The Wire Nails Revolution: The History 1898-2000

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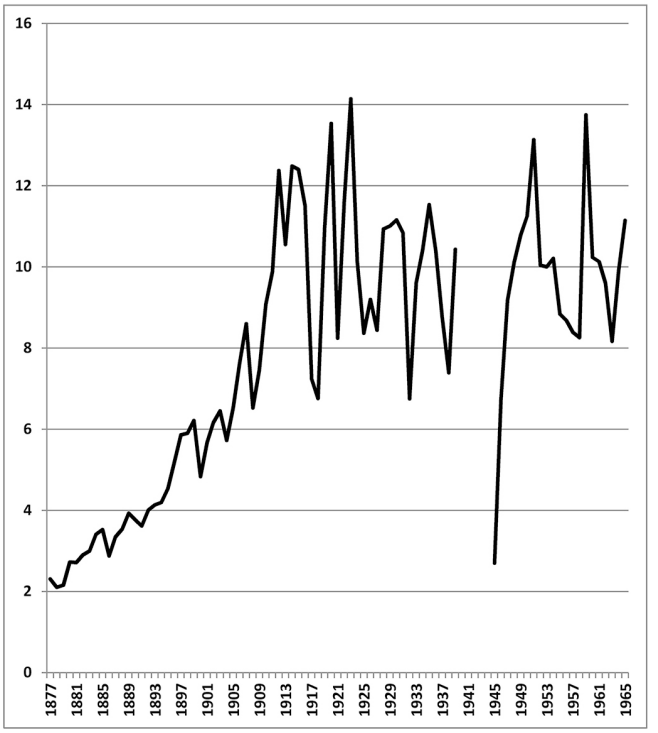
Introduction

The Bessemer process for the production of cheap steel of a high quality changed the steel business in the course of a few years. The transformation was impressive. The statistics for US production of steel tell of the development. In 1876, around 541,000 tonnes were produced; in 1905, production increased more than tenfold; and in 1915, the increase over the 30 years was 37 times to around 20,000,000 tonnes [1].



Graph 1. The consumption of nails per person rose dramatically with the use of cheap wire nails. The illustration is a rough representation because small producers have not been included since the 1930s [Statistisk Årbog, various years].

The construction industry benefitted through the introduction of new machinery and tools. The production of nails made of wire increased radically over a few years, with a dramatic reduction in prices.

In Denmark, the use of nails per person rose drastically from around 1.38 kg per year in 1880 to 3.63 kg per year in 1911 – which was almost three times [2]. This changed the construction business, in which tedious work thus far performed by carpenters was replaced by the use of nails by often-unskilled workers. Construction details were replaced with new ones [3].

For a long time, nails were an international mass-market product, and were almost the same from country to country with some minor cultural differences. The history is based on the situation in Denmark and the factory Traadværket established in 1899 in the Nordiske Kabel og Traadfabriker (NKT) company. Besides nails it produced other products made from wire – springs, barbed wire, telephone wire, and later, screws.

The first years of wire nails

The modern wire nail has a long history. In principle, the art of drawing metal thread got its form when the drawplate was developed at least 500 years ago. It is a die with conical holes through which the thick wire is drawn to make it thinner [4].

The first drawplates were made of iron, and the holes quickly became too big. The relatively soft iron could be hammered so the holes again became small. Precious stones – real diamonds – were used for the drawing of thin threads.

Wire rods were originally made by cast iron bars hammered into a long, round piece that the wire maker could draw. The iron industry and the sizes of rolled products grew rapidly thanks to the steadily improved steam engine. When the first inexpensive industrial process for mass production of steel came with the Bessemer process in the mid-1850s, increasing volumes of wire rods came on the market.

The wire rod became an industrial product, often with a standardised thickness. In the mid-1800s, the coils were delivered at a weight of around 12 kg, but over a few decades, the weight was increased to 60-90 kg.

A wire made of uniform composition was essential for machine production. One important step in the development of the Bessemer process was made by English inventor Sidney Thomas in 1878 with the production of steel with a low content of phosphorus – the so-called Thomas process.

Some years before, in 1865, French engineer Pierre-Èmile Martin developed a furnace with such a high temperature that carbon and other impurities could be burnt out of pig iron to make steel. It was based on an invention by the German-born brothers Friedrich and Carl Wilhelm Siemens, and the process became known as the Siemens-Martin process. However, it took several decades before this furnace dominated the method of producing steel.

