitor, Timothy Flint, noted early (American) use of steam engines at Steubenville in 1818.⁴³⁵

The town of Wheeling, founded in 1798 on a critical pioneer migration crossing of the Ohio River⁴³⁶, was already established as a commercial centre by 1820. It was destined to grow into the largest nail

⁴³¹ LOVEDAY 1983, 39

⁴³² LOVEDAY 1983, 26

⁴³³ Ibid, 44

⁴³⁴ Ibid.

⁴³⁵ Ibid, 39

⁴³⁶ LOVEDAY 1983, 27, 37

manufacturing conglomerate in the United States, but its first ironworks was not built until 1832.⁴³⁷ There had been significant improvements in road infrastructure by 1816, and in steam navigation on the Mississippi/Missouri River by 1820.⁴³⁸ Wheeling, sited over a huge coalfield which extended across three states,⁴³⁹ had easy access to coal, making it a favoured refuelling spot for steamboats as providing ‘the cheapest coal on the river’, fig. 68.⁴⁴⁰ However, the ‘lean’ natural iron ores,⁴⁴¹ were mainly uneconomic siderites,⁴⁴² so for nail production it was cost effective to bring down pig-iron, firstly from Hanging Rock in the iron rich upper Ohio valley.⁴⁴³ Wheeling then switched source to the closer Steubenville iron, which for a while rivalled Pittsburgh as an ‘Iron City’. Wheeling later took pig iron from Pittsburgh, fig. 69.⁴⁴⁴ In 1850 Pittsburgh was a large producer of cut nails with eight factories, but by 1874 Wheeling had attained pre-eminence in American cut nail production.⁴⁴⁵ Between 1865 and 1870 there was a change to blast furnace smelting of high quality Missouri ores, which internalised pig iron production, (Ibid. 68). This change can be seen in the quality of American cut nails found in Australia.

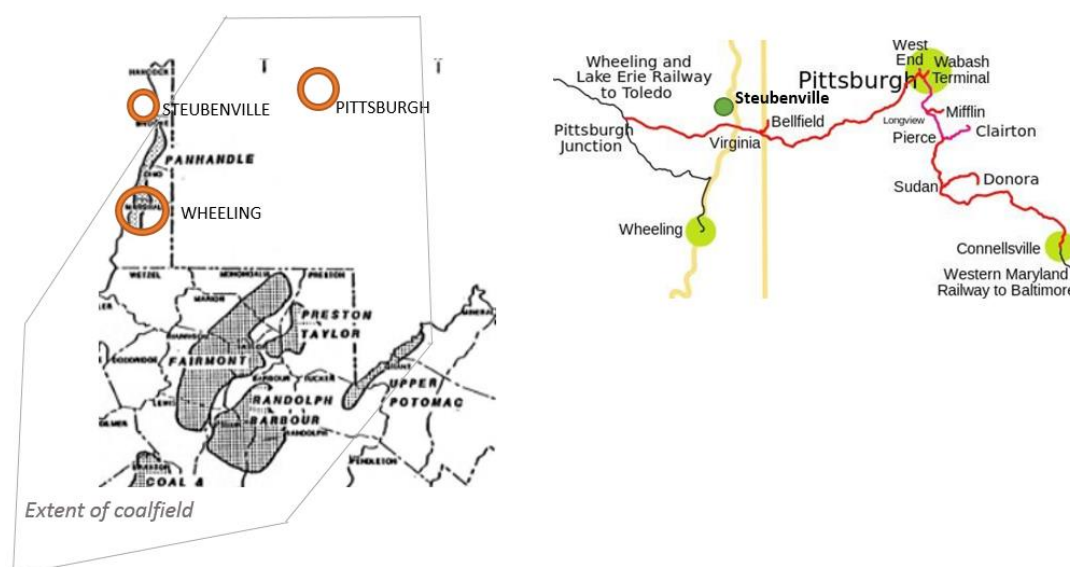


Fig. 69. Wheeling and the West Virginia coalfields, Steubenville, Ohio, and Pittsburgh, Pennsylvania, showing the later rail connections. Source: West Virginian Geological Survey.

3.6.3 Canadian population triples

Divisions of American society were exacerbated by the activities of the rebel factions whereby war-like conditions lasted for eight years (1775-1783), leaving a legacy of unresolved problems. It resulted in some 80000 loyalists departing for Canada, whilst others left for Britain or the Caribbean. This was a bonus for the scattered British colonists in Canada, (refer to footnote 85 for the population numbers circa 1750). This exodus served to consolidate Canadian industry and nail making, such that

⁴³⁷ WHITE 1932, 274-280

⁴³⁸ LOVEDAY 1983, 39

⁴³⁹ TREWALT 2000, 3, 16, 74-75. See also USGS 96-280 for field extent.

⁴⁴⁰ LOVEDAY 1983, 44

⁴⁴¹ WHITE 1932, 274

⁴⁴² HARPER 2013, 9-110

⁴⁴³ LOVEDAY 1983, 39, 44

⁴⁴⁴ LOVEDAY 1983, 44: HOTCHKISS 1883, 15

⁴⁴⁵ LOVEDAY 1983, 43

Canada achieved a near self-sufficiency in nail making by 1865.⁴⁴⁶ In theory the Rush-Bagot Treaty⁴⁴⁷ of 1817 had provided a quiet border but there was on-going unease in Canada which spurred on a sense of rivalry in regards to iron and nail production. Some of the advances came from a continuing trickle of former colonists leaving the USA, such as the blacksmith and inventor Joseph Bigelow. He set up a horse powered nail cutting machine in 1790, and for location he chose an area of Quebec well served by transport and good ore sources. Likewise Ezekiel Cutter arrived in Montreal (Quebec) with a nail machine in 1808, and steam powered nail cutting machines were in use there by 1831.⁴⁴⁸

This regard of Quebec quality iron ores was echoed by Colonel Durnford of the Royal Engineers, who in 1830 had forwarded a perceptive note to London, written by Lt Colonel John By, then stationed at Trois Rivières, and in control of canal works. It concerned how much better the Canadian home-made iron was than was that sent out from Britain:

*Experience has shown that the Iron of this Country is much superior to the English which makes me anxious that the Iron required for the Canal should be procured in Canada. My preference arises from the Metal of this Country being melted with Charcoal, and absorbing a portion of Carbon, renders it more malleable than the English Iron which is melted with Sea Coal.*⁴⁴⁹

The coarse nature of the British shingling nails also caused complaints to London from Nova Scotia in 1825, when a local contractor was obliged to source locally made thin shanked nails for cedar and white pine shingles, in order to avoid cracking the timber grain.⁴⁵⁰ A similar complaint was made by the Commanding Officer in Halifax, a Captain Marshall RE, in 1831, which was also forwarded to London requesting that the No 82 Shingling nail be made more slender. Tellingly, the contractor referred to the better suited local nails as *Canadas*, a name which persisted in nail warehouses in London until the 1990s.⁴⁵¹ A note from a local contractor, William Wagner, shows iron wire nails were being made in Montreal in 1865.⁴⁵²

3.6.4 'American' cut nails

From around 1795, after the advent of the first patents, cut nails became almost synonymous with American nails, which have entered folklore as unique, patriotic endeavours. They became cheaper as time led to various improvements, until wire nail production began to affect cut nail sales in 1888. In that year wire nails represented 20% of American nail production, but within the next seven years they rapidly grew to 75%.⁴⁵³ As the cut nail industry reached its technical plateau in 1850 production of nails had undergone a phenomenal 1300% growth in 40 years and the per capita consumption had risen by 340%. In the following 20 years production doubled, and between 1870 and 1885 it increased another 85%.⁴⁵⁴ In 1882 the industry looked back one year to a halcyon period as it became apparent

⁴⁴⁶ McNALLY 1992, 38-48

⁴⁴⁷ The Treaty essentially demilitarised the Great Lakes, but in fact both sides built land fortifications and the USA maintained a belligerent attitude to Canada till 1872. (British troops were withdrawn in 1870).

⁴⁴⁸ Ibid.

⁴⁴⁹ VINCENT 1993, 142

⁴⁵⁰ VINCENT 1993, 25

⁴⁵¹ Advised by the Head Carpenter at the Weald and Downland Museum, Singleton, Roger Champion, in 2005.

⁴⁵² VINCENT 1993, 164

⁴⁵³ EGERTON 1897, 246-272

⁴⁵⁴ LOVEDAY 1983, 22

that there was serious overproduction. By 1885 the main centre of Wheeling in Virginia was facing disaster.⁴⁵⁵

The advent of cheap steel changed all of this and steel wire nails became the norm across the Western world. *The Wheeling Intelligencer* newspaper at the main centre of the cut nail industries, in Virginia on the Ohio River, noted in October 1884: “So far as Wheeling is concerned, it would have been better if the Englishman (Sir Henry Bessemer) had died before he invented this process”.⁴⁵⁶

The American cut nail industry had, however, become the third major nail industry in the world during the period 1840 to 1888, following Britain and Liège. It was exporting cut nails to New Zealand by 1845, and to Australia during the 1860s in the smaller range, as more softwoods⁴⁵⁷ entered Australia from the Baltic and the USA west coast. There was a small intermittent export of American cut nails to Canada to meet occasional demands.⁴⁵⁸

3.7 ALTERNATIVE METALS

The introduction of various alternative metals provides data and dates of direct use in establishing timelines, in addition to resulting in changes in nail morphology. These appear through the practical considerations of application, either by invention, development, discovery, or simply economic factors. In nearly all cases the metals were known and were available in antiquity, but their scarcity and the expense of the relative technologies did not permit of their economic use within the building construction field.

3.7.1 Tin

The process of tinning iron, as an inlay or a coating to iron was known to the Romans⁴⁵⁹ and there have been finds of Roman tinned rivets, fig. 70. It seems highly probable, given the sophistication of Roman life, that certain types of nails would have been tinned. There are precedents; electrum plating of a votive nail recovered from the Rhone and a gilded bronze votive nail excavated in the Camargue.⁴⁶⁰ There are many references to tinned nails during the medieval period.⁴⁶¹

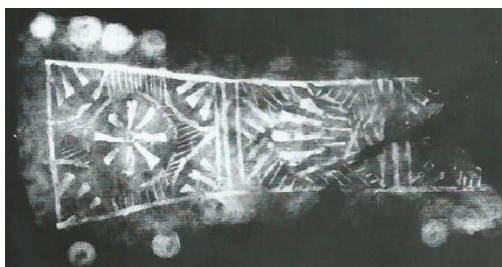


Fig. 70. X-ray of an iron Roman dagger sheath decorated with a tinned pattern and having tinned rivet heads - showing as bright areas. Length 105mm. Courtesy Bayley et al 2008.

⁴⁵⁵ LOVEDAY 1983, 124-129

⁴⁵⁶ Ibid.

⁴⁵⁷ Australian eucalypt timbers are amongst the hardest in the world (HOW 2009, 74-86) and native softwoods quickly reached near exhaustion by 1855 or so. American cut nails up to 1870 (or even later), continued to exhibit cross-grain fracture problems, such that they broke easily in Australian native hardwoods. New Zealand was more abundant in its species of softwood and American nails sold there sooner than in Australia.

⁴⁵⁸ VINCENT 1993,

⁴⁵⁹ BAYLEY et al 2008, 33

⁴⁶⁰ HOW 2019, 219

⁴⁶¹ SALZMAN 1997, 304-308

A recommendation in the *New and Improved Practical Builder* of 1823 suggested zinc, copper, or tinned iron nails should be used to fix slates.⁴⁶² In Britain it is difficult to identify tinned nails of any age due to corrosion, however the practice of tinning nails used in joinery and cabinet work is mentioned by Roubo and a French form of headless pin, circa 1720, from the Rue Frederick Mistral in Aix, was recovered with tinning still intact.⁴⁶³ Tenter hooks, used to hang cloth during manufacture, were often tinned.⁴⁶⁴

3.7.2 Zinc (Calamine)

The first use of the word 'zinc' enters the English language just after the start of the study period, in 1697.⁴⁶⁵ The first European zinc smelter was in Bristol in 1743, but this belies the difficulties involved with the molten metal in which temperature control problems could lead to vaporisation of the metal if the vessel reached 1000 degrees C.

The process of coating iron with zinc for protective purposes was known in antiquity in India and in China, however, one of the first papers suggesting its use in Europe came from the Frenchman, Paul Jacques Malouin of Rouen in 1742. Trials were made on coating ships' bolts by a Dr Pellet at Portsmouth in 1815, but the costs involved with the onerous preparation made the process economically unviable.⁴⁶⁶

In 1805 the Sheffield firm of Sylvester & Hobson managed to carry out rolling of lower grade zinc at elevated temperatures. This permitted the economic use of flat zinc sheet which could be installed in a similar manner to copper roofing, fig. 71.



Fig.71. Flat zinc sheet roofing 1839, Woolmers Cottage, Tasmania.

The Liège inventor and engineer, Jean Jacques Dony, in 1808 resolved the condensation of gaseous zinc by means of setting the retort in a horizontal position, thus realising a much purer form of ductile zinc capable of being rolled into sheet at normal temperatures. This resulted in a more practical production process. Successors of his partner Mosselman, established the firm of *Vielle Montagne* circa 1840, which went on to fabricate zinc composition nails for slates, and for use with their zinc sheet products. Samples of these have shown up in Britain and Australia, obligingly trademarked, fig. 73.

⁴⁶² GWYN 2015, 35

⁴⁶³ The author is indebted to Messieurs Roux & Serra of *Menuiserie L' Ecoincon*, Villelaure, Provence, for this valued find taken from doors held in their archive store. (HOW 2017, 46 figs. 71, 74).

⁴⁶⁴ MOSELEY 1966, 18 & 31

⁴⁶⁵ RAPP 2009, 32

⁴⁶⁶ MCCARTHY 2005, 32-33

3.7.3 Copper

Copper slate nails appear regularly after 1850, and as noted above, they were already being recommended in 1823 but were notably expensive at that time. In Britain, home produced Cornish copper was expensive, but the use of copper was changed by the development of the Burra Mine in South Australia in 1846, quickly followed by that of the 'Copper Triangle' situated at the head of the Spencer Gulf of South Australia in 1861, which radically changed the economics of using copper in construction. The original copper slate nails were cut, and the pattern remained the same up to WWI with some variations in size. Exactly the same pattern cut nail has been found made of iron in Portland in western Victoria and is the same as the later zinc version slate nail shown, fig. 72 (RIGHT).



Fig. 72. Copper slate nails, Chatsworth house, 1850, western Victoria, and Shepton Mallet, 1905 Somerset.



Fig.73. Vieille Montagne trademarked head. (Photo Richard Jones, Caerphilly).

Hot-dipped galvanising was first successfully employed after a patent by William Crawford in 1837 which first treated the iron to be galvanised in a bath containing a 9% solution of sulphuric acid, after which it was fluxed with ammonium chloride. In 1845 the method was successfully used by the inventors Edmund Morewood and George Rogers in their patent sheet metal tile system, fig. 74.



Fig.74. Morewood and Rogers patent tiles, circa 1849 at Brickenden, Longford, Tasmania.

One of the features of the Morewood & Rogers system was that two different sizes of galvanised die-dog nails were employed for fixing the tiles: larger wrought die-dogs on the ribs, and two smaller ones holding down the tray lap. These are widely found and there is some variation in type, fig. 75 (RIGHT).⁴⁶⁷



Fig.75. Morewood and Rogers patent roofing ridge nail, 1851, Moorabool Street, Geelong. (LEFT), and various Morewood and Rogers tray nails 1845-60, Brickenden and Muntham station, (RIGHT). Author.

The year 1847 saw the first major use of corrugated iron at Pembroke Dock in Wales. This was initially fixed with galvanised die-dogs and early sheets show side 'rivets' also of a galvanised die-dog form, fig. 76.⁴⁶⁸



Fig.76. Side lap rivet, 'Muntham' barn, circa 1854, and clenched dog nail of type used. Author.

In addition to fixing patent metal tiles or corrugated iron these same nails occur widely in fixing lead flashings. It is the view of the author that the presence of these galvanised die-dogs sets a threshold date of around 1845. They become relatively common by the 1850s.

Also appearing in the 1850s are common nails which had been galvanised, most of which used a 'stout' form of wrought fence nail with a broad clout head as the basic shape. In that year the British zinc industry was using 10000 tonnes per annum against some 800000 tonnes used in 2002. These galvanised wrought gate nails occur widely, often in remarkably good condition, and are usually found in-situ used to fix lead flashings, fig. 77 (RIGHT).



Fig.77. Galvanised wrought common, Digby cottage, Port Fairy, Victoria, 1856, and galvanised gate nail, Adelaide, South Australia, circa 1855. Author

⁴⁶⁷ The author is obliged to Richard & Louise Archer of Brickenden for access to the property yard and the recovery of samples on several occasions.

⁴⁶⁸ The author is obliged to Dr & Mrs Ryzkov for inspections of the barn at 'Muntham' sheep station, Casterton, in Western Victoria in 2004-6 and for donation of historic iron items to this study.

The early galvanising had a significant ‘grainy’ surface texture. By the late 1860s this coarse look disappeared and a smoother, fan-crystalline appearance, as commonly seen today, took its place. The change is another useful empirical aid to estimating the era of galvanised nails.

Zinc (and copper) nails were recommended for use with slates as early as 1823.⁴⁶⁹ They become common by 1845 but initially had a spindly appearance, fig. 78. By the mid-1850s they were replaced with the common cut form found widespread in Britain (refer back to fig. 72 above), and Australia, and these continued to be the preferred shape up to WWII.



Fig.78. Spindly zinc slate nail circa 1843, Meredith, Victoria. (LEFT), and 1856 version, Warrnambool, Victoria, (RIGHT). Author.

3.7.4 Brass or Bronze

No brass or bronze nails have shown up used in normal buildings during the study period although they were undoubtedly used, and so at the present time there appears to be no dating potential. Brass, a variable alloy of zinc and lead, was non-ferrous and so was in favour for uses in powder magazines where the risk of spark from iron, or simply heat friction, would not be acceptable. In-situ examples were recovered during an investigation in 2015 of early naval fort magazines at Marsden, Portsmouth.⁴⁷⁰

3.7.5 Composition Metal

Following the loss of several wood framed textile mills, industrial fireproofing became an over-riding concern during the late 1790s. Several alternatives aimed at eliminating wooden battens in roofs were tried. An 1881 example which used angle-iron purlins adopted the so called ‘lead nails’, fig. 79. These appear to be a mixture of lead and zinc, which could be bent around the angle purlins to secure slate roofing. The under-surfaces of the roof were ‘torched’ with a lime render to control flame spread and protect the nail shanks from fire.



Fig. 79. Papplewick Pump Station roof repairs. The heads of the ‘lead nails’ can be seen top left, and a straightened example is shown on right. (Photos Terry Hughes).

⁴⁶⁹ GWYN 2015, 35

⁴⁷⁰ WILLIAMSON 2015, personal communication.

An earlier example of this type of soft compound metal nail use occurs in 1813 at St George's church at Everton, Shropshire. In this case lead nails were inserted into pre-drilled holes in cast iron rafters, fig. 80. The specialist contractor, Terry Hughes, believes these were primarily made of lead, but no metallurgical analysis is available.



Fig. 80. St. George's Church, Everton, 1813 patent slate system during roof repairs. A 'lead' nail head is circled, left. An extracted 130mm sample, right. Photos Terry Hughes.

3.8 A WORLD SCENE

A composite, but simplified, picture of the world nail industry and trade routes is provided, fig. 81.



Fig. 81. Major world nail-manufacturing centres and export routes. Author

3.8.1 Dominance of world nail trade

The map shown in fig. 81 indicates how world trade came to be controlled by three major players:

- Liège, almost certainly the oldest nail industry per se, leapt into prominence due to its favoured position, waterpower and water transport, ideal ore sources, concentrated artisan and technological base, and the plentiful high-grade charcoal supply available during its formative and early years.
- Britain was a backward state in respect of industrial endeavours, and a slow learner, suffering almost insurmountable disadvantages with respect to poor ore quality and dearth of quality charcoal. It was saved only by Tudor outreach to Europe and by a high level of determination. Ironically, the very problems at the root of the disadvantages, led to on-going cycles of research as means of circumventing them. This resulted eventually in a many faceted set of solutions springing together to give the industrial revolution at a time of high population growth.

Its nail industry sprang from the three events of; increased demand for nails due to changes in timber sizes; increased demand from within Britain and from overseas colonies, and; concentration of artisanal centres fortuitously sited near coal sources, water transport and export shipping lanes, and plentiful low quality ores able to be smelted by the newly developed technologies (coke, steam power, and hot-air blast).

- The America iron and nail industry was kick-started by the Tudor policies of colonisation just as Tudor technological impetus took effect, and the colonies grew with all the advantages of seeing the problems progressively resolved at their home base. All of the North American colonies, Canada, Nova Scotia, and the thirteen seaboard colonies, were hampered by British politics, but as they grew, so the traditional nail forms of British nails translated across the Atlantic during the lead up to the American Rebellion (1765 - 1783). The American nail industry grew out of the psychological break with the home country, and with the satisfaction of having seen the threat from France removed. This came just at the time when expansion into the interior and population growth dictated greater use of softwoods - leading to a pragmatic solution of using just one main nail type: the brad, either headless or spurred. The misguided legislation forced by Congressman Fisher Ames, acted as a stimulus to industrialised nail making which rebounded on the country folk it was intended to help. Although not entirely true, the Americans claim (with some justification) to have 'invented' the cut nail.

The timing of a breakthrough in independence came in 1820 when the price of coal dropped by half.

⁴⁷¹ This was as much a triumph of developing infrastructure as it was of discovery, and surprisingly, America had been importing British coal up to 1802.⁴⁷² A dogged persistence towards development of a suitable range of cut nails saw the main industrial centre settle on an ideal location at Wheeling, Virginia, in proximity to the Ohio River, fig. 67. Their proximity to the Caribbean saw the American cut-nail industry take over much of the British nail market there,⁴⁷³ and it had later success in New Zealand. Canada, on the other hand, was forced by the border politics to concentrate on its own self-reliance

⁴⁷¹ FRENCH 1858, 21. See also HOW 2009, 75

⁴⁷² Ibid. 75

⁴⁷³ Exports to Havana were established by 1809; report from Boston July 1809: LOWRIE 1832, 439

with respect to iron and nails. The American cut-nail industry may have also forged new markets in the Far East, possibly in China and Japan.⁴⁷⁴

3.8.2 Timing of trade fruitions

Although the Liège industry and the British 'Black Country' tend to align in time of their peak industrial outputs around the early 1700s, Liège appears to have had its roots in the 1500s whereas the British nail industry failed to concentrate much before mid-1650 or slightly later. Liège became a Belgian industry, albeit under separate ownerships, with the additions of Charleroi and Charleville.

The American industry remained scattered and did not start to coalesce until between 1810 and 1820, and then it did so in several widespread locations. There was confusion in regard to the several centres, split by geography, by North-South rivalry, and then by the Civil War (1861-65). Moves towards making Wheeling a major centre did not happen until the mid-1840s by which time the Canadian iron and nail industry was already established in a more concentrated fledgling form. The official founding date for the Wheeling nail-making conglomeration is conventionally quoted as 1860.⁴⁷⁵ At the same time, the other large regional centres and lesser centres (including manufacture by felons and by slaves) continued in parallel to the formation of the massive Wheeling industrial complex.

3.8.3 Times of decline

The Belgian nail industry reacted faster to changing dynamics in the marketplace than did the British nail industry, but it was affected by the Napoleonic Wars and so lost the ability to export overseas for a period. After the wars, France closed its borders to Belgian nails. This preceded a slow loss of German markets as moves towards unification made Germany a more compact, effective economic unit. This loss was to some extent countered by Belgium developing alternative markets in competition with the British. By 1900 this included South America, Africa, the Indies, China and even America.⁴⁷⁶ But, as in Britain, the decline of manually made nails had already commenced by the 1840s. Once again, Belgium had been quick to follow the trends happening concurrently in France such that by 1838 there were a large number of wire nail manufacturers, thanks to the establishment of wire-drawing works only two years earlier.⁴⁷⁷ Thus, there was no 'death' of the industry, but a morphing into a more competitive form, as in all European countries. By 1850 iron wire nails were already taking over from the less economic rod made nails, due to the simplicity of feed mechanisms. (These will be discussed further in Chapter 4).

The British nail industry was placed in a dilemma with respect to changes towards wire, mainly due to the efficient and well respected Ewbank nail, (made from nail rod), which became the standard nail type for Australian eucalypt timbers. Britain was thus slow to react towards manufacturing early iron wire nails which had developed a poor reputation for use in hardwoods still being used in Britain, Australia, in African and in some Asian colonies. Instead it took the best aspects of the American developments, and by dint of superior technology produced better quality, more robust, cut-nails, sometimes on machines designed in America or developed by those Americans seeking out superior technology within Britain itself. Ironically, Bessemer's exothermic converter proved to be the salvation of the wire nail industry as steel wire took over from iron wire.

⁴⁷⁴ GENART et BEATSE 1900, Vol III 64

⁴⁷⁵ LOVEDAY 1983, 37

⁴⁷⁶ GENART et BEATSE 1900, Vol III 63

⁴⁷⁷ FRANQUOY 1861,129

The determination of the Americans to preserve ‘their’ cut-nail industry then became the downfall of the major centre at Wheeling, in the short period between 1878 and 1885.⁴⁷⁸ The use of steel wire nails in America was well established in the following year and the ease with which the machines could be set-up and moved saw a dispersed industry materialise into larger industrial growth centres, such as Chicago.⁴⁷⁹

3.9 SUMMARY OF EFFECTS

With the full benefits of hindsight, it is possible to see that ores and their disposition throughout Europe and North America played a major part in the development of the three main western world nail-making industries and that of Canada also.

3.9.1 The European Scene

The easiest industry to understand is the Belgian (Liège) nailery with its prime location close by an almost ideal ore source of ‘soft’, easily worked iron, close the Ardennes forest for high quality charcoal, and served by the Meuse for both power and transport. To this can be added a tradition of ironworking going back to pre-Roman times, emanating from the earlier Celtic peoples, able to pass on necessary skills in an age dependent of non-literate advances in training. It is true that road communications were limited historically, but Hansotte provides instances of road transport availability. More perplexing is how Liège managed to contrive an export market with the Palatinate to the east through more complex terrain. Sales of product up-river to France are easier to understand. Liège was proactive in seeking out new markets and reacted quickly to the whims of client countries, such as that shown by the Dutch for their navy. The archived nails in the Musées Royaux show how this adaptive ability continued up to WWI, with nail display boards annotated in Spanish or Portuguese. Equally so, Liège responded well with respect to market conditions regarding ores, and to slit rod supply as has been shown above in Table 3.6.

Divisions amongst the various German States ran deep, and were exacerbated by the Thirty Years War (1618-1648).⁴⁸⁰ It was natural for each state to retreat into its own cocoon of safety and reliance on its own ore bodies, industry, and own technology base. The roll-on effect of this was to postpone technical developments until a form of unity evolved under pressure exerted by Prussia under Frederick the Great. The rise of Prussia was remarkable. From a diminutive State with apparently only one iron centre at Peitz in 1550, it became a major technological player by 1753.⁴⁸¹ But it regrettably shifted its focus into controlled, militaristic ambitions.⁴⁸² Soon after 1870 and Bismark’s unification, the exports of Liège nails into Germany effectively ceased.

⁴⁷⁸ LOVEDAY 1983, 104-107

⁴⁷⁹ LOVEDAY 1983, 107-110

⁴⁸⁰ The wholesale ruin of the German States by this destructive, internecine, war did not end with its conclusion. In the north particularly, the populations were then to be caught up in a series of oscillating intermittent conflicts which saw famine, abandonment of land, and occasions of cannibalism occur, to a background of immense savagery. This also spread to parts of the Lowlands, and to the Baltic States. Some areas experienced a 60% reduction in population, and in parts of Brandenburg farming recovery, and its financial considerations, continued to the end of the 1690s. This was then followed by plague in 1709, (CLARK 2006, 24 -62; 86-87).

⁴⁸¹ CLARK 2007, 3

⁴⁸² In 1753, as a result of State-driven entrepreneurship, the Malapane Hutte became the first German ironworks to operate a blast furnace, (CLARK 2007, 176).

3.9.2 British Troubles

The British situation is more complex and presents, at the outset, a sad saga of events. At the core of the problem it was not the poor quality of the ores, or their accessibility, but rather the on-going diminution of forests. One expert suggests that natural woodland had been cut by 50% by 500 BC.⁴⁸³ The same expert suggests that the woodland extent presented by Domesday Book, circa 1080, was alike to woodlands of England today.⁴⁸⁴ Woodlands within the management of the Church, suffered during the dissolution of the monasteries, and those in Royal preserves, or in government hands, suffered again from unpaid parliamentary troops after the civil war, on a help-yourself basis.⁴⁸⁵ The need to preserve trees got set into legislation at least as early as 1272, (refer Footnote 13 above). Experiments with smelting using coal go back to 1589 and possibly earlier.

Thus a two-edged sword effect forced the issue with a growing population in Elizabeth and Stuart times, which was only partly resolved by migration overseas and by 'colonisation' of fens and wastelands.⁴⁸⁶ To build houses more trees had to be cut down, but the rising cost of timber resulted in these being sawn into lighter members. The lighter timbers in turn needed more nails in lieu of pegged wooden joints. The nails then required more trees to be cut down for charcoal, and so on, ad infinitum. The only possible solution short term was to buy timbers from friendly, reliable sources, such as Norway and the Baltic States, and to purchase ready smelted iron in bar-form from the market pertaining at the time. However, these same issues had forced a concentration of the nail trade in manufacturing, already akin to an industry, which saw the domestic market morph into an overseas trade to the colonies, which in turn was caused by over-population above sustainable limits.

Hence the international aspect of the British nail trade came about due to accidental circumstances and, by a stroke of luck, the 220-year-old experiments with 'clean' coal were accidentally resolved by Abraham Darby falling on a low-sulphur source to make coke. Likewise, it was an accidental consequence which saw the separation of the 13 American colonies (although predicted by some), and another accidental consequence, which saw Canada become firmly established, followed then by the foundation of Australia/New Zealand. The ability by the Americans at a later date to supply these colonies, the Caribbean and South America, with nails and other goods, was more a factor of evolution and growth in population, rather than by intention, (Refer fig. 81 for the world distribution patterns).

3.9.3 North America

Lastly the American situation might be said to have followed from the pressure of expansion westwards into the Ohio Valley which led towards the immense coal fields of Pennsylvania and the iron-rich Ohio Valley. The Americans (and Canadians) had immediate use of already resolved and tried technologies when they stumbled on high quality ores and equally good quality coal, which happened just as the resources of oak in the American eastern states came under pressure. To this must be added the benefits of America trading in the same language with the British Caribbean, with Canada, and with the antipodes etc. Reaping also the benefits of the long and arduous British industrial history of false and successful trials.

⁴⁸³ RACKHAM 1996, 38

⁴⁸⁴ RACKHAM 1994, 39

⁴⁸⁵ Pressures put on woodlands and the diminution of forests were featured as chronic during and after the Civil War, (HILL 1991, 43-44; 51; 54; 79; 107; and 359).

⁴⁸⁶ HILL 1991, 50-54

3.10 IDENTIFICATION

The discussion will now turn to the identification process, which starts with understanding the particular shapes in which wrought nails were made, and how they in turn provide clues to their intended use. Some nails take their names from the use to which they are intended, some from their shape, and a few have undiscernible or obtuse names. Not all names relate directly to use, but many do. The next chapter is devoted to explaining the various purposes related to shapes as a guide to all involved in assessing heritage nails and dates. This will then lead to describe new methods of manufacture adjusted to accommodate a new form of nomenclature.

Chapter 4:

Identification, nomenclature & findings

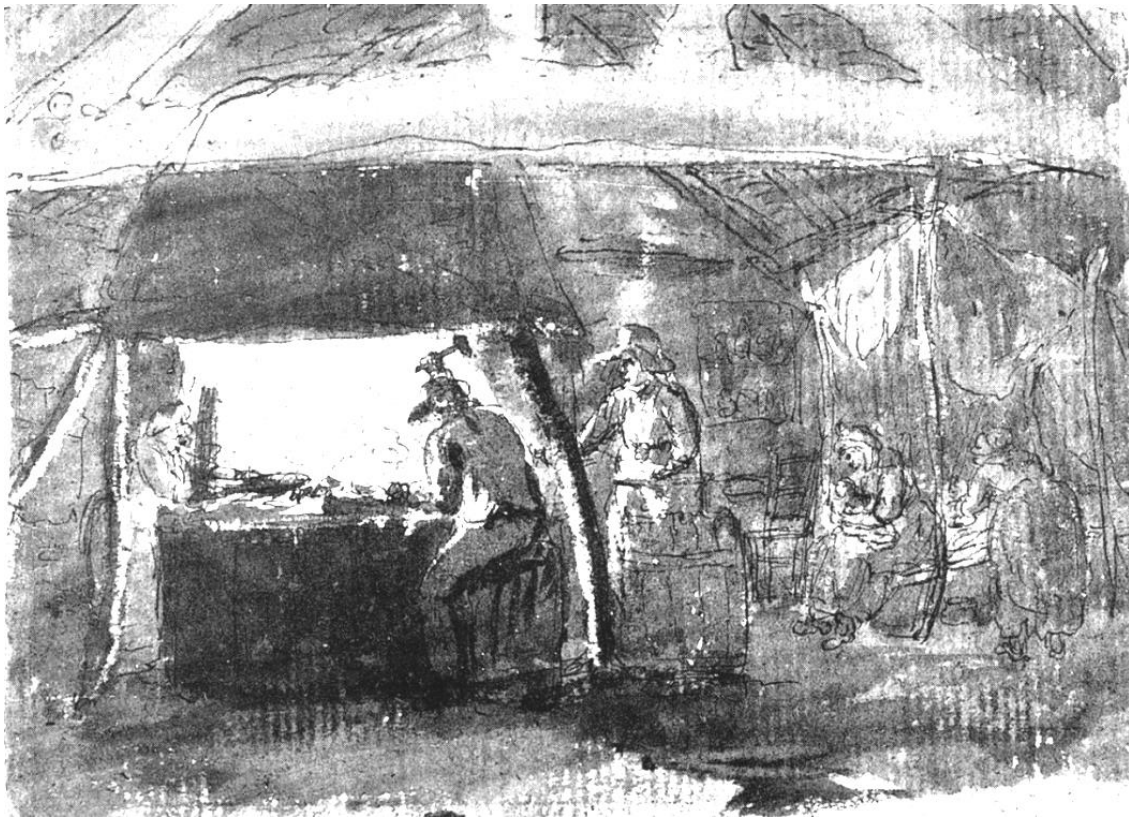


Fig 82. Nailmaker's workshop by Joseph Barker, 1810, Birmingham City Museum & Art Gallery



COMMONS

BRADS & SPRIGS

Headless brad



Spur-headed floorboard brad



Joiners' brad



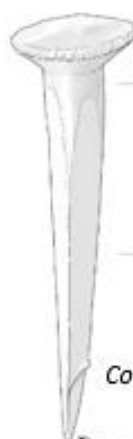
Lath sprig



CLOUTS & TACKS



Nail head viewed from below



Countersunk clout



Flemish tack



Roundhead tack

CLASP



DIE DOGS



COGGED



Fig.83. Major wrought nail groups found in buildings: 1680-1890

CHAPTER 4: IDENTIFICATION, NOMENCLATURE & FINDINGS

The particular kinds of 'em (which are very numerous) shall be described. Richard Neve. 1703

Nails in Building are small Mettalline Members, well known, but are very numerous in their sorts.

William Salmon. 1738

The sorts of nails are very numerous. Joseph Gwilt. 1842

OVERVIEW

At the start of the study period, in 1680, there were already four modes of fabrication in use; Wrought nails; Cast nails in copper and bronze, of which few have survived, with some early cast iron experimental nails; Cut nails in small sizes, as used to secure window panes; and handmade Wire nails, perhaps originating from the Isle de France area, but manually crafted by artisans, such as organ builders in Belgium. (3.3.3 above). This chapter will explain how these means of fabrication grew to include a range of annealed cast iron nails and how industrialisation led to machine made wrought nails, cheap cut nails in a range of sizes, and to both iron wire nails in a wide range prior to giving way to steel wire nails.

Firstly, the way nails tended to be grouped into classical types, fig. 83, partly due to their particular functions, will be enumerated, (which holds true of wherever in the world they originated), and suitable names will be offered emanating from historical texts and museum sources.

4.1 FINDINGS

4.1.1 Nail groupings

Nails found in buildings are only a part of the total spectrum of nails used at any particular time, but building nails tends to follow some familial groupings, fig. 83. By far the largest group of nails used in construction consist of 'commons', and its many variations.

Common nails show up in prodigious numbers in Roman period excavations, but their origins almost certainly predate the Empire. As will be seen below, the shanks vary in thickness, but all common wrought iron nails have a low to medium rise faceted head of modest width. This study has found that in Belgium and France during the period 1680 – 1870, the shanks are of mainly square section, whereas in Britain perhaps 25% of common nails may have rectangular section shanks. The most used commons had 'sharp' points, see 1.2.3 above.

Brads, have either minimal, one-sided, coggled heads, termed 'spurs', or they are headless, fig. 98. Richard Neve, writing in 1703, refers to these as 'Bill brads'. The headless brad is found extensively in flooring in Britain and sometimes in early Australia. Neve terms these as simply 'plain'. He remarks that ironmongers used six classifications of brads:

- *Joyners' brads between 1inch and 2 ½ inches.*
- *Batten brads for wood wainscot; 1d, 2d, 3d, & large 4d, plus extra-large types 5d & 6d.*
- *Flooring brads, plain; for Wood Joysts. 14, 15, 18, 19, 20, 21, 22, 23, 28, 32, & 36 lb per M.*
- *Ditto fit for hard Joysts, the sorts are 15, 18, 19, 24, 32 lb per M.*
- *Quarter heads for soft wood, the sorts are 10m 13, 15, 18, 19, 20, 22, 28, & 32 lb per M.*
- *Ditto Strong for Hard wood Joyst, the sorts are 14, 20, 39, 44, & 54 lb per M.*

NB, Bill-Brads, alias Quarter Heads are very fit for shallow Joysts that are supposed to warp, or for Floors built in hast or by unskilled persons, because the Bill to the Head will hinder the Boards from starting from the Joysts, but doth not make so smooth Work as plain Brads.

Of Barren brads, in the Country they vulgarly call ‘em Joyners Brads”

Clouts are essentially a more specific form of the ‘common’ morphology. They are primarily identified by having a larger, spread head, but these heads were made to be particularly flat. **Tacks** are smaller variations of clouts, also marked by having specially flattened heads. The countersunk head nail is called a clout, presumably because of its flat top surface, but is too large and thick in the shank to be called a tack as they are used to secure iron straps and so forth.

One peculiar anomaly in tacks is the use of die-formed, round head tacks, found sometimes in cupboards and linings where fabrics were employed. These have no specific name in English but are sometimes referred to as saddle tacks, or edging tacks, which belies their wider use.

Clasp nails bear little relationship to any other type. It has been proposed that these are an adaptation of the bi-petal head form found in Belgium, Germany, and in Latvia.⁴⁸⁷ Professor Bolle identified an early clasp form in the Liege archives, but lacking provenance details. Dr Sosnowska found similar variations at the Beguinage at Anderlecht circa 1435.⁴⁸⁸ The evidence for their appearance in England prior to 1690 or so is sparse.

Die-dogs may have been established as a form for nailing sheet iron (*‘Shetnayle’*) as early as 1365⁴⁸⁹, as numerous examples of die-struck nails on ornate chests testify.

Cogged head nails are the most common form of special purpose nails, very few of which pertain to buildings, but in which occasional samples get introduced, either as stop-gaps or because of some perceived folklore apotropaic/magic reason. The most common misapplication being horse shoe nails, retrieved mainly from wall cavities.

4.1.2 Morphology and feature recognition

The word ‘wrought’ is to do with the metal having been worked so that any wrought nail will show traces of the hammer blows used to forge each feature while the iron was still hot. Due to the mixture of iron and silica always present there are subtle colour changes present, reflecting the uneven distribution of impurities resulting from the hammer blow compression, and from the glassy look of the silica. This gives their surfaces (when fully cleaned) a slightly patchy appearance. The more obvious differences in medieval nails when compared to those made after the establishment of slitting, lie in the fully tapered shanks and the heavier, thicker heads, of the earlier period, fig. 84.

⁴⁸⁷ HOW 2015, 119-128

⁴⁸⁸ CHARRUADAS & SOSNOWSKA 2017, 14-17. Dr Sosnowska graciously provided his nail sample photos showing two clearly formed bi-petal heads [AND 001:US229(4). AND 001:US129(6)]

⁴⁸⁹ SALZMAN 1952, 317

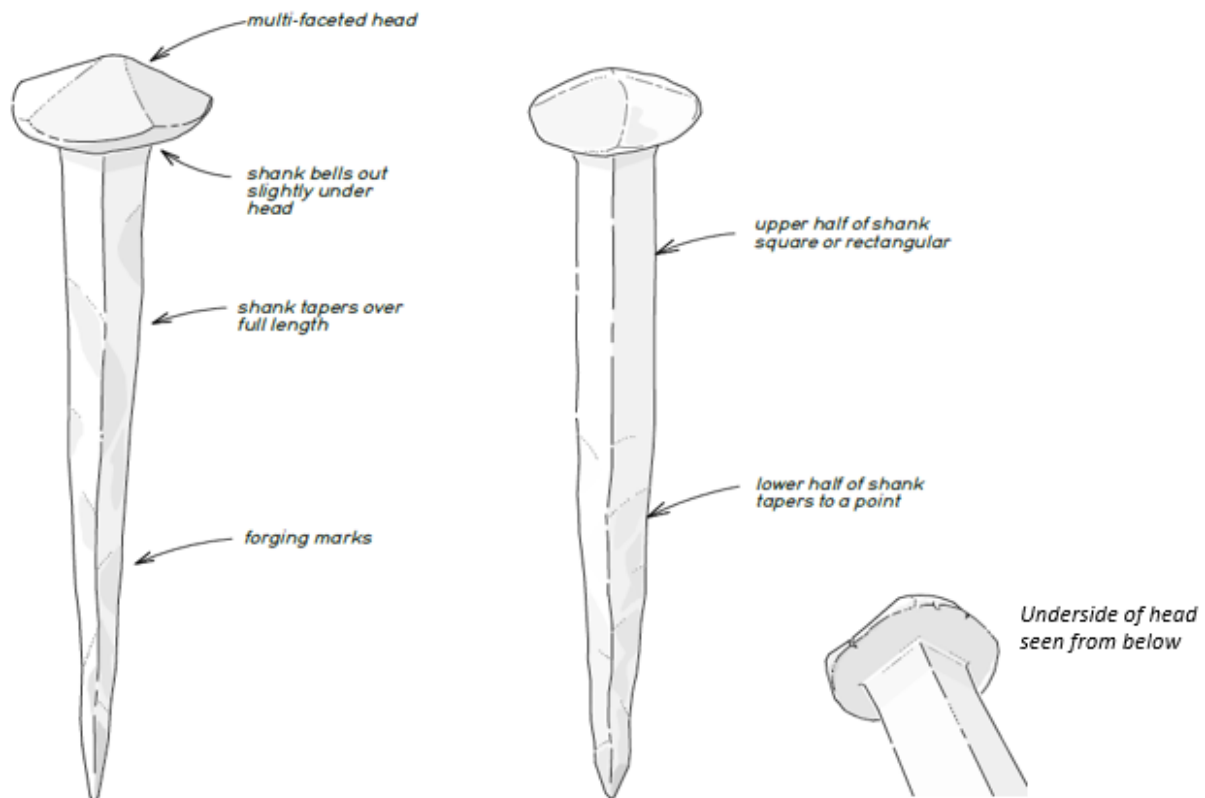


Fig. 84. Comparisons of common nails before and after the introduction of slitting.

Soon after slitting was introduced, English and Belgian nails in particular, lost the fully tapered appearance and around 40% of the upper shank length often retains the parallel look of the nail rod. In the German States the *Zeinhammer* wands were thicker. A sketch showing Georg Flurrer in 1572 shows thick wands, suggesting that nails were still 'forged down' from thicker iron, Fig 85. It is not clear why, after the advent of slitting, French nails retained their fully tapered look for so long, noticeable in the multiple French nail samples obtained for this study.



Fig. 85. Nail rod in Franken, 1572, heavy flanged medieval head, Salisbury Cathedral, c1360

After the introduction of slitting the nail trade expanded, and there was a concomitant reduction in the thickness of most nail head rims. This may be partly due to use of more specialized and more

appropriately sized obores, but it was also due to the ability to more accurately predict the residual amount needed to forge the nail head.

4.1.3 The Penny, Pound, and Length sizes

In a peculiar continuity of medieval description comes the reference to nail size based on their price in pennies paid per hundred nails. As could be expected, the intervention of plague and market forces, saw medieval prices vary.⁴⁹⁰ A nail reference standard, based on a nominal price for the particular sized nails, was set sometime prior to 1346. Documents refer to *'tepeninayls'* at Ely in that year, *'threpenynayls'* at the Tower of London in 1396, and *'fourepenynayll'* in 1438 at St. Pauls, and so on.⁴⁹¹ By 1700 the system was already starting to fall out of use in England. Moxon in 1678 makes three passing references to this antique description,⁴⁹² and although Richard Neave uses the penny system he mostly quotes nails by their weight per thousand or by their length.⁴⁹³ Salmon states categorically that nails are sold by weight per thousand,⁴⁹⁴ but he then reverts to the old penny system when describing flat point nails.⁴⁹⁵ Even more remarkable is that this relic of medieval terminology still exists in America to this day, Table 4.1.⁴⁹⁶

TABLE 4.1: PENNY SIZES COMPARED

Penny size:	2	3	4	5	6	8	10	20
Length (inches):	½	¾	1	1¼	1½	2¼	2¾	3 ½
Ditto (USA):	1	1¼	1½	1¾	2	2½	3	4

⁴⁹⁰ SALZMAN 1952, 305-315

⁴⁹¹ Ibid. A statute of Edward I relating to cloth measure, [33 Edward I. Statute 6, 1305], set a standard 'nail' as a measure of 2 ¼ inches (57mm) long, or 1/16th of a yard. (PENNICK 2004, Chapter 9).

⁴⁹² MOXON 1703 (1970), 158,244

⁴⁹³ NEVE 1703, Nails -17

⁴⁹⁴ SALMON 1738, 67

⁴⁹⁵ Ibid. 66

⁴⁹⁶ FIELDER 1879, 439. He notes that the system is approximate only and that it varied between different manufacturers.

Part One: Wrought nails

"A much commoner kind of nail, the two inch clasp nail, I found being made at Kate's Hill, Dudley.

In a small shop measuring ten feet by nine, and ten feet high in the highest and less than six feet in the lowest part – the structure was in fact a little lean-to shed erected at the back of a dwelling – were five females at work, apparently tearing their hearts out making these nails. Each had two short rods in the hearth which was in the centre. Each in turn gave the bellows a touch, then snatched the heated rod from the fire and quickly beat it to a point, the nail having been hammered well its entire length, save for a quarter inch from the top, which was to form the head. Then came the partial severance, the insertion of the half made nail into a tool known as the bore – which operation, it must be explained, involves the dropping of the hammer and the transfer of the iron from one hand to the other; then the rod is twisted off and thrown down, the hammer resumed, and the head formed by one or two blows, the bore being held firmly in the left hand. This done, the nail is turned out of the bore into a tin can, the bore and hammer are dropped upon the stall, the rod picked up and returned to the fire with the right hand, another rod is taken from the fire, and so the game goes on. -

I mention that 125 two-inch nails may be made an hour, or about 2 per minute, and that 125 nails weigh 1 lb."

Rev. Harold Rylett, English Illustrated Magazine, 1889

4.2.1 Division of labour

As this quotation infers, nailors in the Black Country would specialize in only a few types of nails in order to meet the demands of production. This can be seen to result in a more effective standard product achieved with a maximum utilization of the metal used per nail. The scattered English nail industry stretched back to the early thirteenth century, mainly in the western half of the country. From these developed specialized nail making communities in the Midlands. Workshops in each location usually comprised whole families, including women and children, working the year round in small forges appended to their dwellings.

4.2.2 A starting date for changes

A significant boost to building in England arrived with the restoration of the monarchy which saw grand houses ascend to new styles. These were already developing at the end of the Tudor period, but the effect of the Great Fire of London of 1666⁴⁹⁷ and its aftermath led to direct constraints on construction of townhouses, such as masonry parti-wall construction, window setbacks and a ban on overhanging floors resulting in 'plain faced' buildings. The chosen start of the detailed study (1680) marks a loose watershed between the continuity of medieval nail design and the initiation of 'modern' fire-proof construction.

The Great Fire spawned three acts in rapid succession; the hastily put-together 'Re-building of London Act', of the latter part of 1666, followed by a preliminary act refining the first and setting certain building standards aimed at 'fire-proof' construction. The 1670 Act set five standards:

- Masonry facades with a ban on projecting wooden eaves
- Roofs had to be of slate or tiles, and thatch was forbidden (again)
- Maximum sizes for windows were set, their wooden parts minimised and recessed back
- Roofs had to be set behind front parapets of brick or stone masonry
- Dividing walls between houses had to be thick enough to resist two hours of fire

Internally, the disciplines imposed on builders and designers by construction inside a 'box' of four masonry fireproof walls, saw greater use of smaller timbers and much greater reliance on nailed

⁴⁹⁷JARDINE 2002, 253. The September 1666 fire destroyed 12000 homes and 65000 people were made homeless.

connections than ever before. In effect, the walls and floors throughout town houses were 'suspended' between the partition masonry walls. This forced a design issue whereby any major transverse wall became in itself a truss, which out of necessity had to be penetrated by door openings. To achieve this metal connections and many more nails were required as part of the structural design system.

To compound the problem, the dire shortages of hardwoods available for building after the Great Fire of 1666 had forced builders to use 'Norway' pine (*Pinus sylvestris*), known in England as 'Scots pine'.⁴⁹⁸ This excellent, old and slow growth, redwood timber was high in resin and was the next most durable wood to oak.⁴⁹⁹ It was sawn to basic sizes in Norway prior to shipping.

A further result was an increase in trade with the American colonies of excellent softwood timbers. These were particularly suitable for flooring, as the planks came in wider than average widths, such that they became a prestige item for the *piano nobile* of townhouses.

The author has benefitted from research by Robert Ayton, heritage officer at Westminster City Council, which formed the subject of a Master's dissertation. His study comprised an analysis of five Georgian townhouses in the prestige area of the former Portland Estate, spanning from 1780 to 1810, which demonstrates the above points and shows the effects of the London Re-building acts 1666-1670 (with some subsequent clauses). Ayton's photographic record, when compared to the 1828 Tredgold⁵⁰⁰ text, shows how the load-bearing, trussed panel transverse walls, were evolving, fig. 86.

Nails recovered by Ayton on behalf of the author, showed that the better quality iron, wrought clasp nails had been used in sizes 52, 56, and 78mm long, with a fine form diminutive 20mm cast lath nail in the 1780 townhouse, fig. 86 insert. This changed to medium 22mm cast lath nails by 1784, and from then on did not alter. Disused headless floor brads, as described by Moxon, and a 'strong' version of common were found in intra-floor spaces. It cannot be inferred that all partitions of the era used quality clasp nails, since the client was the wealthy Duke of Portland. No doubt ordinary commons were used elsewhere in London, as Ayton's photo record demonstrates a high level of jointed carpentry, above that shown by Tredgold in 1828, fig. 86 inserted panels. The change from the slender 20mm cast lath nail of 1780 to a heavier version in 1784 is almost certainly due to the difficulties in casting such slender proportions with liquid iron.

The 1670 Act compelled roof drainage to be contained behind brick or stone masonry parapets. This resulted in lead lined box gutters with the familiar counter-flashings, which increased demand for the hitherto rarely used 'pad' or 'paw' nails needed to retain the top counter-flashings. Thus, although not comprising a total change in itself, finds of this type are more likely to have come after 1670-75 or so.

One immediate change in wrought nail morphology was the appearance of flattened common nails used in window reveals and linings, perhaps as early as 1680.⁵⁰¹ We can assign this feature, with some confidence, to the introduction of a simpler form of Oliver, having a plain faced hammer head necessary to produce such flat whole nails.

⁴⁹⁸ The oft quoted saying is, *The Norwegians warmed their hands on the Great fire of London*.

⁴⁹⁹ Beams were 300mm square boxed heart, joists were 77mm wide, 140-300 deep, (AYTON 2007, 25).

⁵⁰⁰ TREDGOLD 1837 re-print of 1828, 200.

⁵⁰¹ The author's colleague in Wales, Richard Jones, found these during the renovation of the Wheatsheaf Inn at

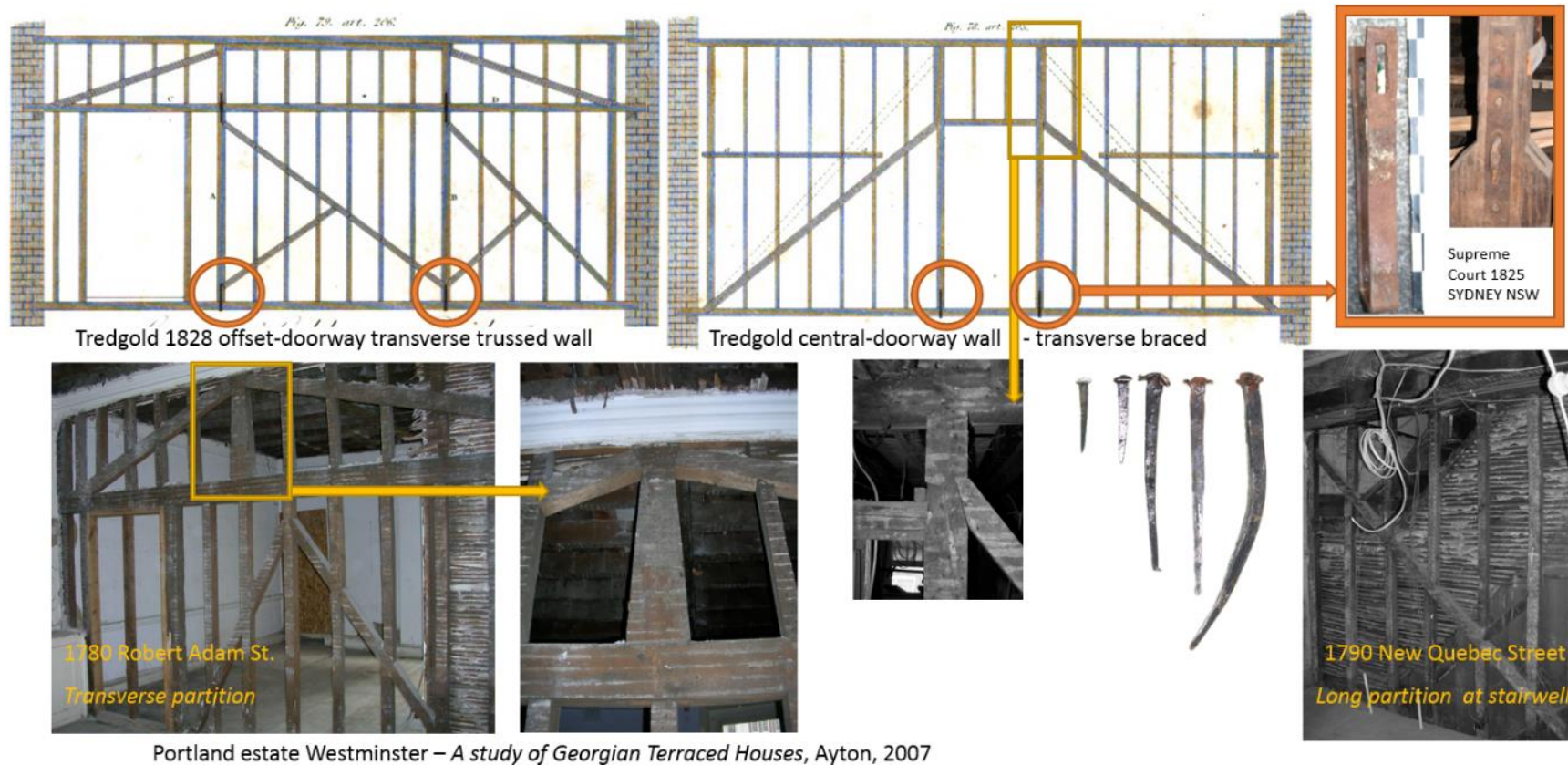


Fig. 86. Basic internal timber parti-wall construction after the 1670 London Building Act.

For the study to proceed it was necessary to establish a norm for building nails during this period, critical to which was the need for a register with nail names.

4.2.3 Nomenclature and its limitations

The general problems surrounding nail names have been outlined in the Introduction (page 6). Most historical writers dealing with nails emphasise the wide range which nails occupy, but they then limit themselves to describing only a very few. In this investigation only those nails used in building are considered. Some exceptions are made where examples from other sources help explain certain aspects of nail development. Names for nails derive primarily from the names used for wrought nails which have changed only a little since Jacobean times, but there has never been an entirely consistent nomenclature. Later names mainly reflect the use to which they would be put, or they reflect the shapes of their heads and shanks, (sometimes in combination), but many medieval names never entirely died out. There are still some names in the historical record which are unclear, and there is confusion over some quirky names. Wherever possible an attempt has been made to unravel these, but various linguistic experts have already trodden this same path, and so the problem is likely to remain.

