8.06a Nails & Screws

a. the wrought nail
b. cut brads
c. machine-made nails
d. the Ewbank nail
e. the wire nail
f. roofing nails & screws
g. local nail manufacture
h. screws
i. anchorage

a. the wrought nail

The availability of cheap and reliable nails was an essential prerequisite for the development of a number of aspects of Australian building practice, most notably the simplified modern stud frame. However, at the time of Australian settlement nails were expensive hand-wrought items, and were not used nearly as freely as in the later nineteenth century and the twentieth century. Much early building in Australia was done without any nails or metal fixings at all. In the novel *Ralph Rashleigh* James Tucker describes the construction of a slab hut on the Hawkesbury in the early 1820s, in which 'the whole framing of the roof was secured as it was needed by wooden pins in order to save the expense of nails, which were then both too scarce and too dear to be used by the lower order of settlers.'[1] Robert Gouger was pleased to report that the hut he built at Holdfast Bay [Glenelg], South Australia, at the end of 1836, used only six nails, as the other joints were tied with cord.[2] Timber dowels and trenails continued tro be widely used in rural buildings up to about 1860,[3] and as late as the 1880s a selector's house in Gippsland, Victoria, was said to be 'constructed altogether of logs, slabs and bark, no nails being used in its construction'.[4]

Both the Hawkesbury and Gippsland examples were bark-roofed, but shingles presented more of a problem. In Britain shingles were traditionally fixed with oak pegs, and in parts of Europe such as the Austrian Tyrol, low-

1 'Giacomo de Rosenberg' [James Tucker] [ed Colin Roderick], *Ralph Rashleigh, or the Life of an Exile* (Sydney 1952 [?c1845; 1929]), p 113.

2 Quoted in Penelope Hope [ed], *The Voyage of the Africaine* (South Yarra [Victoria] 1968), p126.

3 For example the fixing of the round timber ceiling joists to the wall plates at 'Moranghurk' homestead, Victoria, probably 1840s: A R J Billman, 'The Timber Vernacular: Building Techniques of Domestic Timber Architecture in Geelong and the Western District 1840-1870' (BArch, Deakin University, 1992), diagram 23; the foundation pads and round timber floor joists of the barn at 'Ballantyne', Cassilis, New South Wales, probably 1850s: inspected 2002; the kitchen wing, 'Gulf Station', Victoria, perhaps c 1860.

4 Caption to the photograph 'A selector's hut in Gippsland ...', No. 2 in the series *Gippsland Scenery,* by Nicholas Caire, c 1886, La Trobe Collection, SLV.

pitched shingle roofs were laid without any fixing at all. In Sydney also, shingles were at first fixed with wooden pins, but this seems to have been found inadequate because of the warping of shingles made from local timbers. According to Robert Irving nails began to replace wooden pegs in about 1800, and by 1810 they seem to have been the normal fixing for shingles.[5] Samuel Marsden called tenders for shingling his church at Parramatta in 1812, requiring the successful tenderer to supply both the shingles and the nails.[6] In 1815 shingle nails were ordered for the roofing of Rouse Hill House, to the west of Sydney, and in 1818 the purchase of four thousand shingle nails was recorded.[7] Outside New South Wales and Tasmania wrought nails are rarely found: those which are reported by archaeologists and others usually prove to be the ubiquitous Ewbank patent pressed nail, or some cognate type.

Nails had traditionally been specified and sold according to length and weight, the latter in lbs per thousand nails.[8] But in the nineteenth century they were commonly sold on price per hundredweight, from which the approximate size could be inferred. Thus a Sydney advertisement of 1803 offered nails from 6-penny to 40-penny.[9] An excellent idea of the nails which would have been used in Australia at about the time of Macquarie can be gained from a list issued in 1812 by the British Office of Ordnance, in which 163 varieties of nail and spike are illustrated full size, and the weight of each is indicated. There are rose headed and clasp headed nails, countersunk clouts, slating nails, lathing nails, dog nails, spikes up to fourteen inches (356 mm) long, tacks, brads, rivets, and numbers of others including specialised types for boat building, cooperage and other purposes.[10] From 1830 the hand-made nail trade in Britain declined due to the competition of machine-made nails, and in the nail making districts around Birmingham employment dropped from 50,000 to 20,000 by 1866.[11]

An unusual type, not in the Ordnance list, is the double-headed nail, which was specified by the Victorian architect Charles Laing for the fixing of timber ridges.[12] In the Architectural Publication Society's dictoionary it is called a ridge spike, and described as:

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5 Robert Irving, 'The First Australian Architecture' (MArch, University of New South Wales, 1975) p 191.

6 *Sydney Gazette,* 18 April 1812, quoted Irving, 'First Australian Architecture', p 191.

7 Account books in the possession of Gerald Terry, Rouse Hill House, cited by James Broadbent, 'Aspects of Domestic Architecture in New South Wales 1788-1843' (3 vols, PhD, Australian National University, 1985), I, pp 93-4.

8 See, for example, Royal Engineers Office Halifax, *List of Nails and Spikes required for the Service of the Office of Ordnance. Approved by the Honourable Board's Order of the 29 July 1812,* reproduced in *APT Bulletin,* VIII, 3 (1976), pp 91-118.

9 *Sydney Gazette,* 22 May 1803, p 4.

10 Royal Engineers, *List of Nails and Spikes.*

11 Ephraim Ball, 'The Hand-Made Nail Trade', in Samuel Timmins [ed], *The Resources, Products and Industrial History of the Birmingham and Midland Hardware District* (London 1866), p 111.

12 Charles Laing, 'Specification of work to be preformed and materials to be provided in the erection and completion of a Villa intended to be built at Coryule Indented Head for Mesdames Drysdale and Newcomb' (Melbourne 1849), p 5.

> A small piece of wrought-iron spiked at both ends with a shoulder on each of the opposite edges at differing levels. A hole being bored into the upper edge of a wood ridge-piece, the ridge-spike is driven in until the lower shoulder, acting as a gauge, rests upon the wood; the upper shoulder receives the blows of the hammer, and forms a gauge upon which the ridge-roll rests. In very exposed situations the spikes are made long enough to pass through the ridge piece and the roll, and are there clenched.[13]

We know two types, and it is impossible to say which Laing intended. Dick Jones of Wales has obtained examples used to fix the ridge rolls on the roof of the De Winton Hotel, Llandbradach, Caerphilly County, and has provided one. It is cut from plate, and so is uniform in thickness, and it is in the form of a rectangle with a pointed shaft extending from either end. One end was driven into the hip or ridge rafter, and the ridge roll, in this instance pre-drilled, was driven down onto the other end. The rectangle meant that a space was maintained between the ridge and the roll, sufficient for the battens and slates to come between the two. The roll was three inches [75 mm] in diameter, but the nail shaft was slightly longer, so that the point protruded, and was dressed over or clenched. This would of course be concealed because the ridge was then covered in lead.[14] Chris How has provided an example from the 1861 work at Christ Church, Warrnambool, Victoria, which differs mainly in that rectangular section is 200 mm long, so that the space is enough for rafters to meet at the ridge.

The mechanisation of nailmaking had begun with importation of the slitting mill from Liège to England toward the end of the sixteenth century.[15] This could be used to cut sheet iron into nail rods, or strips from which individual nails could then be cut. The smith now received the iron in the form of square rods, which were produced from flat plates by using 'slitting' rollers.[16] Typically, thin bars were produced by repeated rolling, and then passed through the slitting rollers to divide them into between three and six square rods suited to the size of nail required.[17] The slitting mill spread to the United States within decades of reaching Britain, and equipment for slitting nail rods, said to have been in use by 1645 at Saugus, Massachusetts, has been restored and displayed in a museum.

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13 Wyatt Papworth [ed], *The Dictionary of Architecture* (6 vols, London 1853-1892), vol V, sv Ridge Spike.

14 Information from Dick Jones, December 2009, and from the catalogue of his catalogue "R Jones Blackwood Collection of Drive In Fixings" [typescript, no date]. .

15 Hugh Bodey, *Nailmaking* (Princes Risborough [Buckinghamshire] [1983]), p 11. It was not an English invention as stated by J S Swank, *History of the Manufacture of Iron in all Ages, &c* (2nd ed, New York 1892 [1884]), p 48.

16 Charles Hibbs, 'Great Manufactures of Little Things - IX', *Technical Educator* (4 vols, London, no date [? c 1870], IV, p 11: see also F E Martineau, 'Cut Nails', in Samuel Timmins [ed] *The Resources, Products and Industrial History of the Birmingham and Midland Hardware District* (London 1866), pp 612-613. For traditional nailmaking in France see Daniel Boucard [translated Alan Wharf], 'Nailmaking in France', *TATHS Newsletter*, 91 (Winter 2005), pp 22-9, reportedly from Boucard's *Craftsmen's Tools.*

17 Abraham Rees, *The Cyclopædia, or Universal Dictionary of Arts, Sciences and Literature* (42 vols, London 1819), sv 'Nails'.

It was the nailer's job to convert these rods.

> The nailer should have the ends of three or four rods in the fire, and taking the one which has been in longest, after a pull or two at the bellows to bring it to a welding heat, he would taper down the point on his anvil, at the same time making a shoulder for the head. He would then hold it over a chisel or cutting-punch, stuck upright at the side of his anvil, and giving it one tap with his hammer, cut it halfway through; an iron stop in front of the punch giving him the exact gauge for the length. He would then turn down the point of the half-severed nail into a steel instrument called a *bose* (the top of which formed a mould for the head) and twist it off, and then, with a few smart blows, he would beat it down until the head was spread out sufficiently, and assumed the required shape, the nail just turning from red to black as he gave it the finishing tap.[18]

The quality of traditional wrought nails derived from the process of working by the smith, which gave them a fibrous texture and enabled them to be bent without snapping, something which would be totally impossible with a cast nail, and could not be achieved by cut brads or the earlier types of machine-made nail. Nails made from slit rod required forging only of the head and point, but because the original sheet had been rolled (or originally hammered) even the nail shank had some of this fibrous quality.

The importance of this resilient quality was that the more demanding details of timber construction which were subject to changing stresses, such as ledged and braced doors, required a nail to be driven right through the wood and the point bent to one side, or *clenched* [or *clinched*].[19] In shingling it was said to be necessary to drive the nail right through the batten and clench it, which meant that the more expensive wrought nails should have been used, but in practice clenched nails are the exception rather than the rule in surviving shingle roofs. We have no evidence as to whether different or cheaper means of fixing were used for the imported shingles which were fairly widely used about the middle of the nineteenth century, but in general terms it can be said that shingling was not very common before the 1840s, and that the cost of suitable nails was probably the main reason for this.

Right through the nineteenth century much of the general framing of buildings, especially in urban centres and ports, was done in imported timbers which were much easier to work than the local species. But where local timber was used its hardness made wrought nails, or the later patented types, more or less essential even for general carpentry, and though their use could be avoided by the use of appropriate joints, pinned with timber dowels or

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[18] Charles Hibbs, 'Great Manufactures of Little Things - IX', *Technical Educator* (4 vols, London, no date [? c 1870], IV, p 11: see also F E Martineau, 'Cut Nails', in Samuel Timmins [ed] *The Resources, Products and Industrial History of the Birmingham and Midland Hardware District* (London 1866), pp 612-613. For traditional nailmaking in France see Daniel Boucard [translated Alan Wharf], 'Nailmaking in France', *TATHS Newsletter*, 91 (Winter 2005), pp 22-9, reportedly from Boucard's *Craftsmen's Tools.*

[19] C B Mayes, 'Manufactures for the Economical Development of the Resources of the Colony', in *Victorian Government Prize Essays 1860,* (Melbourne 1861), p 325.

trenails, this was labour-intensive and therefore more or less impracticable in economic conditions such as those of the 1850s in Victoria.

b. cut brads

The cut brad is chopped off an iron strip and not worked ar all, so it is really a more primitive artefact than the cut nail. But is a slightly later development, and the two relevant British patents were that of Ecroyd & Wilks in 1825, for a machine which would cut wedge-shaped pieces from plates,[20] and Ledsam (or Ledsom) & Jones in 1827, similarly for machinery to cut brads and sprigs from plates (and specifically stated not to form heads).[21] These may have originated in America. According to one account the two types of nail machine used in Britain both derived from America. In the earlier of the two a flat strip of iron was pushed firmly against a steel plate as cutters descended upon it. The simplest form of nail produced was the 'bill' (or 'cut bill', as there had been cast bills at an earlier date), a long triangle or wedge shape, produced by cutters which began at a slight angle and were then turned slightly to reverse the angle before the next blow, and then continuing to alternate so that a series of bills were cut, alternating head to toe, and no waste was generated. The continual change of angle of the cutters caused great wear and tear on the machine, and an improved machine was therefore developed in which the cutters always descended in the same place, but the nail strip rested on a frame which presented it at alternating angles, so as to achieve the same effect.[22]

The bill was produced mainly for boot heels rather than for building purposes, but a small size (or 'sprig') was sometimes used in glazing, to hold the pane of glass before it was puttied in. This simple triangular shape was all in one plane, and if a true head was to be formed it required a separate operation and an allowance of extra iron for the purpose. Thus a 1¼ inch [32 mm] wide nail strip was used to produce one inch [25 mm] headed nails.[23] However it was also possible to for a head of sorts within the one plane, most easily in the form of a projection in one direction, so that the nail was like an elongated L with a tapering stem. This could still be arranged so that nails (or brads, as they in fact were) were cut alternately head to toe, leaving no waste, but it required appropriately shaped cutters rather than simple straight ones. In this process the end of the nail strip was fed to a fly press, which chopped off a nail from it; then the strip was turned over, and another nail chopped off, and so on. The process of turning meant that heads and points came from opposite sides of the strip in the usual way, and it was possible to devise various nail profiles which could be cut in this way without any waste.

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20 No 5286 to J Ecroyd & J Wilks: Priess & Shaugnessy, 'Inventory of Nail Patents', p 11; Ure, *Dictionary,* p 875.

21 No 6200 to D Ledsam & W Jones: Priess & Shaugnessy, 'Inventory of Nail Patents', p 12; Hibbs, 'Great Manufactures', p 12. Ure, *Dictionary,* p 875, incorrectly gives 'Ledsom'..

22 F E Martineau, 'Cut Nails', in Samuel Timmins [ed], *The Resources, Products and Industrial History of the Birmingham and Midland Hardware District* (London 1866), pp 613-4.

23 Martineau, 'Cut Nails', p 613.

Whatever the profile, however, the widening of the head and the narrowing of the point were in one dimension only: in the other dimension the nail retained the thickness of the strip from which it was cut.[24] A description of 'cut nails' as produced at the Crown Nail Works, Birmingham, in 1851, indicates that they were no more than cut brads to which further work was done to create a three dimensional head.[25]

Cut brads, typically with the head extending to one side only like an elongated L, were much cheaper than the Ewbank and wire nails discussed below, but were unsuitable for structural joints. They were commonly used in flooring, and sometimes also in weatherboartd cladding. Thus the specification for a floor in 1854 read 'No board to be more than six inches wide and to be nailed with 2, 2½" brads to each board and all heads to be punched down.'[26]

The process for cutting brads as shown at the Workmen's International Exhibition of 1870 was essentially unchanged:

> A girl sits in front of a press worked by steam, holding a strip of iron in a pair of long pliers, the handles of which are tightened up to retain it firmly; and turning it over rapidly at each stroke, a continuous stream of well-shaped nails falls from the machine, the head of one being formed from the point of the next, and vice versa. The formation of the die and punch is somewhat peculiar. In the bed of the press is cut a square oblong hole, in which a punch of the same shape works, filling it exactly, and forming a solid block of steel, rising and falling with the motion of the press. The punch never rises entirely out of the hole, but on its underside is cut a step, the shape of the nail to be produced, and the girl inserts the strip of sheet-iron under this step as it clears itself from the hole, pressing the end of the strip against the solid part, and the sharp edges of the press cut off the nail.[27]

By now a more advanced machine was in existence. In 1866 R C Robinson of England was reported to have developed a new nail making machine which was self-feeding and much faster than the old ones, cutting off four nails at a time, and producing good points and heads. Moreover these nails were not hardened by the cutting process, and therefore did not require annealing, as had the earlier cut nails.[28] These sound like cut brads. In 1873 the Birmingham maker John Cornforth and one T Ashford almost simultaneously

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24 *Penny Magazine,* X, 606 (11 September 1841), pp 359-360; see also XIII, 818 (28 December 1844), pp 503-5. For various developments of this system see *Mechanic's Magazine,* XXXIV, 924 (24 April 1841), p 326 (quoting the *Journal* of the Franklin Institute, January 1841); and *Builder,* VI, 277 (27 May 1848), p 262; VII, 331 (9 June 1849), p 274; XII, 595 (1 July 1854), p 351.