The production process was later improved by the oxygen blasting and the electric arc furnace processes used since the 1950s.

Nail machines

For a long time, there was interest in producing nails by machine. From 1790 to 1825, more than 50 patents were issued in Britain and more than 120 in the US. Most of the inventions improved the previous production method by punching nails out of iron plates.

Later, inventions in the production of nails made of wire appeared, with more than 40 different methods developed between 1842 and 1854. One of the most important was an invention by American James White, who was living in Paris [5]. He obtained a 115-year patent on a machine that, in one operation, could make a nail. Such machines were used for the production of small nails for cigar boxes and frames. Even today, small nails are often called “point de Paris” or “Paris nails”.

When cheap iron wire came to market, many nail machines were installed, and soon, one type began to dominate for more than a hundred years. Even in 1870, some machines could produce 500 small nails per minute.

The first machine for wire nails in the United States was built in 1851, and wire nail machines mainly made the smaller sizes of nails up to the 1870s [6]. Steel came to the production of cut nails. In 1884, they formed 5% of the cut nail production, but the share increased to 69% in 1889. The first steel wire nails were produced in 1875 [7], but cut nails still dominated over wire nails, and in 1886, they had their production peak [8]. First, in 1892, the production of wire nails exceeded the production of cut nails [9], but by 1920, cut nails still had 8% of the market [10]. The dominating nail types have given archaeologists a tool to date old buildings [11], although the reuse of old nails and periods with several different types make the method unreliable.

The wire nails had several advantages. The nails consisted of less metal, so customers got many more when they bought a kg of nails. A cautious estimate tells that on average, a kg of nails provided around 190 two-inch cut nails but 300 wire nails [12]

The thinner wire nails were easier to use and did not splinter wood so easy [13]. At the same time, the price of steel declined. A study from the US shows a fall in the relative price of nails by a factor of about 15 times from the mid-1700s to about 1950 [14]. The declines were large enough to enable the development of other products. Apparently, the cheap nails gave low-income people in the US a possibility to build their own homes in the 1870s by using a form of construction called balloon framing instead of employing expensive professional builders and carpenters [15].

The production process

This chapter will explain the production process around 1900. In principle, even today, the basic processes are the same but with a lot of new assistive devices.

The wire is prepared by drawing through a drawplate bored with a succession of conically shaped holes that get gradually smaller. For example, a copper wire on 20 mm should be drawn down to 3 mm by passing 34 different holes.

Fig. 1. Heavy equipment is necessary to draw the wire through the draw plate as seen in the first machinery at Traadværket around 1905 [Middelfart Museum].

The first drawplates were of a German type around 14 kg in weight, 40 cm long and with 100-142 holes. After some years, a smaller English model was introduced in a form like a bat with a shaft and a thin alloyed steel plate welded on a thicker iron plate. It had around 15 holes of the same size.

Even this enforced drawplate became worn quickly. The first drawing of a coil of 65 kg made the hole too wide. Only an increase of 1% was tolerated. Longer coils should therefore be cut in pieces for several drawplates to maintain the accepted thickness.