Moxon, who was writing at the start of the study period, makes reference to only four types of nail. He describes in detail several other useful relevant aspects. Richard Neve, writing in 1703 provides detailed descriptions of 20 types of nail.⁵⁰² Salmon, in 1738, lists 23 types of nails used in building but also gives their respective weights and costs.⁵⁰³ By far the best general reference comes in the form of a tender document written by the Board of Ordnance in London in 1811, which is a little late in relation to the study period.⁵⁰⁴ However, the sheer volume and detail which this provides, with full sized sketches of some 163 different types of nail, demands that this should form the main yardstick for wrought nail names and types, and it has been seized on by other writers on nails in the past. The document shows some cut nails which add to its usefulness. The images from this document provide a substantial listing of wrought nail types then used. Table. 4. 2A compares the various sources:

TABLE 4.2: WROUGHT NAIL NAMES - MAJOR SOURCE INFORMATION

SOURCE NAMES FOR ENGLISH BUILDING NAILS	FOREIGN LANGUAGE SOURCES
<i>Moxon (1678): 4 types described + rivets & hooks. No images</i> <i>Neve (1703): 20 well described nail types</i> <i>Chambers (1728): a copy of Neve's descriptions</i> <i>Salmon (1738): 23 types with weights & prices + rivets & hooks</i> <i>Board of Ordnance tender (1811): 163 types drawn to scale</i> <i>Hebert (1835): 10 poorly drawn types</i> <i>Bevan (1878): 13 poorly drawn types</i> <i>* Nomenclature adopted as being the most useful & reliable</i>	FRENCH -Du Monceau, Diderot, Roubo, Panckoucke 1740-1784: <i>35 well drawn types + rivets + clous de ferronier</i> GERMAN – Weigel 1698: 11 names Krünitz 1777: 15 names <i>In both cases descriptions are brief & no illustrations were found</i>

⁵⁰² NEVE 1703, Nails –17

⁵⁰³ SALMON 1738, 67

⁵⁰⁴ BUGGEY 1976, 88-118

4.2.4 The post Jacobean sources

In order to avoid the dilemma presented by the lateness of the main source, and to set a norm for the various types of nails, the most extensive and reliable source has been adopted comprising the tender document for the supply of nails to the Royal Engineers' Halifax garrison in Nova Scotia. The document sets out a full-sized images for each type of nail to be supplied from a total of 163 different types, not all of which are to do with building, and not wrought. By contrast, Hebert, writing in 1835, shows outlines of ten sorts of nail,⁵⁰⁵ and Bevan in 1878 shows thirteen types.⁵⁰⁶ Other earlier and later writers confine themselves to written descriptions, but, of these, Moxon in 1678,⁵⁰⁷ and Neve in 1703 give some vital clues. To give balance to the historical context the quotations from Moxon and Neve are placed in the text related to identifiable nails of the post Jacobean period. Ephraim Chambers in his dictionary of 1728 essentially re-uses both of these sources,⁵⁰⁸ as does Gwilt in 1824,⁵⁰⁹ and several subsequent writers. Fielder provides a more thorough description of nails and screws as used in 1879, but this useful work is too late to be considered truly representative of the nomenclature of the main study period.⁵¹⁰ In Australia, the longest lasting wrought nail type was the wrought nail which was widely used in doors up until the 1890s whereas most other wrought types disappear by 1855 or so. In England itself many types were apparently made up to and including WWII.⁵¹¹

In Chapter 2 the nomenclatures supplied in the Royal Engineers' tender list are taken as the effective norms for the study period and other descriptions are taken from the oldest available source to explore the historical context. In one particular case an important type, the 'Jobent' nail which is nicely described by Neve, had no corresponding image, neither was it found in any museum context. By fortuitous chance a badly damaged example was loaned to the author by the late Treve Rosoman of the Construction History Society at Cambridge, and the head type could be matched to in-situ examples. A similar example, the 'Hurdle' nail was shown by Bevan in 1878 and examples of two types of hurdle nails showed up in the unique Naish collection described below.

This study takes investigation of nails a step further than other authors by the long process of finding the types, matching them with good quality nail samples, and then placing photos of the nail types described alongside earlier sketches and descriptions. It is perhaps the main reason that the research period has taken so long.

Diderot and d' Alembert, as well as Panckoucke, Roubo, and Duhamel du Monceau, all provide lavish illustrations and text concerning French wrought fixings and equipment, which are only partly applicable to English practice. Translations of the applicable texts have been made by the author which helps with some definitions.⁵¹² The reader will quickly become aware of how European nails tend to fit into a general pattern, and how factors, aside from nationality, take precedence in design. Similar determinants appear to affect the nomenclature used also.

A further recourse is available from the pre-war enthusiast, Mr S. R. Naish, who collected and collated some of the very last samples of wrought nails in England in the 1940s. The Naish Collection in the archives of the Salisbury and South Wiltshire Museum also includes a range of nail correspondence

⁵⁰⁵ HEBERT 1835, 182

⁵⁰⁶ BEVAN 1878, 34

⁵⁰⁷ MOXON 1678, 142-158; 244

⁵⁰⁸ CHAMBERS 1728,

⁵⁰⁹ GWILT 1824, 686, 1111, 1231

⁵¹⁰ FIELDER 1879

⁵¹¹ SALISBURY & SW MUSEUM. Naish Collection, Box 1 correspondence

⁵¹² HOW 2017 & HOW 2019 (draft). See also HOW 2018, 345-356. Roubo's '*L' Art de Menuiserie*' has since been translated into English by Lost Arts Press in Kentucky.

from the pre-war and WWII periods. The collection has been used to verify some earlier nail names and to give names to otherwise obscure nails such as the backing nail.

Lastly, a larger and much older collection has been located in Tasmania dating from around 1818, primarily of British and locally made nails. These nails are in the process of being collated by the author for a permanent display, thanks to the provision of access to these historic artefacts at the Woolmers World Heritage Site.

4.2.5 The later names adopted

With the advent of cut nails, when two types looked remarkably similar to headless and spur-headed brads, this designation continues to be used to this day.

4.2.6 Building zones

In order to arrive at a logical spectrum of nails throughout a typical building, this study assumes five main zones in any conventional structure. This system is somewhat arbitrary but essentially encapsulates the concept of 'locus quo' in the specialization of nails, acknowledging that the system will become a little 'fuzzy' for some later periods.

The five zones considered in the following listings comprise:

- ZONE 1: Roof cladding and exterior.
- ZONE 2: Roof framing and ceilings.
- ZONE 3: Structural framing up to ceiling level, wall claddings.
- ZONE 4: Floors.
- ZONE 5: Internal linings and finishings.

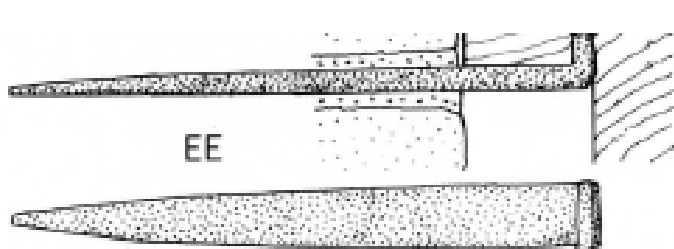
4.2.7 Wrought nail descriptions

In the following listings wrought nails are described individually and the historic sources of an appropriate nomenclature are given and where possible the original archaic name and source is also given. A discreet page is dedicated to each wrought nail type and uses the designation **N -**, followed by a sequential number, the nails being in alphabetical order. There is continuity of the numbering into Part 2, which deals with cast nails. After this cut nails become generic and wire nails become too numerous for separate page analysis. In the case of machine wrought nails, they are too few,

The zone appellations are presented on the basis of where such nails were found.

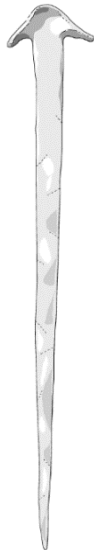
Nail Ref	N 1	BACKING NAIL			
Alternate Names	Bottom, and Back nail				
First Appearance	Pre - 1700		Last Appearance: circa 1840 WC		Size Range circa 75-100 mm
Exemplar grade	From 1828		?	Date	Material Fe FS
Zone: Roof Ext *	Roof Internal	*	Frame	Floor	Linings
Literary References: NEVE 1703 Nails 1; <i>Nails made with flat shanks so as to hold fast and not open the grain of the wood. Proper for nailing boards together for coolers, gutters, or any liquid vessels.</i> CHAMBERS 1728; <i>Nails made with flat shanks to hold fast and not open the wood.</i>					
Identifying Features: Made with parallel sides from flat iron ribbon, with a rose-head having a slight turn-down skirt. The point is blunt.					
Images:					
Sample from Woolmers House 1826. Identical to ones from Netley Marsh, Hampshire, circa 1825. (Courtesy Michael Leek, TATHS.)					
			Abandoned lead-lined, wooden gut or laundry, 1826 W H		
Photos: Author				Sketches: Nil	
Notes: Common width of 12mm but lengths found in the Woolmers store shed vary from 61 to 102 mm. Samples found in England (Naish and Netley Marsh) are same as those found in Australia. Nearly all Australian examples had bent shanks suggesting the nails worked best in softwoods.					
Continuity/Transitions:			Nil KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

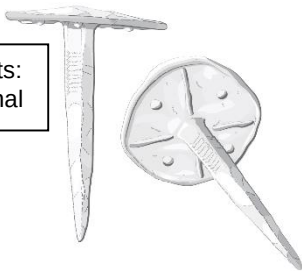
Nail Ref	N 2	BATTEN NAIL		
Alternate Names	'Reparation' nail			
First Appearance	Tudor	Last Appearance circa 1850		Size 45-88 mm
Exemplar grade	From 1732		Date	Material
Zone: Roof Ext *	Roof Internal	Frame	Floor	Linings
Literary Reference: MOXON 1683,244. <i>Used for reparation plain tile lathing (battening) and for inside lathing, others are 4d and 6d used for pantile battens. SALZMAN 1952, 314; great tacknail for batuans.</i>				
Identifying Features: Common nail form with low rose-head, 2 inches (51mm) long with 4mm square shanks is the most used, but the Hampton Court collection shows longer nails were also employed (possibly in lead roofs).				
Images	Hampton Court Palace. Possibly Tudor c 1520. 1732 Bowlish House. Wells Road, Darshill. Somerset, used in elm battens.			
Photos: Author			Sketches. RE tender 1812	
Notes: Salzman's reference of 1375 (see above) from Wallingford, Berkshire, demonstrates a remarkable continuity of type, even though we now expect a tack nail to be fully flat headed.				
Continuity/Transitions: This wrought type was superseded by the Ewbank nail in similar sizes by 1856. This was in turn superseded by cut nails – both British and American- in the following two decades.			KEY: R – Roman M – Medieval T – Tudor IR – Iron rod RR – rolled round FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 3	BRACKET NAIL		
Alternate Names	Shelf nail. Holdfast.			
First Appearance	Perhaps Tudor	Last Appearance		Size – length varies 45-110mm
Exemplar grade	From: WH		Date 1818	Material Fe FS
Zone: Roof Ext	Roof Internal	Frame WALLS	Floor	Linings
Literary Reference: CARLSEN 2013, 264 – circa 1718 Virginia. USA				
Identifying Features				
Images				
 				
Photos. Author			Sketches. Carlson & Lounsbury	
Notes: Carlsen refers to this general type as a 'holdfast', but these would normally have a longer return with piercings for nail holes in the short return. His specific type EE confirms what was found unused in the Woolmers archives in Tasmania. Carlsen relates this to the fitting of wainscoting. The type is not shown by Roubo in <i>'Menuiserie'</i> although he includes numerous secret fitting therein.				
Continuity/Transitions: Nil.				
KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage				

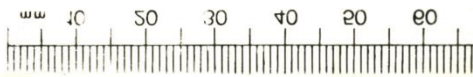
Nail Ref	N 4	BRADS		
Alternate Names	See below refs. + <i>kockspyking, broddis, broddes</i> (Salzman.)			
First Appearance	1252	Last Appearance; circa 1855		Size 13-76 mm
Exemplar grade	From 1805/1835		Date 1856	Material Fe
Zone: Roof Ext	Roof Internal *	Frame	Floor *	Linings *
Literary Reference: MOXON 1683 source. SALZMAN 1952, 304 cites; <i>Bordnayl</i> 1252; <i>Brags</i> 1371, <i>Spykeying</i> 1327; SALMON 1738, 66; <i>Bill brads. Gunners brads. Plain brads</i>				
Identifying Features: <i>A nail to floor rooms with. Size of 10d nail but have their heads made without a shoulder over their flank, instead made pretty thick towards the top that they may be buried into the board and do not catch.</i> MOXON 1683, 158. TREDGOLD 1837, 284 gives floor brads as 56-77mm long				
Images				
Headless brad  Spur-headed floorboard brad   1842  1730  1575  1680 Joiners' brad Lath sprig Pontville, Wells, Somerset. Beckley, Hanham				
1805 Dartmouth		1830 SYDNEY		
Photos: Author: Dr R Luebbbers (Pontville report)		Sketches; Author/McCaig. D & B Martin		
Neve cites six classes of brads: • <i>Joyners' brads between 1inch and 2 ½ inches.</i> • Batten brads "for wainscot; 1d, 2d, 3d, & large 4d, + large 5d & 6d. • <i>Flooring brads, plain;</i> 14, 15, 18, 19, 20, 21, 22, 23, 28, 32, & 36 lb • <i>Ditto Fit for hard Joysts, the sorts are</i> 15, 18, 19, 24, 32 lb • <i>Quarter heads for soft wood;</i> 10m 13, 15, 18, 19, 20, 22, 28, & 32 lb • Ditto Strong for Hard wood Joyst; 14, 20, 39, 44, & 54 lb				
Batten/lining brad example, in-situ, Lady Chapel, Ely cathedral, circa 1350 				
Continuity/Transitions:				
Lath sprigs all show a spur head like to a brad. Brads form the earliest form of simple cut-nails.		 KEY: R – Roman M – Medieval T – Tudor IR – Iron rod RR – rolled round FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		
Small, thick, galvanised masonry brads driven into sandstone, Christchurch, Warrnambool, c1865				

Nail Ref	N 5A	CLASP – English version		
Alternate Names	SALZMAN 1952, 314 gives <i>Gripnayl</i> from 1344			
First Appearance		Last Appearance		Size 35 -120 mm
Exemplar grade	From 1684	Post WWI	Date	Material Fe IR
Zone: Roof Ext	Roof Internal *	Frame *	Floor *	Linings
Literary Reference: NEVE 1703, Nails 4: TREDGOLD 1837, 286 gives sizes as 3d/4d/6d/8d/10d				
Identifying Features; <i>These are 2 sorts: LONG for use in fir or softwood, in 15 sizes. STRONG are for use in Oak and other hardwood, in 5 sizes. The clasp of the head allows them to be driven down below the wood surface. Neve 1703.</i>				
Images	Unused W&D	1786 London	1758 Stourbridge	Hampton Court 1684
				
Photos. Author		Sketch. Author/McCaig: RE tender 1812		
Notes:				
1. There seems to be little difference between Belgian, English, and French Louisiana cut nail finds which show four faceted heads:  2. German clasp nails show subtle differences: see N5 B				
Continuity/Transitions:		KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		
These form the basis of the English cut clasp nail which went through several variations, HOW 2014, 231-238.				

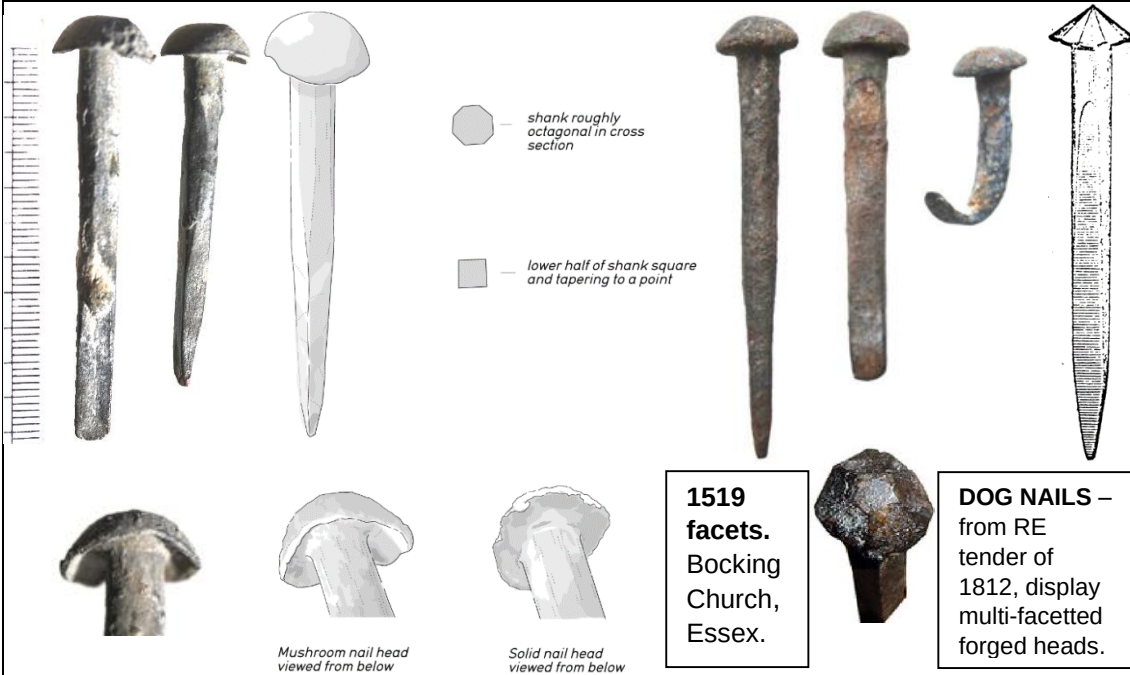
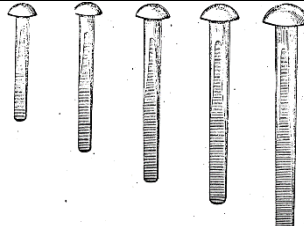
Nail Ref	N 5B		CLASP – German version		
Alternate Names					
First Appearance	Circa 1380		Last Appearance: after 1860		Size 74 -83 mm
Exemplar grade	1650			Date	Material
Zone: Roof Ext	Roof Internal *		Frame *	Floor	Linings *
Literary Reference: Krünitz					
Visual refs: Albrecht Dürer, <i>Melancholia</i> 1510					
Identifying Features: These are made in two grades: Long (or ‘fine’) and Strong (or stout) and they occur widely across southern Germany, pre-dating slitting					
Images:					
					
		Circa 1650 Schloss Wolfegg roof coving. WOLFEGG Oberschwaben		1380-1450 Kupfergasse, Innere Bruecke, ESSLINGEN (Stuttgart)	
Photos; Author				Sketches – Author/McCaig	
Notes: The fully rounded top distinguishes the fine version of the German clasp nail from the British. A smaller, more robust version was found at Nielles les Ardres in a 1685 organ by Van Belle of Ypres. (Courtesy Pierre Courcelle, organ builder) This ties the nail morphology to the typology of the medieval bi-petal head: refer HOW C. BOLLE C., LEOTARD J-M., & LAPINS. A.I 2016. The Medieval bi-petal head nail, in James Campbell et al, (eds.), <i>Proceedings of the Third Conference of the Construction History Society</i> , Cambridge.					
Continuity/Transitions:				KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 6	CLOUTS			
Alternate Names	See below				
First Appearance	R	Last Appearance: Current		Size 25-52mm	
Exemplar grade	From		Date	Material Fe, Cu	
Zone: Roof Ext *	Roof Internal	Frame	Floor	Linings *	
Literary Reference: NEVE 1703, Nails 6: SALZMAN 1952, 311-312, gives <i>cluta</i> in 1292, and <i>cluthnayl for fastening laths and lead</i> , in 1279. TREDGOLD 1837, 284 gives sizes 25-152mm					
Identifying Features; <i>Used to fasten iron onto wood.</i>					
Images:  faceted head   Nail head viewed from below    1680 Brecon Powys: Naish clouts; fine & best: 1684 Hampton Court  Iron clout, Riga Dom roof c1740 (A.Lapins)					
Photos: Author			Sketches; Author/McCaig		
Notes:  Roman copper clouts: author/Ieva Rosenthal  Photo: Penny Copeland, Southampton University					
Continuity/Transitions: Clouts derive from Roman <i>cluta</i> . The shapes are nearly the same today despite now being wire nails			KEY: R – RomanIR – Iron rodM – MedievalRR – rolled roundT – TudorFS – Flat strip Nsh – Naish collection SalisburyW&D – Weald & Downland MuseumW H – Woolmers HouseWCt – Woolmers Cottage		

Nail Ref	N 7	COMMONS			
Alternate Names	Rose head; ROSE (after Tredgold 1837)				
First Appearance	R	Last Appearance: Circa WWI			Size 37-78mm
Exemplar grade	From		Date	Material	Fe
Zone: Roof Ext	Roof Internal *	Frame *	Floor *	Linings *	
Literary Reference: SALZMAN gives <i>standiznayl</i> from 1365, possibly the term used in medieval times. TREDGOLD 1837, 285 gives sizes as 37-78mm					
Identifying Features: Usually four facet rose head with either Strong or Fine shanks					
Images:					
 Unused common 'heavy' rose-head, Nsh. 1835 common nail from cedar lining, Fort Street, Sydney. 1730 window-sill nail, headmasters house, Wells, Somerset.					
Photos: Author			Sketches: Author/McCaig		
Notes:					
Some common rose-head nails were made with flat points to facilitate clenching. (Photo; Bob Stone, 9 Tyers Street, Portland, c 1848).					
Continuity/Transitions:			KEY: R – Roman M – Medieval T – Tudor IR – Iron rod RR – rolled round FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

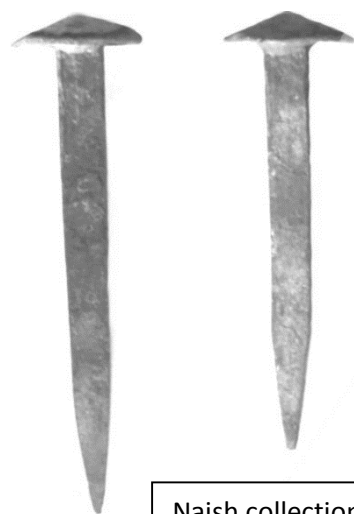
Nail Ref	N 8	COUNTERFLASHING NAIL			
Alternate Names	Paw nail, Thumb head				
First Appearance	M?	Last Appearance			Size 65- 90 mm
Exemplar grade	From		Date	Material FS/IR	
Zone: Roof Ext *	Roof Internal	Frame	Floor	Linings	
Literary Reference: Nil in English but are shown by Diderot.					
Identifying Features These start by being made from 12mm by 3.5mm flat which was pointed at one end and the other end turned down and spread, akin to a 'paw' or thumb. They change in the 1860s ti being made from nail rod.					
Images:				1888. Christ Church tower. Warrnambool, Victoria. 	
1715 Dyrham Park, Gloucestershire.					
		1867 Airlea, Henna Street, Warrnambool, Victoria 			
Photos: Author			Sketches		
Notes: The samples from Dyrham Park and from Bowlsh House of 1732, were identical in respect of the paw pad and the shanks.					
Continuity/Transitions:			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 9	COUNTERSUNK CLOUT			
Alternate Names	-				
First mention	1532	Last Appearance		Size 55-84 mm	
Exemplar grade	From c1818/38	WH & WCt	Date	Material	
Zone: Roof Ext	Roof Internal	DOORS	Floor	Linings	
Literary Reference: SALZMAN 1952, 317; <i>Nayles synck heeded for setting onto plates of iron.</i> 1532,					
Identifying Features: The flat headed clouts have a tapered neck intended to disburse wear by matching a countersunk hole of a metal hinge. Shanks are roughly rounded off (or octagonal), but the neck is round, and the points may be sharp or chisel (flat).					
Images:					
					
					
Photos; Author			Sketches – RE tender: Author/McCaig		
Notes:					
DOUBLE COUNTERSUNK – is similar but with extended depth of taper to match extra deep counter-sinking of thick steel plate in heavily loaded industrial applications. Nsh – pre-WWII:					
					
Continuity/Transitions:			KEY:		
The countersunk depth varies from Britain to France (which is shallower), The unpointed nail set the pattern for one type of modern screw.			R – Roman		IR – Iron rod
			M – Medieval		RR – rolled round
			T – Tudor		FS – Flat strip
			Nsh – Naish collection Salisbury		W&D – Weald & Downland Museum
			W H – Woolmers House		
			WCt – Woolmers Cottage		

Nail Ref	N 10		DIE DOG		
Alternate Names	'Dog nail' in its original form				
First Appearance			Last Appearance		Size 37-127mm
Exemplar grade	From			Date	Material
Zone: Roof Ext *	Roof Internal		Frame	Floor	Linings
Literary Reference: SALZMAN 1952, 317- is possibly a die head form of dog nail. NEVE 1703, Nails 17; 'roundhead'. Bevan 1878, 183 gives sizes above					
Identifying Features. Die-dog heads are either semi-spherical or form a sector of orb.. They appear in advance of the oliver die and were probably struck with a hand die as described by Diderot. One version is hollow below the head and dates from 1845 or so. The shanks are sturdy.					
 1519 facets. Bocking Church, Essex. DOG NAILS – from RE tender of 1812, display multi-facetted forged heads.					
Photos: Author			Sketches: Author/McCaig: 1812 tender		
Notes: The Royal Engineers tender of 1812 shows only flat ended pointed die-dogs in 5 sizes. Several examples of sharp points have been recovered in the period 1855 – 1870, often used to secure lead flashing upturns. The sizes shown are from 40mm to 80mm overall length. 					
Continuity/Transitions:			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		
The blunt end point type transitions to a rolled 'wire' version circa 1875 which was used to fix corrugated iron.					

Nail Ref	N 11	FENCE NAIL			
Alternate Names	Fencing clouts				
First Appearance	Roman?	Last Appearance maybe 1880			Size 55-62mm
Exemplar grade	From	Garvoc	Date circa 1875	Material Fe IR	
Zone: Roof Ext	Roof Internal *	Frame *	Floor	Linings	
Literary Reference: NEVE 1703, Nails 21 - refers only to a heavier version of this type which he terms 'Square': a most useful nail for oak or hardwoods as also for nailing wall-fruit, the points being made stronger. See also: SALMON 1738, 66 – Square.					
Identifying Features: These are essentially large long clout nails with square shanks and sharp points. The heads are flat or nearly so.					
Images: NOTE ALL EXEMPLARS ARE UNUSED.					
 Garvoc, Victoria. Noorat, Vic. Galvanised. Naish Collection, Salisbury, c1930					
Photos; Author			Sketches		
Notes: Rarely found intact when in-situ, due to corrosion.					
Continuity/Transitions:		Nil KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage			

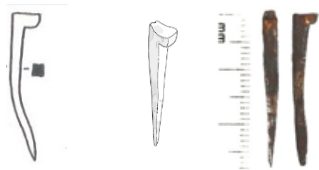
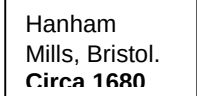
Nail Ref	N 12	FLASHING NAILS		
Alternate Names	Flashing clouts			
First Appearance	Circa 1852	Last Appearance circa 1875		Size Range (mm)
Exemplar grade	From		Date	Material Fe (galv)
Zone: Roof Ext *	Roof Internal	Frame	Floor	Linings
Literary Reference: Nil. Observations show a range of galvanised wrought nails becoming common around 1945 or so, and this galvanised, heavy form, of clout nail appears in tuck flashings soon after.				
Identifying Features: Flat, circular headed, clouts. Some show a full taper which is unusual for English nails. It is not clear if they were made for supporting upturn flashing but they are used equally with galvanised die-dogs during the period 1855 to 1875 or so.				
Images:				
 Glenelg Street, Portland, Victoria, 1856. Govt Offices. Hindley Street, Adelaide. 1855				
Photos: Author			Sketches: none	
Notes: These are a form of a 'heavy' or 'best' clout, and the extra thickness may be due their being galvanised. They are one of the few English nails to exhibit a full shank taper.				
Continuity/Transitions: None. They are predated by strong version commons and succeeded often by Ewbank nails.			KEY: R – Roman M – Medieval T – Tudor IR – Iron rod RR – rolled round FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 13	GATE NAILS		
Alternate Names				
First Appearance		Last Appearance		Range: 55-80 mm
Exemplars Nsh	From	Pre WWII	Date c1930	Material Fe IR
Zone: Roof Ext	Roof Internal *	FIELD GATE	Floor	Linings
Literary Reference: HEBERT 1825, 183: <i>Gate nails, allied to hurdle nails, are similar in form, but are usually made stouter and in various lengths.</i>				
Identifying Features: Roseheads and flat shanks				
Images:				
 Naish collectionW&DWH circa 1828				
Photo: Author			Sketches: Hebert 182; Bevan 34	
Notes: Like hurdle nails these have flat shanks to facilitate clenching.				
Continuity/Transitions: Superseded for domestic alternative uses by Ewbank nails of similar sizes, then by cut forms, and then by wire nails.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 14	HOB NAILS		
Alternate Names	Door nails (often used as synonym). 'Diceheads'.			
First Appearance	M	Last Appearance		Size Range (mm)
Exemplar grade			Date	Material
Zone: Roof Ext	Roof Internal	DOORS *	Floor	Linings
Literary Reference: SALZMAN 1952, 308-9, 314; <i>Dure nayl</i> 1264, <i>Hache nayl</i> 1323, <i>Havednegl</i> , 1288. MOSELEY 1968, 21-22. SALMON 1738, 5 types: Dye, Rose, Skidder, Thick, and Clasp Hobbs				
Identifying Features; Door nails present a smooth profile whereas fortress or cell doors are intended to armour the door against attempts to break it down.				
   Die Hob Skidder Hob Thick Hob    Rose Hob Skidder Hob Clasp Hob 				
Photos; Author			Sketches – Moseley 1968	
Notes: The 'dice' heads are recessed to the level of the bevel in early, high standard work: the church porch door to St John the Baptist at Thaxted Essex, circa 1445. The term 'hache' from the middle ages almost certainly refers to the cut-away bevelled corners of door nails. They function like to the <i>clavus muscarius</i> of antiquity, or to scuttle or pail nails, intended to present a smooth profile.				
Continuity/Transitions:			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	
After 1780 or so these were undercut in price by annealed cast iron nails of almost identical form.				

Nail Ref	N 15	HURDLE NAILS			
Alternate Names	Kent Hurdle and Essex Hurdle, are the most common forms				
First Appearance	Post 1666?		Last Appearance WWII		Size 55-80mm
Exemplar grade	From			Date	Material Fe IR
Zone: Roof Ext	Roof Internal *		Frame *	Floor	Linings
Literary Reference: HEBERT 1879, 439. Not mentioned by Salzman.					
Identifying Features; These have broad, thinnish rose head, clean-drawn, flat shank, a good spear point, well adapted for nailing and clenching oaken hurdles together.					
Images:					
					
KENT HURDLE		SUSSEX HURDLE		ESSEX HURDLE	
WCt 1838		Marsden blacksmith c1910		Nsh	
				1732, Darshill	
Photos: Author				Sketch: Hebert 1879, 439	
Notes: Hebert notes that other variations of hurdle nails exist but that the differences are insignificant. They are adopted into buildings primarily as rafter nails, being well suited by length and robustness. The Sussex hurdle nail varies little from the Kent version. The Essex hurdle nail can be confused with a gate nail. All the rafter nails found in Somerset have Kent hurdle shanks but have rose-heads. Kent hurdle nails are mentioned in the <i>Geelong Gazette</i> shipping imports list of 1845.					
Continuity/Transitions: In Australia these are often superseded by larger spur-head brads of similar length when used in roofs.				KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 16	JOBENT NAIL			
Alternate Names	Hinge nails				
First Appearance		Last Appearance		Size 45-55mm typ.	
Exemplar grade			Date	Material Fe IR	
Zone: Roof Ext	Roof Internal	cupboards	Floor	Linings	
Literary Reference: NEVE 1703, Nail 10 GWILT 1867, 1231, refers to Jobent and Dog nails as both used for fixing hinges.					
Identifying Features: <i>Used to nail thin sheets of iron to wood and small hinges for cupboard doors. Sizes are 2 and 3 lb per thousand. Neave</i>					
Images:					
 WH, c1810. EH c1630 Welsh – no date Pew door nail, circa 1680. Oakham, Leicester					
Photos; Author			Sketches: Author/McCaig		
Notes: Head flanges are thin but the shanks are usually rectangular to allow clenching but thicker under the head. Exemplars may show wear grooves below the head from metal to metal contact. Padlock bracket jobents in Kings College Cambridge, circa 1520. The Jobent nail is better suited to clenching than a Dog nail which has a thicker shank.					
Continuity/Transitions: Dog nails or scupper nails sometimes used as an alternative. Replaced by clout nails after 1850 or so.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 17	LATH Nails (Lath sprigs)																														
Alternate Names	Scotsem nail (Salzman).																															
First Appearance	M	Last Appearance: circa 1845		Size 15-38 mm																												
Exemplar grade		Date		Material																												
Zone: Roof Ext	Roof Internal	Floor		Linings																												
Literary Reference: SALZMAN 1952, 310, 313-314, 316: <i>nayls for laths</i> 1208, <i>woughprig</i> 1367, <i>Scotsem nails otherwise called lath nails</i> 1567. <i>Normandy lath nails</i> , 1534: TREDGOLD 1837, 286 says lath nails were 26mm and mainly cut by 1837																																
Identifying Features; Lath sprigs identified by size, from 25 mm at lath ends to 17mm inside sprigs. Lath nails are small commons with medium rose-heads. English ones are mainly sharp pointed. Spade end versions also found in Australia and can easily be confused with shingle nails.																																
Images: LATH SPRIGS																																
 C 1785. High St. Oxford  Hanham Mills, Bristol. Circa 1680  BISHOPS CAMERA Farnham Palace, Hampshire. Three lath nails from barrel vault roof reconstruction of 1381																																
 LATH NAILS  <table><tr><th>NAIL</th><th>SITE</th><th>AGE</th><th>Weight grams</th></tr><tr><td>1</td><td>Glastonbury</td><td>C 1720</td><td>1.2</td></tr><tr><td>2</td><td>Sydney NSW</td><td>1831</td><td>1.3</td></tr><tr><td>3</td><td>Woolmers TAS</td><td>1842</td><td>2.7</td></tr><tr><td>4</td><td>Ditto</td><td>"</td><td>2.6</td></tr><tr><td>5</td><td>Ditto</td><td>"</td><td>1.9</td></tr><tr><td>6</td><td>Ditto</td><td>"</td><td>2.1</td></tr></table>					NAIL	SITE	AGE	Weight grams	1	Glastonbury	C 1720	1.2	2	Sydney NSW	1831	1.3	3	Woolmers TAS	1842	2.7	4	Ditto	"	2.6	5	Ditto	"	1.9	6	Ditto	"	2.1
NAIL	SITE	AGE	Weight grams																													
1	Glastonbury	C 1720	1.2																													
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5	Ditto	"	1.9																													
6	Ditto	"	2.1																													
Photos; Author	Sketches – David Martin: Author/McCaig; and 1812 RE tender document.																															
Notes: 1. The shift from sprigs to small nails may be due to improved range of slit rod into smaller sizes which most likely occurs in the early 1700s. (See slit rod analysis). 2. The extra heavy Woolmer's nails suggest that the large forge at the tied estate of Brickenden was used to train some convicts as nail makers. Grown men lack the adeptness of women and children nail makers due to coarse hands. Nails 3 and 4 may have been intended as shingle nails, although found in laths.																																
Continuity/Transitions: Several changes occur in types of lath nails, starting with cast lath nails circa 1770. Cut lath tacks appear circa 1825 and reach a standard form around 1835. TREDGOLD 1837, 286 says that cast lath nails were the cheapest available																																
KEY: R – Roman M – Medieval T – Tudor IR – Iron rod RR – rolled round FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage																																

Nail Ref	N 18	LEAD nail			
Alternate Names	Launder nails. Leather nails				
First Appearance	Post medieval	Last Appearance: possibly 1845		Size 32mm	
Exemplar grade	Circa 1828 WH		Date	Material Fe/Pb	
Zone: Roof ext *	Roof Internal *		Floor	Linings *	
Literary Reference: NEVE 1703, Nails 11: <i>These are commonly used to nail lead and canvas to hardwood. The sizes are 4 ¼, 7, & 8 lb per thousand.</i>					
Identifying Features: Lead covered wrought iron commons or tacks.					
Images:					
					
Small lead covered tack from WCt, circa 1840 and an abandoned lead lined launder Woolmers House, circa 1828, showing the lead nails ringed in orange.					
Photos; Author			Sketches - Nil		
Notes: The several medieval references recorded by Salzman almost certainly refer to nails used to fix lead sheet.					
Continuity/Transitions: Lead launders were superseded by galvanised iron sheet circa 1849.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 19	LEAD CLOUT			
Alternate Names	Roofing clouts.				
First Appearance	M		Last Appearance		Size circa 75 mm
Exemplar grade	From			Date	Material Fe
Zone: Roof Ext *	Roof Internal		Frame	Floor	Linings
Literary Reference: SALZMAN 1952, 304, 311: <i>lednail</i> 1327, <i>lednayl</i> 1273, <i>Clouthnayl</i> for fastening laths and lead. 1279					
Identifying Features: Wrought iron clout with thick wide flanged head which shows signs of lead 'dusting' or direct adhesion. The shank is often rounded off to an octagon-like cross section and the neck is round.					
Images:  Tudor, circa 1530, Hampton Court Palace					
Photo: Author				Sketches: Nil	
Notes: It is clear from Salzman's references that the head size varied in medieval times. The Tudor version at Hampton Court is relatively large and designed to exert even pressure on the lead surround.					
Compare to clout above					
Continuity/Transitions:			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 20	LINING NAILS		
Alternate Names	Reveal nails. Door frame nails.			
First Appearance	Possibly 1700	Last Appearance 1880		Size 25-85 mm
Exemplar grade	From		Date	Material Fe
Zone: Roof Ext	Roof Internal	Frame	Floor	Linings
Literary References: None				
Identifying Features: Earliest form shows flattening of head and shank to around 2.5mm thickness from both common rose-heads and clasp nails. Later forms have a distinctive crested head.				
1574  c1690  Wheatsheaf Inn BRECON POWYS 1730  Tower House WELLS 1784  WESTMINSTER 1846  Princes St. PORT FAIRY  Lord cottage, Yankalilla, 1880 from door linings.				
Photos: Author			Sketch: D & B Martin	
Notes: The flattened rose-head form continues to show up into the 1800s in Georgian townhouses. Numbers of the mechanically wrought (rolled) version appear in central Adelaide up to mid-1880s. Lining brads have been found in the Chapter House, Ely Cathedral, c 1351 				
Continuity/Transitions: The later form is followed by a cut version.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 21	HOOK NAILS			
Varieties	Tenter, Netting, Kitchen, hooks, staples and cramps				
First Appearance	R	Last Appearance:			Size mm
Exemplar grade	1828-1878		Date	Material	
Zone: Roof Ext	Roof Internal		Floor	Linings	
Literary Reference:					
Identifying Features: These come in a variety of forms according to their purpose intended and are made locally by blacksmiths: Hooks: kitchen, pipe, Tenter, & net. Forged staple, cramp and water pipe hook.					
Images:					
					
Photos; Author/ Richard Jones/ Terry Hughes				Sketches -	
Notes: Hooks are often found in repair work to stone or slate roofs.					
Continuity/Transitions: Cramps appear often in medieval frame repairs with re-used felloes – Lavenham Guildhall.				 KEY: R – Roman M – Medieval T – Tudor IR – Iron rod RR – rolled round FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 22	PIPE NAILS			
Alternate Names					
First Appearance		Last Appearance:			Size 85-120 mm
Exemplar grade	Circa 1828		Date	Material Fe	
Zone: Roof Ext	Roof Internal		Floor	Linings	
Literary Reference: SALZMAN 1952, 306: <i>large nayls for pipes of latrines.</i>					
Identifying Features: Round nail with minimal or small flanged, rounded, head.					
Images:					
					
C1810 Hobart Museum and Art Gallerv. from an internal well with a roof downpipe.					
					
Photos; Author			Sketches -		
Notes: The second nail is a 'stiddy' version forged from a billet of round bar.					
Continuity/Transitions: The galvanised die-dog may have served in lieu of this nail in many instances. It appears in modern form in rolled rod nails, both of the 'Billycot hat' variety, and 'Survey' nails without an additional flange. Replaced in the 1880s by rolled wire general purpose roofing nails which were also used for pipe bracket fixings.			KEY: R – Roman M – Medieval T – Tudor IR – Iron rod RR – rolled round FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 23	POUND NAILS – SQUARE NAIL		
Alternate Names	Stone nails: allied type is the 'plate' nail.			
First Appearance	Tudor **	Last Appearance: Mid 1700s		Size Range (mm)
Exemplar grade	From C1710		Date in doubt	Material Fe IR
Zone: Roof Ext	Roof Internal *	Frame	Floor *	Linings
Literary Reference: SALZMAN 1952, 311: NEVE 1703, Nails.				
Identifying Features: NEVE 1703: <i>These are four square in the shank and are much used in Essex, Suffolk, and Norfolk. The sizes are 6d, 8d, 10d, and 40d.</i>				
Images:				
 POUND NAIL Part of raised roof at Dolgellau, late 1600s.  SQUARE NAIL Circa 1710. Blakeney, Gloucestershire.  C 1530 TUDOR Hampton Court  PLATE NAIL. Nsh				
Photo: Author/ Terry Hughes – nail 1			Sketches: Nil	
Notes: Neve shows that these nails were intended for use in oak. Terry Hughes reports the extra heavy nail shown was found driven into old dry oak beams in a former roof raising to a stone flag roofed cottage at Dolgellau, North Wales. ** Tudor examples, with heavy shanks, show on the Hampton Court, Royal Palaces' nail boards.				
Continuity/Transitions: These were superseded by the stiddy version of spikes and by round plate nails.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 24	SCARF NAILS			
Alternate Names	-				
First Appearance	M		Last Appearance:		Size mm
Exemplar grade	Circa 1828			Date	Material
Zone: Roof Ext	Roof Internal		Frame:	Floor	Linings
Literary Reference: SALZMAN 1952, 316; <i>Scarfneil</i> , 1276, Canterbury Cathedral. BEVAN?					
Identifying Features: The shanks are made thin to avoid splitting the edge grain, and the heads are minimal.					
Images:  					
Photos. No exemplars found				Sketches – RE tender 1812	
Notes:					
Continuity/Transitions: The shape may have influence the Ewbank nail to a small degree and very similar cut steel nails by Cordes & Co, reappear in the late 1890s.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 25	SCUTTLE NAILS: SCUPPER NAILS		
Alternate Names	Smaller sized heads are called 'Pail nails' or 'Coopers flats'			
First Appearance	R	Last Appearance		Size mm
Exemplar grade	One grade		Date	Material Fe
Zone: Roof Ext	Roof Internal	Frame	Floor	Linings
Literary Reference: GWILT 1867, 1231; These are much used in the fastening of leather and canvas to wood.				
Identifying Features: Short shanks with large round heads. Scupper nails sometimes have square heads.				
SCUTTLE NAIL		 		
SCUPPER NAIL – ROUND & SQUARE				
 				
Photo: Author			Sketch: RE tender 1812	
Notes: Medieval chest in Ely Cathedral, circa 1350. Latch plate at Brickenden farm granary, Tasmania, circa 1820. Pail nails are akin to scuttle nails but with smaller heads and flat shanks.		 		
Continuity/Transitions: These derive from the <i>Clavus Muscarius</i> of the Romans, whereby they are intended to present a smooth head profile to prevent clothes or fabric from snagging on the heads. Roman examples of pail nails are displayed at the Limes Museum, Aalen, Wurttemberg.		KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

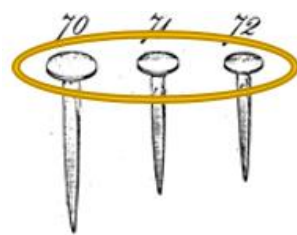
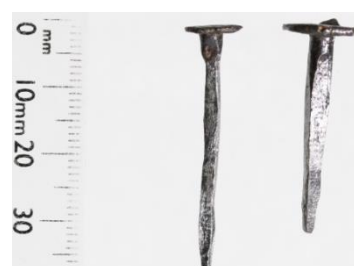
Nail Ref	N 26	SHINGLE NAILS			
Alternate Names	Shingling nail				
First Appearance	M		Last Appearance:		Size 42-48 mm
Exemplar grade	Circa 1801			Date c 1855	Material Fe IR
Zone: Roof Ext *	Roof Internal			Floor	Linings
Literary Reference: SALZMAN 1952, 311; <i>shingle nail</i> 1329; also <i>shiggil</i>					
Identifying Features: These are commons but with a pronounced head rise unlike batten nails with a reduced rise, or slate nails with flat heads. They are mostly sharp pointed but ones found in Australia May have spoon points.					
Images:					
 1801 samples from a cottage roof at Headcorn, Kent. 					
Photos; Author				Sketches – RE tender 1812	
Notes: Occasionally used for fixing laths but somewhat inappropriately as they are oversized for the purpose. Also applied sometimes to fixing thin roofing battens. These nails were found unsuitable for Canadian cedar and softwood shingles and were replaced with a lighter version, known as ‘Canadas’.					
Continuity/Transitions: These start to be replaced by Ewbank nails of similar size by the 1840s. Examples of their replacement with the British version of the American cut nail occurs by 1855. Later Australian fixings of circa 1875 show use of the American face-pressed cut nail but with slightly wider flanges.				KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 27	SIGN HOOKS		
Alternate Names	-			
First Appearance	M	Last Appearance: WWII?		Size 65mm
Exemplar grade			Date 1930s	Material Fe IR
Zone: Roof Ext	Roof Internal	FACADE	Floor	Linings
Literary Reference: Nil				
Identifying Features: Short heavy shank with sharp point and a built-up heavy rectangular, offset, head.				
Images: No samples have shown up during the study, nor is it referred to or does it appear in archaeological works. This exemplar is from the Naish collection in Salisbury.				
				
Photos; Author			Sketches – nil	
Notes: The head is intended to take a ring at the end of a chain suspending the sign. It is presumed that these were fitted in pairs on the facades of shops and inns.				
Continuity/Transitions: This system of hanging signs was essentially abandoned soon after WWII.				

KEY:

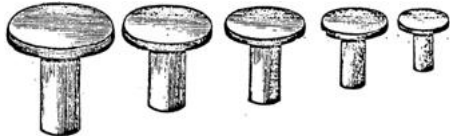
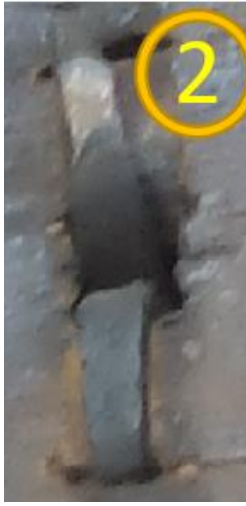
R – Roman	IR – Iron rod
M – Medieval	RR – rolled round
T – Tudor	FS – Flat strip

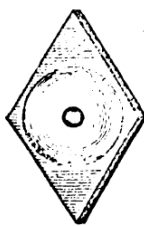
Nsh – Naish collection Salisbury
 W&D – Weald & Downland Museum
 W H – Woolmers House
 WCt – Woolmers Cottage

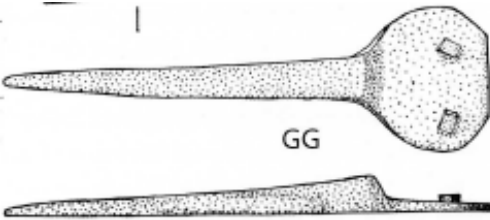
Nail Ref	N 28	SLATING NAILS		
Alternate Names	Slating nails			
First Appearance	T	Last Appearance: circa 1855		Size 19-48 mm
Exemplar grade	See below		Date 1732	Material Fe
Zone: Roof Ext *	Roof Internal		Floor	Linings
Literary Reference: SALZMAN 1952, 311; <i>stonenayl</i> . TREDGOLD 1837, 287 gives sizes as above and says copper and zinc varieties were available by 1837				
Identifying Features: Heads are flat and the necks below the head are rounded to avoid damage to the stone slates. The RE tender document shows three sizes but this study has only found two: 40mm nom. & 30mm nom.				
Images:  1732 sample. Bowlish House, Darshill,    1856 samples from vestry roof. Christ Church. Warrnambool. 1838 -Brickenden farmhouse roof, Longford, Tasmania, & Christ Church vestry roof 1856, Warrnambool, Victoria. The heads are die formed & the nails are zinc dipped. 				
Photos; Author			Sketches – RE tender 1812	
Notes: - The earlier samples appear in a middle grade (weight) of nail and were found in elm battens. The later examples were mainly in ‘fine’ grade and found in softwood battens. - The 1838 samples all appear to be wrought shanks but finished with an Oliver strike to leave circular heads with bevelled perimeter. The heads appear to be tinned (not galvanised). - The similarity of heads ringed above suggests the Oliver header was already in use by 1811.				
Continuity/Transitions: These star to be replaced by cut zinc nails circa 1840, and then by cut copper nails which appear in numbers circa 1880.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

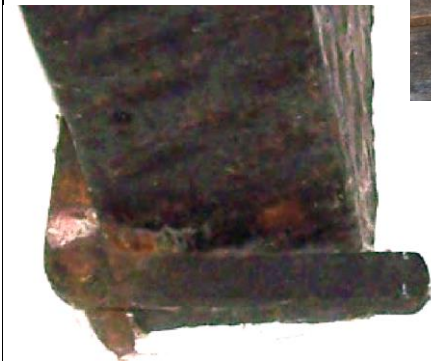
Nail Ref	N 29	SPRIGS and GADS		
Alternate Names	'Sparrow bills', glazing sprigs.			
First Appearance		Last Appearance:		Size 19-26 mm
Exemplar grade	Circa 1828		Date	Material
Zone: Roof Ext	Roof Internal		Floor	Linings
Literary Reference: BEVAN, : FIELDER 1879:				
Identifying Features: These are small forms of brads, and in the case of lath sprigs will have a spur or 'bill' to the head, necessary to hold the lath in place against pressure from plastering the wall surface				
Images:				
Photos; Author			Sketches – Bevan; Tender; Author/Mc	
Notes:				
Continuity/Transitions:			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 31	SPIKES		
Alternate Names	Deck spikes, bridge spikes			
First Appearance	Pre-R	Last Appearance: WWII		Size 120 - 350 mm
Exemplar grade	All sturdy		Date 1732	Material Fe IR
Zone: Roof Ext -	Roof Internal	* Barn frames *	Floor -	Linings -
Literary Reference: SALZMAN 1952, 306; <i>Spykyng</i> 1431, <i>Dubel spykyng</i> 1362: TREDGOLD 1837, 284 gives sizes as 127-176mm				
Identifying Features: Large nails over 125mm long, with square shanks. They have a variety of heads and points. Most heads lie in one dimension. Exceptions are deck and bridge spikes, and some barn spikes where they are used to fix wooden knee brackets, mainly of oak.				
1 -3. Circa 1740 – 1790 Glastonbury, Somerset. 4. Greyhound Farm, 1780, Shepton Mallet, Somerset. 5 & 6.. Bowlish House rear extension, circa 1745, Darshill. 7. Bowlish House, main roof 1732, Darshill. Somerset. 8. Stiddy forged spike, 1875 abattoirs, Warmambool. Vic.				
Photos; Author			Sketch – RE tender 1812	
Notes: 1. These are used more in agricultural buildings than in domestic ones. 2. Large numbers are used in bridge and defensive works, and in ship construction.				
Continuity/Transitions: Stiddy version becomes popular from 1860s			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Fixing ref	N 32	Rivets								
Alternate Names	-									
First Appearance	R	Last Appearance: - still current		Sizes vary						
Exemplar grade ---	Sources shown		Date 1445/50	Material Fe						
Zone: Roof Ext	Roof Int: note 4	DOORS	Floor	Linings- DOORS						
Literary Reference: SALZMAN 1952, 309; clavos de ryvet 1311										
Three types: 1. Plain ends, which are hammered over a rove in cold state. 2. Split shanks, as shown by Violet le Duc and by Hoffsummer. 3. Split end tails, as shown by Duhamel du Monceau. 4. Hoffsummer has established rare cases of their ab initio use in French roofs.										
				WH c1828						
		C 1445. Main door to church of St Mary the Virgin, Saffron Walden, Essex. [Comparable finds made by Hoffsummer at Etampes]								
Photo: Author		Sketches: RE tender 1812								
Note: Only type 1 continued into the modern period										
C1450. Latch to main door of church of St Stephen, Hernhill, Kent		Continuity/Transitions: 1. The use of roves was in decline by the time Moxon wrote in 1683 2. Split shanks still exist as split pins in mechanical works but not in buildings. 3. It is likely that split tails were already a speciality of machinery workshops by the time of Du Monceau, & the rare example shown from Kent is part of a latch.								
		KEY: <table><tr><td>R – Roman</td><td>IR – Iron rod</td></tr><tr><td>M – Medieval</td><td>RR – rolled round</td></tr><tr><td>T – Tudor</td><td>FS – Flat strip</td></tr></table> Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage			R – Roman	IR – Iron rod	M – Medieval	RR – rolled round	T – Tudor	FS – Flat strip
R – Roman	IR – Iron rod									
M – Medieval	RR – rolled round									
T – Tudor	FS – Flat strip									

Fixing ref	N (fixing) 34		Roves		
Alternate Names	Boves				
First Appearance			Last Appearance		Sizes vary
Exemplar grade	From			Date	Material Fe
Zone: Roof Ext	Roof Internal		Frame	Floor	Linings
Literary Reference: SALZMAN 1952.					
Identifying Features:					
Images:					
					
					
Photo: Author				Sketches: RE tender 1812	
Notes:					
Roves are either diamond shaped or are square with bevelled corners. They are frequently let into the face of doors to avoid snagging of clothes. These become a leitmotiv of French door decoration after the Wars of Religion synonymous with the reign of Louis XIV, (HOW 2017, 53-56.					
Continuity/Transitions:				KEY:	
				R – Roman	
				IR – Iron rod	
				M – Medieval	
				RR – rolled round	
				T – Tudor	
				FS – Flat strip	
				Nsh – Naish collection Salisbury	
				W&D – Weald & Downland Museum	
				W H – Woolmers House	
				WCt – Woolmers Cottage	

Fixing ref	N (fixing) 35		Holdfast		
Alternate Names	'Gibb and cotter'				
First Appearance	Pre- 1680		Last Appearance - still current		Size 120-250 mm
Exemplar grade -	From			Date	Material Fe
Zone: Roof Ext	Roof Internal		Frame *	Floor	Linings
Literary Reference:					
Identifying Features: Long thick pointed tang with offset flat disk or lozenge pierced for 1 or 2 nails.					
Images:					
					
1856 'Correagh' Hamilton, Victoria. C 1740. Glastonbury, Somerset. 1905. Princes Street, Port Fairy, Victoria					
					
Photo: Author			Sketches: Carlsen & Lounsbury		
Notes: These were widely used for attachment of timber to masonry: photo of tied porch, Abbey Street, Faversham, Kent					
Continuity/Transitions: Although these are still available in modern industrialised forms, they are currently being superseded by drilled metal fixings.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Fixing ref	N (fixing) 36	Forged insertions		
Alternate Names	Numerous names are used according to usage.			
First Appearance	R	Last Appearance		Sizes various
Exemplar grade -	From		Date	Material Fe
Zone: Roof Ext 8	Roof Internal *	Frame *	Floor *	Linings Nil
Literary Reference: Best described by Du Monceau's term ' <i>clou de ferronnier</i> ' and he displays a wide range of items. Felibien also alludes to forged insertions				
Identifying Features: Each type is specific and frequently of local unique manufacture. They vary according to the prevalent architectural style of the age.				
				
Photo: Author			Sketches: Nil	
Notes: These are distinguished by being of smith's work rather than items coming from the nail making industry. Images shown are all from Australia during the period 1828 to 1852				
Continuity/Transitions:			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Fixing ref	N (fixing) 37		Perched ridge nails		
Alternate Names	Double-ended nails				
First Appearance	Circa 1760	1861			Size 175 mm
Exemplar grade -	From		Date	Material Fe	
Zone: Roof Ext *	Roof Internal	Frame	Floor	Linings	
Literary Reference: Nil					
Identifying Features: Made from 5-6mm flat bar with ends cut away to form sharp points at each end.					
 Christ Church Warrnambool, north nave, 1861, perched ridge, double-ended, 175mm nail.  Left, the Hoop Pine ridge pole sat onto 175mm long double ended nails, as seen above. A 130mm version from De Winton Hotel, Llanbradac, circa 1880. Courtesy Richard Jones. 					
Photo: Author			Sketches: Nil		
			Notes. Christ Church south nave 1856, the ridge roll had an improvised adapted Ewbank nail with head removed, pre-fitted to holes in a Kauri ridge pole		
Continuity/Transitions			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

4.2.8 Nail rod dimensions

A common factor which repeats in the wording of the patent descriptions of the first English slitters is the on-going efforts made to improve the early machines. In order to simplify work on small nails the slitting discs needed to be improved and likewise the regulation of the sheet thickness. As part of the analytical aspect of the study a series of measurements of some 120-nail shank unwrought parts were made. From these measurements a range of 26 results was extracted, being the most representative and covering the period 1680-1870.

Micrometer measurements from the period 1690 to 1831 reveals aspects of the distribution range of sizes for common building nails, Table 4.3. It can be seen that the study period opens with smaller sizes around 3.4mm square, but that this reduces to around 2.3mm square by 1819. No samples were found larger than 12mm or so square.

Even from such a small sample, it is evident that the various illustrations showing the slitting process, (due to the over-riding need for clarity), give an erroneous subliminal message that the nail rod is usually around 12mm square. Table 4.3 supports the written information about Sir Ambrose Crowley's works that the range of slit rods started at a very much smaller size ($3/16^{\text{th}}$ of an inch, or about 4.8 mm). In fact the figures suggest slitting may have gone down to 3.5 mm thickness (about $1/8^{\text{th}}$ of an inch). It is difficult to consider any thinner sections than this being produced by the process and those few smaller sections shown may in fact have been worked down from larger rod. The table assumes the larger dimension was the cut one and that the other represents the rolled thickness of the iron strip.

A second aspect is projected by the table, which is that the most used nails in buildings lie towards the bottom margins of the slitting size distribution: say 3.5 to 8 mm, rather than the common image presented by various illustrations. In fact, in English house construction for most of the study period, very few spikes less than 6 inches long (150 mm) were used and the Glastonbury spikes shown therein may have come mainly from agricultural buildings of the 1800s.

TABLE 4.3 NAIL ROD SIZE ANALYSIS

NAIL TYPES:	Batten	Slate	Gate	Rafter	Purlin	Floor brads	Common roseheads	Hurdle	Clasp	Clout	Dubbel	Lath	Brads	Lining	Jobent	Spikes 140 mm	Spikes 150 mm	Spikes 170 mm
Location																		
Surrey 1680															4.8 x 3.7			
Wheatsheaf Inn				4.1 x 3.1		5.4 x 4.5				3.4 sq		3.1 x 2.7 3.7 x 2.3						
Bowlsh Hse 1732	4.0 sq	4.0 x 3.0* 4.5 x 2.6		5.0 x 3.1 6.1 x 3.1	7.4 sq 8.3 x 6.1											9.0 x 6.9 8.1 x 7.5		
Tower Hse Wells 1730							3.9sq *						3.1 sq	2.8 x 1.9				
Westminster 1730				6.6 x 3.2 & 6.6 sq		6.6 x 3.5			4.7 x 3.7									
Glastonbury 1740+						2.8 sq 3.4 x 3.0				3.5 x 2.6			3.5 x 3.1			6.4 x 5.3 to 11.6 sq	8.5 x 8.0 to 11.7 x 9.0	9.0 x 8.0 to 12.1 x 9.0
Westminster 1750									3.7 x 3.0									
Stourhead 1753									4.9 x 4.4									
Westminster 1764						5.4 x 4.5												
Westminster 1790						5.5 x 4.5												
Hobart Barracks 1803						5.0 x 4.6												
Headcorn cottage 1810							3.0 x 2.7 *											
Woolmers woolshed 1819							2.3 sq fine											
Sydney Supreme Ct 1823	3.3 x 3.1			5.0 x 3.5														
Hobart Art Gallery 1823						6.0 x 5.0												
Woolmers blacksmith 1826		4.0 sq*		4.0 sq														
Woolmers House 1828				6.5 x 5.0 & 4.6 x 3.9*		4.5 x 4.0									4.6 sq			
Sydney Lwr Fort St 1831						5.5 x 4.6* & 4.4 sq*	4.3 x 3.7*						4.3 x 3.6*	3.1 sq				
Muntham station 1836				5.6 x 4.1														
Woolmer: cottage 1810		3.5 sq*										3.8 x 3.1*						
Narryma Hse Hobart 1840						5.5 x 4.8* & 5.1 sq*												
Adelaide St Hobart 1842						6.0 x 4.8 & 5.0 sq												
Steam Pkt Inn Portland 1850				7.0 sq														
Christchurch Wbool 1856		3.0 sq																
Sussex circa 1870			4.3 x 4.0					5.9 x 3.8			6.3 x 4.5							
Windsor c circa 1870																	11.2 x 10.8	

4.2.9 Summary of Part One findings

1. Wrought nails and their names show a high degree of continuity with their medieval precedents.
2. There was a plethora of names for nails in medieval England, but given the three languages in use (Norman French, clerical Latin, and early English), and the wide range of local dialects and pronunciation, there are several signs of descriptions stabilising on certain types.
3. Similarly, nails found in the Roman period are often not dissimilar. Differences can often be traced to changes in styles of construction which saw some nail types die out whilst other new ones developed to suit the medieval world.
4. The slitting machine underwent a series of rapid improvements such that by the start of the study period most nails could be produced from nail rod of appropriate size without recourse to excessive paring down.