25 Great Exhibition of the Works of Industry of all Nations, 1851, *Official Descriptive and Illustrated Catalogue* (3 vols, London 1851), II, p 629.

26 Russell, Watts & Pritchard, 'Specification of the works to be executed in the erection of Two of a row of eight Dwelling houses and offices at North Elwood near St Kilda for Joseph Docker Esqr ... December 13th 1854' (Melbourne 1854), p 8.

27 Hibbs, 'Great Manufactures', p 12

28 *Builder,* 4 August 1866, p 585.

patented devices for turning over the nail strip between each cut,[29] presumably to eliminate the manual operation described in 1870. Other patents followed.[30]

To summarise these incomplete and even conflicting accounts:

- Simple triangular bills or sprigs could cut from a flat sheet, either by shifting the angle of the cutter between strokes, or by shifting the angle of the nail strip as it was fed in.

- By allowing extra iron at the broad end it was possible to provide for the formation of as true three-dimensional head by a separate process.

- By using shaped cutters it was possible to cut brads, in more complex shapes than the basic triangle, and to create a head of sorts still within the same plane.

- A head-to toe arrangement could be achieved either by having two cutters on the flywheel, operating alternately, or by turning the strip over to feed into a single cutter.

- Turning the strip was at first done nanually, later mechanically.

How the three-dimensional head was formed remains to be considered. An English patent was granted in 1808 to Joseph Willmore and John Tonks of Birmingham for a more elaborate method of making nails, which were supposed to be capable of clenching. In broad terms, a piece of nail rod was cut to the approximate dimension; it was held in clamps with a portion protruding, which was formed into a head; it was placed into an appropriately shaped steel bed and struck with a punch to form the end into a chisel shape, then turned at right angles and struck again to create a point; it was annealed to give it the capacity for clenching; and finally it was made red hot and quenched in water or other liquid, making it hard enough to drive.[31] An account of the 1860s is basically similar. The cut nail was held in a pair of nippers to form the neck, then struck with a hammer, which formed the head at one blow. It then remained for the nail to be annealed to make it partly malleable, which was done by heating it to red-hot within an airtight iron box.[32]

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29 Great Britain, patent no 4,057 to J Cornforth, 9 December 1873; no 4,063 to T Ashford, 10- December 1873.

30 Great Britain, patent no 337 to D Wormald, 27 January 1874; no 4,185 to J Comery, 5 December 1874; no 2,479 to W S Hutton, 9 July 1875; no 1,227 [provisional]. to J Dimelow, 22 March 1876; no 3,575 to J R Danks, 12 September 1876.

31 No 3137 to Joseph Willmore and John Tonks, 28 May 1808, in *Repertory of Arts, Manufactures and Agriculture,* 2nd series, XIII (London 1808), pp 366-9. See also Rees, 'Nails, who refers to 'Wilmore and Tonk', and Priess & Shaugnessy, 'Inventory of Nail Patents', p 11, who give 'Touks'.

32 Martineau, 'Cut Nails', pp 614-5.

By 1843 American prices had fallen from 25 to 3 cents a pound,[33] and in the fifties the prices of the inferior English nails were even cheaper, for the market had been flooded,[34] though the price of iron rose with the Crimean War. In 1853 the *Australian Builder* quoted an English report that:

> The quality of nails made at the majority of English works is, at present, so far inferior to that of the United States productions, that the English makers find themselves quite shut out from many foreign markets, in spite of the much higher price charged by the Americans. The general character of the machinery employed in the country for cutting nails, is of a very low class, both the design and the workmanship being exceedingly rude. Indeed we believe there are not more than 4 English makers who can supply good nails at all times. Large quantities of zinc and copper nails are made by the 'cut process' for sheathing and slating, the cut nails having to a very great extent superseded the use of wrought nails for most purposes. But the wrought nail is still made in very large quantities by hand and hammer in the neighbourhood of Pudley. For work where nails are required to clench, cut nails are obviously inadmissible, as they are not sufficiently fibrous and ductile; otherwise it seems not improbable that the use of wrought nails would be still more interfered with.[35]

Despite their dominance of the field, the Americans did not make much of their nails at the Great Exhibition. Morris, Jones & Co of Philadelphia showed 'machine-made cut nails'; Albert Field of Taunton, Massuchusetts, showed iron and copper tacks and nails, neither with any further explanation.[36] C Morey of Boston showed a machine for making spikes, said to have been universally adopted in the United States,[37] but this was presumably for railway spikes rather than large building nails. In 1869, however, Morewood & Co were advertsing that they were sole patentees and manufacturers in England of the American pattern cut nail.[38]

The history of the next half century is dominated by the Ewbank nail and the wire nail, but the traditional types continue, until steel became important in the United States the 1880s. It was reported in 1886 that half the nails made at Wheeling were already of steel, that the necessary machinery was being set up in every nail manufacturing centre, and that within five years iron nails were likely to be completely supplanted. Steel nails were about ten cents a keg cheaper than iron nails 'even where the manufacturer has to purchase his ingots'[39] - wording which does not suggest the wire nails are being referred to.

c. machine-made nails

33 S Giedion, *Space, Time and Architecture* (Cambridge, Massachusetts, 1963 [1941]), p 348.
34 *Builder,* XI, 529 (26 March 1853), p 198.
35 *Australian Builder,* 9 August 1855, p 11, quoting the *Mechanics Journal.*
36 London, Great Exhibition, 1851, *Catalogue,* III, pp 1435, 1464.
37 London, Great Exhibition, 1851, *Catalogue,* III, pp 1469.
38 *Wellington Independent,* 27 June 1869, p 8.
39 *Australasian Ironmonger,* 1 June 1886, p 61.

Historical references to machine-made nails are highly confusing. They may refer to a nail formed simply by chopping it from the end of a nail rod or strip - this is a cut brad of the type discussed above, which is cheap and of little use in structurally important location. They may refer to a true machine-formed nail, which has been produced by processes analogous with those of the blacksmith, and has acquired a similar fibrous quality, strength and resilience. Or they may refer to a hybrid - a nail formed initially by cutting, but subsequently worked upon to a greater or lesser extent to achieve at least some of the attributes of a true wrought nail. Many writers assume that the first machine-made nails were of cut brad type,[40] which is usually triangular and headless, but that is probably not the case, for most or all of the early patents specify means of separately forming a head. Moreover, as the manufacturer was not usually the original inventor or patentee it is often impossible to determine what type of nail is meant, for example, by 'Prince's metal nails', which were on sale in Sydney in 1804,[41]

According to an American account of 1810, quoted by Ure, 'In old countries nails are forged, here they are cut.' In about 1790 nails began to be made in Massachusetts by cutting slices from old hoops, gripping them with a common vice, and forming the head with a hammer.[42] This seems to be a reference either to the rather earlier US patent obtained by Jeremiah Wilkinson of Rhode Island in 1774 for cutting tacks from plates of sheet iron with shears and holding them in a vice while forming their heads,[43] or to the machine for cutting both tacks and nails from plate developed in 1786 Ezekiel Reed of Bridgewater, Massachusetts,[44] or the machine developed by Adam Rogers of Marshfield, by 1788,[45] In Reed's machine a wedge-shaped block cut from a strip of hoop iron was placed point downwards in the jaws of the machine, gripped firmly, and then struck from above with a hammer so as to form the head. The machine was alleged to produce something like a thousand nails a day.[46] In 1794 Thomas Perkins received a patent for a

40 Notably the pioneering paper by L H Nelson, 'Nail Chronology as an aid to Dating old Buildings', *History News,* XXIV, 11 (November 1968), unpaginated. H C Mercer, 'The Dating of Old Houses' (paper read at a meeting of the Bucks County Historical Society, 13 October 1923), unpaginated, is more realistic. Nelson also completely ignores the Ewbank nail and its equivalents.

41 *Sydney Gazette,* 15 July 1804, p 3.

42 Rees, 'Nails'; also quoted less extensively in Andrew Ure, *A Dictionary of Arts, Manufactures and Mines: Containing a Clear Exposition of their Principles and Practice* (Longman, Orme, &c, London 1839), p 874.

43 Priess & Shaughnessy, 'Inventory of Nail Patents' , p 38. F H Norton, *Illustrated Register of the Centennial Exhibition, Philadelphia, 1876, and of the Exposition Universelle, Paris, 1878* (New York 1879), p 43. Sickels, 'Nails and Nailmaking', p 67, dates this development to 1777. Swank, *Manufacture of Iron,* p 448, quoting Knight's *Mechanical Dictionary,* dates it to about 1775.

44 Norton, *Illustrated Register,* p 45; Swank, *Manufacture of Iron,* p 448, quoting Knight. M K Phillips, '"Mechanic Geniuses and Duckies" a revision of New England's Cut-Nail Chronology', *APT Bulletin,* XXV, 3-4 (1994), p 5, dates the invention to about 1780. According to Swank, *Manufacture of Iron,* p 448, quoting Knight, in 1798 Reed obtained a patent for cutting and heading in one operation, but this is clearly a reference the patent of N Read, below.

45 To 'cut nails from, hoops, or plates': 'M K Phillips, 'New England's Cut-Nail Chronology', *APT Bulletin,* XXV, 3-4 (1994), p 5.

46 Phillips, 'New England's Cut-Nail Chronology', p 5.

machine for cutting nails from a sheet,[47] and J G Pierson of New York patented a nail cutting machine.[48] In 1795 Jacob Perkins of Massachusetts patented another machine, which he is thought to have invented about five years earlier.[49]

The first really successful devices for cutting and heading nails were 'two operation' machines, which in effect comprised two distinct machines, one for cutting and one for heading.[50] Jacob Perkins had nail cutting and heading machines in operation at Byfield, on the northern skirts of Boston, in 1794.[51] The cutting was done by what Perkins called an 'ostrich', a 'roller' with two cutters fixed to it in such a way that, when a strip of metal was fed up to it, the right amount was chopped off. The heading was done by fixing the nail blank in a vice, where it was given three successive blows with hammers, lifted by means of a turning tappet wheel. Perkins received a further United States patent in 1799, and then in about 1810 applied for a British one.[52] His machine could produce ten thousand nails a day.[53]

Nathan Read received a US patent in 1798[54] for a machine intended to cut and head a nail in one operation, but it seems to have been used only a short time before it was abandoned, Phillips suggests due to problems with jamming.[55] Meanwhile in 1807 Ezekiel Reed's son, Jesse Reed, patented another machine, which produced 150,000 tacks per day,[56] and in 1815 what must have been this machine or some development of it turned out 150,000,000 tacks.[57] Reed's patents were bought by Thomas Odiorne and his brothers, who set up the Malden Nail Factory in 1807, and two further factories in the following year,[58] and it must be the Read/Odiorne machine which, it was later reported, was by 1810 able to cut and head a nail in one operation, at the rate of one hundred a minute.[59]

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47 Priess & Shaughnessy, 'Inventory of Nail Patents', p 38.

48 Priess & Shaughnessy, 'Inventory of Nail Patents', p 38, refer to J G Peerson's patent for a nail cutting machine. J R Rempel, *Building with Wood and other aspects of Nineteenth-Century Building in Central Canada* (Toronto 1980 [1967]), p 101, refers to him as J Pierson of New York and claims this as the first nail cutting machine in the US, but this makes no sense

49 Norton, *Illustrated Register,* p 45..

50 Norton, *Illustrated Register,* p 43.

51 Phillips, 'New England's Cut-Nail Chronology', p 6.

52 Phillips, 'New England's Cut-Nail Chronology', pp 6-7. Phillips gives the date of the patent as 1799, but both Norton and Elliott (*infra*), give 1795. Norton, p 45, refers also to a patent for a nail making machine granted to Thomas Perkins of Philadelphia in February 1797.

53 Norton, *Illustrated Register*, p 43.

54 Priess & Shaughnessy, 'Inventory of Nail Patents', p 39.

55 Phillips, 'New England's Cut-Nail Chronology', pp 7-8.

56 Swank, *Manufacture of Iron,* p 133. See also Phillips, 'New England's Cut-Nail Chronology', p 9. Rempel, *Building with Wood,* p 101, identifies the son as Jesse Reed of Boston, and refers to his patent as being for a machine which cut and headed nails in the one operation, the first time this had been done successfully.

57 Norton, *Illustrated Register,* p 45.

58 Phillips, 'New England's Cut-Nail Chronology', pp 9-10; however Rosenberg, 'America's Rise', p 43, dates Perkins's patent to 16 January 1795.

59 Tomlinson, 'Nails'.

There had been a flood of US patents from 1796 onwards, mainly for the cutting and heading processes.[60] Twenty-three patents for nail making machinery had been issued up to 1800.[61] According to C D Elliott, in the years following Perkins's 1795 patent the price per pound of nails dropped from twenty-five to eight cents by 1828, and three cents by 1842.[62] Most or all of these machines were water powered, and by 1810 the nails they produced were superior to wrought nails for most purposes, but at one third the cost. The machines Odiorne and Ellis were specifically named.[63]

In Britain in 1790 W Finch of Wimboorne, Staffordshire, had patented a system of manufacture in which water or steam power turned an axle, working a series of tilt or lift hammers, under which a number of nails could be forged at once.[64] But whether this was put into practical effect is not known. The nearest British equivalent to the US developments was S Guppy's patent of 1796 for cutting and heading the nails by means of two separate 'engines'.[65] Guppy's patent of 1796 was for cutting nails by passing iron plates under a roller with two cutters fixed at opposite points on its circumference.[66] This sounds rather like a flywheel with alternate blades for chopping off brads, but it seems that it was more akin to Jacob Perkins's machine. Thirty or forty other British patents followed, but the Americans led the field because of their much greater use of timber in construction.[67]

In 1810 and 1812 Joseph C Dyer of Boston took out English patents for machinery of the American type and prepared to manufacture nails in Britain.[68] Dyer's 1810 patent was for machinery for cutting and heading nails and brads made from strips or plates of iron, copper or other metal. It dealt with four machines, two of which would cut and head nails in one operation, 'that is, to cut, into the desired size and form to head and complete in all its parts one nail at each successive and respective raising and descending of the main levers, which communicate motion and determine the action of the several parts of the machines that are employed in the formation of the nails. Another machine cut brads (which Dyer called 'nail shives' without heads, and a fourth was for forming heads on any sort of cut or wrought nail.[69] His 1812 patent covers inmprovemernts in the same machinery, but so detailed as to

60 Priess & Shaughnessy, 'Inventory of Nail Patents', pp 38-9.

61 Nathan Rosenberg, 'America's Rise to Woodworking Leadership', in Brook Hindle [ed], *America's Wooden Age: Aspects of its Early Technology* (Tarrytown [New York] 1975), p 43.

62 C D Elliott, *Technics and Architecture* (Cambridge [Massachusetts] 1992), p 18.

63 Ure, *Dictionary,* pp 874-5

64 Rees, 'Nails'.

65 No 2133: Priess & Shaughnessy, 'Inventory of Nail Patents', p 10.

66 Hibbs, 'Great Manufactures', p 12; Tomlinson, *Cyclopaedia,* sv 'Nails'.

67 Tomlinson, 'Nails'.

68 Rees, 'Nails'.

69 English patent no 3365 to Joseph C Dyer, 26 July 1810, for machinery for cutting and heading nails and brads made from strips or plates of iron, copper or other metal capable of being rolled into plates. Copies of both patents have kindly been provided by Chris How.

be incapble of being described separately.[70] These are lengthy patents concerning a number of machines, and the implication seems to be that these are not simoly inventions - rather that Dyer has an established suite of machinery for which he has acquired the US patent rights, which he is now extending to England.

By this time American machines, like those of Odiorne and Ellis, were said to produce nails better than wrought ones at about a third the price.[71] However this claim can hardly have been true, given the method of manufacture, and the continuing preference for wrought nails over the next half century gives it the lie. Precisely when wrought nails began to be produced by machinery is unknown, but by the 1850s American factories were making what were described as wrought iron nails on an improved system in which the fibre of the iron lay in the direction of the nail rather than transverse to it. For the smaller nails the machinery was 'self-acting' or automatic, but for the larger ones a boy had to supply the iron to the machine.[72] At this time the Australian colonies were using mainly British nails - and indeed the British Ewbank nail was considered superior to the American nails - but they were not isolated from American developments. As a purely anecdotal level, a label dating from about 1854 has been found in the Singapore Cottage at 17 Coventry Place, South Melbourne:

12 oz.
TACKS
MADE BY
Colwell and Spurring,
NEW-YORK[73]

The Americans completely dominated cut nail technology, but the forming of nails by rolling, pressing or stamping is quite different, and this seems to have been the direction mainly taken by British inventors. Two British patents were taken out in 1790 by Thomas Clifford of Bristol. In the first of these, of 17 July 1790, a steel die was made and the nail iron, pre-formed in an appropriate size, was forced into the die by means of rollers – or, by another account, the nail rod was drawn beween rollers which shemselves had cavities the face to form the shape of the nails. Typically this produced a sheet of nails requiring only to be snipped apart, but they must have been more like brads than nails in the true sense, and would have been incapable of bending without snapping.[74] In the second of Clifford's patents the nail plate was rolled in a wedge-shaped cross-section, and the nails cut or

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70 English patent no no 3543, to Joseph C Dyer, 4 March 1812, for machinery for cutting and heading nails from strips or plates of iron, copper or other metal capable of being rolled into plates.