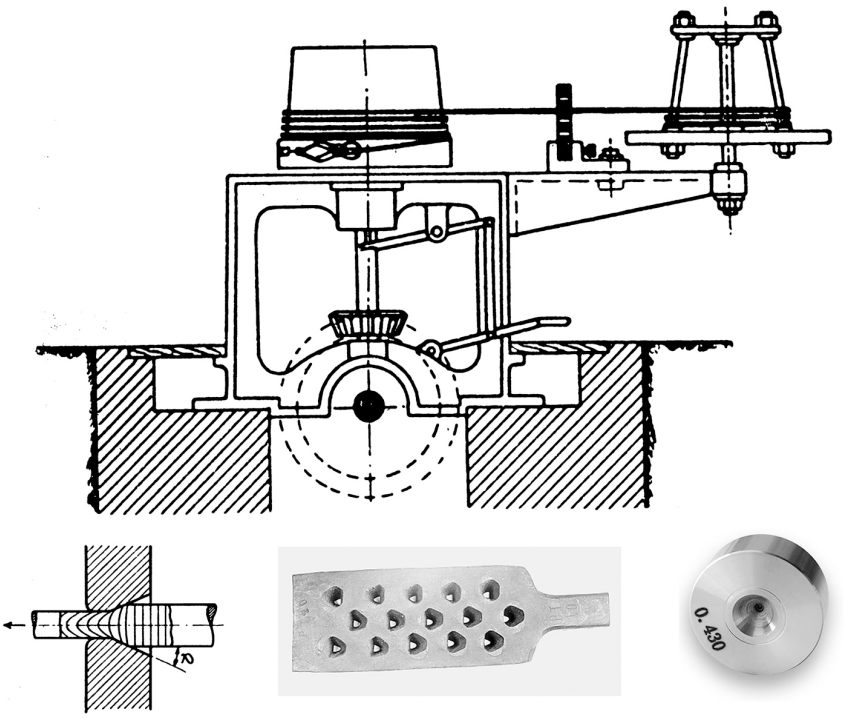


Fig. 2. The coil, right, draws the cold wire through the draw plate. This not only reduces its thickness but also provides a better structure. The draw plate shown with 15 holes is atypical with its triangular holes. Most Danish nails were made using drawplate-stones from the 1950s.

The wire gets longer after each drawing. A coil of wire with a weight of 65 kg was 400 m long when it arrived at the factory. When it was drawn down to 1 mm, it was 10 km long.

The workers needed to work carefully because during the drawing, the steel became harder and brittle. In the end, the wire should not only have the right diameter but also the right hardness. For example, when a wire is drawn from 5 mm to 4 mm diameter, its breaking strength increases from around 40 kg/mm^2 to 60 kg/mm^2; when it is drawn again to 3.2 mm, the breaking strength is perhaps 70 kg/mm^2. Eventually, it is too hard and would break in a further drawing.

In 1899, the factory only used “Thomas” steel, but later came the better – and more costly – quality “Siemens-Martin” steel, first for flat-headed nails.

To keep the wire relatively soft, repeated heating are necessary. Some wire can only be drawn two times before a re-annealing, but the normal was 4-5 drawings. The wire coils are then installed in heavy iron pots for the re-annealing. A pot should be airtight to prevent oxide scale. The steel coils should be heated to 700-800 degrees for six hours, while copper had a lower temperature and time. After the annealing, the red-hot pot should be cooled up to 36 hours.

The factory had 80 nail machines in a hall, and they made a huge noise. With all the machines working, there were 20,000 strokes a minute. The machines worked steadily eating wire and spitting nails out. The nails dropped into a pan on the floor ready for the next process in a tumbler for polishing. The oil and grease was absorbed by sawdust, and "whiskers" remaining from the cutting were also removed. The nails often have gripper marks near the head.