Part Two: Cast nails

Les clous en fer se forgent; les autres se fondant: la fabrication de ces derniers n'a rien de particulier; c'est un ouvrage de Fondeur tres-commun.

Grande Encyclopedie circa 1755

TABLE 4.4: BASIC APPEARANCE PATTERN OF CAST NAILS

Date	1500	1550	1600	1650	1700	1750	1800	1850	1900
Lath							---	---	
Hob-Door							---	---	
Commons							---	---	
Masonry							---	---	---

4.3 OVERVIEW – CASTING CHANGES

The resolution of annealing cast iron into a malleable form arrived in 1769, but its initial application in respect of nails was bizarrely aimed at the production of ornate coffin nails. The first cast iron lath nails appear around 1780 or slightly earlier. In most cases it is easy to detect the differences between nails produced by the wrought process and those which are cast from molten iron since the fettling process leaves vestiges of the sprue entry point to the nail mould. Around 1825 or so a subtle change in the casting medium occurs in which the surfaces become coarser.⁵¹³ This provides further clues to dating, but it does require a degree of familiarity with handing samples of this ilk in order to differentiate the small differences.

4.3.1 Recognition features

Due to the casting process, nails cast from iron appear to have a grainy surface or small surface blisters, and sometimes can appear grey due to a surface stippling effect left by the sand grains - as if they had been galvanised. However, not all of the same type of cast nails were cast from the same source sand and some samples recovered from works prior to 1800 exhibit a more slick, slightly shiny, surface texture. Thus it is important to understand the casting process by which the individual moulds for the particular nail were supplied with molten iron. The molten iron was fed through a system of channels and normally fed direct to the nail head cavity leaving behind a piece of the cast channel after the nail itself had been broken off. This residue piece is termed the 'sprue' and the process of breaking off the nails from the cold casting is termed 'fettling'. The aim of fettling is to reduce the extent of sprue left behind, both for aesthetic reasons and to make it easier to drive the nail.⁵¹⁴ Hence the sprue remaining after the fettling process is the product of individual attention so that the extent and shape of the fragment remaining varies considerably.

A secondary effect which varies from sample to sample is the lack of precision alignment, as the mould used for casting had to be made in two parts. The bottom section has impressions of the lower half of the items to be cast, and then the top section has to be indented with the corresponding parts of the impressions, and then turned over to be accurately placed over the lower section before the liquid metal can be fed in. This can never be done with absolute accuracy, and so the edges between the two halves of the mould show a minor misalignments.

⁵¹³ SALMON & SIMONS 1966, 77-114. Iron was cast at 300 degrees C in a natural sand. (Greensand).

⁵¹⁴ Ibid. 264-267

Cast lath nails of iron from between 1770 and 1825 or so display a very smooth surface but still show the sprues and misalignments. This may be due to the use of a stabilised casting medium such as lime-sand or plaster. Later samples show very clear signs of having been cast against sand with a grainy or stippled appearance, fig 87.



Fig. 87. Unused lath and door cast nail, from Richard Jones, Blackwood, Caerphilly. Author

4.3.2 The Economics of Casting

Almost any shape nail could be cast and highly intricate, decorative nails, which would have required detailed work by a skilled craftsman, could be made much easier and cheaper by using the simple casting process, as noted above by Diderot. The costs involved broke down to making a pattern, the top and bottom boxes of the moulds which, with the greensand medium, could be re-used many times, then the cost of disassembly and fettling.⁵¹⁵ Moseley simplifies the diagram as appropriate to casting small nails, fig. 103 right, but shows overly large boxes. Spretson makes it clear that the wooden boxes are between 75 and 125mm deep, fig.88, left.

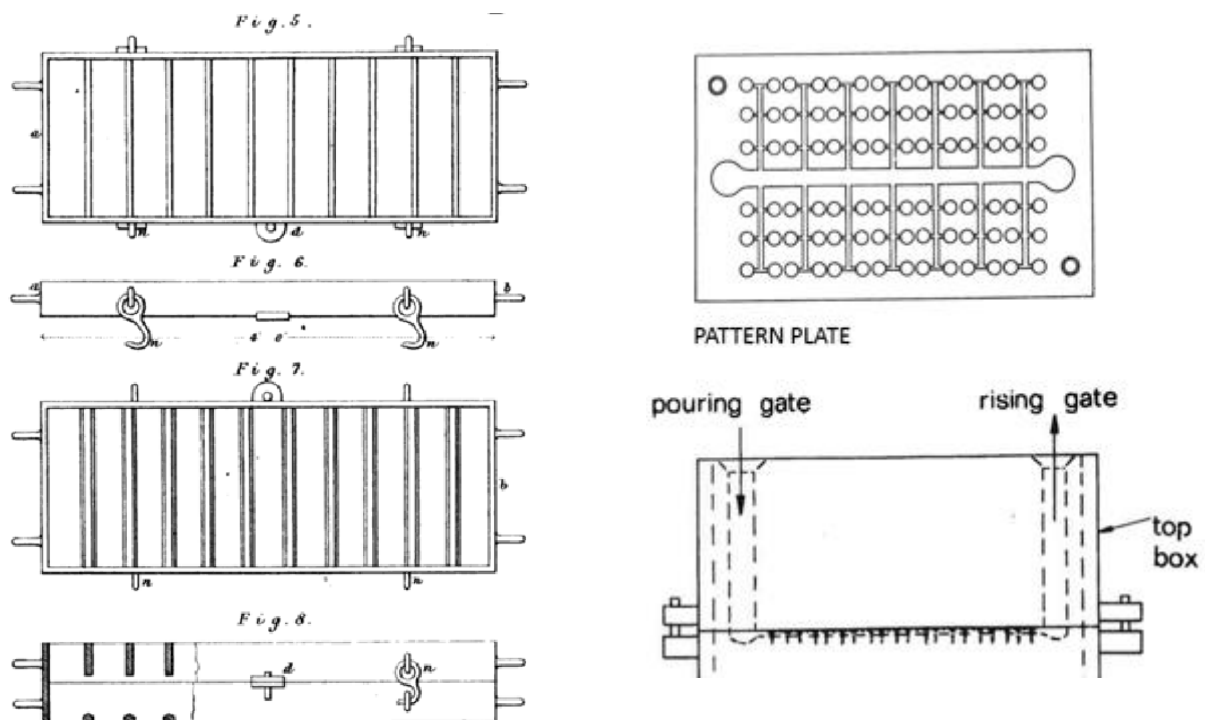


Fig. 88. Casting boxes, left, by Spretson, 1878, and Moseley's simplified concept, 1968, right.

Compared to wrought nails, which had to pass through pig-iron, finery or puddling, rolling, and then slitting, before any work can be carried out by forging, there was a big economic advantage in using the more direct method of cast metal to finished nails in one process. The corresponding disadvantage

⁵¹⁵ SPRETSON 1878, 171-174

lay in the relatively small number which could be made from one pour due to top mould size limitations, and to the annealing process done in sealed ovens.

Moseley shows that one mould could produce 84 lath nails in one pour.⁵¹⁶ In 1968 he was able to talk directly to men involved with the process up to World War II, at the firm of John Maddocks & Co at Oakengates, Salop, fig. 89. Their recollections indicate little change to the process of 1769.

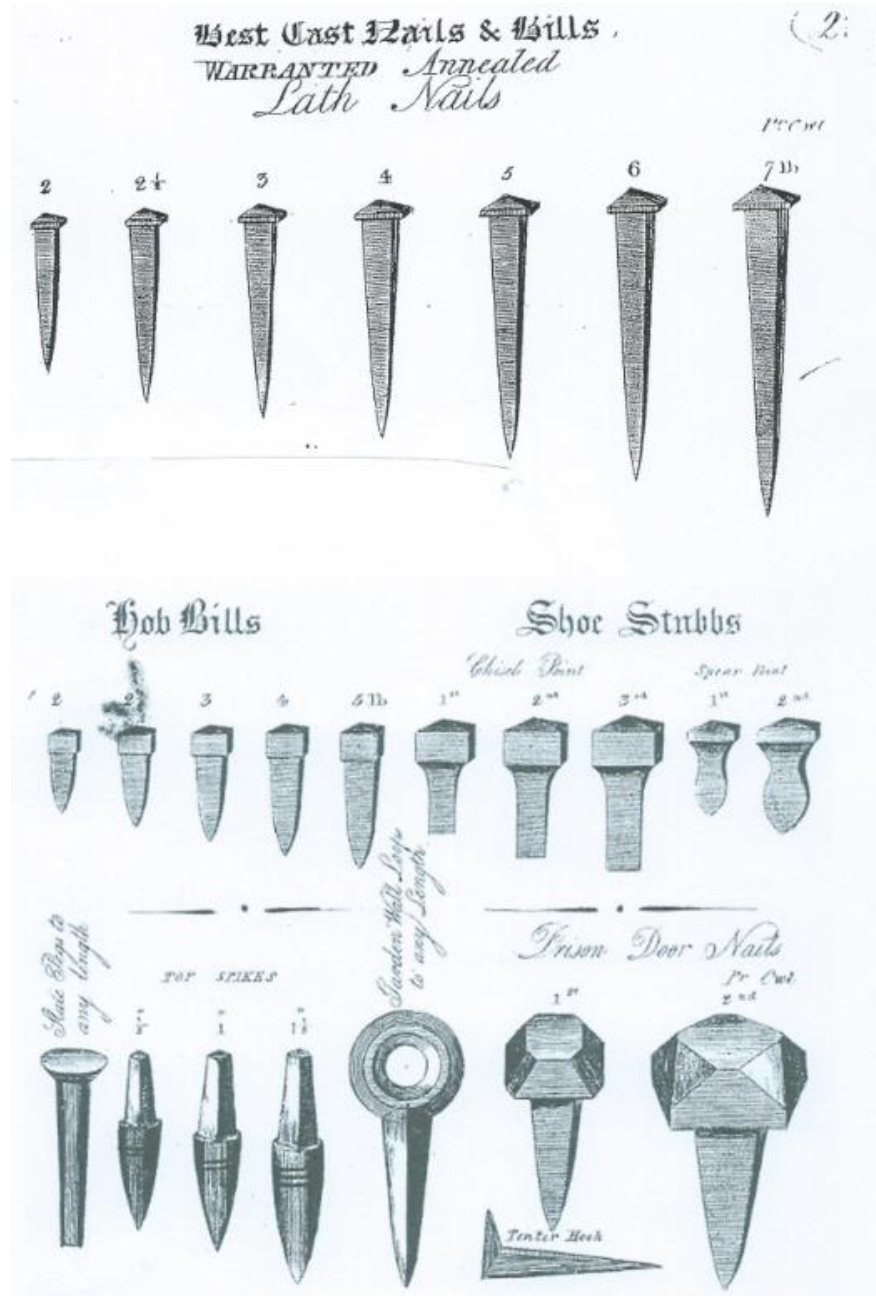


Fig. 89. A page from H. Barnes & Sons, Birmingham, catalogue, circa 1825. Courtesy Ian Stapleton.

Cast nails in bronze or brass form part of the long history of man but being expensive materials they do not figure largely in the history of building construction which makes the advent of annealing so important to nail history.

⁵¹⁶ MOSELEY 1968, 32

4.3.3 Alternative castings (iron)

The detailed and laborious process explained above of using top and bottom moulds with feed channels could be short cut in some circumstances by having only a bottom box into which the full outline of the nail to be cast pressed into the sand medium, fig, 90.



Fig. 90. A 'shank-down' crude door nail. Date and origin unknown. Author

The perimeter outline of the head can be controlled with careful pouring of the molten iron, fig. 90, but the top surface is essentially uncontrolled as can be seen in the nail **N 43-2** listing.

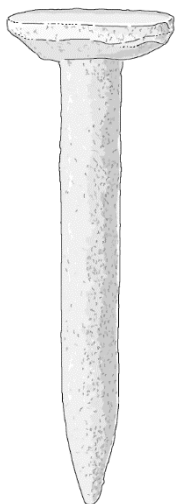
An alternative method is to forge a simple shank with a minimal head and suspend this upside-down such that the molten iron can flow around the suspended end to form a relatively accurate head. An advantage of the method is that a longer length of shank can be provided which is capable of clenching – a desirable quality for a door nail, fig. 91. Refer to nail **N 43-1** listing.



Fig. 91. A cast faceted head with a forged shank, shown in its casting position. Author.

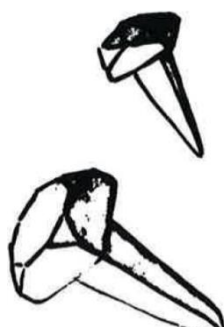
Nail Ref	N 38	Cast lath nail		
Alternate Names				
First Appearance		Last Appearance:		Size mm
Exemplar grade			Date	Material
Zone: Roof Ext	Roof Internal	WALLS	Floor	Linings
Literary Reference: MOSELEY 1968, 31-36				
Identifying Features:				
Images:				
				
Westminster 1780 & 1784, & an 1825 sample from Oakham, Leics.		SYDNEY c1835. From the collection of Ian Stapleton		
				
UNUSED. From collection of Mr R. Jones, Caerphilly.		St Aldates, Oxford, c1840		
Photos; Author			Sketches – Author/McCaig	
Notes:				
These have been found in upper New York State, USA, Newfoundland, to several location in Sydney, Australia. The St Aldate’s types have shown up in various locations in UK.				
The smallest, ‘fine’ samples of 1780 do not repeat at any other later location.				
Continuity/Transitions:			KEY:	
These nails were undercut in price by cut lath tacks which start to appear in numbers in 1830 or so.			R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 39	Cast door nails		
Alternate Names	Cell door cast nails and hobs			
First Appearance	Circa 1780	Last Appearance:		Size mm
Exemplar grade	Pre WWII		Date	Material
Zone: Roof Ext	Roof Internal	DOORS	Floor	Linings
Literary Reference: MOSELEY 1968, 31-36				
Identifying Features: These can be identified in most cases by a bulge left from the sprue of entry point of the molten metal. Nails are rarely 'fine-fettled', which is reserved for artistic castings.				
Images:		Maddocks & Co Ltd, Salop, cast nails. 1939. (After Moseley 1968,  This class is known as 'hobs'. The same term is used for nails in workers' and soldiers' boots; - last nail shown in above sketch. In the Victorian era cast door nails were widely adopted in church 'restoration', left.		
 				
Photos; Author		Sketches – Moseley 1968		
Notes: Moseley noted in 1968 how fortunate he was to find the Maddocks company still operating but no longer making cast iron nails. His enquiries show all of the exemplars in that Company's bins were from before WWII. Remarkably the 'dice-head' door nails were still made in the two sizes adopted in medieval times – items 2 & 3 above.				
Continuity/Transitions: These nails are no longer in fashion.		KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 40	Cast tile pegs			
Alternate Names	Tile pegs				
First Appearance			Last Appearance:		Sizes mostly 48 mm
Exemplar grade				Date	Material
Zone: Roof Ext *	Roof Internal			Floor	Linings
Literary Reference: FIELDER 1879,441. The author is obliged to Roger Champion, former head carpenter at the Weald & Downland Museum for samples, explanations, and the terms used.					
Identifying Features: Exceptionally coarse finish and these are tough but brittle. Large numbers collected by W&D museum, Singleton, and many found of various lengths at Manor Farm Haddenham, Buckinghamshire. UK					
.					
Images: Sizes recovered from Manor Farm, Haddenham were 35,42,48,57, and 71mm long.					
 					
Photos; Author				Sketches – Author/McCaig	
Notes: These are only driven into timber where the position of the clay tile sites directly over a rafter. Otherwise the shank is loose and sits above the batten.					
Continuity/Transitions: Tiles are now fitted by driven clout nails and are made with smaller holes for the nailing.				KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 41	BRASS LOCK NAIL		
Alternate Names	FINGER PLATE NAIL			
First Appearance	Stuart? 1610	Last Appearance: 1760-1790		Size 25 - 50mm
Exemplar grade	-		Date	Material
Zone: Roof Ext	Roof Internal	DOORS	Floor	Linings
Literary Reference: NIL				
Identifying Features: This is an example of a cast shank-down nail. In this case there are 4 fluted sides on a conical form. The centre of the head is depressed due to shrinkage in volume of the brass as it cools				
Images:				
				
Photos; Author			Sketches -	
Notes:				
These pre-date the use of brass screws to fix locks and brass finger plates to doors.				
Continuity/Transitions:			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

Nail Ref	N 42	CATENARY HOOK			
Alternate Names	Line hook				
First Appearance	Circa 1880		Last Appearance: Pre-WWII		Size 61mm
Exemplar grade				Date	Material Cast iron
Zone: Roof Ext	Roof Internal			Floor	Linings
Literary Reference: None found.					
Identifying Features: Cast with indentations such that it can be driven into masonry joints. It holds the end of the supporting catenary cable from which either telephone or electricity cables were suspended.					
Images: Sample from central Adelaide – courtesy heritage architect Luigi Vitale.					
					
Photos; Author				Sketches – None found	
Notes: The type was used for both telephone and electricity supply in Australia; telephone circa 1878 & electricity 1887.					
Continuity/Transitions: Alternative fixings used post WWII.			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage		

Nail Ref	N 43	CAST DOOR STUDS		
Alternate Names				
First Appearance	Roman	Last Appearance: c WWII		Sizes vary
Exemplar grade			Date	Material
Zone: Roof Ext	Roof Internal	DOORS	Floor	Linings
Literary Reference: MOSELEY 1968,				
Identifying Features: Significant variation in clues and three variation of casting are used. Main clues are the sprue and the rough finish due to the casting medium.				
Images: 1  2  3  4  5   				
Photos; Author			Sketches - Moseley	
Notes: 1. Door nail with faceted head. Reverse cast - suspended wrought iron headed shank. 2. Open faced casting (shank down) integral cast iron. 3. Cast door stud, c1885 house, 3 Liebig Street, Warrnambool, Victoria. 4. Naish collection Salisbury, usual form of prison door studs. 5. Chilham Church door stud, Kent. UK. Victorian renovation era c 1875				
Continuity/Transitions: Casting is no longer economic for nail production			KEY: R – Roman IR – Iron rod M – Medieval RR – rolled round T – Tudor FS – Flat strip Nsh – Naish collection Salisbury W&D – Weald & Downland Museum W H – Woolmers House WCt – Woolmers Cottage	

4.3.4 Summary of Part Two Findings

1. Iron cast lath nails had only a brief economic advantage over wrought nails during the period 1770 to 1820-25, but they had an effect in centralising parts of the industry in this niche area of production. It is clear from the paucity of finds after 1830 or so that cut lath tacks made rapid inroads into this select section of the industry, which coincidentally happened to be one of the largest in terms of numbers of nails required following the shift in architectural styles resulting from the 1670 Act. None have been found in Australia after 1845.
2. The slow die-off to this type of lath nail, circa 1845, can be attributed to the relatively large capital outlay sustaining production until a point of no economic return became evident.
3. The problems of telling wrought from cast church and prison door nails can only be resolved by removal of the nail and thoroughly cleaning it. This makes the in-situ detection of changes impractical.
4. The presence of catenary nails is always ambiguous from a dating aspect, since the majority of them would have been retrofitted.
5. Other cast nails or studs can only be relied on for a threshold date of circa 1770.

Part Three: Cut nails

The cutting machines are different sizes with different motions. The larger machine is fed by hand and can give 1,400 strokes in a minute. The machine for heading is not used since the first experiments, as it is found heading is done much better by hand than by any machine as yet invented, both as to the time and goodness of execution.

Pastor Wilson Bentley, 1810, regarding the Salem Iron Foundry.

TABLE 4.5 BASIC APPEARANCE PATTERN OF CUT NAILS

Date	1500	1550	1600	1650	1700	1750	1800	1850	1900
Sprigs				----	----	----	----	----	----
Brads-Lining					By Hand			----	----
Brads-Floor								----	----
Cut Clasp								----	----
Cut Commons								----	----

4.4 OVERVIEW - CUT NAILS

It is not possible to discuss the topic of cut nails without first examining the American claim to this invention, which to them has become a national icon and tribute to their own ingenuity. This is not entirely unjustified. However, as implied by the bon-mot above, to untangle fact from fiction has been a laborious process which has been dealt with in a series of papers.⁵¹⁷

The differences and the ramifications of American reticence to change affecting their cut nail development, related to entrenched commercial interests acting as a break on the former colonies' progress. The way the history of cut nails developed will be briefly described. It needs to be understood that in 1790 patents using the principle of cut nails were lodged on both sides of the Atlantic, but that nails manually cut from iron sheet were already being used. The Romans had used cut copper strip to create tacks for nailing lead sheet and some samples display part of the shear faces.⁵¹⁸

There was a huge demand for cheap effective nails in America, suitable for softwoods. Particularly so as development of the country spread westwards, such that the inferior early nail products sufficed in the softwood timbers. Britain was still tied to the use of hardwoods where available, though by Stuart times prestige buildings were using superior imported softwood timbers from the eastern seaboard American colonies. These facts, centred on matching nails to timber type, set up the direction each country would take in its nail development.

4.4.1 Recognition features

All cut nails are identified by the cutting process which leaves behind distinctive shear burrs on the down-cut side of the cutting blade. Minute irregularities from the blade show on the sides of the cut faces as tiny grooves and roughness. They come as a result of the necessary frequent sharpening of the blade and the marks may be square to the top (down-cut) surfaces, or they may take the form of very flat arcs. There is usually a small accompanying distortion of the shank due to the high pressure placed on the cutting blade and the tendency for the cut piece to lift off the bed as blade pressure transfers along the length of the shank.

⁵¹⁷ HOW 2003, 74-86; HOW 2006, 231-238; HOW 2015, electronic record; HOW 2017, un-numbered.

⁵¹⁸ COPELAND 2006, 3

British cut nails fall into three basic categories:

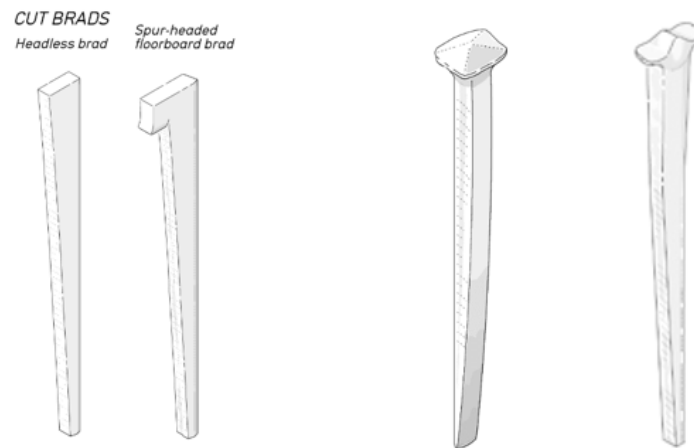


Fig. 92. Plain and spur-head brad, profiled cut nail & side-pressed cut clasp nail.⁵¹⁹

- A simple outline cut from flat iron ribbon, the best-known being spur-head floor or joiners brads, fig. 92, which were displayed in the Royal Engineer's tender document referred to in 4.2.3 above.
- Those formed with parallel cuts from a previously profiled ribbon which had been rolled to a cross section shape akin to an aircraft wing section.
- Simple triangles cut from flat ribbon, which at first were turned over between each cut, and then side pressed to raise a bulge at the head ends. These are then headed under pressure. The best-known example of this type is the cut form of the British clasp nail.

In addition to these forms there are the simple triangular shank cut nails given a flat head, following the American development of this type, which are faced pressed. Very often these machines were either purchased from the Americans or had undergone some joint development by American inventors who had perforce relocated to Britain to take advantage of the superior British technology. All four types are found in Australia and in New Zealand, and there are subtle differences in the dark blue-grey colour of those nails produced in Britain and the later lighter 'Royal blue' coloured cut nails imported from America. With samples in good condition the finishing colour provides a clue to the cut nail origins.

4.4.2 Floor brads and joiners brads

Although these appear to be essentially the same excepting their sizes and scale, it is possible that they started from two points of origin with respect to manufacturing technique. It is pertinent to remind the reader that the advent of steam power in the 1730s saw further development of punching metal sheet for buttons, combs, etc. The technique was successfully applied to the manufacture of buckles and silverware, known as the 'toy' trade, during the period 1712 to 1779.⁵²⁰

⁵¹⁹ WOOD & HENRY 2013, 605-614

⁵²⁰ BERG 1994, 232. Buttons were pressed from metal sheet as early as 1712.

4.4.3 British versus US cut nails

The diverse directions taken by each stem from the technical lead held by the British at that time, in the rolling of iron for tin-plate. This had been in development since 1679⁵²¹ and was developed at Pontypool works in South Wales, eventuating in a patent for rolling which was granted in 1728. It was facilitated by the early application in Britain of steam power to drive machinery, fig. 93.

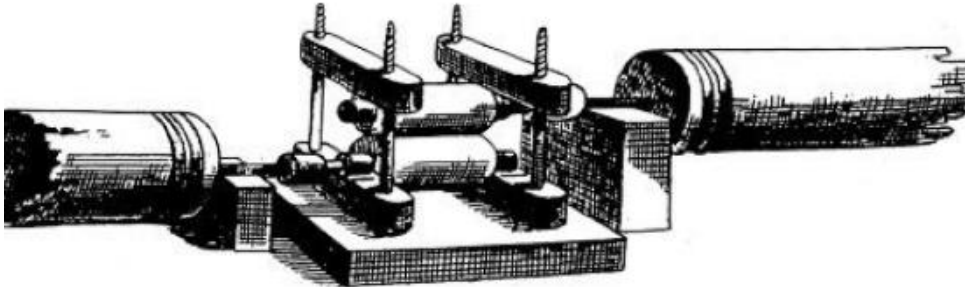


Fig. 93. Hanbury and Payne's 1728 patent rollers sketched by Angerstein in 1765.

The scene shown at Horsley Forge nicely demonstrates the advances made in Britain by the 1790s, fig. 94. Rolled strip nearly 1 metre wide is shown being rolled at the end of the picture; extreme left.

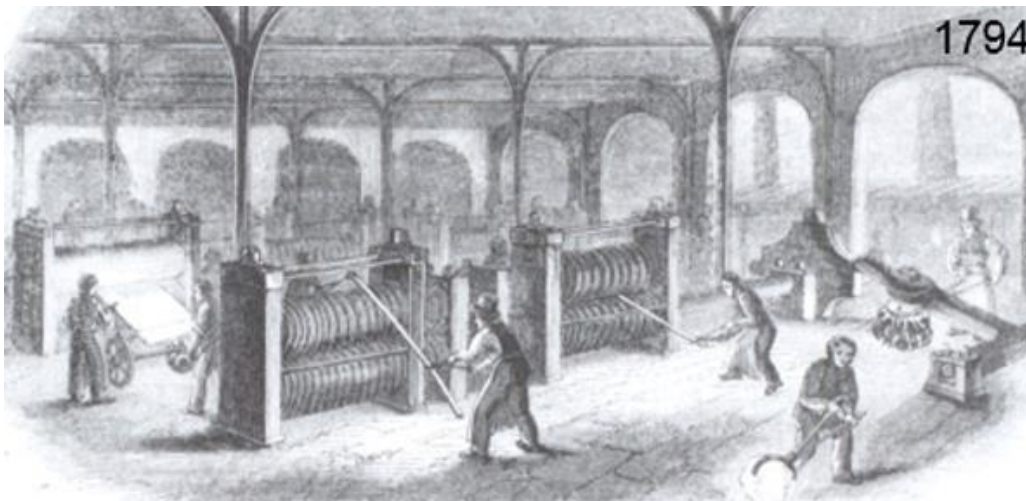


Fig. 94. Rolling of sheet iron and rod at Horsley Forge Birmingham, in 1794.⁵²²

Rolling 'iron' – which is actually a mixture of iron (Fe) and silica, - sets up a grain in the sheet perpendicularly aligned to the rolling direction. This was understood by the American inventors but their industry used narrow rollers worked by water power;⁵²³ a situation which existed until 1828. Their industry was substantially tied to the iron masters of Massachusetts and other New England states, who controlled their own villages and their often extensive infrastructure, in the manner of feudal lords.⁵²⁴

⁵²¹ By Hanbury's agent Thomas Cooke, American Gardens website

⁵²² HAYMAN 2005, 55

⁵²³ Fig. 110 which follows is adapted from EDWARDS & WELLS 1993, 11

⁵²⁴ SMITHSONIAN MUSEUM

4.4.4 Roller technology

The curious ambivalent relationship between Britain and the newly formed USA has been described in 3.6 above, and the large areas covered by the thirteen former British colonies had the effect of widely dispersing the iron industry. It is easiest to understand the dynamics driving the separate development of the British and the Americans if the simpler American situation is dealt with first.

At the time of separation there was no steam power available in North America and so the American mills continued to rely on water power for rolling sheet iron. Because of the limited power output of their water wheels, rolling was done by narrow rollers. As has been shown above, production of iron ribbon could also be effected by hammering,⁵²⁵ a process adopted by many American mills, sometimes alone, and sometimes in connection with water powered narrow rollers.

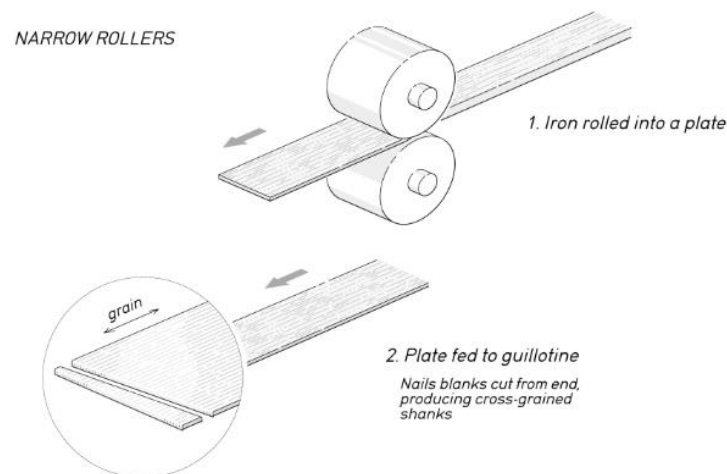


Fig. 95. Narrow roller limitations. Author/McCaig

As a result, lengths of ribbon produced by narrow rollers display a longitudinal grain, fig. 95. Transverse cut shanks thereby suffer incipient shear weakness, fig. 96, which is evident in early American nail samples:⁵²⁶

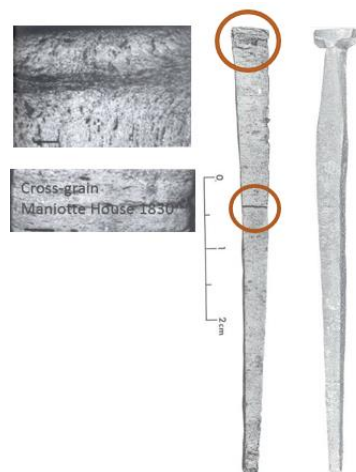


Fig. 96. Maniotte House 1830 and 1818-34, Jackson Barracks. Edwards & Wells.

⁵²⁵ EDWARDS & WELLS 1993, 9-14 & 19

⁵²⁶ RYZEWSKI & GORDON, 54-55; EDWARDS & WELLS 1993,

In addition to this drawback, there was a hardening of the outer layers due to the chill factor from the rollers affecting crystallisation, and a distinct lack of compression attributable to the lesser developed rolling technology, fig. 97.⁵²⁷

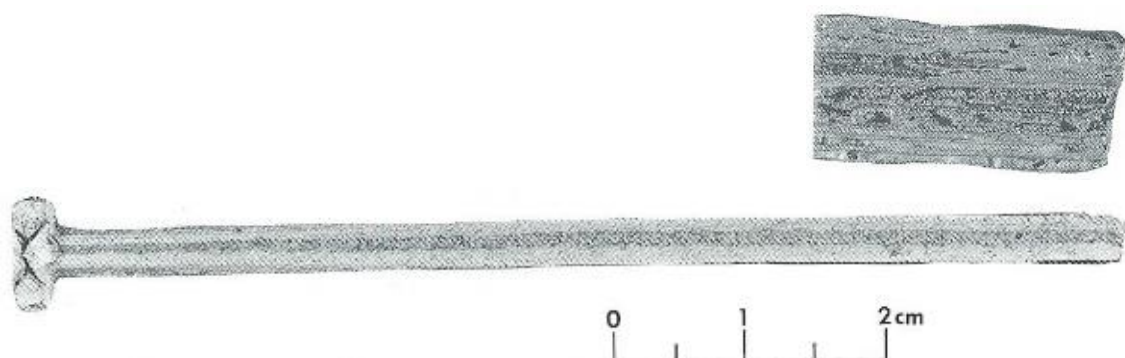


Fig. 97. Dense outer laminates in a Louisiana nail, circa 1836.⁵²⁸

The effect of layering within the iron sheet was not unique to America, and even with the steam powered rollers British cut nails show signs of delamination at the tip. The phenomenon, however, had serious consequences for the American nail head design, effected by side clamps moving together to form a 'waist' effect below the head. (See side-pressing in fig. 98). This caused some crumpling (or concertina action) immediately below the head. As a consequence, American cut nail quickly gained a reputation in Australia for unreliability, since they were being used in extra hard eucalypt timbers. Indeed, it became a sales pitch in adverts for Ewbank nails in Australia – "the heads will not fly off".⁵²⁹ The disastrous effect on sales of American nails was recorded by the Boston trader based in Melbourne, the American George Frances Train.⁵³⁰

Our American cut nails are no good for the wood of this country, for it is of so close a grain they break in being driven. Britain supplies a much better article. Ewbank's pressed nail is much used and well liked.

4.4.5 America's separate path

It is to the Americans' credit that they persevered with developing their cut nail technology and by changing to clamp the face and rear prior to heading they overcame most of the weaknesses of head separation. They arrived at a particularly elegant and aesthetically appealing cut nail, but shank breakages in the tough Australian timbers were never entirely resolved, fig. 99.

⁵²⁷ EDWARDS & WELLS 1993, 57

⁵²⁸ Ibid.

⁵²⁹ BUILDER 1845, 458 quoted by LEWIS 8.06.16

⁵³⁰ DANIEL & POTTS 1970, 25

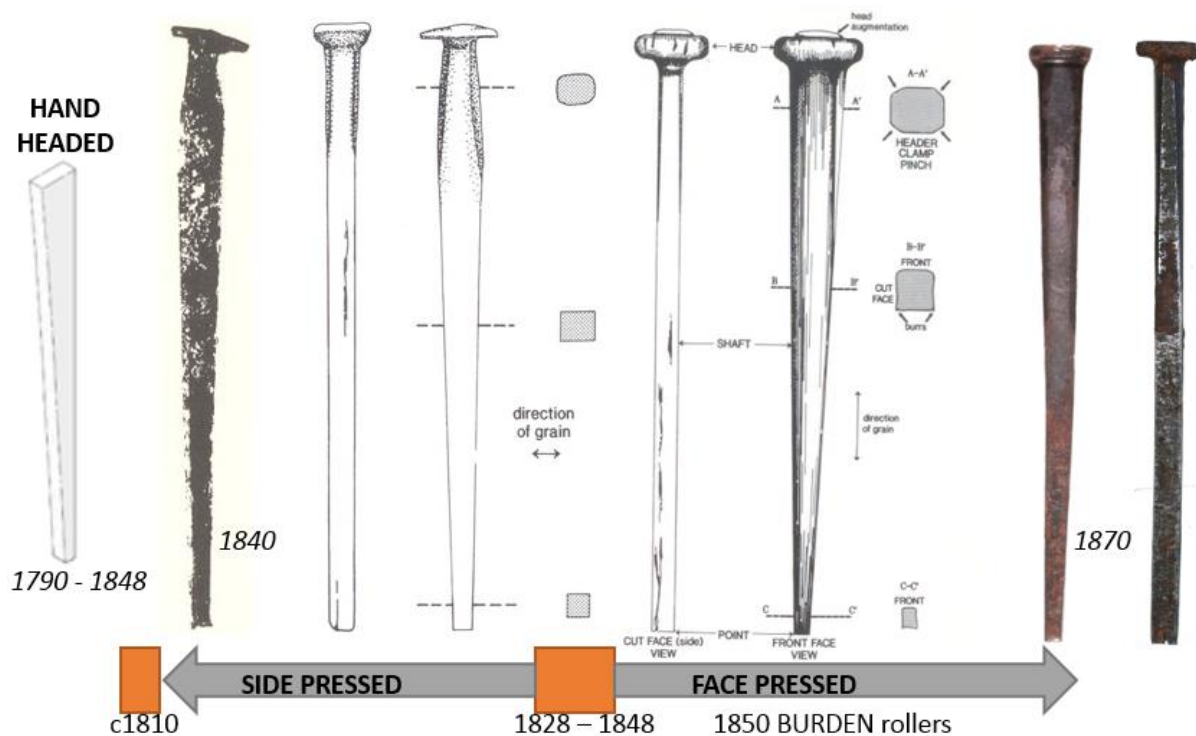


Fig. 98. The basic progression of American cut nails based on Edwards & Wells and Loveday.

The Scottish migrant to America, Henry Burden in 1840⁵³¹ patented his 'concentric rotary squeezer', which accelerated throughput from billet to finery stages. This was intended to lay the grain of the final billet of iron in a transverse direction prior to it being rolled into sheet. This would supposedly overcome the problems associated with narrow rolling. In Australia the smaller range of American cut nails start to show up in houses around 1855 but in nearly all cases they are found in imported American softwoods and can be extracted intact.⁵³² By 1870 larger framing nails appear in both imported softwoods and in indigenous eucalypt timbers. These larger nails show an above average proportion of fractures during removal, fig. 99.



Fig. 99. Lamination 'greenstick' fractures of 1884 American cut nails. Author

The history of cut nails needs to be seen in the context of an Anglo-American set of developments in which each side of the Atlantic viewed with interest the advantages and pitfalls of the other. The American Republic drew ideas and inspiration from the mother country and it was fed a flow of migrants with essential know-how, who stood a better chance of advancement in the New World. At the same time American vested interests amongst the ironmasters kept essential advantages back,

⁵³¹ LOVEDAY 1983, 20. See also HOW 2009, 79-81

⁵³² Australia was deficient in native softwoods, unlike New Zealand.

such that at least three noted American inventors sought out the higher technological available in Britain, all dying in the 'Old Country'.⁵³³ Others, Like Slocum, would reside in England for two or three years in order to absorb the latest technology.⁵³⁴ There was also a call for the latest technology to be sent out in the form of experts from Britain itself, as happened with Jonathan Lucas' rice mill.⁵³⁵ In addition to this counter flow of invention, America had, by 1814, sold some cut nail machines to Britain.⁵³⁶

The 'invention' of cut nails has unfortunately long dwelt in the realm of national pride and contesting claims. Vernacular medieval nails were probably cut from a flattened iron strip whilst still hot using a bolster, and so they were in essence, 'cut'. However, it was the Americans who took the initiative and risk of producing a range of similar simple nails capable of being used in softwoods. It took great perseverance and some inventiveness to arrive at substantial mechanisation of nail production. In the end they created their own specialisations from the basic simple sliver shapes of the original nails. This range of nails, albeit not entirely complete since certain nails such as those intended to be clenched were still wrought, they thereby broke the long tradition of wrought nail names, fig. 100. This shows that some old terms were retained while other new names were introduced.



Fig. 100. The range of cut nails made by Tremont, Massachusetts, circa 2004.

This departure, which served well for use in softwoods was readily accepted by Canada, and it has already been shown in sections 3.6.2 and 3.6.3, that a cross-flow of ideas and inventions from British Canada attracted its own sub-culture and inventors. By the same token, New Zealand in the 1850s, well before Australia, accepted American cut nails for use with its many fine softwood timbers.⁵³⁷

⁵³³ James Cordes, Dyer, and Perkins.

⁵³⁴ HOW 2009b, 832

⁵³⁵ Ibid. page 831

⁵³⁶ HOW 2009, 74-88

⁵³⁷ ISAACS 2009, 83-101

4.4.6 British cut nails

As seen above, fig. 92, Britain committed to a different set of objectives and to a separate path determined by the factors already discussed in Chapter 3; 3.1.3 – 3.3.3. This in turn dictated three potential courses of action:

- Purchase, adapt, and improve American nail making machines
- Develop existing metal stamping technology for simple flat-sided brad production
- Design machine made nail facsimiles of the types in wide use

In each case it was of paramount importance to arrive at nails which would be suitable for use in hardwoods. Britain was in a position to resolve the cross-grain problem simply by cutting strips from off the ends of wide sheet. (This fact had already been realised by American inventors such as Perkins and his agent/inventor, Dyer, prior to 1800, but the will and wherewithal in America was lacking).

The nail shanks if cut with the grain laid along the shank made the nail much stronger. By 1820 the necessary technology was already commonplace in Britain, by virtue of steam power and of concentrated industry, fig 101:

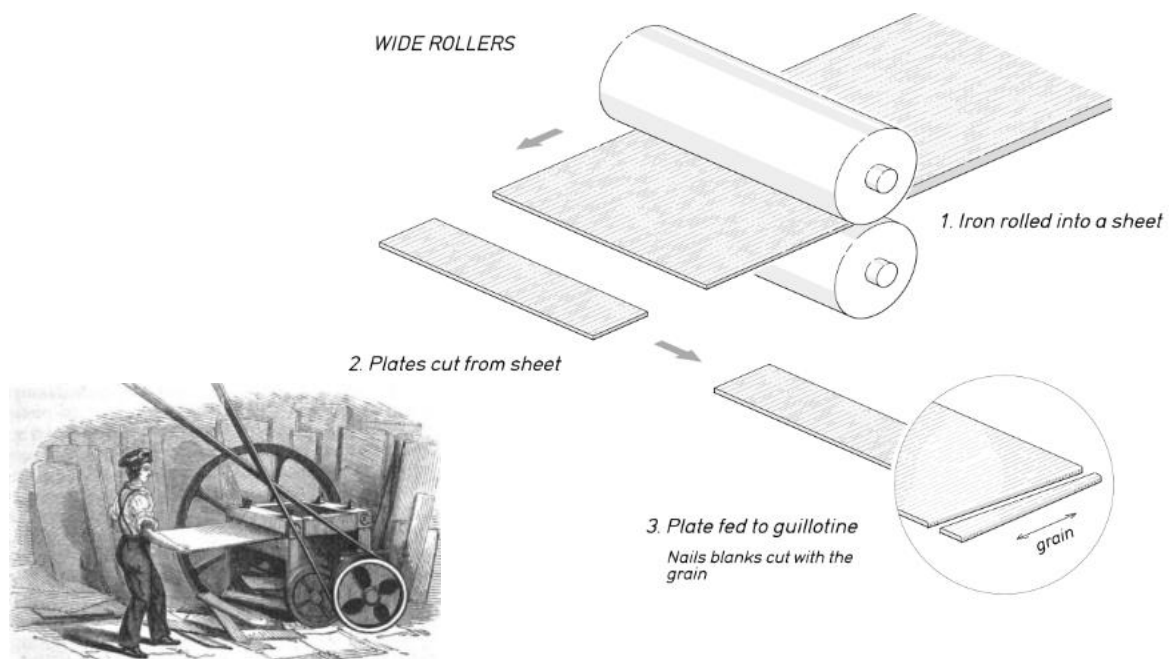


Fig. 101. Cut strip from wide rollers with transverse grain.⁵³⁸ Author/McCaig

4.4.7 Adapted American machine manufacture

The thesis study, which relies on identifying changes, found cut nail samples from the 1850s in Australia of nails which mimicked the American pattern and were face pressed, but which had a higher internal integrity and robustness not evident in the American nails of that time or later. The nails, obtained in several samples,⁵³⁹ were exceptionally stiff and resistant to bending, - a phenomenon almost certainly due to the iron being cut longitudinal to the grain. The features found, and the peculiar circumstances surrounding the finds suggest British, as opposed to American, manufacture for these particular nails, fig. 102, nails 1 & 2. Another candidate of probable British manufacture,

⁵³⁸ TOMLINSON 1852, 45 inserted image

⁵³⁹ From the Christ Church Rectory roof (of 1854) with other more slender versions in an 1866 extension. They were found still embedded in abandoned messmate shingles in the roof space in both cases. The roof rafters were also messmate hardwood. Similar examples have been recovered from elsewhere but in worse condition.

which was a lining nail having an unusual inverted pyramid head, was found in several locations in a pair of Port Fairy cottages built in 1858,⁵⁴⁰ fig. 102, nail 4.



Fig. 102. Cut shingle brads and a lining nail found in Victoria of probable British manufacture. Author

4.4.8 Plain sided brads

Both headless and spur headed brads were recovered in numbers from a house in Newcomen Street, Dartmouth, in Devon dating from 1806, fig, 103.



Fig. 103. Headless and spur-headed cut floor brads, 1806, Dartmouth, and joiners' brads, circa 1825.

Ultimate tensile strength tests undertaken during the study (refer Table 3.3 above) have showed no significant difference between the tensile strengths of British and American nail iron. It needs to be borne in mind that both Britain and America were big buyers of foreign iron for these minor objects. (Refer 3.3.3 above and fig. 54), so this result should not be surprising. However, the British had to contend with the continued use of hardwood species at home and in colonies such as Australia, India, and areas of Africa. Paradoxically, their main sales item was the cut form of clasp nail which retained side clamping as a precursor to heading. The development of the British cut clasp nail has already been covered by the author.⁵⁴¹ The dating potential of this type as it developed has also been published by English Heritage in their *Practical Conservation Series – Roofing* as an appendix by the author.⁵⁴² A summary of this development will now follow:

⁵⁴⁰ In Princes Street, Port Fairy, located not far from the wharf. At this time Port Fairy was receiving immigrant boats directly from Britain. HOW 2006, 32-39.

⁵⁴¹ HOW 2014, 231-238

⁵⁴² WOOD & HENRY 2016, 605-614

4.4.9 Cut commons and tacks

These follow from the first attempt by the Americans toward cut nails and they too adopt side clamping, - that is the clamps applied prior to heading are perpendicular to the cut faces, fig. 104:



Fig. 104. British cut nails circa 1816 -1845 showing 'waists' due to side clamping below the heads. Author

It seems possible that the American émigrés in Britain, as well as British purchasers of the early American machines of around 1814, were influenced by the exigencies of the on-going Napoleonic wars, to concentrate efforts on commons and simple tacks for boxes⁵⁴³ The Boston émigré Joseph Dyer (1781-1871) had by then been based in Birmingham since 1810. With the assistance of another American émigré, London banker, Samuel Williams, he purchased the former Britannia Brewery to convert it to a nail works,⁵⁴⁴ retaining the same name for his works. He was persuaded to purchase the Brewery site by virtue of its ready access to the Birmingham-Fazeley canal. (See section 3.3.2 above). Taking advantage of the available technical advances available in Britain, Dyer equipped the works with a Boulton and Watts 32 horsepower steam engine,⁵⁴⁵ slicing machines,⁵⁴⁶ and gas lighting.⁵⁴⁷ His patent document shows simple tacks in two grades next to a plan of the machine plan,⁵⁴⁸ fig. 105.

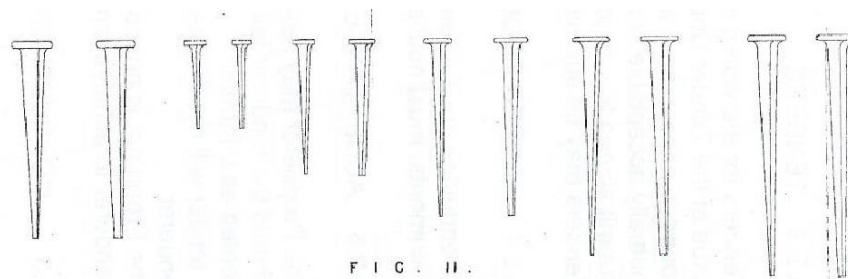


Fig. 105. Cut nails shown on Dyer's British patent of 1810. Sizes vary from 51mm to 107mm. (Note the diamond cross-section effect as seen in nail 2, fig 112 above).

Sjogren attributes Dyer with a founding role in the British cut nail industry which he is confident started just prior to 1814. This however ignores the fact that cut floor brads and cut joiners' brads both showed in the Board of Ordnance tender of 1812 for the Royal Engineers' garrison at Halifax, -

⁵⁴³ The same thing had happened in Paris prior to Napoleon's march on Moscow. HOW 2018, 345-356.

⁵⁴⁴ SJOGREN 2019, 4. The original document uses the word "slitting" but inspection shows they are guillotines.

⁵⁴⁵ Ibid, 113

⁵⁴⁶ Ibid, 117. (Since the nails were cut from iron plate the machines so described were actually cutters akin to guillotines and were used to produce the nail strip; see Fig. 116 above & TOMLINSON 1852, 45 for illustrations.

⁵⁴⁷ Ibid, 117-118

⁵⁴⁸ British patent number 3365, enrolled July 1810

which was probably prepared in London in 1811.⁵⁴⁹ We need examine therefore the facts leading to the first patents.

4.4.10 Precursor cut nails

In Europe, Britain, and North America, cut nails are most likely to have started as simple headless glazing sprigs, cut cold from thin sheet as mentioned in a document of 1692: *naylls to sett the glas in the wood windos*.⁵⁵⁰ As already noted the Romans appear to be the first to have used metal cut nails for ships' hulls and partly prepared sheared shanks have been found at the Portus shipyard.⁵⁵¹

In 1790, Thomas Clifford of Bristol registered two patents as "Machinery for the Manufacture of Nails".⁵⁵² The first relied on pressing heated nail rod into shape; the force being applied either by shaped rollers or, more significantly, by pressure dies. In the second patent Clifford introduced the concept of using pre-profiled iron strips. The first patent involved a stamping out process, similar to buckle production, and nails were thereby pressed out of thin sheet iron into a hollow bed. The significance here is that punching shear was adopted, cutting into an under-well below. This anticipated the rising bed technique used later in producing floor brads. The stamping technique had been in use for cutting buttons and buckles from around 1728 in Birmingham.⁵⁵³ By 1792, French's factory at Winebourn, Staffordshire, was making nails by both of these processes. Cut lining brads were noted to have been in production in 1803,⁵⁵⁴ and they have appeared in Wells and the Welsh Marches from c.1800. Plain sided brads were advertised in the Sydney Gazette of 1809⁵⁵⁵ and cut brads had featured in the Royal Engineers' tender document of 1812 in four sizes: 1¼ inch to ½ inch (31mm to 12mm), fig. 117. By 1895 the British cut nail trade was producing around 18000 tons from Birmingham alone, which were chiefly exported to Australia, India, and other colonies.⁵⁵⁶

4.4.11 Cut common nails

Like Dyer's cut nails, cut commons would have seemed to be the most in demand across Britain, and also for the various colonies. They would have comprised a major sales expectation from manufacturers. In 1808 the clear sighted Dyer and his sometime associate Perkins had seen that concentration of the workplace into factories was not only a better commercial proposition but provided a better outcome for the workers. Sjogren shows how they had been anticipated in this regard by the Quaker and humanitarian, Finch⁵⁵⁷ who had received his patent, "for the making of nails and spikes by machinery" only eleven days after that granted to Thomas Clifford.⁵⁵⁸ Sjogren shows how Finch had examined the need for a factory system in some detail and found it had commercial benefits as well as providing a more reliable wage and healthy environment that the putting-out system lacked in supervision and quality control.⁵⁵⁹

⁵⁴⁹ BUGGEY 1976, 112 & 116

⁵⁵⁰ LEVENS HALL 1692 -95 accounts book. See also HOW 2014, 238: note 10.

⁵⁵¹ COPELAND 2006: <https://www.futurelearn.com/courses/portus/0/steps/10964>

⁵⁵² Patent no. 1762, 31 July 1790 & patent no. 1785, 30 December 1790. British Patent Office.

⁵⁵³ MASON 2009, Introduction by R. McLean.

⁵⁵⁴ REES 1817, sv Nails.

⁵⁵⁵ VARMAN 1993, 178

⁵⁵⁶ AITKEN 1895, 42

⁵⁵⁷ SJOGREN 2018, unpublished PhD note, page 1.

⁵⁵⁸ Ibid.

⁵⁵⁹ SJOGREN 2019, 69 & 71-76

This study has been able to demonstrate that there were early examples of British cut nails in the commons range 62-77mm long which parody a wrought common, fig. 106:⁵⁶⁰



Fig. 106. Types of British cut commons. Author

The study also finds that these are few in comparison to the widely used, and sometimes particularly ugly, British cut clasp nail, which displays a timeline of its own.⁵⁶¹

As seen in fig. 106, there is an incipient move towards 'wings' caused by the unequal head pressing stemming from the side clamping dynamics. It is impossible to say, at this juncture, if this was accidental in the machine settings or if perhaps it is a natural outcome of trying to press a lop-sided element. This is because the side clamps displace volume from off the linear vertical axis.

4.4.12 The British cut clasp nail development

The first step away from ovoid domed heads, fig. 106, was to an asymmetrical head which, from above, shows only three facets, the fourth a mere blip at the rear as the face is forced into a significant swelling. This type appears c.1835, fig. 107, but quickly disappears and none have been found after 1845–1850. At this stage there was no apparent attempt to develop clasp "wings", and lateral projections seem to relate to attempted faceting of the domed heads.

⁵⁶⁰ HOW 2014, 231-238

⁵⁶¹ HOW 2014, : HOW 2017



Fig. 107. British cut nails, Side and front view, 1835. Both have a slight twist due to separation from the guillotine blade and display the eccentric swelling of the nail neck. Author

By 1850 or so, the head eccentricity problems seem to have been fully resolved and the die shape changed to two convex facets that left two clear concave indents on either side of the nail centre. This created the high crown, as previously seen above on the wrought version of the clasp nail (fig. 104, nail 1). It also deflected outwards two pressings of decreasing thickness to form reasonable facsimiles of the wrought clasp nail 'wings', fig. 108.



Fig. 108. Cut clasp nail circa 1855 showing the development of the clasp 'wings'. Author

This is explained by the production sequence shown in fig. 109. Following the original American solution, side clamping is employed which runs down to around 35% of the shank length. The clamps, pressing onto the previously sheared faces, obliterate the signs of roughness left by the shearing action, and leave a slick, mirror surface under the pressure marks, fig 109. Since the cut sliver is a triangular shape, there is more material displaced towards the top than at the base of the clamps. If the side pressure is too high, then a slight step in profile occurs at the bottom of the clamps. This can be seen in the second nail of fig. 104 in the 1845 sample.

The tops of the side clamps terminate in a bevel which leaves a tiny bevel bracket to the head when seen from below. The die force acting in line with the shank is an inverted-shape, which leaves a peaked head and forces the iron outwards to form two wings, as can be seen on plan, Figs 108 and 109. By the 1860s most cut slivers were formed by the rising bed method such that shear burrs occur on one side of the nail blank, fig. 109.

CLASP-HEADED CUT NAIL

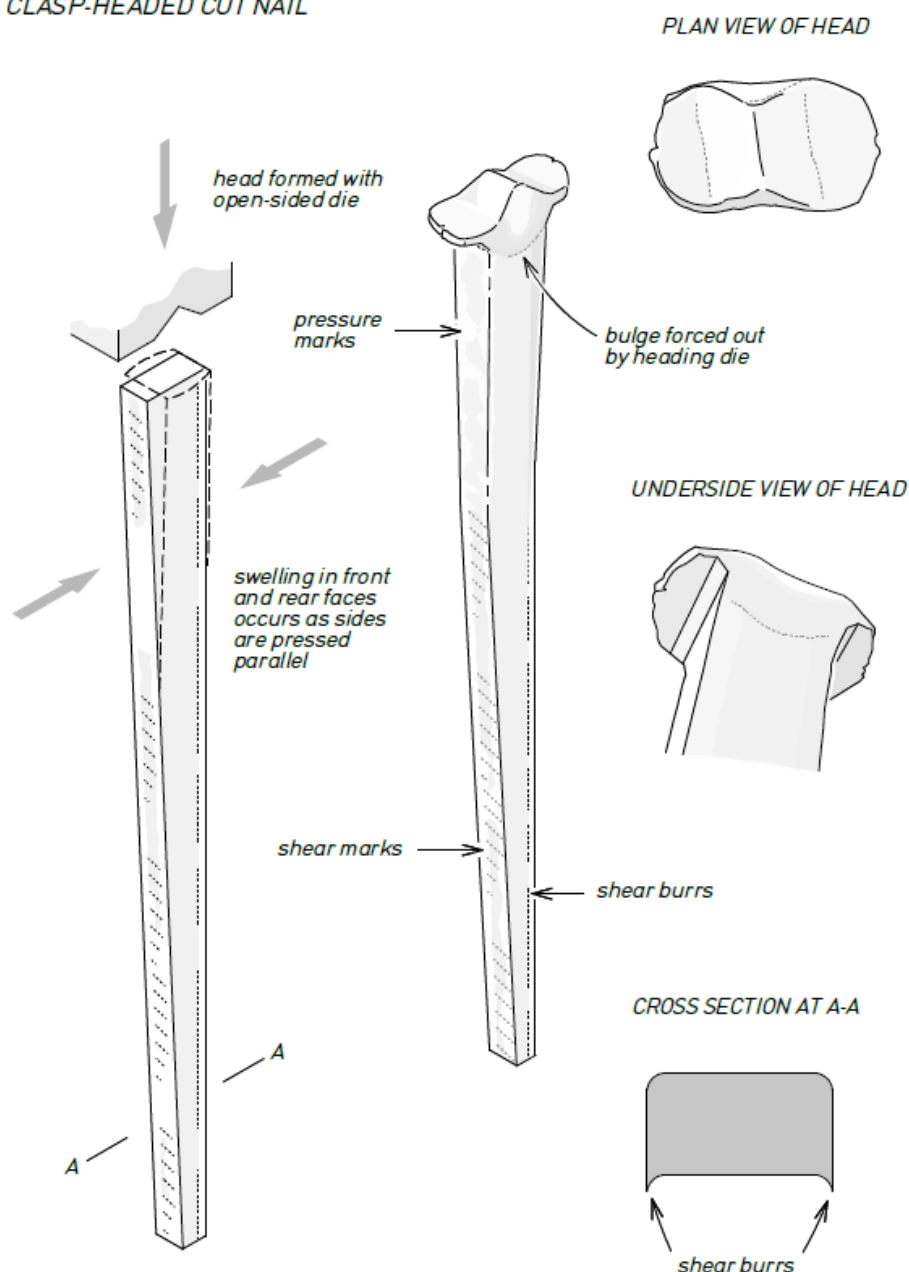


Fig. 109. The production sequence of the British cut clasp nail around 1860-1870. Author/McCaig.