71 Andrew Ure, *A Dictionary of Arts, Manufactures and Mines* (London 1839), s v Nails.

72 *Builder,* XIV, 700 (5 July 1856), p 374.

73 This was recovered in 2008 by Phyllis Murphy, adhering to a sailcloth lining and behind an imitation granite wallpaper with an 1855 registration mark.

74 No 1762: Rees, 'Nails;' Charles Tomlinson [ed], *Cyclopaedia of the Useful Arts* (published in parts, London c 1851-3), sv 'Nails'. Priess & Shaughnessy, 'Inventory of Nail Patents', p 12, refer to cavities in the rollers themselves.

punched out of it, and then placed in a bed to hold the shank while a head was formed by striking or pressing it.[75]

In 1827 Thomas Tyndall, on behalf of Dr W Church, obtained a British patent for a machine which pinched or pressed 'ignited' rods between rollers,[76] and in the following year Edward Hancorne, a London nail manufacturer, patented something rather similar: the rods (whether prepared by slitting or otherwise) were brought to red heat and pressed into 'wedge forms', which created a point at one end, while the other end was stamped to form a head.[77] In 1834 Thomas John Fuller obtained a British patent for apparatus which produced both 'square-pointed' and 'flat pointed' [probably chisel headed] nails, using hammers acting alteranately to form the points, so as to retain the fibrous texture, and then finishing them with rollers.[78] All this leads to the Ewbank nail.

d. the Ewbank nail

The Ewbank nail has been understood only as a result of recent research, and fieldwork especially by Chris How.[79] It is a British nail which found its main markets outside Britain, and most of all in Australia, where the hardwoods presented a problem. Even the American nails, which were generally better than the British, could not be driven into Australian timber without breaking, as was admitted by the Melbourne merchant G F Train, himself an American. The Ewbank pressed nail resolved this problem[80] and was much liked and widely used in Australia, in sizes from one to six inches (25 to 150 mm). But it was the subject of successive patents and was the exclusive product of a single British manufacturer.

J J Cordes received a patent in 1834 for improved nailmaking machinery which included what he called 'stretching rollers',[81] and in some degree simulated the effect of working by a blacksmith. T J Fuller received a patent in 1834 for mechanically hammering the points in such a way as to resemble

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75 No 1785. Rees, 'Nails'. Priess & Shaugnessy, 'Inventory of Nail Patents', p 12.

76 No 5589: Priess & Shaugnessy, 'Inventory of Nail Patents', p 12; Ure, *Dictionary,* p 875. Church obtained forther patents in his own name: no 6145 in 1831 and no 6232 in 1832: Priess & Shaugnessy, 'Inventory of Nail Patents', p 12.

77 No 5717: Priess & Shaughnessy, 'Inventory of Nail Patents', p 12; Ure, *Dictionary,* p 875.

78 Ure, *Dictionary, p*p 876-7.

79 I cite the joint paper by Chris How and myself, but I must explain that while my fairly random collection of Ewbankiana had gone on over a long time, but the systematic research presented in the paper is overwelmingly that of How: Christopher How & Miles Lewis, 'The Ewbank Nail' in K-E Kurrer et al [eds], *Proceedings of the Third International Congress on Construction History* (3 vols, Brandenburg University of Technology, Cottbus 2009, II, pp 829-836. Other recent research has been an account of the company by Malcolm Johnson, a collection of nails and other material by Richard Jones, and family research

80 G F Train, letter of 23 June 1853 in the Boston *Post,* 20 October 1853, reproduced in G F Train [ed E D & A Potts], *A Yankee Merchant in Goldrush Australia* (London 1970), p 25.

81 Great Britain, patent no 6686 to J J Cordes, 1834, for machinery for the manufacture of nails.

hand forging,[82] and John Jackson a patent of 1840 for forming the heads of bolts, nails, rivets and nuts, by stamping.[83] The relationship between these developments is not entirely clear, but some, and probably most, derived from the United States.

The nail business emerged from Cordes and Ewbank's background in the USA: in fact their nailmaking enterprise emerged, somewhat improbably, from the background of the American rice industry. In 1819 Ewbank was described as a merchant of London, and he received a patent for rice dressing machinery in that year[84] and another in 1827, this time in partnership with Jonathan Lucas, for an improved process of dressing.[85] It seems that Ewbank was in partnership with Lucas in a business importing and processing American rice, with Ewbank reponsible at the English end. Lucas & Ewbank seem to have been well-known as London rice millers,[86] and had extensive riverside milling and warehouse facilities at Rotherhithe, on the south bank of the Thames. In 1823 Lucas & Ewbank, rice millers, were listed in the *London Commercial Directory* at Idol Lane near Tower Close.[87] Ewbank married Lucas's daughter, Lydia in 1827,[88] and Cordes, who married another daughter, was associated with them in the rice business.[89] Cordes was an American, born in the United States in 1798.[90] In 1823 Cordes, Lucas, and Lucas's family arrived in London, though what prompted the shift is unclear.

In 1832 Lucas died, and in 1835 his sons-in-law, Cordes and Ewbank formed a partnership to make nails (other partners, Francis Henry Mitchell and John Edward Lee were subsequently admitted[91]). In 1835 they obtained a lease of land at Newport, conditional upon their building a factory and workers' housing within two years[92] They are also reported to have bought the patent

82 Patent of Thomas John Fuller, 27 February 1834, quoted by Ure, loc cit.

83 *Mechanics Magazine,* XXXIII, 894 (26 September 1840]) p 349.

84 Great Britain, patent no 4340 to Henry Ewbank, for Cleansing and Dressing Rice.

85 Great Britain, patent no 5472 to Jonathan Lucas and Henry Ewbank, for Dressing Rice. For the Ewbank and Cordes patents I am reliant upon the initial searches of Richard Jones in 2005 at the Patent Office in Newport, South Wales, and the subsequent work of Chris How.

86 Towards 1830 Lucas & Ewbank of London experimented with the importation of rice from North America still in husk ['paddy'] rather than fully prepared, for this kept much fresher: Basil Hall, *Travels in North America in the years 1827 and 1828* (3rd ed, 3 vols, Edinburgh 1830), III, pp 164-5.

87 In 1836 the mill complex was burnt down, leaving only the fire-damaged granary warehouse: *Times,* 26 September 1836.

88 Great Britain, patent no 4340 to Henry Ewbank, for Cleansing and Dressing Rice.

89 In 1820 the English mechanical engineer, John Galloway, was preparing gearing for rice mills run by the three in Charleston, Carolina: W H Chaloner [ed D A Farnies & W H Henderson], *Industry and Innovation* (London 1990), p 101.

90 Johnson, 'A Place in Time', p 6.

91 Johnson, 'A Place in Time', p 4. Mitchell was associated with the company before Lee, apparently as an investor rather than a partner, but Johnson, p 11, does not specify the date. Lee joined in 1841 by an agreement with Cordes and Ewbank, to which Mitchell consented: Johnson, p 14. In 1853 Ewbank was bought out: a new partnership of Cordes, F M Mitchell, John Lee and F J Mitchell (son of F H) bought the assets from F H Mitchell, Ewbank, Cordes and Lee, and this partnership lasted until 1883: Johnson, p 23.

92 Johnson, 'A Place in Time', pp 9-10.

rights for improved nailmaking machinery from Samuel Slocum of 'New Road, Pancras, London' for £500,[93] but this is perhaps an over-simplification.

Cordes had made simultaneous patent applications in March 1834 for improvements in machinery for making nails and improvements in machinery for making rivets, screw blanks and bolts, each of which was described as a communication from a foreigner living abroad, rather than being his own invention. He received six months protection, but did not proceed to enrol the specifications. In October 1834 he made new applications on the same subjects, and for these the specifications were enrolled in April 1835. They were now referred to as communications from a foreigner formerly resident abroad but now deceased, so he had presumably died between March and October, or somewhat earlier if we allow time for the news to reach London.. The identity of this foreigner is unknown, but it was not Slocum, who was neither dead nor, at this time, resident aboad. Slocum was probably his agent.

Slocum was from Poughkeepsie, New York, and according to various Web sources he was in England working on the development of machinery to make pins and, while there, invented a machine to produce wrought iron nails.[94] This is largely consistent with the fact that he obtained British Patent 6578 in March 1834, for machinery to make pins. The application was simultaneous with those of Cordes, and they must have been connected. A further patent was granted to Slocum in August 1835, 'in connection with J. Cordes patent of 8 October 1834'.[95]

The patent machine, as modified by Slocum, partly replicated the stages by which nails were made by hand from nail rod, simulating the drawing out of the point by the use of converging rollers. In this it was so successful that the nails are frequently mistaken for the hand made type, even by professionals such as archaeologists. Ewbanks were said to have been the first to produce nails which could compete with those forged by hand,[96] and the firm - presumably meaning Cordes & Co - is credited with introducing the Ewbank nail to Australia in about 1838.[97] , and in the Australian market in particular they largely supplanted hand-forged nails.[98] The Ewbank nail was rose-headed, almost chisel-pointed, and particularly adapted for hard woods. By 1853 the factory was producing eighty tonnes of nails weekly.[99]

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93 Johnson, 'A Place in Time', p 13.

94 His dates are 1792-1861.

95 Although it appears over my joint name I cannot account for the statement in How & Lewis, p 8342, that 'A further patent, no 1835, states that that a mechanic was engaged for a consideration of £500 to insert gearing into the original design, such that the converging rollers travelled proportionally together, thereby avoiding problems of curvature of the nail shank.' No patent of that number could have been granted at the relevant time, and no patent would be expected to contain such anecdotal information.

96 Papworth, *Dictionary,* sv Nail, quoting *Builder,* 1860, XVIII, p 156.

97 [Francis Young], *Every Man His Own Mechanic* (London, no date ?c 1882), §328, p 138.

98 Ball, 'Hand-Made Nail Trade'. p 112.

99 Johnson, 'A Place in Time', p 13, quoting the Merlin.

In 1845 Higgs & George of London advertised patent wrought nails, claimed to be tougher and more uniform than the best hand-made nails. The flat-pointed rose nails in particular were recommended for use in oak or other hard woods, because they were 'perfectly chisel-pointed' and therefore required no boring, and could be driven into the hardest wood without splitting it. Moreover the heads were very strong, and would not fly off.[100] It appears that Higgs & George were not the manufacturers but the agents,[101] and that they were in fact the Cordes product. In March 1853 Higgs and George advertised as agents for 'Patent Wrought Nails. Manufactured by J. J. Cordes and Co, frequently known as Ewbank's nails,' and this advertisement continued until December 1866.[102] In this year it was reported they were making eighty tonnes of nails weekly for export to all parts of the world.[103]

It is not entirely clear why Henry Ewbank's name is so strongly associated with these nails. Though reference is commonly made to him as the inventor or manufacturer,[104] it seems that he was in fact no more than an initial partner in the manufacturing company, J J Cordes & Co. Malcolm Johnson claims that Ewbank himself had patented 'automatic' machinery for nailmaking before 1823, which seems improbable. Johnson gives a circumstantial and unsubstantiated description of him as an engineer and merchant who was aware of the nailmaking skills to be found in South Wales, and whose role was to be in manufacturing and engineering while Cordes would raise capital and manage the business.[105] He seems to have been bought out of the partnership in 1853 for £12,000,[106] but he continued as a merchant and nail exporter. Whereas bulk orders of nails were normally supplied in stout sacks, he exported the nails in sealed iron bin, in order that they would arrive in first class condition.[107]

Cordes died in 1867,[108] and in 1869 the partnership of J.J. Cordes became the private company, J.J.Cordes & Co.[109] In 1884 it became a limited liability company, chaired by F J Mitchell, one of three sons of the original partners who joined the firm.[110]

Cordes's Ewbank nails were described as flat-pointed rose nails and flat-pointed strong wire nails. The former were made in sizes from 1 to 3 1/2 inches [25-89 mm] long, the latter - which can be nothing to do with what we

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100 *Builder,* III, 137 (20 September 1845), p 456.

101 Wyatt Papworth [ed], *The Dictionary of Architecture* (London 1853-92), sv Nail, gives the same description and refers to the nails as being 'submitted by the agents in London, Higgs and George, to the notice of builders' in 1852.

102 How & Lewis.

103 Johnson, 'A Place in Time', p 13.

104 According to Papworth, *Dictionary,* sv Nail, Ewbanks were succeeded as manufacturers by J J Cordes & Co of the Dos Works.

105 Johnson, 'A Place in Time', p 8.

106 Johnson, 'A Place in Time', p 23.

107 *Australasian Ironmonger,* 1887.

108 Johnson, 'A Place in Time', p 7.

109 Source - How.

110 Johnson, 'A Place in Time', p 4: the others were Thomas Cordes and Edward Arthur Lee. Francis Johnstone Mitchell (1824-) had joined the firm in 1855

commonly know as Ewbank nails - from 1¼ to 4 inches [32-102 mm].[111] However, a large proportion of the Ewbank nails found in Australia seem to be very considerably larger, and, as will appear, sizes up to six inches [150 mm] were advertised locally. In 1869, or perhaps slightly earlier, Cordes & Co announced that they had adopted a star or cross as their trademark for the patent wrought nails known as 'Ewbank nails', of which they were the sole patentee and manufacturer (though of course no patent dating from as long ago as the 1830s could still be in force). All their exports except clasp nails would henceforth bear this mark.[112] Actual specimens of Ewbank nails are found to have a rectangular shank, tapering slightly in both directions, a pyramidal head, and rather than being 'perfectly chisel-pointed' like those of Higgs & George, they have a curved end. Well preserved specimens show a slightly raised ridge along the arrises on the flat side of the shank, doubtless resultant from the pressing process. The head is basically of the rose type, and in some (presumably after 1869) bears a small equal armed cross or star motif rotated 45º relative to the hips of the pyramidal head. According to Chris How the partly formed nail blank was held (under the original patent) with two slightly cuspate plates, applied to the rear and the front face, and when it was struck with the die of the heading tool the haunches were forced out on either side of the clamps. The heads themselves have a lopsided look, and an irregular perimeter where the metal has broken out at the edges.[113]

Surviving specimens can thus be dated as before or after 1869 (or thereabouts) by the absence or presence of the star. A further change occurs within the star type, possibly in 1878, but is a harder to disagnose. Malcolm Johnson refers to the fact that patents for improved machinery were was taken out in 1870 and 1878 by a Cordes employee, J L Heward.[114] That of 1870 illustrated the nailmaking machine and is described as:

> In a machine for heading and finishing nails, shown in elevation in Fig. 1 and in sectional plan in Fig. 2, the nails are placed in dies *a,* which are fitted into notches a^1 in a wheel A, and are held loosely in place by rings or segments a^2, a^3. The wheel is carried upon friction rollers, and rotated step by step by a lever engaging ratchet teeth A^1. After receiving thne nails, the dies are pressed together by spring plates *b,* and, when opposite the heading-tool *c,* a greater pressure is put upon them by the squeezing-jaws *d, d,* these jaws and the heading-tool *c* being actuated by a slide c^1. After being headed, the nails fall from the dies, or are pushed out by a plate *e* in the groove A^x, or the dies may be opened by fixed cams A circular flat spring may be placed in the groove, to prevent the nails from being inserted too far, and also to remove then when finished.[115]

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111 [Francis Young], *Every Man His Own Mechanic* (London, no date ?c 1882), §328, p 138.

112 *Argus,* 15 May 1869, p 3 The advertisement may have appeared earlier than this, and certainly it continued unchanged for years afterwards, for example *Town and Country Journal,* 28 November 1874, p 876.

113 Chris How, email of 29 June 2006.

114 Johnson, 'A Place in Time', p 13, apparently based upon the listing of these patents in a schedule of company assets published in the *London Gazette,* 1 September 1903 (kindly supplied by Johnson).