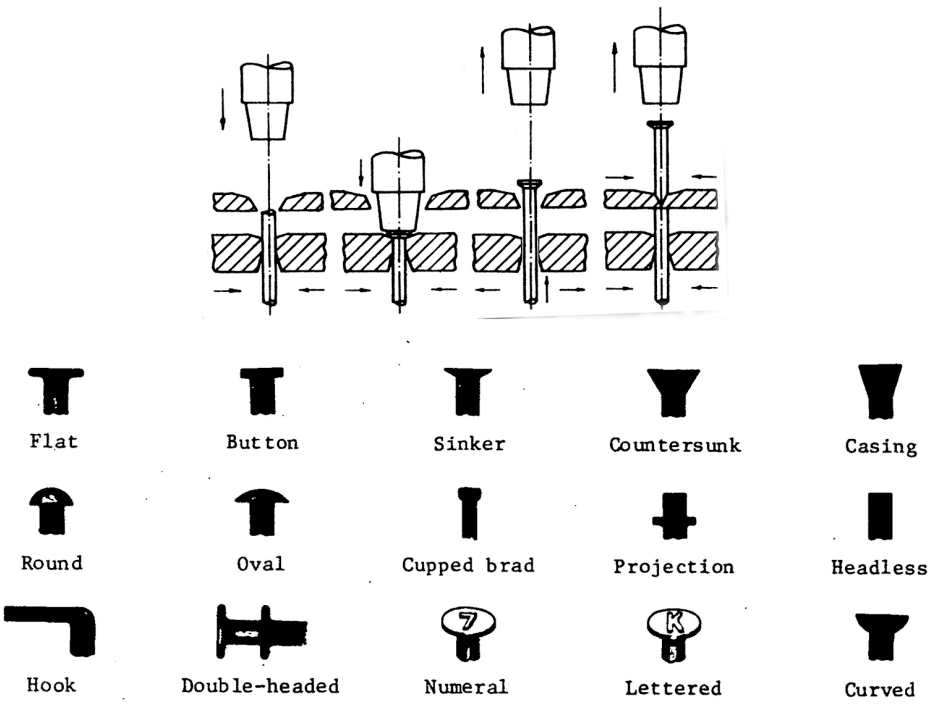


Fig. 3. The principles of shaping a nail: 1) the wire is held, 2) the matrix banks the head in the mould; 3) the wire is moved forward; 4) two oblique blades cut the wire. Different matrices and moulds produce different types of nails [Independent Nails, Featherstone, Certain steel wire nails. Appendice A-54].

A worker at nail machines would be active only when a new coil was to be installed. Otherwise, he controlled the nail quality, for instance, by checking to see if the knives became dull, and the points that were not perfect, cut off.

A general nail machine, as one from the German Company Wafios, originally had an operating rate of 700 revolutions (nails) per minute. Rebuilt machines could reach operating speeds of 900 revolutions when small nails were produced [16].

The largest machine could make a square spike 26 cm long, 2 cm thick, and weighing of 175 grams. The smallest pin was 7 mm long with 52 nails per gram.

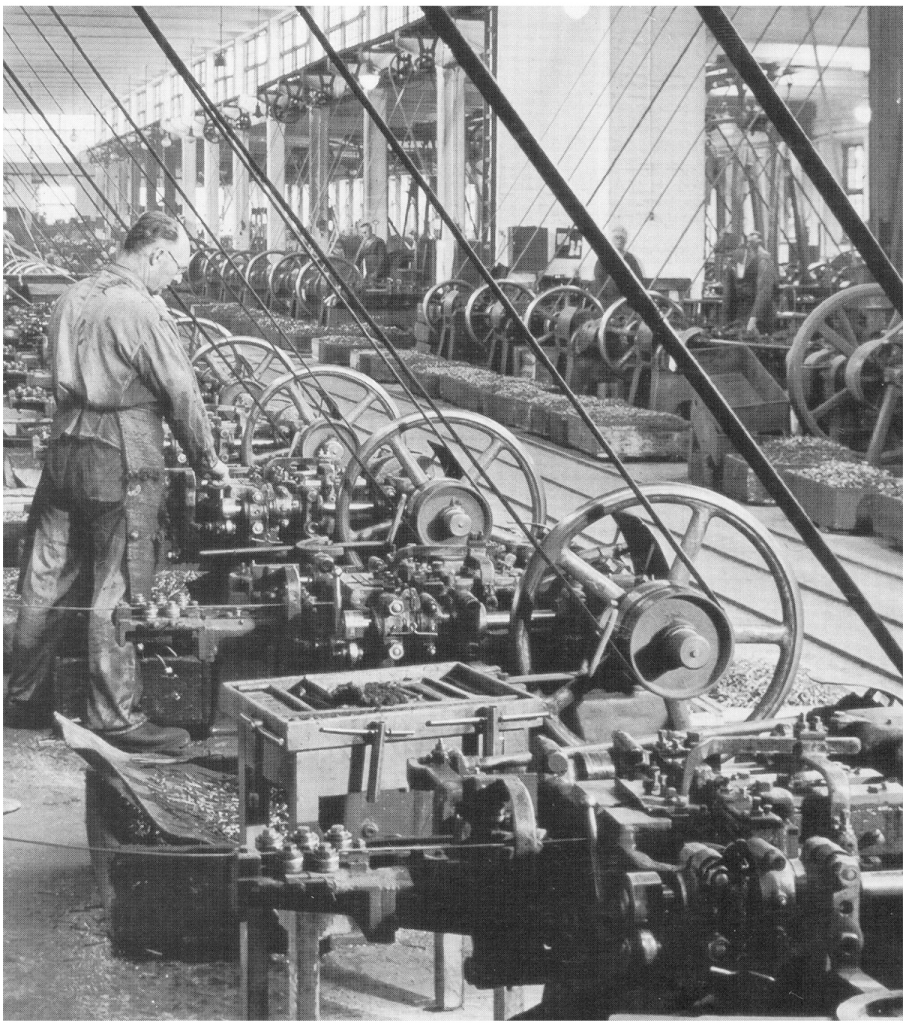


Fig. 4. In 1948, nail machines were still belt driven. As seen in the machine in front, the wire is straightened before the nail is formed [Middelfart Museum].