In addition to the cut clasp nail facsimile, less frequently a rough “bull head” version occurred, lacking the clasp ‘wings’.

One thing to note, is that the solution of cutting with the iron grain resulted in a very early successful, strong cut nail, just as had been predicted by Perkins prior to his migration to Britain. This remarkable sample from an early nailed roof truss from Percival Terrace in Brighton, Sussex, (now on display in the Weald & Downland Museum at Singleton) shows significant distortion without any sign of fracture, fig. 110.



Fig. 110. British cut clasp nail, 1845, Montague Terrace, Brighton, Sussex, showing early 'wings' and significant distortion. Author.

Around 1880 a further change was the reduction of the 'wings to nominal bumps or 'lugs' on either side, fig. 111, left. This change preceded the move to steel cut nails, which became available around 1885, fig. 111, right.



Fig. 111. Cut iron clasp nail, Drill Hall, Warrnambool, 1870, with reduced "lugs", and a steel version, Charleton Road, Shepton Mallet, Somerset, 1905. Author.

4.4.13 Cut clasp nail summary

The steps towards a facsimile clasp pattern of British cut nail went through five main stages:

1814	Machine-headed, robust cut nails introduced, following the basic American pattern, but heavier, fig. 104.
1825- 1844	Transition machine-made nails appear with off-centre faceted head and showing only three facets, Figs. 104 & 105.
1825- 1844	Horizontal wings with two cusped facet pressings to the head to early prototypes gaining full true horizontal "wings" during the 1850s, fig. 110.
1855-65	Distinctive spread wings to the cut clasp nails.
1870- 1908	Less pronounced side wings, which reduce to rounded protuberances on each side and continue to appear as iron cut nails at least until 1908, fig. 111, nail 1.

4.4.14 Profiled sheet cut nails

This comprises the third variation of British cut nails as shown in fig. 101 above, and in its earliest form was the basis of the second patent granted to Thomas Clifford in 1790. Like many inventions, the idea was ahead of its time and its importance has been dismissed by writers in Australia. The type does not figure at all in the American cut nail story and, although its early applications appear as particularly sad reflections on nail design and aesthetics, it nevertheless grew into a significant solution of great strength in the Cordes and Co repertoire circa 1865-70.

Clifford's ingenious concept was developed into a solution involving re-rolling iron ribbon to a profiled cross-section, - akin to the profile of an aircraft wing, - by having a flat bottom roller and a part concave

top roller.⁵⁶² This produced a maximum width to the shank at the mid-point of the nail shank and meant that the ribbon could be fed directly through the guillotine blade without the need to be flipped over between each cut, fig. 112.

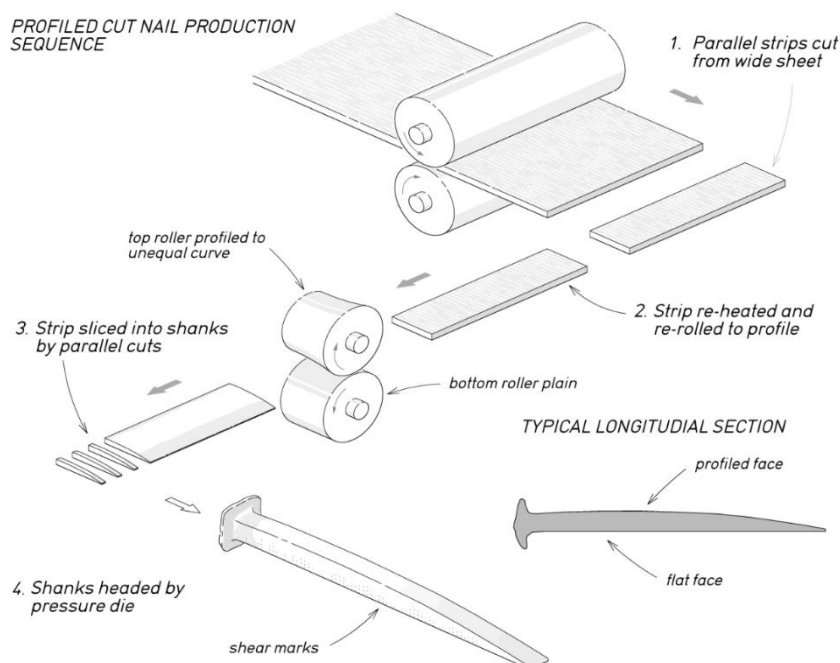


Fig. 112. The re-rolling process. Author/McCaig

Several different variations of this type of profile have shown up in early nails from pioneer Victoria, fig. 113, with a variety of head shapes, some of which are obviously hand forged. This was the forerunner to a successful run of rather clumsy looking nails, one of which showed up in roof repairs in a datable context of 1880, fig 113, bottom right. At the time of writing the earliest dateable finds of the pre-profiled sheet nail have been in an 1843/4 context at Major Charles Newman's bungalow 'Pontville' at Templestowe, east of Melbourne, which was investigated by Dr Roger Luebbers, fig. 113, top left.⁵⁶³ The nails in this group show a single front face nub mark which tends to be associated with manual heading when using a quick-release vice.

Pre-profiled cut cladding nails, with the same single front face clamp and a curious off-set head, were found in an 1853 context in Portland, Victoria, in two sizes and in some numbers. Some more conventionally headed ones from 1851 were found in Warrnambool and almost identical ones to these were found at Haddenham in Buckinghamshire, UK, of around the same date.

⁵⁶² KRUEINITZ 1777, 100/627 recorded Clifford's patent in a later *Encyclopedie* update. A 75 mm profiled cross-section wrot head nail, circa 1850, was retrieved from Augustinierstrasse 17, Stuttgart but the occurrence may be entirely unrelated.

⁵⁶³ LUEBBERS 2014, N1/21 & N1/24



Fig.113. Rafter nail 1843, Pontville, (top left; photo Luebbbers), An 1853 Portland flat profile version, top right. A rafter nail, 1850, Warrnambool, and Princes Highway, Garvoc, 1880. Author.

Cordes & Co later produced a pre-profiled sheet facsimile of their famous Ewbank nail around 1870 termed the T-patent cut nail, fig. 114. This was suitable for the tough Australian eucalypt timbers and nails made on this principle appear in Australia up to WWII. It was copied by other British manufacturers which saw the company instigate a series of lawsuits against “imitators”.⁵⁶⁴

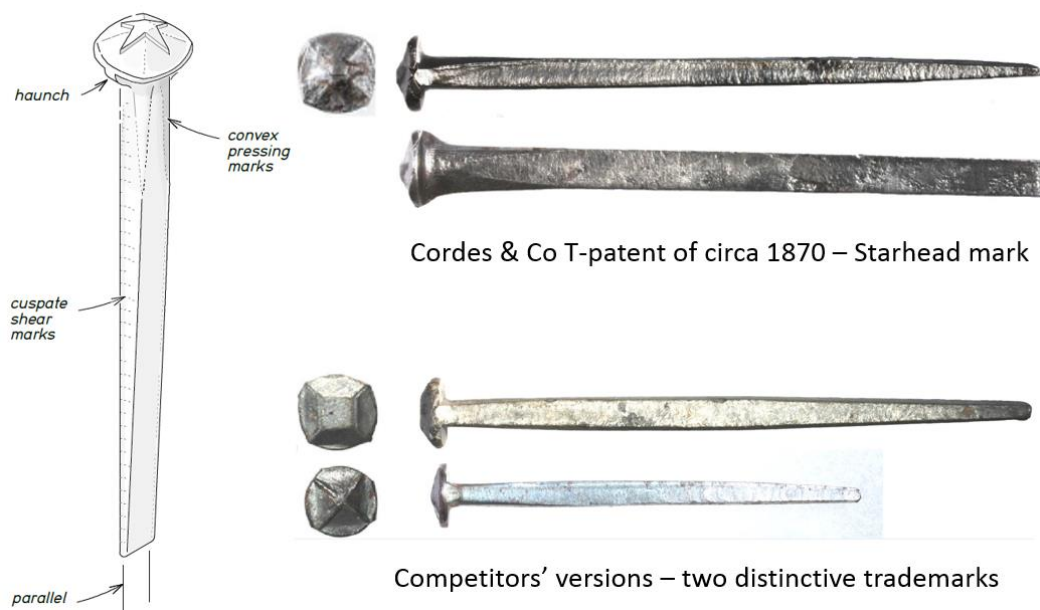


Fig.114. Two of the competitors to Cordes cut version of the Ewbank nail, names unknown. Author/McCaig

A colleague of the author, now deceased, recalls this type of nail being sold at the Lava Street hardware shop belonging to his grandfather in Warrnambool prior to the outbreak of WWII.⁵⁶⁵ Very large versions of 225mm overall length were recovered from the Warrnambool central park in 2016 by a local builder and presented to the author.⁵⁶⁶

4.4.15 The ‘shredded’ lath tack

There is some conflicting evidence relating to the methods adopted for producing cut tacks. One fairly common variation suggests that they were made by ‘shredding’ a flat bar with cutters set on opposing axes, right and left. The proto-shanks were then diverted to feed tubes to be headed by a single strike. These are marked by presenting a triangular cross section and by significant variation to their cut faces. As such they follow the method originally proposed and patented by Guppy in 1796.⁵⁶⁷

⁵⁶⁴ JOHNSON 2008,

⁵⁶⁵ The late Wallace Ponting. He informed me these were then known as “Ewbangs” – a Freudian slip!

⁵⁶⁶ Ken Johnstone, builder, was carrying out fence removal work for the Warrnambool City Council.

⁵⁶⁷ HIBBS 1853, 12. See also LEWIS 8.06.11 for the Guppy patent. Lewis’ unfavourably compares this to later American machines, whereas it should really be compared to Perkins’ primitive hand operated cut nail machine, of some two years later, Fig. 81.



Fig. 115. The three sides of a cut lath tack 1845, Pontville, Victoria. Photo Dr Roger Luebbers.

Lewis suggests that tacks were an American development by Jesse Reed in 1807. He quotes the claim then made of the Reed machine producing 150,000 tacks per day.⁵⁶⁸ In view of the later eyewitness observations made by Pastor William Bentley of the Salem Lutheran Church in 1810, with regards to hand heading of cut nails,⁵⁶⁹ Reed's claim appears incredible. Lewis goes on to quote how the machine received further development by Odiorne in 1810. One is forced to wonder how these supposedly successful tacks do not show up until the mid-1830s. But it is also true that some aspects of the lath tack morphology suggest an American typology. As has already been pointed out, the movement of designers and technicians both ways across the Atlantic makes national claims and subsequent appellations appear futile. As late as 1859 the rates of migration to America were staggering.⁵⁷⁰

4.4.16 Cut lath tack-nails

The earliest example of cut lath tack-nails coming from either Britain or Australia consists of a cut lath tack recovered from inside the roof of the Supreme Court in Sydney, - an 1825 building of Georgian proportions, fig. 117, nail 1. This is almost unique⁵⁷¹ in that it has a rounded 'skull-cap' head, whereas all others have flat heads, in some cases even slightly dished. The typical American cut nail feature of a small raised 'blister' appears on some samples and on these the heads are larger. As seen already in fig. 113 above, the 'blister' feature becomes a useful indicator of an American product over a British one. One further example of the 'skull-cap' type showed up in the nail box of Woolmers house in Tasmania, thus likely to be from circa 1828. From this die-heading method it seems reasonable to infer that these first lath tack-nails were headed by hand, possibly using the device already shown in fig. 44 (left).

In Australia, the last of the wrought lath nails appear in 1856 in Port Fairy. In Tasmania an interesting observation concerns the female convicts' quarters at Woolmers House of circa 1838 in which most of the laths were fixed with oversized wrought nails, except on the finishing section where these change abruptly to cut lath nails of conventional pattern, fig.117, nail 2. In Sydney, the study found that a terraced house at Lower Fort Street of 1835 contained no cut lath nails at all but only wrought ones. So the early evidences for these early types are rare and inconclusive.

The cut lath nail type found first in Australia may be of British origin and is a smaller version of the side clamped nail, fig. 117. These appear in Victoria in 1846 at Port Fairy and in 1848 at Darlington. Larger versions of the type had been used to fix tiling battens in a pub kitchen in Portland of 1846. This type almost certainly comprises a development of the expatriate Dyer, then ensconced in Birmingham with his own 'Britannia' works. It gives lie to the denigration⁵⁷² to which British nails suffered: "The general character of the machinery for cutting nails in this country is of a very low class,

⁵⁶⁸ Ibid.

⁵⁶⁹ HOW 2009, 74-88.

⁵⁷⁰ MACINNIS 2008, 45. In one month alone, September 1859, of 7000 immigrants who left Liverpool, 4800 went to the USA, 1000 to Victoria, 400 to NSW, 400 to the Cape Colony, and 224 to New Zealand.

⁵⁷¹ Apart from the sample from the nail box of Woolmers house. Another like sample lacking provenance, was acquired in Pisa in Italy, by Mr Richard Jones.

⁵⁷² See LEWIS 8.06.8 Ibid.

both design and workmanship exceedingly rude.” In fact this design continued into the following century and was the basis of both zinc and copper cut slate nails, fig. 116:



Fig. 116. Type transfer; Portland, Vic. (Fe), Warrnambool (Zn), Chatsworth (Cu), & Haddenham, Bucks (Zn).

The scaled down version of this type can be seen in this progression (which also continued into the following century), and is widely found in Australia and Britain, fig. 117:



Fig. 117. Lath tack-nail found in Britain and Australia, left to right: Supreme Court Sydney, Woolmers Cottage Tasmania. Brighton UK. Two from Princes St Pt Fairy, Warrnambool, Vic. Bowlish house extension Darshill, Somerset. St Andrew’s Manse, Pt Fairy. Digby Cottage Pt Fairy, and two from Cestria, Melbourne. Author

What can be seen is that neither the batten nail sized cut tack fig. 117, nor the cut lath nail/tack, fig.115, show much evidence of change during the whole of their period of appearance. There are small changes, however. The first being the die-struck ‘skull-cap’ head, which suddenly disappears around 1842 or so. A second small nuance can be noted comparing the first 3 tack-nails with those coming after 1845. This consists of an ‘over-clamping’ whereby a waist like appearance is caused just below the head. It will be recalled that it was this fault which brought the early American nails to grief, and it can be seen in the American researchers’ work, Figs. 96 & 98.⁵⁷³ They are suggesting this fault persisted until 1828. It can be seen uncorrected in some British nails in fig. 120. There are still traces of over-clamping seen in the cut common of 1845, a sample of which was found on Christ Church, Warrnambool nave roof of 1856. In respect of the cut tack lath nails over-clamping disappears around 1846 except for those tacks displaying the American ‘blister’ head, suggesting American origin, fig. 117, nails 5 and 7 from left.

One small observation is that the 1890 samples show a lighter structure to the tack-nail, which although not a positive sign, can be borne in mind when assessing the era of particular lath tack-nail.

⁵⁷³ LOVEDAY 1983, 19, and EDWARDS & WELLS 1993, 29-32

4.4.17 The cut form of lining nail

These hardly show up in Australia but from British sources it appears these may be part of a Cordes and Co gearing up towards cut nail production after 1875. Unfortunately the only recognisable samples of this type have come from the Weald and Downland Museum bins, or have been passed to the author's colleague, Mr Jones in Wales, fig. 118. The most likely threshold date for this type is after 1880.

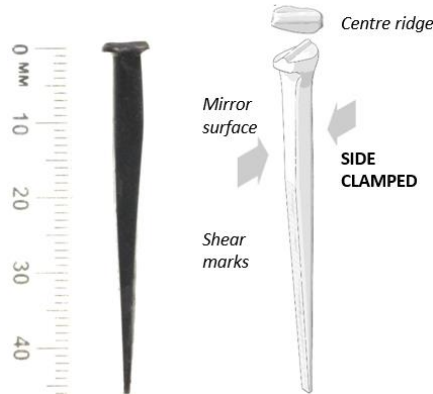


Fig. 118. Cut form of side clamped lining nail. Author/McCaig.

4.4.18 American cut nails in the Antipodes

The best known form of general purpose American cut nail was their exquisitely elegant 'fine' nail, which was visually seductive, fig.119. It was also eminently practical as it needed little room in the nail bag so it was easy for carpenters to carry and was a delight to handle.



Fig. 119. American face-clamped cut nail Christ Church, Warrnambool, 1875; face view, and side view. Author

The one big problem for its use in Australia was its proclivity to fracture in hard eucalypt timbers, the reasons for which have been given above. The study has found that the incidence of fractures continue into the mid-1880s when all the relevant literature advises that problems with cross grain had been resolved by, or soon after, 1850.

The reason why so many fractured examples are found in Australia is probably due to their being misapplied to exceptionally hard Australian timbers. Further separate tests on the outer compressed layers, (that is the faces which had come into contact with the cold rollers) are recommended as time and means outran this part of the study. There is a possibility that during driving of the nails, the hammer blow shock wave through the outer and inner layers, travels at different speeds due to the different densities within the core material and outer layers. This would result in a re-bounce effect of the wave causing an incipient separation of the core close to the halfway mark, where most fractures are noted.⁵⁷⁴ It needs to be said that not all American cut nails show this weakness. Some bent and

⁵⁷⁴ See Fig. 112 above.

twisted examples do show up, but they are rare, especially in comparison with the remarkable strength of the Ewbank nail which remained ubiquitous in Australia and was still in use up to WWII.⁵⁷⁵

The shape of American cut nails varied somewhat between makers but that shown in fig. 119 is fairly representative of the high point of development reached by 1870 or so. Each type tended to hold true to form from then until the 1890s. As seen in fig. 119, there was a general principal applied to creating their cut nails (at least as far as those found in Australia is concerned). The top 40% of the face and rear surfaces of the shank were clamped by two identically indented vice-like concave jaws. In pressing the face and rear the jaws left bevels on each of the four corners of the grasped length, fig. 119, (top).

The smaller sizes gained hugely in popularity with the advent of imported softwoods. American softwood timbers in theory became available in Melbourne prior to 1862.⁵⁷⁶ Californian redwood (*Sequoia sempervirens*) is a particularly soft wood which appears at the very end of the study period. It was not used in large quantities until around 1900 and then continued right through into the 1930s.⁵⁷⁷ In terms of numbers found, the American 'finishing nail' occurs the most. Their maximum period of use was after 1882, but they are never used to fix laths. Larger versions of finishing nails were used to fix skirtings, and reveals to doors and windows, fig. 120.

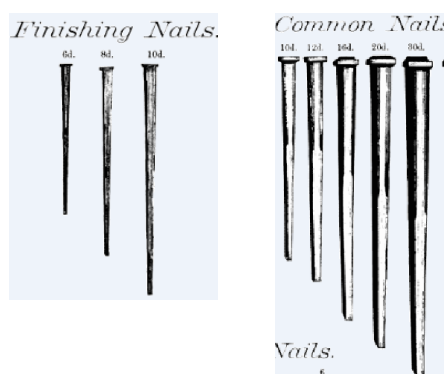


Fig. 120. American finishing nails and commons (part range only show), after Hubbard.

The other type of American cut nail used in Australia was their 'common' equivalent which covered sizes from one inch (25mm) to five inch (127mm), fig. 121. The Americans also exported their spur head cut floor brad to Australia, however, there is no apparent difference between ones found in Dartmouth, England in 1806 and those dating from 1911 found in Warrnambool, although sizes and sheet thicknesses can be seen to vary.

⁵⁷⁵ In January 2020 the first American cut steel nails found in Australia showed in a Melbourne house of 1891.

⁵⁷⁶ MAYES 1862, 33-34. Mayes' builder's guide also shows that Tasmanian Huon pine and NSW Cedar were still available. The American timbers listed were pine and 'Oregon' (Douglas fir).

⁵⁷⁷ The earliest find of Californian redwood has been at 'Danna' Tahara, 1889, fixed by 'fine' lining nails

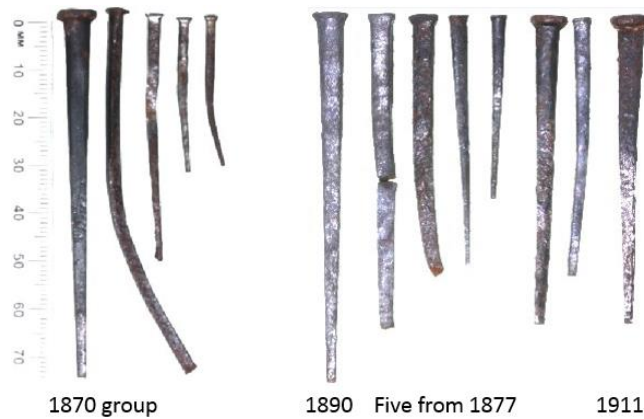


Fig. 121. Comparisons of US cut nails found in Australia. Author

4.4.19 Summary of Part Three Findings

It can be seen from the foregoing that cut nails in Britain and as found in Australia fall into three categories of change:

- Those which exhibit several changes during the study period
- Those with only one or two changes
- Those with no discernible changes

There are also some unsuccessful types which are, generally speaking, so rare as to be oddities in the succession of nail types. Building researchers may come across them by chance but only the date of the covering patent can be used to estimate a first appearance threshold. In relation to dating within this study they can be considered a non-event.

The first category will be assigned the name of 'indicator nails' and in the above listings there are two cases offering good potential for the purposes of dating. These are: the British cut clasp nail, which has been the subject of a paper by the author,⁵⁷⁸ and the cut slate nail, which shows changes both in typology and in the metals used.

Nails which offer only in limited potential need to be interpreted within the total spectrum of nails recovered from a building or ruin. One such is the 'skull-cap' round-head lath tack and the limited finds suggest perhaps just the decade 1825 to 1835, which is when the ubiquitous cut lath-nail appears.⁵⁷⁹ Its other forerunner, the three-sided cut tack, as found by Dr Luebbers at Pontville, seems at this stage just another oddity. Similarly, the Bull-head form of common cut nail has only shown up twice thus far and so is of little dating use. In the case of the cut spur-head floor brad, or any found in the American finishing or common range, there are no identifiable changes, and hence they present little chance of dating potential. It is possible to show these in tabular form and using the rationale of usefulness, table 4.6 shows first the indicator nails:

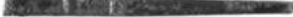
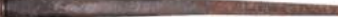
⁵⁷⁸ HOW 2014,231-238

⁵⁷⁹ A sample was found in Liège at the remodelled front of the medieval Hospice.

TABLE 4.6: INDICATOR CUT NAILS

INDICATOR NAIL APPEARANCES		Year	1790	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890	COMMENTS
Cut clasp nail - type 1														Oval top, pinched neck
Clasp nail -2: 3 facet head														Small peak off centre
Clasp nail -3: full wings														Fully developed wings
Clasp nail - type 4: side lug head														No 'wing' effect but side lugs instead
Slate nail spindly shank		Zn												1842
Slate nail		Zn												1842 and 1858
Slate nail		Zn												1855
Slate nail		Cu												

TABLE 4.7: CUT NAIL GENERAL SEQUENCE OF APPEARANCE

CUT NAIL APPEARANCE CHANGES	Year	1680	1700	1790	1800	1810	1820	1830	1840	1850	1860	1870	1880	1890	COMMENTS
Glazing/joiners headless brads															Possibly hand cut from 1680
Headless floor brads				?											Possibly these appear in 1790
Spurhead floor brads				?											Earliest find 1806 in Dartmouth, Devon
Spurhead lining/joiners brads															Punched versions may date from 1750s
Flat head commons and batten nails															Development of Uyer's commons 1810
Profiled-sheet commons															Several variations 1835 - 1890
Cordes profiled-sheet T-patent															Circa 1875
Halket & Bates (?) cross-head															Unknown entry - possibly 1880
Competitor (Brittania) mesa hd															Ditto
Lath tacks - die-skull cap heads															1828 & 1835 finds only
Lath tacks - flat top heads															1842 onwards. Finer version appears 1890
Flat head, strong, shingle nails															1855 finds
Flat head, sloping cut, shingle nails															Circa 1865 finds.
Facet top commons, type 1															First probable date 1825
Round top commons, type 2															First probable date 1840
Round top commons - type 3															First probable date circa 1850
Bull head strong - type 4															Few finds of 1858 only
Cut lining nails															Type 1 find 1858. Type 2 circa 1885
AUSTRALIA & NZ															
American flat top fines & commons															No pertinent changes circa 1868 - 1890

Part Four: Mechanically wrought nails

"Subsequent to (1790) not less than thirty or forty patents have been granted for making brads or nails, and some three or four of them have been successfully worked."

Holtzapffel, 1847

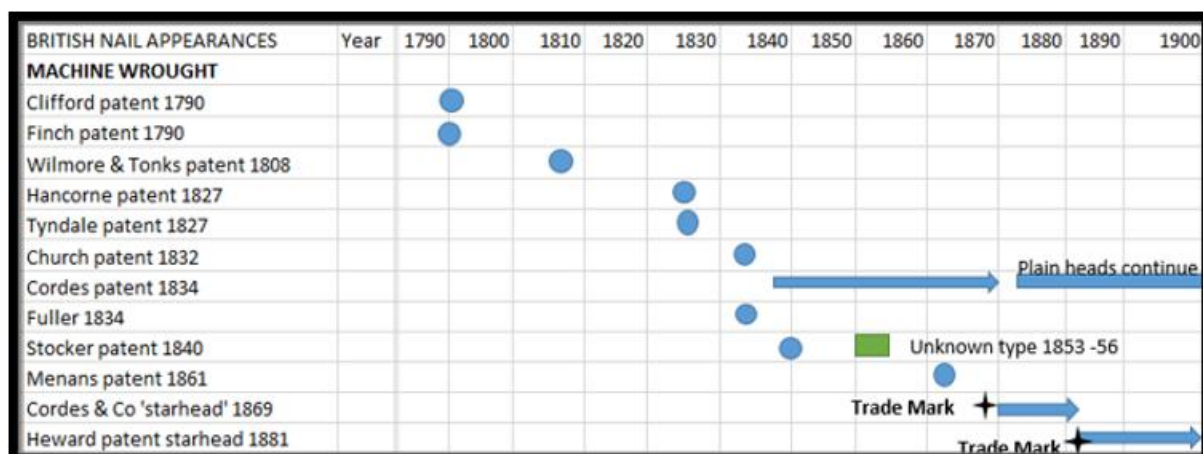
"The nails are made out of nail rods, which are drawn into shape in a machine by means of rolls, which are so arranged as to give the nails a suitable taper. Although these machines have undergone many improvements, the present principal is precisely the same as that of the original machine. ---"

The Company (Cordes & Co) now manufactures two brands of wrought nails, viz., the "Star" and "T". The former is the original, and many improvements have been made in it which render it one of the very best nails in the market. ---"

The holding power of Patent Wrought nails is greater than that of other nail in the market."

The Australian Ironmonger. April 1887.

TABLE 4.8: BRITISH MACHINE WROUGHT NAIL TYPES



4.5 OVERVIEW - MACHINE FORGED

The study concentrates on finds and seeks out evidence of machine working on samples.

4.5.1 Recognition features

These are sometimes referred to as 'machine made nails', which is ambiguous since it ignores the fact that both cut and wire nails were also being made by machines. The particular features are rolling, pressing and die heading all done by machine, fig. 122.

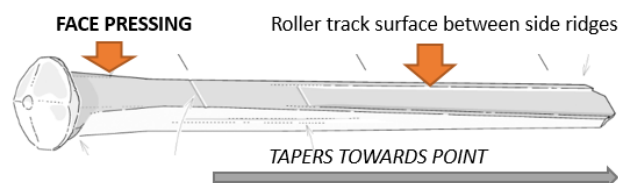


Fig. 122. Recognition features of mechanical fabrication.

This type, more than any other, demonstrates the truth of the quote from Holtzapffel shown above. In the thirteen years of active searching for types of mechanically wrought nails only two types have ever

shown up in numbers. The hugely successful Ewbank nail in several variations, fig. 122, and a Cordes & Co lining nail. Lest any other types should appear soon a generalized perspective of machine marks is given first, and the critical differences between the different types of Ewbank nail follows below.

These would be limited to fabrication from nail rod whilst hot and must be either rolled or pressed (or both) to achieve a tapering shank. The direct result of such pressure is to spread out the hot iron on the transverse axis. Other actions such as advancing the rod, severance, heading the proto-shank, and ejecting the finished piece, being effected by machinery would each leave traces. These minute nuances are difficult to read unless the artefact is clean and in good condition.

4.5.2 Previous patents as yet undiscovered

In 1790 there appears to have been no requirement for patent drawings of the proposed machine to be submitted, and research with the Patent Office succeeded in uncovering only written texts which mostly lack precise description.

Three British patents were issued in 1790 and at least one American. The American Patent Office burnt down in December 1836 and all records were lost, excepting one file, so the records are still far from complete. A series of patriotic claims by some American writers has been given free rein and there are unsustainable claims of liberal exaggeration. The most likely scenario is that the first American nail patent, for a cut nail machine, was lodged sometime that same year.⁵⁸⁰

The three British patents consisted of two lodged by Thomas Clifford of Bristol, which then had a major wrought nail industry. One was for a form of cut nail using a pre-profiled sheet, and the other based on pressing hot nail rod through shaped rollers. The other patent, recently re-examined by Sjogren, was by William Finch, which used nail rod, whereby the manual action of hammering was mimicked by machinery.⁵⁸¹

4.5.3 Finds dictating reality

Extensive searching and intense effort in cleaning some thousands of nails has failed to find any contender to the Ewbank nail in its rolled form, a summary of which has already been quoted in 2.1.7 above. The Ewbank nail has also been the subject of two papers by the author, a published appendix,⁵⁸² and of several talks to heritage groups. To avoid repetition, the following explanation will concentrate on the salient facts leading to identifiable changes, and hence to dating potentials.

4.5.4 The ubiquitous Ewbank nail

The Ewbank nail constitutes the largest single group of nail finds during the period covered from 1838 to 1880, but in Australia it continued to appear in its basic form up to 1910, and in its replica cut form until WWII. It emerged as a joint effort by two brothers-in-law, James Cordes, a Yale educated American Engineer of Huguenot descent, and his older English partner, Henry Ewbank. They had several years of working together in Mexico, and North America in the mining field.⁵⁸³ Their choice of site for their factory was at Newport, now in South Wales, and was based on the logistics of ore and coal movements, as well as the close availability of ports for shipping around Britain and overseas. Construction of the factory, Dos Works, started in 1834 and their first production was in 1836. Professor Lewis has traced the first mention of Ewbanks in Australia to 1838. By curious chance, the re-roofing of the Brickenden farmhouse, at Longford, Tasmania, built in 1838, produced an opportunity to collect large numbers of identifiable Ewbank nails from the roofing battens.

⁵⁸⁰ HOW 2009, 74-88

⁵⁸¹ SJOGREN 2019,

⁵⁸² HOW 2009, 829-836 & HOW 2015 – ICOMOS Australia electronic copy.

⁵⁸³ HOW 2009, 76-81. WOOD & HENRY 2013, 610-611 & 613

The rolled form Ewbanks are particularly well identified by their shanks' spread towards the tips. The machine left other clear identification marks which have been enumerated above in section 2.1.9.

Although the machinery remained essentially the same between 1836 and 1881, the Company structure of Cordes and Co changed from a partnership to a public company in 1869. This event was marked by incorporating a four-pointed star onto the nail heads, which becomes a useful indicator and a dating aid to these face pressed nails. In 1881 a company employee, James Heward, patented a change to the gripping system which superseded the face pressing by introducing a four-sided grip.

The revised form of grip on four sides resulted in a square neck; even though the nail rod itself continued to be rectangular. This change caused four haunches to be formed under the head, set on the diagonals. In other respects the nail remained the same and it used the same star trademark. With a little practice, the absence of face pressing with its two primary haunches replaced by four minor haunches and a square neck, can be easily made out. The nail no longer looked symmetrical but appeared as if 'lop-sided'. There was a bevel on the top edges of this square and a small breakout of metal at the corner gaps which produced four haunches on the diagonals; two primary haunches being slightly larger on one diagonal, and two secondary, figs. 123, 124. The change from square neck to rectangular shank gave rise to an apparent twist in the tops of these nails. This form of square grip to the neck had already appeared in early iron wire nails and the factory's ventures into iron wire nail production⁵⁸⁴ may have directed Heward towards this resolution, purportedly speeding up production.

⁵⁸⁴ JOHNSON 2004, unpublished. See also JOHNSON 2008, unpublished

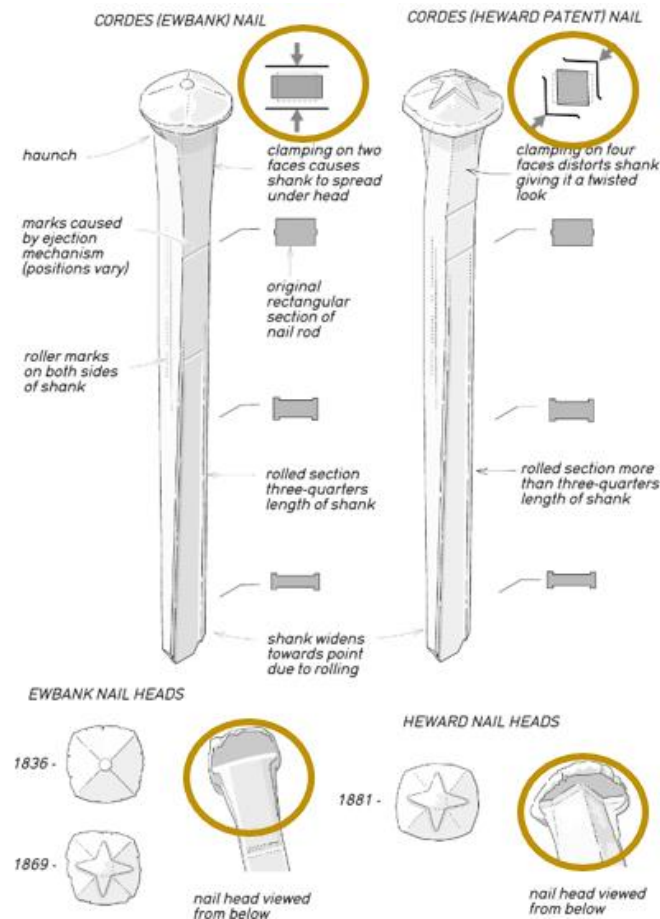


Fig. 123. Clamping differences between the face pressed Ewbank 1834 and the 1881 Heward grip. Author/McCaig



Fig. 124. Ewbank variations; 1834 model, 1869 'Starhead', and 1881 square-grip model, face and side. Author

The changes to the Ewbank nail are useful in setting threshold dates, and because of its ubiquitous nature in Australian buildings, the changes are powerful determinants. One further change, already shown above in fig. 114, section 4.4.15, was the factory's introduction of a replica in cut form. This

was due to a further initiative of the same employee, James Heward. In this instance cut billets of already pre-formed iron ribbon were pressed, whilst still hot, into a close replication of the Ewbank original shape, fig. 114. It proved to be a cheaper version to make, but which (surprisingly) held none of the on-going faults of the contemporary American cut nails when used in Australian timbers. Identification of the differences between the original Ewbank and this cut form replica are difficult at first, but the absence of rolling marks, and the giveaway cusped edges on each side, resulting from the face pressing, provide the necessary clues, fig. 114. The cut replica form appears to pre-date the Heward four-sided grip change, and contextual evidences suggest a date circa 1870 for its introduction.

4.5.5 The Cordes & Co lining nail

The issue of the machine rolled lining nail was fortuitously resolved by the author's colleague in Wales, Mr Richard Jones, uncovering a later round-headed used version of this uniquely formed nail. This still retained an identifiable 1869 Star-head trade mark. In all other respects the characteristics were identical. The earliest finds of these unique lining nails, however, was in the Female Convicts quarters of Woolmers House, which was extended in 1845 from the 1817 original wooden framed house.⁵⁸⁵ Although the fitting out of the attic loft spaces to the Female Convict quarters may have been interrupted by the house extension, it is unlikely that this would have been beyond say 1846 or so. These uniquely formed nails continue to appear regularly in Australia and in Britain. The last machine made sample came from the Lord Cottage near Yankalilla in South Australia circa 1890, fig. 125. Significant numbers of these nails have come from government properties in Adelaide.⁵⁸⁶ There are no identifiable changes during this period, but it seems highly likely that Cordes & Co brought out their cut replica around 1880 or so, and so far all samples of this cut version have come from Britain, fig. 125.

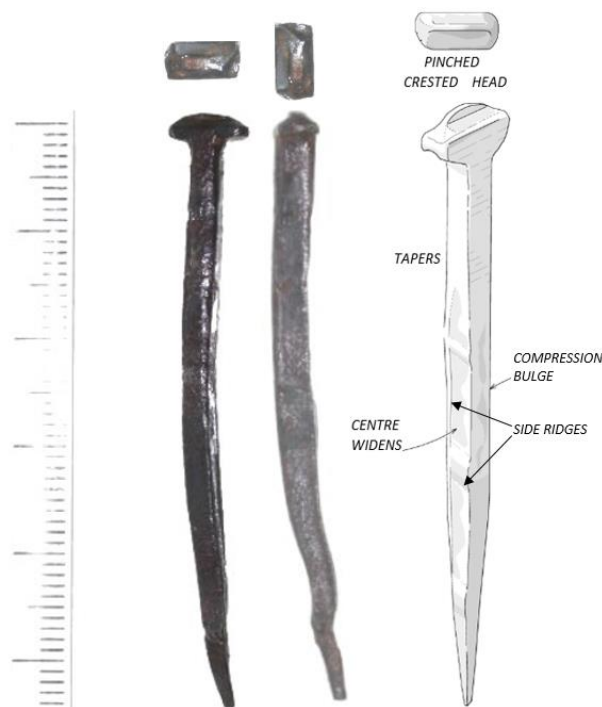


Fig. 125. The Cordes & Co machine made lining nail, sample circa 1890. Author/McCaig.

⁵⁸⁵ CLIVE LUCAS STAPLETON & PARTNERS P/L 2007. 13

⁵⁸⁶ Courtesy of Heritage officers Luigi Vitale and Andrew Steinkopf based in Adelaide.

One last possibility of a machine made nail comes from a single source of a small weatherboard house in Portland, Victoria of 1864, dated from Liverpool newspapers pasted onto the walls. This was in four sizes but most samples recovered were badly corroded. These had a primitive and clumsy appearance. fig 126. It was possible to see, from the better preserved samples that the shanks had been extended to a spade-point by rollers, leaving characteristic side ridges. Interpretation is ambiguous since the nub depression under the heads is more likely to suggest a hand headed nail. This information is included to complete the topic.⁵⁸⁷

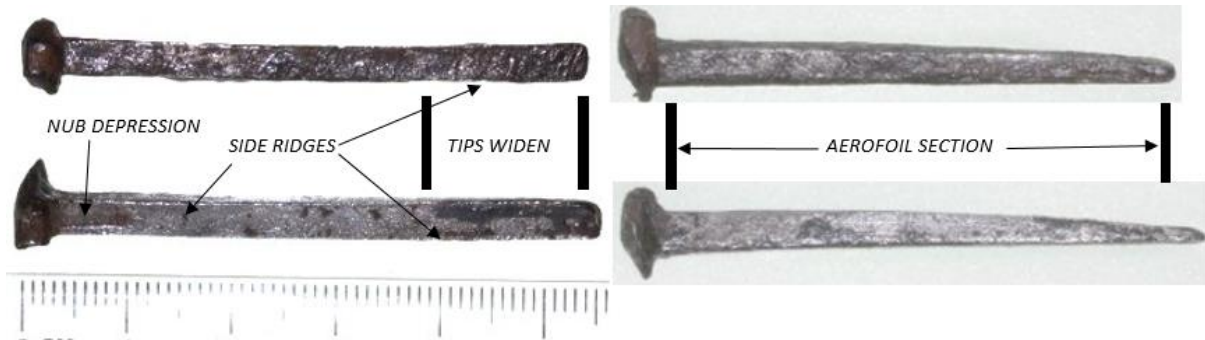


Fig. 126. The Glenelg Street, Portland nails, showing machine marks. Author.

4.5.6 Summary of Part Four findings

In spite of the large number of patents issued, it is evident that in both Britain and in Australia there are only two clearly identifiable sorts of machine wrought nails. However, the easily identified changes occurring with the Ewbank nail, together with its prolific numbers found in both countries provide useful dating aids.

The second mechanically made nail, the Cordes & Co lining nail, shows no signs of variation other than the one nail found by Mr Jones in Wales, which had a definite star-head. Its first appearance date is not well defined either but the large number of finds in South Australia suggest a concentrated time zone of between say between 1865 and 1885 when both American cut nails and steel ovals were used in architraves and linings, etc.

Proper identification of the third type, shown in fig. 126, must attend the appearance of further samples. One possibility is that these nails comprise a hybrid type whereby the shank was extended to length by a unilateral roller, to be then hand headed in a device similar to that shown in fig. 44 above.⁵⁸⁸

⁵⁸⁷ Dr Luebbers found similar, but more basic versions at Pontville, circa 1843/4. Refer fig 127 above.

⁵⁸⁸ Two well formed, but corroded nails from 6 Glenelg Street, Portland, were close to identical with ones found in the nail box at Manor Farm, Haddenham, in Buckinghamshire, UK. The enigma thus revolves around these very eccentric and clumsily shaped heads shown in Fig.139, which are typical of the main group found at Glenelg Street in three different sizes.

Part Five: Wire nails

Deep rooted prejudices of all kinds had to be overcome before the wire nail could be accepted.

Swank, 1892.

The wire nail appeals to certain characteristic national traits. It is cheap, easy to handle, can be driven by any creature that can lift a hammer, and can be readily pulled out again. In an age of shoddy materials and shoddy mechanics, it is inevitable that the cheap, facile wire nail should hold sway.

Henry Dickerson Scott, 1929.

TABLE 4.9: BASIC APPEARANCES OF WIRE NAILS⁵⁸⁹

WIRE NAIL APPEARANCE PERIODS		1816	1850	1860	1870	1880	1890	1900	COMMENTS
	Handmade in Paris, circa 1680								Earlier 1640s samples in Belgium
	First effective wire nail machine by Daguét, Paris; - facet points, teeth marks, & square neck grip								Bruyset 1825 first patent contender
	Early iron wire nails				+				Multiple teeth indentations
	Rose heads and bunheads				+				Facsimiles of forged heads
	Rhomboid heads						+		Heads vary 
	Fluted iron nails						+		Sloane patent 1882
	Opposed side clamping						+		Short lived process
	Pyramid heads						+		
	Iron wire bullet heads					+			These start as drum heads
	STEEL bullet heads						+		
	STEEL ovals						+		Soft steel for clenching

4.6 OVERVIEW – WIRE NAILS

In examining the domain of wire nails as part of this study it has been necessary to exercise caution with written sources and rely as much as possible on samples gathered in the field in Australia, Britain, France, and to a lesser extent in Belgium. This is a tortuous path since Australia received nails from each of these countries as well as America, but more particularly it was in a position to purchase wire nail making machines by the 1870s and then purchase wire from a range of countries. None of the origins of the machines or the particular pattern of nail adopted, or the sources of the wire are clear, nor are they identifiable.

To add to this problem, the early work done by Varman in the 1990s is sometimes wrong (as will become apparent) and several sources seek to identify wire nails as an American development.

Before delving into these controversies the reader needs to be equipped with a basic understanding of wire and how it came to be converted into nails.

⁵⁸⁹ Fluted iron wire nails appear in a western Victoria villa of 1877 but may have been from a local alteration to a rain head. See also LEWIS 8.06.8. Ibid, researched by him and the author following finds of numbers of twisted nails from Glastonbury, Somerset. These may emanate from Montague Wigzell's patent of June 1861.

4.6.1 Wire

Nearly all round wire has to be drawn by being pulled through a series of successively decreasing sized holes in a draw plate. With soft metals, such as gold or silver, this could be done manually providing only a fine wire was desired. The billet of metal needed to be first beaten into a rod of appropriate size, which was then rounded using swages as seen in fig. 25. The end would then be tapered to fit through the largest orifice of the draw plate, fig. 127, first image. Harder metals, such as brass, could still be physically drawn by robust individuals using their leg muscles when seated on a swing, fig. 127, central image.

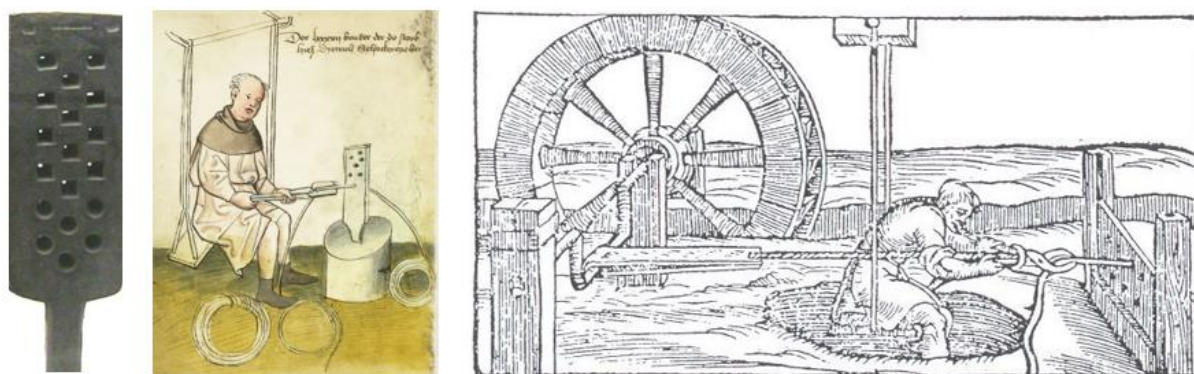


Fig. 127. Draw plate (left) Deutsche Museum, Munich. (Author). Hand-drawing, Nuremberg 1485, and water-power drawing of iron wire after Biringuccio.⁵⁹⁰

The process of drawing reduces the wire diameter by stretching the thin outer annulus of metal in a series of distortions to the molecular structure. After several passes these peripheral distortions accumulate higher stresses compared to the core imparting stiffness. An analogous process is the way whereby the cambium of a tree trunk provides stiffness to the inside of the tree. The stiffening effect was commented on by Reaumur in the making of sewing needles.⁵⁹¹ Build-up of stress in this manner is known as ‘strain hardening’ in which the strain is annular. In the case of iron wire it becomes necessary to lose the outside stresses by annealing the wire coils in a closed oven, after every nine passes or so.⁵⁹² The coils then need to be dipped in acid to assist scale removal, and then ‘rumbled’ in a drum.

During this process the wire would be retained in coil form as seen in fig. 127 above. For iron and steel wire the natural ‘spring’ (or ‘set’) in the wire as it was unrolled, had to be ‘killed’. A two-stage process was involved, which for quality production involved running the wire from the coil through a slalom of nails placed in such a way as to straighten the wire, which was then fed onto a larger diameter wheel.⁵⁹³

With the coming of machine made nails it became impractical to rewind onto larger diameter wheels. Instead the coils were placed on a free-wheeling circular frame which was given a conical taper, fig. 127 foreground.⁵⁹⁴ In lieu of the gentle slalom, and in order to free the wire of ‘set’, the method used was to subject the wire to strong forces from set points. The study has found that for iron wire nails,

⁵⁹⁰ HAWLEY & CROSSLEY 2009, 57; WRIGHT 2010, 8-10

⁵⁹¹ REAUMUR 1761, 53. See also Plate I

⁵⁹² HAWLEY & CROSSLEY 2009, 60-61

⁵⁹³ HAWLEY & CROSSLEY 2009, 63-64: see also HOW 2018, 346 for Reaumur’s description.

⁵⁹⁴ DIDEROT 1769, Vol II 550, Plate 20_13_2. See also HOW 2017, 44, Fig. 68, which shows the wooden original of the later iron frames used by most wire nail manufacturers.

two score marks show on the outside arc of the wire curve, and a lesser single score mark on the opposite side, fig. 128 .

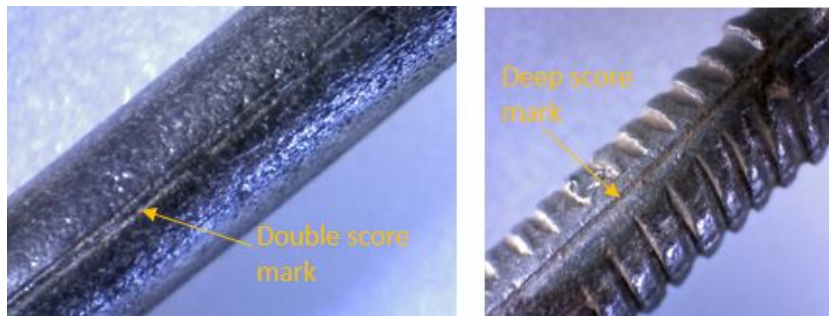


Fig. 128. Double score marks on an 1875 wire nail sample, and deep score on an 1888 sample. Author

Some later samples show only one deep score mark in lieu of the two first used.

When steel wire became available at modest cost, this transfer of technology can be first identified as less discernible score marks on the nail shanks, but these fail to appear after 1895 or so. The most likely scenario is that the application of hardened points was replaced by small wheels, whose relative offset positions could be adjusted for best effect on dressing the wire straight - as seen in this 1950s era machine, fig. 129.



Fig.129. An 'eastern bloc' wire nail machine, circa 1956, Liepaja, Latvia. Courtesy Arturs Lapins

4.6.2 Rolled wire

In mistaking the dressing score marks for “ribs” Varman in his 1993 thesis assumed that the ‘shaped rollers’ developed by Cort in 1783 constituted a method of producing round or square sectioned wire: which he quotes as 7.14mm to 7.94mm diameter.⁵⁹⁵ This unfortunate mind-set has now become established as a feature of wire nails by the *Archaeologists Field Handbook* in Australia. It shows iron wire nails as having a rib (their FIG. A3.2), even though the book’s preceding text refers to wire as

⁵⁹⁵ VARMAN 1993, 161

being drawn.⁵⁹⁶ Further confusion arising from Varman's text is a reference to wire being drawn in a hot state. A clear impossibility when one considers the images shown in fig. 142.

Coupled with this there has been a need for the study to seek out samples of pipe nails, which by fortuitous chance produced an example of reliable provenance from the Hobart Art Gallery of 1828. This sample (**N 22**) clearly started as a piece of rolled rod. It displays the cutting marks transferred from off the rollers which relate to machining of the rolls which is significant as it shows the problems of roller alignment had been resolved by then. It measures 9.4mm diameter. Later in the study a remote property north of Hamilton in Victoria provided samples of original thick iron fencing wire circa 1855.⁵⁹⁷ This heavy iron wire measured 5.5mm diameter but was clearly drawn wire.

The reason for this tedious digression is that around 1885 true rolled round rod was used for pipe nails and for launder nails, - the latter being headed by the 'stiddy' technique, (refer **N 33** nails 3 & 4). The smallest samples of pipe nails were from 1887 and measured 5.5mm diameter. The rigidity of these later samples precludes their ever having been coiled, so it is clear that the round iron lengths were provided in rod form to nailors, or to factories. The importance of this observation lies in the ability to visually analyse the samples relative to a date line. Varman is vague on the period to which he refers, but he mentions a date of 1830 in relation to "rolled wire". It should be noted that wire drawing mill operated until 1926 at the Thurgoland wire mill. Thus there is a serious credibility gap of nearly one hundred years in Varman's assertion.⁵⁹⁸ Samples suggest that the smallest rolled sections were close to 8.5mm diameter.⁵⁹⁹

4.6.3 Reshaped wire sections

The reader must bear a further digression with respect to wire nails of oval, square, and triangular cross-section, since these are in fact produced by the rolling of drawn wire. The method owes much to the development of metallurgy in being able to produce rollers of especially hardened steel, as well as to superior bearings capable of transmitting the large forces involved. It was done in a cold state as elevated temperatures would affect the metallurgical structure of the rollers themselves. Elevated temperatures would also lead to problems with the fine tolerances implicit in the process. The shapes developed will be dealt with next, but since rollers were involved some confusion has already been caused, see section 4.6.2 above.

The easiest reshaped form to understand is the oval nail. It was probably developed by the British to replace the wrought clenching nail. The samples obtained both in England and in Australia show roller marks along the shanks, fig. 130, so it is certain (as well as logical), that coils of round wire would have to be first converted to new cross-sectional profiles. The steps taken to cut the points and to form the heads are otherwise similar to those used for round sectioned wire nails. In the case of ovals a softer grade of steel was produced, presumably to facilitate their being used for clenching.⁶⁰⁰ In the rolling of oval sections a reduction in cross-sectional dimension would be involved and no concomitant change in volume. This is probably the case with square sections and triangular sections, which although shown in British nail catalogues,⁶⁰¹ may have originated from German initiatives. They also may possibly have come from Swedish technology of around 1890 or so. In both cases the intention was to increase the nail surface to volume ratio, thereby increasing nail withdrawal strengths.

⁵⁹⁶ BURKE & SMITH 2004, 377: See also p5, table A 3.5

⁵⁹⁷ Correagh homestead. The author is obliged to Mr Wesley Rogers for his help and nail samples.

⁵⁹⁸ HAWLEY & CROSSLEY 2009, 59

⁵⁹⁹ Due to acceleration as the section was reduced by the rollers. A safe exit speed was around 16km/hour.

⁶⁰⁰ Based on observations of ovals used as floor brads when hard knots have caused shank zig-zags.

⁶⁰¹ JOHNSON, CLAPHAM & MORRIS LTD Manchester, List W8/1958 page 1



Fig. 130. Oval nail, Shepton Mallet, Somerset, 1905, showing roller marks and 'forage cap' head. Author.

4.6.4 Categories of wire nails

It is convenient to consider wire nails as falling into five principal categories:

- Handmade
- Machine made wire nails
- Re-formed rolled section wire nails
- Roofing nails made by adding metal discs or heads of lead
- Small pipe nails, use in roofing or in fixing of flashings etc.

4.6.5 Handmade wire nails - *Clous d'epingles*

These are properly nails manually made from wire which were explained in a paper presented by the author at Cambridge.⁶⁰² Their earliest literary reference comes from Reaumur's excellent description in 1761.⁶⁰³ However, recognisable iron-wire samples appear in organs dating from 1644 and 1685.⁶⁰⁴ Both the organ builders were Belgian and were working in traditional Belgian territory, so there exists a possibility that these small pins nails may not necessarily originate from the Isle de France. The need to soften iron nails, whilst keeping them free of surface oxides, is detailed in a 1766 work, *L' Art de Facteur des Orgues*.⁶⁰⁵ In the same regard there is a reference to purchasing the nails in packets of 100 which reflects Roubo's comments concerning wire nails. It seems Dom Bedos de Celles may have been referring to *clous d'epingles*, which are prone to accumulate hardened surfaces due to the strain hardening effect of drawing.

The manufacturing process described by the French encyclopaedists, (and as dealt with in the author's paper) presents a blueprint of how each step transferred across from the manual to the mechanical process, which will be dealt with next. Apart from the ground points, fig. 131, dressing the wire, gripping, and heading, comprised the essential features of machine-made iron wire nails.⁶⁰⁶

⁶⁰² HOW 2018, 345-356

⁶⁰³ REAUMUR 1761, 53, 72: plates V & VII

⁶⁰⁴ Sint Truden church organ by Christian Ancion de Huy, & from Nielles les Ardres, France; organ by Jan Van Belle of Ypres. Courtesy Pierre Decourcelle, organ builder, & thanks to Prof J-L Vanden Eynde.

⁶⁰⁵ DE CELLES 1766, 180

⁶⁰⁶ Ground points appeared in some *Brevets* after the first practical machine by Francois Daguet in 1816. The 1821 Brevet 1BA1615 by Laroche & Monger of Marseille incorporated ground points, as did Brevet 1BA451 of 1825 by Bruyset & Co of Lyon.

Samples of brass pin nails coming from furniture of 1683, and from 1730, show the score marks left by the wire having been run through the *dressoir*, also the conical ground points, and domed heads from the *estampe*, fig. 131.

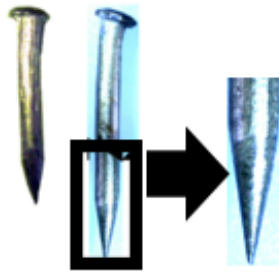


Fig.131. A 14mm long Cucci brass pin-nail of 1683 and a 21mm version from a commode chair of 1730.⁶⁰⁷

An expansion to current assumed knowledge is needed to clarify the assumption that the term '*pointes de Paris*' is synonymous with '*clous d'epingles*'. The term seems to date from a first mentioned the *Brevet* granted to the Japy brothers in 1806. It is worth noting that the *Brevet* awarded to James White in March 1811 still adopted the term *clous d'epingles*.⁶⁰⁸ The term is not used by any of the French encyclopaedists, but small forged points were described by Roubo, Diderot, Duhamel du Monceau, and by Panckoucke. The most common form was of square cross-section, numbers of which have been recovered in Provence. There was also a conically tapering, round version, - often octagonal in cross-section, fig. 132. Roubo uses the terms, *clous sans tetes*, and *caboches*.⁶⁰⁹



Fig.132. French wrought round pins, circa 1684, Pertuis, Provence. Courtesy Dr John How. Author

One further point is that White's application was for a series of hand tools useful in expediting hand-made *clous d'epingles*. Some of these relate to cutting and heading of wire, while others relate to cut nails. His initial application was extended after some months delay to include a slicing action, sliding journal device used to produce tapering slivers of cut iron. This was activated by an eccentric rotating in an elongated slot, thus driving the sliding journal back and forth.

The initial application shows in pencil all of his accumulated range of devices on one sheet of drawing paper, fig. 133.

⁶⁰⁷ Both samples provided by the French furniture restorer, Yannick Chastang, Faversham, Kent,

⁶⁰⁸ Brevet 1BA334. See also *Decrets Imperiaux* 1811, 447 for the American James White.