115 British patent no 2711, 14 October 1870 to J L Heward.

This machine was improved in a patent of 1881, not illustrated:

> Consists of improvements in machinery described in Specification No.2711, A.D. 1870. Four dies are used instead of two, the side dies as well as the header being placed in position by the forward motion of the slide box. The bottom die has removable wearing surfaces and is fixed in a die seat in the bedplate of the machine; it has a narrowed projection in front, against which the side dies come up, and two guides working up and down in a recessed chamber below. The top die is of the same shape but without the guides. While the nail shank is held firmly between these dies, the side dies are pushed along until a square hole is formed between the four dies, when, pressure being brought to bear on the top and side dies, the header moves forwards and spreads out the metal of the shank into the head of the nail. On the header returning, the top and side dies move away an the nail falls out. The top die works in a headstock on a shaft a double eccentric on which raises and lowers the headstock as the shaft revolves. This eccentric motion is converted into vertical motion by a knuckle joint. An eccentric in the the centre of the shaft works a spindle up and down inside the headstock and carries a cutter which cuts off the shank of the nail and points it while the head is being formed. At the same time the shanks are being straightened between another pair of top and bottom dies fixed behind those described. The nail rod is fed into the dies by a pair of feed rolls working with an intermittent motion from a ratchet plate and pinions.

The 1878 patent is not illustrated but seems less relevant:

> Relates to the heading of coopers' and other large-headed nails in two operations, with an annealing process betweeen. In the first operation the nail blank is held between grooved dies countersunk on the top side, the header also having a deep countersunk [*sic*] and thus producing a double pyramidal head. After annealing, the nail is held in other grooved holding-dies, and the head flattened out by a header with a broad shallow countersink [*sic*], giving an equal shoulder all round.[116]

It is not immediately obvious how these relates the visible characteristics of the Ewbank type. Of two later British patents in Heward's name, one is a means of cutting nail shanks and the other an improvement to the machine of 1870[117] seem even less relevant. How has interpreted the subtle change in the appearance of the nails in terms of his belief that the clamps are now applied across the diagonal of the nail blank, each one a right-angled V-shape, and together forming a perfect square. There is a bevel on the top edges of this square, and a small breakout of metal at the diagonal gap, creating what he calls a diagonal haunch. This gives rise to a twist in the top of these nails.[118]

The earliest reasonably authenticated Ewbank nail in Australia seems, in fact, to be earlier than 1838 and of a larger size than those described. It is one recovered from the cottage which was prefabricated in Sydney by the Royal

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116 British patent no 1465, 12 April 1878 to J L Heward.
117 British patents nos 1829, 27 April 1881; 1830, 27 April 1881.
118 Chris How, email of 29 June 2006.

Engineers for Captain William Lonsdale, and erected in Melbourne in 1837. It is a six inch [150 mm] nail which is severely corroded but undoubtedly of the general type, and seems to be correctly dated to 1837.[119] Ewbank nails are reported in a slab cottage at 44 Barden St, Tempe, Sydney, which has been claimed to date from about 1840 - though this seems to be entirely unsubstantiated.[120] They have also been found at 'Pontville', a house of the 1840s at Doncaster, near Melbourne;[121] in large numbers in the shearing shed at 'Warrock', Victoria, also of the 1840s; and it appears (for they are not identified as such by the investigators) in the homestead at Matanaka, New Zealand, also of the 1840s.[122] Ewbank nails have also been found in the shingle roof of a Melbourne cottage of 1853.[123]

In an undated ruin at Hexham, Victoria, Chris How has discovered large numbers of Ewbank nails and smaller numbers of another type. The latter appear to have been cut from a strip, and the head formed subequently. The profile of the shank is one direction simply the thickness of the strip, and in the other a concave tapering shape (as opposed to a simple triangle or wedge). How also reports that the Weald and Downland Museum in England holds a large number of a variant type. They are clearly marked on top with a diagonal St Andrew's cross and are somewhat cruder that the Ewbank . Many are cut well off square, apparently as a result of a very fast passage through the guillotine.[124] Given that Cordes's patrent would gave expired in 1848, or in 1855 if extended, one would expect such competing versions to have appeared.

The first documentary evidence of Ewbank nails in Australia is in 1850 when they were being sold in Launceston in 1¼,1¹3₄, 2, 2½, 3, 3½ and 4 inch sizes [32, 45, 51, 64, 76, 89, 102 mm], together with 2 and 2½ inch patent cut brads.[125] In 1852 a Melbourne importer advertised '500 kegs of Ewbank's patent nails',[126] and in 1861 an auctioneer was offering both 'Ewbank's Nails, genuine' and 'imitation Ewbank's nails',[127] a further problem to which we will return. By 1862 Ewbank nails were listed in Mayes's pricebook in sizes from one to six inches [25-150 mm].[128] They were still listed in Mayes's price book

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119 This nail has been given to me by Ms Nada Brozel, who assisted in the dismantling of the cottage in the 1960s. Although the cottage had a chequered history, it had been moved bodily from site to site, and the later accretions had been stripped by the time the National Trust brought it back to Melbourne. Thus the nail came from the original section and, being so large, is likely to have been from the basic structure.

120 'The Hidden Cottage', *Heritage NSW,* V, 4 (Spring/Summer 2000), p 10.

121 Miles Lewis, 'Pontville' (typescript report to the City of Doncaster & Templestowe, Melbourne 1994).

122 Hardwicke Knight & Peter Coutts, *Matanaka: Otago's First Farm* (Dunedin 1975), p 29. The nail is illustrated, though not identified, and it is implied that it is from the original structure.

123 Miles Lewis, *370 Malvern Road, Prahran* (Melbourne 1989), p 14.

124 Email from Chris How, 19 February 2014.

125 *Launceston Examiner,* 29 May 1850, p 343.

126 These were among goods advertised by Mitchell & Bonneau of Elizabeth St, as having arrived on the *Bernica* and other recently arrived ships: *Argus,* 9 June 1852, p 3.

127 *Argus,* 27 September 1861, p 2.

128 C B Mayes, *The Australian Builders' Price-Book* (2nd ed, Melbourne 1862), p 107.

in 1886, in the same sizes and at the same prices for the smaller ones, slightly less for the larger:[129]

size in inches	lb wt per thou	price per cwt	price per lb
1	2 1/2	80.0	0.10
1 1/4	3 1/2	62.0	0.8
1 1/2	4	68.0	0.7 1/2
1 1/2	7	36.0	0.4 1/2
1 3/4	8	34.0	0.5
2	10	33.0	0.4 1/2
2	7	45.0	0.6
2 1/4	12	30.0	0.5
2 1/2	17	28.0	0.4
3	25	26.0	0.3 1/2
3 1/2	32	24.0	0.3 1/2
4, 4 1/2, 5, 6	23	23.0	0.3 1/2

They were still being advertised by McEwan's of Melbourne at this time,[130] and apparently still in use in England at the turn of the century.[131]

In 1859 Charles Mayes recommended that nails should be manufactured in Victoria, because little manual labour was required, and the working expenses of machinery were less than in Britain or America.[132] In January of the same year a Victorian patent was granted for the forging of various objects, especially nails, by means of two anvils at an angle to each other being brought alternately into contact with the article to be forged, by means of a rocking motion, while at the same time it was struck with a hammer.[133] This was obviously designed to emulate the beneficial effect of hand forging, and was almost certainly the extension of an overseas patent (quite possibly that for the Ewbank nail). The Victorian patentee was John Robert Ricards senior, of Fisher, Ricards & Co, and it may be that local manufacture must have been seriously contemplated: if so, it did not eventuate, and it seems more likely that Ricards was establishing an agency.

The advent of wire nails, effectively in later 1860s, seems to have led to a rapid decline in the use of the Ewbank except in the largest sizes, commonly referred to as 'spikes'. These continued to be used, for example, in joining the top plates of bush huts to the column or post. Is 1879, however, Ewbank nails were still specified for the whole of the carpentry work of the

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129 Charles Mayes, *The Australian Builders' Price-Book* (5th ed, Melbourne 1886), p 145.

130 Mayes, *Australian Builders' Price-Book* (1886), advertisements, p xix.

131 Joseph Gwilt [ed Wyatt Papworth], *An Encyclopædia of Architecture* (London 1899 [1842]), §2257b p 720, refers to Cordes' patent rose, flat points, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/2, 3 and 6 inches long. However Young, *supra,* wrote of them as if they were specially geared to the Australian market, and no longer much used in Britain.

132 Mayes, 'Manufactures', p 325.

133 Victorian patent application no 195 to John Robert Ricards, 26 January 1859; see also Mayes, 'Manufactures', p 325. Fisher, Ricards and Co seem to have specialised in agricultural machinery, and they showed an improved mowing and reaping machine at the 1861 Exhibition. *Catalogue* of the Victorian Exhibition, 1861 (Melbourne 1861), p 224.

Metropolitan Meat Market, in Melbourne,[134] and they were specified as late as 1891 for fastening the cleats of hammer beams, and for most of the roof framing, at 'Benvenuta', Melbourne.[135] Wrought and wire nails were used elsewhere in the building, and one might wonder whether the Ewbanks appear simply as the result of mindless copying of earlier specifications. However a catalogue of Harris, Scarfe, Limited of Adelaide, undated but perhaps about 1910, still lists 'Patent Steel Rose Nails (or Ewbanks) in sizes from two to five inches,[136] and Ewbanks were still advertised by James Moore & Sons of Melbourne in 1913.[137]

schedule of patents

Great Britain

- no 4340, 9 February 1819 (inrolled 8 April 1819), to Henry Ewbank of London, for machinery cleansing and dressing paddy or rough rice.
- no 5472, 10 March 1827 (inrolled 10 May 1827) to Jonathan Lucas and Henry Ewbank both of Mincing Lane, London, for an improved process for dressing paddy or rough rice.
- no 6575, 18 March 1834 (6 months; no specification inrolled) to James Jamieson Cordes of Idol Lane, London, for a certain improvement or improvements in machinery for making nails, being a communication from a foreigner residing abroad.
- no 6576, 18 March 1834 (6 months; no specification inrolled) to James Jamieson Cordes of Idol Lane, London, for a certain improvement or improvements in machinery for making rivets and screw blanks or bolts, being a communication from a foreigner residing abroad.
- no 6577, 18 March 1834 (6 months; no specification inrolled), to Samuel Slocum, machinery for making nails.
- no 6578, March 1834 (6 months; no specification inrolled), to Samuel Slocum, for machinery to make pins.
- no 6686, 8 October 1834 (inrolled 8 April 1835) to James Jamieson Cordes of Idol Lane, London, for a certain improvement or improvements in machinery for making rivets and screw blanks or bolts, being a communication from a foreigner formerly resident abroad, now deceased.
- no 6687, 8 October 1834 (inrolled 8 April 1835) to James Jamieson Cordes of 6 Idol Lane, London, for a certain improvement or improvements in machinery for making rivets and screw blanks or bolts, being a communication from a foreigner formerly resident abroad, now deceased.
- no 6768, 12 May 1835 (inrolled 15 August 1835) to Samuel Slocum of Rotherhithe in August 1835, in connection with J. Cordes patent of 8 October 1834: the frame is longer than Cordes's to admit a second opening; the toothed wheels of Cordes are replaced with spindles

134 G R Johnson, 'Bill of Quantities Metropolitan Meat Market, Bank, Hotel, and Two Shops, &c' (Melbourne 1879), p 7.

135 W S Law, 'Specifications of Residence Drummond St. Carlton for Mrs. L. Abrahams' (Melbourne 1891), p 13.

136 Harris, Scarfe, Limited, *Engineers' Supplies* (Adelaide, no date [?c 1910]), p E12.

137 James Moore & Sons Pty. Ltd., *Price List 96 August 1913* (Melbourne 1913), p 4.

geared together by two equal toothed wheels; the shear shaft is made so that the shears fall in front of the compressing rollers rather than behind.

- no 7486, 26 November 1837 (inrolled 25 May 1838), to James Jamieson Cordes of Idol Lane, London, for an improved mortar for dresing rough rice or paddy, or redressing rice
- no 8572, 18 July 1840 (inrolled 18 January 1841), to James Jamieson Cordes and Edward Locke, both of Newport, Monmouth, for a new rotary engine [not specifically related either to rice or to nails]
- no 2711, 14 October 1870 to James Lockwood Heward of Newport, improvements in machinery for heading and finishing wrought iron nails after the shanks have been forged and cut into suitable lengths. Each nail shank is fed into a pair of steel dies, these dies being arranged around the circumference of a wheel which rotates in steps by a lever and ratchet motion. The dies fit the shank closely except for the portion projecting which is to form the head. Opposite the header the dies are made to grip the shank firmly while the projecting end is forced into the desired shape. The wheel carries the dies between stationary cam or curved surfaces which force them apart and allow the finished nail to drop. [also *Abridgements*].
- no 1465, 12 April 1878 to James Lockwood Heward, of the Dos Works, Newport, for improvements in the manufacture iof hgeadednails of wrought iron and other metals, applicable to cooper's and other large-headed nails [also *Abridgements*].

* no 1829, 27 April 1881 to J L Heward, for the manufacture of nail shanks from a flat strip [*Abridgements*].
* no 1830, 27 April 1881 (provisional protection only) to J L Heward, improvements to to the machinery of no 2711, 14 October 1870 [*Abridgements*].
* no 9765, 17 August 1885 to J W Heward & J L Heward, for an improvement in cut nail machinery [*Abridgements*].
* no 13727, 22 September 1888 to J J Cordes & Co [F J Mitchell], for (improvements in) machinery for making cut nails from blanks [*Abridgements*].

United States
* to L Norcross, 1824, for a wrought nail machine [Priess & Shaughnessy].
* to H Burden, 1825, for the manufacture of wrought nails [Priess & Shaughnessy].
* to S G Reynods, 1829, for a machine for making wrought nails and rivets [Priess & Shaughnessy].
* to S I Gould, 1829, for a machine for making wrought nails and screws [Priess & Shaughnessy].
* to S Davis jnr, 1829, for manufacturing wrought nails [Priess & Shaughnessy].
* to G B Manly, 1830, for manufacturing wrought nails [Priess & Shaughnessy].
* to T W Harvey, 1832, for manufacturing wrought nails [Priess & Shaughnessy].

* to J V Green, 1832, for manufacturing wrought nails [Priess & Shaughnessy].
* to W Slater, 1834, for wrought nails, brads &c [Priess & Shaughnessy].
* to R Daniels, 1834, for manufacturing wrought nails [Priess & Shaughnessy].
* to W C Grimes, 1834, for a wrought nail and spike machine [Priess & Shaughnessy].
* to S G Reynolds, 1835, for a wrought nail machine [Priess & Shaughnessy]. [but S G Reynolds did not die in 1835: he took out further US patents in 1866 and 1867]

e. the wire nail

Wire nails are a useful tool for dating buildings in Australia, for they have usually been assumed to date from after 1870. However, there are some much earlier examples, and light wire nails for carpentry were used in France from at least the first decade of the nineteenth century. They were known as French nails or *pointes de Paris,*[138] 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 a head with one or two hammer blows.[139] Priess suggests that this was possibly no more than the transference of existing technology from bar stock to wire stock.[140] By 1810 the manufacture must have been well established, for the Messrs Mouchel, who were iron and steel wire makers at l'Aigle, Department of l'Orne, used the iron of the area because it was already known to produce the best wire for nails, screws and pins. It was hard and had a polish resembling that of steel wire.[141]

In March 1811 the American inventor James White, then living in Paris, took out a patent for a machine in which the wire was gripped vertically between two notched discs and it was cut to length, the head struck, and the point formed, all in a single operation. This machine, however, was not substantial enough to sustain a continuous manufacturing process, and the industrial production of wire nails was begun only in 1819 by the Lemires, father and son, of Clairvaux in the Jura, using processes developed by a number of inventors between 1806 and 1816. Other wire nail machines followed and by 1840 a number of Parisian works were producing *pointes* mechanically, notably Lenoble & Lambert at Popincourt, and Fiantz at La Villette.[142] By the

138 Peter Priess, 'Wire Nails in North America', *APT Bulletin,* V, 4 (2003), p 91.
139 Michael Baackes, 'The History of the American Wire Nail Industry', *The Iron Age,* 2 January 1896, p 105. However Sickels, 'Nails and Nailmaking', p 68, states that the very first wire nails had no heads.
140 Priess, 'Wire Nails in North America', p 87.
141 'Extract from the Memoir of Messrs. Mouchel, of l'Aigle, in the Department de l'Orne, on the Manufacture of Iron and Steel Wire', *Repertory of Arts, Manufactures, and Agriculture,* 2nd series, XVI, 95 (April 1810), p 309.
142 Charles Frémont, 'Le Clou', *Bulletin de la Société d'Encouragement pour l'Industrie Nationale,* CXVII, March 1912, p 366-7.

late 1840s headed wire nails were being exported from France to the United States.[143]

The critical development was probably the wire nail machine invented by R Frey and shown at the Paris Exposition of 1844,[144] for it seems to have been the basis of large scale manufacture, and the wire nail machines of subsequent decades are all closely related to it. Its operation was described as: 'le fil de fer avançant à chaque tour de la manivelle d'une longeur constante, la tête est façonnée par refoulement, et la pointe formée par deux couteaux mus par deux excentriques qui coupent le fil de fer sous un angle aigu'[145] [the iron wire moves forward by a constant amount with each turn of the crank handle, the head is formed by pushing back against it, and the point is formed by two cutters moving on eccentrics which cut the wire on an acute angle]. According to Frémont, Frey's machine as well as two others by Stoltz were shown at the Great Exhibition of 1851 and the Paris Exposition of 1855.[146] But the 1851 catalogue reveals nothing by Stoltz, nor any French nail machine at all other than that of 'Frey junior', perhaps the son on the inventor, described as:

> A machine for nail-making, upon new principle.
> This machine if of small size, and is adapted for the manufacture of nails from two-fifths of an inch to one inch and one-fifth [10-28 mm] in length. The exhibitor has in his establishment seven various machines of the same description, which manufacture nails from one-fifth of an inch [5 mm] to eight inches [200 mm] in length. These machines are made with a plain framing, and are very easy to be set and repaired.[147]

At the Paris Exposition of 1855, Frey's and Stoltz's machines were joined by that of Rabeau, and Rabeau's was in turn to be the basis of Dubos's machine of 1862, and hence the later machine of Fagette, all of which bear a family resemblance. Frémont illustrates a machine of 1855 by Stoltz, preserved in the Conservatoire des Arts et Métiers, and a 1911 model by Dubos which is remarkably similar.[148] E-O Lami described the manufacture of wire nails in 1883 in terms recognisably similar to the original description of Frey's machine:

> Pointes de Paris. Ces clous se fabriquent aujourd'hui presque exclusivement à la machine. On fait les pointes de Paris avec du fil fer

143 Sickels, 'Nails and Nailmaking', p 68.

144 Frémont, 'Le Clou', pp 366-7. This may be the machine which according to Baackes was invented by a French mechanic at some time between 1840 and 1850, and in which a board on a single leaf spring was suspended from the ceiling, forced up by a cam, then released to create the hammer blow: Baackes, 'The American Wire Nail Industry', p 105.