Nail types

The nail head is designed for its use, both while the nail is hammered in and when stuck. The size of the head is defined by its purpose, where a maximum bearing area is needed when being used for roofing and wall covering. Often, heads are small to make them less visible after being driven [17]. Special nails for framing have texture on the head to prevent a slipping of the hammer.

Countersunk and casing heads are perfect for finishing jobs because the design allows the nail to be driven below the surface, as for flooring. Similarly, the cupped nails with small heads are less visible after being driven – often by the help of a mandrel when installing panelling and trim. Other nails have concave heads that provide the best way to conceal them, as for drywall.

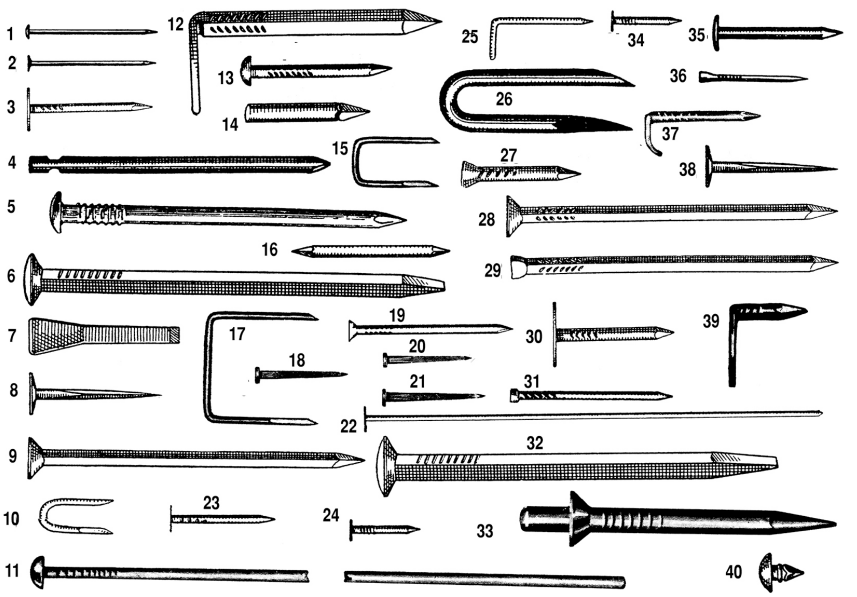


Fig. 5. Traditions have defined the shapes of nails. In Denmark, Germany north of Hamburg, Portugal, Brazil and some parts of Norway and Finland, square nails have been common. In Sweden and, to some extent, Norway and Finland, nails had hollow sides. Some countries overseas have used a triangular or oval shape; otherwise, they were round. The most commonly used Danish nails 1924: 1 and 2. brass pins, 3. reed tissue nail, 4. door handle pin, 5. roofing sheets, 6. normal spike, 7. wooden shoe nails, 8. cut copper nails, 9. square copper boat nails, 10. telephone wire cramp, 11. long pin, 12. hook, 13. window pin, 14. hinge pin, 15. telephone wire cramp with flat crown, 16. connector pin, 17. carpet cramps, 18., 20.,21., tacks, 19. round pin, 22. pin for mould at iron casting, 23. comb pin, 24. pin, 25. hook pin, 26. window cramp, 27. shoe pin, 28. square nail, 29. square diver, 30. steel roofing paper nails, 31. thread dives, 32. ship spike, 33. tear pin, 34. slipper pin, 35. furniture canvas pin, 36. brass shoe pin, 37. round lead cable hook, 38. cut iron nail, 39. cooperage nail for barrels, 40. Paris shoe pin.

Where nails need to have an easy removal at temporary applications, double-headed nails are used. The original use gave them the name "scaffold nail", but nails are not used for scaffolds anymore, so instead they are called "duplex nails" today.