⁶⁰⁹ HOW 2017, 36, Fig.s 58 & 56

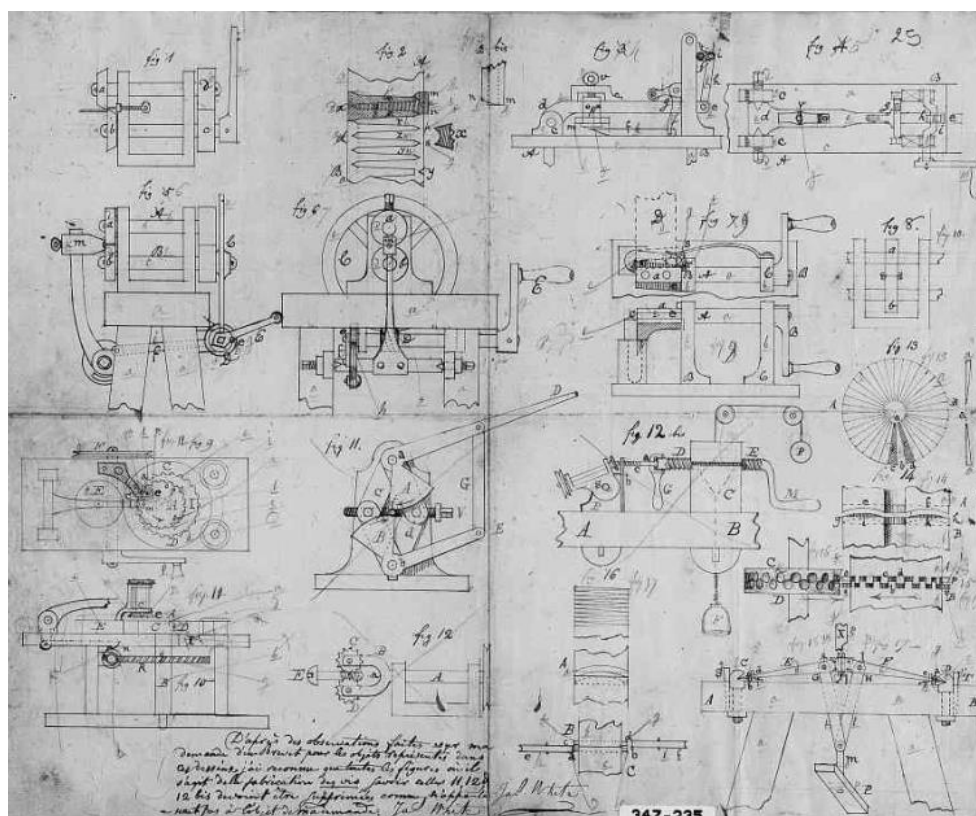


Fig. 133. James White's first application: cutting and heading bench tools on left, & reversing cutter on right, shown with a point grinder below. The right hand quarter shows a carousel for cut slivers and a pedal header device.

Lewis records the patent as “a machine in which the wire was gripped vertically between two notched discs and cut to length, the head struck, and the point formed, all in one operation.”⁶¹⁰ This is difficult to reconcile with what White drew, or to what White wrote in his patent application: “several machines intended to facilitate the accepted methods more rapidly to form the shanks and to forge nail heads.”⁶¹¹ Readers should note the hand cut slivers bottom centre and the two tapering slivers loaded onto the carousel, middle of right-hand side.

One more piece of disinformation needs to be addressed. This is the claim, which has been supported by several writers,⁶¹² that the ‘machine’ for which the Japy Brothers of Colmar made patent application in 1806, could also make *clous d’epingles*. The claim was made by Louis Japy in the brother’s application. The claim is particularly disingenuous since the ‘machine’ was in fact a curiously unique type of lathe, of hollow mandrel form, and as such had to be manually worked by an operator.⁶¹³ Wire, in pre-cut and pre-dressed lengths, was fed through the hollow centre to be machined by the operator in two stages. Firstly, by cutting a cone point, which was then followed by machining a screw thread. A headless screw was thereby produced, falling away as the next cone was cut – thus severing the first produced item. These screws would then be individually cold headed by a second device, and the heads would then be slotted to finish the screws. The patent examiner had cryptically added a note to the patent application to say that Louis Japy was fully aware of the need for the wire to be of high

⁶¹⁰ LEWIS, 8.06a-nails-and-screws, in *The Culture of Building* [dynamic Dropbox document], accessed January 2020. See also 8.06e. His citation seems to be a translation of FREMONT 191, 33

⁶¹¹ HOW 2018, 351 (author’s translation from the original application).

⁶¹² VARMAN 1993, 163

⁶¹³ HOW 2018, 351. The lathe drawings are well executed and form part of Brevet 1BA344 of 9 May 1806.

malleability in order for it to be used in this application. So, the reality of Louis Japy's claim, each panel pin nail produced would have to come from high quality, pre-dressed and cut to length iron wire and then be pointed - but with plain shanks having no cut thread. The conical point would still need to be machined from the expensive wire and separately headed by the second machine. This unlikely scenario would have reflected in the price of an individually machined nail and is unlikely to have been an attractive proposition to either vendors or purchasers.

4.6.6 Machine made wire nails

This subject of the first machine made wire nails needs to be seen in the context of what rapidly became the accepted norm for the production of iron wire nails. By pure chance an identifiable, but headless sample of a French machine-made nail came to the author from a restorer of musical instruments in Melbourne.⁶¹⁴ It displayed four of the five machine made iron wire nail criteria:

- It established a square grip to the neck
- It used teeth indentations to reinforce the grip during heading
- It established faceted points in lieu of conical ones
- The dressing marks showed that the wire had been straightened by the same traditional methods as were to continue for the next 80 years (essentially little different to the pin-nail workshop *dressoir* described by Diderot).
-

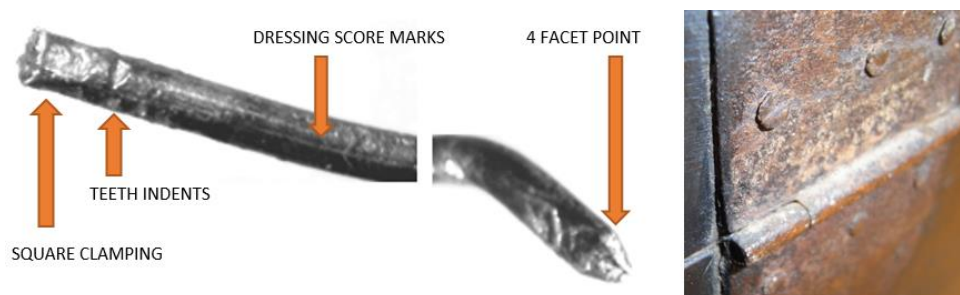


Fig.134. Pin-nail magnified x 10. Author. Instrument case hinge, c.1818. Jerome Deakin

There were no identifiable haunches supporting the head, but it will be noted that the heads (seen on the French Horn Case on right) are slightly domed as if from an *estampe* punch, fig. 134.

As part of the study, and using research carried out by the restorer, Mr Jerome Deakin, the machine involved was traced to Francois Daguet and to his Brevet of 16 July 1816.⁶¹⁵ This remarkable machine has received virtually no previous notice from writers. There is however a substantial fog of misinformation which seeks to identify wire nail machine invention with America or Germany.⁶¹⁶ Charles Fremont portrays James White's devices as a machine and then ascribes the credit to the Lemire (Jura) machine of 1819 as being the first wire nail machine, when precise information concerning Daguet's first practical machine existed in the Paris archives.⁶¹⁷

The plan view and side elevation of the machine give a good idea of how it operated, fig. 135. In other respects the features Daguet used demonstrate breakthroughs in converting wheel drive, fly wheels, gearing, and lever activation. The design made clever use of advancing cogs, slides and transfer arms

⁶¹⁴ HOW 2018, 353-354

⁶¹⁵ Ibid. Brevet number 713, 16 July 1816, valid for five years.

⁶¹⁶ VARMAN 1993, 163/164

⁶¹⁷ FREMONT 1912, 35. He was probably mistaking a reference in the *Dictionnaire Chronologiques (Vol 3)* of 1820, page 270, which refers to the cut slivers as 'pointes'.

to achieve the fabrication process, and it was the first to introduce faceted points to wire pin-nails. It is remarkable that the inventor, Francois Daguet, has been essentially bypassed in the history of technology, and that the introduction of these features has gone apparently unnoticed in the field of nail-making.

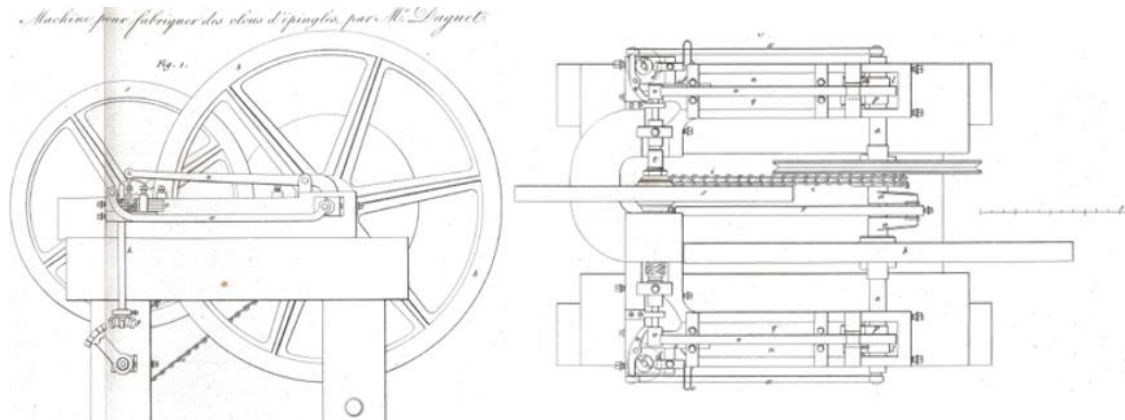


Fig. 135. The Daguet machine of 1816⁶¹⁸

Before leaving this subject of the first wire nail machines, the issue of self-feed was the most important development accorded to the process and should be addressed. Self-feeding, directly from a wire spool, dramatically changed the economics of nail production, enabling wire nails to overtake every other form of production. French ingenuity again provided a first step to this process with Brevet 1BA 451 awarded to Bruyset of Lyon in 1825. It comprised a complete-product wire nail-making machine which included sets of pins for dressing the wire. After pointing and cutting to length, a holding box was shifted laterally to lie plumb with the header. The machine seems to have been the first to incorporate automatic dressing of wire, fig. 136.

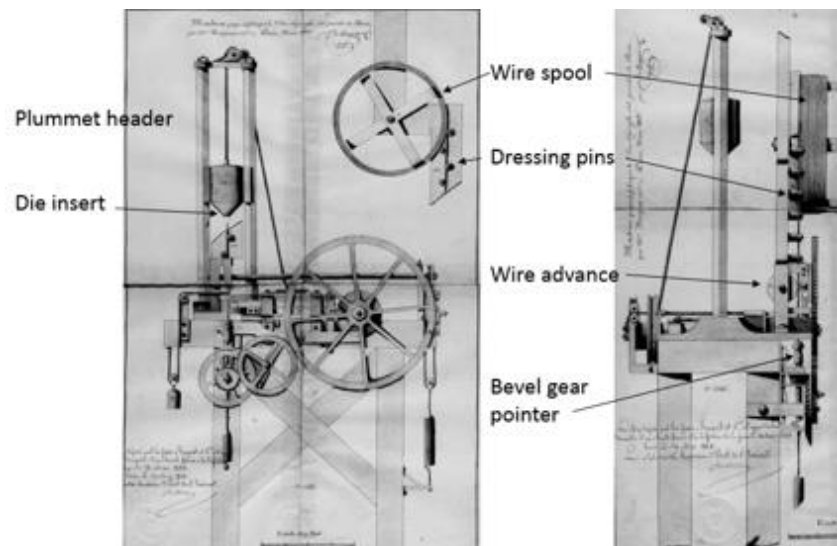


Fig.136. The Bruyset machine of 1825. Notations by author.

⁶¹⁸ Plate 18, patent 713, *Descriptions des machines—dans les brevets d'invention Vol. 9. Issues 614 – 814, 1824*

4.6.7 Wire nails in Australia

The study has found that in Australia machine made iron wire nails were not widely used prior to 1870, and, with only scant numbers of samples available from British sources, it has found that wire nails used in Britain prior to this date were mainly relegated to use in softwoods. Only one sample was found during the study earlier than 1870,⁶¹⁹ which may date from 1865 – 1866, fig. 137.



Fig. 137. Rose-headed 51mm wire nail, Mokangar stables, Cavendish, c1865. Author

The study found that these main features of iron wire nails tend to continue until the advent of steel wire nails and these will now be detailed, fig. 138.

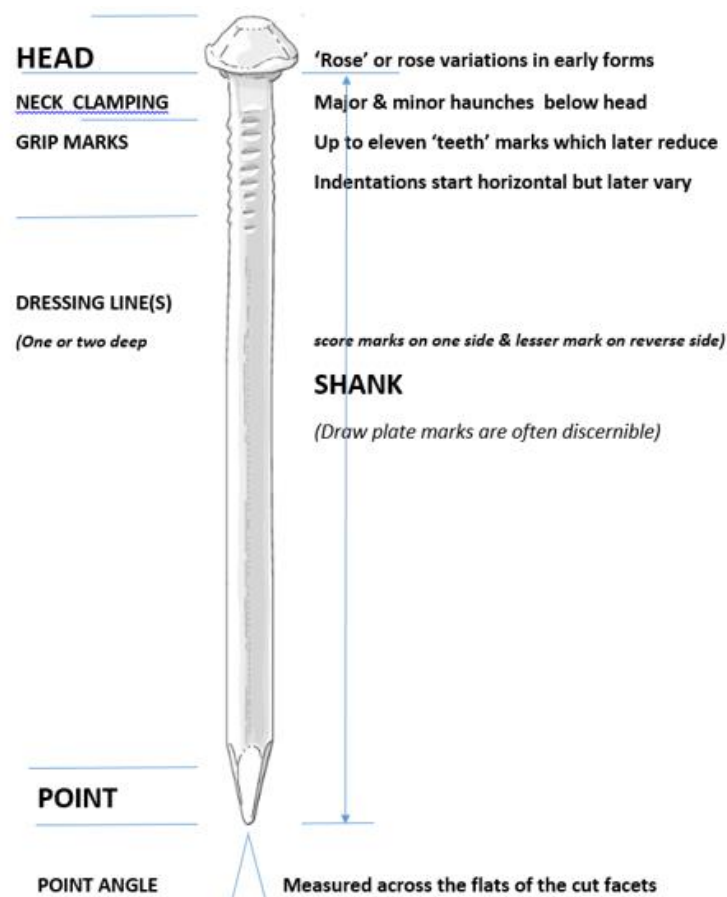


Fig.138. Iron wire nail characteristic features. Author/McCaig

⁶¹⁹ CLUNIE 2008a, 13 shows a similar but longer version to that shown from mid-1860s in NSW

The particular aspects to be noted are:

- Heads, start as four facet rose-commons but variations appear in the first decades.
- Square clamping of the neck is the norm, but this changes later.
- Clamping incorporates haunch supports, major and minor, to underside of head.
- Indentation teeth marks reduce in number as metal quality improves.
- With one exception, scoring remains the same throughout the lifespan of iron wire nails.⁶²⁰
- Iron wire points are distinctly attenuated at a subtended angle of around 26 degrees with only minor variations noted.

4.6.8 Changes in metals

Less identifiable changes occur in the iron colour and surface hardness. These are not easy to detect since the metal needs be brought to a high degree of cleanliness in order to observe both colour and sensitivity to scratching. The changes in metals used follow the pattern but are of little use in dating due to the wide distribution of wire imports into Australia.

Puddled iron: usually has a dull light grey colour common to wrought nails also.

‘Bright’ iron: looks unusually bright and shiny, yet it retains characteristics of iron as opposed to mild steel. Its first Australian appearance was in 1879.

Quasi-steel: is a slightly dull ‘new lead’ coloured iron with a harder, denser surface texture than normal iron. It possibly originates from a curtailed Bessemer process.

Steel: in this context is nearly always mild steel which has a light medium grey, dense, and tight surface which rusts easily.

Copper: is easily identified by its colour and after 1880 or so it became economically viable as ‘pure’ copper after major finds in South Australia.

4.6.9 Changes and variations in iron wire nail heads

In regards to identification of types, these are the easiest features of wire nails to identify. They can be divided into seven generic groups:

- Rose-heads, change with time and provide useful clues with respect to dates
- Cob-heads, have the appearance of a bun or a cob-loaf
- Inverted cone heads
- Rhomboid heads; an apt term used by Varman.⁶²¹ Subtle variations in shape exist
- Flat heads. The study found the first chequered head surfaces in 1874
- Drum heads; These modified in two variations to become the modern bullet head
- Pyramid heads. These can be like a real pyramid shape or be of only modest rise

The feature are best described in pictorial form, Table 4.8. This includes oval nails which show up often in Australia and in Britain. Isolated finds of square section, and fluted triangular section shanked nails, have appeared in South Australia, in Tasmania and at one location in the Western District of Victoria, fig. 139.

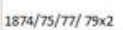
⁶²⁰ Samples of circular iron wire nails having an overall ‘squared-off’ look have been found circa 1879. These might come from the 1875 patent for Evans & Christopherson of Melbourne which is referred to by Lewis. The reference he cites quotes several wires being straightened at the same time, making no sense with respect to the mechanics of forming the wire nail. See Lewis: *ibid.* 8.06.30 e.

⁶²¹ VARMAN 1993, 182



Fig.139.Rolled section iron wire nail types: Oval. Triangular, and Square sections. Author

TABLE 4.10: WIRE NAIL MAIN HEAD VARIATIONS

HEADS/ PERIOD	1860s	1870s	1880s	1890s	1900s	COMMENTS
 ROSE						1910 No systematic change to rise at apex noted
 COB (BUN)						1905 Dimples suggest a transition:
 RHOMBOID						Transitions between Cob & Rhomboid 77/90
 FLAT						Chquer pattern appears in 1870s
 DRUM						Drum shape phases out except for pin nails
 BULLET						
 INVERTED CONE						Appears later in specialist applications
 PYRAMID						1905 This is listed as a rose-head nail
 OVALS						Later versions show reduced head size
 SQUARE						1900 Unknown origin, inferior iron wire used

4.6.10 Oddities and isolated finds

In addition to the above generic types the study has found heads which are square on plan, having bevelled sides, and also heads shaped like a forage cap. The latter form becomes the basic shaped head for rolled oval wire. Wire nails with spiral shanks were also found and they could be related to either the Atkinson patent of 1875 or the Sloane patent of 1882.

4.6.11 Wire nail points

These provide a useful identification feature since all iron wire nails have attenuated points. A range of subtended angles for these was measure as part of the study and (with one exception) the point angles were in the range 23 to 27 degrees. Steel nails used in construction typically measure 42 degrees such that the differences can be discerned by naked eye. One curious anomaly is a fine elongated point given to brass headed picture hanging steel nails⁶²² but this has no relevance to the dating process of the study.

4.6.12 Wire nail shanks

From the head down there are four main features to be considered and noted:

- Haunches to the head: are they present, how many, and how are they shaped?
- Clamping. The clamps oppose the forces developed by heading the nail and can be compared to a temporary anvil which leaves its own traces on the wire nail shank.
- Dressing score marks. These are hardly noticeable in the case of mild steel wire but show clearly (after thorough cleaning of the shanks) for common iron and for 'Bright iron'.
- Indentations, or 'teeth-marks'. These start as simple horizontal lines but develop separate patterns according to the hardness of the metals adopted.

These aspects will now be examined for changes of use in the dating process:

4.6.13 Clamping

Clamping derives directly from the method adopted for holding hand-made *clous d'epingles* as described by Reaumur and Diderot and has been previously translated into English.⁶²³ Reaumur provides the most detailed explanation of the 'gripper' (*mordant*) with a series of transverse grooves in its face, fig. 140. His explanation proceeds to show how the operator had a punch-like tool with which he could refresh the indentations inside the scalloped grooves. These prevented the round shank from sliding down as the head was punched by the *estampe*. The grips show in scores (marked with orange arrows on the pin-nail faces, fig. 156. Note also that haunches are formed by spread of metal into the side gaps, and, due to primary stresses, the spread may lead to incipient splitting, fig. 140.

⁶²² COLLARD patent 8042 of 1884. A brass head was provided over a steel or high quality iron nail head. Several of these have shown up during the course of the study.

⁶²³ HOW 2018, 345-356. Refer also HOW 2017, 39-48

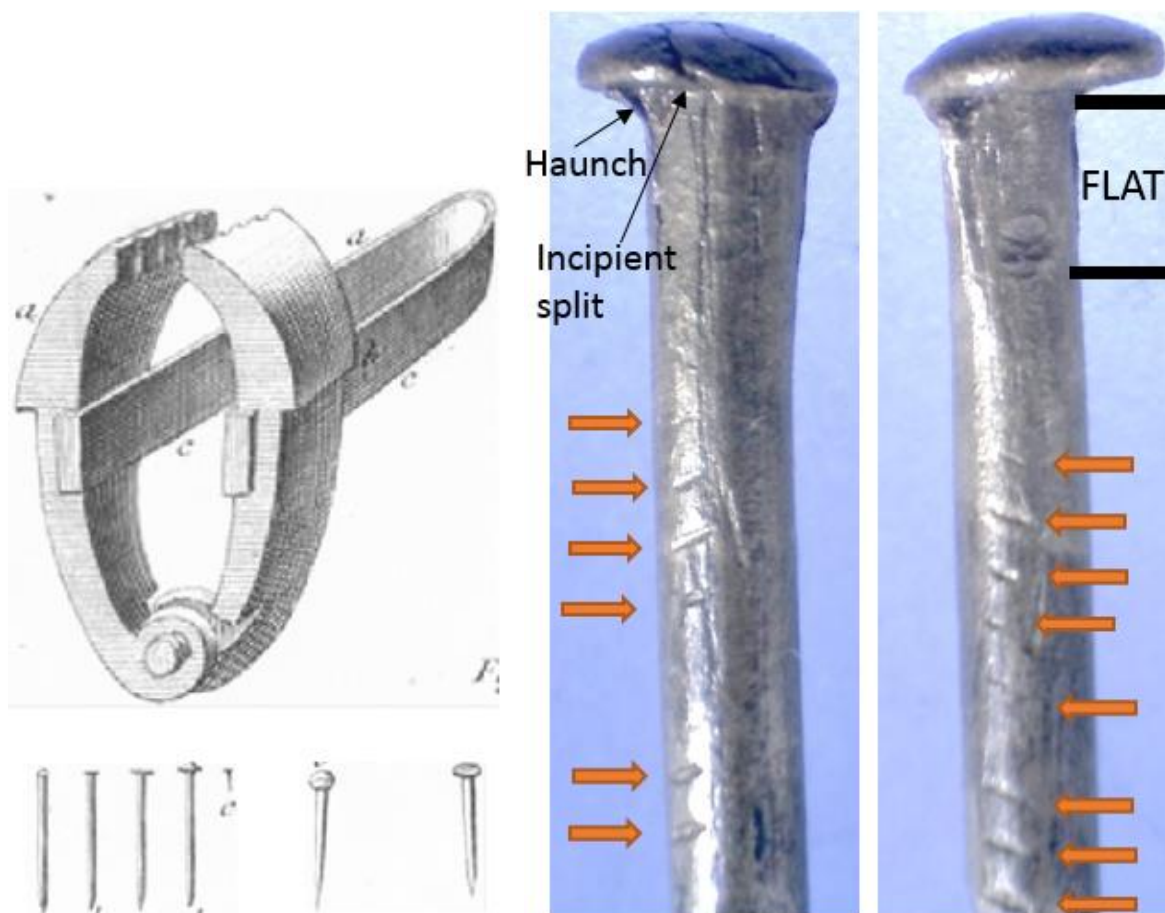


Fig. 140. Mordant gripper & pin-nails, after Reaumur. Handmade 14mm clou d'epingle, Cucci, circa 1683.
Courtesy Yannick Chastang. Author

In the later developments as seen in Australia from the late 1860s onwards,⁶²⁴ iron wire was clamped by four dies advancing from each quadrant, formed in such a way as to create a square section below the head. Very often this is done with precision such that only four faces are visible. In other cases small elements of the round are left making the neck an octagon of unequal surfaces. Since the head formation was done in a cold state, to avoid development of incipient shear lines, the top edges of the dies were rounded off. Major haunches were pressed by extrusion on one axis, and on the transverse axis minor haunches result from the meeting of the two rounded edges on the transverse sides, fig. 141.

The purpose of the major haunch follows from the history of nail head design and it will be recalled that the head weakness of early American cut nail design was resolved through strengthening of the head by giving it extra support, (akin to corbels in masonry). Varman in his thesis adopts the term 'brackets' for these supports to the head, which is also an alternative apt description. He also suggests that the bulk of wire nails being used up to 1890 were British origin.⁶²⁵ Lewis has shown that Sydney was producing wire nails by 1884, but that wire nails were being made in Melbourne in 1880.⁶²⁶

With the arrival of the more homogeneous 'bright' iron wire, two clamps were used, more like to face clamping in cut nails. (See fig. 132 above). The first changes away from four sided clamping is noted

⁶²⁴ CLUNIE 2008b, 5, provides an unsubstantiated date of 1863 for wire nail imports into Sydney, and he shows a range of rose-head wire nails circa 1866, p 14.

⁶²⁵ VARMAN 1993,165.

⁶²⁶ LEWIS 8.06.31. These dates overturn Varman's research with respect to Australian wire nails.

to occur in samples from 1888, and in this case the applied surfaces of the clamps are cusped – intended to present a smooth profile. At this point the earlier issue of ‘waisting’ below the head becomes evident, (as occurred in the pre-1828 American cut nails) and in the next change to the applied surfaces present a ‘diamond’ effect on cross section. Both of these manifestations were short lived, and with the coming of steel wire they both disappeared. They are therefore useful indicators in a stand-alone sense.



Fig. 141. Four sided clamping, 1878 with opposed clamping, concave, 1887, and diamond, 1888. Author

4.6.14 Haunches

It can be seen from fig. 141, nail 1, how the major and minor haunches align with the join in the advancing clamps.



Fig. 142. Opposed clamping on an 1890 wire nail. Note how the teeth marks are impressed over the dressing score. Author

There are a large range of head types involved and these acted as trademarks for some manufacturers, but not all. The grip patterns also vary but so far no definite pattern of identification has emerged, however, Varman’s identification of what he termed ‘rhomboid heads’ and his sketches of such as found in Sydney, clearly were either an earlier form, or they were from a different manufacturer to those found in Victoria. The NSW version is taller and less angular, with reduced dimples such that it more resembles a fez hat, fig. 143. Samples recovered later from the Sydney Supreme Court could be identified as being the latter from the teeth marks, fig. 143. This find came as a salutary lesson in demonstrating just how regional wire nail head types can be, and it shows the end of dependency on British or American made nails by different Australian states creating their own industries.

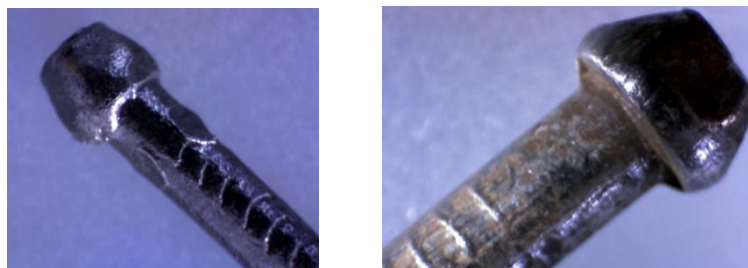


Fig. 143. The Sydney rhomboid head, left, and the Victorian equivalent, right, showing head and grip variations. Author

4.6.15 Secondary features

Using only samples backed by full provenance and preferably obtained directly from examined sites during alterations or demolition, a pictorial table of haunch changes with associated grip is shown of selected exemplars found in a good condition, table 4.9. Thus selectivity becomes an issue, but the approach was made necessary due to the problem of loss of the finer features which occurs due to corrosion. The exercise was justified in that some aspects (additional to those points already given above) can be given an acceptable level of assessment towards development of a dating system. Most of the exemplars have come from various Australian sources, but they represent imported sources from Britain, America, Belgium, and France, as well as locally produced ones.

4.6.16 Sources

Attempts to trace samples to one particular national source have proved fruitless in nearly all circumstances. This is mainly due to the great similarity of American wire nails to British ones. Belgium came into wire nail manufacture after France and Britain.⁶²⁷ American sources show that their wire nail industry was a late starter also.⁶²⁸ British enthusiasm for iron wire nails was at a low level, which has been attributed to conservatism,⁶²⁹ but with British nail exports serving several colonies restricted to dense hardwoods, as well as for the need to deal with existing hardwood timbers at home, iron wire nails frequently proved to be inadequate, fig. 144. Countries with a long tradition of using softwoods in construction embraced iron wire nails more readily than those wedded to a hardwood tradition.

A second issue of iron quality is also raised. British ores were predominantly of low quality, whereas France had excellent ores in several locations. Belgium, as we have seen, had used up most quality sources associated with the Minette ore field. Iron of good quality was necessary in order to form heads with haunches, and in order to slice the iron with some precision to cut points. Thus the lower quartile quality iron which had been used historically would no longer suffice.⁶³⁰ A similar situation existed in America, lasting until the high grade Pittsburgh ore became available. (Section 3.6.2).

These hard facts were evident in an 1888 property in western Victoria, whereby some spectacular failures of iron wire nails were observed, fig. 144.⁶³¹ These included full length longitudinal splitting, head fractures, both at the neck and at the head periphery, and some annular separation of the shanks. It was impossible to say from where either the nails or the wire came. Likewise, the problems exhibited are likely to be a combination of low quality ores plus inattention to proper annealing of the wire after drawing. Australia, at this time, was still dependent on imported wire and purchasing the right quality wire from reputable suppliers, was a skill which had to be acquired.



Fig. 144. Full length splitting in iron wire nails, 1888, Dana, Peppers Lane, Tahara, Victoria. Author

⁶²⁷ Circa 1851: www.mileslewis.net/australian-building/8.06.26

⁶²⁸ As already seen above in 3.6.4

⁶²⁹ LEWIS.8.06a

⁶³⁰ [http://bases-brevets19e.inpi.fr/File 1BA334](http://bases-brevets19e.inpi.fr/File%201BA334). See the patent assessor's caution in 4.6.4 above.

⁶³¹ HOW 2009, 83. The property was 'Dana', Peppers Lane, Tahara. Victoria, in mostly Messmate timber.

TABLE 4.11: WIRE NAIL HAUNCHES

YEAR	SITE	ROSE HEAD	COB (BUN) HEAD	FLAT HEAD	DRUM-BULLET HEAD	RHOMBIC HEAD	GRIP INDENTATIONS	COMMENTS
1855	Tower House, Wells, Somerset							
1865	Mokangar, Cavendish							
1874	Christ Church Porch						 	
1875	Parliament House, Melbourne							
1877	Bonique, Dennington						 	
1879	Hamilton Club		 					
1879	Mortlock Library, Adelaide		 				 	
						 		

TABLE 4.12: WIRE NAIL GRIP MARKS

								
1882	Christ Church tower							
1885	145 Fairy Street, W'boof							
				Steel				
								
1888	Dana, Peppers Lane, Tahara							
								
1891	Page Street, Middle Park, MEL							
								
1891	Cestria, Hawthorn, MELBOURNE							
								
1982	181 Fairy Street, W'boof							
								
1895	Port Fairy							
								

4.6.17 Observations and findings relevant to haunches

Several things can be gleaned from the comparative analysis shown in Table 4.9:

- Most iron wire nails were flat clamped on four sides. and nearly all had haunches which developed from metal extrusion at the gaps between the clamps.
- Not all were clamped the same way. Some cob-head nails had only one pair of haunches.
- The width of the pairs of haunches were usually thick on one a major axis with a minute pair on the transverse, or minor, axis. In some rare cases all the haunches were the same size. No chronological sequence in type was discernable in any of the various combinations.
- All of the exemplars shown had either a radius between the neck and the underside of head, or they had a 45 degree bevel. In one case only the junction was square (see 1891 Cestria large nail).
- Rhomboid head and bullet (drum) head nails show no evidence (or just minimal evidence) of flat clamping, and only the larger nails show minimal haunches. The heading forces seem to have been taken by the opposite end of the nail prior to wire being advanced for cutting to take place.
- Two-sided clamping occurred around 1887 but it only applies to a small range of the spectrum.
- Four sided clamping was used on the first steel nails, appearing around 1877 but disappears soon after as the sliding forces were absorbed by the indentation alone.
- Most, but not all, signs of separate clamping disappear after the arrival of mild steel as a norm. This occurs in the range 1877 – 1890. Very few iron wire nails appear after 1905.

4.6.18 Observations and findings relating to grip marks

Likewise several things can be gleaned from the comparative analysis shown in Table 4.10:

- The traditional grips comprise several teeth-like indentations on the faces of the applied clamps, which in most cases start 1.1 to 1.3 diameters below the head bevels, fig. 145A.
- The number of indentations can vary on each faceted side, fig. 145B.
- Clamps consisted mainly of plain flat surfaces, suitably indented, but some samples demonstrate that the clamps had a concave contact surface, fig. 145C.
- Clamp design adjusts to suit the change to harder metals even with identical nail forms, fig. 145D.
- Round headed wire nails, bullet heads and rhomboid heads, appear to have had opposing front and rear, semi-circular clamps, fig. 145E.
- Clamping of oval wire nails follows a similar pattern, however subtle changes were made concurrently with the change in metals, fig. 145. (Note also the adjustments to heads and haunches).

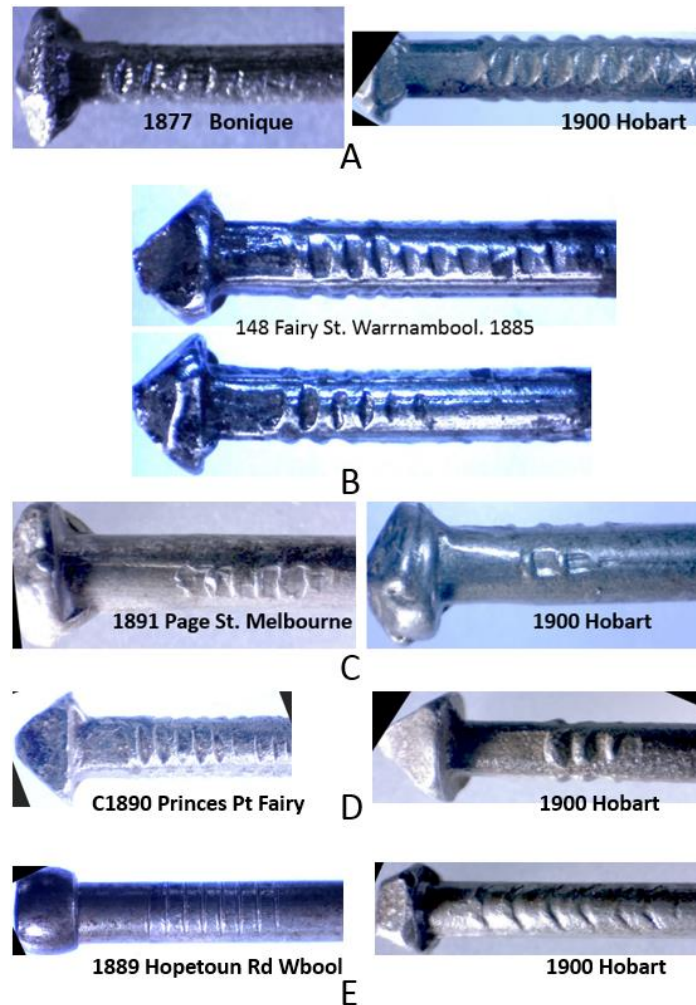


Fig. 145. Wire nail clamping and grip mark variations. Author

4.6.19 Post-rolled iron wire nail types

It perhaps needs to be restated that all normal wire was drawn as the entry to this section on wire nails has already shown. The only practical way to draw wire is through a series of successively reducing round orifices. Wire nails are thus at a disadvantage from a structural standpoint, since the surface area of a circle is less than that of a square, (given the same cross-sectional area). Thus, although round wire nails are well suited to softwoods, they have a lower withdrawal capacity than say a wrought nail. To overcome this tendency of wire nails to pull out easily, round wire was put through shaped rollers under high compression in a cold state simply to alter cross-sections to a larger surface area. From a practical standpoint there were four potentially advantageous alternatives:

- Pass the round wire through cusped surface rollers of appropriate size.
- Pass the round wire through two sets of flat rollers set perpendicular to each other.
- Pass the round wire through three sets of rollers set at 60 degrees to each other.
- Follow up one of the above sequences by rollers having a convex surface to match the particular sized gauge being rolled to produce nails with concave fluted sides.

Of these options the first was the simplest and the findings show it was probably a British initiative as samples of oval cross-section are found in numbers, widely in Britain and in Australia. The second alternative is shown in German texts, but it is widely found throughout the Baltic region.

The third type gives a triangular cross section and small numbers of this type have shown up in packing cases both in Britain and in Australia, but none found in building fabric.

The fourth case can be traced to a British patent of 1863 by G and W Bass., fig. 147.⁶³² So far no four sided fluted nails have shown up in the study in either Australia or in Britain, although there have been several finds of fluted triangular section nails, particularly from Adelaide.

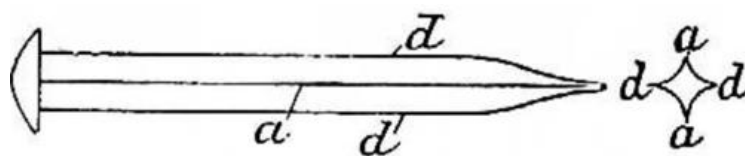


Fig. 146. The Bass patent for a nail fluted on four sides of 1863, after Lewis.

Oval nails have so far only appeared at the end of the study period but help in defining a threshold date for the type. The grip patterns are virtually all to the traditional pattern fig. 147.



Fig. 147. Oval wire nail face clamping, diamond clamping, and head changes. Author

4.6.20 Iron wire roofing nails

During the 1840s corrugated galvanised iron sheeting arrived in Australia to immediate acceptance as a roofing material, and it continued to gain in popularity.⁶³³ It took until 1887 however before the first iron wire roofing nails superseded the galvanised die-dog type domed nail as a fixing means. It will be noted how the patents were based on the British Patent Office for some time even though Stokes was a New Zealander. This is difficult to understand, since the concept of a lead head was ultra-simple and long established (see **N 18** above), and later nails were made to a variety of patterns in Australia on a local basis. See Table 4.13 for the unknown variants). The same events took place in New Zealand also.⁶³⁴

4.6.21 Patented roofing nail based on their abstracts

Hilgers patent. Feb. 19, 1878. This was intended to be used with galvanised iron or glass sheeting in clenched nail form and it had separate lead washers under a nail head with sharp turn-down edges.

Stokes patent. May 10, 1887. The lead top has 'Stokes Patent' cast in raised letters. The lead is moulded onto a stem of the usual hard metal and is intended to form a tight joint between the head and the galvanised iron surface and it is concave underneath. Stokes was a New Zealander and had patented the type two years earlier there.

⁶³² British Patent 1487 of 13 June 1863. The diagram shown was redrawn by Professor Lewis from the patent abstract and is reproduced here with his permission.

⁶³³ SPENNEMANN 2007, 13. HOW 2007, 137. The Muntham barn, c1848, still has its original CGI roof.

⁶³⁴ ISAACS 2015

Davenport invention. Feb 24, 1888. The lead head is formed by casting onto the nail shank which is preferably square.

Evenden invention. Sept 23, 1891. Essentially this is a modern roofing nail except for the disc which is lightly tinned.

Thompson invention. Feb 8, 1892. This is a belled head very like to the Stokes patent

Mackay and Mitchell. Feb 22, 1892. This is essentially a pressed deep bell which has lead embedment as shown, but comparison with those found is inconclusive with respect to the patent description of a pressed concavo-convex dome.

4.6.22 Types of iron wire roofing nails found by the study

These present a potential to assist dating in that, as seen above, they are well documented by patent descriptions, plus the fact that their heads are mostly open to view. In reality both the corrugated iron sheets and the nails have often been covered with paint after construction, and so a nail must be removed and cleaned prior to examination. There are also problems in identifying the heads which fall into two distinct categories:

- Lead, or lead alloy, heads, and
- Metal disc heads.

Of the first type, the patent by Stokes, of 1887, was the most successful which was probably due to the head downturn (or 'skirt'), and consequently it was widely copied, fig. 148. Others relied solely on the ability of the lead head to fill the piercing hole in the corrugated iron, and the study found four variants, one of which may have come from Coops Leadworks in Melbourne. (Refer Table 4.11).



Fig. 148. Pirate copy of Stokes lead head roofing nail. A few copies were marked "WATERPROOF". Author.

The first of the metal 'washer' or disc types, the Evenden patent of 1891, was not galvanised but instead used a tinned disc with only slight belling, fig. 149.



Fig. 149. Evenden disc head later version 48 Hopetoun Road, Warrnambool, with a spiral shank. Author.

Apart from the locally produced lead head roofing nail made by Coops leadworks and the Stokes head nail, all others fall outside the time frame of this study. They are useful in that they occur widely and their appearance dates set ceiling limits on dates when examining roofs. The range of roofing nails found during the study is shown in tabular form below, Table 4.13:

TABLE 4.13: IRON WIRE ROOFING NAIL PATENTS IN THE AUSTRALIAN CONTEXT

YEAR	PATENTEE	PATENT ABSTRACT	IMAGES OF SAMPLE OBTAINED	COMMENTS	PERIOD
1878	J. Hilgers		Nil	None found or identified	Nil
1887	W J Stokes			Widely found - with name embossed	Circa 1888 on
1888	E S Davenport		Nil	None found	Nil
1891	H E Evenden			Found in 3 sizes and with spiral shank	
1892	G Thompson			Seen - but none recovered	Nil
1892	Mackay/Mitchell UNKNOWN TYPES			Possibly superseded by a lower dome	c1895 - 1905
?	Coops Melbourne			Type noted by Prof Lewis	1885 - 1900
1890s?	'Waterproof'			Common in Adelaide & Sth Australia	1885 - 1900
c 1920?	'Helmet'			Common post WWII in Victoria	All unused
?	'Dome'			Less common in post-war Victoria	Few

4.6.23 Circular section roofing nails

This type of roofing nail precedes lead heads and disc heads. These are characterised by displaying a perfectly smooth surface, which has then been galvanised. They started as plain wire but display no signs of dressing marks. The smooth surfaces, which are entirely consistent and very true to diameter size over the period 1865 – 1910, are probably due to the iron wire being dressed by rolling with adjustable sheave rollers in lieu of dressing points, (refer back to fig. 130).⁶³⁵ All samples in this period were 55mm long overall. Earlier samples came in a size range 42mm, 52mm and 58mm. These earlier ones show less sophisticated dressing which has left score marks but would have started as wire. The majority of the samples came from a wide range of buildings and time, and these mainly conform to 5.2 – 5.5 mm dia. The smallest diameter measured 5.0 mm, and came from an 1877 set of samples, all of which showed multiple longitudinal striations, presumably due to roughness in the drawing apertures disguising dressing striations. The thickest samples, from 1856 measured 5.9 – 6.0 mm diameter. For the purpose of the study a change from point dressing to roller dressing types is assumed to have taken place around 1880 and helps provide a useful means of dating.

The other changes noted are to do with the way the points are formed, and unfortunately fit no particular pattern. Some nails have sharp points, but with vastly different angles, most are cut to a square end on one face, and others show a spade end as if the points were pressed. Refer TABLE 4.14.

⁶³⁵ WRIGHT 2010, 10 cites rolling of rods arrived in 1862.

TABLE 4.14: ROOFING NAIL RANGE FOUND DURING THE STUDY

YEAR	ROOFING PIPE NAIL IMAGE	LOCATION	ROOFING SCREW APPEARANCES
1858		Muntham sheep station	
1875		Court Hous sheds, Koroit	
1877		Bonique, Dennington	1879 Sexton's house Warrnambool
1882		116 Banyan Street, Warrnambool	
1887		Artillery Battery hut, Warrnambool	 1885
1888		St Andrews Manse, Port Fairy	1888 Dana, Peppers Road, Tahara
1888		St Andrews Manse, Port Fairy	1890 Elephant Bridge hotel , Darlington
1900		Eagan cottage , Crossley	
1901		Bullen Merri House, Naroghid	
1907		1907 Rifle Downs sheep station	1907 Rifle Downs sheep station

4.6.24 Washers below nail heads

The material composing the washers and their individual thicknesses also appear to be random; some washers were lead, others galvanised iron and a few composition washers were also found.

4.6.25 Launder nails

Before leaving the subject of wire based roof nails, it is pertinent to mention the practice of folding up gutters from flat galvanised sheet iron which were held up by stout long nails passing through both sides of the gutter. The study found three examples of these still in use in-situ and with credible provenance dates on two buildings, table 4.15. The first shown above, nail **N 33**, was found at the Plough Inn, Mount Shadwell, a coaching inn of circa 1865 - 70 of which only the stables survive. This displays the simplest form of gutter made from simple plain sheet. The later find dates from 1888 and was found substantially intact, and the launder nails supported a more elaborate moulded form of gutter, fig. 150.



Fig. 150. Hawthorn Vale farmhouse, Koroit, showing moulded gutter and laundry nails in-situ. Author.

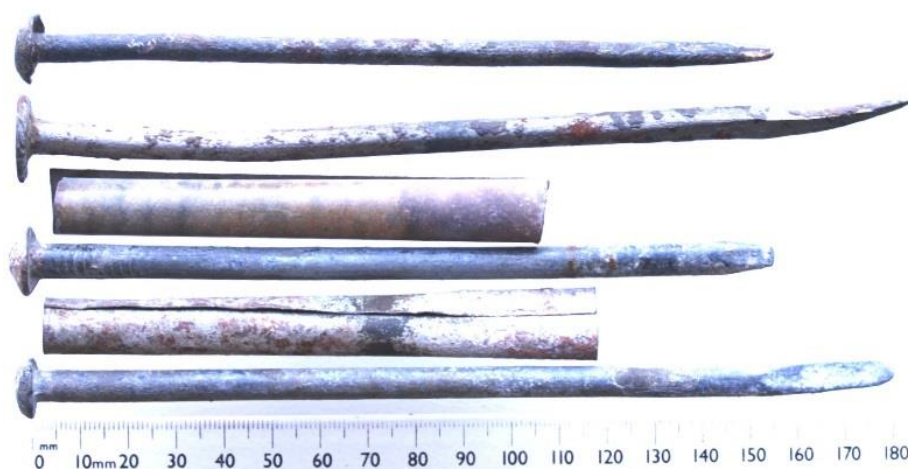


Fig. 151. A range of sheet metal laundry nails & sleeves: the top two were found out of context; nail 3 is from a circa 1880 farm shed: nail four is from an 1888 farmhouse. Author.

It will be noted from the display of typical types of laundry nails found, fig. 151, that three of the samples were produced by the stiddy method, with regular head forms and with points formed by the lower section of the mould. This provides some confirmation of the date range since the documentary evidence suggests that it was in use by the late 1860s in the Black Country (but not in Belper, Derbyshire, where a strike against its introduction occurred in 1872).⁶³⁶

Examination of the samples found show three basic lengths; around 185mm; around 150mm; and some odd sizes around 160mm. The disposition of those found in the study is shown in Table 4.13:

⁶³⁶ BARRAS 1988, 15-16. See also HOW 2017, 81 - 88

TABLE 4.15: LAUNDER NAILS

YEAR	BUILDING & LOCATION	NAIL LENGTH O/ALL	DIA	SLEEVE LENGTH	COMMENTS
1876	History House, Merri St. WARRNAMBOOL	186mm			
1878	Brodie farmhouse, Wangoom Rd.	152mm			Overspill heading
1879	116 Banyan St. WARRNAMBOOL	188mm	7.2mm		Flat head - no chequer
1887	Mozart Hall, Merri St. WARRNAMBOOL	186mm		112mm	
1887	Mozart Hall, Merri St. WARRNAMBOOL	186mm		112mm	
1888	Hawthorn Vale farm, KOROIT	183mm			
1888	Hawthorn Vale farm shed, KOROIT	179mm		105mm	
1889	50 Hopetoun Rd. WARRNAMBOOL	187mm		113mm	
1890	6 Princes St. PORT FAIRY	157mm			
1890	Elm Bank farm shed. ALLANSFORD	160mm		101mm	DISTINCT GRIP MARKS
1890	Elm Bank farm shed. ALLANSFORD	160mm		101mm	DISTINCT GRIP MARKS
1894	91 Lava St. WARRNAMBOOL	183mm			
1905	St Ann's Convent, WARRNAMBOOL	155mm			Possibly earlier
Unknown	Unknown location (WARRNAMBOOL)	152mm			DISTINCT GRIP MARKS

4.7 SUMMARY

The study reveals certain basic changes of direct help in dating finds and these are presented in the order described above:

4.7.1 Wrought nails

At the start of the study period in 1680 there is little to differentiate English and Belgian nails except that the better-quality Belgian iron is evident in the samples once they have been cleaned. France, however, is different as it continued the medieval practice of maintaining a full shank taper. Samples from the German states tend to follow this trend also.

The first change noted is that around 1690 to 1700 or so, a new class of lining nails emerges having fully flattened shanks attributable to the introduction of the Oliver as a single strike flattening tool.⁶³⁷ These curious nails continue until around 1800. Simple headless cut nails were found used in architrave during the study around 1805-1810. There is also some ambiguous evidence that forged forms were made after 1800, similar to the later Cordes and Co rolled lining nail.

Wrought lath nails decrease in numbers with the advent of malleable cast iron versions, circa 1780 but are not fully replaced until 1825 or so, by the cut form lath nail.

Wrought slate nails, having fully regular circular heads are shown by the board of Ordnance tender of 1811/12 and these have appeared in large numbers in 1838, with some isolated finds up to 1856. These identically formed heads (with some occasional extraneous over-strike metal) demonstrate how the die-head Oliver was already in use for this particular service.

Early pipe nails are limited to only two finds during the study and one from 1825 shows clear evidence of having come from rolled rod in the order of 11mm diameter. Smaller diameter swaged samples show forging marks until the mid-1860s.

Production from square rod using the 'stiddy' vertical mould reflects in samples found from around 1863. (See **N 31-8**). The study found that launder nails were most likely formed the same way; initially from stiff wire, but after 1890 or so, from round rod of smaller diameter.

⁶³⁷ HOW 2017, 85-86

A new type of sturdy, tapering shank, flat head, galvanised flashing nail appears in numbers after the mid-1850s. (Refer **N 12**). This continues until the end of the study period.

The paw-head counter-flashing nail is shown by the Grande Encyclopaedie and several samples were collected from 1715 and 1732, made from 12mm wide, thick iron strap. By the mid-1850s samples were made from nail rod with a narrower spread downturn and were galvanised. By the 1880s the downturns were replaced by a weld-on thick circular disc and galvanised after fabrication.

Lastly, the advent of malleable cast iron nails saw significant changes in the forms of the 'medieval' dice-head door nails, - hitherto produced in only two basic sizes. Novel new shapes of door nails become something of a motif of the Gothic revival and the rash of church renovations popular with the coming of the Victorian age. One small point to be noted is that the casting sprue can sometimes be identified on these later nails, since the medieval practice of sinking the nail head partly into the oaken doors was abandoned. This aspect requires further detailed study.

4.7.2 Cast nails

One of the best aids to dating comes from cast lath nails. These appear widely distributed in Britain, Australia, and North America, but all appear to originate from the Birmingham area. They appear in numbers from 1780 on, and the last datable samples have come from 1845 or so. These were effectively replaced by cut lath nails which became ubiquitous by 1825. Their short time span of use is therefore a useful dating tool offering some precision.

The first appearance of the household catenary nail (**N 40**) in 1880 may sometimes help but would need other more conclusive evidences. Similarly, the use of cast brass nails in locks and escutcheons merely provides a suggestion of their predating brass screw popularity, say 1815-30.⁶³⁸

Annealed cast iron door nails have been discussed above, (a).

4.7.3 Cut nails

In the case of British cut nails, the study has found that simple triangular tapering nails were made slightly differently to the American form, in that they normally terminate in a sharp point. These have been found in Britain linings around 1805. The larger sizes, say 50mm or so, have not been found by the study in Australia, and these are later, around 1855.

The first appearance of headed cut nails in Australia found by the study, was in 1854, fig. 117. They were almost certainly produced in England using modified American machines and were made with iron sheet cut counter to the grain, fig. 112 above. By 1870 the American nail was sufficiently established, and the study has found they occurred in large numbers after this date. In one case, circa 1878, the 'medium' variation, was found used to fix large messmate shingle roof palings with only a low number of fractured nails evident.⁶³⁹

The most ubiquitous form of cut nail was the cut floor brad which is still made in Britain, albeit in steel form, having first appeared in 1806, Fig 103. The many slight changes seem to be due to the individual machine settings, and there were no clear changes or chronology evident capable of assisting dating.

⁶³⁸ HOW 2017, 100-101

⁶³⁹ At 84-84 Koroit Street, Warrnambool, circa 1875-78

Profiled sheet cut nails, as derived from the process have no American equivalent, but they appear in several locations in Britain and in Australia starting in 1842 and an unusually late sample was obtained from a weatherboard house of 1889, fig 112.

This nail type is important also because the technique used enabled a close facsimile of the hugely successful Ewbank nail to be made by Cordes & Co. from about 1875, fig. 114. Its success spawned two other like copies from other parts of the nail trade, each using their own trademark head. Several finds of these during the study period suggests that these were produced within a few years of the Cordes & Co. version and all three types continue beyond the end of the study period.

Although available prior to 1870, the American cut nail only appears in numbers around 1870 in the 'fine' version. As more American softwood timber was imported, so the number of finds and the use of the smaller ranges of the 'fine' nail increased. The medium weight version does not start to appear until the very end of the study period around 1888.

4.7.4 Mechanically wrought nails

The first Ewbank nails appear in Australia in 1838 and continue as plain rose-heads until 1869 when the 'star-head' trademarked version appeared. This was followed by the Ewbank square grip version from the Heward patent of 1881. The study found that Ewbanks remained the nail of preference until the end of the study period, with the proviso that Australian carpenters would use the American cut nails in softwood construction as a matter of course.

The big exception to this general rule is that within the then separate colony of South Australia, the Cordes & Co. rolled lining nail appears regularly in approximately the same numbers as the American cut nails used in linings. So far none of the replica cut form of this nail, fig. 133, have shown in an Australian context.

4.7.5 Wire nails

Some generalisations can be made in respect of iron wire nails, and perhaps the most pertinent is the way they are marked by having an acute point and a four-square grip below the head. It is also true that the teeth indentation grip marks are most marked in iron wire nails, but less visible in steel wire nails. A change in metal hardness of around 1879 reflects in a bright coloured iron appearing in small numbers of samples.

The first grey mild steel appears in wire nails in 1888 but after the very first bullet heads, TABLE 4.7. Drum head wire nails and early bullet heads start to appear in numbers in the period 1874-1877.

Some useful dates can be gleaned from the appearance of certain head types:

- The first pyramid head iron wire nails appear around 1874 and continue until the end of the study period.
- The first bun head (or 'Cob' head) appears in 1874 and is only lightly faceted. It continues through to the end of the study period.
- The first squat form of rhomboid head occurs in Victoria in 1882 and proceeds to a regular eight facet form by 1890, repeating in steel wire form till the 1930s.
- Chequered patterned flat heads appear in 1874 and continue through with only minor variations in pattern till modern times.
- The first oval wire nails appear around 1887 in a more malleable steel of light grey colour.

Similarly, the square grip to the underside of heads disappears soon after steel wire nails appear in numbers circa 1890. Prior to this there were some moves towards a two-sided clamping in 1887 and half-round clamping by 1890.

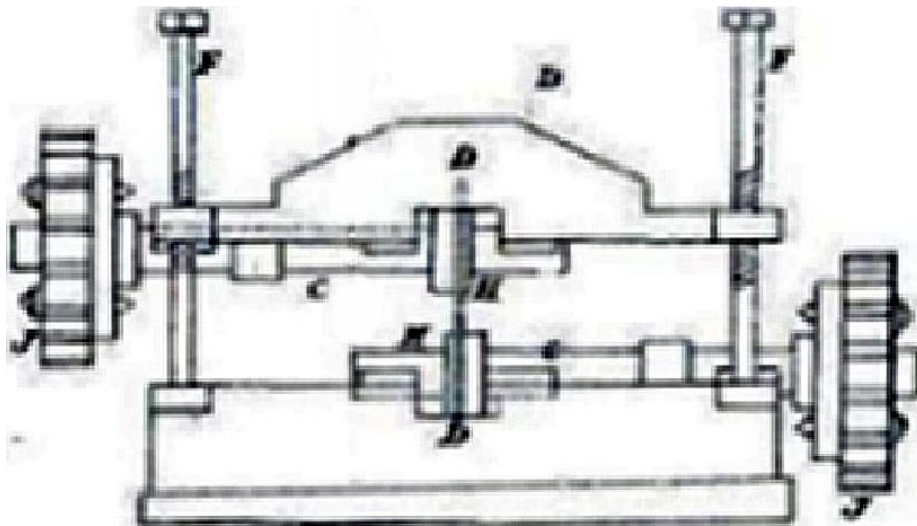
4.8 PROGRESS TOWARDS TIMELINES

The next chapter will use the data obtained to arrive at a tentative timeline system as already outlined in 2.1 above.

Nails shown in this chapter with their origins and provenances are listed in Volume II, Appendix I.

Chapter 5:

Data synthesis



Synchronous gearing of the 1836 Ewbank nail patent rollers.