145 Charles Laboulaye [ed], *Dictionnaire des Arts et Manufactures; Descriptions des Procédés de l'Industrie Française et Etrangère* (2 vols, Brussels 1845), I, sv Clou, and fig 549.

146 Priess, 'Wire Nails in North America', p 88, ref Charles Laboulaye [ed], *Dictionnaire des Arts et Manufactures; Descriptions des Procédés de l'Industrie Française et Etrangère* (2 vols, Brussels 1845, I, fig 549.

147 Great Exhibition, 1851, *Catalogue,* III, p 1254.

148 Frémont, 'Le Clou', pp 367, 365, 366.

> pris en bottes, et le travail s'exécute à froid sur le métal. Le fil de fer, saisi dans une mordache à la tête de la machine, avance, à chaque tour d'une manivelle reliée à l'arbre moteur, d'une quantité constante qui est engagée dans une contre-étampe dépassant légèrement aux deux extrémités. La pointe du clou est alors formée par deux couteaux mus par des excentriques, qui coupent le fil de fer sous un angle aigu, en même temps que l'étampe montée sur un arbre, que commande un excentrique particulier, vient former la tête par refoulement. Le clou se trouve terminé, pendant la période de retour des organes précédents à leur position primitive, un chasse-clou pousse légèrement le clou en dehors de la contre-étampe, et un crochet agissant sur la tête fait tomber le clou fabriqué en dehors de la machine, quoi se trouve dans la même situation qu'au point de départ, et donne lieu à la production d'en nouveau clou. Cette fabrication continue et très économique à l'aide de laquelle en peut, en se servent de fils de grosseurs diverse, établir des clous de modèles très variés, d'une exécution parfaite, a considérablement favorisée l'emploi des pointes de Paris, qui remplacent aujourd'hui avec avantage tous les petits clous forgés qu'on fabriquait autrefois.[149]
>
> [Pointes de Paris. These nails are today made almost exclusively by machine. Pointes de Paris are made from iron wire in bundles and the metal is worked cold. The iron wire, gripped by a clamp at the head of the machine, moves forward at each turn of a crank linked to the drive shaft, by a fixed amount which is engaged in a counter-mould, while extending slightly beyond its two ends. The point of the nail is then formed by two cutters moving on eccentrics, which cut the wire at an acute angle, at the same time as a mandrel, which is mounted on a shaft giving it a particular eccentric motion, has formed the head by pushing back on it. While the components return to their original position, a punch gently pushes the completed nail out of the mould and a hook engages the head and throws it clear of the machine, which is now in its original position and begins to form the next nail. This continuous and very economical mode of manufacture, by which wire of various dimensions can be used to perfectly form a wide variety of nails, greatly favours the use of pointes de Paris, which today can advantageously replace all the small nails once forged by hand.

When Frémont described the process of manufacture in 1912 the most conspicuous difference was that he described the nail as being gripped by the neck during the process of formation, rather than along its full length.[150] However this can hardly have been new, as most wire nails even of the nineteenth century show the marks of the vice around the neck. Lami's description is not accompanied by an illustration of the nails produced, but Chabat illustrates what he calls a *clou d'épingle à chevron,* a *broche,* or a *chevillette.*[151] This is a wire nail, as it has a cylindrical shank, and in any case

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149 E-O Lami, *Dictionnaire Encyclopédique et Biographique de l'Industrie et des Arts Industriels* (8 vols, Paris 1881-91), III, p 538.

150 Frémont, 'Le Clou', p 367.

151 Pierre Chabat, *Dictionnaire des Termes Employés dans la Construction* (Paris 1875), p 318.

Tolhausen equates *clou d'épingle* with *pointe de Paris.*[152] The head of Chabat's nail is thin and flat, and the point is four-faceted, reflecting the action of the cutters. He divides the type into three categories, *clous à chevrons*, *clous fins* [fine nails], and *semence* [tack or sprig].

The British avoided wire nails for three or four decades for no discernible reason other than conservatism, and this is all the more remarkable because the use of wire in making pins seems to have been well established.[153] But in addition to Frey's wire nail-making machine, wire nails themselves were shown at the Great Exhibition by a British maker who was almost certainly using Frey's or other French equipment. John Cornforth of Birmingham displayed his iron, steel and other wire, as well as examples illustrating the process of manufacturing it. It seemed to be more as a curiosity than anything else that he added:

> Wire nails of various sizes and forms. Heads and points of nails manufactured by the patent process known as the Pont de Paris [*sic,* for pointes de Paris], and used by the carpenters of that city, and of France generally, which may be made of any form.

It appears, then, that Cornforth must have acquired the British rights and was making wire nails, but did not see them as being important. This is consistent with the facts that even in 1866 none of the writers in Timmins's *Resources of the Birmingham and Midland Hardware District* made any mention of the wire nail, and in about 1870 Charles Hibbs, writing on nails, also ignored it.[154] Nonetheless another Continental patent, specifically refering to 'Paris points' was extended to England in 1859, though it does not appear to have been of any consequence

Wire nail making machinery was adopted almost as slowly in many other countries.[155] However, by 1851 Paul de Bavay of Brussels was making wire nails in iron, zinc, brass and copper which, like Cornforth, he referred to as *pointes de Paris,* and it seems likely that he had acquired the same French machinery.[156] At the International Exhibition, London, of 182, Hobrecker, Witte, & Herbers, of Hamm, Westphalia, Prussia, seem to have shown an extraordinary range of what they referred to as wire nails of Paris points, from 'the smallest size' up to 16 inches long by ½ Inch thick [300 x 13 mm].[157] Wire nails began to be made elsewhere in Europe in the early 1860s, but in

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152 Alexander Tolhausen [rev Louis Tolhausen] *Technological Dictionary in the English, German & French Languages* (3 vols, Leipzig 1874-8), *Français-Allemand-Anglais* (1877), p 642.

153 William Bundy's patent for a method of heading pins refers to the raw material as being wire: *Repertory of Arts, Manufactures, and Agriculture,* 2nd series, XVIII, 106 (March 1811), pp 203-206.

154 Charles Hibbs, 'Great Manufactures of Little Things - IX. Nails', *Technical Educator* (no date [c 1870], pp 11-13.

155 E F Carter, *Dictionary of Inventions and Discoveries* (London 1974 [1966]), p 122.

156 Great Exhibition, 1851, *Catalogue,* III, p 1162.

157 *The International Exhibition of 1862. Illustrated Catalogue of the Industrial Department. Vol. IV. Foreign Division* (Her Majesty's Commissioners, London 1862), 2nd division, no 2049.

following decade Germany, France and Belgium were mentioned as major producers,[158] Belgium continuing in importance until about 1898.[159]

In the United States the first machine-made wire nails are said to have been made in New York in 1851 by either Adolph Felix Browne[160] or Morton & Bremner. Morton & Bremner's machine is said to have been designed by their foreman, William Hassell, though it seems certain that it was based upon Frey's or some other French patent. Hassell was to acquire all the firm's equipment in 1857, when the partners retired from business, and then established his own factory in Center Street, New York. The machine was called a 'pin machine' because it was used principally to make escutcheon pins, with nails as a secondary concern, and it operated for fifty-three years before Hassell's son John presented it to a company museum.[161] There are a number of other versions of these stories,[162] but on balance it seems that machinery was certainly being used in New York in about 1851, and this contradicts another claim to the effect that a wire nail machine installed at Montreal in 1870 was the first in North America. However this may be, wire nails were very little used in the United States before about 1883.[163]

In about 1871 some German residents of Covington, Kentucky, reportedly cooperated in importing three German wire nail machines. With these they made cigar box nails, small brads and nothing larger than a 3d fine nail, and met with little success until the company was reorganised in 1875 as the American Wire & Screw Nail Company.[164] Another version of the story is that in 1875 one Father Joseph Goebbels, a Roman Catholic priest, migrated from Germany to Covington, and began manufacturing wire nails on the basis of his German experience,[165] in partnership with Michael Baackes. The business was known as the Kentucky Wire Nail Company until it became a stock company in December 1875 as the American Wire & Screw Nail

158 Baackes, 'The American Wire Nail Industry', p 105.

159 Fontaine-l'Eveque, in the Charleroi district, was the centre of nail making, with six factories, and there were one each at Brussels, Marchienne and Gentbrugge, as well as two small works at Hodimont and Luxembourg. The nail wire was imported from the United States, and by the 1890s the competition of the US, as well as that of France and Germany, was driving the Belgian product out of European markets, coming to a crisis point in about 1898. But there is no mention of such a crisis in France, and the German industry was prospering, with eighty-six works combined in a syndicate, and supported by an export premium *Scientific American Supplement no 12175,* 9 June 1900, pp 20439-20440.

160 Thomas Ritchie, *Canada Builds 1867 - 1967* (Toronto 1967), p 171; Rempel, *Building with Wood,* p 369.

161 Sickels, 'Nails and Nailmaking', p 68. Swank wrote in 1892 that six of the wire nail machines first used by Hassall were still operating in his son's factory: Swank, *Manufacture of Iron,* p 450.

162 Graham & Emery, *Audels Carpenters Guide*, I, pp 23, 25, refer to wire nails made by hand by William Hershel in 1851 or 1852, but Priess, p 88, gives this name as Hassall, and cites other contenders, Thomas Morton and Adolphe Brown: ref sources including James M Swank, *History of the Manufacture of Iron and particularly in the United States from Colonial Times to 1891* (New York 1892).

163 Swank, *Manufacture of Iron,* p 450.

164 Swank, *Manufacture of Iron,* p 450.

165 Graham, *Audels Carpenters Guide,* I, p 25. Graham refers to Father Goebel, but Baackes to the Rev Joseph Goebbels.

Company, later changed to the American Wire Nail Company.[166] It is said to have caused a rapid decline in the use of cut nails even during its first decade of operation.[167] Although the wire nails were at first taken up only by furniture manufacturers and cigar box makers, interest was aroused when the company won a silver medal at Philadelphia in 1876, and two other companies, William Hassall of New York, and A Field & Sons of Taunton, Massachusetts, entered the trade.[168] As William Hassall is undoubtedly the Hassell referred to above, the account is a flawed one, but it may refer to a shift in his output towards building nails.

According to Sickels it was the development of the Bessemer process in the 1880s and the invention of an improved wire nail machine by John Hassell in 1884, patented the following year, which caused the decline of iron (non-wire) nail making.[169] The first steel nails, made from Bessemer steel wire, were made by the H P Nail Company of Cleveland, Ohio, from 1879.[170] In making the nail the head was formed with a hammer-like blow from a cam-operated member, much as in the original French machine, and the point by a pair of pliers with V-shaped cutting edges.[171] These nails were harder and tougher, could bend, twist or clench without breaking, and were able to be driven into the hardest timber without breaking. Though at first the extra cost discouraged their use, by the mid-1880s the price was little more than that of iron nails, and they were coming into general use.[172] By 1885 there were twenty-five manufacturers in the United States, operating four or five hundred machines. In 1886 their association issued a card, which had been devised by a member company in the previous year, in which cut nails were compared to wire nails in standard sizes of from one to six inches [25-150 mm].[173] By 1890 there were fifty-seven wire nail works.[174] In 1886 10% of US nails were of steel wire, but by 1892 they were in the majority, and by 1903 they constituted 90% of the market.[175]

But their advance was not inexorable. In 1892 it was reportred that tests by at the Watertown Arsenal had shown that cut nails had much better holding power.[176] In 1900 the *Scientific American* reported that the iron and steel cut nail industry was enjoying a great revival. Shingles fixed with wire nails were found to blow off after ten years, because they could not 'stand the weather' as wrought nails did, a problem partly attributable to the fact that the acid which was used in annealing the wire could not be fully cleaned off.[177] The

166 Baackes, 'The American Wire Nail Industry', p 105.
167 Graham, *Audels Carpenters Guide,* I, p 25.
168 Baackes, 'The American Wire Nail Industry', p 105.
169 Sickels, 'Nails and Nailmaking', p 68.
170 Baackes, 'The American Wire Nail Industry', p 105.
171 *Scientific American,* 12 December 1903, p 438; October 1924, p 252. The latter is partly transcribed from the former, but gives 'dies' rather than 'pliers', presumably in error.
172 *Australasian Builder & Contractor's News,* 27 August 1887, p 250.
173 Baackes, 'The American Wire Nail Industry', p 105.
174 Swank, *Manufacture of Iron,* p 451: according to Swank nearly all the nails were now of steel, but this must be an exaggeration.
175 Visser, 'Nails'.
176 *New York Times,* 1 December 1892.
177 *Scientific American,* 24 March 1900, p 188.

practice was to clean the wire by dipping it into weak sulphuric acid, wash it in water and leave it long enough to corrode slightly, so as to make it easier to grip, then bathe it in lime to neutralize any remaining acid.[178]

According to Robert Varman wire nails were imported to Australia in 1853, though they were not cheap or plentiful until about 1870,[179] and this is borne out by the present research. Fine wire nails which probably date from the 1850s or 1860s have been found in the Sidney Seymour cottage at Romsey, Victoria - a strange building, the walls of which are entirely made of Singapore manufactured doors.[180] The first known Australian importer of wire nails was Frederic Lasseter of Sydney, who in 1863 had taken over the ironmongery business of Iredale & Co from his two partners. By the beginning of 1865 Lassetter was advertising 'best wrought wire nails' from 1¼ to 6 inches [32 - 150 mm] in considerable quantities.[181] These nails were clearly not from the United States but Europe, and at this stage not necessarily Britain. In this very year the Railway Manager's house was built at Rockhampton, using wire nails as well as Ewbanks,[182] and two years later 'Glengallan' homestead near Warwick also used both types.[183] Wire nails thought to be of about this date have also been found in a former billiard room at Chiltern, Victoria.[184] Generally, however, Varman's assessment is born out, and wire nails are not normally found before the 1870s.

In 1877 Lassetters were advertising 'Cornforth's best Wire Nails' from one to six inches [25 - 150 mm].[185] As no other brand has been heard of since Cornforth first showed his wire nails in 1851 it seems likely that he was the leading or sole British maker and the leading or sole exporter of wire nails to Australia during the intervening quarter century. If so, this was now about to change. A British patent for a way of forming two wire nails simultaneously was taken out by B P Walker in 1878[186] - which may be associated with Cornforth's opeation, or it may reflect the appearance of another British maker at about this time, for in 1879 the Imperial Wire Company (Nettlefolds) of Birmingham displayed wire nails at the Sydney Exhibition.[187]

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178 *Scientific American,* 12 December 1903, p 438; October 1924, p 252.