More than a thousand different types of nails and sizes are standard on the market now. More nails have been developed for special purposes made to customers' specifications. When new building materials become available, the manufacturers develop new types, for instance, hooks and roller-shade wood-roller pins. The fastening of gutters needs special-design nails. Other heads are used for decorative effects. Many nails have a smooth shank, making them easiest to drive and offer the least pull-out resistance. Two-pronged shanks make nails or fencing staples useful for attaching mesh fences to wooden posts and frames. Most nails have a diamond point, which is a four-sided pyramid. Some have a blunter point to prevent splitting certain woods.

Masonry nails, now also called concrete nails, are special nails with a high hardness to securing materials to concrete walls and blocks. Square boat nails can handle boat building and hardwood flooring because of their

construction of heavy-duty steel wire and often with a hot-dipped galvanized or copper-coated surface treatment. Similarly, the old fashioned-made cut nails for hard materials still exist.

New fastening technologies created a need for new kinds of nails. For instance, the nail plate introduced in the early 1960s gave a need for a suitable nail [18]. In the family with pins are corrugated fasteners used as a remedy for damaged adjacent timbers.

Nails are made in different sizes, from small – under one inch, often called a tack or brad – to very large, often called spikes. They are made in different length systems. In continental Europe, the metre system is used, in Britain the inch, and in United States nails are often measured in "pennies" called "d" after the abbreviation for the smallest unit of the pre-metric currency systems of Europe, Britain and its Commonwealth – **l**ibrae, **s**olidii and **d**enarii. The origin of the method is not known; some suggest it was the price per hundred nails. A one-inch nail is 2d, and a 10d nail is three inches long.

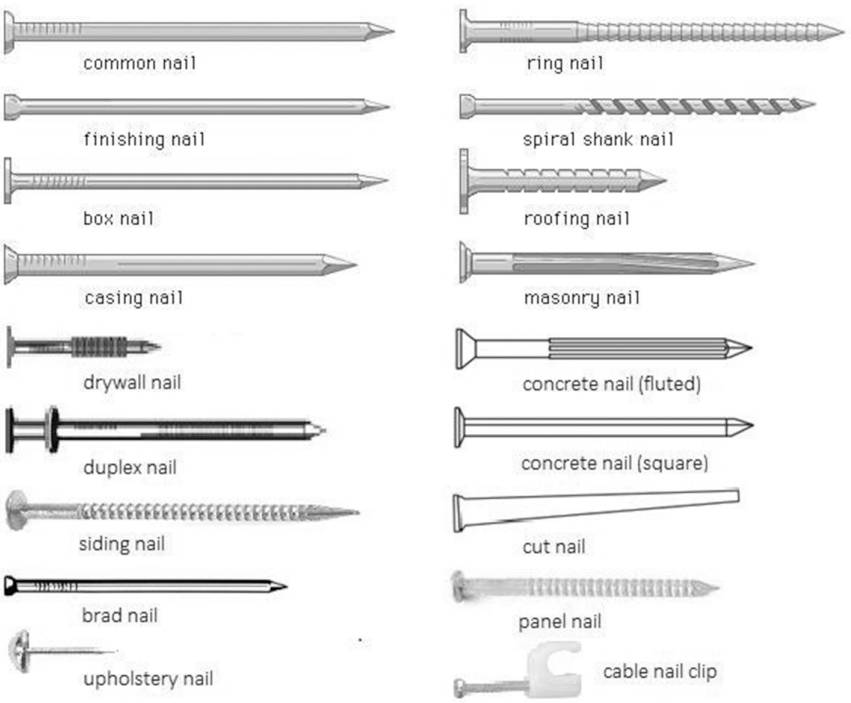


Fig. 6. Modern nails sold in the United States [Bradnailer24h].

Originally, producers of wire named the thickness with a gauge number. The gauge was simply indicated the amount of reduction of a wire by each draw; each successive gauge was around 11 % thinner than the preceding one. Number 1 was the thickest wire and a larger number a thinner wire. In Britain, a standard was established by the trade in the form of the Birmingham Wire Gauge. In 1963 all British measures lost their legal existence in favour of the metric system as France has had for more than a hundred years [19].

To prevent the nails from rusting, they are often treated with a protective coating. Large nails are often coated with zinc. Originally, this was done by a hot dipping in liquid zinc. Later, solutions were made in a cheaper electro-galvanized version. Layers of grey or black phosphate give a light protection. For some tasks, the nails are made of stainless steel, aluminium, brass, copper and silicon bronze. Cement and resin coatings can give the nails extra holding power. The resinous coating melts and gives a tighter bond.