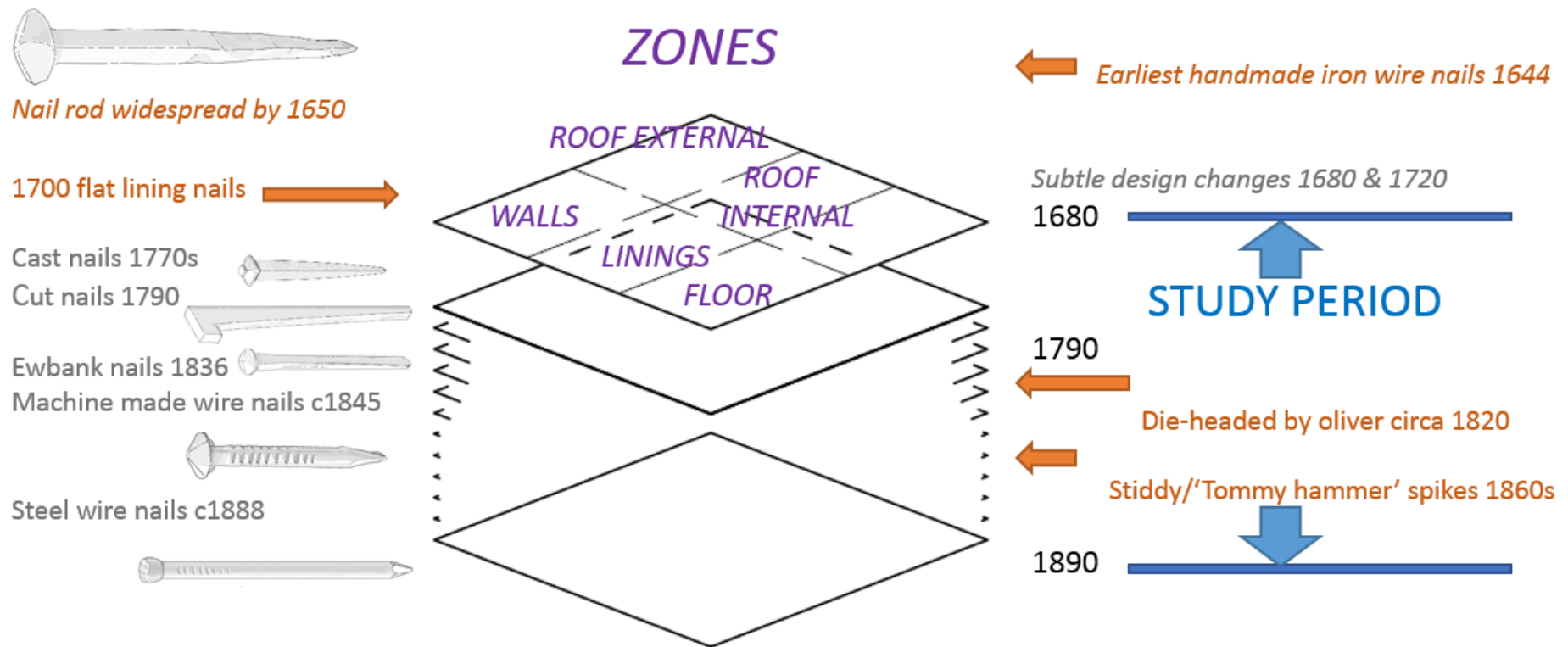


Fig. 152. The matrix adjusted to the study period.

CHAPTER 5: DATA SYNTHESIS

Par cy me le taille. Nicholas de Briart.

OVERVIEW

In order to bring the different elements of the study data together a cut-down version of the matrix developed in chapter 2 provides an analytical model by emphasising the period 1680 to 1890, fig. 152. The different spectra, which for convenience purposes the study breaks into five parts, is superimposed on the decades under scrutiny: Roofs external; roofs internal; floors; Walls and framing; and linings. The types of nails used are lodged around the reduced matrix diagram at their points of introduction, fig. 152. This chapter will detail the progress through the ascending eras which will be broken into more detailed analyses pertaining to the nails found in the various zones, and with respect to the particular era.

5.1.1 Study period changes

The major changes during the study period form already shown in fig. 59 are extended here to provide a useful skeletal framework focussing on how the individual types modify and alter, fig. 153.

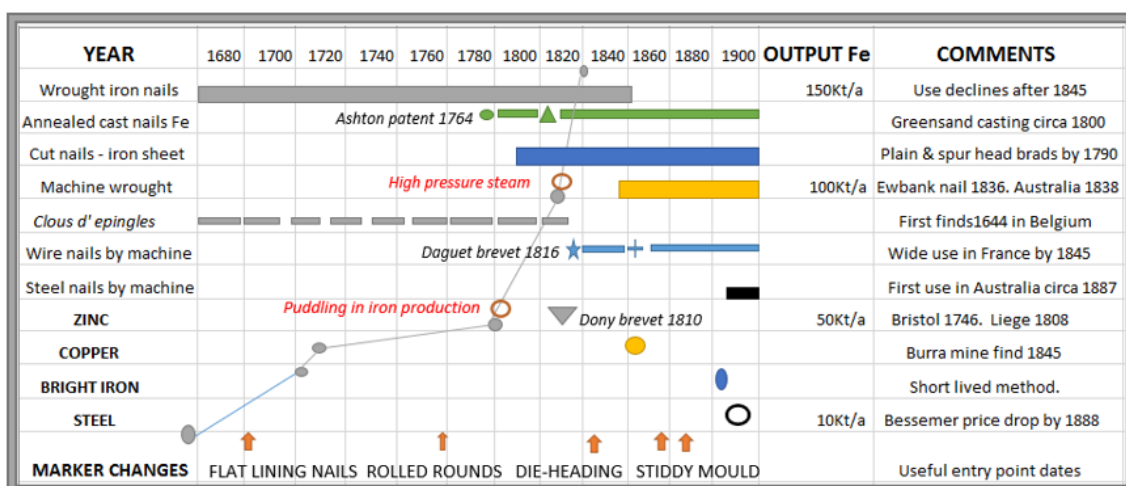


Fig. 153. Inventions and changes in metal production affecting nails during the study period.

The change from one form of metal to another happens in the case of slating nails in particular, and although not absolute in dating, these can be relied upon to give a quick dating range for either the initial construction or for that of re-roofing. As can be seen in fig. 153, the first big change in alternative nail metals came with cheaper zinc produced by the so called 'Liège method' which was developed by the chemist/inventor, Jean-Jacques Dony. The method reduced the price of zinc by nearly two-thirds between 1806 and 1808. Dony received a *brevet d'Invention* in 1810 from the French administration.⁶⁴⁰ The method was quickly adopted across Europe, and, being a homogeneous metal, the existing technology of side pressing for cut nails was more successful than when using cut iron sheet - with its propensity to display lamination. The quality zinc produced by Dony's method was more amenable to cold rolling and it could also be cut easier than iron sheet.⁶⁴¹ The Liège method

⁶⁴⁰ DAY 1996, 377

⁶⁴¹ The method patented by William Champion in 1738, at Bristol, was also a breakthrough in providing zinc sheet, but it required elevated temperatures to successfully roll the sheet, resulting in higher production costs.

reached full development after 1818 under Dony's successors, who then subsequently founded the *Vieille Montagne* Company.

Copper sheet could likewise be easily converted using existing machines and technology, but copper was expensive.⁶⁴² The cost problem was overcome by major finds of high quality copper ores in South Australia at Moonta and Kadina, which was eclipsed by the finding of a huge deposit at Burra, also in South Australia in 1825. It can be seen in fig. 154 how the side pressed iron cut nail technology translated across to both zinc and copper nails unchanged. (See the items marked with a star). Close inspection of these latter samples shows how immaculate the new pressings were in comparison with the cracks and faults which attended the side pressing of iron sheet.

It can also be seen that there was another spindly form of zinc slate nail, found in a 1844 sample from Meredith (near Geelong)⁶⁴³, and again in Portland from 1846. It seems this was quickly abandoned for the existing technology exhibited by the standard cut form of batten nail, Figs. 154 and 116. Its adoption carried with it some risk since the standard form had haunches and an ovoid-rectangular neck. It can be seen, fig. 154, how the standard practice was to make slate nails with a circular neck, which avoided incipient cracking of the stone slates. The same zinc and copper slate nails are found in both Britain and in Australia and both continued unchanged in form into the next century, so presumably the softer metal had little effect on the hole in the stone slate. It should also be noted that a clear die-formed truly circular head wrought type also appears – with an 1838 first find context at Brickenden farmhouse. This has an unusual coating, which requires metallurgical analysis, but which appears to be an alloy of lead and tin. An identical find, but with coarse zinc galvanising instead, was found on the Christ Church, Warrnambool second nave roof of 1861.⁶⁴⁴ The points of entry for the new slate nails provide convenient threshold dates for the study and make them ideal indicator nails.

With the advent of wire nails, copper wire, (perhaps the oldest historical nail material) made a comeback due to its much reduced price and the immediately transferrable technology. They appear towards the end of the study period circa 1875, but at the current state of the study, copper wire nails lack proper provenance.



Fig. 154. The progression of slate nails and the influence of the cut nail technology. Author

⁶⁴² Copper slating nails were recommended prior to the Burra deposit discovery of 1845, but were expensive.

⁶⁴³ Refer back to Fig. 92 for underside view of head,

⁶⁴⁴ The other provenances are; Darshill, Somerset. 1732; Blacksmith's shop at Woolmers, Tasmania 1828; Christ Church rectory 1851; Christ Church first stage nave 1855/6; Chatsworth House roof 1858, Christ Church 1866.

Other types which demonstrate several changes during this period are lath nails, and lining nails. This group of three types form a group of indicator nails and their identification in any building (or part thereof) provides the researcher with a quick appraisal of likely dates, fig. 155.

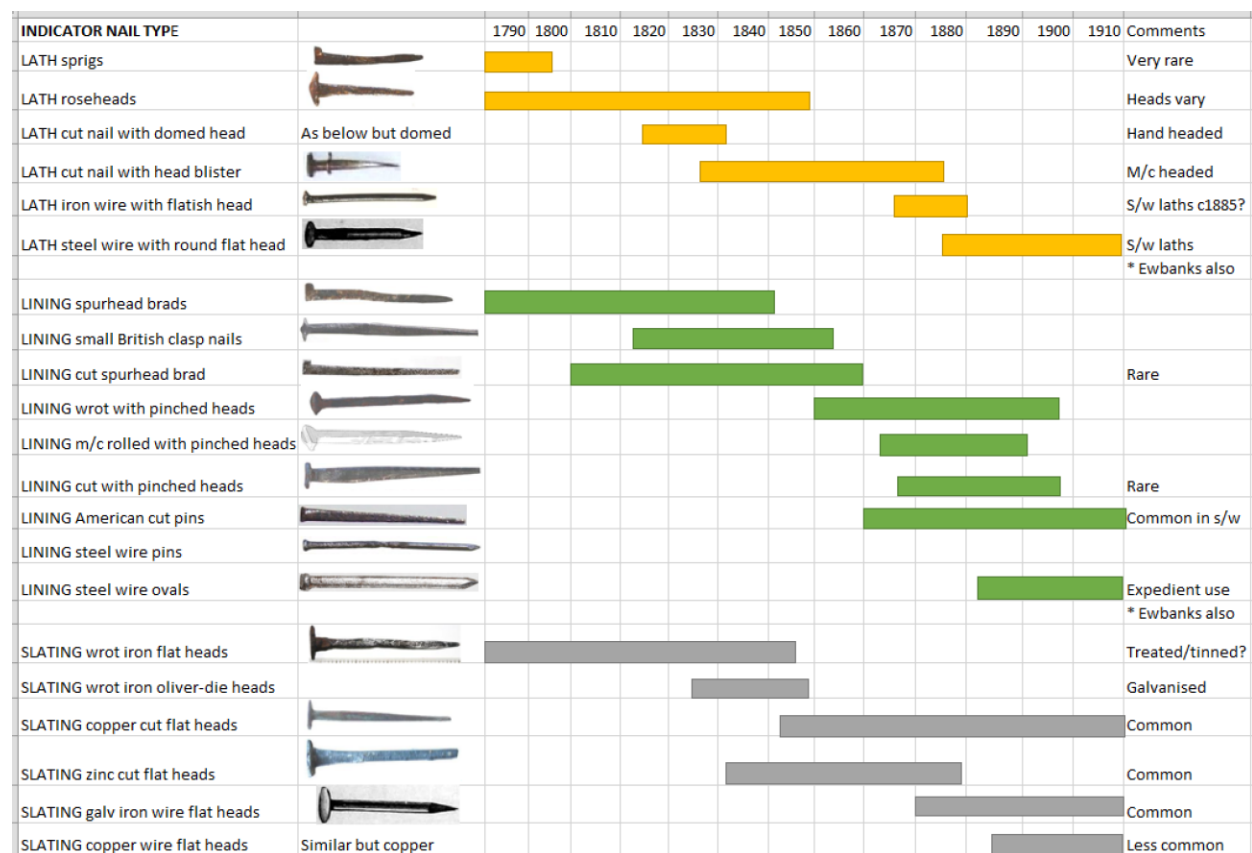


Fig. 155. Changes and timelines from indicator nails: Lath nails, Lining nails, and Slating nails.

5.1.2. Expanding indicator nail timelines

To progress the individual nail-type timeline concept further, certain nail variants, specifically the Ewbank nail and the British cut clasp nail also present clear time lines, fig. 139, and fig. 121; albeit less often. The study has found that these nails are not confined to any one building zone, which can often in itself be an advantage in dating. At one time or another in Australia, the Ewbank nail appears in each of the five building zones. This is undoubtedly a deliberate selection by carpenters of a 'nail of choice', - one which inspired confidence for them to use in the tough and somewhat unpredictable eucalypt timbers. Closely following this, the study found that the British cut clasp nail was also used widely in most zones. Thus we see that the American break with specific types of wrought nail matched to specific use, was a trend which applied to Britain and Australia also.

Whilst these two types fail to exhibit such a large variety of changes, they form a satisfying back-up to the main indicator types. As such they are of importance to researchers in both countries, and in other places influenced by British trade. The Ewbank nail, in its different forms occupies a long presence in Australia (and to a lesser extent New Zealand), first found in 1838 and it was still in use at the outbreak of WWII.

5.1.3. The Ewbank changes

These are particularly easy to follow. As already seen above in Chapter 4, fig. 123, primary identification relates to the spread of the shank towards the tip due to pressure rolling. The balance of identification of the various Ewbank types have also been covered in Chapter 4, sections 4.5.1 – 4.5.3. The original Ewbank nail was a rose-head having a small central pimple, but in 1869 Henry Ewbank sold his interest to the newly formed company of Cordes & Co, which event was marked by the first 'star-head' trademarks, fig. 156. With practice, the next change (of 1881) can be discerned by the square grip to the underside of head. The facsimile version cut nail was probably introduced around 1875 and Professor Lewis has been trying to obtain conclusive proof that this version is the T-patent referred to by the *Australian Ironmonger*.⁶⁴⁵

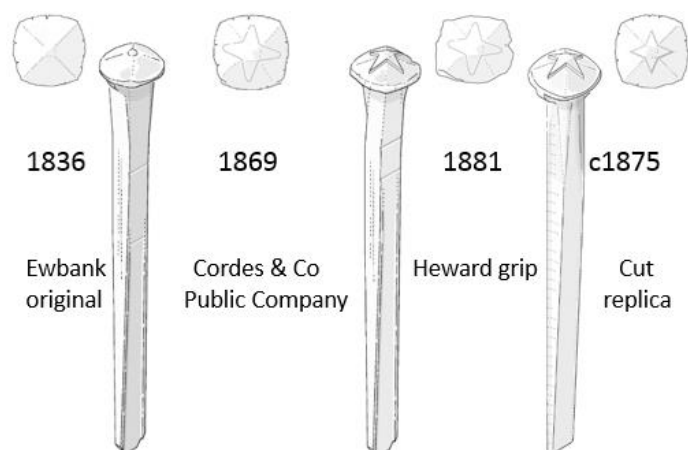


Fig. 156. The progressive changes to the Ewbank nail. Author/McCaig

5.1.4 The British Cut Clasp nail changes

These have already been described above in Chapter 4, sections 4.4.12 – 4.4.13, and also in published articles by the author.⁶⁴⁶ A simplified progression is shown here, fig. 157.

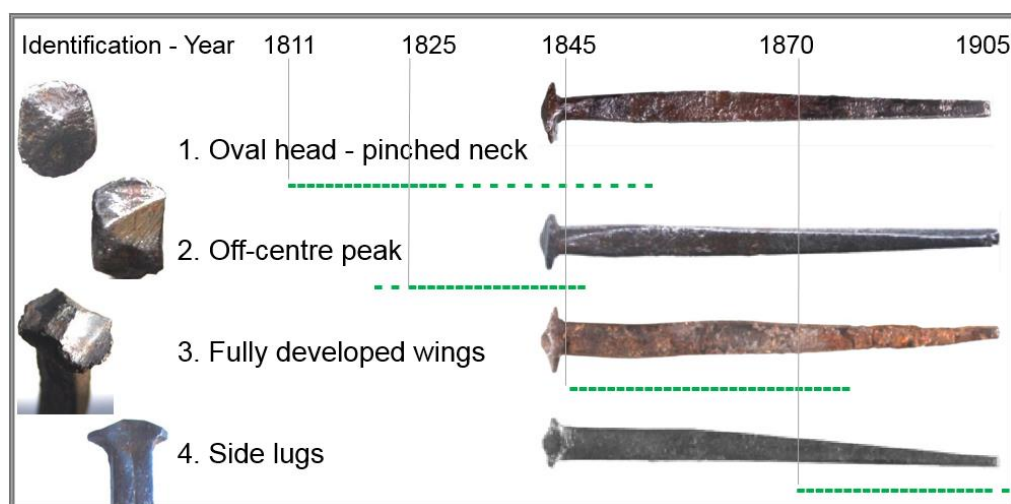


Fig. 157. Progressive changes and tentative timelines for the British Cut Clasp nail.

⁶⁴⁵ HOW 2009, 829-836. Professor Lewis joined me in presenting this paper at the Cottbus CHS conference in 2009. A further Ewbank paper was presented at the Australia ICOMOS Adelaide conference: HOW 2015.

⁶⁴⁶ HOW 2014, 231-238. See also TATHS Newsletter 137 of October 2017.

These derive from a side pinched cut version of the common nail which has been found in both Britain and Australia, and late examples of these were found in 1848 and 1856 contexts. Samples of the first trend towards splayed 'wings' have been found in an 1825 in Brighton in England, in a circa 1850 context. Large numbers of samples, in widespread locations, of a fully 'winged' version appear from 1846 to towards the end of the study period. However, a reduced side extension supersedes the version with wings around 1870, which has remnant lugs each side of the head. This version continues through into the following century and is then gradually replaced by steel versions which are even more restrained laterally.

5.2 Nail occurrence patterns within each Zone

Although all nail types present individual time lines their presence varies according to the building zone and the era in which they were inserted. The following charts present the information gained by the study, as time lines related to where they were found. Key events may be of short duration and they and others have no particular relevance to any one particular zone. Thus these events have been termed 'zone-free', and in the series of charts which follow these are presented first, fig. 158.

ZONE-FREE: SHORT TERM EVENTS & FIRST APPEARANCES (AUSTRALIA)

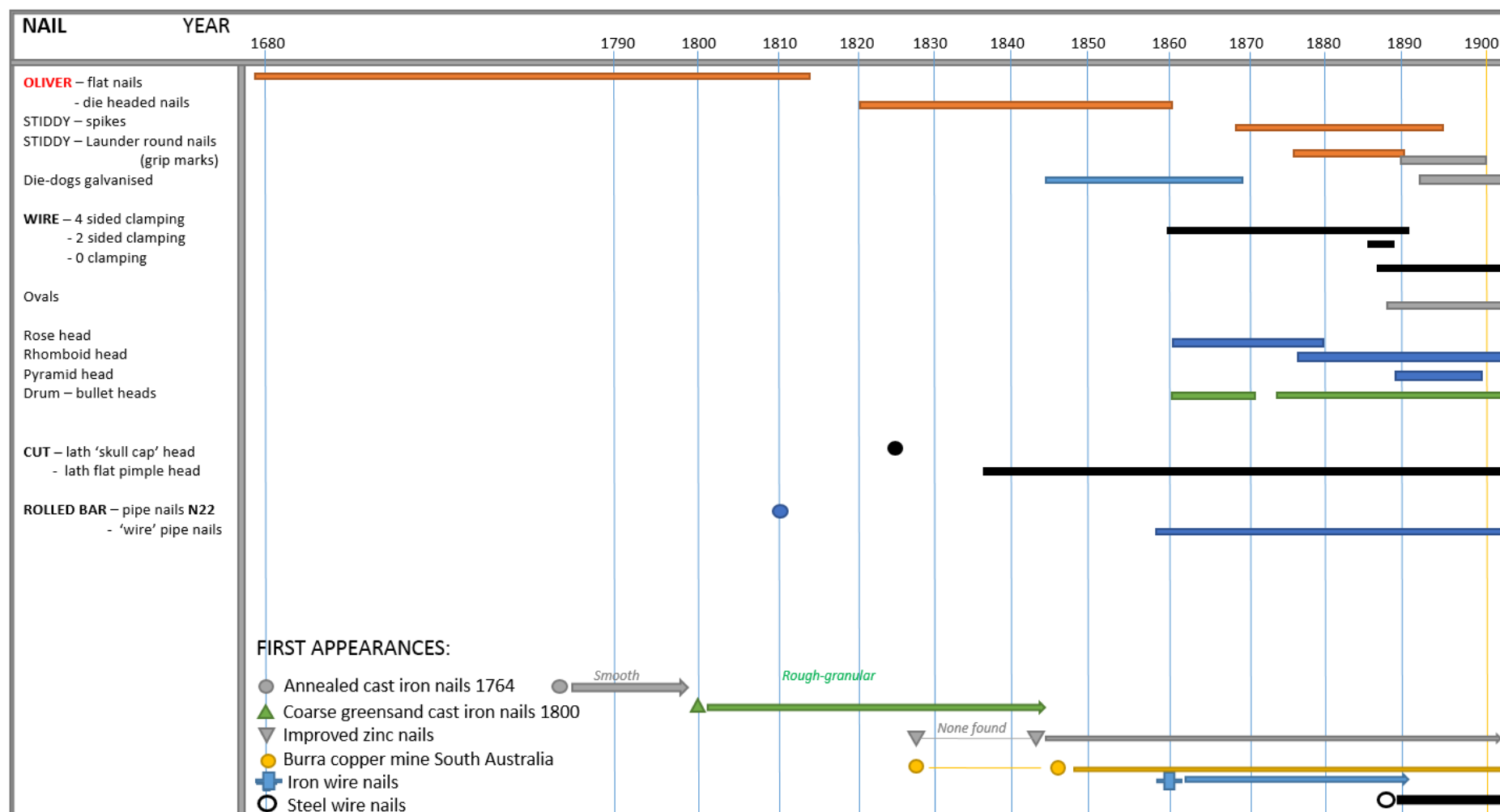


Fig. 158. Individual and short term events presenting dating possibilities.

ZONE 1: Roof external – coverings, flashings, and gutters

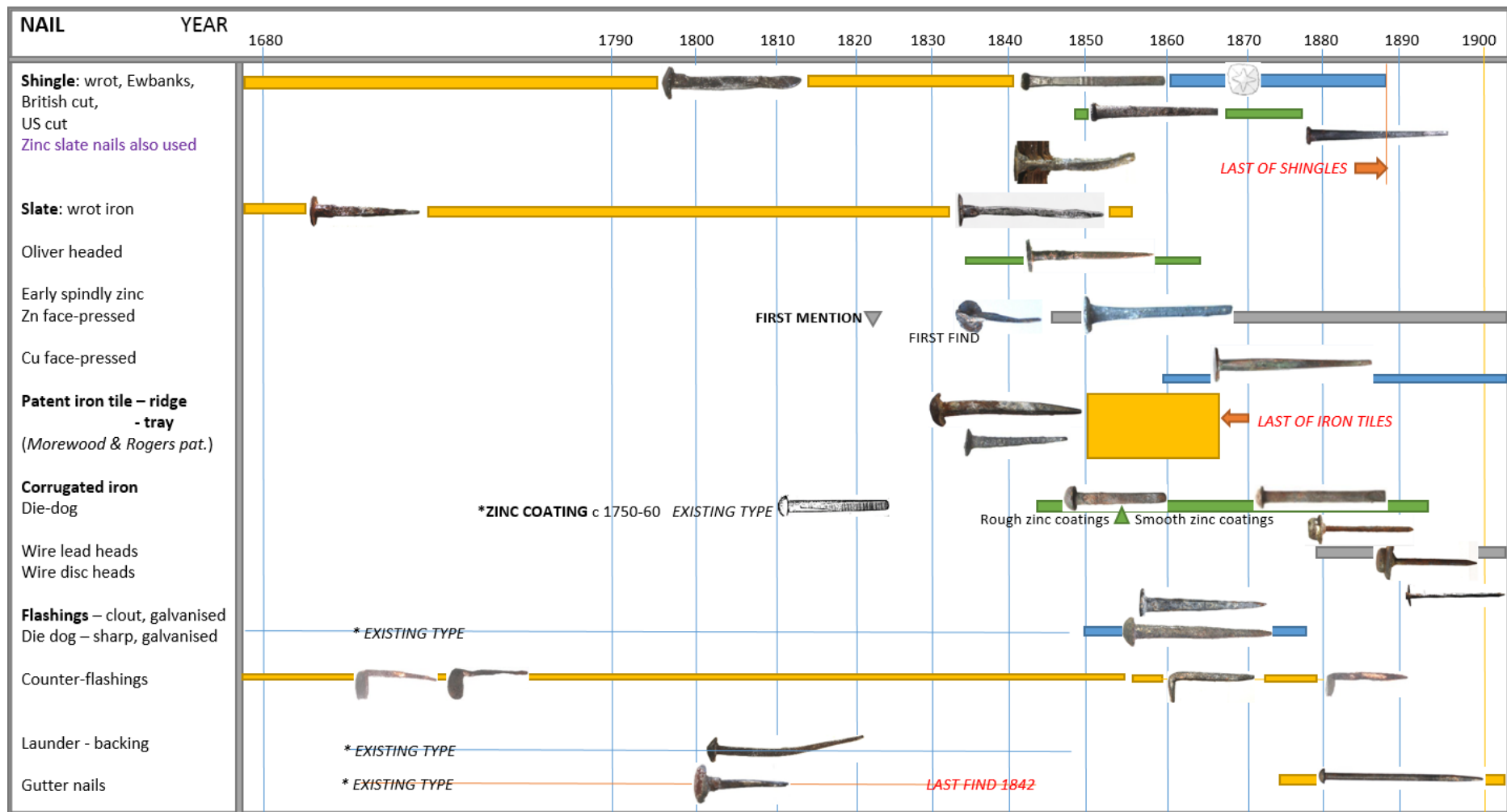


Fig. 159. Zone 1 nails - used in external roof cladding during the study period.

ZONE 2: Roof internal – battens, rafters, purlins

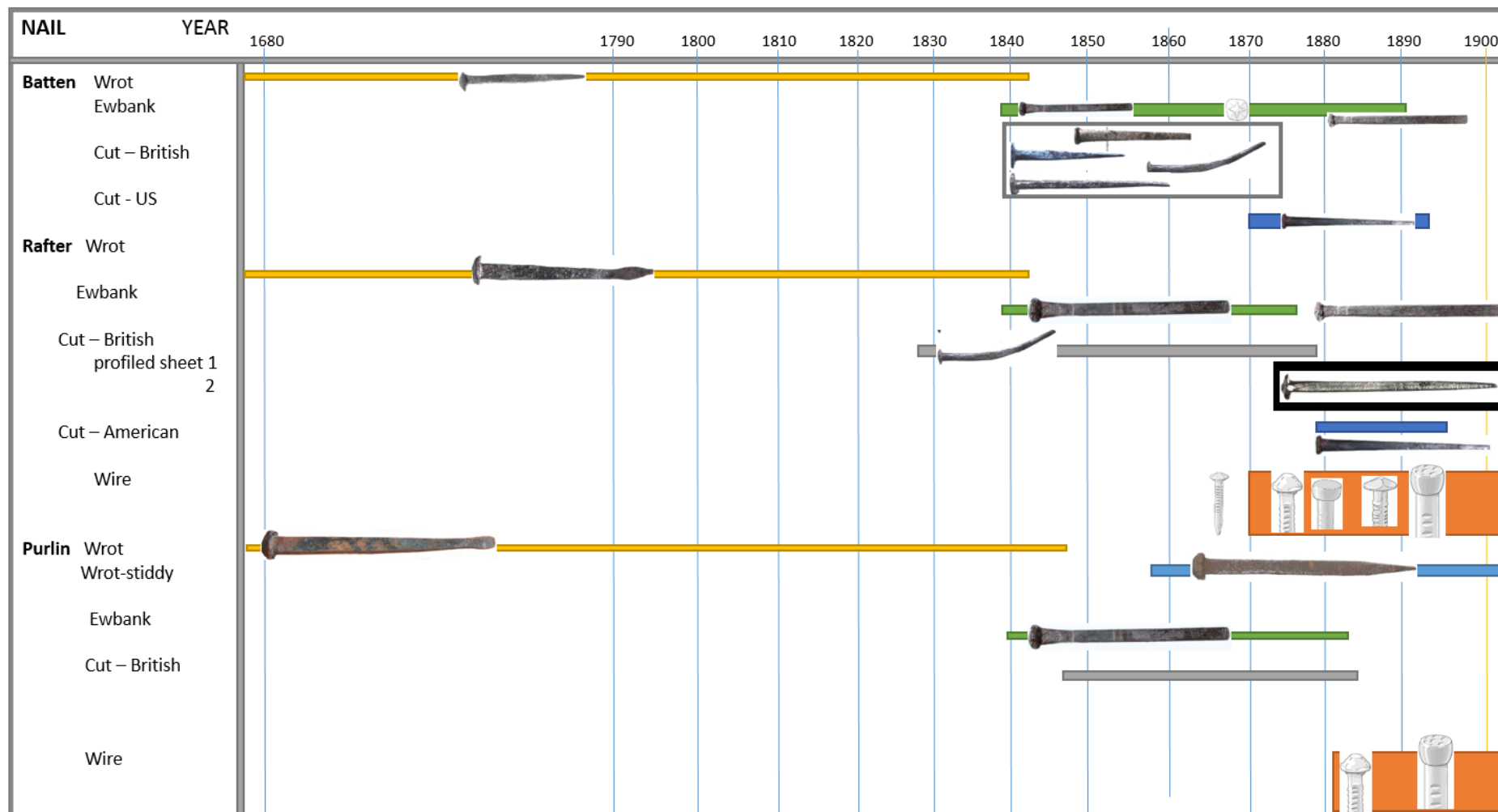


Fig. 160. Zone 2 nails - used in internal roof framing during the study period.

ZONE 3: Walls — frames, partitions, laths, fixed items

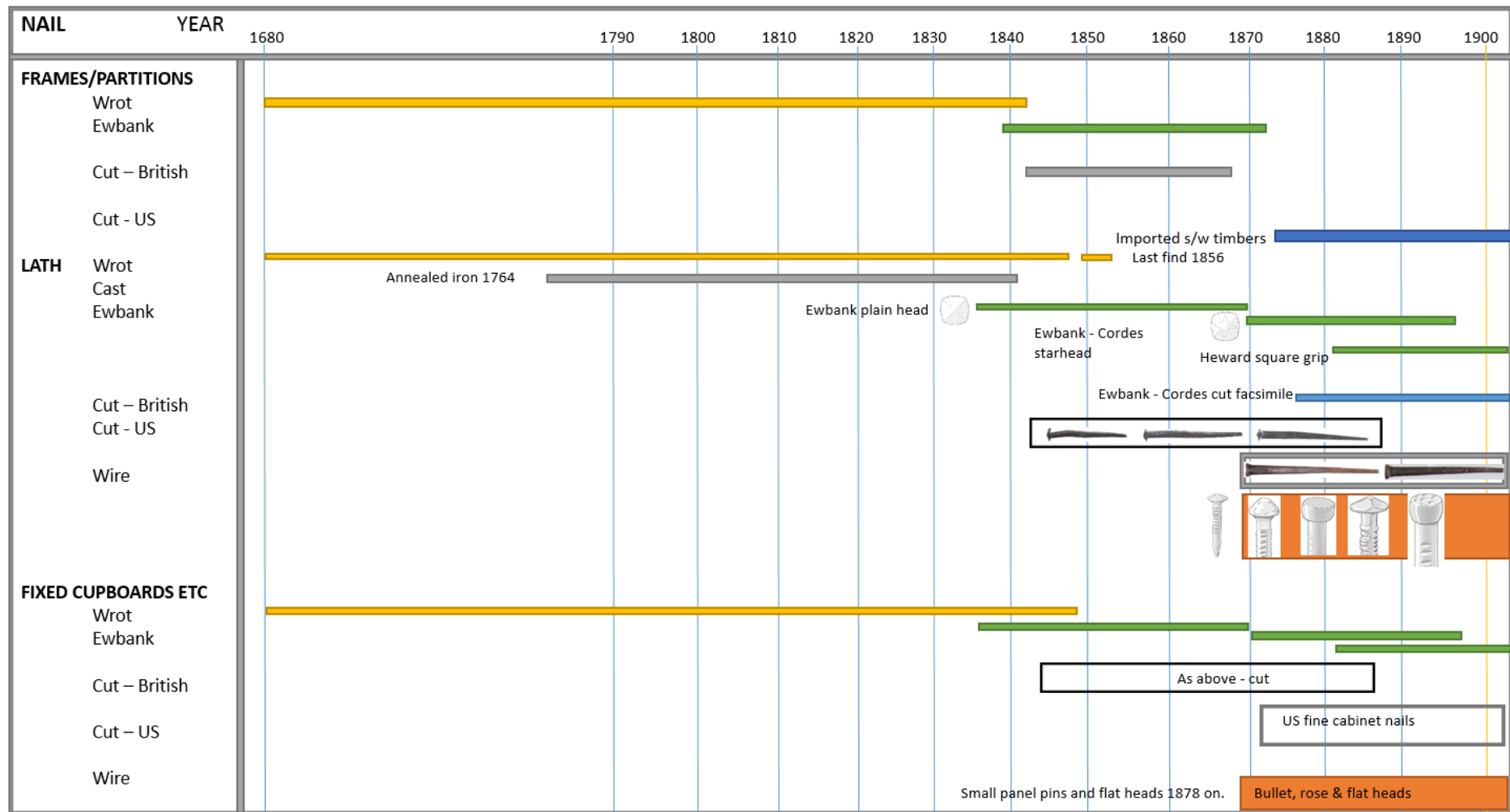


Fig. 161. Zone 3 nails - used in walls and partitions during the study period.

ZONE 4: Floors – floorboards, joists, bearers

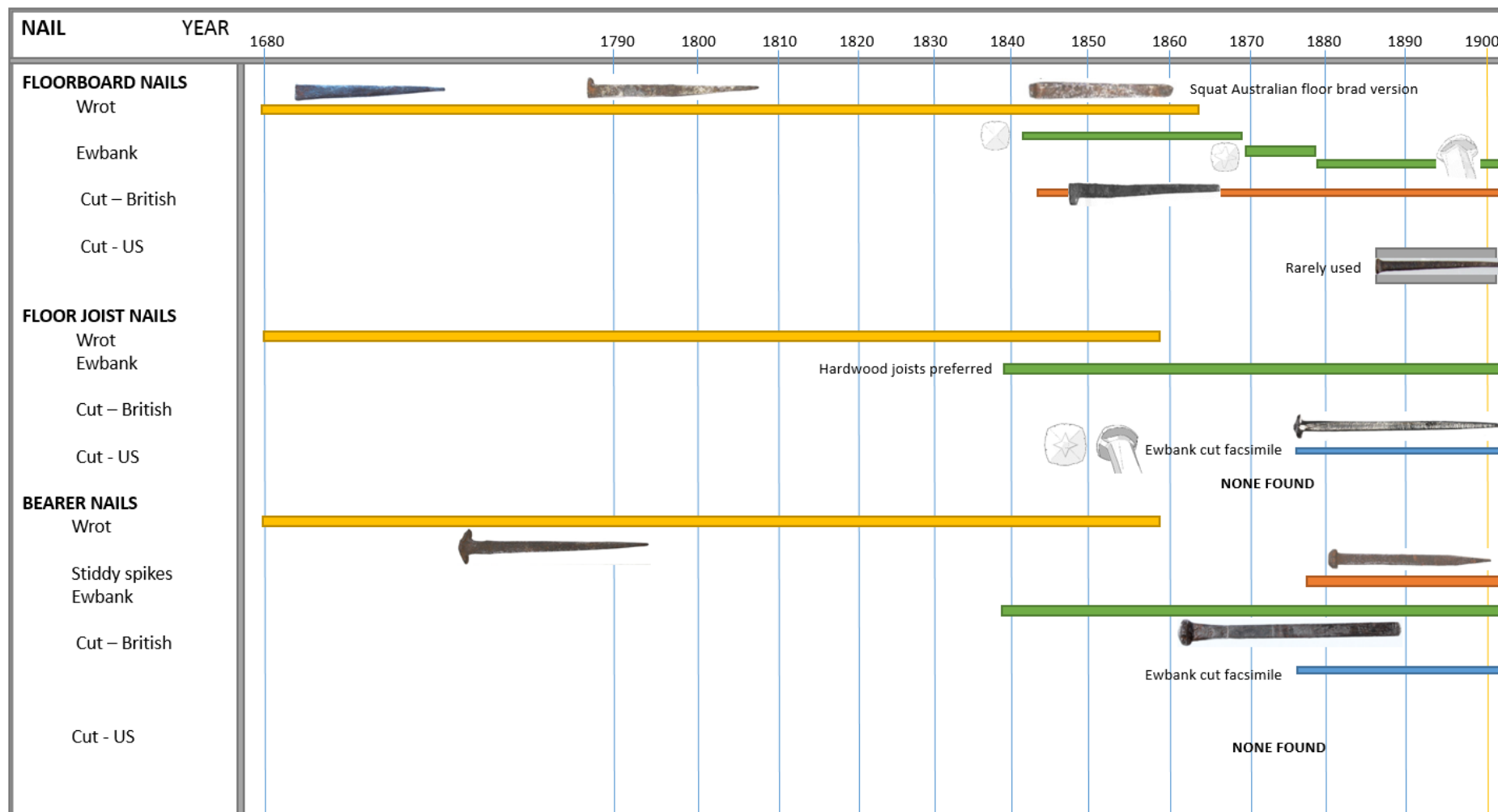


Fig. 162. Zone 4 nails - used in floorboards and sub-floors during the study period.

ZONE 5: Linings — door and window frames, casement reveals, sills, architraves

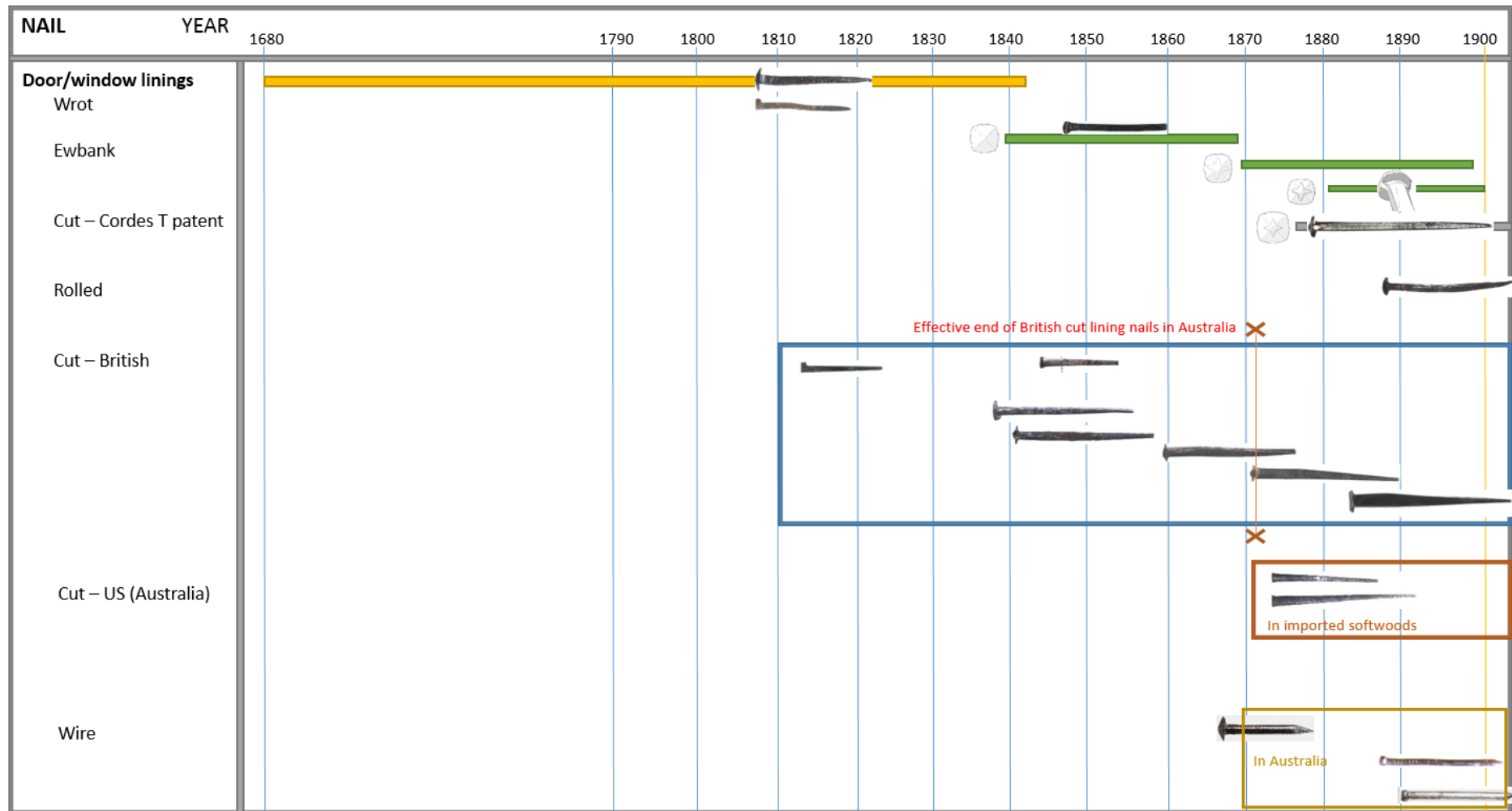


Fig. 163. Zone 5 nails - used in floorboards and sub-floors during the study period.

5.3 Nails in Zone analysed by decades

By combining the information into a series of charts representing the decades a simple set of charts can be derived of use to heritage officers, archaeologists and all other interested parties. These charts now follow, but with the proviso that there are no significant changes able to be used for dating purposes prior to 1790, although some inferences can be drawn.

To further ease the strain of recalling all the historical events and characteristics already outline above and in the author's papers, each chart is accompanied by a set of explanatory notes.

The main sources of nails for the study in the Australian context are set out in fig. 164.

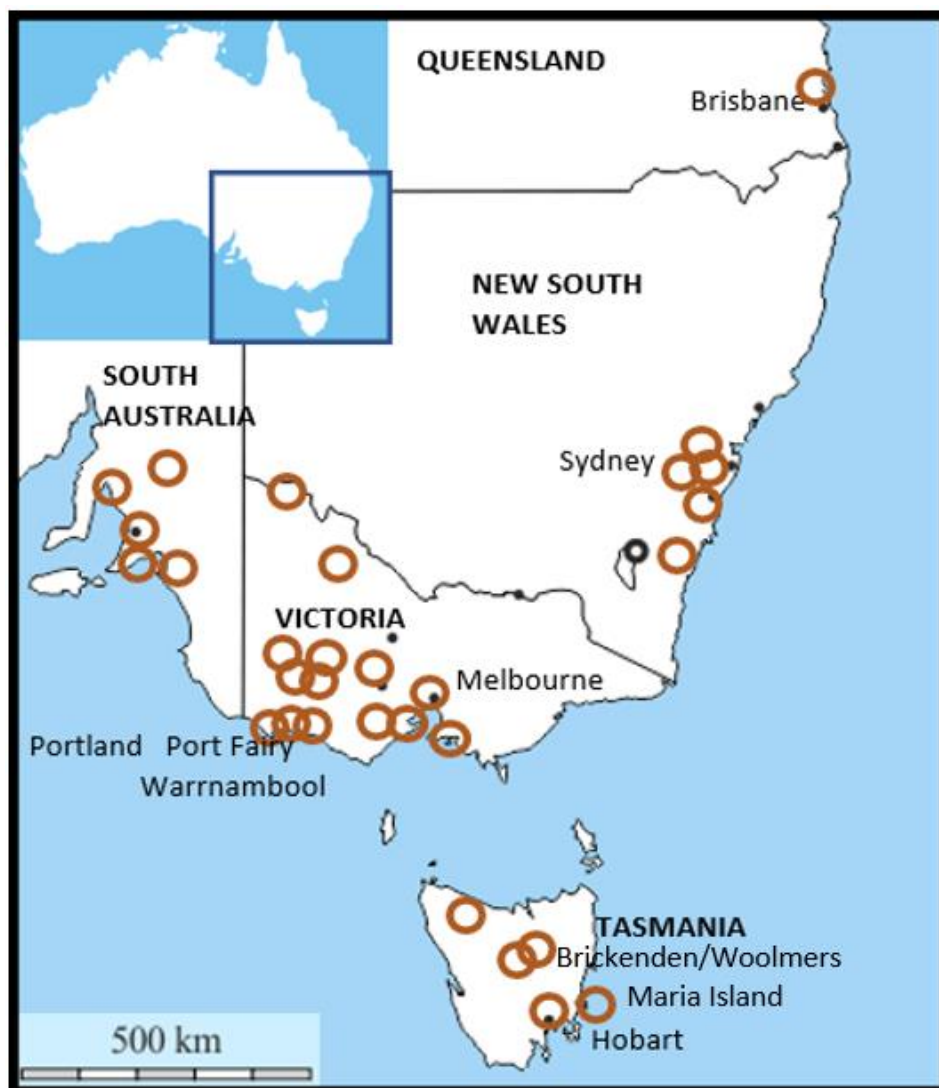


Fig. 164. Locations of the main Australian nail sources of used in this study.

5.3.1 DECADES DURING PERIOD 1750 -1790

Pertinent events

Flattened lining nails regularly appear during this period but none has yet been found with a provenance post 1804.

In 1788 the First Fleet lands at Botany Bay in New South Wales with selected numbers of Royal Marines with a trade background to teach the transported convicts nail-making and other trades.

Characteristics:

In Britain steady progress was made during this period which circumvented problems with inferior iron ores by the use of coke and improved smelting techniques. Steam power assisted both mining and industry from 1712 onwards with a major jump in efficiency in 1776 from the Bolton-Watt engine. Russian iron comprised the cheapest source of nail rod iron during the whole of this period.

Zone 1 – nails adopted for roof claddings and for external features

Existing styles of wrought nails were adapted and made suitable for the new style of buildings dictated by the regulations enacted after the Great Fire of 1666.

Zone 2 – nails used for roof interiors

As noted above. Greater use of parapets created a need for flashings and counter-flashings which required the turn-down 'thumb' head. It also increased the use of internal launders with lead head nails and backing nails.

Zone 3 – nails used in wall framing and for lathing

As above, except for the range of annealed cast iron nails arising from Ashton's patent for coffin nails of 1764. This opens new possibilities for cast lath and cast door nails circa 1770. Refer figs. 102, 104, **N 36**, **N 37**, and **N 41**. Annealed cast iron lath nails appear in both Britain and Australia and present a useful change in surface texture in which a smooth surface is found prior to 1800 or so, and then changes to a coarse sand finish after.

Zone 4 – nails used flooring and sub-floor construction

As above for Zone 1.

Zone 5 – nails used in linings, window and door reveals and second fixings

As above for Zone 1.

DECADE 1790-1800				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			12mm rolled bar	N 28-1. N 26-2. N 2-4. N 8-1./ N 19. N 7-1732 Darshill chimney.
Z2 Roof inside				N 15-4. N7-1732 Darshill. N 31-5 Ditto. N 31-6./ N5A-3. N23. N 18. N 1. N 31-3. N 23-3.
Z3 Walls			Smooth casting medium Cast Fe	N 5A-2. N 2-4. N 7. N 17A-1. N 17 B1. N 36-3
Z4 Floors				N 4-1. N 4-1784 W/m. N 31-4./ N 23-2.
Z5 Linings			Oliver flattened nails Cast bronze	N 20-2. N 20-4. N 6-1. N 39./ N 3. N 6-typ 1680. N 6-typ 1680b

Fig. 165. Tentative nail spectrum for 1790 – 1800.

5.3.2 DECADE PERIOD 1790-1800

Pertinent events:

Thomas Clifford of Bristol lodged two ground breaking patent applications. The first, number 1762 of July 1790 was for a machine for rolling out strings of shaped nails. The second adopted profiled rolling of iron sheet. In the same year the first American patent application was lodged for nail shanks cut from rolled flat sheet. In 1796 Guppy patented a revolving drum device using opposed slanting cutters to sever thin brads, a principle which anticipated the later shredding of nail strip in the manufacture of simple lath tacks.

Characteristics:

The culmination of factors at the advent of this epoch, shown in Table 3.2, help to explain the quantum leap in iron production post 1783. For the first time we see (effectively) three methods of nail manufacture in process: wrought nails adapted to suit the new style of fireproofed buildings which had been in development since the 1680s, cheap annealed cast iron nails, and machine made nails which start to take off just prior to 1790.

Zone 1 – nails adopted for roof claddings and for external features.

These were essentially untouched by the technical advances of annealing and machine manufacture, apart from the surge in several types of large iron spike nails used in roof construction which became possible as improved costs in iron production allowed heavier nails to be made.

Zone 2 – nails used for roof interiors

These comprise wrought rosehead commons whose application is distinguished by length: Rafter heel and birds-mouth circa 55mm; Rafter/plate circa 85mm. Rafter to purlins are nominal 150mm spikes - usually T-headed, but some round headed ones occur also.

Zone 3 – nails used in wall framing and for lathing

Cast lath nails appear alongside wrought lath nails. Both types continue into the 1840s but both become slightly larger after 1800. Annealed cast iron lath nails present a useful change in surface texture in which a smooth surface is found prior to 1800 or so, and then changes to a coarse sand finish after.

In Australia wrought lath nails get to be the same size and characteristics of shingle nails of an earlier period. The speciality 'strong' version rose-head has been found in this decade but appears to phase out soon after 1800. Wrought clasp nails are widely used in quality buildings in London, with only a few rose-head commons found.

Zone 4 – nails used flooring and sub-floor construction

Headless floorboard brads were the preferred nail for use in hardwood floors and extensive use of these continued into this decade. The wrought version was not plain sided but had a lateral swelling mid-span and a slight transverse widening at the head. Only a few plain sided cut brads have been found. Spur head floorboard nails appeared prior to 1790 but become more common in softwood flooring. Joist/bearer connections used small spikes, both T-heads and round heads.

Zone 5 – nails used in linings, window and door reveals and second fixings

These continue to be the familiar lining brads and wrought iron tacks as used earlier.

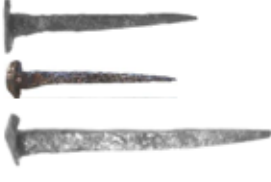
DECADE 1800-1810				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			First ref to Zinc slate nails 1808 Rolled 12mm bar.	N 28-1. N 26-2. N 2-4./ N 8-1. N 2-4.
Z2 Roof inside				N 15-4. N 32-2. N 31-5./ N 15-4.
Z3 Walls		 Change to sand casting		N 2-4. N 31-6. N 17 B1. N 36-3 Cast Fe
Z4 Floors				N 4-1. N 4-2. Fig. 118-1&2
Z5 Linings				N 20-4. N 6-typ 1680. N 6-1./ N 16-1. N 9.

Fig. 166. Tentative nail spectrum for 1790 – 1800.

5.3.3 DECADE PERIOD 1800-1810

Pertinent events

British industry increased and modified with the aid of steam power to supply British and allied forces in the fight against Napoleon. New South Wales experienced hardships and meagre supply due to French naval forces in the Indian Ocean, but a new colony, Van Diemen's Land (Tasmania), was founded by establishing bases in Hobart in 1803 and in Port Dalrymple in 1804.

Characteristics:

There are few direct physical changes between this decade and the earlier one, except that it is marked by an increase in the number of cut brads used to secure floorboards. It possibly marks the end of Oliver-flattened lining nails since so far none have shown up in this period. High quality nails requiring clenching were still dependent on Swedish iron, but British iron was used for most nail products.

Zone 1 – nails adopted for roof claddings and for external features

These continue to be wrought nails made to specific patterns.

Zone 2 – nails used for roof interiors

These continue to be wrought nails after traditional usage.

Zone 3 – nails used in wall framing and for lathing

These continue to be wrought nails after traditional usage.

Zone 4 – nails used flooring and sub-floor construction

Wrought floorboard brads, both headless and spur-head continue to be used but their cut forms appear alongside them in small quantities.

Zone 5 – nails used in linings, window and door reveals and second fixings

These continue to be light commons with the familiar lining brads and wrought iron tacks as used earlier.

DECADE 1810-1820				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			Composition metal nails	Fig. 170-1838 N 28-1. N 26-2. N 2-4./ N 8-1. Fig.95.
Z2 Roof inside				N 15-4. N 31-5 N 31-6./ N5A-3. N23. N 18. N 1. N 31-3.
Z3 Walls				N 7-2. N 7-1. N 17 B1. N 36-3.
Z4 Floors				N 4-1. N 4-2. Fig. 118-2. N 31-4./ N 23-2
Z5 Linings				N 7-2. N 20-4. N 6-typ 1680./ N 3.

Fig. 167. Tentative nail spectrum for 1810 – 1820.

5.3.4 DECADE PERIOD 1810-1820

Pertinent events:

Advances in steam power and in technology affect nail production during this period particularly in respect of cut nails. By 1815 Britain was self-sufficient in iron production and costs had fallen below Swedish iron. Small amounts of Russian iron were still used for nail rod production.

Characteristics:

There are still few direct physical changes between this decade and the earlier ones. Although some wrought floor brads still occur there is a further increase in the number of cut brads used to secure floorboards. No Oliver-flattened lining nails have so far none have shown up in this period.

Zone 1 – nails adopted for roof claddings and for external features

A proportion of wrought iron slate nail shanks are thinner in this decade which may be due to nail rod being slit to smaller dimensions. Some innovative cast nails using a composition metal appear in Britain but not in Australia. There are suggestions that slating nails were being made at several centres by local blacksmiths and these are heavier than the English pattern.

Zone 2 – nails used for roof interiors

These continue to be wrought nails after traditional usage.

Zone 3 – nails used in wall framing and for lathing

Annealed cast iron lath nails appear in both Britain and Australia and present a useful change in surface texture in which a smooth surface is found prior to 1800 or so, and then changes to a coarse sand finish after.

The first cut lath tacks, which had a 'skull cap' shaped head, were found in Tasmania circa 1828 and in Sydney 1835.

Zone 4 – nails used flooring and sub-floor construction

Wrought floorboard brads, both headless and spur-head continue to be used. Cut forms of floor board nails appear in larger quantities. Heavy 'square nails' are found, used to penetrate the dense eucalypt timbers used in sub-floor bearers etc.

Zone 5 – nails used in linings, window and door reveals and second fixings

These continue to be light commons with the familiar lining brads and wrought iron tacks as used earlier.

DECADE 1820-1830				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			Zn slate nails available 1808 none found. Oliver die-head slating nails	N 28-1. N28-3. N 26-2./ N 8-1.
Z2 Roof inside	Wrought nails & first British cut commons 			Fig. 121-1
Z3 Walls			First die-head cut lath tacks appear in Aus. circa 1827. Wrot lath nails over sized in Aus.	N 17 B1. Fig. 132-1 N7-1. N 36-3./ Fig. 132-2
Z4 Floors			Less wrought spur head floor nails used. Locally made Australian floor brads.	N 4-2. Fig. 118-2. N 31-4./
Z5 Linings			Flat lining nails no longer appear	N 7-2. N 20-4.

Fig. 168. Tentative nail spectrum for 1820 – 1830.

5.3.5 DECADE PERIOD 1820-1830

Pertinent events:

By mid-decade the advances in steam power and in technology had enormously increased iron production. This affected nail production during the period and saw much progress made in respect of cut nails. Importation of Russian iron for nail rod production ceased.

Characteristics:

In spite of the large number of patents lodged there are few remarkable changes during this period.

Zone 1 – nails adopted for roof claddings and for external features

There have been tentative finds of Oliver-headed circular headed slating nails which have an unusual surface protective coat. Although zinc slating nails are referred to during this period none have so far been found. British cut clasp nails have been found used to fix slating battens. Batten nails are often cut form iron resembling the cut zinc slating nail in shape and size. Ewbank nails, with a plain rose-head enter Australia in 1838 and significant numbers of this date were recovered from battens to Brickenden farm house.

Zone 2 – nails used for roof interiors

British cut clasp nails found used to skew nail rafters.

Zone 3 – nails used in wall framing and for lathing

The first cut lath nails show at the end of the last decade and are remarkable in having a rounded 'skull-cap' head – probably hand headed with a bench Oliver. Later versions are machine headed.

In Australia locally made lath nails appear in well oversized dimensions – resembling shingle nails.

Zone 4 – nails used flooring and sub-floor construction

Wrought floorboard brads, both headless and spur-head were still used. Cut forms of floor board nails appear in larger quantities alongside a short stubby spur-head floor brad which is always found in sawn eucalypt flooring. Short wrought spikes used to secure joists to bearers.

Zone 5 – nails used in linings, window and door reveals and second fixings

No Oliver-flattened lining nails have been found in this decade.

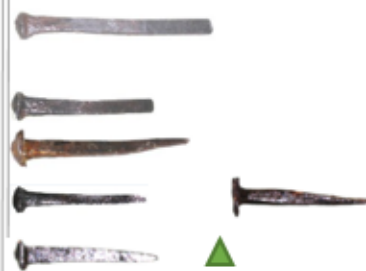
DECADE 1830-1840				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			Die heads by oliver. Ewbanks 1838. Zn slate nails	N 28-5. N 28-3. N 26-2. Fig. 131-1. T4-5. T4-6./ 1838 Ewbank N 8-1. Fig. 20-4
Z2 Roof inside			Early British cut clasp nails. Profiled cut nails.	1838 Ewbank. Fig. 50. Fig. 119-1. Fig. 128-3
Z3 Walls			Small Ewbanks often used for lathing. Cut lath tacks prominent. Cast Fe.	1838 Ewbank. 1846 Ewbank. N7-1. Fig. 132-1. Fig. 132-2. N 36-3.
Z4 Floors			Wrought floor brads still in use, with stubby Aus made floor brads.	Cut brad 1848. N 4-2. Fig. 118-2. Fig. 28-4.
Z5 Linings			Wrot clasp nails still used till 1908	N 7-2. N 20-4. 1840 Ewbank. Wrot tack 1860

Fig. 169. Tentative nail spectrum for 1830 – 1840.

5.3.6 DECADE PERIOD 1830-1840

Pertinent events:

The advent of rail at the start of the decade saw increased export of British iron goods including nails and an effective end to Canal construction by mid-decade. However, canals continued to provide the main method of transport for bulk coal, ore, coke and finished products.

The relatively prosperous conditions would change in 1839 due to bad weather across Europe and the British Isles which brought disease to wheat, rye, and a potato blight. Hardships in England and Ireland spurred migration.

Characteristics:

The production of Ewbank nails from Dos Works at Newport in 1836 sets a dominant marker date for this period. Production started in Britain in 1836 but it seems the first Ewbanks to reach Australia were in 1838. Zinc slating nails started to take over iron ones. The earliest were spindly but they were quickly followed by the standard cut form. This decade appears to be the start of the profiled sheet cut nail and many samples have been found in Britain and Australia

Zone 1 – nails used in roof claddings and for external features

In addition to the points already mentioned the first cut batten nails have been found. No copper slate nails were found in this decade, but several finds of coated Oliver-formed head wrought iron appeared.

Zone 2 – nails used for roof interiors

Wrought, cut, profiled sheet cut, and Ewbanks were all used.

Zone 3 – nails used in wall framing and for lathing

This decade sees a preponderance of cut lath tacks with the typical 'blister' head established. Cast and wrought lath nails all appear in different buildings.