179 R V J Varman, 'The Nail as a Criterion for the Dating of Buildings and Building Sites', in Judy Birmingham & Damaris Bairstow, *Papers in Australian Historical Archaeology* (Sydney 1987) [first published in volume 10 no 1, March 1980]), p 107.

180 Miles Lewis, 'Sidney Seymour Cottage' (typescript report, Melbourne 1994): the cottage dates from 1855 and the nails are found in an extension of the shingle roof which, on the balance of probabilities, is very early.

181 *Bulletin* [Rockhampton], 12 January 1865, advertisement by Frederick [*sic*] Lasseter, late Iredale & Co, 421 George St, Sydney: courtesy of Margaret Strelow.

182 Margaret Strelow, 'A seemingly insignificant scrap of notepaper ...' (unpublished ms, Rockhampton [Queensland] 2002), passim.

183 Information from Margaret Strelow, 2003.

184 The building is believed to be of the 1860s and the nails seem to be contemporary, but as they have so been identified only in skirtings and architraves it is possible that they were later. Information from Deborah Kemp 2005.

185 Charles Mayes, *The Australian Builders' Price-Book* (3rd ed, Melbourne 1877), p 157.

186 Great Britain, patent no 1,141 , 22 March 1878, to B P Walker.

187 Sydney International Exhibition 1879, *Official Catalogue of the British Section* (London 1879), p 185.

In 1875 two Melbourne engineers, G S Evans and H O Christopherson, obtained a Victorian patent for improvements in wire nail-making machinery. As we do not know of wire nails being made locally at this stage, this was probably the extension of an overseas patent, though whether Evans and Christopherson were acting simply as agents for the overseas patentee, or had themselves secured the Victorian rights with as view to manufacturing the nails, is not apparent. Under this patent the wire was first straightened by passing it through a perforated plate and under a grooved roller, a number of lengths being handled simultaneously. As the roller moved back the heading die moved into place.[188]

By 1883 Mayes's *Australian Builders' Price-Book* listed wire nails in sizes from 3/4 inch to six inches [18.5 - 150 mm],[189] and in 1886 he noted that 'Patent Oval Samson Wire' cost much more than common wire, but was said to be so superior in strength that it was more economical to use.[190] The 'Patent Oval Samson Wire' must be a version of the 'oval wire nail with brad head',[191] or 'oval steel brad', an English type which is round (not oval) in section and has the characteristic circumferential grooving resulting from the grip of the vice. The head is round but rather deep, like a little drum. The 'French nail' is similar in appearance but that it has a rather large flat head, more like that of a clout, which is left to lie on the surface of the timber rather than being punched in, and which suggests it is the original *pointe de Paris*, the head of which is of this type. It was thought to be rather unsightly, though the nail itself was strong and tenacious.[192] It, or someth\ing like it, was described as a'wire slating nail' in a contemporary catalogue. Another wire nail had a smaller flat head, grooved in a diaper pattern, and was designed to be countersunk.[193]

In 1885 the Anchor Nail Works in Palmer St, Richmond, Victoria, were established by Frank Gold. As the factory made other products, such as brads and roofing nails, we cannot be certain that wire nails were made from the outset, but it seems highly probable, and by 1901 there were thirteen wire nail machines, all practically identical but producing nails of different sizes, thirty-five in all. The wire was wound onto reels, or 'swifts', from which it was fed into the machine, which produced 200-300 nails per minute.[194] Although he made other types of nail from steel, it is possible the Gold was using iron wire for the nails, as in 1887 Bennie Teare & Co claimed to be the sole local patentees and manufacturers of the steel nails.[195]

188 Victorian patent no 2049 to George Sexton Evans & Henri Oscar Christopherson.

189 Charles Mayes, *The Australian Builders' Price-Book* (4th ed, Melbourne 1883), p 128.

190 Mayes, *Australian Builders' Price-Book* (1886), p 143.

191 George Farmiloe & Sons, *General Catalogue* (Farmiloe, London 1887), p 322D; T & W Farmiloe, *T. & W. Farmiloe's Miniature Catalogue* (London 1894), p 928. The word 'oval' probably refers to the practice in drawing steel wire of rolling it alternately into an oval and then a square section, which improved its properties: *Scientific American,* 12 December 1903, p 437; October 1924, p 252.

192 S Barter, *Woodwork* (London 1892), pp 85-6.

193 George Farmiloe & Sons, *General Catalogue,* p 322D; T & W Farmiloe, *Miniature Catalogue*, p 928.

194 'Australian Manufactories No. II - The "Anchor" Nail Factory', *Australian Storekeeper's Journal,* March 1901, p 81.

195 *Australasian Builder & Contractor's News,* 3 September 1887, p 260.

In 1880, the English company John Lysaght of Bristol had established a selling agency in Melbourne managed by Thomas Davey, under the name of the Victorian Galvanized Iron & Wire Co, until 1899 when it became Lysaght's Galvanized Iron Pty Ltd.[196] In 1884 Lysaghts began producing wire netting from imported wire feed at Five Dock on the Parramatta River, New South Wales,[197] the source of the material being Rylands Warrington (UK). A local company was incorporated as Lysaght Bros and Co. Limited from 1 January 1886, but they do not appear to have been making nails at this stage. At the Melbourne Centennial Exhibition of 1888-9 Cordes & Co showed wire nails, and do not seem to have bothered with their traditional Ewbank type, though it was still manufactured.[198] A number of other British manufacturers showed wire nails at the exhibition, including C W M Wilson of London, proprietors of the 'Hercules' brand.[199] In 1889 it was reported that wire nails had almost driven the other types out of the market in Australia. Briscoe, Drysdale & Co of Sydney had thousands of cases of nails in stock, in all thicknesses and in lengths from one to six inches [25 to 150 mm].[200] This suggests that the larger nails and spikes of the earlier types may still have had a role, and it is true that these larger sizes seem to be found in later structures, though it is rarely possible to date them precisely.

f. roofing nails & screws

The best slating nails were of copper, but other types were of zinc or of 'composition'. The Vieille Montagne Company, leading zinc producers, made zinc nails for slating.[201] Composition, otherwise known as bell metal or yellow metal, was a mixture of 60% copper and 40% zinc, and the nails were formed by casting this in a bed of sand, into which holes of the required size were pricked.[202] Composition nails were advertised in Melbourne in 1853[203] and were specified for a pair of terrace houses in 1854.[204]

A local specification of 1849 calls for what seem to be iron nails for slating, but requires them to be steeped in hot linseed oil.[205] Towards the end of the

196 John Lysaght (Aust.) Pty. Ltd., *Lysaght Venture* (Sydney 1955), p 2.

197 John Lysaght (Aust.) Pty. Ltd., *Fifty Years of Industry and Enterprise 1885-1935* (Melbourne 1935), p 126.

198 Centennial International Exhibition 1888-1889, *Official Record* (Melbourne 1890), pp 466, 737, 964.

199 Centennial International Exhibition 1888-1889, *Official Record* (Melbourne 1890), p 469.

200 *Australasian Builder & Contractor's News,* 13 July 1889, p 46.

201 Halina Eckersley reported in 1997 discovering nonferrous nails labelled 'VIE ...' in the remains of a slate roof of the east wing of the Old Melbourne Gaol, possibly original to the work of the 1860s.

202 Frank Bennett & Alfred Pinion, *Roof Slating and Tiling* (London 1960 [1948]), pp 51-2.

203 *Argus,* 20 July 1853, p 7.

204 Russell, Watts & Pritchard, 'Specification ... for Dwelling houses ... at Elwood ,... for Joseph Docker', 13 December 1854 (Docker Papers, Manuscript Collection, SLV), p 18.

205 Charles Laing, 'Specification of work to be preformed and materials to be provided in the erection and completion of a Villa intended to be built at Coryule Indented Head for Mesdames Drysdale and Newcomb' (Melbourne 1849), p 42.

century wire slating nails with broad flat heads were advertised in Britain,[206] but if they were of iron or steel, as appears, they can hardly have been as satisfactory as those of copper or zinc. In 1890 a specification for a roof of English-made Roman pattern tiles called for every third course to be nailed with two zinc nails,[207] but the Marseilles tile which was to become more popular was usually tied with wire. M W Wigzell of Exeter patented a 'screw nail' in 1859,[208] and in 1861 his 'spiral fluted nail',[209] which now began to be manufactured in England. This nail automatically revolved as it was driven in, and not even the largest sizes required pre-drilled holes.[210] These nails, however, did not find favour and were soon abandoned.[211]

The fixing of roofing iron was a specialised matter. At first large-headed galvanized nails were first used, but they proved a failure, and gave way to screws and washers, or occasionally bolts. A 59 mm [perhaps a nominal 2 1/4in] roofing screw from 'Watford Villa', Avoca, Victoria, is of the earlier non-pointed type (as discussed below) and appears to date from about 1854. It has what look like two washers, possibly iron below and lead above, and flat rather than coned or domed.[212] A British patent of 1869 had a bolt head with a curved underside to match the corrugation (meaning, of course that the bolt could not be turned), while on the underside there was a rubber disc and curved washer, fixed with a nut had a domed head (so that it could turn).[213] However Thomas Hardy's notebook, of about 1862-72, shows a simple bolt passing from the top of the corrugation through the batten, with a washer beneath. He notes that they should have two coats of red lead. 'This is better than galvanized bolts which "go" (the man said)'.[214] Such bolts have not been reported in Australia. Screws or bolts required holes to be drilled, and time taken to turn the screws in - though this was sometimes avoided by hammering them in, with predictably poor results.[215] In other respects screws were very satisfactory, for they were strong and durable, and they made it easy to recycle the iron.

Andrew Learmonth wrote in 1859 to his brother Tom (about work in progress at their property 'Ercildoune', Victoria):[216]

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206 Farmiloe, *Miniature Catalogue*, p 928.

207 Hyndman & Bates, 'Specification, &c, Villa Residence Tank +c / Camberwell / Arthur J Fuller Esq / Normanby Chambers Chancery Lane' (Melbourne 1890), p 20A.

208 Great Britain, patent no 14 to M W Wigzell, 1 January 1859.

209 Great Britain, patent no 1,369 to M Wigzell, 1 June 1861; also nos 1,998 and 1,999, both of 10 August 1861.

210 *Builder,* XIX, 604 (31 August 1861), p 604, citing the *Devonport Independent.*

211 Charles Hibbs, 'Great Manufactures of Little Things - XI. Screws (*continued*)', *Technical Educator,* IV (no date [c 1870]), p 219.

212 Sampled February 2007. It would have been used with 134 mm or 5 1/4 in pitch corrugated iron, some of which remains on site.

213 Great Britain, patent no 1,520 to G Allan, 1 May 1869.

214 Hardy, Notebook, p 53.

215 *Australasian Builder & Contractor's News,* 8 October 1887, p 358.

216 Andrew Learmonth to Tom Learmonth, 8 April 1859, Manuscripts Collection, State Library of Victoria, quoted by Hanut Singh-Dodd, Australian Architecture B, Melbourne University 1995.

> Roof with iron screwed into purlins, like the new part of the house and frame principally like it. Should we want to put another story on it can then be taken off in a few hours and plugged with a white-leaded pigment of oakum round the neck of the screw.

At 'Mount Rothwell' in 1872 '1 3/4 gal screws and washers of lead' were specified for fixing the corrugated iron,[217] while a South Australian specification of 1878 called simply for 'a 2 1/4 screw in every other flute',[218] subsequently revised to 'galvanised iron screws and washers spaced 12 and 18 inches apart respectively'.[219] In 1879 Brooker, Dore & Co of London showed 'Galvanized Cone Head Screws for Roofing' at the Sydney International Exhibition.[220] In 1890 the corrugated iron roofing of a city building was specified to be 'all well screwed down and rivitted',[221] which is somewhat ambiguous, and may in any case represent the unthinking repetition of an old-fashioned specification clause, for screws were by now largely out of favour.

Roofing nails, as opposed to screws, regained some favour when they too were equipped with flexible heads to adjust to the shape of the corrugated iron, typically a cup head which would adjust as it was driven against the surface, with a washer to seal it. The cup form had already been developed for nails used in upholstery and related trades.[222] What may be the first roofing nail of the cup head type was designed for tiles rather than iron, and patented in 1873, providing for a cup head and leather washer.[223] In 1878 nails for iron and other roofing were patented, in which the iron head had a turned-down edge, which embedded it into a lead washer underneath.[224] But these were probably not the same as the 'corrugated iron nails' which they shown at the Melbourne Exhibition of 1880 by J J Cordes & Co of Monmouthshire, better known as makers of the Ewbank nail.[225]

In 1883-4 three different patents for roofing nails are said to have ben issued in New Zealand, tthough the available information is confusing.[226] A form of

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217 Research by Jeananne Wells, 2001, quoting the Chirnside papers, State Library of Victoria.

218 G & W Sarat Dunstan, 'Specification for the Several Works required in the Erection of Banking Premises for the Bank of Australasia, Kooringa' (Aberdeen [South Australia] 1878), p [6].

219 Reed & Barnes, 'Specification of Work to be done and Materials to be used in the Erection of Banking Premises at "Kooringa S.A." for the Bank of Australasia' (Melbourne 1878), p 42.

220 Sydney International Exhibition 1879, *Official Catalogue of the British Section* (London 1879), p 181.

221 Wright, Reed & Beaver, 'Specification for Erection of Premises for the National Mutual Life Association of Australasia. Corner of Collins & Queen Streets Melbourne' (Melbourne 1890), p 27.

222 Great Britain, provisional patent no 2,629 to W H Richards, 7 September 1867.

223 Great Britain, patent no 1,137 to J L Nancarrow, 27 March 1873.

224 Great Britain, patent no 678 to W A Barlow [J Hilgers], 19 February 1878.

225 Melbourne International Exhibition, 1880, *Official Catalogue of the Exhibits* (Melbourne 1880), II, p 387. Neither Hilgers nor Barlow are known to have been Cordes connections.

226 Isaacs, 'Nails', pp 15-16, makes a number of assertions which are not substantiated, and seems not to take account of the fact that the a patentee is commonly not the inventor, but has the rights from the original inventor or from an intermediary. Thus, by

nail with a cup-shaped head, for use with corrugated iron, had been developed by the Christchurch ironfounder William Stokes, and was used in New Zealand from 1883.[227] The hollow head, of lead or other soft metal, adjusted as the nail was driven in, so as to closely fit the roofing iron. The Christchurch plumber Joseph Venable patented a lead-headed nail in 1883, but seemingly didn't make them until about 100. The Auckland plumber Samuel Parker patented a 'galvanised lead-headed nail' in 1883, and by 1886 was producing roofing nails and other products at his Southern Cross Iron Works.[228] This patent nail is doubtless the same as the same as the 'Acme' roofing nail manufactured at a slightly later date at Parker's Southern Cross Galvanised Iron Manufacturing Co of Auckland, and which was awarded a gold medal for its products at the Auckland Exhibition of 1898.[229] They may in turn be related to the galvanised conehead nails and galvanised conehead screws for corrugated iron roofing which were advertised in Britain in the 1890s, together with galvanised iron washers and lead washers. Nails of the Stokes type were used in New Zealand right up to the 1970s, and only then superseded by the 'Ter' screw and 'Ter' gun for fixing.[230] However in 1928, according to Isaacs, the Lino Roofing Nail Company of Dunedin complained to factory inspectors that local plumbers were unfairly making their own lead-headed nails.

A British patent was obtained for the Stokes nail in 1887,[231] and in the same year the rights were taken up by McLean Bros & Rigg of Melbourne.[232] They displayed the nails at the Centennial Exhibition in 1888,[233] and the nails appear to have been manufactured locally, probably at Gold's Anchor Nail Factory. In 1901 Gold was making galvanised iron solid-headed or mushroom-headed roofing nails, in which the even-shaped mushroom worked like a washer.[234] Bill Nairn of Adelaide has found specimens in place, but believes that - in contrast with the situation in New Zealand - they were generally used only in limited areas, such as for fixing the ridge, and that they did not remain in use for long. In part, he suggests, this may have been due to the acquisition of the Lysaght parent company in Britain by Guest, Keen & Nettlefold,[235] itself a manufacturer of fixings. However the evidence suggests that other makers were more active at this time in the field of roofing nails.