Distribution and sale

The sale and distribution in the first half of the 1900s was rather rigid. The wholesalers placed their orders almost a year before the delivery – far from the present day-to-day delivery. The planning of the production was rigid with the production of large series. The transportation system explains some of the rigidity because the wholesalers would have to purchase at least one filled railway wagon with 10 tons.

The factory's first years gave a deficit. The quality was not high enough, with complaints that the nails were too soft or had different lengths and thicknesses.

At the start, 60 German and 20 American nail machines were ordered. When they came into function, it was discovered that the American machines made the nails in a different shape than the well-known type from the German machines.

The company had problems with the delivery of some sizes of nails because it had no suitable machines, and those nails were bought from other companies. Often the German nail factory in Gleiwitz was chosen as a supplier because its nails were the most beautiful and sonorous nails with the largest and almost circular heads.

The company, through the first 20 years, installed new machines so it could produce more than 1,000 nails in different types and packages in sizes from 6 mm long to 32 cm. The nails were mostly packed for retail sale by weight. Only a few nails were sold by numbers. The smallest were sold in packages of 20 grams, while the biggest one weighed 10 kg.

In German, companies in the nail business occasionally made cartel agreements. For some years, the companies had agreement regarding the sale, and customers could only buy nails through the cartel's central office.

Similar national cartel agreements gave the inspiration for international cartels. Most of the important nail producers in Europe met in 1930 and came to an agreement. The negotiations ended with an agreement regarding the distribution of the sale of the total European market. This strong agreement pressed the American and British companies to join the cartel organized by the international export federation International Wire Export Company (IWECO) since 1932.

Supply problems

During the two world wars, the factory had problems with acquiring raw materials. The least problems were during WWI, where it could get wire coils from both Germany and Great Britain under the prerequisite of promising not to re-export to the counterparty.

A much severe problem was the delivery during WWII after the German occupation of Denmark. Then, only Germany could deliver wire rods, and the deliveries were small and unstable. Some nails could be imported from Sweden, and in this way the Danish customers learned of the Swedish type of nails with a coved shaft.

The sale of nails was rationed, but the production was very small. However, the inventiveness was active. For example, a man "invented" the 100-year-old production method of cutting nails out of a flat plate. The state tried to regulate the trade and introduced a maximum price in 1942. Still, there were too few nails on the market, and a black market arose. While the regulated price should have been 4.42 DKR, the price on the black market was 20 DKR.

The problems continued after the occupation, and at the end of the 1940s, people still had problems in acquiring nails. The situation was so desperate in 1947 that Traadværket invested in the newly established Danish steelworks, Staalvalseværket. This company bought a complete wire rod production machinery from Sweden, and a large part of the necessary commodities was delivered to the factory.

Improvement of the production process

The production method saw a comprehensive improvement after the war. Central in the process was the new draw plate, or rather a draw-die with only one hole and made of a very hard alloy of tungsten carbide. The old draw plates could create a difference in the thickness of the wire of 0.2 mm from the beginning and the end of a small coil of wire. The new draw-die could handle 20 ton in one draw with a difference of less than 0.02 mm from start to end, which produced nails of a really higher quality.

This improvement revolutionized the whole production process. The shift from a coil of 300 m to the new one of 1,600 m (at around 260 kg) gave savings of three shifts of wire. Over a few years, the steelworks made coils on up to 2 ton, and by then 20-25 switch-overs for each coil at the drawing machine were saved.

The use of large coils made the new forklift truck necessary. At the nail machines, the workers no longer needed to weld small coils to a large coil. This welded piece on the thread created bad nails that had to be removed. Now the nail machine could produce fine nails for hours.

The construction of the draw-die had been underway for decades. German producer Widia had notable success with its die beginning with its first tungsten carbide draw-die, which came into production in 1926. The consequence was an increase in production of 10-30%, and it simultaneously gave a better tolerance and less scrap. The name Widia became a name for that kind of draw-dies, including dies from other companies.

Factories in Germany had long used this type of draw-dies and were followed by factories in other countries in the 1930s. The Danish factory waited until 1949. One reason was that most Danish nails were square. When a draw-die was too worn, it could be remade for a larger-dimension hole. Square holes could at that time only be made outside Denmark, which was costly and time consuming.