Zone 4 – nails used flooring and sub-floor construction

Ewbank nails with a plain facet head  appear in all zones, including sub-floor, where used as short spikes.

Zone 5 – nails used in linings, window and door reveals and second fixings

There are no apparent changes to lining nails in this decade excepting the use of Ewbank nails often with heads flattened by hammer to align with grain.

DECADE 1840-1850				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			Rolled pipe nails 1848. Effective end of wrought nails in Aus.	N 8-1. Fig. 20-4. N 26-2. Fig. 117-1. 1838 Ewbank. N 10-3./ Fig. 23-2. Fig. 90-2. N 28-5
Z2 Roof inside				Fig. 50. Fig. 128-3 Fig. 121-5
Z3 Walls	 Small Ewbank lath & lining nails ▲ Last finds circa 1842			1844 Ewbank. Fig. 121-4.
Z4 Floors				Cut brad 1848. Fig. 118-2. N 4-2. Fig. 28-4.
Z5 Linings			First cast brass screws replace nails in locks etc	Fig. 121-4. N 7-2. N 20-4. 1844 Ewbank

Fig. 170. Tentative nail spectrum for 1840 – 1850.

5.3.7 DECADE PERIOD 1840-1850

Pertinent events

In addition to the points already mentioned the first cut batten nails have been found also. This decade also sees the entry of flat galvanised iron tile roofing by Morewood and Rogers requiring galvanised ridge and tray nails. Around 1845 the first zinc coated die dogs appear and grow in numbers in the next two decades. CGI entered use in Britain in 1847 and by the early 1850s was making an impact in Australia.

Characteristics:

Ewbank nails became a dominant feature during this period, particularly in lath and batten size. The period was marked by the absence from buildings of nearly all wrought nails by the mid-1840s. Slate nails are balanced between the round-headed Oliver-die struck heads and a mix of the last wrought nails and cut zinc versions. Slating nails made of copper are rare in this decade. Many zinc slate nails. Many galvanised die-dogs.

Zone 1 – nails adopted for roof claddings and for external features

Zinc slate nails have shown up in wooden shingles with many finds of the sturdy British cut nail

Zone 2 – nails used for roof interiors

Wrought, cut, profiled sheet cut, and Ewbanks were all used. Most surprisingly extensive use of the Australian made floor brads was made in hardwood truss framing.

Zone 3 – nails used in wall framing and for lathing

British cut nails with rounded oval head appear in walls and roofs during this decade.

Zone 4 – nails used flooring and sub-floor construction

The last of the wrought iron floorboard nails appear in lesser numbers. Apart from cut spur-heads, Ewbanks were also used.

Zone 5 – nails used in linings, window and door reveals and second fixings

Wrought, cut and Ewbanks were all used in different locations

DECADE 1850-1860				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			Patent wire Fe. Zn coat mod Few finds of wrot nails till 1855 & last of wrot slate nails.	Fig. 131-1. N 28-5. Fig. 131-2. Fig. 131-3. 1861 Ewbank/ N 12. N 28-5 N 28-5 & 3
Z2 Roof inside		 1836 head		Fig. 50. Fig. 128-3 Fig. 121-5 Fig. 28-4.
Z3 Walls				1855 Ewbank. Fig. 128-3 N 7-3 1860 cut clasp 1848 Ewbank
Z4 Floors				Fig. 28-4. Fig. 118-2. 1855 Ewbank.
Z5 Linings				Fig. 117-4. N 20-4. 1848 Ewbank. 1860 cut clasp 1853 Ewbank.

Fig. 171. Tentative nail spectrum for 1850 – 1860.

5.3.8 DECADE PERIOD 1850-1860

Pertinent events:

The population of the Australian colonies triples. Disruptions were caused by the Gold Rush (circa 1851-58) and by an economic depression in the opening years, and there was no concomitant increase in building activity until the next decade. Southern areas of Victoria were hit by severe bush fires in 1851. Transportation of convicts ended in 1852 and in 1853 Queensland became a separate colony. Road and harbour infrastructure commenced in Victoria with the first short railway in 1854. Most nails used in Australia came from Britain, which by 1855 were delivered to minor ports on the Victorian coastline via steam powered migrant ships. This reversed a decline in building activity.

Characteristics:

Apart from the dominant Ewbank nails, this period more use made of the standard British range of cut nails, both in Britain and in Australia. Few wrought iron nails are found in Australia after 1855. British flat headed cut nails and small Ewbank nails replaced wrought iron shingle nails. In this decade a form of galvanised gate nail appears which continues in popularity for the next two decades. At the end of this decade the 'stiddy' formed spike appears and was widely used in the harder Australian eucalypt timbers such as red gum and Ironbark.

Zone 1 – nails adopted for roof claddings and for external features

Zinc, copper, and die-headed galvanised iron slating nails were found with small numbers of wrought iron nails. Common to this period were stout versions of galvanised gate nails, all of which found so far were dedicated to securing upturn flashings around chimneys or to skillion extensions meeting walls. Zinc coatings to iron nails change circa 1855 from a rough sand-cast look, to smooth fan shaped crystal surfaces.

Zone 2 – nails used for roof interiors

Wrought, cut, profiled sheet cut, Ewbanks, and early iron wire nails all used.

Zone 3 – nails used in wall framing and for lathing

The spectrum of nails utilised increased to include Ewbank nails and the last of the wrought framing nails, as well as both types of cut nail.

Zone 4 – nails used flooring and sub-floor construction

Ewbank nails in the larger sizes are used sub-floor as well as the larger British cut-clasp nail.

Zone 5 – nails used in linings, window and door reveals and second fixings

Spur-head wrought brads continued to appear along with the first style Ewbanks and an inverted pyramid head British cut nail, which is only marginally different to the American cut nails appearing in the next decade. In many applications the British cut clasp nail was used. These latter continue to be the nail of preference in South Australia, the first colony to not have convicts, which was mainly colonised by direct migration from Britain and by German Lutheran refugees.

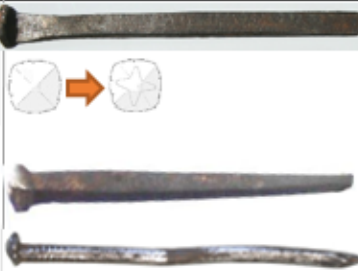
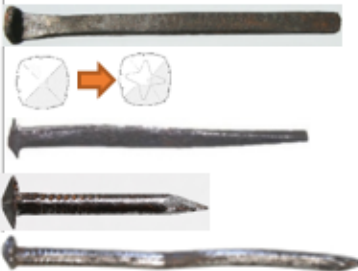
DECADE 1860-1870				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			C/flashing change in 1867.	Fig. 131-1. N 28-5./ N 12-3. N 8-4
Z2 Roof inside			Starhead 1869 Stiddy spikes & wire nails by 1870.	Fig. 50. Fig. 121-5 T 4.8 -3./ N 33-2.
Z3 Walls				Fig. 50. 1863 cut clasp T 4.8 -2. T 4.8 -3.
Z4 Floors				T. 4.6 – 3 1863 cut clasp 1855 Ewbank
Z5 Linings			First US cut nails appear circa 1865	1848 Ewbank 1854 cut clasp 1863 cut clasp T 4.8 -2. 1879 wrot tack

Fig. 172. Tentative nail spectrum for 1860 – 1870.

5.3.9 DECADE PERIOD 1860-1870

Pertinent events:

Development of the Bessemer converter changes the price of steel but iron continues to be used in nail making during this decade.

Australian softwoods sourced from Tasmania were exhausted by 1867. An alternative source of Hoop pine from Queensland was used from 1853 to 1874.

Characteristics:

Apart from the dominant Ewbank nails, this period sees the use of American cut nails in major Australian cities such as Melbourne and Sydney during the mid to late 1860s used in conjunction with mainly imported softwoods. In 1869 there was a change in Ewbank nails' heads which after the formation of the public company Cordes & Co, were marked by a four-pointed star.



Zone 1 – nails adopted for roof claddings and for external features

Zinc, copper, slating nails were used with a small number of die-headed galvanised iron slate nails. Timber shingles were falling out of use except for agricultural buildings and in the poorer homes, and these were invariably fixed by small Ewbank nails.

Zone 2 – nails used for roof interiors

This decade is marked by the appearance of iron wire nails in Australia where they seem to have been accepted quicker than in Britain although large numbers have been recovered in fragmental condition or otherwise damaged. In areas of very dense species of eucalypts stiddy spikes were used for preference and wire nails were not used. Also found were some unusual 'bull-headed' British cut nail of stout form.

Zone 3 – nails used in wall framing and for lathing

Ewbanks and the British cut clasp nail forms were used with early wire nails.

Zone 4 – nails used flooring and sub-floor construction

The spur-head cut floor brad continues to be the floor nail of choice, but also used were Ewbanks and British cut clasp nails.

Zone 5 – nails used in linings, window and door reveals and second fixings

Spur-head wrought brads no longer appear. But Ewbanks and British cut clasp nails were used with occasional finds of the first stout wire nails. Wrought tacks were still used, mainly the sturdy 'Flemish' tacks.

DECADE 1870-1880				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside				T 4.13-2. Fig. 131-1. N 28-5. 1888 pvr head T 4.14 3 (1879)/. Fig. 131-1. N 8-1
Z2 Roof inside			Cordes T cut c1875 Stiddy spikes	1878 rhomboid T 4.8 -3. N 33-2. T 4.14 3 (1879)/.
Z3 Walls		Used in softwood framing		1875 square hd. T 4.8 -3. 1880 pvr head. 1878 rhomboid 1875 US fine.
Z4 Floors			Ditto	T. 4.6 – 3. N 33-2.
Z5 Linings		Used in softwood trims & architraves.		1880 US fine. 1880 US finishing nail. 1873 bullet head. 1873 lining.

Fig. 173. Tentative nail spectrum for 1870 – 1880.

5.3.10 DECADE PERIOD 1870-1880

Pertinent events:

Depression in Australia in 1870 and British troops leave the colonies, each effectively became self-governing. Tolls on roads cease. Financial crisis is followed by prosperity and steady growth which continues to 1910.

An alternative softwood, Kauri Pine from New Zealand, was imported from 1875.

Characteristics:

Steam power from imported and Melbourne built engines in wide use. Strong financial confidence supports building booms in most of Australian colonies. Local pit-sawing and split timber still in use. Increased use of both Baltic and American softwoods. Australian softwoods effectively exhausted.

Zone 1 – nails adopted for roof claddings and for external features

This decade was dominated by the use of corrugated galvanised iron roofing and timber shingles disappear for normal use. Large amounts of terra-cotta tiles were imported from Marseille which needed no nails for fixing. Small ‘pipe’ nails, of around 8mm diameter were the most used nail with CGI but roofing screws of similar size provided an alternative. A nail-rod adapted counter-flashing nail appears in this decade and launders or gutters were fixed using stiddy formed rod nails of around 6.5mm diameter.

Zone 2 – nails used for roof interiors

The cut form of the Ewbank nail appears in roofs in this decade and wire nails start to become dominant excepting for dense hardwood area where stiddy spikes remain a preferred type.

Zone 3 – nails used in wall framing and for lathing

Ewbank nails used in framing become rare and iron wire nails take over. Larger imports of American timber into Australia saw the American cut nail used appropriately.

Zone 4 – nails used flooring and sub-floor construction

The spur-head cut floor brad continues to be the floor nail of choice, but Ewbanks were also used.

Zone 5 – nails used in linings, window and door reveals and second fixings

Large amounts of the American fine cut nail were used in Australia in imported American softwoods. Next most prominent was the bullet head wire nail in a bright, semi-steel, metal.

DECADE 1880-1890				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside			Stokes nail Patent 1887 Spirals 1887	T 4.12-2. T 4.13- 2. Fig. 131-2&3./ N 8-2. N 40. T 4.8-5. N 33-2.
Z2 Roof inside				1880 pyr head. 1886 bun head 1878 rhomboid 1881 Cordes sq grip. N 33-1./ 1875 square hd. 1875 US fine.
Z3 Walls			First steel wire nails used circa 1888	1880 pyr head. 1878 rhomboid 1875 US fine. Fig. 132-10. 1886 panel pin./ 1881 Cordes 1886 steel bun 1881 Cordes
Z4 Floors			Steel ovals circa 1890	Fig. 118-2. T 48-8. N 33-2.
Z5 Linings			Steel wire nails used in doors/ linings circa 1888	Fig. 140. 1880 US fine. 1880 US casing Brit cut lining fig. 133.

Fig. 174. Tentative nail spectrum for 1880 – 1890.

5.3.11 DECADE PERIOD 1880-1890

Pertinent events:

Alternative softwood, Douglas fir (Oregon) imported from America widely used after 1884.

Characteristics:

Steel nails become prominent by the end of this era,

Zone 1 – nails adopted for roof claddings and for external features

The first lead-head roofing nails used with corrugated iron sheeting appear in New Zealand before the end of the decade but are not patented in Britain until 1892. Other roofing nails carry over from the previous decade but a new 'spiral' form wire nail appears used in roof guttering. Cast hook nails appear in roof fascia used to carry catenary wires for telephone and electricity.

Zone 2 – nails used for roof interiors

In this decade wire nails start to become dominant, and the cut form of the Ewbank nail appears in roofs. In dense hardwood area where stiddy spikes remain the preferred type. Otherwise wire nails are the preferred type inside roof areas.

Zone 3 – nails used in wall framing and for lathing

Small Ewbank nails continued to be used in lathing, but the main lath nails were standard cut tacks.

Zone 4 – nails used flooring and sub-floor construction

The spur-head cut floor brad continues to be the main floor nail used with no discernible change of shape since 1810. At the end of the decade, around 1889, a flattened form of wire nail in a softer steel, the 'oval' appeared but it never ousted the cut spur-head.

Zone 5 – nails used in linings, window and door reveals and second fixings

During the latter half of this decade a rolled form of long lining nail appeared based on a pinched head shape. The steel oval was also used and the smaller range of American lining nails wherever softwoods were used.

Post Study-end change markers 1890s -				
ZONE	Indicator nails	Other nails used	Events	Notes
Z1 Roof outside				Disc-head roof nails gain prominence after 1891
Z2 Roof inside				Mainly steel wire used but iron wire nails appear after 1900
Z3 Walls				
Z4 Floors				
Z5 Linings				

Fig. 175. Typical nail spectrum 1890 – 1910.

5.4 THE POST STUDY PERIOD 1890 ONWARDS

This information is included as a means of deciding which decade should be applied to finds at the outside limit of the study period, or as is often the case, applied to alterations or repair works effected later in any one particular spectrum. Anomalies in the spectrum distribution often present an opportunity for dating of a later modification or repair, as frequently happens in roofs.

5.5 SUMMARY

It can be seen that changes between decades are present in each decade, but these are restricted in the early decades. Conversely, there are plentiful changes towards the end of the study period and a veritable explosion of types after the end of the study period.

Chapter 6 will present discussions as a lead-up to the conclusions reached.

Chapter 6:

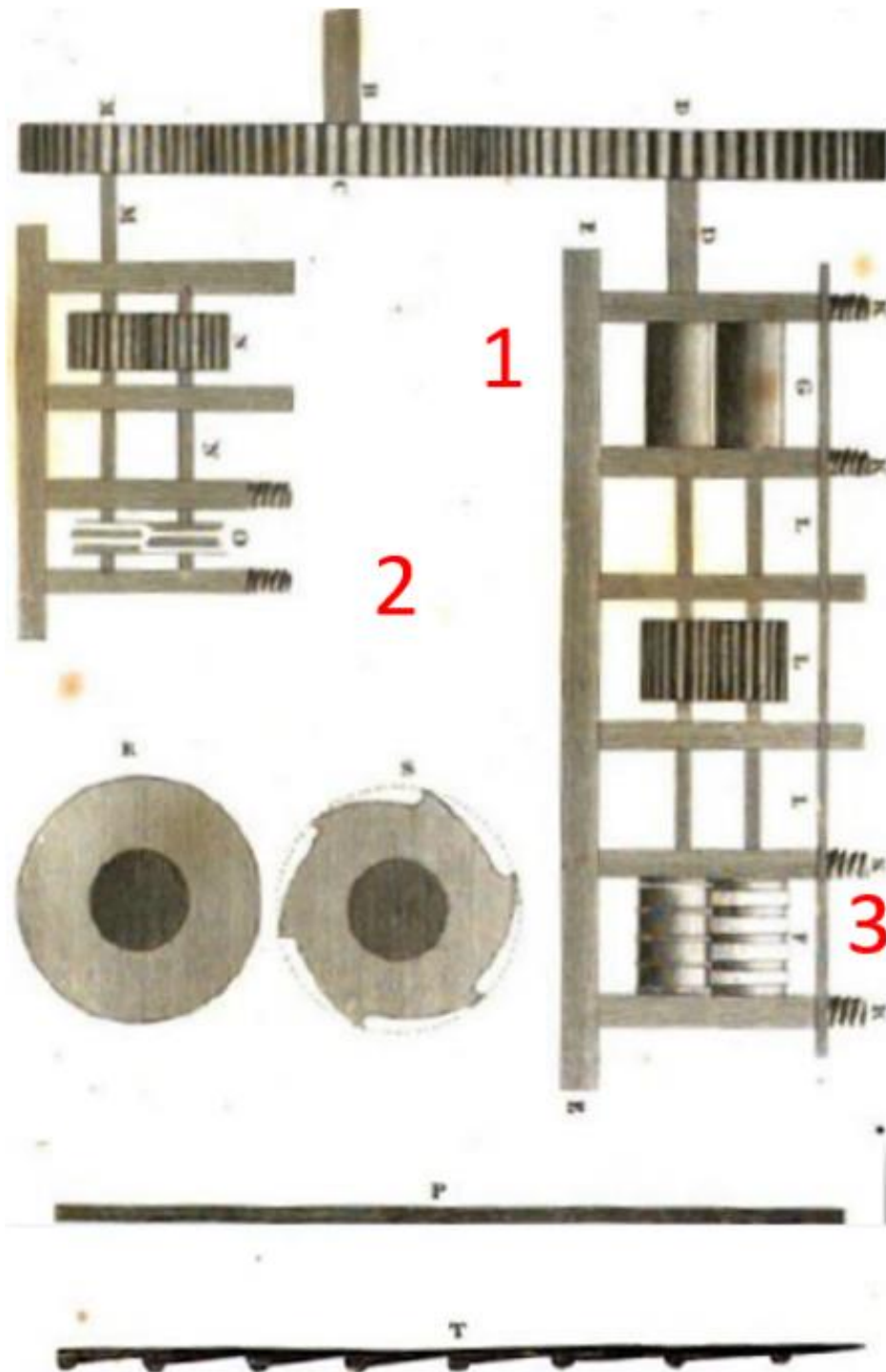
Discussions



Fig. 176 Dyer's Britannia Works in 1814, steam-powered and gas lit.⁶⁴⁷

The beginning of the end for hand-made nails.

⁶⁴⁷ Birmingham Art Gallery (Courtesy Dr Guy Sjogren.)



KEY: 1. Plain rollers 2. Slitting rollers 3. Shaped pressing rollers
T - represents a finished nail string awaiting separation

Fig. 177.
Wrought

nail

making machine using tapering rollers, 1803.⁶⁴⁸

⁶⁴⁸ BPO. Patent 2739: Booth Hodgetts. *Machinery for rolling of iron for shanks and for forming shanks into nails.*

CHAPTER 6: DISCUSSIONS

You must look at facts, because facts look at you. Winston Spencer Churchill

OVERVIEW

The unusually long course of this study and its wide ranging investigations have added a significant amount of worthwhile information to current knowledge. However, this has not been a solo journey on the part of the author, and neither is all of the information 'new' but a prolonged plumbing of the depths of sources in French and In German, as well as utilising the exceptional help provided by contributors as far apart as China and Japan, several states in Australia, from Sweden, Denmark and USA. All of this has provided fresh material previously unexploited in the English speaking world.

Having regard to the large amount of 'new' information, the discussion falls into two categories:

- Examining the background parameters. Those which arise from antiquity, but run through the middle ages and into early modern times.
- Developments within historical times. These comprise those variations of nail technology which cause morphological changes, and hence came to affect identification as a dating method during the study period and its lead-up.

6.1. PART 1 – BACKGROUND PARAMETERS

6.1.1 Techniques – Western and the Orient

Central to the study of nails generally lies the problem of what constitutes a nail - as opposed to say a furniture pin. The problem of definition is compounded by the fact that nails (particularly when used in hardwoods) were sometimes driven into pre-drilled holes – as has already noted in footnote 98. It goes without saying therefor that any definition cannot include a point at one end of the shank. (Refer the bon mot by Diderot for Chapter 1). Likewise over some hundreds of years, it was customary in the Western world to make headless brads, such that the nail head becomes irrelevant in respect of a general definition. As can be seen in fig.2, a significant number of historic Oriental nails were made in China much like simple brads as used in the Western world.

Neither do nails have to be made of metal - as has been shown in fig. 21. Timber, bone, and ivory, have all been effectively employed. (Refer Section 1.2).

So this important aspect of understanding nails starts with a paradox. Definitions are either wrong, or the wise commentator has simply left open this consideration, - either by ignoring a definition, as does Neve for example, or they make the assumption that everyone knows what constitutes a 'nail' without seeing the need for further clarification, - as for example does Salmon.⁶⁴⁹

However, this should not be the end of the subject. There is a common factor recognised by humans, whether Western or Eastern, and this common factor appears to be that nails need to be driven in order to seat home. The many items which look like nails, such as are found in ancient Egyptian tombs (as seen in Appendix IV), resolve simply as pins needed as pivots in furniture.

From this point it has been possible to make a broad definition of what makes Western nails recognisable, which is that most of these were made using a heading stick, an obore (*clouiere*). There are exceptions to this. Notably, certain cases of Italian nails used to affix plaster, suggest that a folding technique had been used to form the heads. This feature can also be seen in the cache of unfinished

⁶⁴⁹ See the bon mots accompanying Chapter 4 heading. (Page 136).

Swedish spikes shown in Appendix IV-4, fig. 25, where it is clear that a folding technique was employed for the head formation. It is also possible that a folding technique was used for the French floorboard nail as displayed by Roubo.⁶⁵⁰ The *clou de ferronnier* uncovered by Prof Vanden Eynde at Rue Haute, Ath, clearly show how a lateral folding technique was adopted. So far, it would appear that this thesis is the first to clearly enunciate their use and make in English.

In the far Orient the first signs of western influence can be seen in fig. 2 and which is shown in Appendix IV-4, fig. 21, most probably dating from the 17th century. It is worth noting in Appendix IV-4, fig. 19, that ancient China was using nails before ancient Egypt, fig. 11. A further question then arises from the Baochuanchang shipyard finds as to where did Roman influence extend and when did it commence. This is a subject well beyond the scope and intent of this thesis but certain facts have emerged which are well worth recording.

6.1.2 Origins and uniformity in the West

The one common historical denominator which Europe had, and which can be said to have spread eastwards, was Roman cosmopolitan culture, figs. 22 & 23. The astonishing range of Roman trade with the Indian sub-continent saw Roman trade extended up the east coast of India and into the Ganges River. This extent lapped Roman influences with those of contemporary Imperial China, but, as shown in Appendix IV, the nub point appears to be ancient Ceylon. A Western style door nail with a square boss was uncovered from excavations at Polonnaruwa,⁶⁵¹ (the former Royal Palace complex burnt down circa 1410 AD) in the central Cultural Triangle of the dry zone in Sri Lanka. It is not within the scope of this thesis to explore Roman connections further, but the range of Roman finds suggests that further research will reveal signs of Roman influence in the very few cases of nails being used in what was basically nail-less construction in ancient Ceylon.

Within Western Europe the conformity of nails to a Roman pattern appears obvious and certain styles of nails continued to be used as long as wrought nails were made, Appendix IV figs. 17 & 18. The recent research enabled by the close inspection of the Rhone river barge (*chalande*) at Arles has greatly extend the findings from earlier Roman vessels found in the Thames and the surprisingly large number of Roman vessel remains found across Europe.

6.1.3 A Celtic iron nail foundation

As shown above in Appendix IV-2 and in Sections 1.2.7 and 1.2.8, it is clear that Roman conquest saw the absorption of Celtic iron working techniques – possibly over a long period of time, and a formalisation to set standards of nail production. Although Celtic iron forged items were dominant in Pre-Roman Europe, which probably included iron nails, it was the enforced Roman discipline and its organisation of a multi-national army and commissariat which set the patterns for forged nails. From this comes the continuity of nail typologies, their uniformity of styles, and European nail technology during the medieval and pre-modern era. It can veritably said that up to WWII we were effectively still living in a Roman nail period.

One of the overlooked aspects, rarely commented on, relates to pre-drilling (in smaller diameter holes) when iron nails were used in hardwoods such as oak. Conclusive proof of this has come from the detailed examination of the Rhone *chalande*, and is backed up by Dürer's crucifixion scene, fig. 178.

⁶⁵⁰ ROUBO 1769, 259 Plate 98, Fig. 2. See also HOW 2017, 36 & 37.

⁶⁵¹ Now displayed in the on-site museum which forbids photography.



Fig. 178. Pre-drilled nail holes in the *chalande* oak hull, 90 AD (ARC-Nucléart), and as shown by Dürer in 1511.

Although not especially relevant to nails used in construction, there have been benefits to our understanding of nail morphology which have come from research into votive nails, hitherto an item relegated and known only to a specialised few archaeologists. Further research will probably establish a link between the decorative heads of votive nails and the medieval vogue for patterned and floral heads on items of value. It has also been one of the pointers leading to understanding the curious phenomenon of fully tapering shanked nails, once again, greatly benefitting from study of the retrieved artefacts recovered from the Rhone at Arles.

6.1.4 Supply forms of nail iron

Familiarity with the Roman finds from the Arles Regional Museum, and to a lesser extent with those displayed at St. Germain-en-Laye, has assisted in unfolding a further aspect of how iron was supplied to nail-makers. There is an apparent, but little known continuity of iron in baton form, from Roman to Anglo-Saxon (refer Section 1.1.4.) and into Medieval times, fig. 11. An unexpected cross-confirmation coming from Sweden, fig. 13, and Section IV-4, suggests that the finds from the Titan reef off Saintes Maries de la Mer in the Camargue bear similarities to recent Swedish forging of iron in thick baton form. This prompts an angle of future research for archaeologists specialising in Roman machinery.

Similarly, further research into Anglo-Saxon documents relating the iron production to pre-conquest industrial centres such as Gloucester may provide further clues as to how, and in what form, iron was supplied.

6.1.5 Continuity of nail names

As shown in 0.3.3 above, the confused state of pre-Conquest language and the lack of a conventional spelling system hampered development of names. Nevertheless, in Salzman's careful recording of nails and ironwork items a level of continuity can be seen coming from the medieval period, of nail names and uses. Likewise from those recognisable descriptions: *latneyl* (1316) and *clavis laterez* (1222) for lath nail; *shiggil* (1329) and *scindul* (1248) for shingles; *spykyng* (1327) and *kokspykyng* (1336) for plain headed small spikes and ones with a spur head.

Others are less recognisable but *gripnail* (1344) suggests a form of clasp nail; *synck head* (1532) suggests a countersunk head.

Sadly, none of the names suggest a Latin root. In spite of the odd mixture of Latin and Early English, the reference to '*Cluta*' (1292) turns out to be a clerical version of clout. Instead, a closer examination of common nail names, clout, brad, and tack, all appear to date from Anglo-Saxon or the melding of Anglo-Saxon with Old Norse languages: *clut*; *brord* (A-S) and *broddr* (Old Danish); then 'tack' appears

to derive from another melding, *takke* and *tacque*, being from Old Danish and Old Norman French respectively.

There is one further possible connection with the word ‘clout’. One of its several meanings in modern English survives only in the form of a traditional saying; “Cast not a clout till May is out”. This refers to items of clothing (or simply cloths) worn for extra warmth, such that a ‘breach-clout’ was any early form of underwear. However, cloths were often used to line cottage ceilings and walls. Several examples of this were found in Victoria and in South Australia in pioneer buildings. Thus there is a possible link with the broad head nail, the ‘clout’, being used to affix cloth in antiquity. By extension, when used as a verb – ‘to clout’ would infer an applied patch of cloth or leather, thus also pertinent to nailing on one or the other if used in the context of building or construction. A further meaning of the same word is to administer a forceful blow, either by hammer, or colloquially, by hand. In these meanings we can see a thread of continuity involving all of the descriptive meanings.

6.2 PART 2 - LEAD-UP TO STUDY PERIOD

6.2.1 The Theux Chisel hammer

The remarkable survival of hard evidence in the form of a hammer head, plus a first reference (so far) of 1449 places this tool as a forerunner to both the Zeinhammer and to slitting. It would appear more than likely that the Theux hammer concept was remodelled in Regensburg or in the Steiermark to specifically suit production of iron wands for wire production, thus leading to the *Zeinhammer*. Research should now be on-going to find samples of nails with characteristic signature traces suggestive of being produced from ‘*fer stendu*’. This research must necessarily lie outside the scope of the present study.

6.2.2 *Zeinhammer, Reckhammer, and Krausseisen*

The relevance of these tools and their product has comprised a particularly difficult part of the study but its resolution has added a significant amount of worthwhile information to world knowledge, previously bypassed due to the complex problems of translation from a now defunct dialect. Indeed, the problems were perceived to be too difficult or obtuse by the author’s German colleagues. A key was finally established from a reference supplied by an art restoration expert in Berlin who provided the reference to Zedler’s *Lexicon*, fig. 15. (Refer to Section 1.1.5).

It would appear that the reference to *Krausseisen* (wavy iron) has never been traced back before in either English or in French, and it was fortunate that a circa 1505 nail sample (or appropriate size and with wavering edges) was salvaged from the waste material at Beutelsbach, fig. 17. Likewise, this interpretation enables the viewer to understand the artist’s intent whereby a wavy section of thick batten is shown below the almoner’s stool in the 1482 manuscript image, fig. 10.

There is a complimentary satisfaction in having established that the pattern of *Zeinhammer* use was limited to the German speaking Duchies and Kingdoms of the south. It opens the possibility of slitting having been adopted early by the Kingdom of Saxony and perhaps two or more of the north German States, fig. 19. It also explains why the (apparently) singular reference to *schlichtern* (slitting) comes from Saxony. (Refer Section 1.1.5).

6.2.3 The Nuremberg trade tests

Translation of the nail trade competency requirements, as set out by Christoff Weigel in 1698 and shown in 3.5.1, allows us to see the rigid and exacting Nuremberg trade tests required of nailors operating within the Holy Roman Empire. It seems probable that these tests set a standard for nails throughout the German States, and hence to areas of German expansion towards the east in the Sudeten, in Poland, and in Courland. This specific information, together with the detailed analysis of the iron trade seen through Johannsen's text in Section 3.2.1, and the extensive role of the Hansa in distribution of manufactures, all shed some light on the guild system for nail makers in central Europe, complimenting Diderot's description of the Isle de France nailors' guilds.

It is clear that medieval England too had a guild system operating in the major centres, fig. 57. It seems certain that this was eroded over time by a dearth of suitable charcoal for iron production and forging. By 1327 proximity to coalfields may have factored in an early restructuring of English nail making centres.⁶⁵² As seen in the excerpts from Salzman, medieval England had frequent recourse to purchasing Spanish, French and Belgian nails, no doubt due to the problems of low grade ores and inadequate smelting arising from the shortage of good quality charcoal. There was a further destructive wave to the native nail trade operatives, and to its supply chain (which Salzman shows worked through regular country fairs), caused by the Black Death (1348 – 1349). The pandemic's subsequent spasmodic recurrences continued to devastate the population and trade between 1361 and 1405.

A resurgence of building during the relative stability of Elizabeth I's reign, as noted in Section 3.2.9, would appear to be the stimulus which was needed to reform the nail trade in England and Wales, which then focussed on emerging major centres in the west and north, particularly around the Forest of Dean, Bristol, and Sheffield.

In a different, but equally destructive period in respect of forest resources, was the Civil War (1642 – 1651). Wholesale felling of timber by unpaid troops during the conflict, and by lawless elements continued into the period of the English Republic which came to a close in 1660.

The question of how the guild system worked in Belgium, and how it came to concentrate in Liège, can only be partly explained by the present research. So far we have only tantalising glimpses of a long continuity of artisanship from pre-Roman times, as seen in section 3.4. It lies primarily outside the scope of this thesis but it could be explored further by a Flemish speaking, or bilingual researcher. At present there is a dichotomy between the Roman concentrations, shown by Brulet, and the later emergence of the nail industry so nicely investigated by Hansotte.

It would appear that this thesis is the first recognition made of Liège being a dominant player on the world nail scene in the English language.

⁶⁵² Refer to footnote 306 page 93.

6.2.4 Other emergent factors

Amongst the fruits of international cooperation has come the first tracking back of *clou d'épingles* and the first photographs confirming their conical ground points, fig. 179.⁶⁵³ Likewise, an unexpected find of earlier iron *clous d'épingles* from an organ at St Trond in Belgium, came as a surprise.⁶⁵⁴

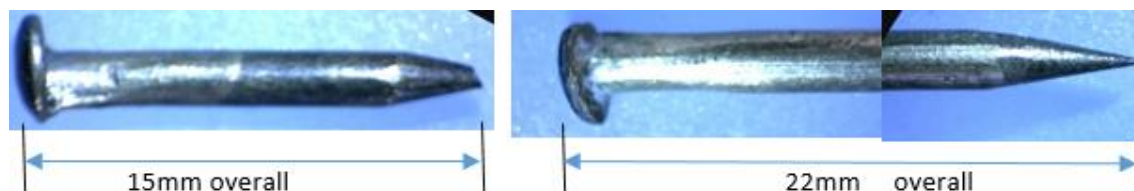


Fig. 179. Ground points on a 1683 & 1730 brass pin nails. Courtesy Yannick Chastang. Author.

The earliest cut brad yet found came from a 1715 item of furniture made in Grenoble, and, the only samples so far found of *Clous de Ferronnier*, conforming to Du Monceau's illustration, came from 23 Rue Haute, Apt, with a provenance of 1535.⁶⁵⁵ This is an important piece of information since it shows a continuity of fabrication of nails lying outside the normal nailor's trade, made using a different set of techniques.

Although the link between clenched nails and doors or shutters is well known, it seems that this thesis creates the first reference table for detritus and wear relating to nail diagnostics. This becomes a useful tool to heritage officers, archaeologists, and historians working in field studies, since many nails found no longer sit in their original positions but are, nevertheless, useful in establishing pertinent facts about a building or a repair.

6.2.5 Clarifying terms

It has unfortunately become the convention in the English speaking world to assume the term *pointes* is merely a shortened form of *pointes de Paris*, and thus refers to machine-made wire nails. As part of the overall study many samples of square and round tapering pins used in window frames, cupboards and furniture have shown up in the Midi, fig. 132. Other samples of these have been passed to the author through colleagues in TATHS.⁶⁵⁶ They would appear to be the original *pointes*, and hence the term *pointes de Paris* refers specifically to those available to artisans in the Paris area.

A sequel to this unusual nomenclature happened by pure chance, as seen in Section 4.6.6, which was the unexpected discovery of an original first *pointe de Paris*. It was possible to identify this, using the original documents in the Paris archives, as the invention made by François Daguet circa 1818. The discovery manages to close the claims made by various parties as to an American or German origin for the first machine made wire nails. It also sets in place a proper chronology for the first wire nail machines. Less importantly, research of the Brevets in the Paris archives shows that the claims of invention by the American, James White, in respect of a wire nail making machine is fallacious, since it depicts *pointes* in a general sense, (as shown in 6.2.3), in this instance ones made from cut slivers. (See Section 6.3.8 below).

⁶⁵³ The 1683 sample is from a piece by Cucci, and the 1730 from a commode by Boulle, loaned by the eminent restorer of French period furniture, Yannick Chastang, now based in Faversham, Kent, England.

⁶⁵⁴ From a 1644 organ by Christian Ancien du Hoy, renovated by Pierre Descourcelle, courtesy Prof Vanden Eynde.

⁶⁵⁵ Sample from Yannick Chastang. The house at Apt is being restored under Prof Vanden Eynde's supervision.

⁶⁵⁶ The Tools and Trades Historical Society in Britain.

Another term apparently overlooked to date relates to how European descriptions cross-relate through several countries

6.3 LESSONS FROM THE STUDY PERIOD

6.3.1 Developing national & international nail industries

Although there has been a large accumulation of evidence regarding the growth and maturation of the Liège and satellite cities' nail industry, little of this has impacted the English speaking world. The study has found that:

- (a) Liège was almost certainly the first organised nail industry in the Western world with origins probably pre-dating the first mention found by Hansotte to a nailor's strike in 1406.
- (b) The centralisation of guild powers in the Isle de France and in Nuremberg acted as a restraint on development of a progressive nail industry in France and the Holy Roman Empire. It is probable that centralisation of the economy within the State of Liège was due to careful control by the Church through the offices of the Prince-Archbishop, and which Hansotte describes as slipping into a cartel of nine major merchants by 1600, (Section 3.4.1). The advantages of site allowed the nailery to adapt quickly to changing demands for their products, led by Charleroi. It can be said that the Walloon naileries comprise the first international industry, feeding major projects in Holland, Spain, France and Germany, benefitting from its neutrality during the thirty years war and immediate aftermath
- (c) English nail production was more widespread and beset by numerous difficulties until innovative research over several centuries paid off. The policies of expansion overseas provided the outlets for nail commerce making the English nail industry a close follower on Liège's success.
- (d) The American nail industry, much vaunted as an original, lagged third as an international industry. This was partly due to self-absorption of peak production but partly due also to the same difficulties faced by England earlier, and which the Americans were slow in adopting.

6.3.2 Advantages and difficulties

These effects have already been summarised in Chapter 3, Section 3.9 but, without undue repetition they can be dealt with respect to the three main world players:

- (a) Proximity to good quality ores played a major role in how the State of Liège prospered in its nail major industries. To this must be added the long familiarity of a people conversant with mining, smelting, and forging. Access to good quality charcoal, to water power, and to the Meuse as a major transport mechanism added to the basic advantages of its early iron industry. It should not be forgotten that the Church, in the guise of the Cistercian Order, held a technical advantage of specialised knowledge over potential competitors, which included the base of an international language (Latin) with an infinite number of connections across Europe which extended all the way to Riga and central Sweden during medieval times. A trump card was still in reserve as pressures on charcoal production began to impair the financial viability of nail production, in the form of extensive coal reserves nearby. Fortuitously, this occurred as England, its long term associate, resolved both coke production and steam power. Thus, it is hardly surprising that this small State was able to become a world player.

- (b) England's, and then Britain's, struggles with the deficiencies of poor ores and with resources generally, as already outlined above, took centuries to catch up with iron production from Wallonia and Flanders. But for the wars of religion, it may have taken much longer to take the first step away from its support base of the southern Lowlands. The compulsion driving England towards research had started in Tudor times, but the study has found that the initial breakthrough in respect of coke for smelting was only a partial answer. It was not until the advent of the puddling process and subsequent variations, that full benefit was achieved. This then led to the need for both canal building in order to transport of bulk materials (in itself not new), and the use of horse tramways as precursors to railways.

Although French ingenuity had beaten the British to the use of steam transport with the arrival of Cugnot's steam tractor in 1769, for practical purposes high pressure steam engines in 1805 led the way forward into rail transport. This took over much of the bulk transport of ores, coal, and iron products. The efficiency of water transport in respect of bulk materials saw canal building continue until 1835 by which time a significant rail network had evolved which was able to transport bulk materials faster than by water.

- (c) The study has found that initial establishment of the American Republic led to several years of dislocation and discontent which set in place concomitant growth and industrial advance in Canada. Canada at that time held several advantages including discoveries of superior iron ores, such that the break with the thirteen Eastern Seaboard colonies fostered creation of Canada's iron industry. The reluctance in America to adopting 'English' ideas on canals and rail transport also acted as a break on American iron production generally until 1828. The drain of smart American minds relocating to Britain, or in many cases to Canada, has become almost a taboo subject in Australia but the study finds that this phenomenon had much to do with the more advanced technology which Britain had developed in order to defeat of Napoleon.

As with England itself, most of the early American iron ore sources were of low grade until pressures to migrate westwards revealed the first significant finds of good quality ores at Wheeling on the Ohio River. Ironically, Wheeling lay close to superior ore deposits at Pittsburgh, but for some time Wheeling became the hub of the western world's third major nail industry - based on cut nails, which were well suited to softwoods. In the meantime, American maritime endeavours had opened up new markets in the Caribbean, South America, and China, ensuring a future for American know-how which started to make an effect towards the middle of the century. An absolute breakthrough came with completion of the trans-continental railway in 1869, fig. 68. Nails already being exported from the Eastern Seaboard could now take the shorter, and more economic route to the Antipodes, and to the Far East, fig. 81. The study has revealed a significant increase in the numbers of American nails found in Australia after 1875. The Americans were also able to capitalise on this trade by exporting pre-sawn softwood timber to Australia, which is still the case today.

6.3.3 'Hands-free' nail making

The effect of the *Grande Encyclopaedie*, with Jean Moreau's superb illustrations, has been to convince Anglo readers of a French uniqueness in respect of the mortice system of setting the obore. A system which allowed the nailor to retain his hammer for most movements involved in fabricating nails. Christoff Weigel's scene of a Regensburg nail workshop in 1698 predates that illustrated by Moreau and throws a slightly different light on the process, fig. 65;

- None of the anvils shown, used in paring down the shanks to a point, is the same shape, and even the 'towers' which contain the mortices vary slightly.
- The nails shown being produced are all in the middle to larger range.
- Three work positions are shown, in disparate deployment around the hearth, with two in use whilst one person is shown tending the hearth.
- Two nailors are standing in the familiar stance of English, Belgian, and French nailors, but one has been provided with a simple bench to sit on.

Weigel's illustration, fig. 65, calls into question who first adopted the mounted obore system. Was it perhaps a rapidly dispersed improvement which infiltrated 'Belgium' from the Palatinate as part of the Holy Roman Empire, before spreading down to the Isle de France nail-makers? Equally possible is that the 'engine house' of Liege first developed this system and the technique flowed both east and south. There appears to be insufficient evidence to say how this system came about. In Weigel's illustrations, the anvils are shaped like those shown in the Nuremberg manuscripts, but one has a curved upper surface more appropriate to forging curved objects, figs 10 and 14.

Whereas the Nuremberg manuscripts depict seated elderly almoners, the sitting nailor shown in Weigel's image appears to be a young man, also the ergonomics of forging nails called for frequent access to the hearth, whereas the hearth is shown in the image is clearly out of arm's length.

Nevertheless, and these reservations aside, we are provided with clear evidence of a wider use of the ergonomically efficient nailor's stages. This then reflects on the British retaining their archaic system (hardly changed from the 1327 depiction, fig. 14). The answer appears to lie in their training from childhood to produce a limited number of nail types; - four or five types only. Coming with such specialization was development of speed of production, and the astonishing number that skilled nailors could make; - up to 3000 per day being recorded.

In contrast to this philosophy Weigel provides us with a description of a Regensburg nailor needing to be competent in a wide range of nails currently in use. For these he quotes the absolute miniscule 'floaters', up to major nails for castles, and then the need to pass a further test by outfitting the ironwork for different types of vehicles.

The size of nails shown by Weigel should not be surprising. The grand master of Fachwerk, Carl Schaefer, shows how the blending of Celtic elements with the plainer square panel construction of northern Germany led to greater use of decorative elements in Franconia, and he also shows how nails were used in their fixing. At the same time, the roof sprocket (*Aufschiebling*) nails and in some cases the main spar pitchings, relied on large nails in which the *Krausseisen* origins show.

6.3.4 Establishing nail nomenclature and morphology

The study has successfully completed a pictorial review of most wrought nails used in building during the study period applicable to Britain and to Australia. It has found that the further back into the study period and before this list is compromised by the use of strictly local or made-up names pertinent to trade in limited circle and thus there will always be room for criticism. The criteria for selection of

names has already been explained in 0.3.3 but a pragmatic approach has been adopted to finding names for nails which are most likely to be of help in dating heritage buildings.

In regards to wrought nail changes, these are subtle and relate to building legislation driving development of new styles after the Great Fire of 1666. Thus, the finding of samples and establishment of a photographic record portended a negative outcome for identifying changes before 1790. However, there was an outstanding need for such a task to be confronted, especially a recording of types by carefully illustrated three dimensional sketches, and then by the less satisfactory means of photography. So far as is practical, both methods have been adopted and the results speak for themselves.

What has emerged from this detailed compilation is the high level of uniformity between wrought British nails and those of America. The expected differences in nails originating from American states such as Louisiana and Florida, has so far not eventuated and the slight nuances found are hardly worth reporting since normal variation between sources is of the same order.

6.3.5 Freshly uncovered typologies and techniques

The building of a register of wrought nail types produced some nail types thought to have been lost, and led to some insights into the sorts of techniques used by nail makers. The reader will have already noted that **N 5B** is an oddity showing clasp nails of German origin in which the head formation was rounded over in one smooth, lozenge-shaped, surface. Compared to **N 5A**, it can be seen that, in the British versions, the head was formed by four spreading facets comprising the downward pointing wings – which act to provide the clasp action. What is noticed too is the shape seen from above in the British version creates a figure-8 shape, as opposed to the lozenge seen on the German versions. The latter is shown in a 1425 Nuremberg almoner's sketch in which a basket of finished 'bi-petal head' nails are shown

By fortunate chance, research by the archaeology department of Wallonia in Liege had uncovered potential forerunners of clasp nails of good provenance and state of preservation. These in turn reflect a general morphology of early rectangular head plan nails found in Riga. These finds formed the basis of a paper to the Construction History Society.⁶⁵⁷

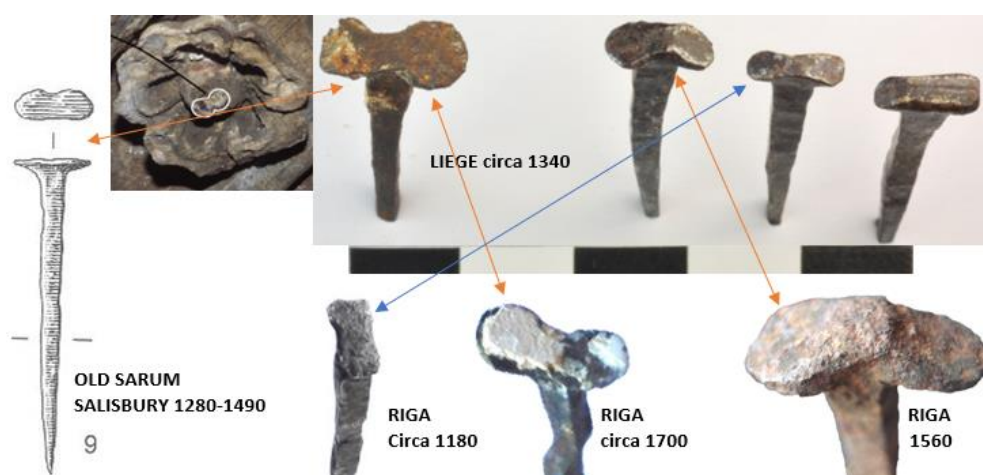


Fig. 180. Developments and distributions of types of clasp nail morphologies.
Images by Nicholas Griffiths⁶⁵⁸, Caroline Bolle, Jean-Marc Leotard, author, Arturs Lapins and Ilmars Dirveiks

⁶⁵⁷ *The Medieval Bi-petal head Nail*, Chris How, Jean-Marc Leotard, Caroline Bolle, & Arturs Lapins

⁶⁵⁸ SAUNDERS 2012, 154 & 186

There is a vital clue exhibited by the rare find of the early clasp form from Esslingen, Stuttgart, which can be seen towards the top of the shank. This comprises a V-shaped void, almost certainly left by the hack iron chisel, from which we can assume that the shank was split at one end in an oblique manner, in order to fold out the wings. It follows that this method was the method adopted for the other forms shown in fig. 180. The early development of full downward pointing wings can be seen in the second Liege nail.

Perhaps no other image quite demonstrates the spread of a consistent technique over a wide span of time and distance inside northern Europe. The fact that Belgium has so many well preserved examples of early nails makes the pursuit of technique development an ideal task for future studies at Louvain or Liege. The author's colleague in Riga, Arturs Lapins, has already had discussion with blacksmiths in Latvia in respect of replicating nails for restoration purposes.

None of this addresses the question of when clasp nails entered England. So far no recognizable clasp nails have come to light earlier than the Hampton Court 1684 exemplars **N 5A** - nails 4 and 5. They do not seem to have been used in England in medieval times although there is a reference in Salzman to a *gripnaill* of 1344,⁶⁵⁹ which may possibly refer to an early clasp nail. The closest type of nail head to a winged nail was often used on iron-clad chests, such as the famous pay-chest for King's College in Cambridge with provenance to 1508, and one removed from a chest in Salisbury of circa 1490, fig.181.



Fig. 181. Salisbury Corporation chest nail c1490⁶⁶⁰ and two views of King's College chest nails of 1508

Before leaving this subject, the shape of some particular nails was formerly particularly obtuse. Thus there was no reference suggesting a shape of a 'jobent' nail but traces of wear in the form of a localized groove, just under the head of a nail from an English heritage house, of circa 1630, together with its particularly thin broad flanged head, enabled it to be fitted to Neve's description of 1703. Thus advised, three more examples were all identified, **N 16**.

In similar manner the 'backing nail' was identified from a sample in the Naish collection at Salisbury after many exemplars had shown up at Woolmers World Heritage site in Tasmania, and two members of TATHS had donated almost identical samples to the author. Likewise with nail **N 3**, no logical explanation for the strange items found in the archive boxes at Woolmers was forthcoming. Neither had others like it been found by any of the author's contacts until it was traced to an illustration in *The Chesapeake House*, published by Colonial Williamsburg in Virginia.

⁶⁵⁹ SALZMAN 1952, 314. See also *grapnayl* 1341 *ibid*.

⁶⁶⁰ SAUNDERS 2012, 155 & 187

6.3.6 Die heads linked with Oliver use and the ‘stiddy’

The paucity of written references to the Oliver formed part of a paper presented by the author, and one potential reference, dating back to 1352 is problematic.⁶⁶¹ The clear evidence for the use of a heavy hammer die header is fairly conclusive in respect of the die headed spike shown in the Board of Ordnance tender of 1812, **N 31** – nail 1. To strike a die-head of this size would not be possible using a trussel (*estampe*) and hand held hammer, so the illustrations form tentative evidence of the earliest use of the Oliver in head forming. As noted in the nail register, **N 20**, evidence for the use of the Oliver flat faced hammer appears to extend back to 1690 or so.

When used with the vertical ‘funnel’ mould, the ‘stiddy’, secondary evidence indicating its use can be gleaned from small, off-centre, misalignments of strike seen on the head periphery, or, in some cases the head is noticeably off-centre, fig. 182. The first exhibits by a crescent shaped extrusion to one side of the head. The second by the anvil section being off-plumb with the hammer, fig. 44- left.⁶⁶² Such a misalignment, coupled with a spreading point to the shank, helped identify the method of manufacture for the launder nail seen in **N 33**-nail 4.

This latter case helped establish some evidence with respect to some rarely employed round headed nails used to fix plaques to masonry walls, like the ones found this year (2020) at an 1888 Courthouse in Moonee Ponds, Melbourne. By extension, this suggests that Olivers with stiddy attachments had reached a niche industry supplying certain specialist trades in Australia. There have been no indications that these were imported items. Being items in relatively small demand, local fabrication seems to be a reasonable assumption.



Fig. 182. An off-centre head wrought plaque nail, Courthouse, Moonee Ponds, 1888. Author.

6.3.7 Disparate successes in cut nail development

The study found significant correlation of the research by the American writers Edwards and Wells concerning cross-grained in nails produced in the USA, and its deleterious effects when cut nails were used in hardwoods. Consistent and unusual ‘greenstick’ fractures were found in a high percentage of cut nails imported into Australia from the USA, which persisted well beyond the dates in which the Americans solved the teething problems of production, somewhere between 1830 and 1850. In fact, the pattern of greenstick fracture continues to exhibit until around 1875 and isolated examples show up even later, fig. 99. This reasons behind this might form the basis of some future research, but as noted above, the core problem appears to be due to lack of density within the middle third of the shank cross-section, fig. 97. This is also the case with British cut nails, but the effect of lesser forces used in rolling becomes more marked in the American samples.⁶⁶³

⁶⁶¹ HOW 2017, 86

⁶⁶² See also Appendix II, Glossary, “stiddy”.

⁶⁶³ From a statistical aspect the slightly higher UTS results obtained from British cut nails by destructive testing of historic samples are considered to be insignificant.

Stubbier versions appear in Australia in the 1850s which seem to be of British origin. At this point the record becomes exceptionally confused since the American, Dyer was producing cut nails soon after 1813 in Birmingham,⁶⁶⁴ supposedly on a version of an American machine, but no equivalent advanced machine seems to be recorded this early in America. It seems that Dyer's machine was the result of combining the advantages gained from both countries. Dyer's Britannia works factory may have been the first serious attempt to bring industrialised nail making into one central complex able to function through winter and long into the evenings by dint of gas light and of steam power, fig. 176.⁶⁶⁵ In his recent thesis, Dr Sjogren has suggested Dyer's cut nails were first produced in 1813.⁶⁶⁶ Note that nails which are very close in generic form to those found in Australia were shown in Dyer's patent drawings of 1809, fig. 105.

The other prodigious American inventor Jacob Perkins, "a gentleman of great mechanical genius",⁶⁶⁷ who influenced British cut nails, was in partnership in with Samuel Guppy and another expatriate Englishman, John Warren Armstrong, when his prototype machines came to fruition in 1795.⁶⁶⁸ One machine cut shanks from an iron strip, and the second machine headed the blanks. Frustrations with problems of jamming in the machine caused friction among the partners and two returned to England in 1798, to be followed by Perkins in 1819, who died there in 1849. The close inter-relationship of invention and development of the first cut nail machines is exemplified by these four gentlemen, two born in Massachusetts and two in Bristol.

The success of cut nails lay with the changes to softwood framing both in America and Canada. New Zealand was in a position to exploit some native softwoods, as was the case in the early days of Australia before native softwoods were exhausted.

6.3.8 Unsung success with profiled sheet cut nails

Apart from the obvious need to provide nails capable of being used in hardwoods (especially the dense eucalypts found in Australia), a further lesson is revealed in 6.3.6 above, which is the sad fate of inventors conceiving ideas ahead of contemporary technology. As such it has been the norm to dismiss the endeavours of Thomas Clifford. However, his simple idea of re-rolling cut strips of iron sheet to a tapering profile eventually paid off with the introduction of the T-patent by Cordes and C. These were still in use up to, and possibly including, World War II. His second patent of 1790 of rolling nail rod undoubtedly was the key factor to the success of the Ewbank nail of 1836. As seen in fig. 177, Booth Hogget's 1803 patent comprised a fruition of Clifford's ideas which, in turn, led to the Ewbank nail machine.

⁶⁶⁴ Dyer made several visits to Britain prior to domiciling there in 1811. It appears he was not the originator of the cut spur-head flooring brad.

⁶⁶⁵ SJOGREN 2019, 73-74 ascribes the idea to William Finch in 1790, "to have all under one roof".

⁶⁶⁶ Dyer ordered the Britannia Works steam engine from Soho Works in July 1812. SJOGREN 2019, 113.

⁶⁶⁷ SJOGREN 2019, 93. The quote is from Jedidiah Morse, *The American Gazetteer*, 1804

⁶⁶⁸ SJOGREN 2019, 94.

6.3.9 *Pointes and clous d'épingles* wire nails

Entrenched ideas espoused with resolute aversion of the gaze from the facts about each of the above foretell a controversy of some sort will be inevitable in broaching this topic. Nevertheless, the wider scope used in this study suggests that the term *pointes* originally applied to the small, octagonal or square nails used in France for securing cupboard hidden-hinges, fig. 132.⁶⁶⁹

A significant confusion was created by the contents of James White's first application for a brevet made on 27th November 1810. This covered a range of hand tools, which included cutting wire to length for both screws and *clous d'épingles*, as well as one for *pointes* made from thin slivers of thin iron sheet. For this latter, there was a tool acting as a reversing cutter for a strip of sheet of exact length for slicing thin iron sheet into slender triangular slivers (his fig. 16). These slivers were intended to be loaded onto plate carousels, each holding 36 slivers (his fig. 13), to be held by a waffle-plate clutch (his fig. 14). They were then placed onto a stout wooden frame with metal fittings, located under a trip-hammer. (The figure number for this was omitted but was added to later in the same hand but in a different shade of pencil as fig. 18). The slivers were then headed, and at the same time forced through an aperture towards the centre of the carousel in order to make a sharper point, fig. 133.

This somewhat complicated (and jumbled) set of devices was then later grossly simplified by a journalist in a garbled, but upbeat, account for the *Dictionnaire Chronologiques* some years later. This was picked up by the eminent Charles Frémont and condensed further. It is now firmly embedded in English, thanks to the gravitas of Professor Lewis, as comprising just one machine producing wire nails in one operation, as already noted in footnote 588.

Professor Lewis unfortunately reinforces the confusion by his select reference to nineteenth century terminology:

"They were known as French nails or *pointes de Paris*, which was to remain the French term for wire nails, and they were first made by taking a piece of wire, forming the point on a grindstone, then holding the shank in a vice and forming the head with one or two hammer blows."

The result of these simplifications is to disregard or overlook the major efforts made by Réaumur, Du Monceau, and Perronet, and shuffle into obscurity the original *pointes*, and the more correct terminology, *clous d'épingles*.⁶⁷⁰

It is also clear that *clous d'épingles* were multi-purpose small nails suitable for numerous items of furniture, but as shown by Roubo, they were widely used in fitting out buildings in sizes up to 52mm long, in two gauges of wire. At this point the potential for controversy increases once more, since the earliest find of a 1644 iron wire *clou d'épingles* was from Belgium, not the Isle de France. Furthermore, it came from the allied trade of organ builder (*Facteur des orgues*). The next earliest do come from the Paris workshops of master cabinet makers, but they are of brass, fig. 131. It is not beyond the bounds of probability that a harder metal was needed in order to impart specific tonal qualities important in an organ, which may have made iron nails a necessity within this trade.⁶⁷¹ There is no

⁶⁶⁹ HOW 2017, 46. Fig. 46 shows a range of *pointes* found in Provence and a tinned version circa 1740 is shown in Fig. 45. The method of fixing hidden cupboard hinges is seen in figs. 78 & 79.

⁶⁷⁰ REAUMUR 1761, 52 suggests these were made only by Parisian pin makers, but he avoids using the term *pointes de Paris*.

⁶⁷¹ DE CELLES 1766, 180. Dom Bedos lays emphasis on the annealing of iron nails.

way of knowing how iron wire first came to be used for these wire pins and so presently all is conjecture.

More obvious is the transition towards machine made *pointes de Paris*. By a most fortunate chance was it possible to push back in time the date of this invention to 1816 and the patent of François Daguet.⁶⁷² Locating actual samples enabled the critical features of Daguet's machine to be identified. Close inspection by Digi-scope revealed that these samples from circa 1818 show a four facet blunt point.⁶⁷³ Such a point suggests that the facet were impressed using a burin (*bavure*), as shown by Fremont still in use around 1910.⁶⁷⁴ Whilst this might work with iron shanks, the later steel points needed perforce to be cut, and hence the change in angle subtended by the points.