In 1886 James Clements, an engineer of Ipswich, obtained a Queensland patent for lead-headed wire roofing nails, but this was ignored by others,

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a remarkable coincidence he has both Samuel Parker and Joseph Venables patenting roofing nails in 1883, the same year as Stokes.

227 *Australasian Builder & Contractor's News,* 8 October 1887, p 358. Nigel Isaacs, 'Nails - a brief New Zealand History (with links to Britain and the USA)', *CHS Newsletter,* 78 (August 2007), p 15, dates the patent to 1884, and reports Stokes as appearing in local directories as a nail maker from 1887 to at least 1896.

228 Isaacs, 'Nails - a brief New Zealand History', p 15.

229 Geoff Chapple et al, *Corrugated Iron in New Zealand* (Wellington 1983), pp 27-8.

230 Information from Bill Nairn of Adelaide.

231 Great Britain, patent no 6,884 to F Chapman [communication of W J C Stokes], 10 May 1887.

232 *Australasian Builder & Contractor's News,* 8 October 1887, p 358.

233 Centennial Exhibition 1888-9, *Official Record,* p 736.

234 'The "Anchor" Nail Factory', p 81.

235 John Lysaght Limited, *The Lysaght Century 1857-1957* (Bristol 1957), p 29.

particularly one Boothman, which freely admitted to making them and proposed to continue. In 1887 Clements obtained an injunction to prevent Boothman from making them,[236] pending court action, the outcome of which is unknown. In 1888 a British patent was taken out by E S Baldwin, on a communication from H Davenport, for a lead-headed nail designed for corrugated iron roofing. A nail either of the 'ordinary' or an 'improved' form, and preferably with a square shank, would have lead cast around its head (that is, presumably, the head would be suspended downwards in a small mould filled with lead).[237] The difference from the Stokes nail is unclear except that the leaden head was pressed or moulded on rather than cast. Nails of the Stokes or Davenport type must soon have been made in Australia. At Ercildoune, Victoria, lead-topped nails branded 'COOP'S LATEST' have been found Coop's eadworks established in Melbourne in 1854 is referred to elsewhere, and pipes were made there from 21857, but nothing is known ofrofing nails. ,[238] though it is most unlikely that these nails are nearly so early as the discussion between the Learmonth brothers quoted above. Similar nails, apparently of twentieth century date, have been found at the Venus Crushing battery, Charters Towers, Queensland, branded 'SAXON SEAL [?TIGHT]'.[239]

Two nails patented in February 1892 combined aspects of the cup head and the lead head. One had the lead head itself cast into a cup shape, much as in the Stokes nail.[240] The other had a cup-shaped dome or washer, and was inverted into molten lead or tin, so the cup was partly filled with the softer metal.[241] Whether either came into commercial use is not known, for a much simpler type had been patented by R E Evenden the year before. It was a wire nail, onto which a slightly conical washer was threaded below the head and pressed together.[242] It was presumably this type that was described in Australia ten years later as Evenden's Patent Spring-Head Roofing and Fencing Nail for galvanized iron,[243] though neither the source nor the local agency is known. Jeffries's *Australian Building Estimator* of 1907 lists both spring head nails and lead head nails,[244] and shottly afterwards Harris, Scarfe, of Adelaide three types of Evenden spring head roofing nails, the plain shank, the twisted shank, and the screw, nail, which are self-explanatory. They also stocked an Evenden springhead roofing screw.[245] By the 1950s the Quemslsnmd Metal Co was making QMC lead head nails.[246]

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236 *Australasian Ironmonger,* 1 June 1887, p 143.

237 Great Britain, patent no 2,748 to E S Baldwin (communication of H Davenport), 24 February 1888.

238 James Coop was the first to manufacture lead pipes in Melbourne, in 1857: Intercolonial Exhibition 1866-67, *Official Record,* pp 327-8

239 One has kindly been sent to me by Jinx Miles, who believes that the building was last re-roofed in the 1950s.

240 Great Britain, patent no 2,364 to G Thompson, 9 February 1892.

241 Great Britain, patent no 3,424 to J J Macky & J Mitchell, 22 February 1892.

242 Great Britain, patent no 16,133 to R E Evenden, 23 September 1891.

243 *Building, Engineering and Mining Journal,* 27 July 1901, supplement, no page.

244 Walter Jeffries, *The Australian Building Estimator* (Sydney 1907), P 153.

245 Harris, Scarfe, *Engineers' Supplies,* p E12.

246 E J A Weller [ed], *Official Queensland Architecture & Building Year Book* (6th ed, Brisbane 1953), p 46.

Though bolts were much more expensive than nails, their use was less problematic because they could be placed accurately, and the head or the washer could be pre-formed to fit the shape of the corrugation, as in British patents of 1869 and 1889.[247] Bolts were indispensable in iron-framed structures, which would not take nails or screws, and hook bolts for fixing corrugated sheeting to iron or steel purlins are discussed below in the context of cyclone design, though they were by no means restricted to that purpose. Asbestos cement was a more delicate material and required specialised fixings. A British patent of 1928 covered clamps, each of which could secure the sheet to bolt, and hence to the frame below, but did not require any hole through the sheet itself. The clamps had teeth, spaced apart, which bit into the underside of the sheet. One model fitted below the convex and one below the concave section of the corrugation.[248]

g. local nail manufacture

By 1887, when McLean Brothers & Rigg may have begun making the Stokes nail in Melbourne, the hand forging of nails must have been almost a lost art, and there appear to have been no established nail factories. However in 1888 John Rose reached Melbourne from Dunedin, New Zealand, and in 1889 entered partnership with Alexander McNeil to establish the Titan Engineering Works. A factory was opened in Amess Street, North Carlton, for the manufacture of barbed wire from imported stock, and the barbed wire machinery was itself made on the premises to designs based on American models. Soon after the company moved to Spencer Street and then to South Melbourne, meanwhile expanding its operations to include wire nails and later a range of sheet metal goods.[249]

Soon Sydney Cooke was manufacturing a springhead roofing nail,[250] and Frank Gold of the 'Anchor' nail factory patented a solid head roofing nail made by using 'immense' pressure to squeeze the head into an evenly shaped mushroom which acted like a washer. In 1901 he had six machines to make these, each of which weighed nearly 2.5 tonnes. Gold also invented the 'combination' roofing screw, which could be either driven or screwed in and could be subsequently screwed out again, which minimised the damage to the roof sheeting. Patents were taken out all over the world.[251] James MacDougall's Austral Nail Co was established at South Melbourne in 1889, and confined itself to nail manufacture until 1905, when it began making barbed wire. Austral Nail was the first to begin wire drawing from imported rods in 1911, and in 1919 transferred to Newcastle to a new wire mill near to its new source of raw material, BHP's rod mill, which had been bought from

247 Great Britain, patent no 1,520 to G Allen, 18 May 1869; no 16,443 to H Smith, 18 October 1889.

248 Great Britain, patent no 326,177 to G R Speaker, 5 December 1928.

249 James Smith [ed], *Cyclopedia of Victoria* (3 vols, Melbourne 1903-5), I, p 569; *Fifty Years,* op cit, p 148.

250 Able Cooke Company records / corporate brochure 1992, quoted by Ivan Pavlekovic-Smith, History of Building, Melbourne University, 1992.

251 'Australian Manufactories No. II - The "Anchor" Nail Factory', *Australian Storekeeper's Journal,* March 1901, pp 81-2.

the Morgan Construction Company of Worcestershire and begun production in 1918.[252]

In 1921 Rylands Brothers of Warrington, England, set out to establish an Australian works for netting and wire products, but a merger with the Austral Nail Company was arranged in 1923 under the style of Rylands Brothers (Australia) Limited.[253] By 1925 there had been some trading and financial difficulties and BHP acquired a controlling interest in Rylands by a share exchange. It is now the Newcastle Wire mill. In 1927 the Titan company's nail and barbed wire manufacture was taken over by BHP, renamed the Titan Nail Wire Pty Ltd, and its production integrated with Rylands Bros (Aust) Ltd.[254] BHP also took a majority interest in Lysaght Bros in 1929, and the plant at Chiswick is now the Sydney Wire mill. A new factory was built in South Melbourne in 1935.[255] By the 1930s there were a number of special nails in production in Australia, designed to give enhanced holding power by means of twisted shanks, barbs, rusting with ammonium chloride, sand rumbling, or cement coating. These, however, seem to have been intended less for conventional carpentry than for packing cases, where the strains of movement tended to pull them.[256] In the 1950s Mills Scaffolds were selling an odd nail with a double head, called the 'Duplex'. The lower head would rest on the timber surface and complete a tight joint, but the shaft continued up to a second head which stood proud of the surface and could conveniently be used in extracting the nail. It was designed for temporary nailing in applications such as formwork.[257]

By 1934 BHP fully controlled the wire industry of Australia, and in 1958 Australian Wire Industries Pty Ltd was formed as a holding company, incorporating Rylands Bros (Aust) Pty Ltd, Lysaght Bros and Co Pty Ltd, Australian Wire Rope Works Pty Ltd and Bullivants Australian Co Pty Ltd. AWI was then one of the largest wire companies in the world in terms of volume and product range.[258] Since that time, AWI has produced all Australia's reinforcing wire requirements. Of recent years it has expanded into wire and strand for prestressing, and steel fibres for concrete.

h. screws

252 Helen Hughes, *The Australian Iron and Steel Industry 1848-1962* (Melbourne 1964), pp 82-4 , ref J K MacDougall, 'Some Reminiscences of the Wire Industry in Australia', *B.H.P. Review*, XIV, 2, p 2.

253 *Fifty Years*, op cit, p 120; *Seventy-Five Years of B.H.P. Development in Industry* (Melbourne [c 1960]), p 81; Hughes, op cit, p 84.

254 Hughes, op cit, pp 101-2, ref 'The Titan Nail and Wire Proprietary Limited', *B.H.P. Review*, XV, 5, pp 10-11. For the Titan Nail Co products see *Handbook for ... the Broken Hill Proprietary Company Limited* [BHP *Shapes and Sections*] (Melbourne 1930), pp 499 ff.

255 *Age,* 8 October 1935.

256 Ian Langlands, *The Holding Power of Special Nails* [CSIR Division of Forest Products technical paper no 11] (Melbourne 1933).

257 *Building, Engineering, Lighting,* 25 February 1957, p 88.

258 *Seventy-Five Years*, op cit, p 81.

In 1827 Alexander Berry of 'Coolangatta', Shoalhaven, obtained 'a die for large screws, and a machine for wooden screws', and it seems that he did not have screew-cutting lathe (for which this would have been rather an early date), though he did have iron and wood turning lathes.[259] This is a reflection of the long pre-industrial tradition of screw making. Screws were at first handmade and very expensive, and in the sevententh century, when they were coming into use for furniture, they acquired a quasi-mystical significance as exemplifying the moral virtue of 'jointness'. The church historian Thomas Fuller pointed the contrast with the nail, which if it did not break or bend in the driving, would 'rive and split that which should be fastened therewith'. Whereas 'That may insensibly be screwed which may not be knocked into people'.[260]

The traditional British process of manufacture was laborious. Wire was cut into the required lengths, a head was formed in a shank by a blacksmith, a 'nick' was cut across the top with a fine-toothed handsaw, and finally the thread or worm was filed out by hand. The quality was poor but the product expensive.[261] The first machinery more or less replicated this process. Between 1751 and 1760 John, Job and William Wyatt, of Birmingham, effected various improvements, including the first successful automated manufacturing process. John Wyatt is credited with the first parallel shank / parallel head wood screw, the parallel thread being the key to holding ability.[262] He and a partner, Thomas Blockley, sought a patent for wood screw making machinery in 1751, though it is not clear whether it was granted. In 1860 his brothers Job and William Wyatt obtained a patent for 'a certain method of cutting screws of iron commonly called wood screws'.[263] Job was the owner of a water-powered corn mill at Tatenhill and it was because he planned to turn it into a screw facotory that he directed his attention to the processes involved. In the event he died before he could effect the conversion, but the property ultimately passed to his nephew William, who did so in 1776.[264]

At the beginning of the nineteenth century there were improvements in the manufacture of screw head blanks,[265] and then the process of manufacture

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259 Rachel Roxburgh & Douglass Baglin, *Colonial Farm Buildings of New South Wales* (Adelaide 1978), p 38.

260 Adam Nicholson, *Power and Glory: Jacobean England and the Making of the King James Bible* (London 2003), pp 68-9.

261 Joseph Chamberlain, 'Manufacture of Iron Wood Screws', in Samuel Timmins [ed] *The Resources, Products and Industrial History of the Birmingham and Midland Hardware District* (London 1866, pp 605-6.

262 Warren Hewertson, 'Another Turn of the Wood Screw', *TATHS Newsletter* [90 (Autumn 2005), pp 2-3

263 G G Jenkinson, Metal *Wood Screws: the Evolution and History* (Panorama [South Australia] 1999), pp 40-41. The Wyatt family is a complex one in which the same forenames are often repeated, but it seems clear that the three in question were brothers, being sons of John Wyatt and Jane Jackson, viz John, inventor (1700-1766); William, land agent (1701-1772), and Job, inventor (1719-): J M Robinson, *The Wyatts: an Architectural Dynasty* (Oxford 1979), genealogical table.

264 Robinson, *The Wyatts,* p 17, ref H W Dickinson, 'Origin and Manufacture of Wood Screws', *Newcomen Society,* xxii (1946), pp 80-1..

265 Hewertson, 'The Wood Screw', pp 2-3

was somewhat streamlined by the introduction of the continuous-action mandrel lathe, described by Mercer as

> axled on a guide screw, and which therefore, advancing as it revolves and clasping at one end the screw shank, threads the latter by twisting it through a knife-edged hole, or, more exactly, between two steel-cutting points compressible by a lever.[266]

Exactly how this was introduced is unclear. The details of a screw-cutting machine patented in the United States by J Andrews in 1817 are lost, but it has been argued that it was this machine, patented in England through the agent J Colbert, which was bought by the Nettlefolds and used at their new factory at Sunbury-on-Thames from about 1819.[267]

The process as described in 1851 was still essentially that of the Wyatts::

> Operation 1. From a coil of wire placed on a wheel and introduced into the screw-making machine, a piece, sufficient to form a screw is cut off, caught up, and headed; that is to say, the portion which forms the head is compressed into shape, and the now-called 'blank; is dropt into the receptacle below. Operation 2, consists in flattening the head and smoothing the countersink, which is performed by the 'blank,' being held in both clams, and having a small cutter revolving in front and another behind. 3. Slitting the head; the 'blank' is placed in a pair of nippers, which is moveable on centres by means of a lever action, the head is pressed against a small revolving circular saw, and the slit made. 4. Threading is effected by the 'blank' being introduced into a pair of clams which is attached to a spindle, the back part of which is cut by a worm or thread corresponding to that of the screw to be cut, and which propels forward the clams and the 'blank' against small-toothed cutters, which groove out the thread; three runnings down is sufficient to complete the manufacture of an ordinary sized screw. The difference in the finest threads arises from the shape of the cutters.[268]

After 1840 screw-cutting lathes came into wide use.[269] However no uniformity or system had been established in the trade, in relation to size or shape, and this was remedied only in stages. Holtzapffel published a table of the screws used in their workshops,[270] and then in 1841 Joseph Whitworth [later Sir Joseph] tabulated a uniform system of screw threads for steam engines and machinery, which he submitted to the Institution of Civil Engineers. The thread was an isosceles triangle with an angle at the peak of 55º, though this was slightly rounded off, as was the angle of the groove.[271]

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266 H C Mercer, *Ancient Carpenters' Tools* (Mineola [New York] 2000 [1929]) p 256.

267 Hewertson, 'The Wood Screw', p 3, citing G G Jenkinson, *Metal Wood Screws* (author, Adelaide 1999).

268 Great Exhibition, 1851, *Catalogue,* II, p 629.

269 For example, the Small Slide and Screw-Cutting Lathe of Charles Watson, Leeds: *Imperial Journal of Art, Science, Mechanics and Engineering* (Manchester), I, no date, pp 627-8 & plate.

270 *Screws and Screw-Making* (Colchester [Essex] 1891), pp 9, 182.

271 *Screws and Screw-Making,* pp 9-11, 18-26.