The new die had another advantage. Hitherto, the wire should have been put in a bath with acid and a light coating to better slide in the draw plates. In the late 1940s, a new method was introduced using phosphate and borax, which led to reduced wear on the draw plates and drawing by a higher speed.

Industrialization of the building process

Around 1960, a producer of ties and connector plates asked Traadværket to produce ringed nails with a six-times-higher pull-out resistance. The company could not see any market for the product and said no. It should not have done so. The producer went to Sweden and got the Swedish company Gunnebo to make the nails, and the Swedish company became an important delivery source for the new building method.

More forms of shanks were developed. The screw-like ring shank nails gave 40% more holding power than common nails, which are useful for floors, plywood and roofing. Ringed shanks are best for soft woods and objects of medium density. A fluted shank gives a very strong hold on cinder blocks and masonry and prevents cracks through their design.

To rationalize, working with nails has been an idea for more than a hundred years, but with the use of compressed air to drive a nail gun, a system was ready to be developed since its first construction in 1944 [20]. The first stable product with enough power to hammer several nails in series was the Spotnails model, which was issued around 1958.

Fig. 7. Nail guns have reduced the tedious work of hammer nails. The nails need to be mounted in long clips or connected with plastic or paper.

Nail guns are perfect for jobs such as the binding of pallets and crates, fencing, garden furniture, external cladding fixation, etc. Nails for nail guns are often assembled together in coils with steel wires, which have given them the name “coiled nails”. Other types are collated by plastic strip or bands to prevent deterioration due to weather conditions, or the safer but more expensive paper strips. The main types of these nails are coiled smooth-shank nails, coiled ring-shank nails and coiled screw nails.

Traadværket contacted the American producer of the Illinois Tool Works (ITW)-owned Paslode nail gun and sold this machine together with foreign-made nails. The nails were round, but the Danish tradition for nails was square. Because the Danish factory-made high-quality nails, Paslode reached an agreement on the production of those nails. This production expanded later to more than 50 different types of nails. Because every dimension could have different surface treatment, the total production became more than 400.

The production process of high-quality nails was strengthened in the 1970s when Traadværket developed a new nail machine with a rotary forming process that allowed wire feeding, wire cutting and head forming to take place in one continuous process. Models were developed for the most important nails, for instance, for short nails with a production of 1,700 nails a minute. It is today produced by the company Enkotec with many advantages, among them a low noise level.

The market situation changed gradually at the end of the 1970s. Building activity fell and the too-big production capacity in Europe created a sharper competition. Production came in from Japan, Hong Kong, Taiwan and the Eastern European countries. Around 1980, the production of several products at Traadværket was stopped in a structural rationalization, and the items were bought from foreign producers instead. Today the plant in Denmark produces only a few products. Its sales division can deliver all kinds of nails – now bought from factories in China or elsewhere for the lowest price. This internationalization had consequences for the business. In 1999, the plant was purchased by the US-based international company ITW.

The package has changed in the last years. Around 1960, the cardboard boxes changed sizes to be more suitable for the new transport on pallets. Twenty years later, sales promotion in the self-service shops demanded additional new packages for the self-service shops' display racks.

Conclusion

The industrial production of wire nails has created a multitude of different nails to meet every need. The quality of the nails, including their rust protection, has improved and become more durable. The use of more nails has replaced some carpentry tasks. This development accelerated after World War II with the extended use of ties and connector plates together with specially designed nails. A new design was also necessary for the use of nail guns to automate the use of nails as much as possible.

The increased production of wire nails is not only a Danish concept but an international one. For instance, each person in New Zealand used around 2.2 kg per person in 1871, with a rise to 4.4 kg in 1900. This higher consumption than in Denmark can be explained by the widespread use of wood and the need for houses for many immigrants [21]. In contrast, the dominant building method in Denmark was with bricks.

Traditions among carpenters created cultures with some special profiles. For instance, the typical Danish nail was square and not round as in many other countries.

The nail market seen from Denmark was at first totally dominated by German companies. The Danish company NKT was established to form a national counterweight. This succeeded, but the national and international cartels disappeared after World War II, and for the last decades, the market has been global, with most nails produced away from Europe.

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