6.3.10 Metals

There is little to be added to what has already outlined in Section 4.6.7 except perhaps to stress how spectrographic analysis of all the metals mentioned would benefit a future study. The potential of this topic was briefly discussed with Professor Wouters at Vrije Universiteit Brussel, which has this facility within the Faculty of Engineering building.

6.3.11 Tracing the origins of wire nails

Sadly, this is an unfinished task requiring more data from Britain, USA, Belgium, and France, all of which sent wire nails into Australia. Makers of wire nails also set up in Melbourne by the 1890s.⁶⁷⁵ Two of these are worth mentioning. Anchor works, set up in 1885 may not have started manufacture of wire nails until later, but the peculiar pyramid head shape appears to have started with this company, fig. 145 - nails B, D, and E (right).⁶⁷⁶ The reasons for the range of grip marks exhibited by this particular nail is presently unclear, but pyramid head nails of reduced height also appear which may or may not be the result of copying by competitors.

The other company, Bennie Teare & Co, also of Melbourne, in 1887 is thought to be the only Australian manufacturer of steel wire nails.⁶⁷⁷ The wire was imported and of unknown origin. Wire nails of an early bright steel have shown up in Hamilton in Western Victoria in an 1879 provenance, and may possibly have come from a British source.⁶⁷⁸ The clamping was four-sided as was then the norm for iron wire nails, suggesting a softer form of steel wire was used. The heads were variations of a faceted bun. At the present time no illustrations have appeared indicating what style heads were used by Bennie Teare & Co.

The wide range of head details, together with a wide range of clamping, seen in Tables 4.11 and 4.12, are of little use in dating the artefacts, with the exception of the brief change to opposed-side clamping seen in figs. 141, and 142, being V-shaped and semi-circular, set dates around 1887/88 and 1890 respectively. (Refer also Table 4.9). Likewise the appearance of the flattened wire into oval nails provides a threshold date of 1888, fig 147.

⁶⁷² HOW 2018, 345-356

⁶⁷³ HOW 2018, 345-353 Fig. 8 on page 354. See also Fig. 149 of this volume, page 226.

⁶⁷⁴ FREMONT 1912, 45

⁶⁷⁵ LEWIS. Personal communication of 17 Feb 2020.

⁶⁷⁶ LEWIS web site 8.06.30 dated June 2014, section 8.06a

⁶⁷⁷ Ibid.

⁶⁷⁸ The source was the Hamilton Club of 1879. Iron wire and early-steel wire nails were both found.

Only one or two generic clues can be used to indicate country of origin. One that stands out is the 'forage cap' style of nail head. It appears first in fig. 140 as a version of the pinched head lining nail made by rolling technique and was traced back via a Star-head version to be a Cordes & Co nail. It then reappeared in cut form, fig.133. The similarity of head shape continues through to one form of oval head as seen in fig. 145. Two nails have been found in Tasmania having the same form of head, but on round wire nails, circa 1890. One came from Hobart Art Gallery and the other circa 1895, was from Maria Island which lies off the east coast, approximately 40 km from Hobart.



Fig. 183. Three Digi scope views of the Hobart Art Gallery 'forage cap' head wire nail, Author

The second consistent feature has already been mentioned above, the pyramid-head wire nail. Other types of head appear to move through a series of evolving changes best suited to wire nails, and in this respect, the harder steel wire of the 1890s did away with the four sided clamping and bullet heads then led the way towards the entire omission of clamping, it being replaced by teeth gripping.

6.4 SUMMARY

The uncovering of fresh or overlooked evidences, particularly those factors which have emerged in the last twenty five years ago, suggest that we should stay alert to the possibility of some fundamental changes to accepted wisdom arising from archaeological sources. Likewise, future research inside Belgium might be profitably directed into seeking out traces of Roman forging equipment and continuity of Roman standards into the Middle Ages, either through the medium of guilds, or by the actual methodologies adopted in forging iron nails.

There are still significant advantages to be had in future research reassessing Roman nail finds with respect to later nail uses, and both Belgium and France hold excellent museum and archive resources in this regard.

Much of the accepted wisdom written about nail history is in need of revision now that more original documents are available through internet sources. Faulty, entrenched ideas which currently hold sway, have been revealed and discredited by the study. Notably, the key role of the first slitting engine in expediting wire drawing by water power, the supply form of iron for nail production, and the first machine made wire nails. Similarly, examination of samples from a wider range of sources has found that handmade wire nails extend back well before current published dates in the English speaking world. A general complaint raised by this study is that much more is written in French (and also in German) than that being quoted by most respected English language sources.

In similar vein, there is a supercilious quality by some modern writers to believe that past inventors or industrial applications were somehow governed by prejudice or by conservatism, instead of by commercial realities.

Lastly, the study so far has found that the explosion of different design approaches towards wire nails, suggest that more samples are required within each of the main players up to 1890, as necessary to

plot the various spectra. This will be a difficult area to assess, but both Belgium and Britain offer good initial possibilities.

Chapter 7 will deal with conclusion reached in similar groupings to those used in these discussions:

- Information arising from the study of background parameters
- Information gained in relation to the lead-up to the study period
- Accuracies and limitations of the dating methods chosen

Chapter 7:

Conclusions



Fig. 184. The final test; an assay atelier after Biringuccio

CHAPTER 7: CONCLUSIONS

*There must be a beginning of any great matter,
but the continuing through to the end until it be thoroughly finished yields the true glory.*

Sir Francis Drake: *Dispatch to Walsingham*.

OVERVIEW

Due to the wide scope of the research, both in time and location, necessary to support the emergence of informed data, the conclusions are many and are widely spread.

The formal context of this study commences in 1680 but it was first perforce necessary to establish a norm and nomenclature for wrought nails as used in Britain. It was also necessary to fill in the missing, or often jumbled notions of nail evolution prior to 1680. The research aim has been to develop a useful system for dating from nail finds which would be applicable to both Britain and Australia. This Australian context especially requires some background to explain the strange choice of locations. Whilst diametrically opposed on the globe's surface, they were inextricably woven together by the historic factors recounted above. Nails found in Australia can be understood by relation to events which were taking place during the chosen period, and the choice of end date in 1890 is dictated to some extent by these events.

The First Fleet landed in Botany Bay, Sydney, in 1788, but the last components of administration by Britain started to disappear in 1855 as the separate colonies achieved independence on an individual basis.⁶⁷⁹ The effective withdrawal of direct control by Britain was essentially complete by 1870 when the last British troops left, since the colonies by then had their own militia and ships.⁶⁸⁰ The states formally became a federation in 1901 to form the Commonwealth of Australia.

This study jumps between Britain and the Australian colonies in regards to nails and nail technology. Since it took time to build a critical mass of population in each colony, which then included current Australian territories and New Zealand. Britain had to nurse the infant colonies through the crippling war years which ended in 1815 with the defeat of Napoleon. As seen from the dates presented in the footnote below, much had been achieved by 1855,⁶⁸¹ just after the last formal link with New Zealand had been broken, but the reality was that then only Sydney in NSW, and Melbourne in Victoria, had any sort of industrial base. It could also be said that nails coming from Britain were predominant until then, even though some wrought iron nails had been locally made ever since first settlement. Both the main centres (Sydney and Melbourne) grew wealthy on income from gold, which was found in NSW and Victoria in large quantities, and these centres therefore had the capital necessary to support and to expand industries.

The gold rushes, which affected both states, brought in numbers of Americans during this and the following decade, many with mercantile background and experience. This introduced the states about to form Australia to a bi-fold exposure to two rapidly growing industrial countries, to the eastern colonies in particular; speaking the same language, and with similar pioneer experience. The longer

⁶⁷⁹ These were: New Zealand in 1853, NSW, Victoria, and Van Diemen's Land, all in 1855, South Australia, and Norfolk Island in 1856, Western Australia in 1890, and the Northern Territory in 1911.

⁶⁸⁰ A contingent of Royal Marines was on loan from the British to the Royal Australian Navy until 1913.

⁶⁸¹ Ocean going steam ships were in vogue by 1850. The first steamship from Sydney reached Warrnambool in 1853, and the first from Liverpool in England reached it in 1855.

term effect was to accelerate the introduction of American nails and much needed softwoods into Australia, as well as more sophisticated wares.

The research considers only American nails as found in a range of Australian locations, and it was found that South Australia and Tasmania were the least affected by American nail technology. As a consequence, Australia having both wrought nails, British cast, cut, and machine rolled nails, as well as American cut nails, available for study, has created a unique opportunity for comparisons in morphologies and relative developments. This has greatly added to the study findings, and to their importance as a future study resource. They are discussed in more detail below, and sometimes the findings are at loggerheads with conventional wisdom currently proscribed in Australia and America.

For convenience, the study conclusions have been split into four main groups:

- The background parameters which arise from antiquity but which run through the middle ages and into early modern times.
- Developments occurring during the lead-up period prior to 1690 and conclusions reached arising from the information gained thereby.
- The goals reached pertaining to the study period 1680 – 1890 and the conclusions which have emerged.
- Conclusions arrived at from observed nail variations and changes in nail technology which translates into nail timelines. These become characteristic nail spectra for each zone across individual decades. Critiques are made reflecting the dating method, as to how they reflect accuracies and limitations within the nail spectra.

7.1 GOALS AND CONCLUSIONS

7.1.1 Group 1 – conclusions coming from antiquity onward

These can be summarized as:

- (a) *First nails.*
Nails are mentioned in Chinese ‘Oracle Bone’ script, dating from the 17th century BC suggesting that the oriental nail tradition is much older than that of the West.
- (b) *World classification.* Research found only two divisions of nail morphologies exist on a grand scale. The one found in the Far East was based on alternative sets of principles governing nail technology, and these were unique until the establishment of Portuguese and Dutch trading links. In China the first signs of Western influence are suggested by nails found at Baochuanchang shipyard, fig. 2 -centre. The close similarity of Japanese nails, as conforming to a broader ‘Eastern’ school, is noted in the Glossary under Eastern School. The common element present in the Far East is that a folding technique was used in nail head formation, as opposed to most heads being separately formed in the Western world.
- (c) *Western nail tradition.* The study’s scope and findings have been outlined and discussed in section 1.1.3 above. The conclusions drawn are that Celtic forged iron nails dominated Pre-Roman Europe. However, the research suggests that Roman discipline and its organisation of a multi-national army set in place common patterns for forged nails. A continuity of nail typo-morphologies, uniformity of styles, and a relatively uniform European nail manufacturing technology continued into the medieval and pre-modern era.

7.1.2 Group 2 - conclusions emanating from the lead-up period

These fall into six main elements:

- (a) *The Theux hammer*. Although research is ongoing, it seems incontrovertible that splitting of iron into baton form, '*fer stendu*', was already taking place in Liege well ahead of slitting and probably ahead of production of *Krauss-eisen*.
- (b) *Krauss-eisen*. The study finds that this element influencing nail technology came about as a result of power wire drawing within the allied dialect areas of Franconia, Bavaria, and the large iron producing area of Steiermark in Austria, around 1485. Power drawing demanded a big increase in the supply of iron filaments. To meet the demand a forging hammer with an adapted head was developed, able to shear the iron; - the *Zeinhammer*, (as described in 1.1.5). *Fachwerk* used more large nails in building so the thickness of the *Krauss-eisen* was not a significant disadvantage. As already seen (fig.17), the width produced was governed by eye alone, producing the thick wavy filament of around 14mm square termed *Krausseisen*, (wavy iron).
- (c) *The slitting engine*. The study has found that this was the most important technological advance in the history of nail-making. Research shows that its origins lay with ideas presented, by a Peter Anthony Van Ghemen in 1567. The development was resolved by two mining engineers, Christopher Schütz, an anglicized Saxon, and Bevis Bulmer, his younger English associate, (refer Appendix II), and it was in service by 1576.
- (d) *The Liège nail industry*. The research concludes that the Liège industry was the premier world nail industry prior to the emergence of the English Midlands, Black Country nail industry around 1650. The research has established that the Liège nailery at its fullest extent (i.e. including Charleville and Charleroi), supported markets export worldwide.
- (e) *The British nail industry*. The study concludes that lengthy research (as described in section 3.3), played a role in resolving development difficulties. Ultimately, the solutions to processing inferior ores lay in their fortuitous proximity to coalfields, to the development of steam power, to canal and river improvements, and then finally to railways. The emergence of the Black Country as a world player was driven in main by the success of Britain's colonies in North America and elsewhere.
- (f) *Hard-won lessons and Innovations*. The research found that the greatest changes in nail spectra came about as a result of the London building regulations following the Great Fire of 1666. The study has found that the resultant regulations effectively created new styles of building which stimulated changes in nail design and increase in number of nails used. Internal partitioning increased the demand for cheaper lath nails, satisfied by annealed cast iron lath tacks.

7.1.3 Group 3 – goals and conclusions reached by study

The research has probed in depth the types of wrought iron nails used in construction which appeared during the study period 1680- 1890. By and large, exemplars to match the descriptions given in reliable texts have been located. These have been recorded, photographed, and in some case 3-dimensional sketches have been prepared. There is a proviso concerning nail names shown in these inventories in that some variations of names, in particular occurring at the outset of the study period, appeared to be either local, or coined by persons within the trade at that particular time. Conversely, the study

found long continuity in the morphologies of certain types, as seen in fig. 97. Several morphologies can be traced to their Roman equivalents, but the study was unsuccessful in linking pre-1680 nail names back to Latin equivalents such as *clavus muscarius*, *clavus trabilis*, or *clavi caligulae*, whose morphologies and purposes have continued over two millennia. Instead, the study established several links with Anglo-Saxon names. (Refer section 6.1.4).

An analysis was made of rod nail sizes using samples collected, Table 4.3. This was made possible by measuring the cross-section dimensions of the un-pared length of shank. The study found that the distribution of slit rod sizes remained, surprisingly, fairly constant over the period 1680- 1831.

Wrought nails were complimented by annealed cast iron nails and used in a variety of tasks. Notably this included lath nails, with a first find of 1780 from Westminster, and a probable earlier, somewhat slighter, sample from Glastonbury, Somerset. Widespread distribution of finds of this same nail were found in Sydney, in many locations around England, and references were found to their use in Upper New York State. Other exemplars of annealed iron nails had little to do with building construction and lacked both identifiable change and provenance.

In regards to the form of iron supplied, the study reaches some tentative conclusions of a broad continuity through post-Roman times of iron supply in heavier baton form. A curious spread in time was found of iron supplied this way; Roman, (fig. 12); Anglo-Saxon, (section 1.1.4); Medieval, (fig. 11); and the curious apparatus described by Emerson which is explained in Appendix V. A tentative conclusion ties this latter to the need for extra-large nails for bridge works, canal locks, and fortifications. In this regard it finds that Emerson's apparatus of 1758, coincided appositely with a major increase in canal works,⁶⁸² and major demands for lock nails. Similarly, Sweden continued to rely on iron in baton form since it suited fabrication of their larger nails and spikes, (fig. 13). Further research into this topic is recommended as this topic is beyond the concerns of the present study.

- (a) *'Fer stendu'*. As seen above and in Appendix III, a first priority from a Belgian perspective should be to match the theoretical production signature of this form of baton iron to actual nail samples. It seems possible that this should start with samples already held by Dr Maggi. The effects of corrosion and of wear notwithstanding, it should be possible to now find some traces of shear and tear signature as Belgian medieval nails have so far shown up in better condition than, for example, their British counterparts.
- (b) *Use of the Oliver*. As a result of this research a hitherto unreported form of flattened lining nail was found in Westminster, on the Welsh Marches, and in Wells, Somerset, which was suitable for the new range of imported softwoods. These were traced back to a first provenance in the 1690s. The study concludes that the Oliver (as noted in section 1.4.3), was already in use, but in a less sophisticated role. Confirmation of its use as a die-header for slating nails came from an 1838 provenance, (refer **N 28**) matching ones shown in the 1812 Board of Ordnance tender document. The study makes a tentative conclusion that the Oliver mechanism was sufficiently accurate by 1800 or so, to provide a consistent guided hammer strike.
- (c) *The 'stiddy adaption*. The study found the use of the Oliver in conjunction with the vertical mould, or 'stiddy', comes from 1875 (for square iron billets), and from circa 1894 for rounds..

⁶⁸² SATCHELL 2018, section 5.

Its use in Belgium was recorded by Genart and Beatse in an image of circa 1900, but it may have been used much earlier.⁶⁸³

- (d) *Cut nails.* The study has found that the development of cut nails is just as much British as American, simply because of the two-way movement of inventors; an under-reported phenomenon in both America and Australia. The consistent level of failures found in American cut nails imported into Australia, confirmed the need to match nail strength to timber strength. That said, the range of cut nails developed by the Americans was adequate for use in North American softwoods (fig. 113), and for their own purposes they arrived at a range of cut nails which broadly superseded wrought ones (fig. 115). Their cut nails in the 'fine' range, (fig. 135), were particularly elegant, handy, and appealing in design, and once Australia increased its use of American timbers they were well received.

Research has found that the ingenious American solution to avoid separation of proto-shank layers, led to a thinner, weaker zone below head level. (Refer 'face clamping', fig. 134).

The research suggests the British showed more innovation in their approach to cut nail technology. The study found samples, circa 1800, showed the British practice was to cut the nail shanks to lie with the iron grain. The study also found pre-profiled proto-shanks cut square to the plate circa 1840.

- (e) *Non-ferrous nails.* Samples found in Britain and Australia show that slating nails comprised the only large group of nail use for non-ferrous nail types. The wide range of climatic zones investigated in Australia and in Britain, has shown that zinc nails only survive well when the locus is away from the coast. Samples from 1856 and 1870 from Warrnambool and Port Fairy, both in the coastal saline atmosphere, had almost 100% decay into zinc oxide, whereas older zinc nails from an inland site at Meredith, near Geelong, were in very good condition. Copper cut nails, to the same essential morphology have always been recovered in good condition, regardless of site location. There appears to be no difference between the zinc and copper cut slating nails found in Britain or in Australia, Table 4.5. (Refer also fig. 131). Belgian '*Vieux Montagne*' nails were found in Adelaide with an 1878 provenance. (See FN 396).
- (f) *The Ewbank nail (Cordes & Co).* The study concludes that this nail grew in dominance after 1845 or so, in Britain, Australia and possibly New Zealand. Its physical changes (refer figs. 138, & 139), provide major leads in defining dates of finds in these countries.
- (g) *French wire nail patents.* The appearance of wire nails in New Zealand, well ahead of their use in Australia, has been conclusively attributed to a Mission building constructed by French Marist Brothers circa 1842.⁶⁸⁴ The study has therefore probed the lineage of *brevets* in the Paris archives with the limited aim of assessing the accuracy of 'conventional wisdom', and then perhaps finding a first contender for the machine manufacture of wire nails. (Refer to section 4.6.6). The conclusions reached by research of the Paris archives are that the patent by François Daguet comprised the first real wire nail machine. The claims made about the American James White's involvement in the development of wire nails are spurious. The

⁶⁸³ VARMAN 193, 117. The picture shown is incorrectly labelled by Varman as a 'traditional method'.

⁶⁸⁴ CLUNIE 2008, 5.

study has also disposed of the strange, disingenuous, claim in this regard made by the Japy brothers, since their lathe device did not comprise manufacture by a machine since each *clou d'epingle* had to be individually machined. Hence the method was neither mechanical nor was it a commercial proposition in regards to nail production.

- (h) *British wire nails.* The research recovered Light gauge drumhead and inverted cone head iron wire nails ⁶⁸⁵ from Wells in Somerset, in a probable 1845-1855 context. These had been used in softwood reveals around sash windows, originally inserted around 1730 and removed for maintenance at about this period. The study's tentative conclusion is that around these dates the British were producing a limited range of iron wire 'panel pins' in at least two head versions, specifically for use in softwoods. One further conclusion can be inferred which relates to bullet head wire nails, which still remain standard items to this day. This early find of a drum head wire nail strongly suggests that it may have been a British initiative as, so far, none have come from French or Belgian sources.
- (i) *Slow acceptance of iron wire nails.* The study found there was no significant difference in attitude between either the Americans or the British in regard to adopting iron wire nails. It finds that in Australia iron wire nails were only used in unseasoned eucalypt timbers, such as Messmate and Stringybark. This allowed their slow adoption by around 1870. ⁶⁸⁶ The study also found that improvements in iron metallurgy occurred the years 1870 to 1890.

7.1.4 Group 4 – Timelines, changes, and decade accuracy

- (a) *Timelines.* With regard to the timelines the study concludes that identifiable changes in nails since 1680 can only be successfully used as a means of dating buildings and extensions from 1790 onwards. However, certain earlier events provide clues to establishing dates during the prior period, notably the introduction of annealed cast nails, which appear as new forms of lathing nails from the early 1780s. These first appear in slender form, but gain a robust regular size circa 1800. On a quantitative basis cast nails enjoyed a surge in popularity as refurbishment of English churches took off during the period 1844-1875, and some enthusiasm for these unsound alterations continued until the end of the study period. The study was unable to find any useful trends emanating from cast nail designs or usage, as once developed, the morphologies tended to remain unchanged.

On the basis of personal experience, the master chart of changes, fig. 169, p272, was simplified for convenient use in site inspections, to a few useful 'indicator' types, fig. 171. To these could fortuitously be added the easily identified changes of the Ewbank/Cordes & Co range, (refer figs 172, & 129). Similarly, the British cut clasp nail ran through four identifiable changes in shape, (fig. 173), which add to an on-site, quick analysis methodology.

⁶⁸⁵ These were 52mm and 47mm long respectively. There were signs of alterations to the sash frames occurring around this date to Tower House, a former diocese house of the Cathedral School headmaster of circa 1390.

⁶⁸⁶ Significant percentages of failure and unusual fractures have been found. See Fig. 160 p243. The origins of the wire nails is not known,

In converting useful changes in nails to zones within the buildings, the study found that use of any particular nail type tended to drift into wider use as time progressed and acceptances (or necessities)⁶⁸⁷ changed. Identification of these small variations of usage has only been possible by seeing buildings during renovation. There is an obvious caveat that one nail found out of its usual application cannot be used to form conclusions for the whole zone. The zonal charts (figs. 174-178), are thereby less certain in some areas – those marked by asterisk -, due to this alternative nail application:

Zone 1 – nails adopted for roof claddings and for external features

*Zone 2 – nails used for roof interiors**

Zone 3 – nails used in wall framing and for lathing

*Zone 4 – nails used flooring and sub-floor construction**

Zone 5 – nails used in linings, window and door reveals and second fixings

In the case of Zone 2*, the internal parts of roof carpentry, the joints are difficult to reach and the nail heads are normally driven home, so that they are essentially obscured. Similarly in Zone 3, walls, these are usually concealed. In some cases partial demolition allows samples to be recovered. Access to these parts is less easy than to the other zones, as is the sub-floor section of Zone 4*, which is rarely accessible and unless samples are taken during demolition, they are almost impossible to obtain. As a consequence, there is a lack of balance in some areas which is difficult to overcome and can only be acknowledged as a challenge for researchers. Conversely, there are compensatory factors, such as the relative ease with which roof spaces can be accessed, - often containing much discarded, but extremely useful material.

- (b) *Decade charts.* These have been assembled from the research findings and form an extension to the zone timelines. Experience gained during the course of the study suggests that this form of presentation proves the most useful as a guide for site analysis of buildings. Certain areas progress through several levels of change and roofs in particular are more subject to decay than other areas and, as seen above, samples from previous changes as well as timber fragments often are left in roof spaces. The study concludes that the changes in nails occurring between the two decades 1790-1800 and 1800-1810 are small and easily missed. The nail spectra during both these decades have some regional variation. For example, within major cities, such as London, the latest improvements in nail design fell into use quicker, reflecting a general greater use of nails. Within the more rural areas the turnover of nail types was likely to be slower and it took time for innovations to reach into the hinterland. Thus a lapse of perhaps several years might have been involved - thereby affecting the dating method. For the remaining decades, the conclusions are that the dating system works tolerably well from 1810 onwards, but that it gains greatly in efficiency from the late 1830, becoming more efficient with time.

⁶⁸⁷ As an apprentice in 1940 the late Ron Bishop of Warrnambool Public Works Office told the author that only cut spur head brads were available for all site carpentry.

- (c) *General conclusion in respect of a dating system.* The study finds that the system developed works well. It greatly enhances the chance of accurately dating building, extensions and repairs when used in conjunction with other features, particularly changes in screws and in joinery, and to a lesser extent door and window furniture.
- (d) *Divergence of field data.* The study concludes that the same system of dating can be used in Britain and Australia up to 1870-1875. After this date the availability of the later designed American nails and increases in import of American timbers, alters the modes of occurrence somewhat in that the nail once more matches the wood for which they were intended,
- (e) *The end of study markers.* After 1890 changes are distinctive and the proportion of wire nails found increases dramatically. However, numerous other changes can be noted in other nail forms, such as the changes from iron to steel in cut nails, which leaves distinctive modification to the pressing and to head flanges. These changes effectively ensure that the chance of mistaking the construction date for a pre-1890 decade is very unlikely.

7.2 SUMMARIES

These fall into two groups of which neither form part of the conclusions given above. They are:

- Aspects of the research outline and the methodology adopted, and
- Aspects arising out of the research which comprise items offering potential for further study.

7.2.1 The Research outline and methods adopted

It will come as no surprise to the reader that methods have had to adapt to circumstances throughout this research. With the full benefits of hindsight, meticulous adherence to archaeological site practice would have eased many problems, but may have hindered receiving samples having only slight provenance. Mistakes in excess cleaning of samples showed up early and so a careful, long-winded approach has been taken at the cost of a great deal of time. In the opinion of the author this had paid off. It has led also to the practice of leaving sufficient interpretable traces on the nail bodies for future researchers.

The broad outline of investigation will leave this thesis out to criticism but the field of current knowledge and literature has omitted many pieces of critical information which give unbalanced, and frequently simplistic historical viewpoints. In this regard the methods taken are felt to be justified in providing a fuller, more complete picture.

7.2.2 Items worthy of future research

There are seven unanswered, and somewhat difficult questions, which arise out of the research:

- Where does the effective boundary between Eastern School of nail making and Western School occur?
- Did the Romans use tilt-hammers?
- Was it Roman practice to smelt iron at source?
- Was there a continuity of artisanship in eastern Belgium after the Roman departure?
- Are there further references to iron supply in heavy baton form during the Middle Ages?

- Did the *Zeinhammer* originate in the Steiermark of Austria or did it emulate the Theux chisel hammer?
- Where did Peter Anthony Van Ghemen come from, what was his background, and what caused his sudden disappearance from England?

This thesis suggests that there was a continuity of descent of an artisan workforce emanating from the forward concentration areas of the Roman army in the general area of Tongeren – Liege. Such a continuity of trades-people over two millennia would be impossible to prove, however, Hansotte's research found a link back to 1406 in circumstances suggesting an already long established tradition. Bertholet's recent research has discovered an already old industry around Franchimont by 1449. With the development of improved techniques in archaeology this avenue of future research is well worth following.

7.2.3 Expectations

With so much work done already on Belgian nail history, the information contained in this thesis can be followed as a guide to completing a nail inventory similar to that shown in Chapter 4 which would greatly benefit the field of construction history. Such an extension of this work would be of benefit to Archaeologists and Conservators alike.

CONCLUSIONS - française

En raison de la vaste portée de la recherche, tant dans le temps que dans le lieu, nécessaire pour soutenir l'émergence de données éclairées, les conclusions sont nombreuses et sont largement répandues.

Le contexte formel de cette étude commence en 1680, mais il a d'abord été nécessaire d'établir une norme et une nomenclature pour les clous forgés comme utilisé en Grande-Bretagne. Il était également nécessaire de remplir les notions manquantes, ou souvent brouillées de l'évolution des clous avant 1680. L'objectif de recherche a été de développer un système utile pour la datation à partir de découvertes des clous qui serait applicable à la fois à la Grande-Bretagne et l'Australie. Ce contexte australien nécessite surtout un peu de fond pour expliquer le choix étrange des lieux. Bien que diamétralement opposés à la surface du globe, ils étaient inextricablement tissés ensemble par les facteurs historiques racontés ci-dessus. Les clous trouvés en Australie peuvent être compris par rapport aux événements qui ont eu lieu au cours de la période choisie, et le choix de la date de fin en 1890 est dicté dans une certaine mesure par ces événements.

La Première Flotte débarqua à Botany Bay, Sydney, en 1788, mais les dernières composantes de l'administration par la Grande-Bretagne commencèrent à disparaître en 1855 lorsque les colonies séparées atteignaient leur indépendance sur une base individuelle⁶⁸⁸. Le retrait effectif du contrôle direct par la Grande-Bretagne était essentiellement achevé en 1870, lorsque les dernières troupes britanniques sont parties⁶⁸⁹, puisque les colonies avaient alors leur propre milice et leurs propres navires. Les États sont officiellement devenus une fédération en 1901 pour former le Commonwealth d'Australie.

Cette étude saute entre la Grande-Bretagne et les colonies australiennes en ce qui concerne les clous et la technologie des clous. Puisqu'il a fallu du temps pour construire une masse critique de population dans chaque colonie, qui comprenait alors les territoires australiens actuels et la Nouvelle-Zélande. La Grande-Bretagne dut allaiter les colonies infantiles pendant les années de guerre paralysantes qui se termina en 1815 avec la défaite de Napoléon. Comme on peut le voir dans les dates présentées dans la note de bas de page ci-dessous, beaucoup avait été réalisé en 1855⁶⁹⁰, juste après que le dernier lien formel avec la Nouvelle-Zélande eut été rompu, mais la réalité était que Sydney en Nouvelle-Galles du Sud et Melbourne à Victoria avaient une base industrielle quelconque. On pourrait aussi dire que les clous en provenance de Grande-Bretagne étaient prédominants jusque-là, même si certains clous en fer forgé avaient été fabriqués localement depuis le premier règlement. Les deux principaux centres (Sydney et Melbourne) se sont enrichis en revenus d'or, qui se trouvaient en grande quantité en Nouvelle-Galles du Sud et à Victoria, et ces centres disposaient donc des capitaux nécessaires pour soutenir et développer les industries.

Les ruées vers l'or, qui ont affecté les deux États, ont amené un nombre d'Américains au cours de cette décennie et la décennie suivante, beaucoup avec des antécédents et de l'expérience mercantiles. Cela a introduit les États sur le point de former l'Australie à une exposition double à deux pays industriels à croissance rapide, aux colonies orientales en particulier; parlant la même langue, et

⁶⁸⁸ Il s'agissait de la Nouvelle-Zélande en 1853, de la Nouvelle-Galles du Sud, de Victoria et de Van Diemen's Land, tous en 1855, de l'Australie-Méridionale et de l'île Norfolk en 1856, de l'Australie-Occidentale en 1890 et du Territoire du Nord en 1911.

⁶⁸⁹ Un contingent de Royal Marines est prêté par les Britanniques à la Royal Australian Navy jusqu'en 1913. Les navires à vapeur de l'océan étaient en vogue en 1850

⁶⁹⁰ Les navires à vapeur de l'océan étaient en vogue en 1850. Le premier navire à vapeur de Sydney atteint Warrnambool en 1853, et le premier de Liverpool en Angleterre l'atteint en 1855.

avec une expérience pionnière similaire. Plus le effet terme était d'accélérer l'introduction de clous américains et de résineux bien nécessaires en Australie, ainsi que des marchandises plus sophistiquées.

La recherche ne considère que les clous américains comme trouvés dans une gamme d'endroits australiens, et il a été constaté que l'Australie du Sud et la Tasmanie étaient les moins touchés par la technologie américaine des clous. En conséquence, l'Australie ayant à la fois des clous forgés, des clous britanniques moulés, coupés et roulés à la machine, ainsi que des clous coupés américains, disponibles pour l'étude, a créé une occasion unique pour les comparaisons dans les morphologies et les développements relatifs. Cela a grandement ajouté aux résultats de l'étude et à leur importance en tant que ressource d'étude future. Ils sont discutés plus en détail ci-dessous, et parfois les résultats sont en désaccord avec la sagesse conventionnelle actuellement interdite en Australie et en Amérique.

Pour plus de commodité, les conclusions de l'étude ont été divisées en quatre groupes principaux :

- les paramètres de fond qui découlent de l'Antiquité, mais qui traversent le Moyen Âge et les premiers temps modernes.
- Les développements se sont produits au cours de la période d'avance avant 1690 et les conclusions tirées découlant des informations obtenues ainsi.
- Les objectifs atteints concernant la période d'étude 1680–1890 et les conclusions qui ont émergé.
- Les conclusions sont arrivées à partir des variations observées des clous et des changements dans la technologie des clous qui se traduit par des chronologies des clous. Ceux-ci deviennent des spectres des clous caractéristiques pour chaque zone à travers les décennies individuelles. Les critiques sont faites reflétant la méthode de datation, quant à la façon dont ils reflètent les accusations et les limitations dans les spectres des clous.

7.1 OBJECTIFS ET CONCLUSIONS

7.1.1 Groupe 1 – conclusions provenant de l'Antiquité

- (a) *Premiers clous.* Les clous sont mentionnés dans l'écriture chinoise d'Oracle Bone, datant du 17^{ème} siècle avant JC suggérant que la tradition orientale des clous est beaucoup plus vieille que celle de l'Ouest
- (b) *Classement mondial.* Celui trouvé en Extrême-Orient était basé sur d'autres ensembles de principes régissant la technologie des clous, et ceux-ci étaient uniques jusqu'à l'établissement de liens commerciaux portugais et néerlandais. En Chine, les premiers signes d'influence occidentale sont suggérés par les clous trouvés au chantier naval de Baochuanhang, fig. 2 -centre. La similitude étroite des clous japonais, comme conforme à une école « orientale » plus large, est notée dans le Glossaire de l'École de l'Est. L'élément commun présent en Extrême-Orient est qu'une technique de pliage a été utilisée dans la formation de la tête des clous, par opposition à la plupart des têtes étant formées séparément dans le monde occidental.
- (c) *Tradition des clous occidentaux.*
La portée et les conclusions de l'étude ont été exposées et discutées à la section 1.1.3 ci-dessus. Les conclusions tirées sont que les clous de fer forgés celtiques dominaient l'Europe préromaine. Cependant, la recherche suggère qu'il s'agissait d'une discipline romaine et son organisation d'une armée multinationale mis en place des modèles communs pour les clous forgés. En conséquence vient une continuité des typologies des clous, l'uniformité des styles,

et une technologie européenne relativement uniforme de clou, qui a continué dans l'ère médiévale et pré-moderne.

7.1.2 Groupe 2 - conclusions émanant de la période d'avance

Ces conclusions se répartissent en cinq éléments principaux:

- (a) *Le martinet de Theux.* Bien que la recherche soit en cours, il semble incontestable que la division du fer en forme de bâton, « fer stendu », avait déjà lieu à Liège en 1446, bien avant la fente et probablement en avance sur la production de *Krauss-eisen*.
- (b) *Krauss-eisen.* L'étude révèle que cet élément influençant la technologie des clous est le résultat du dessin de fil de puissance dans les zones dialectales alliées de la Franconie, en Bavière, et la grande zone de production de fer de Steiermark en Autriche, vers 1485. Le dessin de puissance a exigé une grande augmentation de l'approvisionnement en filaments de fer. Pour répondre à la demande, un martinet forgé avec une tête adaptée a été développé, capable de cisaler le fer; - le *Zeinhammer*, tel que décrit dans 1.1.5. Cette technologie a été immédiatement transférable à d'autres métiers utilisant des filaments de fer – y compris la fabrication des clous. *Fachwerk* a utilisé des clous plus grands dans la construction, l'épaisseur de la *Krauss-eisen* n'était pas un inconvénient significatif. Comme on l'a déjà vu (fig.17), la largeur produite était régie par les yeux seuls, produisant l'épais filament ondulé d'environ 14mm carré, appelé *Krausseisen*, (fer ondulé).
- (c) *Le mécanisme de fente (fenderie).* L'étude a révélé qu'il s'agissait de l'avancée technologique la plus importante de l'histoire de la fabrication de clous. La recherche montre que ses origines reposent sur des idées présentées par un Peter Anthony Van Ghemen en 1567. Après cela, la preuve est moins claire, mais soutient généralement une conclusion que Van Ghemen a abandonné le développement du moteur. Le développement a été résolu par deux ingénieurs miniers, Christopher Schütz, un Saxon anglicisé, et Bevis Bulmer, son jeune associé anglais, (voir annexe II), et il était en service en 1576
- (d) *La clouterie liégeoise.* La recherche conclut que l'industrie liégeoise était la première industrie mondiale des clous avant l'émergence de l'industrie anglaise des clous des Midlands, "Black Country" vers 1650. La recherche a établi que dans toute sa mesure (y compris Charleville et Charleroi), les marchés soutenus par les clous exportent dans le monde entier.
- (e) *L'industrie britannique des clous.* L'étude conclut que la longue recherche (telles que décrites à la section 3.3) ont joué un rôle dans la résolution des difficultés de développement. En fin de compte, les solutions à la transformation des minerais inférieurs se trouvaient dans leur proximité fortuite des champs de charbon, au développement de l'énergie à vapeur, à l'amélioration des canaux et des rivières, puis enfin aux chemins de fer. L'émergence du "Black Country" qu'acteur mondial a été motivée en grande partie par le succès des colonies britanniques, en Amérique du Nord et ailleurs

En fin de compte, les solutions à la transformation des minerais inférieurs se trouvaient dans leur proximité fortuite des champs de charbon, au développement de l'énergie à vapeur, à l'amélioration des canaux et des rivières, puis enfin aux chemins de fer. L'émergence du Pays

Noir en tant qu'acteur mondial a été motivée en grande partie par le succès des colonies britanniques en Amérique du Nord et ailleurs.

- (f) *Leçons et innovations durement gagnées.* La recherche a révélé que les plus grands changements dans les spectres des clous sont survenus à la suite des règlements de construction de Londres à la suite du Grand Incendie de 1666. L'étude a révélé que les règlements qui en résultent effectivement créé de nouveaux styles de construction qui ont stimulé des changements dans la conception des clous et l'augmentation du nombre de clous utilisés. Le cloisonnement interne a augmenté la demande pour les clous de lattes moins chers, satisfaits par les pointes de fonte annellées.

7.1.3 Groupe 3 – objectifs et conclusions atteints par étude

La recherche a examiné en profondeur les types de clous en fer forgé utilisés dans la construction qui sont apparus au cours de la période d'étude 1680-1890. Dans l'ensemble, des exemples correspondant aux descriptions données dans des textes fiables ont été localisés. Ceux-ci ont été enregistrés, photographiés et, dans certains cas, des croquis tridimensionnels ont été préparés. Il y a une condition concernant les noms des clous indiqués dans ces inventaires en ce que certaines variations de noms, en particulier au début de la période d'étude, semblaient être soit locales, soit inventées par des personnes dans le commerce à ce moment-là. Inversement, l'étude a trouvé une longue continuité dans les morphologies de certains types, (comme on le voit dans la fig. 97). Plusieurs morphologies peuvent être attribuées à leurs équivalents romains, mais l'étude n'a pas réussi à relier les noms des clous d'avant 1680 à des équivalents latins tels que le *clavus muscarius*, le *clavus trabilis* ou les *calgulae clavi*, dont les morphologies et les buts se sont poursuivis sur deux millénaires. Au lieu de cela, l'étude a établi plusieurs liens avec les noms anglo-saxons, (comme discuté à la section 6.1.4).

Une analyse a été effectuée sur la taille des clous de tige à l'aide d'échantillons recueillis, (tableau 4.3). Cela a été rendu possible en mesurant les dimensions transversales de la longueur non parée de la tige. L'étude a révélé que la distribution des tailles de tiges de fente est demeurée, étonnamment, assez constante au cours de la période 1680-1831.

Les clous forgés ont été complétés par des clous en fonte annealed et utilisés dans une variété de tâches. Notamment cela comprenait des clous de lattes, avec une première découverte de 1780 de Westminster, et un probable plus tôt, un peu plus léger, échantillon de Glastonbury, Somerset. La distribution répandue des découvertes de ce même clou a été trouvée à Sydney, dans beaucoup d'endroits autour de l'Angleterre, et des références ont été trouvées à leur utilisation dans l'état supérieur de New York. D'autres exemples de clous de fer annealed avaient peu à voir avec la construction de bâtiments et manquaient à la fois de changement identifiable et de provenance.

En ce qui concerne la forme de fer fourni, l'étude arrive à quelques conclusions provisoires d'une large continuité à travers les temps post-romains de l'approvisionnement en fer sous forme de bâton plus lourd. Une curieuse propagation dans le temps a été trouvée de fer fourni de cette façon; Roman, (fig. 12); Anglo-Saxon, (section 1.1.4); Médiéval, (fig. 11): et l'appareil curieux décrit par Emerson qui est expliqué à l'annexe V. Une conclusion provisoire lie ce dernier à la nécessité de clous extra-larges pour les travaux de pont, les écluses de canal, et les fortifications. À cet égard, il constate que l'appareil d'Emerson de 1758, coïncidait avec une augmentation importante des travaux de canal, et des

demandes majeures pour les clous de serrure⁶⁹¹. De même, la Suède a continué de s'appuyer sur le fer sous forme de matraque puisqu'elle convenait à la fabrication de leurs plus gros clous et pointes, (fig. 13). D'autres recherches sur ce sujet sont recommandées car ce sujet dépasse les préoccupations de la présente étude.

- (a) *'Fer stendu'*. Comme on le voit ci-dessus et à l'annexe III, une première priorité, du point de vue belge, devrait être de faire correspondre la signature théorique de production de cette forme de fer à matraque à des échantillons des clous réels. Il semble possible que cela commence par des échantillons déjà détenus par Dr Maggi. Malgré les effets de la corrosion et de l'usure, il devrait être possible de trouver des traces de cisaillement et de déchirure, car les clous médiévaux belges sont jusqu'à présent en meilleur état que, par exemple, leurs homologues britanniques.
- (b) *Utilisation de l'Oliver*. À la suite de cette recherche, une forme jusqu'ici non déclarée de clou de doublure aplatie a été trouvée à Westminster, sur les frontières galloises, et à Wells, Somerset, qui convenait à la nouvelle gamme de résineux importés. Ceux-ci ont été retracés à une première provenance dans les années 1690. L'étude conclut que l'Oliver (comme indiqué à la section 1.4.3), était déjà utilisé, mais dans un rôle moins sophistiqué. La confirmation de son utilisation comme tête de matrice pour les clous de lattes est venue d'une provenance de 1838, (référence N 28) correspondant ceux indiqués dans le 1812 Board of Ordnance document d'appel d'offres. L'étude conclut provisoirement que le mécanisme Oliver était suffisamment précis à environ 1800, pour fournir une frappe guidée constante de marteau.
- (c) *L'adaptation 'stiddy'*. L'étude a révélé que l'utilisation de l'Oliver en conjonction avec le moule vertical, ou « itod », provient de 1875 (pour les billets de fer carré), et d'environ 1894 pour les tours. Son utilisation en Belgique a été enregistrée par Genart et Beatse dans une image de vers 1900, mais il peut avoir été utilisé beaucoup plus tôt⁶⁹².
- (d) *Les clous coupés*. L'étude a révélé que le développement des clous coupés est tout autant britannique qu'américain, simplement en raison du mouvement bidirectionnel des inventeurs; phénomène sous-déclaré en Amérique et en Australie. Le niveau constant des échecs trouvés dans les clous coupés américains importés en Australie, a confirmé la nécessité de faire correspondre la force des clous à la force du bois. Cela dit, la gamme de clous coupés mis au point par les Américains était adéquate pour être utilisée dans les résineux nord-américains, (fig. 113), et pour leurs propres besoins, ils sont arrivés à une gamme de clous coupés qui ont largement remplacé ceux forgés, (fig. 115). Leurs clous coupés dans la gamme « ie », (fig. 135), étaient particulièrement élégants, maniables et attrayants dans la conception, et une fois que l'Australie a augmenté son utilisation de bois américains, ils ont été bien reçus.

La recherche a constaté que la solution américaine ingénieuse pour éviter la séparation des couches de proto-tige, a conduit à une zone plus mince et plus faible au-dessous du niveau de la tête. (Se référer à la « primage du visage », fig. 134).

⁶⁹¹ SATCHELL 2018, section 5

⁶⁹² VARMAN 193, 117. L'image montrée est incorrectement étiquetée par Varman comme une « méthode traditionnelle »

La recherche suggère que les Britanniques ont montré plus d'innovation dans leur approche pour couper la technologie des clous. L'étude a trouvé des échantillons, vers 1800, a montré que la pratique britannique était de couper les jarrets d'ongle pour se trouver avec le grain de fer. L'étude a également trouvé des proto-shanks pré profilés taillés carré à la plaque vers 1840.

- (e) *Clous non ferreux.* Des d'échantillons trouvés en Grande-Bretagne et en Australie montrent que les clous de lattes constituaient le seul grand groupe d'utilisation de clous pour les types de clous non ferreux. Le large éventail de zones climatiques étudiées en Australie et en Grande-Bretagne, a montré que les clous de zinc ne survivent bien quand le locus est loin de la côte. Les échantillons de 1856 et 1870 de Warrnambool et de Port Fairy, tous deux dans l'atmosphère saline côtière, se désintègrent presque à 100 % en oxyde de zinc, tandis que les anciens clous de zinc d'un site intérieur à Meredith, près de Geelong, étaient en très bon état. Les clous coupés en cuivre, à la même morphologie essentielle ont toujours été récupérés en bon état, indépendamment de l'emplacement du site. Il ne semble pas y avoir de différence entre les clous de latte de zinc et de cuivre trouvés en Grande-Bretagne ou en Australie, tableau 4.5. (Voir aussi fig. 131). Des clous belges « Vieux Montaine » ont été trouvés à Adélaïde cica 1860.
- (f) *Le clou Ewbank (Cordes et Co).* L'étude conclut que ce clou s'est développé en dominance après 1845 environ, en Grande-Bretagne, en Australie et peut-être aussi en Nouvelle-Zélande. Ses changements physiques, (se référer figs. 138, & 139), fournissent des pistes majeures dans la définition des dates de découverte dans ces pays.
- (g) *Français brevets de clous de fil.* L'apparition des clous de fil en Nouvelle-Zélande, bien avant leur utilisation en Australie, a été attribuée de façon concluante à un bâtiment de la Mission construit par Français Frères Maristes vers 1841.⁶⁹³ L'étude a donc sondé la lignée des brevets dans les archives parisiennes dans le but limité d'évaluer l'exactitude de la « sagesse conventionnelle », puis peut-être de trouver un premier concurrent pour la fabrication de clous métalliques. (Reportez-vous à la section 4.6.6). Les conclusions des recherches des archives parisiennes sont que le brevet de François Daguet constituait la première véritable machine à clous de fils. Les affirmations faites au sujet de l'implication de l'Américain James White dans le développement des clous de fils sont fallacieuses. L'étude a également éliminé l'étrange, malhonnête, revendication à cet égard faite par les frères Japy, puisque leur dispositif de tour ne comprenait pas la fabrication par une machine puisque chaque clou d'épingle a dû être usiné individuellement. Par conséquent, la méthode n'était ni mécanique, ni une proposition commerciale en ce qui concerne la production des clous.
- (h) *Clous de fil britanniques.* La recherche a récupéré un clou à tête de tambour de jauge légère et les clous de fil de fer inversés de tête de cône⁶⁹⁴ à Wells, Somerset, dans un contexte probable de 1845-1855. Ceux-ci avaient été utilisés dans le bois résineux révèle autour des fenêtres de ceinture, à l'origine insérés vers 1730 et enlevés pour l'entretien à environ cette

⁶⁹³ CLUNIE 2008, 5.

⁶⁹⁴ Ceux-ci étaient 52mm et 47mm de long respectivement. Il y avait des signes de modifications aux cadres de ceinture se produisant autour de cette date à Tower House, une ancienne maison du diocèse de la cathédrale directeur de l'école d'environ 1390.

période. La conclusion provisoire de l'étude est que les Britanniques autour de ces dates produisaient une gamme limitée de fil de fer « broches de panneau » dans au moins deux versions de tête, spécifiquement pour une utilisation dans les résineux. Une autre conclusion peut être déduite qui se rapporte aux clous de fil de tête de balle qui restent des articles standard à ce jour. Cette découverte précoce d'un clou de fil de tête de tambour suggère fortement qu'il peut avoir été une initiative britannique car, jusqu'à présent, aucun n'est venu de Français ou de sources belges.

- (i) *Acceptation lente des clous de fil de fer.* L'étude a révélé qu'il n'y avait aucune différence significative d'attitude entre les Américains ou les Britanniques en ce qui concerne l'adoption de clous de fil de fer. Il constate qu'en Australie, ce n'est qu'en Australie que l'utilisation de bois d'eucalyptus non assaisonnés de la gamme plus légère, comme Messmate et Stringybark, qui a permis leur adoption lente de clous de fil de fer vers 1870⁶⁹⁵. Il constate qu'en Australie, les clous de fil de fer n'étaient utilisés que dans des bois d'eucalyptus non assaisonnés, comme Messmate et Stringybark. Cela a permis leur adoption lente vers 1870. L'étude a également révélé que des améliorations dans la métallurgie du fer se sont produites les années 1870 à 1890.

7.1.4 Groupe 4 – Échéanciers, changements et précision de la décennie

- (a) *Échéanciers.* En ce qui concerne les délais, l'étude conclut que les changements identifiables dans les clous depuis 1680 ne peuvent être utilisés avec succès comme un moyen de datation des bâtiments et des extensions à partir de 1790. Cependant, certains événements antérieurs fournissent des indices pour établir des dates au cours de la période précédente, notamment l'introduction de clous moulés annealed, qui apparaissent comme de nouvelles formes de clous de lathing du début des années 1780. Ceux-ci apparaissent d'abord sous une forme mince, mais gagnent une taille régulière robuste vers 1800. Sur une base quantitative, les clous moulés ont connu une montée en popularité alors que la rénovation des églises anglaises a décollé entre 1844 et 1875, et un certain enthousiasme pour ces altérations malsaines s'est poursuivi jusqu'à la fin de la période d'étude. L'étude n'a pas été en mesure de trouver des tendances utiles émanant de la conception ou de l'utilisation des clous coulés, comme une fois développées, les morphologies ont eu tendance à rester inchangées.

Sur la base de l'expérience personnelle, le tableau principal des changements, fig. 169, p272, a été simplifié pour une utilisation pratique dans les inspections des sites, à quelques types d'indicateurs utiles, fig. 171. À cela s'ajoutaient fortuitement les changements faciles à identifier de la gamme Ewbank/Cordes & Co, (figs 172, & 129). De même, le clou de fermoir coupé britannique a traversé quatre changements identifiables de forme, (la fig. 173), qui ajoutent à une méthodologie d'analyse rapide sur place.

En convertissant des changements utiles dans les clous en zones à l'intérieur des bâtiments, l'étude a constaté que l'utilisation d'un type de clou particulier avait tendance à dériver vers une utilisation plus large au fur et à mesure que le temps avançait et que les acceptations (ou les nécessités)⁶⁹⁶ changeaient. L'identification de ces petites variations d'utilisation n'a été possible qu'en attrapant des bâtiments pendant la rénovation et comprend donc une

⁶⁹⁵ Des pourcentages significatifs d'échec et de fractures peu communes ont été trouvés. Voir Fig. 160 p243. Les origines des clous métalliques ne sont pas connues.

⁶⁹⁶ En tant qu'apprenti en 1940, feu Ron Bishop de la Bureau de Travaux Publiques a Warrnambool Works a dit à l'auteur que seuls les brads de tête d'éperon coupés étaient disponibles pour toute la menuiserie du site.

ressource limitée qui diminue avec chaque année suivante. Il ya une mise en garde évidente qu'un clou trouvé hors de son application habituelle ne peut pas être utilisé pour former des conclusions pour l'ensemble de la zone. Les graphiques zonaux (figs. 174-178), sont ainsi moins certains dans certains domaines – ceux marqués par l'astérisque -, en raison de cette application alternative des clous:

Zone 1 – clous adoptés pour les revêtements de toit et pour les caractéristiques extérieures

*Zone 2 – clous utilisés pour les intérieurs de toit**

Zone 3 – clous utilisés dans l'encadrement des murs et pour la lathing

*Zone 4 – clous utilisés plancher et construction sous-plancher**

Zone 5 – clous utilisés dans les revêtements, fenêtres et portes révèle et deuxième fixations

Dans le cas de la zone 2*, les parties internes de la menuiserie du toit, les joints sont difficiles à atteindre et les têtes des clous sont normalement conduites à la maison, de sorte qu'elles sont essentiellement masquées. De même, dans la zone 3, les murs, ceux-ci sont généralement dissimulés. Dans certains cas, la démolition partielle permet de récupérer des échantillons. L'accès à ces pièces est moins facile qu'aux autres zones, tout comme la section sous-sol de la zone 4*, qui est rarement accessible et à moins que des échantillons ne soient prélevés pendant la démolition, ils sont presque impossibles à obtenir. Par conséquent, il y a un manque d'équilibre dans certains domaines qui est difficile à surmonter et qui ne peut être reconnu que comme un défi pour les chercheurs. Inversement, il y a des facteurs compensatoires, tels que la relative facilité avec laquelle les espaces de toit peuvent être accessibles, - contenant souvent beaucoup de matériaux jetés, mais extrêmement utiles.

- b) *Graphiques de la décennie.* Ceux-ci ont été rassemblés à partir des résultats de la recherche et forment une extension aux échéanciers de la zone. L'expérience acquise au cours de l'étude suggère que cette forme de présentation s'avère la plus utile comme guide pour l'analyse du site des bâtiments. Certaines zones progressent à travers plusieurs niveaux de changement et les toits en particulier sont plus sujets à la décomposition que d'autres zones et, comme on le voit ci-dessus, des échantillons de changements antérieurs ainsi que des fragments de bois sont souvent laissés dans les espaces du toit. L'étude conclut que les changements dans les clous qui se produisent entre les deux décennies 1790-1800 et 1800-1810 sont petits et facilement manqués. Les spectres de clous au cours de ces deux décennies ont une certaine variation régionale. Par exemple, dans les grandes villes, comme Londres, les dernières améliorations dans la conception des clous sont tombées en usage plus rapidement, ce qui reflète une utilisation générale plus grande des clous. Dans les zones plus rurales, le chiffre d'affaires des types des clous était susceptible d'être plus lent et il a fallu du temps pour que les innovations atteignent l'arrière-pays. Ainsi, un lapsus de peut-être plusieurs années aurait pu être impliqué - affectant ainsi la méthode de datation. Pendant les décennies restantes, les conclusions sont que le système de datation fonctionne très bien à partir de 1810, mais qu'il gagne beaucoup en efficacité à partir de la fin des années 1830, devenant plus efficace avec le temps.
- (d) *Conclusion générale à l'égard d'un système de datation basé sur des changements dans les clous.* L'étude révèle que le système développé fonctionne bien. Il augmente considérablement la possibilité de dater avec précision bâtiment, extensions et réparations lorsqu'il est utilisé en conjonction avec d'autres caractéristiques, en particulier les

changements dans les vis et dans la menuiserie, et dans une moindre mesure les meubles de porte et de fenêtre.

- (e) *La fin des marqueurs d'étude.* Après 1890, les changements sont distinctifs et la proportion de clous métalliques trouvés augmente considérablement. Cependant, de nombreux autres changements peuvent être notés dans d'autres formes des clous, tels que les changements du fer à l'acier dans les clous coupés, qui laisse la modification distinctive au pressage et aux brides de tête. Ces changements garantissent effectivement que la possibilité de prendre la date de construction pour une décennie d'avant 1890 est très peu probable.

7.2 RÉSUMÉS

Il s'agit de deux groupes dont aucun des deux ne fait partie des conclusions ci-dessus. Ils sont:

- Les aspects de la recherche présentent les grandes lignes et la méthodologie adoptée, ainsi que
- Les aspects découlant de la recherche qui comprennent des éléments susceptibles d'être étudiés plus avant.

7.2.1 Les grandes lignes de la recherche et les méthodes adoptées

Il n'est pas surprenant pour le lecteur que les méthodes aient dû s'adapter aux circonstances tout au long de cette recherche. Avec tous les avantages du recul, l'adhésion méticuleuse à la pratique du site archéologique aurait atténué de nombreux problèmes, mais aurait pu entraver la réception d'échantillons n'ayant qu'une légère provenance. Des erreurs de nettoyage excessif des échantillons se sont manifestées tôt et une approche prudente et à long terme a été effectuée au prix d'une grande partie du temps. De l'avis de l'auteur, cela avait porté ses fruits. Il a également conduit à la pratique de laisser des traces interprétables suffisantes sur les corps des clous pour les futurs chercheurs.

Les grandes lignes de l'enquête laisseront cette thèse à la critique, mais le domaine des connaissances et de la littérature actuelles a omis de nombreux éléments d'information critique qui donnent des points de vue historiques déséquilibrés et souvent simplistes. À cet égard, les méthodes prises sont censées être justifiées pour fournir une image plus complète et plus complète.

7.2.2 Éléments dignes de recherches futures

Il y a sept questions sans réponse et quelque peu difficiles, qui découlent de la recherche:

- Où se trouve la frontière efficace entre l'École de fabrication des clous de l'Est et l'école de l'Ouest?
- Les Romains ont-ils utilisé des martinets?
- Était-ce la pratique romaine de faire fondre le fer à la source?
- Y a-t-il eu une continuité de l'artisanat dans l'est de la Belgique après le départ romain?
- Y a-t-il d'autres références à l'approvisionnement en fer sous forme de bâton lourd au Moyen Âge?
- Le *Zeinhammer* est-il originaire du Steiermark d'Autriche ou a-t-il imité le martinet de ciseau trouvé à Theux?
- D'où venait Peter Anthony Van Ghemen, quels étaient ses antécédents, et ce qui a causé sa disparition soudaine d'Angleterre?

Cette thèse suggère qu'il y avait une continuité de descente d'une main-d'œuvre artisanale émanant des zones de concentration avant de l'armée romaine dans le général sont Tongres - Liège. Une telle continuité des gens de métier sur deux millénaires serait impossible à prouver, cependant, la recherche de Hansotte a trouvé un lien de retour à 1406 dans des circonstances suggérant une tradition déjà établie depuis longtemps. Les recherches récentes de Bertholet ont découvert une industrie cloutière déjà ancienne autour de Franchimont en 1449. Avec le développement de techniques améliorées en archéologie, cette voie de recherche future vaut la peine d'être étudiée.

7.2.3 Attentes

Avec tant de travail déjà effectué sur l'histoire des clous belges, les informations contenues dans cette thèse peuvent être suivies comme un guide pour compléter un inventaire de clous similaire à celui indiqué au chapitre 4 qui bénéficierait grandement au domaine de l'histoire de la construction. Une telle extension de ce travail serait bénéfique pour les archéologues et les restaurateurs.