In the United States, however, a different system was developed following a report in 1864 by a committee of the Franklin Institute, and it became known (for somewhat complex reasons) as the United States Standard, Sellers' and Master Car Builders' Thread - in section an equilateral triangle with one eighth of the height chopped off the top, and the base of the groove filled by the same amount.[272]

At the mid-century the process of manufacture was described as:

> Operation 1. From a coil of wire placed on a wheel and introduced into the screw-making machine, a piece, sufficient to form a screw is cut off, caught up, and headed; that is to say, the portion which forms the head is compressed into shape, and the now-called 'blank' is dropt into a receptacle below. Operation 2, consists in flattening the head and smoothing the countersink, which is perfomed by the 'blank' being held in both clams, and having a small cutter revolving in front and another behind. 3. Slitting the head; the 'blank' is placed in a pair of nippers, which is moveable on centres by means of a lever action, the head is pressed against a small revolving circular saw, and the slit is made. 4. Threading is effected by the 'blank; being introduced into a pair of clams which is attached to a spindle, the back part of which is cut with a worm or thread corresponding to that of the screw to be cut, and which propels forward the clams and the 'blank' against small-toothed cutters, which groove out the thread; three runnings down is sufficient to complete the manufacture of an ordinary sized screw. The differences in the finest threads arises from the shape of the cutters.[273]

The slit inthe head was cut with a small circular saw.[274]

The drawback of the new machinery was that it could not form a point, and though the shank might taper, it necessarily terminated in a blunt end.[275] Screws of this form are found in Australia, and were doubtless made on such machines probably in Britain. Hand-formed pointed screws likely to have preceded the machine have not been reported, and a pointed screw should normally be assumed to be later in date. Sloane illustrates three phases in the United States: until 1840 screws had no taper at all, the end was completely blunt, and the head might be formed by flaring out from the shank. After 1840 the end remained flat but there was a slight taper in the shank, and the heads were of modern form, either countersunk or domed and jutting out sharply from the flank. After 1846 screws become more tapered and fully pointed.[276]

Early forms of pointed screw were difficult to make and relatively ineffective in operation, but J T Sloan of New York patented a form in which the the thread

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272 *Screws and Screw-Making,* pp 10-11, 27-40, 178.

273 Note bvy W C Aitken, in London, Great Exhibition, 1851, *Catalogue,* II, p 629.

274 Robert Hunt [ed], *Hunt's Hand-Book to the Official Catalogue of the Great Exhibition: an Explanatory Guide to the Natural Products and Manufactures of the Great Exhibition of the Industry of all Nations, 1851,* (Cambridge UP 2011 [1851]), I, p 94..

275 Mercer, *Ancient Carpenters' Tools*, p 256; Rempel, *Building with Wood,* p 103, also illustrates examples.

276 Eric Sloane, *A Reverence for Wood* (New York 1973 [1965]), p 25.

continued to the point at the same pitch, and in 1846 developed a process to manufacture it. The invention was licensed to companies in the United States,[277] and in 1856 it was reported in Britain that the very superior wood srews used throughout the United States were made by automatic machinery quite different from that used in England, and for most purposes did not require pre-drilled holes 'as they force their own way, by reason of their gimlet or taper-screwed point'.[278] It appears that Sloan or his successors demanded £30,000 for the British rights, and Nettlefolds were were obliged to raise the capital by taking Joseph Chamberlain into their business, as Nettlefold & Chamberlain. They thus acquired the rights in 1854, and henceforward made not only the screws but the manufacturing equipment.[279]

At the Great Exhibition Whitworth & Co of Manchester showed, amongst other things, a self-acting bolt-head and nut-shaping machine, and a patent screwing machine for nuts and bolts,[280] and Andrew Shanks of London showed a bolt screwing and tapping machine.[281] The Patent Pointed Screw Company of Wolverhampton, however, showed screws of malleable iron, formed by casting in sand. It was claimed that these could be driven into wood without first boring a hole, which may have been a function of the more pointed form, as well as the fact the thread was sharper (though they were otherwise considered slightly inferior to the wire-formed screw).[282]

According to Hibbs steam screw cutting machinery was invented by a German called Colbert, and introduced in about 1849,[283] though this does not seem to be reflected in the exhibits of 1851. In any case it was very soon surpassed by American machinery, which it is impossible to explain here,[284] but which must be the same as the American patent self-acting machinery said to have been introduced to the United Kingdom in 1854.[285] W R Lake, one of the most prolific patentees of screw-making machinery in Britain, had at least two of the inventions communicated to him by the American Screw Co,[286] but it is not clear which company he himself belonged to. The American machinery required considerable capital and marked the end of the small manufacturer:[287] Indeed in about 1866 the general wood screw trade of Birmingham was said to have been absorbed into the business of Nettlefold & Chamberlain.[288] Nettlefold is said to have introduced 'a beautiful screw' in

277 Hewertson, 'The Wood Screw', pp 3-4. Mercer, 'Dating of Old Houses', p 24, cites Sloan's patent as no 4704 of 20 August 1846.
278 *Builder,* XIV, 700 (5 July 1856), p 374.
279 Hewertson, 'The Wood Screw', pp 3-4.
280 Great Exhibition, 1851, *Catalogue,* I, p 296.
281 Great Exhibition, 1851, *Catalogue,* I, p 292.
282 Great Exhibition, 1851, *Catalogue,* II, p 664.
283 Charles Hibbs, 'Great Manufactures of Little Things - X. Screws', *Technical Educator* (no date [c 1870]), IV, p 117.
284 Hibbs, 'Screws', p 118.
285 Chamberlain, 'Manufacture of Screws', p 607.
286 Great Britain, patent no 3,998 to W R Lake [American Screw Co.], 16 October 1876, for 'machinery fof shaving and nicking screws'; no 4,891 to W R Lake [American Screw Co.], 18 December 1876, for 'an arrangement for dislodging the screws from [the machine]'.
287 Chamberlain, 'Manufacture of Screws', p 607.
288 Chamberlain, 'Manufacture of Screws', p 609.

which 'The shaft was tapering and pointed at the end; the thread was deep and bold, the under side having as great an inclination as could be given to it, while the upper side was almost flat.'[289] In about 1880, Nettlefolds, with J H Nettlefold as manager, took over the Birmingham Screw Company (Limited), as well as John Cornforth, the Manchester Steel Screw Company, and Lloyd & Harrison. Now something of a monopoly had indeed been established[290] F Lowe & Co of Melbourne were importers of Nettlefold's screws and bolts in the 1880s.[291] By 1888 Nettlefolds had works at London, Birmingham, Smethwick, Kings Norton and elsewhere, and at the Centennial Exhibition, Melbourne, they were able to show screws, nuts, bolts, fencing wire and wire nails.[292]

As with screws, the manufacture of nuts and bolts in Britain was revolutionised by the introduction of American machinery, in this case by one Watkins, of Watkins & Keen. The company moved its operations from Smethwick to London, and then in 1864 were bought out by the Patent Nut & Bolt Company. In 1865 this company amalgamated with Weston & Grice of the Stour Valley Works. This now extensive organisation produced bolts, nuts, rivets, coach screws, washers and other products for use in engineering, railway construction, bridge building, ship building and coach building.[293] The Patent Nut and Bolt Company had a number of factories in Britain, exhibited at Sydney in 1879, and had an extensive Australian connection, but this appears to have consisted principally in supply of railway fastenings (to all colonies other than Western Australia) rather than bolts for the building industry.[294]

Screws must have been cut locally when required, and indeed a patent screw-cutting lathe was demonstrated in action at the Melbourne International Exhibition of 1880.[295] But, both screws and bolts were normally imported into Australia until well into the twentieth century, and overwhelmingly from Britain. Although it does not appear that any screws were systematically manufactured in Australia, bolts and nuts of their own manufacture were advertised by the Victoria Iron Rolling Company of Melbourne in the 1880s.[296] In 1919 the majority interest in the English company of John Lysaght Ltd, associated with the Lysaght family, was sold to the Berry Group, and then in January 1920 the controlling interest was transferred to what had by now become Guest, Keen and Nettlefolds Ltd.[297] By 1924 Nettlefold's screws and other products were marketed in Australia through or in association with Lysaghts.[298]

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289 Hibbs, 'Screws', p 117.

290 *Australian Engineering and Building News,* 1 June 1880, p 271.

291 *Australasian Ironmonger,* I, 7 (1 October 1886), advertisement p vii.

292 Centennial Exhibition 1888-9, *Official Record,* pp 468, 964.

293 Chamberlain, 'Manufacture of Screws', p 609.

294 Sydney Exhibition 1879, *Catalogue of British Section,* p 188.

295 Melbourne Exhibition 1880, *Catalogue,* p 50.

296 *Australasian Ironmonger,* I, 7 (1 October 1886), advertisement p viii.

297 John Lysaght Limited, *The Lysaght Century* (Bristol 1957), p 29.

298 John Lysaght (Aust.) Ltd., *The Referee* (14th ed, Sydney 1924), p 43. According to this John Lysaght (Australia) Ltd represented Guest, Keen & Nettlefolds in relation to plates,

i. anchorage

The usefulness of screws for fixing elements to the carcase of a building was greatly enhanced by the development of expanding plugs. Tradition had been to cut a hole, or gouge out part of a mortar joint, and drive in a wooden plug, but in principle this could be pulled out again when a load was applied to it. A wooden fixing brick was a better solution, but only when the fixing was planned in advance, and this was still more necessary for the use of the Ackrill's patent fixing bricks which have been discussed above.

There were numerous approaches towards prepared anchorages. One of the earlier British patents, that of R J Badge in 1857, was specifically designed for the trenails which fixed railway chairs to sleepers, but the principle was generally applicable, and was in fact the same as the stonemason's plug and feathers. A slightly waisted cylinder, divided into two or more parts, was first driven into the hole, then a pin was driven between them so as to force them outwards and lock them against the sides of the hole.[299] In 1902 a British patent was granted for a fixing system in which a socket or sleeve with a nut at the bottom was inserted into a pre-drilled hole. It was so shaped that when a bolt was screwed in it was forced to expand and lock firmly into the masonry.[300] Later in the year a simpler design developed by W H Griffiths relied upon the forcing apart of the socket, but not upon the incorporation of a nut or the use of any complicated geometry.[301]

Another type, of 1907, used a socket of which the inner part only was of soft metal, so the expansion would not damage the material of the wall.[302] The same inventor, H B Newhall, in 1909 developed a further type in which the pieces forming the socket had circumferential ridges around the outer face, to create a ratchet-like profile to lock against the masonry.[303] The 'E & F Patent' expanding bolt was recommended for a range of uses, including fixing machinery to foundations,[304] but the precise way in which it worked is not apparent. However the 'Clincher' plug was a cylinder of wood, which at the end had a recess in the form of the frustrum of as cone: this fitted over a solid conical frustrum (perhaps of metal) of slightly larger diameter. As the plug was driven in and forced onto the cone its inner end neccessarily spread outwards and thus locked it into place.[305] There many other inventions, of which few were probably brought into commercial use, especially given that a less elaborate model now supervened

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bars, pig iron, &c, but J K Merrott, of Melbourne and Sydney, in respect of screws, nuts, bolts and accessories.

299 Great Britain, patent no @,656 to R J Badge, 17 October 1857.

300 Great Britain, patent no 5,344 to D W Bennett, 4 March 1902.

301 Great Britain, patent no 14,677 to W H Griffiths, 1 July 1902.

302 Great Britain, patent no 26,512 to H B Newhall, 30 November 1907.

303 Great Britain, patent no 8,571 to J W Mackenzie (communication of H B Newhall), 8 April 1909.

304 Pryke & Palmer, *Illustrated Catalogue* (London no date [c 1900]), p 304.

305 Pryke & Palmer, *Illustrated Catalogue,* p 306.

In 1911 J J Rawlings patented a screw socket which was distinguished by its extreme simplicity, containing no metal parts and no complicated shapes. Strips or rods of material such as jute, hemp, asbestos, cardboard, or leather were to be arranged in a cylinder and loosely held together with an adhesive or a fabric sleeve. The cylinder was put into a pre-drilled hole, and when a screw was turned in it would cut its own thread and press the rods of material outwards, breaking the adhesive bond or the sleeve in the process.[306] The material actually used at this stage, according to the company history, was hemp.[307]

Further patents from 1924 onwards were taken out by Rawlings jointly with the Rawlplug Co Ltd. One improvement of 1925 provided for a lubricant such as graphite, within the fibre plug.[308] A further improvement of 1927, which seems to have originated with the American arm of the company, the Rawlplug Co, Inc, was to improve the durability of the fibre. Coagulated blood albumen was used as the adhesive, and materials such as resin and sulphur were added 'to render the plug resistant to moisture, to act as a preservative or antiseptic, and to exert a gripping action between the plug and the wall of the hole'.[309] In 1928 patents was taken out for indenting the outer surface of the cylinder to improve its grip,[310] and for providing a rudimentary thread at the top of the plug, to more readily receive coach screws &c.[311] What was probably a later improvement, for it is not mentioned in these earlier patents, was to twist the fibre itself in a spiral, such that the individual fibres would not be cut by the screw.[312]

After twenty years the Rawlplug was in worldwide use.[313] Indeed it was accepted in Australia well before this, for Rawlplugs were used to fix all fittings to the concrete walls of the Government Savings Bank, Sydney, completed in 1928.[314] R F Higgs & Company of Sydney were advertising in 1927 as the Australian agents, not only of the standard fibre plug, but also of the 'Rawlplug Bolt Anchor' in which a bolt head is inserted into a hole in a hard material, such as concrete, and is held in place by a conical ring of chilled iron, which digs into the side of the hole when tension is applied to the bolt.[315] By about 1936 D & W Chandler were selling Rawlplugs, though the bolt anchor is not mentioned.[316] The dating of this and other types is slightly problematic. The company history would have us believe that Rawlings's first plug was of metal, consisting of four sections of stamped brass, impressed

306 Great Britain, patent no 22,680 to J J Rawlings, 14 October 1911.
307 H A J Lamb et al, *Modern Fixing Practice* (London 1936), p 129.
308 Great Britain, patent no 257,303 to J J Rawlings and Rawlplug Co Ltd, 28 March 1925.
309 Great Britain, patent no 306,203 to J J Rawlings and Rawlplug Co Ltd (communication of Rawlplug Co Inc), 28 November 1927.
310 Great Britain, patent no 323,581 to J J Rawlings and Rawlplug Co Ltd, 18 October 1928.
311 Great Britain, patent no 323,583 to J J Rawlings and Rawlplug Co Ltd, 20 October 1928.
312 J Lamb et al, *Modern Fixing Practice,* p 130.
313 Lamb, *Modern Fixing Practice,* p 130.
314 *Building,* 12 December 1928, p 64.
315 C E Mayes, *The Australian Builders & Contractors' Price Book* (9th ed, Sydney 1927), advertisement p 5.
316 Chandler, *Catalogue 48* [c 1936], p 26.

with the rudiments of a thread, which could be inserted into the hole while folded together, but would expand under the action of the screw.[317] If this is true, it is not reflected in the patents, for it was in 1924 that Rawlings, jointly with the Rawlplug Co Ltd, first patented a metallic version. It was a cylinder of soft metal, shaped so that it would similarly break into a cluster of rods as a screw was forced into it.[318] Another scheme of 1926 for tubular metal sockets for screws and nails, patented in 1926, departs substantially from the basic rawlplug concept, and may or may not have been put into production.[319]

Despite the fact that there were many other inventions in the field, the rawlplug patents were so varied and extensive that it must at first have been very difficult for any competition to establish itself. But as these patents successively expired (normally after fourteen years) other makers could challenge the monopoly. In Australia the main rivals were probably the 'Sebco' anchors, marketed as 'Dryvin' for nails, 'Loxin' for bolts, 'Tampin' for machine screws or bolts, and 'Scruin' for wood screws. By 1937 they were being adverised by McPherson's of Melbourne,[320] though in 1949 they were, rather oddly, advertised in the British General Electric Co's Australian catalogue, together with at least some of the Rawl products.[321] According to the Sebco company their products were tested in the 1930s by 'a Commonwealth Government department', after which they were widely adopted by contractors.[322] In the 1950s these products were marketed by Ogden Industries, the proprietors of Lockwood products.[323]

317 J Lamb et al, *Modern Fixing Practice,* p 130.

318 Great Britain, patent no 178,680 to J J Rawlings and Rawlplug Co Ltd, 18 March 1921. A related patent for a bolt anchor is no 249,922, to J J Rawlings and Rawlplug Co Ltd, 31 December 1926.

319 Great Britain, patent no 280,987 to J J Rawlings and Rawlplug Co Ltd, 24 July 1924.

320 McPherson's Proprietary Limited, *Catalogue for Engineers & Industrialists* (Melbourne 1937), pp 251-2.

321 British General Electric Co. Pty. Ltd., *B.G.E. General Catalogue* (4th ed, Sydney 1949), pp 400-402.

322 *'Sebco' Modern Masonry Anchoring Methods* (Huntingdale [Victoria], no date, c 1950s), passim.

323 F W Ware & W L Richardson [eds], *'Ramsay's Architectural and Engineering Catalogue* (3rd ed, Melbourne 1954), § 23/1.